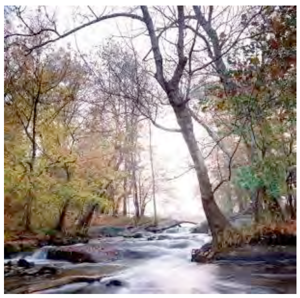
# SAVING LAKE GREENWOOD

*An action plan for restoring and protecting water quality*


Prepared by

UPSTATE FOREVER

www.upstateforever.org

for the Saluda-Reedy

Watershed Consortium

www.saludareedy.org


April 2009

**UPSTATE FOREVER**

and

**THE SALUDA-REEDY WATERSHED CONSORTIUM**

wish to thank

**V. KANN RASMUSSEN FOUNDATION**

and

**FUJIFILM MANUFACTURING USA, INC.**

for their extraordinarily generous support

for this project

# TABLE OF CONTENTS

This page intentionally left blank

# INTRODUCTION: WHY WATER MATTERS

*The importance of clean and abundant water for quality of life and economic prosperity in the Upstate*

One of the jewels of the Upstate is Lake Greenwood, a beautiful 11,400 acre lake that is the source of drinking water, tourism, economic benefits and pride for the entire Greenwood community and Upstate. But the lake is in serious trouble. Sediment, stormwater runoff, and wastewater discharges combine to create a brew that is terrible for the lake and is a primary driver of the algae problems that have plagued its waters in recent years.

There is much at stake. Lake Greenwood has a well-deserved reputation as a recreational mecca, and it lures a considerable number of retirees to the Upstate. For decades, companies have moved to the region for its abundant supply of clean water vital to their operations. And a substantial portion of the residential growth in the Upstate is fueled by a desire to live close to natural splendor along the shores of Lake Greenwood and the rivers that feed it.

A healthy future for the lake begins with sound science, and that is one of the primary purposes of the Saluda-Reedy Watershed Consortium (SRWC), a broad based coalition of universities, nonprofit organizations, government agencies and private businesses which have conducted a wide range of research on Lake Greenwood and its watershed. The findings of SRWC-affiliated researchers can provide the solid footing we need to make water resource management decisions in Laurens, Greenwood, and Greenville Counties and beyond that will protect our water resources. In our housing and commercial developments, in our farm fields, along our lakeshores, and with our industrial and wastewater discharges, our challenge is to move beyond older policies that have been harmful to, or at best neglectful of, the health of our water.



This report is a synthesis of studies sponsored by SRWC and others. It offers a comprehensive picture of the lake's health and future. The next four sections cover the current condition of Lake Greenwood; the root causes of water quality deterioration in the lake; a long-term prognosis of the lake's health; and recommended management strategies to protect and restore water quality into the future.

As the researchers note, the whole Upstate region is interconnected. Our waterways link us together, and everything and everyone in Laurens, Greenwood, and Greenville Counties and across the region – human, plant, and animal – cannot flourish alone.

This page intentionally left blank

# SECTION ONE: CURRENT CONDITIONS

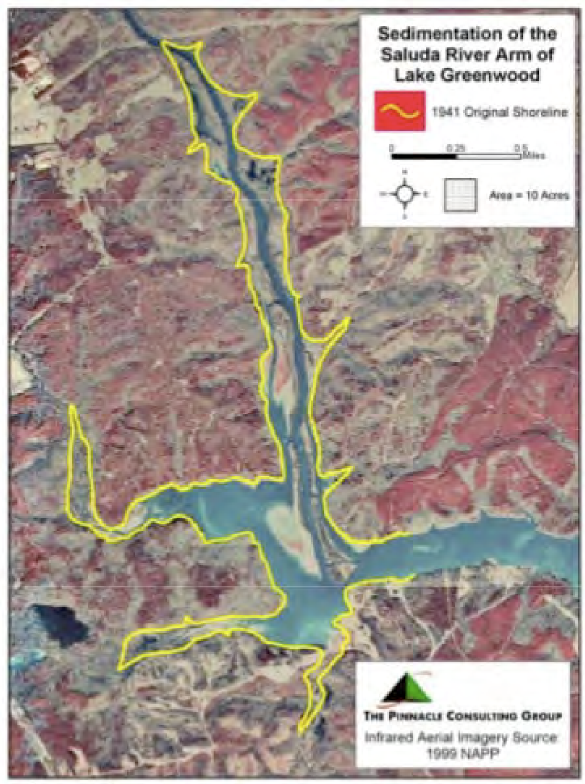
*How and why sediment and nutrients impair the health and threaten the future of Lake Greenwood*

Sediment and phosphorus are the primary culprits of the degradation of Lake Greenwood. That's the verdict from the Saluda Reedy Watershed Consortium, whose members have spent the last five years engaged in a variety of studies about the health of the lake. They've conducted an in-depth assessment of historic water quality trends, developed predictive models of land use change and water quality dynamics, investigated the loss of lake storage capacity, and more. (To download the full research reports, visit www.saludareedy.org/research.) Their research and analysis point to sediment and the phosphorus it carries as the principal causes of the lake's worst problems, from silting in of shallow bays to fish kills to algae blooms. Solving these problems requires a clear understanding of these pollutants and their impacts.

**SEDIMENT IS BUILDING UP FAST.** Analysis of historical photographs and satellite imagery shows that nearly 310 acres of water in the upper reaches of Lake Greenwood have become dry land over the last 60 years. In the process, roughly 6,200 acre-feet of water storage capacity has been lost in these reaches. Including the sediment volume accreted above waterline, the total volume of sediment delivered to just this portion of the lake is about 11 million cubic yards—enough to fill the Clemson football stadium to the brim 10 times over.

While this represents a relatively small portion of the total volume of the lake, the physical impact of sedimentation is felt disproportionately in certain areas. The deep water in the main stem of Lake Greenwood is unlikely to fill in anytime soon, but the upper reaches and small side coves are particularly at risk. Given how much of the lake's shoreline is along these coves, Lake Greenwood may effectively become a significantly smaller lake if sediment continues to build up at the current rate.

**SEDIMENTATION IN LAKE GREENWOOD**




This aerial photo of the Saluda arm of Lake Greenwood shows how much of the lake's original area has been lost to sediment.

**SEDIMENT ACTS LIKE A SPONGE AND VEHICLE FOR CONTAMINANTS.** Phosphorus, heavy metals, bacteria, and other pollutants are attracted to and bind with tiny particles of clay that make up the most visible component of the sediment in our rivers and lakes. The smallest of these contaminated particles pass through conventional stormwater detention ponds and silt fences. They stay in suspension for a long time, transporting pollutants for miles downstream and eventually into Lake Greenwood. This means that when sediment enters the lake, it brings many more problems with it than just its physical presence.

This development site in Greenville is typical of many in the region, with extensive bare dirt and failing erosion control structures. It took only a 20-minute shower to send a plume of sediment down to the nearest stream and into the Reedy River.

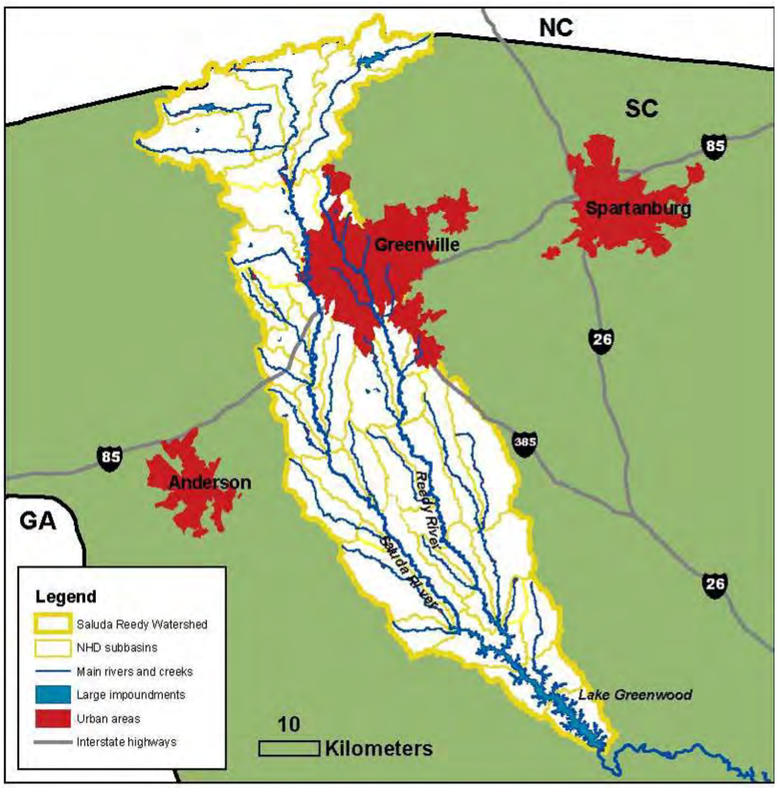
**TOO MANY NUTRIENTS CAN LEAD TO TOO MUCH ALGAE.** Originating from wastewater treatment plant discharges and overland runoff, phosphorus and nitrogen travel to the lake and provide critical nutrients required for algal growth. When an overload of phosphorus and nitrogen are introduced to the lake, algae growth can increase to an uncontrollable level. As the algae dies and sinks to the bottom, the decay process consumes a substantial amount of dissolved oxygen. A combination of low bottom-water oxygen levels and high surface water temperatures that often occur in the summer can leave many fish and other aquatic life with little or no suitable habitat.

In 1999, a bloom of algae covered portions of the upper reaches of Lake Greenwood in a mat so thick that turtles and ducks could walk on top of the water. It hasn't happened again, mostly due to a substantial effort by the South Carolina Department of Natural Resources (DNR) and Greenwood County to monitor and control algae populations. But the impetus for SRWC research comes from the need to address underlying causes of algae blooms, as the ongoing algae control efforts demonstrate that there are persistent water quality problems.

**LAKE GREENWOOD'S WATERSHED IS RAPIDLY DEVELOPING.** A lake's watershed is all the land, both upstream and along the lakeshore, that drains into the lake. Like any lake, Lake Greenwood is a creature of its watershed, an interaction that involves regional geography, in-lake dynamics, and human actions. Rapid population growth and development within the watershed drive land use changes throughout the watershed, providing the opportunity for the highly erosive soils of the Upstate to enter our waterways. Increasing populations and associated burdens on wastewater infrastructure also drive the levels of phosphorus entering our waterways and eventually Lake Greenwood. What follows in an overview of some of the watershed characteristics that affect how much sediment and phosphorus are entering the lake.

*Watershed size and shape.* As the size of a watershed increases, runoff volumes and rates increase. This puts a lake that is small relative to its watershed—as is the case with Lake Greenwood—at proportionately greater risk of filling in with sediment or becoming overloaded with nutrients than a large lake with a relatively small watershed. Lake Greenwood is at the bottom of the Saluda-Reedy watershed, a populous and rapidly developing region about 40 times larger than the surface of the lake. By contrast, Lake Keowee, about the same size as (but much deeper than) Lake Greenwood, is fed by the watershed of the Jocassee and Keowee Rivers, an area only about 12 times larger than the lake. Keowee enjoys a reputation for clean and clear water in part due to its small drainage area.

**LAKE GREENWOOD AND ITS WATERSHED**




Lake Greenwood is at the bottom of the Saluda-Reedy watershed, a broad area of land that includes more than 1,400 miles of streams, parts of 18 towns and seven counties, and more than a third of a million people.

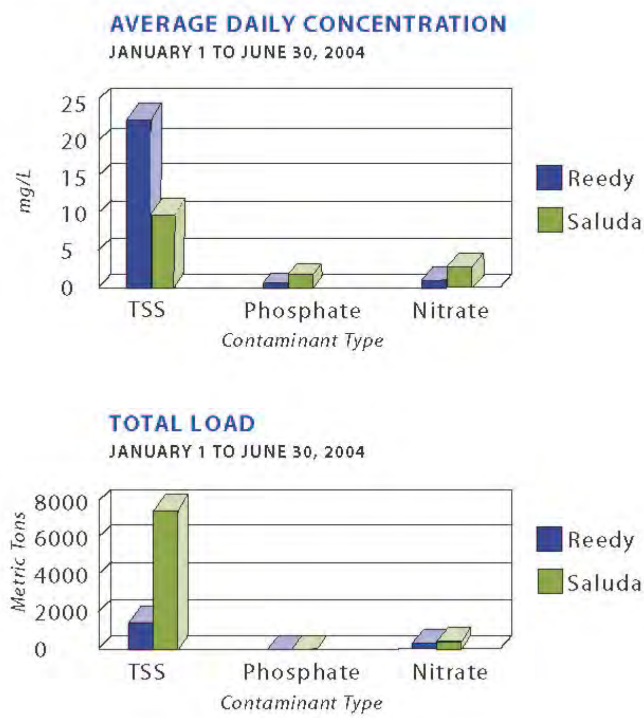
*Watershed topography and soils.* The topography of a lake's watershed greatly influences the volume rate of runoff as well. The topography of Lake Greenwood's watershed produces greater runoff rates than does the landscape of a watershed with a gentler slope. In addition, the watershed's thin, mostly clay soils allow more runoff than would deep, permeable soils. Finally, vegetation also affects the rate and volume of runoff, and the rapid loss of tree cover in the Upstate over the last three decades has played a significant role in exacerbating erosion.

*Hydraulic residence time.* A lake's hydraulic residence time is the average amount of time required to completely replace the lake's water volume. If the volume is relatively small and the flow of water is relatively high, the hydraulic residence time is short. Under some circumstances, this scenario can cause sediment and nutrients to pass through and out of the lake fairly quickly.

In Lake Greenwood's case, these circumstances do not occur. The lake is quite long for its volume, which means that a significant proportion of the sediment and phosphorus that enters the lake settles out and never leaves. An intensive look at the flow of sediment into and through Lake Greenwood over 16 months reveals that the lake retains about 80 percent of the suspended sediment that enters from its two main sources, the Reedy and Saluda. (The lake retains virtually all of the heavier sediment – known as "bedload" – that enters it.) As fate would have it, then, the lake functions exceptionally well as a retention basin for phosphorus-charged sediment that would otherwise migrate downstream.

*Land use.* Human activity that modifies the landscape is the number one source of sediment coming into Lake Greenwood, both today and in the past. The lake appears to have experienced a significant increase in the amount of sedimentation shortly after it was built in 1940, most likely due to a combination of factors: the tail end of major commercial cultivation of corn and cotton (two of the most erosive crops), the construction of the Army airfield south of Greenville during the war, and a post-war construction boom. Sedimentation slowed down for a couple of decades, but increased in the 1980s as the pace of development picked up once again. Even with improved sediment control, the extent of development over the last three decades has caused our rivers to run red with mud after even a relatively insignificant rainstorm.

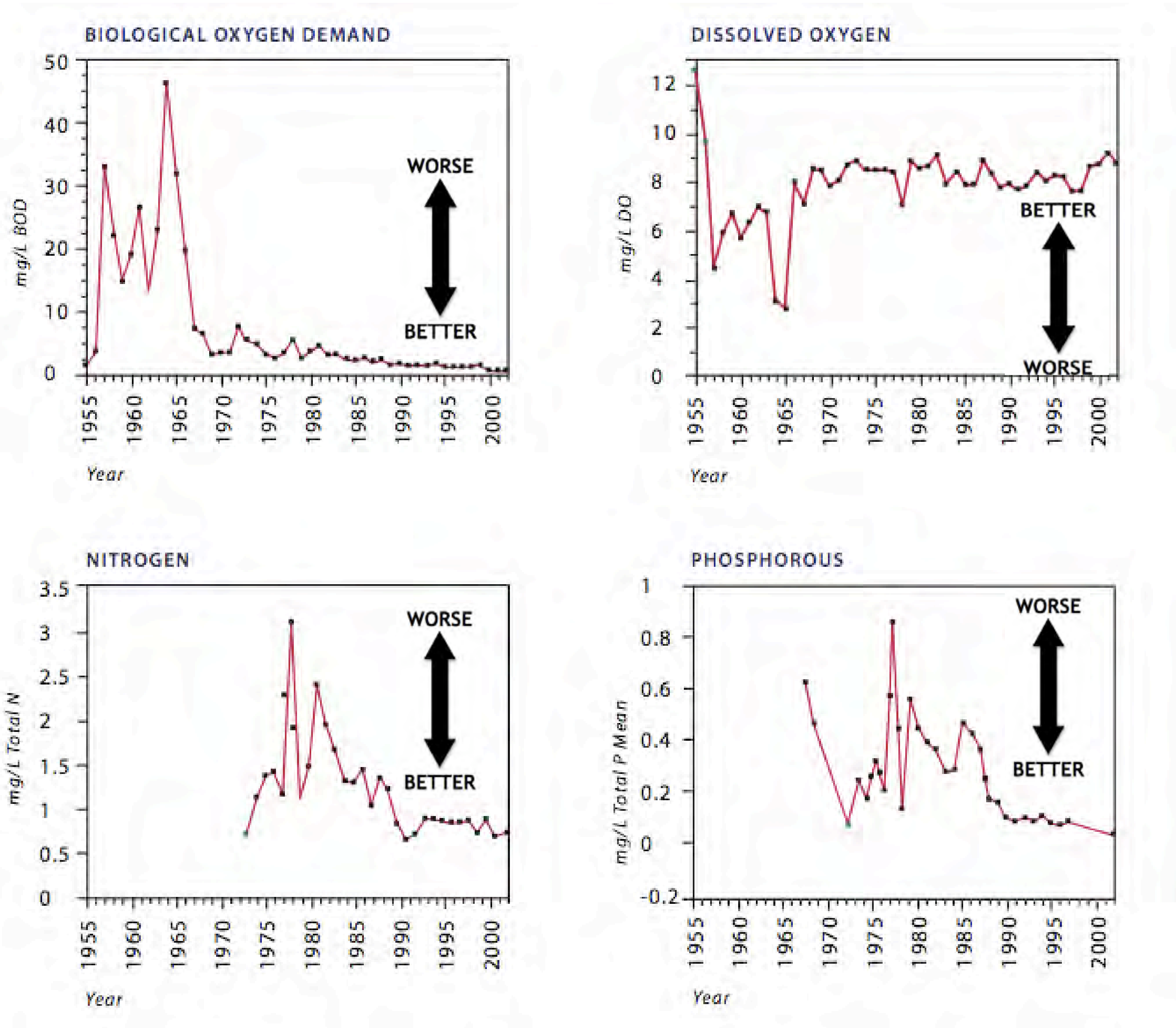
**POLLUTANT LOADS IN THE SALUDA AND REEDY RIVERS**




Data collected during storms at sampling stations on the Reedy and Saluda where each enters the lake show that the Saluda River contributes eight to ten times more sediment (known as "total suspended solids," or TSS) to the lake than does the Reedy. However, the load of nitrogen and phosphorous is about equal in the two rivers. This is because the Reedy's load of contaminants comes mostly from sewage treatment plants and other "point source" discharges, while the Saluda's comes mostly from polluted runoff.

**BECAUSE OF THE COMBINATION OF SEDIMENT AND PHOSPHORUS POLLUTION, THE LAKE'S HEALTH MAY BE HEADED FOR THE WORST.** It is no coincidence that the problem of too much phosphorus-charged sediment comes at a time of major economic growth in the watershed. Though water quality has improved significantly since passage of the Clean Water Act of 1972, most of the gains were from easily attainable treatment of industrial effluent and sewage discharge into the rivers, not from better erosion control and advanced phosphorus removal from discharges. As a consequence, while Lake Greenwood and the Saluda and Reedy Rivers are cleaner now than they were 50 years ago, those gains are at risk because of the "one-two punch" of phosphorus and sediment. This is why the SRWC partners believe that these two issues – sediment from upstream development and phosphorus from wastewater discharges – are the chief causes of water quality impairment in the lake. In fact, they believe that if left unaddressed, these threats could undo 30 years of progress, especially given the fact that phosphorus-charged sediment that washes into a river can take years, sometimes decades, to make its way to the lake. This "lag time" means that the problems that are already in the pipeline are worse than those we currently see in the lake. The time to act is now.

## LONG TERM WATER QUALITY TRENDS IN THE SALUDA-REEDY WATERSHED, 1955-2002




SRWC scientists assessed water quality in Lake Greenwood based on a variety of parameters, including the availability of dissolved oxygen for fish and other aquatic species, and the concentration of phosphorus and nitrogen. Analysis of thousands of measurements taken between 1955 and 2002 indicates that dissolved oxygen levels and nutrient loads in the rivers feeding Lake Greenwood are currently at levels that are sufficient to support most aquatic life and that pose no immediate threat to people. However, the relatively high nutrient loads remaining in the rivers — improvements of the last 40 years notwithstanding — tend to stimulate algae growth in the lake. This causes a persistent pattern of oxygen depletion in the lake's deeper waters.

This page intentionally left blank

## SECTION TWO: ROOT CAUSES

*Where pollution is coming from and what it is doing to the lake*

The challenges to water quality in an era of rapid population growth and land use change are strikingly different from those of a generation or two ago. Today the problem goes beyond how and to what level industries and sewage treatment plants treat their waste (known as *point-source pollution*) to also include how communities manage the whole landscape so as to reduce the *nonpoint-source pollution* that comes mostly from growth and development.

**NEW SOURCES OF POLLUTION PRESENT NEW CHALLENGES.** Nonpoint-source pollution is the technical term for the sediment, nutrients, and toxic contaminants that are washed from the land when it rains and are carried with stormwater runoff into the nearest stream. Sediment is the most important, but certainly not the only nonpoint source pollutant in our region. Because nonpoint sources are by definition dispersed across the entire landscape, they can be difficult to control. From the point of view of the watershed, they often end up causing a "death by a thousand nicks."

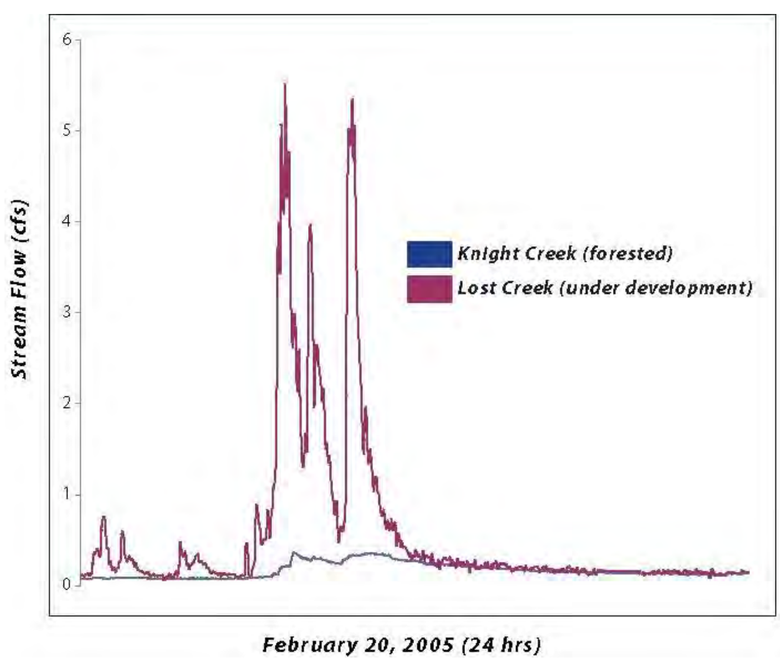
The sources of nonpoint-source pollution can be divided into three categories. In order of significance for the Upstate, they are: soil erosion, runoff from streets and other hard surfaces, and poor land use along lakeshores and river banks. These sources come together in a confluence of impacts to present a large and growing threat to the future health of Lake Greenwood.

*Soil erosion.* Erosion has been a problem in the Upstate ever since the early 1800s. From that time all the way to the 1930s, careless farming practices caused massive amounts of topsoil to erode each year into rivers and streams. During the Great Depression, the Soil Conservation Service (now the Natural Resources Conservation Service) introduced and promoted farming practices that began to rein in erosion. By the 1940s, industrialization had drawn enough people away from rural small-scale farming and into cities and towns for better paying jobs that a significant amount of previously cultivated land began to revert to forest. Combined with the spread of better practices on remaining agricultural lands, this shift in land use caused erosion to decline significantly across the Upstate. By the late 20th century, though, land clearing was again on the rise, this time for development.

### CHANGE IN LAND COVER IN THE SALUDA-REEDY WATERSHED FROM 1985 TO 2000

| LAND COVER TYPE | 1985 (sq.mi.) | 2000 (sq.mi.) | CHANGE (sq.mi.) |
|---|---|---|---|
| Open Water | 21 | 22 | 1 ↑ |
| Developed | 122 | 248 | 126 ↑ |
| Barren | 0 | 18 | 18 ↑ |
| Forest | 880 | 783 | 88 ↓ |
| Cultivated | 142 | 88 | 54 ↓ |
| Wetlands | 11 | 7 | 4 ↓ |

### STORM RUNOFF: DEVELOPED VS. UNDEVELOPED LAND




Between 1985 and 2000, the amount of developed land in the Saluda-Reedy watershed more than doubled, while nearly 90 square miles of forested land were lost. Though the extent of land under development in a given year is still much less than that of land under cultivation during the Upstate's agricultural period, today's development practices cause soil to erode at rates far greater than was typical even for a poorly managed farm.

*Runoff from streets and other hard surfaces.*

The Upstate region receives on average about 50 inches of rain a year. When it rains, stormwater washes over streets, roofs, parking lots, and other hard surfaces, and if the runoff isn't managed properly it carries fertilizer, motor oil, heavy metals, and other pollutants directly into rivers and streams. Stormwater runoff from developed areas in the Saluda-Reedy watershed is a major source of these and other contaminants, many of which travel with sediment all the way to Lake Greenwood.

This graph illustrates the dramatic differences in stormwater runoff generated in an undeveloped "subwatershed" (Knight Creek) as compared with an adjacent one (Lost Creek) that was under development at the time it was monitored. Both subwatersheds are in Greenville County.

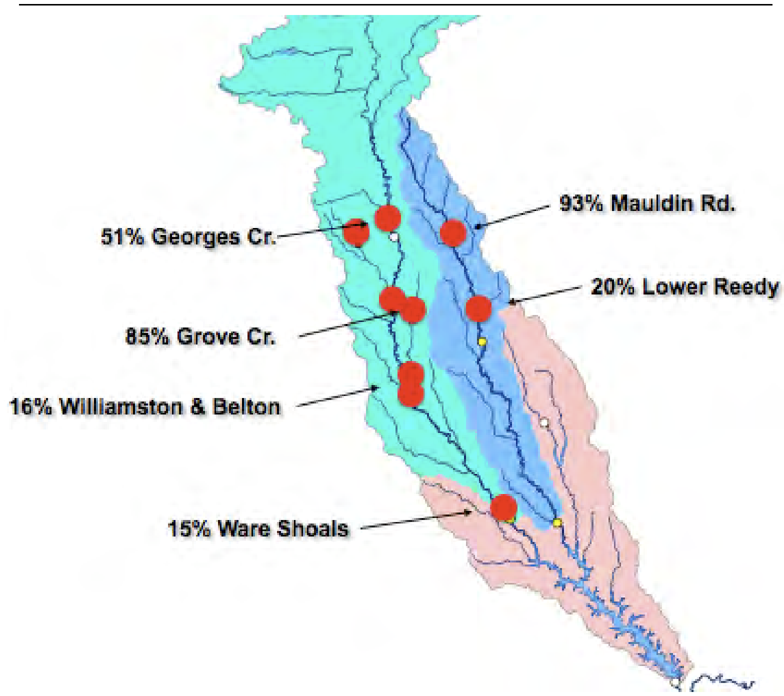
In addition, the flooding that comes with poorly managed stormwater often causes stream banks to become unstable, leading to massive erosion within the stream channel itself. A developed landscape causes flooding because too much water runs off and not enough soaks into the ground, which puts more water into streams than they can handle. The in-stream erosion that results is an unfortunate consequence of the stream "re-sizing" itself in response to the increased runoff, and Greenville's downstream neighbors are the unwilling recipients of the sediment that this erosion produces.

*Land use along lakeshores and river banks.* Not all nonpoint-source pollution comes from upstream. The land around Lake Greenwood (which, of course, is also part of the lake's watershed) makes its own contribution to water quality problems. Poor erosion control during construction, loss of shoreline vegetation, and contaminated runoff from lawns all play a significant role. However, while improving lakeshore land use is critical to protecting water quality in the lake, it is now abundantly clear that the problem cannot be solved unless upstream sources are addressed.

**TRADITIONAL SOURCES OF NUTRIENT POLLUTION PRESENT CONTINUED CHALLENGES.** Phosphorus and nitrogen are critical nutrients for plant growth, including algae. Both of these pollutants are constituents of wastewater discharges in the Saluda-Reedy watershed, contributing to high concentrations of each in Lake Greenwood. In fact, SRWC researchers found that point source discharges of phosphorus from upstream wastewater treatment plants are the primary source of phosphorus loading to Lake Greenwood. However, there is one critical difference between these two nutrients that fundamentally shapes each of their long-range impacts on water quality.

The difference has to do with how phosphorus and nitrogen behave within the global nutrient cycle in which each participates. Nitrogen in the water column "wants" to leave the water and enter the air, as the atmosphere is the final resting place for nitrogen. This is why the atmosphere is about three-quarters nitrogen. Phosphorus, on the other hand, "wants" to attach to suspended sediment in the water column, and as a consequence, its final resting place is within the sediment resting at the bottom of the lake.

**PHOSPHORUS LOADING IN THE SALUDA-REEDY WATERSHED**




Based on 2006 data, this image shows the percentage of in-stream phosphorus that can be attributed to each wastewater treatment plant at the downstream monitoring station directly below the point of discharge. For example, 93% of the phosphorus in the Reedy River at the monitoring station below the Mauldin Road plant is attributable to the phosphorus released from that plant. The remaining 7% of phosphorus in the river at this station originates from other sources. By comparison, the Lower Reedy plant contributes only 20% of the phosphorus at the next monitoring station.

What this means is that if one were to reduce the amount of nitrogen that entered a lake in a given year, the concentration of nitrogen in the water column would reliably decline. Because nitrogen in the water column tends to migrate into the atmosphere in relatively short order, nitrogen levels in Lake Greenwood will always be responsive to changes in nitrogen inputs from the Saluda and Reedy rivers and other sources. In other words, while nitrogen is a problem for lakes, all else being equal, it will be no harder to solve a decade from now than it is to solve today.

Phosphorus is an entirely different kind of problem. Because it tends to adhere to sediment, and because recent studies have shown that about 80 percent of the suspended sediment that enters Lake Greenwood never leaves, most of the phosphorus that enters the lake is there to stay. This means that bottom sediment is in effect a "bank" where an ever-increasing amount of phosphorus is stored. In addition, sampling of bottom sediments by Lander University researchers has shown that in a typical year conditions at the bottom of the lake cause phosphorus to "un-bind" from the sediment and enter the water column in a form that is available to algae. Thus, over time more and more of Lake Greenwood's phosphorus problem will already be "built into" the lake – independent of however much phosphorus does or doesn't come in from upstream – and the lake will increasingly fuel its own algae blooms.

**IMPACTS COMPOUND EACH OTHER TO THE DETRIMENT OF THE LAKE'S WATER QUALITY.** No one factor is the key culprit. Rather, a variety of forces all act on one another to influence the complex and delicate dynamics of water quality in Lake Greenwood. The unique combination of interacting factors within the Saluda-Reedy watershed strongly favors regular algal blooms:

- Soil erosion and stormwater runoff contribute sediment to Lake Greenwood, causing the lake to become shallower over time.
- As sediment is carried through the watershed, it "picks up" phosphorus from wastewater treatment plant discharges.
- Suspended sediment makes the water darker in color. This cloudy, shallow water heats up faster than clear, deep water.
- Warmer water makes algae grow faster.
- Ongoing inputs of sediment-bound phosphorus and nitrogen from point sources also make algae grow faster.

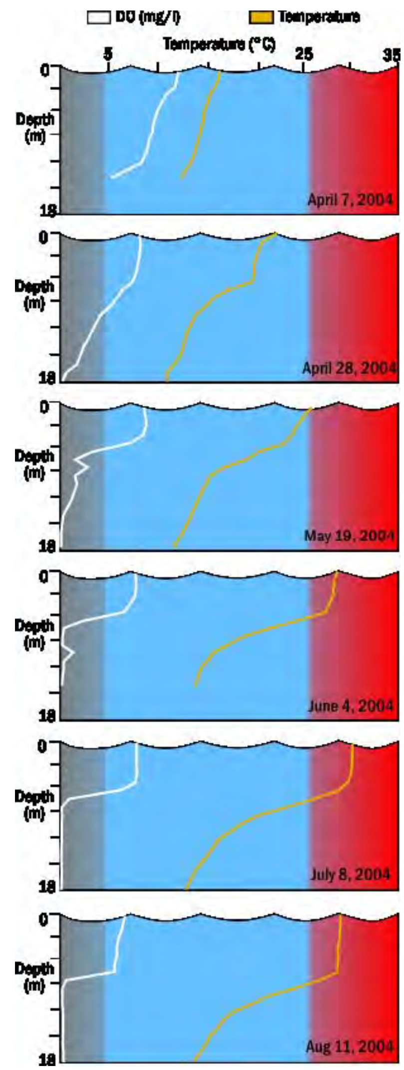
When large masses of algae die, sink to the bottom and decay, they consume large amounts of dissolved oxygen and cause widespread oxygen depletion in the deeper waters of the lake. Coupled with seasonal increases in water temperature at the surface of the lake, the decline in oxygen in deeper waters leaves very little water that is sufficiently cool and sufficiently oxygen-rich for high-quality fish habitat.

How extreme the water quality impairments in Lake Greenwood are likely to become in a given year depends on the magnitude of each of the factors discussed above and the degree at which they interact with each other. A water quality model developed by DNR biologist Hank McKellar gives a sense of how the complex and delicate dynamics of Lake Greenwood would interact under a variety of circumstances to produce different conditions. McKellar and his colleagues used the model to predict consequences of changes in the amount of phosphorus coming into Lake Greenwood. The model showed that any reduction of phosphorus would lead to some improvement in water quality, but that it would take a large reduction in phosphorus to produce broad and lasting improvement.

The model then used various scenarios of phosphorus loading to simulate the location and extent of chlorophyll peaks in the lake in order to predict patterns of algal blooms in Lake Greenwood. It showed that a 25 percent *increase* in loading of phosphorus from the Saluda and Reedy Rivers would extend algae blooms into the Saluda arm and downstream into the midsection of the lake. Conversely, a 25 percent *decrease* in loading would eliminate most major algae blooms, while a 50 percent *decrease* would bring algae levels into compliance with state standards throughout the lake. Finally, the model predicted patterns of oxygen depletion and fish habitat that would likely result from predicted levels of phosphorus. It showed that a 50 percent reduction in phosphorus from both rivers would lead to a 27 to 30 percent *decrease* in hypoxic (oxygen-depleted) conditions as well as a 38 percent *increase* in tolerable habitat for striped bass.

The bottom line, then, is simple: on every critical measure of water quality, from algae blooms to fish habitat, a healthy future for Lake Greenwood will require that we cut in half the amount of phosphorus that enters the lake from upstream. The model made clear one other critical point: that a 50 percent reduction in the amount of phosphorus entering the lake from the Reedy alone would not be enough, as it would produce only a 14 percent reduction in how much phosphorus enters the lake overall. This means that phosphorus reductions in *both* rivers are necessary for lake-wide improvements in water quality.

## WATER QUALITY AND FISH HABITAT




These graphs show how water temperature and dissolved oxygen in Lake Greenwood changed over the course of a growing season. For fish to thrive at a given depth, both the dissolved oxygen line and the temperature line have to fall within the blue zone.

Since sewage treatment plants play a major role in phosphorus loading to both the Saluda and Reedy Rivers and the transport mechanism, sediment, originates from nonpoint source runoff from development sites, achieving a 50 percent reduction in phosphorus in the Saluda-Reedy watershed will require two fundamental actions: far better management of nonpoint sources and substantial reductions in the amount of phosphorus discharged from treatment plants. Both actions are essential to saving Lake Greenwood.

## Section Three: Long-term Prognosis

*The importance of acting now to restore Lake Greenwood's health*

When a woman from Utah called a researcher studying Lake Greenwood to discuss her plans for retiring along the lake, she asked what kind of shape the lake might be in ten years from now. Like many who have moved to the lake, this woman was drawn to living at its edge for the sense of peace that water provides. But she was also well aware that lakes, and lakeshore landowners, are in many ways at the mercy of everyone who lives upstream. Her fundamental question was this: is this lake and its watershed a good investment?

What she (and all of us) hope is that, ten years from now, her investment will have appreciated not only financially, but also in the more subtle currency with which we measure quality of life. Her hope and ours is that the lake will be cleaner than it is now. She hopes that she will find that because of reduced sediment and pollutant loads, the lake will not have suffered another catastrophic algae bloom. She hopes the water will be clearer and cooler in the summer than it is today. And she hopes that her many new neighbors who moved in after she did will be equally happy with the investment they made in the lake.

A worst-case scenario, though, would look something like this: As water quality in the lake continues to deteriorate over the next decade or so, a drought could trigger another algae bloom that extends substantially farther downlake than the 1999 bloom. A few years later, another algae bloom could come, this time without a significant drought or other obvious cause. The next year, it might become clear that residents much farther down the lake are having trouble finding enough deep water to get their boats out into the lake. Then algae blooms might come two years in a row, accompanied by serious fish kills. And all of a sudden, the attitude in the community would no longer be, "This is a fine lake with a few relatively minor problems," but rather, "This is a lake that is in serious trouble."

**ALGAE BLOOM OF 1999**

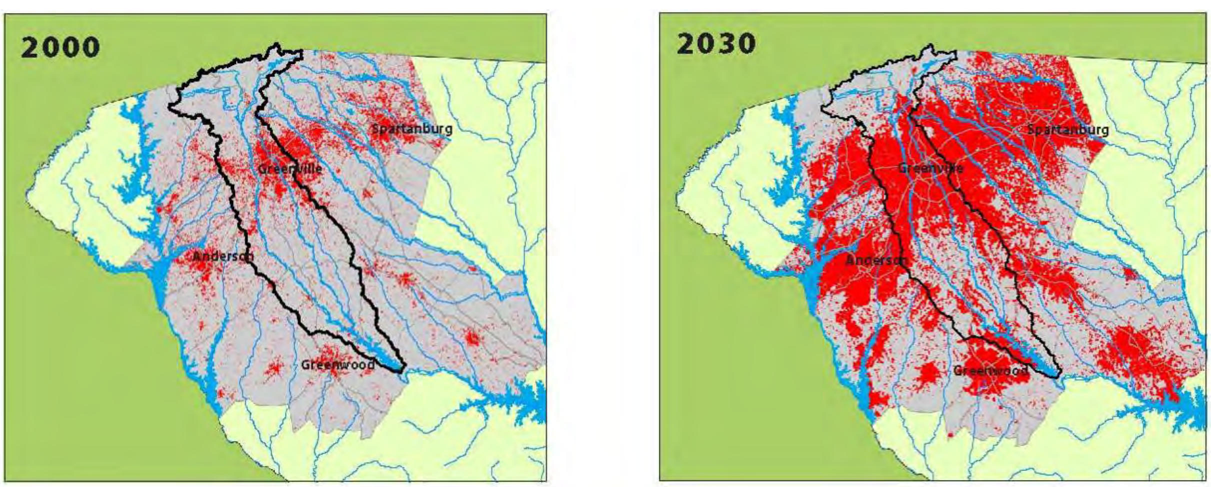
The 1999 algae bloom in Lake Greenwood's Reedy arm.

Which of these scenarios comes to pass depends largely on whether or not the Lake Greenwood community takes concerted action to save the lake – and pushes its upstream neighbors to do the same. More important than any one variable, though, is the *timing* of action. A few key steps taken now are far more likely to make a difference than a comprehensive strategy whose implementation is delayed a decade or more. This section explains why time is of the essence.

**PHOSPHORUS DOESN'T GO AWAY.** Phosphorus is clearly the driving water quality pollutant for algae growth in Lake Greenwood. It is also clear is that wastewater dischargers will not disappear and that population growth and continued development will occur in the Saluda-Reedy watershed. Because phosphorus binds to sediment and sediment settles out and accumulates in the quiet waters of the lake, the unavoidable conclusion is this: the longer we wait to reduce phosphorus inputs from upstream, the more drastically they will have to be reduced. Right now, the amount of phosphorus already in the lake is such that it will take about a 50 percent reduction in inputs to keep water quality reliably within desirable parameters. But after another decade or two of phosphorus-laden sediment pouring into the lake, it may well take a 75 percent reduction or greater to achieve the same level of water quality. It won't be long, then, before the level of reduction that is needed may well be greater than is practical to achieve.

**ONCE UPSTREAM SPRAWL HAPPENS, IT CAN'T BE UNDONE.** While phosphorus is the most important immediate driver of water quality in Lake Greenwood, an accompanying dynamic is upstream land use change. For the moment, the lake's saving grace is that a substantial number of the creeks that feed the Saluda and Reedy Rivers flow through land that is still largely rural. Most of this rural land is either forest or pasture, both of which contribute far less sediment to the watershed than row crops or development. This clean water dilutes the impact of more polluted water from creeks that flow through developed areas.

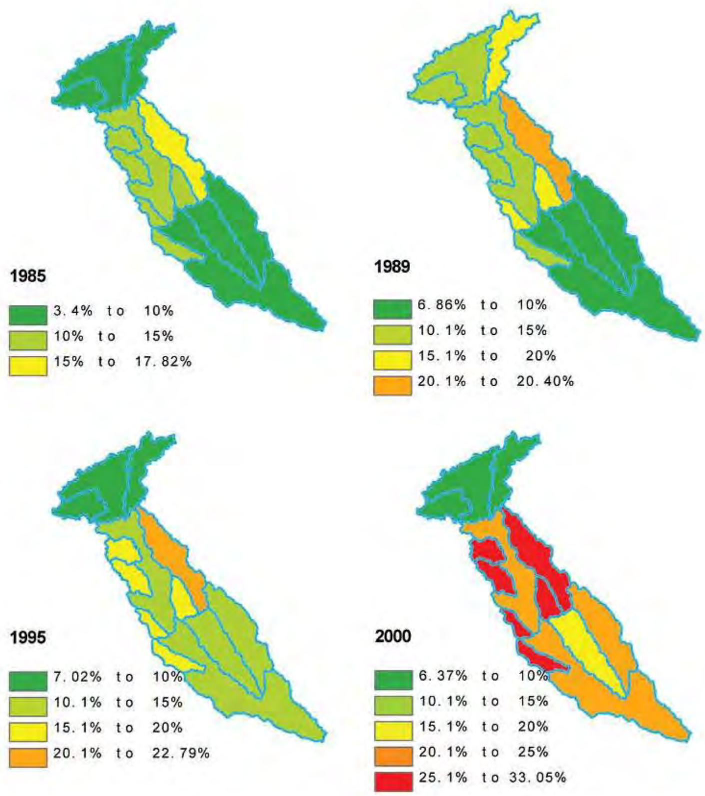
**PREDICTED CHANGE IN DEVELOPED LAND IN THE UPSTATE, FROM 2000 TO 2030 BASED ON CURRENT TRENDS**




These maps show how much development is likely to occur in the Upstate over the next 30 years unless current development practices and policies are changed.

This all will change, though, if current growth trends continue. Sprawl has defined the Upstate for the last three decades, and in the process, we have converted land from rural to suburban at five times the rate of population growth. Projected into the future, this dynamic promises to shift a large number of subwatersheds (that is, watersheds of smaller streams) from part of the solution to part of the problem.

**CHANGE IN PERCENT IMPERVIOUSNESS BY SUB-WATERSHED**




Analysis of satellite data shows a dramatic increase in the amount of impervious cover in the Saluda-Reedy watershed between 1985 and 2000.

The critical point to understand is how different levels of development affect water quality. Contrary to what one might think, low-density development is not necessarily better for rivers than high-density development. In fact, a recent study by the EPA demonstrated that for a given amount of population growth, spreading development out over a large area is actually the worst thing you can do.

The reason is simple. Within a given subwatershed, impacts on water quality tend to be relatively minimal as long as total impervious cover in the subwatershed stays below about 10 percent of the land area. Around 10 percent, water quality and stream health start to show signs of stress, and beyond 10 percent serious degradation occurs. In the Saluda-Reedy watershed, in 1985, only one of the 13 sub-watersheds was above 10 percent, but just 15 years later, 10 sub-watersheds exceeded this threshold. In fact, six of the 10 subwatersheds are above 25 percent. This disturbing trend makes the action plan recommended in the following chapter all the more important.

**IF PUBLIC OPINION ABOUT THE LAKE CHANGES, IT WON'T CHANGE BACK.** Even if upstream sprawl continues unabated and phosphorus-charged sediment keeps pouring into Lake Greenwood, it is unlikely that the lake will suddenly and unexpectedly hit a "tipping point" at which water quality plummets from pretty good to really bad. Rather, the lake will suffer a slow downward slide in which conditions get just a little worse every year, until one day we wake up and notice that the lake is nothing like it used to be.

Public opinion, on the other hand, is highly likely to operate on a "tipping point" model. When people have made a significant investment – financially, emotionally, or both – in a given resource, there is often a certain resistance to acknowledging a decline in the value of that resource. If things get bad enough, public opinion can flip remarkably rapidly and then become just as resistant to going back to positive as it was to flipping in the first place.

If public opinion ever passes that critical point, the challenges will become immense for those who are invested in Lake Greenwood. Once Upstate communities view Lake Greenwood as "damaged goods," people will stop buying lots. Prices for existing homes along the lake will stagnate or decline. As the tax base shrinks, tax rates on existing residents will rise to compensate. Business recruitment, which relies heavily on the lake to attract new investment, will struggle, leading to erosion of the employment base. Recovering from an economic decline of this magnitude would be extremely difficult, and even if it could be done, it would be unimaginably expensive. More likely than not, the lake would never recover its former stature, and the community would have to learn to live with a resource so diminished in value that it functions almost more as a liability than as an asset.

The primary task that we face, then, is to reduce phosphorus and sediment inputs into the lake – in large part by reining in sprawl and reducing phosphorus from wastewater treatment plants – so that the scenario outlined above never comes to pass. This is a tall order, but we really have no viable alternative. We must act now.

# SECTION FOUR: ACTION PLAN

*How to restore and protect Lake Greenwood for future generations*

Water quality originates upstream – it is as simple and obvious as gravity. What might not be as obvious is that in many ways, we all live both downstream and upstream: downstream from our polluting neighbors and upstream of neighbors who likewise are affected by our actions. If we are serious about water quality, it is essential that we remember this interconnection. Everyone has to do their part, as we are all upstream of someone.

SRWC-sponsored research has built a foundation of scientific knowledge to help community leaders and others take steps to improve water quality in Lake Greenwood and across the watershed. The following action items offer practical strategies for reaching that goal.

## SOLUTIONS FOR UPSTREAM LOCAL GOVERNMENTS

Growth and water quality are not a zero-sum game. Greenville and other Upstate communities can accommodate growth and commerce while protecting and improving the quality of the water they send downstream to Lake Greenwood. The key is to develop in a way that preserves and restores to the maximum extent possible the natural capacity of the land to absorb and detain stormwater runoff and associated pollutants.

**GET SERIOUS ABOUT GROWTH MANAGEMENT.** The *extent* of development, even more so than the *character* of that development, is one of the most important factors that will determine the future health of the lake. Communities can ensure more compact and efficient growth by creating and enforcing forward-thinking plans that concentrate development around urban cores and provide significant disincentives for major development in far-flung rural areas.

### ACTION ITEMS

- [ ] Adopt the 1 to 1 growth ratio (where the rates of population growth and land development are equal) as the basic guiding policy for all future land use and planning decisions
- [ ] Establish infrastructure and service boundaries designating where roads, schools, water and sewer will be provided in the future
- [ ] Establish transfer of development rights programs
- [ ] Establish local conservation banks for protecting important natural and historic resources
- [ ] Enact traditional neighborhood design ordinances
- [ ] Enact mandatory open space ordinances

- [ ] Adopt the transect model

These and other important policies are explained in Upstate Forever's comments and recommendations on the Greenville County comprehensive land use plan at www.upstateforever.org/GCountyLandUsePlan.pdf

**PUT SOME TEETH INTO LOCAL STORMWATER ENFORCEMENT.** Analysis by SRWC partners has documented an urgent need for better erosion control on construction sites in the Upstate. Impacts to streams and rivers are significant, widespread, and ongoing. Encouraging developers and contractors to do the right thing is not enough. Communities need to raise the bar and keep it high using substantial enforcement measures.

### ACTION ITEMS

- [ ] Hire enough inspectors that all violations are investigated within 24 hours and all sites are inspected at least monthly
- [ ] Impose substantial fines for violations and work with the magistrate court to ensure that fines are not waived or reduced
- [ ] Implement a plan review fee structure that covers the costs of review and enforcement and that creates an incentive to submit innovative, well-thought-out plans
- [ ] Use and enforce stop-work orders

**REVISE LOCAL ORDINANCES AND PROGRAMS TO PROMOTE LOW-IMPACT DEVELOPMENT.** One of the best ways to fight sedimentation and polluted runoff is to reduce how much impervious cover new developments create in the first place. Fortunately less impervious cover means lower development costs, reducing impacts on the bottom line as well as on the environment. Communities must implement sensible but ambitious standards and incentives that turn local development-related ordinances into a blueprint for change.

### ACTION ITEMS

- [ ] Update local standards for parking lot size, street width, cul-de-sac design, and other rules governing the amount of pavement created by new development so as to minimize additional impervious cover and provide substantial incentives for adhering to these standards
- [ ] Incorporate significant incentives for runoff reduction into the stormwater plan approval process (such as a reduction in the development's annual stormwater fee)
- [ ] Quantify and pre-approve bioswales, constructed wetlands, and other ecologically based stormwater management structures and promote their benefits to developers

These and other important recommendations are set forth in the LID Roundtable Report for Greenville County at www.upstateforever.org/LIDRecReport.pdf

**CREATE AND IMPLEMENT FORWARD-THINKING FLOODPLAIN MANAGEMENT PLANS.** Development in floodplains and destruction or degradation of wetlands reduce the ability of the landscape to absorb and dissipate rising waters. Besides placing homes and businesses in harm's way, it also facilitates rapid flushing of sediment into the streams that feed the Saluda and Reedy rivers, and in turn, into Lake Greenwood. Local communities can restore the natural flood-mitigation function of floodplains and wetlands by ensuring that they remain dedicated to their highest and best use—flood protection—while allowing for riverside parks, greenway trails, and other compatible recreational uses.

**ACTION ITEMS**

- ☐ Prohibit development in the floodplain (including sewage treatment plants) and place strict limits on development that lies outside the floodplain but less than four feet above it
- ☐ Appropriate the local funds needed to secure FEMA money for acquiring flood-prone properties, removing repetitively flooded structures, and restoring floodplain function
- ☐ Create and implement a greenways master plan that requires that floodplain lands in new developments be deeded to a local government entity (such as a recreation district) and managed as public open space

**SYSTEMATICALLY RETROFIT "LEGACY" STORMWATER PROBLEMS.** Long-term maintenance of stormwater management structures is an ongoing and pervasive problem throughout the Upstate and the Saluda-Reedy watershed. Often the structures are filled with sediment and do not perform to the standard they were designed to meet. In older developed areas, there are frequently no stormwater controls at all, and as a consequence, a huge flush of polluted runoff enters the nearest stream with every storm.

**ACTION ITEMS**

- ☐ Enact a stormwater fee that is based on impervious area rather than lot size and that is dedicated exclusively to funding stormwater retrofits
- ☐ Work with adjacent municipalities to identify sub-watersheds and prioritize them for retrofits based on their contribution to flooding problems and water quality impairment
- ☐ Develop and implement sub-watershed retrofit plans that rely on both in-street and off-street structures and modifications to detain, infiltrate, and purify stormwater runoff
- ☐ Require that stormwater management on redevelopment sites adhere to the same performance standards as greenfield development
- ☐ Allow developers of infill sites to pay a fee in lieu of detention and use the funds generated to improve stormwater management on a subwatershed basis

## SOLUTIONS FOR DOWNSTREAM LOCAL GOVERNMENTS

With several thousand houses dotting Lake Greenwood's 212-mile shoreline and many more under construction, the lake's popularity plays a significant and growing role in shaping water quality dynamics in the lake. In particular, shoreline development, landscaping, and septic tank management are critical factors for the lake's long-term health.

**DEVELOP A LAKE MANAGEMENT PLAN.** Although Greenwood County owns the lake and therefore has the greatest stake in its future, less than half of the lakeshore is inside its borders. Therefore, Greenwood, Laurens and Newberry Counties should coordinate to establish a lake management plan for protecting and improving the health of the lake. The management plan should include the following action items.

### ACTION ITEMS

- ☐ Create a multi-county lakeshore management overlay district that sets both basic mandatory and enhanced voluntary standards for land use within a certain distance of the lake and that offers significant incentives for compliance with voluntary standards
- ☐ Set specific water quality targets using the water quality model developed for the lake by SRWC and DNR
- ☐ Identify and implement strategies that will make the greatest possible contribution to meeting these targets
- ☐ Develop and implement an aggressive public awareness campaign to promote the plan and publicize its goals and strategies
- ☐ Enter into cooperative agreements with DNR and DHEC to collect and analyze data as necessary to track progress towards goals

**MANAGE LAKESHORE SEPTIC SYSTEMS PROACTIVELY AND SYSTEMATICALLY.** Some lakeshore homes were built as early as the 1940s and 1950s, and many of these homes probably still have their original septic systems. Bringing older systems into compliance with modern standards would help keep tanks from leaking nitrogen, phosphorus, and other contaminants into the lake.

### ACTION ITEMS

- [ ] Create a septic management utility that collects a fee from all septic system owners within a certain distance of the lake
- [ ] Develop a management protocol that dedicates a portion of the fee to regular maintenance of all systems
- [ ] Draw up a long-range capital investment plan for using the balance of the fee to fund replacement of failing septic systems
- [ ] Prioritize areas for septic system upgrades based on likelihood of failure and of impacts to the lake
- [ ] Require inspection of and repairs to septic systems as a condition of sale or transfer of land

# SOLUTIONS AT THE REGIONAL AND STATEWIDE LEVELS

**SECURE SPECIAL PROTECTION FOR LAKE GREENWOOD.** Saluda-Reedy watershed policymakers face a thorny political problem: the bulk of the impairment to one community's key resource—the lake—is a direct result of another community's effort to develop economically. The solution may lie in part in a state statute that allows for the designation of certain watersheds for special protection. If such designation were secured for the watershed of Lake Greenwood, the law would provide a framework for establishing watershed-wide standards for protecting water quality.

**ACTION ITEMS**

☐ Request that DHEC name Lake Greenwood a "Designated Watershed" as described in regulation 72-309 issued under the S.C. Stormwater Management and Sediment Reduction Act

☐ Form a Watershed Advisory Committee and develop a Watershed Master Plan as outlined in this regulation

**LIMIT PHOSPHORUS CONCENTRATIONS AND LOADINGS FROM WASTEWATER TREATMENT PLANTS.** SRWC studies show that the twelve wastewater treatment plants in the watershed are the primary sources of the phosphorus loading in Lake Greenwood. These plants require discharge permits from DHEC that must be renewed every five years. As of April, 2009, ten of the plants are slated to renew their permits by June, 2010. This affords an outstanding opportunity to impose more stringent limits on phosphorus discharges from the plants and thus improve water quality in Lake Greenwood.

**ACTION ITEMS**

☐ Establish more stringent limits on phosphorus concentrations and loadings from each of the twelve wastewater dischargers within the Saluda-Reedy watershed

**WORK TOGETHER AS A REGION.** Just as rivers don't respect political boundaries, neither does growth. We are growing and developing as a region, and we urgently need to address land use, transportation, and water quality issues at the regional level. Fortunately, a regional growth management initiative called "Ten at the Top" (referring to the 10 Upstate counties) is already underway. Its goal is to bring together public and private sector leaders from across the Upstate with a shared goal of maintaining economic prosperity and environmental health through sensible growth management policies.

**ACTION ITEMS**

☐ Support and participate in the Ten at the Top initiative

# CONCLUSION

The science is clear. If we do nothing, Lake Greenwood will cease to be a valuable resource. SRWC findings have demonstrated conclusively that sediment and wastewater discharges, specifically the phosphorus-charged sediment that enters the Saluda and Reedy rivers and eventually the lake, are to blame. But this research also tells us that it's not too late to correct the problem. By doing a better job of managing growth, controlling runoff, and reducing point source phosphorus loadings, we can protect and improve the lake and ensure that it remains a cornerstone of the economic and environmental well-being of the Greenwood area and the entire Upstate.

The problem seems large. After all, we're dealing with pollution flowing in from twelve wastewater treatment plants and from thousands of nonpoint sources across a large watershed. No single act by one person can save Lake Greenwood, but with sufficient political will and cooperation, Lake Greenwood can be passed down to future generations in good condition. The future of the lake starts with change today.

FOR MORE INFORMATION
www.saludareedy.org
864-250-0500