

sustainable water resource management

A PLAN FOR RESTORING AND PROTECTING
THE WATER RESOURCES OF THE PEACE CREEK WATERSHED
AND WINTER HAVEN, FLORIDA





foreword by Dale L. Smith, city manager, city of winter haven



As someone who grew up in Florida and is a long-time resident of Winter Haven, I know firsthand how fortunate we are, both across the state and in the City of Winter Haven, to have such diverse and abundant water resources. In the past, though, as the state was being developed, those water resources were often not valued through a lack of knowledge or vision, or merely through expediency.

In Winter Haven, many of the high, dry, sandy places where water once rapidly soaked into the ground were built over, reducing our community's natural ability to capture, store, and cleanse water in our aquifers, wetlands, and lakes. In lower-lying areas of the watershed, ditches and canals were dug to remove water from the land and move it out of the watershed as fast as possible, to reduce flooding and to make the land more "useful" for agriculture and other human uses. This has lowered the water level in our aquifers by nearly 10 feet in some cases, reducing the amount of water that is available for human consumption and the environment, and affecting water quality in the lakes.

We have since come to realize that draining the watershed is a shortsighted approach that will not leave us with enough water to meet the long-term needs of the community—especially with continued economic growth. We now understand that protecting and restoring our area's water resources is the key to our community's future health and sustainability. The vision is to reconnect the parts of the water network that recharge and sustain our regional water system, restore lakes close to their historical levels, protect water quality and natural systems, create parks for our community, and provide increased flood protection for our neighborhoods.

The community must put the ideas in this Sustainable Water Resource Management Plan into place so that our grandchildren and great-grandchildren will continue to have a good quality of life. This work could be expensive and will take time, but its value in the next few decades will far exceed its cost. A restored water heritage and provisions for a sustainable future will set the long-term course for the City of Winter Haven.



dear
neighbors by
Anne-Marie
Leedy, city of
winter haven
resident





Currently, lake levels are down and our region is in the midst of a drought. But could things be better?

In a perfect and natural scenario, rainwater falls on the earth and slowly seeps into a shallow, underground aquifer, or "surficial" aquifer, which is separated from the deeper Floridan aquifer by a confining bed of clay. This process allows for the filtering of fertilizers, pet waste, and other harmful substances. The filtered water is then delivered to our lakes through the aquifer during the drier months, when lake levels begin to fall. This is the natural process by which our lakes are kept full.

Each time we develop and pave over or drain an area, we alter the natural movement of water through that area. Rainwater now flows through our storm drains and directly to our lakes within minutes, shortcircuiting the natural process of recharging the aquifer and filtering the water. Making matters worse, the stormwater that flows to the Peace Creek Canal is quickly routed out of the watershed in a matter of days (a process that would normally take months). The levels of the Floridan aquifer and some lakes have dropped about 10 feet over the last 90 years.

The City of Winter Haven has worked with PBS&J (an environmental science consulting firm) and local experts to develop a Sustainable Water Resource Management Plan. With this approach, our rainwater would flow more naturally and the watershed would hold more rainwater. By developing a water network that reflects the natural meander of water through the watershed, we would benefit from natural wet areas surrounding our City. These would offer habitat for wildlife and recreational opportunities, and preserve our wetlands. This concept is referred to as the "sapphire necklace" around the City.

We are one of the first cities in the country to use this approach. By holding more water in the watershed, we have the opportunity to ensure water availability for future generations. Keeping our aquifer levels up is a comprehensive way to restore natural systems, keep lake levels up, and improve water quality. During a drought, cleaner water would still be delivered to the lakes through the natural process of slow seepage.

With the addition of the CSX facility to southeast Winter Haven, the area will experience tremendous growth in the form of commercial properties, residential neighborhoods, and highways. This Sustainable Water Resource Management Plan is an opportunity to protect Winter Haven's identity as not just another sterile community off a highway exit, but rather as a peaceful City with a unique intent to restore, preserve, and protect our natural resources.

Please take the time to read this Plan carefully. I would like everyone to be aware and supportive of this exciting initiative.

Anne-Marie Leedy



acknowledgments

VALUABLE INFORMATION AND INSIGHTS IN THE DEVELOPMENT OF THIS PLAN WERE GAINED FROM STAKEHOLDERS WITH KNOWLEDGE OF THE COMMUNITY'S WATER RESOURCES. STAKEHOLDERS WHO PARTICIPATED IN PLANNING WORKSHOPS AND PROVIDED INPUT ON THE PLAN INCLUDE:

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Special acknowledgment goes to Mike Britt, who had the knowledge, experience, and vision to conceive of this Plan, and to Jeff Spence, Bob Viertel, and Roger Griffiths—all long-time Polk County residents and committed water resource professionals who had significant input into the creation of the Plan. Tom Champeau, Regional Director, Florida Fish and Wildlife Conservation Commission, was an early contributor to the concepts formulated for the area and also deserves special acknowledgment. Mike Britt provided many of the photographs of Winter Haven used in this report.

The content, organization, and design of this document—from both an artistic and editorial perspective—are critical elements in conveying technical information to a very diverse audience of technical and nontechnical individuals who love and care for the water resources of Winter Haven. Special thanks go to the MediaGroup at PBS&J's Miami office, and to Word, Ink for their extraordinary contributions to this Plan.

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Purpose and Overview

The Winter Haven area has had a number of severe weather extremes in the past 10 years, including the lowest recorded lake levels in history in 2001, 3 hurricanes that caused extensive flooding in 2004, and one of the worst 3-year droughts on record from 2007 to 2010. As a result, the community has focused its attention on how best to meet its future water resource needs, including improved water quality, increased water supplies to support both population growth and natural systems, and improved flood control.

Even before these extreme events took place, the goal of restoring the Peace

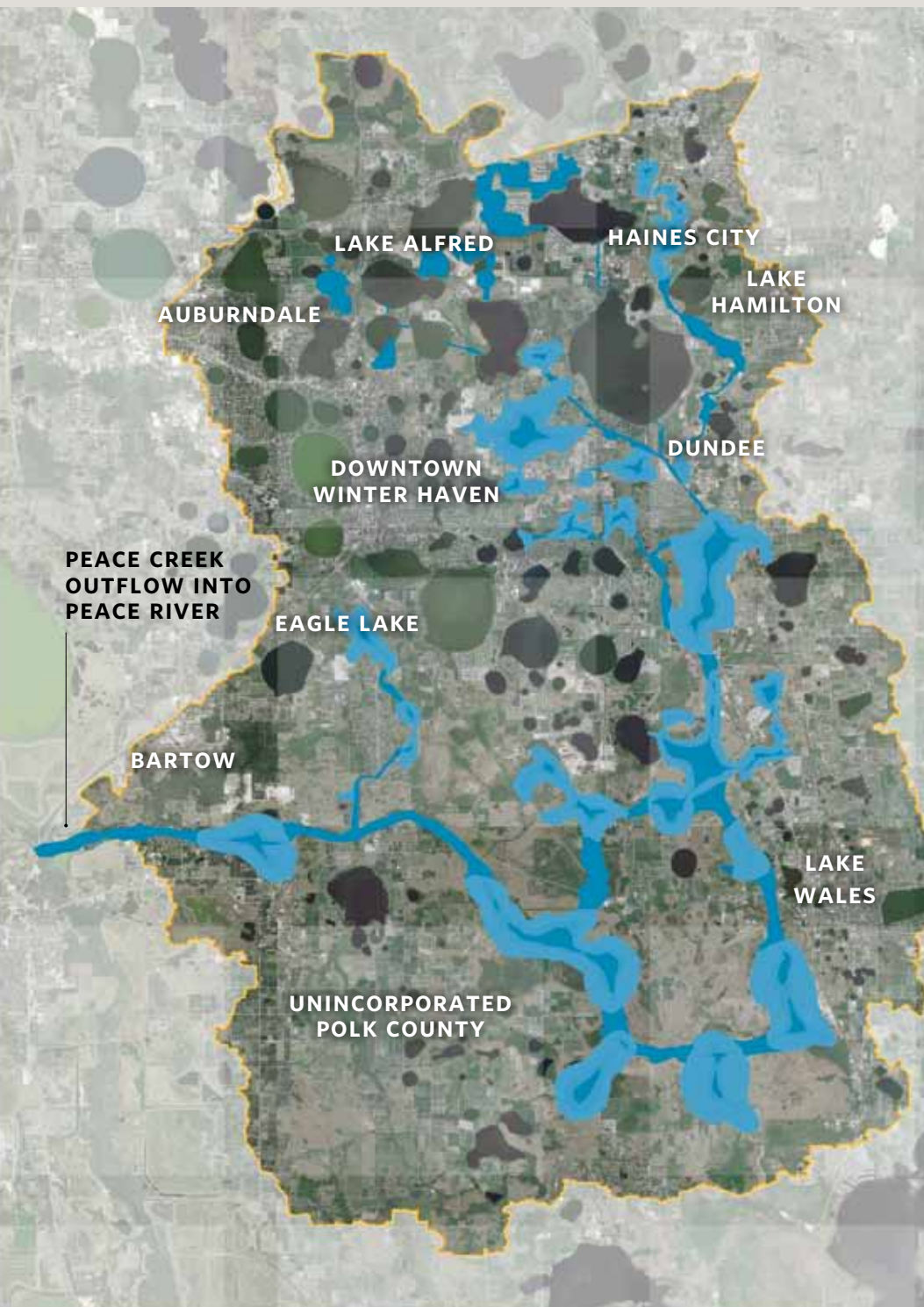
Creek watershed and storing more water in the Polk County area had been discussed for at least the past 20 years. Today, the following conclusions are clear:

- *Past efforts to manage water by draining, piping, and covering recharge areas in the Peace Creek watershed and regional aquifer drawdowns have had, and will continue to have, negative effects on Winter Haven's water resources, including lakes.*
- *At best, today's regulations keep things the same but do not provide for restoration. At worst, they allow the further gradual degradation of water resources. The current rules for wetland mitigation and storm-water management encourage further degradation of the Peace Creek watershed.*
- *The Peace Creek watershed will experience significant new growth in the coming decades that could further harm the networking of water in the watershed—or help it, if that growth is planned correctly.*
- *Managing the area's water supply for both people and natural systems such as lakes are equally important.*
- *Using the natural infrastructure, which provides many hydrologic benefits at a much lower cost, is far preferable to engineered, structural solutions that are expensive to build and maintain, and that generally address single issues.*



GOALS OF THE SUSTAINABLE WATER RESOURCE MANAGEMENT PLAN

The area's restored hydrologic network resembles a "necklace" of water, known in Winter Haven as the "sapphire necklace."



- *Meet the long-term water resource needs of people and natural systems.*
- *Manage all sources of water—including floodwaters, stormwater, reuse water, groundwater, and rainfall—as a finite, interconnected resource.*
- *Establish a local leadership role in managing water resources and not rely on others to make decisions for the watershed.*
- *Ensure that the unique characteristics of the Peace Creek watershed are considered in local and regional decisions.*
- *Use existing experience, information, and science to make sound decisions for today and the future.*
- *Direct today's actions for a defined future result—that of water resource sustainability.*
- *Preserve and restore the natural infrastructure as much as possible and use it to provide multiple hydrologic functions and benefits.*
- *Ensure that all approaches are aligned with goals for economic growth; key considerations include providing opportunities for nature-based tourism, recreation, open space, water amenities, and urban development.*
- *Mitigate any impacts to water supply, water quality, hydrology, and natural systems within the Peace Creek watershed.*
- *Integrate water storage and treatment areas into the community using nature parks.*
- *Manage land to improve water resources in the future and not allow their gradual degradation as in the past.*



- *Today's body of knowledge, gained through scientific studies, staff experience, and historical perspective, represents the best chance of addressing the watershed's water resource issues over the long term.*
- *Managing land and managing water are inseparable activities and responsibilities.*
- *As part of the much larger Peace River Basin, the City of Winter Haven can actively work to influence not only the health of its local water resources but also to help preserve the water resources of the entire region.*

The current approach to managing water resources is not sustainable. If future residents want the same or a better quality of life, difficult choices have to be made. If the community chooses to do nothing, the sustainability of water resources will continue to decline, and future generations will be burdened with paying for projects to restore water resources that are being impacted today. Alternatively, the City can act to improve water resources for future generations.

The clear choice is for the community to actively pursue partnerships between governmental agencies, citizens, and private development interests in implementing projects to

restore and improve water resources, while at the same time moving forward with comprehensively planned and strategically located economic growth. If this choice is not made today, future generations will pay a high financial, economic, and social price.

This document lays out a *Sustainable Water Resource Management Plan* that will enable the City of Winter Haven and the other communities in the Peace Creek watershed to manage their surface water and groundwater resources for the future—including water for residents, business and industry, agriculture, and the environment. It discusses the unique hydrology of the Peace Creek watershed and the Winter Haven area; how water moved through the watershed historically; how that network of water was altered by ditching, draining, and covering recharge areas with impervious surfaces; and how the natural hydrologic functions of the watershed can be restored to support the needs of both people and the environment.

When implemented, the *Sustainable Water Resource Management Plan* would restore as much as possible the networking of water that existed before



the watershed was altered. The restored hydrologic network, combined with existing lakes and other waterbodies, resembles a "sapphire necklace" of water (see map on page vii). Infiltration and treatment areas in the headwaters of the watershed would carry water into the surficial and Floridan aquifers. From there, it would move into a number of different storage and conveyance areas in the middle and lower reaches.

The Plan is an investment in the watershed's natural infrastructure, as opposed to man-made infrastructure. In the long term, using natural infrastructure such as aquifers, lakes, and wetlands to provide services will result in a less costly, more efficient water storage and delivery system for all future generations.

The power of the *Sustainable Water Resource Management Plan* is that it provides the opportunity for all public and private organizations involved in water management to coordinate their activities in order to maximize local and regional benefits, avoid unintended consequences, and create accountability for decisions. Ultimately, the success of the Plan will depend on how well projects are implemented as part of an integrated approach. Carrying out local and regional activities will create local benefits, and local activities will also provide regional benefits.

The *Sustainable Water Resource Management Plan* is a cornerstone of the City's initiative to work towards a sustainable community. It represents the City's commitment to its current and future citizens

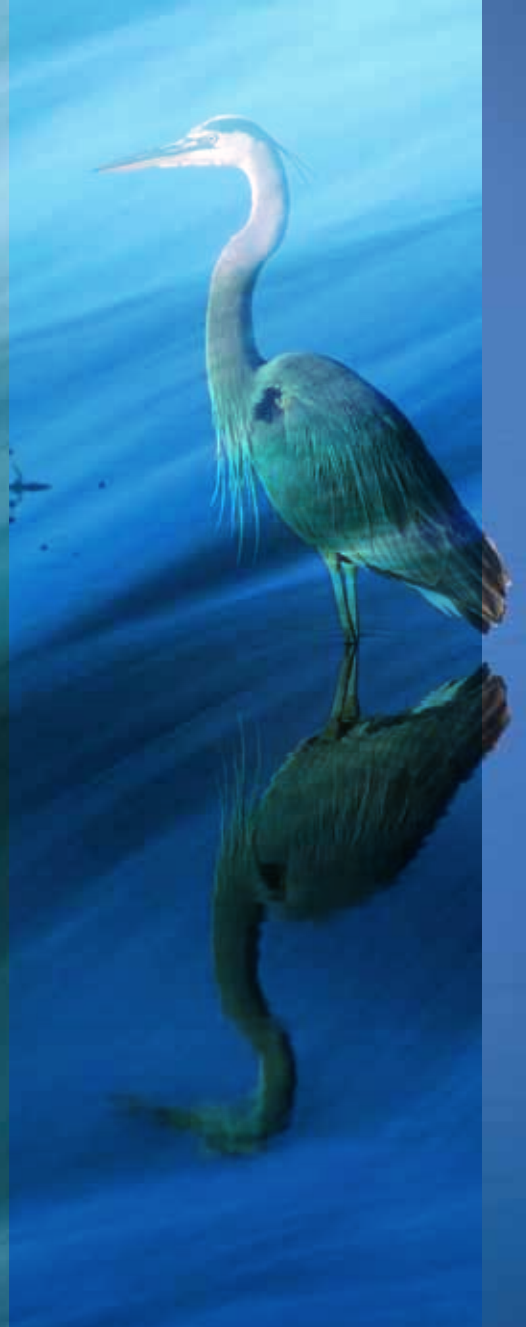
to provide a desirable, enjoyable, beautiful, and safe place to live. It preserves and enhances the innate ability of the watershed's unique landscape to provide many different water resource benefits, such as improved water quality, water supply, natural systems, and flood protection. Incorporating restoration projects into a series of interconnected nature parks will provide trails, vistas, opportunities for wildlife observation, scenic beauty, and water resource amenities that will attract growth and economic development. These amenities will help to integrate the Plan into the economic and cultural fabric of the City and make it sustainable. Other benefits include a strengthened local economy; greater social, cultural, and recreational opportunities; and a more aesthetically beautiful City. Together, all of these will enhance the community's quality of life and preserve it for future generations.





SUSTAINABLE WATER RESOURCE MANAGEMENT
IS BROADLY DEFINED AS THE USE OF WATER RESOURCES
"IN A WAY THAT MEETS THE NEEDS OF THE
PRESENT WITHOUT COMPROMISING THE ABILITY OF
FUTURE GENERATIONS TO MEET THEIR OWN NEEDS."

— Brundtland Commission, 1987



INTRODUCTION

"We shall explore, first for the ends, and second for the means: we shall seek first our destination and then the way to get there." —Benton MacKaye, *The New Exploration*, 1928

Water is the most essential and precious resource on our planet. It supports all life, connecting and sustaining our human and natural environments. For people, water is vital for drinking, sanitation, and food and energy production. In the natural environment, plants and animals depend on water for survival, and its presence or absence determines which species live where. Oceans, rivers, lakes, estuaries, wetlands, springs, and aquifers support many different habitats and species, and for people they provide the foundation for a strong local, regional, state, and national economy.

Water has profoundly influenced—and will continue to influence—patterns of human settlement everywhere on the Earth. Florida is no exception. With 8,460 miles of coastline, 51,858 miles of rivers, over 7,700 lakes, 4,054 square miles of estuaries, 17,830 square miles of wetlands, over 500 freshwater springs, and some of the most productive aquifers (underground storage) in the world, the state's abundant and diverse water resources have both attracted and limited human activities.

Over time, these valuable and once self-sustaining water resources have been greatly altered for human uses. As a result, they are contaminated and depleted in many parts of the state. Today, the protection of our water resources is the most critical component of our current and future well-being and the single greatest challenge that we face as a state. It is an issue that threatens the economic viability of every Florida community.

Florida is blessed with abundant rainfall, and we have generally managed for too much water (by controlling flooding and draining water from the land surface to make it usable for homes, agriculture, and industry). However, Floridians are now beginning to understand that water is a finite resource, that it can easily become contaminated, and that we have to manage for too little water as well as too much. We must manage our water resources more efficiently and effectively.

Along with Florida's continued population and economic growth, which have increasingly placed a strain on the availability of fresh water, the climate appears to be changing. An extended drought has severely affected water quality and water supplies over the past three years, not only in Florida but in many other states in the southwest, south, and southeast. As a result, state and local governments are increasingly focusing on how to best to conserve, protect, and restore their water resources.

The protection of our water resources is the most critical component of our current and future well-being and the single greatest challenge that we face as a state. It is an issue that threatens the economic viability of every Florida community.



Taking advantage of the opportunity to restore and protect water resources today ensures that future generations will also have the benefits of those resources.

When the well's dry, we know the worth of water.

— Benjamin Franklin, *Poor Richard's Almanack*, 1746

watershed

A watershed is the geographic area through which water flows across the land and drains into a common body of water, such as a stream, river, lake, or ocean. It includes tributaries (wetlands, streams, canals, and ditches) as well as stormwater that runs off the land. Watersheds are usually separated from other watersheds by naturally elevated areas.

Because the water in a watershed ultimately drains to other waterbodies, it is essential to consider these downstream impacts when carrying out activities to protect and restore water resources. Everything upstream ends up downstream.

—Adapted from the Florida Department of Environmental Protection's Watershed Management Website at www.dep.state.fl.us/water/watersheds/index.htm

Like many other communities in Florida, the City of Winter Haven wants to ensure that its future water needs are met, both for people and natural systems. One of the key realizations of this process is that many opportunities still exist for restoring the natural ability of the landscape to provide multiple benefits. This is why the backbone of the Plan is an interconnected network of lakes, canals, wetlands, aquifers, open spaces, and parks, designed to meet the long-term water resource needs of the entire community, including supply (water quantity), treatment (water quality), flood protection, and the preservation of natural resources.

Because the lakes are essential to the community's unique character, Winter Haven—from its early development to the present—has sought to preserve and protect these extraordinary and valuable resources. Winter Haven's roads meander around its lakes, enhancing the City's charm and beauty, and its small-town atmosphere. The 50 lakes inside and adjacent to the City are a source of great pride to its residents, and an economic engine that has long attracted people to the area. The City's economy, its quality of life, and its current and future viability depend on preserving and sustaining the health of its water resources, the most visible of which are the lakes.

Currently, about 70% of the Peace Creek watershed is undeveloped. Within the next 10 to 20 years, however, the situation is likely to change dramatically. The new CSX Integrated Logistics Center proposed for southern Winter Haven, immediately adjacent to Peace Creek, will potentially bring significant growth to the area. The U.S. Highway 27 corridor and the State Road 60 corridor—also immediately adjacent to Peace Creek—will continue to attract growth and new development, such as Legoland Florida, as will the construction of the proposed Central Polk Parkway.

As development continues, it is crucial that the community actively work to protect, preserve, and restore its water resources—especially the lakes, which are one of the reasons that brought people to Winter Haven in the first place, and one of the reasons that will keep them there in the future. It is especially important to meet future water resource needs for both people and natural systems. The decisions made today on how the City manages its water resources will affect its future for decades, perhaps even permanently. Taking advantage of the opportunity to restore and protect water resources today ensures that future generations will also have the benefits of those resources.



Because Winter Haven is situated at the headwaters of the surface water and groundwater systems that comprise the much larger Peace River Basin, the water that falls within the watershed is the only source for all uses. The Peace Creek watershed, shown at left, is approximately 150,000 acres in size and comprises about 11% of the Peace River Basin. From its beginning in Winter Haven, Peace Creek flows into the Peace River, which extends 110 miles south to Charlotte Harbor and the Gulf of Mexico.

- GREATER WINTER HAVEN AREA
- GROUNDWATER BASIN
- PEACE RIVER BASIN
- COUNTY BOUNDARIES



Winter Haven, a community of 34,400 people in Polk County, is largely defined by its lakes. Fifty freshwater lakes border or are contained within the City limits. In fact, there are so many lakes that Winter Haven calls itself "the Chain of Lakes City." The Winter Haven Chain of Lakes consists of 9 lakes in the Northern Chain (shown in darker blue—see note below) and 16 lakes in the Southern Chain (shown in light blue). Little Lake Hamilton and Middle Lake Hamilton are also part of the Northern Chain but lie outside the City. Out of the City's total area of about 25 square miles, water covers almost 8 square miles, or almost one-third. Like Winter Haven, the surrounding region also has many lakes; there are 554 lakes in Polk County. The numerous lakes are a reflection of the enormous stores of water that are potentially contained within the landscape. The orange line on the map is the dividing line between the Winter Haven Ridge and the Polk Uplands.

NOTE: Generally, Lake Henry is not considered a part of the Northern Chain, since the canal is not navigable. However, since most of the management plans include Lake Henry for planning purposes, it is shown as part of the Chain on the map.



winterhaven



ISOLATED WETLANDS

SEEPAGE WETLAND

STRANDS & SLOUGHS

FLOODPLAIN FORESTS

FIGURE 1. A typical natural landscape in Florida, showing how water is retained and moves through the landscape. This graphic is also broadly applicable to the Peace Creek watershed.

Source: Mark T. Brown for PBS&J

PAST AND PRESENT NETWORKING OF WATER THROUGH THE PEACE CREEK WATERSHED

"We find ourselves in the shoes of our forefathers: their job was to unravel the wilderness of nature; ours is to unfold the wilderness of civilization."—Benton MacKaye, The New Exploration, 1928

The introduction, Chapter 1, describes how water connects and sustains both human and natural environments and how the future economic viability of every community in the state, including the City of Winter Haven, depends on protecting and managing water resources in the face of continued economic and population growth.

This chapter explores the unique relationship between Winter Haven and the water resources in the Peace Creek watershed. It discusses how the climate, geology, and physical environment of the watershed influence the movement and storage (or "networking") of water through the watershed. It also characterizes the natural networking of water before the watershed was altered for human use, including the construction of the Peace Creek Canal in the early 1900s for agricultural use, and the alteration of lake levels for improved navigation. In addition, the chapter discusses how the alterations have lowered lake levels, reduced aquifer storage, and affected water quality, and how proposed new land uses—especially in the lower watershed—might further affect water resources.

The Natural Hydrology of the Peace Creek Watershed

Florida's natural landscapes before European settlement were organized to efficiently store both surface water (lakes, rivers, and streams) and groundwater (aquifers), and to allow it to move slowly through the landscape. *Figure 1* shows a typical natural landscape in Florida. In the headwaters of the system, lakes and isolated wetlands provide water quality treatment and infiltration into both the shallow and deeper underground aquifers. In some places, the aquifer literally seeps out of the landscape into wetlands, lakes, and streams. These form disconnected strands and sloughs in the middle reaches of the watershed. The wetlands, along with the broad floodplain forests in the lower reaches, provide important surface water storage and conveyance during large storm events by allowing water to spread over the landscape.

The harm results, generally, when wet lands must be drained to be made habitable; ...when the water table is so lowered that creeks no longer flow; when forests are cut and burned so that native wildlife is destroyed, the wild animals driven away, and the very charm and beauty that made the area desirable in the first place is no longer left in existence.

— Letter dated October 18, 1972, from Garald Parker, Senior Scientist and Chief Hydrologist, Southwest Florida Water Management District, to Richard D. Pope, founder of Cypress Gardens, regarding his concern with the importance of the Green Swamp

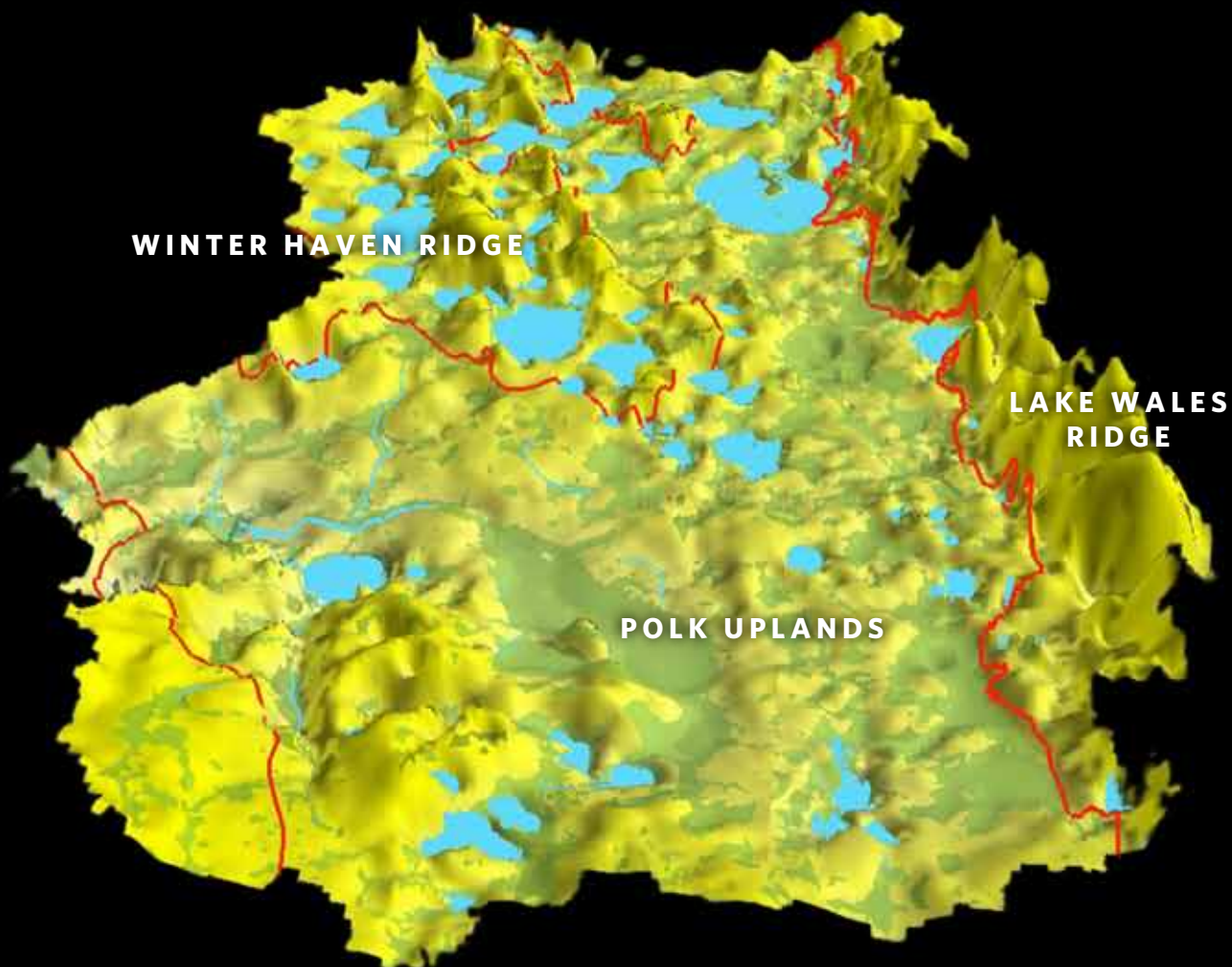


FIGURE 2. A perspective view of the natural Peace Creek watershed, showing the large number of lakes in the headwaters (on the Winter Haven Ridge) (top left), and the large number of wetlands (shown in light green) in the middle and lower portions (in the Polk Uplands), located between the Winter Haven and Lake Wales Ridges. The elevations shown in this map are exaggerated by a factor of 10 to differentiate the high, dry land of the headwaters/Ridge area from the low-lying land in the middle and lower reaches/Polk Uplands area. The red lines represent different regions that in part reflect these differences in elevation. Source: PBS&J

The Natural Hydrology of the Peace Creek Watershed—*continued*

The movement of surface water and groundwater in the natural Peace Creek watershed is similarly organized. In the headwaters/Ridge area, where the elevation is highest (the area outlined in red at top left in *Figure 2*), ancient sand dune deposits contain sandy soils with very high infiltration rates. Over time, percolating rainwater dissolved areas of the underlying limestone, and the surface subsided and formed lakes. These lakes are well connected to the aquifer system and rise and fall with aquifer levels.

There are very few, if any, surface streams in the sandy headwaters/Ridge area of the watershed, indicating that rainwater did not run off the land surface. Instead, it infiltrated into the ground and then slowly moved through the surficial and Floridan aquifers to recharge the area's many lakes.

Groundwater that accumulated under the Ridge seeped out to form lakes and wetlands in the middle and lower reaches. This area, the Polk Uplands, encompasses about two-thirds of the watershed (the term "Polk Uplands" is a misnomer of sorts, since this is actually the lowest part of the watershed). During heavy rains, the lakes overflowed their banks, and the water moved across the landscape through elongated strands, sloughs,

and wetland areas, much like those of the Everglades in south Florida. These spread the water over a wide area and retained it in the landscape before the water flowed out of the watershed into the Peace River.

During periods of drought and low rainfall, there was little flow in the Peace Creek system. However, during periods of high rainfall, excess water moved quickly through the system because it spread out over the landscape. In the lower portion of the watershed, where Peace Creek flows into the Peace River, sloughs likely connected to form forested swamp floodplains with a network of numerous small, meandering channels.

In its natural condition, the Peace Creek watershed held water on the land surface in lakes, wetlands, floodplains, and streams, and held water below the surface in aquifers. The water stored in the surficial and Floridan aquifers in the upper part of the watershed kept lake levels higher during periods of low rainfall. Similarly, in the middle and lower portion of the watershed, wetlands and the surficial aquifer stored floodwaters and slowed water flow, gradually releasing the water to maintain higher flows in the Peace River during dry seasons.

In its natural condition, the Peace Creek watershed held water above the land surface in lakes, wetlands, floodplains, and streams, and held water below the surface in aquifers.



The amount of water storage in the surficial aquifer, lakes, and wetlands is critical to maintaining enough water to meet water demand from both people and natural systems throughout the year.

Seasonal Storage and Demand in the Natural Peace Creek System

The monthly patterns of rainfall and sunlight on the landscape affect how water moves through the natural system, including lakes, in the Peace Creek watershed. Periods of high solar radiation during the summer create a high demand for water because of increased evaporation from lakes, wetlands, and natural and developed land surfaces, as well as increased transpiration by plants. This total water demand, called evapotranspiration, and represented by the yellow curve on the graph in **Figure 3**, is particularly high in the summer. During the winter, it is much lower, as sunlight is much less intense.

Rainfall in central Florida (shown as the turquoise curve in the graph) varies significantly throughout the year, with a small peak from January through March as cold fronts move across Florida, and with most of the rain falling from June through October as summer thunderstorms occur and

tropical systems move through the area. The periods in between (April and May; November and December) have much less rainfall.

The difference between these two curves (the area shown in color) represents either a water surplus or a water deficit (in inches). The green and blue area above the yellow line indicates a surplus, and the purple area below the yellow line indicates a deficit. If rainfall is higher than water demand, as is usually the case in winter and summer, then a water surplus occurs. A small portion of the surplus, shown in green, rehydrates the soil for plant growth (soil water recharge), while a much larger portion, shown in blue, is stored in the natural system. If rainfall is lower than water demand, then the system has a water deficit, shown in purple, which usually occurs in spring and fall.

During periods of water deficit, water demand is met from the water already stored in the system—

in this case from water in the surficial aquifer and lakes. The water level in the lakes (represented by the dark blue curve at the bottom of the graph, measured in feet) rises as surplus water is stored in them, and falls as water leaves the system, to make up the water deficit. During deficits, plants draw moisture from the soil (soil water utilization) to survive.

Increased Water Storage: A Critical Factor

The amount of water storage in the surficial aquifer, lakes, and wetlands is critical to maintaining enough water to meet the water needs of people and natural systems. When there is a water surplus, especially during very wet years, the water should be stored in the watershed. If it is instead discharged from the watershed, then the amount of stored water available to meet future demand decreases. If the ability to store water is decreased, then the water supply for both lakes and people will drop further during periods of water shortage.

evapotranspiration

The water vapor produced through the natural processes of evaporation and transpiration. When rain falls on the earth, some of the water evaporates from the land surface and from waterbodies, returning to the atmosphere. Plants also transpire water vapor through small openings in their leaves.



SEASONAL WATER SURPLUSES AND DEFICITS IN CENTRAL FLORIDA

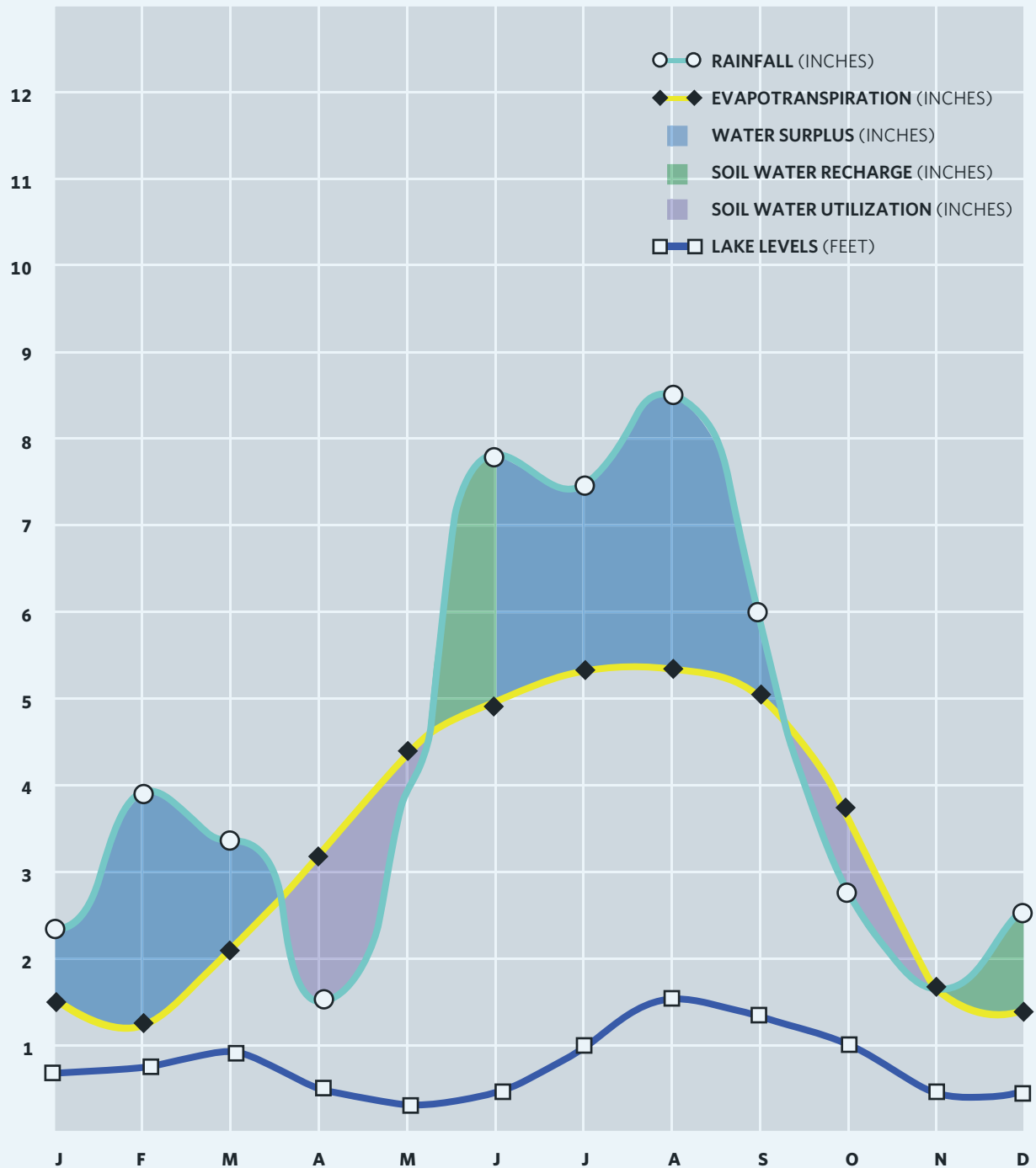


FIGURE 3. A graph of seasonal water surpluses (storage) and deficits (demand) in Central Florida, showing how evapotranspiration (the yellow line) rises and falls seasonally; it is much higher during the summer than in the winter because of the increased solar radiation. Rainfall in central Florida (the turquoise line) also rises and falls seasonally. The difference between these two curves represents either a water surplus (the green and

blue area above the yellow line) or a deficit (the purple area below the yellow line). During periods of water deficit, demand is met from water stored in the surficial aquifer and lakes. Thus it is critical to store surplus water rather than discharge it from the system, as the surplus is used to meet water demand for both public supply and the lakes during dry periods.

Source: Mark T. Brown for PBS&J

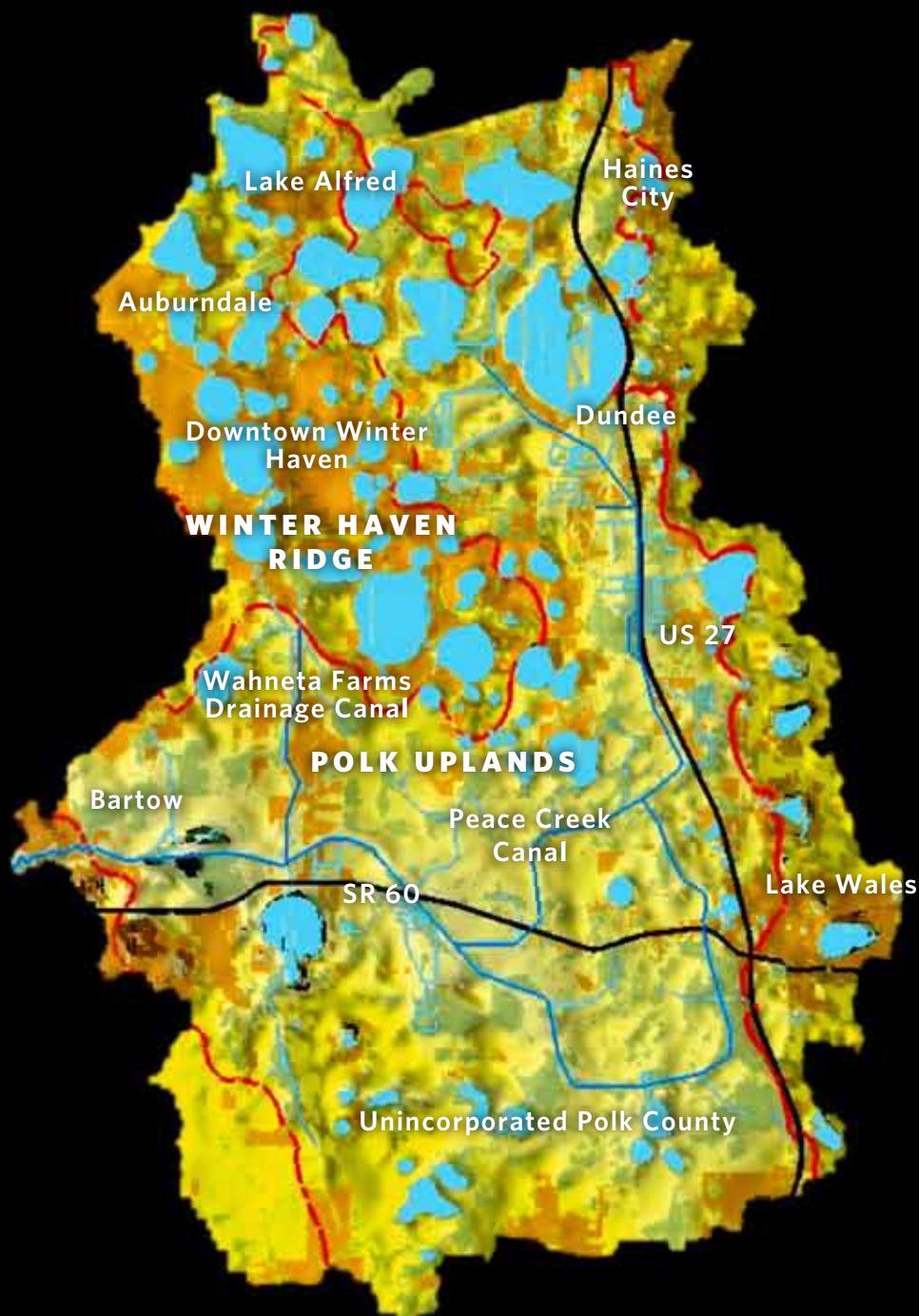


FIGURE 4. A plan view of the hydrologically altered Peace Creek watershed, showing the Peace Creek and Wahneta Farms Drainage Canals (the dark blue lines at the bottom), which initially provided significant drainage improvements for human uses. As the community of Winter Haven was developed, agriculture gave way to urban development in these low-lying areas, which are still prone to flooding.

Source: PBS&J

New development, especially in the storage/conveyance areas of the watershed, will likely result in further dewatering of the watershed, if development is allowed to occur as in the past.

The Hydrologically Altered Peace Creek Watershed

Although today we know more about the long-term effects of altering an area's hydrology, this was not known or understood historically. In many watersheds nationwide, historical drainage projects and development patterns have led to a significant loss of hydrologic function that has created long-term impacts to water supply and water quality, lowered lake levels, increased flooding, reduced river flows, and caused habitat destruction. The movement and storage of water are altered for human uses such as agriculture, homes, schools, businesses, industry, and roads. Urban development often occurs first in the highest, driest areas with the greatest potential for aquifer recharge. The last areas to be developed are usually those that were historically wet; often these are still prone to flooding.

The hydrologically altered Peace Creek watershed is no exception. The higher, drier areas in the headwaters/Ridge portion of the watershed were developed first for residential and business use. These high-recharge areas historically helped maintain water levels and water quality in the lakes, streams, and aquifer systems. Historical drainage "improvements" (as opposed to present-day stormwater treatment systems) associated with the resulting

development took the rainwater that once percolated underground into the surficial aquifer and instead directed it into the lakes. Regional agricultural, urban, and phosphate mining withdrawals lowered Floridan aquifer levels. The resulting changes in infiltration, flow, and storage have contributed to lowered lake levels and degraded water quality.

In the early 1900s, a number of canals were constructed in the watershed (*Figure 4*): the Peace Creek Drainage Canal was constructed to provide an outflow for the Northern Chain of Lakes and to drain the surrounding lands (*Figure 5*); the Wahneta Farms Drainage Canal was built to allow outflows from the Southern Chain and to drain neighboring areas; and numerous other canals were constructed to connect Winter Haven's lakes so that they were navigable. As a result, water was rapidly moved out of the watershed, and levels in a number of lakes and the surficial aquifer have dropped by approximately 10 feet over the last 90 years. In addition, some of the canals connecting the lakes go dry during drought years. Today, many of the 50 lakes in the City are listed as impaired for nutrients, which can lead to the overgrowth of algae that reduces oxygen levels in the water and causes fish kills.



FIGURE 5. *The Peace Creek Canal has effectively drained agricultural lands during the past century. Source: Southwest Florida Water Management District, March 2006*

The City's water supply wells are located in the headwaters/Ridge area of the watershed. Most of the water pumped out of the ground in this area is discharged from the headwaters, where it could do the most good. Five million gallons per day of treated wastewater are sent to the Peace Creek Drainage Canal in the southern part of the watershed, where the water very rapidly flows downstream to the Peace River.

New development, especially in the storage/conveyance areas of the watershed, could result in the further dewatering of the watershed, since existing stormwater, wetland, and floodplain regulations allow further degradation to water resources. It is critical that the communities in the watershed plan for future development in a proactive, long-term manner, with the sustainable management of water resources and economic stability and viability as the primary goals.

Draining the watershed has increased the amount of agricultural and urban land;

however, that increase has resulted in lost storage in the watershed.

Water Storage and Demand in the Peace Creek Watershed

Changes in the Headwaters/Ridge Area

Urban development in the Peace Creek watershed began in the higher areas of the Winter Haven Ridge. The construction of buildings, parking lots, and roads covered the landscape with impervious surfaces, reducing the area available for water to infiltrate into the surficial and Floridan aquifers. Instead, the water that ran off the land surface was collected by underground pipes and discharged directly into the lakes, thus decreasing storage in the aquifer systems.

A second change in the system allowed this water to leave the headwaters/Ridge area much faster than it had in the past. Many of the lakes were lowered so that they could be connected by canals to allow for navigation. Outfalls were established from the lake chains, allowing water to flow out of the chains to the Peace Creek and Wahneta Farms Drainage Canals during periods of high rainfall.

As a result of these connections, some lake levels were lowered around 10 feet from historical elevations. This represents not only a loss of storage in the lakes themselves, but also a loss in the surficial and Floridan aquifers, which are highly connected to the lakes and essential to the needs of both people and the

environment. The system can no longer store as much water in the headwaters/Ridge area as it once did, because water continually drains from the lakes into the aquifer system.

Changes in the Middle and Lower Reaches/Polk Uplands Area

In this part of the watershed, the Peace Creek and Wahneta Farms Drainage Canals were dug into the landscape to help remove surface water from wetlands and increase the amount of available land. These canals provided channels that moved water quickly off the landscape, instead of allowing it to spread across wide areas. Land that was once frequently wet became dry enough for agriculture and development. Because the canal channels were dug deep into the land surface, they continue to drain water from the surficial aquifer even when no surface water is flowing from the lakes. This represents lost storage during flood conditions and a drain on water stored during the dry season.

Land Management and Water Storage

The total available water to meet water demand for people and the environment consists of stored water plus rainfall (as shown

Panorama, looking south, Winter Haven, Florida, 1919.



in *Figure 6*, the light green line indicates a low-rainfall year and the dark green line a high-rainfall year). As the population of the area increases, its water needs increase. When the increased human demand is overlaid with the water needs of the environment (purple line), eventually there will not be enough water to meet the needs of both (orange line).

To meet its future water needs, the community will need to protect areas vital to water resource management, including water storage in the headwaters/Ridge area, while at the same time allowing future development. However, increasing the amount of land used for water storage does not mean reduced economic opportunities. The two goals can be accomplished simultaneously.

The graph shows that when this balance between storage and demand is achieved, the water needs of the community can be met even during periods of low rainfall. In effect, what is good for the lakes and the environment (storage) is good for the community (supply). However, the community is at the brink of having to make some hard choices about how it chooses to manage land uses in the future.

LONG-TERM WATER STORAGE AND DEMAND

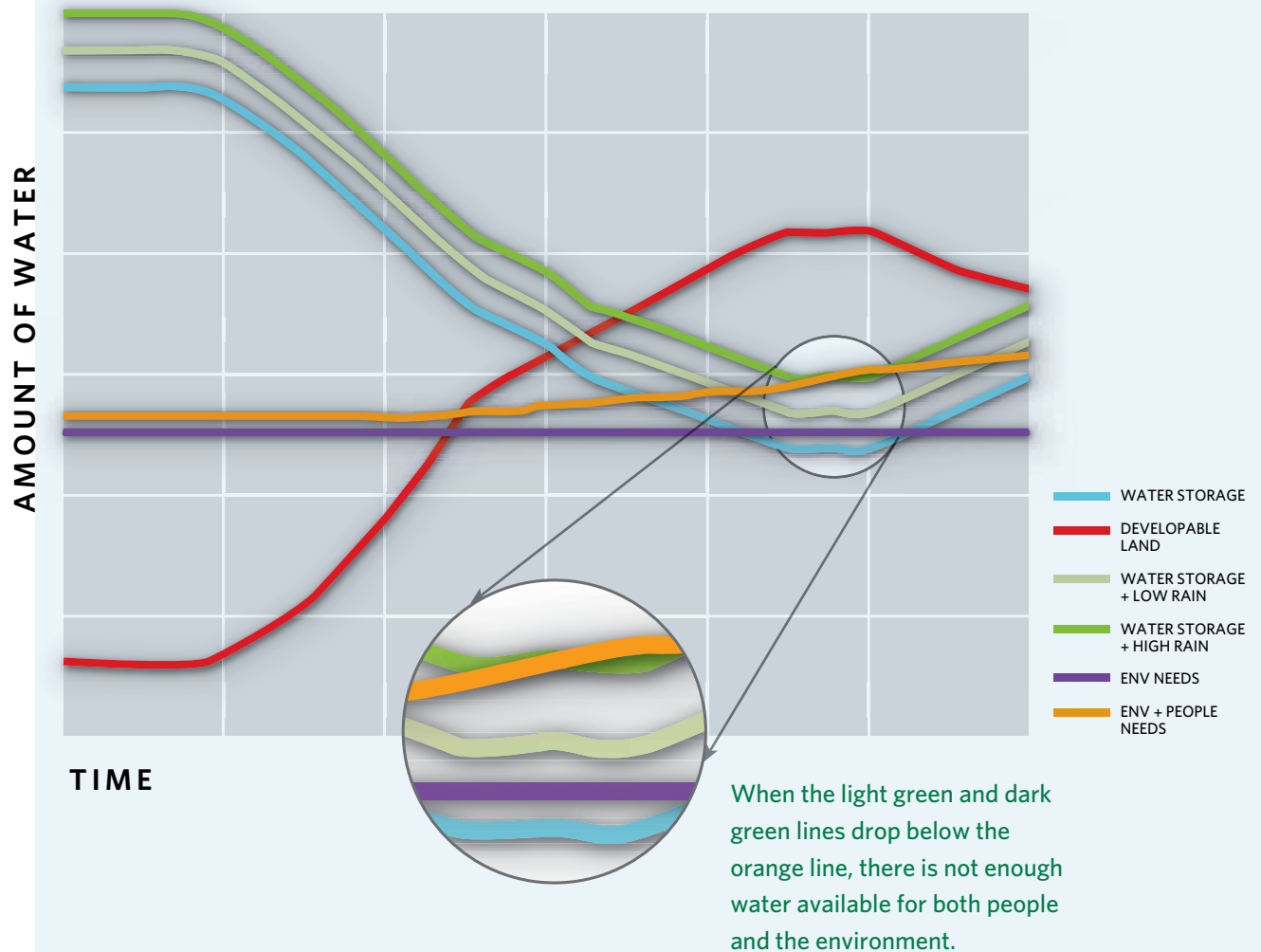


FIGURE 6. A conceptual graph of water storage and demand in the Peace Creek watershed, showing how connecting the lakes and draining the watershed have increased the amount of developable land (represented by the increase of the red line on the graph). That increase has come at the cost of lost storage in the system (shown by the decrease in the blue line). The total available water to meet water demand consists of stored water plus rainfall (the light

green line for a low-rainfall year and the dark green line for a high-rainfall year). As the population of the area increases, its water needs increase. When compared with the water needs of the environment (purple line), eventually the amount of available water will not be sufficient to meet both the needs of people and the environment (orange line).

Source: Mark T. Brown for PBS&J

At least 2 billion gallons per year (5.5 million gallons per day) of rainfall are now piped to the lakes as direct stormwater runoff.

Estimating the Loss of Storage in the Peace Creek Watershed

The lost infiltration and storage of water in the watershed, and the lost storage and increased discharges of water out of the watershed, have depleted the supply of water that is needed to protect lake levels and water quality, provide flow to rivers and streams, and recharge aquifers for water supply.

Storage Losses in the Headwaters/Ridge Area

Because of the sandy soils in the headwaters/Ridge area, there was little to no stormwater runoff under the natural conditions that existed before development. Rainfall mostly percolated into the shallow surficial and deeper Floridan aquifers and/or was temporarily stored in isolated wetlands.

Today, however, a substantial amount of stormwater runoff is generated from this urbanized area, and less water infiltrates into the ground to replenish the surficial aquifer. The amount of water that no longer percolates into the surficial aquifer is estimated as the amount of stormwater runoff into the lakes. At least 2 billion gallons per year (5.5 million gallons per day) of rainfall are now piped to the lakes as direct stormwater runoff. This calculation is

based on the water budget for the Southern Chain of Lakes (*Figure 7*) developed by the Southwest Florida Water Management District in establishing pollutant reduction goals for the Winter Haven Chain of Lakes (McCary and Ross, 2005). Because the Southern Chain makes up less than 50% of the lakes in the headwaters/Ridge, this calculation provides a very conservative estimate of the loss of surficial aquifer recharge that results from directing stormwater runoff to the lakes. *Appendix A* provides details of the calculation.

If redirected to allow percolation, the 2 billion gallons would be available to recharge the surficial aquifer. Water reintroduced into the surficial aquifer would then recharge the adjacent lakes via groundwater seepage and contribute to deeper Floridan aquifer recharge. Some additional water would also be lost to evapotranspiration.

Reestablishing percolation and surficial aquifer recharge as the primary method for water to enter the lakes could reduce stormwater discharges to the lakes. Low lake levels during droughts and dry seasons would be moderated by additional flow from the surficial aquifer if more water percolated into the ground during the wet seasons. Additional benefits include the treatment of stormwater runoff to filter particles and to reduce the levels of nutrients such as phosphorus and nitrogen.

Storage Losses in the Middle and Lower Reaches/Polk Uplands Area

In its natural condition, the Polk Uplands, in the middle and lower reaches of the Peace Creek watershed, historically acted as a storage reservoir for the Peace River. This area received wet season rains, temporarily stored them in wetlands that comprised nearly 30% of the watershed's surface area, and slowly released them over the next several months. The hydrologic system functioned to maintain water in wetlands and upland soils for long periods. The considerable friction that slowed the meandering flow of water through wetland sloughs ensured that the landscape remained wet well into the dry season and that groundwater flow to both Peace Creek (baseflow) and the Peace River farther downstream was maintained year-round. As a result, the landscape was less suitable for agriculture or other forms of development.

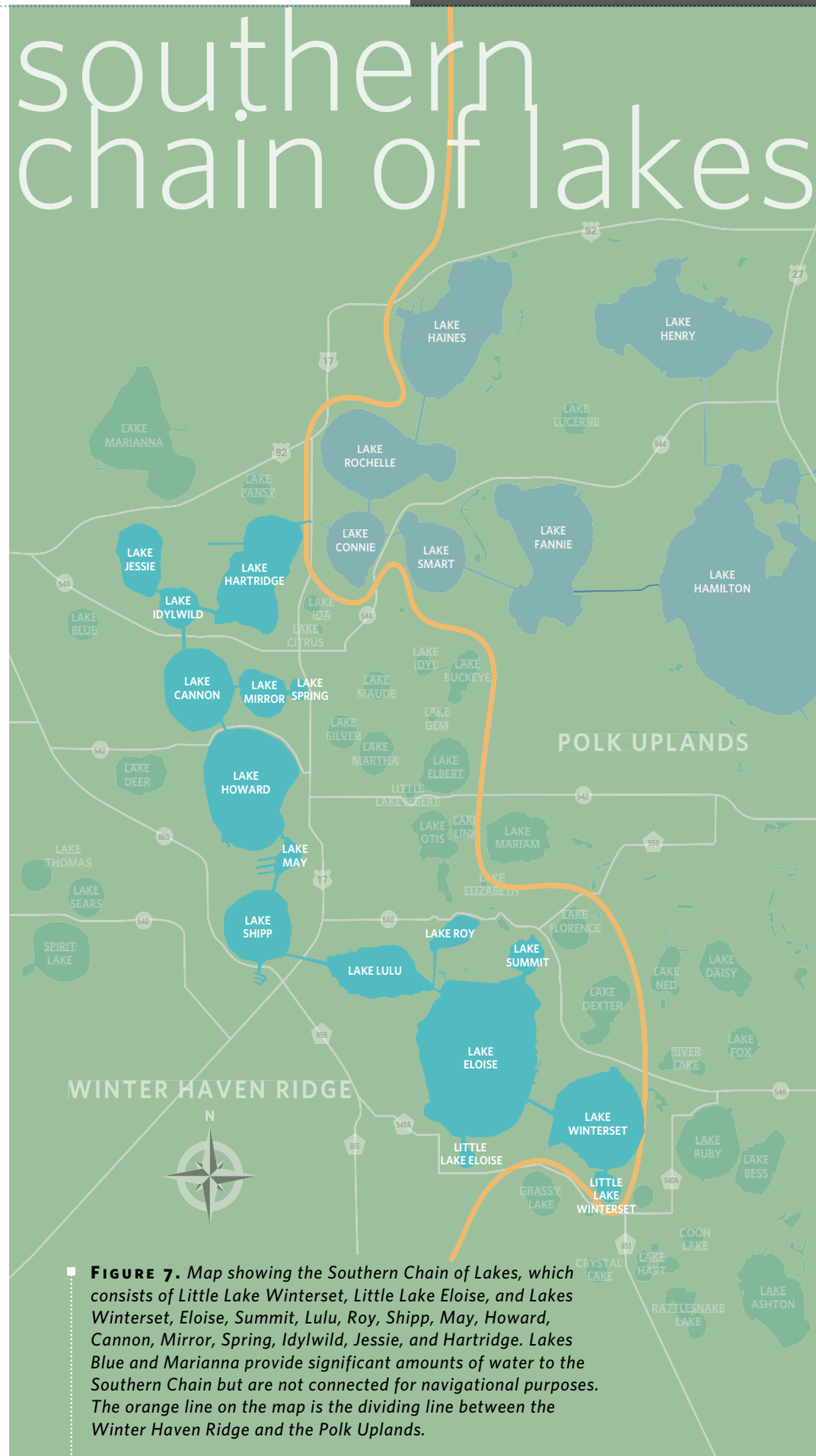
water budget

A water budget describes what happens to water entering and leaving a watershed. The components of a water budget include the amount of rainfall; surface water and groundwater flows; the amount of water stored in lakes, wetlands, and aquifers; the amount of water taken up by plants; and the effects of natural conditions such as sunlight, rain, and wind.

southern chain of lakes

The digging of the Peace Creek Canal and the subsequent draining of wetlands and the surficial aquifer resulted in a decrease of wetland area of nearly 9,000 acres (a reduction of over 30%) in the storage/conveyance areas of the Polk Uplands. *Appendix B* lists estimates of wetland losses in the Peace Creek watershed, from its natural state to the hydrologically altered condition today. This has led to the loss of about 6 billion gallons of wetland storage and the loss of about 21 billion gallons of surficial aquifer storage, for a total storage loss of about 27 billion gallons.

The loss of storage, combined with the ditching and draining, has increased peak surface water runoff by almost 75% and increased the cumulative discharge from Peace Creek by about 28% (*Appendix C*). Much of the additional discharge comes during the wet season, when Peace Creek and the Peace River need it the least. Conversely, flow is reduced during the dry months, when the Peace River needs it the most.



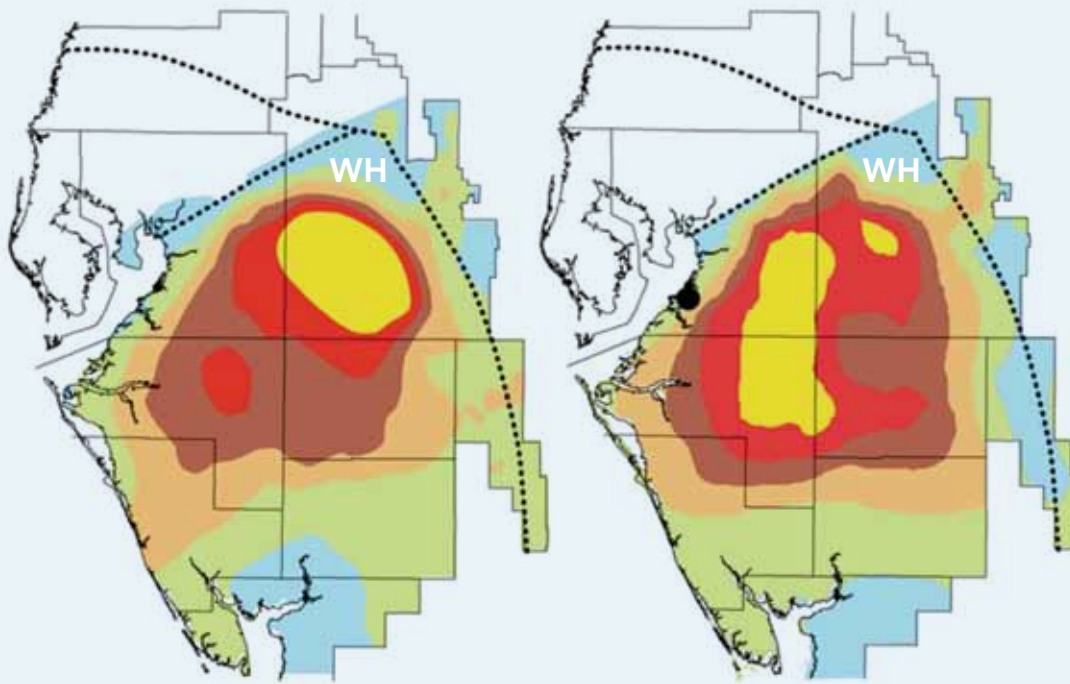


FIGURE 8. Relative long-term declines in the potentiometric surface in the region's Floridan aquifer wells before human disturbance through 1975 (the left-hand map) and through 2000 (the right-hand map). The dotted lines show the regional groundwater basin, and the colored areas indicate the estimated drawdown of the aquifer, measured in feet, during both periods. The abbreviation "WH" shows Winter Haven's location. The size of the areas affected by the aquifer drawdown between 1975 and 2000, and the total amount of groundwater withdrawn, are both similar. However, the area undergoing the greatest impacts from groundwater

withdrawals has shifted from Polk County to southern Hillsborough and northern Manatee Counties, because of decreased water use for phosphate mining and increased use for agriculture and urban development. Lowered aquifer levels may be allowing saltwater intrusion along the coast near Tampa Bay; they also contribute to reduced flows in the upper Peace River and lowered lake levels in some lakes in the upland areas of Polk and Highlands Counties—including the Winter Haven lakes located in the headwaters/Ridge area of the Peace Creek watershed. Source: Southwest Florida Water Management District

REGIONAL GROUNDWATER BASIN

Change in feet

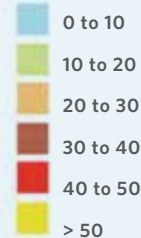
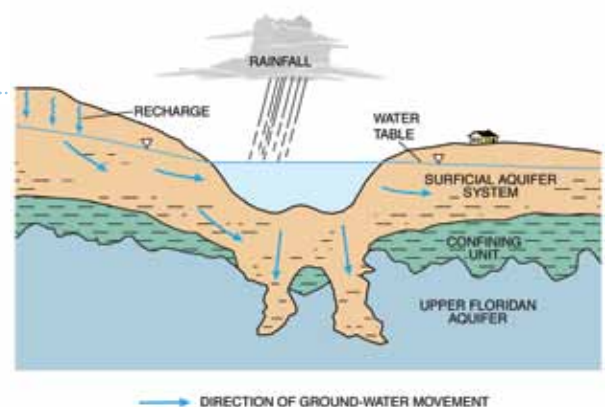


FIGURE 9. Generalized cross-section of groundwater flow through a Florida lake. Source: U.S. Geological Survey, 1999



potentiometric surface

An imaginary surface that represents the height to which water will rise when trapped between impermeable layers of rock or in a cased well.

Relationships between Surface Water and Groundwater

Peace River Region

Floridan aquifer water levels in the Peace River region of southwest central Florida have declined significantly due to withdrawals in the last century for public supply, agriculture, mining, power generation, and recreational uses. These withdrawals have resulted in declines of more than 50 feet in some areas. Although withdrawals have leveled off, the lowered aquifer may be causing saltwater intrusion in Hillsborough County wells along the coast near Tampa Bay; it also contributes to reduced flows in the upper Peace River and lowered lake levels in the upland areas of Polk and Highlands Counties—including the lakes in the City of Winter Haven.

The Water Use Caution Area designation is given to areas where water supplies are or will become critical in the next 20 years. In 1992, the Southwest Florida Water Management District designated the Southern Water Use Caution Area (SWUCA). The SWUCA encompasses 5,100 square miles and includes all or part of 8 counties (all of DeSoto, Hardee, Manatee, and Sarasota Counties and parts of Charlotte, Highlands, Hillsborough,

and Polk Counties) in the southern part of the district. Because of the area's geology, the effects of regional withdrawals on the lakes, wetlands, and rivers of the Peace Creek watershed and the Peace River just below Peace Creek are more pronounced than in any other part of the SWUCA. The district has developed a Recovery Strategy for the SWUCA in order to reduce the rate of saltwater intrusion, restore flows in the upper Peace River, restore lake levels, and ensure sufficient water supplies to support current uses.

Figure 8 compares changes in the potentiometric surface of the Floridan aquifer in the region during two periods—before development through 1975 (the left-hand map), and before development until 2000 (the right-hand map). The dotted lines show the regional groundwater basin, and the colored areas indicate the decline of the potentiometric surface (in feet) during both periods.

A comparison of the two maps shows that the size of the area affected by the decline is similar for the two periods. The total amount of groundwater withdrawn during both periods is also similar. However, the area undergoing the greatest impacts from groundwater withdrawals from 1975 to 2000 has

changed. In 1975, the center of the potentiometric surface decline was in Polk County's phosphate mining region. By 2000, it had moved to the southwest, into southern Hillsborough and northern Manatee Counties, due to a shift in water use from phosphate mining to agriculture and urban development.

The City of Winter Haven is located in the northeast corner of the maps in *Figure 8* (indicated by the abbreviation "WH"). As shown in the figure, the Floridan aquifer levels in this area have been drawn down as much as 10 feet from the predevelopment level.

Peace Creek Watershed

As discussed earlier, the lakes in the headwaters/Ridge area of the Peace Creek watershed formed over time when rainwater dissolved the underlying limestone, creating depressions that filled with rainwater and groundwater, which rapidly seeped through the sandy soils. This area has some of the highest infiltration rates to the surficial aquifer in Florida—as much as 10 to 20 inches per hour. From the surficial aquifer, the water eventually seeped laterally into the lakes and recharged the deeper Floridan aquifer, as shown in *Figure 9*.

THE RANGE OF CONDITIONS IN FLORIDA LAKES

Figure 10 represents the range of conditions in lakes in Florida. These conditions can be either naturally occurring or created through hydrologic alterations. The top and middle figures represent conditions where the potentiometric surface of the Floridan aquifer is below the lakes. *Figure 10A* shows that when lake water levels are higher than the surrounding water table, water

leaks out of the lake and into the surrounding surficial aquifer, and may eventually reach the Floridan aquifer. In many lakes, this represents a normal but temporary condition—that is, lake levels rise during periods of high rainfall, and water gradually leaks out until lake levels are the same as the water table. However, in Winter Haven, this can be a periodic condition—with

constant leakage out of the lakes into the surficial and Floridan aquifers. The potentiometric surface used to help maintain lake levels, but today it does not because regional aquifer declines have altered the local hydrology, lowering water levels in the surficial and Floridan aquifers. Currently, the lakes leak water faster than they used to.

In *Figure 10B*, the direction of water flow reverses. As rain enters the soil and recharges the surficial aquifer, the water table near the lake rises above the lake water level, and the lake receives seepage from the surficial aquifer. This is the prevalent condition in the headwaters/ Ridge lakes today.

In contrast, *Figure 10C* represents the natural hydrology of many central Florida communities, and the historical condition in Winter Haven. In this case, the potentiometric surface of the water in the Floridan aquifer is both above the surface of the lake and above the water table of the surficial aquifer during dry conditions. The upward pressure of the water in the Floridan aquifer forces water back into the lake, providing the lake with a source of water as lake levels start to decline. Generally, surficial aquifer levels are also higher, and the water table provides additional seepage into the lake.

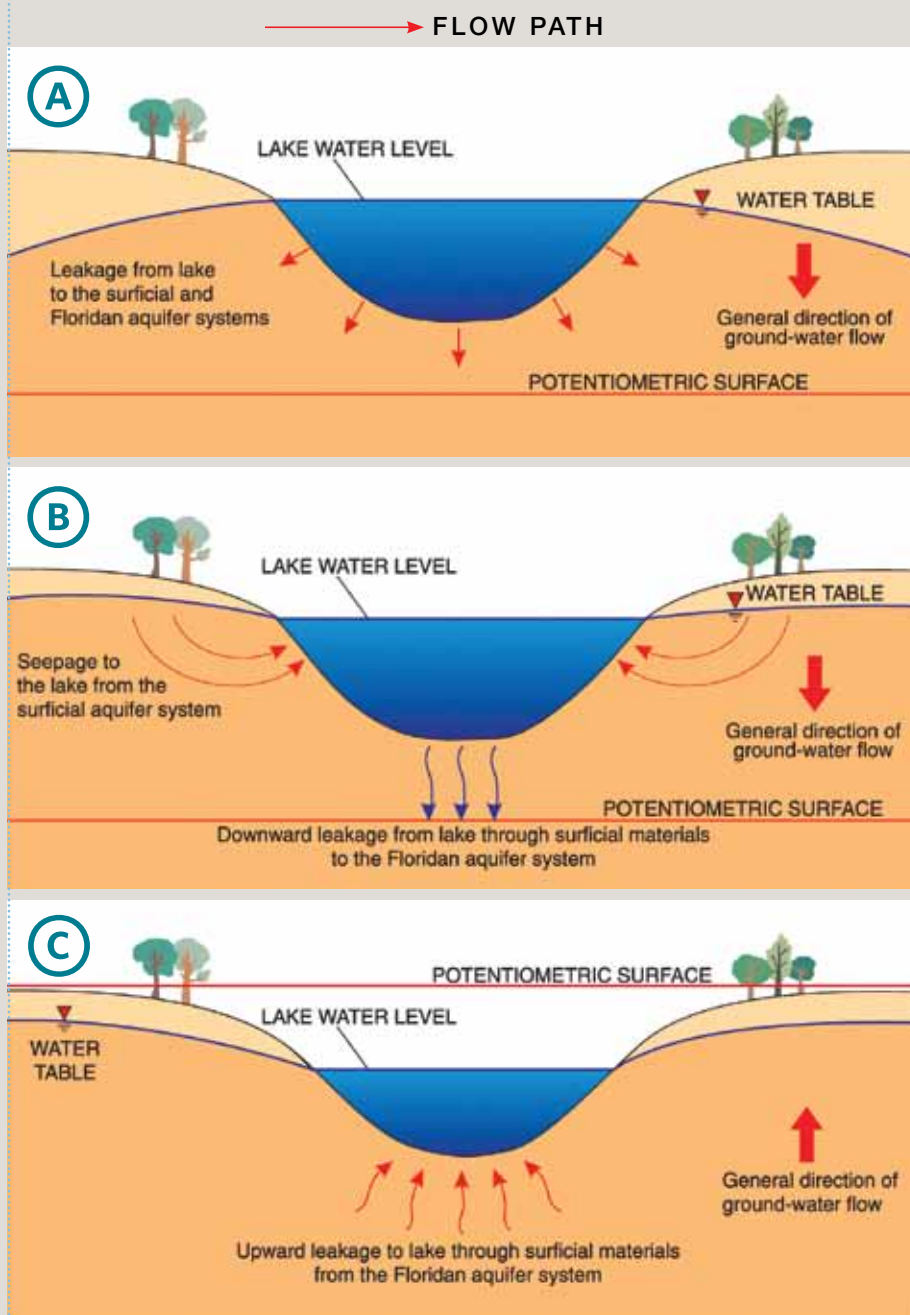


FIGURE 10. Interactions between groundwater and lake water levels.
Source: Schiffer, 1998

Relationships between Surface Water and Groundwater—continued

Real-Life Interactions

The real-life interactions between lakes and groundwater are very complex. The direction and amount of flow are influenced by the characteristics of the underlying soils and geology, as well as the position of the lake surface in relation to three factors: the water table, surficial aquifer, and potentiometric surface of the Floridan aquifer.

In the Peace Creek watershed, the situation that exists today results from lowering the regional aquifer and building over high-recharge areas, as well as piping stormwater runoff directly to the lakes. All of this has changed the way that the lakes receive water and has

contributed to lower lake levels. In the middle and lower reaches/Polk Uplands area of the watershed, the surficial aquifer has been drawn down because of increased drainage from the canals and lowered Floridan aquifer levels due to regional withdrawals.

Part of the scope of this Plan is to restore water levels in lakes and the surficial aquifer. It may not be possible to restore the watershed to the natural conditions that existed before human disturbance (*Figure 10C*), and there are limits to what the City can accomplish by itself. However, increasing local groundwater recharge as far up into the headwaters/Ridge area as possible would increase the level of the water in the surficial and Floridan aquifers, raise lake levels, and provide additional treatment

for stormwater flowing into the lakes. Any improved recharge in the headwaters/Ridge that eventually infiltrates into the middle and lower reaches/Polk Uplands area helps to provide water to downstream users.

In addition, water levels in the surficial aquifer would be increased by storing floodwaters during wet seasons, stopping the constant discharge of water from the middle and lower reaches/Polk Uplands area of the watershed, and slowing water flow by dechannelizing portions of the Peace Creek and Wahneta Farms Canals. These actions are all worth doing, both to preserve the City's water resources and, as part of an ongoing effort by all the communities in the area, to restore regional water levels in the Floridan aquifer.



Simulation Modeling

In reality, very little is known about how individual lakes receive and discharge water. **Figure 11** provides examples of how water can enter or leave a particular lake in myriad ways—sometimes recharging and discharging, and sometimes simply serving as a passthrough for water.

In simulation modeling, detailed information about a specific place is entered into a computer model, and

different scenarios are simulated to gain a better understanding of the possible outcomes—in this case, how water delivered to Winter Haven's lakes affects surficial aquifer levels, and how aquifer levels have changed over time. Even though the models are not intended to be predictive, they are very useful in understanding the unique geology that gives rise to the conditions in Winter Haven's lakes; the complex, dynamic interactions between groundwater and

the lakes; and the alterations that have occurred. This understanding provides an essential foundation for any future activities to restore water table levels in the surficial aquifer as well as lake levels.

Modeling Results

As part of the development of the *Sustainable Water Resource Management Plan*, the concept of restoring surficial aquifer levels was evaluated by Mark T. Brown, Ph.D.,

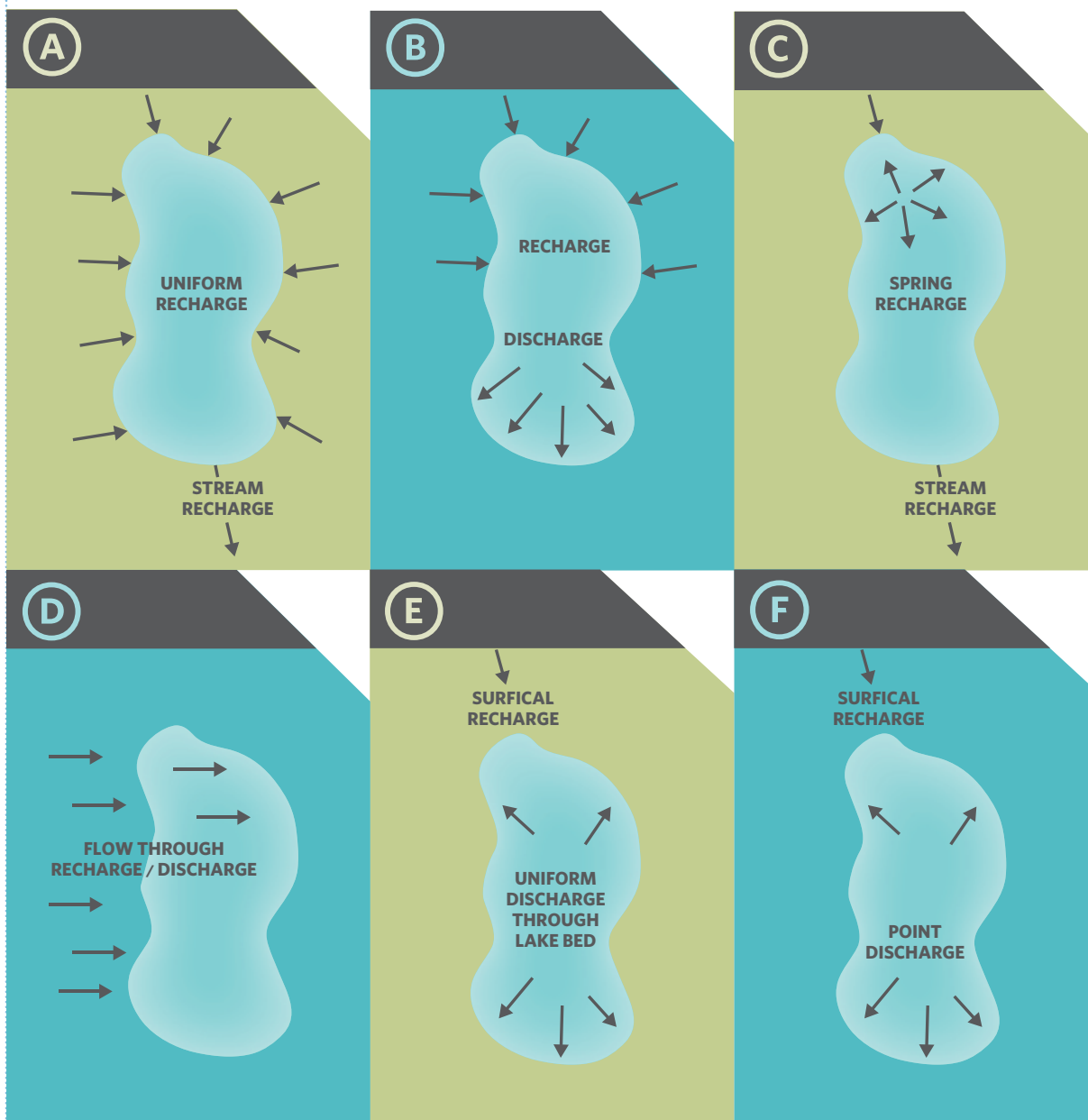


FIGURE 11. Six main classes of surface water and groundwater movement in lakes. Source: Boyle, 1994

of the University of Florida's Howard T. Odum Center for Wetlands, through whole systems simulation modeling of the Winter Haven Ridge and Polk Uplands (see *Appendix C*). Both predevelopment and postdevelopment models were run using a number of different scenarios. The modeling showed an 18% decrease in recharge to the upper Floridan aquifer from the surficial aquifer (equivalent to 2 billion gallons per year, or 5.5 million gallons per day), a 41% increase in recharge to the upper Floridan aquifer from the lakes, a loss of 6.7 billion gallons per year from increased surface discharge (equivalent to 18.4 million gallons per day), and a decrease in Peace Creek baseflow of 50% (from 100 to 50 cubic feet per second).

The results of this effort confirm that lowered Floridan aquifer water levels lead to lower surficial aquifer water levels and lake levels in the Winter Haven area. Furthermore, lower surficial aquifer water levels from reduced infiltration exacerbate the decline in lake levels. The modeling results also indicate that direct discharge to the lakes effectively "starves" the Floridan and surficial aquifers of water that would historically have recharged the aquifers. The lakes need to store as much water as possible to improve water quality and increase recharge to the Floridan aquifer. Routing stormwater to infiltration basins to increase the recharge to the surficial aquifer that gradually flows via groundwater seepage into the lakes will maintain nearly

historical lake and surficial aquifer water levels. Increased infiltration in the headwaters/Ridge area may initially exacerbate problems with lake levels, but the long-term benefits of improved water storage and water quality will outweigh the short-term concerns.

In addition, water will not have to be discharged prematurely whenever there are significant amounts of rainfall (this premature discharge means that the water is forever lost to the community). Finally, raising surficial and Floridan aquifer water levels through increased recharge will have the effect of sustaining higher lake levels, and will also benefit users of the Floridan aquifer within the SWUCA.



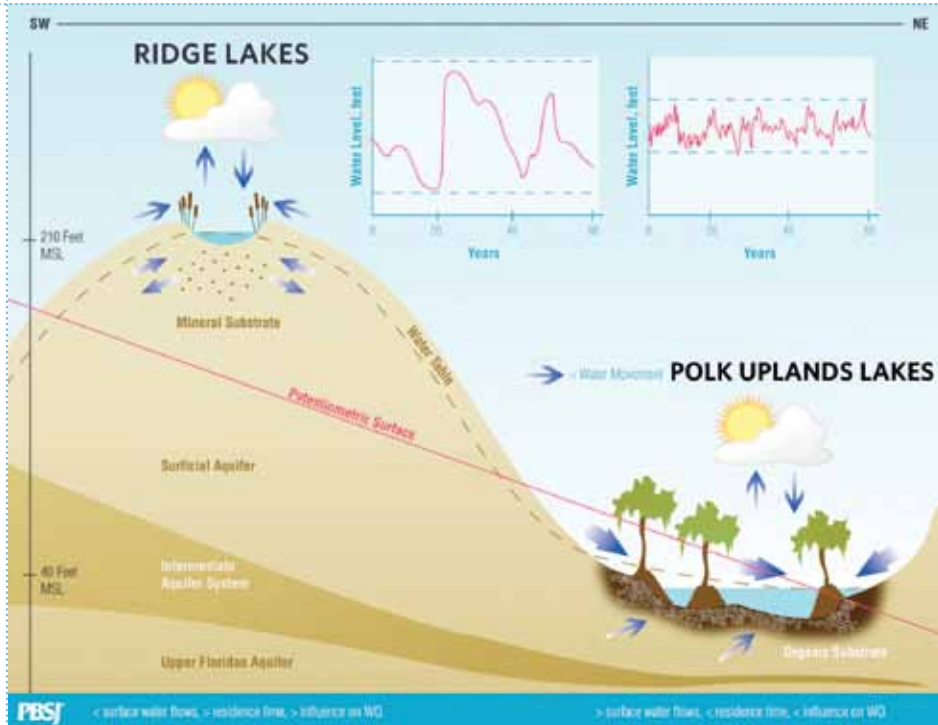


FIGURE 12. Illustration of how water moves through the hydrologically altered watershed, showing the interactions between surface water, groundwater, and lake levels for the higher elevation lakes in the headwaters/Ridge area and the lower elevation lakes in the middle and lower reaches/Polk Uplands area. Source: PBS&J

How Surface Water and Groundwater Connections Affect Lake Water Quality

The dynamic relationships between surface water, groundwater, and lake levels described in the previous section influence lake water quality. **Figure 12** summarizes how water moves through the hydrologically altered watershed, showing the interactions between surface water, groundwater, and lake levels for both the higher elevation lakes in the headwaters/Ridge area and the lower elevation lakes in the middle and lower reaches/Polk Uplands area.

The Ridge lakes are highly connected to both the shallow and deeper aquifers, rising and falling with aquifer levels. The graph at the top left of the figure shows that in these lakes, water levels vary widely between the wet and dry seasons; they are also affected by drought and excess rainfall over longer periods. Because the potentiometric surface of the Floridan

aquifer is below lake levels, there is a continuous loss of water from the Ridge lakes as water leaks out into the surficial and Floridan aquifers. In this part of the watershed, the sandy soils and the underlying limestone geology are highly permeable, allowing more water to be lost than in the Polk Uplands lakes.

Like the Ridge lakes, the Polk Uplands lakes are also connected to both the shallow and deeper aquifers, but not as well connected. However, in contrast to the Ridge lakes, they are continuously recharged by groundwater when the potentiometric surface of the Floridan aquifer is above the lakes. The graph at the top right of the figure shows that water levels in the Polk Uplands lakes are less variable over time than the Ridge lakes, and the largest fluctuations reflect the fact that soils found at the bottom of the lakes in this lower-lying part of the watershed are relatively impermeable compared with the sands underlying the Ridge lakes. These organic soils retard the downward movement of water and give rise to forested wetlands, also called swamps. At the same time, the organic soils do not limit the lateral and upward movement of water into the lakes from the Floridan and surficial aquifers, caused by upward pressure from the potentiometric surface of the Floridan. The more water there is in the surficial and Floridan aquifers, the greater the potential for water to flow laterally and upward into the lakes.

Other Factors Affecting Lake Water Quality

Just as the interactions between surface water, groundwater, and lake levels differ between the Ridge and Polk Uplands lakes, so do the various factors influencing lake water quality. These include the source, timing, and amount of water entering or leaving the lakes. The sources can consist of water entering the lakes through groundwater seepage, stormwater runoff, or rainwater falling directly on the lake surface. The timing can be seasonal (wet and dry seasons), longer term (floods and droughts), or extreme events that occur occasionally (hurricanes and tropical storms). The impacts of these events can be mild, moderate, or severe. The amount of water flowing into or out of the lakes depends on how much water is already stored in the system's lakes, aquifers, and wetlands, and

the potentiometric surface of the Floridan aquifer.

Seasonal Variations

For the Ridge lakes, water quality is typically worse in low water conditions during the dry season, when stormwater runoff and direct precipitation are lowest, than during the rainy season, when water levels are higher. Studies in the Winter Haven Chain of Lakes and elsewhere have shown that this is due mostly to the increased ease of resuspension of bottom sediments when water levels are low. A lack of color increases the vulnerability of Ridge lakes to algal blooms, in contrast to the Polk Uplands lakes, whose increased color helps to buffer them from nutrient loading. Shallow lakes have the worst water quality. For deeper lakes, these seasonal differences are of little matter.

transformation of nutrients into phytoplankton by shading or limiting the amount of light entering the lakes. This reduces the frequency and intensity of algal blooms.

For both the Ridge and Polk Uplands lakes, bottom sediments are potential sources of legacy nutrients from historical point and nonpoint source discharges. Because these nutrients can significantly degrade water quality, it is essential for any future restoration activities to address the removal of both internal and external loads. This issue is being addressed by the Sediment Removal Feasibility Study that has just been completed for Lakes May, Shipp, and Lulu by the City and Southwest Florida Water Management District.

Higher Water Levels: Summary of Benefits

Higher water levels provide many important benefits for both Ridge and Polk Uplands lakes, but for different reasons. In the Ridge lakes, they improve water quality by diluting contaminants, increasing circulation, and preventing the resuspension of sediments, so that fewer nutrients are recycled. The shallower the lake, the more vulnerable sediments are to resuspension from wind and wave action, or boat traffic. Water quality in the Polk Uplands lakes improves because of reconnected wetlands and floodplains, and increased water color. Other high-priority benefits for both the Ridge and Polk Uplands lakes include improved navigation and more water for aquifers and streams locally and regionally.

legacy nutrients

Legacy nutrients are nutrients deposited in a stream, river, or lake from past human activities, including land clearing, past wastewater discharges, untreated stormwater, and poor agricultural practices. Rainwater carries the nutrients to nearby surface waters, where they are taken up by aquatic plants such as algae. Once the plants die and decompose, the nutrients are released into the water, only to be taken up again by new plant growth. This cycle is endlessly repeated. Restoration efforts can only succeed if they address both this nutrient recycling (internal loads) and nutrients carried into a waterbody from outside sources (external loads) such as untreated stormwater.

Increasing the amount of rainfall that percolates into the surficial aquifer appears to be the most important mechanism for increasing lake levels and improving water quality during the dry season. Higher lake levels reduce nutrient recycling in lakes with muck, reconnect wetlands to Polk Uplands lakes, and help to make the water less stagnant.

For the Polk Uplands lakes, higher lake levels are likely to benefit water quality the most during the wet season, because they enhance the hydrologic connections between the lakes and their adjacent forested wetlands. These swamp shorelines are the primary source of tannins, which moderate the



Protecting and preserving water quality, water supplies, and natural systems, as well as providing adequate or improved flood protection, are all equally important.

Concepts and Conclusions

A number of important concepts and conclusions were derived from the information provided in Chapters 1 and 2. These were used to develop the guiding principles of sustainable water resource planning and management listed at right. In turn, these principles provided the foundation for developing the *Sustainable Water Resource Management Plan* presented in the next chapter, as well as the strategic recommendations for implementation in Chapter 4.

The long-term economic viability of the City of Winter Haven depends on adequate water resources in the future for both people and natural systems. Protecting and restoring water quality, water supplies, and natural systems, as well as providing adequate or improved flood protection, are equally important. The history of human activities in Florida, Polk County, and the City of Winter Haven makes it clear that, in the long term, population growth and economic development in the area will continue. For watersheds such as Peace Creek that do not receive contributions of water from outside the immediate area, managing water as a finite resource is critical.

The decisions that the City makes about water resources today will affect its future for decades—perhaps even permanently. At the local level, the preservation of Winter Haven's lakes is especially critical to the community.

However, the effects of the City's decisions will reach far beyond its local jurisdiction. They will also affect the amount and timing of water delivered to the Peace River system downstream, and eventually Charlotte Harbor and the Gulf of Mexico. Also, because Winter Haven lies at the headwaters of the regional groundwater basin, decisions made by the City about water resources will affect supplies in the larger region.

The assessment carried out as part of the development of this Plan has led to a better understanding of the losses in hydrologic function—and the accompanying losses in water resource benefits—that have occurred in the watershed because of human activities. These consist of the loss of water storage benefits such as water treatment and infiltration in the headwaters/Ridge area, and the loss of storage and conveyance in the middle and lower reaches/Polk Uplands area. To restore these essential functions, restoration and protection efforts should focus on re-creating the historical networking of water in the watershed.

To meet its future water needs, the community will need to decide how much land to allocate both for future economic growth and for essential hydrologic functions, including water storage, treatment, and conveyance. Incorporating water percolation and storage into plans for future growth can work

with already accepted practices for landscaping, stormwater management, and wetland mitigation planning. When a balance is achieved between human land use needs and natural hydrologic functions, the water needs of the community can be met even during periods of low rainfall. In effect, what is good for the lakes and the environment (storage) is good for the community (supply).

Restoration can accomplish significant improvements, approximately equivalent to conditions that existed 75 years ago. As part of the restoration effort, to buffer the hydrologic system and increase its resilience, the increased amount of water stored in the aquifer in the headwaters/Ridge area of the watershed should include provisions for extended droughts. In the middle and lower reaches/Polk Uplands area, historical wetlands should be restored, providing storage for floodwaters and allowing recharge of the surficial aquifer.

In addition to restoring and protecting the historical networking of water, other efforts are also crucial. Development should be planned and coordinated to avoid the cumulative impacts that have occurred in the past across Florida—impacts that are far greater than those of individual development projects.

principles of sustainable water resource planning & management

The impacts to water resources of future development should be considered and addressed during the planning and approval process. Furthermore, all impacts to water resources should be compensated for or mitigated locally, if possible, since the Peace Creek watershed receives no water from outside the watershed.

Cost-effective best management practices (BMPs) to increase infiltration, improve water quality, protect natural systems, and improve flood protection should be required and implemented for all existing and proposed development. In addition, stormwater and treated wastewater should be recycled and reused to supplement aquifer recharge.

Incorporating water resource restoration projects as amenities for development, recreation, and beautification will increase the sustainability of water resources as well as the community's economic and cultural viability.

If the City and neighboring communities continue with future development according to today's standards, the condition of the area's water resources will only continue to worsen in the future. As economic and population growth continue, significant opportunities exist for the sustainable management of water resources over the long term. The time is right for a proactive, long-term approach.

① **The total rainfall in the region is that region's water budget**—supplies from outside the region are considered to be "borrowed" or "leased" and cannot be counted on during drought or after the watershed is built out. The storage of water in the landscape—in aquifers, lakes, rivers, and wetlands—allows variations in rainfall to be averaged, and this vital function should be restored and protected.

② **In the long run, it is far more efficient and cost-effective to use the watershed's natural infrastructure to provide multiple long-term water resource benefits than to restore lost hydrologic function using structural, man-made means**—it is essential to preserve and protect whatever is left of the watershed's existing natural landscape, which provides multiple water resource services and benefits (such as improved water quality, water supply, natural systems, and flood protection) at a lower cost.

③ **Any impacts to water resources in a watershed should be mitigated in the watershed**—specifically, mitigation for wetlands, water quality, recharge, and flooding impacts should be carried out in the areas of the watershed that are critical to increased infiltration, storage, and conveyance.

④ **The locations of surface water and groundwater storage areas to protect and restore water resources must be integrated into urban and community design**—the development of areas such as nature parks and the setting aside of open spaces create a strong sense of place in the community.

⑤ **Stormwater, wastewater, and reuse water should be viewed as a valuable resource, rather than a form of waste to be disposed of. This resource should be recycled and recharged at a rate commensurate with use**—the storage and recharge of stormwater, wastewater, and reuse water should be achieved at the neighborhood, community, and regional scale.

⑥ **Each parcel of land should contribute to the water budgets of both the watershed and the region**—the postdevelopment water budget for each parcel should equal the predevelopment water budget as much as possible, and historical hydrologic functions such as recharge, water quality treatment, storage, and conveyance should be restored and protected to the greatest extent possible.

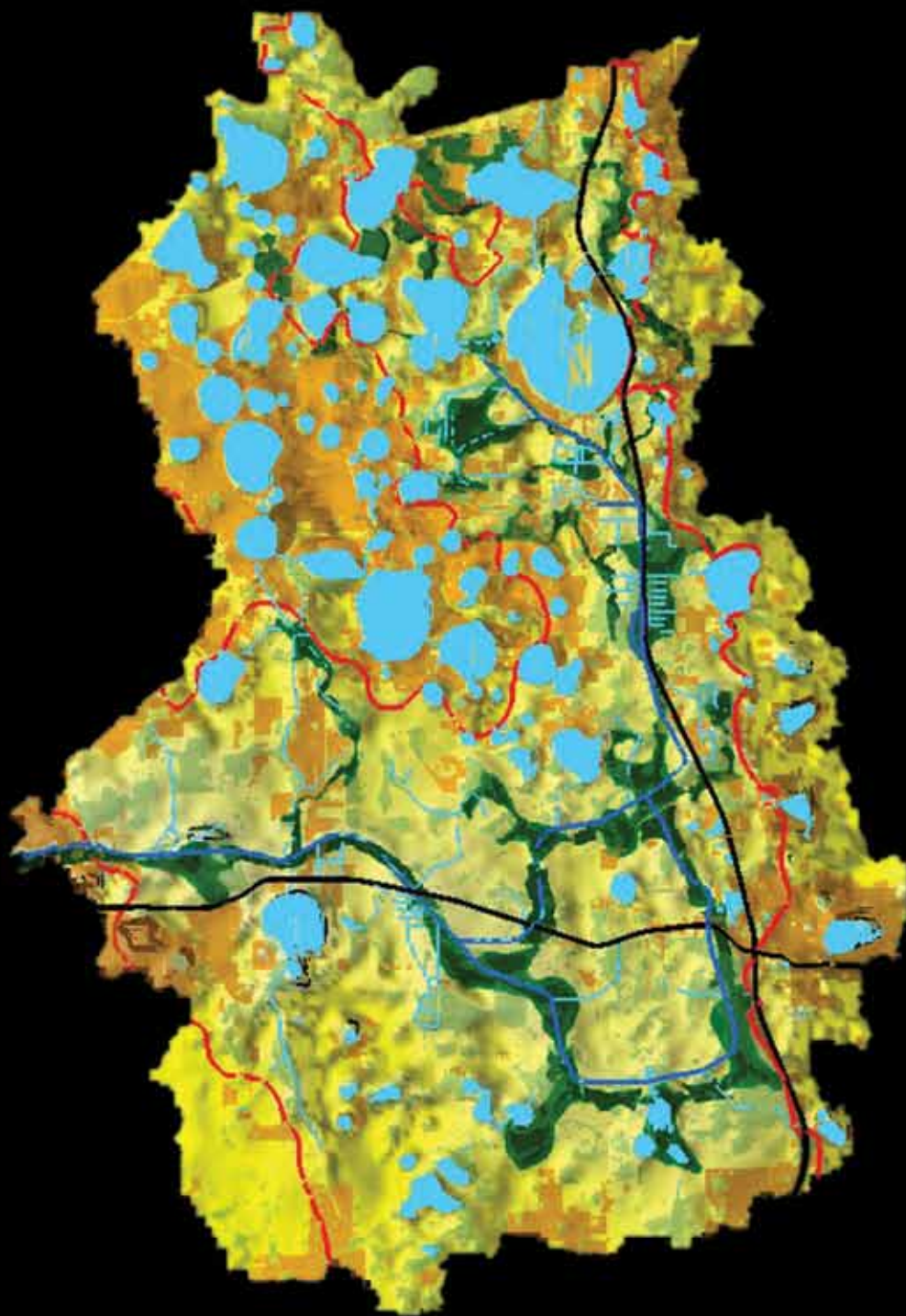


FIGURE 13. A plan view of the reconnected hydrologic network in the Peace Creek watershed, with restoration features (shown in dark green) that provide treatment and infiltration in the headwaters/Ridge area of the watershed, and an interconnected series of wetlands that provide storage and conveyance in the middle and lower reaches/Polk Uplands area. Source: PBS&J

A PLAN FOR PRESERVING AND RESTORING THE WATER RESOURCES OF THE PEACE CREEK WATERSHED

"The essentials of the old exploration were actualities; the essentials of the new exploration are potentialities. The old exploration described that which is, while the new exploration projects that which can be. The first was based on descriptive science; the second is based on applied science."

—Benton MacKaye, *The New Exploration*, 1928

In any community, a detailed understanding of the movement and storage of water provides a sound foundation for water resource management. Through the comprehensive assessment described in Chapter 2, the City of Winter Haven and other communities in the Peace Creek watershed have gained a much better understanding of the hydrologic functions and benefits that have been lost through human alterations. The goal of the *Sustainable Water Resource Management Plan* described in this chapter is to restore as much of the historical storage and movement of water through the watershed as possible, using stormwater, floodwater, and reuse water as a resource, while still providing adequate flood protection. The Plan would increase aquifer storage throughout the watershed and restore about 6,300 acres of wetlands in the middle and lower reaches/Polk Uplands area. It effectively meets the water needs of both people and natural systems, and provides for the sustainable management of water resources.

This new approach offers tremendous opportunities but also difficult challenges, as the community makes choices about how its future water needs are to be met. To restore balance to the system and still meet the needs of both people and the

environment, the amount of water storage should be increased. That can only happen by understanding and using the hydrologic functions of different areas of the watershed as efficiently as possible, including preserving land areas for natural storage—in other words, to let the system naturally do what it does best.

The principal opportunities for restoring the watershed's hydrologic function are as follows:

- **INCREASED TREATMENT AND INFILTRATION**—*The most important opportunity in the headwaters/Ridge area, including the residential and commercial areas around downtown Winter Haven, is to restore the infiltration of stormwater to recharge the surficial aquifer. This will provide storage capacity and flow for lakes during dry seasons, and will also ensure that adequate treatment is provided before the stormwater reaches the lakes or the aquifer. Treated water from local wastewater facilities (called reuse water) also provides opportunities for greater aquifer recharge and increased lake levels in the headwaters/Ridge area.*
- **INCREASED STORAGE AND CONVEYANCE**—*The most important opportunity in the middle and lower reaches/Polk Uplands area, which has the highest development pressure today, is to provide for additional*

storage of water and wider conveyance paths through the system during wet seasons. Increasing the amount of available storage will allow more water to be retained in the lakes in the headwaters/Ridge area during years with a water surplus. In the event of a storm, excess water will flow into the middle reaches, where it will be stored in the landscape (wetlands). Increased storage on the land results in higher surficial aquifer levels, which will provide more consistent outflows to Peace Creek and the Peace River during dry seasons. Finally, in the lower portion of the watershed, a wider conveyance area will allow large volumes of water to move through the system more quickly with less damage to property during flood events. At the same time, planning for this increased conveyance with future development will protect property from flood damage.

Figure 13 shows the reconnected hydrologic network. In the headwaters/Ridge area, a number of features provide increased treatment and infiltration. Although some of these features can be seen in the downtown area, they are more difficult to discern at this scale and are described in greater detail later in the chapter. In the middle and lower reaches/Polk Uplands area, an interconnected series of wetlands provides storage and conveyance, generally in the area near the Peace Creek Canal.



The City's nature parks are heavily used by residents and visitors, and are very pleasant places because of the combination of water, natural systems, and wildlife found in the midst of a developed urban area.

Increasing Water Treatment and Infiltration in the Headwaters/Ridge Area

To provide for the infiltration of stormwater in the headwaters/Ridge area of the Peace Creek watershed, open land is needed in an already developed urban landscape. An initial goal is to devote 5% of the watershed's current land area to implementing stormwater infiltration technologies such as rain gardens, swales, and percolation systems. This percentage is based on the calculation that about 2 billion gallons a year of stormwater are no longer infiltrated because of altered hydrologic function, and 5% of the watershed's land area would be needed to infiltrate that quantity of water annually (see *Appendix C* for details of this calculation).

By providing depressions in the landscape to collect runoff before it enters storm drains, the City can capture most of the runoff so it can be infiltrated into the surficial aquifer. The best strategy is to develop as many small depressions as possible, spread throughout the landscape, to mimic infiltration patterns in the natural system.

Different approaches to capturing stormwater are required for the various land use types and locations in the watershed. Opportunities in the residential and downtown commercial areas, and at the City's edge where development is ongoing, are described below and on the next two pages.

① Opportunities To Capture Stormwater in Residential Areas

Figure 14 shows a stormwater capture system that covers 5% of the surface area (highlighted in green) of an existing residential neighborhood in southwest Winter Haven near Lake Shipp. Stormwater can be collected in the following ways:

- **Capturing the water that runs off the roofs of private homes.** Private rain gardens in homeowners' yards can be incorporated into landscaping and located anywhere in the yard where a depression can be created to capture water from the roof.
- **Capturing the water that runs off streets and driveways.** In some areas, water can be collected in long, vegetated swales that parallel the road. These swales can be located in a median if present, or within the public right-of-way along a road.
- **Using portions of neighborhood parks for larger retention areas.** There are two different types of nature parks, or hydric parks. Some contain water all the time, and others fill with water only during heavy storms. (see the box on nature parks on page 38).



FIGURE 14. Aerial photo of a residential neighborhood in southwest Winter Haven, showing a stormwater capture system that covers 5% of the surface area (highlighted in green).

Source: Mark T. Brown for PBS&J

2 Opportunities To Capture Stormwater in Commercial Areas

Figure 15 shows a stormwater capture system (highlighted in green) that covers 5% of the downtown Winter Haven commercial district. Commercial areas can be one of the most challenging places to capture stormwater because of the high percentage of impervious surface and lack of available land. Besides roofs and roads, parking lots make up a large portion of the surface area. Three principal ways exist to capture stormwater in commercial areas:

- **Constructing swales and rain gardens within and along the edges of parking lots.** This is one of the best ways to capture stormwater in areas with little land. Some parking spaces could be lost to provide enough area for runoff infiltration.
- **Constructing roadside swales in the City's commercial district to capture runoff from street surfaces.** Although swales are an important way to capture stormwater and provide treatment in the headwaters/Ridge area, they are particularly important in providing treatment before stormwater runs into the lakes.
- **Retrofitting parks and open spaces with shallow depressions to collect runoff.** In higher density commercial areas, such as downtown Winter Haven, rain gardens and swales will be smaller but more numerous than in the more open residential areas. The City has a central park that provides a large, open space in the urban center. This provides some opportunities for retrofitting, and helps to prevent a heat island effect through the use of green spaces. Retrofitting is especially important in areas that are being redeveloped in the headwaters/Ridge portion of the watershed. The use of pervious concrete in areas undergoing redevelopment would also increase the amount of stormwater captured.

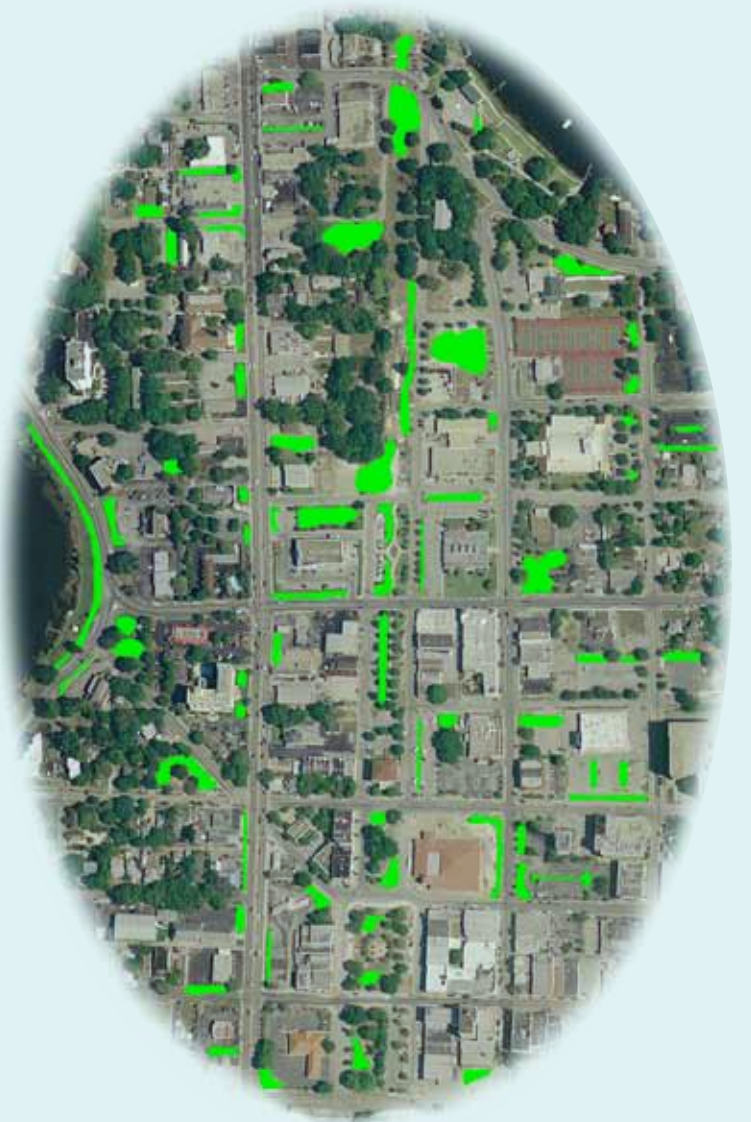


FIGURE 15. Aerial photo of the downtown Winter Haven commercial district, showing a stormwater capture system that covers 5% of the surface area (highlighted in green). Source: Mark T. Brown for PBS&J



③ Opportunities To Capture Stormwater at the City's Edge

Some of the greatest opportunities to maximize treatment and infiltration are found at the edges of cities, where development has not yet occurred, or is still occurring. Planning, design, permitting, and implementation should all reinforce each other, and should focus on the preservation of both natural hydrologic function and as many existing natural features as possible.

There are four major recommendations for developing areas at the outer edges of Winter Haven, as follows (*Figure 16*):

- **Preserve pre-existing, low-lying areas that collect and infiltrate rainwater.** Don't fill these in, but allow them to continue their important and essential function in the landscape, and enhance these areas where possible.
- **Enhance and extend the wetland edges of lakes with nature parks, or hydric parks.** These wetland areas can be used to treat stormwater before it enters the lakes, providing water quality benefits. They also store floodwaters and become recreational attractions (see the box on nature parks on page 38).
- **Preserve wet corridors in the landscape.** During heavy rainfall, having a path for the water to move across the landscape without affecting permanent structures is critical to maintaining high water levels and healthy lakes during normal weather patterns. These wet corridors can be enhanced to create wetland areas that act as wildlife and recreational corridors in the landscape.
- **Require new development to use low-impact stormwater management techniques, such as rain gardens and percolation ponds.** Requiring a new development to manage all its runoff within the development itself ensures that it is not creating a problem that will require more land elsewhere to solve.

■ **FIGURE 16.** Strategies for permitting development in undeveloped areas of Winter Haven include (1) preserving existing low-lying, undeveloped areas, (2) enhancing and extending wetland lake fringes, (3) preserving wet corridors, and (4) requiring low-impact development. Source: Mark T. Brown for PBS&J

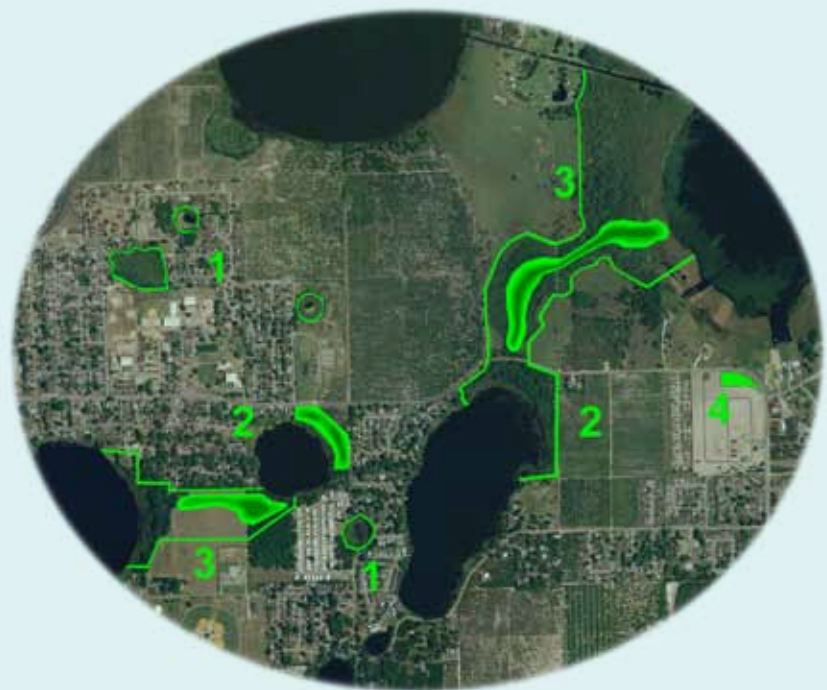


FIGURE 17. Technologies for capturing stormwater in the landscape for treatment and infiltration include roadside and parking lot swales, pocket wetlands, and rain gardens.

Stormwater Treatment Technologies

Figure 17 shows some of the different stormwater capture technologies discussed on the previous pages as they look when they are incorporated into the landscape. Roadside and parking lot swales (top photos) are built on the edges of paved areas. They can be constructed with curb breaks to allow water to enter, as in the parking lot swale, or without any curbs, as illustrated in the roadside swale.

Rain gardens (center and bottom right) can be added in the area of downspouts on buildings, or out in the yard as part of the landscaping. With careful design, they can be both low maintenance and aesthetically pleasing.

Finally, pocket wetlands (bottom left) can be created to hold water for longer periods. These create variety in the landscape and help provide better stormwater treatment, because the living organisms that flourish in such systems work to break down contaminants. If such areas already exist, they provide a natural fit. Places where groundwater has historically seeped to the surface, if present, would be ideal locations for creating such features. Pocket wetlands in the headwaters/Ridge area could also be used to infiltrate reuse water.

ROADSIDE SWALE



PARKING LOT SWALE



POCKET WETLAND

RAIN GARDEN

Sources: **Roadside swale:** Public Utilities Department, Seattle, Washington **Parking lot swale:** Government of Monroe County, Indiana **Pocket wetland:** Ramsey-Washington Metro Watershed District, Twin Cities, Minnesota **Rain garden:** Theresa Watkin, Institute of Food and Agricultural Sciences, University of Florida **Downspout rain garden:** Ginny Stibolt, Florida

low-impact development

LID is a set of principles used to develop land, or to retrofit existing development, and can be adapted to many different kinds of land uses. It focuses on working with nature to manage stormwater as close to the source as possible, in order to reduce human impacts and promote the natural movement and storage of water in a watershed or ecosystem. Stormwater is viewed as a resource, rather than a waste product to be disposed of.

—Adapted from the U.S. Environmental Protection Agency's Nonpoint Source Pollution Website at www.epa.gov/nps/lid



In the event of a storm, excess water will flow into the middle reaches, where it will be stored in the landscape (wetlands).

Increasing Water Storage and Conveyance in the Middle and Lower Reaches /Polk Uplands Area

Ninety percent of storm events in Florida generate less than an inch of stormwater runoff. This water should be retained on the landscape and allowed to infiltrate. However, in a channelized system such as Peace Creek, the water from many of these smaller storms is conveyed off the land as stormwater. With more than an inch of rainfall, only the excess should be discharged. For peak events, all of the water can be passed through the system and discharged, but only when absolutely necessary to prevent flooding.

Increased water storage can be provided by creating wetland storage areas, stormwater treatment areas, and forested wetland sloughs to help buffer the system against droughts, while at the same time providing flood protection (see *Figure 18*). This can be done by designing a system with significant surface water storage along the current Peace Creek Canal, and a wider conveyance corridor that facilitates high-volume flows during flood events, as shown in the cross-section view of the restored canal in *Figure 18*.

Wetland Storage

In the restored hydrologic network, portions of the Peace Creek Canal would be strategically dechannelized in as many places as possible, and barriers (called ditch blocks) would be placed in the canal to hold back water and allow it to spread across the landscape, as shown in *Figures 18* and *19*. These changes would slow down the water moving through the system, and the water would be stored for a much longer time, allowing it to recharge the surficial aquifer.

The newly created wetland storage areas would hold floodwaters to reduce flooding, and then release the water slowly downstream to increase baseflow in Peace Creek and the Peace River during the driest times of the year, when water is most needed in the system. By storing more water, these areas would also reduce peak flows during heavy rains, helping to provide flood protection downstream. In addition, the wetlands would serve as valuable waterfront amenities, providing recreational opportunities and wildlife habitat.

Wetland storage areas should be designed with varying water depths that allow a wide range of wetland habitats and support diverse plant and animal life. Higher land areas with shallow water should be provided to support forested wetlands and emergent wetland marshes. Medium-depth pools provide for submerged vegetation. Deep open-water areas create refuges for wildlife when the system goes through dry cycles and the majority of the wetland dries out. The variation in water depth and hydroperiod will create a system that contains all the biological components necessary to adapt to changing conditions in the future, with little human maintenance.

hydroperiod

The length of time that a wetland or pond contains water.

FIGURE 18. Cross-section of a wetland storage area. The center of the middle graphic shows the existing canal, with wetland storage on either side. In some places, the canal will actually remain as a central feature, and in other places the channel could be expanded, as shown in the top and bottom graphics. Wetland storage areas should be designed with variations in water depth to allow a wide range of wetland habitats and support diverse plant and animal life.

These variations will create a system that contains all the biological components necessary to adapt to changing conditions in the future, with little human maintenance. Flood protection to the surrounding lands will be maintained or improved by increasing the cross-section width of the discharge area.

Source: Mark T. Brown for PBS&J

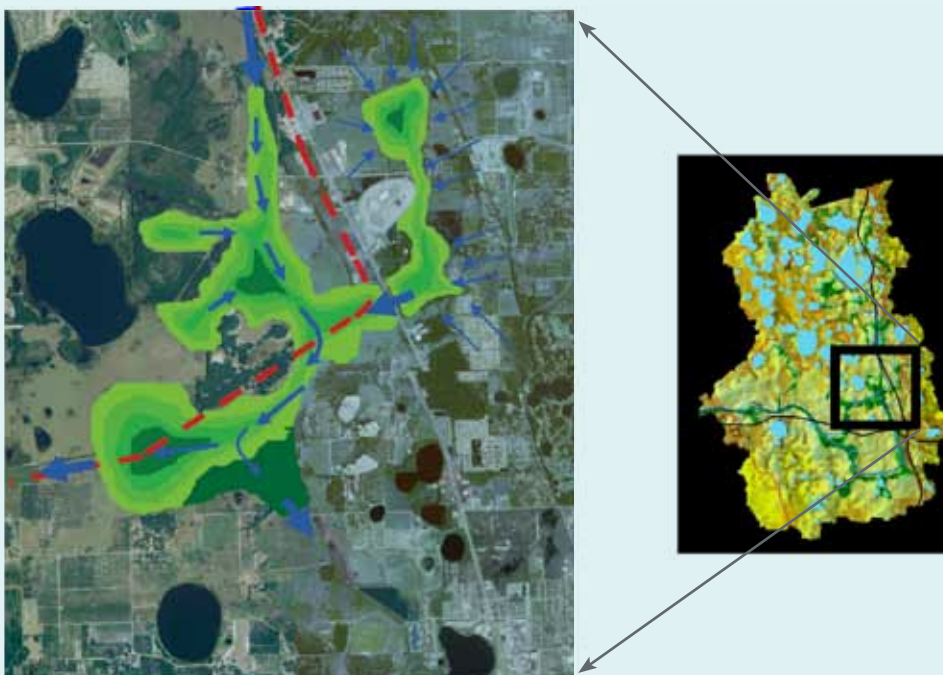
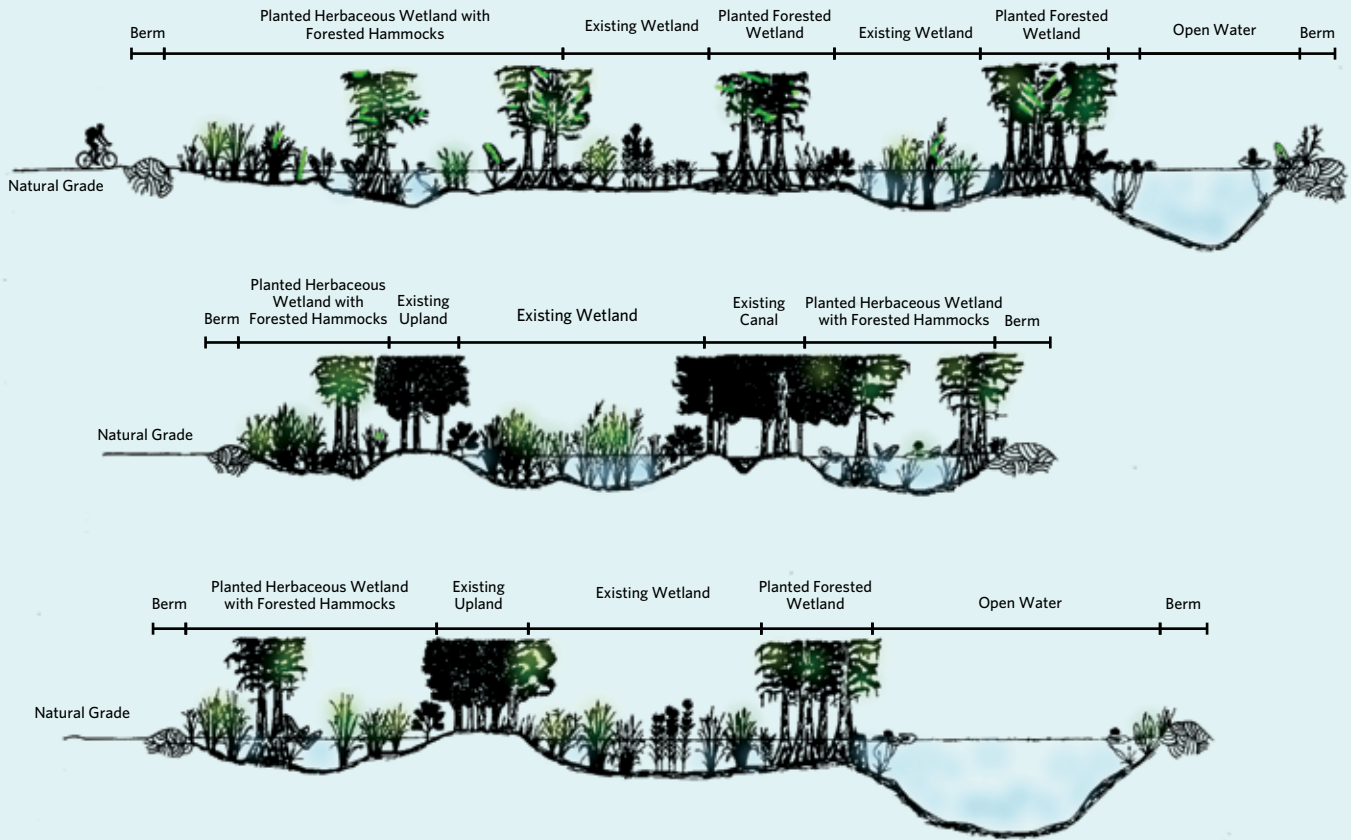


FIGURE 19. Conceptual map of a wetland storage area. The green highlighting shows areas where water could be stored. Darker shades indicate the deepest part of the system. The blue lines represent the new path of water as it flows through the system. The Peace Creek Canal (the dashed red line) would be strategically removed, and water would be allowed to spread out across the landscape. This would slow water movement through the system, provide longer storage, allow surficial aquifer recharge, provide water quality treatment, increase baseflow to Peace Creek and the Peace River during dry periods and reduce peak flows during high rainfall, provide flood protection downstream, and create waterfront amenities for future development and wetland mitigation areas for that development. Source: Mark T. Brown for PBS&J



Increased water storage can be provided by creating wetland storage areas, stormwater treatment areas, and forested wetland sloughs to help buffer the system against droughts, while at the same time providing flood protection.

Stormwater Treatment

Wetland areas in the restored Peace Creek watershed would treat stormwater flowing off developed and agricultural lands. These areas would naturally remove nutrients, sediments, and other pollutants through biological, chemical, and physical processes. The large surface area would provide

high-efficiency treatment for normal amounts of rainfall and significantly increase water quality in the system (*Figures 20 and 21*), helping to prevent waterbodies from becoming impaired and restoring and preserving water quality in urbanizing areas. The treatment areas would provide additional groundwater storage

through slow infiltration. Portions of the wetlands would be designed to provide additional stormwater treatment to address existing or future water quality impacts. These created wetlands could also provide further treatment for reuse water before it is discharged to aquifers, lakes, or wetlands.

FIGURE 20. Cross-section of a typical constructed stormwater treatment area.

Source: Mark T. Brown for PBS&J

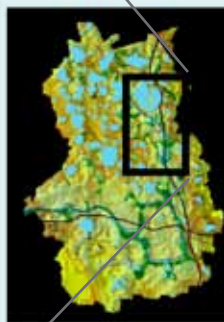
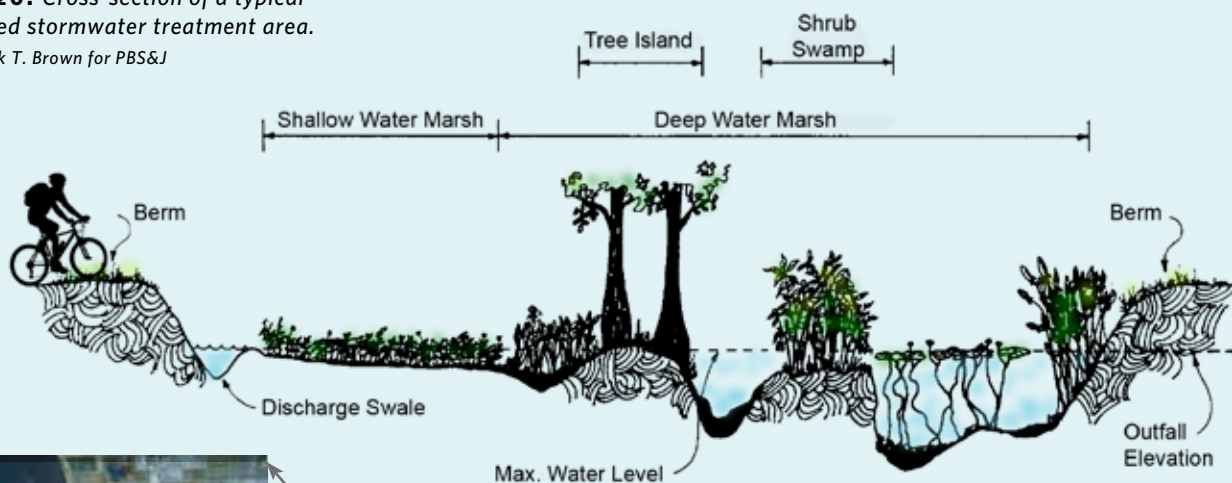


FIGURE 21.

Wetland areas in the restored Peace Creek watershed would treat stormwater flowing off developed and agricultural lands. These areas would improve water quality by removing sediments, nutrients, and other pollutants through natural biological, chemical, and physical processes.

Source: Mark T. Brown for PBS&J

Storage and Conveyance

The wetland storage and storm-water treatment areas, both of which store surface water, should be connected by forested wetland corridors, or sloughs, that can accommodate flows after heavy rains, when large quantities of water need to be moved quickly through the system (**Figure 22**).

During periods of excessive rainfall, water would flow over the barriers and across a broad cross-section of the canal (an area broader than the canal) to maintain flood protection to neighboring properties. At the same time, these corridors should help to minimize the amount of water lost from the watershed during the dry season, when water storage is important.

The numerous small stream channels in a slough create friction,

helping to slow the water. When water levels rise, a much wider corridor allows large amounts of flow. This wider area is kept clear of vegetation and brush by the tree canopy overhead. The wetland trees shade out vegetation below and can tolerate the system's constant variation in water levels.

In contrast, the current conveyance system, which consists of canal channels cut into the ground, is designed to carry surface water and groundwater out of the watershed all the time, even during periods of low rainfall. To ensure high flows during storms, the canals are kept clear of any obstacle to flow. Although this approach works well to move water out of the system, in the dry season water from the surficial aquifer enters the canal and

continues to flow once stormwater has abated, continually seeping from underground supplies.

The conveyance capacity in the restored system is equal to or greater than that of the existing system, including an allowance for friction loss. For example, if the existing channel was 60 feet wide by 10 feet deep (or 600 square feet), the restored system would provide the same conveyance capacity if it was 200 feet wide by 3 feet deep. The revised capacity would be validated through modeling, using the Southwest Florida Water Management District's Peace Creek model. Using this approach, the sloughs will at least maintain, if not enhance, the capacity of the system for flood protection.

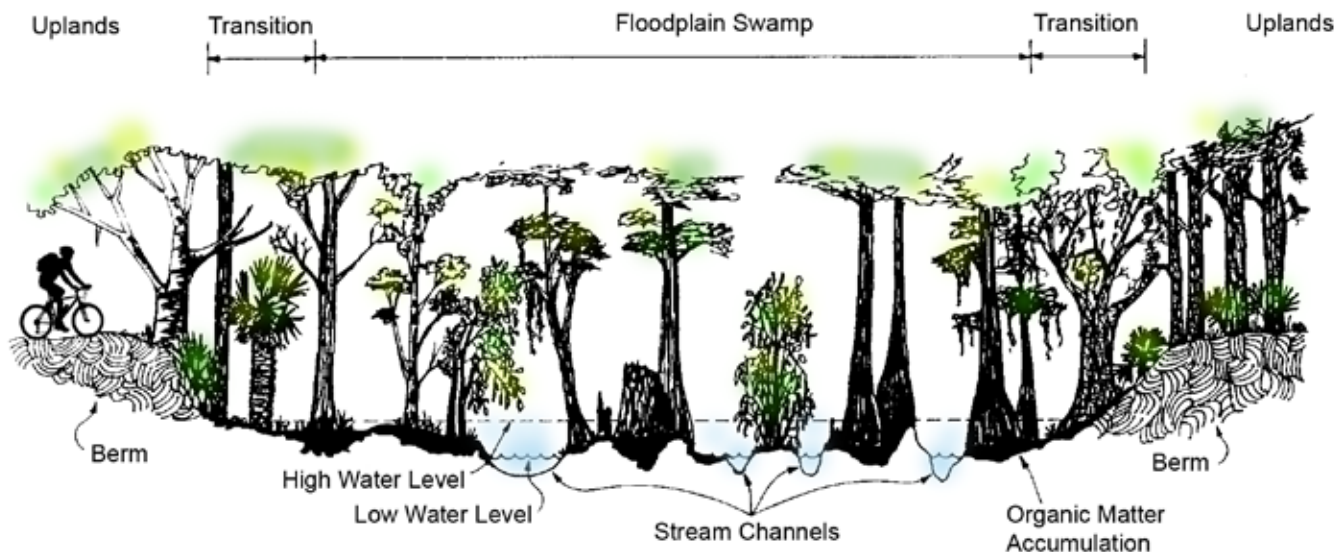


FIGURE 22. Cross-section of a typical forested wetland slough with multiple stream channels that provide paths for water to flow across the landscape slowly, and wide corridors that can move floodwaters through quickly. Flood protection to the surrounding lands would be maintained or improved by increasing the cross-section width of the discharge area. Source: Mark T. Brown for PBS&J

Nature Parks: An Essential Component of Hydrologic Restoration

These hydrologic restoration projects also serve as amenities, including recreation, water frontage, wildlife corridors, and scenic vistas.

Some elements of the *Sustainable Water Resource Management Plan* are already evidenced in the City of Winter Haven's existing and planned nature parks (also called hydric parks). As an essential component of hydrologic restoration, the nature parks conceptualized in the Plan offer many different kinds of opportunities to capture, treat, and store water both in the headwaters/Ridge and the middle and lower reaches/Polk Uplands areas of the watershed. For example, nature parks can be used to enhance and extend the wetland edges of lakes, and to treat stormwater before it enters the lakes. They can be used in residential neighborhoods, at the City's edge, or in a more rural landscape. Depending on the space available, they can be compact or cover large areas.

In addition to their water quality and water storage benefits, the parks will significantly contribute to the area's recreational system and provide beautiful vistas that attract development. They are intended to become recreational and aesthetic amenities that draw people to them, preserve

the beauty of the landscape, create habitat for fish and wildlife, and provide economic and social benefits to the City and to neighboring areas. They generally contain passive recreational features such as hiking trails, boardwalks, fishing/observation decks, benches, picnic tables, and educational displays.

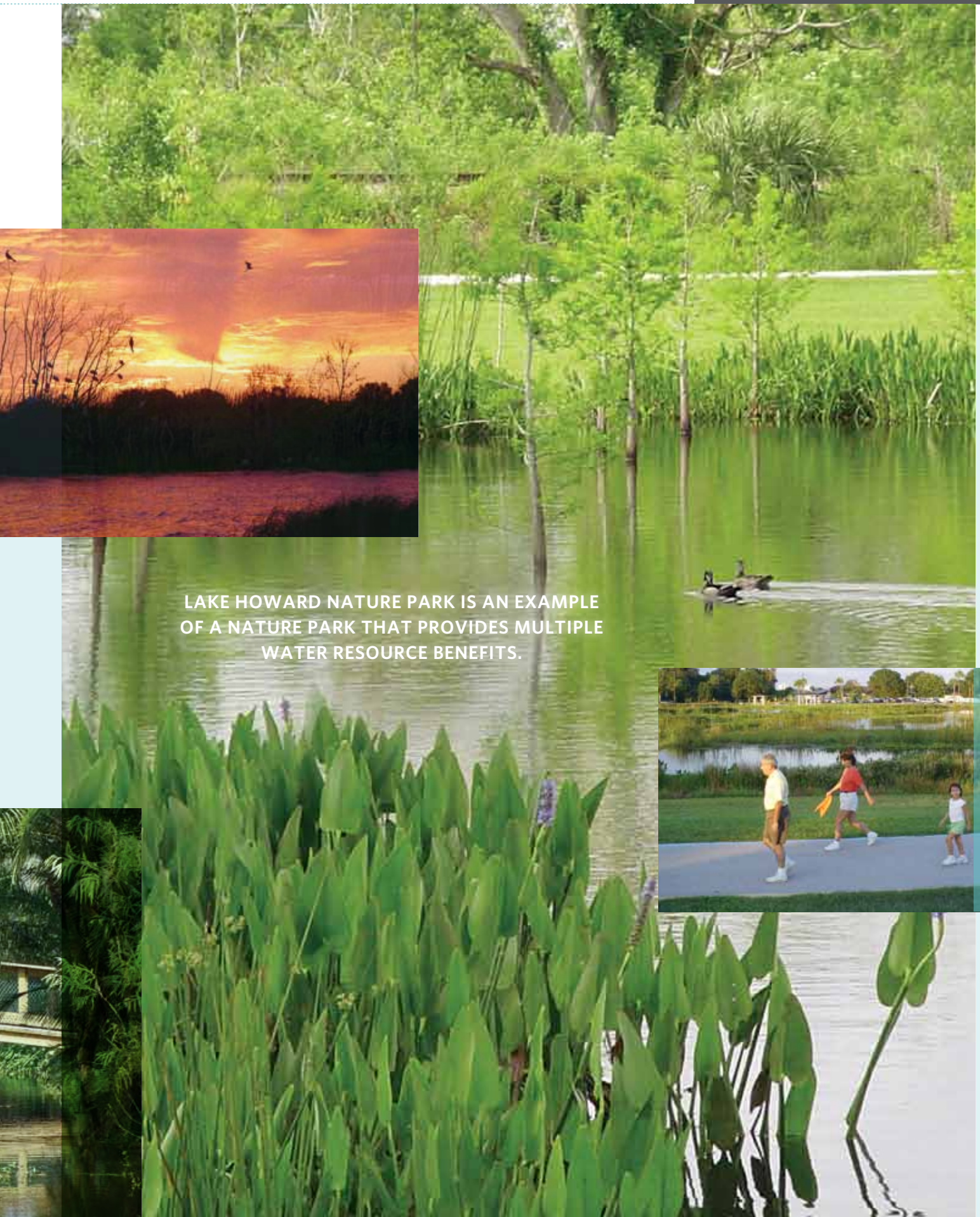
The City has already constructed three nature parks in the urban area to receive stormwater. The first, an 11-acre nature park at Lake Howard, captures and treats stormwater runoff from a 578-acre watershed. The second, a 6-acre nature park at Lake Hartridge, captures and treats runoff from a 105-acre watershed. The third park treats runoff from a 7-acre residential watershed and restores approximately 1,000 feet of lake shore at Lake Maude. A fourth park, still in the planning stages, will cover 34 acres and treat stormwater from a 328-acre watershed at Lake Conine.

Another nature park, the Circle B Reserve, was created by Polk County and the Southwest Florida Water Management District. Located between

Lakeland and Winter Haven, this park, along with a new nature center, is one of the biggest tourist attractions in Polk County because of the large number of birds found there.

The nature parks conceptualized in this Plan will provide new water features in the landscape that will benefit both people and the environment. The City of Winter Haven envisions a series of interconnected nature parks throughout the watershed, linked by the Peace Creek channel, that will attract future development and create economic opportunities for future generations.





LAKE HOWARD NATURE PARK IS AN EXAMPLE
OF A NATURE PARK THAT PROVIDES MULTIPLE
WATER RESOURCE BENEFITS.



The restored natural systems provide many additional benefits, including improved habitat for fish and wildlife; recreational, aesthetic and waterfront amenities; a more livable, enjoyable, and safe community with increased property values; a strengthened community identity; and an improved quality of life.

Meeting Future Water Resource Needs for People and the Environment

The goal of the *Sustainable Water Resource Management Plan* for the Peace Creek watershed is to restore as much as possible the historical movement and storage of water to provide multiple benefits, not just the singular benefits usually targeted by expensive structural solutions. These benefits include supply for people and the environment (water quantity); treatment for aquifers, lakes, and rivers (water quality); flood protection; and the restoration and preservation of natural systems. In contrast, engineered infrastructure is very expensive to build, requires more long-term maintenance, and is much less efficient in storing and delivering water for future use.

Currently, stormwater is directed to the lakes and moved out of the headwaters/Ridge area as quickly as possible. When it reaches the middle and lower reaches/Polk Uplands area, the water is drained rapidly through canals and into the Peace River. In contrast, in the restored network, increased infiltration and treatment of rainwater in the headwaters/Ridge area will help to improve water quality in lakes and aquifers, provide higher water levels throughout the year, and conserve water in the system so it is available during dry seasons. In the middle and lower reaches/

Polk Uplands area, up to 6,300 acres of wetlands will be restored. These areas will provide increased storage and conveyance, buffering the effects of dry seasons and extended droughts, reducing peak flows during major storms, and accommodating floodwaters. They will also help to remove pollutants and support natural ecosystems.

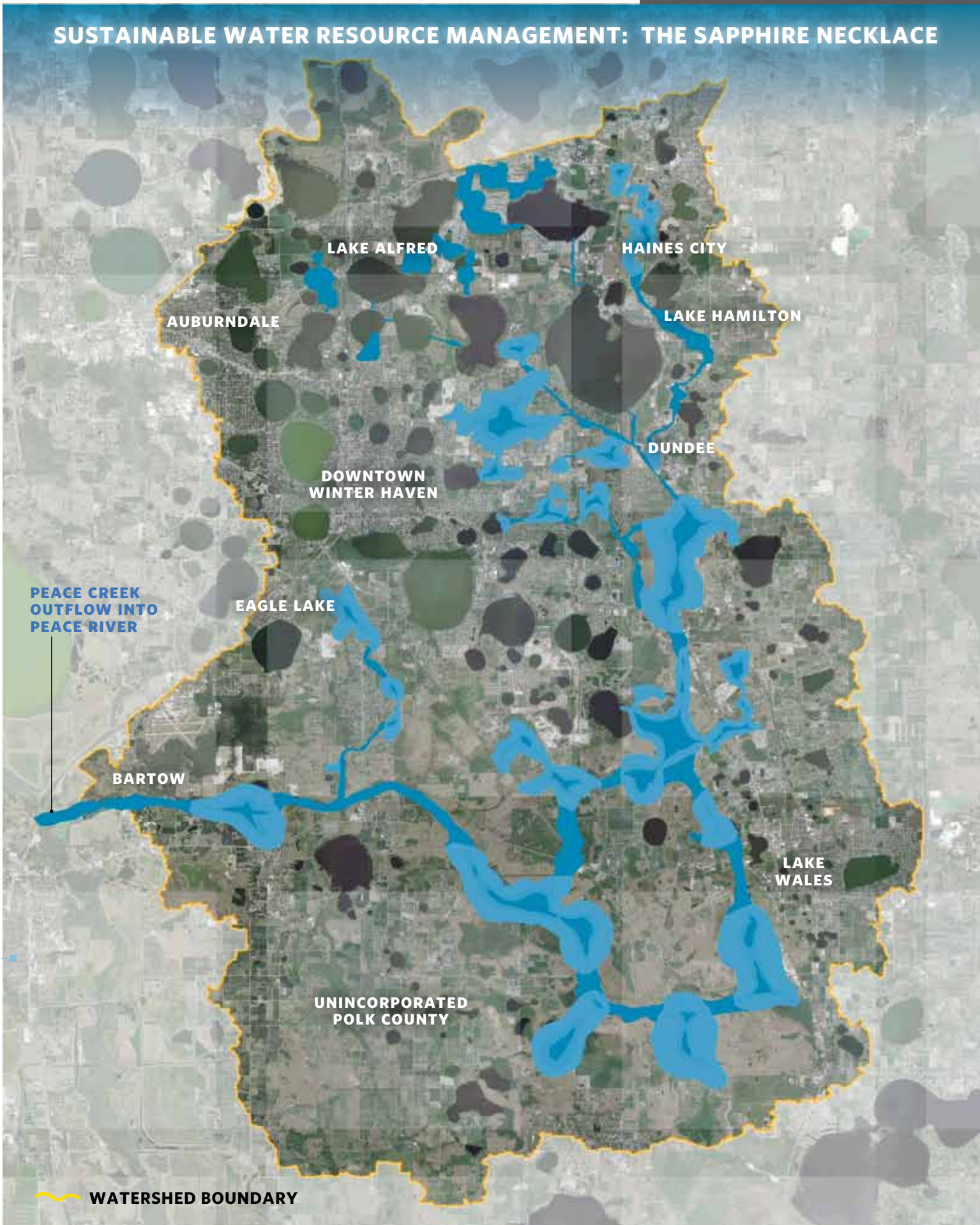
The *Sustainable Water Resource Management Plan* is based on a detailed understanding of how the watershed functioned in the past, the loss of hydrologic function that has occurred because of human alterations, and the opportunities for restoring the movement and storage of water in the Peace Creek watershed. This information provides the foundation for an integrated, comprehensive approach that will enable the communities in the watershed—including Winter Haven, Auburndale, Lake Alfred Haines City, Lake Hamilton, Dundee, Lake Wales, Bartow, and unincorporated Polk County—to meet their current and future water resource needs for both people and the environment. The sustainable management of water resources is essential if these communities are to achieve long-term economic, social, and environmental sustainability.

The Plan links most of the east Polk County communities in the Peace Creek watershed hydrologically, providing a basis for consistent, comprehensive land and water planning on a regional scale, as well as a means to develop common recreational amenities (*Figure 23*). Regional storage and mitigation provide benefits to individual landowners, allowing development to occur, while preserving natural systems and meeting the water resource needs of people and the environment. At the same time, flood protection for adjoining neighbors or the region is also improved. Additional benefits of the Plan include improved habitat for fish and wildlife; recreational, aesthetic, and waterfront amenities; a more livable, enjoyable, and safe community with increased property values; a strengthened community identity; and an improved quality of life.

FIGURE 23. The restored hydrologic network, combined with existing lakes and other waterbodies, resembles a "sapphire necklace" of water. Infiltration and treatment areas in the headwaters/Ridge portion of the watershed carry water into the surficial and Floridan aquifers. From there, it moves into a number of different storage and conveyance areas in the middle and lower reaches/Polk Uplands. These areas, which provide scenic buffers for neighboring communities, are connected by the Peace Creek Canal.

Source: Mark T. Brown for PBS&J

SUSTAINABLE WATER RESOURCE MANAGEMENT: THE SAPPHIRE NECKLACE



Benefits of the Sustainable Water Resource Management Plan

The *Sustainable Water Resource Management Plan* is an investment in the capacity of the natural landscape to provide multiple water resource benefits. In contrast, man-made structural solutions such as channels, ditches, reservoirs, and pipes are generally implemented primarily for singular benefits. In the long term, using the natural landscape to provide these multiple benefits will result in a less costly, more efficient water supply system for people and the environment. The Plan's multiple benefits include the following:

WATER QUALITY BENEFITS—Improves water quality in the Peace Creek watershed's lakes, rivers, and wetlands, and restores water quality in impaired waters as part of the state's Total Maximum Daily Load (TMDL) Program.

ENVIRONMENTAL BENEFITS—Restores wetlands; enhances water levels in the lakes and the wetlands surrounding those lakes; creates and protects quality habitat for fish, wildlife, and plants native to the community; and helps to restore natural rainfall and climate patterns in the area.

ECONOMIC BENEFITS—Restores and protects lakes, which are the reason that many people move to the area; expands the effective amount of waterfront to attract future development; creates economic opportunities for mitigation banking, water storage, and stewardship for landowners; facilitates economic growth by establishing a viable watershed approach to mitigation planning and stormwater permitting for future development; and saves money over the long term by using the natural infrastructure to provide valuable water resource services. Paying for these services now by restoring and preserving the natural infrastructure will provide more benefits and will be less costly than implementing and maintaining structural solutions in the future.

WATER SUPPLY BENEFITS—Recharges aquifers where all public water supply and most other supplies originate; provides more water for natural systems, lakes, and aquifers in the Peace Creek watershed; contributes to the maintenance of Minimum Flows and Levels (MFLs) in the Peace River; and is an important component of the Southwest Florida Water Management District's Recovery Strategy for the larger regional aquifer.

FLOOD PROTECTION BENEFITS—Increases the capacity of the landscape to treat and store the water from small rainfall events that is currently being discharged from the watershed in the name of flood protection and, through increased storage and conveyance, provides much-needed flood protection during large storms.

SOCIAL, CULTURAL, AND RECREATIONAL BENEFITS—Provides an integrated system of parks, trails, and other recreational areas (such as greenways and blueways), improves the area's aesthetic beauty, provides a more enjoyable and safe place to live with increased property values, strengthens the community's identity, creates a collaborative water resource management framework for many of the east Polk County cities and towns, provides the basis for making future land use decisions, and improves quality of life.

IMPLEMENTING THE SUSTAINABLE WATER RESOURCE MANAGEMENT PLAN FOR THE PEACE CREEK WATERSHED

There is no endeavor more noble than the attempt to achieve a collective dream. When a city accepts as a mandate its quality of life; when it respects the people who live in it; when it respects the environment; and when it prepares for future generations, the people share the responsibility for that mandate. This shared cause is the only way to achieve that collective dream.

—Jaime Lerner, *Toward a Rechargeable City*, *Whole Earth Review*, Spring 1995

The previous chapters describe the current state of water resources in the City of Winter Haven and Peace Creek watershed, where changes to the land have affected water resources. The hydrologic alteration of the watershed that began in the early 1900s has reduced wetland areas by over 30%, or nearly 9,900 acres. As a result, at least 27 billion gallons of water are no longer stored in the landscape. This is no small quantity—it is enough to meet all of the public supply needs for the City of Winter Haven for nearly 7 years.

The alterations to the watershed's hydrology have improved flood protection near drainage ditches such as the Wahneta Farms and Peace Creek Canals and made more land available for agriculture, homes, and businesses. However, the economic, environmental, and social costs of these alterations to the Winter Haven community, the Peace Creek watershed, and the larger Peace River Basin are far greater than their benefits. Many of these costs cannot be quantified and will more than likely be paid for with public funds in the future.

The most significant cost to the City of Winter Haven is the loss of its ability to provide adequate water resources in the future for both people and the environment (including lakes, wetlands, and

aquifers). This loss affects the City's long-term economic viability. Major environmental costs include declining lake levels, decreased lake water quality, surficial aquifer drawdowns, navigable waterways that are dry part of the year, and less habitat for fish and wildlife. All of these result in a diminished quality of life and decreased sustainability.

For the larger region, the impacts include the environmental degradation resulting from reduced base-flow to the Peace River alternating with large pulses of nutrient-laden water during heavy storms, as well as regional aquifer declines that reduce the available supply of water for all uses.

In addition, the City (and the entire region) faces challenges such as changing rainfall patterns, prolonged drought, and continued economic and population growth. New development could result in further impacts if current regulations and approaches are followed. In the same way, increased water supply demands outside the watershed could make matters worse by lowering the regional aquifer further.

The current approach to managing water resources is not sustainable. If future residents want the same or a better quality of life, alternatives have to be considered as to

how best manage water and land. The "do nothing" alternative will continue to reduce the quality and sustainability of water resources, and future generations will be burdened with paying for projects to restore water resources that are being impacted today in order to have the same quality of life. Alternatively, the community can choose to begin taking action to improve water resources for the future.

The clear choice is to actively pursue partnerships between governmental agencies, citizens, and land development interests to restore and improve water resources, while moving forward with comprehensively planned and strategically located economic growth. If this choice is not made today, future generations will pay a high economic, social, and environmental price.

Community Vision

For a watershed such as Peace Creek, which receives no surface or groundwater from outside its geographic area, preserving and restoring the watershed's natural hydrologic functions is essential for the long-term sustainability of its water resources. The vision for the Peace Creek watershed consists of an interconnected hydrologic network of lakes, canals,

wetlands, aquifers, open spaces, and parks that will help meet long-term water resource needs, including supply (water quantity), treatment (water quality), flood protection, and the preservation of natural resources. By managing its water resources to meet the current and future needs of both people and the environment, the City is building a solid foundation to improve community quality of life and maintain economic, social, and environmental sustainability.

By proactively identifying the essential hydrologic functions that must be restored and protected, the *Sustainable Water Resource Management Plan* (described in Chapter 3) provides a road map to making this vision a reality. The Plan outlines a framework to restore and preserve as much as possible the historical movement and storage of water throughout the watershed before drainage and other alterations took place, using stormwater runoff, excess floodwaters, and reuse water as resources, while still providing adequate flood protection. It effectively balances the water needs of both people and the environment by using the capacity of the natural landscape as efficiently as possible, including preserving land for water storage.

In other words, the system would be allowed to do naturally what it does best. Ultimately, what is good for the lakes and the environment (storage, treatment, and recharge) is good for the community and economic growth (supply and flood protection).

To provide the volume of storage needed to ensure adequate water supplies and flood storage in the future, about 6,300 acres of wetlands in the lower and middle reaches/Polk Uplands area of the watershed should be restored. As part of the natural landscape, these features provide opportunities for storage with many more benefits than traditional man-made structures and controls. The restoration of these natural features, along with increased treatment and aquifer recharge in the headwaters/Ridge area, will provide additional benefits.

The story of Winter Haven and the Peace Creek watershed not only provides compelling reasons why the protection and restoration of water resources are essential to a community's future, but the City's ongoing efforts also serve as a good example of how other communities can work to understand and manage their water resources.

Most communities evaluate water by looking at existing hydrologic conditions. In contrast, Winter Haven has evaluated the natural Peace Creek watershed before hydrologic alterations and is using that as a model for future land and water resource management.

While the City of Winter Haven can carry out many restoration activities within the Peace Creek watershed, a coordinated effort is needed to solve the larger problems that are outside the City's jurisdiction but affect all communities in the area. Restoring the regional aquifer and addressing other issues such as diminished Peace River flows must be carried out in collaboration with the other communities in the watershed, in concert with the Southwest Florida Water Management District, Florida Department of Environmental Protection, Florida Department of Transportation, Polk County, Lake Region Lakes Management District, and other agencies.

Priorities, Strategies, and Recommendations for Implementing the Plan

The Plan can be used to direct a wide range of activities to restore and protect water resources on a neighborhood, community, and regional scale. Basically, the goal of implementation is to mitigate the impacts of existing development and provide a framework for future development that will help to preserve and restore the watershed's essential hydrologic functions. As described in Chapter 3, the



Sustainable Water Resource Management Plan establishes two major priorities for restoring and preserving the essential hydrologic functions in the Peace Creek watershed:

1. *Increased infiltration and treatment in the headwaters/Ridge area; and*
2. *Increased storage and conveyance in the middle and lower reaches/ Polk Uplands area.*

Although both priorities are important, it is especially crucial to focus on the second priority listed: restoring storage and conveyance. Put simply, there is no point in increasing the amount of water infiltrating into the system only to have it drain quickly out of the watershed; it would be like trying to fill a bathtub with the drain still open.

This chapter lays out recommendations and strategies for implementing these two priorities, based on a collaborative effort with other communities in the region, as well as state and regional agencies. It also discusses specific next steps that the City can take as it begins to implement the Plan. The recommendations and strategies discussed here are, in essence, a set of tools that can be used to fund, direct, and support the implementation of the *Sustainable Water Resource Management Plan*, and to measure the results of implementation. They do not require a choice between people and the environment, but support both.

The tools to be considered—which can be political, regulatory, financial, incentive based, or project related—

can be used simultaneously on both local and regional scales. They include land use planning, mitigation banking (and other funding options), redirecting stormwater and reuse water, and monitoring to measure progress towards specific goals. They build on activities that are already under way in the City of Winter Haven, Polk County, and the larger region, as well as those of regional and state agencies, and provide a long-term approach to implementation. They can be carried out by the City as part of a coordinated, collaborative effort with Polk County and other communities in the region, as well as with state and regional agencies, to minimize costs and avoid duplicated effort. Opportunities for public/private partnerships as well as profit-making private initiatives are also encouraged to further the Plan's implementation.

Many of these tools are subject to additional evaluation to identify their feasibility in the Peace Creek watershed and the City of Winter Haven. Some options may be more feasible than others; some may be more cost-effective; some can be implemented relatively quickly; and others would need to be implemented over a period of years. The tools will also need further fine-tuning in terms of design and implementation. In addition, new tools may become available that are not discussed in this document. Any proposed restoration activities using these tools should also be considered in light of the six guiding principles of sustainable water resource management described in detail at the end of Chapter 2 and summarized at right.

THE SIX GUIDING PRINCIPLES OF SUSTAINABLE WATER RESOURCE MANAGEMENT

- 1 *The total rainfall in the region is that region's water budget—supplies from outside the region are considered to be "borrowed" or "leased" and cannot be counted on during drought or after the watershed is built out.*
- 2 *In the long run, it is far more efficient and effective to use the watershed's natural infrastructure to provide multiple water resource benefits than to restore lost hydrologic function using structural, man-made means.*
- 3 *Any impacts to hydrology in the watershed should be mitigated within the watershed.*
- 4 *The locations of surface water and groundwater storage areas to protect and restore water resources must be integrated into urban and community design.*
- 5 *Stormwater, wastewater, and reuse water should be viewed as a valuable resource, rather than a form of waste to be disposed of, and this resource should be recycled and recharged at a rate commensurate with use.*
- 6 *Each parcel of land in the region should contribute to the water budgets of both the watershed and the region—that is, the postdevelopment hydrologic condition for each parcel should equal the predevelopment hydrologic condition as much as possible.*



Wood storks—an endangered species in Florida—are frequent visitors to the South Lake Howard Nature Park.

Priority 1: Increased Storage and Conveyance in the Middle and Lower Reaches/Polk Uplands Area

This recommendation is the highest priority, since there is no point in increasing the amount of water infiltrating into the system in the headwaters/Ridge area of the watershed, only to have it drain quickly out of the watershed through the canals in the middle and lower reaches/Polk Uplands area. Storing the large quantities of excess floodwaters in the natural landscape, including aquifers, lakes and wetlands, prior to discharging them downstream is essential to achieving long-term water resource sustainability within the watershed.

ACTION: Use Comprehensive Land Use Planning and Land Development Codes To Direct and Guide Development and Restoration Activities

This *Sustainable Water Resource Management Plan* creates a framework by which the City of Winter Haven can make future land use and water resource management decisions. The City's Comprehensive Land Use Plan is the legal instrument that guides future land use decisions. This Plan should be adopted as a part of the Comprehensive Land Use Plan to ensure that future land use and water management decisions are integrated. The recommendations

contained in this Plan should be incorporated as policies in an updated Comprehensive Land Use Plan.

In addition, future plans for managing water resources, including water supply, water quality, and drainage, will need to incorporate the concepts contained in this Plan. The City's development of a Water Quality Management Plan for the Northern and Southern Chains of Lakes should include the hydrologic restoration concepts contained in this Plan as a road map for improving water quality and lake levels. Future plans for water supply should consider concepts for the recharge of stormwater and reuse water.

ACTION: Identify Future Storage and Conveyance Areas

The *Sustainable Water Resource Management Plan* shows the general locations of areas that historically stored significant amounts of water. This information can be used to begin scientifically investigating areas that need further evaluation. Historical wetland, floodplain, and soil maps should be evaluated to identify in more detail the areas that could be used to store water. The hydrologic models currently under construction by the Southwest

Florida Water Management District will provide excellent tools to further evaluate potential storage sites.

ACTION: Develop a Water Resource Overlay District and Ordinance

Once potential storage sites are identified, they can be protected. An overlay district and ordinance is a good example of a form of protection that already exists and is being used in other areas of Florida and around the country. It is a way to proactively protect important features in the landscape as communities grow and develop. Overlay districts and ordinances have been used successfully to preserve historic areas; protect wellheads; establish buffers or setbacks from surface waters such as lakes, rivers, floodplains, and wetlands; restrict development in floodways (which are prone to damage from rapidly moving floodwaters); and protect critical water recharge areas. A notable example is the Innovation Way overlay development ordinance in Orange County, Florida, described on the facing page, that was created to protect and preserve the natural land and water resources of the Econlockhatchee River Basin.

Innovation Way: Protecting the Econlockhatchee River Basin

Innovation Way is a planned development corridor that encompasses approximately 32,000 acres bordering the Econlockhatchee River in east Orange County, Florida. This blackwater river is one of the last unspoiled rivers in central Florida, an Outstanding Florida Water, and the second largest tributary to the St. Johns River. The northern portion of the 17-mile-long development corridor already contains residential, commercial, and institutional development; the southern portion is largely undeveloped. To protect and preserve the natural resources of this ecologically valuable watershed, including the river and its floodplain, Orange County enacted a number of land use policies to promote the environmentally sensitive development of the area. For example, these policies include the following provisions:

- *Development plans must delineate and identify natural corridors that allow wildlife to move through needed upland and wetland habitats, such as wetlands and other environmentally sensitive areas.*
- *Lands acquired for wildlife preservation must be protected by a management plan that promotes the maintenance of native species diversity and offsets unavoidable development impacts elsewhere in the development corridor.*
- *New crossings of identified wetlands or other environmentally sensitive corridors must be evaluated on a case-by-case basis, and the number of new crossings must be minimized. Crossings must be appropriately sized, and fencing must be used to direct species to the crossings.*
- *The county's land development code must consider and implement appropriate mechanisms to preserve environmentally sensitive lands through acquisition and/or conservation easements.*
- *As part of the county's development approval, all new development in the area must maintain and monitor baseline data on species number and species diversity, in order to recognize the cumulative effects of development on species diversity and habitat over time. With sufficient data, the county can determine if additional policies are needed to protect species by protecting habitat types.*
- *Development must minimize damage to the 100-year floodplain, wetlands, and other environmentally sensitive areas by ensuring that public and private roads are sited to avoid crossing the floodplain and wetlands. Crossings must be located at the narrowest point of a floodplain or wetland system to ensure the continuity of a corridor.*
- *The county must consider amending the land development code to require upland buffers for environmentally sensitive areas in the development corridor and determine the appropriate criteria for these buffers.*
- *The interim use of stewardship lands is allowed, provided it does not negatively affect a property's long-term environmental viability.*

The goal of implementation is to mitigate the impacts of existing development and provide a framework for future development that will help to restore the watershed's essential hydrologic functions.

Overlay ordinances apply a common set of standards to a designated area that shares significant traits. These ordinances overlay existing land use codes and, in doing so, apply additional guidelines to achieve a common goal. For example, the federal government is trying to prevent development in floodways. The federal floodways in the Peace Creek watershed are identified in Federal Emergency Management Agency (FEMA) flood maps used for flood insurance rating purposes. A number of areas on either side of the Peace Creek Canal are identified as floodways where no development is allowed, and many of them correspond with elements of the *Sustainable Water Resource Management Plan*.

In the Peace Creek watershed, the overlay concept could be applied to preserve, restore, and protect the various essential elements of the hydrologic network described in the *Sustainable Water Resource Management Plan*, including critical aquifer recharge areas, lakes, floodplains, wetlands, stormwater treatment areas, and floodways. In fact, these areas would make excellent mitigation banking sites (see the discussion of mitigation banking on page 50). An overlay ordinance would allow the City of

Winter Haven to extend protection into hydrologically important areas that are not otherwise protected. Any new requirements would have to be consistent with the policies of regional or state agencies, but additional site-specific criteria could be provided based on local needs.

Today, each individual development can address its own flood protection, stormwater treatment, and wetland mitigation needs onsite. This significantly reduces the amount of development that can occur on that individual parcel. In addition, the capacity of a single piece of land to carry out many different hydrologic functions is easily lost, and there is no provision for moving water during extreme flood events.

In contrast, implementing an overlay ordinance would facilitate development, particularly in the floodprone middle and lower reaches/Polk Uplands area of the watershed. With overlay ordinances, development would be allowed to occur within a larger, regional network of natural stormwater management features that would ensure flood protection. As a result, more of each individual parcel could be developed, while at the same time creating a regional benefit.

Overlay ordinances can be used to designate where water can be stored and treated, and how it will flow during flood events, thus leading to development in the right places in the right way. It allows the City to provide for development, but with foresight about how water moves and is stored in the Peace Creek watershed.

The use of overlay ordinances provides opportunities to carry out restoration work in support of the *Sustainable Water Resource Management Plan* at the same time that development is carried out. This is achieved by working with developers to incorporate elements of the Plan into their development projects. Development incentives, including expedited permitting, guaranteed future water supplies, reduced impact fees, and the creation of mitigation opportunities up front, could be provided to developers who help implement the Plan. A basic premise of this Plan is that the restoration of water resources and development are interdependent.

Nature gives the Florida Peninsula a larger supply of rain and natural recharge than she gives most places elsewhere on Earth. All we need to enjoy these blessings is the intelligent management of water and related land resources. Most of the "messes" we now suffer have developed without an understanding of the requirements of good water-and-land management. We have these understandings now and we need not repeat the errors of the past . . . We can, if we will, live within our individual and regional water crops and still have enough water to meet the needs of all. But our most precious resource, our water supplies, can be needlessly ruined if we continue the careless and wasteful ways of the past. —Garald Parker, *The Hydrogeology and Problems of Peninsular Florida's Water Resources*, 1975

RECOMMENDATIONS FOR DIRECTING AND GUIDING DEVELOPMENT AND RESTORATION ACTIVITIES

- 1 The City of Winter Haven should develop a Water Resource Restoration overlay ordinance and land development codes to direct and guide development in the Peace Creek watershed in a way that will restore, preserve, and protect water resources for people and the environment, including water supply, water quality, natural systems, and flooding. The various components of the overlay ordinance could include the following:
 - a. Proactively identifying those areas important for future water supplies;
 - b. Transferring development out of the floodplain and potential water storage areas;
 - c. Requiring mitigation work to be completed within the Peace Creek watershed;
 - d. Providing connections to wildlife corridors;
 - e. Providing for interconnected pedestrian corridors;
 - f. Using existing tools such as conservation easements, stewardship agreements, land trusts, and established drainage districts to manage newly created watershed projects;
 - g. Establishing incentives for improving water resources, not just limiting impacts; and
 - h. Creating rain gardens and percolation ponds to recharge groundwater in the headwaters/Ridge area of the watershed, as opposed to piping water to a large stormwater pond in the lower-lying middle and lower reaches/Polk Uplands area.
- 2 Once the overlay ordinance is developed, Polk County, as well as the other cities and towns in the watershed, should adopt a similar ordinance to cover the entire watershed. One idea is for Polk County to adopt the ordinance, with the cities having approval authority. The Central Florida Regional Planning Council may be able to provide assistance in this coordination effort.
- 3 The Southwest Florida Water Management District Peace Creek Watershed Management Model and other technical resources should be used to identify the potential storage areas, impacts, water control structures required, and other important details for implementing the Plan.



Background: Mitigation Banking and Mitigation Credits

Mitigation banking is based on the requirement that if the hydrology of a parcel of land is altered through development, that impact must be mitigated, or compensated for. A mitigation bank is an aquatic resource, such as a wetland or stream, that has been restored, established, enhanced, or sometimes preserved to compensate for unavoidable impacts to aquatic resources permitted under a federal (Section 404), state, or local wetland regulation. A government agency, corporation, nonprofit organization, or other entity undertakes these activities through a formal agreement with a regulatory agency. Mitigation banks have four components, as follows:

BANK SITE—The physical acreage restored, established, enhanced, or preserved;

BANK INSTRUMENT—The formal agreement between the bank owners and regulators;

INTERAGENCY REVIEW TEAM (IRT)—The federal interagency team that provides regulatory review, approval, and oversight; and

SERVICE AREA—The geographic area where permitted impacts can be compensated for.

A mitigation bank's value is defined in mitigation credits. A bank instrument establishes liability, performance standards, management and monitoring requirements, and the terms of bank credit approval. It also identifies the number of credits available for sale and requires the use of ecological assessment techniques to certify that those credits provide the required degree of ecological improvement.

The amount of credit is determined using a functional assessment method such as the Uniform Mitigation Assessment Method (UMAM) (Rule 62-345, Florida Administrative Code) to establish the value of the improvement. The credits are then sold to third parties who need to offset their own proposed impacts. This transfer of management responsibilities and liability is very attractive to permit holders, who would otherwise be responsible for the design, construction, monitoring, ecological success, and long-term protection of a site.

—Adapted from the U.S. Environmental Protection Agency's Website at <http://www.epa.gov/owow/wetlands/facts/fact16.html>

ACTION: Use Mitigation Banking To Direct the Location and Funding of Restoration Activities

Since restoration activities are usually far more costly than protecting water resources in the first place, funding restoration is a major consideration. Possibilities include using mitigation banks to direct restoration to the areas identified in the *Sustainable Water Resource Management Plan* and to pay for restoration, as well as using the Southwest Florida Water Management District's Surface Water Improvement and Management (SWIM) restoration funds to mitigate impacts from Florida Department of Transportation activities. Other funding possibilities, discussed later in this chapter, include the City's existing stormwater and water supply utilities.

Agricultural, industrial, commercial, and residential land uses affect the movement, storage, and treatment of water. Federal and state regulations seek to minimize or compensate for the impacts of those land uses through a process called mitigation. Mitigation means that the amount and type of lost hydrologic function must be calculated and then re-created somewhere else. Examples include mitigation

for wetland losses, losses of habitat essential to threatened and endangered species, and impacts to riverine systems, as well as water quality and flood protection. The mitigation process can also be extended to include pollutant and carbon trading.

Historically, mitigation occurred onsite; however, isolated mitigation projects resulted in the fragmentation of hydrologic and wildlife habitat systems. The cumulative impacts of many individual projects reduced the resilience of natural systems to act as a buffer against droughts and other environmental stresses, and often led to flooding. The U.S. Army Corps of Engineers and state and local governments are now encouraging mitigation at a watershed scale, to ensure that water resources are preserved as part of a larger hydrologic system, to retain that system's essential hydrologic function, and to protect wildlife habitat. The *Sustainable Water Resource Management Plan* is consistent with current rules that encourage the use of watershed-scale mitigation instead of onsite mitigation.

Mitigation banking can be a valuable restoration tool. Since development affects water resources, the bank sells mitigation credits to fund activities to restore those resources. As part of the implementation of the *Sustainable Water Resource Management Plan*, a developer would purchase mitigation credits

from a mitigation bank, and those funds would be used to carry out restoration work in the areas identified in the Plan as priorities. In effect, the mitigation efforts of future development would pay for implementing significant portions of the Plan. It is important that mitigation planning also consider the impacts of historical alterations. For the Peace Creek watershed, the goal is not only to mitigate for planned development, but also for many years of hydrologic alterations.

Mitigation banks can be either public or private. Both options work well. If the bank were publicly owned, bank profits could be used to acquire additional lands for restoration and to increase the size of the mitigation bank—both of which are desirable. If the bank were owned by private investors or some other entity, it would be paid to restore lands identified in the *Sustainable Water Resource Management Plan* as restoration priorities. The CSX Integrated Logistics Center facility and/or other anticipated private and public projects in the Peace River Basin could be the mitigation bank's customers.

The Southwest Florida Water Management District has identified the entire Peace River Basin as an area for mitigation banking, meaning that an impact in the Peace Creek watershed can be mitigated anywhere in the Peace River Basin. However,

this does not help the sensitive Peace Creek watershed but only makes matters worse, since mitigation will likely occur downstream of one of the most severely affected areas in the Peace River Basin.

The Peace Creek watershed needs to be identified as the area for mitigation banking because of its unique hydrologic function and the important role it plays in the entire Peace River Basin and the regional aquifer systems. Any improvements in the Peace Creek watershed would also benefit the Peace River's surface water and groundwater system.

In addition, to the greatest extent possible, the mitigation banks should be directed to the areas identified in the *Sustainable Water Resource Management Plan*. For example, the storage areas and floodways described in the Plan would be a good location for one or more mitigation banks.

Ideally, the Southwest Florida Water Management District would designate the Peace Creek watershed as a "nested regional watershed" within the Peace River Basin. This "watershed-within-a-watershed" is created to concentrate mitigation in a smaller area with different specific needs than those of the larger regional watershed. There is no Southwest Florida Water Management District precedent for this designation. However, the

St. Johns River Water Management District, with identical statutory authority and nearly identical regulations, has established five nested regional watersheds in its district. Each of these watersheds contains wetlands and/or associated creeks and riparian areas that the district has deemed to be of such unique value (such as habitat for listed species) that impacts can only be offset close to these unique resources.

Mitigation banking requires authorization from the U.S. Army Corps of Engineers (known as a Mitigation Banking Instrument) and the Southwest Florida Water Management District (through an Environmental Resource Permit). State rules currently allow onsite or nearby mitigation, but practices and policies increasingly favor the use of mitigation banks on a watershed scale, because of the relatively poor success rate of many onsite mitigation projects.

Federal law also allows for water quality and hydrologic mitigation, while state policy is primarily concerned with wetland mitigation. In the Peace Creek watershed, improvements in hydrologic function will ultimately improve the natural system, and these elements should be allowed to compensate for each other as a part of an overall watershed restoration strategy.

RECOMMENDATIONS FOR DIRECTING THE LOCATION OF AND FUNDING FOR RESTORATION ACTIVITIES THROUGH MITIGATION BANKING

- ① *All hydrologic impacts from development in the Peace Creek watershed, including wetlands destruction, water quality degradation, flooding, and decreased aquifer recharge, should be mitigated in the Peace Creek watershed, rather than the larger Peace River Basin.*
- ② *To accomplish this goal, the Southwest Florida Water Management District should identify the Peace Creek watershed as a nested regional watershed within the larger Peace River Basin, and possibly also within the Southern Water Use Caution Area. This would require the district to revise its map of regional watersheds to add the boundaries of the Peace Creek watershed, and to add a footnote in the map denoting the Peace Creek watershed as a nested regional watershed, using language similar to that of the St. Johns River Water Management District in its map of regional watersheds. The rule should state that all hydrologic impacts,*
- including wetlands, water quality, and hydrologic impacts (past and present), should be managed according to the needs of the Peace Creek watershed.*
- ③ *The City of Winter Haven should ask the state to identify the Peace Creek watershed as a receiving area for other impacts throughout the Peace River Basin (and possibly the Southern Water Use Caution Area), as a pilot program for implementing watershed-scale hydrologic restoration. The mitigation of other impacts could be directed to the Peace Creek watershed, as a part of restoring the headwaters of the Peace River Basin.*
- ④ *The City should evaluate opportunities for establishing a mitigation bank and opportunities for mitigation, including identifying the acres of land and the value of the credits available in the Peace Creek watershed. These opportunities could be public, private, or a public/private partnership.*
- ⑤ *The City should evaluate the feasibility of mitigation banking as a mechanism for restoring the areas identified in the Sustainable Water Resource Management Plan (Appendix D provides a detailed description of the evaluation process).*
- ⑥ *Developers who carry out restoration activities according to the Sustainable Water Resource Management Plan should gain multiple permitting benefits. Since a master plan is already prepared for wetland and hydrologic mitigation, permit applications that are consistent with the Plan should be expedited.*





ACTION: Use Surface Water Improvement and Management (SWIM) Restoration Funding To Mitigate Impacts from Florida Department of Transportation Activities

The Florida Department of Transportation's ability to offset the destructive impacts of its road construction activities, such as wetland destruction, is often severely restricted because of existing development and the fact that there may be no mitigation opportunities in a particular right-of-way. Thus, the agency pays a fee to the Southwest Florida Water Management District's SWIM Program in lieu of providing mitigation. This option is also available to other transportation authorities, including toll and expressway authorities.

The district should identify the areas in the *Sustainable Water Resource Management Plan* as being the recipients of these mitigation dollars.

This is an ideal route, because the district could specifically direct those funds towards building elements of the Plan. However, SWIM funds can only be used for elements of the Plan that are publicly owned. A district-sponsored SWIM project in the Peace Creek watershed would be funded through a Florida Department of Transportation escrow fund.

ACTION: Manage the Hydrologic Network Identified in the Sustainable Water Resource Management Plan as a Regional Stormwater Management System

The restoration of areas for water storage and conveyance, as proposed in the *Sustainable Water Resource Management Plan*, will help the City manage its stormwater as a resource to be preserved and protected. Rather than having each individual development address its own stormwater management needs, a larger system of

interconnected water features can be managed more effectively and comprehensively than if it is split into many different pieces. This comprehensive approach meets the requirements of individual developments but also provides water resource benefits to the entire community. In fact, it may allow lands that would not otherwise be developed, because of their potential for flooding, to be developed for intensive land uses that are compatible with environmental protection.

The Southwest Florida Water Management District's hydrologic and hydraulic model can be used to ensure that flood protection is not compromised or reduced, and that the *Sustainable Water Resource Management Plan* provides adequate flood protection that meets the water resource needs of individual developments and the community.

RECOMMENDATIONS FOR MITIGATING IMPACTS FROM FLORIDA DEPARTMENT OF TRANSPORTATION ACTIVITIES

- 1 The Southwest Florida Water Management District should identify the Peace Creek watershed, and specifically the areas identified in the *Sustainable Water Resource Management Plan*, as the receiving areas for mitigating Florida Department of Transportation wetland impacts throughout the district.

RECOMMENDATIONS FOR MANAGING THE HYDROLOGIC NETWORK AS A REGIONAL STORMWATER MANAGEMENT SYSTEM

- 1 The City should use the Southwest Florida Water Management District's hydrologic and hydraulic model to ensure that the implementation of the Sustainable Water Resource Management Plan provides adequate flood protection for current and future development, while at the same time meeting the water resource needs of individual developments and the Winter Haven community.
- 2 The City should investigate the feasibility of using pollutant trading credits to help meet requirements for state and federal water quality standards and stormwater quality treatment within the Peace Creek watershed.
- 3 The City should consider requesting that the Peace Creek watershed be subject to a "special basin rule" of the Southwest Florida Water Management District permitting process to incorporate a regional stormwater approach, while also managing flood storage, wetland restoration, water quality improvements, and aquifer recharge (quality and quantity).

Priority 2: Increased Aquifer Recharge and Water Quality Treatment in the Headwaters/Ridge Area

While the City of Winter Haven and other entities work to increase the amount of water stored in the middle and lower reaches/Polk Uplands area of the watershed using wetland restoration combined with increased conveyance for large storm events, the second major priority is to "prime the pump" in the headwaters/Ridge area. By viewing stormwater and treated wastewater as valuable resources, and increasing recharge and water quality treatment in the headwaters/Ridge area to the greatest extent possible, the water can gradually make its way through the hydrologic system, providing the maximum benefit to aquifers and lakes. Stormwater is water provided by nature at no cost that would have historically infiltrated, and the reuse of treated wastewater can be used to supplement stormwater recharge.

The two principal ways to increase aquifer recharge and water quality treatment are as follows:

1. Redirect stormwater into the ground throughout the headwaters/Ridge area, including downtown Winter Haven, using features such as rain gardens, pocket wetlands, and roadside and parking lot swales; and
2. Use treated reuse water for irrigation, percolation, or aquifer recharge on the land surface as high up as possible in the headwaters/Ridge area. It is also essential to evaluate the effects of these activities on aquifer and lake levels, and on water quality, through a surficial aquifer and lake monitoring program. The City is already proposing to implement such a program.

The costs and issues associated with each of these options vary widely. For increased stormwater infiltration, there is the expense of retrofitting

developed areas with rain gardens and percolation swales, so that rainwater does not run off from impervious surfaces into the lakes but is captured on the land surface so that it can soak into the ground.

For reuse, there are costs associated with treating, piping, and pumping the irrigation water to be applied to the land. With reuse water in particular, nutrients such as nitrogen and phosphorus also can affect the quality of drinking water supplies and accelerate plant and algal growth in surface waters.

For both options, an overlay ordinance could be used to specify where and how retrofits would be constructed, as well as requirements for new development. Other ordinances could be enacted to require individual homes and businesses to connect to the reuse supply for irrigation use.

ACTION: Redirect Stormwater into Rain Gardens and Treatment Areas Throughout the Downtown and Residential Areas To Recharge the Aquifer

The City of Winter Haven, as well as the other communities in the headwaters/Ridge area of the watershed, should recharge the surficial aquifer in this area with the amount of stormwater that would have historically infiltrated locally, and that is currently discharged via pipes to the lakes. As discussed earlier, this amount for the Southern Chain of Lakes (approximately 2 billion gallons per year, or 5.5 million gallons per day) can be recharged by constructing water storage features on about 5% of the total land surface in the City's downtown and residential areas.

Because recharge is so rapid in many parts of the headwaters/Ridge area, there is little or no time for stormwater to receive treatment before it enters the surficial aquifer. As described earlier, once the water enters the surficial aquifer, a large portion of it enters the lakes. Thus, as the City designs and builds features to redirect and absorb stormwater, it will need to consider the source of the water and the amount of treatment needed to improve water quality. For example, water flowing off a roof is relatively clean and requires virtually no treatment, while water coming off a road picks up contaminants and requires additional treatment to remove oil, grease, sediments, nutrients, and other substances.

To increase the amount of local stormwater infiltration and treatment, the City should implement as many small projects as possible in its downtown commercial and residential areas, which are underlain by sandy Ridge soils. Features such as rain gardens, swales, and pocket wetlands can be used to incorporate these projects as landscape amenities. A number of projects, including the following, are currently under way or planned:

- *The first project, just completed, is just across the street from City Hall to the east: a shallow (9-inch-deep), broad rain garden will receive drainage from about 65% of the roof area of the City's Technical Services/ Building Department building.*
- *On 4th Street Northwest, across from the Library, there has been a persistent problem with standing water. A French drain percolation system is currently under construction that will allow water to seep into the ground.*
- *On Avenue C Northwest—an area with persistent drainage problems—a right-of-way will be used for a French drain percolation system to solve drainage problems, as opposed to creating a new inlet to allow the water to directly discharge to the lakes.*
- *The City recently retrofitted a significant portion of the 6th Street Southeast corridor with rain gardens during the reconstruction of this area.*

To provide additional treatment in areas receiving more pollutants, wetlands, swales, and rain gardens should be designed as bioretention areas. These features would include grasses and other native plants to capture sediments and take up nutrients. Oil and grease would settle in the grass and eventually break down in sunlight and through natural processes.

The Southwest Florida Water Management District is providing grant funding to the City to develop more water quality treatment and infiltration projects in the downtown and residential areas. It is anticipated that this cooperative effort will provide a significant start to a long-term effort to ensure that stormwater is used as a beneficial resource.

The City should identify opportunities for increased stormwater recharge and treatment in areas yet to be developed. It is essential to preserve and protect important hydrologic features before any development occurs because of the important functions they carry out. These functions, such as protecting water quality in lakes and helping to maintain lake water levels, are provided at no cost to the public. The City could protect many of these hydrologic features using public utility dollars, possibly including funds from its stormwater utility. As new development and redevelopment occur, the overlay ordinance could require these features to be preserved and protected.

RECOMMENDATIONS FOR REDIRECTING STORMWATER TO RECHARGE THE AQUIFER

Downtown and Residential Areas (areas with high recharge/infiltration rates)

- ① In addition to the sites that staff have already identified, the City should carry out a comprehensive survey of its downtown and residential areas to locate publicly owned sites (such as parking lots, roads, and large rooftops) that can be used to infiltrate stormwater runoff. The goal is to identify 5% of the total downtown and residential area that can ultimately be set aside for this use.
- ② Once these areas are identified, the City should determine which type of feature is appropriate for each individual site and establish priorities based on cost, ease of installation, amount of infiltration, and amount of treatment needed, with the goal of increasing infiltration as much as possible at the lowest cost.
- ③ The City should adopt land development codes to ensure that stormwater is percolated into the ground in the headwaters/Ridge area using low-impact development concepts, as opposed to allowing new development to direct stormwater downhill into large stormwater treatment ponds. This will allow infiltration into the sandy headwaters/Ridge area for storage, as opposed to simply providing stormwater treatment and discharge. Existing codes should be reviewed to encourage landscaping and parking that allow historical percolation.
- ④ The City should reduce the use of pesticides and fertilizers in publicly owned areas by implementing environmentally sensitive approaches such as Florida-friendly landscaping, which

provides a framework for activities such as integrated pest management (IPM) and reduced fertilizer use., This will help to reduce the amount of contamination entering groundwater and surface water.

- ⑤ The City should provide education and incentives that encourage homeowners to reduce stormwater runoff and increase infiltration in residential areas by using swales, downspout rain gardens, and features such as natural depressions. Other residential options include encouraging the use of rain barrels and pervious driveways. Incentives could include mini-grants for homeowners to construct rain gardens, or credits for their stormwater utility fees, or reductions in their stormwater utility fees.
- ⑥ The City should provide education and incentives that encourage homeowners to use approaches such as IPM and Florida-friendly landscaping to reduce the use of fertilizers and pesticides in residential areas. This will help to reduce the contaminants entering groundwater and surface water. Incentives could include mini-grants, or reductions in homeowners' water and stormwater bills.

Developing Areas at the City's Edge (areas with low recharge/infiltration rates)

- ① The City should identify the most essential portions of the hydrologic network and the valuable natural functions these areas perform, so that they can be preserved. Geographic information system (GIS) databases for wetlands and floodplains can be used to identify these areas initially.

- ② As in the downtown and residential areas, the City should identify opportunities for increased stormwater recharge and treatment in areas still to be developed. An overlay ordinance can be created to direct efforts in those areas where they will benefit overall water resources.
- ③ The City should also implement an overlay ordinance immediately to protect essential portions of the hydrologic network at the City's edges from development, and address how development would be allowed to occur in other areas. The ordinance could include no-development zones in the most critical areas, and limited-development zones or buffers to guide the development process in less critical areas.
- ④ The City should increase the number of nature parks at its edge, with decisions about the type of park (wet vs. dry) based on the amount of treatment needed to improve water quality before infiltration occurs.
- ⑤ Concepts such as rain gardens, percolation areas, the transfer of development rights, and the encouragement of "conservation subdivisions" should also be included on a case-by-case basis, depending on the unique hydrologic conditions of an area.
- ⑥ As a general recommendation, the City should take an active role in helping other communities in the Peace Creek watershed implement similar restoration strategies and efforts. This will also ensure the viability of their future water supply, water quality, and quality of life, and address flooding issues.

RECOMMENDATIONS FOR ADOPTING AN OVERLAY ORDINANCE TO PROTECT ESSENTIAL HYDROLOGIC FEATURES

- 1 For both increased stormwater infiltration and reuse, an overlay ordinance should immediately be developed and adopted to protect essential portions of the Peace Creek watershed's hydrologic network and address how development is allowed to occur—including where and how retrofits will be constructed and requirements for new development.
- 2 The City should provide this protection before the watershed is built out, not after.
- 3 The overlay ordinance should be used to create restoration zones in the most critical areas, and limited-development zones or buffers to guide the development process in less critical areas. Concepts such as transfer of development rights, designations for conservation subdivisions, and other incentives should be explored to ensure the long-term protection of these areas.
- 4 The City should build additional nature parks, and should do so based on the conditions and treatment requirements in specific places. Parks with wet ponds that contain water all the time should be used to treat stormwater runoff from contaminated areas such as roads and parking lots, while parks with dry ponds should be used to rapidly infiltrate stormwater runoff that requires little or no treatment.

ACTION: Adopt an Overlay Ordinance for the Ridge/Headwaters Area and City's Edge

In areas containing significant wetlands, lakes, and other important hydrologic features—such as the Ridge/headwaters area and the City's edge—the City should establish and adopt overlay zones immediately to provide special protection for essential portions of the Peace Creek watershed's hydrologic network and to address how development is allowed to occur. The City should do this before the watershed is built

out, not after. To protect important features needed for storage and increased recharge to the lakes, overlay ordinances could be used to create restoration zones in the most critical areas, and limited-development zones or buffers could be used to guide the development process in less critical areas. Concepts such as transfer of development rights, designations for "conservation subdivisions," and other incentives need to be explored to ensure the protection of these areas.

Nature parks, or hydric parks, discussed on page 38, will be a crucial component of the City's strategy to increase storage and treatment in a

way that integrates these functions into community life and at the same time supports the local economy. The City has already constructed three such nature parks in the urban area, with a fourth in the design and permitting stages:

- An 11-acre nature park at Lake Howard captures and treats stormwater runoff from a 578-acre watershed;
- An 8-acre nature park at Lake Hartridge captures and treats runoff from a 105-acre watershed;
- An 11-acre nature park at Lake Maude treats runoff from a 5-acre residential watershed and restores approximately 1,000 feet of lake shoreline; and
- A planned nature park at Lake Conine will cover 34 acres and treat stormwater from a 328-acre watershed.



It will be important for the City to supplement aquifer recharge from stormwater by also applying reuse water to the land at strategic locations.

Located in populated areas of the watershed, the nature parks are perhaps the most visible part of the City's approach to increasing the storage and treatment of stormwater, because they are seen and used by residents and visitors. Not only do they provide both water quality and water storage benefits, they become recreational and aesthetic amenities that attract people, preserve the beauty of the landscape, create habitat for fish and wildlife, and provide economic and social benefits to neighboring areas. The parks can be small or large, to accommodate different circumstances. They can be used in residential neighborhoods, in areas of new growth, or in more rural areas (such as the Circle B Reserve, located between Lakeland and Winter Haven) to enhance and extend the wetland edges of lakes, and to treat stormwater before it enters the lakes.

Not only should the City build additional nature parks, it should do so based on the conditions at a specific place. For example, nature parks with wet ponds that contain

water all the time should be used to treat stormwater runoff from roads, parking lots, and other areas with significant amounts of contamination. In contrast, parks with dry ponds should be used to rapidly infiltrate stormwater runoff that requires little or no treatment.

ACTION: Redirect Reuse Water To Augment Aquifer and Surface Water Recharge

Because communities are looking for ways to offset surface water and groundwater withdrawals for water supply, the bulk of the water supply projects in the state over the last decade have been reuse projects. Reuse water consists of treated, or reclaimed, water from a wastewater treatment plant that is recycled and used for other applications, such as golf course and residential irrigation. Although the water is highly treated and safe, under current state regulations it cannot be used for drinking water or for other uses involving human consumption.

While many wastewater facilities still discharge treated wastewater to surface waters, eventually all these facilities may be required to reuse all or most of their effluent. The state now requires coastal areas with ocean outfalls of wastewater to reuse this resource beneficially. The conversion to reuse is currently under way in many coastal areas and in other parts of the state where new supplies of potable drinking water are becoming harder to find.

However, the challenge facing many communities statewide is that there are not enough strategically located places to apply all the reuse water, or the treated reuse water is not in a location where it can do the most good. The City of Winter Haven provides a good example of this scenario. Water is pumped from the area east and southeast of the downtown area, but it is treated and discharged in the lower reaches/Polk Uplands area of the watershed, where it discharges to Peace Creek. To be used most effectively, the water needs to be brought back to the headwaters/Ridge area, to recharge the aquifer from which it came.

In addition, treated reuse water is high in nutrients—particularly nitrogen and phosphorus—compared with the levels in drinking water and natural systems. When the reuse water is applied as irrigation on the land surface, the nutrients benefit plant growth. However, those same



Example of a rapid infiltration basin (RIB) in Orlando, Florida.

RECOMMENDATIONS FOR REDIRECTING REUSE WATER TO RECHARGE THE SURFICIAL AQUIFER AND SURFACE WATERS

- 1 The City of Winter Haven should recycle and reuse all wastewater and reuse water that comes from the Peace Creek watershed within the watershed, as opposed to discharging the water from the watershed.
- 2 The City should examine the possibility of using reuse for augmenting aquifer recharge or surface water supplies in the Peace Creek watershed on a facility-by-facility basis.
- 3 The City should carefully examine the specific areas where the reuse water would be applied. The most viable options for applying reuse water are probably indirect aquifer recharge using rapid infiltration basins (RIBs), as well as discharge to natural and man-made wetlands and potential discharge to surface waters such as lakes, streams and rivers. The quality of water recharged using RIBs is a major consideration.
- 4 The City should explore the application of reuse water to surface waters or indirect aquifer recharge in the headwaters/Ridge area, to maximize the benefits to the watershed and increase the amount of water storage and the length of time the water is stored.
- 5 The City should consider the acquisition of a wetland storage site in the recharge zones of the most significant wellfields that could also be used to store floodwaters during high flows.
- 6 The City should consider using the large, interconnected system of wetlands proposed in the Sustainable Water Resource Management Plan to supplement the treatment of reuse water and floodwater before they enter the surficial aquifer and adjacent surface waters. An important factor to be considered is sizing the wetlands to store enough water for a long enough period to provide the necessary treatment, before the water is discharged. Such a system could provide multiple benefits, including water storage, treatment, locations for infiltration basins for aquifer recharge, wetland habitat, and public recreation.
- 7 The City should ask the Southwest Florida Water Management District to provide a "water reservation" as aquifer levels recover in the Peace Creek watershed, to ensure that hydrologic improvements continue and that the district does not issue permits for future consumptive uses until full restoration occurs.

nutrients, if they enter surface water as runoff, can disrupt a waterbody's health by accelerating the growth of algae. If excessive amounts of reuse water percolate underground, the nitrogen can be carried into surface waters via groundwater.

The drawdown of the regional aquifer and the recent prolonged drought have significantly affected the City of Winter Haven's ability to restore local aquifer levels. It will be important for the City to supplement aquifer recharge from stormwater by applying reuse water to the land at strategic locations. Also, other

communities need to be included as partners in creating an integrated approach for reuse water to help restore the watershed.

In addition, as the City seeks to augment aquifer recharge, it will need to ensure that nutrients are at low enough levels and the reuse water is applied at a rate that does not exceed the capacity of soil and plants to take up the nutrients. This could mean implementing additional water quality treatment at wastewater facilities to lower nutrient levels even further if necessary, or using man-made wetlands to provide adequate treatment and

storage to protect water that goes to the surficial aquifer and lakes.

The application of reuse water to augment aquifer recharge or surface water in the Peace Creek watershed will need to be examined on a facility-by-facility basis, as will the specific areas or waterbodies where the reuse water will be applied. The most viable options for applying reuse are constructing RIBs for aquifer recharge, using reuse water for irrigation in specific areas where recharge is needed, using existing dry retention ponds for percolating water in the dry season, discharging treated reuse water

to natural or created (man-made) wetlands for treatment, and potentially discharging to surface waters such as lakes, streams, and rivers.

The large, interconnected system of wetlands proposed in the *Sustainable Water Resource Management Plan* could be used to supplement the treatment of reuse water before it goes into the aquifer and adjacent surface waters. One important factor to be considered is sizing the wetlands to store enough water for a long enough period to provide the required treatment, before the water is discharged indirectly to the aquifer or directly to surface waters. This approach may prove more efficient than providing additional wastewater treatment to reduce nutrients.

Of the City's current wastewater facilities, Plants #2 and #3 provide additional treatment suitable for the reuse of wastewater. Reuse water from Plant #2 primarily goes to land application (a golf course and cemetery) in the northern part of the watershed, and the water from Plant #3 goes to the Peace Creek Canal, where it quickly leaves the watershed.

Ideally, the application of reuse water to surface waters or indirect aquifer recharge should be carried out as high as possible in the headwaters area (but within the same groundwater basin), to maximize the benefits

to the watershed by increasing the amount of water stored for longer periods. One of the existing reuse lines runs through downtown Winter Haven and thus is ideal for recharging the headwaters/Ridge area. As discussed earlier, the challenge is how to apply the reuse water for indirect aquifer recharge, or to surface water, including man-made wetlands, without water quality degradation. Given the geology of the region and the close connection between groundwater and the lakes, the City will need to make an effort to protect water quality so that the lakes and surficial aquifer are not degraded. The increased wetland areas proposed for the watershed could be used to provide these water quality improvement services.

Unfortunately, it is difficult to direct reuse water to lawns, golf courses, parks, and agricultural fields in the most strategic locations. The storage of reuse water during the wet season is also a consideration. In addition, since not all the nutrients are removed from treated wastewater, achieving 100% reuse without creating additional water quality problems presents another difficulty. Even if nutrient concentrations in wastewater are further reduced, if application rates are increased, then the amount of nutrients being applied also increases.

Thus, the challenge is finding a way to return large quantities of treated wastewater to surface water and groundwater supplies without causing water quality degradation. The regulations covering reuse water continue to evolve, and the state is currently investigating these issues in the Wekiva River watershed near Orlando—where increased algal growth and other problems have resulted from higher levels of nitrates in the watershed—and developing new regulatory approaches. Clearly, similar investigations should be conducted in the Peace Creek watershed. A cooperative funding request approved by the Southwest Florida Water Management District to investigate the feasibility of redirecting reuse water for more beneficial uses will provide additional information to meet this challenge.

The regulation of wastewater treatment plants and the application of reuse water are very complex and address issues of direct and indirect aquifer recharge and the discharge of wastewater to natural waterbodies such as rivers and natural and man-made wetlands. *Appendix E* summarizes some of the most relevant reuse regulations.

RECOMMENDATIONS FOR INCREASING AND MAINTAINING LAKE STORAGE, WHILE ALSO MAINTAINING FLOOD PROTECTION

- 1 The City of Winter Haven should evaluate specific ways to provide valuable water storage in the lakes, and at the same time meet flood protection needs.

ACTION: Develop Strategies for Increasing and Maintaining Lake Storage, While Also Maintaining Flood Protection

As lake and surficial aquifer levels increase and are sustained at higher levels for longer periods, and as water storage and conveyance are increased in the middle and lower reaches/Polk Uplands area of the watershed, it will be important to increase the conveyance and discharge of water from the lakes during periods of excessive rainfall to prevent flooding. To accomplish this, new outfall structures may

need to be built and new management schedules may need to be implemented that allow the rerouting of water from the lakes. For example, redirecting water from the Southern Chain of Lakes to the Northern Chain and the Peace Creek storage and conveyance system would significantly increase the amount of water stored prior to its discharge from the watershed. This would also increase the amount of recharge and water quality treatment, since the water would travel more than 3 times the distance than it would if it were conveyed through the Southern Chain

(i.e., the water would travel 34 miles through the Peace Creek system, compared with 10 miles through the Southern Chain of Lakes). The red arrows in **Figure 24** show opportunities to connect the Southern Chain to the Northern Chain. In evaluating these opportunities, it will also be important to consider the varying water quality in each of the lakes, the presence of invasive exotic plants and animals that could be introduced to other lakes, and the outflow capacity of each lake.



FIGURE 24. Opportunities for connecting the Southern Chain to the Northern Chain (shown by red arrows) include the following:

- Lake Roy to Lake Otis;
- Lake Howard to Lake Silver;
- Lake Hartridge to Lake Conine;
- Lake Winterset to Lake Dexter; and
- Lake Summit to Lake Florence.

ACTION: Continue To Use the City's Existing Stormwater and Public Supply Utilities for Increasing and Restoring Water Storage

In 2004, the City of Winter Haven implemented a stormwater utility to fund projects to protect and maintain lake water quality. It is the only stormwater utility in the country with dedicated funding to restore water quality. In addition to providing ongoing maintenance of the stormwater system, the City has funded five major water quality restoration projects in Lakes Howard (two projects), May, Lulu, and Hartridge. It has also funded a water quality study to evaluate the removal of sediments and other treatment options in Lakes May, Shipp, and Lulu, and is developing a water quality management plan to guide lake restoration in the City. These efforts have established the City as a leader in lake restoration, both statewide and nationally.

The City's water supply utility helped fund the development of the *Sustainable Water Resource Management Plan* and provided funds to match the Southwest Florida Water Management District grant to develop rain gardens and other infiltration projects in the headwaters/Ridge area. Because of the need to increase aquifer storage and ensure future water supplies for public use, the utility should continue to be a partner in funding capital improvement projects that help recharge the aquifer and protect future supplies. In the past, utility rates only covered the transmission of the water, not the cost of the water itself. Using the water supply utility for funding allows the users of the water to fund restoration projects that help keep the system sustainable.

The water and stormwater utility rates could be modified to encourage the implementation of the Plan. For example, rate reductions could be offered as an incentive to conserve irrigation water, build and maintain rain gardens, or implement Florida-friendly landscaping principles.

ACTION: Monitor Lake and Aquifer Levels To Guide Restoration and Measure Results

As the *Sustainable Water Resource Management Plan* is implemented, there will be a need for detailed and reliable information on lake and aquifer levels that can be used to direct and monitor restoration activities and measure their results.

Agencies are currently measuring lake levels in many of the lakes monthly; however, depending on the time of month and the frequency of rainfall events, monthly readings can miss significant hydrologic events. To collect information more often, the City is investigating the feasibility of using automated data collection systems to continuously report lake levels. Lake level monitoring equipment could relay information to a central data management system.

RECOMMENDATIONS FOR FUNDING INCREASED WATER STORAGE AND RECHARGE

- 1 The City should continue to fund water storage and aquifer recharge projects consistent with the goals of the Sustainable Water Resource Management Plan.
- 2 The City's stormwater and water utilities should both be considered for funding storage and recharge projects.
- 3 The City should consider offering water and stormwater utility rate reductions as an incentive to conserve water and implement projects to increase aquifer recharge.

RECOMMENDATIONS FOR MONITORING AND EVALUATING THE RESULTS OF RESTORATION ACTIVITIES

- ① *The City should continuously monitor lake, aquifer levels, water movement, and rainfall to provide more detailed and reliable information that can be used to guide and monitor the success of management actions to restore lake water levels.*
- ② *The City should create and maintain a fully integrated GIS-based system for comprehensively managing land and water resources and to guide and monitor the implementation of the Sustainable Water Resource Management Plan.*
- ③ *The City should work with agencies such as the Southwest Florida Water Management District and U.S. Geological Survey to develop a better understanding of the inter-relationships between the watershed's lakes, wetlands, seepage rates, recharge rates, and the surficial and Floridan aquifer systems.*

In the past, utility rates only covered the transmission of the water, not the cost of the water itself. Using the water supply utility for funding allows the users of the water to fund restoration projects that help keep the system sustainable.



Coordination with Other Plans and Programs To Support the Implementation of the *Sustainable Water Resource Management Plan*

The Peace Creek watershed and the larger Peace River Basin are currently the focus of a number of major ongoing initiatives and plans to (1) enhance regional water supplies; (2) restore water quality in lakes, rivers, and streams, including lakes in the Winter Haven Chain; (3) ensure flood protection in the area of the Peace Creek Canal; and (4) restore local and regional natural systems. It is crucial for the City to coordinate the efforts described in the *Sustainable Water Resource Management Plan* with these ongoing initiatives, in order to accelerate the implementation of the Plan and to leverage its limited resources by working with other agencies, organizations, programs, and plans. The table on the following pages describes some of the major initiatives under way by the Southwest Florida Water Management District, Florida Department of Environmental Protection, Florida Department of Transportation, Polk County, City of Winter Haven, and others.

The *Sustainable Water Resource Management Plan* provides the opportunity for all the entities listed in the table to coordinate efforts and cooperate with each other in carrying out ongoing and planned projects. This integrated approach will maximize local and regional benefits, avoid unintended consequences, and create accountability for water management decisions. In the long run, the Plan's success will depend on how effectively

projects are integrated and carried out at the local scale. Local projects and activities—when implemented throughout the Peace Creek watershed—will also provide regional benefits in the future.

Southwest Florida Water Management District: Activities and Initiatives

The Southwest Florida Water Management District has a number of plans, projects, and studies under way that provide a basic understanding of the water resource limitations in the Peace Creek watershed and information on managing the area's water resources for all uses. The *Sustainable Water Resource Management Plan*—with its focus on restoring the landscape and storing more water locally in lakes and aquifers—supports the district's initiatives in the region, such as aquifer recovery, watershed planning, permitting processes, and flood protection. Linking the goals and activities of the water management district and those of the City of Winter Haven is essential to the Plan's success, and this approach can be used as a model for many of the communities in the Southern Water Use Caution Area (SWUCA).

The Southwest Florida Water Management District's ongoing initiatives that affect the Peace Creek watershed include the following:

- *The Southern Water Use Caution Area (SWUCA) Recovery Strategy for this area focuses on restoring*

flows in the upper Peace River, restoring lake levels, and ensuring sufficient water supplies to support current uses. The West-Central Florida Water Restoration Action Plan (WRAP) is an implementation plan for components of the Recovery Strategy. The plan describes the district's strategy for ensuring that adequate water supplies are available to meet growing demands, while at the same time protecting and restoring the area's water resources and related natural resources. The goals of both the Recovery Strategy and the WRAP are consistent with the City's Sustainable Water Resource Management Plan.

- *In accordance with the SWUCA Recovery Strategy goals, the Peace Creek Watershed Management Plan has identified potential water storage areas to prevent flooding, protect water supplies and natural resources, provide water for aquifer recharge, and contribute to the restoration of Minimum Flows and Levels (MFLs) for the upper Peace River. The hydrologic model developed for this plan will be a significant tool in designating storage areas and designing structures that can help store water in historical wetlands. These goals and activities are consistent with the City's Sustainable Water Resource Management Plan.*

- *The Peace River Integrated Surface/Ground Water Model is scheduled for completion in fall 2010. This model will provide the most comprehensive analysis to date of the interaction between surface water and groundwater in the basin, and should be used to help determine priority actions for storing water, increasing lake levels, and recharging aquifers.*
- *The Management and Storage of Surface Water (MSSW) and Environmental Resource Permit (ERP) processes are used to govern the location of water storage structures, stormwater treatment, and wetland permitting. The water management district's regulatory programs could significantly influence the implementation of the Sustainable Water Resource Management Plan. Because of the unique circumstances in the Peace Creek watershed, one consideration is for the district, Florida Department of Environmental Protection, or Florida Legislature to create a special basin rule that would allow for comprehensively managing wetlands, stormwater treatment, aquifer recharge, and flooding to restore lost hydrologic function for local and regional benefit, as proposed in the Sustainable Water Resource Management Plan. A special basin rule would give regional and state significance to restoring the watershed, above some of the local significance conveyed in this Plan.*
- *The Peace Creek Canal Maintenance Program maintains the unobstructed conveyance of water through the canal to provide flood protection for the middle and lower reaches/Polk Uplands area of the watershed. The water management district assumed responsibility for maintaining the canal for flood protection following the widespread flooding associated with tropical storms and hurricanes in 2004 and 2005. The primary cause of the flooding was the fact that water could not be conveyed rapidly enough out of the canal because of accumulated debris. The program's goal of providing adequate flood protection is consistent with the Sustainable Water Resource Management Plan.*
- *The Winter Haven Chain of Lakes Surface Water Improvement and Management (SWIM) Plan identifies projects and management strategies for restoring and managing the Chain of Lakes, including goals for restoring water quality by reducing the pollutants entering the lakes. Ongoing studies include the Sediment Removal Feasibility Report and the Chain of Lakes Water Quality Management Plan. The SWIM Plan's goal of raising lake levels to improve water quality is consistent with the City's Sustainable Water Resource Management Plan.*
- *The Water Use Permitting and MFL Programs are related to the SWUCA Recovery Strategy and WRAP, and could be useful in restoring aquifer levels in the watershed. Currently, regulations are established to ensure that aquifer levels do not decline, while in the future, restoring aquifer levels to ensure the protection of lake levels and river flows should be a primary consideration.*



Winter Haven is already working with the water management district to ensure that the City's activities are consistent with the SWUCA Recovery Strategy and the Peace Creek Watershed Management Plan, and to ensure that the district's plans are consistent with those of the City. Many of the storage areas identified by the district are incorporated in the City's Sustainable Water Resource Management Plan, and much of the information compiled by the district, including detailed topography, can be used to refine the location and design of various elements in the Plan. In addition, the district's hydrologic and hydraulic model will be a valuable tool to ensure that the implementation of the Sustainable Water Resource Management Plan provides adequate flood protection for current and future development.

MAJOR ONGOING RESTORATION ACTIVITIES AND PLANS IN THE PEACE CREEK WATERSHED

PLAN/PROJECT OR ACTIVITY	DESCRIPTION	STATUS
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT		
District Water Management Plan	Describes water management district responsibilities for water supply, flood protection, water quality, and natural systems.	Approved 2005
Regional Water Supply Plan	Assesses projected water demands and potential sources of water to meet demands from 2000 to 2025.	Approved 2006
Southern Water Use Caution Area (SWUCA) Recovery Strategy	Identifies strategies for ensuring that water supplies are available to meet growing demands, while protecting and restoring the area's water resources and related natural resources.	Approved 2006
West-Central Florida Water Restoration Action Plan (WRAP)	Consists of an implementation plan for components of the Recovery Strategy—works with local and regional partners to introduce agricultural best management practices and stormwater treatment, restore surface water storage and flows, and maximize the beneficial use of alternative supplies to further reduce groundwater withdrawals.	Approved 2008
Upper Peace River Minimum Flows and Levels (MFLs)	Establishes MFLs to restore flow to the upper Peace River and to restore Ridge lake levels, to protect them from harm from future withdrawals for consumptive use.	Approved 2002
Lake Hancock Lake Level Modification and Outfall Treatment Projects	Consists of restoration projects to increase water storage in Lake Hancock and control water releases to meet the minimum flow and water level requirements for the upper Peace River, and to treat the water discharging from the lake to improve water quality throughout the entire Peace River and protect Charlotte Harbor.	Approved 2009; Construction 2009—11
Peace Creek Watershed Management Plan	Identifies potential water resource projects to help recover watershed storage and restore minimum flows and water levels for the Peace River in accordance with the SWUCA Recovery Strategy goals.	Ongoing
Peace Creek Canal Maintenance Program	Provides ongoing maintenance of the Peace Creek Canal to maintain conveyance and reduce flooding.	Ongoing
Winter Haven Chain of Lakes Surface Water Improvement and Management (SWIM) Plan	Identifies projects and management strategies for restoring and managing the Chain of Lakes, including Pollutant Load Reduction Goals (PLRGs) to restore water quality in the lakes. Ongoing studies include the Sediment Removal Feasibility Report and the Chain of Lakes Water Quality Management Plan.	Approved 1998
Peace River Integrated Surface/ Groundwater Model	Enhances the understanding of the factors affecting flow in the Peace River; assesses the impact of climate, land use, and water use on Peace River flows; evaluates various engineering options for restoring flows in the Peace River; and develops predictive simulations for climate, land use, pumping, and MFLs.	Phases 1 through 4 completed; Phase 5 results expected by end of 2010
Environmental Resource Permit (ERP) Program	Combines the Wetlands Resource Permit and Management and Storage of Surface Water (MSSW) Permit to provide for flood control, stormwater treatment, and wetlands protection, and to increase statewide consistency in minimizing the impacts of new land uses.	Ongoing
Water Use Permit (WUP) Program	Allows the withdrawal of a specified amount of water, either from the ground or from a lake or river.	Ongoing
Florida Forever Program	Acquires environmentally sensitive lands to conserve natural resources and preserve the state's natural and cultural heritage (replaces Preservation 2000 [P2000]), the largest public land acquisition program of its kind in the country).	Ongoing
FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION		
Peace River Cumulative Impact Study	Evaluates the relative impacts of phosphate mining, agriculture, urbanization, and climate change on the Peace River, which is a major source of drinking water.	Completed 2007
Nutrient Total Maximum Daily Loads (TMDLs) for 8 Lakes in the Winter Haven Southern Chain of Lakes	Establishes pollutant loading limits for phosphorus to restore water quality in Lakes Cannon, Howard, Idylwild, Jessie, Lulu, May, Mirror, and Shipp.	Adopted 2007
Fecal Coliform and Nutrient TMDLs for the Peace Creek and Wahneta Farms Drainage Canals	Establishes pollutant loading limits for fecal coliform and nutrients to restore water quality in the Peace Creek and Wahneta Farms Drainage Canals.	Adopted 2007
Winter Haven Chain of Lakes Pre-Basin Management Action Plan (BMAP) Assessment	Evaluates existing data and information to guide management. activities to restore and protect water quality in the lakes.	Completed 2008

AND THE LARGER PEACE RIVER BASIN

PLAN/PROJECT OR ACTIVITY	DESCRIPTION	STATUS
FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION — Continued		
Integrated Habitat Network/ Coordinated Development Area	Establishes a comprehensive plan for the nine-county southern phosphate mining district of southwest Florida to maintain and protect regional water resources, balance intensive and nonintensive land uses, and restore and protect critical native plant and animal habitats.	Ongoing
Statewide Stormwater Rule Update	To address ongoing issues with contaminated urban stormwater, develops and implements a statewide stormwater treatment rule based on a higher performance standard.	Final rule adoption between July 1, 2010, and June 30, 2011
FLORIDA DEPARTMENT OF TRANSPORTATION		
Polk Parkway Extension Alignment Study	Evaluates alternative road alignments for extending the Polk Parkway south through the Peace Creek watershed.	Ongoing
POLK COUNTY		
Polk County and Municipalities Comprehensive Water Supply Plan	Assesses projected water demands and potential sources of water to meet demands from 2010 to 2030.	Ongoing
Gateway Selected Area Study	Evaluates future development scenarios associated with the construction of the CSX Integrated Logistics Center (intermodal transportation facility) and the SunRail commuter rail system.	Ongoing
Wahneta Farms Canal Maintenance	Carries out activities to maintain the Wahneta Farms Drainage Canal.	Ongoing
Lake Gwynn Restoration Project	Restores the 120-acre wetland, which drains directly to Peace Creek, in order to re-establish historical surface water levels, help maintain minimum flows, improve aquatic habitat and fisheries, improve floodplain storage and conveyance, and restore wetland functions.	Ongoing
Environmental Lands Program	Acquires and manages natural lands to protect water, wildlife, and wilderness resources.	Ongoing
CITY OF WINTER HAVEN		
Sustainable Water Resource Management Plan for the Peace Creek Watershed and Winter Haven, Florida	Creates a regional system for managing water that is designed to meet the long-term water resource needs of both people and the environment, including supply (water quantity), treatment (water quality), flood protection, and the preservation of natural resources.	Completed 2010
Winter Haven Chain of Lakes Water Quality Management Plan	Identifies management actions to restore and protect water quality in the Chain of Lakes.	Completed 2010
Winter Haven Stormwater Utility	Provides a dedicated source of funding for water quality improvement projects.	Ongoing
Winter Haven Environmental Lands Program	Purchases environmentally sensitive or important lands in the City.	Ongoing
FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION		
General Activities	Manages fish and wildlife resources for their long-term well-being and the benefit of people, in collaboration with volunteers; private landowners; anglers; hunters; wildlife viewers; boaters; scientists; environmental, industrial, and recreational interests; and other governmental agencies ranging from local to federal levels.	Ongoing
LAKE REGION LAKES MANAGEMENT DISTRICT		
General Activities	Works to protect water quality, provide safe and convenient navigation, construct launching basins, control lake pests, construct and maintain navigation and drainage canals, aid in flood control and lake level management, and carry out other activities for the general convenience and safety of those using the area's lakes and canals.	Ongoing
CHARLOTTE HARBOR NATIONAL ESTUARY PROGRAM		
General Activities	In partnership with citizens, elected officials, resource managers, and commercial and recreational resource users, works to protect the estuaries and watersheds in a 4,700-square-mile area extending from Venice to Bonita Springs to Winter Haven, and addresses issues of fish and wildlife habitat loss, water quality, and water flow.	Ongoing

Southern Water Use Caution Area (SWUCA) Recovery Strategy

The Southwest Florida Water Management District's SWUCA encompasses 5,100 square miles and covers all of DeSoto, Hardee, Manatee, and Sarasota Counties, and parts of Charlotte, Highlands, Hillsborough, and Polk Counties.

The designation is given to areas where water resources are or will become critical in the next 20 years. Water withdrawals in this area for public water supply, agriculture, mining, power generation, and recreational uses during the past 60 to 70 years have resulted in declines in the Floridan aquifer

of more than 50 feet in some areas. In parts of the Peace Creek watershed and the City of Winter Haven, the Floridan has been drawn down by as much as 15 feet as the result of these regional declines. Although the City's *Sustainable Water Resource Management Plan* will help restore aquifer levels locally, recent activities by the water management district focusing on aquifer level recovery on a regional scale would also help local water resources.

RECOMMENDATIONS FOR COORDINATING WITH THE SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

- ① *The City of Winter Haven and Polk County should ask the Southwest Florida Water Management District Governing Board to approve and/or adopt the Sustainable Water Resource Management Plan as being consistent with the district's programs.*
- ② *The Sustainable Water Resource Management Plan should be incorporated into the district's West-Central Florida Water Restoration Action Plan (WRAP) study that recommends action to help maintain Minimum Flows and Levels (MFLs).*
- ③ *The water management district should adopt the Sustainable Water Resource Management Plan as an alternate means of conveying floodwaters during extreme flood events. It should also phase out canalization as the storage and conveyance projects outlined in the Plan are implemented.*
- ④ *The City should ask the district to provide a "water reservation" as aquifer levels recover in the Peace Creek watershed to ensure that the district does not approve permits for future consumptive uses until full restoration occurs.*
- ⑤ *The water management district's Management and Storage of Surface Water (MSSW) and Environmental Resource Permit (ERP) processes should consider the special conditions of the Peace Creek watershed, including the mitigation of all hydrologic impacts in the watershed and ground-water basin. One consideration is to create a special basin rule to allow for restoration activities.*
- ⑥ *The updated information in the Federal Emergency Management Agency (FEMA) flood maps should be used to evaluate the options for increasing storage and conveyance.*
- ⑦ *The City has already incorporated into the Sustainable Water Resource Management Plan the storage areas identified by the district. It should use the information compiled by the district, including detailed topography, to refine the location and design of various elements in the Plan. In addition, the district's hydrologic and hydraulic model can be used to ensure that the Sustainable Water Resource Management Plan provides adequate flood protection for current and future development.*
- ⑧ *The City should ask the water management district to include the Peace Creek corridor in the Florida Forever Program, since it meets the program's criteria. If it is included, the Florida Forever Program should coordinate with local Environmental Lands Programs for purchasing land and development rights in critical areas identified in the Sustainable Water Resource Management Plan.*
- ⑨ *The City should ask the Southwest Florida Water Management District to designate the Peace Creek watershed as a "nested regional watershed" within the Peace River Basin, in order to concentrate mitigation activities in the smaller watershed, which has different specific needs for offsetting development impacts than the larger regional watershed.*

Florida Department of Environmental Protection: Activities and Initiatives

In the Peace River Cumulative Impact Study completed in March 2007, the Florida Department of Environmental Protection evaluated the impact of hydrologic and land use changes on stream flow, water quality, and natural resources in the Peace River Basin. The study recommends ways to mitigate and minimize the impacts of past and future development. Two major recommendations in the study are (1) restoring wetlands to increase water storage and surface water

flows, and (2) protecting uplands in the 100-year floodplain to protect water quality and wildlife and provide flood protection. These are both key elements of the City's *Sustainable Water Resource Management Plan*.

In 2006, the Florida Department of Environmental Protection developed a Total Maximum Daily Load (TMDL) for 8 lakes in the Winter Haven Southern Chain of Lakes with impaired water quality from excess nutrients (a TMDL is the maximum amount of a given pollutant that a waterbody can receive and remain

healthy). The agency has since identified an additional 12 lakes in Winter Haven, including 6 in the Northern Chain of Lakes, that will require nutrient TMDLs. The City and the Southwest Florida Water Management District are cooperating on the Winter Haven Chain of Lakes Water Quality Management Plan to address these concerns. The Florida Department of Environmental Protection has also developed TMDLs for the Peace Creek and Wahneta Farm Drainage Canals, both of which are impaired for nutrients and coliform bacteria.

RECOMMENDATIONS FOR COORDINATING WITH THE FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

- ① *Because all of the recommendations in the Sustainable Water Resource Management Plan are consistent with the goal of restoring the Peace River, the City should ask the Peace River Basin Management Advisory Committee to endorse the Plan.*
- ② *The City should coordinate its restoration activities in the Peace Creek watershed with the activities of the Peace River Basin Management Advisory Committee in the larger Peace River system.*
- ③ *The City should make the recommendations in its Sustainable Water Resource Management Plan a high priority for any future water quality improvements for impaired waters in the Winter Haven area.*
- ④ *The City should ask the Florida Department of Environmental Protection to incorporate the recommendations in the Sustainable Water Resource Management Plan into its Basin Management Action Plan (BMAP) for restoring impaired waters and any other plans that affect the Peace Creek watershed.*
- ⑤ *The various elements of the Sustainable Water Resource Management Plan to increase lake levels and enhance water quality in the lakes, as well as to increase storage and conveyance along the Peace Creek Canal, should all be incorporated into the City's plans for restoring water quality in impaired waters under the TMDL Program. The City should look to the Chain of Lakes Water Quality Management Plan for specific guidance on restoring and managing the lakes for improved water quality and other benefits.*
- ⑥ *The City should work with the Florida Department of Environmental Protection to manage the elements of the Sustainable Water Resource Management Plan as a network of wildlife corridors. It should also coordinate with the activities of the Peace River Integrated Habitat Network, which connects with the restoration areas proposed in the Plan and with wildlife corridors created by other programs.*

RECOMMENDATIONS FOR COORDINATING WITH THE FLORIDA DEPARTMENT OF TRANSPORTATION

Florida Department of Transportation: Activities and Initiatives

The Florida Department of Transportation is currently evaluating alternative road alignments for extending the Polk Parkway south through the Peace Creek watershed to serve future development, especially in the middle and lower reaches of the watershed. The study will be completed by 2013.

The Florida Department of Transportation could use the City's *Sustainable Water Resource Management Plan* as a guide to minimize the hydrologic and environmental impacts of building the parkway. The storage and conveyance areas identified in the Plan could be incorporated into the design of the stormwater management system for the road and identified as receiving areas for mitigating wetland losses and other hydrologic impacts. This could streamline the permitting process, save significant time and money, and jump-start the implementation of the *Sustainable Water Resource Management Plan*. The City of Winter Haven, Polk County, and other local governments in the area will need to work closely with Florida Department of Transportation officials to ensure that local mitigation is a priority, and that past hydrologic alterations are corrected where possible.

- ① *The City should ask the Florida Department of Transportation to use the Sustainable Water Resource Management Plan as a guide to minimize the hydrologic and environmental impacts of building the Central Polk Parkway.*
- ② *The City should ask the Florida Department of Transportation to incorporate the storage and conveyance areas identified in the Plan into the design of the stormwater management system for the road.*
- ③ *The City should ask that the storage and conveyance areas identified in the Plan be included as receiving areas for mitigating wetland losses and other hydrologic impacts.*
- ④ *The City, Polk County, and other local governments in the area should work closely with Florida Department of Transportation staff to ensure that local mitigation is a priority, and that historical hydrologic alterations are corrected where possible.*

Polk County: Activities and Initiatives

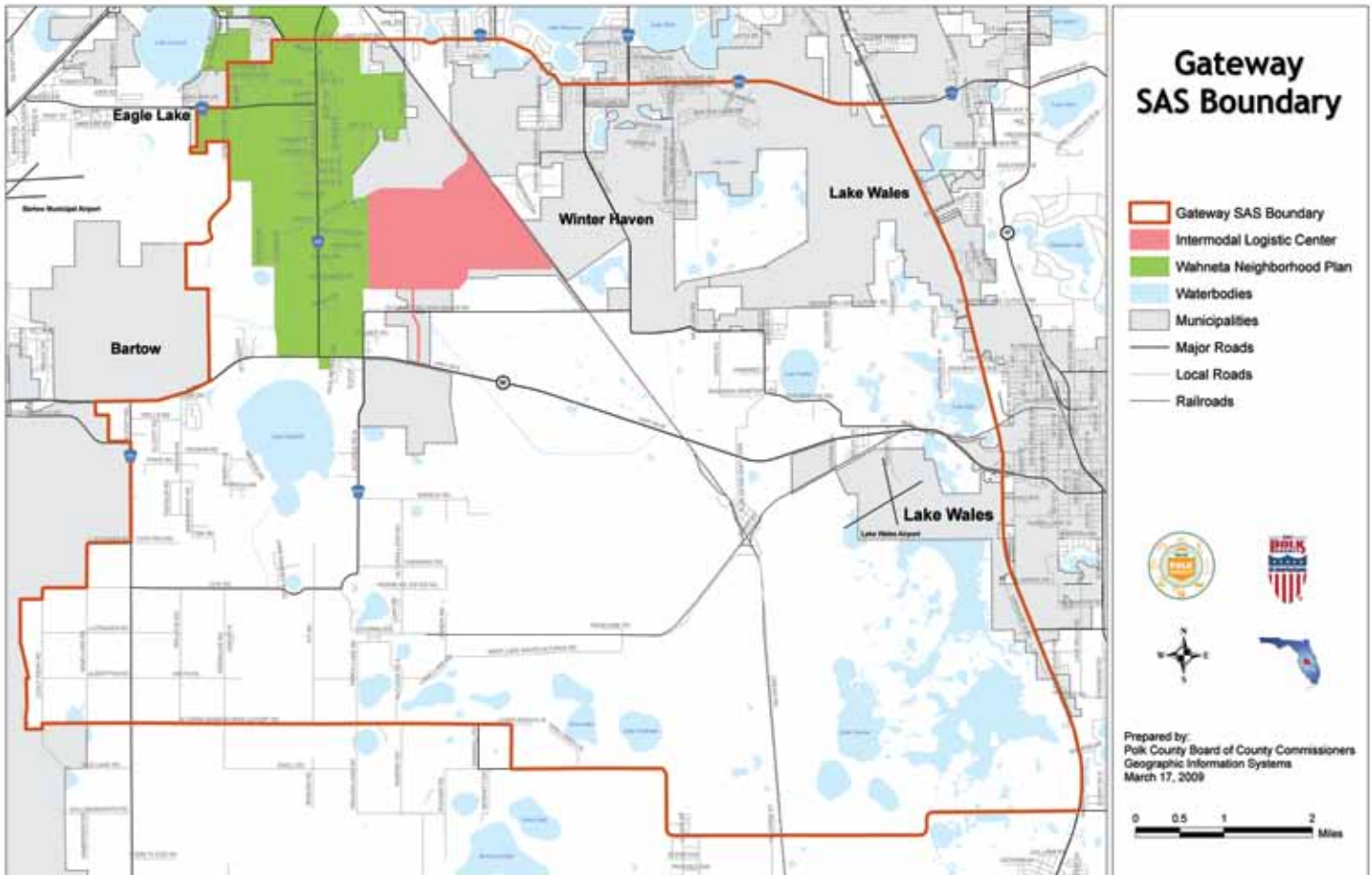
Many areas in the middle and lower reaches/Polk Uplands portion of the watershed are flood prone, and development will only make matters worse unless all agencies with land use authority in the watershed plan otherwise. Planned future development in this area could cause further impacts if developed according to today's approaches and regulations, exacerbating the existing losses of aquifer and wetland storage, increasing stormwater runoff pollution, and magnifying stormwater discharge.

Polk County and the City of Winter Haven are partnering in an effort to plan for future development in this area, which is known as the Gateway Study Area (*Figure 25*). The *Sustainable Water Resource Management Plan* should be included in the water infrastructure element of the Gateway Study Area. By helping to address water quality, water

supply, natural systems, and flood protection needs, the Plan provides a way to develop the area so that the objectives of the community are achieved. It also provides a conceptual foundation for where and how essential infrastructure such as new roads is constructed, where and how development should occur, and how the impacts from any new development could be handled expeditiously.

At the center of this new development is the proposed CSX Integrated Logistics Center, a transportation hub that uses trucks and railways to carry goods. To support the new facility through build-out, plans are being created to increase road capacity into and out of the area. Pollard Road will be expanded and extended to State Road 60 to provide primary access to the Logistics Center, and the capacity of State Road 60 may also need to be expanded.

FIGURE 25. Map showing the location of the Gateway Selected Area Study and Polk Parkway extension in the middle and lower reaches/Polk Uplands area of the Peace Creek watershed.



If road construction is allowed to occur in the same way as in the past, it could continue to alter the hydrology of the area. It is essential to carry out improvements in a way that is sensitive to the land form and that takes advantage of opportunities to store water, convey large amounts of water through the system during major storms, AND at the same time provide adequate flood protection.

Polk County is developing a comprehensive water supply plan for the county and its 17 municipalities, including Winter Haven. The county's plan evaluates the projected water



demands and potential sources of water to meet the demands from 2010 to 2030. The projections for 2030 indicate the need for an additional 27.8 million gallons per day (MGD) in permitted capacity in the county, with 24% (6.6 MGD) of that capacity required to meet the water needs of the City of Winter Haven.

While the City's primary strategy will be to decrease per capita water consumption through water conservation, the *Sustainable Water Resource Management Plan* will help address increased future demand by focusing reuse water and conservation strategies to limit the need for new water supply sources, and by restoring and preserving the historical storage and movement of water through the Peace Creek watershed as much as possible. By increasing recharge to the Floridan aquifer and the amount of water storage, the implementation of the *Sustainable Water Resource Management Plan* will also help all other water supply utilities in the area.

Other cities in the Peace Creek watershed may want to adopt a similar approach to the one in this Plan, since many are in the same hydrologic situation as the City of Winter Haven. Most of the recommendations presented in this Plan are applicable to the other communities in the watershed.

Other Governmental Agencies: Activities and Initiatives

It is essential for the City of Winter Haven to work in partnership with other governmental agencies in the region—including the Florida Fish and Wildlife Conservation

RECOMMENDATIONS FOR COORDINATING WITH POLK COUNTY

- ① *The City and Polk County should use the Sustainable Water Resource Management Plan as a foundation for determining where and how essential infrastructure such as new roads is constructed, where and how development should occur, and how to handle the impacts to water resources from new development.*
- ② *The City and Polk County should include the Sustainable Water Resource Management Plan in the water infrastructure element of the Gateway Study Area, to ensure that the community's current and future water resource needs are addressed.*
- ③ *Any planned future development in the middle and lower reaches/Polk Uplands area of the watershed should not be carried out according to today's approaches and regulations, but on a broader, watershed-wide scale, to address cumulative impacts such as lost aquifer and wetland storage, increased stormwater pollution, and higher stormwater volume.*
- ④ *Any activities to increase road capacity and expand roadways should be carried out in a way that is sensitive to the land form of individual areas and takes advantage of opportunities to store water, convey large amounts of water through the system during major storms, AND at the same time provide adequate flood protection.*
- ⑤ *Polk County, as well as the other cities and towns in the watershed, should adopt an overlay ordinance to protect the water resources in the entire watershed, with the cities having approval authority.*

Commission and the Lakes Region Lakes Management District—on projects that will help to meet the goals of the *Sustainable Water Resource Management Plan*. These include restoring and protecting the area's wetlands, increasing water storage, improving fisheries habitat, and restoring flows for fish passage in the Peace River, while at the same time improving flood protection. All of these activities will benefit not only the communities in the Peace Creek watershed but also those downstream in the larger Peace River Basin.

Nongovernmental, Nonprofit, and Private Organizations/Environmental Groups/Private Landowners: Activities and Initiatives

Organizations and individuals interested in participating and partnering in restoration activities in the Peace Creek watershed include the Charlotte Harbor National Estuary Program (CHNEP), environmental groups such as the Sierra Club and Audubon Society, and private landowners. All of these will play an important role in supporting and helping to implement the *Sustainable Water Resource Management Plan*. While each of these organizations and individuals has different interests and needs, they all have something important to contribute to the collaborative process and will also bring to the table their unique, place-specific knowledge of the region.

Furthermore, each shares with the City of Winter Haven and other governmental entities a desire to meet the current and future water

RECOMMENDATIONS FOR COORDINATING WITH OTHER AGENCIES, ORGANIZATIONS, AND PRIVATE LANDOWNERS

- ① *The City should identify other governmental entities that are interested in supporting and contributing to the implementation of the Sustainable Water Resource Management Plan.*
- ② *The City should work cooperatively with other agencies to evaluate how their ongoing and planned projects can contribute to implementing the Plan, while at the same time meeting the needs of the individual agencies.*
- ③ *Locally, regionally, and statewide, the City should identify organizations, groups, and individuals who are interested in supporting and contributing to the implementation of the Plan.*
- ④ *The City should work to identify major landowners who want rural land in the Peace Creek watershed to remain rural.*
- ⑤ *The City should evaluate the feasibility and costs of implementing water farming and other long-term management alternatives such as conservation easements and stewardship plans.*

needs of people and/or the environment, both in the Peace Creek watershed and the larger Peace River region. The Plan offers a way for the City to establish a common base of understanding with these different groups and individuals, to work cooperatively with them on developing new approaches, and to adapt existing rules and regulations to meet local and regional needs.

One of the primary means for implementing the Plan is to manage future urban growth to facilitate water management. In one possible solution, landowners who want their land to remain rural could be compensated for storing water on their property—an approach called "water farming." However, the feasibility, benefits, and costs of

this approach will need to be carefully evaluated, as will the possibility of implementing other long-term alternatives to protecting water resources, including conservation easements, stewardship plans, and similar programs.



conclusion

Over the past century, the Peace Creek watershed was drained to make way for agricultural and urban development. As a result, much of its natural hydrologic function—including aquifer recharge, storage in lakes and wetlands, water quality treatment, and measured releases to the Peace River downstream—was destroyed or significantly altered. The consequence of this historical approach is that today the City of Winter Haven and the other communities in the Peace Creek watershed will not have enough water to meet the long-term needs of both people and the environment in the face of continued economic and population growth.

The Peace Creek watershed receives no water other than rainfall. What falls on the ground is all that is available for current residents, natural systems, and future growth. This situation is unique to the entire Peace River Basin and the region encompassed by the Southwest Florida Water Management District's Southern Water Use Caution Area (SWUCA).

Protecting and restoring the Peace Creek watershed's hydrologic system so that water is stored naturally during the wet season for use in the dry season—and also stored during wet years for use in dry years—is critical to meeting the future water resource needs of people and the environment. Natural storage, with its many benefits, including natural systems and flood protection, is much more desirable than structural, man-made storage, which usually has only a single purpose, is expensive to construct

and maintain, and often is limited in managing extreme events (for example, no matter how much money is spent, there will always be storms that exceed a structure's design capacity).

Merely holding the line on maintaining current aquifer levels is not enough: the City needs to identify specific actions to restore aquifer levels, which are critical to the future sustainability of the region. Many of the watershed's historical wetland areas still exist, but future development plans may preclude the use of these areas in the future; thus the City needs to act NOW.

Through the implementation of the *Sustainable Water Resource Management Plan*, the City has the opportunity to serve as a model for other communities in the region. However, the City cannot restore regional aquifer levels by itself; to succeed, other communities and agencies will need to participate in this effort.

While the Southwest Florida Water Management District did not create the problem of the regional aquifer drawdown, it has the responsibility to solve the problem. Neither the district nor local communities can solve the problem independently, but together, they can leverage common goals to integrate regional water resource planning with local land use decisions.

The Plan's success ultimately depends on how effectively projects are integrated and carried out throughout the watershed. Coordination and cooperation among all the agencies carrying out projects in the

watershed are essential. Not only will these coordinated local and regional activities provide local benefits, but local projects and activities—when implemented throughout the Peace Creek watershed—will create a "critical mass" that results in long-term regional benefits.

There is no project or single solution that will restore aquifer levels; it will require a comprehensive and adaptive management approach, sustained long-term effort, and significant funds. To a large extent, future development will need to pay for restoration through mitigation banking and other activities. In turn, developers will require economic incentives to carry out restoration work.

Ironically, while the watershed was dewatered as a result of historical development, one of the best opportunities to preserve and restore lost hydrologic function is to partner with future development. The key lies in managing the types of development that are planned and built, where they are located, and the conditions that the City and other governmental agencies and entities place on that development. The City's long-term future is sustainable only if the watershed is developed in a way that is sensitive to the unique land and water resources in the region. This will take a bold, new approach, as well as courage and leadership. Current and future efforts to restore the Peace Creek watershed's water resources must be supported and encouraged by agencies and entities at all levels, both public and private, as well as individual landowners and residents.

The Peace Creek watershed receives no water other than rainfall. What falls on the ground is all that is available for current residents, natural systems, and future growth. This situation is unique to the entire Peace River Basin and the region encompassed by the Southwest Florida Water Management District's Southern Water Use Caution Area.

It is time to speak your truth, to create your communities, to be good to each other and to not look outside of yourself for a leader.

This could actually be a good time. There is a river flowing now, very fast. It is good and great and swift and there are those who will be afraid. They will try to hold on to the shore. Know that the river has its destination. The elders say we must let go of the shore, push off into the middle of the river, keep our eyes open and our heads above the water, see who is with us and celebrate. . .

The time of the lone wolf is over. Gather yourselves. Banish the word "struggle" from your attitude and your vocabulary. All that we do now must be done in a sacred way and in celebration. We are the ones we have been waiting for.

— Hopi Elder Prayer



Water is the most critical resource issue of our lifetime and our children's lifetime.

The health of our waters is the principal measure of how we live on the land. —Luna Leopold



ENJOYING WINTER HAVEN'S
LAKES AND CANALS



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RAIN GARDENS THROUGHOUT WINTER HAVEN





glossary

Algal bloom—A rapid increase in the number of algae (phytoplankton) in an aquatic system, caused by excess nutrients in fertilizer and stormwater runoff. When the algae die and decay through natural processes, they consume oxygen in the water, which can lead to fish kills.

Aquifer—Underground water storage.

Basin—Also referred to as a watershed, a basin is the geographic area through which water flows across the land and drains into a common body of water, such as a stream, river, lake, or ocean. It includes tributaries (wetlands, streams, canals, and ditches) as well as stormwater that runs off the land. Basins are usually separated from other basins by naturally elevated areas.

Best management practice (BMP)—Methods that have been determined to be the most effective, practical means of preventing or reducing pollution from nonpoint sources.

Bioretention area—A shallow, landscaped depression constructed to receive runoff from impervious surfaces. These areas slow the speed of stormwater runoff and filter pollutants from the water.

Biosolids—Treated sewage sludge.

Coliform—Bacteria that live in the intestines (including the colon) of humans and other animals that are used as a measure of the presence of feces in water or soil.

Conservation subdivision—A residential or mixed-use development where a significant portion of the buildable land is designated as undivided, permanently protected open space, with houses clustered on the rest of the property. Communities can use this designation to help preserve open space and natural areas, protect water quality and wildlife habitat, reduce subdivision construction and maintenance costs, and expand public trails and greenways.

Conveyance—A broad, relatively shallow corridor through which floodwaters can pass.

Consumptive use—Water that is consumed and not returned to the source from which it originated. It consists of the water that evaporates, is used in products or crops, or is consumed by humans or livestock.

Designated use—The specific uses that Florida applies to each waterbody or waterbody segment (such as drinking water, swimmable, fishable) for which there are water quality standards. The state has five designated use categories, as follows:

Class I: Potable water supplies

Class II: Shellfish propagation or harvesting

Class III: Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife

Class IV: Agricultural water supplies

Class V: Navigation, utility, and industrial use (there are no state waters currently in this class).

Ditch block—A barrier placed across a canal or ditch, designed to deflect water flow.

Drawdown—The lowering of an aquifer or reservoir.

Dry season—The dry part of the year—in Florida, generally defined as November through May.

Environmental Resource Permit (ERP)—A water management district permit that is required before an applicant initiates any construction activity that would affect wetlands, alter surface water flows, or contribute to water pollution.

Evapotranspiration—The water vapor produced through the natural processes of evaporation and transpiration. When rain falls on the earth, some of the water evaporates from the land surface and from waterbodies, returning to the atmosphere. Plants also transpire water vapor through small openings in their leaves.

External loads—Pollutants originating from outside a waterbody that contribute to its pollutant load.

Floodplain—A low-lying area next to a waterbody that allows floodwaters to spread out, and where man-made structures such as buildings are prone to damage from floodwater.

Floodway—A stream channel and the surrounding areas that carry floodwater.

Florida-friendly landscaping—A set of landscaping principles designed to reduce stormwater runoff and fertilizer and pesticide use, and to protect water resources from contamination and overuse. It includes using low-maintenance plants, mulch, integrated pest management, water conservation, and other environmentally sustainable practices.

glossary cont.

Floridan aquifer—A deep aquifer system made up of a layer of thick carbonate rock that underlies an area of about 100,000 square miles in southern Alabama, southeastern Georgia, southern South Carolina, and all of Florida. It is the principal source of potable (drinking) water in these areas.

French drain—A ditch covered with gravel or rock that channels surface water and groundwater away from an area.

Green infrastructure—The network of natural environmental components, green spaces (plants), and blue spaces (water) that provides multiple social, economic, and environmental benefits. In the same way that the transportation infrastructure is made up of a network that includes roads, railways, and airports, green infrastructure has its own physical components, including rivers, wetlands, parks, street trees, and grass.

Groundwater—Water below the land surface, including shallow and deep aquifers.

Groundwater basin—A discrete underground deposit of water in the form of a single aquifer or a group of interconnected aquifers.

Headwaters—The area or place where a stream or river originates.

Hydric—Holding water.

Hydric park—Also called a nature park, this is a water treatment and storage area that also significantly contributes to an area's recreational system, provides habitat for fish and wildlife, and provides economic and social benefits to neighboring areas. These parks generally contain passive recreational features such as hiking trails, boardwalks, fishing/observation decks, benches, picnic tables, and educational displays.

Hydrologic system—The way in which water moves through and is distributed and stored in a specific area such as a watershed. It can also refer to a conceptual model, called the hydrologic cycle, of the cyclical movement, distribution, and storage of water that occurs between the atmosphere and above and below the Earth's surface.

Hydrology—The study of the movement, distribution, and quality of water. The term is also used to describe the movement of water through an area or watershed.

Hydroperiod—The length of time that a wetland or pond contains water.

Impaired—The condition of a waterbody that does not achieve water quality standards (designated use) due to pollutants or an unknown cause.

Infiltration—The absorption of stormwater into the ground.

Infiltration basin—A shallow pond constructed to infiltrate stormwater into the ground. A type of best management practice (BMP), it is used to manage stormwater runoff, prevent flooding and downstream erosion, and improve water quality in adjacent waterbodies. Infiltration basins generally do not discharge to surface waters but are designed with overflow structures that are used during flood conditions.

Internal loads—The recycling of nutrients from organic material that enters a waterbody, decomposes, and is stored in bottom sediments.

Land application—The application of treated sewage sludge (also called biosolids) to the land surface.

Legacy nutrients—Nutrients such as nitrogen and phosphorus that are deposited in a stream, river, or lake from past human activities, including land clearing, past wastewater discharges, untreated stormwater, and poor agricultural practices. Rainwater carries the nutrients to nearby surface waters, where they are taken up by aquatic plants such as algae. Once the plants die and decompose, the nutrients are released into the water, only to be taken up again by new plant growth. This cycle is endlessly repeated.

Limited-development zone—An ecologically sensitive or valuable area where development activities are limited in scope.

Loading—The total quantity of pollutants in stormwater runoff that contributes to water quality impairment in a waterbody. It is calculated by multiplying the concentration of the pollutant by the rate of flow, expressed as a volume per unit of time.

Low-impact development (LID)—A set of principles used to develop land, or to retrofit existing development, that can be adapted to many different kinds of land uses. LID principles are focused on working with nature to manage stormwater as close to its source as possible, in order to reduce human impacts and promote the natural movement and storage of water in a watershed or ecosystem. Stormwater is viewed as a resource, rather than a waste product to be disposed of.

Management and Storage of Surface Water (MSSW) permit—A permit required by the water management districts before applicants carry out any activities that affect surface water, in order to prevent harm to Florida waters. These activities include the construction of stormwater management systems, dams, impoundments, reservoirs, dredging, filling, and the creation of canals, ditches, culverts, impoundments, fill roads, buildings, and other impervious surfaces.

Minimum Flows and Levels (MFLs)—Flows and levels for waterbodies established by the water management districts to prevent significant harm as a result of water withdrawals.

Mitigation—The process of calculating the amount and type of lost hydrologic function caused by human land uses, and compensating for those impacts by restoring or setting aside other areas with the same function. Examples include mitigation for wetland losses, losses of habitat essential to threatened and endangered species, and impacts to riverine systems, as well as water quality and flood protection. The mitigation process can also be extended to include pollutant and carbon trading.

Mitigation bank—A public or private entity that sells mitigation credits to developers to compensate for the ecological impacts of their activities, such as wetland destruction and habitat loss. The funds are then used to purchase conservation land or carry out restoration projects. This transfer of management responsibilities and liability is very attractive to permit holders, who would otherwise be responsible for the design, construction, monitoring, ecological success, and long-term protection of a site. A mitigation bank's value is defined in mitigation credits.

Mitigation credit—The value of an ecological improvement, determined using a functional assessment method such as the Uniform Mitigation Assessment Method (UMAM) (Rule 62-345, Florida Administrative Code). The credits are sold to developers who need to offset the ecological impacts of their activities.

Natural infrastructure—Also called green infrastructure, this consists of interconnected, healthy natural areas (both land and water) that provide multiple ecological services and benefits, supporting human, animal, and plant life at no cost. The term is also used to describe strategically planned and managed networks of naturally functioning areas—such as open spaces, forests, swamps, rivers, and aquifers—that operate as a whole to preserve and restore ecosystem values and functions.

Nature park—Also called a hydric park, this is a water treatment and storage area that also significantly contributes to an area's recreational system, provides habitat for fish and wildlife, and provides economic and social benefits to neighboring areas. These parks generally contain passive recreational features such as hiking trails, boardwalks, fishing/observation decks, benches, picnic tables, and educational displays.

Nested regional watershed—A watershed within a watershed, created to concentrate mitigation in a smaller region than the larger regional watershed.

Nitrogen—One of the three major nutrients required for plant growth (the others being phosphorus and potassium). Nitrogen plays a role in almost all plant metabolic processes.

No-development zone—An ecologically sensitive or valuable area where no construction is permitted.

Nonpoint source—Diffuse runoff without a single point of origin that flows over the surface of the ground by stormwater and then flows to surface water or ground water. It includes atmospheric deposition and runoff or leaching from agricultural lands, urban areas, unvegetated lands, onsite sewage treatment and disposal systems, and construction sites.

Nutrients—Chemical elements, such as nitrogen, phosphorus, and potassium, that are required for plant growth. Excessive amounts of nutrients that reach a waterbody through runoff from agricultural or residential areas can cause algal blooms.

Outfall—The place where a sewer, drain, or stream discharges into a waterbody.

Overlay district—A special zone, created for a significant natural resource such as a floodplain or aquifer, where additional restrictions are applied to land uses. The underlying zoning remains in place. More than one overlay district may be applicable to a single area.

Overlay ordinance—An ordinance that applies a common set of standards to a designated area, to minimize or control the impacts of development—for example, where water can be stored and treated, and how it will flow during flood events.

Percolation—The downward flow of water through soil.

Pervious—Porous; allowing water to pass through.

Phosphorus—One of the three major nutrients required for plant growth (the others being nitrogen and potassium).

Pocket wetland—An artificially constructed shallow marsh system for storing stormwater and removing pollutants.

Point source—An identifiable and confined discharge point for one or more water pollutants, such as a pipe, channel, vessel, or ditch.

Pollutant loading—The amount of a pollutant entering a waterbody.

Potentiometric surface—An imaginary surface that represents the height to which water will rise when trapped between impermeable layers of rock or in a cased well.

Predevelopment—The natural vegetative community types and hydrologic condition prior to modification for agricultural, urban, or other uses.

Rain garden—A planted depression that holds stormwater runoff from impervious urban areas such as roofs, driveways, and sidewalks, so it can be absorbed into the ground.

glossary cont.

Rapid infiltration basins (RIBs)—A group of artificially constructed basins used to percolate treated wastewater rapidly through underlying soils when the demand for reuse water (for uses such as irrigation) is low.

Reach—A section of a river.

Recharge—The addition of water to the groundwater system.

Retention pond—An artificially constructed, permanent pool of water designed to store stormwater runoff.

Reuse—The application of reclaimed wastewater for a beneficial purpose. Section 62-610.810, Florida Administrative Code, contains the criteria used to classify projects as "reuse" or "effluent disposal."

Riparian—Related to the banks on either side of a river.

Riverine—Related to a river.

Runoff—Rainwater that is not absorbed into the ground but flows across the land surface, picking up contaminants.

Saltwater intrusion—The movement of saline water into a freshwater aquifer, often caused by groundwater pumping in coastal areas.

Simulation model—In simulation modeling, detailed information about a specific place is entered into a computer model, and different scenarios are simulated to gain a better understanding of the possible outcomes.

Slough—A soft, low-lying, swampy area, through which water moves slowly.

Soil water recharge—The amount of water retained in the soil during the wet season.

Soil water utilization—The water stored in the soil that is extracted by plants to meet their evapotranspiration needs during period of low rainfall.

Southern Water Use Caution Area (SWUCA)—An area designated by the Southwest Florida Water Management District in 1992 where water resources are or will become critical in the next 20 years. The SWUCA encompasses 5,100 square miles and covers all of DeSoto, Hardee, Manatee, and Sarasota Counties, and parts of Charlotte, Highlands, Hillsborough, and Polk Counties.

Southern Water Use Caution Area Recovery Strategy—A Southwest Florida Water Management District restoration strategy for the SWUCA that focuses on restoring flows in the upper Peace River, restoring lake levels, and ensuring sufficient water supplies to support current uses.

Stormwater—Water that falls on the land surface from a rainfall event.

Stormwater capture system—A system designed to capture and hold stormwater, allowing it to infiltrate into the ground.

Stormwater runoff—The portion of rainfall that hits the ground and is not evaporated, percolated, or transpired by vegetation, but flows over the ground surface into a receiving waterbody.

Stormwater treatment area—An artificially constructed, vegetated wetland, designed to store water and to remove nutrients and other contaminants from stormwater.

Strand—The land bordering a waterbody.

Surface water—Water on the land surface, including rivers, lakes, streams, estuaries, and oceans.

Surface Water Improvement and Management (SWIM)—In 1987, the Florida Legislature created the SWIM Program. The water management districts develop SWIM plans for priority waterbodies to restore damaged ecosystems, prevent pollution from stormwater runoff and other sources, and educate the public. Currently, 29 waterbodies are on the priority list.

Surficial aquifer—A shallow aquifer below the land surface.

Sustainable—Resource use that meets the needs of people and the environment in the present, while also enabling future generations to meet their own needs.

Swale—A shallow, linear, grassy depression designed to capture stormwater from roads and parking lots.

Swamps—Forested wetlands.

Tannins—Chemicals leached from the breakdown of organic matter, such as leaves, that turns water a dark tea or coffee color. Tannins reduce the amount of light penetrating the water.

Total Maximum Daily Load (TMDL)—A TMDL is the maximum amount of a given pollutant that a waterbody can receive and remain healthy.

Transfer of development rights—The sale of development rights to a property, used to preserve open space, restrict growth, or protect ecologically sensitive areas.

Wastewater—The combination of liquid and pollutants from residences, commercial buildings, industrial plants, and institutions, together with any ground water, surface runoff, or leachate that may be present.

Water budget—A water budget describes what happens to water entering and leaving a watershed. The components of a water budget include the amount of rainfall; surface water and groundwater flows; the amount of water stored in lakes, wetlands, and aquifers; the amount of water taken up by plants; and the effects of natural conditions such as sunlight, rain, and wind.

Watershed—Also called a basin, this is the geographic area through which water flows across the land and drains into a common body of water, such as a stream, river, lake, or ocean. It includes tributaries (wetlands, streams, canals, and ditches) as well as stormwater that runs off the land. Watersheds are usually separated from other watersheds by naturally elevated areas.

Water table—The level of the groundwater surface.

Water Use Caution Area (WUCA)—A designation given by the water management districts to areas where water supplies are or will become critical in the next 20 years.

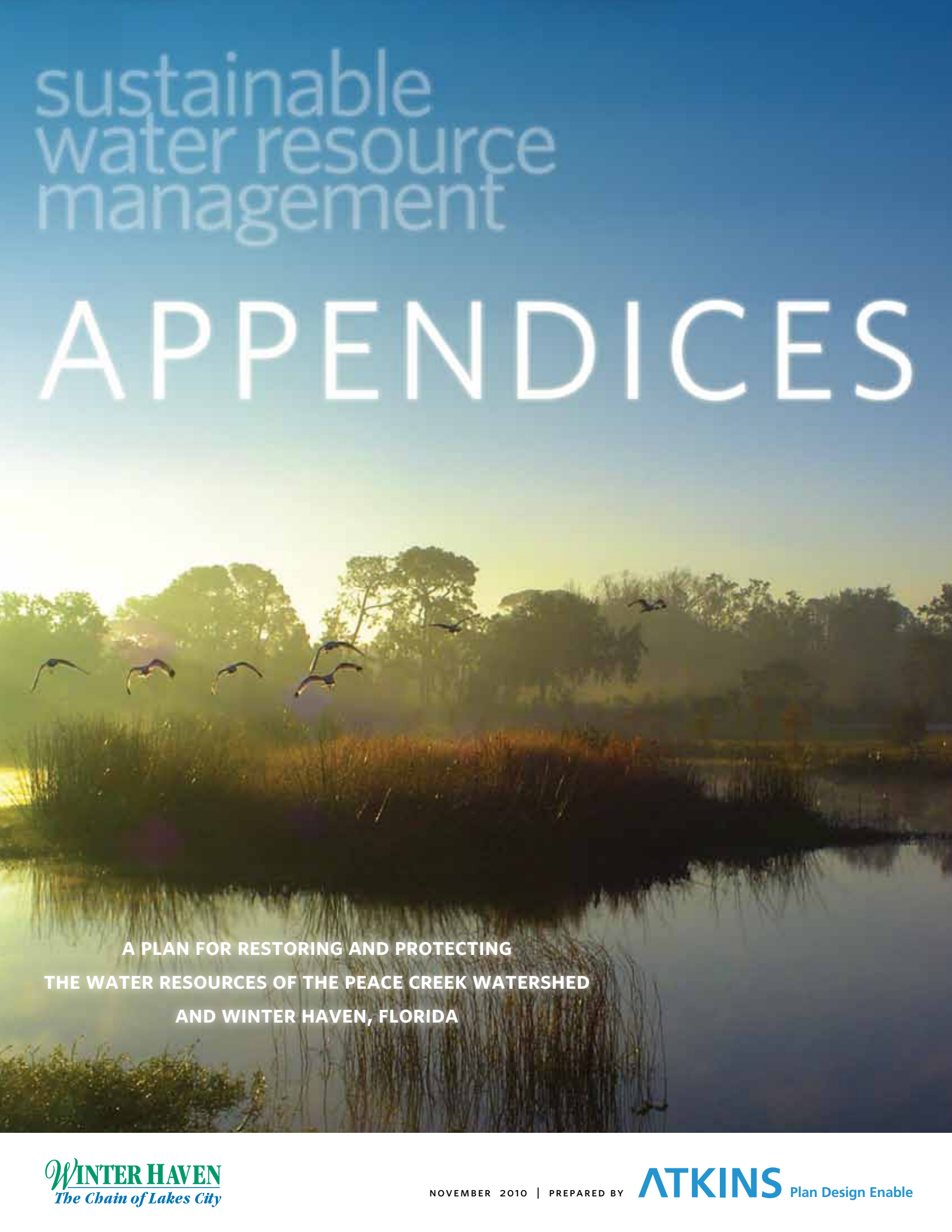
Wetland—A low-lying area containing soils that are saturated with water permanently or seasonally. They may contain pools of water and can be forested or marshy. Wetlands are the most biologically diverse of all ecosystems and provide valuable habitat for fish and wildlife. They also remove nutrients and other pollutants from water.

Wetland storage area—An artificially constructed wetland, designed to store water and to remove nutrients and other contaminants from stormwater.

Wet season—The rainy part of the year—in Florida, generally defined as June through October.

Withdrawal—The extraction of water for human use.





sustainable
water resource
management

APPENDICES

A PLAN FOR RESTORING AND PROTECTING
THE WATER RESOURCES OF THE PEACE CREEK WATERSHED
AND WINTER HAVEN, FLORIDA

These appendices contain supporting documentation for the *Sustainable Water Resource Management Plan* for the City of Winter Haven, Florida.

The Plan is an investment in the capacity of the natural landscape to provide multiple water resource benefits. In contrast, man-made structural solutions such as channels, ditches, reservoirs, and pipes are generally implemented primarily for singular benefits. In the long term, using the natural landscape to provide these multiple benefits will result in a less costly, more efficient water supply system for people and the environment. The Plan's benefits include the following:

- **Economic**
- **Environmental**
- **Water supply**
- **Flood protection**
- **Social, cultural, and recreational**

For more information, please contact the Natural Resources Division, City of Winter Haven, Florida.



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APPENDIX A

Method for Evaluating Lost Storage in the Surficial Aquifer

—by Dave A. Tomasko, Ph.D., Senior Scientist, PBS&J

Both conceptually and as is pointed out in various landscape-level hydrologic process models, there is agreement that the increased urbanization of a watershed should result in both an increase in the amount of stormwater runoff generated, and a concurrent reduction in the amount of rainfall that percolates into the surficial aquifer. Determining the amount of rainfall that becomes runoff, versus that available for percolation, depends in large part on the amount of directly connected impervious area (DCIA) associated with various land use categories. There is a subtle, yet important, distinction between DCIA and the “percent impervious” nature of a landscape.

For example, rainfall on a low-density residential neighborhood occurs on impervious features such as rooftops, sidewalks, and

driveways; these areas comprise perhaps a third of the total area of any neighborhood (as an example, **Table A.1** lists the DCIA values used by the Florida Department of Environmental Protection [FDEP] [2003] to estimate runoff from the Orange Lake watershed, in Alachua County). However, runoff from a roof can then drain to a grassed yard that then infiltrates to the surficial aquifer, or it can run off the property and go to either a street or a dry retention pond for later percolation. For this reason, FDEP and other entities use DCIA as the primary method for determining stormwater runoff quantities with various landscapes (e.g., FDEP, 2003). The pollutant loading model for Sarasota Bay also calculated hydrologic loads by considering the DCIA component of the landscape (Heyl, 1992).

Residential landscapes typically have between 12% and nearly 30% of their surface area as DCIA. In the Sarasota Bay area, estimated DCIA values for residential neighborhoods range between 20% and 40% (Heyl, 1992). Of that amount of landscape that is DCIA, it is further assumed that the amount of runoff generated is in the range of 80% or higher (Heyl, 1992; FDEP, 2003). Therefore, a DCIA value of 30%, combined with a presumed 80% runoff coefficient, means that 24% of rainfall is expected to become stormwater runoff from the “typical” rain event falling on the DCIA portion of a high-density residential landscape ($0.30 \times 0.80 = 0.24$). This 24% value is then added to the expected runoff from the non-DCIA portion of the landscape. Assuming (for high-density residential landscapes) that 70% of the area is non-DCIA, and assuming a runoff

Table A.1. *Directly connected impervious area (DCIA) for various land use types (Orange Lake watershed, Alachua County). Source: FDEP, 2003*

LAND USE CATEGORIES	DCIA	REFERENCE
Forest/Rural Open	0.5%	Watershed Management Model (WMM) User's Manual, 1998
Urban Open	0.5%	WMM User's Manual, 1998
Agriculture	3.7%	Brown, 1995
Low-Density Residential	12.40%	Brown, 1995
Medium-Density Residential	18.70%	Brown, 1995
High-Density Residential	29.60%	Brown, 1995
Communication and Transportation	36.20%	Brown, 1995
Rangeland	3.7%	Camp Dresser & McKee (CDM), 1990
Water/Wetlands	30%	Harper and Livingston, 1999

coefficient of 15% for pervious areas (Heyl, 1992; FDEP, 2003), these portions of the landscape would add an additional 10.5% of rainfall ($0.70 \times 0.15 = 0.105$), for a total expected runoff amount of 34.5% of rainfall ($24 + 10.5 = 34.5$) from a high-density residential landscape.

For the Orange Lake watershed, FDEP (2003) used a DCIA value for forested landscapes of less than 1%, similar to the values used for Sarasota Bay (Heyl, 1992). The runoff from non-DCIA areas is expected to be approximately 15%. Thus, for forested (nondeveloped) landscapes, the total runoff amount is the sum of the DCIA ($0.01 \times 0.80 = 0.08$) plus the non-DCIA ($0.99 \times 0.15 = 0.15$), which equals approximately 15.8%.

Consequently, the conversion of the watershed from a forested landscape to one entirely dominated by high-density residential neighborhoods is expected to increase the amount of runoff from 15.7% of rainfall to 34.5% of rainfall, a more than twofold increase.

With most landscapes, increased development thus increases stormwater runoff amounts from relatively small percentages of rainfall to larger percentages. However, in the Winter Haven Chain of Lakes (WHCOL), there is some question as to whether or not *any* runoff occurred under natural conditions. Within the description of the techniques used for developing a water budget for the Winter Haven Chain, the University of South Florida

(USF) report (McCary and Ross, 2005) stated, "In general, pervious runoff was negligible due to...the sands that are predominant in the Winter Haven area." Elsewhere in that report, the authors state that runoff was "insignificant." As such, it seems that the developers of the pollutant loading model for the WHCOL (McCary and Ross, 2005), upon which was based the Total Maximum Daily Load (TMDL) for the WHCOL (FDEP, 2007), concluded that there was likely no surface runoff at all (or very little) occurring for most of the WHCOL watershed. In contrast, there is at present a substantial amount of surface water runoff generated in the watershed, as would be expected from such a highly urbanized area.

This then allows for the application of a technique to estimate the "lost" storage quantity associated with decreased percolation into the surficial aquifer, as follows:

- *Under predevelopment conditions, runoff would have been negligible to absent in the WHCOL region;*
- *Thus, under predevelopment conditions, rainfall would have mostly resulted in percolation into the surficial aquifer and/or temporary storage via isolated wetlands;*
- *To estimate the volume of "lost" storage in the surficial aquifer, one could estimate the volume of rainfall that is no longer percolating into the surficial aquifer;*

- *Direct stormwater runoff into the WHCOL represents rainfall that would likely have percolated into the aquifer in predevelopment conditions;*
- *Therefore, the volume of stormwater runoff into the WHCOL lakes themselves can be used as an estimate of the amount of water no longer able to percolate into the surficial aquifer; and*
- *The volume of stormwater runoff into the WHCOL can be used as an estimate of the amount of "lost" storage in the surficial aquifer.*

The Pollutant Load Reduction Goal (PLRG) report for the WHCOL (McCary and Ross, 2005) summarizes the data and techniques used to develop the water budget for the Chain of Lakes, as the development of a water budget is the first step in developing a pollutant loading model. The water budget (McCary and Ross, 2005) included estimates of rainfall, seepage into the aquifer, lake-to-lake water movement (via canals), evaporation, and direct stormwater runoff. For the reasons outlined above, the metric of most interest for this effort is the determination of the amount of direct runoff to the lakes. **Table A.2** displays the results of the water budget.

Based on these results, the average lake in the WHCOL receives approximately 132 million gallons of direct stormwater runoff per year. The range of values lies between 32 million gallons per year of direct runoff for Lake Summit to 316 million gallons per year for Lake Marianna. Lake Howard, a

large lake near the center of Winter Haven, receives approximately 297 million gallons per year of direct stormwater runoff. The very high rates of runoff into Lakes May, Blue, and Spring reflect the finding that sufficient runoff occurs into these lakes that they “export” surface flows to adjacent lakes via interconnected canals. In total, the WHCOL is estimated to receive an average

of approximately 2.7 billion gallons of stormwater runoff per year.

However, the lakes in the Northern Chain of Lakes system (Haines, Rochelle, Conine, Smart, and Fannie) are problematic, in that they are thought to receive a substantial amount of their water via groundwater inflows. The water budget estimates in the PLRG study

(McCary and Ross, 2005) indicate that approximately five times as much water enters these lakes via groundwater inflow than as direct stormwater runoff. As the water budget was somewhat compromised by the lack of sufficient data on groundwater inflows (McCary and Ross, 2005), FDEP felt it was premature to develop TMDLs for the Northern Chain (FDEP, 2007).

LAKE	AREA (ACRES)	RUNOFF VOLUME (ACRE-FEET/YEAR)	RUNOFF VOLUME (MILLION GALLONS/YEAR)
Winterset	548	206	67
Eloise	1,163	533	174
Summit	64	98	32
Lulu	307	468	153
Roy	74	174	57
Shipp	277	584	190
May	52	617	201
Howard	625	911	297
Cannon	328	640	208
Blue	54	438	143
Mirror	126	175	57
Spring	23	128	42
Idylwild	93	232	76
Jessie	186	521	170
Marianna	511	971	316
Hartridge	415	533	174
Conine*	233	384	125
Rochelle*	573	196	64
Haines*	689	402	131
Smart*	274	82	27
Fannie*	738	191	62
Average	350	404	132
Sum	7,353	8,483	2,764

Table A.2. Summary of findings for the water budget for the WHCOL. Source: McCary and Ross, 2005

* Located in the Northern Chain of Lakes.

Consequently, a conservative approach would be to eliminate the lakes of the Northern Chain from further consideration for the purposes of developing a “lost percolation” estimate. **Table A.3** revises the information in **Table A.2**, by omitting the lakes of the Northern Chain of Lakes system.

Upon the removal of the Northern Chain of Lakes from this analysis, the estimated surface runoff into the remaining lakes of the WHCOL system is approximately 2.4 billion gallons per year. As there was likely little to no surface water runoff coming into these lakes in a

predevelopment condition (McCary and Ross, 2005), it is likely that the amount of water now routed to the lakes via stormwater runoff—a consequence of the highly urbanized watershed—represents water that no longer percolates into the surficial aquifer.

It is thus likely that a rainfall amount on the order of 2 billion gallons per year (5.5 million gallons per day) no longer percolates into the surficial aquifer in the WHCOL watershed, and instead is now routed to the lakes via direct stormwater runoff. If redirected toward percolation, this amount would likely be

available to recharge the surficial aquifer. Water reintroduced into the surficial aquifer would then potentially recharge the adjacent lakes via groundwater seepage, or contribute to deeper aquifer recharge. Vegetation would also use a portion of this water for transpiration. In effect, reestablishing percolation and surficial aquifer recharge as the primary method for water to enter the WHCOL lakes could result in a less “flashy” system, where wet season inflows would be moderated, and dry season lake levels could be maintained at higher levels via increased groundwater seepage during periods of reduced rainfall.

LAKE	AREA (ACRES)	RUNOFF VOLUME (ACRE-FEET/YEAR)	RUNOFF VOLUME (MILLION GALLONS/YEAR)
Winterset	548	206	67
Eloise	1,163	533	174
Summit	64	98	32
Lulu	307	468	153
Roy	74	174	57
Shipp	277	584	190
May*	52	617	201
Howard	625	911	297
Cannon	328	640	208
Blue*	54	438	143
Mirror	126	175	57
Spring*	23	128	42
Idylwild	93	232	76
Jessie	186	521	170
Marianna	511	971	316
Hartridge	415	533	174
Average	303	452	147
Sum	4,846	7,229	2,357

Table A3. Summary of findings for the water budget for the WHCOL (from McCary and Ross, 2005) minus

Lakes Haines, Rochelle, Conine, Smart, and Fannie * Lakes with enough runoff that they “export” surface flows to adjacent lakes via interconnected canals.

Prior work has shown that the “Ridge-type” lakes of the WHCOL would benefit from higher water levels during the dry season (PBS&J, 2008). Additionally, routing water from surface water runoff into the surficial aquifer would allow for additional treatment of stormwater runoff via the filtration of particles, the absorption of phosphorus onto any carbonate sediments, and (potentially) nitrogen reduction via denitrification. A recent study in the WHCOL (PBS&J, 2009) showed that lake levels in Lake Haines fluctuated in correlation with the level of the surficial aquifer, but only when the surficial aquifer was at a higher elevation than the lake itself.

Combined, these findings suggest that maintaining higher water table levels in the WHCOL watershed could be a useful strategy for improving water quality via maintaining lake levels via groundwater seepage during the dry season and via the improved treatment of water during seepage through the soil itself (rather than direct discharge via runoff). The total quantity of stormwater runoff that could potentially be rerouted to percolation is estimated as close to 2 billion gallons a year.

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APPENDIX B

Estimate of Wetland Losses in the Peace Creek Watershed from Predevelopment to the Postdevelopment Condition Today

PHYSIOGRAPHIC REGION	HISTORICAL WETLANDS (HYDRIC SOILS, ACRES)	EXISTING WETLANDS (FLUCFCS, ACRES)	WETLAND LOSS (ACRES)	PERCENT CHANGE
Polk Uplands	29,587	20,606	-8,981	-30%
Winter Haven Ridge	3,835	2,895	-940	-25%
Total	33,422	23,501	-9,921	-30%

Sources: U.S. Department of Agriculture, Natural Resources Conservation Service soils map (hydric soils) Geographic Information System (GIS) coverage; Florida Land Use, Cover and Forms Classification System (FLUCFCS), Southwest Florida Water Management District 2006 land use GIS coverage.

APPENDIX C

Simulation Modeling of the Winter Haven Ridge and Polk Uplands —by Mark T. Brown, Ph.D., and David Pfahler, University of Florida

Introduction

Macroscopic mini-models are simulation models that are macroscopic in detail and small in complexity, so as to capture the behavior of relatively complex systems without resorting to large numbers of components and complicated mathematical equations to express relationships. The process of modeling in itself is a process of simplifying the complex, for a model represents a simplification of the systems that are being studied. Many simulation models, seeking to reproduce reality, strive for ever-greater complexity with the conviction that the more complex the model, the better it can predict the future.

A macroscopic mini-model, on the other hand, is an aggregation (not a simplification) of the real world designed to capture the fundamental nature of the system being studied, without the complexity. Macroscopic is the opposite of microscopic; thus the macroscopic model strives to grasp overall system behavior by considering the whole system rather than by trying to build understanding from the pieces up. Macroscopic modeling is sometimes called top-down modeling to draw attention to the idea that its perspective is that of an overview, blurring detail in favor of overall system behavior.

The models discussed in this appendix are macroscopic mini-models intended to explore and explain the behavior of the Peace Creek watershed's hydrologic system, rather than predict the future. Using past rainfall data and general relationships between surface water, the surficial aquifer, and the deep Floridan aquifer, the models explore how changes in several important parameters affect the overall behavior of the hydrologic system.

In the simulations, different parameters are varied, such as the area of impervious surface, storm-water discharges to the lakes, the lowering of surficial aquifer levels through drainage practices, and the lowering of the Floridan aquifer's potentiometric surface. Varying these parameters illustrates their effects on the overall system—for instance, the storage of water in lakes and aquifers—and provides better insight into the management implications of human actions.

The intent of the simulations is not to predict the future, but to learn from the models how human actions affect the hydrologic system. These macroscopic mini-models illustrate the effects of different management alternatives, thus highlighting in a more holistic manner the interconnections between the various parts of the hydrologic system and the effects of human activities. As a result, they help humans to make better management decisions.

Estimating the Flow and Storage of Water in the Winter Haven Southern Chain of Lakes

Historical Flows and Storage

Figure C.1 shows a systems diagram used to model the historical flows and storage in the Winter Haven Southern Chain of Lakes. Each of the pathways of water flow has been estimated. The values on the pathways are in billions of gallons per year, and the quantities in storage (the tanklike symbols) are in billions of gallons. The assumptions used to estimate the flows and storage are as follows:

Total area = 11,580 acres, including 300 acres of wetlands and 4,280 acres of lakes;

Annual average rainfall = 50.2 inches per year;

Average water depth in lakes = 8 feet overall;

Average water depth in wetlands = 1.5 feet overall;

Depth of surficial aquifer = 50 feet, with 40% porosity;

Runoff from uplands to lakes and wetlands = nonexistent in historical condition;

Evapotranspiration (ET) = 66% of rainfall overall;

Outflows from wetlands as percentage of inflows = 34% to lakes and 66% ET;

Outflows from lakes as percentage of inflows = 0% as surface outflow, 35% to Floridan aquifer, and 65% to evaporation;

Outflows from surficial aquifer as percentage of inflows = 23% to recharge of Floridan aquifer, 14% to recharge lakes, 56% as ET, and 7% as seepage;

Groundwater inflow = negligible, since Winter Haven Ridge is elevated recharge area.

Total rainfall over the 11,580-acre Southern Chain watershed area equals 15.8 billion gallons per year (average rainfall of 50.2 inches per year). Of the total rainfall, about 31% (4.9 billion gallons per year or 15.6 inches per year) is deep recharge of the Floridan aquifer. Outflow from the surficial aquifer toward the lower-lying Polk Uplands area is about 3% of rainfall (600 million gallons or 2 inches per year) and evapotranspiration accounts for approximately 66% of rainfall (10.3 billion gallons or 32.6 inches per year).

The diagram shows that the flow between the surficial aquifer and the lakes can change direction based on the relative amount of water stored in different parts of the system. If the surficial aquifer water level is higher than the lake water level, there is seepage into the lakes; if the surficial aquifer level drops below the lake water level, water leaks from the lakes into the surficial aquifer. The flow may be in different directions at different times of the year. In the model, the annual net flow is from the surficial aquifer into the lakes.

Current Flows and Storage

Figure C.2 is the same systems diagram, except that flows are changed to estimate the impacts of urbanization on the hydrologic system of the Southern Chain (the changes are shown in red). A summary of the changes is as follows:

Decrease in average lake storage = 16% (from 11.2 billion to 9.4 billion gallons/year);

Decrease in surficial aquifer storage = 16% overall (from 188.7 billion to 138.5 billion gallons/year);

Increased urbanization = 30% of rainfall falling on uplands flows directly into lakes;

Decreased surficial aquifer levels = 180% increase in infiltration from lakes to surficial aquifer; and

Regional drawdown of Floridan aquifer due to increased withdrawals = induced increase of 13% recharge from surficial aquifer.

The most notable effect is the decline in rainfall recharge of the surficial aquifer (from 9.5 billion to 7 billion gallons/year). Historically, little if any rainfall ran off the land surface into the lakes, but instead infiltrated into the surficial aquifer. Urbanization alters the imperviousness of the land surface (represented by the gray box in the center of the figure), increasing the surface water inflow into lakes and decreasing infiltration into the surficial aquifer. The net effect of this inflow has been to replace infiltration that would have entered the lakes from

the surficial aquifer; however, the surficial aquifer level continues to decline with time. It is estimated that seepage to the Polk Uplands may have decreased as a result of the lower surficial aquifer levels in the Southern Chain of Lakes area.

A regional drawdown of the Floridan aquifer over the last 50 years has increased the net recharge of the Floridan from the lakes by 41%. This is because the lakes are modeled as having a direct conduit to the Floridan aquifer. When levels in the Floridan aquifer drop, the head potential of the lakes increases, which increases recharge. While the water level of the Floridan aquifer is not explicitly modeled here, it should be noted that this increased recharge is likely not sufficient to compensate for the regional drawdown of the aquifer.

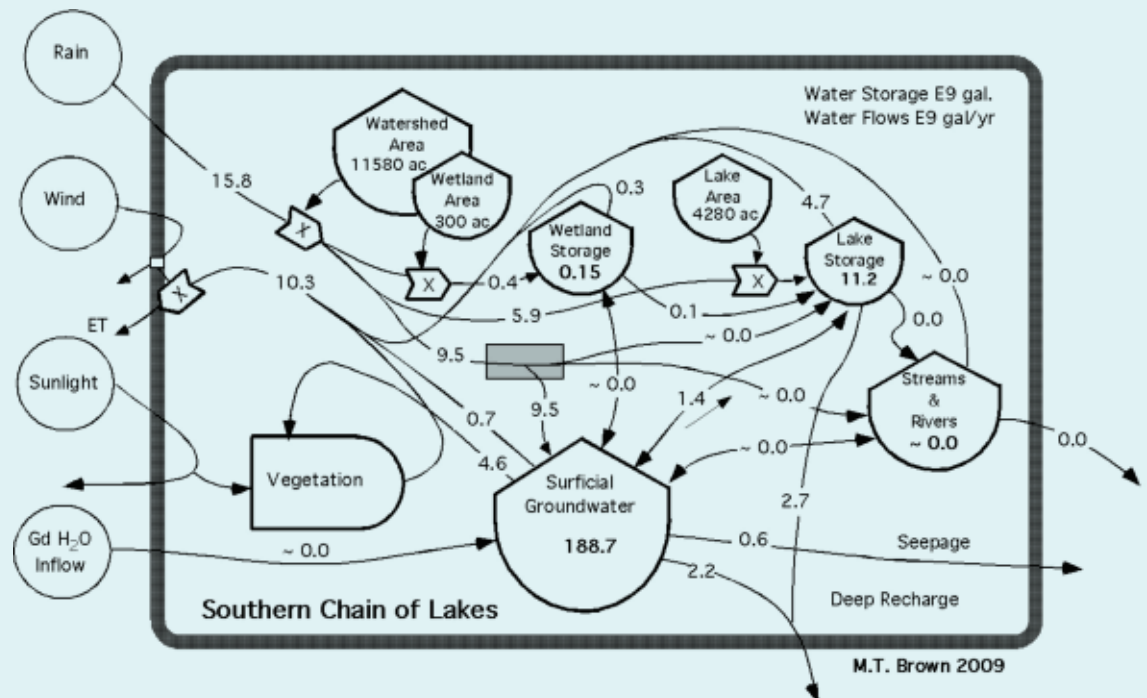


Figure C.1. System diagram of the Southern Chain of Lakes, showing the historical flows and storage of water in the system. Flows are in billions of gallons per year and storage is in billions of gallons.

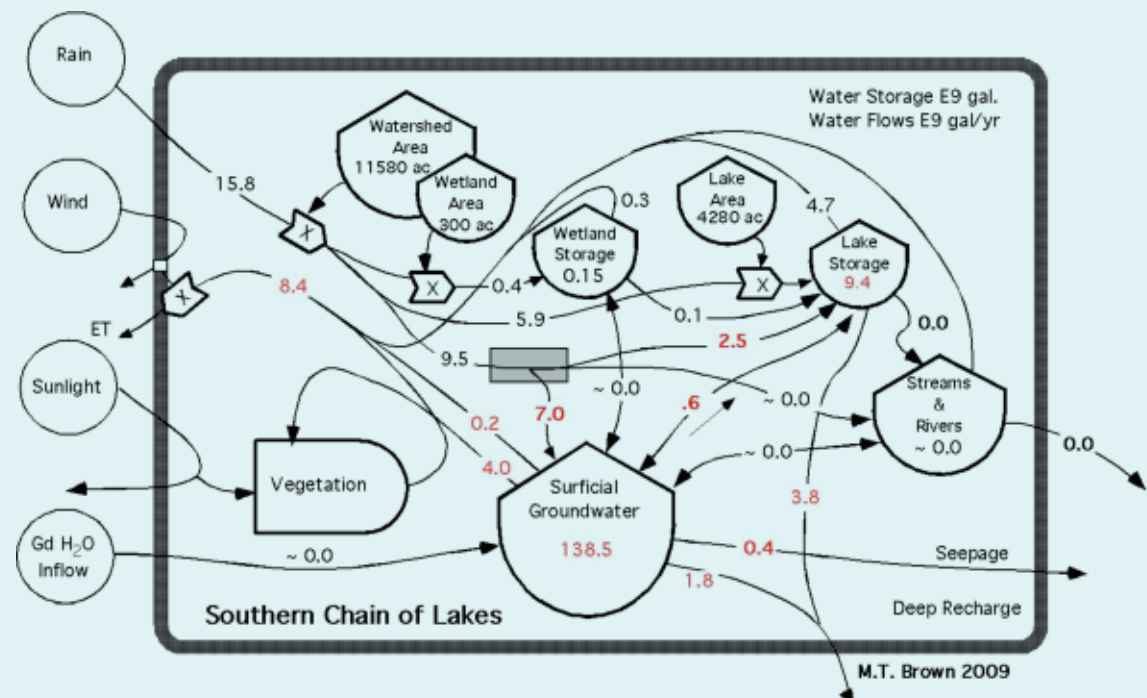
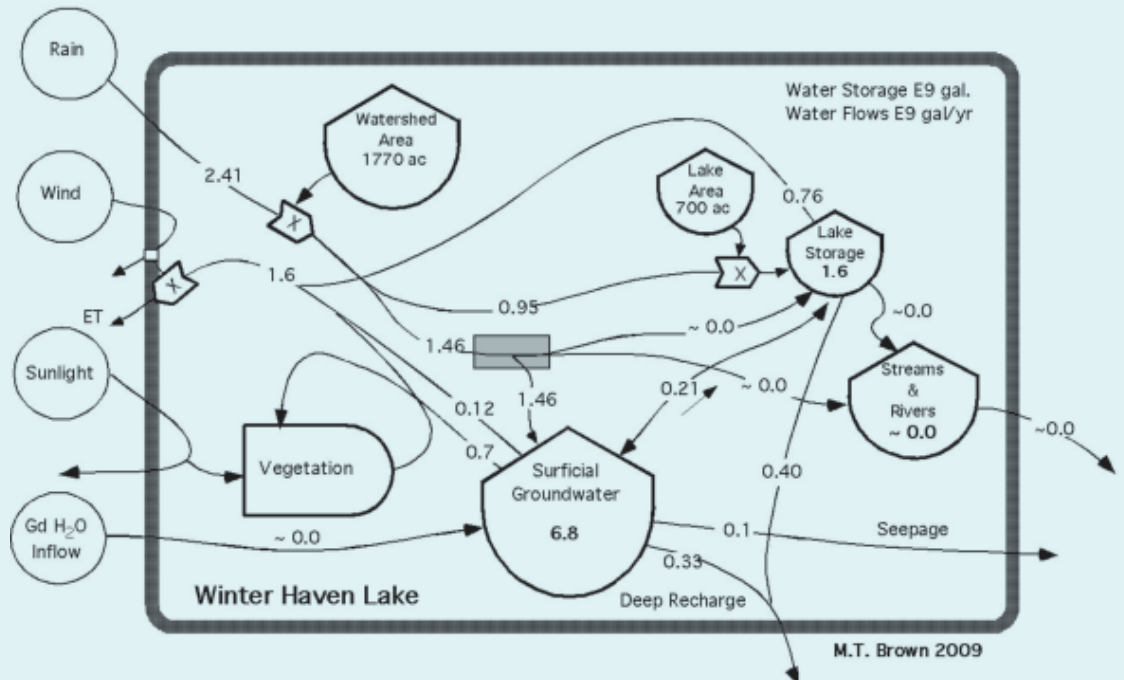


Figure C.2. System diagram of the Southern Chain of Lakes, showing the current flows and storage of water in the system. Flows are in billions of gallons per year and storage is in billions of gallons. The gray box in the center of the figure represents the imperviousness of the land surface, which increases with urbanization.

Figure C.3. Aggregated system diagram of historical water movement and storage in the Winter Haven Ridge Lake Model, showing the conceptual relationships between the amount of rainfall, the amount of water stored in lakes and surficial groundwater, and the amount of water leaving the system through evapotranspiration and surface flow. The model is calibrated for an "average lake" in the Southern Chain of Lakes. Flows are in billions of gallons per year and storage is in billions of gallons.



Simulation Models

To understand the factors affecting the integrated hydrologic system of the Winter Haven area, two hydrologic simulation models were undertaken that can be used to visualize the interconnected nature of this dynamic system and the net effects of historical alterations.

Simulation of the Winter Haven Ridge Lake Model

The Winter Haven Ridge Lake Model (*Figure C.3*) is a conceptual simulation model based on average historical conditions for lakes in the Winter Haven Ridge area. The system has been aggregated somewhat from the Southern Chain of Lakes diagram, and the wetlands component has been eliminated from the model to simplify the simulation parameters. The simulation model

does not represent any particular lake, but instead an average lake with a surrounding watershed.

The assumptions used in the model are as follows:

Total area = 1,770 acres, of which 700 acres is lake and 1,070 acres is watershed;

Annual average rainfall = 50.2 inches per year;

Water depth in lake = average 8 feet overall;

Depth of surficial aquifer = 50 feet, with 40% porosity;

Runoff from uplands to lakes = nonexistent in historical condition and increases to 50% in current condition;

ET = 66% of rainfall overall;

Outflows from lakes as percentage of inflows = 0% as surface outflow, 34% to Floridan aquifer, and 66% to evaporation;

Outflows from surficial aquifer as percentage of inflows = 23% to recharge of Floridan aquifer, 7% as lateral seepage, 56% as ET, and 14% recharge to the lake;

Groundwater inflow = negligible, since Winter Haven Ridge is elevated recharge area.

A main assumption of the model is that under historical conditions, there was no surface runoff into the lakes and the only water inputs to the lakes were rainfall and surficial aquifer seepage. The actual lake water level elevation is arbitrary, although it represents an elevation similar to that of Winter Haven's lakes (approximately 135 feet North American Vertical Datum [NAVD]).

The most important relationship is between lake level and surficial aquifer level (SAL). The model was calibrated with the SAL an average of 4 feet above the lake level. Seepage into and leakage out of the lake is driven by the difference between the relative elevations of the lake and SAL. When the elevation of the SAL is above that of the lake, seepage into the lake is driven by the difference in elevation times a soil conductivity coefficient. When the lake level is above that of the SAL, the recharge of the SAL is driven by the difference in elevation times the soil conductivity coefficient.

Both the lake and the surficial aquifer are affected by evaporation and transpiration (evapotranspiration). The model assumes that if the surficial aquifer is deeper than 4 feet from the surface, there is no evaporation. Recharge to the Floridan aquifer from the lake is driven by the head difference (or difference in elevation) multiplied by a seepage coefficient, which considers the rate at which water moves through different types of soil. When the potentiometric surface of the Floridan declines, the head difference increases, thus increasing recharge. The surface outflow elevation from the lake was set at 136 feet NAVD.

Figures C.4 and C.5 show the simulation results of the Winter Haven

North American Vertical Datum
A geodetic datum, or scientific system, such as NAVD measures elevation as accurately as possible using a specific reference coordinate—usually a tidal gauge along the ocean shore.

Ridge Lake Model using rainfall records for Winter Haven between 1941 and 2007.

First Simulation of Ridge Lake Model: Changes Due to Lowered Floridan Aquifer

The first simulation, *Figure C.4(a)*, assumes no development in the watershed and no decline in the Floridan aquifer during the period of record. This simulation serves as the “base condition” with which to compare the impacts on surficial aquifer and lake water levels and declines in the potentiometric surface of the Floridan.

Figure C.4 shows the elevation (NAVD) of the surficial and Floridan aquifers (left) and lake stage (right). In the base condition simulation, *Figure C.4(a)* (no declines in the Floridan aquifer), the surficial aquifer varies overall about 5 feet between its lowest level around 1956 and its highest level around 2004. Overall, lake levels average around 132 feet in elevation, varying between a low of 130 feet NAVD in 1956 and a high of 135 feet NAVD in 2004. All variation in aquifer and lake levels in this simulation is due to the variation in rainfall. It is interesting to note that the surficial aquifer rarely goes below 134 feet.

When the model is simulated incorporating declines in the Floridan aquifer beginning in 1950, shown in *Figure C.4(b)*, both surficial aquifer and lake levels decline. The dry years at the end of the simulation show precipitous declines in all water levels. By the end of the simulation in 2007, the Floridan is 11 feet

lower, and the surficial aquifer is 4 feet lower. The decline in lake levels is even more accentuated since the lakes act as conduits for water to reach the Floridan. Simulated lake levels drop between 5 and 6 feet. As shown in the next model, these dramatic impacts to lake levels have not been seen in current lake levels because of the mitigating effects of urbanization in the watershed. This model illustrates the importance of the Floridan aquifer in sustaining lake levels, particularly during dry periods with low rainfall, as seen at the end of the simulation between 2005 and 2007.

Second Simulation of Ridge Lake Model: Effects of Increased Stormwater Runoff due to Urbanization

The simulation results in *Figure C.5* illustrate the combined effects of a decline in the Floridan aquifer and increased urbanization of the watershed. The increased urbanization helps to mitigate the impact of the lowered potentiometric surface of the Floridan. In this model, stormwater is discharged from impervious surfaces directly to the lakes. This model represents the system as it exists today. *Figure C.5(a)* shows that lake levels are maintained higher than in the case of Floridan aquifer decline without urbanization, as shown in *Figure C.4(b)* on the previous page. This is because the lakes recharge to the aquifer more quickly than the surficial aquifer, and support a higher Floridan level. The runoff into the lakes helps to replenish the Floridan aquifer. Note that even the surficial aquifer level improves slightly in

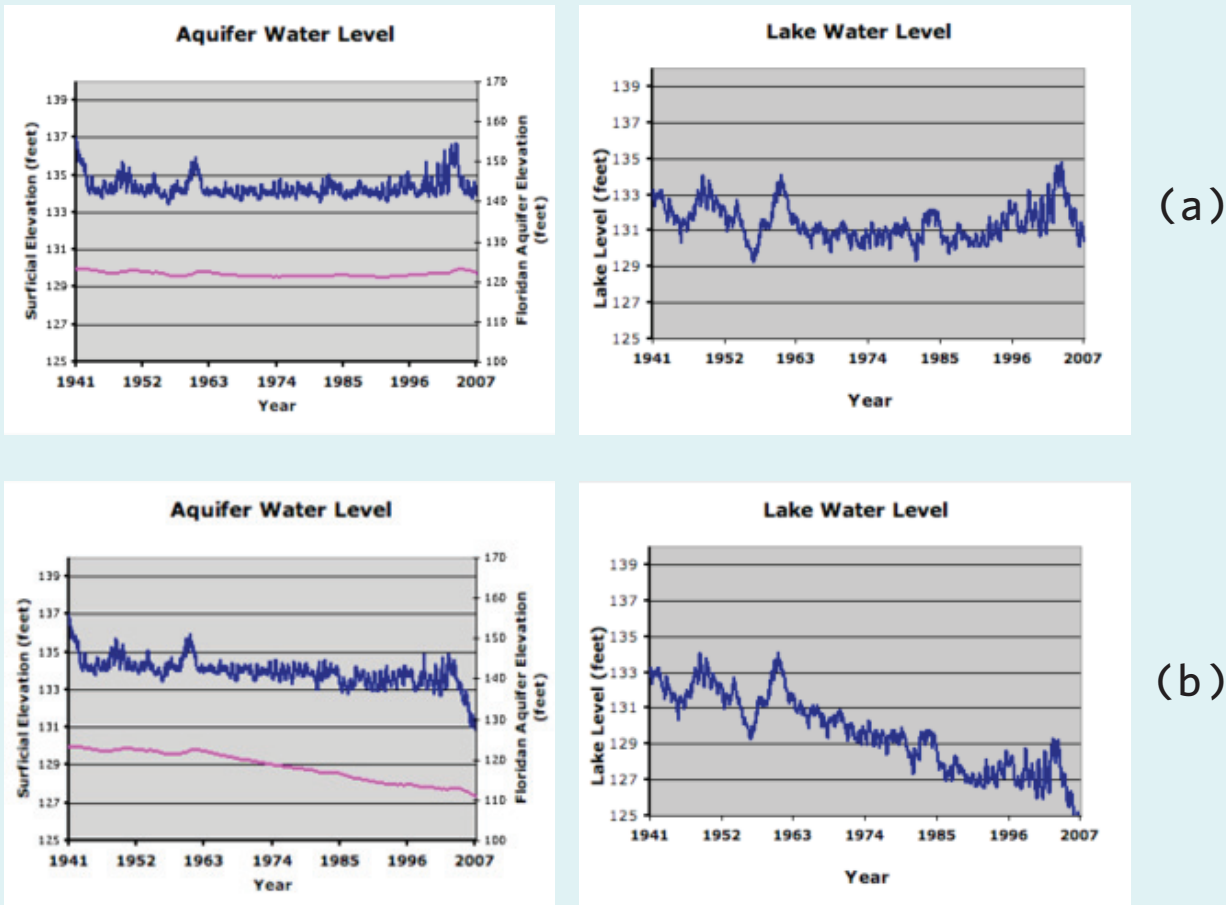


Figure C.4. Effects of the decline in the potentiometric surface of the Floridan aquifer. Simulation results of the Winter Haven Ridge Lake Model, showing the average elevation (NAVD) of the surficial aquifer (left) and lake level and lake discharge (right) from 1941 to 2007, assuming (a) no declines in the potentiometric surface of the Floridan aquifer, and (b) declines in the Floridan beginning in 1960, such that by 2007 it is lower by approximately 11 feet. With the decline in the Floridan (shown in the purple line on the left graphs), there is a significant decline in both the surficial aquifer and overall lake levels (see trend line).

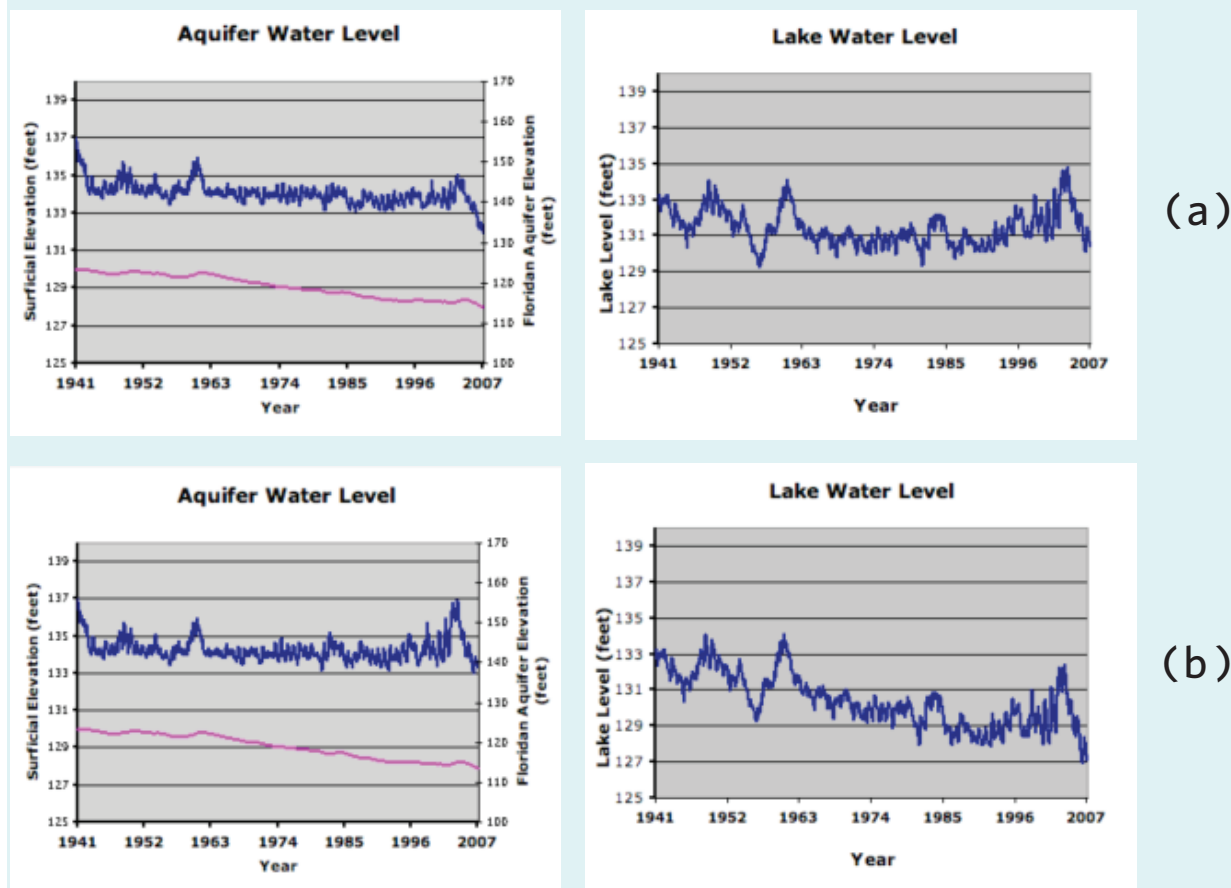
this scenario due to higher water levels in the Floridan than in *Figure C.4(b)*. Lake levels are maintained at acceptable levels up until the end of the simulation. The dry years of 2005 to 2007 continue to show a rapid drop in the surficial aquifer and lake levels. With little rain, there is not enough stormwater runoff to maintain the lake levels. The bottom pair of graphs, *Figure C.5(b)*, illustrates the effect of routing some stormwater to infiltration basins that increase recharge to the surficial aquifer, which in turn gradually

flows through groundwater seepage into lakes. This model shows that surficial aquifer levels do increase, exhibiting much healthier levels. However, there is a lowering of lake levels due to less direct stormwater runoff entering the lakes. The next set of simulations explore this effect in increased detail and show how under most circumstances, lake levels will improve over time.

While it appears that the net effect of routing stormwater to the lakes is higher water levels, it is important

to notice the precipitous declines in the surficial aquifer in the last 5 years of the simulation, as it is starved for recharge. The bottom two graphs show that the increased recharge from the infiltrated stormwater maintains higher surficial aquifer levels and gradually flows through groundwater and seeps into the lakes. Lake levels are slightly lower during dry periods as the lakes receive less stormwater runoff.

Figure C.5. Combined effects of lowered potentiometric surface and development. Simulation results of the Winter Haven Ridge Lake Model, showing the average elevation (NAVD) of the surficial and Floridan aquifers (left) and lake levels (right) from 1941 to 2007, assuming the combined effects of declines in the potentiometric surface of the Floridan aquifer starting in the 1950s and development increasing beginning in 1960 until the amount of impervious surface equals 60%. These simulations illustrate (a) the effects of stormwater runoff discharged directly into the lakes, and (b) the effects of stormwater routed to infiltration basins, rather than directly discharged to lake surface waters. While it appears that the net effect of routing stormwater to the lakes is higher water levels, it is important to notice the precipitous declines in the surficial aquifer in the last 5 years of the simulation, as it is starved for recharge. The bottom two graphs show that the increased recharge from the infiltrated stormwater maintains higher surficial aquifer levels and gradually flows through groundwater and seeps into the lakes. Lake levels are slightly lower during dry periods as they receive less stormwater runoff.



Third Simulation of Ridge Lake Model: Extending Results and Including Reuse Water

To highlight more recent trends, the graphs in *Figure C.6* show the last 10 years of the data record (1997 to 2007) and add an additional 10 years into the future (2007 to 2017) by reusing the same rainfall data from the previous 10 years. They show (a) the effects of development runoff discharging directly into the lakes, (b) the effects of using stormwater infiltration basins instead of direct discharge into the lakes

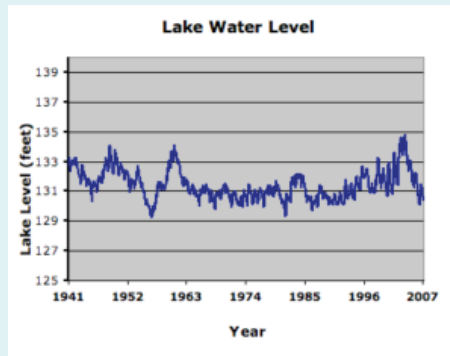
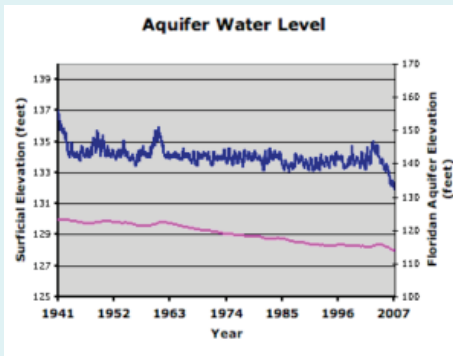
and, finally, (c) the effects of using stormwater basins and applying reuse water (highly treated wastewater effluent) to the landscape.

Figure C.6(a) shows the system with all stormwater directed into the lakes. The second half of the graph shows that after a dry period such as that seen from 2005 to 2007, neither the surficial aquifer nor the lake levels rebound to equivalent levels even though the rainfall used in the two periods is identical. Instead, surficial aquifer levels have

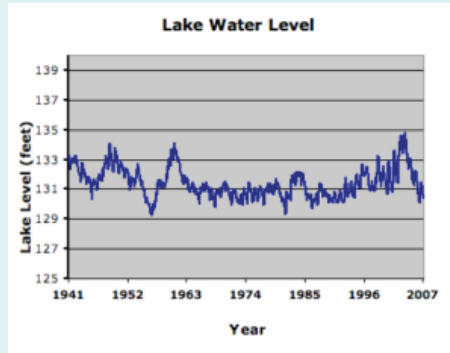
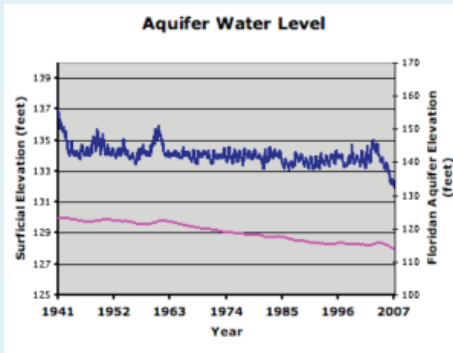
decreased by 1.5 feet, and lake levels have decreased by 2 feet.

Figure C.6(b) shows the system with a portion of the stormwater infiltrated into the aquifer. At the end of the second 10-year period, surficial aquifer levels have lost only 0.5 feet compared with the drop of 1.5 feet in the first 10 years. Lake levels have lost only 1 foot compared with the 2-foot drop in the first 10 years. Compared with *Figure C.6(a)*, lake levels are lower at the end of the first 10 years, but higher at the end

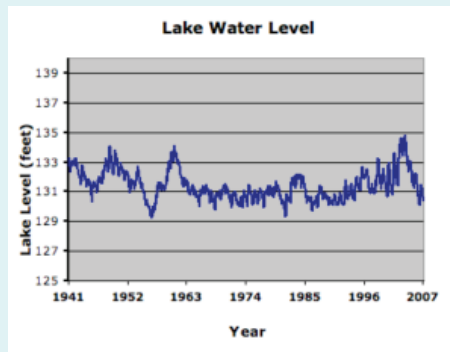
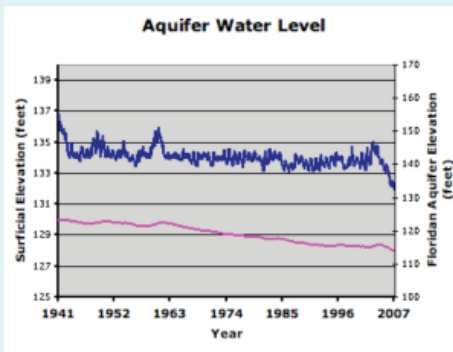
(a)



(b)



(c)



of the second 10-year period by 1 foot. This model suggests that increasing surficial aquifer levels by stormwater recharge will improve lake levels over the long term.

Figure C.6(c) shows the impact of further improving surficial aquifer levels by infiltrating reclaimed wastewater into the surficial aquifer, beginning in 2010. Surficial aquifer levels are brought back up to historical levels, and lake levels are improved by almost 2 feet. This simulation suggests that restoring

surficial aquifers with reclaimed water should be explored as a method to rebuild the sustainability of the Winter Haven lake system.

With the drier years beginning in 2005, the surficial aquifer declines precipitously and lake levels follow. The middle two graphs (b) illustrate the effect of stormwater infiltration basins and surficial aquifer recharge instead of direct discharge to the lakes. While the surficial aquifer still declines because of the low rainfall, the decline is not as steep and

Figure C.6. Evaluation of recent trends. Simulation results of the Winter Haven Ridge Lake Model, showing the average elevation (NAVD) of the surficial (blue line) and Floridan aquifers (pink line) (left) and lake levels (right) from 1997 to 2017, assuming declines in the potentiometric surface of the Floridan aquifer and urbanization increasing until the amount of impervious surface totals 60%. The simulation is driven by 10 years of actual rainfall data (from 1997 to 2007) that is repeated in the second 10 years of the simulation. The top two graphs (a) illustrate the current condition (i.e., stormwater discharged directly to the lakes). With the drier years beginning in 2005, the surficial aquifer declines precipitously and lake levels follow. The middle two graphs (b) illustrate the effect of stormwater infiltration basins and surficial aquifer recharge instead of direct discharge to the lakes. While the surficial aquifer still declines because of the low rainfall, the decline is not as steep and overall lake water levels are higher. In the bottom two graphs (c), not only is stormwater stored and recharged to the surficial aquifer instead of being directly discharged to the lakes, but 5 million gallons per day of wastewater is recycled to the landscape beginning in 2010. This has the significant effect of raising the surficial and Floridan aquifer levels and the net effect of higher lake water levels.

overall lake water levels are higher. In the bottom two graphs (c), not only is stormwater stored and recharged to the surficial aquifer instead of being directly discharged to the lakes, but 5 million gallons per day of wastewater is recycled to the landscape beginning in 2010. This has the significant effect of raising the surficial and Floridan aquifer levels and the net effect of higher lake water levels.

Winter Haven Ridge Lake Model: Summary of Simulation Results

These simulations are analogous to the overall situation in the Winter Haven Southern Chain of Lakes. Floridan aquifer levels have been declining over the past several decades as a result of both regional water use and withdrawals in the Peace Creek watershed area.

Simultaneously with the Floridan aquifer declines, the amount of impervious surface area has increased. While some of the newest development uses best management practices (BMPs) that reduce stormwater runoff, stormwater is discharged directly to the lakes from a significant portion of the urban area.

The simulations show that if some stormwater is used to recharge the surficial aquifer, this results in higher lake water levels in the long run—not to mention the water quality benefits that are derived through better treatment of these waters as they infiltrate through the sands of the surficial aquifer. Management of this system for high lake levels might require discharging directly to the lakes during low rainfall periods to maintain lake levels, and recharging the surficial aquifer during high rainfall periods to build a buffering reservoir that will generate higher lake levels during dry periods. If this water is infiltrated into the surficial aquifer, it becomes a storage reservoir that slowly recharges lake levels over a longer period, thus minimizing the water quality impacts of stormwater discharge to the lakes and providing

a buffering effect that allows the lakes to fluctuate naturally with the wet and dry seasons.

When the model is simulated to include the recycling of treated wastewater on the landscape, significant benefits are experienced in all three components of the Winter Haven hydrologic system: the surficial aquifer is maintained at a much higher level; the Floridan aquifer elevation improves; and lake water levels remain higher than they do with direct discharge.

The simulations are models of how we believe the Winter Haven system is operating. They are based on real rainfall data for Winter Haven, and are calibrated to records of lake levels measured over the last 20 years. The models have to assume relationships in flow rates between lakes and aquifers for which little or no data are available. These rates are average rates for the entire system, and they are chosen based on experience with similar hydrologic systems and reviews of past studies of the Winter Haven system. The simulations are best used to develop and test hypotheses about how changes to the system will affect lake and aquifer levels. They can be used to test management strategies and show which are the most promising based on a current understanding of the system. The models should be viewed as a synthesis of current knowledge, and not as actual measurements of flows within the system.

Simulation of the Polk Uplands Model

A simulation model of Polk Uplands (Storage and Conveyance Areas) was undertaken to determine whether increased storage within the landscape would positively affect downstream wetlands or baseflow to the Peace River.

The Polk Uplands is a broad, relatively flat basin, defined by the Winter Haven Ridge to the west and the Lake Wales Ridge to the east. The slope of the basin from the north near Lake Hamilton to the south at the Peace River is a very gradual 1.4 feet per mile. Historically, the Polk Uplands was dominated by shallow, expansive wetlands that fed wet season rains to slowly draining wetland sloughs, which in turn passed the waters on to Peace Creek and the Peace River.

The Polk Uplands is a landscape that historically acted as a storage reservoir, receiving wet season rains, temporarily storing them in the extensive area of wetlands (nearly 30% of the surface area), and then slowly releasing them over the next several months. The hydrologic system functioned to maintain water in wetlands and upland soils for long periods. The considerable friction that slows down the water meandering through wetland sloughs ensured that the landscape remained wet well into the dry season, and that baseflow to Peace Creek and eventually the Peace River was also maintained. Of course, as a result, the landscape remained flooded for long periods, rendering it unsuitable for agriculture or other forms of development.

The diagram in **Figure C.7** illustrates the hydrologic system of the Polk Uplands, with estimates of the average quantities of water stored in the surficial aquifer, wetlands, and Peace Creek, as well as average annual flows. The assumptions used to estimate flows and storage are as follows:

Total area = 78,750 acres, including 29,587 acres of wetlands and 800 acres of stream;

Annual average rainfall = 50.2 inches per year;

Water depth in wetlands = 2 feet;

Depth of surficial aquifer = 20 feet, with 40% porosity;

ET = 66% of rainfall;

Groundwater inflow = 5x inflow from Winter Haven Ridge based on linear distance of Lake Wales Ridge compared with Winter Haven Ridge;

Surface runoff = 23% of rainfall;

Wetland recharge of surficial aquifer = 12% input (from model);

Wetland surface discharge = input - (recharge + ET);

Recharge to surficial aquifer = rainfall - surface runoff;

Deep recharge = 10% of rainfall;

Evaporation from surficial aquifer = 5% of input;

Groundwater outflow = 2% of inflows;

Surficial aquifer discharge to surface water = inflows - outflow; and

Peace Creek discharge = sum of outflows from wetlands, surficial aquifer, and runoff.

To accommodate agriculture and other development, the Polk Uplands

was drained. Networks of ditches were dug, and Peace Creek was straightened and deepened. The result is illustrated in **Figure C.8**, which diagrams the estimates of the current hydrologic system. The flows that have changed are indicated in red. The assumptions used to estimate flows and storage are as follows:

Total area = 78,750 acres, including 20,600 acres of wetlands and 800 acres of channelized creek;

Annual average rainfall = 50.2 inches per year;

Water depth in wetlands = 2 feet;

Depth of surficial aquifer = 16 feet, with 40% porosity;

ET = 53% of rainfall;

Groundwater inflow = 5x inflow from Winter Haven Ridge based on linear distance of Lake Wales Ridge compared with Winter Haven Ridge;

Surface runoff = 32% of rainfall;

Wetland recharge of surficial aquifer = 17% of input;

Wetland surface discharge = input - (recharge + ET);

Recharge to surficial aquifer = rainfall - surface runoff;

Deep recharge = 8% of rainfall;

Evaporation from surficial aquifer = 5% of input;

Groundwater outflow = 2% of inflows;

Surficial aquifer discharge to surface water = inflows - outflow; and

Peace Creek discharge = sum of outflows from wetlands, surficial aquifer, and runoff.

The ditching and draining resulted in a decrease in wetland area of nearly 9,000 acres (a reduction of over 30%) that has led to a loss of about 6 billion gallons of wetland storage and declines in the surficial aquifer of nearly 10% (or a loss of about 21 billion gallons of storage). In all, the total loss of storage is estimated at about 27 billion gallons.

The loss of wetland and surficial aquifer storage, as well as ditching and draining, have increased surface runoff almost 70%, resulting in a 24% increase in Peace Creek discharge. While an increased discharge from Peace Creek might be viewed by some as a positive result, bear in mind that the timing of much of the increased discharge is not advantageous, as it comes when the creek and river need it the least. The models illustrate that during times of decreased average rainfall, the discharge can fall below historical trends because the flows are no longer buffered by storage in the wetlands and surficial aquifer.

This analysis indicates that the recharge to the Floridan aquifer has decreased by approximately 18% (from 11 billion to 9 billion gallons/year, or the equivalent of 5.4 million gallons per day) as a result of alterations to storage within the Peace Creek watershed. Historically, water stored in the wetlands and surficial aquifer was available to recharge the deeper Floridan aquifer. When water is drained from the system and discharged as surface water, this water is no longer available to recharge the Floridan aquifer.

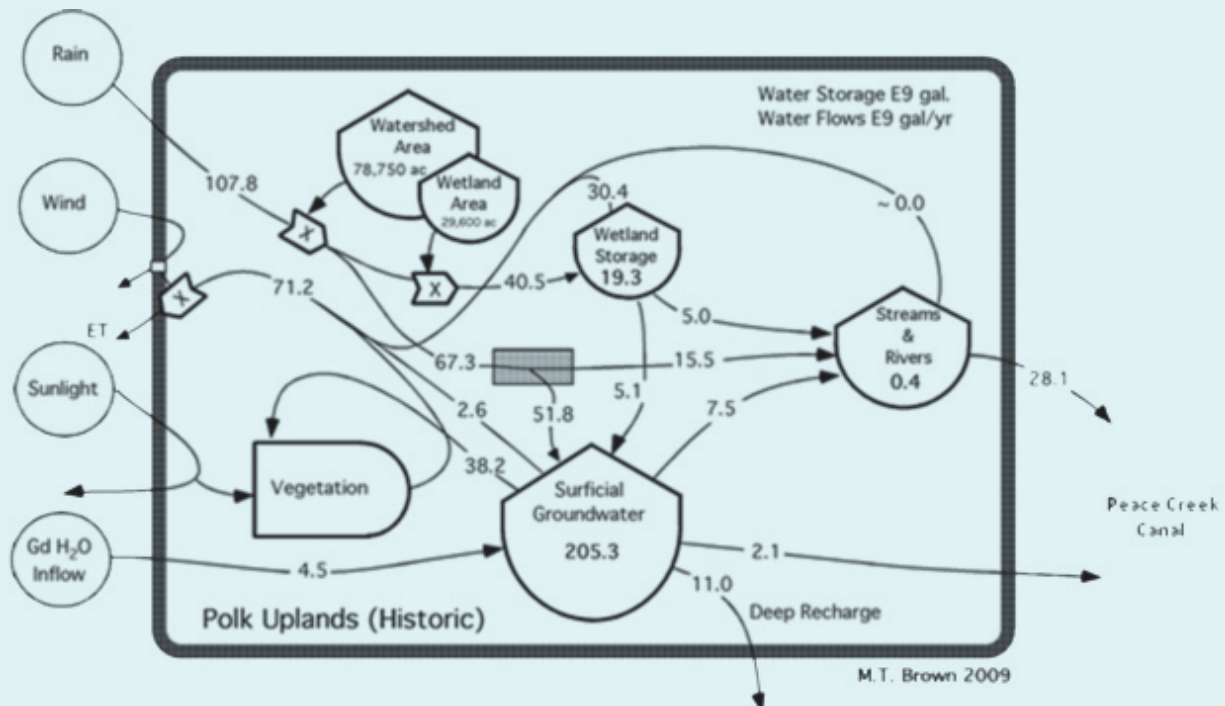


Figure C.7. Diagram of the historical hydrologic system of the Polk Uplands. Water storage is in billions of gallons and flows are in billions of gallons per year.

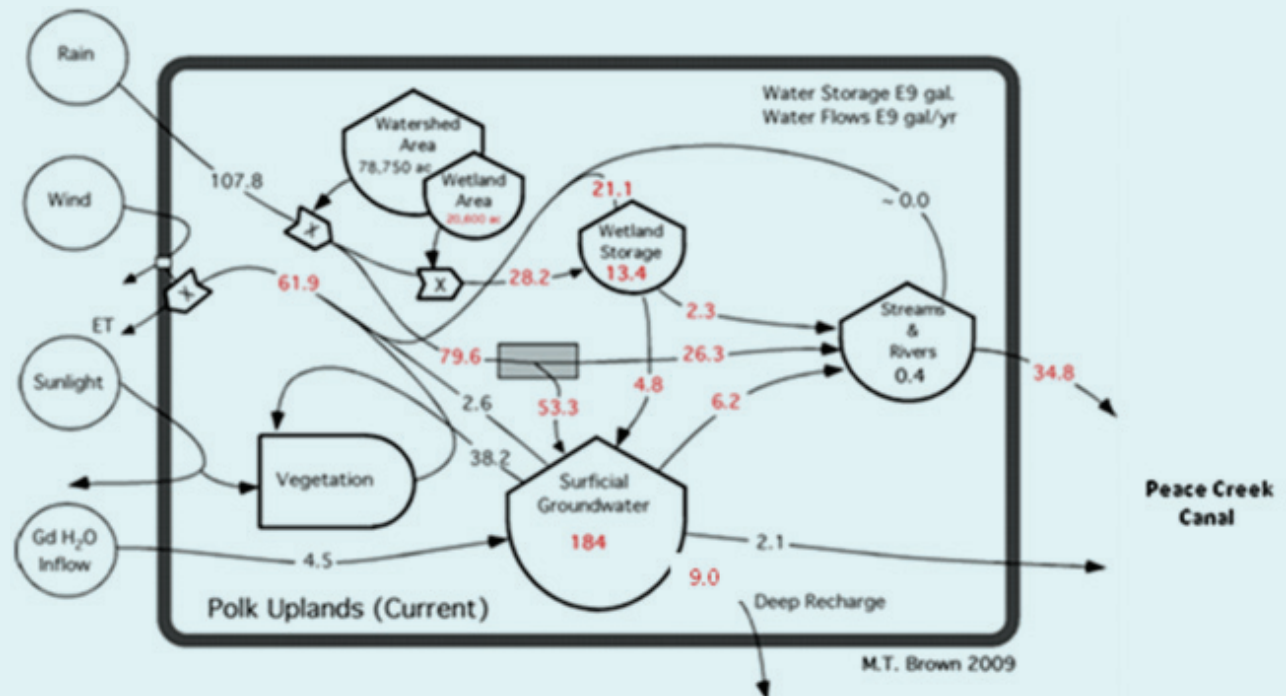


Figure C.8. Diagram of the current hydrologic system of the Polk Uplands. Water storage is in billions of gallons and flows are in billions of gallons per year.

To better illustrate the hydrodynamics of the system, a simulation model of the Polk Uplands was developed using the main storage and flows in *Figures C.7* and *C.8*. The model uses the entire rainfall record beginning in 1941 to the present. However, to illustrate the impacts of ditching and draining on the hydrologic behavior of the system, only the last 5 years of data (2002 to 2007) are presented. The graphs in *Figures C.9* and *C.10* show the simulation results from the model.

The results in *Figure C.9* depict the historical condition prior to development (using rainfall data from 2002 to 2007, but with all other coefficients and flows set to mimic historical conditions). It should be noted that these 5 years have a lower than average rainfall of 48.5 inches, almost 3 inches below the 50.2-inch average. The surficial aquifer shows a slight decline through the 5 years of the simulation as a result of the decrease in rainfall during that period. Wetland water levels also exhibit declines. The Peace Creek discharge follows rainfall patterns, with the highest discharges immediately following the rainy season. Baseflow in Peace Creek would have averaged about 100 cubic feet per second (or a total of about 64 million gallons per day).

The results in *Figure C.10* depict the current condition. The surficial aquifer has about 10% less storage as a result of the lowered water tables precipitated by the network of ditches and "improvements" to

Peace Creek. The effects on wetland storage and the Peace Creek discharge illustrated in the right-hand graph are far more dramatic. Wetland water levels decline so that there are longer periods of dry conditions, and Peace Creek discharges are significantly greater in number and higher in magnitude following rainfall events; both consequences will stress downstream ecosystems.

Also of importance is the large number of very low discharge periods, for without the buffering capacity of wetland storage and the friction of meandering wetland sloughs, stormwater is shunted toward the Peace River at times of the year when the river little needs the additional water. Once discharged during the wet season, stormwater is not available to feed and enhance baseflow during the dry season. Baseflow averages less than 50 cubic feet per second or less than 30 million gallons per day under current conditions in the simulation. While it appears as if the total discharge is larger than would have occurred under historical conditions, because there are many more peaks, overall discharge to the Peace River is actually 22% less than would have occurred historically.

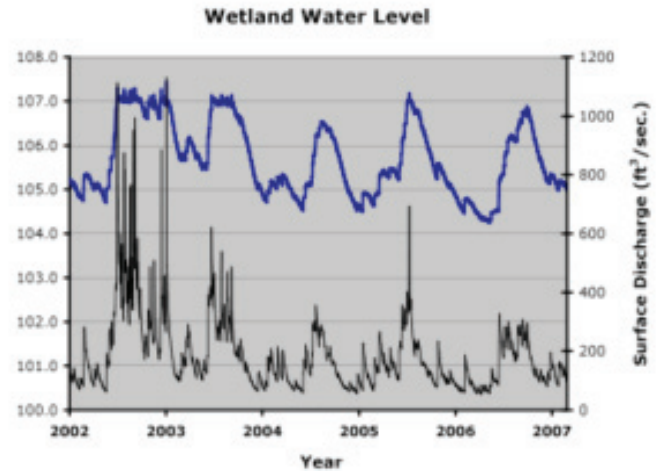
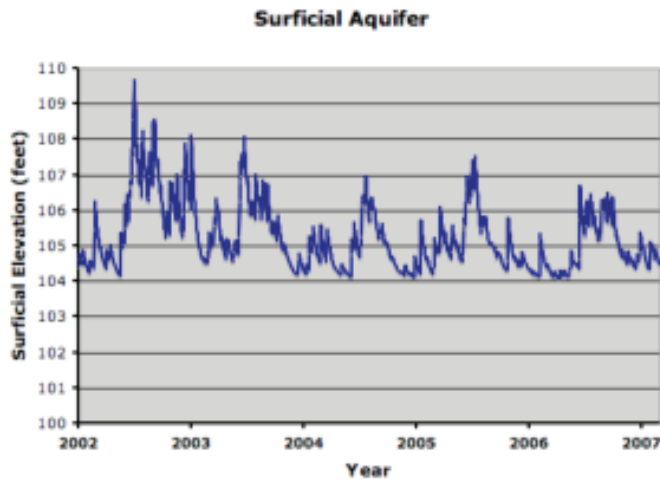


Figure C.9. Simulation results of the model depicted in **Figure C.7** (i.e., assuming historical conditions with no ditching and draining) for the period from 2002 to 2007. The graph on the left shows the water level of the surficial aquifer varying about 3 feet per year. The graphs on the right show the water levels in wetlands (top blue line) and Peace Creek discharges (bottom black line). Water levels in the wetlands vary about 2 feet between the wet season and dry season.

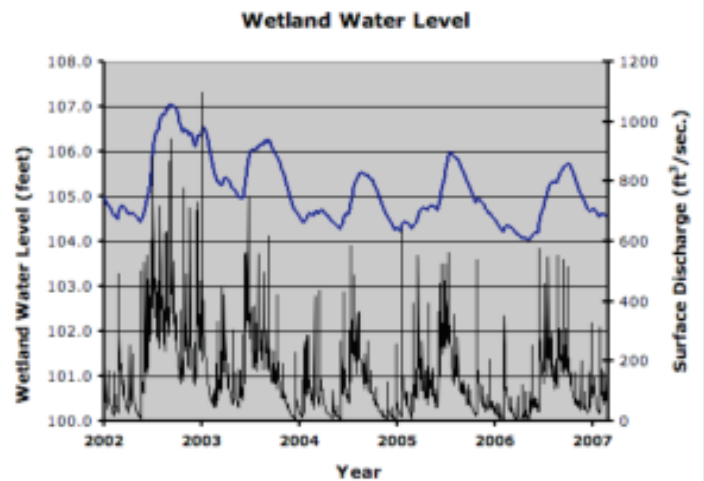
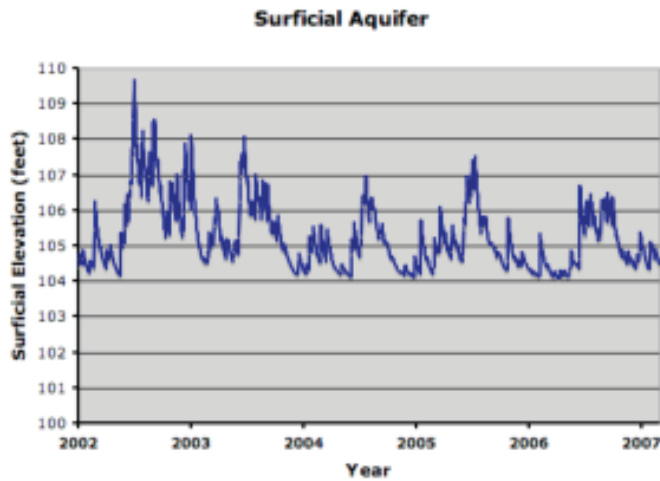


Figure C.10. Simulation results of the model depicted in **Figure C.8** (i.e., assuming current conditions) for the period from 2002 to 2007. The graph on the left shows the water level of the surficial aquifer varying about 2 1/2 feet per year. The graphs on the right show the water levels in wetlands (top blue line) and Peace Creek discharges (bottom black line). Water levels in the wetlands vary about 1 1/2 feet between the wet season and dry season.

**Polk Uplands Model:
Summary and Conclusion**

The future condition of the Polk Uplands, and ultimately the future of the Peace River, depend on two things: developing increased storage that mimics the historical condition, and dechannelizing Peace Creek (and other tributaries). These simulations were undertaken to demonstrate, first, the lost functions that have resulted from improper land and water management in the past and, second, that restoration can accomplish significant improvements. The magnitude of potential improvement is illustrated by comparing the historical condition with the current condition, and in essence reversing trends and conditions to those characteristic of the Polk Uplands 75 years ago.

Historically the watershed used to store vast amounts of water. Today, the watershed is managed to efficiently and effectively get rid of water for flood protection. Restoring parts of the watershed using the natural landscape can recreate lost storage and help contribute flows to the Peace River during the dry season and drought conditions, and help increase recharge to the Floridan aquifer.

APPENDIX D

Mitigation Banking

—by Ed Cronyn, Senior Scientist, PBS&J

Introduction

All human land uses—such as agricultural, industrial, commercial, and residential development—affect the movement and storage of water. Federal and state regulations seek to minimize or compensate for the impacts of those land uses through a process called mitigation. Mitigation means that the amount and type of lost hydrologic function must be calculated and then re-created somewhere else. Examples include mitigation for wetland losses, losses of habitat essential to threatened and endangered species, and impacts to riverine systems.

Historically, mitigation occurred on site; however, isolated mitigation projects resulted in the fragmentation of the hydrologic system. The cumulative impacts of many individual projects reduced the resilience of the natural system to act as a buffer against droughts and other environmental stresses, and often led to flooding. The U.S. Army Corps of Engineers (Corps) and state and local governments are now encouraging mitigation at a watershed scale, to ensure that water resources are preserved as part of a larger hydrologic system and to retain that system's essential hydrologic function. The *Sustainable Water Resource Management Plan* is consistent with current rules

that encourage the use of watershed-scale mitigation instead of on-site mitigation.

This appendix provides additional information on the basic concepts of mitigation banking, the mitigation banking process, regulatory criteria, financial considerations, the mitigation service area, and the ecological feasibility of the Winter Haven mitigation bank. It also summarizes the major tasks involved in assessing the feasibility of mitigation banking as the principal approach to funding the restoration of wetlands in the Peace Creek watershed.

The following summarizes conclusions regarding potential mitigation banking activities in the Peace Creek watershed:

- *Mitigation funding for the City of Winter Haven project is potentially available through two routes: mitigation banking and specific Southwest Florida Water Management District (SWFWMD) funding as a Surface Water Improvement and Management (SWIM) Program project to offset Florida Department of Transportation (FDOT) wetland impacts.*
- *Mitigation banking requires authorizations from the Corps (known as a Mitigation Banking Instrument) and SWFWMD (via the Environmental Resource Permit Program).*
- *The service area for mitigation banking would likely consist of the Peace River Basin.*
- *The SWFWMD could also create a "nested regional watershed" in the Peace River Basin. There is no precedent within SWFWMD for this designation. However, the St. Johns River Water Management District (SJRWMD), with identical statutory authority and nearly identical regulations, has established nested regional watersheds in that District.*
- *Funding as a mitigation bank would occur through the sale of mitigation credits, whose current market value is approximately \$125,000 per Uniform Mitigation Assessment Method (UMAM) credit. A UMAM credit represents approximately 2 acres of restoration/enhancement at a mitigation bank and offsets a little more than 1 1/2 acres of typical wetland impact.*
- *Funding as a SWFWMD-sponsored SWIM project would occur through a FDOT escrow fund, at a value of over \$100,000 per acre of FDOT wetland impact, translating to approximately \$167,000 per UMAM credit.*
- *CSX and/or other anticipated private and public projects within the Peace River Basin would be the customers for this mitigation bank.*

Basic Wetland Mitigation Banking Concepts

Mitigation Credits — The degree of improvement in ecological value expected to result from the establishment and operation of a mitigation bank, as determined using a functional assessment methodology (such as UMAM [Rule 62-345, Florida Administrative Code]). Functional assessment methods are used to establish the value of an improvement, representing units roughly equivalent to acres of fully successful wetland creation or restoration from uplands, which can then be sold to third parties who need to offset their own proposed impacts.

Mitigation Service Area (MSA) — The geographic region within which wetland impacts can be offset via the purchase of credits at the mitigation bank. SWFWMD has consistently authorized MSAs comprising solely the regional watershed within which the bank is located. **Figure D-1** shows the SWFWMD map of 16 regional watersheds (Exhibit 1 in its mitigation bank rule). However, impacts for linear projects such as roadways, pipelines, and utilities are not bound by the MSA; they may be mitigated at any mitigation bank with the appropriate type of credits.

Nested Regional Watershed — A watershed within a watershed, created for the purpose of concentrating mitigation in a smaller region than the larger regional watershed. To date, SWFWMD has not designated any nested regional watersheds. However, the SJRWMD, with identical statutory authority and regulations that are substantially equivalent to those of SWFWMD, has recognized five nested watersheds via the following notation on its adopted watersheds map:

NOTE FOR NESTED BASINS:
Basins 5, 6, 13, and 19 are designated as nested basins, which means that these areas are both individual basins and part of larger basins. The effect of this designation is that, for impacts that are outside of a nested area, but within the larger basin of which it is a part, mitigation within the nested area will be considered to be in the same drainage basin for cumulative impact review purposes. For impacts that are located within a nested area, mitigation that is located outside of the nested area but within the larger basin of which it is a part will be considered to be outside of the drainage basin for cumulative impact review purposes.

Credit Release Schedule — The timing of allowable credit sales, dependent on meeting the conditions established in the mitigation bank permit. Typically, around 10% of credits are available for sale after the bank receives the permit, records a conservation easement, and establishes the financial assurance mechanism (generally a bond or letter of credit guaranteeing that the authorized work will be performed). The remaining amounts are released in phases upon the completion of construction activities (such as weir construction and scrapedown/vertical relocation), the removal of exotic/invasive plants, the planting of native species, and the achievement of a certain percentage of coverage by appropriate native vegetation.

Uniform Mitigation Assessment Method (UMAM) — A procedure adopted by rule and binding on the Florida Department of Environmental Protection (FDEP), water management districts, and local regulatory agencies that require wetland mitigation. UMAM evaluates three ecological parameters—location/landscape position, water environment (water quality and hydrology), and community structure (vegetation and contours)—at two points in time: "existing condition" before the bank is implemented, and "with bank" anticipated conditions upon the successful completion of restoration activities.

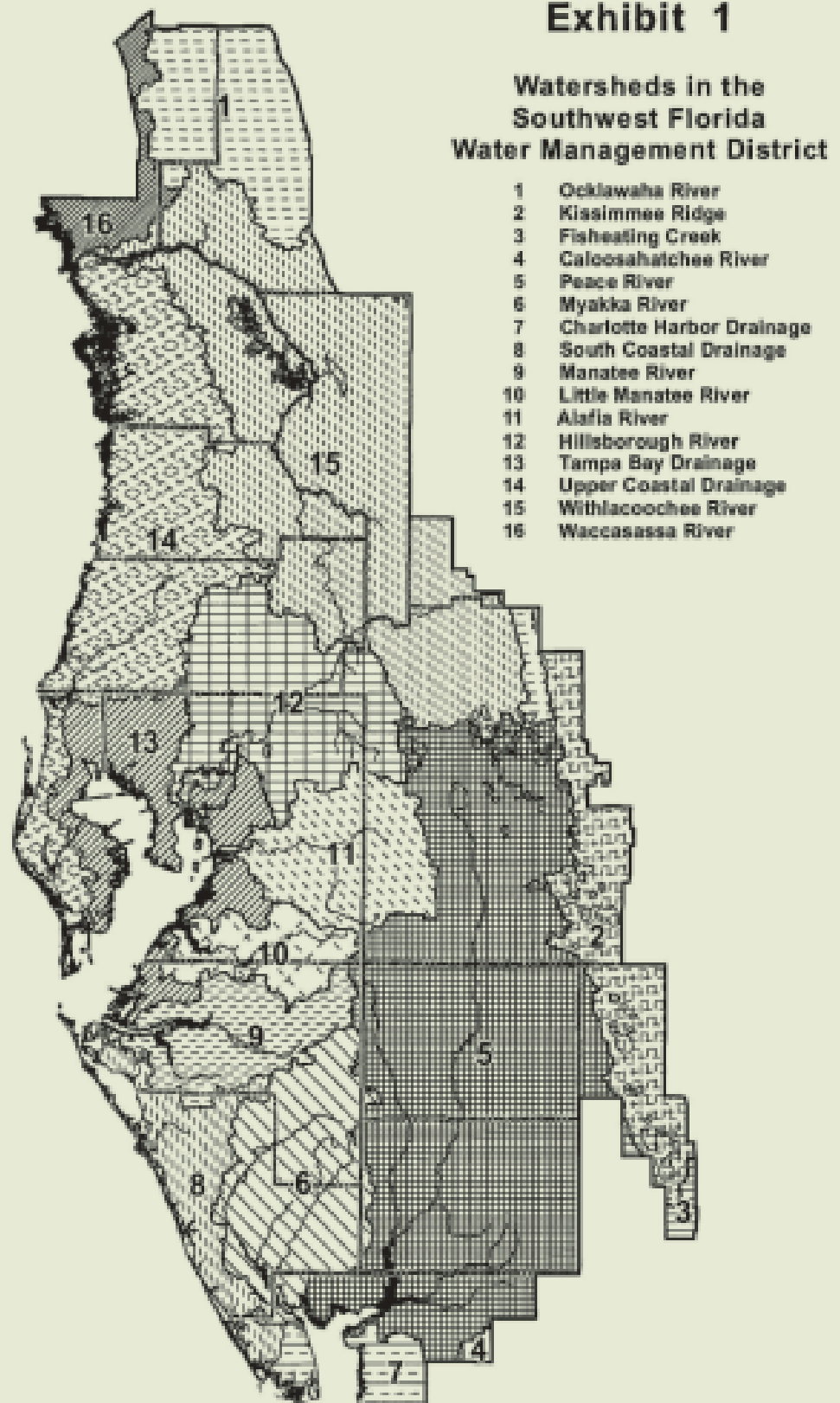
To determine the "existing condition" score, these 3 parameters are each scored on a scale of 0 to 10, and then averaged together and divided by 10 to arrive at a score between 0 and 1. This score is then subtracted from the "with bank" condition score to arrive at a "delta," representing the amount of ecological improvement. The "delta" is then adjusted by 2 additional factors to account for the amount of time necessary to achieve full restoration and the degree of risk involved. All of the ecological parameters, time

lag, and risk factors are assigned according to criteria established in the UMAM rule, as interpreted by the reasonable professional judgment of the reviewing agency.

For example, a hypothetical 1,000-acre proposed mitigation bank site has a current UMAM value of 0.3 per acre (that is, a low, degraded ecological condition). The property owner proposes a restoration plan that will result in an eventual UMAM value of 0.8 per acre (a very good but not perfect ecological condition).

The "delta" in this case is 0.5 UMAM units per acre (0.8 minus 0.3). However, because a moderate amount of time is necessary for the hydrology, vegetation, and soils to achieve restoration goals (a UMAM score of 0.8), and because there is a risk that the project will not achieve this score, the adjusted "delta" reflecting time and risk becomes 0.4 per acre. This mitigation bank can sell a total of 400 credits (0.4 times 1,000 acres), assuming that the criteria laid out in the permit are met.

Figure D.1.
SWFWMD map of regional watersheds



Mitigation Banking Process

The basic process for obtaining a mitigation bank permit is as follows (Figure D.2 provides a flow chart):

1. Conduct a Feasibility Assessment

Interested landowners generally hire an experienced mitigation banking consultant to conduct a feasibility study before determining whether to proceed with a mitigation bank permit application. The feasibility study includes a review of the site's suitability from the following perspectives:

- **Ecological** (approximately how much UMAM improvement can be reasonably expected);
- **Technical** (various engineering, construction, and hydrologic constraints);
- **Financial** (the amount, value, and timing of credits to be sold versus the cost of the restoration plan and other reasonable and beneficial land uses); and
- **Regulatory** (the compatibility of the restoration plan with state and federal regulatory criteria).

2. Regulatory Process

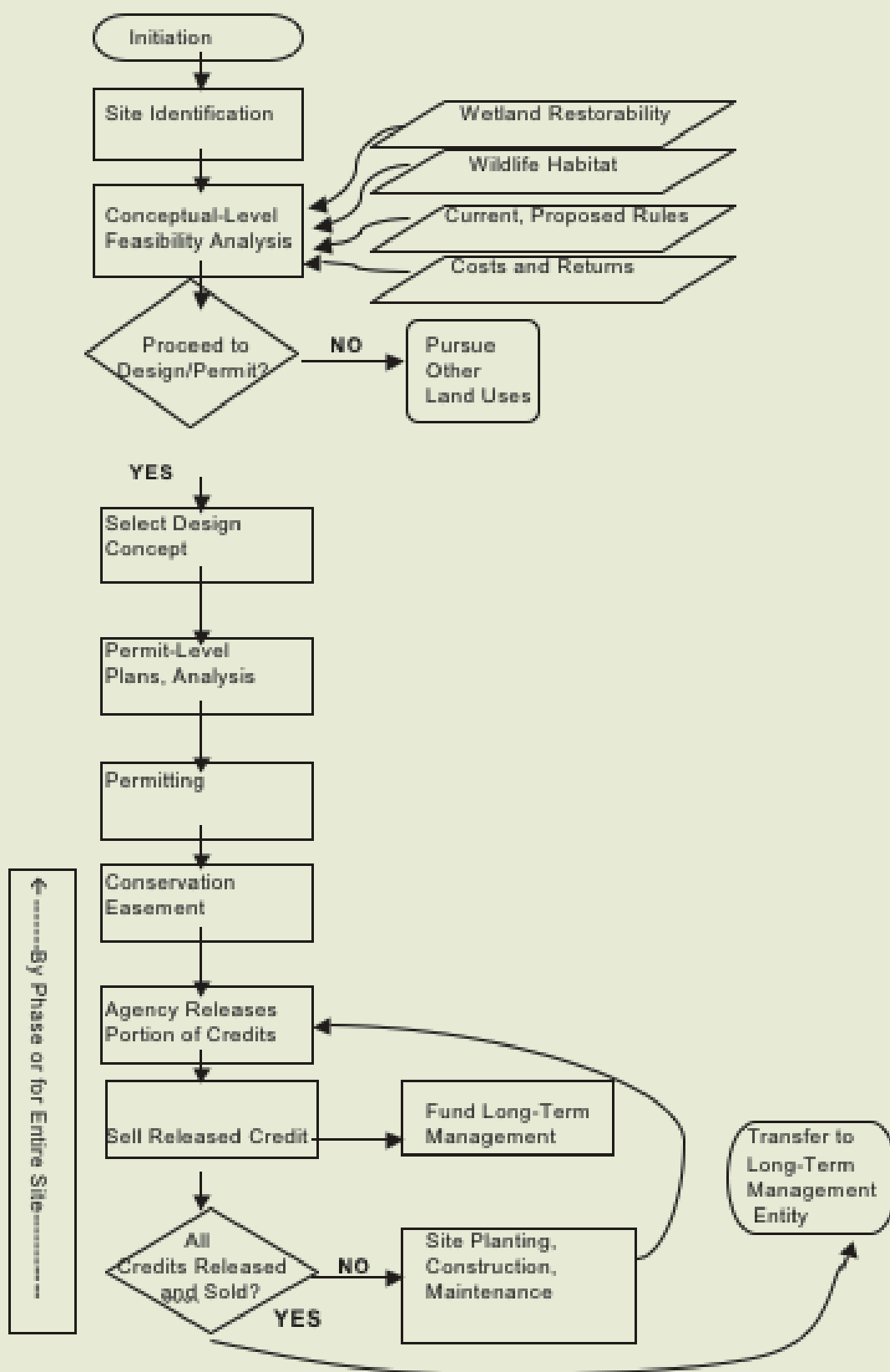
Two agencies have primary authority for reviewing and authorizing mitigation banks—the Corps for the federal government and the appropriate water management district for the state of Florida. FDEP only reviews and issues a state permit if a water management district sponsors or owns the project. The Corps also consults other federal and state agencies in a forum known as the Interagency Review Team (IRT). Federal agencies typically participating in the IRT include the Corps, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. Department of Agriculture's Natural Resources Conservation Service, and occasionally the National Oceanic and Atmospheric Administration's National Marine Fisheries Service.

Mitigation bankers usually conduct one or more preapplication meetings with state and federal agencies. The IRT, convened by the Corps, is one forum for this discussion to occur. The purpose of the preapplication discussion is to identify the agencies' perspective on the overall mitigation banking concept, service area, and restoration plan, as well as any particular issues of concern that should be resolved during the permitting process. Failure to obtain IRT approval before an application is submitted to the Corps generally results in a difficult process.

Federal Application Process

The federal process consists of the following four steps:

- **Development of the prospectus, or preliminary mitigation banking instrument (PMBI)** — Provides basic summary information for presentation to the IRT.
- **Preparation of the Draft MBI** — Contains all the information necessary to demonstrate consistency with federal regulatory criteria, credit assessment, MSA, etc. The submittal of this document initiates the federal review process.
- **Receipt of letters and responses** — This process often takes a year, during which the Corps and mitigation bank applicant fine-tune the MBI.
- **Preparation of the final MBI** — Prepared by the applicant in response to comments and adopted by the Corps.

Figure D.2. *Mitigation bank process*

State Application Process

The state agency—either the water management district or FDEP—reviews mitigation bank permit applications within the same process and timelines as required by any other Environmental Resource Permit. State agencies (water management districts, Florida Fish and Wildlife Conservation Commission) are encouraged to participate in the federal IRT to ensure that this forum includes all agencies' comments, but their participation is not required.

The state process is similar to the federal process, except that agency review timelines are mandated, so that the state process is often completed months in advance of the federal. The applicant submits an Environmental Resource Permit application for a mitigation bank, and the agency reviews and comments on the application, until the application is deemed complete and approved. A state agency may award a different amount of credits than the federal agency, due to differences in regulations and the interpretation of UMAM.

Operation and Management

- Credits released in phases according to criteria in the federal MBI and state permit;
- Mitigation banker implements restoration plan to achieve additional releases;
- Marketing and sales of credits to applicants requiring mitigation for state and/or federal wetland impacts (two different ledgers—one for the state, one for the federal);

- Ongoing maintenance activities for compliance with permit;
- Portion of proceeds from credit sales is directed into long-term management fund;
- Landowner (if not a government or nonprofit conservation organization) turns land over to a long-term management entity (government or nonprofit conservation organization) along with the management funds.

Regulatory Criteria

The state and federal criteria are substantially similar, although the process and outcomes may differ. One important difference is the new federal emphasis on watershed-level mitigation and concomitant de-emphasis on on-site mitigation. State rules still emphasize on-site or nearby mitigation, but practices and policies have become more favorable to the use of mitigation banks due to the relatively poor success rate of many on-site mitigation projects.

Federal (33 CFR Parts 325 and 332; 40 CFR Part 230)

- Emphasizes watershed planning: "Watershed plan means a plan developed by federal, tribal, state, and/or local government agencies or appropriate non-governmental organizations, in consultation with relevant stakeholders, for the specific goal of aquatic resource restoration, establishment, enhancement, and preservation";

- Twelve fundamental components of all mitigation plans:
 - Objectives
 - Site selection
 - Site protection instrument (conservation easement)
 - Baseline information
 - Determination of credits (UMAM)
 - Mitigation workplan
 - Maintenance plan
 - Performance standards
 - Monitoring requirements
 - Long-term management plan
 - Adaptive management plan
 - Financial assurances (bond/letter of credit/trust fund)
- "Soft" preference for mitigation banks vs. other forms of mitigation;
- Commitment (but not hard-and-fast requirement) to review mitigation banks within timelines;
- IRT review, with dispute resolution process;
- Umbrella mitigation banking instrument allows multiple sites to be authorized with one instrument.

State Mitigation Bank Statute (373.4136, F.S.)

Must provide reasonable assurance that the mitigation bank will do the following:

- Improve ecological conditions of the regional watershed;

- Provide viable and sustainable ecological and hydrologic functions for the proposed mitigation service area;
 - Be effectively managed in perpetuity;
 - Not destroy areas with high ecological value;
 - Achieve mitigation success;
 - Be located adjacent to lands that will not adversely affect the perpetual viability of the mitigation bank due to unsuitable land uses or conditions;
 - Meet regulatory requirements for any constructed, operated, or abandoned surface water management system;
 - Have sufficient legal or equitable interest in the property to ensure perpetual protection and management of the land;
 - Meet the financial responsibility requirements prescribed for mitigation banks.
- The water management districts each annually update a plan to provide mitigation for FDOT's mitigation needs within their jurisdictional boundaries, in consultation with FDEP, Corps, and other agencies;
 - SWIM and other projects defined by the districts via their annual FDOT workplan are implemented, using the escrowed funds;
 - FDOT cost for this is currently over \$100,000 per acre of impact;
 - FDOT may opt out of the FDEP/ water management district program on a project-by-project basis if approved by FDEP and the district; the South Florida Water Management District is the only district that routinely authorizes this opt-out.

Financial Considerations

- Complexity of permitting often requires substantial up-front investment for design and permitting; these costs should be estimated and budgeted accordingly;
- The length of the permitting process, plus the pre-permit preparation and discussions, may mean a waiting period of several years between the time of initial concept and the sale of the first credit;
- UMAM credits currently sell for about \$125,000 to \$145,000 in central Florida;
- Sale of credits depends on development;
- Upcoming development includes CSX project: should include this and other known/anticipated development in market demand projections.

Mitigation Service Area

- Peace River Basin is one of the largest watersheds in SWFWMD—this is good for a broad market area, but also represents large areas where competing mitigation banks can be established (including an existing Peace River Mitigation Bank operated by EarthBalance).
- A nested regional watershed as defined by SJRWMD establishes a potential precedent for SWFWMD to establish a nested regional watershed for the Peace Creek watershed; this would add value to mitigation credits sold for projects within this smaller watershed.

Ecological Feasibility of Winter Haven Project

- The proposed project anticipates improvements to hydrology, water quality, connectivity, and vegetation of the wetlands;
- Anticipate UMAM credits equivalent to approximately 0.4 to 0.6 UMAM credits per acre, based on similar mitigation bank projects (e.g., 1,000 acres would generate 400 to 600 credits);
- Presenting this as a single, cohesive mitigation bank would improve the regulatory feasibility (rather than as several individual parcels, each permitted separately);
- Improvements should be geared towards eventual self-sustaining wetland systems (e.g., not requiring pumps, operable weirs, etc.).

FDOT/FDEP/WMD Work Plan (373.4137, F.S.)

Provides an alternative for FDOT mitigation that does not use mitigation banks:

- FDOT and certain other transportation authorities annually submit a three-year work plan, indicating estimated wetland impacts and mitigation needs;
- FDOT and other authorities each fund an escrow account to pay for the estimated mitigation needs, updated quarterly;

Proposed Scope of Work— Feasibility of Mitigation Banking

The feasibility of mitigation banking or FDOT/SWFWMD mitigation funding for this project relies on several factors. The following plan summarizes the major tasks involved in mitigation feasibility assessment for this project.

Task 1: Conceptual Restoration Plan(s)

This task flows directly from the work completed to date for the City of Winter Haven and would include specific conceptual-level plans for restoring wetlands, including improvements in the hydrology and vegetation resulting from those plans.

Task 2: Ecological Feasibility

This task would include review of the information already gathered, the conceptual restoration plans, Geographic Information System (GIS) and other data sources, and additional data gathered through site visits. This baseline ecological data assessment provides the necessary understanding of the existing condition of the sites in order to better determine which restoration concepts are most likely to be successful. A key element of the ecological feasibility assessment will be ballpark estimation of achievable UMAM mitigation credits under each of the conceptual restoration plans.

Task 3: Technical Feasibility

This task complements Tasks 2 and 3 by reviewing the conceptual restoration plans from engineering,

hydrologic, and constructability perspectives. Key elements will include evaluation of various design elements to determine whether they can be constructed using readily available materials and techniques, whether they will result in measurable improvements in wetland hydrology, and whether they would result in adverse changes in flood protection of other property.

Task 4: Financial Feasibility

This task consists of two basic functions: (1) estimation of design, permitting, construction, and operation costs associated with the conceptual restoration plans, in parallel with Tasks 1 through 3, as well as marketing and land management; and (2) estimation of the return on investment, including anticipated market value, timing of demand, and amount of mitigation credit sales. These ballpark estimates of costs and returns will help to further refine the selection of one or more restoration conceptual plans for further development.

Estimates of the market value and future demand for mitigation credits are typically based on review of recent and long-term trends in wetland impacts within the mitigation service area (e.g., SWFWMD and FDEP permitting databases); known public and private developments in the planning stages (e.g., CSX Intermodal project, highway projects, etc.); Realtors' and economists' projections of future growth; local governments' comprehensive plans; and known and anticipated mitigation alternatives

(e.g., the Boran Ranch and Peace River Mitigation Banks operated by EarthBalance). Currently, the Boran Ranch Mitigation Bank has 50 to 60 mitigation credits available to offset impacts to herbaceous wetlands, at a cost of \$97,000 per credit. The Peace River Mitigation Bank has over 100 credits available to offset impacts to forested wetlands, at a cost of \$149,000 per credit. As indicated above, each credit offsets impacts to slightly less than 2 acres of typical wetland impact. Mitigation charges for FDOT projects via the SWFWMD mitigation program are currently slightly more than \$100,000 per acre of wetland impact, with future increases or decreases pegged to the Consumer Price Index.

Finally, this task includes evaluation of public-private partnership opportunities. Publicly owned banks are typically designed, permitted, operated, and marketed by private consultants. In some cases, the consultant provides some of these services at a limited or no up-front charge, with their fees paid as a percentage of mitigation credit sales.

Task 5: Regulatory Feasibility

This task includes review of the degree to which the proposed wetland restoration plans are consistent with the mitigation banking criteria summarized above and/or the FDOT/SWFWMD mitigation program.

One component of particular importance for mitigation banking is the possibility for SWFWMD to designate the Peace Creek watershed

as a "nested regional watershed" within the larger Peace River Basin. SJRWMD and SWFWMD have nearly identical rules regarding mitigation bank service areas. However, SJRWMD recognizes five nested regional watersheds within their District and SWFWMD has none. Recognition of the Peace Creek basin as a nested regional watershed would simply require a revision to SWFWMD map of regional watersheds (see *Figure D.1*) to add the boundaries of the Peace Creek watershed and a footnote within that map denoting that basin as a nested regional watershed, similar to language used by SJRWMD in their map of regional watersheds. If successful, the designation of a nested regional watershed would provide significantly greater value to the credits generated by banks within the nested basin. Banks within nested regional watersheds in SJRWMD charge twice as much per credit as other banks within the same larger regional watershed but outside the nested regional watershed.

State statute also requires publicly owned mitigation banks to charge "full cost" for mitigation bank credits, meaning that the price needs to generate a net profit for the land-owning government agency, including the value of the land. The intent of this statutory provision is to avoid a public "subsidy" that would enable a government agency to undercut the price charged by private mitigation banks by using free public lands already owned by taxpayers. Other states have enacted provisions outright prohibiting publicly sponsored

mitigation banks, so regulatory feasibility assessment also needs to include the analysis of the likelihood and severity of the effect of potential legislation.

Another option, substantially similar to mitigation banking, would be to pursue a permit for a portion or the entire restoration plan as a "regional off-site mitigation area." This option entails the development of a phased mitigation plan, implemented on a pay-as-you-go basis from credit sales. State and federal statutory requirements for a regional offsite mitigation area are increasingly identical to those for a mitigation bank, such that there is no tangible benefit to pursue this approach rather than a mitigation bank.

Evaluation of one or more projects' compatibility with the FDOT/SWFWMD mitigation program, as an alternative to traditional mitigation banking, would focus on FDOT's need for mitigation in the Peace River Basin and SWFWMD's interest in designating one or more projects for this purpose via their SWIM Program. One notable limitation on use of the SWIM Program is that the lands must be publicly owned. Therefore, private lands would not be eligible unless the mitigation plan includes public acquisition of those lands.

Task 6: Alternative and Emerging Markets

This task includes evaluation of markets other than wetland mitigation. One currently available opportunity is the sale of credits based on improvements to

endangered species' habitat. In Florida, endangered species' credits have included panthers, scrub jays, sand skinks, gopher tortoises, and wood storks. Additional rules that are currently under development will provide other market opportunities. Ongoing development of rules and criteria for Total Maximum Daily Loads, a statewide water quality trading rule, and a statewide stormwater quality rule all provide potential market opportunities if the project will reduce nutrient loads to downstream waterbodies.

As implemented for the Lower St. Johns River Basin and in other states, water quality trading allows landowners within the same basin to buy and sell water quality credits representing reductions in nutrient loadings. There is no statutory prohibition on using a single parcel of land to provide multiple forms of mitigation credits (e.g., wetlands, endangered species, and water quality). However, to date, the common practice preferred by regulatory agencies and adopted by most mitigation bankers is to modify their wetland mitigation bank permit to delete any acreage that is used for other mitigation purposes.

Task 7: Selection of Concept for Design and Permitting

This task consists of a comprehensive analysis of the results from the first six tasks, to determine which conceptual plan(s), if any, provide(s) the greatest opportunities for design and permitting as a mitigation bank and/or FDOT/SWFWMD mitigation program. At this stage, it may

be necessary to develop additional details to more accurately project costs and return on investment, such as a pro forma projecting the costs and revenues for a 10-year period.

Recommendations for Directing the Location of and Funding for Restoration Activities

- 1. All hydrologic impacts from development should be mitigated in the Peace Creek watershed. To accomplish this goal, the water management district would need to identify the Peace Creek watershed as a nested regional watershed within the larger Peace River Basin.*
- 2. The City of Winter Haven should seek to have the district identify the Peace Creek watershed—specifically the areas identified in the conceptual plan—as the receiving areas for mitigating FDOT wetland impacts, and possibly impacts from the larger Peace River Basin.*
- 3. The state could also identify the Peace Creek watershed as a receiving area for other impacts throughout the Peace River Basin as a pilot program for implementing watershed-scale restoration. Other impacts and the mitigation of those impacts could be directed to the Peace Creek watershed, as part of restoring the headwaters of the Peace River Basin.*
- 4. Next, the value of that bank and that opportunity should be evaluated to determine how many acres and million dollars of credit are available in the Peace Creek watershed.*

Evaluating the Feasibility of Mitigation Banking

Interested landowners generally hire an experienced mitigation banking consultant to conduct a feasibility study before determining whether to apply for a mitigation bank permit or FDOT/SWFWMD mitigation funding. The study evaluates the suitability of the mitigation site from a number of perspectives, including the following:

- *The degree of ecological improvement that can be reasonably expected;*
- *Technical issues such as engineering, construction, and hydrology;*
- *Financial issues, such as the amount, value, and timing of credits to be sold versus the cost of the restoration plan and other reasonable and beneficial land uses; and*
- *Regulatory issues, such as the compatibility of the restoration plan with state and federal regulatory criteria.*

The following major steps are recommended to evaluate whether to use mitigation banking or FDOT/SWFWMD mitigation funding for restoration work:

1. Develop Specific Conceptual Restoration Plan(s)

The restoration plan(s) would be based on the *Sustainable Water Resource Management Plan* prepared for the City of Winter Haven, and would include specific, conceptual-level plans for restoring wetlands, including improvements in hydrology, water quality, connectivity, and

wetland vegetation anticipated from those plans.

2. Evaluate Ecological Feasibility

The information already gathered, the conceptual restoration plans, GIS and other data sources, and additional data gathered through site visits would be reviewed. This baseline assessment provides a detailed understanding of the existing condition of the sites to better determine which restoration approaches are most likely to succeed. A key element of this assessment is a general estimate of achievable mitigation credits under each of the conceptual restoration plans.

3. Evaluate Technical Feasibility

The conceptual restoration plans would be reviewed from the perspectives of engineering, hydrology, and construction. Key elements include evaluating various design elements to determine whether they can be constructed using readily available materials and techniques, whether they will measurably improve wetland hydrology, and whether they will adversely affect flood protection on other property. Restoration activities should focus on wetland systems that are self-sustaining and low maintenance, and that do not require pumps, operable weirs, or other equipment and structures.

4. Evaluate Financial Feasibility

In parallel with the steps listed above, the design, permitting, construction, and operation costs associated with the conceptual restoration plans

would be evaluated, as well as marketing and land management issues. The amount of return on investment, including anticipated market value, the timing of demand, and the amount of mitigation credit sales would also be calculated. These general projections of costs and returns help to refine the selection of one or more conceptual restoration plans for further development.

The complexity of permitting often requires a substantial up-front investment for design and permitting. These costs should be estimated and budgeted for accordingly. Also, the length of the permitting process, plus the pre-permit preparation and discussions, may require a waiting period of several years between the initial concept and the sale of the first credit.

UMAM credits currently sell for between \$125,000 and \$145,000 in central Florida. The sale of credits depends on development. Market demand projections should include known and anticipated future development, including the proposed CSX intermodal facility. Based on similar mitigation bank projects, UMAM credits equivalent to approximately 0.4 to 0.6 credits per acre are anticipated—that is, 1,000 acres would generate 400 to 600 credits.

Finally, public-private partnership opportunities would be evaluated. Publicly owned mitigation banks are typically designed, permitted, operated, and marketed by private consultants. In some cases, the consultant provides some of these

services at a limited or no up-front charge, with fees paid as a percentage of mitigation credit sales.

5. Evaluate Regulatory Feasibility

The degree to which the proposed wetland restoration plans are consistent with mitigation banking criteria and/or FDOT/SWFWMD mitigation funding would be evaluated. Carrying out the restoration work using a single, cohesive mitigation bank improves regulatory feasibility (rather than as several individual parcels, each permitted separately).

One particularly important issue for mitigation banking is the possibility of designating the Peace Creek watershed as a "nested regional watershed" within the larger Peace River Basin. SJRWMD and SWFWMD have nearly identical rules on mitigation banking service areas. However, SJRWMD recognizes five nested regional watersheds, and SWFWMD has none. Recognizing the Peace Creek watershed as a nested regional watershed would simply require the SWFWMD to revise its map of regional watersheds.

If successful, this designation would significantly add to the value of the credits generated by mitigation banks in the nested watershed. Mitigation banks in nested regional watersheds in SJRWMD charge twice as much per credit as other banks within the same larger regional watershed but outside the nested regional watershed.

State statute also requires publicly owned mitigation banks to charge "full cost" for mitigation bank credits, meaning that the price needs to generate a net profit for the land-owning governmental agency, including the value of the land. This avoids a public "subsidy" that would enable an agency to undercut the price charged by private mitigation banks by using free public lands already owned by taxpayers. Other states have enacted provisions prohibiting publicly sponsored mitigation banks, and thus the regulatory feasibility assessment also needs to include an analysis of the likelihood and severity of the effect of potential legislation.

Another option that should be evaluated, which is similar to mitigation banking, is pursuing a permit for part of or for the entire restoration plan as a "regional off-site mitigation area." This entails the development of a phased mitigation plan, implemented on a pay-as-you-go basis from credit sales. Generally, however, state and federal statutory requirements for a regional offsite mitigation area are increasingly identical to those for a mitigation bank, so that there is no tangible benefit to pursue this approach rather than a mitigation bank.

Evaluation of one or more projects' compatibility with the FDOT/SWFWMD mitigation program, as an alternative to traditional mitigation banking, would focus on FDOT's need for mitigation in the Peace River Basin and SWFWMD's interest in designating one or more projects for this purpose via its SWIM Program. One important limitation on use of

the SWIM Program is that the lands must be publicly owned. Private lands would not be eligible unless the mitigation plan includes the public acquisition of those lands.

6. Evaluate Alternative and Emerging Markets

Markets other than wetland mitigation would be evaluated. One currently available opportunity is the sale of credits based on improvements to endangered species' habitat. In Florida, these credits have included panthers, scrub jays, sand skinks, gopher tortoises, and wood storks. Additional rules currently under development will provide other market opportunities. Ongoing development of rules and criteria for Total Maximum Daily Loads, a statewide water quality trading rule, and a statewide stormwater quality rule all provide potential market opportunities if the project will reduce nutrient loads to downstream waterbodies. As implemented for the Lower St. Johns River Basin and in other states, water quality trading allows landowners in the same basin to buy and sell water quality credits representing reductions in

nutrient loadings. There is no statutory prohibition on using a single parcel of land to provide multiple forms of mitigation credits (e.g., wetlands, endangered species, and water quality). However, to date, the common practice preferred by regulatory agencies and adopted by most mitigation bankers is to modify their wetland mitigation bank permit to delete any acreage that is used for other mitigation purposes.

7. Select Concept for Design and Permitting

The results from the first six steps would be comprehensively analyzed to determine which conceptual plan(s), if any, provide(s) the greatest opportunities for design and permitting as a mitigation bank and/or an FDOT/SWFWMD mitigation program. At this stage, it may be necessary to develop additional details to more accurately project costs and return on investment, such as a pro forma projecting the costs and revenues for a 10-year period.

APPENDIX E

State Regulations on Reuse —by Cheryl Wapnick, Senior Scientist, PBS&J

Indirect aquifer recharge involves the application of reclaimed water to an unsaturated ground surface, so that it will be treated as it flows through the plant-soil matrix before infiltrating through the surficial aquifer and eventually reaching the upper Floridan aquifer. Current methods for indirect recharge include, but are not limited to, the following:

1. *Sprayfields/irrigation—slow rate land application;*
2. *Rapid infiltration basins (RIBs)—percolation ponds;*
3. *Unlined storage ponds—evaporation or storage ponds;*
4. *Discharge to percolation wetlands—treatment wetlands; and*
5. *Vadose wells—wells in the non-saturated part of the subsurface (Montgomery Watson Harza [MWH], 2009).*

Summary of Relevant Regulations

The Florida Administrative Code (F.A.C.) describes the permitting requirements for reclaimed water recharge projects. More specifically, Rule 62-610, F.A.C., addresses the primary regulations for the reuse of reclaimed water and land application. Key elements of the

regulations for each type of reuse are summarized below, along with specific issues that should be considered by the City of Winter Haven. Although setback distances are described for potable water wells and surface waters, additional regulations may also apply.

Slow-Rate Land Application Systems—Restricted Public Access

Slow-rate land application systems generally involve the use of reclaimed water that has received, at a minimum, secondary treatment and basic disinfection. Subsurface application systems can also be used, but must be designed and operated to prevent saturated conditions on the land surface. The design application rate is typically less than 2 inches per week annual average, depending on specific site characteristics regarding the ability of the plant-soil system to remove pollutants (Florida Department of Environmental Protection [FDEP], 2004).

These systems must also meet an additional Total Suspended Solids (TSS) criterion of no more than 10 milligrams per liter (mg/L) at all times, unless FDEP approves alternative control measures to ensure that clogging will be prevented. A 500-foot setback is required from the edge of the reclaimed water application area to

existing or approved potable water supply wells, as well as Class I and Class II surface waters. Setback distances for Class I waters can be reduced to 200 feet if the facility reliability requirements specified in Subsection 62-610.462(1), F.A.C., are met, and to 100 feet if high-level disinfection is also provided.

In general, facilities that provide high-level disinfection should be designed to result in reclaimed water or effluent in which 75% of fecal coliform values over a 30-day period are below detectable limits in 100 milliliters (mL) of a sample; any single sample should not exceed 25 fecal coliform values per 100 mL. Prior to disinfection, effluent should have a TSS of no more than 5.0 mg/L.

In cases where chlorine is used for disinfection, a total chlorine residual of at least 1.0 mg/L should always be maintained, and contact times must be at least 15 minutes at the peak hourly flow. More specific regulations on total chlorine residuals and contact times are outlined in Subsection 62-600.440(c), F.A.C., for new or expanded wastewater treatment facilities (WWTFs) that use chlorine for disinfection. Due to the possible harmful effects of chlorine for disinfecting wastewater, FDEP encourages the use of

alternative methods of disinfection (e.g., ultraviolet light). Criteria for establishing disinfection resulting from these alternative methods that demonstrate the appropriate microbiological criteria and that provide reasonable assurance public health is protected should be provided by the permittee.

Considerations for the City of Winter Haven in implementing slow-rate land application systems without public access include the following:

- *Determining surface area requirements;*
- *Determining the extent of the confining unit for subsurface application (its thickness increases from north to south);*
- *Restricting application during rainfall to prevent ground saturation and ponding;*
- *Establishing setbacks based on transmissivity rates; and*
- *Reducing total nitrogen (TN) in applied reclaimed water to 10.0 mg/L (FDEP recommendation) in areas with a thin confining unit or high leakage to lakes.*

Slow-Rate Land Application Systems—Public Access Areas

Because of public health considerations, the regulations for slow-rate land application systems in public access areas such as golf courses, residential areas, parks, and agricultural areas growing edible crops are more stringent than for nonaccessible areas. For example,

preapplication water must meet, at a minimum, secondary treatment and high-level disinfection levels and should not contain over 5.0 mg/L TSS before the application of the disinfectant. Filtration should also be provided to control TSS levels.

As treatment standards are higher for sites with public access, setback distances are considerably lower than for application sites without public access. For public access sites, a minimum 75-foot setback distance is required from the edge of the wetted areas of the application site to existing or approved potable water wells. There are no setback requirements for surface waters.

Considerations for the City of Winter Haven in implementing slow-rate land application systems with public access include the following:

- *Determining surface area requirements;*
- *Determining the extent of the confining unit for subsurface application (thickness increases from north to south);*
- *Restricting application during rainfall to prevent ground saturation and ponding;*
- *Restricting use through agreements with local users or by local ordinance;*
- *Preserving public health and providing public education;*

- *Not allowing use to be controlled by any one user (because demand often exceeds supply in dry times, volumetric rate schedules should be implemented for users to achieve more effective and efficient use of reclaimed water);*
- *Determining setbacks based on transmissivity rates; and*
- *Reducing TN in applied reclaimed water to 10.0 mg/L (FDEP recommendation) in areas with a thin confining unit or high leakage to lakes.*

Rapid-Rate Land Application Systems

Rule 62-610, F.A.C., also covers rapid-rate land application systems, including RIBs and absorption fields. The use of RIBs involves spreading reclaimed water in a system of basins or percolation ponds that may have subsurface drains below them. The percolation area must be divided into at least 2 basins so that alternate loading and resting can be achieved.

Subsurface absorption fields are used to apply large volumes of domestic reclaimed water at high application rates. As with RIBs, these systems are designed so that alternate loading and resting can occur without disrupting the application process.

Application rates for both systems may be as high as 9 inches per day annual average. Because these systems provide limited treatment, these projects must meet ground water criteria at the edge of the

zone of discharge. At a minimum, the preapplication reclaimed water must meet secondary treatment and basic disinfection levels.

In general, facilities providing basic disinfection should be designed to result in no more than a monthly mean of 200 fecal coliform values per 100 mL of reclaimed water or effluent sample in an annual period. In addition, no more than 10% of samples collected during a 30-day period should exceed 400 fecal coliform values per 100 mL, and any single sample should not exceed 800 fecal coliform values per 100 mL. If chlorine is used for disinfection, at least 0.5 mg/L total chlorine residual should be maintained after at least 15 minutes of contact time at the peak hourly flow.

Nitrate concentrations should not exceed 12 mg/L (as nitrogen [N]), unless it can be demonstrated that nitrate levels greater than 10 mg/L (or background levels in the receiving groundwater, whichever is less stringent) will occur at the edge of the zone of discharge. For systems using absorption fields, TSS should not exceed 10 mg/L in the reclaimed water prior to discharge, unless specific provisions are made to ensure that the system is reliably operated and maintained.

As with slow-rate land application systems, a setback distance of 500 feet is necessary from the edge of the RIB or absorption field to existing or approved potable water supply wells, as well as Class I and Class II surface waters. Setback distances may be reduced to 100 feet from

Class I and Class II waters if high-level disinfection is used. Unlike slow-rate land application systems, setback distances can be reduced to 200 feet from potable water wells if provisions are made to ensure Class I reliability, provide high-level disinfection, and provide reasonable assurance that the applicable water quality standards will not be violated at the point of withdrawal.

Considerations for the City of Winter Haven in implementing rapid-rate application systems include the following:

- *Reducing TN to 3.0 mg/L in applied reclaimed water (FDEP recommendation) in areas with a thin confining unit or high leakage to lakes;*
- *Reducing TN to 6.0 mg/L in applied reclaimed water (FDEP recommendation) in areas with a thicker confining unit and less leakage to lakes;*
- *Providing limited, if any, additional treatment after discharge;*
- *Determining the added costs of providing additional treatment before discharge;*
- *Determining the environmental impacts of the increased chlorination needed for treatment prior to discharge;*
- *Determining which additional pathogens should be tested for; and*
- *Determining the influence of reuse applications on lake levels.*

Projects for which additional levels of preapplication treatment are necessary include, but are not limited to, the following:

1. *Projects located over groundwater in aquifers used for public water supply, where the rapid movement of reclaimed water into the aquifer will occur;*
2. *Projects where new rapid-rate land application projects involve continuous loading to a single basin or absorption field; and*
3. *Projects where annual loading rates exceed 9 inches per day.*

In these instances, the requirements of Rule 62-610.525, F.A.C., must be followed, including the requirement that the preapplication water must meet, at a minimum, secondary treatment and high-level disinfection and contain no more than 5.0 mg/L TSS before the application of the disinfectant. The low level of TSS before disinfection is required to help inactivate viruses and other pathogens. TN levels must also be limited to a maximum annual average of 10 mg/L, and WWTFs must meet primary and secondary drinking water standards.

Overland Flow Systems

Overland flow systems, also regulated by Rule 62-610, F.A.C., involve the land application of wastewater by sprinkling or flooding the upper portions of terraced, sloped, vegetated surfaces before discharging to surface waters via a runoff conveyance system. For

these systems, reasonable assurance must be provided that, at a minimum, effluent discharged to surface waters from land treatment sites will meet secondary treatment and basic disinfection levels over the long term.

Preapplication effluent should not exceed 40 to 60 mg/L of 5-day carbonaceous biological oxygen demand (CBOD₅), 40 to 60 mg/L of TSS, and 2,400 fecal coliform values per 100 mL. A setback distance of 500 feet is necessary from the edge of the wetted area to existing or approved potable water supply wells, as well as Class I and Class II surface waters. These setbacks for potable water wells should only be applied for new or expanded overland flow systems and are not necessary for permit renewal.

Considerations for the City of Winter Haven in implementing overland flow systems include the following:

- *Determining surface area requirements;*
- *Determining the extent of the confining unit for subsurface application (thickness increases from north to south);*
- *Restricting use during rainfall to prevent ground saturation and ponding, to maintain secondary treatment levels before discharging; and*
- *Reducing TN in applied reclaimed water to 10.0 mg/L (FDEP recommendation) in areas with a thin confining unit or high leakage to lakes.*

Wetlands Application

Rule 62-611, F.A.C. describes the state's wetland discharge regulations for the treatment and application of domestic wastewater reuse to wetlands and surface water. Treatment wetlands may not include areas in Outstanding Florida Waters, locations designated as Areas of Critical State Concern (as of October 1, 1985), Class I or Class II waters, or herbaceous wetlands, unless the *Typha* spp. (cattail) comprises more than 50% of the herbaceous groundcover of the entire wetland, or the wetland has been hydrologically altered. The last two requirements also apply to the use of wetlands as receiving wetlands.

Hydraulic loading rates should not exceed 2 inches per week; hydrologically altered wetlands may accept up to 6 inches per week depending on the design and associated approval by FDEP. Reclaimed water must be detained within a treatment wetland for a minimum of 14 days, unless the required level of water quality can be demonstrated for the discharged water within a shorter period. In addition, to maximize the assimilative capacity of the wetlands, TN should not exceed 25 grams per square meter per year (g/m²/yr), except for hydrologically altered wetlands where TN can reach up to 75 g/m²/yr, and total phosphorus (TP) should remain below 3.0 g/m²/yr, or 9.9 g/m²/yr for hydrologically altered wetlands.

All reclaimed water discharged to treatment wetlands must receive secondary treatment with nitrification. The discharge limits, on an annual average basis, to receiving wetlands are as follows:

CBOD ₅	5 mg/L
TSS	5 mg/L
TN (as N)	3 mg/L
TP (as P)	1 mg/L

In addition, reuse water discharged to a treatment or receiving wetland must not exceed a monthly average of 2.0 mg/L total ammonia (as N).

In cases where wetlands are being used for the discharge or treatment of reclaimed water or effluent, public access is restricted, and the resulting reclaimed water is not permitted. Under Part III of Rule 62-610, F.A.C., intermediate disinfection criteria can be used to replace the high-level disinfection criteria described above. For example, facilities designed under these conditions should result in no more than a monthly mean in an annual period of 14 fecal coliform values per 100 mL of reclaimed water or effluent; the median fecal coliform values for at least 10 samples, all collected on different days within a 30-day period, should also not exceed this level. In addition, no more than 10% of the samples collected during a 30-day period should exceed 43 fecal coliform values per 100 mL, and any single sample should not exceed 86 fecal coliform values per 100 mL.

If chlorine is used for disinfection, a total chlorine residual of at least 1.0 mg/L should be maintained after at least 15 minutes of contact time at the peak hourly flow. These criteria can also meet the requirement for high-level disinfection in cases where the discharge is to surface waters; is serving as a back-up disposal system associated with a reuse system permitted under Part III of Rule 62-610, F.A.C.; and is not subject to regulation as a discharge to Class I waters or tributaries to Class I waters.

Unless Water Quality Based Effluent Limitations (WQBELs) have been established, the discharge from treatment and receiving wetlands is limited to an annual average of 3 mg/L (as N) for TN concentration, of which only 0.02 mg/L (as N) may be in the form of unionized ammonia, or a TP concentration of 0.2 mg/L. FDEP may waive compliance levels for phosphorus (P) if it is demonstrated that P is not a limiting nutrient or a contaminant. If this is not the case, FDEP will require plans for the additional removal of P.

Section 62-611.500, F.A.C., discusses standards for the environmental and biological quality of treatment and receiving wetlands. For example, the flora and fauna of the wetland, including benthic macroinvertebrates, fish, and vegetation, should be maintained so that the ability of the wetland to support the propagation and maintenance of healthy, well-balanced populations of fish and wildlife is not impaired.

Man-made Wetlands

The criteria for natural wetlands do not apply to reclaimed water discharged to man-made wetlands, assuming that the surface water quality standards for heavy metals described in Rule 62-302, F.A.C., are applied. Although discharges to man-made wetlands are not required to meet all surface water quality standards described in Rule 62-302, F.A.C., those criteria described in Section 62-302.500, F.A.C., are applicable. In general, discharges to these wetland systems would have to meet secondary treatment and basic disinfection (described above) and pH control standards. Secondary treatment should result in effluent after disinfection that contains no more than 20 mg/L CBOD₅ and 20 mg/L TSS, or, if more stringent, 90% removal of each of these pollutants from the influent. A pH between 6.0 and 8.5 must also be maintained in the reclaimed water or effluent after disinfection. In addition, water discharged from the man-made wetlands would have to meet the standards for the receiving water (personal communication with J. Hilton, FDEP, June 16, 2009).

If the man-made wetland is contiguous to other waters, reasonable assurance is necessary that the discharge limits for treatment and receiving wetlands will be met at the boundary between the two systems. If this cannot be achieved, a permit is necessary for the discharge of reclaimed water

to wetlands and for the associated discharge from the man-made wetland to waters of the state. Lastly, a man-made wetland created for mitigation as part of a dredge-and-fill permit authorized by FDEP may not be used as a treatment wetland, though it may be used as a receiving wetland.

Summary of Existing Winter Haven WWTPs and Associated Water Reuse Practices

The City of Winter Haven currently operates two permitted Type I activated sludge domestic wastewater treatment plants (WWTPs), WWTP #2 and WWTP #3, both of which have a slow-rate land application-based reuse component. The City is not currently using any RIB systems.

WWTP#2, located just north of the City of Winter Haven's downtown area, has an annual average daily flow (AADF) permitted capacity of 2.0 million gallons per day (MGD) for a public-access reuse system (R-001). This facility is operated to achieve secondary treatment with high-level disinfection, including liquid chlorine, for public access reuse. The primary users are businesses, commercial and industrial operations, farms and other agricultural activities, and golf courses. Other uses include residential and lawn irrigation.

According to Permit No. FLA129747, a setback distance of 75 feet must be maintained between the edge of the wetted area and potable

water supply wells. In addition, the reclaimed water limits for TSS and nitrate in a single sample are 5.0 mg/L and 12.0 mg/L, respectively, and over a 30-day period, at least 75% of fecal coliform values should be below detection limits, with no single sample exceeding 25 fecal coliform values per 100 mL. Intervals for sampling for *Giardia* and *Cryptosporidium* should not exceed 2 years. The annual average flow allowed is 2.0 MGD. There are 8 surficial groundwater monitoring wells that should be sampled quarterly in association with Reuse System R-001. These wells range in depth from 10 to 20 feet. Compliance levels for N, nitrate, and TN (as N) are 10 mg/L.

WWTP#3 is located just north of State Road 60 and south of downtown Winter Haven at 4400 Pollard Road. In February 2007, FDEP gave notice of its intent to revise Permit No. FL0036048, originally dated July 13, 2005, for WWTP#3 to be upgraded to advanced wastewater treatment (AWT) and to relocate the sampling point for one of the outfalls. In addition, the overland flow system was to be decommissioned and has since been sold. This facility is operated to achieve an AADF permitted capacity of 0.7 MGD for a slow-rate restricted public access land application system (R-001 comprises an 86-acre, on-site irrigation sprayfield).

An on-site overland flow treatment system connected to a surface water discharge was originally permitted for effluent reuse and disposal. Effluent from the overland flow system was permitted to discharge to the Peace Creek Canal. Wet weather storage is not required with the existence of the surface water discharge component.

The annual average hydraulic loading rate to the restricted access sprayfields is limited to no more than 2.25 inches per week and should not result in surface runoff or ponding. The annual effluent flow of surface water discharge before and after permit modification is not to exceed an annual average of 7.5 MGD.

Prior to permit modification, only unionized ammonia (as N) had a specific effluent limit: not to exceed 0.02 mg/L in a single sample. This limit did not change with the permit modification. Both TN and TP did not have assigned effluent limitations. As of March 1, 2008, effluent limitations for TN were assigned as 3.0, 3.75, 4.5, and 6.0 mg/L for an annual average, monthly average, weekly average, and single sample, respectively. Similarly, TP levels were not to exceed 1.0, 1.25, 1.5, and 2.0 mg/L (using the same intervals as for TN). In addition, the arithmetic mean of monthly fecal coliform values collected during an annual period should not exceed 200 per

100 mL of effluent sample, and no more than 10% of samples during a period of 30 consecutive days should exceed 400 fecal coliform values per 100 mL. Any one sample should not exceed 800 fecal coliform values per 100 mL.

The reclaimed water limits for TSS and nitrate in a single sample are 60.0 and 12.0 mg/L, respectively, and did not change with permit modification. The limitations for fecal coliform in reclaimed water samples are the same as those for surface water discharge effluent.

For the duration of the permit, reclaimed water or effluent is to be monitored annually for primary and secondary drinking water standards (except for turbidity, total coliform, color, and corrosivity).

There are six surficial ground water monitoring wells that should be sampled quarterly in association with Reuse System R-001. These range in depth from 12 to 17 feet. Compliance levels for N, nitrate, and TN (as N) are 10 mg/L.

Conclusions

The most important wastewater and reuse considerations for the City of Winter Haven are as follows:

- *Impacts to groundwater are not restricted to reuse. Surface water*

and groundwater contributions from other sources (contaminants from human activities on the land surface, including stormwater from crops, pastures, residences, and recreational land uses; as well as septic tanks) all need to be considered and addressed in terms of the nutrients and bacteria levels they carry.

- Areas to the north have a more direct influence or more rapid impact on the Floridan aquifer due to a thin and discontinuous confining unit and increased soil permeability, and therefore require a higher level of protection:
 - Define protection zones, as done in the Wekiva springshed; and
 - Use a target of 0.2 mg/L of nitrate-nitrogen as a goal to determine the level of treatment necessary in each zone.
- The Peace River above Bowlegs Creek is highly characterized by karst features, and the aquifer in this area requires a higher level of protection because it is extremely vulnerable to contamination from overland flow and infiltration into depressions.
- Buffer zones should be used around karst features.
- Siting of reuse applications should consider that areas of greater head difference between the surficial aquifer and Floridan aquifer indicate a greater potential for downward recharge to the Floridan (higher aquifer vulnerability).
- State regulations protect public health by setting standards for groundwater used as drinking water. However, those standards are not protective of surface waters in places where groundwater flows to surface water—which is the case in the headwaters of the Peace Creek watershed where groundwater seeps into the lakes. Preventing increased quantities of nutrients from making their way to the lakes in Winter Haven is critical, as many of the lakes have been identified as impaired for nutrients.

References

Florida Department of Environmental Protection. December 2004. A strategy for water quality protection: Wastewater treatment in the Wekiva Study Area.

Montgomery Watson Harza. 2009. Feasibility of using reclaimed water for aquifer recharge, Task 4.0, Final summary report. Prepared for the South Florida Water Management District.

Table E.1. Summary of reuse water criteria for parameters of interest in Winter Haven, Florida. Discharge Monitoring Reports (DMRs) were obtained for WWTP#2 and WWTP#3 from September 2008 to February 2009. Monitoring data reported for WWTP#3 reflect the results from Station EFD-01, located at the discharge of the postaeration basin, before discharge to D-001, unless otherwise indicated. NA = not available

Current Facility	Parameter (unit of measurement)	DMR Levels	Current Permitted Criteria	RIB Criteria	Wetlands Criteria	Man-made Wetlands Criteria
WWTP#2 @EFA-01	CBOD ₅ (mg/L)	3.85 – 5.76 (Monthly Average)	20 (Annual Average) 30 (Monthly Average)	NA	5.0 (Annual Average)	20 (Maximum) or 90% removal from influent (whichever is more stringent)
WWTP#3	CBOD ₅ (mg/L)	2.223 – 2.985 (Monthly Average)	3.0 – 10.0 (Monthly Average) 3.0 – 12.0 (Weekly Average)	NA	5.0 (Annual Average)	20 (Maximum) or 90% removal from influent (whichever is more stringent)
WWTP#2 @ EFB-01	TSS (mg/L)	<1.0 – 7.75	5.0 (Maximum)	5.0 (Maximum) before disinfectant if annual average loading rate >9 inches/year	5.0 (Annual Average)	20 (Maximum) or 90% removal from influent (whichever is more stringent)
WWTP#3	TSS (mg/L)	1.565 – 2.419 (Monthly Average) 6.80 (Maximum)	20.0 (Annual Average) 30.0 (Monthly Average) 45.0 (Weekly Average) 60.0 (Maximum)	5.0 (Maximum) before disinfectant if annual average loading rate >9 inches/year	5.0 (Annual Average)	20 (Maximum) or 90% removal from influent (whichever is more stringent)
WWTP#2 @EFA-01	Fecal Coliform (#/100mL)	<1.00 (Monthly Average) 2.0 (Maximum)	75% below detection limits; no sample exceeding 25	200 (Annual Average) 200 (Monthly Geometric Mean) 400 (90%) 800 (Maximum)	14 (Monthly Average) 43 (90%) 86 (Maximum)	200 (Monthly Average) 400 (90%) 800 (Maximum)
WWTP#3	Fecal Coliform (#/100mL)	<1.00	200 (Annual Average) 200 (Monthly Geometric Mean) 400 (90%) 800 (Maximum)	200 (Annual Average) 200 (Monthly Geometric Mean) 400 (90%) 800 (Maximum)	14 (Monthly Average) 43 (90%) 86 (Maximum)	200 (Monthly Average) 400 (90%) 800 (Maximum)
WWTP#2 @EFA-01	Nitrate Nitrogen (mg/L)	0.350 – 7.630	12.0 (Maximum)	12.0 (Maximum)	NA	12.0 (Maximum)
WWTP#3	Nitrate Nitrogen (mg/L)	NA	NA	12.0 (Maximum)	NA	12.0 (Maximum)
WWTP#2	TN (mg/L)	NA	NA	NA	3.0 (Annual Average)	NA
WWTP#3	TN (mg/L)	0.856 – 1.544 (Monthly Average)	3.0 (Annual Average) 3.75 (Monthly Average)	NA	3.0 (Annual Average)	NA

Table E.1 — continued

Current Facility	Parameter (unit of measurement)	DMR Levels	Current Permitted Criteria	RIB Criteria	Wetlands Criteria	Man-made Wetlands Criteria
		2.87 (Maximum)	4.5 (Weekly Average) 6.0 (Maximum)			
WWTP#2	TP (mg/L)	NA	NA	NA	1.0 (Annual Average)	NA
WWTP#3	TP (mg/L)	0.067 – 0.169 (Monthly Average) 0.590 (Maximum)	1.0 (Annual Average) 1.25 (Monthly Average) 1.5 (Weekly Average) 2.0 (Maximum)	NA	1.0 (Annual Average)	NA
WWTP#2	Nitrogen, Total Ammonia (as N) (mg/L)	NA	NA	NA	2.0 (Monthly Average)	NA
WWTP#3	Nitrogen, Total Ammonia (as N) (mg/L)	0.098 – 0.210 (Monthly Average)	1.0 – 10.0 (Monthly Average) 3.6 – 12.0 (Weekly Average)	NA	2.0 (Monthly Average)	NA
WWTP#2 @EFA-01	Total Residual Chlorine (for disinfection) (mg/L)	1.00 (Minimum)	1.0 (Minimum)	0.5 (Minimum)	1.0 (Minimum.)	0.5 (Minimum)
WWTP#3 @EFA-01	Total Residual Chlorine (for disinfection) (mg/L)	0.51 (Minimum)	0.5 (Minimum)	0.5 (Minimum)	1.0 (Minimum.)	0.5 (Minimum)
WWTP#2	Total Residual Chlorine (for dechlorination) (mg/L)	NA	NA	NA	NA	NA
WWTP#3	Total Residual Chlorine (for dechlorination) (mg/L)	<0.01	0.01 (Maximum)	NA	NA	NA
WWTP#2	Flow (MGD)	0.930 – 1.123 (Monthly Average)	2.0 (Annual Average)	NA	NA	NA
WWTP#3 (@ FLW-02, at discharge from postaeration basin)	Flow (MGD)	3.633 – 4.402 (Monthly Average)	7.5 (Annual Average) Report (Monthly Average)	NA	NA	NA

Source: FDEP, 2004; MWH, 2009.

WINTER HAVEN

The Chain of Lakes City

This Sustainable Water Resource Management Plan for the City of Winter Haven, Florida, is an investment in the capacity of the natural landscape to provide multiple water resource benefits. In contrast, man-made structural solutions such as channels, ditches, reservoirs, and pipes are generally implemented primarily for singular benefits. In the long term, using the natural landscape to provide these multiple benefits will result in a less costly, more efficient water supply system for people and the environment. The Plan's benefits include the following:

- *Economic*
- *Environmental*
- *Water supply*
- *Flood protection*
- *Social, cultural, and recreational*



For additional information, please contact the Natural Resources Division, City of Winter Haven, Florida.