STATEMENT OF WORK
For Springs Protection Initiative:
Springs Protection Initiative Science (SPIS)-PHYSICOCHEMISTRY WORK GROUP

I. INTRODUCTION AND BACKGROUND

Over recent decades, many of Florida's springs have experienced reduced flow rates, increased levels of nitrate, increased biomass and cover of attached algae, decreased abundance of submerged aquatic vegetation, and changes in fish and invertebrate communities (Lowe 2013). In particular, increases (blooms) of attached algae, presumed to be caused by increased nitrate concentrations, and declines in submersed vegetation in many springs have been primary concerns by water resource agencies (FSTF 2000). Increased nitrate concentrations with time have been shown in multi-spring data sets (Brown et al. 2008) and in Silver Springs (Munch et al. 2006). These same studies documented potentially confounding relationships between nitrate concentrations and discharge that were both positive (Wekiva Springs, Brown et al. 2008) and negative (Silver Springs, Munch et al. 2006).

Experimental work with two taxa of attached algae prominent in Florida springs showed growth responses to concentration ranges of nitrate and phosphate found *in situ*. However, whereas phosphate concentrations in springs often are at or close to natural levels, nitrate concentrations often are elevated and could be reduced (Stevenson et al. 2007). A eutrophication hypothesis, that increased nitrate supply to springs has caused proliferation of attached algae and a decline in submersed macrophytes, is one reason why water resource agencies have sought to reduce nitrogen loads. Although reduction in excessive nitrogen loads is necessary for several reasons, relationships between elevated nitrate and excessive growth of attached algae have been difficult to demonstrate in the field and could be complex or indirect. Literature and data reviews have stressed the potential importance of multiple factors in determining relative success of attached algae and submersed macrophytes in springs, including light, water velocity, inhibitory effects of NO_3 on macrophytes, and effects on grazer populations of changes in nitrate and dissolved oxygen (Brown et al. 2008, Heffernan et al. 2010).

The purpose of the Springs Protection Initiative Science effort is to "Provide a sound scientific foundation for development of cost-effective approaches for management of forcings (variations in environmental drivers) influencing the hydrology, hydrodynamics, physicochemistry, and biology of spring ecosystems" (Lowe 2013).The major objectives are to

- Improve the scientific foundation for management of nitrate loading to springs using the Silver Spring System as the primary study site

- Evaluate the need for management of forcings other than nitrate loading in order to reduce benthic algal abundance and restore ecological structure and function to acceptable levels
- Elucidate the relative influence and manageability of each driver affecting the biological structure and function of springs with special emphasis on the Silver Springs system

Within the Springs Protection Initiative Science, the Physicochemistry Work Group intends to use the Silver Springs Ecosystem as the primary study site to clarify interrelationships between hydrologic and hydraulic system drivers and physicochemical attributes and to assess the effects of physicochemical drivers on ecological structure and function with emphasis on benthic algal and SAV abundance.

II. OBJECTIVES

The major objectives of the Physicochemistry Work Group are to

a) Determine whether reduction in nitrate concentrations alone will restore densities of attached algae and SAV to desirable levels
b) Determine what other system drivers affect the composition of the primary producer community
c) Review and interpret existing major studies of water chemistry and biota of the Silver Springs ecosystem and other Florida springs and compile existing data
d) Develop conceptual and empirical models that describe relationships between water chemistry, hydrologic flow regimes, and select water-dependent biota

This work plan follows a hierarchical spatial organization. The Silver Springs ecosystem is the primary focus area. Alexander Springs Run is a secondary area for study as a comparison site with limited anthropogenic influence and low nutrients. Finally, we will collaborate with District staff in the Biology Work Group to conduct a synoptic study of about fourteen Florida springs with broad ranges in hydrologic, chemical, and biological conditions. Relationships between primary producer community structure and other variables in this data set will help to understand conditions in Silver Springs.

III. SCOPE OF WORK

Objective (a) will be met by a combination of experiments and field studies and will inform in turn the modeling efforts in Objective (d). Experiments include nitrogen depletion assays conducted with *in situ* benthic chambers equipped for continuous monitoring of DO, NO3, and other variables in a variety of benthic vegetation types in both Silver Springs and Alexander Springs. We will evaluate these data to reach conclusions about effects of nitrate concentration on plant assimilation and metabolism rates, nutrient uptake kinetics, and nutrient limitations on growth rates. Further experiments will be conducted in laboratory mesocosms with the primary SAV species from Silver Springs and varying nitrate levels. We will monitor multiple shoot and root growth metrics and tissue nutrient and protein content. Field studies include the analysis of diel changes in dissolved oxygen concentration to calculate net and gross system primary production and respiration and the simultaneous analysis of diel changes in nitrate concentration to calculate components of nitrogen metabolism. Further field studies involve measurements of *in situ* SAV growth at multiple sites in Silver Springs and Alexander Springs and in situ measurements of sediment pore water concentrations of N species and estimation of N supply from sediments through both diffusive and advective fluxes. The District's Springs Synoptic Study will provide additional information on composition of the primary producer community in springs at varying nitrate levels.

Objective (b) similarly will be met by a combination of experiments and field studies and will inform modeling efforts for Objective (d). Experiments will be conducted with *in situ* benthic chambers equipped for continuous monitoring of DO, NO3, and other variables in both Silver Springs and Alexander Springs. These experiments will vary sediment type, vegetation type, trace nutrient concentrations, and density of grazing organisms to study controls on primary producers such as light, sediment texture, trace elements, phosphorus, and aquatic grazers. Further experiments will be conducted in laboratory mesocosms with the primary SAV species from Silver Springs. These experiments will study the effects of current velocity, sediment types, and micronutrient concentrations on epiphytic algal abundance and plant growth. Field studies include estimates of orthophosphate uptake and release rates from analyses of diel changes in concentration at multiple sites in Silver Springs and Alexander Springs coincident with measurements of net and gross system primary production and respiration (above). Further field studies involve measurements of in situ SAV growth at multiple sites in Silver Springs and Alexander Springs and in situ measurements of sediment pore water concentrations of SRP, sulfate, sulfide, and trace metals and estimation of supply from sediments through diffusive and advective fluxes. Collaborative work with the Biology and the Hydrodynamics/Hydraulics work groups will provide additional experimental and field data on effects of water velocity and grazers on PPCS. The District's Springs Synoptic Study will provide information on composition of the primary producer community in springs at varying discharge levels, DO concentrations, and grazer community structure and density.

Objective (c) will be met by compilation of historical and current water chemistry and flow data for Silver Springs and other District springs by District staff; calculation of descriptive statistics, correlations, and trends; and calculation of relationships between discharge and levels of water chemistry variables. These analyses will comprise a series of district reports. Furthermore, District staff will produce summaries and analyses of literature information for two subjects: 1) the potential for nitrate-nitrite inhibition of submerged aquatic vegetation (SAV) in Florida springs, and 2) macroinvertebrate grazers, dissolved oxygen stress, and the loss of top-down control of algae in Florida spring ecosystems. These literature analyses will be finalized as District reports and, potentially, peer-reviewed journal publications.

Objective (d) will be met by collaborative analyses by District and UF members from the three work groups in the springs ecosystem supergroup (work groups in hydrodynamics/ hydraulics, physicochemistry, and biology) plus the technical project leads from both organizations. The format and specific approaches for that modeling have not yet been developed and will be fleshed out as data collection and analysis begins. Subsequently, the Springs Protection Initiative Science program likely will expand modeling to incorporate the work of both the springs ecosystem supergroup and the springshed supergroup (work groups in surface water hydrology, groundwater hydrology, and nitrogen biogeochemistry). Here as well, the format and specific approaches for this final, integrative modeling have not yet been developed and will be worked out in years two and three of the project.

IV. TASK IDENTIFICATION AND REQUIRED RESOURCES

Task 1. Benthic sources and sinks of nutrients

- Subtask 1A Map the thickness of benthic sediments within the Silver River channel. *UF-SPIS contract. Requires District assistance with permits and logistics.*
- Subtask 1B Identify biogeochemical transformations of the pore water compositions with particular emphasis on N, SRP, and dissolution of Fe-Mn oxides. *UF-SPIS contract. Requires prior identification of sampling sites and evaluation of sampling gear by UF and District assistance with permits and logistics.*
- Subtask 1C Estimate diffusive and advective fluxes of solutes from the sediment to the overlying water column. *UF-SPIS contract. Requires measurements by UF of hydraulic head gradients between the river and sediment pore water and sediment and pore-water characteristics from Subtasks 1A and 1B.*

Task 2 Nitrogen Dynamics and Metabolism

- Subtask 2A Quantify continuous C and N and, where feasible, P metabolism using in situ sensor data from the District. *UF-SPIS contract. Requires District continuous monitoring of dissolved oxygen, nitrate, orthophosphate, and temperature at four sites in the Silver*

Springs system and two sites in Alexander Springs Run. UF staff will monitor additional sites in both ecosystems for short periods. Requires discharge data from District monitoring and travel times from the Hydrodynamics – Hydraulics Work Group.

- Subtask 2B Conduct in situ nitrogen depletion experiments. *UF-SPIS contract. Requires design, construction, and testing of benthic chambers by UF; District assistance with permits and logistics; and collaboration with Biology Work Group on grazing experiments.*
- Subtask 2C Conduct in situ SAV growth experiments. *UF-SPIS contract. Requires District assistance with permits and logistics.*
- Subtask 2D Conduct mesocosm measurements of SAV growth. *UF-SPIS contract. Requires District assistance with permits and logistics.*

Task 3 SJRWMD Review, data management and analysis, and administration

- Subtask 3A: Management of work plans and work orders with UF and internal project management
- Subtask 3B: Overall planning and scientific review
- Subtask 3C: Data management and analyses of springs physicochemistry
- Subtask 3D: Springs spatial analyses and contract GIS analyst

V. SCHEDULE

A. Task Schedule

	Data collection/Analysis
	Interim report
	Final report

		FY14		FY15				FY16				FY17	
		Work Plan Yr 1 (Phase 1)				Yr 2 (Phase 2)				Yr 3 (Phase 3)			
		Cal Yr 2014			2015				2016				2017
		2	3	4	1	2	3	4	1	2	3	4	1
Task 1	Benthic sources and sinks of nutrients												
Subtask 1A	Map thickness of benthic sediments												
Subtask 1B	Biogeochemical controls on pore water chemistry												
Subtask 1C	Collect data and estimate diffusive and advective fluxes of solutes												
Task 2	Nitrogen dymanics and metabolism												
Subtask 2A	Metabolism calculations												
Subtask 2B	Nutrient depletion experiments												
Subtask 2C	In situ SAV growth experiments												
Subtask 2D	SAV mesocosm experiments												
Task 3	SJRWMD Review, data management and analysis, and administration												
Subtask 3A	Management of work plans and work orders												
Subtask 3B	Overall planning and scientific review												
Subtask 3C	Data management and analyses of springs physicochemistry												
Subtask 3D	Springs spatial analyses and contract GIS analyst												

B. Interim and Final Deliverables

Subtask	Product	Target
3C	Final report: Literature survey and analysis, The potential for nitrate-nitrite inhibition of submerged aquatic vegetation (SAV) in Florida springs	Dec 2014
3C	Final report: Literature survey and analysis, Macroinvertebrate grazers, dissolved oxygen stress, and the loss of top-down control of algae in Florida spring ecosystems	Mar 2015
2B, 2C, 2D	Interim reports: Nutrient depletion experiments, In situ SAV growth experiments, SAV mesocosm experiments	Mar 2015
1A	Interim report: Map thickness of benthic sediments	Sep 2015
3C	Final reports: Physical and chemical characteristics of a subset of Florida springs and relationships to discharge	Sep 2015
2A, 2B, 2C, 2D	Interim reports: Metabolism calculations, Nutrient depletion experiments, In situ SAV growth experiments, SAV mesocosm experiments	Mar 2016
1B	Interim report: Biogeochemical controls on pore water chemistry	Sep 2016
All Subtasks	Final project reports	Mar 2017

VI. BUDGET

A. District Staff Assignments (projected FY2015)

Person	FTE
M. Coveney (leader)	0.25
J. Di	0.11
M. Guyette	0.30
J. Hendrickson	0.20

Person	FTE
R. Mattson	0.20
C. Neubauer	0.10
T. Trent	0.40
W. VanSickle	0.30

B. Contractual Budget Summary by Fiscal Year

Subtask	FY14	FY15	FY16	FY17
UF Subtask 1A: Map thickness of benthic sediments	30645	39145	8500	0
UF Subtask 1B: Biogeochemical controls on pore water chemistry	0	18000	31125	13125
UF Subtask 1C: Collect data and estimate diffusive and advective fluxes of solutes	3000	14955	38090	26135
UF Subtask 2A: Metabolism calculations	0	9500	17000	7500
UF Subtask 2B: Nutrient depletion experiments	25290	45415	28682	8557
UF Subtask 2C: In situ SAV growth experiments	14000	29500	26000	10500
UF Subtask 2D: SAV mesocosm experiments	27286	43281	33945	17951
Subtotal UF contract	100221	199797	183343	83767
District Subtask 3D: Springs spatial analyses and contract GIS analyst	14880	39000	39000	39000
Total all work	115101	238797	222343	122767
Grand Total UF contract only				567127
Grand Total all work				699007

VII. LITERATURE CITED

Brown, M. T., et al. 2008. Summary and synthesis of available literature on the effects of nutrients on springs organisms and systems. Florida Department of Environmental Protection, Tallahassee, Florida, USA.

FSTF [Florida Springs Task Force]. 2000. Florida's springs: strategies for protection and restoration. Florida Department of Environmental Protection, Tallahassee, Florida, USA

Heffernan, J. B., D. M. Liebowitz, T. K. Frazer, J. M. Evans & M. J. Cohen. 2010. Algal blooms and the nitrogen-enrichment hypothesis in Florida springs: evidence, alternatives, and adaptive management. Ecological Applications, 20(3): 816–829

Lowe, E. F. 2013. Draft Work plan for Springs Initiative Investigation (SII). February 19, 2013. St. Johns River Water Management District, Palatka, Florida, USA.

Munch, D., Toth, D. Huang, C., Davis, J., Fortich, C., Osburn, W., Phlips, E., Allen, M., Knight, R., Clarke, R., and Knight, S. 2006. Fifty-year retrospective study of the ecology of Silver Springs, Florida. Special Publication SJ2007-SP4, St. Johns River Water Management District, Palatka, Florida, USA.

Stevenson, R., A. Pinowska, A. Albertin, and J. O. Sickman. 2007. Ecological condition of algae and nutrients in Florida springs: the synthesis report. WM 858, Florida Department of Environmental Protection, Tallahassee, Florida, USA.