Fact Sheet ("Study Guide") on the Rainbow Springs Basin, Spring and Spring Run

Purpose of this fact sheet – To provide a simple, easy to understand reference guide for stakeholders who care about and want to be involved in the restoration of Rainbow Springs and the Rainbow River.

Overview of the Restoration Planning Effort

The stakeholders who are involved with the Rainbow Springs Basin Working Group during 2010 and onwards will engage in a process to create a Restoration Plan for the spring and river. Additionally they may engage in restoration actions to benefit these aquatic resources. These actions will most likely be those called for by the plan but any actions which benefit the springs and river are to be encouraged.

The plan will document the historical and current conditions found within the Rainbow Spring Basin, at the spring and along the spring run. It will also document actions that have been taken and are ongoing at present.

A vision for the restoration will be crafted which will guide development of the rest of the plan. The causes of impairment currently found in the spring will be described. To achieve the vision for restoration, goals, objectives and strategies will be crafted and refined. Monitoring will be recommended to determine the effectiveness of restoration actions and scientifically based benchmarks will allow a means to measure progress.

A draft of the plan will be completed by June 2011 and continued work will refine that draft through June of 2013. Actions to benefit the springs and river will be encouraged throughout this period. Resources to support actions will need to be identified and an active effort to secure resources engaged in.

Overview of the Rainbow Springs System

Rainbow Springs is located in the southwest corner of Marion County about 4 miles north of the village of Dunnellon. The springs give rise to the Rainbow River which flows south for 5.7 miles where it joins the Withlacoochee River about 1 mile east of Lake Rouseau. Rainbow Springs is a series of springs which, taken together, are first magnitude springs and qualify as one of the most productive in flow in Florida. An average of 493 million gallons per day (mgd) flows from the springs. Water emanates from the Upper Floridan Aquifer which is fed by rain falling on approximately 700 square miles of land in western Marion, eastern Levy and southern Alachua Counties.

Rainbow River/Rainbow Springs Fact Sheet

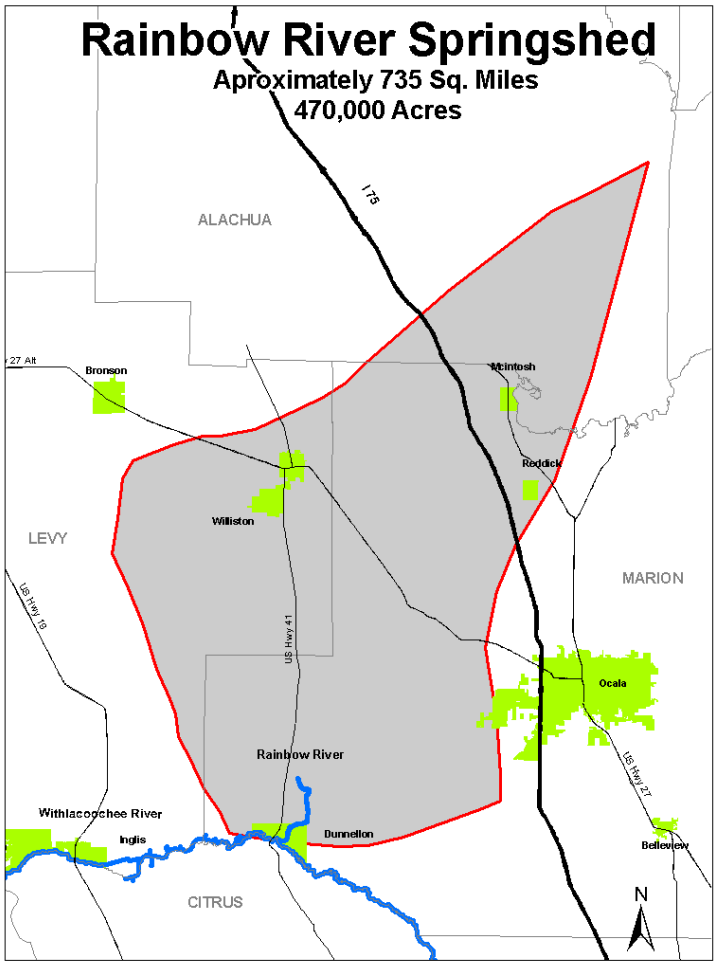
Updated from SWFWMD fact sheet – permission from Chris Zajac

- Rainbow Springs is a first magnitude spring group that forms the Rainbow River. It has an average discharge rate of 763 cubic feet per second, or 493 million gallons per day, and is one of 33 first-magnitude spring systems in the state.
- The river flows south from the headspring approximately 5.7 miles to the tannic Withlacoochee River.
- The Rainbow River and its immediate surroundings were mined for phosphate in the early part of the twentieth century.
- From 1934 to 1973 the headspring complex was used as a tourist attraction that included glass bottom boats and mermaid shows.
- The unique ecological attributes of Rainbow River/Rainbow Springs were recognized by the state of Florida when the system was designated an aquatic preserve in 1986 and an Outstanding Florida Water in 1987.
- In 1989, the Southwest Florida Water Management District (District) adopted the Rainbow River as a SWIM water body and developed the first Rainbow River SWIM Plan.
- The Florida Park Service opened Rainbow Springs State Park in 1995.
- Current water quality monitoring results show nitrate concentrations at the Rainbow River headspring are *consistently above 1.6 mg/L, and on several occasions have been in excess of 2.0 mg/L*.
- Groundwater discharge accounts for 97–99% of the river flow, with very little surface runoff from the watershed.
- The Rainbow River watershed is approximately 47,000 acres (73 sq. mi.) while the groundwater recharge area or springshed is 470,000 acres (735 sq. mi.) covering portions of Alachua, Levy and Marion counties.
- It has been estimated that ground water may take up to 30 years to reach the spring vents from the recharge areas.
- The District is currently in the process of establishing a minimum flow for the Rainbow River.
- The District partnered with Marion County in 2007 to assist in the implementation of the Marion County Springs Protection Program.

Basic Description of the Rainbow Springs Basin

A **springshed** or **spring basin** is a representation of the area of land that receives rain water that then flows underground to supply the spring. Rain hits the land surface and is absorbed either through the soil directly or it runs off to a **sinkhole** or **swallet** and then percolates and flows down into the **aquifer**.

Fig 1: Extent of Rainbow Springs Basin



Establishing a Spring Basin Boundary

The boundary of a spring basin is not as easy to define as the boundary of a **watershed**. A watershed is bounded by high points on the land surface and water flows down towards a river by gravity. Groundwater that supplies a spring "flows" based upon **potentiometric pressure** (which is also dependant upon gravity). This pressure can be measured in wells and it represents the upward pressure exerted by water in a well. The higher the upward pressure, the more likelihood that the water will flow away from that area under the ground towards areas of lower pressure. Spring basins are delineated by "ridges" of higher potentiometric pressures from which groundwater flows away. A "ring" of higher potentiometric pressures = the boundary of the spring basin.

Insert potentiometric map here

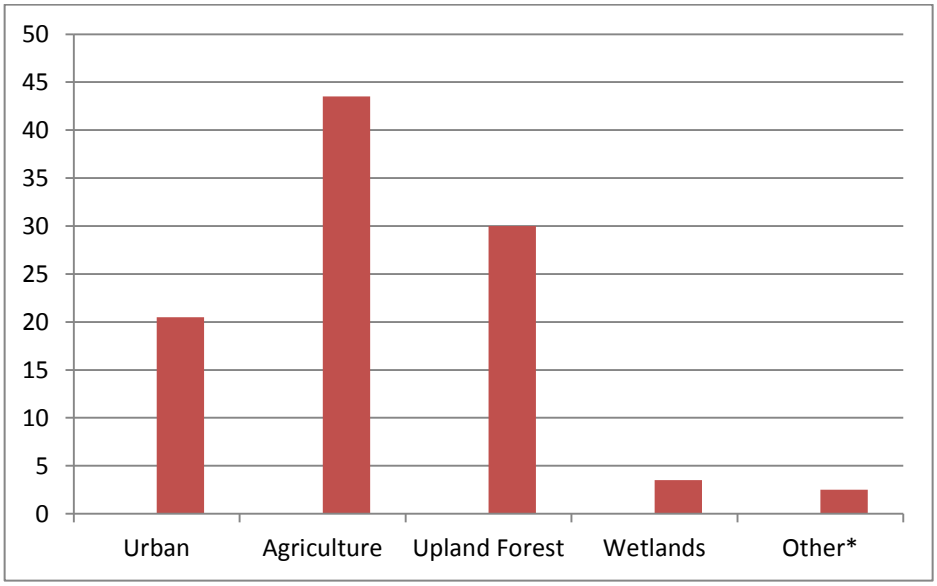
This boundary is not fixed by topography as a surface watershed boundary is. The areas of higher potentiometric pressure can shift based on several factors, the most obvious one being the amount of rainfall in areas on either side of it. Water withdrawals on one side of a potentiometric ridge can cause it to shift as well. For these reasons, the mapped boundaries of spring basins are estimates based on the data that are available at the time the pressures are measured and mapped.

Landuse in the Rainbow Springs Basin

The Rainbow Springs Basin is primarily rural with agricultural land uses dominant (see Fig. 3). Much of the land is used for equine farms and is composed mostly of horse pastures with a mix of barns, practice tracks and exercise paddocks. There is also forested land and land used for the growing of various crops.

Housing developments have been increasing in recent decades with centers of development near the spring and river. The largest incorporated area within the Rainbow Springs basin is Williston in Levy County, about 20 miles to the north of the spring. Williston has a population of XXXX and has a sprayfield for sewage effluent about ½ mile south of the developed part of the city.

Fig 3: Landuses in Percent in the SWFWMD Portion of the Rainbow Spring Basin in 2007 (approx)



* Other includes surface water, barren lands, other uplands and transportation and utility uses.

Aquifer Vulnerability

(This section is based on a presentation to the Silver Springs Basin Working Group by Gail Mowry of the Marion County Stormwater Program).

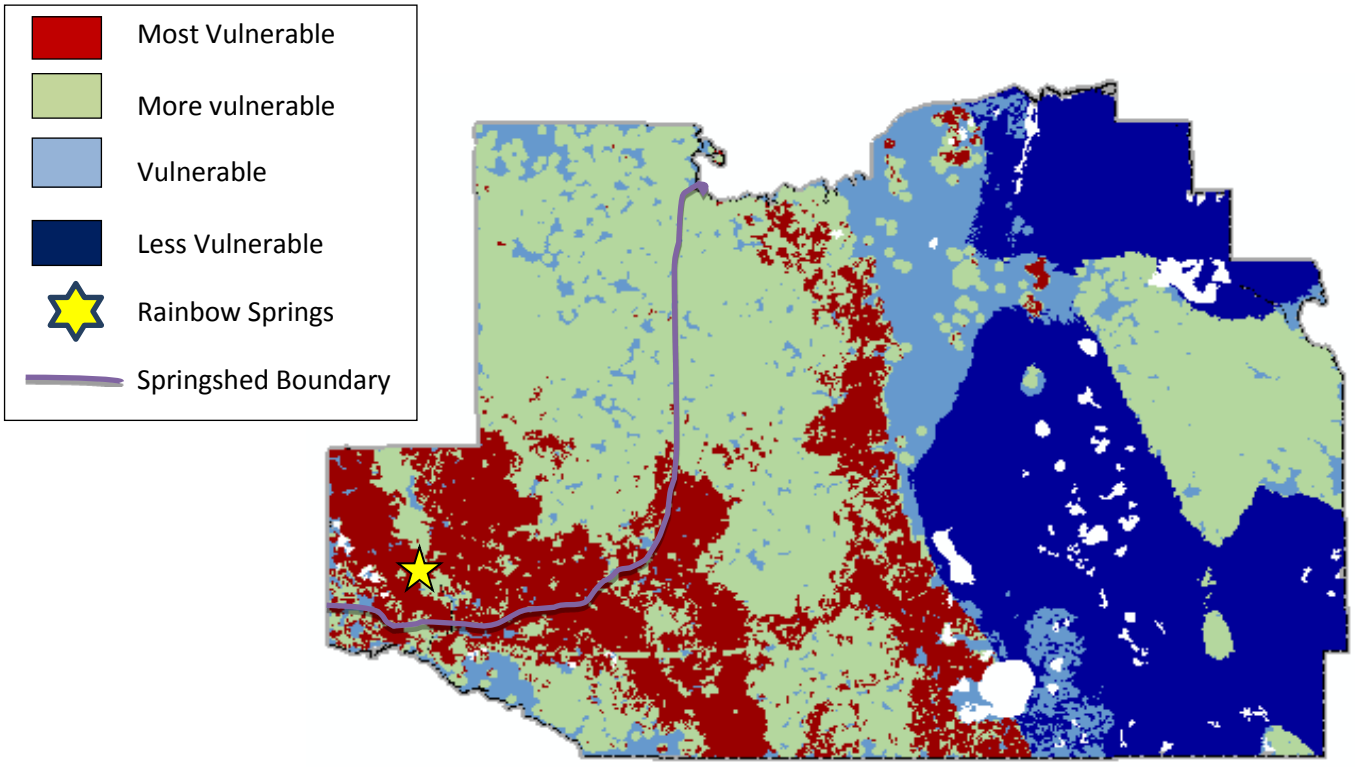
Marion County has completed its own assessment of aquifer vulnerability (called MCAVA) which indicates that essentially the entire portion of the Rainbow Springs Basin within the county is ranked as either most vulnerable, more vulnerable or vulnerable (see Fig 4). Aquifer vulnerability is determined

based on several factors. It represents a measure of how rapidly surface water percolates down into the aquifer. If the aquifer is close to the ground surface (due to thin soil) and there is no impermeable layer such as clay to prevent rapid water infiltration, then water will reach the aquifer quickly and likely carry with it any pollutants present. Karst features such as sinks and swallets may make the situation more severe. Different soils allow water to pass through at different rates. When drainage is rapid there is little opportunity for soil organisms to process or use nutrients such as nitrate so it is more likely that nutrients will infiltrate the aquifer and then later appear in spring water.

Figure 4 indicates clearly that the area of the Rainbow basin close to Rainbow Springs is classified as most vulnerable and therefore most susceptible to aquifer pollution. There are several housing developments in this area which may cause groundwater contamination from surface runoff of lawn and garden fertilizers, , oil, gasoline, pesticides and other chemicals. Septic tank effluent is a concern too.

There is no equivalent county assessment available for Levy County. However, the statewide aquifer vulnerability assessment (FAVA) shows eastern Levy county to have the same "More Vulnerable" status as western Marion County (the red area of Fig 5)

Fig 4: Marion County Aquifer Vulnerability Assessment (MCAVA)



Closely associated with aquifer vulnerability is the presence of karst features such as sink holes and swallets. To date there is incomplete information available on these features in both Marion and Levy Counties. The Florida Geological Survey did make an effort to map these features statewide but the effort was hampered by several factors not the least of which was the difficulty of access to private lands. Part of the MCAVA process was a Lidar mapping assessment that shows the locations of "closed

topographic depressions" (low points in the ground to which water will flow either from surface water features – less likely - or percolate downwards through the soil – most likely). The Lidar map of the depressions is presented as Fig 6 and indicates clearly there are most likely numerous karst features present within the Rainbow Basin. A more detailed surface analysis of these features would reveal a more complete picture of the nature of the karst features present.

Fig 5: Florida Aquifer Vulnerability Assessment (FAVA)

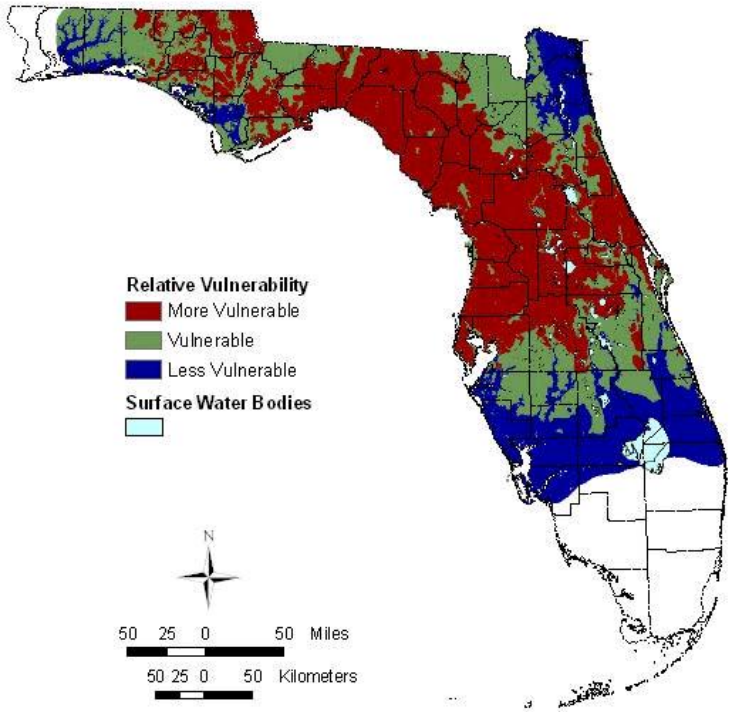
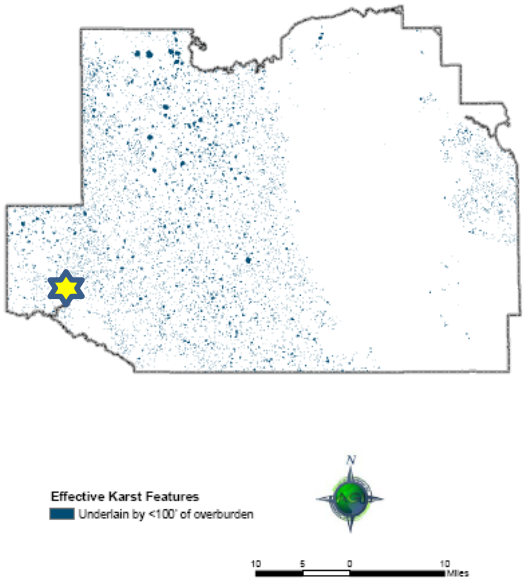


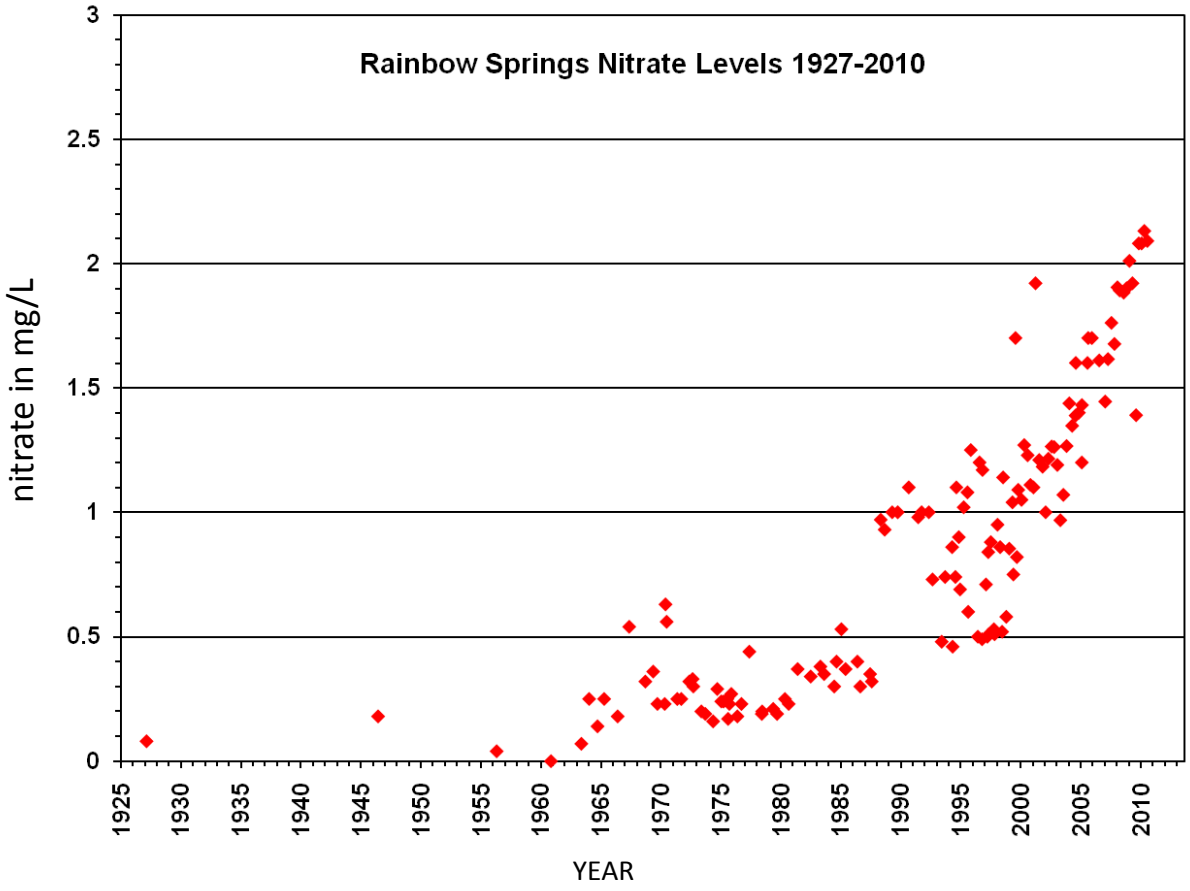
Fig 6: Effective Karst Features in Marion County (from MCAVA analysis)
(Location of Rainbow Springs indicated by a yellow star)



Water Quality
Water quality is a very important factor to consider in association with restoration. There are a number of parameters to consider including nutrients, clarity, oxygen, pH, conductivity, toxins, and bacteria.

Nurients
The major nutrients to be considered here include phosphates and nitrates. Both are common components of fertilizers and both can cause severe problems in freshwater systems. Both parameters act to stimulate plant growth by supplying an essential nutrient and both have been shown to be historically low in Florida springs (under 0.1 mg/L for both). Phosphates have remained low in Rainbow Springs with a current average reading of between 0.05 and 0.1 mg/lt. Nitrates have increased and in 2010 have regularly been measured over 2 mg/L (about a 40 fold increase over historical levels). Fig 7 shows that nitrate levels remained at historical "background" levels until the 1960's at which point they started to increase. Nitrates reached an average of about 0.9 mg/L over the next 40 years and have risen to an average of approximately 1.5 mg/L over the last 10-15 years.

Fig 7: Composite graph of historical and current nitrate levels in discharge from the headspring pool at Rainbow Springs

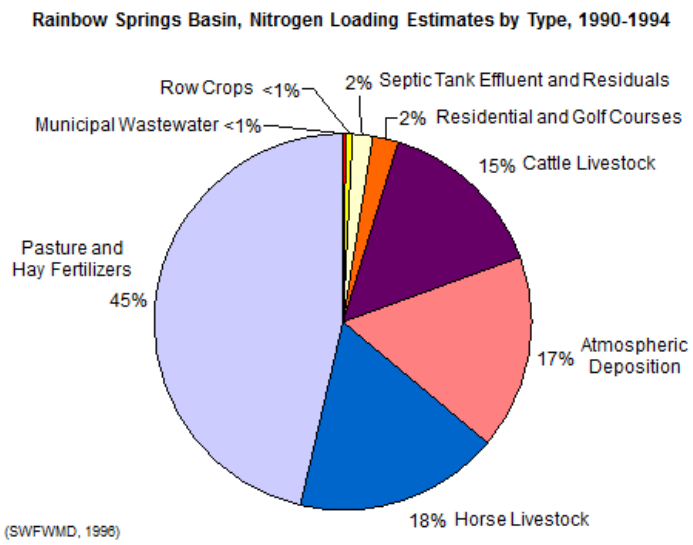


There is some controversy over exactly what this increase in nitrates will cause in the Rainbow Springs System and River. At the time of this writing there is limited evidence of detrimental impacts. Nitrate is known to be a major factor in **"eutrophication"** in surface waters, a condition that causes a general

degrading of water quality associated with increased growth of many undesirable plant species including algae.

Evidence based on recognized chemical signatures indicates that the majority of the nitrate emerging with the groundwater from the spring is of inorganic origin. This points to fertilizers as the cause (effluent from human and animal waste is organic). Fig 8 shows that agricultural activities most likely represent the largest contributor of nitrates to groundwater. It is important to keep in mind that changing land uses (agricultural to residential, for example) can change the percentages. The age of the water emerging from the spring is important too. Older water may well have nitrates from 2-3 decades ago.

Fig 8:



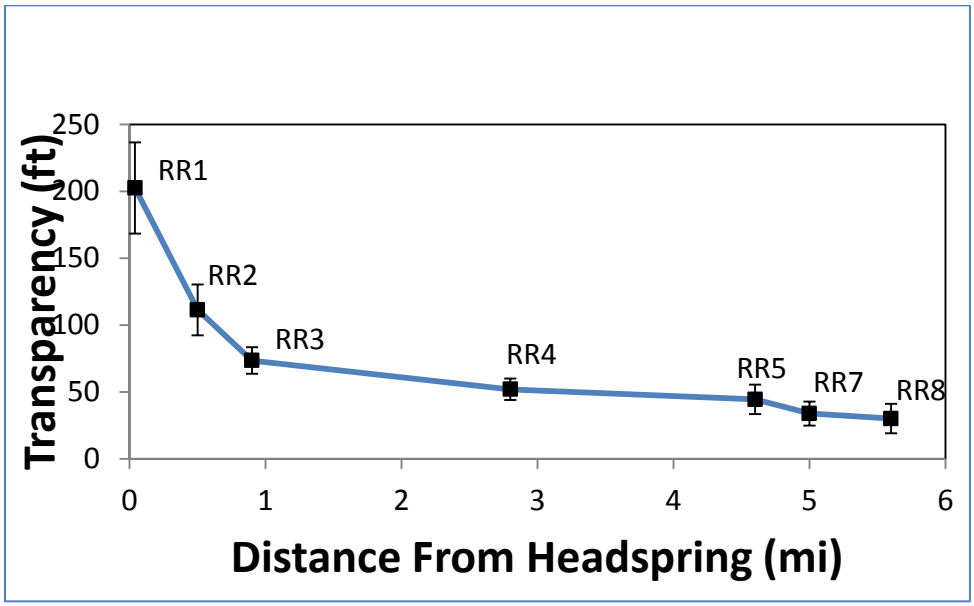
Nitrate in Groundwater

It is important to realize that nitrogen exists in the environment in a variety of forms with nitrate being only one. This is the form that plants take up from the soil. Its conversion to other forms (ammonia and nitrite for example) is heavily dependant upon the actions of soil microorganisms. If nitrate is dissolved in groundwater and percolates down into the aquifer, there is very limited opportunity for bacterial actions to change it. Hence it emerges in springs unchanged and starts to act as a fertilizer in the water of the spring run for photosynthetic organisms such as phytoplankton and aquatic plants. It is forthis reason that it is so important to control the amount of nitrate that is allowed to enter the aquifer.

Water clarity is affected by both sediments (particles suspended in the water) and microscopic organisms carried in the water column. Clarity is typically measured using a black and white disk known as a Secchi disk. The disk is held in the water and the distance from it that an observer can see it represents a relative measure of lateral clarity (relative to other observation times in the same water body and measurements taken in other water bodies). Rainbow River, like all of Florida's spring runs, has traditionally had very clear water near the head springs with readings averaging 200 feet (Fig 9). Sediments are usually low except during severe storm events. Photosynthetic organisms in the water column affect clarity, particularly further downstream – see Fig 9. This may be affected by nitrates in the water fueling the growth of organisms.

Disolved Oxygen in water is important because it provides all the oxygen that aquatic organisms need to survive. It derives from oxygen that dissolves into water from the air, rainfall that percolates into the aquifer and as a by-product of photosynthesis occurring under water. In general, the colder the water, the more oxygen can dissolve into it. Groundwater is naturally low in oxygen due to it being separated from air but readings taken at different springs around the state vary widely. Rainbow Springs has relatively high dissolved oxygen readings in the range of 5-7 mg/L. High dissolved oxygen **may** mean an average short residence time for water in the ground. The possible correlation between high oxygen and short residence time may require closer scrutiny to determine its significance to sources of pollutants, particularly nitrate.

Fig 9: FY2002-2009 Spatial Distribution of Water Clarity, Rainbow River



Coloform Bacteria

Coloform bacteria have during most years they have been measured remained below levels that trigger concern. However, there was an episode in the summer of 2009 that triggered concern when beaches had to be closed due to excessive levels of fecal coliform bacteria in the river. This is cause for long-term concern as it may indicate failing waste water and septic systems for residences near the river and spring.

Hydrology / Flow

Figure 10 indicates that flow from Rainbow Springs during the period of record (1932 to 2007) has fluctuated between about 500 cubic feet per second (cfs) and 1000 cfs with a reported average of about 703 cfs. The average is equivalent to about 493 million gallons of water per day. Fluctuation is due largely to changes in rainfall from year-to-year with other factors playing a role. One of those is the possible change in the extent of the spring basin due to hydrogeologic forces that are not currently

completely understood. Another would be groundwater withdrawals for human use – more water out of the aquifer = less available for the spring.

The regulatory tool that Florida has to maintain spring flows is the **Minimum Flows and Levels (MFL) program**. An MFL is being developed by SWFWMD for the Rainbow River now and is expected to be completed in 2011. The MFL will be set at a level whereby ecological damage to the aquatic system will be prevented due to low water flow. It will effectively establish a limit on groundwater withdrawal. The MFL is complex to calculate due to the numerous factors associated with groundwater flows and climate and the interaction between the two.

Fig 10: United States Geological Survey Discharge Record for Rainbow Springs measured in Cubic Feet/Second (cfs)

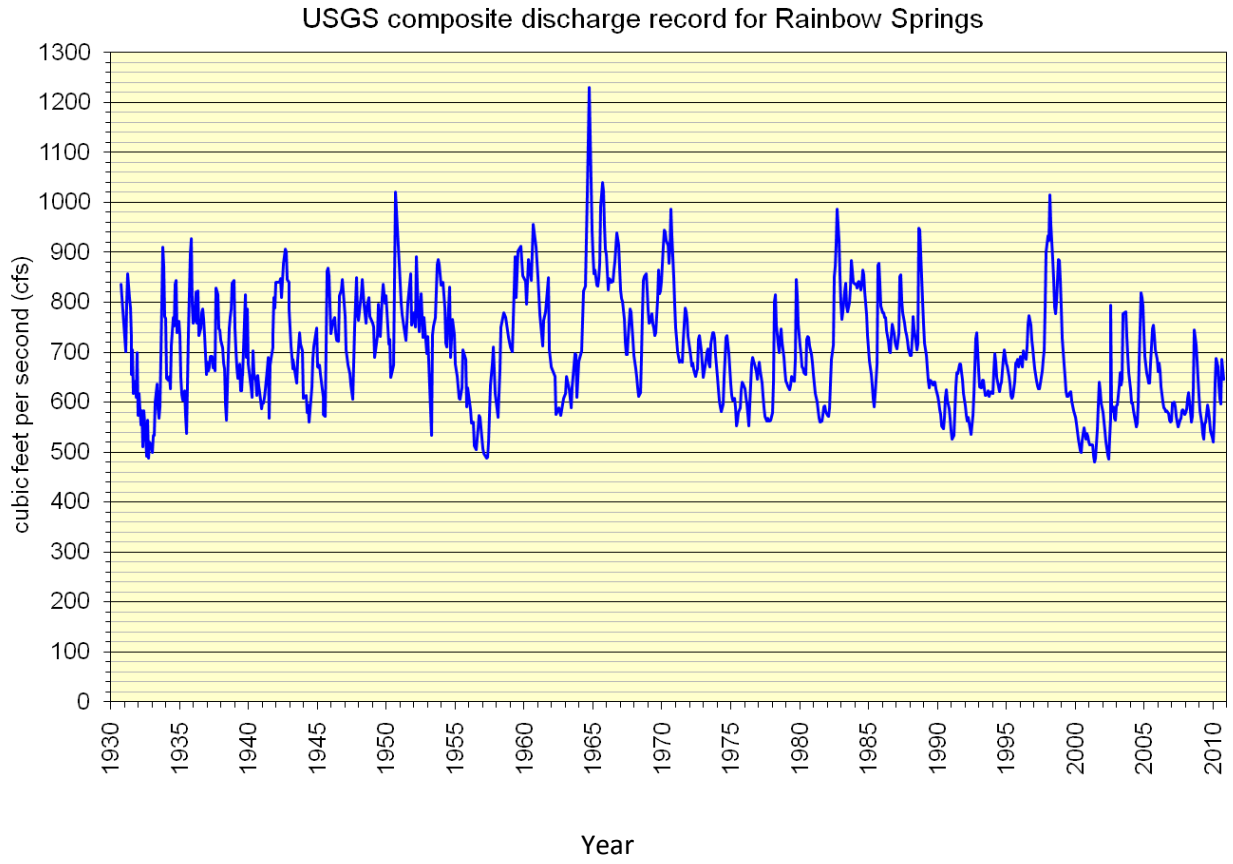


Figure 10 indicates that flow from Rainbow Springs during the period of record (1932 to 2007) has fluctuated between about 500 cubic feet per second (cfs) and 1200 cfs with a reported average of about 703 cfs. The average is equivalent to about 450 million gallons of water per day. Fluctuation is due largely to changes in rainfall from year-to-year with other factors playing a role. One of those is the possible change in the extent of the spring basin due to poorly understood hydrogeologic forces.

Another would be groundwater withdrawals for human use – more water out of the aquifer = less available for the spring.

The major regulatory option that Florida has to maintain spring flows is the **Minimum Flows and Levels (MFL) program**. An MFL is being developed by SWFWMD for the Rainbow River now and is expected to be completed in 2011. The MFL will be set at a level whereby ecological damage to the aquatic system will be prevented due to low water flow. It will effectively establish a limit on groundwater withdrawal. The MFL is complex to calculate due to the numerous factors associated with groundwater flows and climate and the interaction betweenthe two.

There is some evidence of a decline in the flow of the Rainbow Springs during the last 40 years although over the last 80 years the flow has remained within the same general range. The first decade of the 21st century has seen lower rainfall than in previous decades and this may be a major factor. Lining up the spring flow data with rainfall data over the same period would assist with reading the situation more accurately. This is being done for the MFL calculation.

This Fact Sheet is a work in Progress. It is presented at this time to assist working group members with their thoughts and deliberations. Information presented came from a variety of sources including presentations given at meetings of the Rainbow Springs Basin Working Group.