Appendix E

PBS&J. 2009. Vegetation mapping of the Homosassa River in support of minimum flows and levels establishment; final – January 2009. Tampa, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Errata: *The term "Ruppia" at the beginning of the first paragraph on page 3-8 should be italicized.*

The reference "PBS&J 2008" included in Table 1 on page 3-8 is not listed in the references cited section. A reference to "PBS&J 2008 unpublished" is included in the second paragraph on page 3-11.

Location information for rivers other than the Homosassa River in the third paragraph on page 3-12 is incorrect. The Chassahowitzka and Weeki Wachee rivers are located south of the Homosassa River, not north of the river as indicated in the text. Also, the Withlacoochee and Crystal rivers are located north, not south of the Homosassa River.

Scientific names for plants included in Table 2 on page 3-16 should be italicized.

The shoreline lengths for the "Maintained Landscaping" and "Seawall" shoreline categories in Table 5 on page 3-19 are incorrect. The correct values should be 410 m for "Maintained Landscaping" and 8,405 m for "Seawall".

The listing " L. Perry and K. Williams. 1996. Effects of salinity and flooding on seedlings of cabbage palm (Sabal palmetto). Oecologia 105(4):428-434" on page 5-3 in the References Section should be deleted. This paper is correctly listed under "Perry, L. and K. Williams…"

The listing "Wolfe, S.H., ed. 1990. An ecological characterization of the Florida Springs Coast: Pithlachascotee to Waccasassa Rivers. U.S. Fish Wildl. Serv. Biol. Rep. 90(21). 323 p." on page 5-4 in the References Section should be deleted. The listing is a duplication of a more correctly formatted listing for the report.

VEGETATION MAPPING OF THE HOMOSASSA RIVER IN SUPPORT OF MINIMUM FLOWS AND LEVELS ESTABLISHMENT

FINAL - JANUARY 2009

Funded by:

Southwest Florida Water Management District

Prepared by:

PBS&J

5300 West Cypress Street
Suite 200
Tampa, FL 33607

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Executive Summary

The purpose of this study was to provide technical support to the Southwest Florida Water Management District (SWFWMD) in establishing minimum flows and levels (MFLs) for the Homosassa River and therefore address the statutory directive for establishing MFLs (Section 373.042 F.S.). Under the statute, the minimum flow for a given watercourse is defined as the limit at which further withdrawals would be "significantly harmful" to the water resources or ecology of the system.

Submersed and emergent aquatic vegetation (SAV and EAV, respectively), shoreline woody vegetation, and altered shoreline were surveyed along the river, from the headsprings of the Homosassa River at River Kilometer (RK) 13 and from RK15 on the Halls River (west of U.S. 19), to the mouth of the Homosassa River. The extent and percent of shoreline vegetation (EAV and woody vegetation) and areal extent of SAV were quantified and mapped in GIS.

Mapping efforts were completed in October 2008. Boat surveys of SAV were supplemented with underwater sampling transects due to poor visibility and relatively limited distribution of the SAV. Several transects were established in areas where SAV was anticipated based on previous studies and SAV was sampled by snorkeling along transects and identifying vegetation by visual and/or hand recognition. PBS&J data were supplemented with SAV data provided by the SWFWMD, the Florida Fish and Wildlife Conservation Fisheries Independent Monitoring Program (FWRI), and Frazer *et al.* (2001 and 2006), all of which have ongoing studies in the river.

The distribution of shoreline vegetation and SAV in the Homosassa River corresponded to salinity ranges typical of individual species. SAV species sampled included eel grass (*Vallisneria americana*) along the middle river reaches and strap-leaf Sagittaria (*Sagittaria spp.*) in the upper reaches. Strap-leaf Sagittaria typically occurs at <3 ppt, while eel grass is tolerant of ≤ 10 ppt salinities.

Freshwater EAV species were limited to the Homosassa River upstream of its confluence with the Halls River at RK11. Salt-tolerant EAV species extended downstream to the limits of individual tolerances, although only very salt tolerant species characteristic of salt marshes occurred downstream of RK7.

Results of the present study were consistent with those of previous and ongoing efforts that document relatively little SAV along the Homosassa River, similar to what has been described for the spring-fed Chassahowitzka and Crystal rivers, although the results are in contrast with the Rainbow River, where SAV is extensive. Declining SAV in the Homosassa, Chassahowitzka, and Crystal rivers since 1998 has also been documented (Frazer *et al.* 2001 and 2006, Hoyer *et al.* 2005, *FWRI* (unpublished data), others). The decline has been coincident with increases in macroalgae and the “blue green algae” *Lyngbya,* as well as increased nutrient loads and recreational use. However, recent studies of springs in Florida (PBS&J 2008 unpublished, Hoyer *et al.* 2005, Frazer *et al.* 2006) have concluded that nutrient loads and concentrations accounted for little variance in SAV biomass after accounting for flow and related substrate type, light and salinity.

SAV is often a good indicator for establishing MFLs based on salinity intrusion and has been used as such in the Caloosahatchee and Suwannee rivers, among others. However, it is not an adequate indicator of increasing salinities in the Homosassa River due to its limited and declining distribution. EAV distributions may provide a good indicator for establishing MFLs along the Homosassa River. EAV species distributions generally correspond to mean high salinities along tidally influenced rivers and freshwater species respond relatively quickly to changes in salinities.

The true freshwater portion of the Homosassa River extends no farther downstream than RK13, upstream of the confluence of the Halls and Homosassa rivers. Shifts from freshwater to oligohaline salinities and corresponding species would indicate a persistent salinity increase. Salinities are less than 5 ppt from below the confluence of the Halls and Homosassa rivers at RK11 upstream to (but not including) the head springs on the Homosassa River and upstream along the Halls River to RK15. The mesohaline portion of the salinity gradient extends from RK3 to RK10 and includes the most developed portion of the river at RK8 and RK9. Freshwater tree distributions along the Homosassa River extend about 2 km farther downstream when compared with EAV distributions and may indicate historically lower salinities in the middle and upper reaches of the river, consistent with isohaline locations predicted by Yobbi et al. (1989). However, the presence of freshwater trees along the mesohaline river reaches suggests that many of the woody species may be at elevations above the tidal range of the river.

1.0 Introduction

The statutory directive for minimum flows and levels (MFLs) included in the Florida Water Resources Act was enacted by the Florida Legislature in 1972. Section 373.042 F.S. of the Act directs each water management district to establish MFLs for surface water bodies, watercourses, and aquifers within their respective jurisdictions. Under the statute, the minimum flow for a given watercourse is defined as the limit at which further withdrawals would be "significantly harmful" to the water resources or ecology of the area. The determination of MFLs must also be based on the "best available" information.

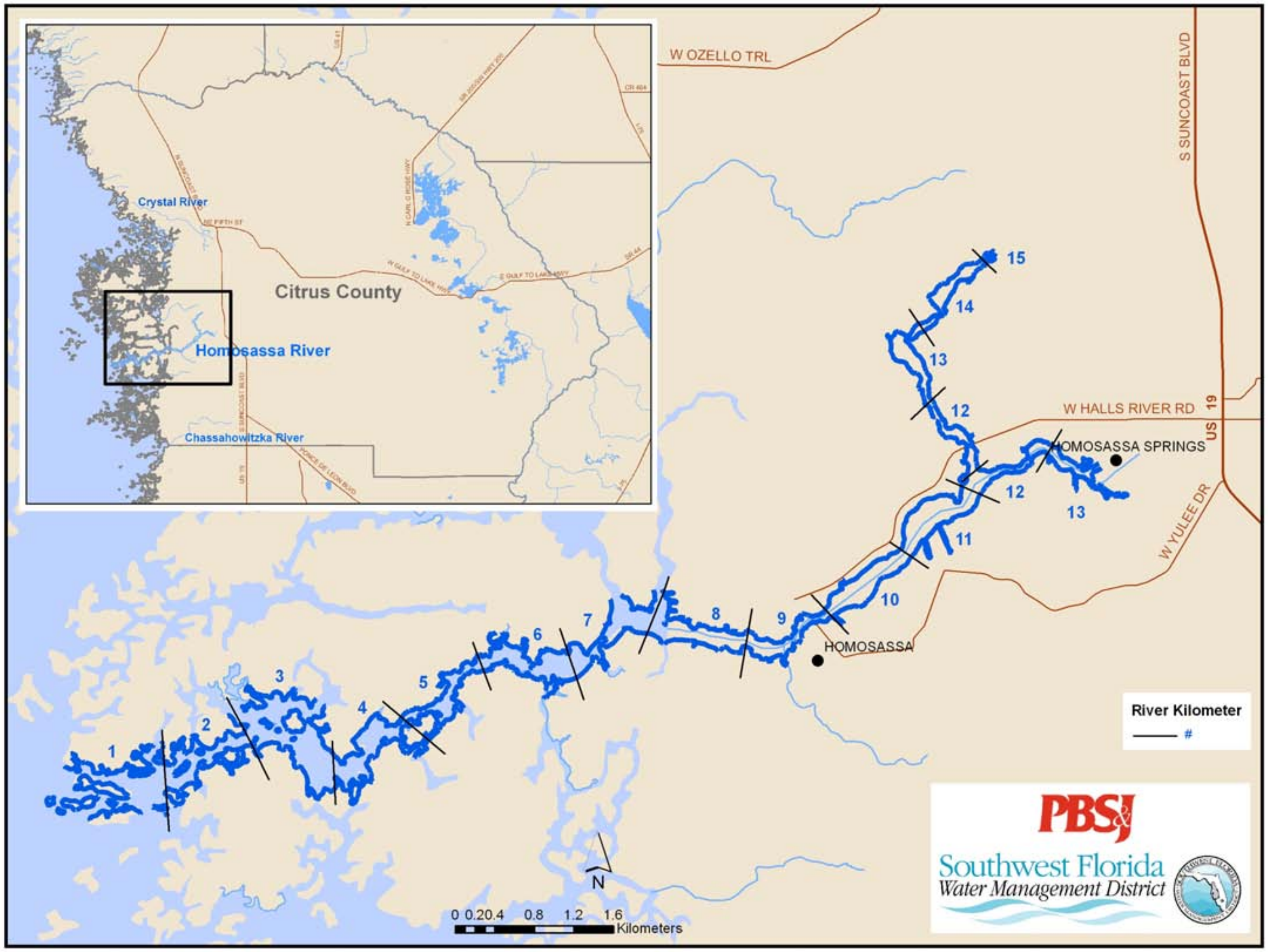
The purpose of this study was to map and characterize the submersed and emergent aquatic vegetation (SAV and EAV, respectively) along the Homosassa River to assist the Southwest Florida Water Management District (SWFWMD) in establishing MFLs for the river. The assumption is that SAV and EAV distributions reflect salinity changes and may act as indicators of increasing salinities under reduced freshwater flows in the river. PBS&J contracted with DCW, Inc, for a portion of the mapping and GIS required for this project.

Location

The Homosassa River and Springs are located in western Citrus County about six miles downstream of the headsprings of Crystal River at King's Bay and about one mile southwest of the intersection of S.R. 490A and U.S. Highway 19 (Figure 1).The Homosassa River is one of several rivers in the Coastal Springs region of Florida. The other rivers include the Rainbow, Withlacoochee, Crystal, Homosassa, Chassahowitzka, and Weeki Wachee (Estevez et al. 2001). Like the Rainbow River to the north, the sources of water for the Homosassa, Crystal, Chassahowitzka, and Weeki Wachee, are major springs or spring groups. The flow of the rivers, prior to mixing with sea water moving upriver under the influence of tides, is predominantly ground water. The Crystal, Homosassa, Chassahowitzka, and Weeki Wachee rivers flow west through hardwood hammocks, freshwater floodplain forests, fresh, brackish and salt marshes, and occasional groups of small mangroves before reaching the Gulf of Mexico.

The springs group of Homosassa Springs includes three large vents in a collapsed-cavern feature that make up the main spring and many smaller vents over an area of nearly four square miles (SWFWMD 2001). The Homosassa River originates at the main springs. The spring-fed Southeast Fork of the Homosassa River and the spring-fed Halls River both flow into the Homosassa River. Springs in the Homosassa Springs group include Homosassa Main Springs, Trotter Main, Pumphouse, Hidden River Head, and Halls River Head Spring. The average annual discharge of the Homosassa Springs group is approximately 229 million gallons per day (MGD). Historic average daily discharge of the river at the town of Homosassa was about 390 cfs, including about 140 cfs from the head springs, 80 cfs from the Southeast Fork of the springs, and 170 cfs from the Halls River (Cherry and others, 1970, after Yobbi and Knochenmus 1989).

Figure 1. Location of the Homosassa River in Citrus County, Florida (Distance is Mapped in Kilometers from River (RK) Mouth)



General Water Chemistry

Ground water discharging into the Homosassa Springs group may be fresh or brackish, depending on tides and water levels in the Floridan aquifer (SWFWMD 2001). At low tide, water quality varies across the spring group and total dissolved solids (TDS) concentrations can increase from less than 250 mg/l along the southeastern fork of the Homosassa River to greater than 1,500 mg/l in springs at the head of Halls River. Chloride concentrations across the group may range from less than 50 mg/l to greater than 500 mg/l, indicating that water quality at the spring group is strongly influenced by the coastal transition zone even at low tide. Nitrate concentrations at the Homosassa Springs group are typically below 0.7 mg/l. The concentrations vary among the individual springs of the group, possibly in response to mixing in the coastal transition zone and variations in nitrate in the Floridan aquifer ground water. Research conducted by the SWFWMD's Water Quality Monitoring Program indicates that the nitrate discharging from the springs is most likely derived from an inorganic source of nitrate - inorganic fertilizers applied to residential and golf course turf grass near the springs.

Most of the cavern system in Homosassa Springs has developed in the Ocala Limestone. However, the contact between the Ocala Limestone and Avon Park Formation was measured at a depth of 48 feet below sea level. The maximum depth reached by divers in the cave was 70 feet. Although extremely narrow passages continued deeper into the system, they were beyond the safe reach of divers.

Minimum Flows and Levels

In-stream flows are important to maintaining the health and function of rivers and stream systems, fish and wildlife habitat, recreation, navigation, and consumptive uses such as irrigation and domestic water supply. MFLs are intended to guide water resource and water supply development to ensure water resource sustainability for people and the natural environment. They will also be used to assist in making water use and other permitting decisions. In summary, MFLs are being established to:

- Address Florida Statute 373.042(1)(a)&(b)
- Protect water resources and ecology
- Determine water availability

The SWFWMD Governing Board has the final authority to set MFLs within its jurisdiction, using several guidelines provided by the state (and listed below):

- Using the best information available
- When appropriate, setting MFLs to reflect seasonal variations
- Considering the protection of non-consumptive uses of water (e.g. recreation, navigation, and fish and wildlife habitat)

The primary objective of this study was the completion of a geo-referenced map of vegetation species coverage and class attributes in a GIS format sufficient for the SWFWMD to use in characterizing changes in vegetation that may occur as a result of potential changes in flows, and therefore salinity, in the river. Shoreline (EAV and woody species) vegetation and SAV were the focus of the mapping effort. The vegetation classification system and mapping protocol followed the basic mapping effort performed for the Rainbow River mapping project (PBS&J 2007).

This project included three major tasks: (1) Identification of Vegetation Gradients/Refine Mapping Methods, (2) Field Data Collection/ Mapping, and (3) Reporting. The first two tasks were completed and are addressed in detail in the methods section of this report. Summary maps are included in the main report, however, numerous maps were completed for the project and are provided in a map appendix and referenced where appropriate. The individual sections of this report are outlined below.

- Introduction
- Methods
- Results and Discussion
- Conclusions
- Literature Reviewed
- Map Appendices

2.0 Methods

Submersed and emergent aquatic vegetation (SAV and EAV), shoreline woody vegetation, and altered shoreline were surveyed along the river, from the headsprings of the Homosassa River and from RK15 of the Halls River (just west of U.S. 19), to the mouth of the Homosassa River. The extent and percent of shoreline vegetation (EAV and woody vegetation) and areal extent of SAV were quantified and mapped in GIS. PBS&J contracted with DCW, Inc, for a portion of the mapping and GIS.

Mapping efforts were completed in October 2008. Boat surveys of SAV were limited due to the limited distribution of the SAV and poor water clarity. SAV surveys were subsequently supplemented by snorkeling along several transects established in areas where SAV was anticipated based on results from previous studies and identifying vegetation by hand /touch recognition. PBS&J data were supplemented with SAV data provided by the Florida Wildlife Research Institute (FWRI) Fisheries Independent Monitoring Program (FIM), the SWFWMD, and Frazer *et al.* (2006). These data are all part of ongoing studies.

2.1. Identification of Vegetation Classes and Refinement of Mapping Methods

Dominant plant species were identified along the Homosassa River. Several of the submersed species (*Vallisneria americana, Sagittaria kurziana, Hydrilla verticillata*) and shoreline vegetation (*Cladium jamaicense, Sagittaria lancifolia*) may be associated with salinity gradients.

Florida Land Use Classification and Forms (FLUCFCS) maps were also reviewed during the mapping effort and compared with the EAV mapping as a means of providing general field verification of the FLUCFCS maps. The SWFWMD provided PBS&J with the most recent geo-referenced aerial photography available for the project area, as well as boundary .shp files for the Homosassa River. An initial reconnaissance field visit with the SWFWMD's Ecological Evaluation staff and discussions following subsequent PBS&J field visits were completed to confirm project boundaries, methods, and reporting necessary to meet the SWFWMD's needs.

Observations of shoreline vegetation and SAV were made during a reconnaissance field visit. The PBS&J team worked with the SWFWMD's Ecological Evaluation Section to select a vegetation classification system that would associate vegetation with salinity gradients. Mapping methods were tested at the onset of the project. Spatial accuracy tests indicated excellent alignment of newly collected GPS data with aerial photography and previously mapped data. A mobile computer with integrated GIS and GPS served as a reference tool during field mapping. Relevant GIS layers and aerial photography were loaded onto a tablet computer for use with ESRI ArcPad™ software.

2.2. Field Data Collection/ Mapping

Data Collection

Shoreline and SAV features were hand-drawn onto hard copy field maps at a scale of 1 inch = 150 feet. A standardized notation system was used to record species and percent coverage categories. After each field mapping session, the information was transferred and compiled into a comprehensive, geographically referenced GIS database using ESRI ArcMap. The vegetation information was digitized heads-up (on screen) and attributed. Any questions that arose were resolved during the subsequent field mapping effort.

Georeferenced, orthorectified, 2007 images with one foot resolution and natural color were obtained from the SWFWMD and used as the backdrop for mapping. The base map for emergent vegetation was a river boundary (shoreline) provide in GIS format by the SWFWMD. The shoreline was assessed at the onset of the project and considered precise enough for the purposes of this project. The shoreline in the base map was refined in three instances: 1) to depict mangrove islands near the Gulf as distinct features rather than a single polygon, 2) to reflect changes in EAV at the upstream extent of the Halls River, and 3) to more closely reflect the configuration of the uppermost extent of the Homosassa River.

Shoreline Emergent Vegetation Mapping

Shoreline emergent vegetation mapping was limited to vegetation directly adjacent to the water edge (<5 feet from edge of water). Altered shorelines were classified by condition of the bank, such as rip-rap, vegetated rip-rap, seawall, maintained, or modified. The modified category includes vegetation that is relatively natural (not a maintained lawn or landscaping) but has been previously modified.

Natural shoreline vegetation was mapped using a Braun-Blanquet approach to include FLUCFCS level IV mapping. The five categories were:

- 0 percent (no vegetation)
- 0-25 percent
- 25-50 percent
- 50-75 percent
- 75-100 percent

The category "other" was included in the 0-25 percent cover category to address unidentified species such as some inconspicuous grasses. EAV was not mapped as polygons and was noted as such in the GIS file. Emergent species and cover categories were recorded as shoreline length. Distance upstream from the river mouth was mapped in river kilometers (RK) (Figure 1).

Emergent vegetation and altered shorelines were field-mapped after testing and refining the selected data collection method and identifying vegetation classes. The dominant and subdominant species were identified and included as mapping attributes to characterize the vegetation community structure.

SAV Mapping

Observations made during shoreline mapping and data compiled from other sources indicated that the distribution of SAV in the Homosassa River is very limited. Visibility was less than six inches in the water column during sampling events and mapping SAV from the surface was inadequate for the purposes of this study. Consequently, PBS&J data were supplemented by data from other sources and SAV was sampled along transects. The approach to mapping SAV varied in different portions of the river according to visibility and available data. The same five cover categories were used for SAV and EAV for classification.

Additional data were collected along the Homosassa River during ongoing investigations by the SWFWMD, Tom Frazer (University of Florida), and FWRI. These data were included (and identified by source) in maps. In the upper portion of RK (reach) 13 in the Homosassa River, SAV observations were made by snorkeling along transects where visibility was adequate. Percent cover and aerial extent were estimated visually and mapped as polygons. Water depths were generally greater and visibility extremely limited in reaches 12 and 13. Substrate observations were made using an Aqua-Vu underwater camera at several locations (generally 5 equidistant points) along transects. In the Halls River, where water was shallow and visibility was limited to several feet, observations were also made by snorkeling along transects. Transects were selected at distances of approximately 100 meters to provide adequate representation of the resources present.

Analysis and Quality Control

Updated (2008) river centerline and river kilometer (RK) files were provided by the SWFWMD to map EAV by river reach (kilometer). At each kilometer interval, a line was drawn perpendicular to the centerline. GIS tools were used to ensure the line was perpendicular to the centerline. Shoreline segments (with accompanying vegetation data) were assigned attributes according to which river reach they belong. GIS data were exported in tabular format for further analysis and reporting using SAS statistical software (Carey NC).

Calculations of species presence, absence, and relative cover were made using GIS for select species and areas in order to verify results of the SAS analysis. Relative linear distance of all species were calculated in SAS and exported in Excel files.

The density weighted cover of each EAV species was calculated by transforming Braun-Blanquet cover categories to percentages using the midpoint of each cover category and was calculated for species along the entire river and for each river reach. First, the total length of shoreline occupied by a species in each of the four cover categories (0-25 percent; 25-50 percent; 50- 75 percent and 75-100 percent) was measured. Then, the shoreline length associated with each cover category was multiplied by the midpoint of the same cover category (12.5 percent, 37.5 percent, 62.5 percent and 87.5 percent). The products of (shoreline length X cover midpoint) were summed to generate density weighted cover for each species. The density weighted cover was then normalized for each river reach to account for differences in shoreline length among river reaches dividing the density weighted cover (length) by the total shoreline length in that reach segment.

Quality control (QC) of the GIS map was extensive and was included to verify that all polygons were correctly labeled. Field data were reviewed to assure that field notes and information were correctly transferred to the final map. Verification of GIS labels, attributes, and adjacent features were verified during the QC process. GIS metadata were developed using the ESRI ArcMap 9.2 template. Maps were developed using ArcMap 9.2 and are included in this report in .pdf format.

3.0 Results and Discussion

The distribution of shoreline vegetation and SAV in the Homosassa River corresponded to salinity ranges typical of individual species and was consistent with data from other sources. SAV mapping proved difficult as a result of very poor water clarity and the limited distribution of SAV in the river. The extent of SAV was subsequently documented based on PBS&J field mapping and supplemental field data from additional sources.

Summary maps are presented within the text of this report as Figures, where appropriate. Maps for individual shoreline woody vegetation, EAV, and SAV are included in the appendices and referenced as appropriate.

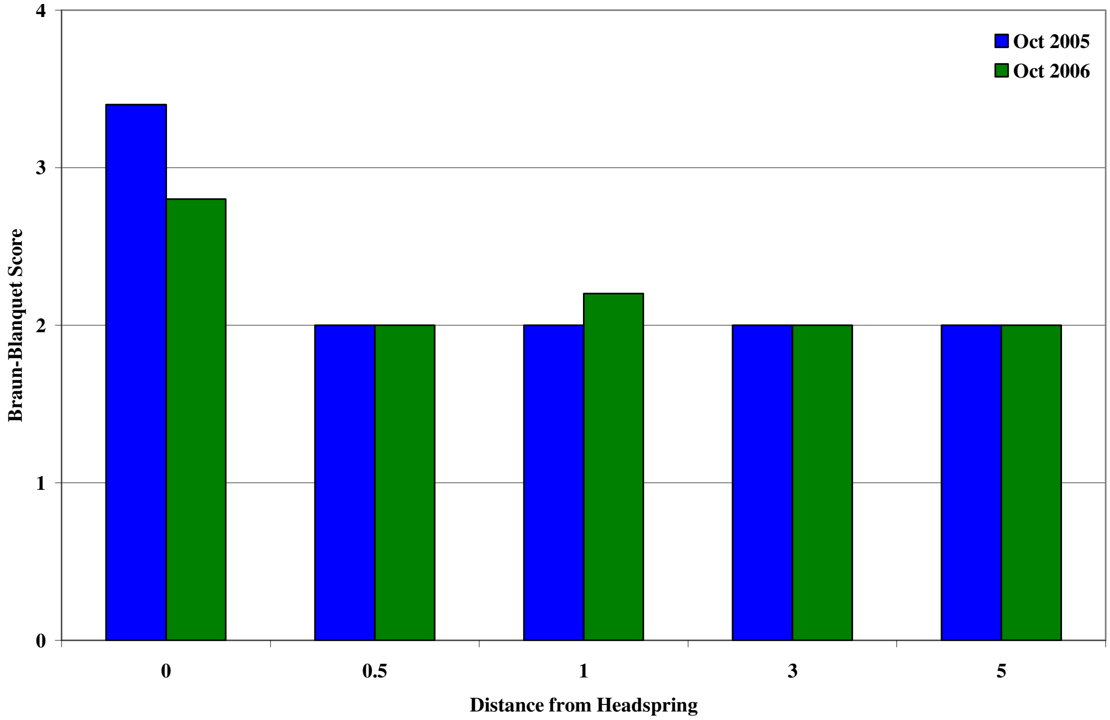
3.1. Supplemental Data and Sources

Additional data sources were critical to the completion of this study due to the poor visibility in the water and the need for salinity data to provide a context for vegetation distributions along the Homosassa River. The three sources were the SWFWMD, FWRI, and Frazer *et al.* 2001 and 2006 (contracted by the SWFWMD). Maps of SAV data by individual source are provided in Appendix A and addressed further in Section 3.3, below.

SWFWMD SAV Data

The SWFWMD completed two surveys (unpublished data, SWFWMD Environmental Section, October 2005 and October 2006) on the Homosassa, Weeki Wachee, and Chassohowitzka rivers to assess submerged aquatic vegetation (SAV) and algal cover. For this report, only the SAV data from the Homosassa River were evaluated. Five sampling locations were established along the Homosassa River at 0, 0.5, 1, 3, and 5 miles downstream from the headspring. Using a 1-m^2 quadrant, five measurements of SAV coverage were quantified at each site utilizing a modified Braun-Blanquet technique. SAV cover was classified based on the following scale: 1= no SAV, 2= 0-25 percent, 3= 25-50 percent, 4= 50-75 percent and 5= 75-100 percent. An average of the five measurements at each site was calculated and graphed (Figure 2). The results of the survey indicate that more SAV is present at the headspring in October 2005 (>50 percent) compared to October 2006 (>25 percent). Approximately, 0-25 percent of SAV cover was found throughout the remaining of the river.

Figure 2. Average Bran-Blanquet of SAV coverage on the Homosassa River at each site and sampling trip (source: SWFWMD).



FWRI

FWRI completed a two- year agreement with the SWFWMD to evaluate the fisheries population within the Homosassa and Halls rivers (FWRI 2009, in preparation). A stratified, randomized sampling design was used to select 24 sites along the Homosassa and Halls river and the sites were sampled monthly from December 2006 to November 2007 and every other month (i.e. alternating) from December 2007 to November 2008. Five sampling zones were designated in the Homosassa River and two in the Halls River to insure that the sample sites were representative of the entire estuary.

Seine sampling effort was allocated equally among the seven zones with three shoreline seines conducted in each zone. One trawl set was conducted in each of the zones where trawl samples could be collected (three of the seven zones). At each sampling site, biological, hydrological and habitat variables were recorded. As part of these surveys, FWRI documented the dominant bottom vegetation type, proportion of each bottom vegetation type present and total percent bottom vegetation cover at each site. The total percent bottom vegetation was evaluated for the SAV mapping effort as outlined below.

- Value = 0 to 100 - Percentage of the bottom covered by any type of bottom vegetation. If BottomVeg = UN then a value was not recorded.

- Value = 101 - Percentage of the bottom covered by any type of bottom vegetation was unable to be determined but bottom vegetation was identified.

FWRI provided PBS&J with preliminary data through November 2007 for the Homosassa and Halls rivers survey on April 29, 2008. It is important to note that FWRI completes an extensive QA/QC of all data collected and that the data presented here have not undergone that review.

The monthly percent bottom vegetation cover values from FWRI sampling events conducted from December 2006 to November 2007 are presented in four maps by season (Appendix A). Overall, the data show the presence of SAV in the Halls River, near the Homosassa headspring and the marsh complex. The majority of the river appears devoid of vegetation or present along the shoreline edge and associated with minor tributaries. The maps indicate the spatial and temporal variability along the river.

Frazer *et al.* 2001 and 2006

The University of Florida (UF) has completed two extensive physical, chemical, and vegetation characterizations of several rivers along the Springs Coast in Florida for the SWFWMD (Contract No. 98CON000077). Tom Frazer is the project manager for the UF study and the study is referred to as *Frazer et al.* in this report to avoid confusion with the previously described SWFWMD data.

The study encompassed field surveys in 1998, 1999 and 2000 for the Weeki Wachee, Chassahowitzka, Crystal, Withlacoochee, and Homosassa rivers (Frazer *et al.* 2001). A second study was completed in 2006 for data collected in 2003, 2004, and 2005 for the Weeki Wachee, Chassahowitzka, and Homosassa rivers (Frazer *et al.* 2006). A third survey of the springs rivers, including the Homosassa River, is underway and will provide additional information on the temporal and spatial changes that occur. While data are available for the five rivers surveyed, only the data associated with the Homosassa River were reviewed for the PBS&J analysis of submerged aquatic vegetation.

Twenty sampling locations along the Homosassa River from the headspring to the marsh complex were selected for water quality analysis as part of this study. For the SAV analysis, the first ten sampling locations were selected with an additional ten sampling locations interspersed with the original sites for a total of 20 sampling locations for SAV. Therefore, within the Homosassa River, the SAV survey does not extend to the marsh complex. At each location a transect with five sampling sites was established. To determine SAV presence or absence, a 0.25 m^2- quadrant was used and all above-ground biomass was removed for identification and mass determination. The surveys were completed in August-September of each sampled year.

The results of the presence/absence survey for all years evaluated are presented in Appendix A. The maps illustrate a decline in SAV coverage from 1998-2003. Specifically, a decline in the frequency of the native SAV, *Valisneria americana,* has occurred along the Homosassa River

(Frazer *et al.* 2006). Frazer *et al.* 2006 suggested that an increase in nitrate concentrations in the river associated with groundwater inputs have had a negative effect on SAV growth.

3.2. Salinity

Salinities were not measured specifically as part of this study. However, the studies described above have documented salinities in the Homosassa River and PBS&J includes salinity monitoring on the Homosassa River as part of a benthic monitoring project (under a contract with the SWFWMD for the *Collection of Benthic Macroinvertebrate Samples from the Upper Chassahowitzka and Homosassa/Halls River Systems*). Salinity data from these studies are mapped and summarized into salinity zones in Figure 3. Salinities mapped in Figure 3 provide a means of comparing vegetation in freshwater and saline portions of the river. The summary map was prepared to illustrate the extent of freshwater (<0.5 ppt), oligohaline (0.5 to <5 ppt), mesohaline (5 to 18 ppt), and polyhaline (18 to 30 ppt) river zones along the Homosassa River, based on the Venice Classification System.

The Venice System is illustrated in Figure 4 (after Odum *et al.* 1984) and illustrates the changes in riverine communities that correspond to a salinity gradient. River reaches (RK segments) corresponding to the four salinity zones are listed below.

- Freshwater – RK13
- Oligohaline – RK11 to RK12 on Homosassa River, RK11 to RK 15 on Halls River
- Mesohaline – RK3 to RK10
- Polyhaline – RK1 and RK2

The true freshwater portion of the Homosassa River extends no farther downstream than RK13. Shifts from freshwater to oligohaline salinities and corresponding species would indicate a persistent salinity increase. Salinities are less than 5 ppt from below the confluence of the Halls and Homosassa rivers at RK11 upstream to (but not including) the head springs on the Homosassa River and upstream along the Halls River to RK15. The mesohaline portion of the salinity gradient extends from RK3 to RK10 and includes the most developed portion of the river at RK8 and RK9.

Figure 3. Salinity Gradient along the Homosassa River

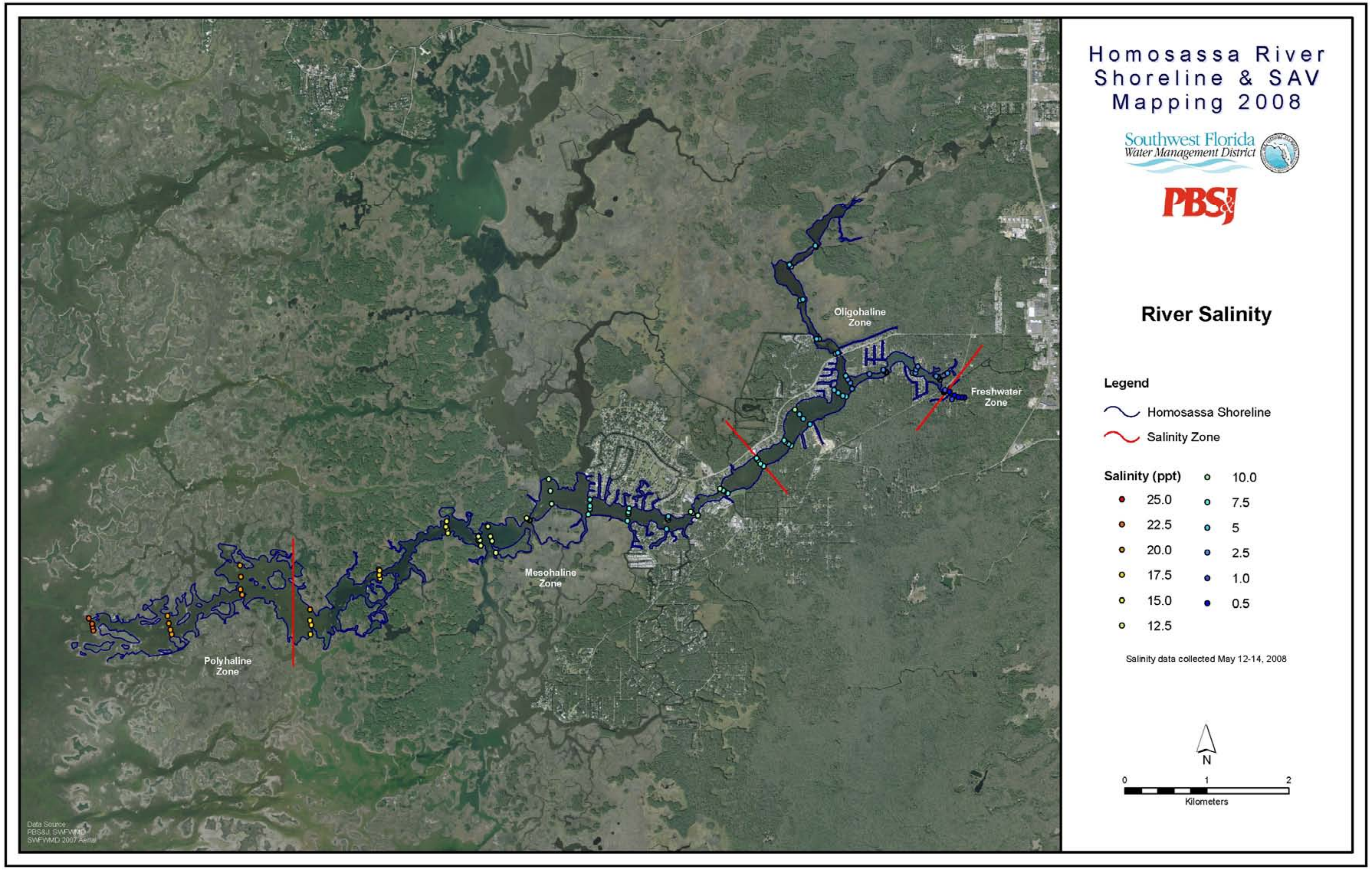


Figure 4. Illustration of Venice Classification System for River and Estuary Salinity Gradient (modified after Odum *et al.* 1984).

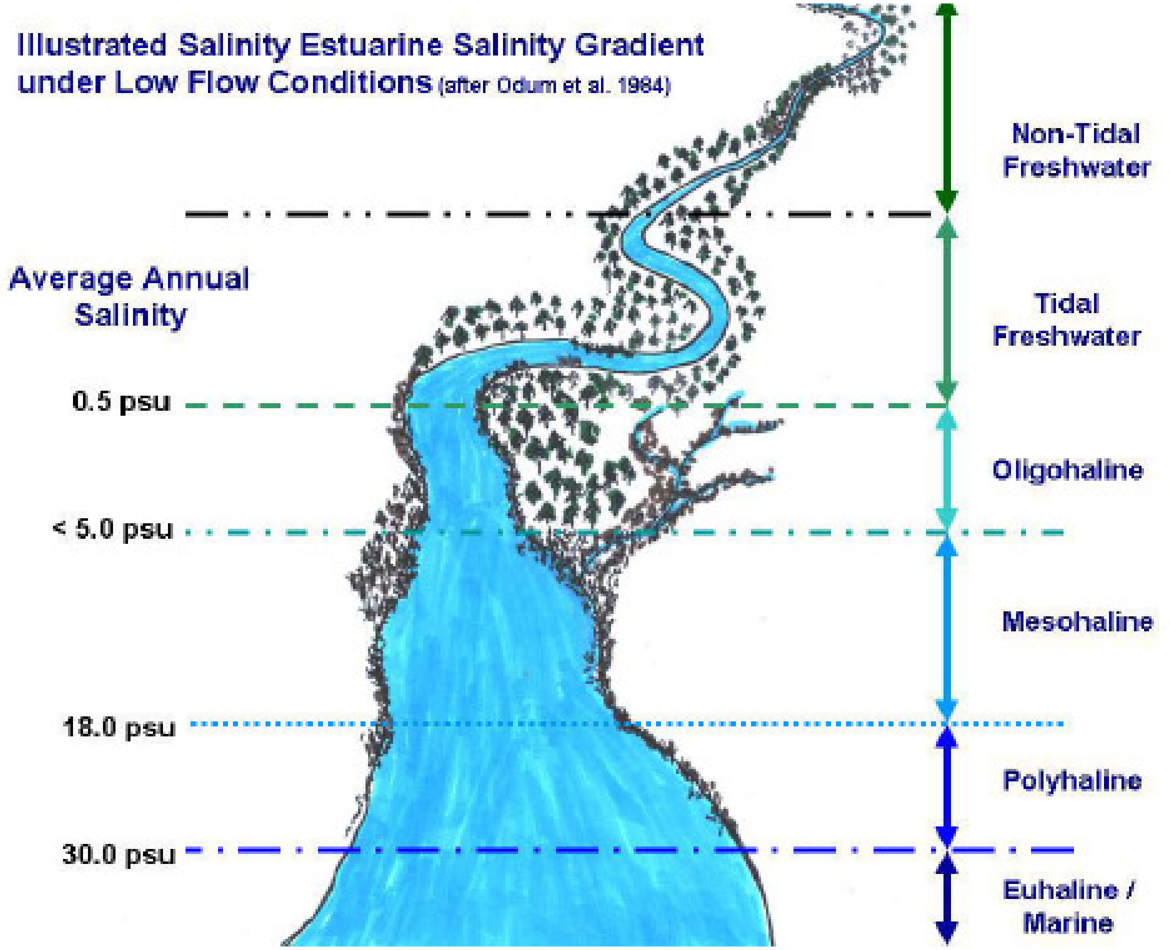


Exhibit Illustration of Venice estuarine salinity gradient (after Odum et al. 1984.The Ecology of Tidal Freshwater Marshes of the United States East Coast: A Community Profile," FWS/OBS-83/17, US Fish and Wildlife Service, Washington, D.C.

Yobbi and Knochenmus (1989) collected and analyzed salinity, flow, and tide data to characterize the distribution and movement of salt water in the Homosassa River. The investigators described the water in the Homosassa River as “well mixed considering the stream flow and high tide conditions”. Stream flow ranged from 38 to 308 cfs and high tide stage ranged from 1.37 to 3.26 feet. Vertically averaged 5 ppt salinities in the Homosassa River occurred between 4.83 (3 miles) and 8.05 (5 miles) kilometers upstream of the river mouth. The vertically averaged 2 ppt salinity was located between 6.44 (4 miles) and 9.66 (6 miles) kilometers upstream of the river mouth. These data suggest lower salinities in the middle and upper reaches of the Homosassa River when compared with more recent data.

Yobbi and Knochenmus found that the 18 ppt isohaline (break between oligohaline and mesohaline) in the Homosassa River was located between 3.22 km (2 miles) outside, and RK 6.44 (4 miles) upstream, of the mouth of the river. The vertically averaged 25 ppt salinity is generally between 9.66 km (6 miles) outside the mouth and RK 1.61 (1 mile) upstream of the river mouth.

The Homosassa River estuary has broad salinity gradients along the entire estuary and the upstream extent of salt water mixing is dependent on stream flow and high tide stage. Relations among flow, high-tide stage, and the maximum upstream extent of the vertically averaged 5- and 2-ppt salinities in the Homosassa River were evaluated using regression analysis.

The shifts in the 2 and 5 ppt isohalines in the Homosassa River were influenced by tide as well as stream flow and the primary effect of the change was a higher predicted tide under low flows.

3.3. Submersed Aquatic Vegetation

Submerged aquatic species sampled during this study included infrequent occurrences of eel grass (*Vallisneria americana*) along the middle river reaches and strap-leaf Sagittaria (*Sagittaria spp.*) in the upper reaches. Strap-leaf Sagittaria typically occurs at <3 ppt, and, although eel grass is tolerant of salinities as high as 10 ppt, it is a salt-tolerant freshwater plant abundant in lakes and freshwater rivers.

The SAV species encountered during sampling along the Homosassa River are listed in Table 1. Several typically “freshwater” SAV species are tolerant of salinities as high as 10 ppt., placing them in the lower range of mesohaline conditions. A summary of the locations sampled for SAV by PBS&J and other sources is mapped in Figure 5. A summary map of SAV that includes combined data from these sources is presented in Figure 6. Maps of presence and absence of SAV observed during this study (PBS&J), by the SWFWMD, FWRI, and Frazer *et al*. are provided in Appendix A.

Distributions of SAV were consistent with individual species salinity ranges and individual maps are also provided in Appendix A. The freshwater species *Ceratophyllum demersum* (coontail) is a freshwater species and was not found below RK11 at the confluence of the Homosassa and Halls rivers. Another freshwater species, *Myriophyllum aquaticum* (parrot feather) occurred downstream to RK6. *Vallisneria* spp., *Sagittaria*, and *Potomogeton* were limited to low salinity and freshwater portions of the river upstream of RK11.

Ruppia occurred from RK4 up to RK15 on the Halls River (but not above RK11 in the Homosassa River). Along the lower river reaches characterized by saltmarsh species along the shore, *Sargassum* was found below RK5, and *Halodul*e was found in RK5.

Distributions of SAV along the Homosassa River indicate that freshwater species are most abundant in the Halls River, but extend downstream in the Homosassa to about kilometer 8. Upstream encroachment of these species would indicate increased salinities due to decreases in freshwater flows. The greater abundance of SAV in Halls River could be related to the shallow depth of river, differences in nutrient concentrations, less boat traffic, and/or other factors.

Table 1. SAV Species Identified along the Homosassa River (PBS&J 2008)

Common Name	Species	Typical Salinity Conditions*
Coontail	*Ceratophyllum demersum*	Fresh (< 5 ppt)
FGA	Filamentous green algae	Fresh (< 5 ppt)
Parrot Feather	*Myriophyllum aquaticum*	Fresh (< 5 ppt)
Tape Grass	*Vallisneria spp.*	Freshwater – Low Mesohaline (0 – 10 ppt)
Musk Grass	*Chara sp.*	Oligohaline – Low Mesohaline (0 – 10 ppt)
Hydrilla	*Hydrilla verticillata*	Oligohaline – Low Mesohaline (0 – 10 ppt)
Sagittaria	*Sagittaria sp.*	Oligohaline – Low Mesohaline (0 – 10 ppt)
Southern Naiad	*Najas guadalupensis*	Oligohaline – Low Mesohaline (0 – 10 ppt)
Potamogeton	*Potamogeton pectinatus*	Oligohaline – Low Mesohaline (0 – 10 ppt)
Halopholia	*Halophila englmanii*	Low Mesohaline – Polyhaline (20 – 40 ppt)
Thalassia	*Thalassia testudinum*	Polyhaline - Marine (20 – 40 ppt)
Halodule	*Halodule wrightii*	Polyhaline (20 –30 ppt)

*After Estevez 2000, NCDENR 2005, others.

Figure 5. Summary Map of SAV Sampling Points

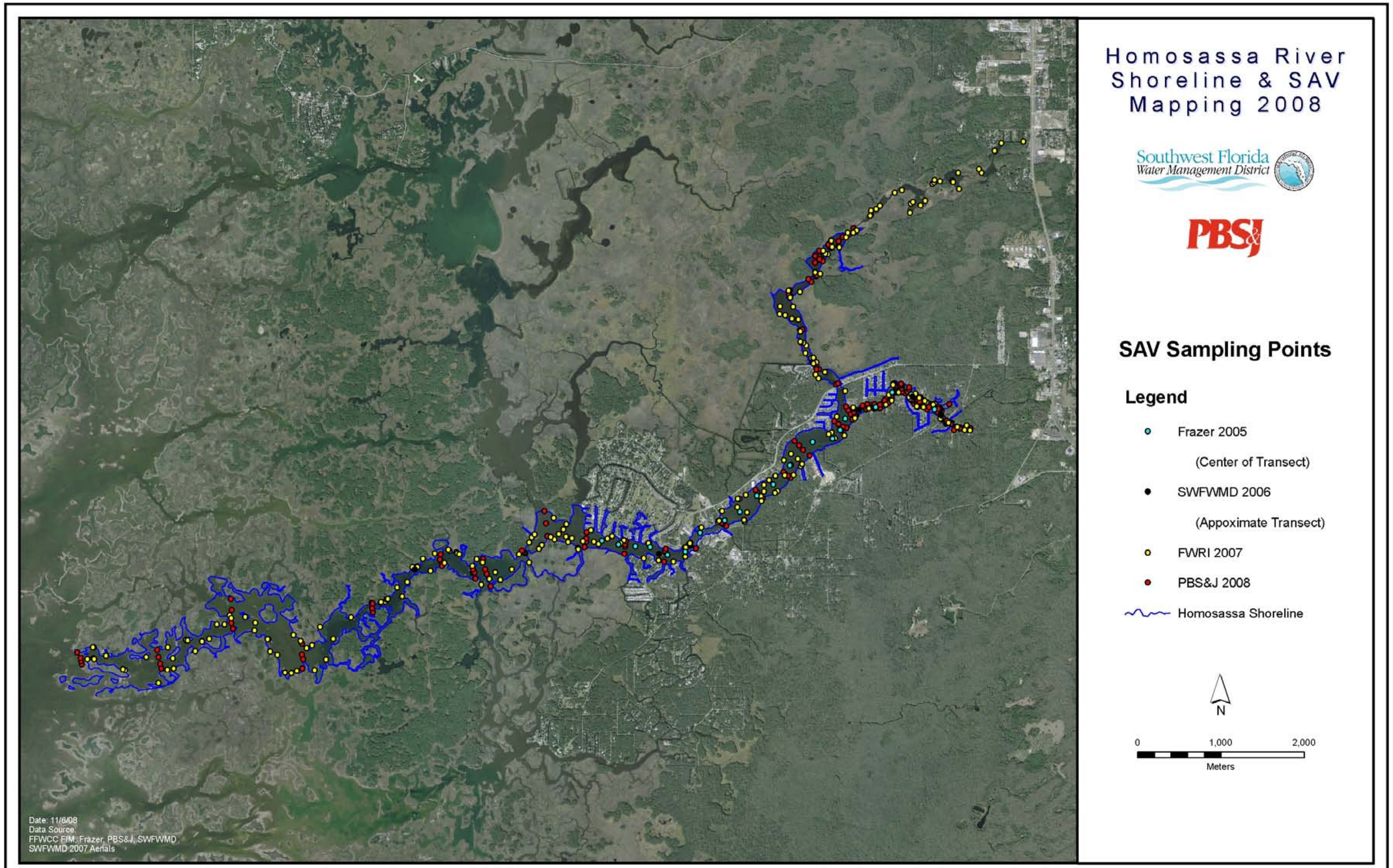
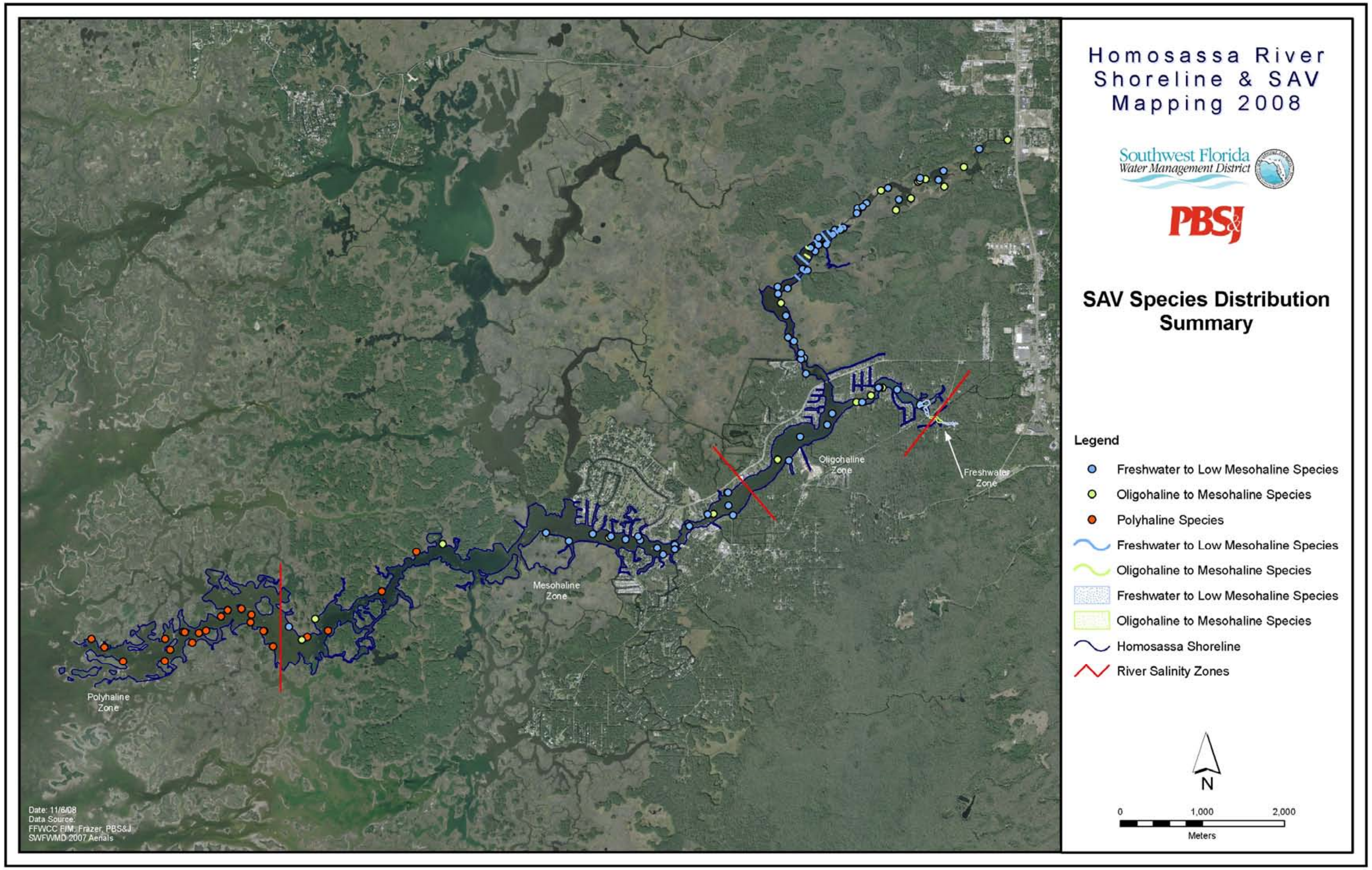


Figure 6. Summary Map of SAV Distributions



Results of the present study were consistent with those of previous and ongoing efforts that document relatively little SAV along the Homosassa River, similar to what has been described for the spring-fed Chassahowitzka and Crystal rivers, although they are in contrast with the Rainbow River, where SAV is extensive. Declining SAV in the Homosassa, Chassahowitzka, and Crystal rivers since 1998 has also been reported. Frazer *et al.* (2006) documented a decline in SAV from 1998-2003, specifically, a decline in the frequency of the native SAV, *Vallisneria americana,* and suggest that an increase in nitrate concentrations in the river associated with groundwater inputs have adversely impacted SAV growth in the Homosassa River. However, SAV biomass and cover are strongly related to light and salinity and low SAV biomass has been linked to annual average salinities greater than 3.5 ppt (Hoyer *et al.* 2005).

The decline is coincident with increases in macroalgae and the "blue green algae" *Lyngbya,* as well as increased nutrient loads and recreational use (FDEP 2008, Hoyer *et al.* 2005, Frazer et al 2006). However, nutrient loads and concentrations account for little variance in SAV biomass after accounting for flow and related substrate type, light and salinity (PBS&J 2008 unpublished, Hoyer *et al.* 2005, Frazer *et al.* 2007). The relationship between nutrients and spring ecosystem structure and function primarily focuses on the state-wide increase in spring nitrate concentrations derived from anthropogenic sources and the observed decline of these ecosystems. Other factors that may have affected trends include differences in:

- Rainfall averaged 45 inches from 1998-2000, compared with 60 inches from 2003 to 2005.

- Discharge averaged 282.5 cfs during 1998-2000, compared with 635.6 cfs during 2003-2005.

The relationships among nutrients and other factors of primary productivity have not been identified and quantified and therefore, predicting impairments related to excessive algal growth and/or loss of SAV, as well as subsequent restoration, is not possible. Diagnostic studies that determine how nutrients, other factors, and interactions among factors affect or limit production, competition, and other relationships among periphyton, macroalgae and vascular plants, remain necessary. Consequently, the issue of declining SAV and increases in macroalgae and blue green algae, combined with the potential effects of nutrients and disturbance, remains unresolved in the Homosassa River.

The dominant SAV species in the Rainbow River to the north of the Homosassa River is the native *Sagittaria kurziana* (FDEP 2000). The plant occurs in about 53 percent of the river and may occur over 74 acres of the total 140 acres of submersed area along the river. *Vallisneria americana* (eelgrass) is the second most common native plant and was found in 12 percent of the river. Loss of approximately 13 acres of SAV in the Rainbow River has been documented by FDEP (2000) and other native species, such as *Najas guadalupensis* and *Chara* sp. also decreased during the study period. Bare substrate increased by about five acres from 1996 to 2000, primarily in the State Park swimming area (FDEP 2000) and may be a result of recreation activities (Dutoit 1979, Mumma *et al.* 1996). During the summer, it is not uncommon to have more than 500 visitors on the river (Pridgen *et al.* 1992, after the SWFWMD 2004). In the lower portion of the river the blue green algae *Lyngbya* sp. and the exotic *Hydrilla* are dominant and the native species are relatively scarce.

Seagrasses are widely recognized as the ultimate, downstream barometers of estuarine water quality (Dennison 1993). Using salinity as a first-order stressor and as an indicator of associated, second order stressors (Estevez 2000) has been successful in the Chesapeake Bay, Tampa Bay, the Suwannee River, the Caloosahatchee River, Florida Bay and other rivers, estuaries, and bays. For example, salinity tolerance of SAV has successfully been used to estimate a minimum flow required to maintain the salt tolerant SAV species *Vallisneria americana* at the head of the Caloosahatchee River estuary and a maximum flow required to prevent mortality of the marine SAV species *Halodule wrightii* at its mouth (Doering *et al.* 2002). Little or no growth occurred in *Vallisneria* between 10 and 15 ppt and in the field. Mortality occurred at salinities <6 ppt in *H. wrightii* and there was little growth between 6 and 12 ppt. *Ruppia* has also been proposed as an indicator for establishing MFLs based on salinity: at salinities > 30 ppt, *Ruppia* is typically absent and does not reproduce (Rudnick *et al.* 2006).

SAV is often a good indicator for establishing MFLs based on salinity intrusion and has been used as such in the Caloosahatchee and Suwannee rivers, among others. However, it is not an adequate indicator of increasing salinities in the Homosassa River due to its limited and declining distribution. EAV distributions may provide a good indicator for establishing MFLs along the Homosassa River. EAV species distributions generally correspond to mean high salinities along tidally influenced rivers and freshwater species respond relatively quickly to changes in salinities.

3.4. Shoreline Vegetation

Shoreline vegetation included EAV and woody vegetation (trees) along the Homosassa River within approximately 5 meters of the water. The true freshwater portion of the Homosassa River extends from the confluence of the Halls and Homosassa rivers upstream to the head springs. Freshwater EAV species were limited to the Homosassa River upstream of it's confluence with the Halls River at approximately RK11. Shoreline vegetation are summarized and mapped in Figures 7 (EAV) and 8 (woody species). Individual maps for each species are provided in Appendix B (EAV) and Appendix C (woody vegetation/tree species).

Overlap among species appears as thicker lines in maps, color coded by the species zones. For example, along the Halls River, bright green lines surrounded by pale yellow indicate oligohaline species (bright green) overlap with mesohaline (pale yellow) species. In fact, the mesohaline species exhibited the only overlap with other species and overlapped with all salinity zones, indicating a very broad range of salinity tolerance for these species. It should be noted that these oligohaline and mesohaline species are tolerant of low salinities or brief periods of inundation by higher salinity waters. For example, sawgrass is tolerant of tidal inundation and is typical of the downstream extent of freshwater in tidal rivers and is characteristic of the Everglades. Salinity limits the downstream extent of these species, while freshwater species better able to compete under freshwater conditions limit their upstream distribution. The distributions of plant species, by river mile and salinity zone, are summarized in Table 2.

Emergent Aquatic Vegetation and Herbaceous Shoreline Vegetation

Species of EAV and herbaceous shoreline vegetation encountered along the Homosassa River, corresponding distance upstream from the river mouth (RK), and proportion of river segment occupied by each species (weighted by density based on vegetation category: 0 to 25 percent, etc.), are listed in Table 2 (graphs by river km for each species are provided in Appendix D). The shift from freshwater to salt-tolerant species is apparent in the table and the extent of these species is consistent with salinity tolerance ranges of each of the species. Species with greater salinity tolerance extended farther downstream, although only very salt tolerant species occurred downstream of RK7. Under freshwater conditions, the freshwater species, such as arrowhead, out-compete the salt tolerant species, such as black needlerush, while under more saline conditions, the freshwater species are precluded due purely to salt intolerance.

Distributions of the EAV and shoreline vegetation along the Homosassa River were consistent with this paradigm. Plant species distributions were also generally consistent with those described for the same species by Clewell *et al*. (2002), who performed vegetation surveys along the Chassahowitzka, Crystal, and Weeki Wachee rivers along the Springs Coast along Pasco, Hernando, and Citrus counties, as well as Little Manatee, Peace, and Myakka Rivers farther south. These same studies documented the characteristic saltmarsh cordgrass communities at the mouths of the Springs Coast rivers, in contrast with mangroves that characterize the mouths of rivers farther south.

In contrast with the vegetation of the Springs Coast rivers surveyed by Clewell *et al*., vegetation along the Homossassa River included leather fern along much more of the river, the presence of bulrushes, and a greater number of freshwater species. Occurrence of bulrushes and leather fern was documented by Clewell *et al*. on the Chassahowitzka and Weeki Wachee rivers (both located north of the Homosassa River), but not the Withlacoochee or Crystal rivers (both located south of the Homosassa River) and may represent differences in distribution of these species along the coast rather than salinity ranges.

Freshwater Species. Freshwater species did not extend below the confluence of the Homosassa and Halls rivers at RK12. Freshwater species intolerant of salinities >0.5 ppt (e.g. wild taro, *Colocasia esculenta)* were limited to the head springs area (RK14) and did not extend farther downstream then the confluence of the Halls and Homosassa rivers (RK12).

Oligohaline and Mesohaline Species. Oligohaline species did not extend bellow RK7 on the Homosassa River or RK12 on the Halls River. Species such as arrow head (*Sagittaria latifolia*) extended from RK15 west of U.S. 19 to RK8 downstream of the heavily developed area on the river.

Overall, sawgrass (*Cladium jamaicense*) made up from 1 to 31 percent of the shoreline cover upstream of RK 3 on the Homosassa and Halls rivers and was exceeded in cover only along two Halls River segments (RK 13 and RK14). The dominant species along the Halls River were cattails and sawgrass, each making up from 13 to 83 percent of the shoreline. Sawgrass was exceeded in proportion of occurrence along the shoreline by cattails upstream of RK 12 on the Halls River.

Species such as sawgrass are typical of oligohaline (0.5 to 5 ppt) but can extend into mesohaline conditions (5 to 18 ppt) and were found along nearly the entire river length, from RK15 on the Halls River to the upstream extent of the saltmarsh (RK4), except for their notable absence above the confluence of the Halls and Homosassa Rivers. Leather fern and sawgrass overlapped almost completely, although sawgrass was more common than leather fern.

Black needlerush (*Juncus roemerianus*) has a greater range of salinity tolerance and was the single EAV species sampled from RK15 on the Halls River, all the way to the mouth of the Homosassa River. Black needlerush also had the greatest percent shoreline cover (between 31 and 62 percent) downstream of RK8, compared with less than 5 percent of any other species. Black needlerush was absent upstream of RK 9 until it appeared again in the Halls River. The downstream distribution of black needlerush was more consistent with the distribution of saltmarsh species, which is its typical habitat, and the absence of the freshwater flows from the headsprings in the Halls River may account for its presence there. Other saltmarsh EAV species such as saltmarsh cordgrass (*Spartina alterniflora*) and glasswort (*Salicornia perennis*) occurred upstream of the river mouth as far as RK7.

Polyhaline Species. Marsh species in the polyhaline zone of the lower Homosassa River included marsh elder, Christmas berry, saltmarsh cordgrass, sea oxeye daisy, glasswort, and sea purslane. None of these species were observed upstream of river kilometer 8.

Trees and Woody Species

Tree distributions along the river corresponded to salinity tolerances. There are fewer salt tolerant trees when compared with EAV and SAV, although mangroves occur almost exclusively in saline environments. Woody shoreline vegetation encountered along the Homosassa River, corresponding distance upstream from the river mouth (RK), and proportion of river segment occupied by each species (weighted by density based on vegetation category: 0 to 25 percent, etc.), are listed in Table 3 (graphs by river km for each species are provided in Appendix D).

Freshwater Species. Freshwater wetland tree species, including red maple (*Acer rubrum*), ash species (*Fraxinus* spp.), and swamp bay (*Persea palustris*) were consistently present along the shoreline of the Homosassa River above RK8. Swamp bay occurred the most frequently. A single occurrence of a less than robust water hickory (*Carya glabra*) was noted at RK4, although it was several feet above the mean high water line and unlikely to be impacted by more than salt spray.

Freshwater tree distributions extend downstream to RK9, about 2 km farther downstream when compared with EAV distributions (RK11) in the Homosassa River. This difference may indicate historically lower salinities in the middle and upper reaches of the river, consistent with isohaline locations predicted by Yobbi et al. (1989). However, the presence of freshwater trees along the mesohaline river reaches suggests that many of the woody species may be at elevations above the tidal range of the river.

Oligohaline and Mesohaline Species. Cabbage palm (*Sabal palmetto*) and red cedar (*Juniperus virginiana*) are tolerant of average salinities up to about 10 ppt and were the most frequently present trees upstream of RK2, although both were present as far downstream as RK1. Cabbage palm and red cedar are tolerant of salinity flushes to about 10 ppt. and tidal fluctuations of 2 and 1 meters, respectively (McPherson and Williams 1996, Mattson and Krummrich 1995, Burns and Honkala 1990, Harms *et al.* 1980). Higher salinities are lethal to cabbage palm and cedar trees and their occurrence along the downstream portions of the Homosassa River, like that of holly, is limited to scattered limestone outcrops that are generally above the influence of the tidal inundation. Salinities of 20 ppt and 15 ppt are lethal to the cabbage palm and cedar, respectively (Perry and Williams 1995, Tolliver 1997).

Saltbush (*Baccharis* spp.) was also present the entire length of the river. Proportion of shoreline along which these species were present was greatest from RK4 to RK7, declined from RK9 to RK12 on the Homosassa River (coincident with heavy shoreline development along this reach of the river), and increased along the Halls River.

Polyhaline Species. Red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and buttonwood (*Conocarpus erectus*) are typical of polyhaline conditions (18 to 30 ppt) and extended upstream on the Homosassa River no farther than RK7 (consistent with the general break from mesohaline to oligohaline). The mangrove distribution in Florida typically terminates north of the Anclote River due to winter freezes. However, mangroves are present in isolated sheltered areas, including on Dog Island, off the coast of Franklin County in north Florida where the Apalachicola River enters the Gulf of Mexico. Mangroves at the mouth of the Homosassa River were small and likely die back during winter freezes but remain established due to the relatively mild winters.

Altered Shoreline

Altered shoreline along the Homosassa River is mapped in Figure 9 and summarized in Table 5. Altered shoreline makes up approximately 30 percent of the total shoreline is only intermittent along the Homosassa River downstream of RK7 and upstream of RK12 on the Halls River. Along these relatively natural river reaches, smaller areas of altered shoreline are composed almost exclusively of modified shoreline rather than hard rip-rap or seawall.

Both modified shoreline and seawall make up most of the shoreline along the Homosassa River upstream of its confluence with the Halls River to the head springs. The modified category makes up approximately 6,803 linear meters (11 percent of the total shoreline measured) and occurs intermittently along the entire river. Sea walls make up the largest category of altered shoreline along the Homosassa River and include approximately 8,405 linear meters (14 percent of the total shoreline measured) of the river, nearly all of which is upstream of RK8 to the springs on the Homosassa River and up to RK12 on the Halls River. Rip-rap characterizes approximately 2,614 linear meters of the river, almost entirely along the north side of RK8 at the town of Homosassa Springs. The remaining altered shoreline is maintained landscaping to the river edge and includes approximately 4,010 linear meters (one percent) of the river shoreline.

Table 2. Density Weighted Percent Cover of EAV and Herbaceous Shoreline Vegetation Observed along the Homosassa and Halls Rivers

	Scientific Name	Common Name	Homosassa River Kilometer												Halls River Kilometer				Head Spring
			1	2	3	4	5	6	7	8	9	10	11	12	12	13	14	15	13
Fresh	Colocasia esculenta	wild taro													1				1
Fresh	Crinum americana	swamp lily											1	0					2
Oligohaline	Amaranthus australis	Southern water hemp							0										
Oligohaline	Arundo donax	Giant Reed							1				2	1			0	3	2
Oligohaline	Saggitaria lancifolia	arrowhead													1	0	0		
Oligohaline	Scirpus sp.	Bullrush														1	6		
Oligohaline	Scirpus validus	Soft-stem bullrush														1	3		
Oligohaline	Typha sp.	cattail							2	3	4		2	1	13	47	25	83	
Oligohaline	Achrostichum spp.	leather fern		0	1	4	7	1	3	6	1	1				1	2		
Mesohaline	Cladium jamaicense	sawgrass				1	3	2	15	13	5	1	2	1	24	31	24	1	2
Mesohaline	Juncus roemerianus	black needlerush	31	47	62	60	24	27	29	8					5	13	15	2	
Polyhaline	Iva frutescens	marsh elder	5	5	5	2	2	1	2										
Polyhaline	Lycium carolinianum	Christmas berry	2		2	1		1	1	1									
Polyhaline	Spartina alterniflora	Saltmarsh cordgrass	0	1	1	3	1	1											
Polyhaline	Borrichia frutescens	sea oxeye daisy	1	2	3	1													
Polyhaline	Salicornia perennis	Glasswort	0																
Polyhaline	Sesuvium portulacastrum	Sea purslane	0																

Table 3. Density Weighted Percent Cover of Shoreline Woody Vegetation and Trees Observed along the Homosassa and Halls Rivers

	Scientific Name	Common Name	Homosassa River Kilometer												Halls River Kilometer				
			1	2	3	4	5	6	7	8	9	10	11	12	12	13	14	15	Head Spring
Freshwater	*Acer rubrum*	red maple									2	2	6	5	4		2		4
Freshwater	*Carya aquatica*	water hickory				1													
Freshwater	*Cornus fomena*	dogwood																	1
Freshwater	*Fraxinus spp.*	ash									1	6	2	2	4				8
Freshwater	*Liquidambar styraciflua*	sweet gum									2			1	4				3
Freshwater	*Magnolia virginiana*	sweetbay magnolia										7	1	1	5	1	1		8
Freshwater	*Myrica cerifera*	wax myrtle									1	4	1	3	7	0	9		9
Freshwater	*Persea paulustris*	swamp bay									2	1	6	2	4	0	1		10
Freshwater	*Salix caroliniana*	carolina willow																	1
Freshwater	*Ulmus americana*	American elm										2	1	1					
Oligohaline Mesohaline	*Juniperus virginiana*	red cedar	2	2	7	7	16	27	15	1	2	3	1	2	14	1	14		4
Oligohaline Mesohaline	*Sabal palmetto*	cabbage palm	0	1	4	4	4	6	6	1	1	4	7	4	9	0	14		10
Oligohaline Mesohaline	*Baccharis spp.*	Salt bush	0	2	2	3	0	1	1		1	2	4		3	5	1		3
Polyhaline	*Ilex sp.*	Holly sp.	1	1	2	1													
Polyhaline	*Avicennia germinans*	black mangrove	15	6	2														
Polyhaline	*Rhizophora mangle*	red mangrove	28	21	5	5	1	1	0										
Polyhaline	*Conocarpus erectus*	buttonwood		2	4	1	0	2											

Table 4. Density Weighted Percent Cover of Upland and Exotic Woody Vegetation and Trees Observed along the Halls and Homosassa Rivers

Scientific Name	Common Name	Homosassa River Kilometer												Halls River Kilometer				Head Spring
		1	2	3	4	5	6	7	8	9	10	11	12	12	13	14	15	13
Casuarina spp.	Australian pine							0	0									
Persea borbonia	redbay																	1
Quercus laurifolia	laurel oak										4	2	6	2		1		3
Quercus spp.	xeric oak hybrid		1		0	1	1	3		0	1				1	14		
Quercus virginiana	live oak						1	2							0	2		
Schinus terebinthifolius	Brazilian pepper	1	8	6	3	3	7	7		1								
Serenoa repens	saw palmetto															4		

Table 5. Meters of Altered Shoreline and Percent of Altered and Total Shoreline along the Homosassa River

Shoreline Category	Shoreline Length (m)	Percent	
		Altered Shoreline	Total Shoreline
Maintained Landscaping	4,010	2	1
Modified	6,803	37	11
Rip-Rap	2,614	14	4
Seawall	8,4054	47	14
	18,232	100	30

Figure 7. Summary Map of EAV Species Distributions along the Homosassa River

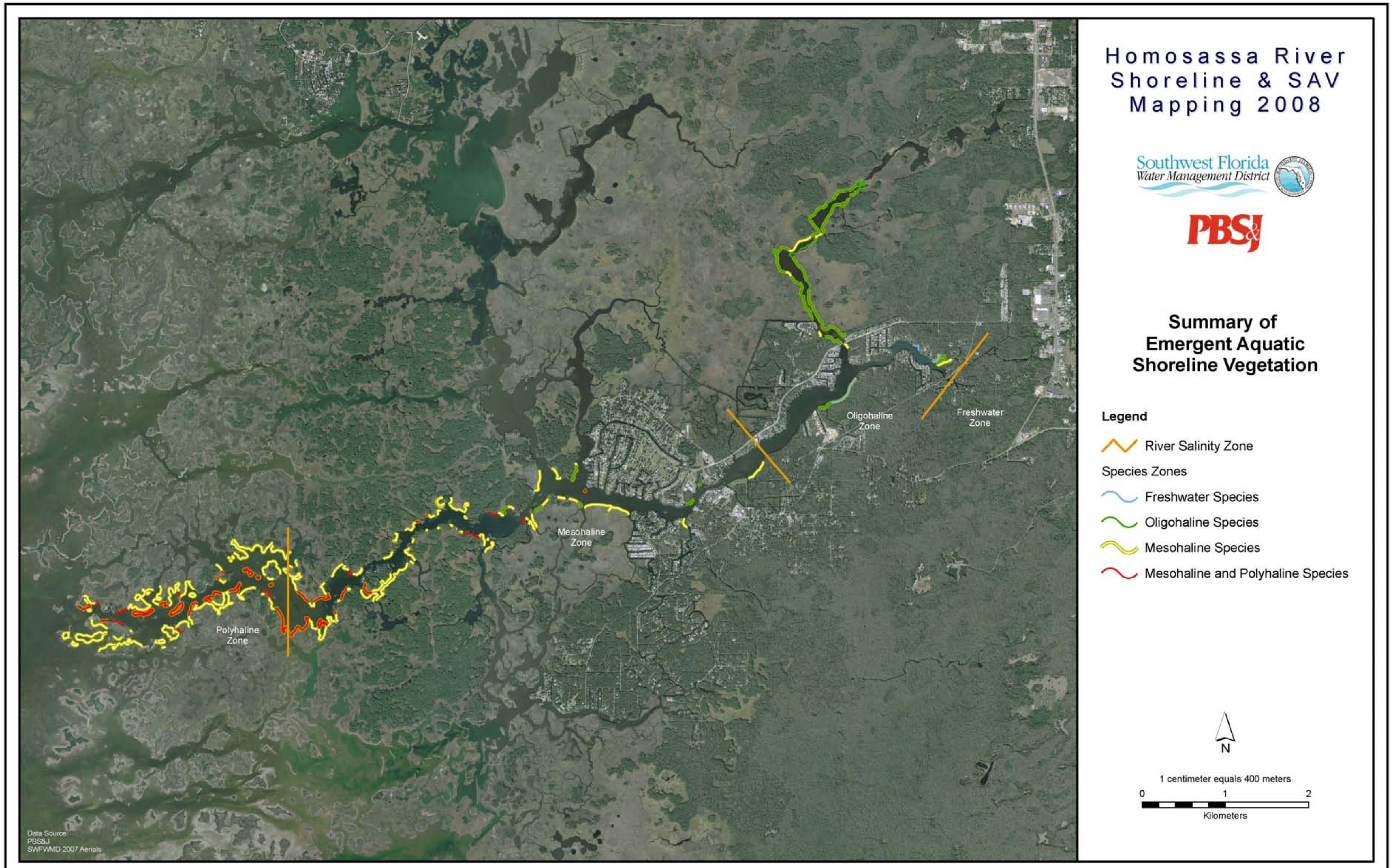


Figure 8. Summary Map of Woody Species Distributions along the Homosassa River

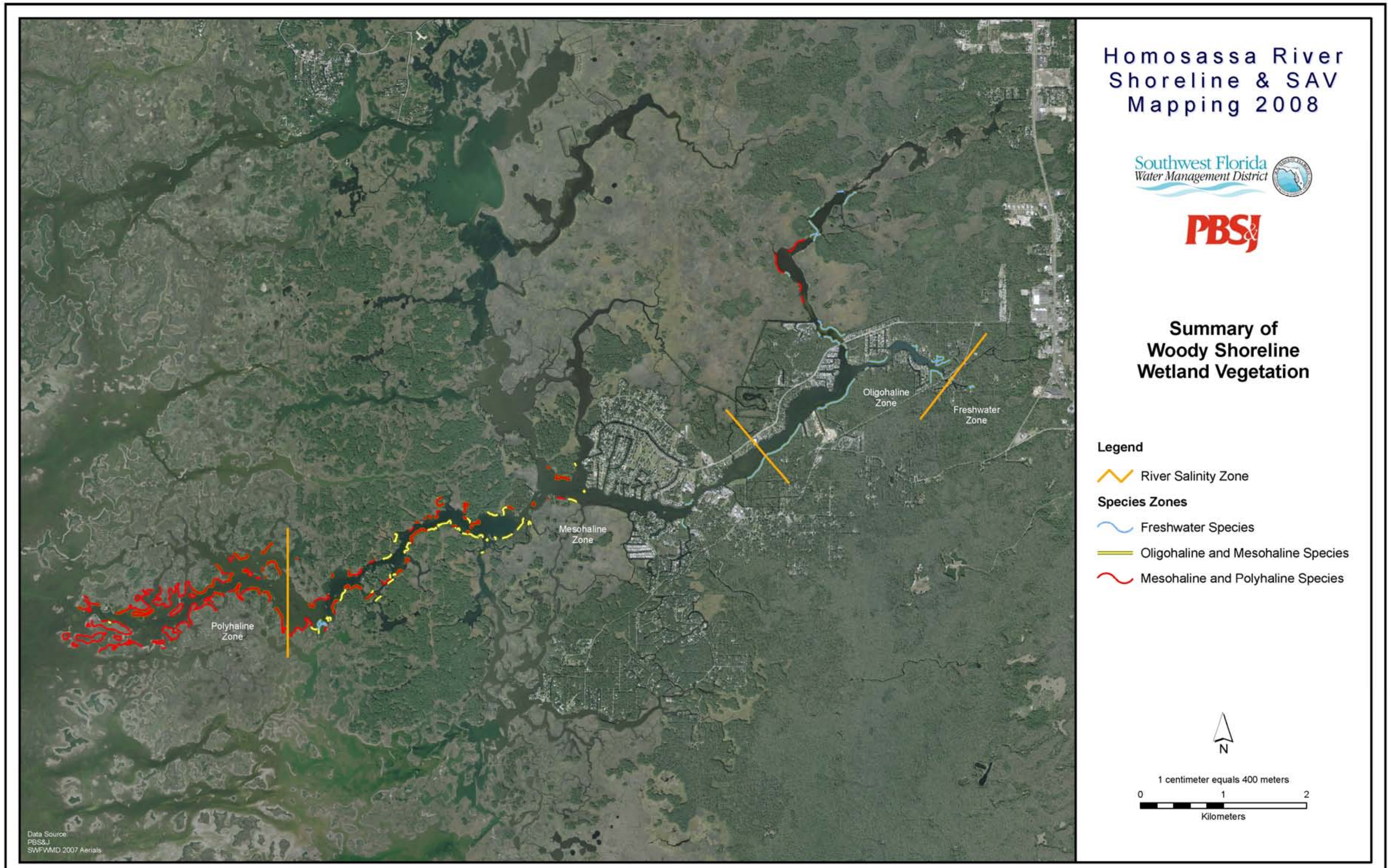
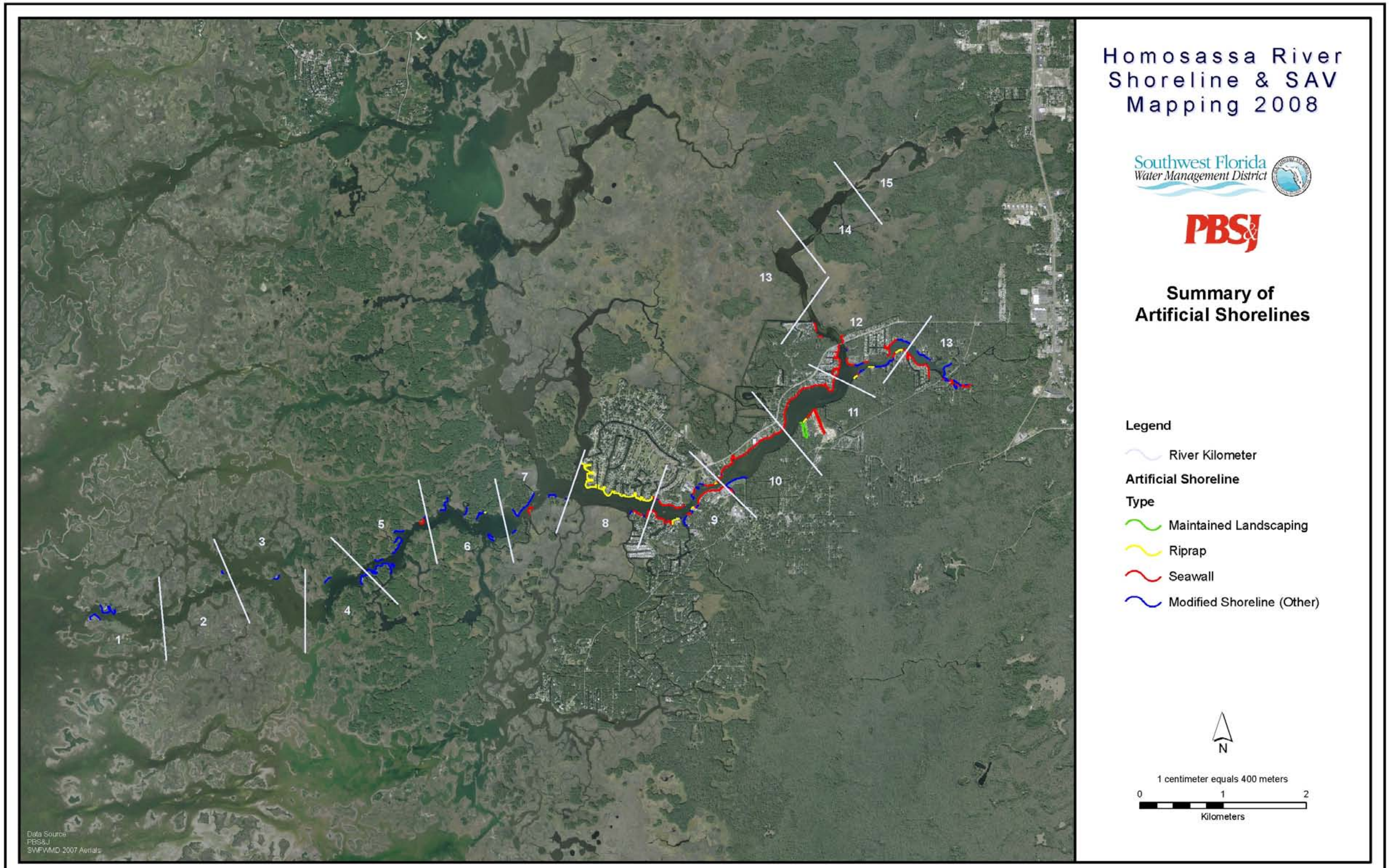


Figure 9. Altered Shoreline along the Homosassa River



4.0 Conclusions

Results of the present study were consistent with those of previous and ongoing efforts that document relatively little SAV along the Homosassa River, similar to what has been described for the spring-fed Chassahowitzka and Crystal rivers. SAV distributions along the Rainbow River and parts of the Suwannee River, in contrast, are extensive. The freshwater species Sagittaria was absent downstream of the headspring, while species with low salinity tolerance, including V*allisneria, Potomogeton, and Ceratophyllum* were absent downstream of RK11 at the confluence of the Homosassa and Halls rivers.

SAV in the Caloosahatchee and Suwannee rivers has been used as an indicator of changing salinity, and therefore, of changes in freshwater flows. However, it is not recommended for use as an indicator in the Homosassa River due to its limited and declining distribution. EAV distributions, however, may provide a good indicator for establishing MFLs along the Homosassa River. EAV species distributions mapped as part of this project likely correspond to annual average salinities and freshwater species respond relatively quickly to salinity increases.

The freshwater portion of the Homosassa River extends only a short distance downstream from the head spring (RK13). Oligohaline conditions extend downstream to include RK12 and RK11 on the Homosassa River and the full length of the Halls River (up to and including RK15). The mesohaline portion of the river (5 ppt to 18 ppt) includes the largest portion of the river (RK3 to RK10) and only river segments RK1 and RK2 were characterized by polyhaline conditions (18 ppt to 30 ppt). Freshwater tree distributions extend farther downstream when compared with EAV distributions and may suggest historically lower salinities in middle and upper reaches of the river, consistent with isohaline locations predicted by Yobbi et al. (1989). However, the presence of freshwater trees along the mesohaline river reaches suggests that many of the woody species may be at elevations above the tidal range of the river.

5.0 References

Burns, R. and B. Honkala. 1990. Silvics of North America, Volume 1. Conifers. Agricultural Handbook No. 654. United States Department of Agriculture, Forest. Service. 675 pp.

Clewell, A.F., M.S. Flannery, S. Janicki, R. Eisenwerth, and R. Montgomery. 2002. An Analysis of Vegetation-Salinity Relationships in Seven Tidal Rivers on the Coast of West-Central Florida (DRAFT). Technical Report of the Southwest Florida Water Management District. Brooksville, Florida.

Cowell, B.C. 1990. Factors Contributing to the Growth of *Lyngbya* at Kings Bay/Crystal River, Florida. Department of Biology, University of South Florida, Tampa, FL. Prepared for the SWIM Program, Southwest Florida Water Management District.

Cowell, B.C. and C.J. Dawes. 2002. Growth and nitrogen uptake by the freshwater cyanobacterium, *Lyngbya wollei* (Farlow ex Gomont). Prepared for the SWIM Program, Southwest Florida Water Management District.

David Ornelas, El Paso Water Utilities. Agricultural Research and Extension Center at El Paso Texas Agricultural Experiment Station. The Texas A&M University System.

Dennison, W.C., Orth, R.J., Moore, K.A., Stevenson, J.C., Carter, V., Kollar, S., Bergstrom, P.W. & Batiuk, R. (1993) Assessing water quality with submersed aquatic vegetation. *Bioscience* 43, 86-94.

Doering, P. 2002. Using submerged aquatic vegetation to establish minimum and maximum freshwater inflows to the Caloosahatchee estuary, Florida. Estuaries and Coasts. 25(6): 1343 – 1354.

DuBarry, A.P., Jr. 1963. Germination of bottomland tree seed while immersed in water. Journal of Forestry 61: 225-226.

E.D. Estevez. 2000. Matching Salinity metrics to Esturaine Seagrasses for Freshwater Inflow Management. In Seagrasses: Monitoring, Ecology, Physiology, and Management. Ed. S.A. Bortone. CRC press. 318 pp.

Estevez, E.D., L. K. Dixon, and M.S. Flannery. 1991. West-coastal rivers of peninsular Florida. Pp 187-222 *In* Livingston, R.J. (ed.) The Rivers of Florida. Springer-Verlag. New York. 289 pp.

Florida Department of Environmental Protection 2000. Rainbow Springs Aquatic Preserve 2000 vegetation mapping project: an assessment of the plant assemblages. Rainbow Springs Aquatic Preserve, Dunnellon, FL.

Florida Department of Environmental Protection. 2008. Effects of Nutrients on Spring Ecosystems. Prepared by the University of Florida Water Institute. University of Florida, Gainesville, FL. Submitted to 376 pp.

Florida Springs Task Force. 2000. Florida's Springs: Strategies for Protection and Restoration Report to the Florida Department of Environmental Protection, Tallahassee, FL. Florida: Origin of Increasing Nitrate Concentrations. Southwest Florida Water Management District, Brooksville, FL.

Florida Wildlife Research Institute (FWRI) Fisheries Independent Monitoring Program (FIM). 2009. An investigation of fish and invertebrate use of the Homosassa River and relationships with freshwater inflow. In preparation.

Frazer, T, Notestein, S., and W. Pine, Jr. 2006. Changes in Physical, Chemical and Vegetative Characteristics of the Homosassa, Chassahowitzka and Weeki Wachee Rivers. University of Florida. Submitted to Southwest Florida Water Management District. Contract No. 03CON000038.

Frazer, T. K., M. V. Hoyer, S. K. Notestein, J. A. Hale, and D. E. Canfield. 2001. Physical, Chemical, and Vegetative Characteristics of Five Gulf Coast Rivers. Prepared for the SWIM Program, Southwest Florida Water Management District.

Harms, W.R., H.T. Schreuder, D.D. Hook, C.L. Brown, F.W. Shropshire. 1980. The effects of flooding on the swamp forest in Lake Ocklawaha, Florida. Ecology 61(6):1412-1421.

Hoyer, M., T. Frazer, and S. Notestein. 2005. Vegetative characteristics of three low-lying Florida coastal rivers in relation to flow, light, salinity and nutrients. Hydrobiologia. 528(1-3): 31-43.

Hunt, M.J. and P.H. Doering. 2000. Significance of Considering Multiple Environmental Variables when using Habitat as an Indicator of Estuarine Condition. In Estuarine Indicators. pp. 211-212.

Jones, G. W., S. B. Upchurch, and K.M. Champion, 1996. Origin of Nitrates in Ground-Water Discharging from Rainbow Springs. Southwest Florida Water Management District, Brooksville, Florida.

Jones, G. W., S. B. Upchurch, K. M. Champion, and D. J. Dewitt. 1997. Water Quality and Hydrology of the Homosassa, Chassahowitzka, Weeki Wachee, and Aripeka Spring Complexes, Citrus and Hernando Counties,

L. Perry and K. Williams. 1996. Effects of salinity and flooding on seedlings of cabbage palm (Sabal palmetto). Oecologia 105(4):428-434.

Latham, P. J., W. M. Kitchens, L.G. Pearlstine. 1994. Species associations changes across a gradient of freshwater, oligohaline, and mesohaline tidal marshes along the Savannah River. Wetlands 14: 174-83.

Loucks, W.L. and R.A. Keen. 1973. Submergence tolerance of selected seedling trees. Journal of Forestry 71. 496-497.

McPherson, K. and K. Williams. 1996. Establishment growth of cabbage palm, *Sabal palmetto* (Arecaceae). American Journal of Botany (83)12:1566-1570.

North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Quality/ Environmental Sciences Section. 2006. SAV Ground-Truthing Study. 20p.

Perry, L., and K. Williams. 1996. Effects of salinity and flooding on seedlings of cabbage palm (*Sabal palmetto*). Oecologia (105): 428-434.

Poff, N.L., D. Allen, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks and J.C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. BioScience 47(11): 769-784.

Romie, K. F. 1990. An Evaluation of Factors Contributing to the Growth of Lyngbya species in Kings Bay/Crystal River, Florida. Southwest Florida Water Management District, Brooksville, FL.

Rosenau, J. C., G. L. Faulkner, C. W. Hendry, and R.W. Hull. 1977. Springs of Florida, Florida Bureau of Geology and Florida Department of Environmental Regulation, Bull. 31 (revised). 461 p.

Rudnick, D., M. Hunt, C. Madden, R. Bennett, A. McDonald, and J. VanAman. 2006. Ecological effects of potential minimum flows and levels for Florida Bay. Presentation by the SFWMD. January 2006.

S. Miyamoto, I. Martinez, M. Padilla, A. Portillo. 2004. Photo Guide: Landscape Plant Response to Salinity. Texas A&M University Research and Extension Center at El Paso

Strong, W.A. 2004. Temporal Water Chemistry Trends within Individual Springs and within A Population of Florida Springs. A Thesis Presented to the Graduate School of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Master of Science. University of Florida, Gainesville, Florida. 54 pp.

SWFWMD. 2001. Regional Water Supply Plan. Southwest Florida Water Management District. 2379 Broad Street Brooksville, Florida 34604.

SWFWMD. 2001. The Hydrology and Water Quality of Select Springs in the Southwest Florida Water Management District. Prepared by the Water Quality Monitoring Program of the Southwest Florida Water Management District.

SWFWMD. October 2005. Unpublished data, SWFWMD Environmental Section.

SWFWMD. October 2006. Unpublished data, SWFWMD Environmental Section.

Tolliver, K.S., D.W. Martin and D.R. Young. 1997. Freshwater and saltwater flooding response for woody species common to barrier island swales. Wetlands, 17:10-18.

Tolliver, K.S., D.W. Martin, and D.R. Young. 1997. Freshwater and saltwater flooding response for woody species common to barrier island swales. Wetlands 17(1).

Wolfe, S. H., R. W. Simons, R. E. Noss, J. A. Reidenauer, M. S. Flannery, and M. J. Bland. 1990. An Ecological Characterization of the Florida Spring Coast: Pithlachascotee to Waccasassa Rivers. Biological Report 90(21). United States Department of the Interior, Fish and Wildlife Service and Minerals Management Service.

Wolfe, S.H., ed. 1990. An ecological characterization of the Florida Springs Coast: Pithlachascotee to Waccasassa Rivers. U.S. Fish Wildl. Serv. Biol. Rep. 90(21). 323 p.

Yobbi, Dann K., and Lari A. Knochenmus. Salinity and Flow Relations and Effects of Reduced Flow in the Chassahowitzka River and Homosassa River Estuaries, Southwest Florida. U. S. Geological Survey, WRI Report 88-4044, 1989.

Appendix A

SAV Sampling Points on the Homosassa River

Homosassa River Shoreline Mapping 2008

Southwest Florida Water Management District

PBSJ

Figure 1

SAV Sampling Data Frazer 2005

Legend

Sampling Points

SAV Present

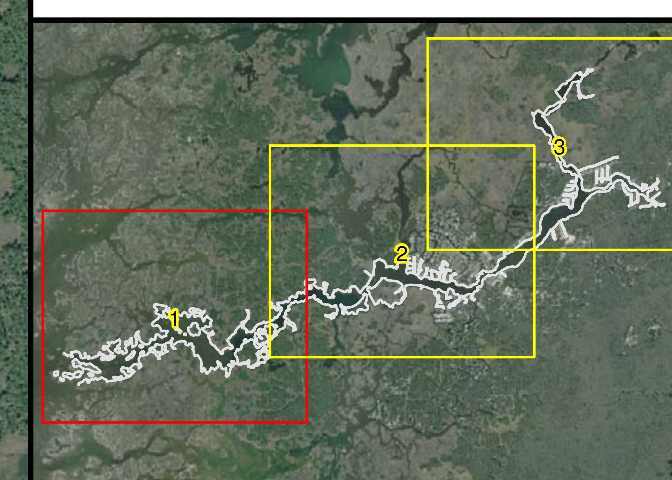
SAV Absent

Homosassa Shoreline

N

0 200 400 600 800 1,000 Meters

1 centimeter equals 150 meters



Homosassa River Shoreline Mapping 2008

Southwest Florida Water Management District

PBS&J

Figure 2

SAV Sampling Data Frazer 2005

Legend

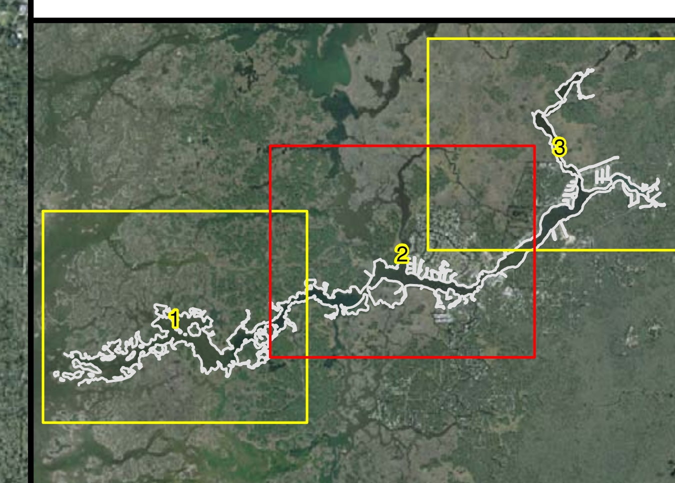
Sampling Points

- SAV Present
- SAV Absent
- Homosassa Shoreline

N

0 200 400 600 800 1,000 Meters

1 centimeter equals 150 meters



Homosassa River Shoreline Mapping 2008

Southwest Florida Water Management District

PBS&J

Figure 3

SAV Sampling Data Frazer 2005

Legend

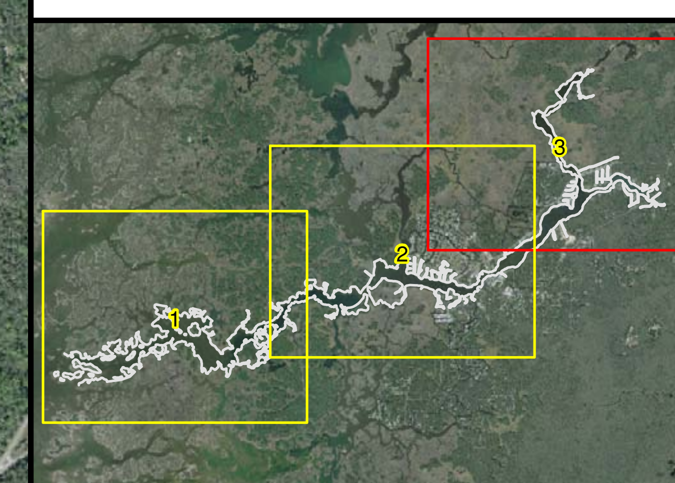
Sampling Points

- SAV Present
- SAV Absent
- Homosassa Shoreline

N

0 200 400 600 800 1,000 Meters

1 centimeter equals 150 meters



Homosassa River Shoreline Mapping 2008

Southwest Florida Water Management District

PBSJ

Figure 4

SAV Sampling Data SWFWMD 2006

Legend

Approximate Sampling Point

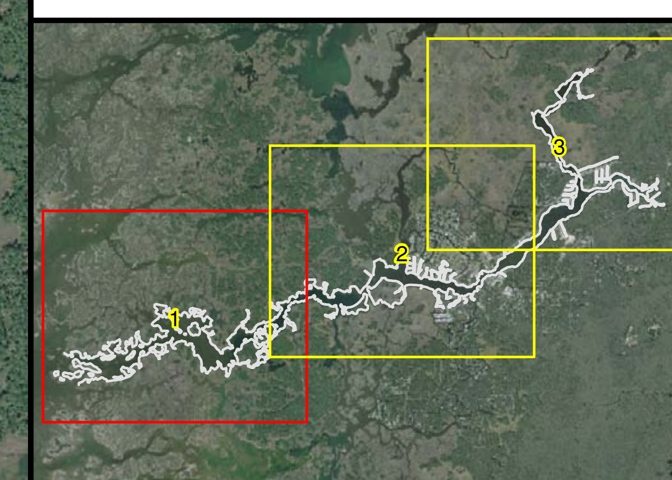
SAV Present

Homosassa Shoreline

N

0 200 400 600 800 1,000 Meters

1 centimeter equals 150 meters



Homosassa River Shoreline Mapping 2008

Southwest Florida Water Management District

PBS&J

SAV Sampling Data SWFWMD 2006

Figure 5

Legend

Approximate Sampling Locations

- SAV Present
- Homosassa Shoreline

N

0 200 400 600 800 1,000 Meters

1 centimeter equals 150 meters