Water Quality Study of the Ichetucknee River

Sampled 22 September 2005
Bureau of Laboratories

February 2006

Executive Summary

This study of the Ichetucknee River and its recharge basin was conducted to meet three objectives:

1) To compare potential changes in the water quality at selected sites between 1996 and 2005 (although there are limitations with only two data points),
2) To determine if potential contamination at sites in the recharge basin was influencing water quality in the springs along the Ichetucknee River, and
3) To determine if algal growth in portions of the Ichetucknee River was causing impairment.

Pesticide and herbicide contamination did not appear to be an issue throughout the basin, as only a non-problematic level of hexazinone (an herbicide used in silviculture) was detected at a single location (Ichetucknee Head Spring). Similarly, metals were detected throughout the basin at concentrations that complied with Class III surface water quality criteria, except at Clay Hole Creek at Highway 47, where mercury and lead exceeded their respective criteria. The hydrologic conditions at this site during sampling were unusual, in that there was no flow, with only stagnant, disconnected pools present. Therefore, current results from Clay Hole Creek at Highway 47 can not be considered representative of typical conditions.

Total phosphorous (TP) concentrations in the recharge area sites were higher than the TP levels at the Ichetucknee River sites, and with one exception, there appeared to be no significant temporal trends in total phosphorus. Between 1996 and 2005, TP at Clay Hole Creek (at Highway 47) decreased by 55%. Water at most sites tended to have similar total phosphorus concentrations between the two sampling events. All total phosphorus values in the Ichetucknee River area remained relatively low compared with other Florida streams (at or below the 30^{th} percentile concentration). Ortho-phosphate levels were low at the Ichetucknee River sites and displayed no significant changes over time.

Conversely, nitrate-nitrite concentrations were much lower in the sinkhole-captured streams than they were in the Ichetucknee springs. The Ichetucknee river sites were all elevated with respect to nitrate-nitrite, tending to exceed the $85\text{-}90^{th}$ percentile concentrations for typical Florida streams (Appendix). These results suggest that nitrate-nitrite inputs from direct groundwater discharges (*e.g.*, fertilizer applications, septic tanks, potentially the sprayfield) in the recharge area are more significant than the surface water sources captured by the sinkholes. Nitrate-nitrite concentrations in the Ichetucknee River sites during 2005 tended to be slightly higher (Appendix) than those recorded in 1996.

Fecal coliform bacteria at all sites complied with the Class III surface water quality criterion except at Clay Hole Creek at Highway 47. Fecal coliforms at the Ichetucknee River sites (ranging from 2 to 6 CFU/100 mL in 2005) were all very low. Fecal coliform levels at Rose Creek cave, downstream of the wastewater treatment plant (WWTP) sprayfield, were very low (2 CFU/100 mL), suggesting no significant bacterial influence from the sprayfield. Other bacterial indicators (total coliforms, *E. coli*) tended to follow this same trend (Appendix).

Caffeine was detected at Clay Hole Swallet, at a concentration of 0.016 ug/L, which is less than the practical quantitation limit (PQL) for caffeine. The presence of a small

amount of caffeine suggests that a well diluted source of human waste influences the area.

Fluorometric readings in water samples collected in the Clay Hole and Rose Sink sample locations, as well as Devil's Eye Spring, indicate that modest levels optical brighteners may be present at those locations, suggesting that grey water contributions from domestic or municipal sources may be affecting those waters.

Polycyclic Aromatic Hydrocarbons (PAHs) in sediments were not detected except at one site. Pyrene was found at Clay Hole Creek at Highway 47 at a level below its consensus-based sediment quality guideline Threshold Effect Concentration. No other organic contaminants were found in sediments at any station.

The average periphyton chlorophyll *a* concentration was found to more than double at the site below Mission Spring (537 mg/ m^2) compared to levels measured at the site above Mission Spring (248.5 mg/m^2). Additionally, algal thickness followed this same trend. EPA guidance suggests that designated uses may be impaired when periphyton chlorophyll *a* exceeds 150 mg/ m^2. Excess nutrients, acting in concert with low dissolved oxygen, contributed to the excessive algal growth below Mission Spring, and is considered an imbalance of aquatic flora (Rule 62-302.500 (48)(b) FAC).

Overall, water in the Ichetucknee River and associated springs complied with Class III surface water quality criteria. Nitrate-nitrite enrichment was an issue throughout all the Ichetucknee River springs sampled; excessive algal growth, leading to imbalances of aquatic flora, was observed below Mission Spring.

Introduction

The Ichetucknee drainage basin is located in north-central Florida, southwest of the Osceola National Forest. The drainage/recharge basin of the Ichetucknee River begins in the area around Alligator Lake near Lake City. Streams that drain the basin empty into sinkholes located southwest of Lake City and flow through underground cavities and calcareous formations before emerging into several springs within the Ichetucknee Springs State Park. The Ichetucknee River is formed by these springs, and flows southward to join the Santa Fe River

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1) To compare potential changes in the water quality at selected sites between 1996 and 2005 (although there are limitations with only two data points),
2) To determine if potential contamination at sites in the recharge basin was influencing water quality in the springs along the Ichetucknee River, and
3) To determine if algal growth in portions of the Ichetucknee River was causing impairment.

Sampling sites are shown in Figure 1. Sites sampled in the recharge area included the Lake Harris drain, Clay Hole Creek (2 locations), Clay Hole Swallet, Rose Creek cave, and Rose Creek Swallet. The Ichetucknee River group of sampling sites is located in the Ichetucknee River State Park, and consisted of seven sites along the river, including the Ichetucknee Head Spring, Blue Hole Spring, a site above Mission Spring, a site below Mission Spring, Devil's Eye Spring, Mill Pond Spring, and Coffee Spring.

Sites for the 2005 study were somewhat different from those sampled during the 1996 FDEP Bureau of Laboratories study. Cannon Sink, the Lime Rock Mine sites, and Suwannee River Water Management District (SRWMD) Monitoring Well were not sampled in the 2005 study. The 1996 study site known as "Roaring Springs" is referred to as "below Mission Spring" for this 2005 study, and a site in the Ichetucknee River located just above Mission Spring was added.

In 1996, the monitoring was conducted to provide baseline data for the Ichetucknee River system. Water samples were tested for nutrients, minerals, trace metals, organic priority pollutants, pesticides, herbicides, and coliform bacteria. Sediment and fish tissue samples were tested for trace metals, organic priority pollutants, pesticides and herbicides. The 1996 results are reiterated in this report to compare with the 2005 results.

Some new sites and parameters were added in the 2005 study. In 2005, sediments were tested for PAHs, chlorinated pesticides, and nitrogen/phosphorus based pesticides. Water was tested for metals, nutrients, total and fecal coliform bacteria, *E. coli*, Enterococci, chlorinated pesticides, and nitrogen/phosphorus based pesticides, PAHs, minerals (boron, calcium, magnesium, sodium, potassium), caffeine, and optical brighteners. Additionally, a comparative periphyton study was conducted at the two Mission Spring sites.

Methods

All field and laboratory biological methods followed FDEP Standard Operating Procedures (SOPs, see http://www.floridadep.org/labs/qa/2002sops.htm for details) and met FDEP quality assurance/quality control standards (see http://www.floridadep.org/labs/qa/index.htm). The grab sampling technique was used to collect water directly into the bottles. Water samples for metals were collected following the FDEP field SOP FS 8200, Clean Sampling for Ultra-trace Metals in Surface Waters. Sediment samples were collected following the DEP SOP FS 4000, Sediment Sampling. Corers and dredges were used to collect sediment samples.

Optical brightener samples were analyzed in the laboratory using a Turner Designs Model 10-AU Field Fluorometer that had been equipped with a filter/lamp setup that included a narrow bandpass filter designed to reduce potential interferences by long wave-length oils and dissolved organic matter. This analysis is based upon the method described in Memorandum of Agreement (50312-01-13-PT) between the Virginia Department of Conservation and Recreation and the Virginia Department of Health (Hagedorn et al. 2002).

A periphyton assessment was conducted at the sites above and below Mission Spring using a modified version of the Rapid Habitat and Periphyton Assessment (RHPA) method (Stevenson, R.J. et. al., 2004). At each site, 10 transects were run 10m apart arranged from upstream to downstream across the Ichetucknee spring run. Each of the ten transects were separated into nine observation points where algae was measured, for a total of 90 sampling points per site. Substratum type and algal thickness were determined for each point. Thickness was measured and ranked according to an ordinal scale from 0.5 to 5.

At each transect, one of the 10 points was randomly selected to sample a single blade of eel grass (*Sagittaria kurziana*) for periphyton chlorophyll *a* analysis. A 10 cm rectangular section was measured from the top of each blade and placed in site water in a vial. The vials were then held at 4˚ C until processed in the laboratory.

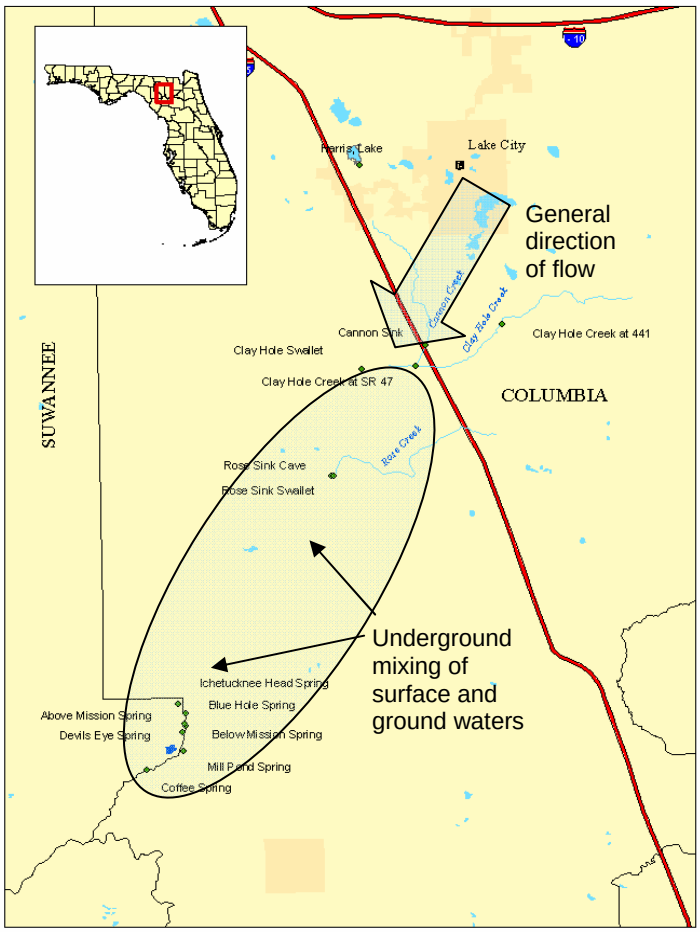

Figure 1. Study location.

Results and Discussion

Pesticides/ Herbicides

Water at all sites was analyzed for a comprehensive list of pesticides and herbicides (see Appendix). Hexazinone was detected (0.012 ug/L) at the Ichetucknee Head Spring. This concentration of hexazinone is well below the Rule 62-777 F.A.C. groundwater cleanup

target level of 231 ug/L. Pesticides and herbicides were undetected at all other sites in the Ichetucknee River and recharge area.

Metals

Overall, metals were detected at higher levels in the recharge area than at the Ichetucknee River sites, with only one problem area identified (Appendix). Clay Hole Creek at Highway 47 exceeded the 12 ng/L Class III surface water quality criterion for mercury, with a value of 26 ng/L. Water at this same site also exceeded the 1.69 ug/L hardness based Class III surface water quality criterion for lead, with a value of 10.1 ug/L. All other metals were either undetected or complied with Class III surface water quality criteria (Appendix).

Nutrients

Total phosphorous concentrations in the recharge area (ranging from 0.12 mg/L to 0.43 mg/L) were higher than the TP levels found at the Ichetucknee River sites, which ranged from 0.02 mg/L to 0.06 mg/L (Figures 2 and 3, Appendix). With one exception, there appeared to be no significant temporal trends in total phosphorus. Between 1996 and 2005, TP at Clay Hole Creek (at Highway 47) decreased from 0.65 mg/L to 0.29 mg/L. Water at most sites tended to have similar total phosphorus concentrations between the two sampling events (e.g., TP at Blue hole was 0.044 mg/L in 2005 compared with 0.042 mg/L in 1996, Appendix). All total phosphorus values in the Ichetucknee River area remained relatively low compared with other Florida streams (at or below the 30^{th} percentile concentration, Appendix).

Trends in ortho-phosphosphate concentrations tended to be similar to those seen in the total phosphorus data (Appendix). Ortho-phosphate levels were low in the Ichetucknee River sites (ranging from 0.022 mg/L to 0.056 mg/L) and displayed no significant changes over time.

The ammonia concentration at Clay Hole (at Highway 441) was 0.18 mg/L, which ranked it higher than 70 percent of other Florida streams (Appendix). Ammonia was low at the remaining recharge area sites (ranging from 0.015 mg/L to 0.053 mg/L). All sites complied with the Class III un-ionized ammonia surface water quality criterion of 0.02 mg/L. Ammonia was very low or undetected at the Ichetucknee River sites (Appendix).

With one exception, nitrate-nitrite was generally low (below the 20^{th} percentile concentration for typical Florida streams) at the recharge area sites, with levels ranging from 0.005 mg/L to 0.025 mg/L (Figures 4 and 5, Appendix). The nitrate-nitrite concentration at Rose Creek cave, located down-gradient of the wastewater treatment plant sprayfield, was 0.43 mg/L, a level more similar to the those found at the Ichetucknee stations. Since there was no control site up-gradient of the sprayfield, the potential contribution from the sprayfield can not be established, although it is a potential nitrogen source. The Ichetucknee river sites (ranging from 0.42 mg/L to 0.74 mg/L) were all elevated with respect to nitrate-nitrite, tending to exceed the $85\text{-}90^{th}$ percentile concentrations for typical Florida streams.

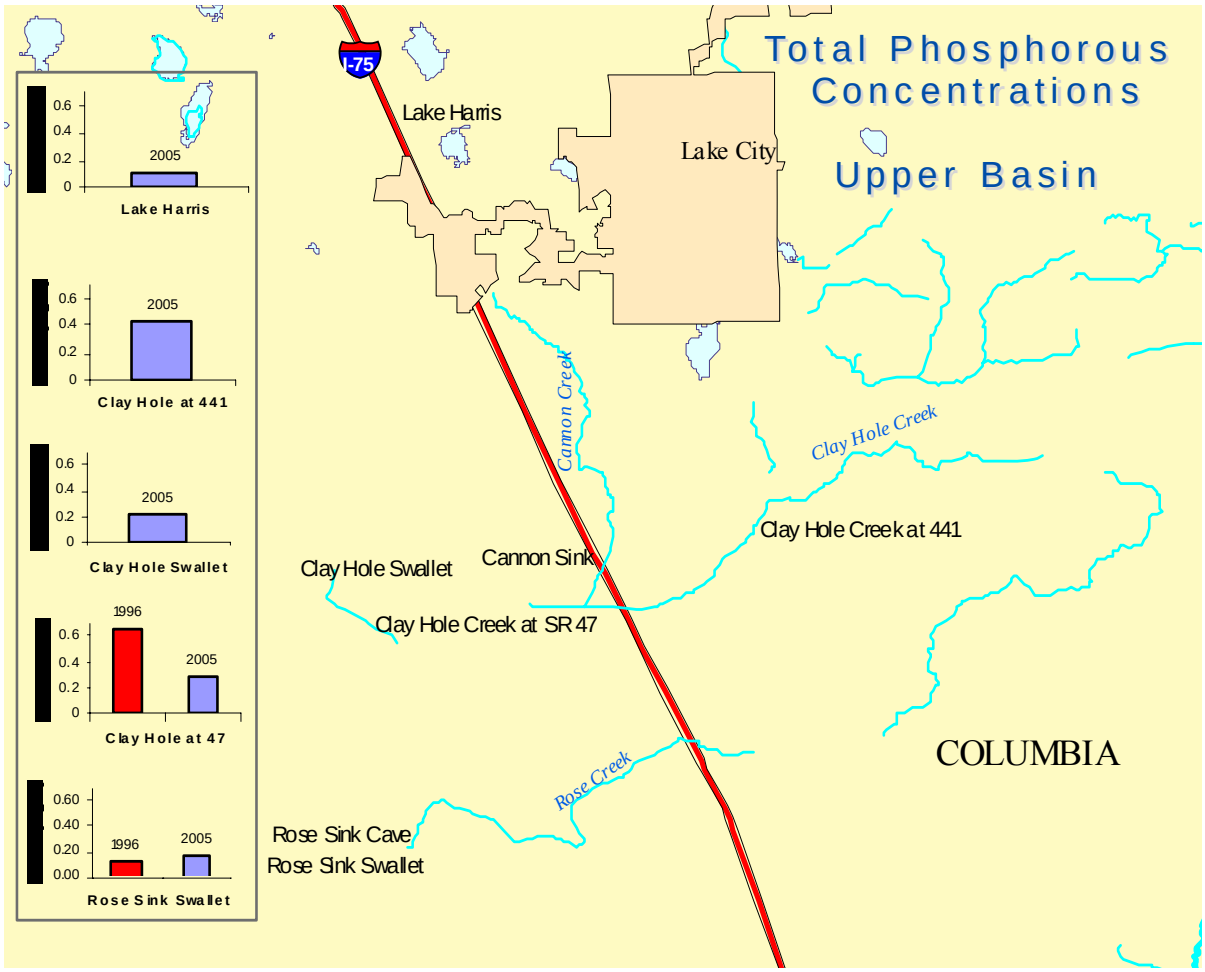

Figure 2. Total phosphorus at recharge area sites.

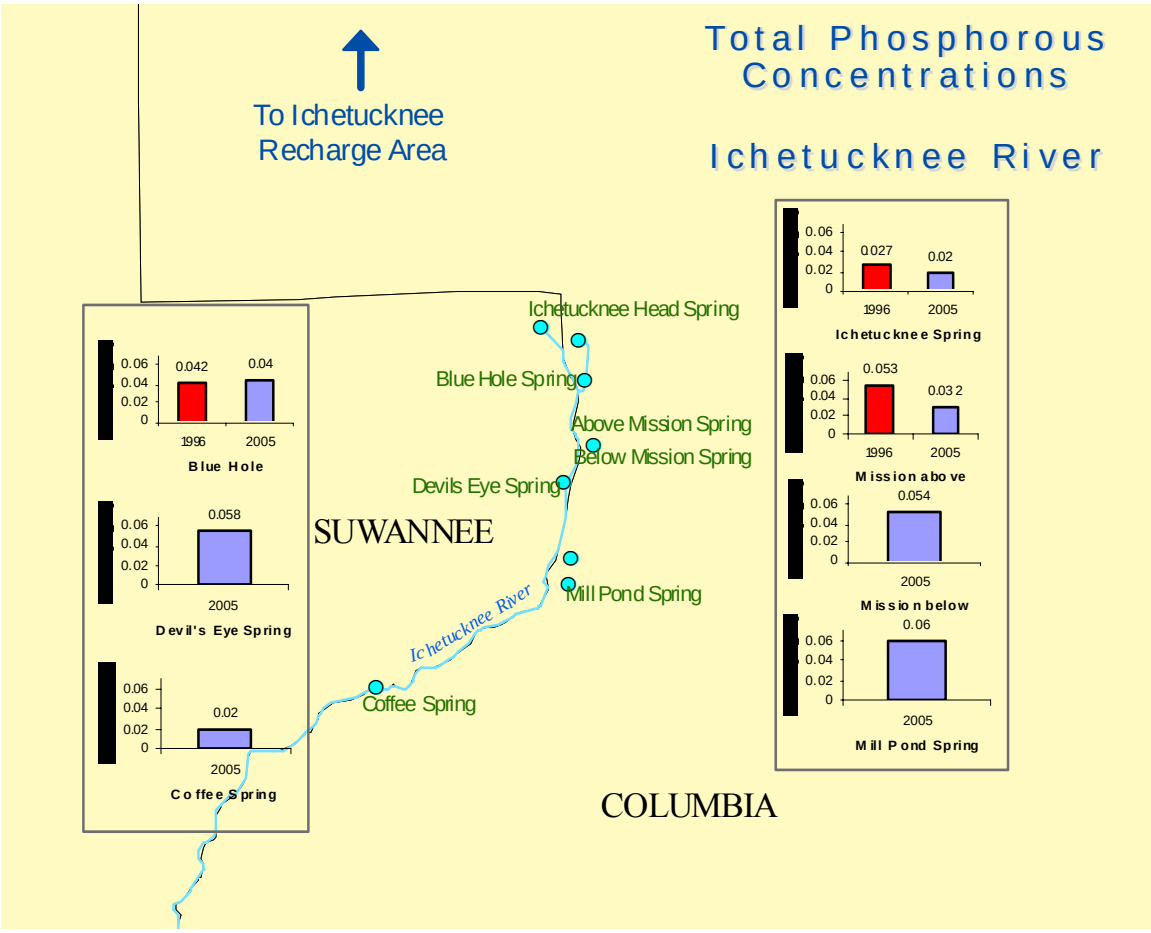

Figure 3. Total phosphorus at Ichetucknee River sites.

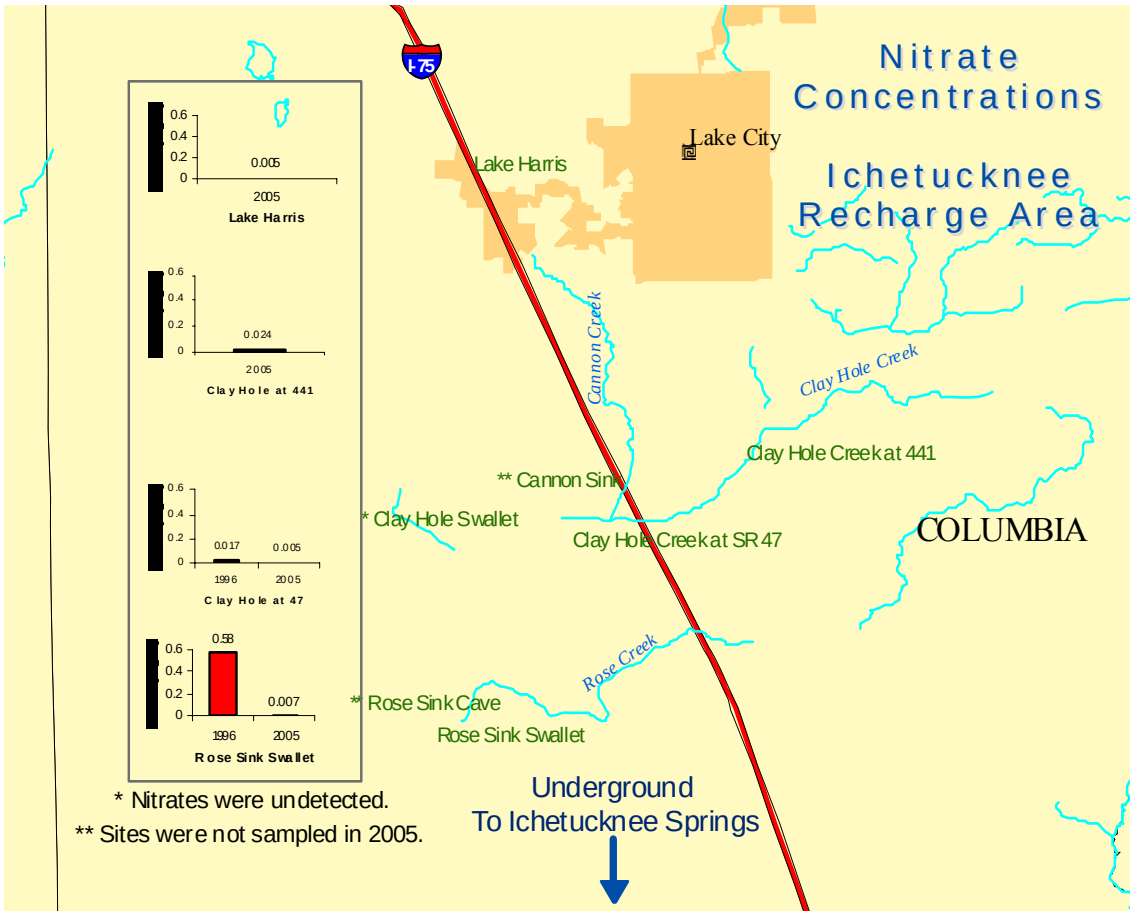

Figure 4. Nitrate-nitrite at recharge area sites.

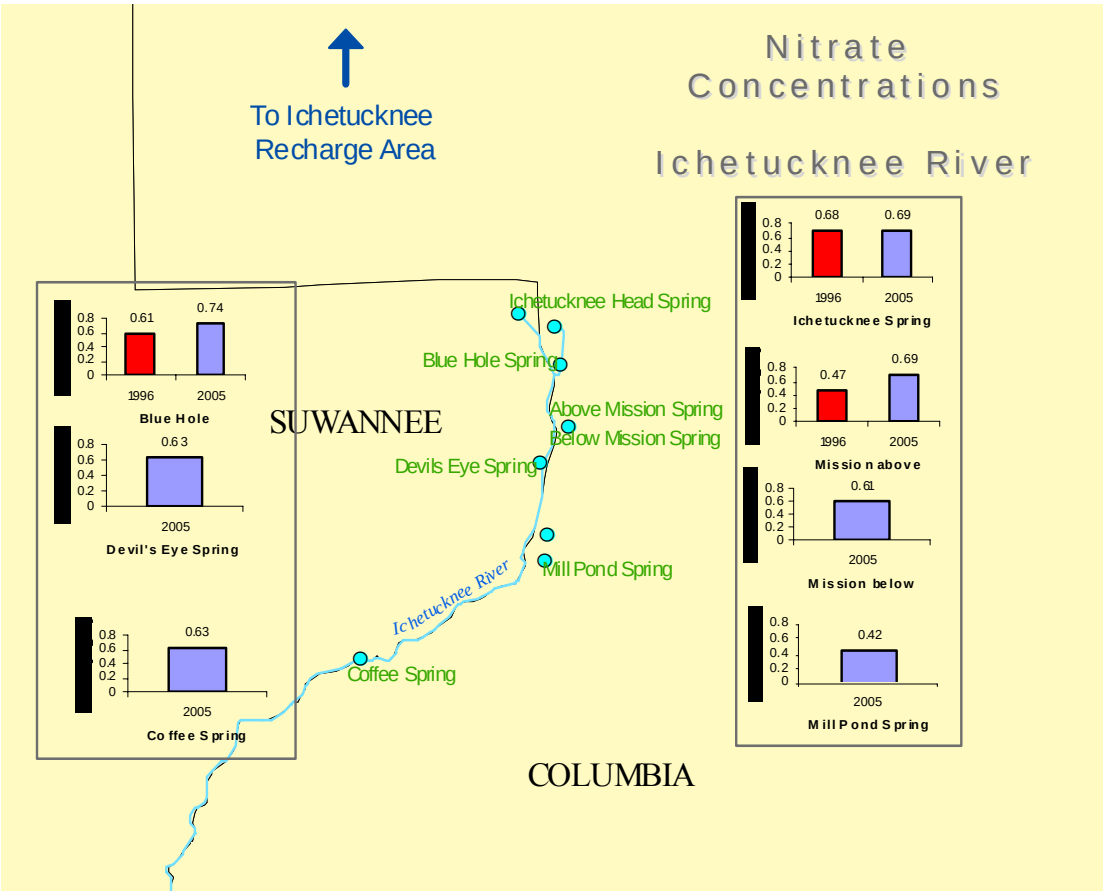

Figure 5. Nitrate-nitrite at Ichetucknee River sites.

These results suggest that nitrate inputs from direct groundwater discharges (*e.g.*, fertilizer applications, septic tanks, potentially the sprayfield) in the recharge area are more significant than the surface water sources captured by the sinkholes. For example, although the nitrate-nitrite concentration at Rose Sink Swallet actually decreased from 0.58 mg/L in 1996 to 0.007 mg/L in 2005, nitrate concentrations in the Ichetucknee River tended to be slightly higher than those recorded in 1996.
Total Kjeldahl Nitrogen (TKN) at the recharge area sites ranged from 0.62 mg/L to 1.3 mg/L, with decomposing leaf litter the most probable source. In contrast, TKN was undetected at all Ichetucknee River sites

Bacteria

With one exception, fecal coliform bacteria at the recharge area sites complied with the Class III surface water quality criterion of 800 CFU/100 mL for a single sampling event (Figures 6 and 7, Appendix). Fecal coliforms were quite elevated at Clay Hole Creek at Highway 47 (66,000 CFU/100 mL, exceeding the Class III criterion). This same site also exceeded the fecal coliform standard during the 1996 sampling, suggesting a chronic source of fecal bacteria in the area. Note that the site conditions during the 2005 sampling (no flow, stagnant water) may help partially explain the extremely

elevated result. In contrast, fecal coliforms at the Ichetucknee River sites (ranging from 2 to 6 CFU/100 mL in 2005 (Appendix)) were all very low.

Fecal coliform levels at Rose Creek Swallet were also higher in 2005 (600 CFU/100 mL) than in 1996 (17 CFU/100 mL). Fecal coliform levels at Rose Creek cave, downstream of the WWTP sprayfield, were very low (2 CFU/100 mL), suggesting no significant bacterial influence from the sprayfield.

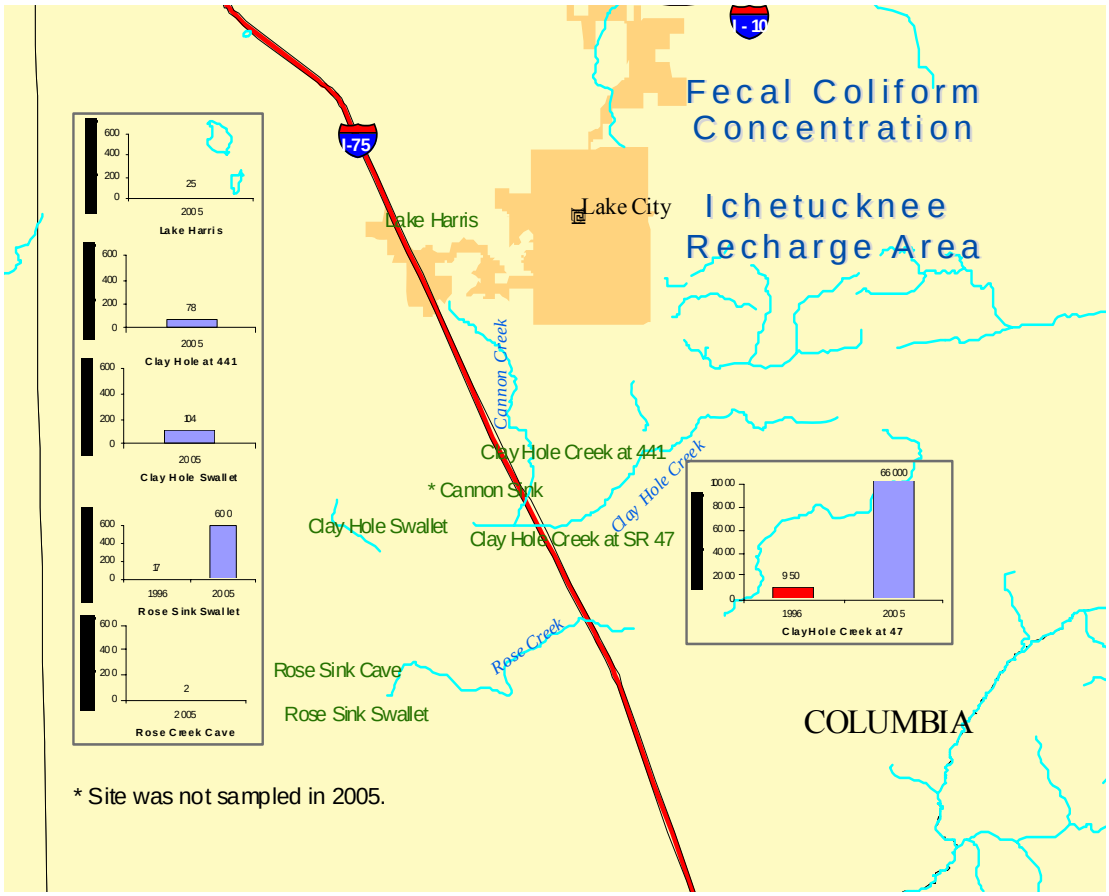

Figure 6. Fecal coliform bacteria at recharge area sites.

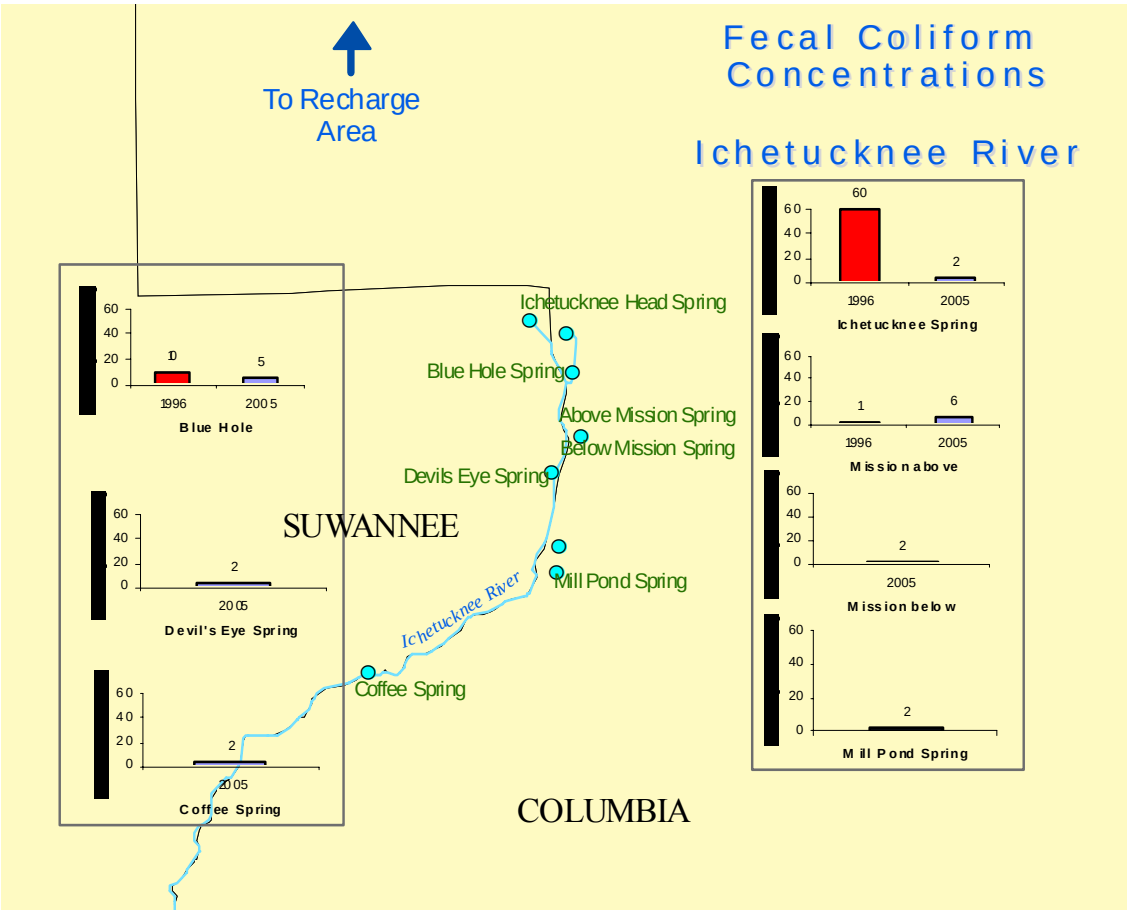

Figure 7. Fecal coliform bacteria at Ichetucknee River sites.

Total coliforms exceeded the surface water quality criterion (2,400 CFU/100mL) in 2005 at Clay Hole Swallet (3,200 CFU/100 mL) and Clay Hole Creek at 47 (90,000 CFU/100 mL. Rose Creek cave had the lowest total coliform levels of the recharge area sites (4 CFU/100 mL).

Escherichia coli bacteria tended to be higher at recharge area sites (ranging from a low of 2 CFU/100 mL at Rose creek cave to 94,000 CFU/100 mL at Clay Hole Creek at Highway 47), than at Ichetucknee River sites (ranging from 2 CFU/100 mL to 8 CFU/100 mL) (Appendix). Clay Hole Creek at Highway 47 and Rose Sink Swallet exceeded the EPA single sample bathing beach guideline of 235 CFU/100 mL for *Escherichia coli* bacteria, with 94,000 CFU/100 mL and 800 CFU/100 mL, respectively.

All the recharge area sites exceeded the EPA Enterococci single sample bathing beach guideline of 61 CFU/100 mL, except for Clay Hole at 441 (58 CFU/100mL) and Rose Creek cave (2 CFU/100mL). There are questions concerning the applicability of this guideline to Class III waters.

Caffeine

Caffeine was detected at Clay Hole Swallet, at a concentration of 0.016 ug/L, which is less than the practical quantitation limit for caffeine. The presence of a small amount of caffeine suggests that a well diluted source of human waste influences the area.

Optical Brighteners

Optical brighteners are dyes that are used in both powdered and liquid laundry detergents to make clothes look whiter and brighter and are therefore associated with grey water contributions to domestic or municipal sources. The fluorometric method has been used successfully in other studies to identify where failing septic tanks or municipal pipelines were leaking into ground or surface waters (Hagedorn et al, 2005, Hagedorn, et al, 2002, McDonald, et al, 2005). Since some home owners have separate septic and laundry grey water waste streams, the optical brightener signal may not always be associated with fecal contamination. Based upon the increased fluorescence reading, modest levels of optical brighteners were potentially detected at test sites from Clay Hole down to Rose Sink (Appendix). The fecal indicators and boron showed a similar trends except for Devils Eye where these indicators were not remarkable. Boron is another chemical parameter that could be linked to grey water through the use of powdered detergents.

Sediments

Polycyclic Aromatic Hydrocarbons (PAHs) were detected in sediment samples at Clay Hole at Highway 47, but at levels lower than those in 1996 (Appendix). At Clay Hole at Highway 47, pyrene was detected at 83 ug/kg in 2005, compared to 1,500 ug/kg in 1996. The current pyrene concentration in the sediments at Clay Hole (83 ug/kg) is below the consensus-based sediment quality guideline Threshold Effect Concentration for pyrene of 195 ug/kg, indicating that harmful effects would not be expected at this level (McDonald *et. al*, 2000). PAHs were undetected for all other sites. No other organic contaminants were found in sediments at any station.

Periphyton Above and Below Mission Spring

The average periphyton chlorophyll *a* concentration at the site below Mission Spring (537 mg/ m^2) was more than double the concentration at the site above Mission Spring (248.5 mg/m^2). Algal thickness followed this same trend (Figures 8 and 9, Appendix). EPA guidance suggests that designated uses may be impaired when periphyton chlorophyll *a* levels due to filamentous algae exceeds 150 mg/ m^2.

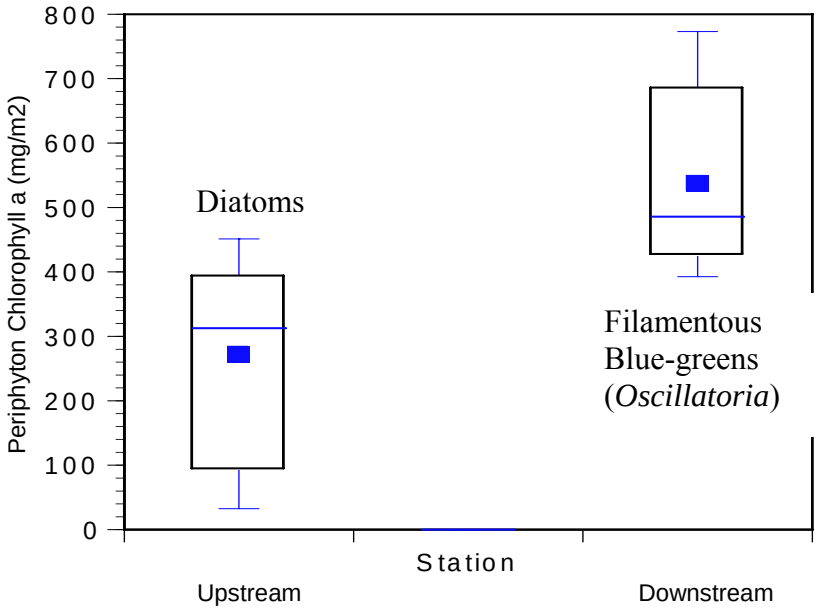

Figure 8. Periphyton chlorophyll *a* harvested from eel grass above and below Mission Springs (n= 10 blades per site).

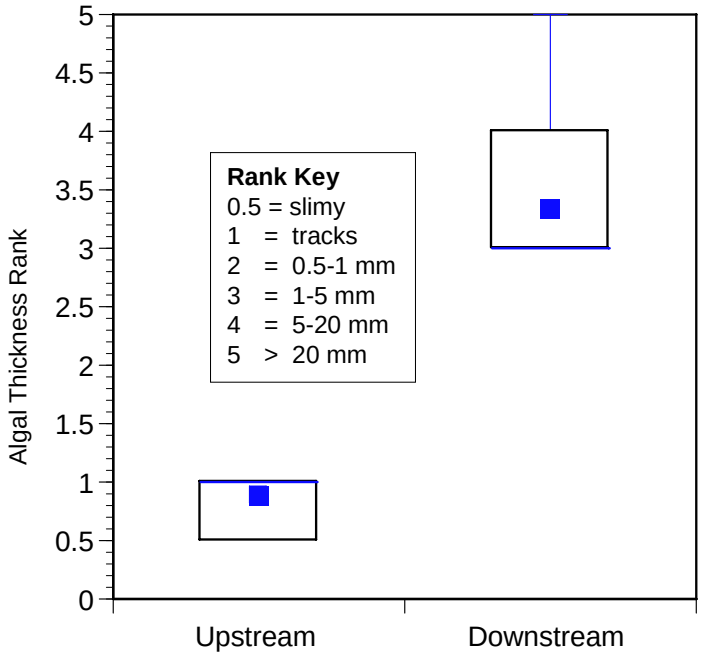

Figure 9. Periphyton thickness above and below Mission Springs (n = 90 observations per site).

Nitrate-nitrite concentrations were similar at both sites, ranging in the 90th percentile concentration for typical Florida streams. The concentration below Mission Spring (0.61 mg/L) was slightly lower than the site above Mission Spring (0.69 mg/L), suggesting nitrates are not the sole factor influencing the differences in algal growth. The dissolved oxygen decreased from 6.3 mg/L above Mission Springs to 1.1 mg/L below Mission Springs, a value that does not comply with the Class III dissolved oxygen criterion of ≥5.0 mg/L. The lack of dissolved oxygen (potentially a natural occurrence near the boils of most springs) could decrease the algal grazers (*e.g., Elimia floridense*), which could result in increased algal accumulation at the site below Mission Springs. Therefore, excess nitrates, acting in concert with naturally low dissolved oxygen, contributed to the excessive algal growth below Mission Spring. The nuisance algal biomass (filamentous blue-greens) below Mission Spring interferes with aesthetics and recreational use of the area, and is considered an imbalance of aquatic flora (Rule 62-302.500 (48)(b) F.A.C.).

Conclusions

Pesticide and herbicide contamination did not appear to be an issue throughout the basin, as only a non-problematic level of hexazinone (an herbicide used in silviculture) was found at a single location (Ichetucknee Head Spring). Similarly, metals throughout the basin were found at concentrations that complied with Class III surface water quality criteria, except at Clay Hole Creek at Highway 47, where mercury and lead exceeded their respective criteria. The hydrologic conditions at this site during sampling were unusual, in that there was no flow, only stagnant disconnected pools were present. Therefore, current results from Clay Hole Creek at Highway 47 can not be considered representative of typical conditions.

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Conversely, nitrate-nitrite concentrations were much lower in the sinkhole-captured streams than they were in the Ichetucknee springs. The Ichetucknee river sites were all elevated with respect to nitrate-nitrite, tending to exceed the 85-90th percentile concentrations for typical Florida streams. These results suggest that nitrate inputs from direct groundwater discharges (*e.g.*, fertilizer applications, septic tanks, potentially the sprayfield) in the recharge area are more significant than the surface water sources captured by the sinkholes. Nitrate concentrations in the Ichetucknee River sites during 2005 tended to be slightly higher than those recorded in 1996.

Fecal coliform bacteria at all sites complied with the Class III surface water quality criterion except for at Clay Hole Creek at Highway. Fecal coliforms at the Ichetucknee River sites (ranging from 2 to 6 CFU/100 mL in 2005) were all very low.

Fecal coliform levels at Rose Creek cave, downstream of the WWTP sprayfield, were very low (2 CFU/100 mL), suggesting no significant bacterial influence from the sprayfield. Other bacterial indicators (total coliforms, *E. coli*) tended to follow this same trend.

Caffeine was detected at Clay Hole Swallet, at a concentration of 0.016 ug/L, which is less than the practical quantitation limit for caffeine. The presence of a small amount of caffeine suggests that a well diluted source of human waste influences the area.

The optical brightener results suggest that there are widespread grey water contributions downstream of the sprayfield, but within the Itchetucknee springs only Devil's Eye, and to a much lesser extend Mill Pond Spring, is being influenced by grey water sources.

Polycyclic Aromatic Hydrocarbons (PAHs) in sediments were not detected except at one site. Pyrene was detected at Clay Hole Creek at Highway 47 at a level below its consensus-based sediment quality guideline Threshold Effect Concentration. No other organic contaminants were found in sediments at any station.

The average periphyton chlorophyll *a* was found to be more than double at the site below Mission Spring (537 mg/ m^2) when compared with the site above Mission Spring (248.5 mg/m^2). Algal thickness followed this same trend. EPA guidance suggests that designated uses may be impaired when periphyton chlorophyll exceeds 150 mg/ m^2. Excess nutrients, acting in concert with low dissolved oxygen, contributed to the excessive algal growth below Mission Spring, and is considered an imbalance of aquatic flora (Rule 62-302.500 (48)(b) FAC).

Overall, water quality in the Ichetucknee River and associated springs complied with Class III surface water quality criteria. Nitrate-nitrite enrichment was an issue throughout all of the Ichetucknee River springs and an imbalance of aquatic flora was observed below Mission Spring.

Citations

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Appendix

Table 1. Organic pollutants in Water.

Pesticides/Herbicides in Water Samples (mg/L)								
	Acephate		Hexazinone		Atrazine		Simazine	
Sample Site	1996 data	2005 data	1996 data	2005 data	1996 data	2005 data	1996 data	2005 data
Lake Harris	*	*	*	0.0096 U	*	0.0096 U	*	0.0096 U
Lake Harris dup	*	*	*	0.0095 U	*	0.0095 U	*	0.0095 U
Clay Hole at 441	*	*	*	0.0096 U	*	0.0096 U	*	0.0096 U
Clay Hole at 441 dup	*	*	*	0.0096 U	*	0.0096 U	*	0.0096 U
Clay Hole Creek at 47	1.5 U	*	0.19 U	0.0096 U	0.047 U	0.0069 U	0.047 U	0.0096 U
Clay Hole swallet	*	*	*	*	*	*	*	*
Rose Sink Swallet	*	*	0.19 U	0.011 U	0.047 U	0.011 U	0.047 U	0.011 U
Rose Sink cave	*	*	*	0.01 U	*	0.01 UJ	*	0.01 U
Lime Rock Mine #1	*	*	0.19 U	*	0.047 U	*	0.047 U	*
Lime Rock Mine #2	*	*	0.19 U	*	0.047 U	*	0.047 U	*
Ichetucknee Spring #1	*	*	0.2 U	0.012 I	0.05 U	0.0096 U	0.049 U	0.0096 U
Ichetucknee Spring #2	1.5 U	*	0.2 U	0.012 I	0.049 U	0.0096 U	0.05 U	0.0096 U
Blue Hole Spring	*	*	0.19 U	0.0096 U	0.046 U	0.0096 U	0.046 U	0.0096 U
Roaring (Mission above)	*	*	0.19 U	0.0097 U	0.046 U	0.0097 U	0.046 U	0.0097 U
Mission below	*	*	*	0.0099 U	*	0.0099 U	*	0.0099 U
Devil's Eye Spring	*	*	*	0.0096 U	*	0.0096 U	*	0.0096 U
Mill Pond Spring	*	*	*	0.0097 U	*	0.0097 U	*	0.0097 U
Coffee Spring	*	*	*	0.0097 U	*	0.0097 U	*	0.0097 U
SRWMD Monitoring Well	*	*	0.19 U	*	0.047 U	*	0.047 U	*
Cannon Sink	***1.5 T***	*	***0.19 T***	*	*0.10 I*	*	***0.047 T***	*
*** No data**								

Italicized values indicate the results reported are below quantitation limits.

Italicized boldfaced values indicate the results reported are below routine detection limits.
N/A indicates that acephate was not analyzed in those samples.

Table 2. Nutrients in water.

Nutrients in Water Samples (mg/L)								
	O-Phosphate-P		TP		NH3		Un-ionized ammonia	
Sample Site	1996 data	2005 data	1996 data	2005 data	1996 data	2005 data	1996 data	2005 data
Lake Harris	*	0.006 I	*	0.12	*	0.01 U	*	U
Lake Harris dup	*	0.007 I	*	0.12	*	0.01 U	*	U
Clay Hole at 441	*	0.4	*	0.44	*	0.18	*	0.00019
Clay Hole at 441 dup	*	0.4	*	0.43	*	0.19	*	0.00020
Clay Hole Creek at 47	0.26	0.13	0.65	0.29	0.050	0.017 I	0.00022	3.22E-06
Clay Hole swallet	*	0.16	*	0.22	*	0.053	*	2.10E-05
Rose Sink Swallet	0.058	0.094	0.12	0.17	*0.014 I*	0.015 I	2.37E-05	2.37E-06
Rose Sink cave	*	0.061	*	0.07	*	0.01 U	*	U
Lime Rock Mine #1	0.004 U	*	0.024	*	*0.016 I*	*	0.00025	*
Lime Rock Mine #2	0.004 U	*	*0.01*	*	*0.018 I*	*	0.00054	*
Ichetucknee Spring #1	0.021	0.022	0.02	0.021 I	0.01 U	0.01 U	U	U
Ichetucknee Spring #2	0.019 (0.029)	0.022	0.027 Y	0.021 I	0.01 U (0.01 U)	0.01 U	U	U
Blue Hole Spring	0.041	0.045	0.042	0.044 I	0.01 U	0.022	U	0.00017
Roaring (Mission above)	0.056	0.035	0.053	0.032 I	0.01 U	0.01 U	U	U
Mission below	*	0.056	*	0.054 I	*	0.01 U	*	U
Devil's Eye Spring	*	0.055	*	0.058 I	*	0.01 U	*	U
Mill Pond Spring	*	0.056	*	0.06 I	*	0.016 I	*	0.00018
Coffee Spring	*	0.027	*	0.02	*	0.01 U	*	U
SRWMD Monitoring Well	0.043 A	*	0.058	*	0.01 U	*	U	*
Cannon Sink	0.030	*	0.13	*	0.039	*	0.00057	*
*** No data**								

Italicized values indicate the results reported are below quantitation limits;

Values in parentheses are results from a second sampling exercise;

N/A - The analyses could not performed due to a sample preservation error.

Table 2 Continued.

Nutrients in Water Samples (mg/L)				
	NO2 +NO3		TKN	
Sample Site	1996 data	2005 data	1996 data	2005 data
Lake Harris	*	0.005 I	*	1.3
Lake Harris dup	*	0.004 U	*	1.2
Clay Hole at 441	*	0.024	*	0.79
Clay Hole at 441 dup	*	0.025	*	0.75
Clay Hole Creek at 47	0.017	0.005 I	1.1	0.62
Clay Hole swallet	*	0.004 U	*	0.65
Rose Sink Swallet	0.58	0.007 I	0.10	0.91
Rose Sink cave	*	0.43	*	0.08 U
Lime Rock Mine #1	6.9	*	0.25	*
Lime Rock Mine #2	1.9	*	0.15	*
Ichetucknee Spring #1	0.68	0.69	0.06 U	0.06 U
Ichetucknee Spring #2	* (0.8)	0.69	* (0.06 U)	0.06 U
Blue Hole Spring	0.61	0.74	0.06 U	0.06 U
Roaring (Mission above)	0.47	0.69	0.06 U	0.06 U
Mission below	*	0.61	*	0.06 U
Devil's Eye Spring	*	0.63	*	0.06 U
Mill Pond Spring	*	0.42	*	0.06 U
Coffee Spring	*	0.63	*	0.06 U
SRWMD Monitoring Well	0.079 A	*	0.06 U	*
Cannon Sink	0.020 A	*	0.88	*
*** No data**				

Table 3. Metals in water.

Metals in Water Samples (ug/L)

	Mercury (ng/L)	Arsenic	Chromium	Copper	Lead	Zinc	Boron
Sample Site	2005 data	2005 data	2005 data	2005 data	2005 data	2005 data	2005 data
Lake Harris	3.8	2.59	0.78 I	0.64 I	0.73 I	2 I	16 I
Lake Harris Dup	3.5	2.64	1.1 I	0.69 I	0.83 I	2 U	16 I
Clay Hole at 441	5.4 A	1.06	0.65 I	0.5 U	0.45 U	5.2 I	17 I
Clay Hole at 441 Dup	5.2	0.85 I	0.85 I	0.5 U	0.49 I	7.1 I	17 I
Clay Hole Creek at 47	26 A	1.48	12.9	3.7	10.1	16	15 I
Clay Hole Swallet	1.5	1.34	2 U	0.5 U	0.45 U	3 U	18 I
Rose Sink Swallet	2.2	0.89 I	2 U	0.5 U	0.45 U	3.5 I	10 U
Rose Sink Cave	1	1.14 I	2 U	0.5 U	0.51 I	3 U	10 I
Lime Rock Mine #1	*	*	*	*	*	*	*
Lime Rock Mine #2	*	*	*	*	*	*	*
Ichetucknee Spring #1	0.3 I	0.78 I	2 U	0.5 U	0.45 U	3 U	10 U
Ichetucknee Spring #2	*	*	*	*	*	*	*
Blue Hole Spring	0.39 I	0.86 I	2 U	0.5 U	0.45 U	3 U	10 U
Roaring (Mission above)	0.6	0.98 I	2 U	0.5 U	0.45 U	3 U	10 U
Mission Below	0.55	1.38	2 U	0.5 U	0.45 U	3 U	10 U
Devil's Eye Spring	0.39 I	1.4	2 U	0.5 U	0.45 U	3 U	10 U
Mill Pond Spring	0.46	1.39	2 U	0.5 U	0.45 U	3 U	10 U
Coffee Spring	0.3 I	0.73 I	2 U	0.5 U	0.45 U	3 U	10 U
SRWMD Monitoring Well	*	*	*	*	*	*	*
Cannon Sink	*	*	*	*	*	*	*

* No Data

Table 4. PAH in sediment.

PAH in Sediment Samples (ug/kg)

	Benzo(b)fluoranthene		Benzo(a)pyrene		Benzo(g,h,i)perylene		Chrysene	
Sample Site	1996 data	2005 data	1996 data	2005 data	1996 data	2005 data	1996 data	2005 data
Lake Harris	*	*	*	*	*	*	*	*
Lake Harris Dup	*	*	*	*	*	*	*	*
Clay Hole at 441	*	*	*	*	*	*	*	*
Clay Hole at 441 Dup	*	*	*	*	*	*	*	*
Clay Hole Creek at 47	3.90E+02 I	150	*	69 I	1.05E+03	59 I	2.60E+03	77 I
Clay Hole Swallet	*	41 U	*	41 U	*	41 U	*	41 U
Rose Sink Swallet	87 U	37 U	*	37 U	87 U	37 U	87 U	37 U
Rose Sink Cave (ug/L)	*	*	*	*	*	*	*	*
Lime Rock Mine #1	*	*	*	*	*	*	*	*
Lime Rock Mine #2	*	*	*	*	*	*	*	*
Ichetucknee Spring #1	91 U	39 U	*	39 U	91 U	39 U	91 U	39 U
Ichetucknee Spring #2	*	*	*	*	*	*	*	*
Blue Hole Spring	170 U	40 U	60 U	40 U	170 U	40 U	170 U	40 U
Roaring (Mission Above)	100 U	67 U	*	67 U	100 U	67 U	100 U	67 U
Mission Below	*	37 U	*	37 U	*	37 U	*	37 U
Devil's Eye Spring	*	39 U	*	39 U	*	39 U	*	39 U
Mill Pond Spring	*	30 U	*	30 U	*	30 U	*	30 U
Coffee Spring	*	*	*	*	*	*	*	*
SRWMD Monitoring Well	*	*	*	*	*	*	*	*
Cannon Sink	2.20E+02 I	*	*	*	89 U	*	1.30E+02 I	*

Table 4 Continued.

PAH in Sediment Samples (ug/kg)

	Fluoranthene		Indeno(1,2,3-cd)pyrene		Pyrene	
Sample Site	1996 data	2005 data	1996 data	2005 data	1996 data	2005 data
Lake Harris	*	*	*	*	*	*
Lake Harris Dup	*	*	*	*	*	*
Clay Hole at 441	*	*	*	*	*	*
Clay Hole at 441 Dup	*	*	*	*	*	*
Clay Hole Creek at 47	3.00E+03	110 I	1.50E+03	54 I	3.20E+03	83 I
Clay Hole Swallet	*	41 U	*	41 U	*	41 U
Rose Sink Swallet	87 U	37 U	87 U	37 U	87 U	37 U
Rose Sink Cave (ug/L)	*	*	*	*	*	*
Lime Rock Mine #1	*	*	*	*	*	*
Lime Rock Mine #2	*	*	*	*	*	*
Ichetucknee Spring #1	91 U	39 U	91 U	39 U	91 U	39 U
Ichetucknee Spring #2	*	*	*	*	*	*
Blue Hole Spring	170 U	40 U	170 U	40 U	170 U	40 U
Roaring (Mission Above)	100 U	67 U	100 U	67 U	100 U	67 U
Mission Below	*	37 U	*	37 U	*	37 U
Devil's Eye Spring	*	39 U	*	39 U	*	39 U
Mill Pond Spring	*	30 U	*	30 U	*	30 U
Coffee Spring	*	*	*	*	*	*
SRWMD Monitoring Well	*	*	*	*	*	*
Cannon Sink	1.60E+02 I	*	89 U	*	1.40E+02 I	*

Table 5. Bacteria in water.

Bacteria Counts in Water Samples (#/100 mL)

	Fecal Coliform		Total Coliform		Enterococci		Escherichia Coli	
Sample Site	1996 data	2005 data	1996 data	2005 data	1996 data	2005 data	1996 data	2005 data
Lake Harris	*	25 BQ	*	200 Q	*	4800	*	12
Lake Harris dup	*	25 BQ	*	210 Q	*	4100	*	13
Clay Hole at 441	*	78 Q	*	250 Q	*	58	*	78
Clay Hole at 441 dup	*	58 Q	*	350 Q	*	48	*	72
Clay Hole Creek at 47	*950 AQ*	66000 BQ	*3850 AQ*	90000 BQ	*	2800	*	94000
Clay Hole swallet	*	104 Q	*	66000 BQ	*	490	*	200
Rose Sink Swallet	17 A	600 Q	355 A	3200 Q	*	200	*	800
Rose Sink cave	*	2 K	*	4 B	*	2	*	2
Lime Rock Mine #1	1 K	*	30	*	*	*	*	*
Lime Rock Mine #2	1 K	*	250	*	*	*	*	*
Ichetucknee Spring #1	*60 Q*	2 BQ	*200 Q*	16 BQ	*	6	*	2
Ichetucknee Spring #2	*22 Q (1 Q)*	2 BQ	*200 Q (40 Q)*	16 BQ	*	6	*	2
Blue Hole Spring	*10 Q*	5 ABQ	*40 Q*	26 ABQ	*	11	*	2
Roaring (Mission above)	1 K	6 ABQ	1 K	14 ABQ	*	66	*	2
Mission below	*	2 KQ	*	280 Q	*	2	*	8
Devil's Eye Spring	*	2 KQ	*	6 BQ	*	14	*	2
Mill Pond Spring	*	2 KQ	*	4 BQ	*	8	*	2
Coffee Spring	*	2 KQ	*	18 BQ	*	2	*	2
SRWMD Monitoring Well	30	*	300	*	*	*	*	*
Cannon Sink	*300 Q*	*	*2000 Q*	*	*	*	*	*

*** No Data**

Italicized values indicate that holding times for bacterial analysis were exceeded.

Values in parentheses are results from a second sampling exercise.

Results at Ichetucknee Springs #2 represent averages from two samples.

Table 6. Optical brightener results.

Optical Brightener Analysis
FDEP Bureau of Laboratories
Biology Section

Project	Ichetucknee River
Date Sampled	9-22-05
Date Analyzed	10-05-05
Analyst	RB
Sample Analysis Temp (°C)	21 °C
Blank	DI water
Blank Percent	154%
Span	80%
Date Calibrated	10-05-05
Date Standard Stock made	6-22-05

Sample ID	Fluorescence Reading (ppb)	Comment
Blank	-0.1	
Devils Eye	8.81	Reading jumped around then slowly increased
Mill Pond	1.30	Slow increase
Blues Hole	0.601	Slow increase
Dup 1	4.62	Stable (Lake Harris Dup) 0.65% RPD
Mission Below	0.257	Slow increase
Ichetuck Spring	0	Stable
Coffee Spring	0	Stable
Clay Hole Swallet	4.48	Stable
Lake Harris	4.59	Stable
Clay Hole @ 47	5.94	Stable
Mission Above	0	Stable
Clay Hole @ 441	5.26	Stable
Field Blank	-0.2	Stable
Rose Sink	7.25	Stable
Dup 2	5.22	Stable (Clay Hole @ 441 Dup) 0.76% RPD
Standard 6.25	5.97	4.6 % RPD
Blank	0	
Calibration Run		(Standard analyzed prior to analysis)
STD 50 ppb	50.8	
STD 25 ppb	25.4	
STD 12.5 ppb	12.5	
STD 6.25 ppb	6.0	

Typical Values for Selected Parameters in Florida Waters
Adapted from Joe Hand, FDER, personal communication, 1991
(data was collected between 1980 and 1989)

Percentile Distribution

Parameter	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%
STREAMS (1617 stations)											
Phytoplankton Chlorophyll *a*	0.22	0.52	0.94	1.60	3.02	4.63	6.72	9.87	14.68	27.35	48.70
Periphyton Chlorophyll *a*	0.31	0.43	0.77	1.04	2.16	2.94	6.45	10.51	17.00	39.51	60.85
H-D Diversity	0.84	2.12	2.48	2.74	2.88	3.09	3.25	3.40	3.52	3.76	3.90
Qualitative Taxa Richness	9.00	12.00	17.00	20.00	22.00	24.50	26.00	28.00	31.00	37.00	53.00
H-D Taxa Richness	6.00	6.50	9.00	11.50	13.00	15.00	17.00	21.50	26.00	29.00	32.00
TKN	0.30	0.39	0.56	0.73	0.87	1.00	1.11	1.26	1.49	1.93	2.80
Ammonia	0.02	0.02	0.04	0.05	0.06	0.08	0.11	0.14	0.20	0.34	0.60
NO2-NO3	0.01	0.01	0.03	0.05	0.07	0.10	0.14	0.20	0.32	0.64	1.05
Total Phosphorus	0.02	0.03	0.05	0.06	0.10	0.13	0.18	0.25	0.39	0.74	1.51
Ortho Phosphate	0.01	0.01	0.03	0.04	0.05	0.08	0.11	0.17	0.27	0.59	1.37
Turbidity	0.60	0.90	1.20	1.45	2.10	2.80	3.60	4.50	6.65	10.45	16.30
LAKES (477 stations)											
Phytoplankton Chlorophyll *a*	0.80	1.71	2.88	4.28	10.06	13.40	20.00	30.10	47.20	65.44	113.90
Dredge Diversity	0.71	0.97	1.43	1.74	1.98	2.12	2.21	2.59	2.85	3.15	3.17
Dredge Taxa Richness	3.00	5.00	6.50	7.00	9.00	10.00	11.00	13.00	15.00	17.00	21.00
TKN	0.36	0.49	0.67	0.83	1.08	1.26	1.40	1.51	1.68	2.11	3.46
NH3+NH4	0.01	0.02	0.02	0.03	0.04	0.06	0.08	0.12	0.15	0.21	0.28
NO2-NO3	0.00	0.00	0.01	0.01	0.01	0.02	0.04	0.05	0.10	0.14	0.23
Total Phosphorus	0.01	0.02	0.02	0.03	0.05	0.07	0.09	0.11	0.14	0.23	0.42
Ortho-Phosphate	0.00	0.01	0.01	0.02	0.03	0.04	0.05	0.06	0.08	0.21	0.32
Turbidity	1.00	1.25	1.55	2.05	2.75	4.50	6.45	9.60	14.10	26.00	40.00
ESTUARIES (690 stations)											
Phytoplankton Chlorophyll *a*	2.14	3.28	4.49	5.13	6.00	6.93	7.94	9.60	12.40	17.60	22.20
Dredge Diversity	1.34	1.53	1.91	2.28	2.56	2.90	3.15	3.59	4.01	4.53	4.98
Dredge Taxa Richness	4.00	6.00	9.00	11.00	15.00	18.50	25.00	35.00	41.00	62.00	90.00
TKN	0.26	0.34	0.42	0.50	0.59	0.69	0.76	0.82	0.95	1.30	1.49
NH3+NH4	0.01	0.02	0.03	0.04	0.05	0.06	0.08	0.09	0.13	0.22	0.28
NO2-NO3	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.05	0.08	0.17	0.23
Total Phosphorus	0.01	0.02	0.06	0.07	0.10	0.11	0.14	0.17	0.23	0.43	0.59
Ortho-Phosphate	0.01	0.02	0.03	0.04	0.04	0.05	0.07	0.09	0.12	0.21	0.44
Turbidity	3.50	4.00	4.50	5.05	5.40	5.60	6.30	6.80	8.00	11.40	11.75

Units:

Phytoplankton Chlorophyll *a* (ug/L), Periphyton Chlorophyll *a* (mg/m^2), Nutrients (mg/L), Turbidity (NTU), Taxa richness and diversity values are for macroinvertebrates