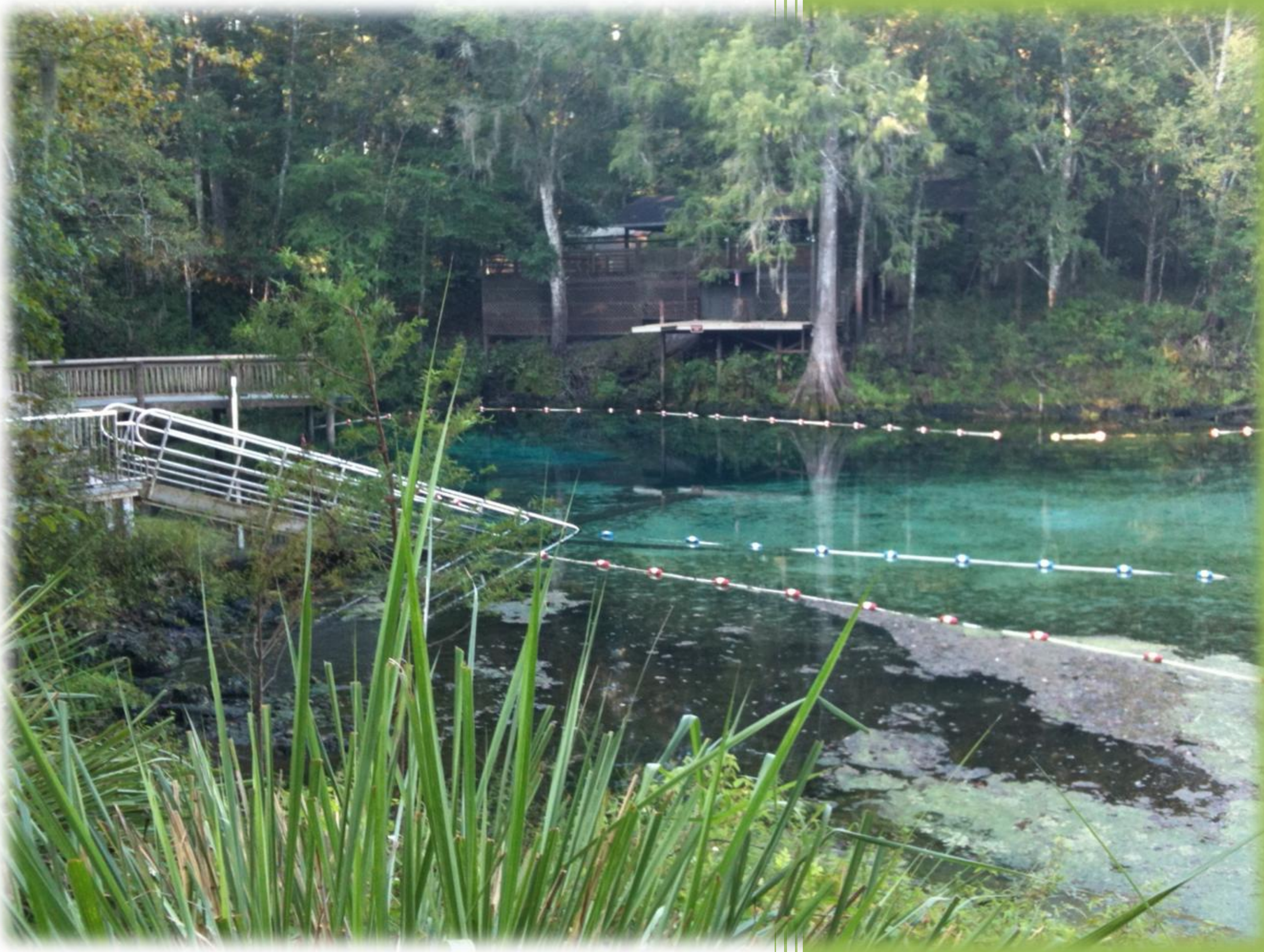
2010

Fanning Springs Restoration Plan



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Executive Summary

Fanning Springs is a second magnitude spring located inside Fanning Springs State Park in Levy County. It is a popular recreation site that allows swimming, camping and boating. Unfortunately, fanning Springs is also one of the most impacted springs in the state. It has a nitrate level of 4.8 mg/L, almost no submerged aquatic vegetation, and flow levels reduced from historic records.

Other issues affecting the springs are structural, including a floating boat dock and a seawall which limit the spring's ability to support manatees, a listed species, and other flora and fauna that a natural slope would allow, such as turtles and wetland plants.

The high levels of nitrate at Fanning Springs are the result of several inputs. The dominant land use inside the Fanning Springs springshed, which spans parts of Gilchrist and Levy County, is agriculture. Based on fertilizer sale records it is clear that agriculture is responsible for a significant concentration of nitrates entering the groundwater, which eventually discharges at the spring. Other sources of nitrate include the urbanized areas inside the springshed that use septic tanks that provide minimal treatment before discharging high concentrations of nitrogen into the groundwater.

The lack of submerged aquatic vegetation (SAV) has occurred relatively recently. Before the spring became a state park in 1997 it still had a lot of SAV in the spring and spring run. Since it has been made a park, thousands of visitors a year come to swim and wade in its shallow spring pool. This disturbs the bottom soil and makes SAV growth nearly impossible. The spring run is subject to occasional dredging in order to support boat travel to the floating boat dock that separates the boats from the swimming area. This dredging is responsible for the lack of SAV growth in the spring run.

The reduced flow levels that Fanning Springs is experiencing are the result of increased groundwater pumping from agriculture, residential and public, as well as industrial use. Groundwater pumping results in a drawdown of the aquifer, which changes the potentiometric water level which drives the flow of the spring. Even places as far away as Jacksonville have an affect on the water level of the aquifer due to large quantities of groundwater being pumped.

The purpose of this report was to develop recommendations for the restoration of Fanning Springs. These recommendations include working with stakeholders and local government to establish water conservation guidelines and direct future water, nutrient, and zoning policies. They also include making structural changes that help return the spring to its natural physical state. This includes the relocation of the floating dock to the river and the removal of the sea wall.

Other recommendations include the replacement of septic systems with performance versions, the use of a wetland treatment system to further reduce the nutrient load entering the groundwater, banning of boats from the spring run, and replanting native aquatic plants.

By implementing these changes according to the timeline given, Fanning Springs can once again be a healthy thriving ecosystem that people will be able to enjoy for years to come.

Fanning Springs Restoration Plan

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Introduction

Fanning Springs is a second magnitude spring located inside Fanning Springs State Park on the Suwannee River in Levy County, Florida. There are two springs at the park, Fanning and Little Fanning. The park is a popular site for recreation and offers swimming, volleyball, hiking, and camping. The swimming area includes a dive platform over the main boil, which averages around 18 feet deep, while the rest of the swimming area is inches to 6 feet deep. (Florida State Parks)

Purpose

Fanning Springs is one of the most heavily impacted springs in Florida (Spear). Due to its popularity as a recreational area combined with its shallow spring pool, its short run to the Suwannee River, and nutrient runoff from the surrounding landscape, most of the natural vegetation is lost (Spear) and nutrient levels are the second highest of any springs (4.8 milligrams per liter, Farrell & Upchurch) in the state.

The purpose of this document is to provide a plan for the restoration of Fanning Springs. It will seek to provide accurate information regarding the historical and current state of the spring, as well as provide recommendations for actions to be taken in order to improve the chemistry, biology and habitability of the spring.

History

People have been enjoying Fanning Springs for thousands of years. Provided below is a short timeline explaining some of the events in Fanning Springs' Past.

14,000 years ago – Paleo-Indians came to the area and made their homes near the spring as confirmed by archeological investigations.

1838 – Fort Fanning was built near the spring during the Second Seminole War. It was named in honor of Colonel Alexander Campbell Wilder Fanning.

1936 – Point of the Southernmost Bridge spanning Suwannee River. Port for the export of cotton, lumber, turpentine, etc. and import of farming supplies.

1993 – State purchased the land that later became the state park

1997 – Florida Park Service became the caretaker of the property and began operating it as a state park.

Sources: Floridian Nature, Florida Park Service

Current Conditions

Location

Fanning Springs (Latitude 29° 35’ 15.3”, Longitude 82° 56’ 7.1”) is located in Levy County, FL inside of a Florida State Park. The spring run flows 450 feet to the Suwannee River (Scott et al. 2002). Figure 1 shows an aerial view of Fanning Springs State Park and some of the surrounding land.

Figure 1. Aerial view of Fanning Springs and surrounding land.

Land Use

The springshed of Fanning Springs is composed of 450 square miles of northwestern Levy County and southwestern Gilchrist County. 75% of the land use in these two counties is composed of pine plantations, improved pasture, hardwood conifer forests, wetland-mixed forests, temperate hardwood forests, and forest regeneration areas. (Farrell & Upchurch 2005)

Figure 2 shows the boundary of the springshed, along with the land uses by color. The graph shows how this area is predominantly agricultural with small pockets of residential and urbanized land. Agriculture land typically has high nutrient loading due to fertilizer and animal waste. These excess nutrients will eventually enter the groundwater and then the spring if precautions are not taken.

There are two densely populated areas within the springshed, including Chiefland, FL and Trenton, FL with populations of 2000 and 1617 residents respectively (Farrell & Upchurch 2005). Dense populations can lead to heavy nutrient loads in wastewater that must be treated in order to prevent excessive nitrates polluting groundwater.

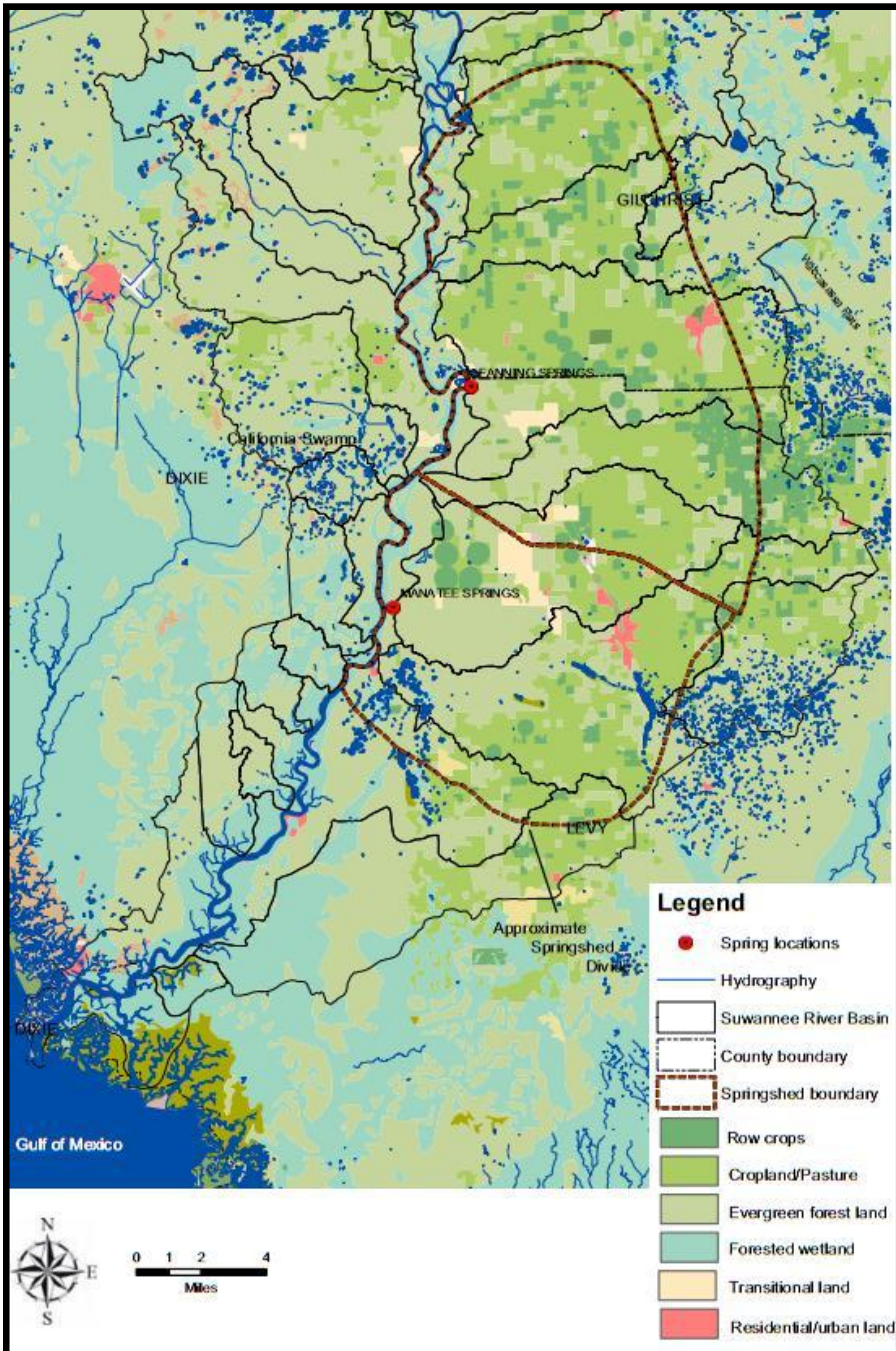

Figure 2. Land Use Map of the Fanning & Manatee Springshed (Farrell & Upchurch 2005)

Water Balance

In order to determine the current state of a spring it is important to look at a water balance, which will show where the water is coming from and where it is going. Fanning Springs was once known as a first magnitude spring (Scott et al. 2002) meaning its average flow was over 100 ft^3/s but is now considered second magnitude, meaning it's average flow is between 10 and 100 ft^3/s. Table 1 below lists historical discharge measurements taken at Fanning Springs.

Table 1. Historic discharge measurements at Fanning Springs

Fanning Springs Discharge	
Date	ft^3/s
10/25/1930	109
3/14/1932	79.2
12/17/1942	137
5/1/1956	64
11/18/1960	111
3/27/1963	83.4
4/25/1972	98.7
7/31/1973	139
10/24/2001	51.5

Florida receives an annual precipitation of approximately 53 inches per year, of which almost 40% is eventually infiltrated back into the groundwater as recharge to the Floridan aquifer. This results in 428.5 MGD of water a day entering the aquifer. Table 2 shows the water budget for Florida.

Table 2. Water Budget for the state of Florida.

Simple Water Budget for Florida (Farrell & Upchurch 2005)			
Average Rainfall	53	in/yr	100%
Evapotranspiration	33	in/yr	62%
Infiltration	20	in/yr	38%

This groundwater will then either exit through groundwater pumping or through a spring. Table 3 below shows the breakdown of water consumption for Levy and Gilchrist County inside the Fanning Springs springshed. The uses are separated into agriculture, commercial and industrial, rural self supplied and public water supply. Agriculture is responsible for the majority the water pumping (82%). Given the average flow of Fanning springs is currently 94 ft^3/s or 60.75 million gallons per day (MGD) (see Table 4), agricultural pumping represents an amount equal to almost 40% of the Fanning springs flow.

Table 3. Fanning Springshed water use by sector.

	Levy Co.	**Gilchrist Co.**	**Both**
Fanning Springshed Water Use	MGD	MGD	MGD
Agriculture	13.9	10.9	24.8
Comm/Ind/Min/Power	2.0	0.2	2.2
Rural self-supplied	1.1	0.7	1.8
Public water supply	1.1	0.2	1.3
		Total:	30.1

Figure 3 provides a visual depiction of the percentage of total water pumping for each human use. Agriculture claims 83% of the 30.1 million gallons per day used, while rural self-supplied and public water supply account for 6% and 4%, respectively. Commercial, Industrial, Mining and Power account for the remaining 7%. These uses of water each return a percentage back to the groundwater along with contaminants particular to its use, for example, agricultural wastewater will be nutrient rich, whereas powerplant wastewater will be warmer than the background levels. Each of these water uses will have an affect on water quality, and as the economy in the springshed grows, so will the water quality issues.

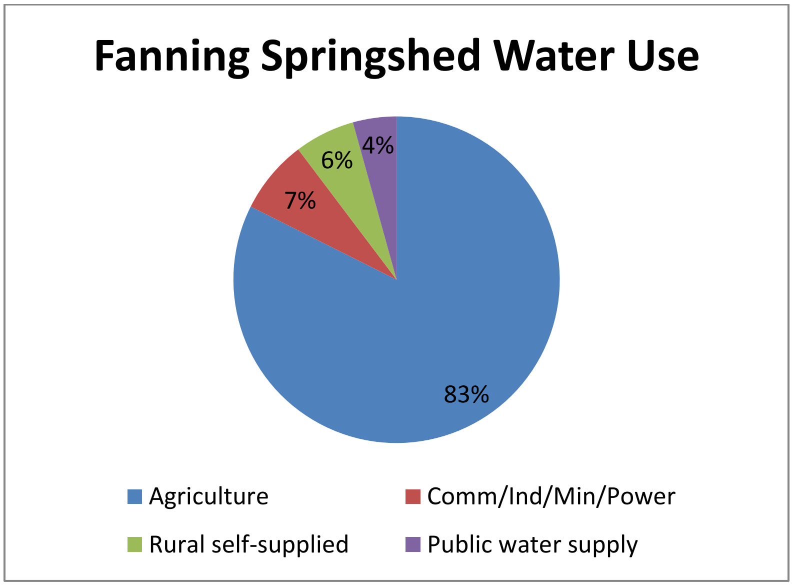

Figure 3. Percentage of the Fanning Springshed Water Use.

Water Quality

Table 4 compares the current values (most recent available data) to the historical values (earliest known records) for multiple ecosystem parameters. Next the recommended values for each parameter are presented in the third column. For those parameters that have not changed from historical records or are not outside of background levels, the goal is to keep them the same.

The main water quality issue affecting Fanning Springs is the high nitrate concentration (4.8 mg/L) which is almost 100 times the background level (0.05 mg/L) and rising (see Figure 4). Annually, 1200 tons of nitrate are applied as fertilizer to the agricultural areas of the springshed in Gilchrist county (FDACS 2004) which result in a annual loading of around 2.46 mg/L or 50% of that found discharging from the spring.

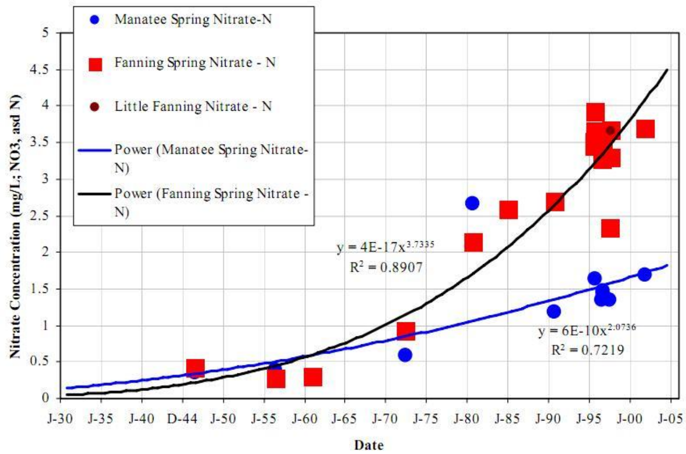

Figure 4. Graph of rising nitrate levels at Fanning Springs

Table 4. Current, historical and recommended conditions of ecosystem parameters at Fanning.

Spring Conditions			
Parameter	**Current**	**Historical**	**Goal**
Flow level	94 ft^3/s	109 ft^3/s	100 ft^3/s
Temperature	22.7 °C	23 °C	23 °C
pH	6.97	7.3 - 8.0	7
TDS	256 mg/L	-	256 mg/L
Specific Conductivity	421 µS/cm	357 µS/cm	357 µS/cm
DO	2.15 mg/L	-	2.15 mg/L
NO3	4.8 mg/L	0.05 mg/L	0.35 mg/L
PO4	0.072 mg/L	-	0.072 mg/L
SAV Percent Cover			
-Run	5%	100%	100%
-Pool	0%	100%	50%
-Boil	5%	100%	100%
Manatee Population	0	8	8
Richness			
-SAV	4 taxa	-	≥ 4 taxa
-Fish	40 taxa	-	≥ 40 taxa
-Algae	27 taxa	-	≥ 27 taxa
Sources: Farrell & Upchurch 2005, Scott et al 2002, Taylor 2006			

Impairments

There are a number of impairments affecting Fanning springs. The shallow spring pool is mainly void of vegetation due to excessive trampling from swimmers. The large numbers of recreational users have also caused increased bank erosion and sedimentation. In 2002 the main vent was dredged to remove sediments and help restore the original conditions. (Farrell & Upchurch 2005)

Other signs of impairment include the presence of large floating algal mats and Hydrilla verticillata (White 2003). The main vegetation consists of patches of floating algae. In 2000 FDEP conducted assessments that concluded that 95% of the species were diatoms and the taxa found were indicative of nutrient-rich conditions (Farrell & Upchurch 2005).

A floating dock spans the width of the spring run and may make it difficult for manatees to reach the spring during low water levels, reducing its habitat capability (see Figure 5). In order to support boat travel, the spring run must be occasionally dredged, damaging submerged aquatic vegetation and causing increased erosion. (Farrell & Upchurch 2005)

Other impairments include decreased flow levels and increased nitrate levels. Reduced flow levels can impede the travel of manatees into the spring and negatively affect productivity. Elevated levels of nitrate can decrease diversity, cause algal blooms, and stress native aquatic plants and animals.

Figure 5. The floating dock spans almost the entire spring run.

Goals

The goal of this restoration plan is to address the various issues affecting Fanning Springs in a holistic and comprehensive way. There are several issues considered most pressing for the restoration of Fanning Springs which will be the focus of this plan. They include poor submerged aquatic vegetation (SAV) coverage in the spring and spring run, reduced flow level of the spring, and rising nitrate levels.

SAV coverage in Fanning Springs was dominant before the site became a public park in 1997 (Spear 2010) (See Figure 6). Over the course of a little more than a decade the SAV has almost vanished from this system (see Figure 7). SAV, such as Vallisneria or Sagittaria, is an important component of a spring ecosystem, providing a habitat structure for flora and fauna to survive as well as a food source for species ranging from snails to manatees. The loss of this vegetation severely limits the ability of the spring to support life. This plan aims to restore the SAV to its former abundance according to Table 4. Due to the popularity of the park, it is unlikely to restore 100% vegetation in the spring pool unless swimming is no longer allowed, which is considered unrealistic at this time. That is why the SAV coverage goal for the spring run (where no swimming occurs) and the spring boil (where it is too deep to wade) are 100% coverage and the spring pool is 50%.

Figure 6. Photo of Fanning Spring from 1989 showing the dense SAV cover.

Figure 7. Photo of present conditions showing sediment dominated system.

Fanning Spring was historically a 1st magnitude spring (Scott et al. 2002), but is now considered a 2nd magnitude. Flow reductions are the result of increased groundwater pumping due to highly populated areas throughout the state, such a Jacksonville, which alter the potentiometric surface of the aquifer and therefore alter the springshed boundaries as well. Aquifer drawdown is also due to agricultural and other industrial processes within the springshed which permanently remove a certain percentage of the water consumed from the groundwater supply.

Flow level is important in Fanning Springs due to its recognition as a thermal refuge for manatees (Taylor 2006). Given that manatees require a certain water depth in order to be able to reach a spring (>5 ft), this plan aims to reduce drawdown and maintain a minimum spring level by working with stakeholders and government agencies in order to establish best management practices (BMPs) for farming and other processes that minimize consumptive water use. See Table 1 and Table 4 for the current and historic flow levels.

Lastly, nitrate (NO_3) levels have been rising exponentially at Fanning Springs since the 1970's. Fanning Springs, in fact, has the second largest NO_3 loading of any spring (Knight 2010a). These high nitrate levels not only cause algal blooms, but they start to stress the species present and to cause extinctions. It is the goal of this restoration plan to develop methods of reducing NO_3 load to the springshed in order that it can maintain a high level of diversity. See Table 4 and Figure 4 for more information on current and historic levels of nitrate. To meet the current Total Maximum Daily Load (TMDL) for Fanning Spring (Farrell & Upchurch 2005), the NO_3 levels will have to be reduced by over 90%. This plan aims to bring the springs nitrate levels down to the designated TMDL level of 0.35 mg/L.

Recommendations

Restoration Activities

The actions required to restore Fanning Springs will need to occur on three different levels. The state level applies to actions that will help increase the flow of Fanning Springs by reducing the drawdown of the Floridan Aquifer. The Springshed level focuses on reducing the pollutant load, increasing water recharge, and educating the public. At the level of the Fanning Springs Park itself, the recommendations focus on structural implementations to help restore the springs to their natural state. The following sections describe the actions recommended at each level.

State Level

- Coordinate with the St. John's River Water Management District to address the drawdown of the Floridan aquifer as a result of pumping in highly populated areas, such as Jacksonville, FL. (Burkhardt 2010, Swirko 2009). Implement practices to reduce water consumption and increase water recharge in highly populated areas.

- Coordinate with Water Management Districts, cities, farmers, and other stakeholders in order to relocate agricultural areas from the most sensitive lands in a springshed. Focus should be placed on locating agricultural activities in areas that are confined from the Floridan by the Hawthorne clay formation or similar confining units.

Springshed Level

- The most direct way to gain control over pollutant loads on springshed land is to purchase the land. Acquiring the most sensitive lands in a springshed is worth pursuing where possible. Other options include purchasing the development rights for the area or imposing conservation easements (Deadman 2008).

- Work with city planners to designate sensitive areas as rural or suburban zones. Since 75% of the two counties included as a part of the springshed is forested or pastureland, there is still a large amount of recharge area available. In order to ensure future recharge capability on springshed land, city zoning can incorporate specifications for springshed lands that ensure an adequate percentage of a parcel remain undeveloped (Deadman 2008).

- Help implement Best Management Practices (BMPs) for agricultural land. While moving agricultural land would be complicated, working with farmers in the springshed to implement Best Management Practices that were developed by the EPA (EPA 2008) to help protect water quality would be a positive way to get them involved. The BMPs include the following policies:

    - **Conservation tillage** – This practice results in less runoff, which improves water quality by having fewer nutrients washed away from the agricultural area.

    - **Crop nutrient management** – Includes monitoring nutrient levels to avoid over fertilizing, especially in sensitive areas.

  - **Pest management** – Minimize pesticide use, explore alternatives, and match pesticide to the site features to minimize groundwater contamination.

  - **Conservation buffers** – Includes vegetative filters, such as wetlands, which could remove many nutrients before they reach the groundwater.

  - **Irrigation Water Management** – Emphasize efficient watering practices to minimize nutrient transport to groundwater.

- Ensure wastewater treatment is sufficient enough to meet the Total Maximum Daily Load (TMDL) of 0.35 mg/L established for Fanning Springs before the water is sent to spray fields. The city of Fanning Springs has recently received funding and approval for a wastewater treatment (WWT) plant and sprayfield (SRWMD 2010, Scohier 2010). Ensuring the treatment meets the TMDL standard will prevent the WWT plant from negatively affecting water quality.

- Alternative WWT should be investigated, including the use of treatment wetlands to reduce nitrate and phosphorus levels. Treatment wetlands can reduce nutrient loads significantly at a much cheaper operating cost than traditional WWT plants.

- Promote the conversion of current septic systems to performance based units which can reduce the total nitrogen from approximately 35 mg/L to 10 mg/L (Gaudio 2010). This can significantly reduce the load reaching the groundwater and spring. By providing rebates to those located in sensitive springshed areas, conversion to a new system is made more economically viable.

- Get the public involved! Often education alone is not enough to cause behavior change (McKenzie-Mohr & Smith 1999) although it can be an important part. Hold informational meetings to update the public on current plans and ways they can help, such as reducing lawn fertilization, xeroscaping, reducing lawn watering, converting to advanced septic systems, etc.

  Another way to get the public on board is the use of pilot studies on the reduction of nitrate associated with different practices. Then honor those who adopt conservation practices or convert to performance based septic systems. For example, by placing a local area map in a public place, such as a library, and then placing a sticker on homes that have promised to help reduce nitrate loads, people can see whether their neighbors are participating and get on board or encourage their neighbors.

Park Level

The determination of how to restore Fanning springs to its original condition is difficult due to limited historical records, however, records from nearby springs, such as Manatee Springs, can be used to assist in determining its pre-development state. Several structural changes should be made in order to promote natural processes.

- Remove the floating dock that spans the length of the spring run. This dock is used by recreational visitors for sunbathing and by boaters to tie their boats when they come in from the Suwannee. This dock is potentially limiting the access of manatees to the warm spring waters. Its location also requires the occasional dredging of the spring run for boat access, which destroys the submerged aquatic vegetation (SAV) there. The loss of SAV results in less habitat viability for spring fauna, and less nutrient treatment for downstream waters.

  Relocating the dock on to the Suwannee River and allowing boaters access to the spring from there via an extended boardwalk would promote natural plant and animal life to return while accommodating visitors. This was done at Manatee Springs with success (White 2003).

- No longer allow motorized boats in spring run. Allowing boats to dock on the river and restricting boat access to non-motorized boats such as canoes and kayaks will stop the introduction of Hydrilla in the spring run from boat propellers and prevent the damage caused by dredging. Canoes and kayaks could still be allowed during non-manatee season up to a roped off portion of the spring designated for swimming which includes the spring boil.

- Close off the spring and spring run to swimming and boating during manatee season, which lasts from November through April (Farrell & Upchurch 2005). This will promote the return of manatees to the area.

- No longer dredge spring run in order to let native vegetation return. This will allow the soil to stabilize and promote greater SAV growth. The growth of SAV also acts as a sink for nutrients, a habitat for smaller species such as fish and snails and as a food source for manatees.

- Plant Sagittaria, Vallisneria, and other SAVs in spring boil, pool, and run. This should be done during the summer months in order to give the plants the best conditions for growth and reduce the impact of herbivory by manatees that come in the winter. Exclusion barriers may also be appropriate for spring pool and run plantings until the SAVs are established.

- Replace on-site septic-tanks with high efficiency versions. The bathrooms located at the park are a potential source of nutrients for the springs and if the septic tanks were upgraded then the risk of high nutrient loads reaching the springs due to them is reduced.

- Remove the seawall and recreate the natural slope of the shore. The seawall at Fanning Springs supports the deck and dive platform from which visitors can enter the spring, however, these can be set back further and the natural slope recreated. Allowing a natural slope provides more area for plants to grow, turtles to sun, etc.

Timeline

The execution of these restoration activities must take place over time, as energy and funding allow. Figure 8 below is a recommended timeline for the implementation of each. Several actions are recommended to start immediately, including the coordination with SJRWMD, farmers and the public. The relocation of the boat dock to the Suwannee River should also occur first in order to implement further recommendations.

Next, policy decisions at the park level can be initiated, including closing off the spring run to boat traffic and discontinuing dredging there. At this time the replanting of SAV should begin. At the springshed level, construction of a wetland treatment system should begin now.

The City of Fanning Springs is in the process of building a water treatment plant. For those springshed areas that are unable to hook up to the sewage system, a solution is to switch failing septic systems to performance versions that remove a significantly larger amount of nitrogen. This can also be implemented inside the state park itself.

By 2013 the public will be aware of the need for springs protection from the public involvement campaign and it will now be feasible to institute zoning designations that limit development on sensitive springshed lands. Another method of controlling pollution levels entering the springs is to assess the feasibility of moving agricultural land through land swap deals. After this has been explored, funding should be acquired in order to purchase land most critical to spring protection.

Finally, after the planted SAV has had a few years to establish itself, the sea wall can be removed and the dock entrance moved back in order to recreate the natural slope of the spring. This allows greater habitat function and diversity, but the SAV are necessary to limit erosion likely to occur during the process.

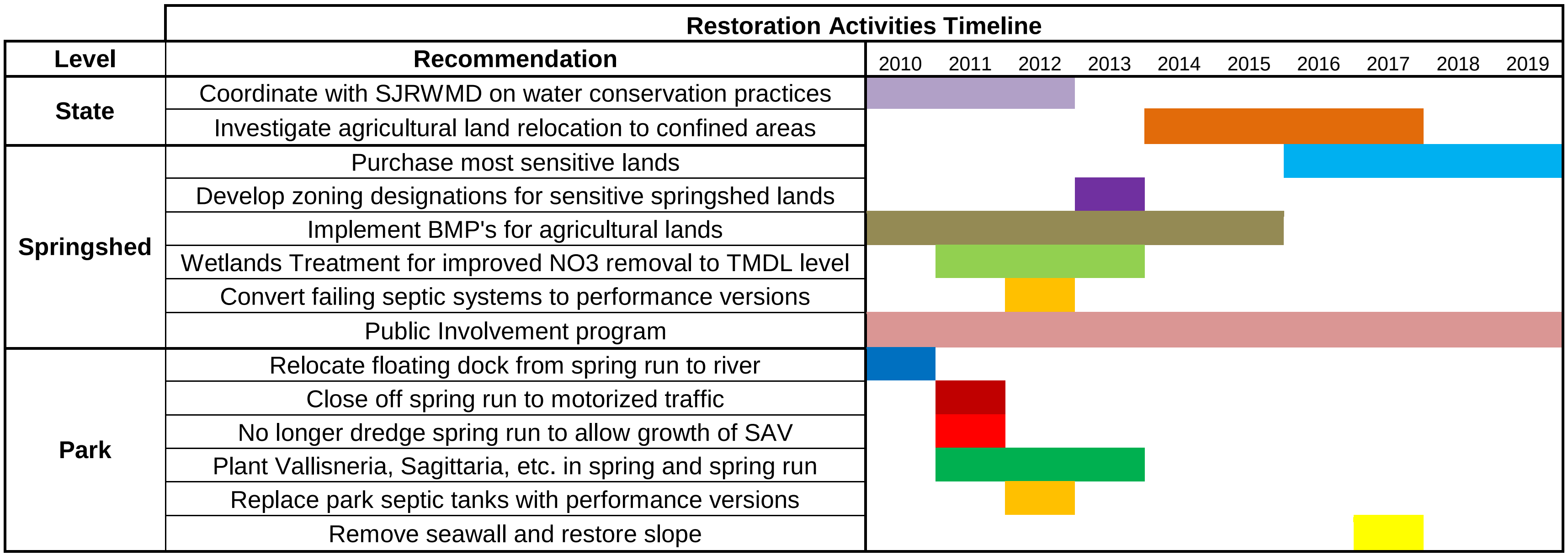

Figure 8. Timeline for the implementation of state, springshed, and park level restoration activities.

Funding

Key to any restoration is the acquisition of funds needed to make plans a reality. Table 5 displays the estimated cost of each activity and a potential funding source to help cover the costs of the venture. The Environmental Protection Agency, Florida Department of Environmental Protection, Department of Community Affairs, U.S. Department of Agriculture and the US Geological Survey can provide funds through donations, grants, etc.

Purchase price of agricultural land will vary depending on parcel size and market value, thus the total suggested for this purpose was an estimate of the amount required to purchase several large tracts of land.

Activity	Funding	Source
Re-locating dock to Suwannee River	$ 65,000.00	EPA
Launch site on Suwannee River	$ 20,000.00	EPA
Block spring sun to motorized boat traffic	$ 10,000.00	EPA
Re-plant spring and spring run		FDEP
- Cost of plants	$ 8,500.00	
- Labor (Divers)	$ 9,000.00	
- Fencing for exclusions	$ 2,000.00	
Replace on-site septic tanks with high-performance versions	$ 75,000.00	FDEP
Public involvement campaign	$ 50,000.00	DCA
Wetland treatment system	$500,000.00	FDEP
Purchasing agricultural land on sensitive areas in springshed	$1,000,000.00	USDA
Determine most sensitive areas of springshed	$ 20,000.00	USGS
Total:	$1,759,500.00	

Table 5. Estimated costs for the restoration of Fanning Springs.
Sources: Knight 2010b,White 2003, That Fish Place (2007)

Research Needs

There are several areas of research that will require further investigation in order to make educated decisions concerning future restoration ideas. The list below is far from exhaustive, but should provide a jumping point for planning agencies and research organizations.

- Monitoring the physical, biological and chemical changes of the spring ecosystem in relation to the restoration steps taken would provide valuable insight into the most dominant forces within a spring ecosystem and valuable data for future projects.
- Concerning spray fields and agricultural areas in the springshed, determine how much nitrate (NO_3) each crop can assimilate to find out proper loading ability.
- Studies should be implemented to discover where the most sensitive areas in the springshed are located. This could be done using core samples to determine where the Hawthorn layer is thinnest, or via dye testing to discover short-circuit locations with a direct outlet to the spring.
- The location of any sinkholes within the springshed could be investigated in order to discover whether any illegal dumping is taking place in order that appropriate actions might be taken. Prevention strategies could be researched concerning illegal dumping in sinkholes.
- Pilot studies to determine the effectiveness of water use reduction techniques in the springshed area, such as moisture sensitive sprinkler systems or once per week watering limits, should be implemented.
- Experiment with the various BMPs suggested for farming practices to determine which are most effective and appropriate in the springshed area.
- Another topic could be how to determine percentage of land plot that should be reserved for recharge in order to minimize impact of development on spring flow.
- A clear delineation of the springshed would help identify stakeholders as well as major impacts to the spring.

Research should be a big part of monitoring the success of implemented ideas, and it is a great way to get other organizations involved, such as Universities through graduate research.

Evaluation of Success

The success of this spring restoration will need to be analyzed through periodic monitoring of certain key areas. Through this monitoring it will be clear which portions are most effective and which will need revising. The following are the recommended subjects to monitor and evaluate:

- **NO_3 level** – Current levels are around 4.8 mg/L so a reduction of over 90% would be necessary to meet the TMDL of 0.35 mg/L for Fanning Springs. Due to the nature of groundwater, there is likely to be a time lag between reduction efforts and response in springs, so long term monitoring is important.

- **Water chemistry** – parameters such as total dissolved solids (TDS), specific conductance, pH, and dissolved oxygen concentration (DO) give important information about springs health and changes that are occurring in the source waters.

- **Flow level** – Monitoring flow levels is important to determine the success of improved recharge, reduced consumption efforts at the springshed and state levels over time.

- **SAV percent cover** – Many areas of Fanning Springs are bare sand, or algae dominated. In order to determine the success of replanting efforts, the percent cover of SAV and algae should be monitored using quadrants and percent cover estimations. Success will be considered to be when SAV are established in an abundance that they can survive natural fluctuations in flow and herbivory and propagate on their own.

- **Manatee population** – Counting the manatee population present each year will determine whether their numbers are increasing. As a listed species, success can be determined by seeing improving population numbers to a level sustainable in the given spring area.

- **Richness of fauna and flora** – Richness can give a good indicator of the health of an ecosystem. By establishing a baseline richness and then documenting the improvement of species richness over time will show the success of the restoration activities recommended.

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