

MINIMUM FLOWS AND LEVELS

STEINHATCHEE RIVER, FLORIDA

SUWANNEE RIVER WATER MANAGEMENT DISTRICT
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1.0 INTRODUCTION

This report, entitled *Minimum Flows and Levels, Steinhatchee River, Florida*, presents the data and analyses that provide technical support for the establishment and adoption of Minimum Flows and Levels (MFLs) for the Steinhatchee River. The location of the Steinhatchee River and its watershed is shown in Figure 1-1.

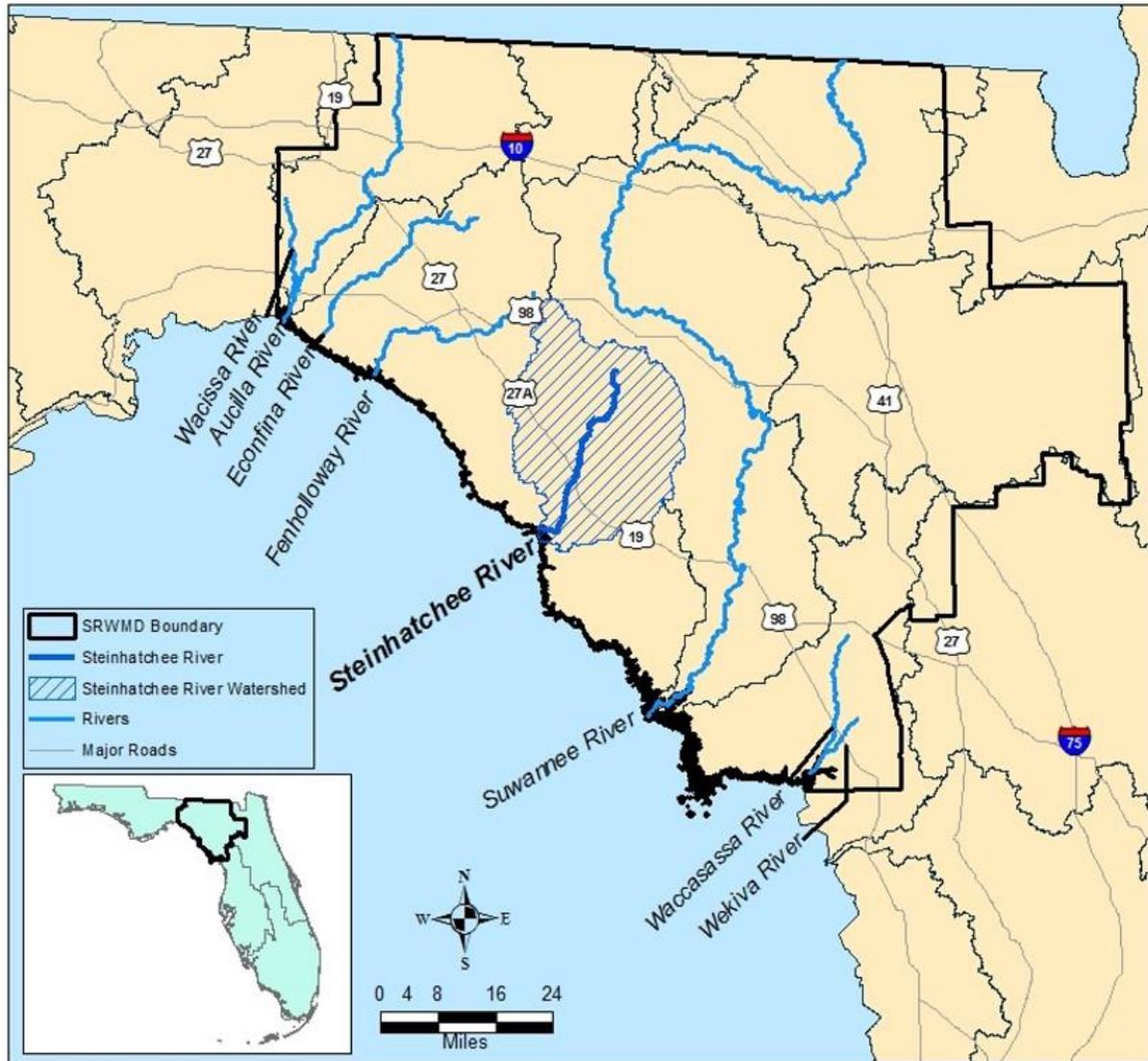


Figure 1-1. Location of the Steinhatchee River watershed.

Section 1.0 of the report provides an overview of the requirement for establishing MFLs, the water policy framework and scope of the Steinhatchee River, and regional context for the MFLs.

1.1 REQUIREMENT TO ESTABLISH MINIMUM FLOWS AND LEVELS

The Florida Legislature has directed the Suwannee River Water Management District (SRWMD) to establish MFLs for streams, springs, rivers, lakes, and other priority water bodies within its boundaries [Chapter 373.042, Florida Statutes (F.S.)]. Chapter 373.042, F.S., specifies that:

1. Within each section, or the water management district as a whole, the Department (Florida Department of Environmental Protection) or the (District) Governing Board shall establish the following:
 - a. Minimum flows for all surface watercourses in the area. The minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.
 - b. Minimum water level. The minimum water level shall be the level of groundwater in an aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area.

The statute provides that MFLs shall be established using the best information available, that where appropriate, may reflect seasonal variations in flows and levels, and may provide for the protection of non-consumptive uses (Chapter 373.042[1], F.S.). Factors are provided in Chapter 373.021, F.S. that the Governing Board may consider when determining the appropriate reference point for MFL establishment. The statute recognizes that the historical hydrological condition of a waterbody may be an appropriate reference point for MFL establishment and allows certain exclusions if returning to those conditions may not be feasible.

Additional policy guidance regarding MFLs is provided in the State Water Resource Implementation Rule (Chapter 62-40.473, Florida Administrative Code [F.A.C.]), indicating that

“...consideration shall be given natural seasonal fluctuations in water flows or levels, nonconsumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology. These environmental and water resource values may include:

- a) Recreation in and on the water,

- b) Fish and wildlife habitats and the passage of fish,
- c) Estuarine resources,
- d) Transfer of detrital material,
- e) Maintenance of freshwater storage and supply,
- f) Aesthetic and scenic attributes,
- g) Filtration and absorption of nutrients and other pollutants,
- h) Sediment loads,
- i) Water quality, and
- j) Navigation.”

A discussion of the environmental and water resource values that are applicable to the Steinhatchee River is provided in Chapter 4.

Prior to the establishment of MFLs, SRWMD may voluntarily subject technical work to independent scientific peer review (Section 373.042, F.S.). The purpose of the peer review is to conduct an independent examination of the scientific or technical data, methodologies, and models, including all scientific and technical assumptions employed in each model, used to establish each minimum flow or level.

Once the MFL has been determined, if the existing flow or level in a waterbody is below the applicable MFL, SRWMD is required to develop and implement a recovery strategy. If the MFL is currently being met, but the waterbody is expected to fall below it within 20 years, a prevention strategy must be developed and implemented. Rule 62.40.473(5), F.A.C., requires that when recovery or prevention strategies are needed, they are to be simultaneously approved with the adoption of the MFL.

Once established by rule, MFLs are used in both SRWMD’s water supply planning and consumptive use permitting programs. In planning, MFLs are used to evaluate which water sources could be used, while protecting the needed flows and levels for the water resource. In permitting, applicants must provide reasonable assurances that the proposed withdrawal will not violate an adopted MFL and is in accordance with any approved recovery or prevention strategy (Rule 62.40B-2.301, F.A.C.).

1.2 WATER POLICY FRAMEWORK

SRWMD completed and accepted the 2010 Water Supply Assessment in December 2010 (SRWMD 2010). The Water Supply Assessment report utilized an interim MFL for the Steinhatchee River that would limit the reduction in river flow to 10 percent.

1.3 SCOPE OF THE STEINHATCHEE RIVER MFL

The Steinhatchee River watershed encompasses 562 square miles from Mallory Swamp in Lafayette County to its mouth at Deadman's Bay in Dixie/Taylor County (Figure 1-1). It flows in a southwesterly direction to the Big Bend region of Florida. The total length of the river is approximately 40 miles.

1.4 WATER RESOURCES ISSUES IN THE STEINHATCHEE RIVER WATERSHED

The total water use is relatively modest and totals less than 4 million gallons per day (mgd). The water use in this area is not surprising since neither urbanized areas nor agriculture make up a significant portion of the landscape in and around the Steinhatchee River watershed. A more comprehensive presentation and analysis of the nature of the Steinhatchee River and its watershed is provided in Chapter 2.

1.5 CONTENT OF REMAINING SECTIONS

The remaining chapters of this report contain the following:

Chapter 2.0 – Provides an overview of the study area's geology, surface water hydrology, riverine and wetland habitats, water use, and land use.

Chapter 3.0 – Provides a review of the study area's ecological characteristics

Chapter 4.0 – Describes the conceptual model and approach used to develop the proposed MFLs, including a discussion of the Water Resource Values (WRVs) of the system and the in-channel and out-of-bank WRVs in the river system.

Chapter 5.0 – Provides the methodology for the development of minimum flows for the Steinhatchee River. Descriptions of data collection and analyses are included for each WRV.

Chapter 6.0 – Presents the proposed MFLs for the Steinhatchee River.

Chapter 7.0 – Literature cited

2.0 DESCRIPTION OF THE STEINHATCHEE RIVER SYSTEM

The Steinhatchee River watershed encompasses 562 square miles from its headwaters in Mallory Swamp in Lafayette County to its mouth at Deadman's Bay in Dixie/Taylor County. It is located near the center of the Big Bend region of Florida. The majority of the watershed falls within the Gulf Coast Lowlands. Further downstream, it crosses into the Coastal Swamp Region (Figure 2-1).

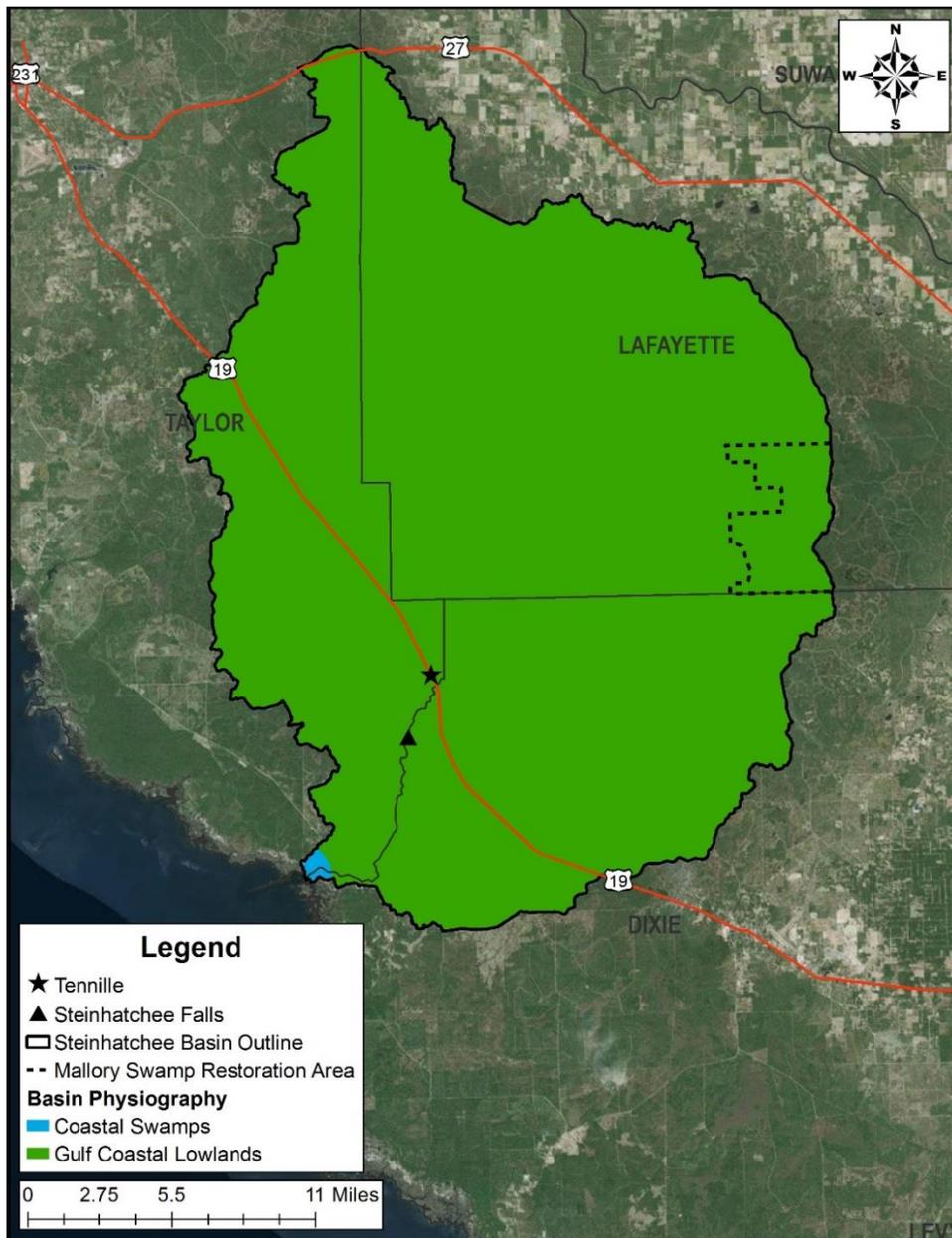


Figure 2-1. Steinhatchee River watershed with physiographic provinces.

The Steinhatchee River headwaters begin in the swampy hammocks of Mallory Swamp (Figure 2-1), located in Lafayette County, and flow southwestward in a narrow-incised valley, generally lying 10 feet or fewer above mean sea level (MSL). It forms the southern boundary of Taylor County, separating it from Dixie County. The Steinhatchee River flows in a narrow channel cut into Eocene carbonates, which commonly crop out along the lower portion of the river. The river flows underground for a 1-mile stretch near the community of Tennille and emerges about 0.3 mile west of U.S. Highway 19 (US 19). The underground portion of the river's route is mirrored at the surface by a topographic valley containing only intermittent flow. The Steinhatchee River is a sluggish, generally tannic stream, widening near the coast as it enters the coastal salt marshes. The lowlands adjacent to the river are typically very narrow, widening significantly in one area northeast of the Town of Steinhatchee. For the purposes of this report, references to river location are provided by river mile from the mouth of the river at the Gulf of Mexico. Figure 2-2 presents a map showing the river miles.

The Lower Steinhatchee River is characterized by developed areas primarily on the northern shore and extends to expansive tidal marshes marked by numerous tidal creeks (Figure 2-3). The developed shoreline extends northward to river mile (RM) 8. The channel narrows to about 50 feet between RM 5 and RM 6. The river width ranges from 300 to 2,500 feet below RM 4. River substrate generally reflects the exposed limestone and its overlying thin veneer of undifferentiated Pleistocene and Holocene surficial sands, clayey sands, and alluvium (Ruppert 1991, 1996).

Above RM 8, much of the channel falls within a more undeveloped area. Between RM 6 and RM 10, the river width ranges from 50 to 75 feet. A number of shoals within this section of the river vary between river flow and tidal backwater, depending upon the downstream tidal water level. Figure 2-4 presents a photo of one of the shoals in this area during a lower tidal condition. The upper reaches of the river are underlain by Suwannee limestone of the Oligocene Epoch, but its narrow channel cuts into carbonates of the earlier Eocene Epoch, which commonly crop out along the lower portion of the river. The Eocene carbonates comprise the Ocala Formation, which becomes exposed approximately 12 miles inland, where the slope of the river thalweg becomes relatively steep prior to leveling out near Steinhatchee Falls (Ruppert 1991, 1996).

Steinhatchee River Watershed - River Miles

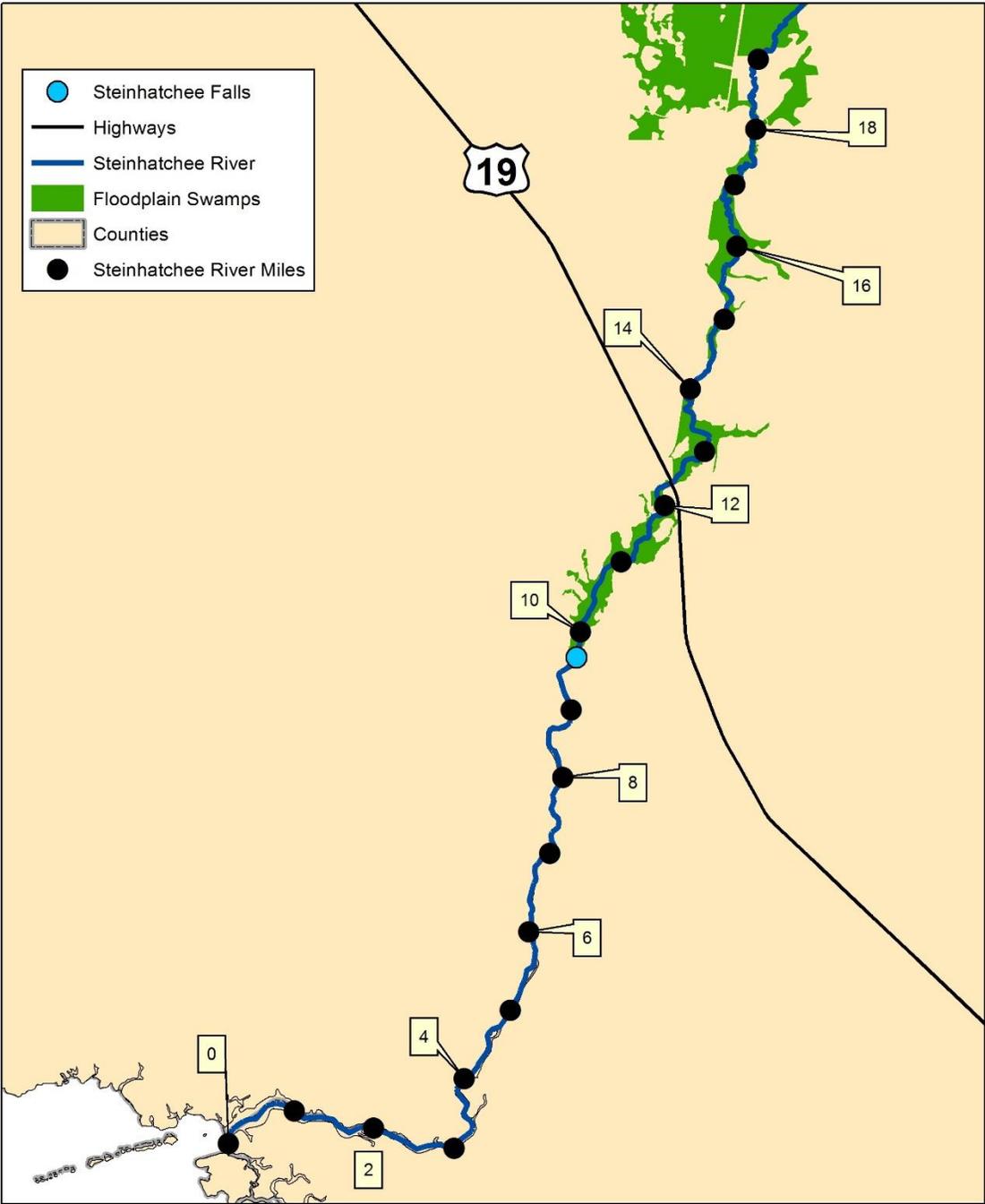


Figure 2-2. Steinhatchee River with river miles.

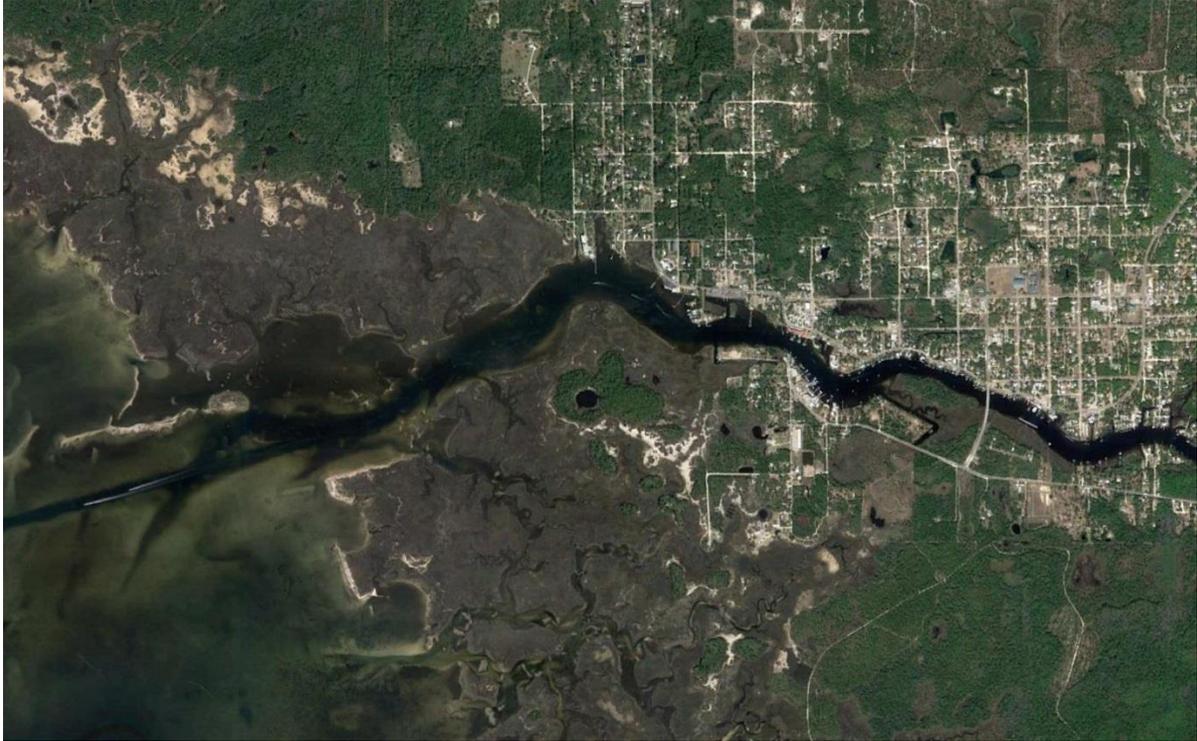


Figure 2-3. Lower Steinhatchee River (Source: Google Earth).



Figure 2-4. Shoal between RM 6 and RM 10 at low tide.

Steinhatchee Falls is a much-visited area on the river located near RM 10.2 (Figure 2-5). The channel is approximately 60 feet across, with a drop in the channel bottom of approximately 2 to 3 feet. Above RM 10, the river width ranges between 30 to 50 feet. A series of shoals (Figure 2-6) are located between RM 12 and RM 15. Limestone outcrops are the primary bottom type in this reach of the river.



Figure 2-5. Steinhatchee Falls.



Figure 2-6. Steinhatchee River shoals.

2.1 GEOLOGY, GEOMORPHOLOGY, AND HYDROGEOLOGY

2.1.1 GEOLOGY

The Steinhatchee River Basin is contained almost entirely within the gulf coastal lowlands physiographic province (White 1970). Four distinct units comprise the surficial geology within the watershed: Undifferentiated Quaternary sediments, Miccosukee Formation, Torreya Formation of the Hawthorne Group, and Suwannee Limestone. The top of the Suwannee Limestone varies in depth, from surface outcrop to about 30 feet below the surface. The limestone surface is highly eroded, containing numerous solution pipes, holes, small caves, sinks and pinnacles. Although some of these features may be seen on the Steinhatchee River, they are generally masked by infilling with younger, unconsolidated sands and clayey sands. In shallower spots of the Steinhatchee River, the Suwannee Limestone bed is visible and forms shoals separating deeper pools. Figure 2-7 illustrates the surface geology of the area.

2.1.2 GEOMORPHOLOGY

The watershed is contained within the Ocala Karst Geomorphic Region, which is subdivided locally into the Perry Karst/San Pedro Bay and the Woodville Karst Plain (Figure 2-8). The Perry Karst subdivision is a narrow transitional zone between the Woodville Karst Plain to the west and San Pedro Bay on the east. The Perry Karst area is poorly to moderately drained, whereas San Pedro Bay is extremely poorly drained. The Suwannee Limestone underlies the Perry Karst/San Pedro Bay in this area. In the San Pedro Bay, a clay layer up to 5 feet thick overlies the limestone, providing confinement to the Floridan aquifer system (FAS) (Copeland 1982). Plio-Pleistocene sediments cover the entire area, and the unit is poorly to very poorly drained.

The Woodville Karst Plain has common karst features that include springs, disappearing streams (swallets), and resurgent streams. Elevations, in general, range from sea level to approximately 50 feet. Relief is very low over the entire area and drainage is poor, resulting in vast swamps. Tertiary carbonates underlie the entire area beneath a thin siliciclastic cover. The Lower Oligocene Suwannee Limestone underlies the karst (Scott et al. 2001). The Cody Scarp is located at the watershed's northern extent, as indicated by the Geomorphic District Boundary illustrated in Figure 2-8.

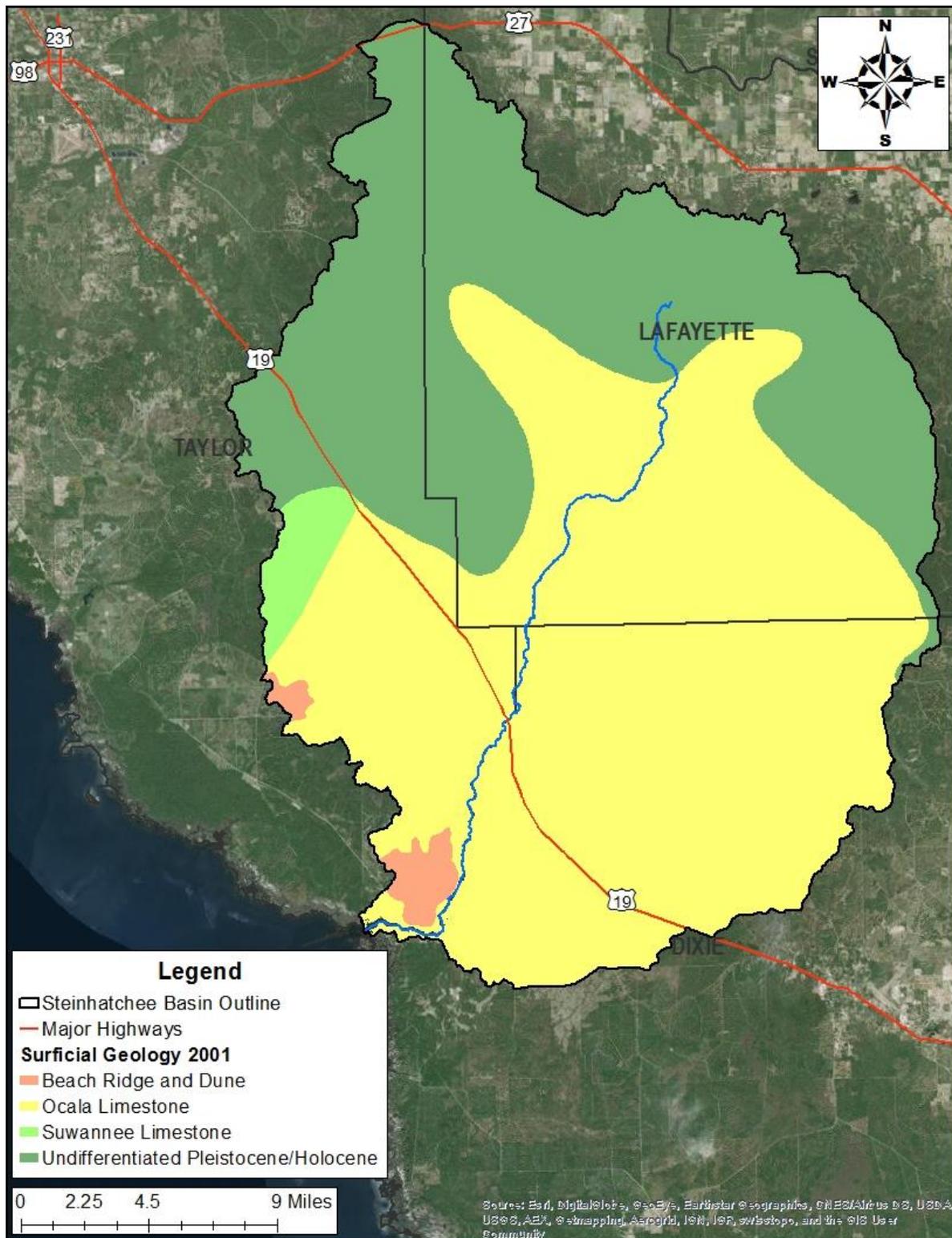


Figure 2-7. Surface geology of the Steinhatree River watershed. [Source: Florida Geographic Data Library (FGDL)]

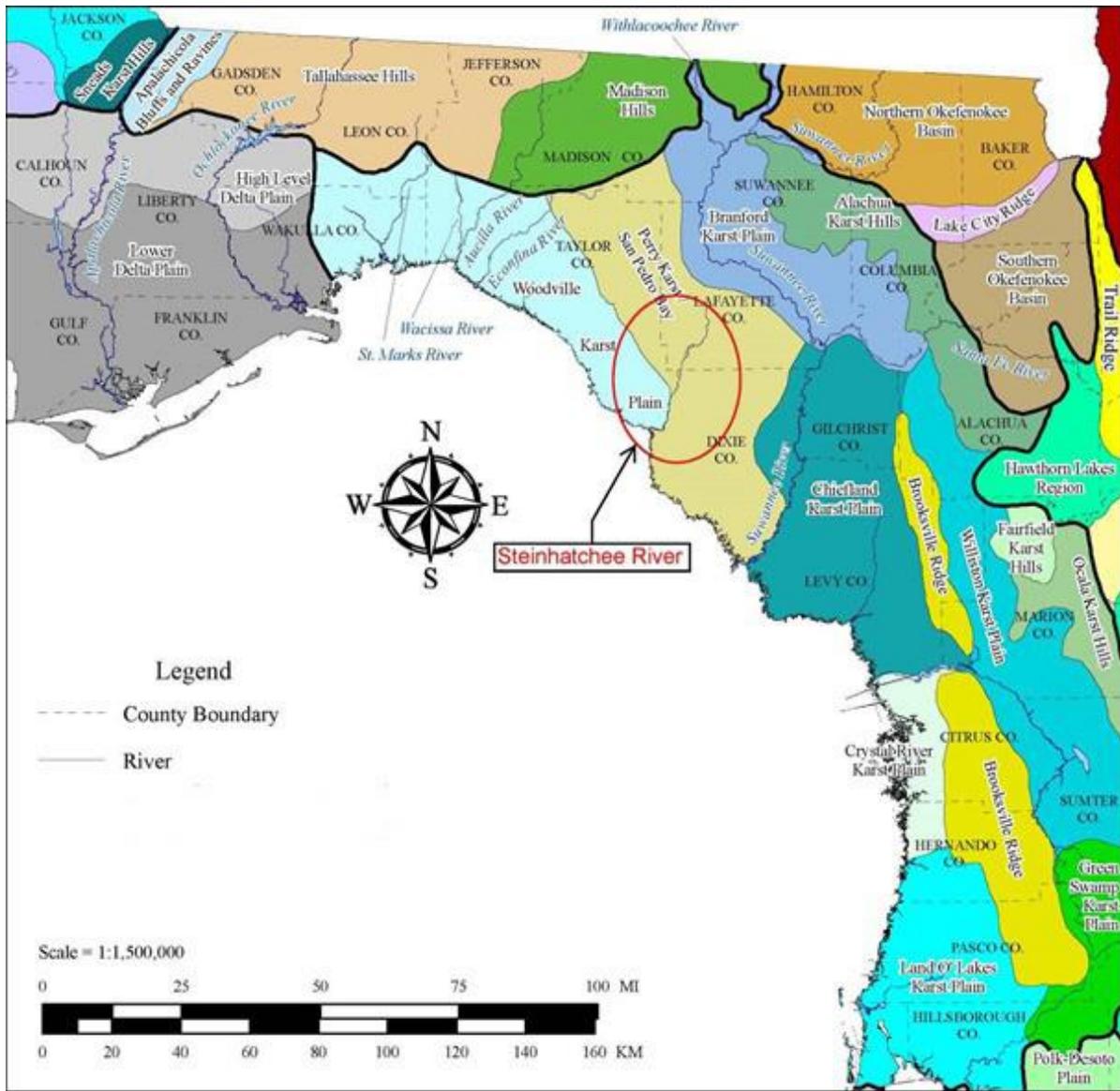


Figure 2-8. Geomorphology of the Florida Big Bend area and the Steinhatchee River watershed. From Paul et al. (2008).

2.1.3 HYDROGEOLOGY

Table 2-1 illustrates the hydrogeologic framework in the Steinhatchee River Basin (Scott et al. 2001). The pertinent units include the surficial aquifer system, the intermediate confining unit, and the Floridan aquifer system.

The extent of the surficial aquifer system has not been well defined in the basin. This aquifer system is a water-table aquifer (unconfined) within post-Miocene clayey sands. In the San Pedro Bay area, a surficial (water table) aquifer system reaching maximum thicknesses of 50 feet has been reported (Burnson 1982).

Table 2-1. General relationships between geologic and hydrogeologic units in the Steinhatchee River Basin.

System	Series	Formation	Aquifer System
Quaternary	Holocene/Pleistocene	Undifferentiated/Quaternary	Surficial
Tertiary	Pliocene	Miccosukee Formation	Surficial
Tertiary	Miocene	Hawthorn Group -Torreya Formation	Intermediate Aquifer System
Tertiary	Oligocene	Ocala/Suwannee Limestone	Upper Floridan

The intermediate confining unit, where present, comprises clayey Miocene (Hawthorn Group) sediments and, in some cases, the relatively clay-rich post-Miocene sediments. The extent of the intermediate aquifer system has also not been well defined in the basin (Arthur 1991).

The Floridan aquifer system underlies the entire basin and is between approximately 1,250 and 1,475 feet thick (Miller 1986 and Arthur 1991). Depths to this aquifer system range from 0 to about 60 feet below land surface. The uppermost geologic formations of this system include either the Suwannee Limestone (where present) or the Ocala Limestone (Arthur 1991).

2.1.4 RECHARGE TO THE UPPER FLORIDAN AQUIFER

A spatial evaluation of recharge to the Upper Floridan Aquifer (UFA) is important to understand the overall water budget of the system. Figure 2-9 presents the general recharge characteristics in the Steinhatchee River Basin. The UFA recharge potential was evaluated using a ranking system for use in a geographic information system (GIS) context. In general, this is an area of low to medium-low recharge potential. The higher recharge areas are found in the upper portions of the watershed and gradually decrease closer to areas of lower elevation. Figure 2-9 indicates that discharge occurs in areas in the river valley and lowest elevations of the watershed. The beginning of the discharge area corresponds with the presence of several small springs.

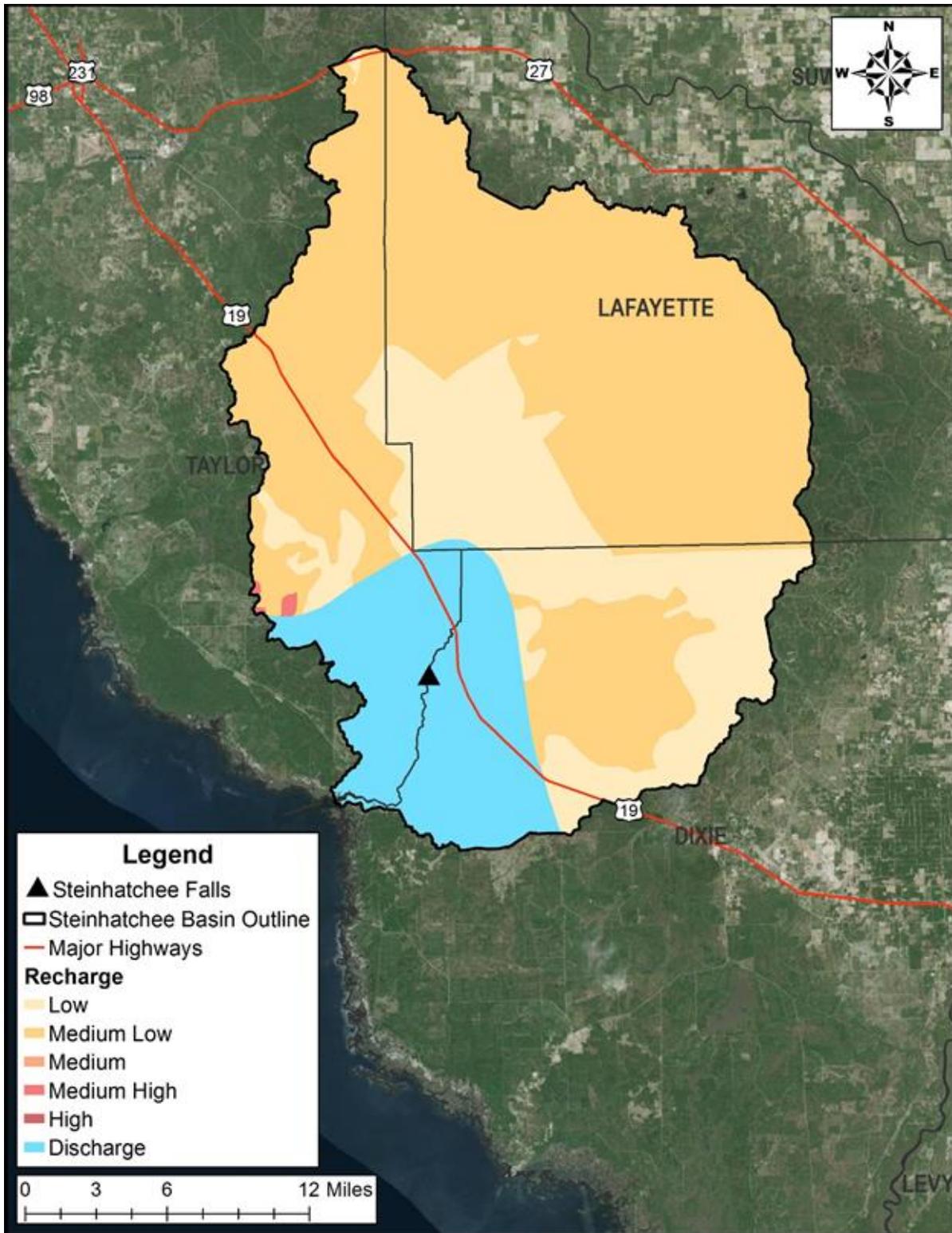


Figure 2-9. Upper Floridan Aquifer recharge and discharge in the Steinhatchee River Basin. (Source: SRWMD)

2.1.5 RELATIONSHIP OF THE STEINHATCHEE RIVER TO THE UNDERLYING AQUIFERS

The potentiometric surface of an aquifer system reflects the surface (or elevation) to which the ground water would rise due to hydrostatic pressure. When an aquifer system is confined by overlying impermeable beds, the potentiometric surface may be situated above land surface. Figure 2-10 presents the potentiometric surface of the UFA in May 2014, a wetter period. Figure 2-11 presents the potentiometric surface of the UFA in May of 2000, a very dry period. A potentiometric high occurs in the northern portion of the watershed in San Pedro Bay, and declines moving southwest toward the coast. The Steinhatchee River channel becomes more incised beginning in southern Lafayette County. In this area, the aquifer becomes artesian, as evidenced by the presence of numerous small springs.

Under artesian conditions, if an unconfined path exists between the aquifer system and the surface, ground water will flow freely at land surface in the form of seeps and springs. Numerous springs occur along the Steinhatchee River (Figure 2-12), indicating the groundwater is under some amount of pressure from within the Floridan aquifer system with respect to the river stage. The figure shows all of the springs in the system with the two Priority Springs (Steinhatchee River Rise and Beaver Creek Spring) shown as a distinct symbol. The two Priority Springs are the ones for which MFLs are established in this document.

The importance of flow from these two priority springs is dependent on the flows in the Steinhatchee River Main Stem. The observed flow in the main stem ranges from 2.5 cubic feet per second (cfs) to 17,600 cfs with a median flow of 102 cfs. The flow in Steinhatchee River Rise originates primarily from Steinhatchee River Sink, which is located approximately 0.5 mile downstream of USGS Gage 02324000. USGS estimates that all flow in the Steinhatchee River below approximately 500 cfs goes underground, reappearing at Steinhatchee River Rise south of US 19/98. The aboveground channel remains dry most of the time, since 500 cfs represents approximately an 80th percentile flow, or a flow that is exceeded approximately 20 percent of the time. A flow of 350 cfs was measured at the Rise on July 6, 1999. This compares to a flow at the USGS gage on that date of 229 cfs. Beaver Creek Spring is a 2nd magnitude spring that had a measured flow approximately 75 cfs on July 6, 1999.

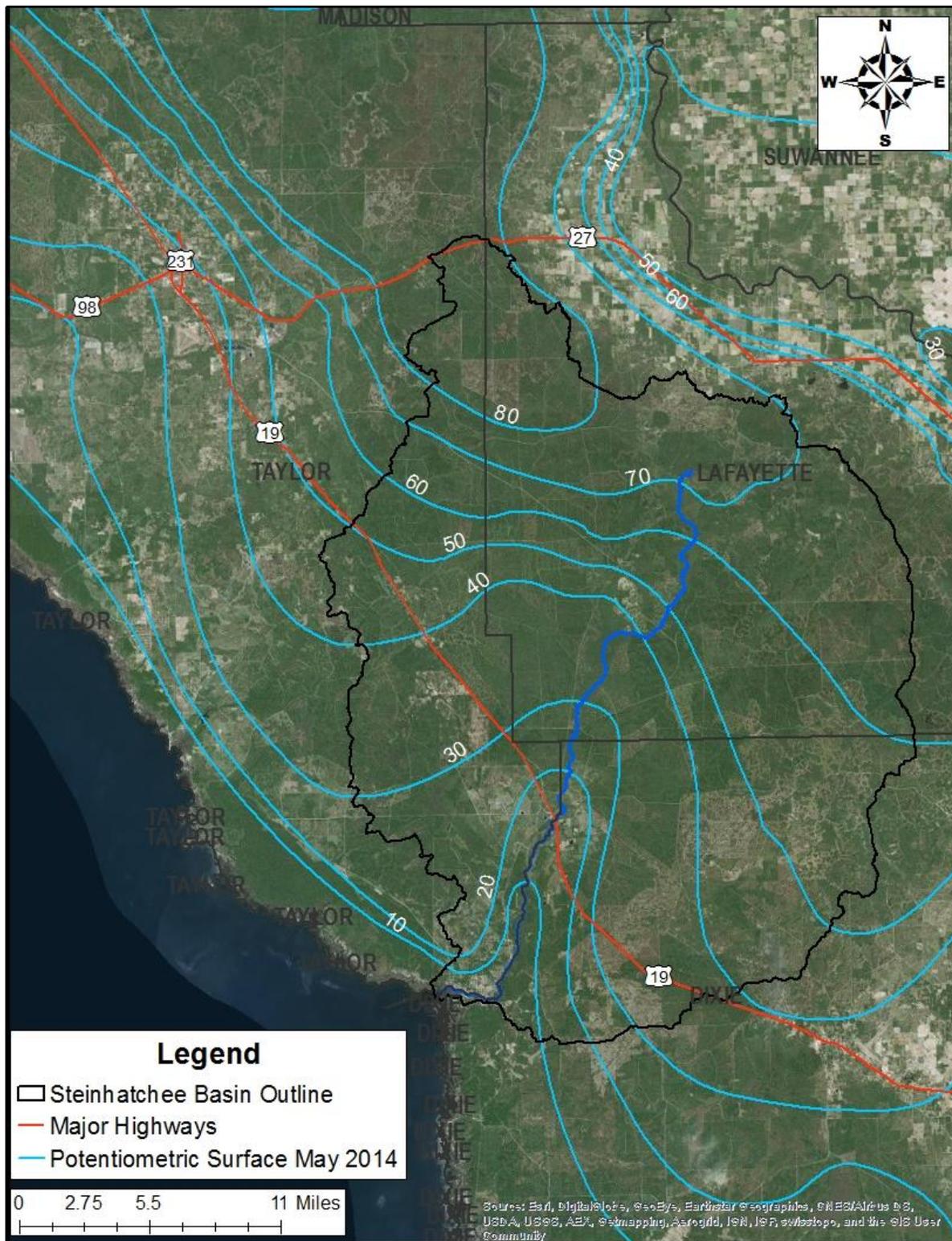


Figure 2-10. Generalized potentiometric surface of the Upper Florida aquifer along the Steinhatchee River, May 2014. [Source: Florida Geological Survey (FGS) and the Florida Department of Environmental Protection (FDEP)]

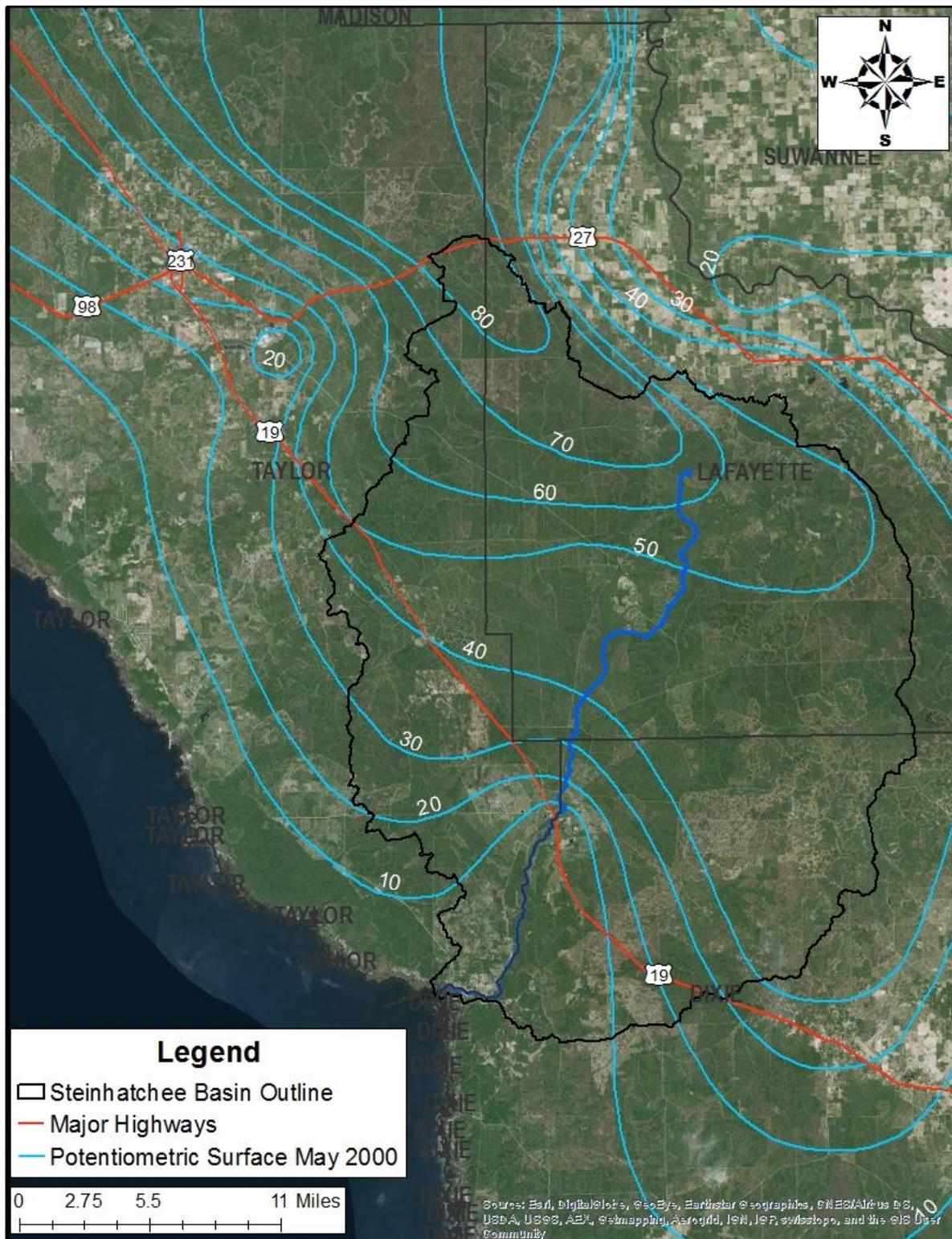


Figure 2-11. Generalized potentiometric surface of the Upper Florida aquifer along the Steinhatchee River, May 2000. (Source: FGS/FDEP)

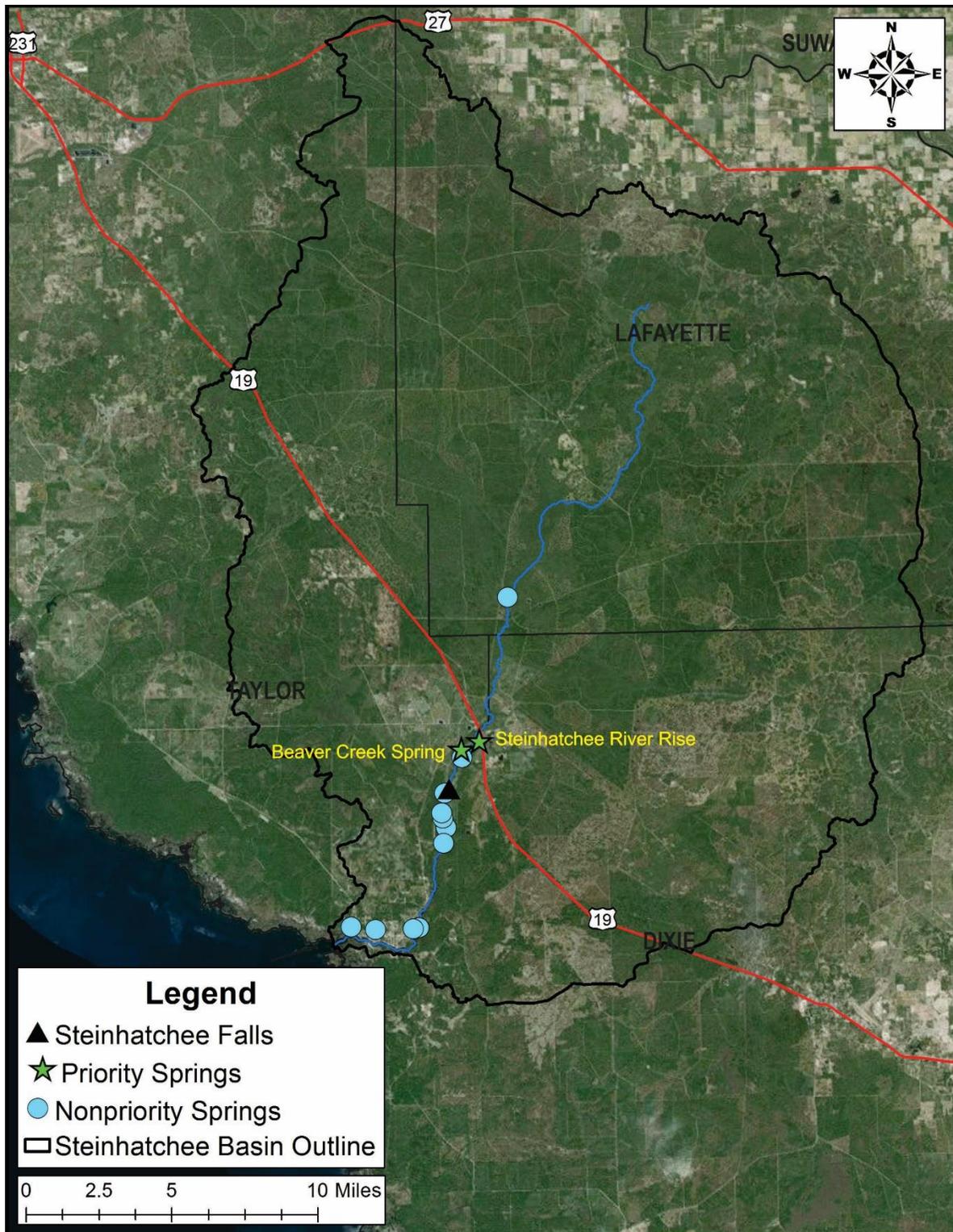


Figure 2-12. Springs in the Steinhatchee River watershed. (Source: SRWMD)

The following sections discuss the two Priority Springs shown on Figures 2-13 and 2-14 (Steinhatchee River Rise and Beaver Creek Spring) as described in Scott et al. (2004):

Steinhatchee River Rise

Steinhatchee River Rise is the re-emergence of the Steinhatchee River from underground. There was very little flow during October 2001 visit. Spring pool measures 72 ft (21.9 m) north to south and 30 ft (9.1 m) east to west. The depth is 12 ft (3.7 m). Tannic water flows northwest out from underneath a limestone ledge. Algae are present on limestone substrate. Some cypress trees are near water's edge. The area around the rise has nearby sink depressions and elongated fissures in limestone that run into the Steinhatchee River from its banks. Uplands both north and south of the rise have planted pines. The uplands rise steeply to 10-12 ft (3-3.7 m) above water level on both sides of river channel. This river rise is located in a river flood channel. High water would bring river water flowing over the rise depression from the southeast. Utilization-Land owned by SRWMD and public access granted. No development, planted pines nearby. Discharge-July 6, 1999: 350 ft³/s (discharge measurement by SRWMD) (Scott et al. 2004).

Beaver Creek Spring (TAY76992)

Beaver Creek Spring forms an oval-shaped pool 120 ft (36.7 m) by 80 ft (24.4 m), and 6 ft (1.8 m) deep. Two small vents are located in the center of the sand bottom spring pool. Detritus and brown algae also coat the bottom and the spring water is slightly cloudy. Two small boils are visible in the center of the pool. The spring run is 10 ft (3 m) wide, 3 ft (0.9 m) deep, and flows 0.3 miles (0.5 km) south into the Steinhatchee River. The SRWMD property around this spring is a lowland hardwood forest. Evidence of beavers is apparent around the spring pool and run. Discharge of Beaver Creek Spring measured on July 6, 1999 was 74.98 ft³ /s (discharge measurement by SRWMD) (Scott et al. 2004).



Figure 2-13. Steinhatchee River Rise. (Photo by R. Means)



Figure 2-14. Beaver Creek Spring. (Photo by A. Millet)

2.2 LAND USE WITHIN THE STEINHATCHEE RIVER BASIN

Land use and land cover of the basin are major contributors to defining the hydrologic response to rainfall. Changes in land use of a basin can contribute to changes in the water balance. The water budget can be further modified given water withdrawals to satisfy potable demands in the case of urbanization, or to offset evapotranspiration (ET) in the case of agricultural land use.

2.2.1 LAND USE AND COVER

The most recent available mapping of land cover/land use conditions for the basin was based on 2010 aerial photography. Mappings from the 1950s, 1970s, 1988, 1994 and 2010 were also obtained for analysis. Land use conditions for the Steinhatchee River watershed in these time periods are shown in Figures 2-15 through Figure 2-19. The 1950s and 1970s land cover were developed for the Steinhatchee River Basin Management Plan (KBN Engineering et al. 1990). The 1988 and 1994 land cover data were obtained from SRWMD. The 2010 land cover was developed by FDEP (2011).

The coverages were developed at different resolutions; consequently, they were aggregated and grouped by generalized Florida Land Use, Land Cover Classification System (FLUCCS) codes, resulting in the summary shown in Table 2-2 and illustrated in Figure 2-20. These land use conditions were examined for changes from the 1950s to 2010.

Forested land cover dominates the Steinhatchee River Basin, covering more than half of the basin. Urban and agricultural land uses have remained a small percentage of the land use since the 1950s. While the coverages over the years were developed at different resolutions, it is possible to note one important transition, the conversion of upland and wetland areas from tree plantation (silviculture). Tree plantations constituted 51.1 percent of the land cover in the 1970s. This percentage has decreased to 43.2 percent in 2010, largely as the result of conservation and restoration efforts in the watershed.

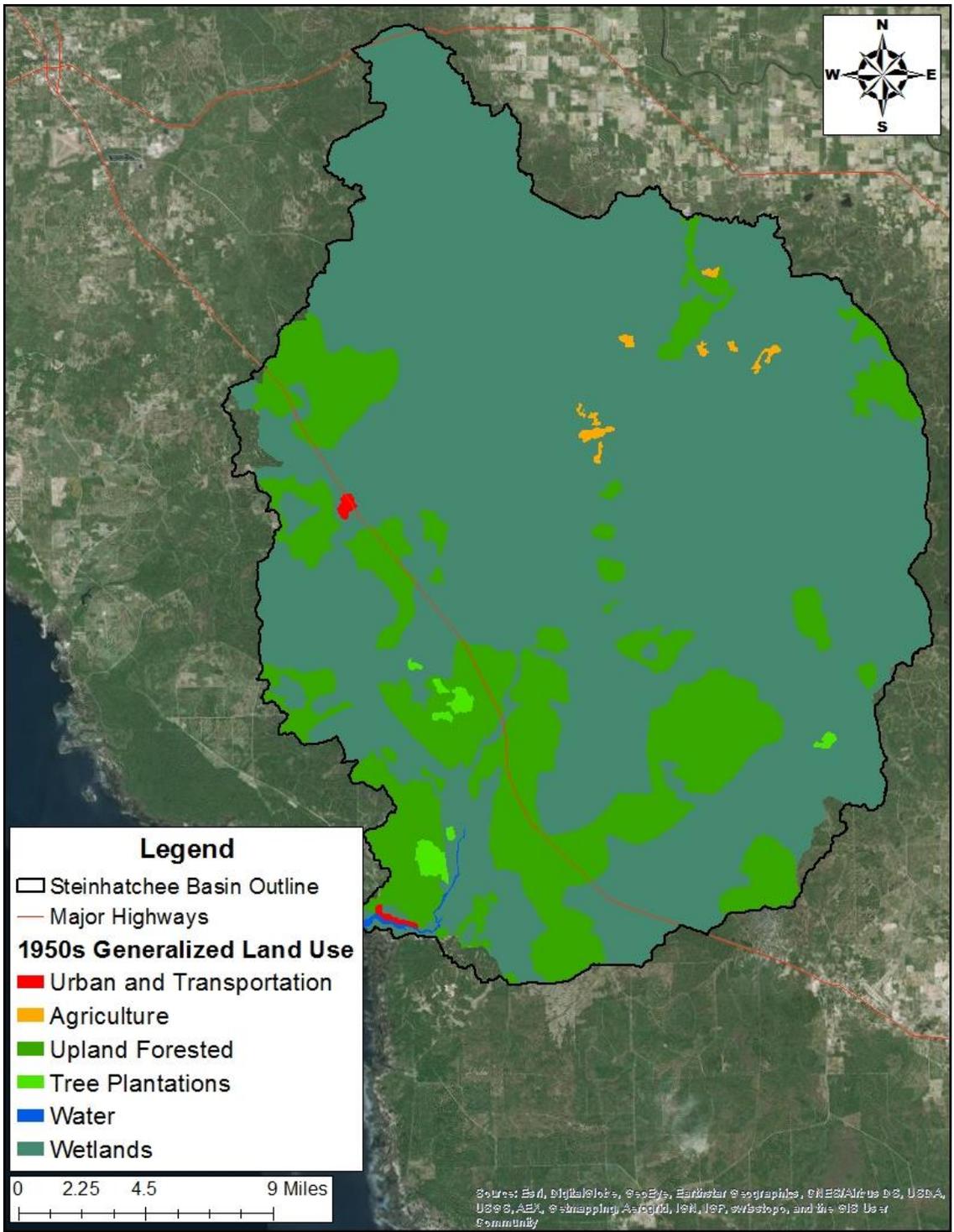


Figure 2-15. 1950s land use within the Steinhathee River watershed.

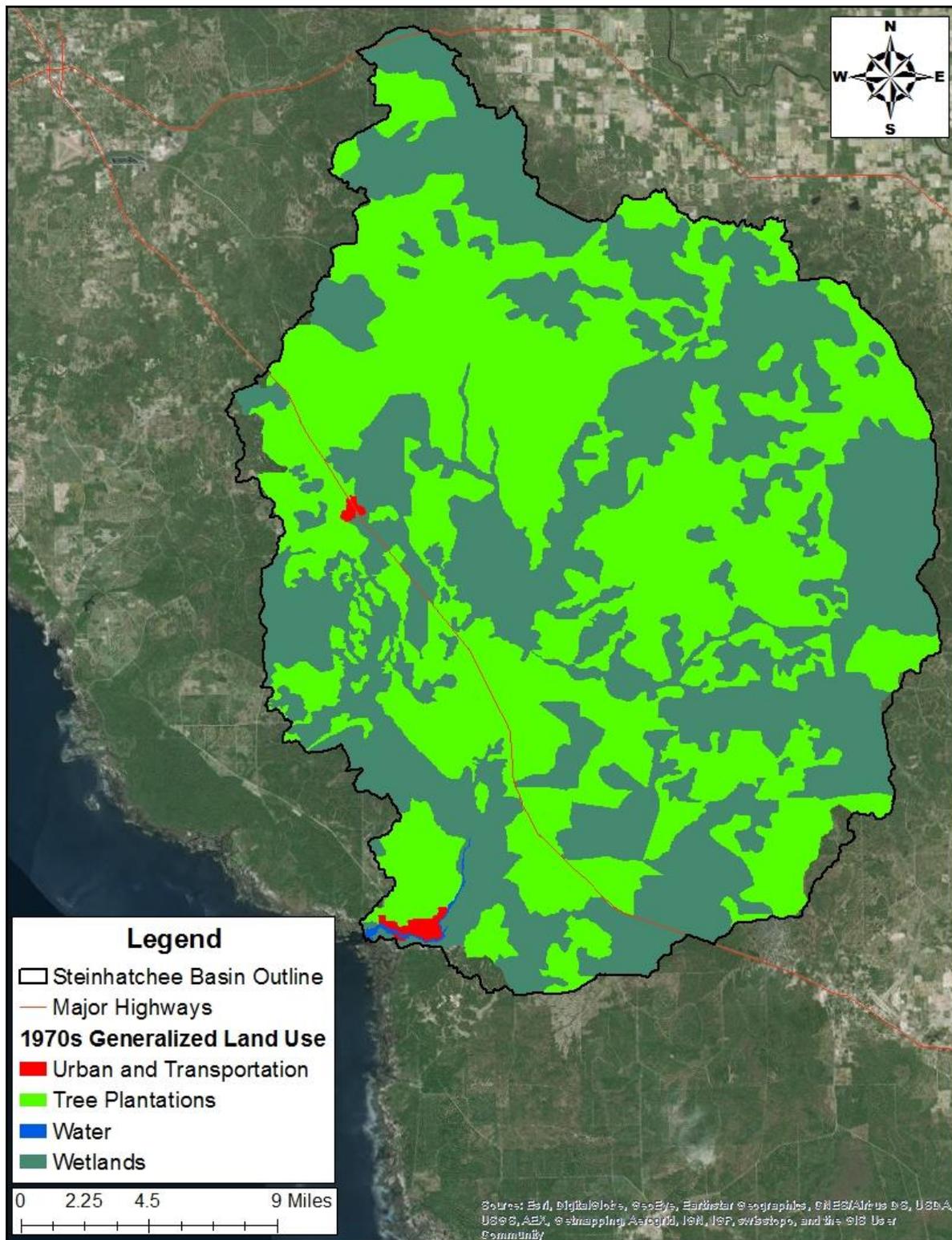


Figure 2-16. 1970s land use within the Steinhatchee River watershed.

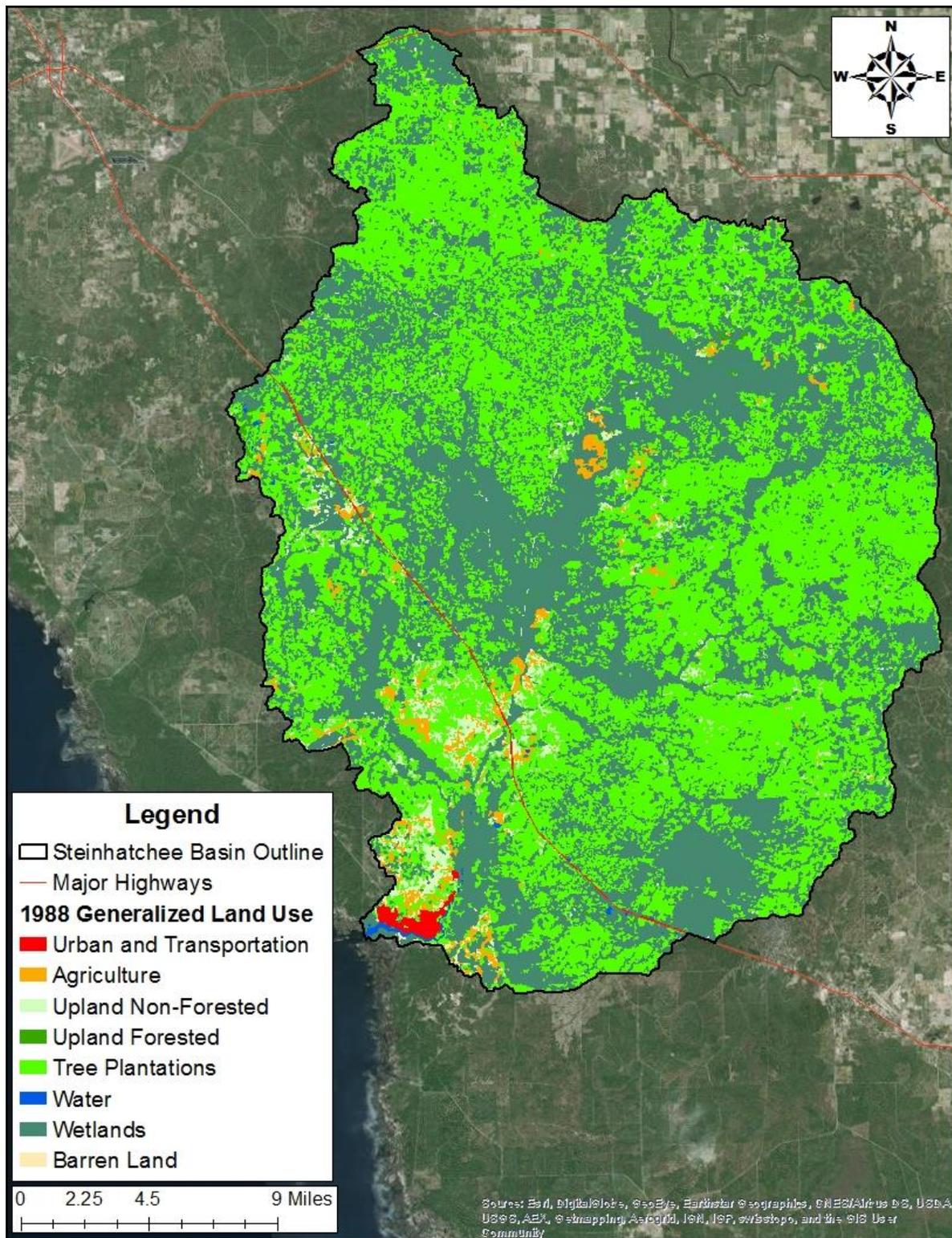


Figure 2-17. 1988 land use within the Steinhatchee River watershed.

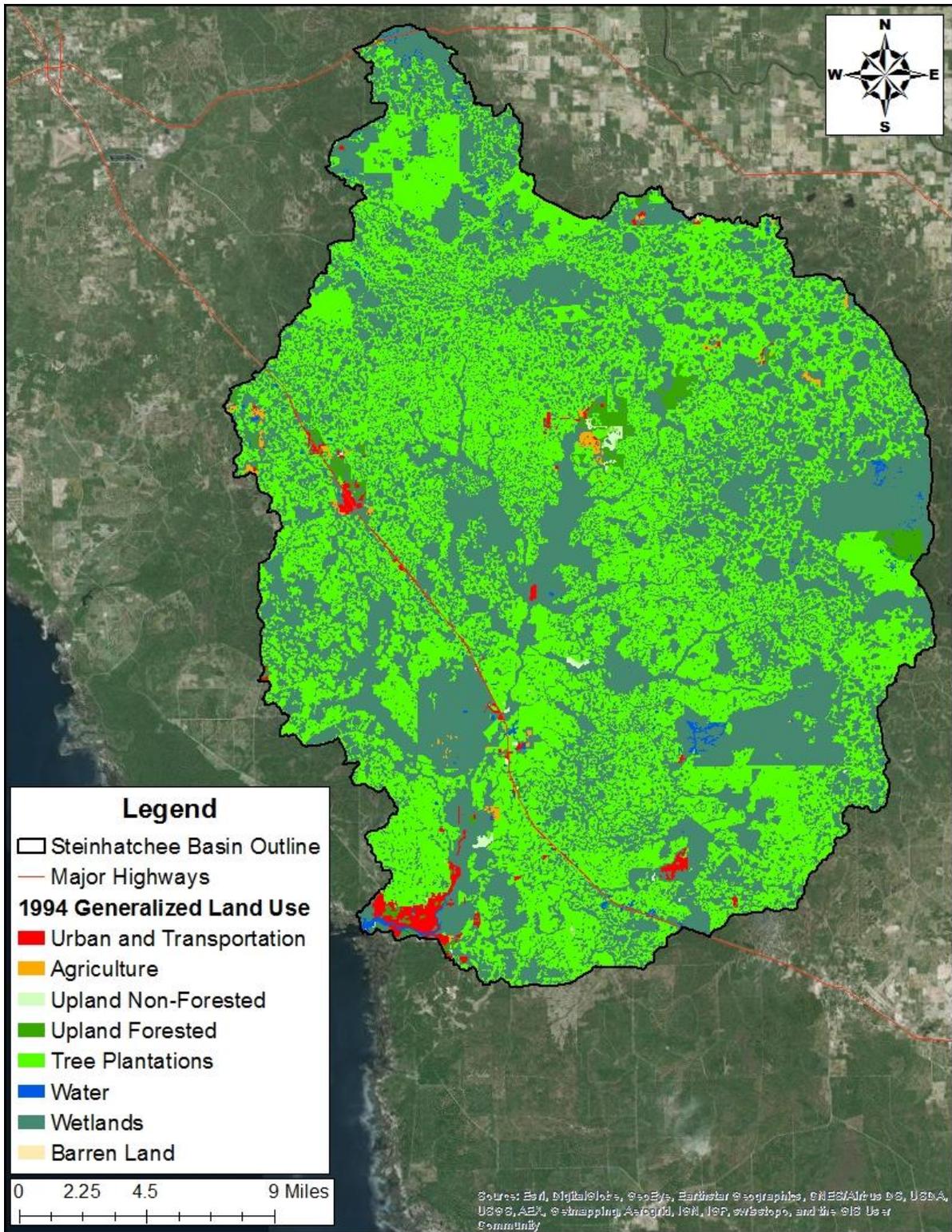


Figure 2-18. 1994 land use within the Steinhatchee River watershed.

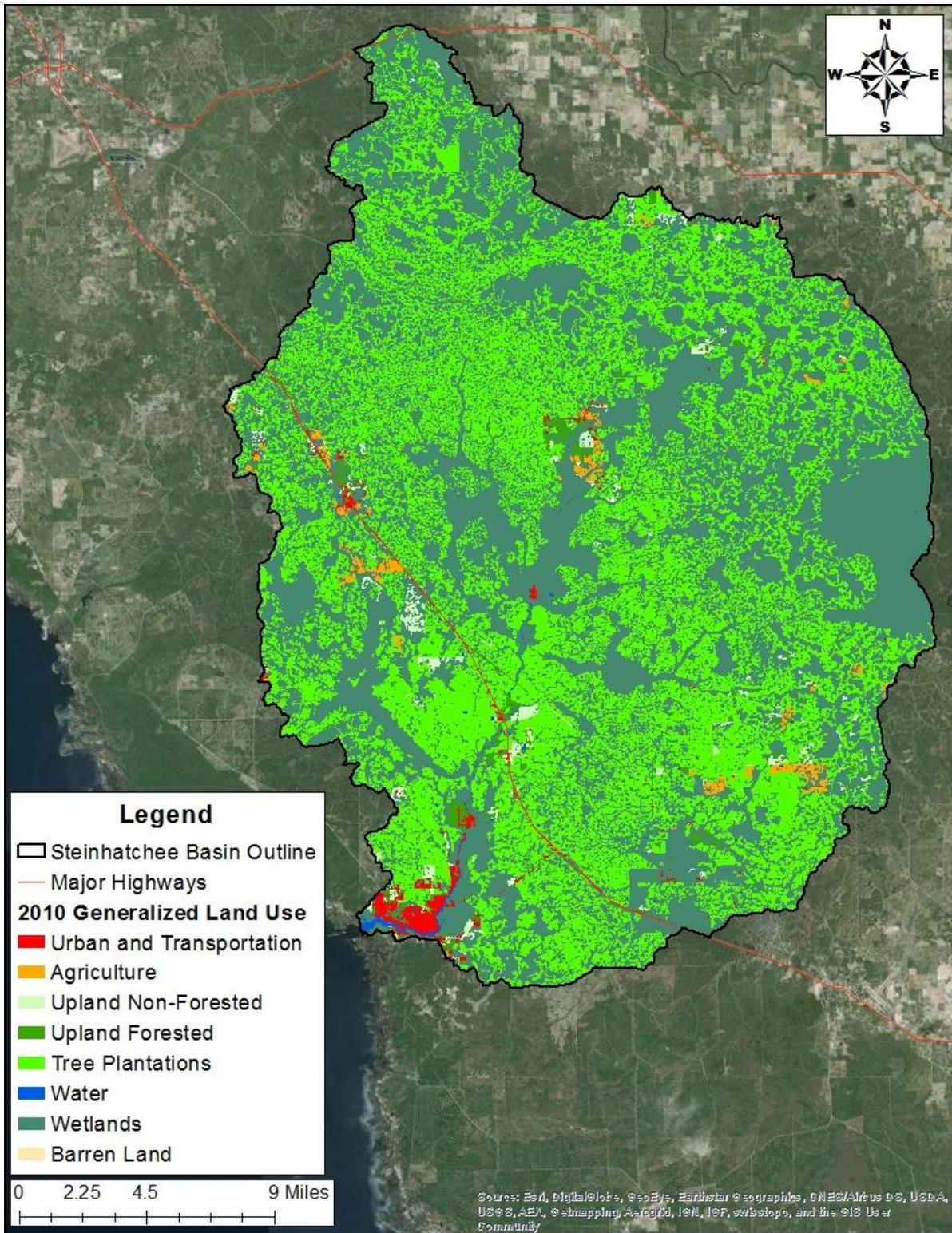


Figure 2-19. 2010 land use within the Steinhatchee River watershed.

Table 2-2. Land use within Steinhatchee River Basin in the 1950s, 1970s, 1988, 1994 and 2010.

FLUCC	Description	1950s		1970s		1988		1994		2010	
		Area (acres)	Percent								
1000	Urban	449.0	0.1	1,063.0	0.3	1,552.0	0.4	3,617.0	1.0	3,217.0	0.9
2000	Agriculture	979.0	0.3	0.0	0.0	6,260.0	1.7	1,068.0	0.3	2,534.0	0.7
3000	Upland Non-Forested	0.0	0.0	0.0	0.0	8,923.0	2.5	694.0	0.2	3,947.0	1.1
4000	Upland Forested	73,362.0	20.7	0.0	0.0	721.0	0.2	3,714.0	1.0	3,843.0	1.1
4400	Tree Plantations	1,676.0	0.5	181,103.0	51.1	182,265.0	50.7	175,261.0	48.7	15,5493.0	43.2
5000	Water	395.0	0.1	407.0	0.1	580.0	0.2	1,981.0	0.6	709.0	0.2
6000	Wetlands	277,830.0	78.3	172,099.0	48.5	158,638.0	44.1	173,365.0	48.2	189,923.0	52.8
7000	Barren Land	0.0	0.0	0.0	0.0	776.0	0.2	15.0	0.0	51.0	0.0
Total		354,690.0	100.0	354,672.0	100.0	359,715.0	100.0	359,715.0	100.0	359,715.0	100.0

Land Use Comparison for the Steinhatchee Basin

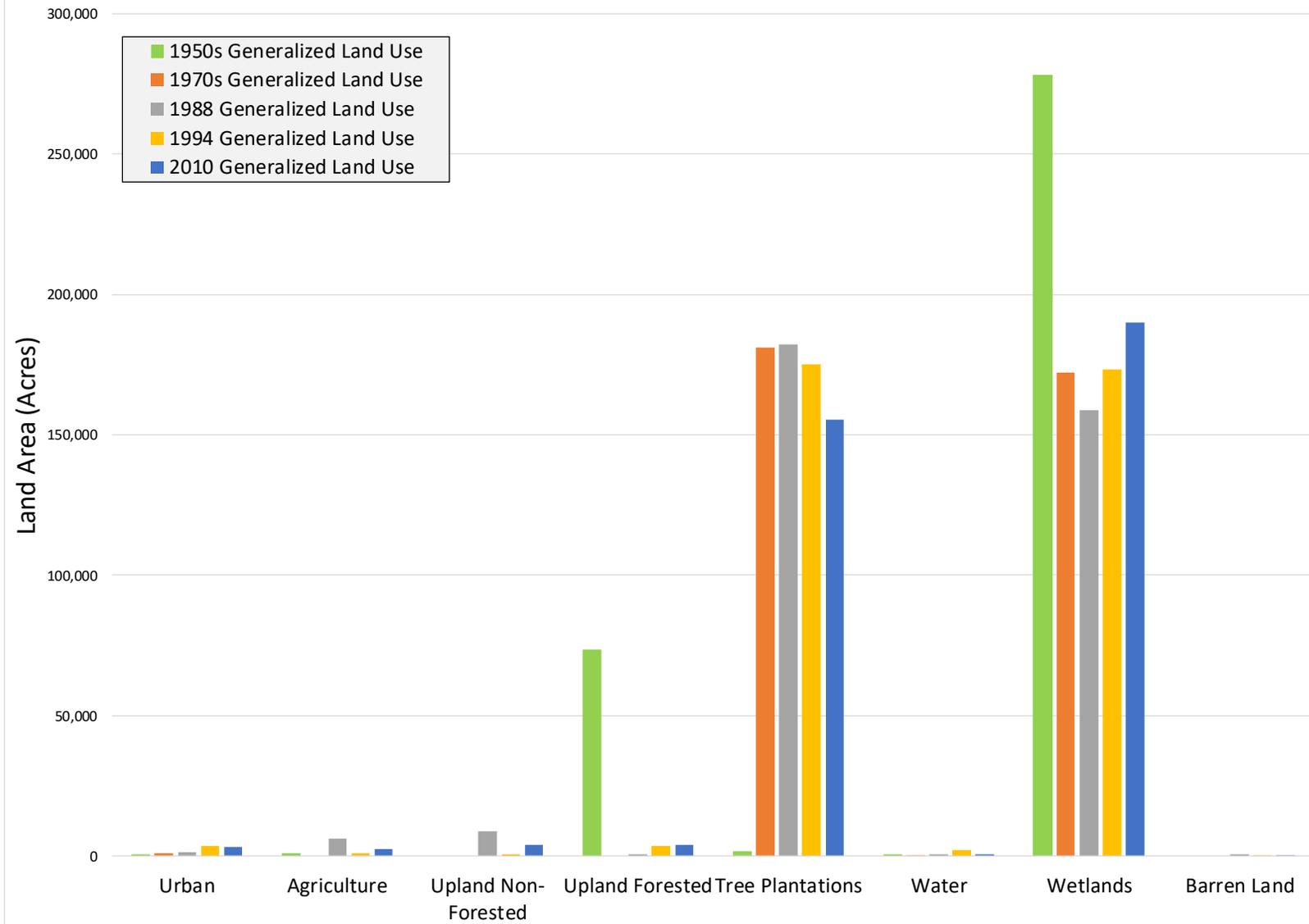


Figure 2-20. Land use comparison within the Steinhatchee River Basin.

The forested land cover, although heavily modified through silviculture, has little impact on the overall basin hydrologic response, other than the possibility of increasing peak flows. The increase in peak flows are not a result of increased planting density but are a result of silviculture management practices of ditching and draining to facilitate seedling planting and timber harvesting (KBN Engineering et al. 1990), and the planted areas are certainly denser than natural forested areas. The increased forest density would tend to increase ET losses. The significance of increased ET loss is generally small compared to the overall water balance between natural forested areas and the planted forested area (KBN Engineering et al. 1990).

2.2.2 STATE-OWNED AND CONSERVATION LANDS

State-owned and conservation land comprises a significant acreage in the Steinhatchee River Basin. These areas are presented in Figure 2-21. In addition to the lands adjacent to the Steinhatchee River, the Upper Steinhatchee Conservation Area and the Mallory Swamp Restoration Area were acquired with the goal of restoring these pine plantation areas to their natural state prior to conversion. Numerous structures have been installed in old ditches, with the goal of restoring hydrologic patterns in these areas. The effectiveness of these practices has not been quantified to date.

2.2.3 SOILS

An analysis of soils data obtained from National Resource Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA) was conducted. The data were downloaded and processed for further analysis within a GIS environment focusing on its hydrologic characteristics, or hydrologic soil group (HSG) (Figure 2-22). NRCS defines the HSGs as follows:

- Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.
- Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

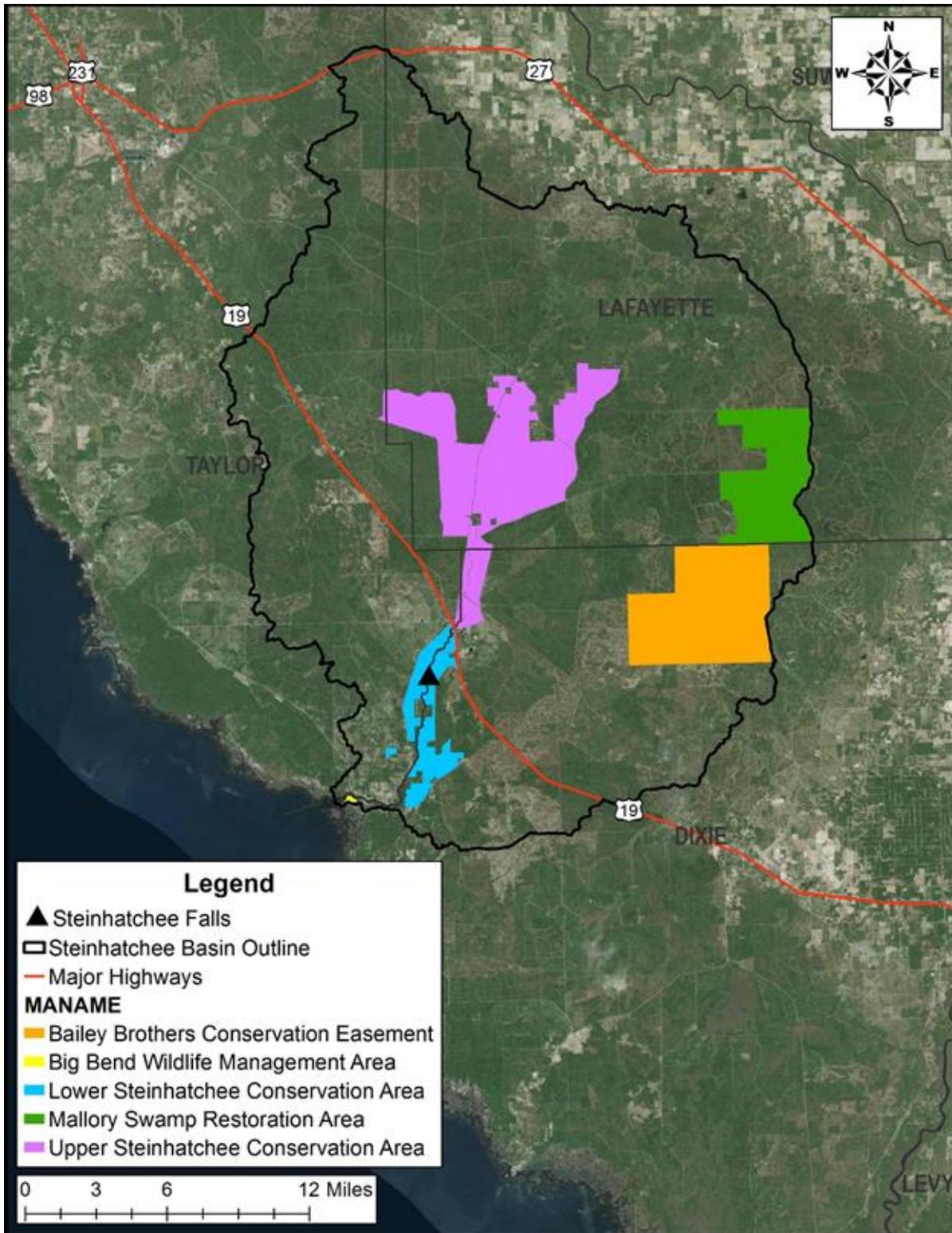


Figure 2-21. State-owned and conservation lands within the Steinhatzee River Basin.
 (Source: SRWMD)

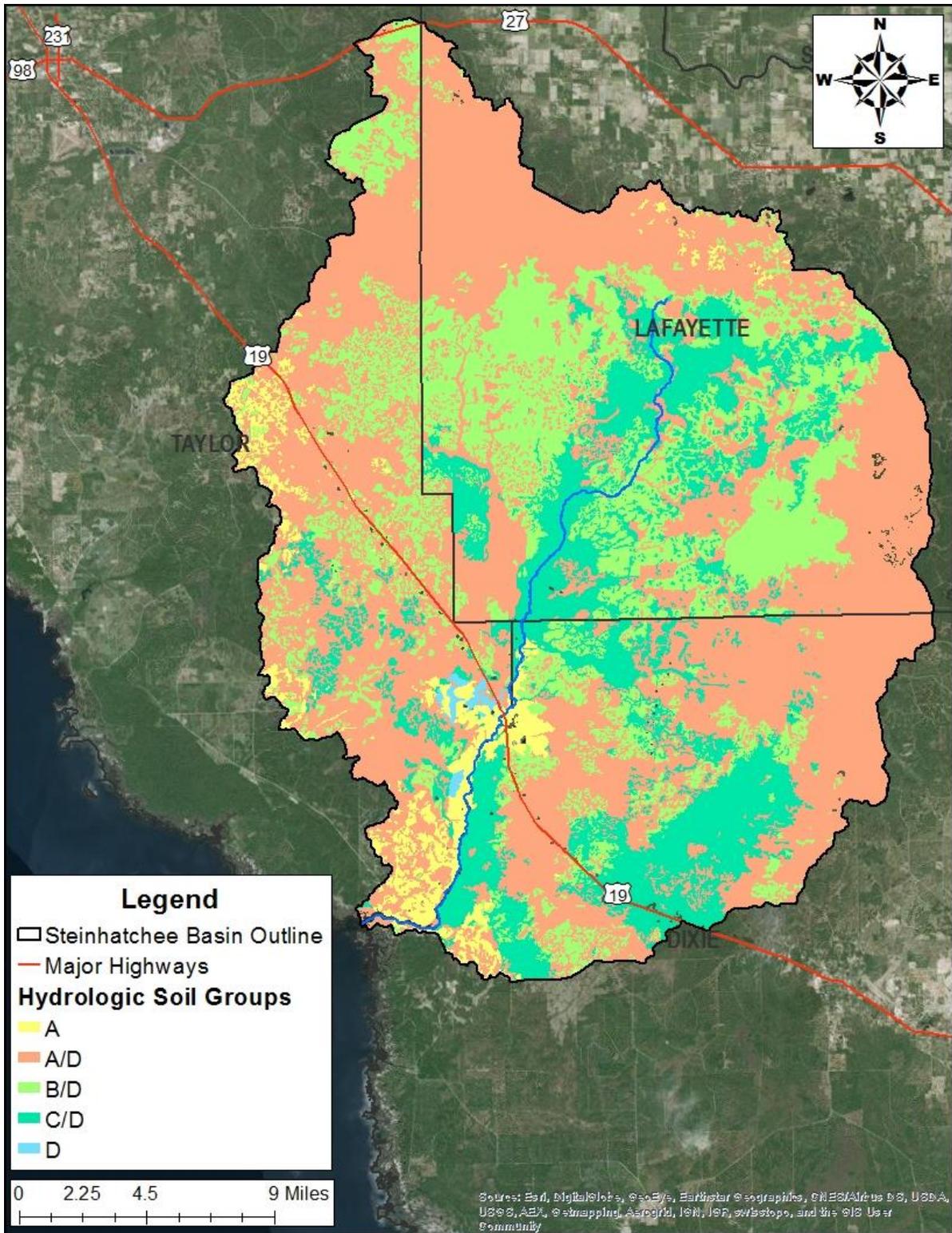


Figure 2-22. Hydrologic soils in the Steinhatchee River watershed. (Source: NRCS)

- Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
- Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Certain wet soils are placed in Group D based solely on the presence of a water table within 60 centimeters [24 inches] of the surface, even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition. For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 60 centimeters [24 inches] below the surface in a soil where it would be higher in a natural state.

Soils of the A/D type make up the largest percentage within the watershed. Much of the headwater area is made up of A/D soils (Table 2-3). These soils exhibit a mix of high infiltration rates and very low infiltration rates. These were followed by B/D soils, exhibiting a mix between soils of moderate infiltration with low runoff potential, and low infiltration with high runoff potential throughout the middle one-third of the watershed. The lower one-third is made up of primarily C/D soils, with low to very low infiltration and high runoff potential.

Table 2-3. Soils within the Steinhatchee River Basin.

Hydrologic Group	Acres	Percent
A	14,660	4.1%
A/D	192,329	53.7%
B/D	84,831	23.7%
C/D	65,623	18.3%
D	1,020	0.3%

2.3 HYDROLOGY OF THE STEINHATCHEE RIVER

2.3.1 HISTORICAL RAINFALL CONDITIONS

Rainfall has been monitored at gages in and near the Steinhatchee Basin, including Mayo, Steinhatchee, Cross City and Perry (Figure 2-23). The National Oceanic and Atmospheric Administration (NOAA) rainfall data from the Mayo and Steinhatchee gages were examined to determine general characteristics of point rainfall measurements near the Steinhatchee River. The annual rainfall at the Steinhatchee gage for the period of available data (1962 to 2000) has ranged from approximately 35 inches to more than 83 inches, with a mean of 57 inches. The annual rainfall measured at the Steinhatchee gage for the period of available data is shown on Figure 2-24.

The annual rainfall at the Mayo gage for the period of available data (1950 to 2008) has ranged from approximately 34 inches to more than 93 inches, with a mean of 54 inches. The annual rainfall measured at the Mayo gage for the period of available data is shown on Figure 2-25.

Long-term rainfall records from the PRISM Climate Group (Daly et al. 2008) were available for analysis. Monthly rainfall totals for the conterminous United States on a 4-kilometer (km) grid from Water Year (WY) 1951 through WY 2015 were utilized, where data were available. The term U.S. Geological Survey (USGS) "water year" in reports that address surface-water supply is defined as the 12-month period October 1, for any given year, through September 30, of the following year. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. The PRISM grid cell rainfall monthly totals are based on regional point rainfall gages similar to those mapped on Figure 2-23. The period-of-record (POR) for annual rainfall as contained in PRISM is presented in Figure 2-26. The PRISM record was not complete for WY 2015 so only partial data were available for that year.

The annual rainfall in the PRISM data for the POR (WYs 1951-2015) has ranged from approximately 39 inches to more than 83 inches, with a mean of 56 inches and a median of 57 inches. The distribution of rainfall by month is presented in Figure 2-27.

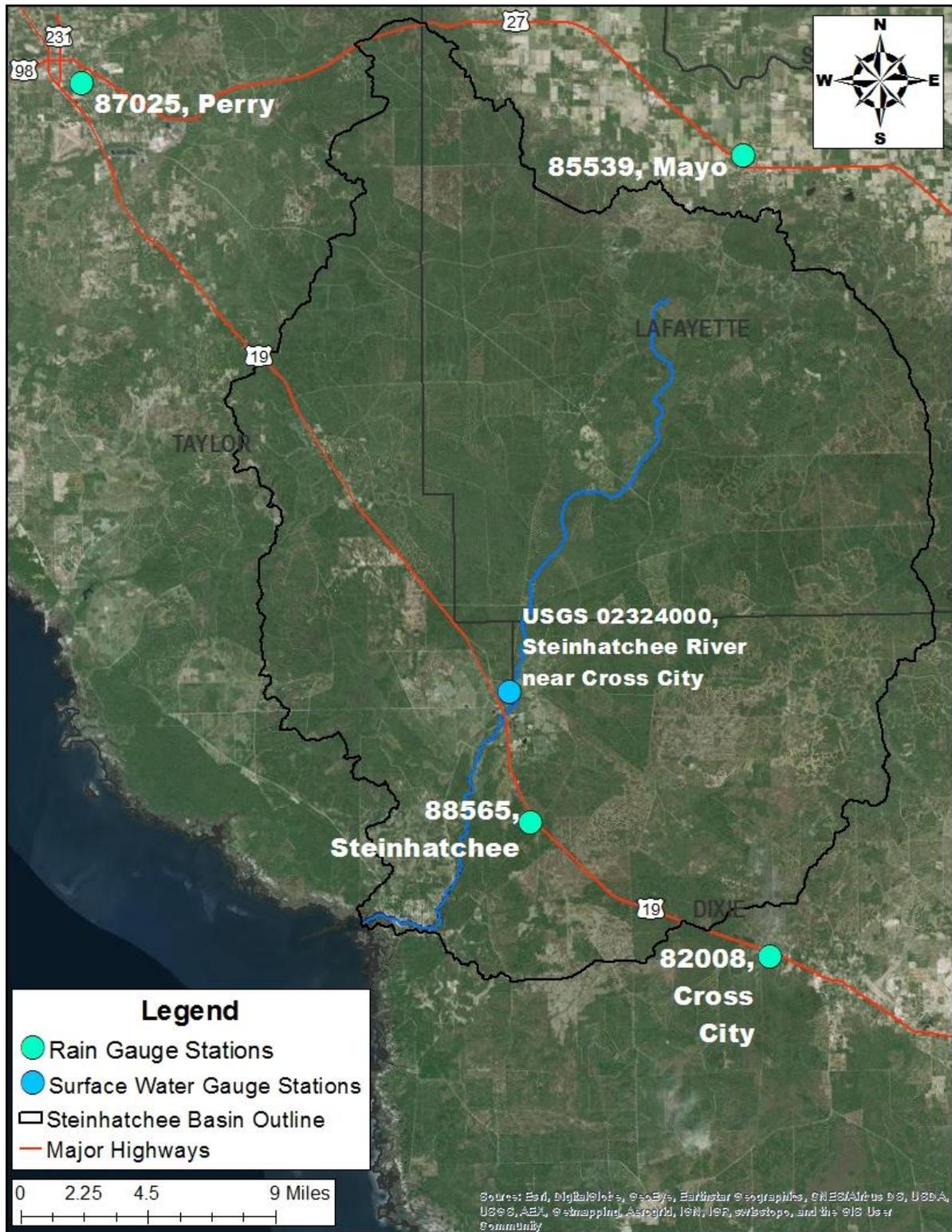


Figure 2-23. Surface water hydrology and rainfall monitoring locations.

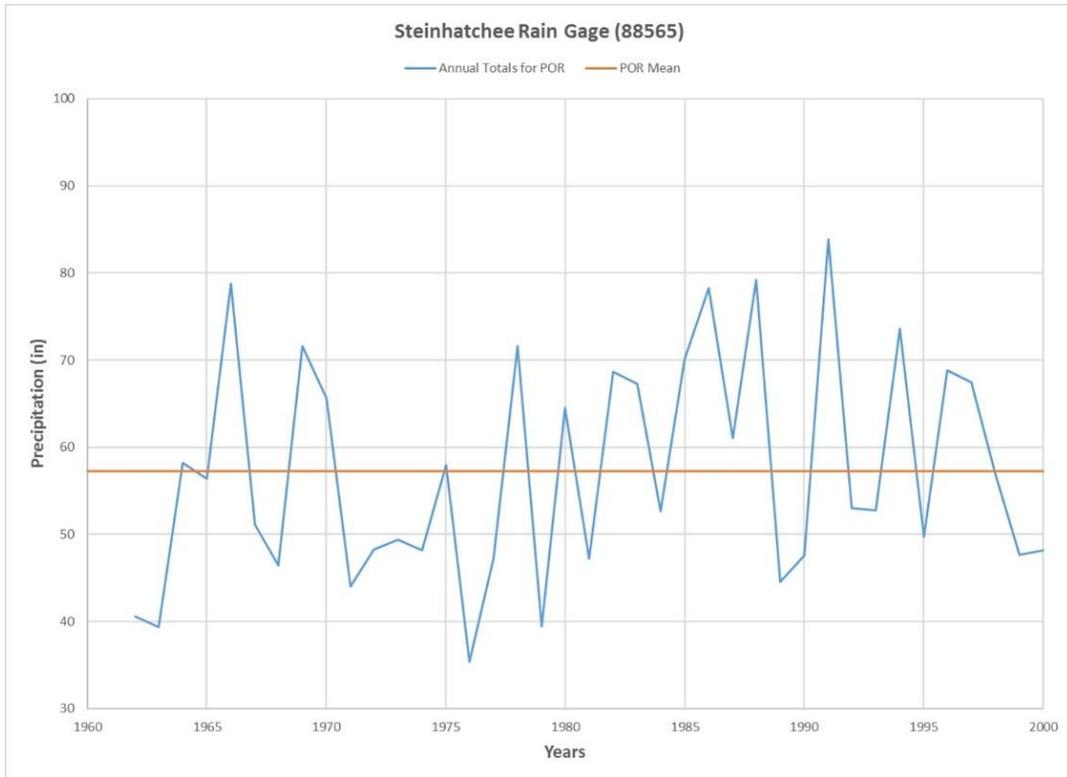


Figure 2-24. Annual precipitation for the NOAA Steinhatchee gage (88565).

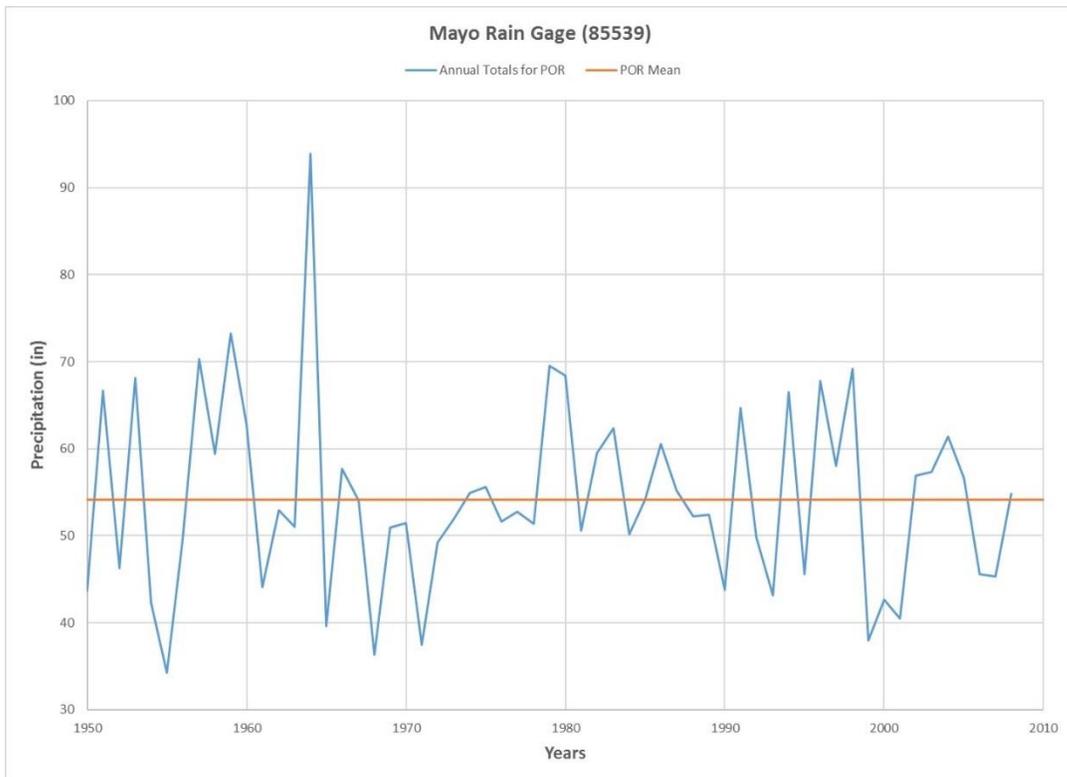


Figure 2-25. Annual precipitation for the NOAA Mayo gage (85539).

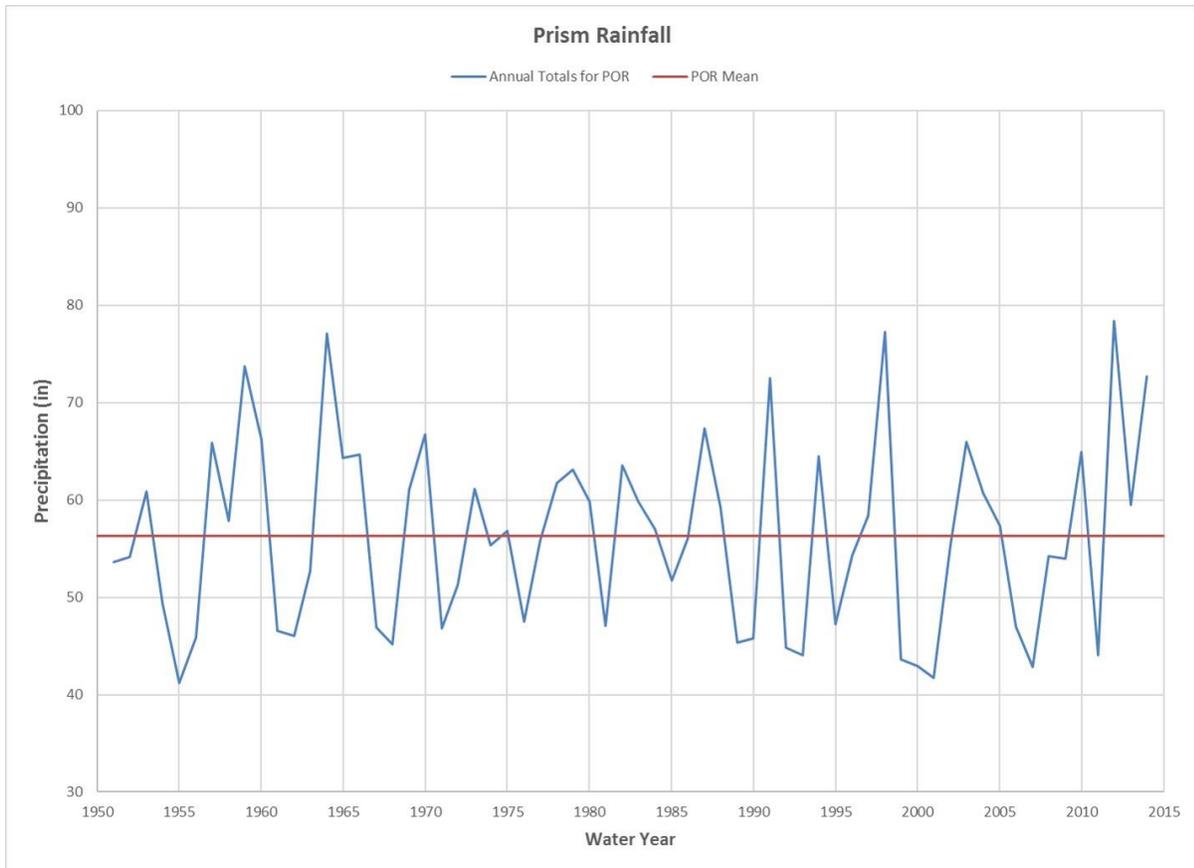


Figure 2-26. PRISM annual precipitation data for the Steinhatchee River gauge (02324000).

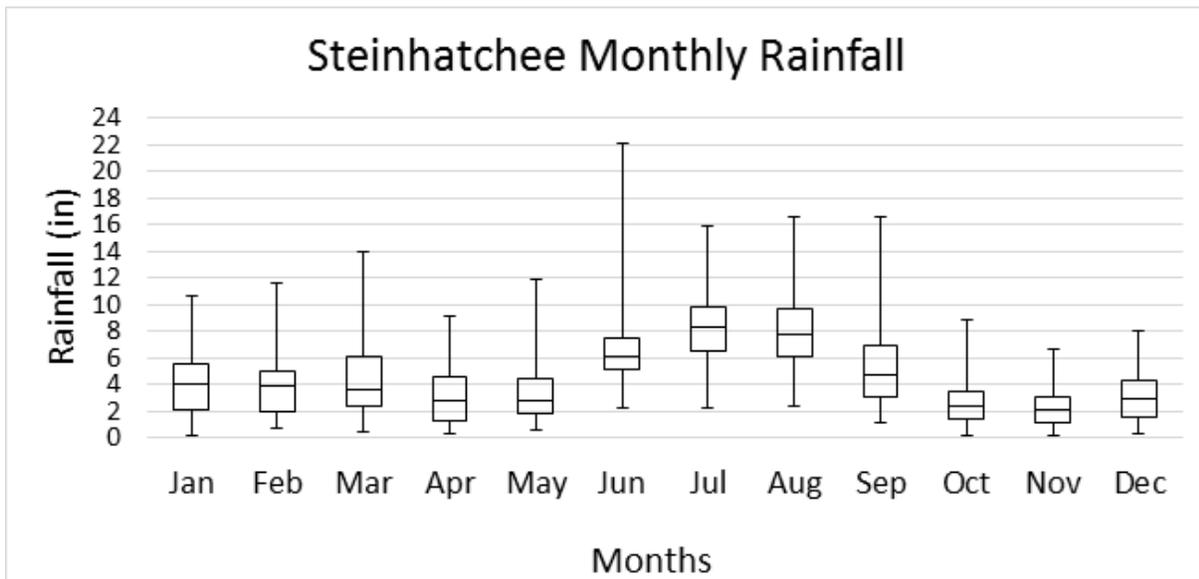


Figure 2-27. Distribution of rainfall by month for PRISM data at the Steinhatchee River gauge (02324000).

A seasonal pattern emerges, with two wet seasons, one in the summer and the second during the winter. The pronounced wet season that occurs in the summer months (June through September) is associated with localized, convective thunderstorms or periodic tropical weather systems (hurricanes, tropical storms). The less-pronounced winter wet season (January through March) precipitation events are due to mid-latitude frontal weather systems, with individual rainfall events that are usually more widespread. Because of the lower ET rates in the winter, the effect of even this less-pronounced wet season on Steinhatchee River flow is significant.

2.3.2 EXISTING SURFACE WATER DATA

The U.S. Geological Survey (USGS) operates the primary gage where Steinhatchee River flows are monitored (02324000) near Cross City (Figure 2-23). The POR used in this report is from WYs 1951-2015. Much of the Steinhatchee River flow is provided by surface runoff. Baseflow is provided through small springs and seeps in the eroded Suwannee Limestone (SRWMD 1995). Figure 2-28 presents the mean daily stages for the Steinhatchee River near Cross City for the POR. Figure 2-29 presents the mean daily flows for the Steinhatchee River near Cross City for the POR, along with its flow duration curve (FDC). The median flow for this period is 102 cubic feet per second (cfs) and the 95th percentile (P95) and the 5th percentile (P5) are 6.2 cfs and 1,240 cfs, respectively. Table 2-4 provides a more complete characterization of the flow record. There are several recent periods during which the mean daily flows were particularly low, including WYs 2000, 2001, 2008 and 2011.

2.3.3 SEASONAL FLOW PATTERNS

Heath and Conover (1981) recognized the existence of a “climatic river basin divide” in Florida that approximates a portion of the eastern Suwannee River Basin boundary. The divide is illustrated as the red line in Figure 2-30.

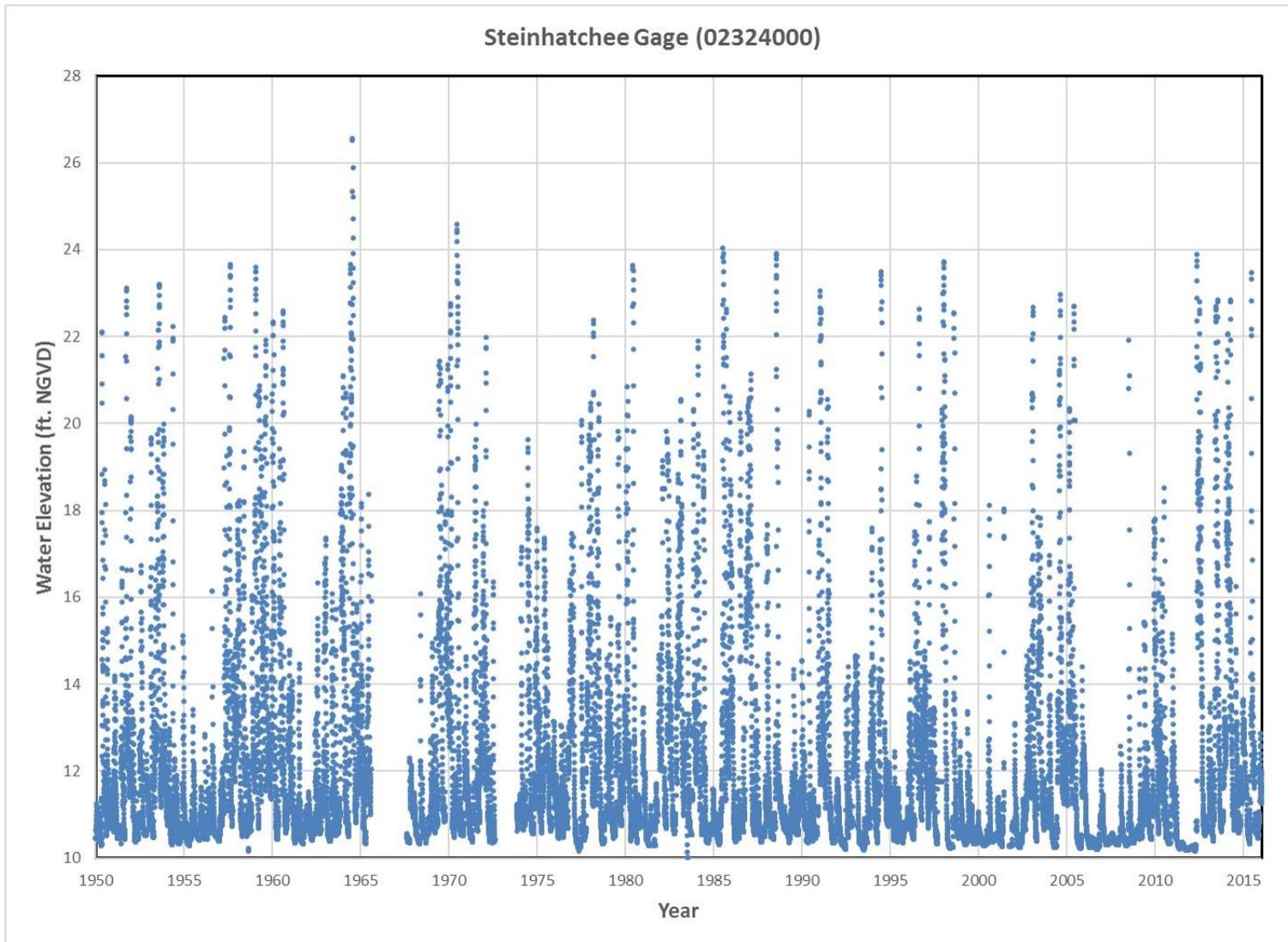


Figure 2-28. Mean daily stage hydrograph at USGS Gage 02324000 on the Steinhatchee River.

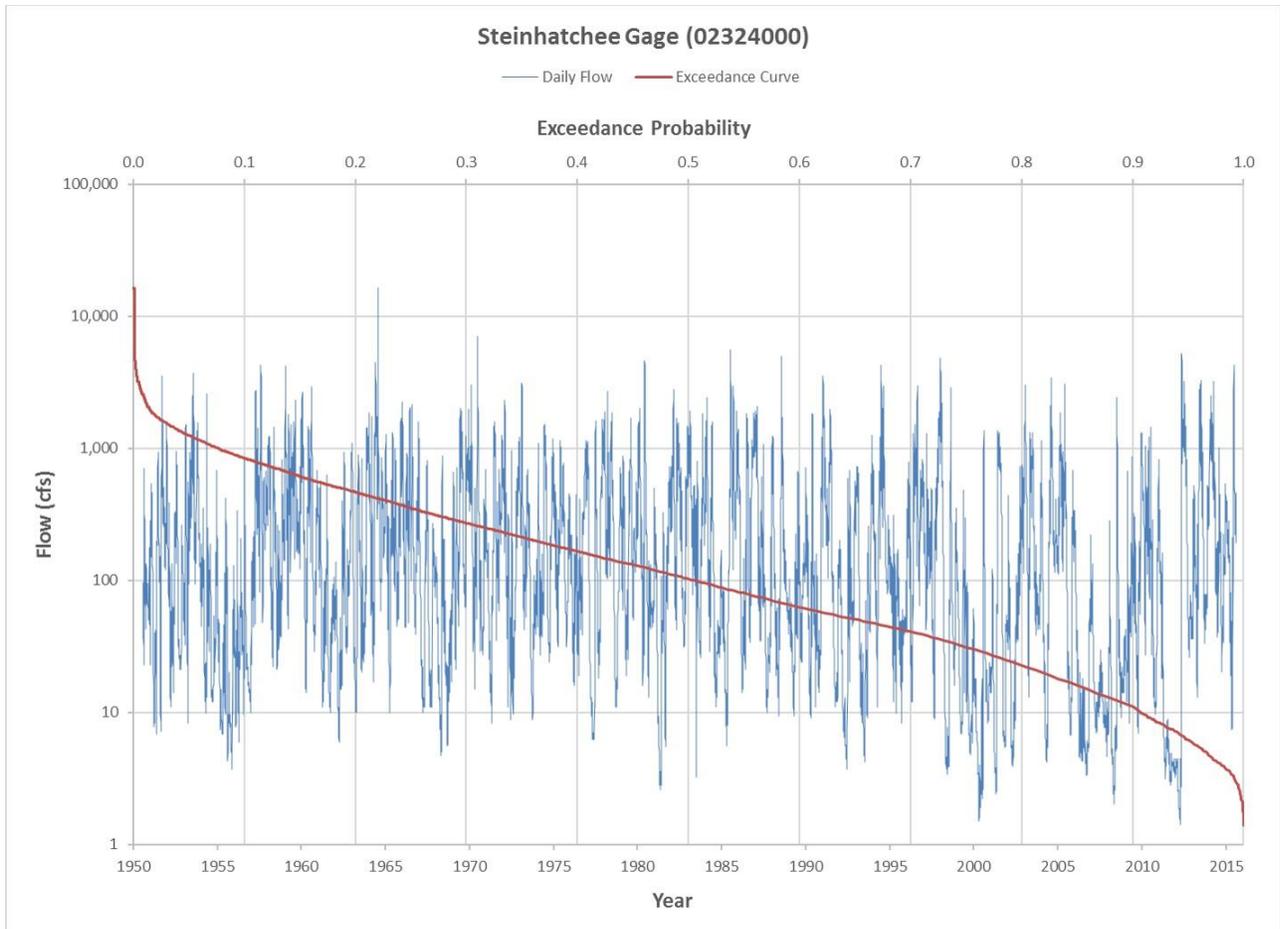


Figure 2-29. Comparison of hydrograph of the Steinhatchee River near Cross City with its flow duration curve.

Table 2-4. General percentile statistics for flow at Steinhatchee River gage.

Statistic	POR (WYs 1951-2015) (cfs)
5 th percentile	6.2
10 th percentile	11.0
25 th percentile	31.0
50 th percentile (median)	102.0
75 th percentile	350.0
90 th percentile	838.0
95 th percentile	1,240.0
Mean	300.2
Standard Deviation	526.1

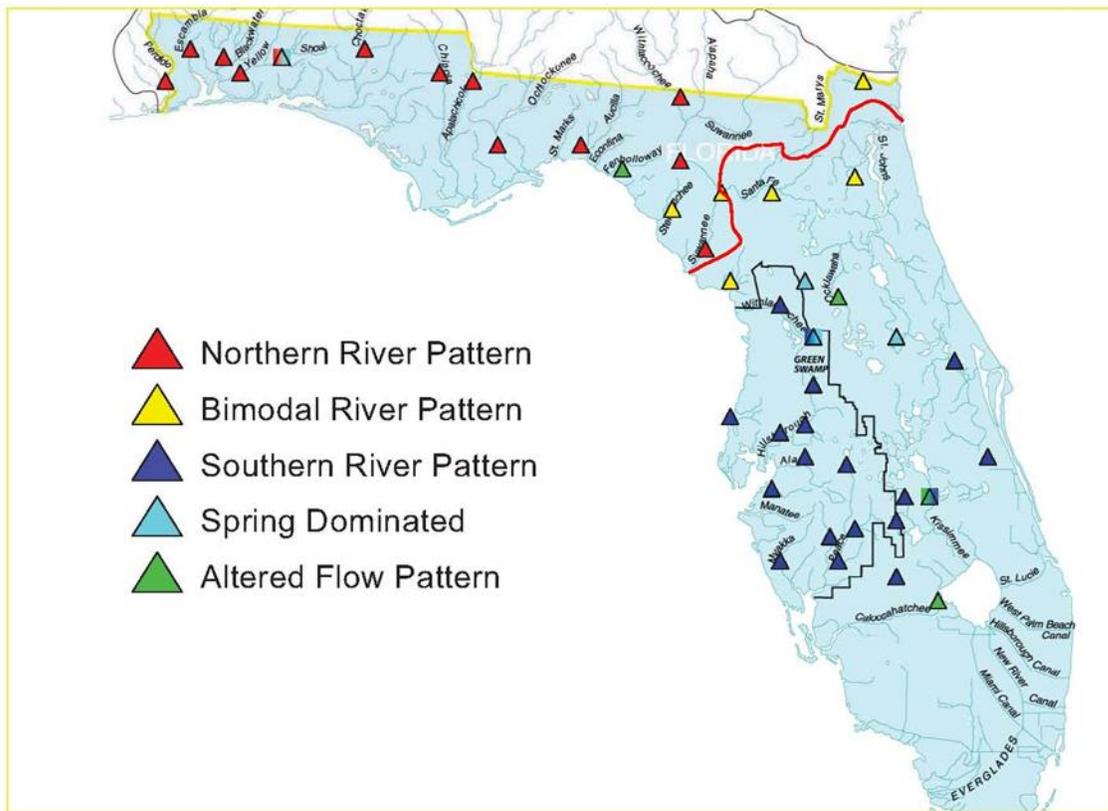


Figure 2-30. Map showing the geographic distribution of sites exhibiting various river flow patterns. From Kelly 2004.

Streams north and west of the climatic divide exhibit high flows in the late winter/early spring, with low flows in the late spring and fall. Streams south of the climatic divide exhibit high flows in the late summer/fall, with low flows in the spring. Streams lying along the climatic divide tend to exhibit a mix of both of these patterns (a “bimodal” pattern of floods in the spring and fall). More recently, Kelly (2004) reconfirmed these hydrologic patterns in streams in Florida, which he termed the “northern river” pattern (spring flooding), the “southern river” pattern (fall flooding), and the “bimodal” pattern (both spring and fall flooding). Stream gaging sites exhibiting these flow patterns are mapped in Figure 2-30.

These temporal flow patterns are driven, in part, by climatic characteristics. The Steinhatchee watershed lies in the transitional climatic area between the warm, temperate climate of the southeastern United States and the subtropical climate of the Florida peninsula. Higher, late winter/early spring rainfall and lower ET in the northern part of the state drives the spring flooding. In contrast, high summer rainfall in combination with tropical

weather events creates the southern river flooding pattern in peninsular Florida (Kelly 2004). Rivers that fall in the transitional area often reflect a bimodal pattern, with characteristics of both the warm, temperate climate of the southeastern United States and the subtropical climate of the Florida peninsula. Figure 2-31 presents the median daily flows for the Steinhatchee River near Cross City based on data from WYs 1951-2015.

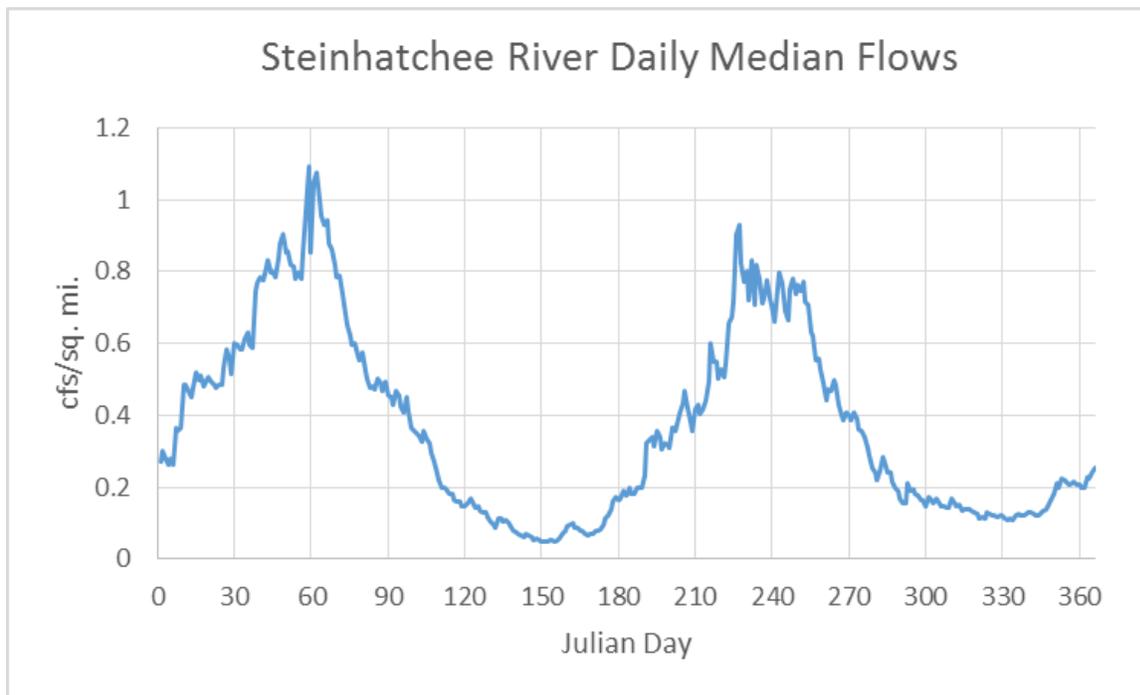


Figure 2-31. Median daily flows at USGS gage site on the Steinhatchee River using data from WYs 1951-2015.

2.3.4 WATER USE

The bulk of consumptive water is drawn from near-surface limestone of the Floridan aquifer. The top of this aquifer locally corresponds to the top of the Suwannee Limestone that is 0 to 30 feet below the surface. Numerous shallow domestic wells draw freshwater from this component. Domestic wells near the coast are typically drilled into the limestone to depths of 10 to 80 feet, although some deeper wells in excess of 100 feet reach the Ocala Limestone. Locally, the portion of the Floridan aquifer containing potable water may attain a thickness in excess of 500 feet. Figure 2-32 presents the locations of water use permits within the Steinhatchee watershed. The total water use is relatively modest, less than 4 mgd.



Figure 2-32. Water use permit locations within the Steinhatchee River watershed.
 (Source: SRWMD, Data received February 2016)

2.4 ESTUARINE HYDRODYNAMICS

Estuarine hydrodynamics are the interaction of tides, currents, and freshwater inflow in the lower portions of the Steinhatchee River and nearshore Gulf of Mexico, and their relationships to the temporal and spatial changes in water level, salinity and temperature. The estuarine hydrodynamics are a key component of the MFL because they are the drivers for how salinity behaves in the system and, ultimately, how reductions in freshwater inflow will impact salinity.

From October 2015 through April 2016, three continuous monitoring stations were installed within the estuarine portions of the Steinhatchee River and offshore. The purpose of the monitoring was to provide data that characterized the hydrodynamic conditions within the estuarine portions of the river and provide data for calibration of a hydrodynamic model. The development and calibration of the hydrodynamic model are presented in detail in Appendix B, along with a more detailed description of the monitoring effort and the data collected. Figure 2-33 shows the locations of the continuous monitoring stations. Table 2-5 presents the parameters measured at each station, where the measurements were taken in the water column, and the period over which the data were collected.

Figure 2-34 presents a plot of the daily averaged flows measured at the USGS gage (02324000) upstream of Steinhatchee Falls for the period of the data collection. The flows ranged from a daily average maximum of 397 cfs to a minimum of 25 cfs. Table 2-4 provided the range of flow percentiles for the POR of the flow. Based on the values in this table, the maximum flow during the period of the hydrodynamic data collection was above the 75th percentile flow, and the minimum was below the 25th percentile of flow. The following provides a description of the hydrodynamics (water level, currents, and salinity) within the estuarine/tidal portions of the Steinhatchee River, based on analyses of the continuous data and reconnaissance during field operations.

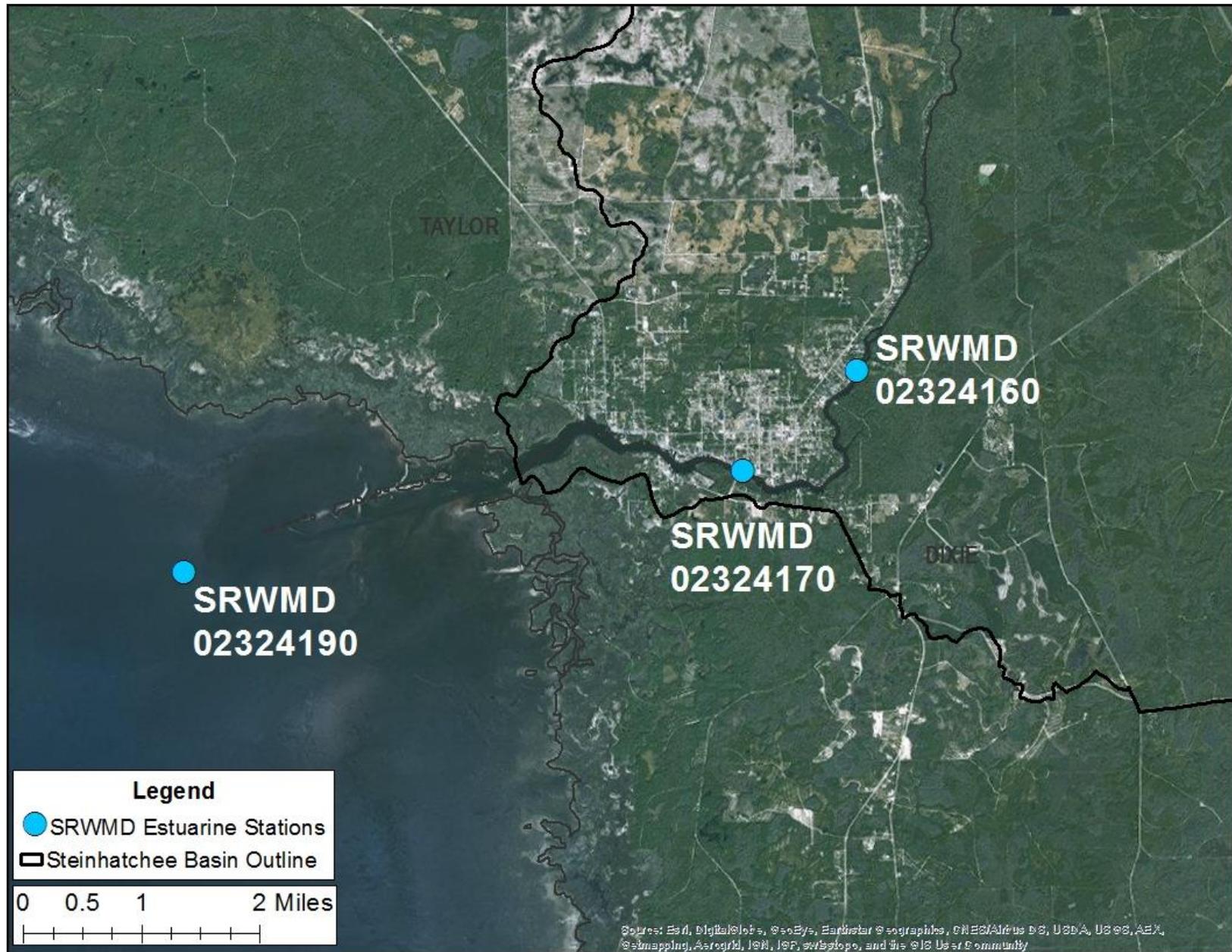


Figure 2-33. Locations of SRWMD continuous estuarine monitoring stations.

Table 2-5. Continuous monitoring station specifications.

Station Identifier	Parameter(s)	Location in Water Column	Period-of-Record
SRWMD 02324190	Water Level, Salinity, and Temperature	Bottom	September 25, 2015 through April 30, 2016
SRWMD 02324170	Salinity and Temperature	Bottom	January 12, 2016 through April 30, 2016
	Salinity, Temperature, and Water Level	Middle	September 30, 2015 through April 30, 2016
	Salinity and Temperature	Surface	September 30, 2015 through April 30, 2016
	Horizontal Velocity Profile	Middle and Surface	September 30, 2015 through April 30, 2016
SRWMD 02324160	Water Level, Salinity and Temperature	Bottom	September 25, 2015 through April 30, 2016

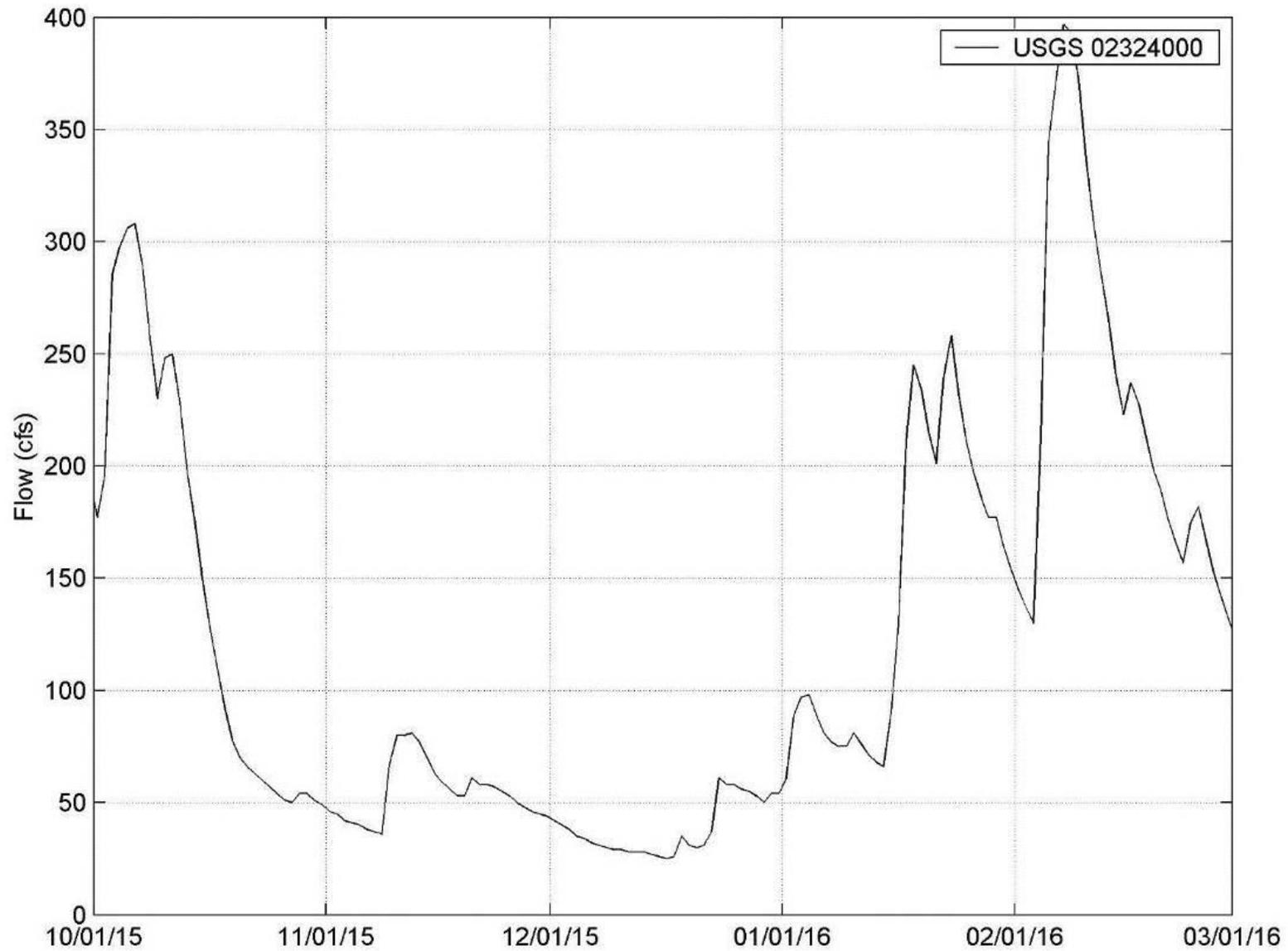


Figure 2-34. Daily average flows measured at USGS Gage 02324000 for the period of data collection.

2.4.1 WATER LEVELS

Figure 2-35 presents a series of plots showing the measured water levels at the offshore station (SRWMD 02324190), the middle station (SRWMD 02324170), and at the upstream station (SRWMD 02324160). The plots show the measured data over the full period of the data collection. Figure 2-36 presents plots of the same stations over a 1-month period. Looking at the plots in Figure 2-36, the data show the characteristic mixed tide conditions found within the Gulf of Mexico, varying from semi-diurnal to diurnal. Looking at the full period of the data, the tide ranges vary in the typical spring-neap cycle, with daily tide range values greater than 5.0 feet under spring conditions and less than 2.0 feet under neap conditions.

Comparison of the offshore tides with those measured at the middle and upstream stations shows nearly identical tide ranges as well as high and low water elevations. There is little to no damping of the tidal wave moving up past the upstream station. Additionally, the data do not show a rise in the low or high-water level elevations at the upstream station (in relation to the offshore) even under relatively high flow conditions, i.e., greater than the 75th percentile.

The water level elevations range from highs above 3.0 feet referenced to the North American Vertical Datum of 1988 (NAVD88) and lows below -2.0 feet NAVD88. Examination of available cross-section data upstream of SRWMD 02324160 identified that the thalweg elevations do not exceed -4.0 feet NAVD88 upstream to Steinhatchee Falls. Based upon this, the lack of tidal damping seen in the upstream station, along with the general characteristics of the river in the upstream area, it is anticipated that, at times, the tidal influence will reach up to Steinhatchee Falls. Upstream of SRWMD 02324160, above the area where the river begins to braid out and below Steinhatchee Falls, there are three identified shoals. Figure 2-5 presented a photograph of one of these shoals. These shoals go from being inundated under high tide conditions to acting somewhat like a fall or sill during low tide conditions. These features are key aspects of the tidal propagation between RM 6 and RM 10 (Steinhatchee Falls) as they retain water in upstream pools when the tides recede below the shoals' downstream thalweg elevation. Appendix B presents more detailed discussion on the tidal conditions in this area.

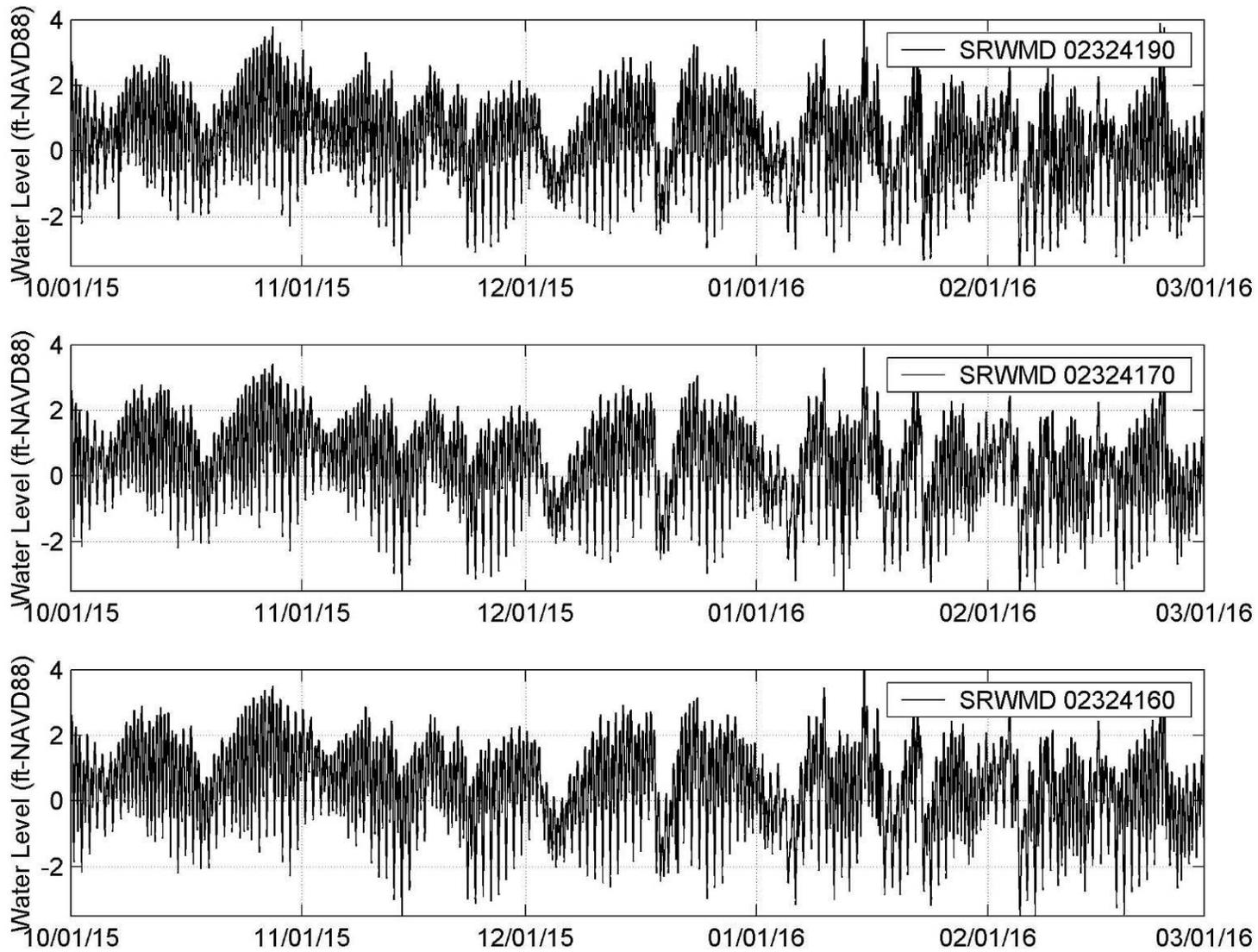


Figure 2-35. Measured water levels at SRWMD Stations 02324190, 02324170, and 02324160 for period of data collection.

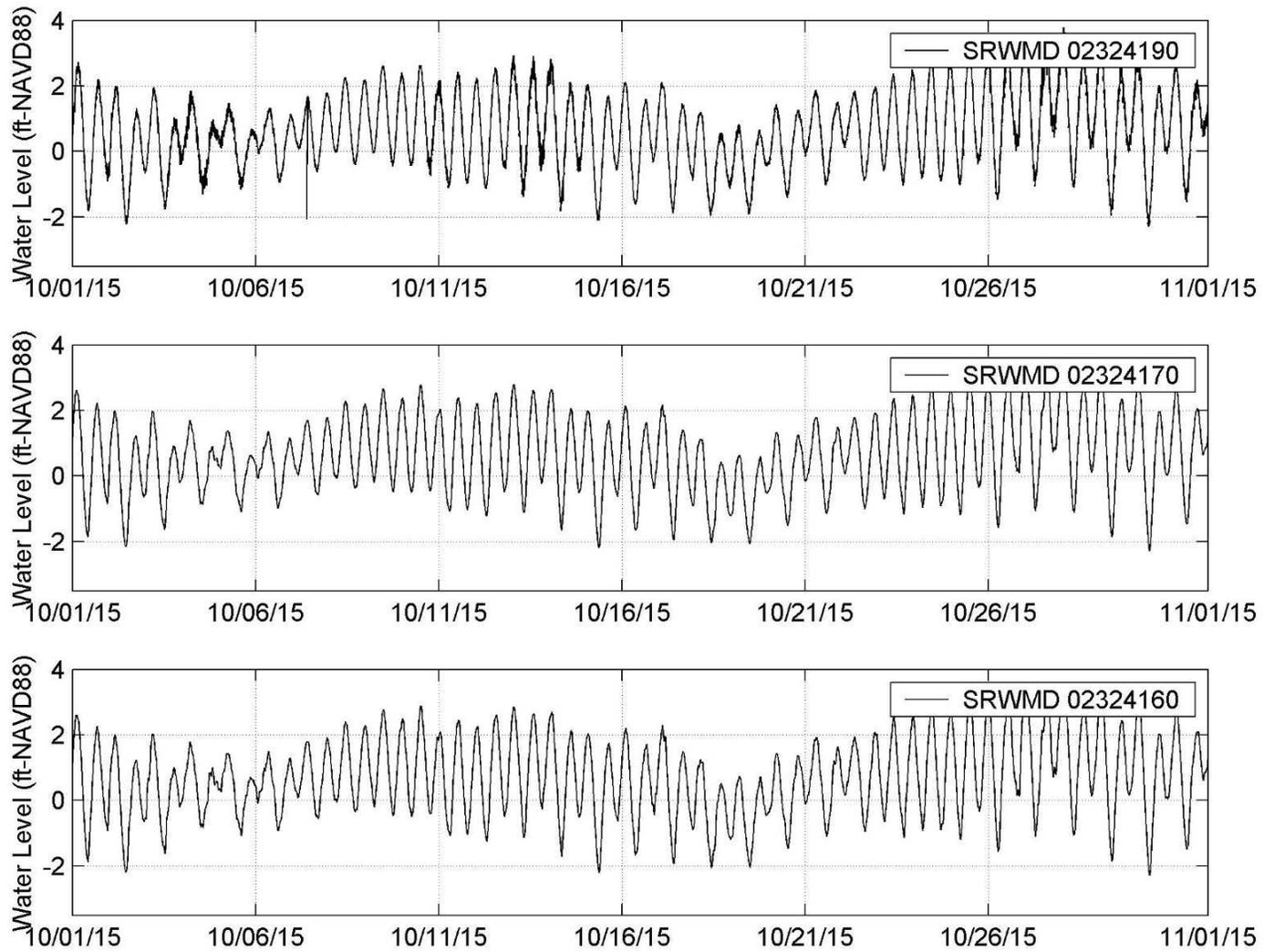


Figure 2-36. Measured water levels at SRWMD Stations 02324190, 02324170, and 02324160 for October 2015.

2.4.2 SALINITY

Figure 2-37 presents a series of plots showing the measured salinity at the offshore station (SRWMD 02324190), the middle station (SRWMD 02324170), and at the upstream station (SRWMD 02324160). The plots show the measured data over the full period of the collection. For the upstream (02324160) and downstream (02324190) data, the salinities were measured at the bottom. For the middle station (02324170), measurements were available on the bottom from January through April and the middle and near surface for the full data collection period. The data presented in Figure 2-37 for SRWMD 02324170 are data collected near the middle and bottom portions of the water column.

The offshore salinities ranged from a low of 23 parts per thousand (ppt) to a high of 34 ppt, with the lows corresponding to the period of highest flows at the beginning of February 2016 and the highs during the lowest flow period around mid-December of 2015. The data for the middle station (02324170) include the bottom data from mid-January 2016 and the data from the middle of the water column for the full period; both data sets show large fluctuations in the salinity levels with values ranging from 0 up to 29 ppt. In contrast, the upstream (02324160) bottom measurements generally show lower levels of daily fluctuation, with salinities over the period of the data collection ranging from 0 up to 27 ppt.

An important aspect of the salinity dynamics in the Steinhatchee estuary is the level of salinity intrusion driven by stratification of the water column, i.e., lower density freshwater laying over higher density salt water. This intrusion or “salt wedge” is moved longitudinally by the tidal currents and is also influenced by vertical stratification. Figures 2-38 and 2-39 illustrate these effects. Figure 2-38 presents a plot of the bottom salinity at the upstream station (02324160) with a plot of the daily tide range (calculated from the tidal measurements) indicating a relatively clear cyclic rise and fall, and the rise corresponds to the period of the lowest tide range. Additionally, the measured freshwater inflows at the USGS gage are plotted on the upper graph.

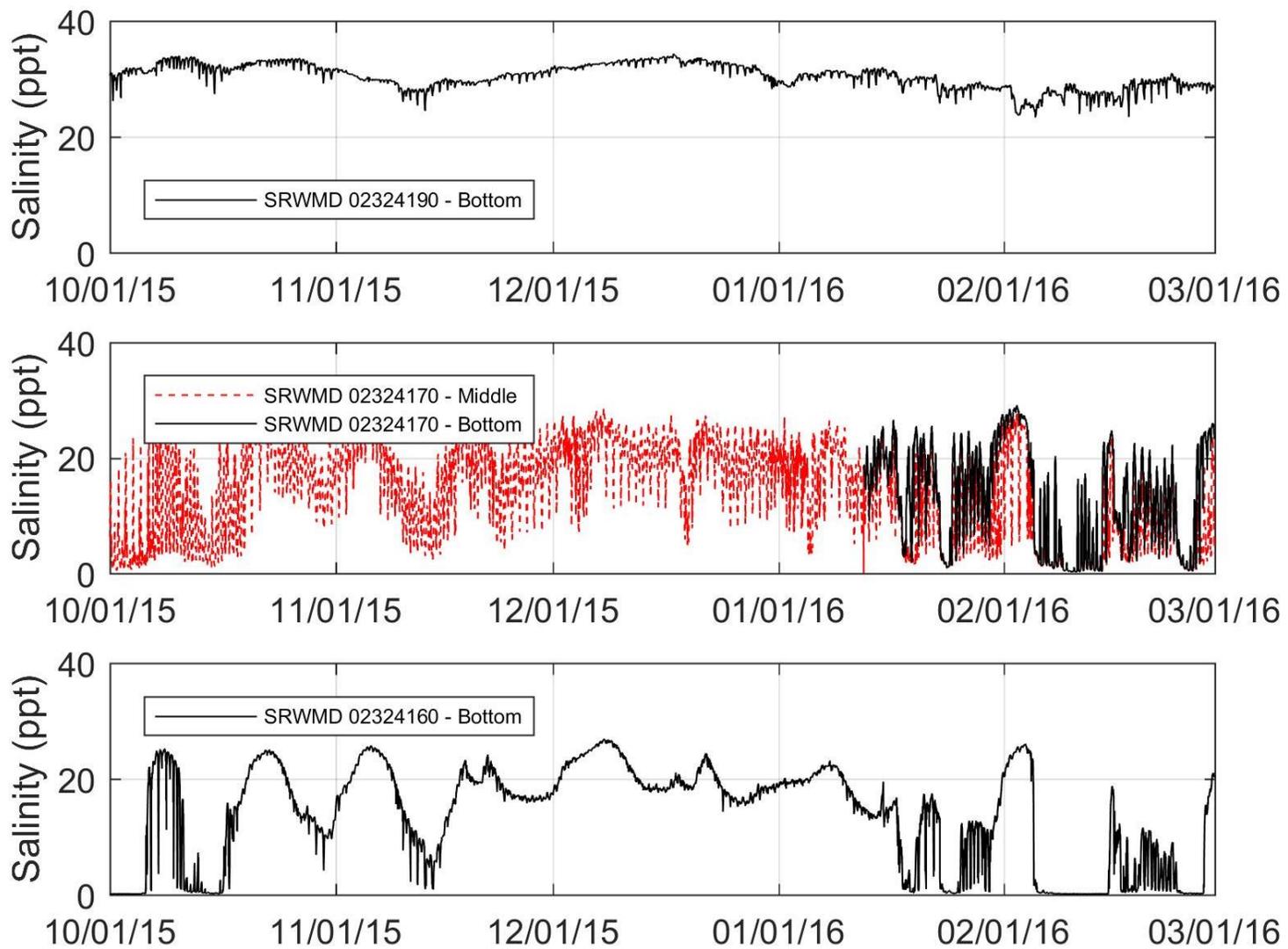


Figure 2-37. Measured salinity at SRWMD Stations 02324190, 02324170, and 02324160 for period of data collection.

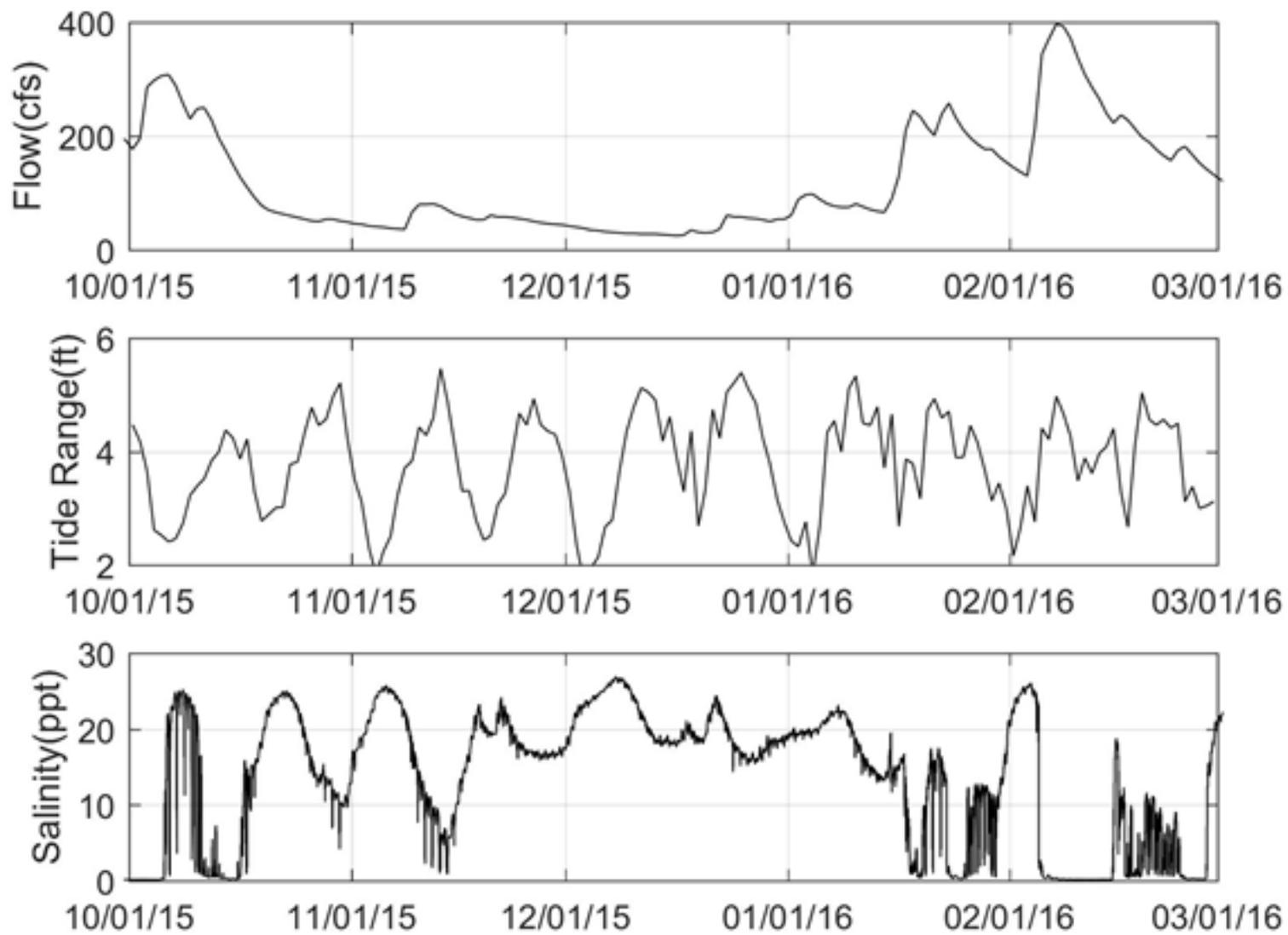


Figure 2-38. Measured salinity at upstream station versus tide range and flow for period of data collection.

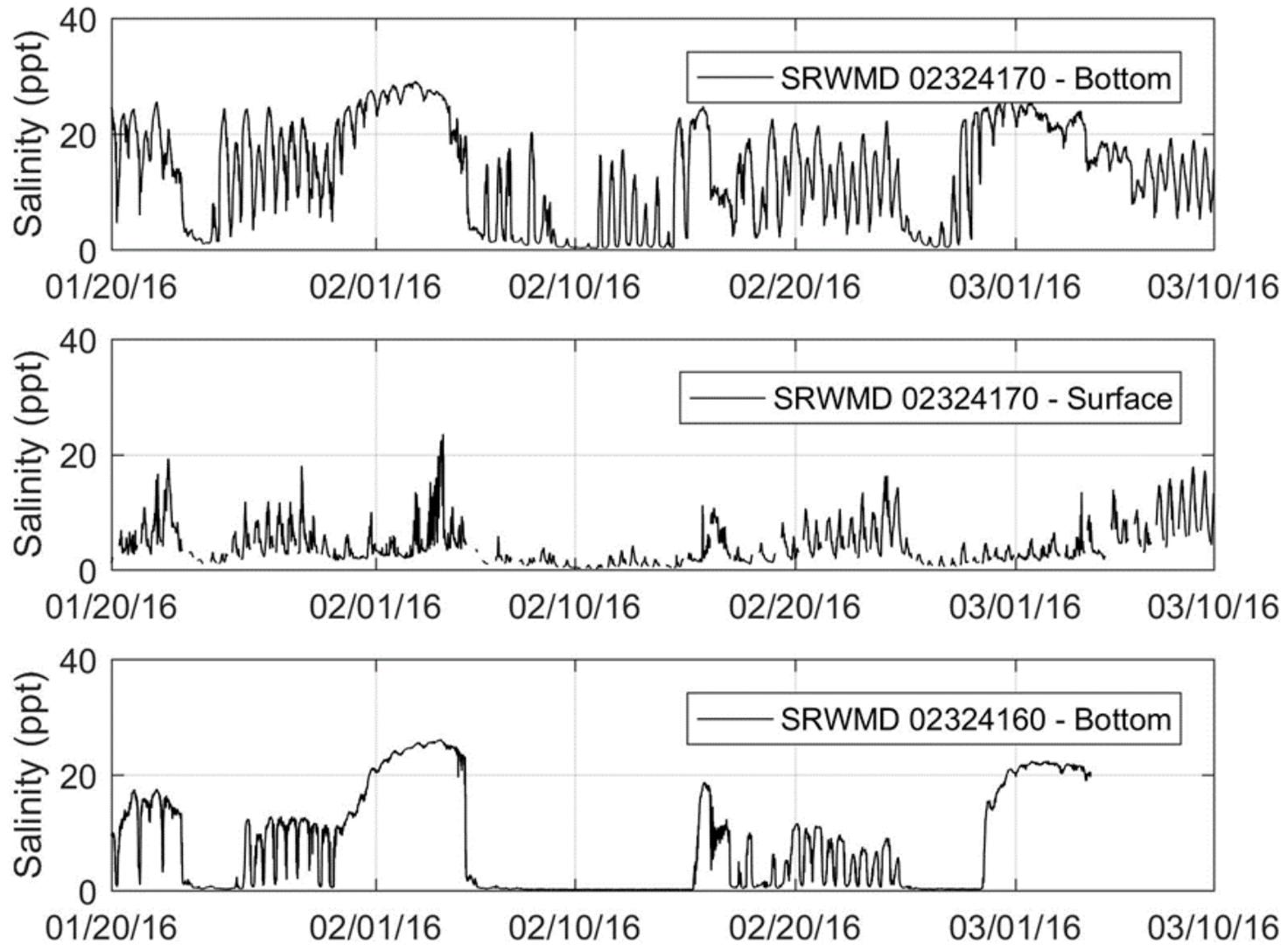


Figure 2-39. Measured surface and bottom salinity at SRWMD Station 02324170 versus measured bottom salinity at Station 02324160.

During neap tide conditions, currents are reduced along with the available energy for mixing the water column; the system stratifies to a greater degree, and the salt wedge intrudes further. The data plotted in Figure 2-39 illustrate the surface and bottom salinity at the mid-station (02324170), along with the bottom salinity at the upper station (02324160). When the difference between the bottom and surface salinity is greatest for the longest period, the upstream station (02324160) salinity levels rise as the salt wedge moves further up the system. It is interesting to note that the maximum bottom salinity measured at the upstream station is somewhat independent of the flow conditions. During the period when flows were between 200 and 300 cfs the maximum bottom salinity was near 25 ppt. The maximum bottom salinity during the low flow period near the beginning of December (when flows were down around 10 cfs) is around 27 ppt. Under the higher flow conditions, during the spring tide conditions, the salinities drop back down near zero, which does not happen during the low flow period, but the maximums (during the neap tide conditions) are similar under both high and low flows.

3.0 ECOLOGICAL CHARACTERISTICS OF THE STEINHATCHEE RIVER AND WATERSHED

This chapter presents a summarized description of the Steinhatchee River and watershed. Specific elements of this description include:

- Water quality
- Habitats – in-river and watershed
- Biota – freshwater and estuarine.

The focus is on those characteristics that are particularly relevant to the potential WRVs used in the development of the MFLs for the Steinhatchee River (refer to Chapter 4).

3.1 WATER QUALITY

3.1.1 STATUS AND TRENDS

Water quality within the Steinhatchee River has been monitored by FDEP at one station (21FLGW 6978) and by SRWMD at three stations: STN031C1, STN040C1, and STN060C1 (Figure 3-1). From upstream to downstream, the station order is 21FLGW 6978 (most upstream, above Steinhatchee Falls), STN031C1, STN040C1, and STN060C1 (most downstream, in the Steinhatchee River Sound). Data for the SRWMD stations were provided by official request to SRWMD and were available roughly quarterly. Data for the FDEP station (available on a nearly monthly basis) were obtained from the FDEP Impaired Water Rule Dataset Run 50. FDEP data were also available from a nutrient longitudinal study completed in 2008-2009 to evaluate downstream biological responses to naturally high upstream phosphorus levels (EPA 2010). While these data are comprised from just two sampling dates (August 2008, January 2009), data were collected from five estuarine and three upstream freshwater sites (Figure 3-2), providing a qualitative representation of spatial variability of water quality parameters in the Steinhatchee River and estuary. The following describes the spatial and temporal variation in a number of water quality constituents that have been monitored.

Steinhatchee River Watershed - Water Quality Monitoring

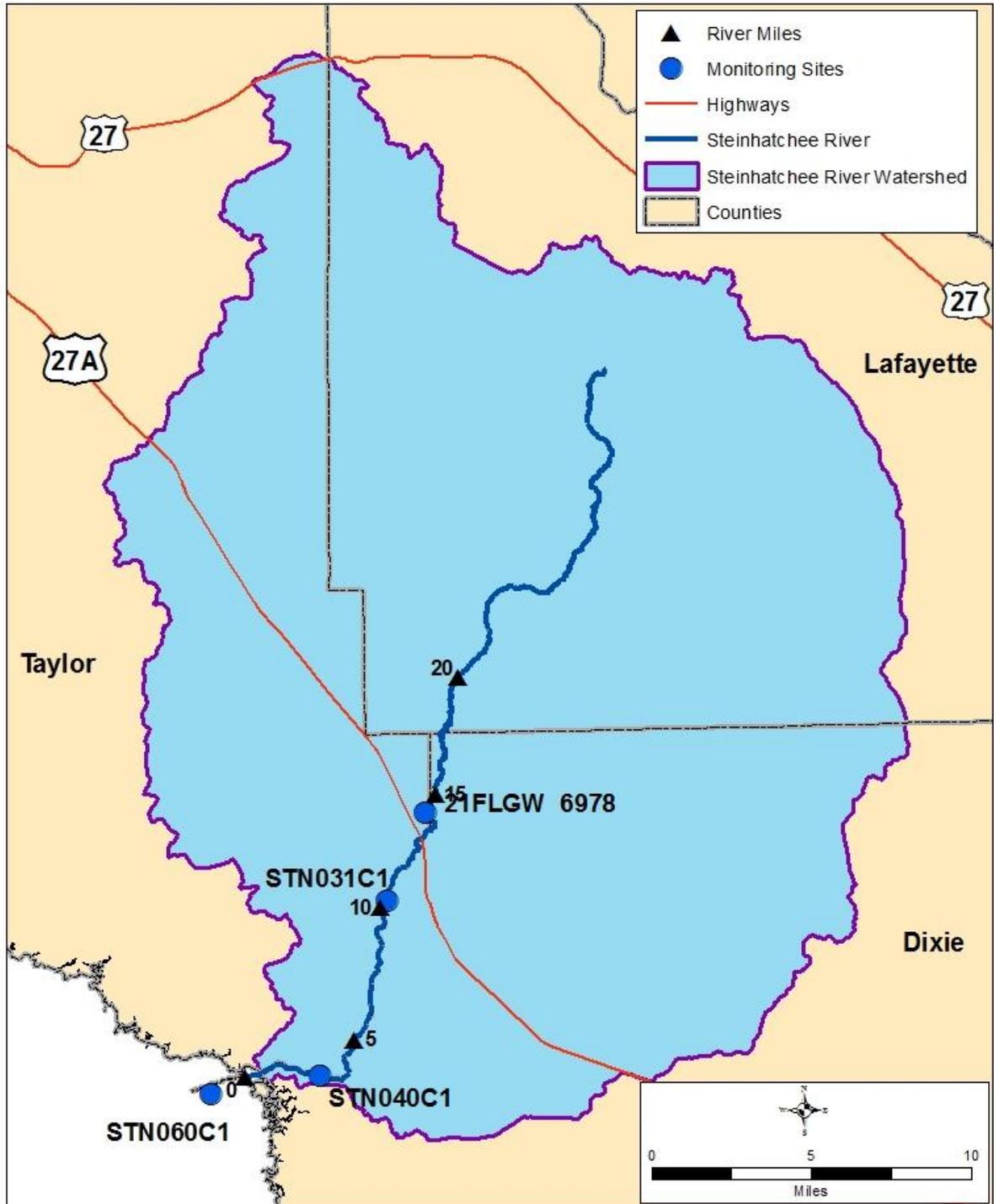


Figure 3-1. Long-term water quality sampling stations on the Steinhatchee River.

Steinhatchee River Watershed - FDEP Longitudinal Study Sites

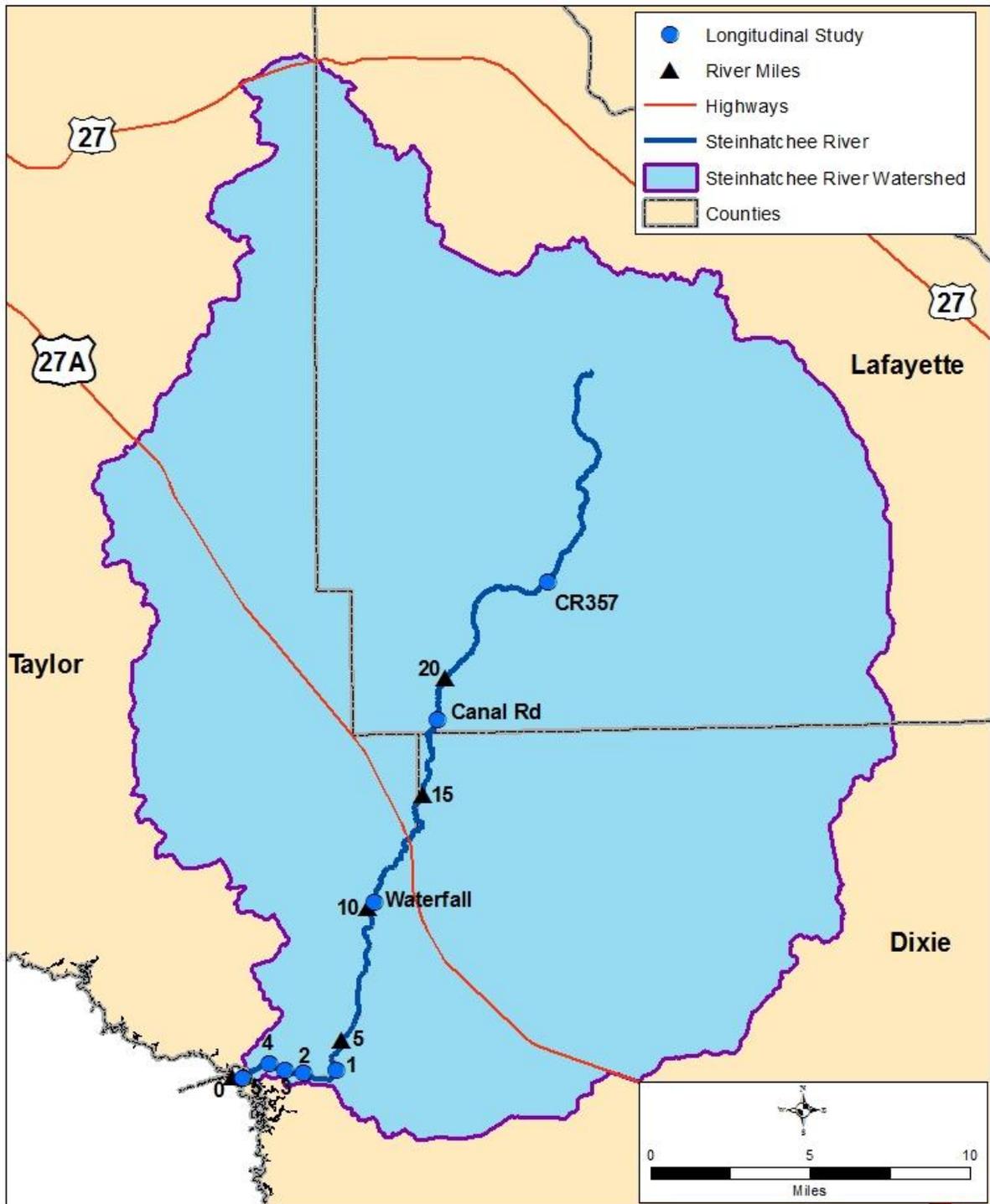


Figure 3-2. FDEP longitudinal study stations on the Steinhatchee River.

- Water Temperature – Figure 3-3 presents the water temperature data for the three SRWMD and one FDEP monitoring stations on the Steinhatchee River. The following provides the POR used for each station:

21FLGW 6978: October 1999 through August 2014
 STN031C1: February 1991 through November 2015
 STN040C1: February 1990 through August 2010
 STN060C1: November 2001 through November 2015

Median water temperatures ranged from 20.45°C at the upstream SRWMD station (STN031C1) to 22.3°C at the intermediate SRWMD station (STN040C1) (the more upstream FDEP station had a median temperature of 20.95°C). This longitudinal gradient, and the narrower range in extreme temperatures, may be the result of the proximity downstream of Steinhatchee Rise and an intervening 2nd magnitude spring, TAY76992. The most downstream SRWMD station (STN060C1) had a median temperature of 21.45°C. A similar pattern of increase from STN031C1 to STN040C1 and then decrease to STN060C1 was found for the lower (10th percentile) temperatures, as well as the maximum and minimum observed temperature. No apparent temporal trend was noted in the observed water temperatures.

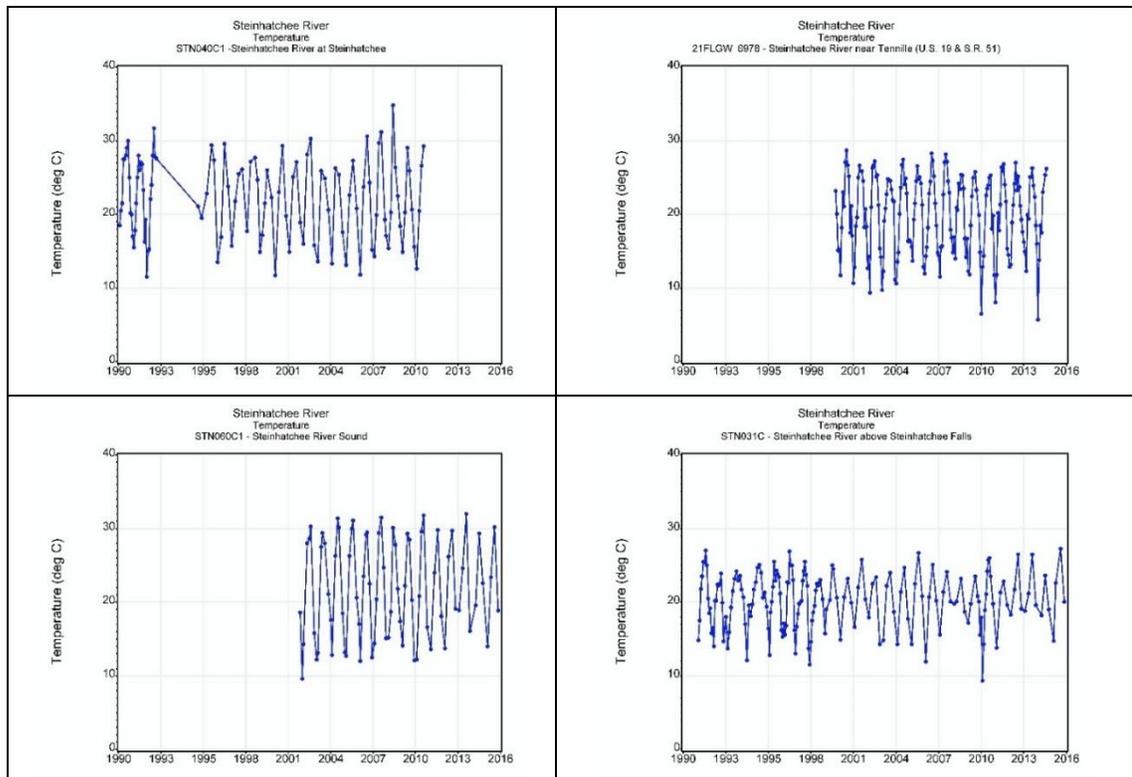


Figure 3-3. Time series of water temperatures from four stations on the Steinhatchee River.

- Conductivity – Figure 3-4 presents the field measured conductivity data for the one FDEP and three SRWMD monitoring stations on the Steinhatchee River. The PORs were the same as for water temperature. The median conductivities for the two stations above a waterfall at Steinhatchee Falls (21FLGW 6978 and STN031C1) were relatively low [<400 micromhos (μmhos)], as were the maximum values (<700 μmhos). The highest conductivity values were observed in the most downstream station (STN060C1), which is in the sound. Conductivity was most variable at STN040C1 (minimum = 112 μmhos , maximum = 43,838 μmhos) due to tidal influence. No apparent temporal trend was noted in the observed conductivity.

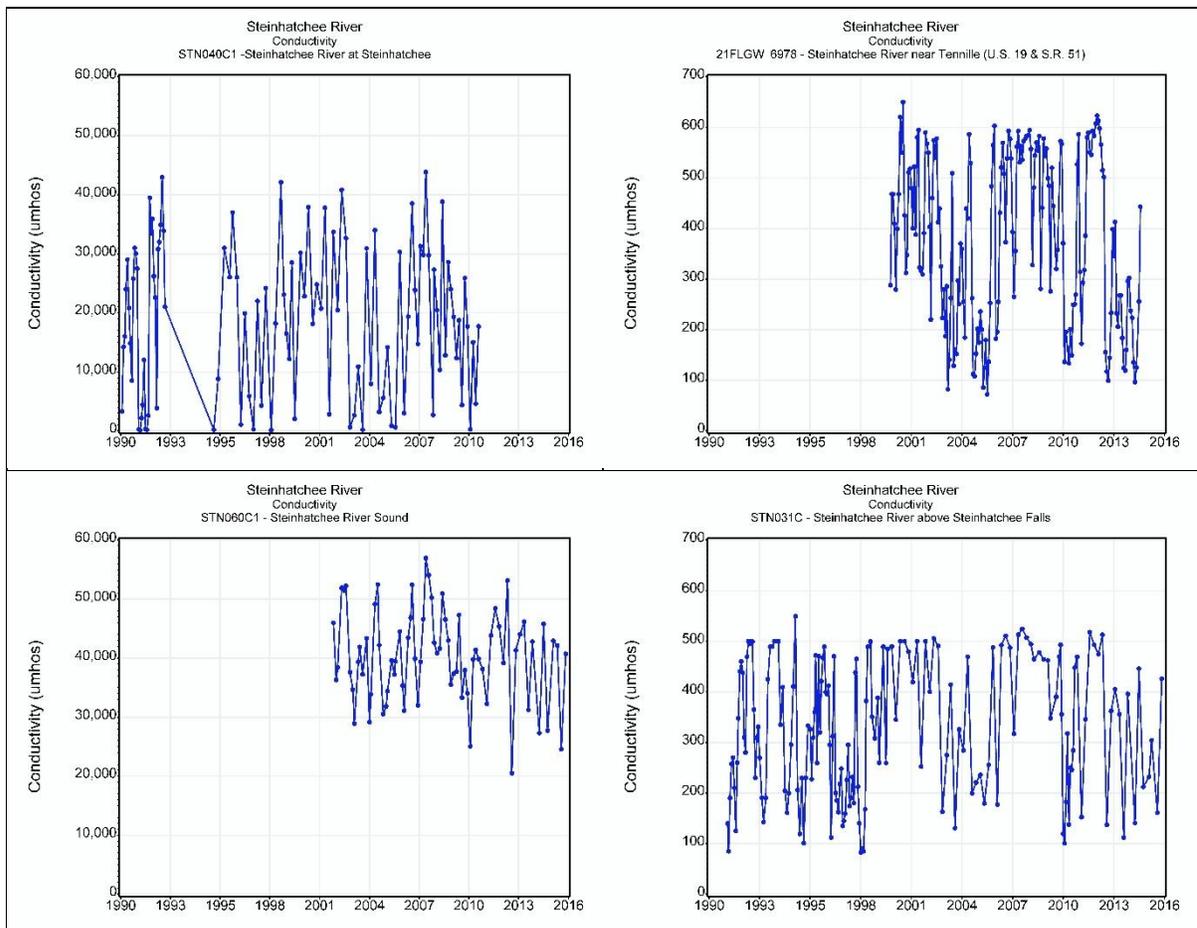


Figure 3-4. Time series of conductivity from four stations on the Steinhatchee River.

- Dissolved Oxygen – Figure 3-5 presents the dissolved oxygen (DO) data for the one FDEP and three SRWMD monitoring stations on the Steinhatchee River. The PORs were the same as for water temperature. Median values, as well as the lower (10th percentile) and higher (90th percentile), decreased from the most upstream station (21FLGW 6978) to the next station just above the falls (STN031C1) and then increased down to the lowest station in the sound (STN060C1) (median values 6.2 mg/L, 3.6 mg/L, 5.2 mg/L and 7.4 mg/L, respectively, for the four stations from upstream to downstream). This may be a function of the influence of groundwater intrusion. Patterns for percent oxygen saturation were similar to DO. The median percent saturation for the most downstream station (STN060C1) was 98 percent. No apparent temporal trend was noted in the observed DO conditions.

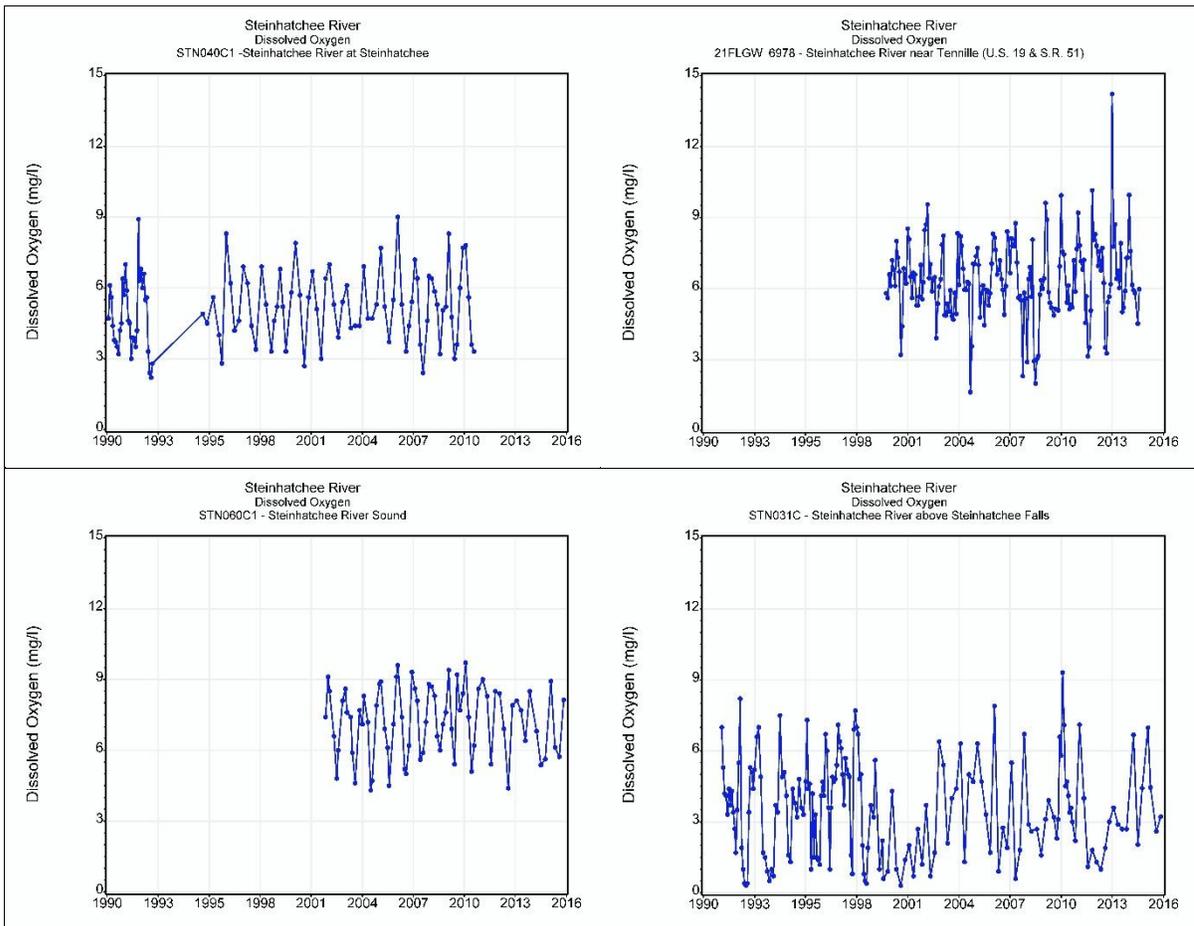


Figure 3-5. Time series of dissolved oxygen (DO) from four stations on the Steinhatchee River.

- Water Color – Figure 3-6 presents the color data for the one FDEP and three SRWMD monitoring stations on the Steinhatchee River. The PORs were the same as for water temperature. Color is an indicator of the relative effects of decomposing organic carbon, often of allochthonous origins. Drainage from wetlands can often be detected by increasing color. In general, observed color decreased from the two stations above the falls (medians equal to 150 and 188 Platinum-Cobalt Scale (PtCo) units for 21FLGW 6978 and STN031C1, respectively), downstream to the station located in the sound (median = 30 PtCo units at STN060C1). Lower values (10th percentile and minimum) increased slightly from the most upstream station (21FLGW 6978) to the next downstream station just above the falls (STN031C1), but then exhibited the decreasing pattern down to the station in the sound (STN060C1). The observed variability in the color data is likely related to seasonal variation in river flow and annual variation in rainfall.

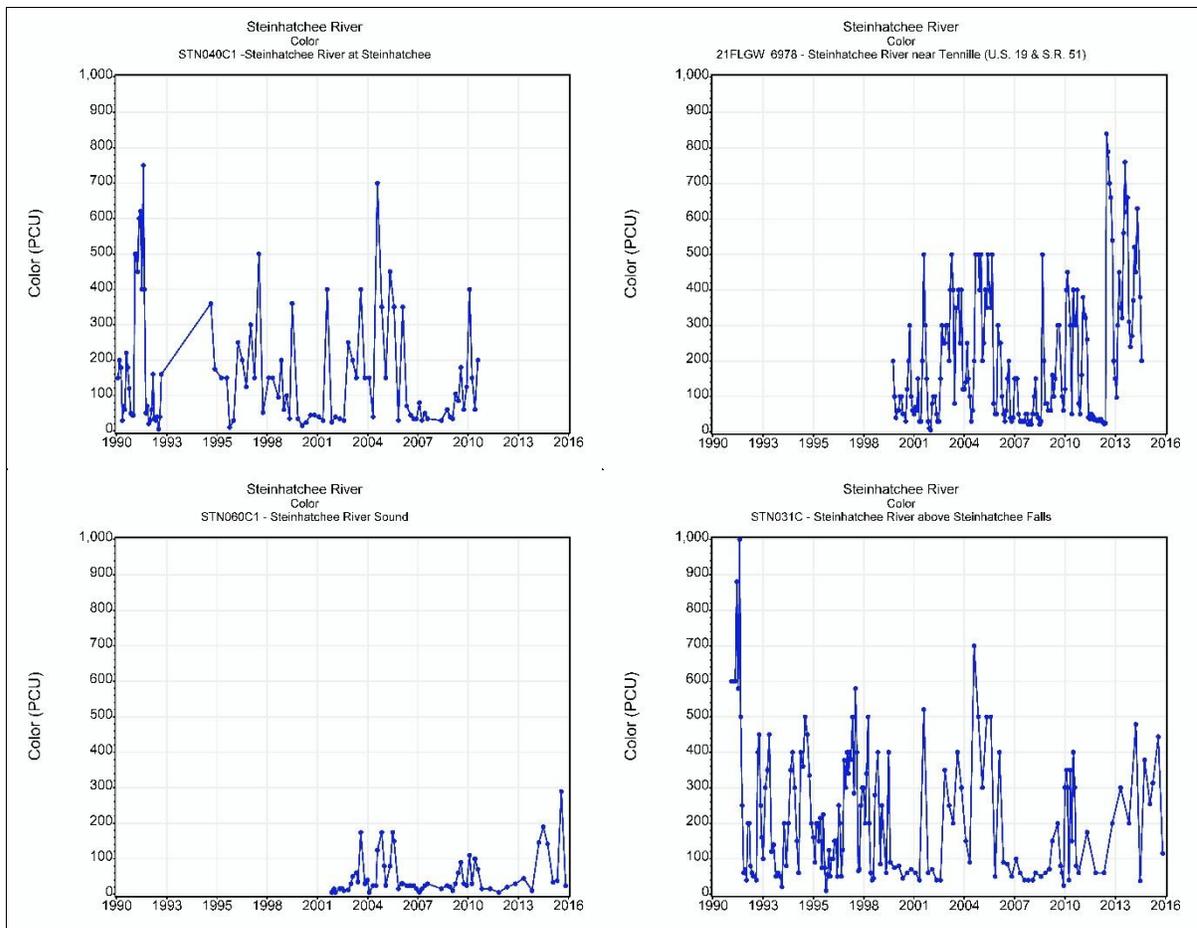


Figure 3-6. Time series of color from four stations on the Steinhatchee River.

- Total Nitrogen – Figure 3-7 presents the total nitrogen (TN) data for the one FDEP and three SRWMD monitoring stations on the Steinhatchee River. The PORs were the same as for water temperature. The mean and median TN values decreased from the most upstream station (21FLGW 6978) (mean = 0.91 mg/L, median = 0.87 mg/L) to the most downstream station (STN060C1) (mean = 0.71 mg/L, median = 0.61 mg/L). This spatial variation is often found in tidal rivers, where upstream nutrient loading is diluted as the upstream water mixes with estuarine water that typically has relatively low TN concentrations (Hendrickson 2016). In contrast, however, the short-term average TN values from two dates of sampling (August 2008 and January 2009) reported in the FDEP nutrient longitudinal study do not exhibit this trend (Figure 3-8). TN values instead generally increased from freshwater to estuary sites. However, the range in values observed during the longitudinal study is much smaller and captures a relatively small portion of the natural ranges in flow, than that encountered in the long-term time series from the one FDEP and the three SRWMD stations.

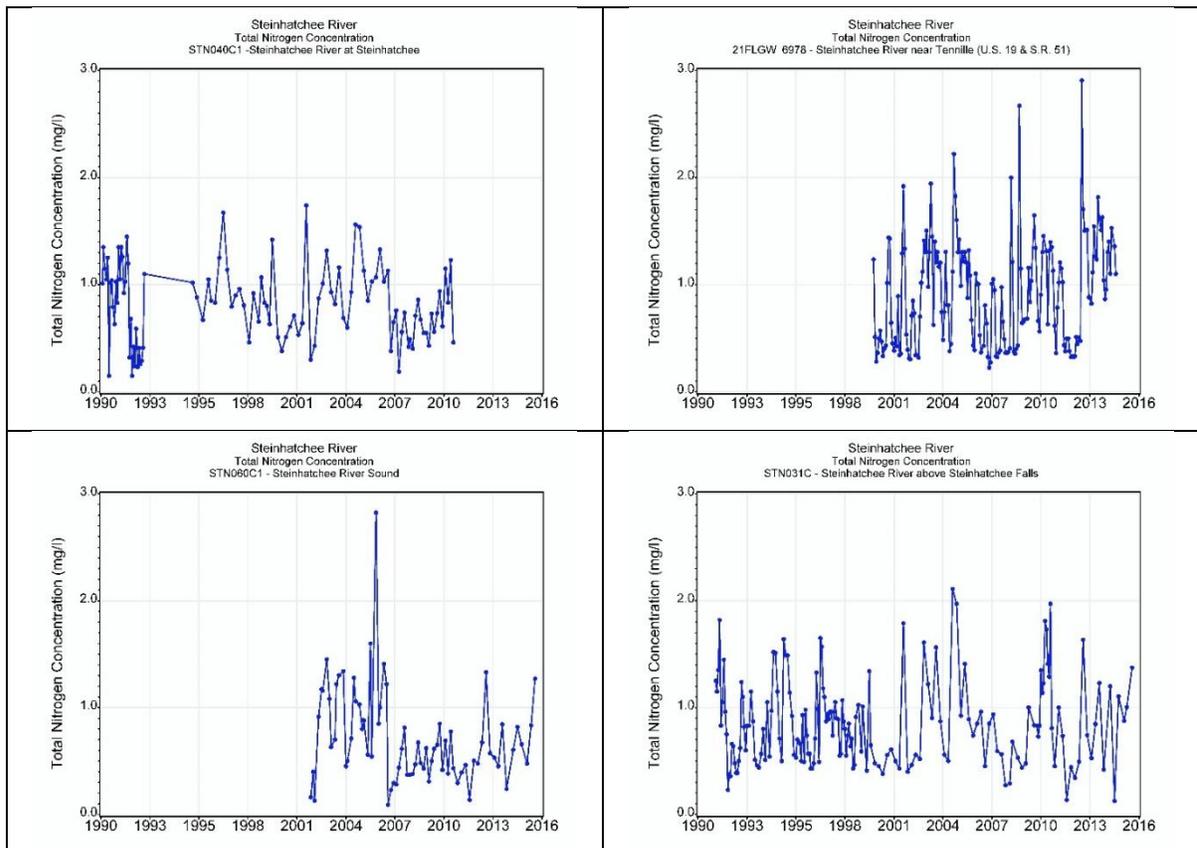


Figure 3-7. Time series of total nitrogen (TN) from four stations on the Steinhatchee River.

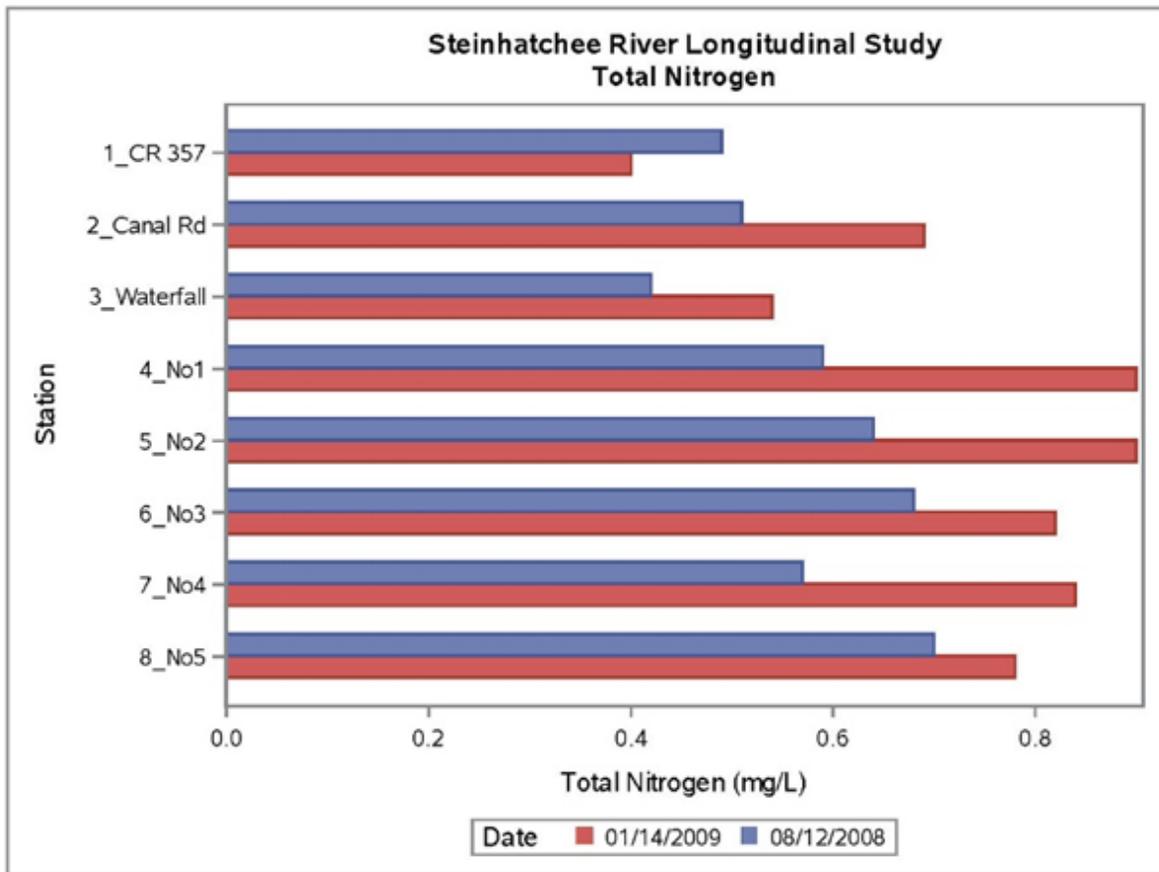


Figure 3-8. Average Total Nitrogen (TN) from two FDEP longitudinal study sampling dates.

- Total Phosphorus – Figure 3-9 presents the total phosphorus (TP) data for the one FDEP and three SRWMD monitoring stations on the Steinhatchee River. The PORs were the same as for water temperature. Mean and median values for TP exhibited a decreasing trend along the gradient from upstream to downstream (median values 0.07 mg/L, 0.06 mg/L, 0.05 mg/L, 0.04 mg/L, respectively). The short-term average TP values from two dates of sampling (August 2008 and January 2009) reported in the FDEP nutrient longitudinal study also exhibited this trend (Figure 3-10). TP values for the most upstream station in the longitudinal study exceed the 90th percentile of the Peninsula benchmark streams (0.116 mg/L), and another freshwater upstream site exceed the 75th percentile (0.088 mg/L) (EPA 2011, 2009; FDEP 2012). Average TP values in the estuary were below 0.05 mg/L. The longitudinal study reported that while TP levels in the Steinhatchee River have typically been above average compared to TP values in Peninsula benchmark streams, there has been no adverse effect on chlorophyll *a* (Chl *a*) levels within the river.

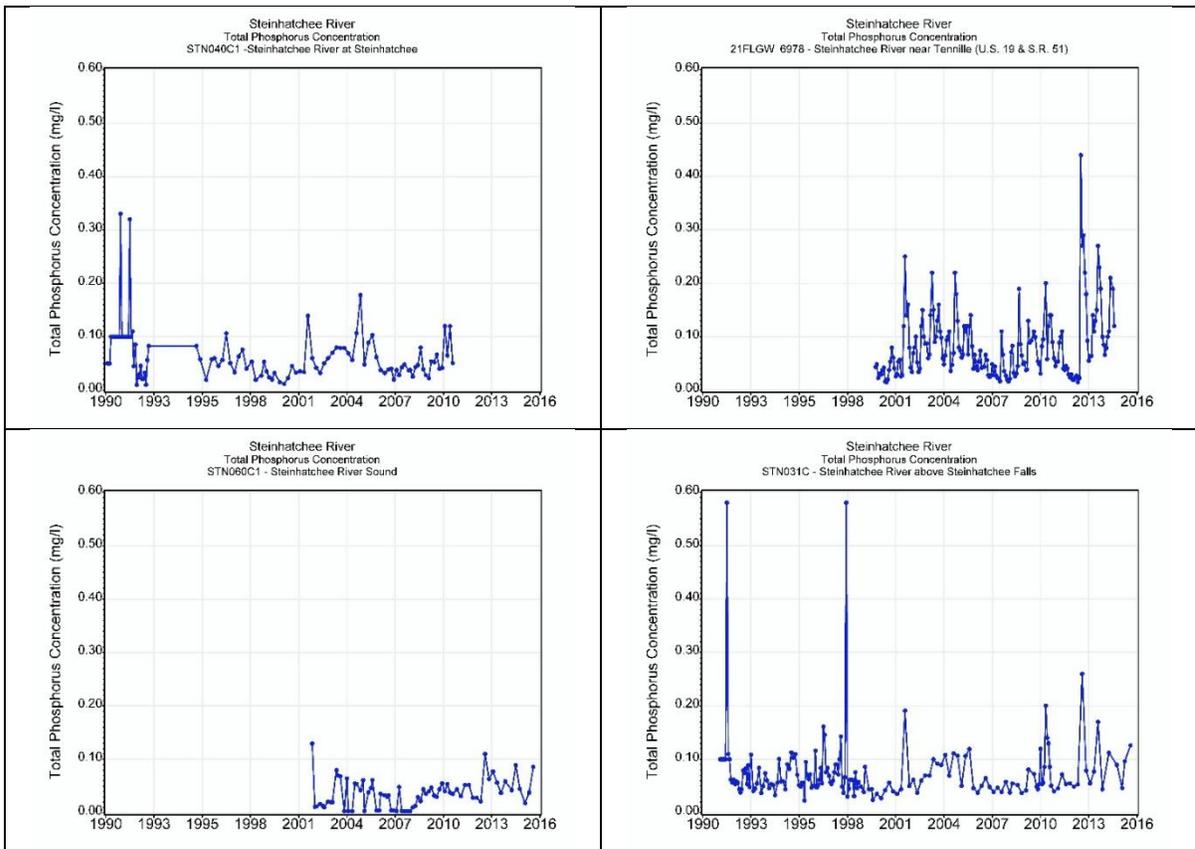


Figure 3-9. Time series of total phosphorus (TP) from four stations on the Steinhatchee River.

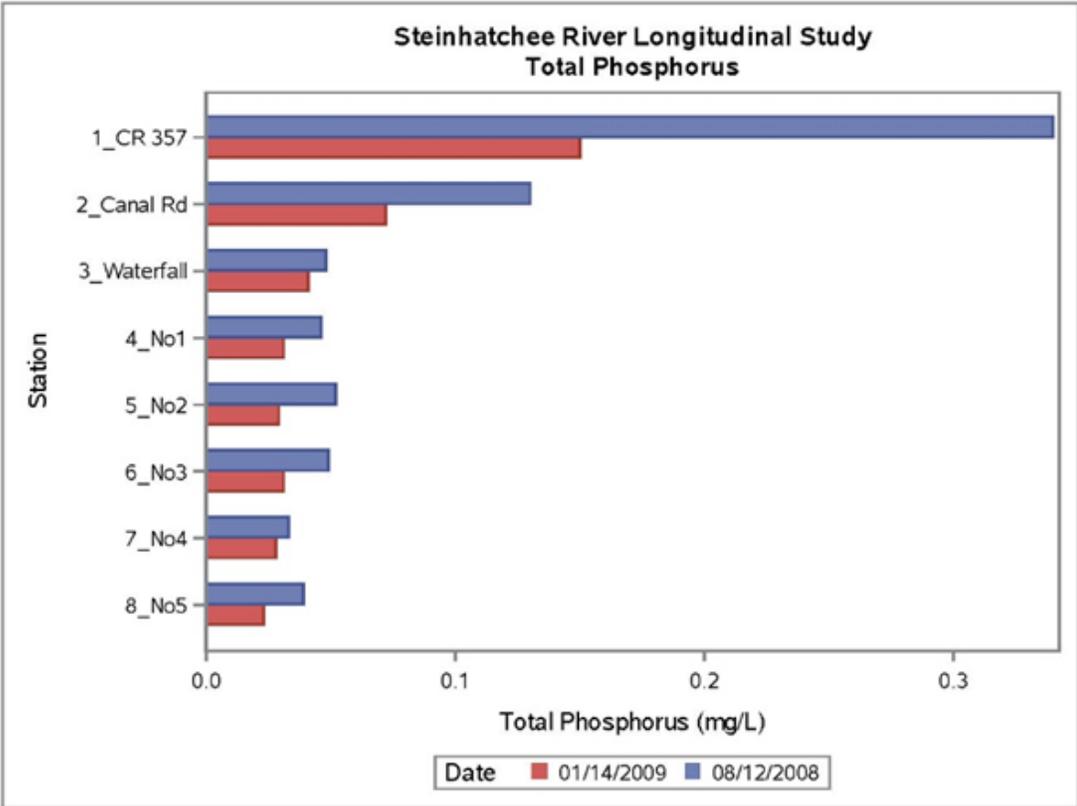


Figure 3-10. Average Total Phosphorus (TP) from two FDEP longitudinal study sampling dates.

- Turbidity – Figure 3-11 presents turbidity data for the one FDEP and three SRWMD monitoring stations on the Steinhatchee River. The PORs were the same as for water temperature. The most upstream station (21FLGW 6978) had the lowest median value for turbidity [nephelometric turbidity units (NTUs)] and median values for turbidity were similar between the three SRWMD stations (1.6 to 1.7 NTUs). No apparent temporal trend was noted in observed turbidity data.

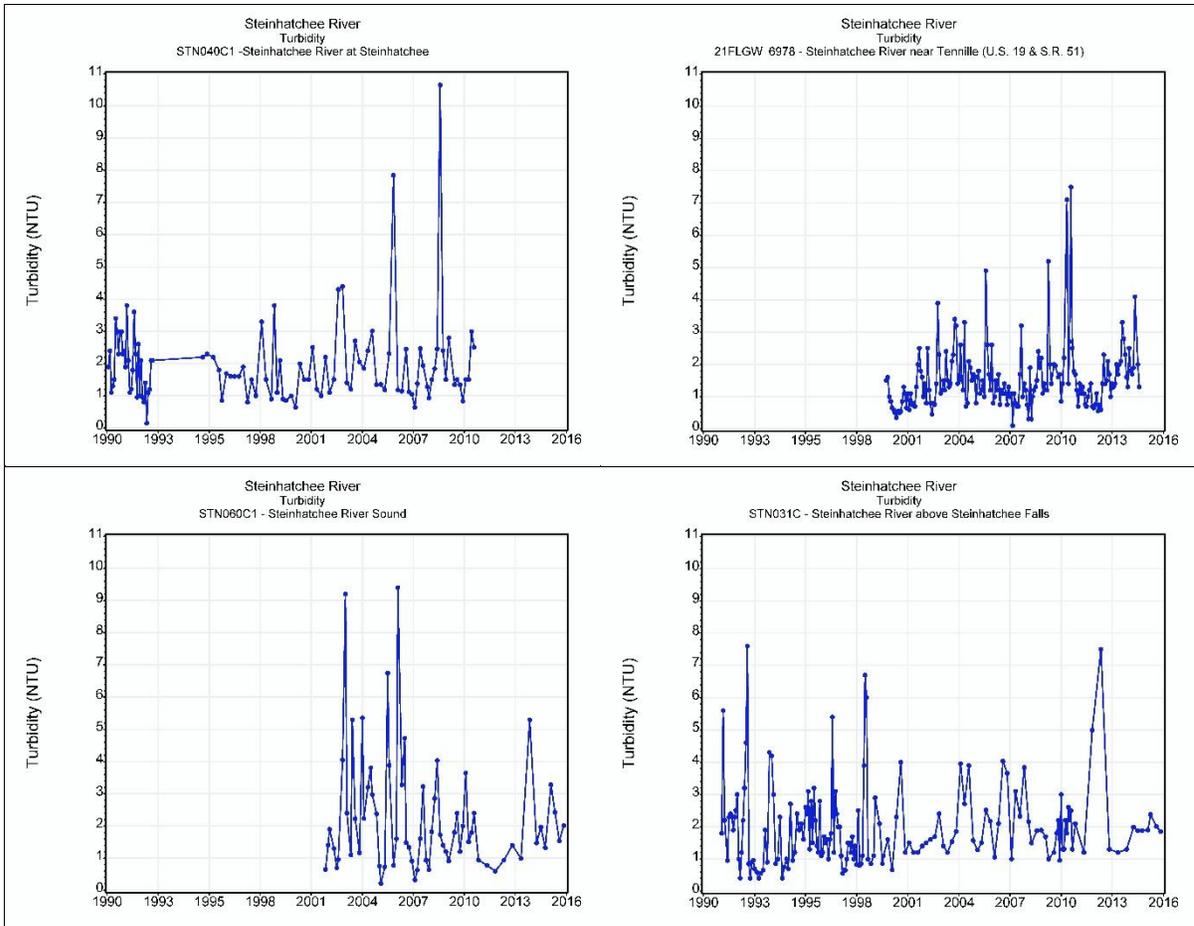


Figure 3-11. Time series of turbidity from four stations on the Steinhatchee River.

- Chlorophyll *a* – Figure 3-12 presents the Chl *a* data for the one FDEP station (21FLGW 6978), and SRWMD Stations STN031C1 and STN060C1. Chl *a* data were not available with sufficient frequency for SRWMD Station STN040C1 to create a time series or compute reliable summary statistics. Additionally, Chl *a* data were available at STN031C1 for the period April 2014 – November 2015 and at STN060C1 for November 2001 – August 2002 and November 2011 – November 2015. The period-of-record for Chl *a* was the same as for temperature at station 21FLGW 6978. Chl *a* values, in general, were low, with median values less than 2 micrograms per liter ($\mu\text{g/L}$). The maximum reported values were 46 $\mu\text{g/L}$ for the upstream Station 21FLGW 6978 and 7.2 $\mu\text{g/L}$ for the downstream Station STN060C1. All values of Chl *a* reported after September 2008 were less than 10 $\mu\text{g/L}$ for all stations. Average Chl *a* values in the FDEP longitudinal study were higher in the estuary than in the freshwater portions of the river (Figure 3-13). However, the report indicates that all the average values at the estuary sites were well below the 11 $\mu\text{g/L}$ annual mean threshold for nutrient impairment of estuarine waters in the Impaired Waters Rule (IWR) effective at the time of the report. Additionally, Chl *a* values for the freshwater sites were all much lower than the threshold for nutrient impairment of streams (20 $\mu\text{g/L}$ annual mean for streams). The longitudinal study also investigated available chlorophyll data from 1999-2009 and found that concentrations were mostly below the method detection limit (MDL) and show no trend over the 10-year time period.

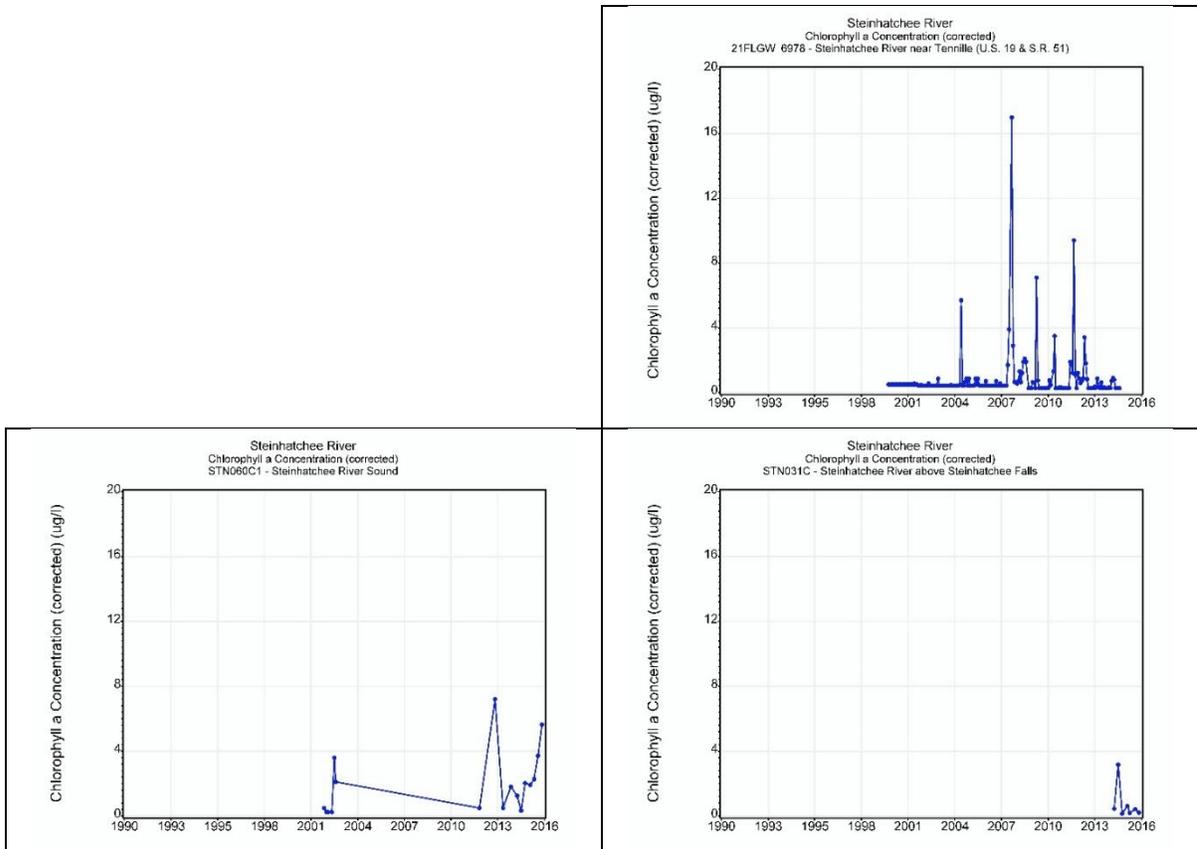


Figure 3-12. Time series of chlorophyll a from three stations on the Steinhatchee River.

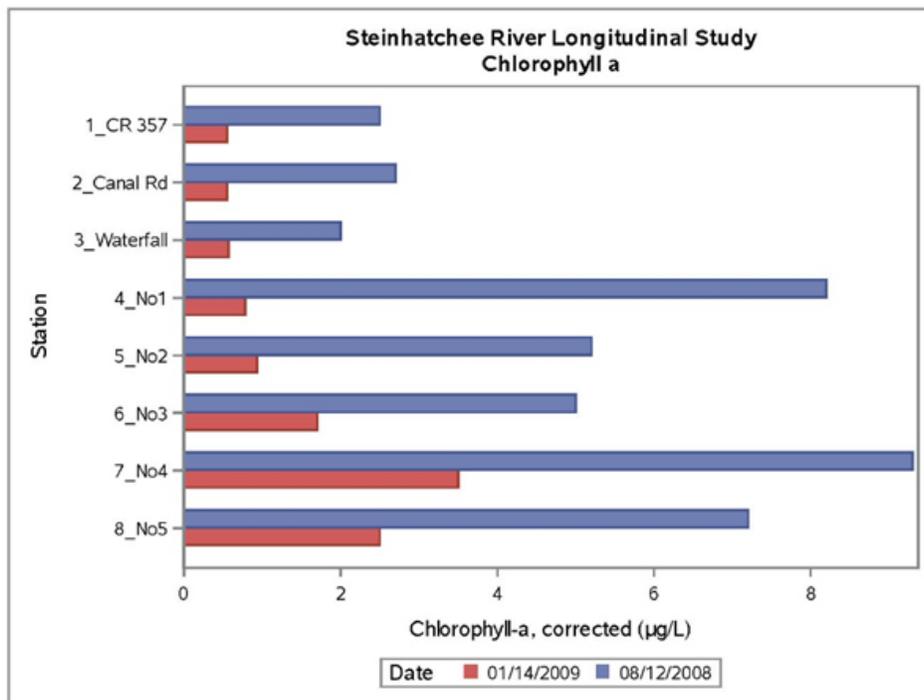


Figure 3-13. Average chlorophyll a from two FDEP longitudinal study sampling dates.

3.1.2 REGULATORY ASSESSMENT

FDEP periodically assesses water quality in the Steinhatchee River watershed to determine the impairment status relative to existing water quality criteria and standards. FDEP assessments occur on a 5-year rotation, known as cycles, with the Steinhatchee River watershed currently within the Group 1, Cycle 4. The most recent assessment was completed in 2013. Numeric nutrient criteria (NNC) are further dependent on the geographic location of a waterbody segment (WBID) to account for the spatial variability around the state. The freshwater stream WBIDs fall within the Panhandle East nutrient region, and the Steinhatchee Offshore coastal segment it discharges to falls within the Big Bend and Apalachee Bay nutrient region. The DO criterion has also changed recently. DO is no longer expressed as a concentration but rather as percent saturation. This change allows for the consideration of temperature, salinity and time of day the measurement was taken. Criteria relevant to nutrients and DO are provided in Table 3-1.

Table 3-1. Relevant numeric nutrient and dissolved oxygen criteria for the Steinhatchee River.

Class	Type	Region	TN (mg/L)*	TP (mg/L)*	NO ₂ +NO ₃ (mg/L)*	Chlorophyll a (µg/L)*	DO Saturation (%)**
3 Fresh	Spring	Panhandle East			0.35		
	Stream		1.03	0.18		20	34
3 Marine	Estuary	Steinhatchee Offshore	Narrative			11	42
	Coastal		0.45	0.21		3.3	42

*Expressed as annual geometric means not to be exceeded more than once in a 3-year period.

** Cannot be below this value more that 10% of the time.

The Steinhatchee River watershed is broken up into assessment units known as WBIDs and identified as a stream, estuary, lake, or spring (Figure 3-14). All the waters in the watershed are designated as either Class III marine or freshwaters, meaning they have a designated use of Fish Consumption, Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife (fishable or swimmable). Much of the Steinhatchee River watershed falls within the freshwater stream class. None of the WBIDs in the Steinhatchee River watershed are impaired due to elevated nutrient concentrations or low DO saturation, which are most likely affected by river or stream flow. However, currently two WBIDs are impaired within the watershed, both for fecal coliform bacteria (FDEP 2015). These are WBIDs 3573B and 3603; the former is a segment of the river mainstem upstream of Steinhatchee Spring, and the other is Bevins (Boggy) Creek which discharges to the river downstream of Steinhatchee Falls. EPA has developed a TMDL for Boggy Creek to

address the fecal coliform impairment. (EPA 2007). Bacteriological quality standards are undergoing revision as Florida plans to replace fecal coliform with *Escherichia coli* in freshwater systems and *Enterococci* in marine systems.

Steinhatchee River Watershed - Water Quality Assessment WBIDs

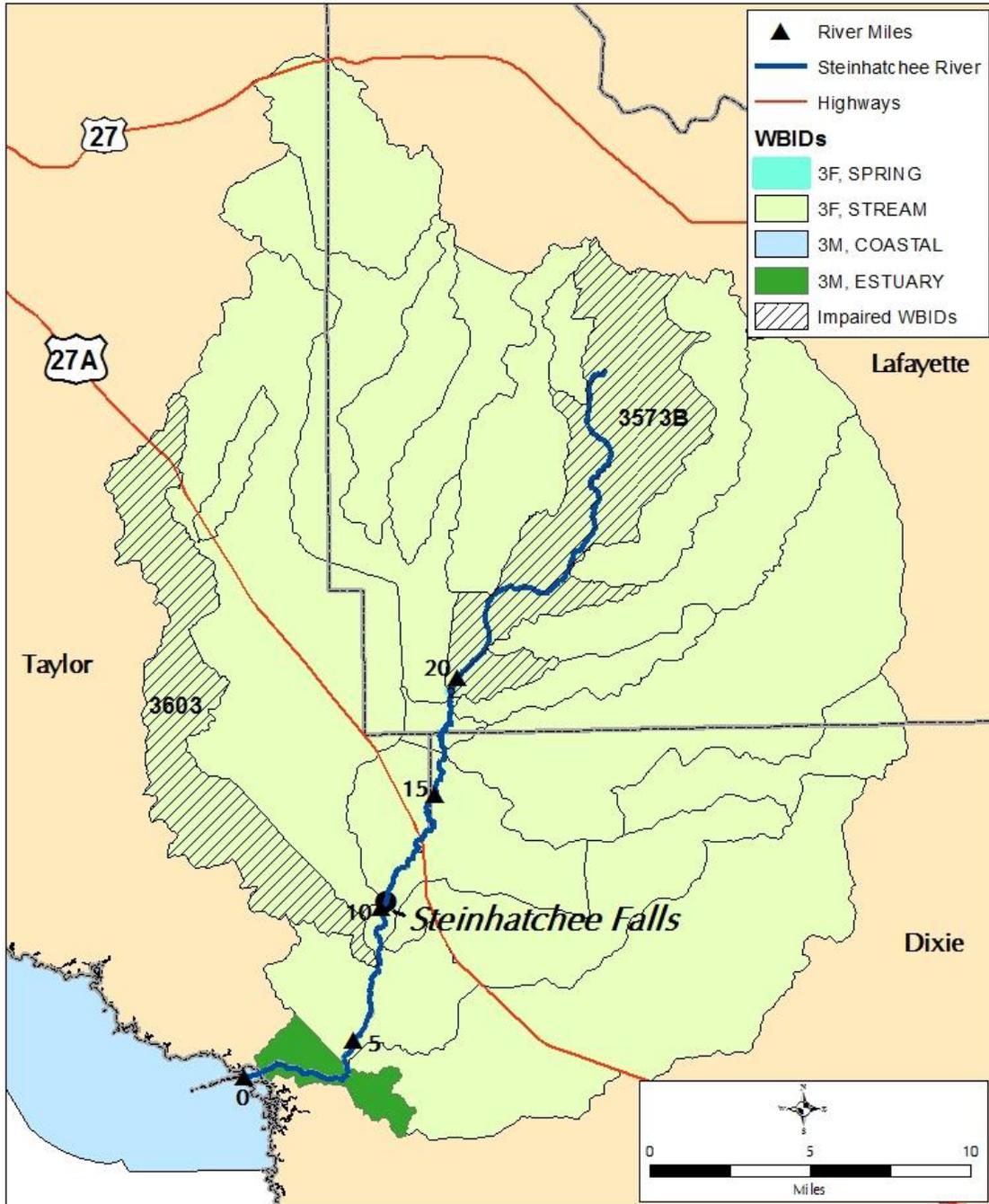


Figure 3-14. WBIDs within the Steinhatchee River watershed.

3.2 HABITATS

3.2.1 WATERSHED HABITATS

For the purposes of mapping vegetation communities in the Steinhatchee River floodplain, SRWMD staff determined Version 3.1 of the Cooperative Land Cover Map [CLC; Florida Fish and Wildlife Conservation Commission (FWC) 2016] was best for delineating boundaries of historical and current natural communities and land use, especially when considering land cover classes directly adjacent the river. The FWC's purpose in creating the CLC was to fill a priority data gap of Florida's State Wildlife Action Plan for improved habitat mapping. The CLC integrates three primary data types:

- Local or site-specific data sources;
- Data derived from areas that Florida Natural Areas Inventory (FNAI) ecologists reviewed with high-resolution aerial photography; and
- Data represented by Florida Land Use Land Cover Classification System (FLUCCS) data from the FDEP and the water management districts. The CLC map integrates data from the following years: Northwest Florida Water Management District (NFWMD): 2006 – 07, SRWMD: 2005 – 08, St. Johns River Water Management District (SJRWMD): 2004, SFWMD: 2004, and Southwest Florida Water Management District (SWFWMD): 2008.

Within the boundaries of the Hydrologic Engineering Centers River Analysis System (HEC-RAS) model, the CLC polygons adjacent to the river are composed of a mixture of cover classes (Figure 3-15). The natural communities are represented predominantly by floodplain swamp; followed by salt marsh, hydric hammock, freshwater forested wetlands, and smaller areas of floodplain marsh (Table 3-2). Tree plantations comprise the third largest vegetative cover class and are mainly located upstream of US 19.

The floodplain swamp cover class was field-verified for spatial accuracy and vegetative species composition in the non-tidally influenced segment of the river, within the bounds of the HEC-RAS model, between RM 10 and RM 17. Approximately 21 percent of the underlying soils within the floodplain swamp community are described as frequently flooded, with a chance of flooding more than 50 percent in any year (Soil Survey Staff 2016). Site visits were conducted between February 4 and 16, 2016. General methods for field-verification are discussed in the following paragraphs.

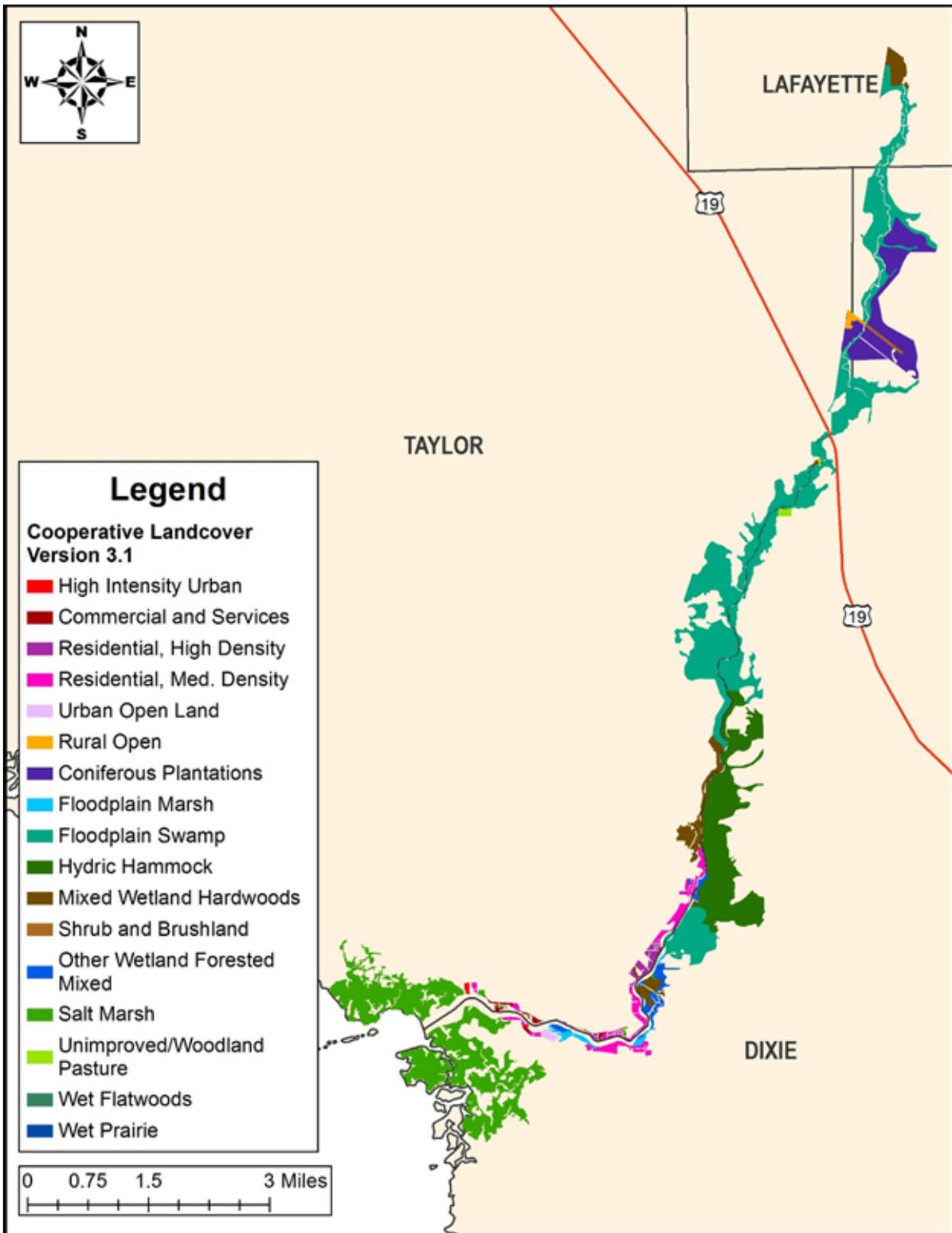


Figure 3-15. Cooperative Land Cover classes mapped adjacent the Steinhatchee River within the HEC-RAS model domain.

Table 3-2. Cooperative land cover (CLCv3.1) classes adjacent to the Steinhatchee River within the HEC-RAS model domain, and their areas.

CLC Cover Class Code	Cover Class Name	Acres
2215	Floodplain Swamp	1,676.15
5240	Salt Marsh	1,034.17
2232	Hydric Hammock	669.84
18333	Tree Plantations	397.09
2200	Freshwater Forested Wetlands	263.55
1822	High Intensity Urban	207.18
2123	Floodplain Marsh	34.08
1830	Rural	27.46
1821	Low Intensity Urban	13.99
1500	Shrub and Brushland	12.95
2110	Prairies and Bogs	2.95
2221	Wet Flatwoods	0.66

An easily accessed subset (n = 9) of the HEC-RAS transects were systematically selected for an even distribution along the length of the segment of interest (Figure 3-16). At each of these transects, at least one site was visited within the community classified as floodplain swamp. When possible, additional locations were visited along select transects, and a total of 18 sites were documented. In the field, geo-referenced imagery was collected at each verification site, and plant species occurrences were documented in their respective strata (i.e., canopy, shrub/sub-canopy, ground cover). The maximum radius of the area described at each site was approximately equal to the distance where no new species were discernable in the canopy.

In some cases, plant identification was performed to the lowest practical taxonomic level, as field verification was conducted prior to the spring leaf emergence. However, a follow-up visit to additional transects above RM 17 yielded spring blossoms that aided in limited species-level identification (Figure 3-17). A listing of dominant canopy, subcanopy and shrub vegetation is provided in Table 3-3, including the number of sites where each species occurred.

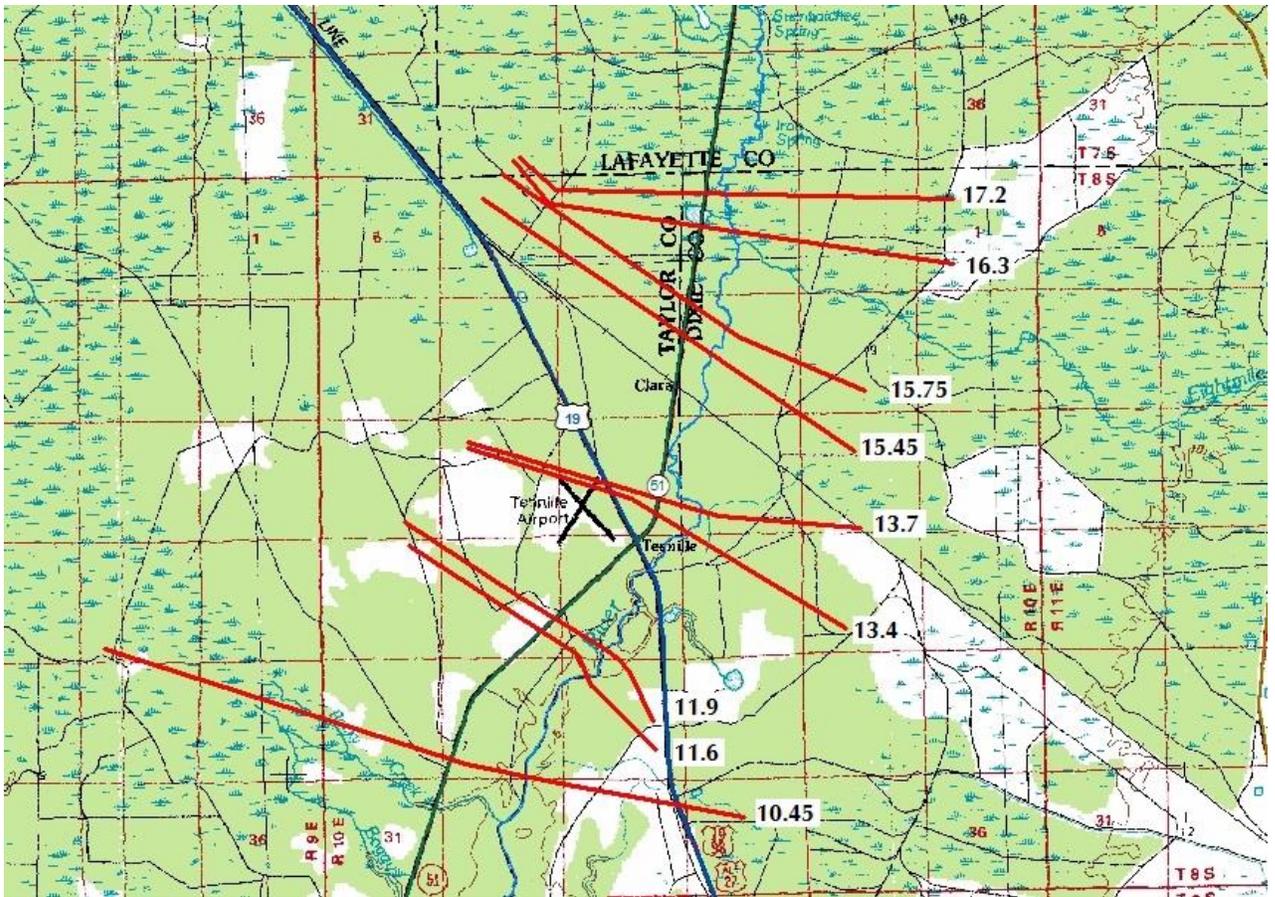


Figure 3-16. Transects selected for field-verification of the floodplain swamp cover class.



Figure 3-17. Green hawthorne (*Crataegus viridis*) blooming in the Steinhatchee floodplain on March 22, 2016.

Table 3-3. Plants occurring at Steinhatchee River floodplain swamp verification sites, February 4-16, 2016.

Scientific Name	Common Name	DEP Vegetative Index	Count*
<i>Sabal palmetto</i>	cabbage palm	FAC	18
<i>Carpinus caroliniana</i>	musclewood	FACW	15
<i>Quercus laurifolia</i>	laurel oak	FACW	15
<i>Quercus nigra</i>	water oak	FACW	15
<i>Crataegus spp.</i>	mayhaw	OBL	14
<i>Serenoa repens</i>	saw palmetto	NL	11
<i>Quercus virginiana</i>	live oak	NL	10
<i>Sebastiania fruticosa</i>	Sebastian bush	FAC	10
<i>Liquidambar styraciflua</i>	sweetgum	FACW	9
<i>Ilex decidua</i>	swamp holly	FACW	8
<i>Ilex opaca</i>	American holly	FAC	6
<i>Vaccinium elliotii</i>	Elliotts blueberry	FACW	6
<i>Bumelia spp.</i>	bully	FAC	5
<i>Celtis laevigata</i>	hackberry	FACW	5
<i>Ilex vomitoria</i>	yaupon holly	FAC	5
<i>Pinus taeda</i>	loblolly pine	NL	5
<i>Myrica cerifera</i>	wax myrtle	FAC	4
<i>Ulmus americana</i>	American elm	FACW	4
<i>Viburnum obovatum</i>	Walters viburnum	FACW	4
<i>Persea borbonia</i>	redbay	NL	3
<i>Vaccinium arboreum</i>	sparkleberry	NL	3
<i>Carya spp.</i>	hickory	NL	2
<i>Crataegus marshallii</i>	parsley hawthorne	FACW	2
<i>Aesculus glabra</i>	buckeye	NL	1
<i>Cornus foemina</i>	swamp dogwood	FACW	1
<i>Taxodium distichum</i>	bald cypress	OBL	1
<i>Acer rubrum</i>	red maple	FACW	1

* Count indicates the number of sites where each occurrence was documented.

A well-developed, closed canopy was ubiquitous throughout the floodplain swamp, and it is evident that cabbage palm, musclewood, laurel oak, and water oak comprised the majority of this stratum among the sites surveyed. Most of the plants in Table 3-3 are listed as either obligate or facultative wetland vegetation, per 62-340, F.A.C. Others are indicative of disturbed environments or floodplains (e.g., Sebastian bush, bully, and hackberry).

Although no quantitative assessments of density were determined, the groundcover stratum was sparse in the floodplain swamp, likely due to season, shading, and flood frequency.

Groundcover species composition was fairly consistent among sites and exhibited a mix of species that tolerate a broad-range of flood-tolerance. Commonly occurring plants are provided in Table 3-4.

Table 3-4. Commonly occurring ground cover species.

Scientific Name	Common Name
<i>Dichondra caroliniensis</i>	pony-foot
<i>Mitchella repens</i>	partridge berry
<i>Senecio glabellus</i>	butterweed
<i>Saccharum strictum</i>	slender plume grass
<i>Panicum anceps</i>	beaked panicum
<i>Sisyrinchium angustifolium</i>	blue-eyed grass
<i>Nothoscordum bivalve</i>	false garlic
<i>Dichantherium</i> spp.	witch grass
<i>Asclepia</i> spp.	milkweed
<i>Hypoxis</i> spp.	yellow star grass
<i>Viola</i> spp.	violet
<i>Xyris</i> spp.	yellow-eyed grass
<i>Aristida</i> spp.	threeawn
<i>Chasmanthium</i> spp.	wood-oats
<i>Carex</i> spp.	carex sedge
<i>Clematis crispa</i>	swamp leather flower
<i>Gelsemium sempervirens</i>	Carolina jessamine
<i>Smilax</i> spp.	greenbrier
<i>Vitis</i> spp.	grapevine
<i>Rubus</i> spp.	blackberry

Figure 3-18 depicts rectified aerial photography from 1944 showing where three main transportation corridors converge: SR51, US19/98, and the abandoned Seaboard Coastline Railroad (UF 2016). The abandoned Seaboard Coastline Railroad right of way runs diagonally from the northwest to southeast corners of the image. Note the minor rail trams in the southeast corner. The thick black line near the right side of the image is an anomaly created where two images were spliced. The floodplain swamp is outlined in light green. FNAI mapped the historical natural communities within the Steinhatchee Conservation Area using resources that included historical aerial photography (Surdick et al. 2007). Many of the communities adjacent to the floodplain swamp included wet flatwoods, mesic flatwoods, and mesic hammock. The timber resources in these adjacent communities were harvested circa 1944, as evidenced by the image, and since then have been managed for timber. The

narrow river corridor has remained relatively intact, underscoring its location in the landscape and its value in the maintenance of rare and unique occurrences, including habitat types (i.e., hydric hammocks) and floral and faunal species.

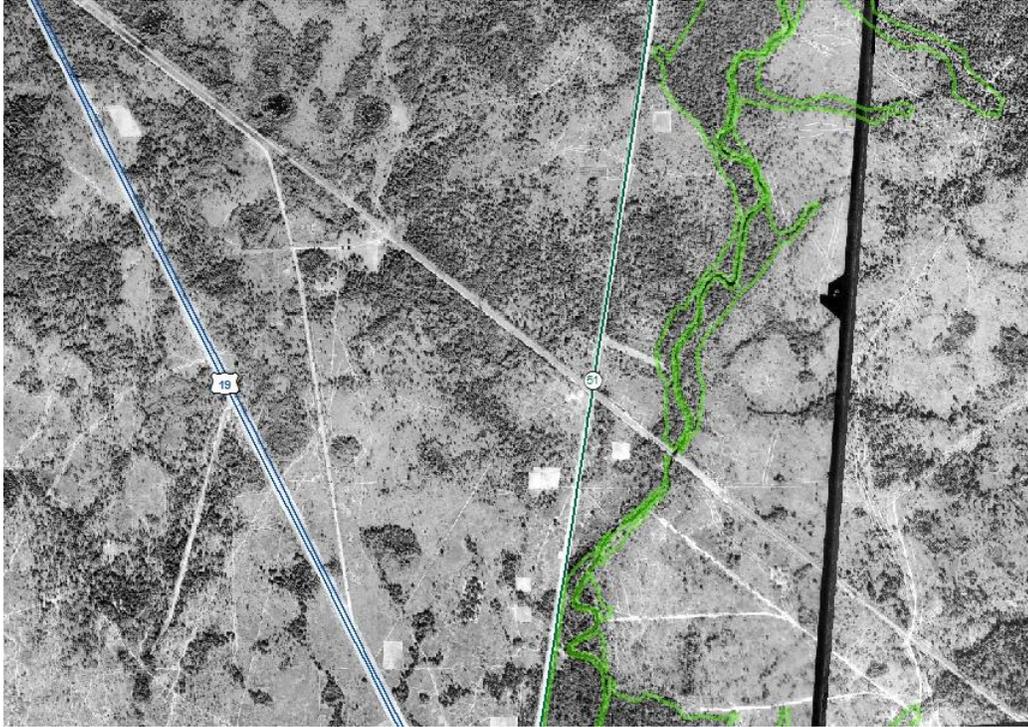


Figure 3-18. 1944 aerial photography showing the floodplain swamp adjacent the Steinhatchee River (light green) within the vicinity of three major transportation corridors.

FNAI determined the rare plant and animal species present in the Steinhatchee Conservation Area during surveys conducted between December 2000 and September 2001 (FNAI 2001a and 2001b), and between October 2006 and October 2007 (Surdick et al. 2007). In reaches above Steinhatchee Falls, pinewoods dainties [*Phyllanthus liebmannianus* ssp. *platylepis* (SE), Figure 3-19], and atamasco lilies (*Zephyranthes atamasco*) were documented. (Imagery in Figure 3-19 was captured south of the Canal Road, which borders an excavated conveyance from Mallory Swamp known as the south canal.) The latter is not currently listed by the State. Below the falls, several rare and listed species were documented, particularly in the karst floodplain of Sand Hill Creek, near Jena, in Dixie County; including pinewoods dainties, angularfruit milkvine (*Matelea gonocarpos*), Godfrey's swamp privet [*Forestiera godfreyi* (SE)], broad halberd fern (*Tectaria heracleifolia*), maidenhair fern (*Adiantum capillus-veneris*), and cardinal flower (*Lobelia cardinalis*).



Figure 3-19. Pinewoods dainties (*Phyllanthus liebmannianus* ssp. *platylepis*) growing in the Steinhatchee floodplain, downstream of the discharge from the south canal, March 22, 2016.

In addition to the floral floodplain components, FNAI stated in its reports that deciduous forests and forested wetlands support many species of neotropical migratory birds, a collective term used generally for species that breed in North America and spend their non-breeding period south of the United States. Several birds in this important group were encountered on the Conservation Areas studied in 2007. Most notable include the Acadian flycatcher (*Empidonax virescens*), blue grosbeak (*Guiraca caerulea*), hooded warbler (*Setophaga citrina*), Mississippi kite (*Elanoides forficatus*), northern parula (*Setophaga americana*), red-eyed vireo (*Vireo olivaceus*), yellow-billed cuckoo (*Coccyzus americanus*), and the yellow-throated vireo (*Vireo flavifrons*).

Although designated as floodplain swamp in the CLC, the vegetative composition of the field-verified sites is more accurately characterized by FNAI's bottomland forest community description (FNAI 2010). Bottomland forest is an associate of the floodplain swamp, as are alluvial forest, hydric hammock, and occasionally baygall. These communities may occur exclusively or as a mosaic. The segment of the river that was surveyed for verification

represents a relatively steep stream gradient, where out-of-bank flows do not result in prolonged growing season floodplain inundation, especially in the lower-end of the reach, due to interaction with a highly karst environment. Vegetative communities of river reaches upstream of Steinhatchee Springs exhibited hydrophytic vegetation and evidence of natural processes that are more representative of floodplain swamps (FNAI 2010, Figure 3-20). However, these communities were not field-verified since the HEC-RAS model was applied further downstream.



Figure 3-20. The Steinhatchee River in the vicinity of Cooks Hammock, Florida. Floodplain communities from this river reach accurately represent floodplain swamps.

3.2.2 IN-CHANNEL HABITATS

The lower Steinhatchee River is characterized by developed areas primarily on the northern shore and extends to expansive tidal marshes marked by numerous tidal creeks. The developed shoreline extends northward to RM 8. The channel narrows to about 50 feet between RM 5 and RM 6. The river width below RM 4 ranges from 300 to 2500 feet. River substrate generally reflects the exposed limestone and its overlying thin veneer of undifferentiated Pleistocene and Holocene surficial sands, clayey sands, and alluvium (Ruppert 1991, 1996).

Above RM 8, much of the channel falls within a more undeveloped area. Between RM 6 and RM 10, the river width ranges from 50 to 75 feet. The upper reaches of the river are underlain by Suwannee limestone of the Oligocene Epoch, but its narrow channel cuts into Eocene carbonates that commonly crop-out along the lower portion of the river. The Eocene carbonates comprise the Ocala Formation, which becomes exposed approximately 12 miles inland, where the slope of the river thalweg becomes relatively steep prior to leveling out near Steinhatchee Falls (Ruppert 1991, 1996).

Steinhatchee Falls is a much-visited area on the river near RM 10.2 (Figure 3-21). The channel is approximately 60 feet across, with a drop in the channel bottom of approximately 2 to 3 feet. Above RM 10, the river width ranges from 30 to 50 feet. A series of shoals (Figure 3-22) are located between RM 15 and RM 20. Woody snag habitats (Figure 3-23) can be commonly found above RM 12. Again, limestone outcrops are the primary bottom type in this reach of the river.



Figure 3-21. Steinhatchee Falls.



Figure 3-22. Steinhatchee River shoals.

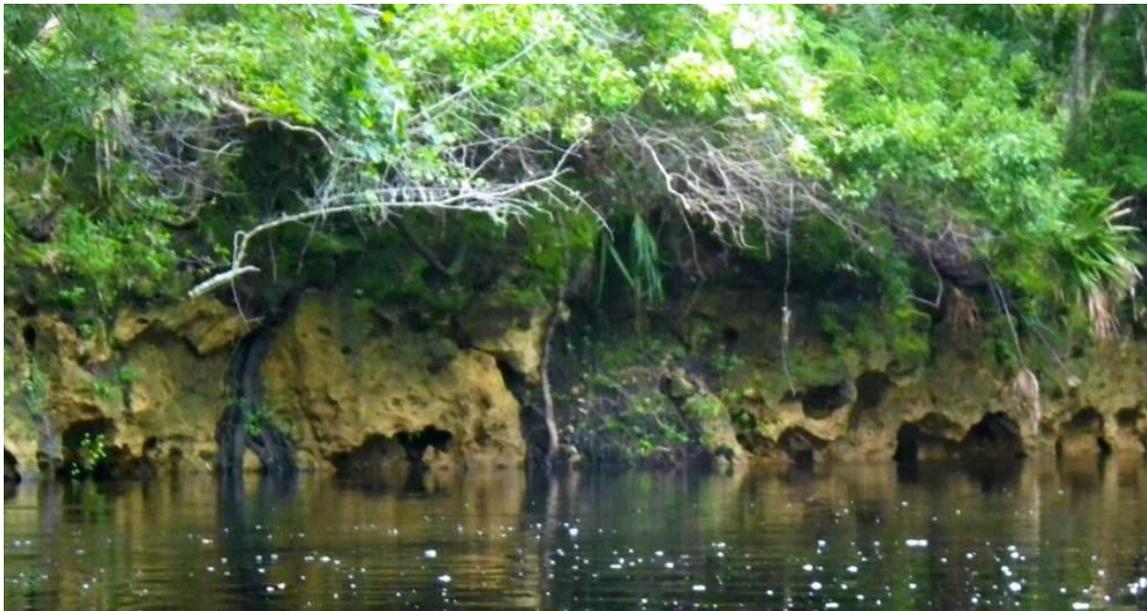


Figure 3-23. Woody snag habitat along the Steinhatchee River.

3.3 AQUATIC BIOTA

Flow can affect both the water quality and biology of a river system. This study considered relationships between flow, water quality, fish, and macroinvertebrates. Freshwater flow affects water quality variables, including both concentrations and loadings. The magnitude and timing of freshwater inflows affect the amount of nutrients and organic matter that enters a waterway and the subsequent effects on the productivity of the waterbody.

Freshwater flow can affect aquatic biota either directly (physical factors), or indirectly (by affecting salinity or other environmental parameters). Depending upon flow regime, in terms of both volume and velocity, available habitat for a given species may be altered. In estuarine and coastal habitats, alterations to the salinity regime (e.g., timing and magnitude of change) will also affect the types and numbers of species that occur.

3.3.1 ESTUARINE BIOTA

Both flora and fauna within the estuarine portion of the Steinhatchee River have specific habitat requirements that are dependent to some degree upon freshwater flows from the watershed. The following sections discuss the seagrasses, fishes, and benthos (particularly the bay scallop) that are common to the Steinhatchee River estuary and nearshore Gulf of Mexico waters.

3.3.2 SEAGRASSES

Seagrasses comprise a significant habitat within estuarine waters. Seagrasses are flowering marine aquatic plants inhabiting low-velocity zones in primarily 3 to 12 feet of water. Seagrass habitats play a significant role at the mouth of the Steinhatchee River, providing critical habitat for many species including the bay scallop. This area is well known for and part of the largest recreational scallop fishery in the state (Mattson et al. 2007). Beyond habitat, seagrasses provide other services such as filtering particulates from the water column, shoring up shoals, and acting as a sentinel to water quality changes such as excess Chl *a* or changes in salinity.

The seagrasses of the Steinhatchee River and its coastal region fall within the Big Bend Seagrasses Aquatic Preserve and are monitored by both FDEP (field monitoring) and FWC (field monitoring and mapping based on aerial photography) staff. Both programs conduct annual field monitoring surveys. The area was last mapped based on aerial photography in 2006 (Figure 3-24) and showed a rather dramatic decline. Between 2001 and 2006, the southern Big Bend experienced a net loss of about 3,500 acres (6 percent) of seagrass, which reflects the deterioration of 7,100 acres of continuous beds into 3,600 acres of patchy beds (Carlson and Yarbro 2009, FWRI 2016, Figure 3-24).

Steinhatchee River Watershed - Seagrass Habitat

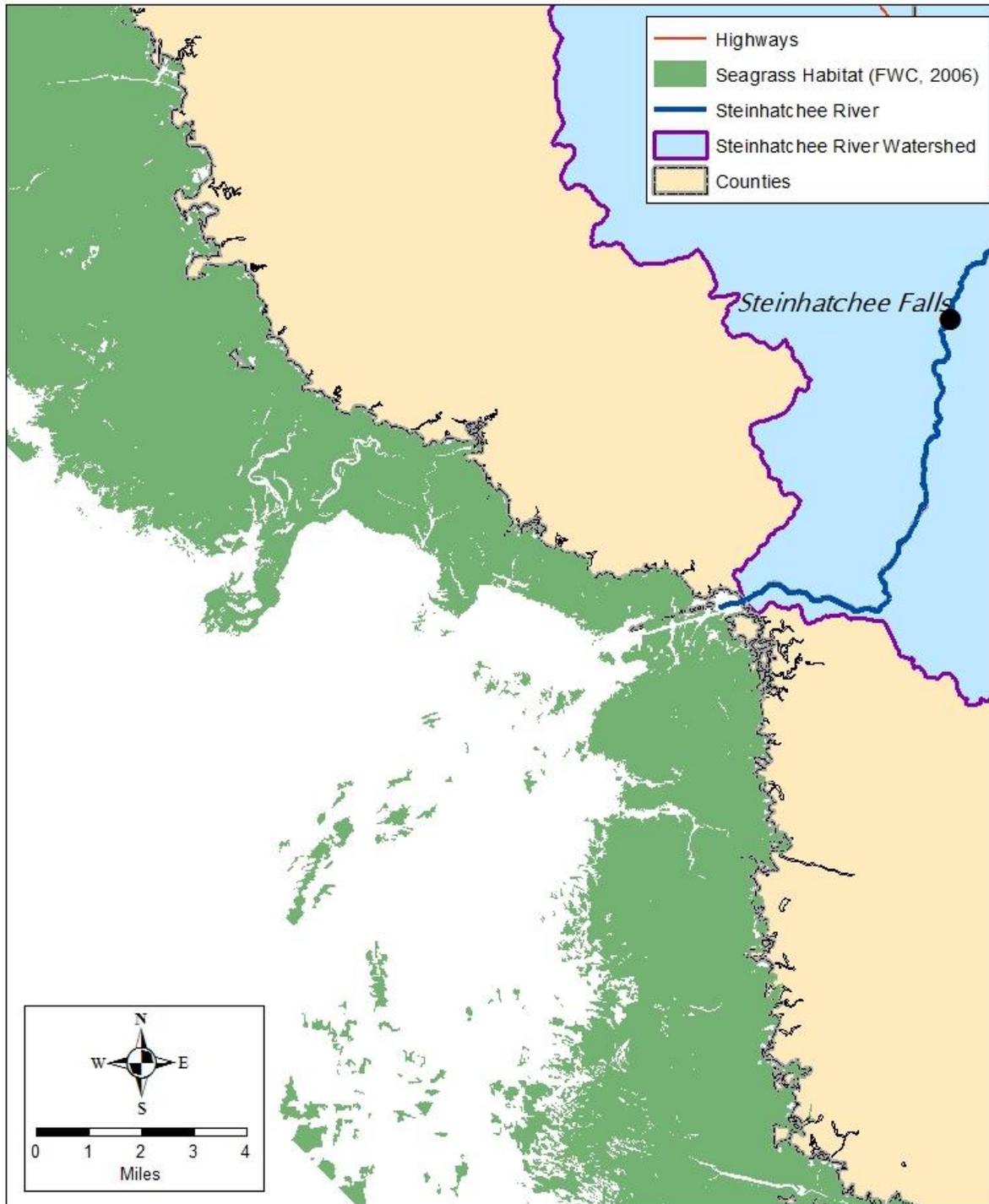


Figure 3-24. 2006 seagrass coverage in nearshore waters of the Steinhatchee River.

Five species of seagrasses (Figure 3-25) have been reported in this area, including turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii*), star grass (*Halophila engelmannii*), and widgeon grass (*Ruppia maritima*). Each of the species listed can tolerate different ranges of salinities and, therefore, occupy different areas of the system. Turtle and manatee grasses prefer higher ranges of salinity, greater than 20 ppt and occupy the areas offshore and near the mouth of the river. Shoal grass prefers salinities between 10 and 25 ppt, and widgeon grass prefers fresh to brackish waters and is often confused with shoal grass in those environs.



Thalassia testudinum
(turtle grass)



Syringodium filiforme
(manatee grass)



Ruppia maritima
(widgeon grass)



Halophila engelmannii
(star grass)



Halodule wrightii
(shoal grass)

Figure 3-25. Seagrasses common to the nearshore waters of the Steinhatchee River.

3.3.3 FISHES

The fish communities within the Steinhatchee River estuary and nearshore Gulf of Mexico waters are both ecologically and economically important and are dependent upon the freshwater flow regimes that define their habitat requirements. This section summarizes some recent work conducted in the study area. There are no available studies of freshwater fish in the Steinhatchee River.

Tsou and Matheson (2002) analyzed 4 years of juvenile fish data collected in the Florida Marine Research Institute's (FMRI's) Fisheries Independent Monitoring (FIM) Program in the Suwannee estuary and found that tidal creeks were an important explanatory variable accounting for the distribution and abundance of several important "FWRI selected taxa." These included important forage species such as spot (*Leiostomus xanthurus*), pinfish (*Lagodon rhomboides*), silversides (*Menidia* spp.) and mojarras (*Eucinostomus* spp.); juvenile sportfish including redfish (*Sciaenops ocellatus*) and spotted seatrout (*Cynoscion nebulosus*); and commercial taxa including blue crab (*Callinectes sapidus*), pink shrimp (*Farfantepenaeus duorarum*), and mullet (*Mugil cephalus*). The researchers attributed one of the main habitat values of tidal creeks to be the associated areas of reduced salinity. Thus, a suitable regime of freshwater inflows is necessary to maintain the fishery habitat values of tidal creeks.

The FWC FIM program has collected fisheries data since 2008. The sampling stations in the area nearest the Steinhatchee River are shown in Figure 3-26. The fisheries data from these stations were analyzed to identify the most abundant (total number of individuals of a species in the sample) (Table 3-5) and most commonly found number of samples where a fish species occurs (Table 3-6).

Three taxa are both relatively abundant and commonly found in the nearshore area: pinfish, pigfish, and black sea bass (Figure 3-27). Pinfish (*Lagodon rhomboides*) was the most abundant (Table 3-5) and commonly found (Table 3-6) species captured by the FIM program. Other abundant and commonly found fish species included pigfish (*Orthopristis chrysoptera*), black sea bass (*Centropristis striata*), planehead filefish (*Stephanolepis hispidus*), and spottail pinfish (*Diplodus holbrookii*).

Steinhatchee River Watershed - Fisheries Independent Monitoring

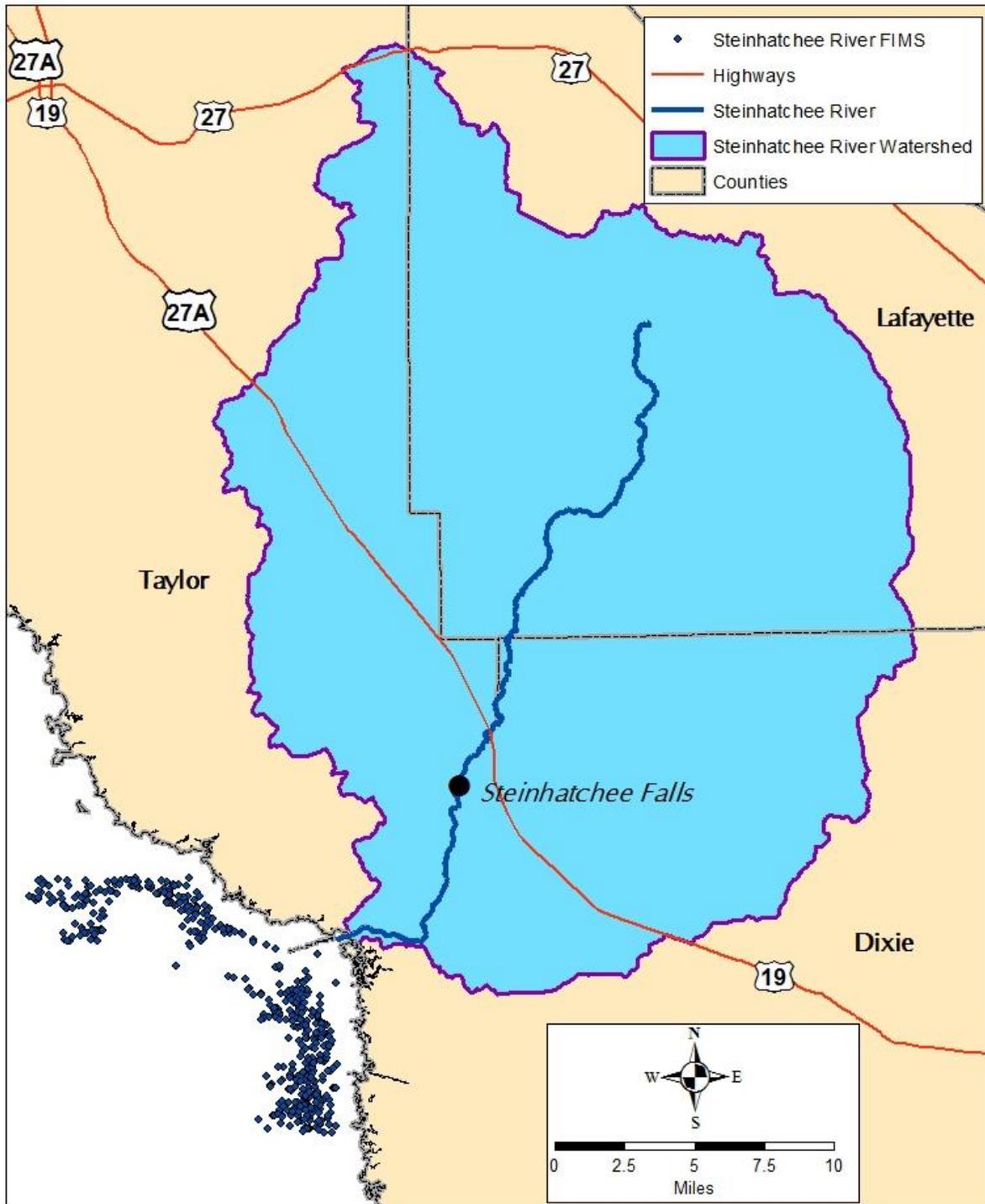


Figure 3-26. Locations of FIM fish sampling stations near the mouth of the Steinhatchee River.

Table 3-5. Ten most abundant fish species collected by the FIM program from stations identified in the study area.

Scientific Name	Common Name	Total Number	Rank
<i>Lagodon rhomboides</i>	pinfish	24,031	1
<i>Orthopristis chrysoptera</i>	pigfish	10,244	2
<i>Diplodus holbrookii</i>	spottail pinfish	5,542	3
<i>Centropristis striata</i>	black sea bass	4,194	4
<i>Stephanolepis hispidus</i>	planehead filefish	2,948	5
<i>Bairdiella chrysoura</i>	silver perch	2,707	6
<i>Syngnathus floridae</i>	dusky pipefish	2,631	7
<i>Monacanthus ciliatus</i>	fringed filefish	1,541	8
<i>Calamus arctifrons</i>	grass porgy	1,208	9
<i>Opsanus beta</i>	gulf toadfish	1,188	10

Table 3-6. Ten most commonly found fish species collected by the FIM program from stations identified in the study area.

Scientific Name	Common Name	# of Samples	Rank
<i>Lagodon rhomboides</i>	pinfish	406	1
<i>Orthopristis chrysoptera</i>	pigfish	384	2
<i>Centropristis striata</i>	black sea bass	375	3
<i>Syngnathus floridae</i>	dusky pipefish	351	4
<i>Stephanolepis hispidus</i>	planehead filefish	335	5
<i>Diplodus holbrookii</i>	spottail pinfish	267	6
<i>Opsanus beta</i>	gulf toadfish	248	7
<i>Chilomycterus schoepfii</i>	striped burrfish	240	8
<i>Calamus arctifrons</i>	grass porgy	235	9
<i>Bairdiella chrysoura</i>	silver perch	226	10



Figure 3-27. Pinfish (*Lagodon rhomboides*) left, pigfish (*Orthopristis chrysoptera*) center, and black sea bass (*Centropristis striata*) right.

3.3.4 BENTHOS

There is a lack of data regarding the composition, distribution, and abundance of estuarine benthos in the Steinhatchee River. Recent studies of estuarine benthos provide some insight to the nature of this critical ecosystem component and how freshwater flows affect their composition, distribution, and abundance.

Steinhatchee River benthic invertebrate samples were collected using petite ponar in November 2005 and March 2006, during a salinity study contracted by SRWMD. Monitoring sites are shown in Figure 3-28, as designated in the study. The sites were sampled beginning approximately 2 miles (3.22 km) from the mouth of the river in Deadman Bay (Site STN00 in Figure 3-28) and ending 0.35 mile upstream of RM 6 (9.66 km) (Site STN666 in Figure 3-28). A maximum of seven salinity sampling events were conducted at each site, at a frequency of ≥ 1 month between October 2005 and September 2006. Mean bottom salinities ranged from 30.70 ppt at STN00 (n=4) to 0.27 ppt at STN666 (n=3) (Figure 3-29), representing an estuarine system ranging from marine to tidal freshwater (Odum et al. 1984). Invertebrate samples were described in terms of biodiversity for each sample site using metrics that included the total number of organisms and the total number of species sampled. The sample collected during the study with the greatest number of individuals included 1,116 individuals from STN509 (Figure 3-28) in November 2005, predominantly polychaetes in the genera *Mediomastus* and *Streblospio*, both typical of marine environments. The total number of species counted in a sample ranged from two at STN336 to 32 at STN085, indicating species richness at these locations may have depended on factors other than salinity, as both sites were polyhaline (salinities \approx 18-30 ppt).

Janicki Environmental (2007) examined the benthic invertebrate communities of a series of rivers from the Springs Coast to Charlotte Harbor along the Gulf Coast. Macroinvertebrate communities were described using metrics including taxon distribution, taxon abundance, prey group taxa abundance, community composition, community diversity and community richness. Analysis of benthic community structure was then used to understand the general geographical differences in benthic communities among rivers. The most abundant and commonly found taxa across all rivers included three amphipod crustaceans and a polychaete - *Grandidierella bonnieroides*, *Ampelisca abdita*, *Apocorophium louisianum*, and *Streblospio gynobranchiata*. The Springs Coast rivers had the most unique dominants (n =

16), even though the fewest samples were collected from these rivers. Ten of these 16 were crustaceans, including four amphipods.



Figure 3-28. SRWMD 2005 and 2006 salinity and benthic macroinvertebrate sampling sites.

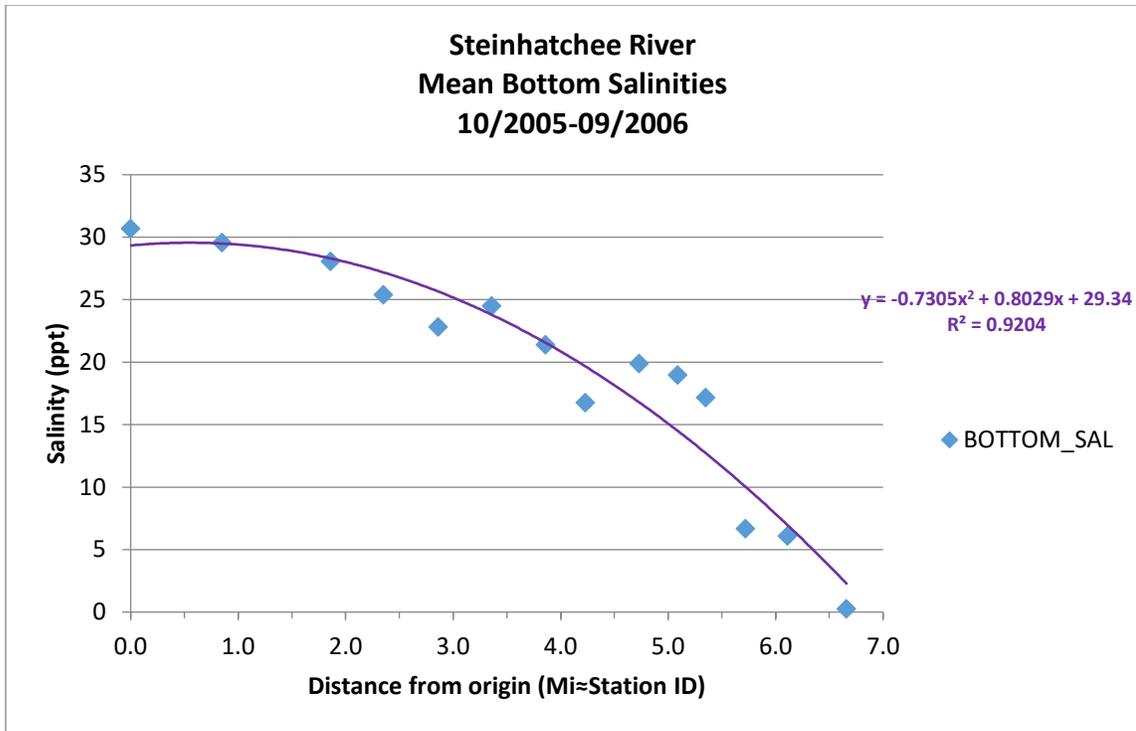


Figure 3-29. Mean measured bottom salinities during sampling events conducted in 2005 and 2006 at SRWMD salinity sampling sites.

The bay scallop (*Argopecten irradians*) is found throughout much of the Florida Gulf Coast (Figure 3-30) and supports one of the most popular and family-oriented fisheries currently pursued in Florida coastal waters. Arnold et al. (1998) indicates that only two consistently productive local populations remain in Florida, one located in the coastal waters near Steinhatchee and the other located within St. Joseph Bay. Many of the local jobs in the Steinhatchee community depend on the water, including guides, or commercial fishermen, and those who work in restaurants or lodgings that cater to people who visit Steinhatchee for boating and scalloping during the summer season (Florida Department of Community Affairs 2009).

The primary habitat for bay scallops is seagrass beds, particularly *Thalassia* and *Syringodium*, but it is not uncommon for scallops to be found in open sand areas or lying on algal mats among the seagrass beds. Scallops are commonly found in patches that are densely populated relative to background abundance (Arnold 2009). Growth variation is controlled by temperature in young scallops, and by temperature and food supply in larger scallops (Tettelbach and Rhodes 1981, Kirby-Smith 1970).

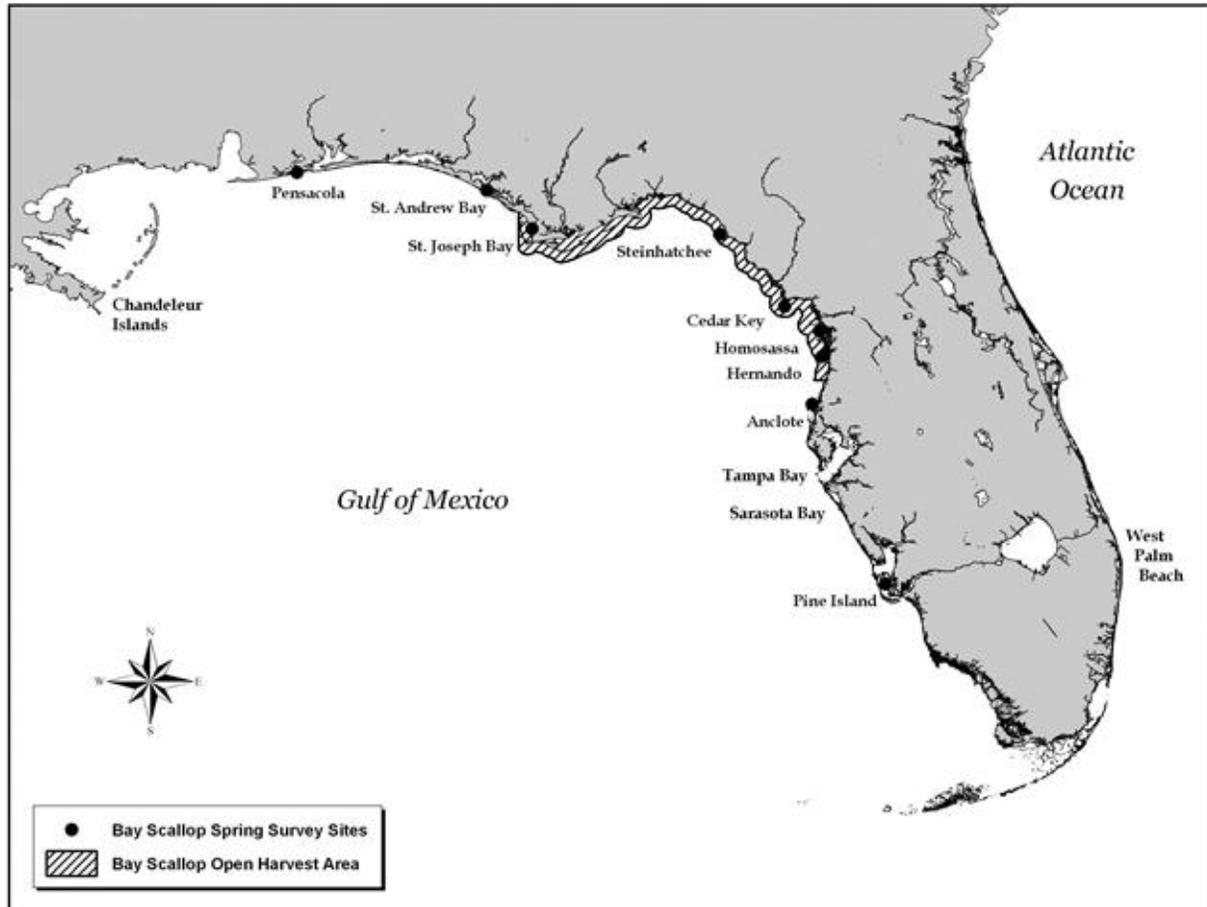


Figure 3-30. Bay scallop open harvest areas on Florida’s gulf coast. From Arnold (2009).

Laboratory studies suggest that either high (> 30 ppt) or low (<20 ppt) salinity can result in mortality, with an apparent optimal salinity of approximately 24 ppt (Tettelbach and Rhodes 1981). Bay scallops may survive low salinities (7 ppt) by closing their valves for very short periods of time of less than 2 hours (Sastry 1961 *in* Leverone 1993). Short exposures to low salinities from heavy runoff may not affect bay scallop survival, but in shallow estuaries (such as Tampa Bay) such events can result in prolonged salinity reductions, which would ultimately and severely affect bay scallop survival (Leverone 1993). High turbidity levels interfere with normal growth and reproductive processes in bay scallops and soft mud and silt substrates are harmful to the survival of settling juveniles (Leverone 1993). Survival of juvenile *Argopecten irradians* is significantly affected by mercury, and the toxicity at low concentrations is enhanced by high temperature and low salinity (Leverone 1993). A study in Tampa Bay (Leverone 1993) found scallops can tolerate moderate to prolonged exposures to DO concentrations less than 2 mg/L.

Bay scallops are short-lived (about 12 to 18 months in Florida waters), functionally hermaphroditic bivalves thought to spawn once as water temperatures decline in the fall (Leverone 1993, Geiger et al. 2010). While peak spawning appears to occur in the fall season in Florida, ongoing studies show that spring spawning occurs in some years, and recruitment has been recorded in almost every month of the year (Arnold 2009). In the Anclote River Estuary, Geiger et al. (2010) reported fall peaks in recruitment, minor spring peaks, and frequent, prolonged periods of recruitment involving small numbers of recruits. The patchy distribution pattern of bay scallops may facilitate successful reproduction. Since scallops are broadcast spawners, the likelihood of successful fertilization is enhanced by proximity (Levitan 1995 in Arnold 2009). Geiger et al. (2010) describe the developmental cycle of bay scallops. Larvae first settle and attach to seagrass blades where pediveligers (larvae that have developed a foot) grow into juvenile scallops, or spat, and gradually move up the seagrass blades out of the reach of bottom-dwelling predators. When the juveniles reach about 20 millimeters (mm) in shell height, they detach from the grass blades and fall to the bottom, where they spend the rest of their lives. They can move small distances by expelling water and scooting either backward or forward through the water.

Bay scallops are filter feeders, straining food particles on the gill cilia. The primary foods of bay scallops are benthic and tychopelagic diatoms, although a variety of algal species are efficiently utilized (Leverone 1993). Common benthic predators of bay scallops include various crab species, starfish, sea urchins, oyster drills, whelks, and cownose rays. Gull (ring-billed and herring) predations have also been cited as responsible for late fall declines in North Carolina (Leverone 1993). The pea crab (*Pinnotheres maculatus*) is an internal commensal parasite of the bay scallop. Infected scallops have been shown to have slower growth and lower mean dry weights than uninfected scallops (Kruczynski 1972 in Leverone 1993). A small portion of bay scallop mortality has been attributable to parasites and disease, although the occurrence of these agents in natural populations of scallops is low, however, disease under hatchery conditions can cause high mortalities (Leverone 1993).

The popularity of scallops as a target for recreational and commercial fishermen appears to have contributed to local declines and the implementation of more stringent management measures (Arnold et al. 1998, Arnold 2009). Relatively high-density local populations of bay scallops are now limited to areas north and west of the Suwannee River. For populations south of the Suwannee River, overfishing, habitat degradation, and toxic dinoflagellate

blooms may be contributing factors for population collapse (Arnold et al. 1998). The loss of some local populations may have imperiled nearby populations that are dependent on the influx of allochthonous larvae for their long-term survival and, thus, the lack of recovery of those populations may reflect reductions in larval supply and subsequent recruitment failure (Arnold et al. 1998).

Arnold (2009) describes the regulatory history for bay scallops in Florida. The first substantial regulations regarding commercial or recreational harvesting of Florida bay scallops were implemented in 1985 with a closed season, recreational bag limit and definition of allowable dimensions for commercial harvest gear. Regulations banning the commercial fishery for bay scallops in Florida began in 1994. Additionally, the recreational harvest area was limited to the area north of the Suwannee River for a limited period of each year. Various open seasons and bag limits were instituted over the years and, in 2002, the area from the Suwannee River south to the Weeki Wachee River was reopened to recreational harvest and the area from the mouth of St. Joseph Bay west to the Florida-Alabama line was closed to harvest due to low scallop abundance in that area. The Florida Fish and Wildlife Conservation Commission (FWC) (<http://myfwc.com/fishing/saltwater/recreational/bay-scallops/>) lists the current open recreational season as the Saturday before July 1 (unless July 1 is a Saturday) through September 24 in the bay scallop harvest zone defined as state waters from the Pasco-Hernando County line to the west bank of the Mexico Beach Canal in Bay County. In fall 1998, the first major stock enhancement effort was made with the stocking of spawner restoration stocks in Homosassa Bay, Anclote Estuary, and Tampa Bay (Arnold et al. 2005, Bert et al. 2014).

Various researchers (as cited in Bert et al. 2014), including Arnold et al. (1998), have postulated that Florida Gulf bay scallops are distributed as a series of disjunct subpopulations that together formed a metapopulation and that the Steinhatchee subpopulation might be the main provider of migrants to other subpopulations. Bert et al. (2014) genetically tested these theories and found that for the Florida Gulf bay scallop metapopulation, Steinhatchee and Homosassa area scallops are the core source population; however, every population has at least one subpopulation that could act as a local source. Additionally, Bert et al. (2014) determined that the location and extent of seagrass beds, together with the circulation patterns of the four Florida Gulf seasonal

current domains, were the basis for Florida Gulf bay scallops metapopulation structure. Genetic evidence indicated that the core source population, including Steinhatchee and Homosassa, is the largest and most stable population, and it is essentially self-sustaining (Bert et al. 2014). Bert et al. (2014) indicate that the combined effects of prolonged intensive harvesting, loss of critical seagrass habitat, decline in water quality, and mortality resulting from red tides and floods have decreased the number of stable populations in the Florida Gulf to just 1 metapopulation – the core area (principally Steinhatchee in some years, Homosassa in others). The continued general reduction in bay scallop abundance and number of stable subpopulations after years of closure of most of the fishery and restrictions on open areas (Arnold 2009) indicates the metapopulation is in decline. Bert et al. (2014) also indicate that current Florida Gulf bay scallop fishery regulations include a component that is not advocated as a management strategy for metapopulations: heavy harvesting in source subpopulations (primarily Steinhatchee and Homosassa).

The FWC has conducted annual scallop surveys in the spring (and, at a lesser frequency, in the fall) at the Steinhatchee since 1994 (Figure 3-31). Mean annual abundance indices for scallops at the Steinhatchee survey site are shown in Figure 3-32. Patterns in mean abundance are similar for sampling stations to the north and the south of the Steinhatchee River. However, in some years, mean abundance is higher to the north, and in other years, higher in the south. According to the 2014 bay scallop annual report (FWC 2015), spring abundance value in 2014 was 7 percent of the highest density observed during spring surveys in 1996. Additionally, the percentage of stations with scallops present decreased, as did the number of patches (stations with greater than 60 scallops). Based on available data, the site was classified as vulnerable and sparse (FWC 2015). The report cited poor visibility during the spring survey following 2 years of locally intense rainfall and freshwater runoff.

FWC (2015) concluded that peaks in abundance at the Steinhatchee site are decreasing in amplitude and frequency. However, the population is considered the most stable population in the state and is deemed to be the core population of Florida bay scallops (FWC 2015). Despite declining densities, the report states that the population has never collapsed, remains a highly targeted area for recreational harvesters, and has been resilient in the past, recovering quickly from a 1998 El Niño and even after a 4-year low period (2004-2007; FWC 2015).

Steinhatchee River Watershed -FWC Scallop Monitoring

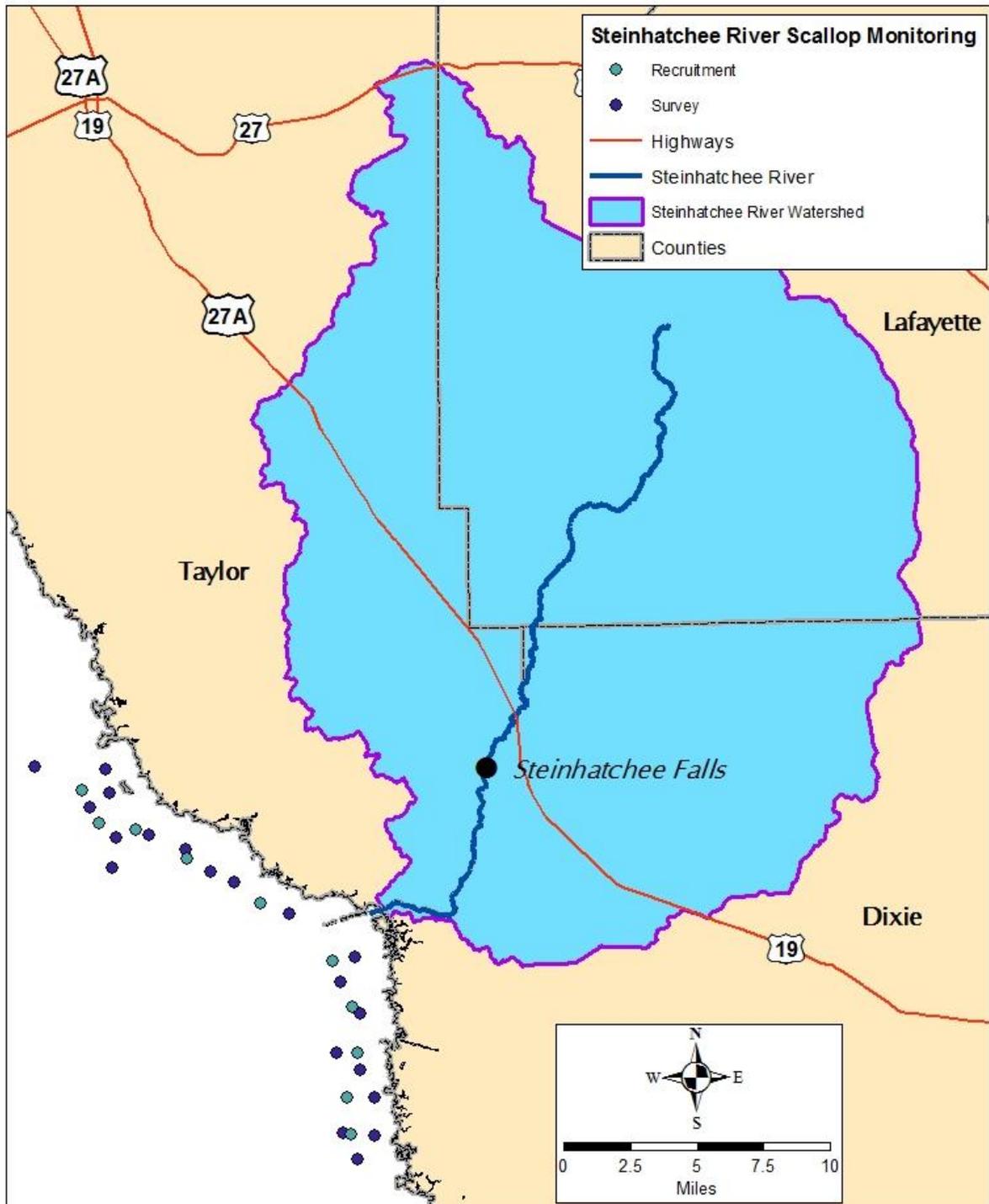


Figure 3-31. The FWC Steinhatchee bay scallop study site.

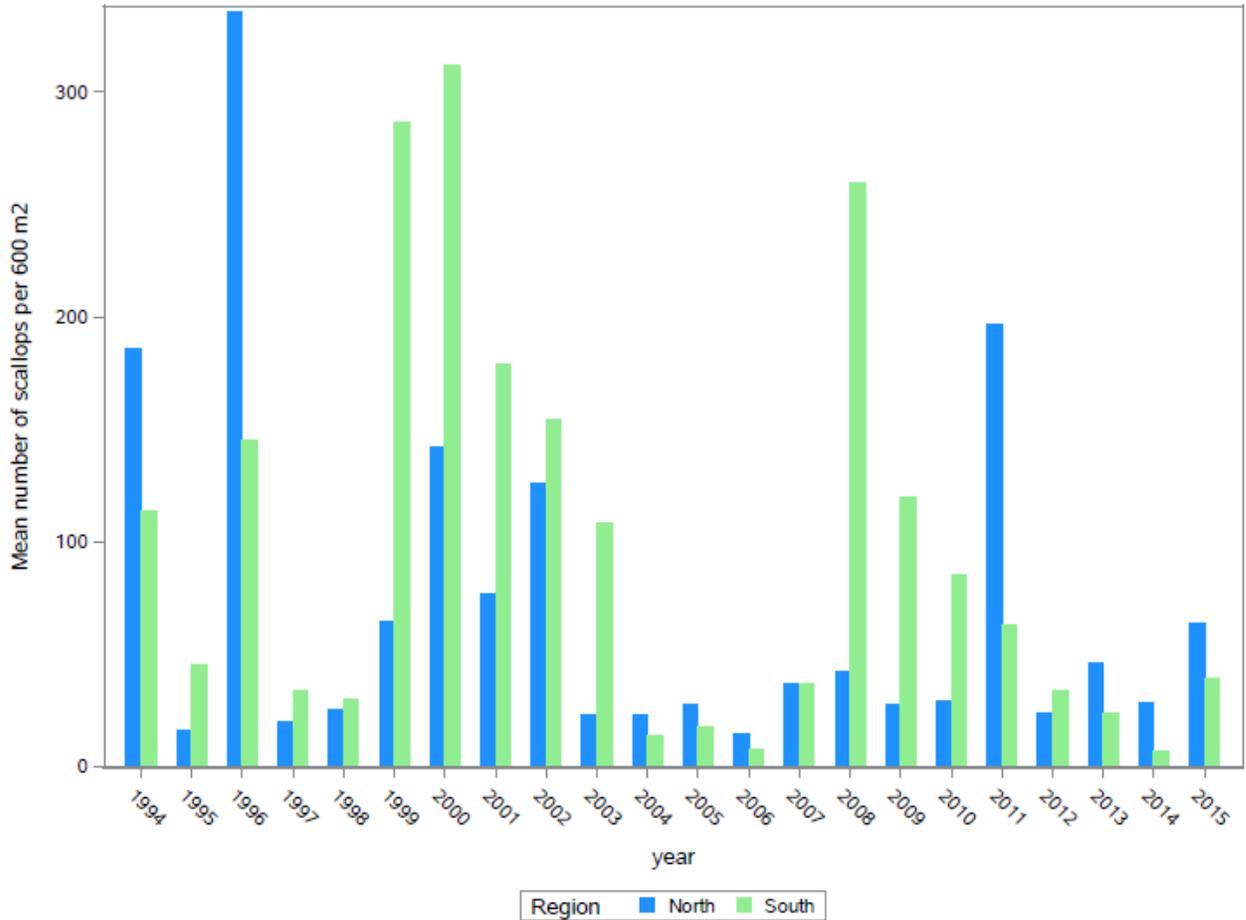


Figure 3-32. Mean number of scallops per 600 m2 during annual spring scallop surveys conducted by FWC north and south of the Steinhatchee River. Data obtained from FWC.

3.4 FRESHWATER BIOTA

Benthic taxonomic data for the Steinhatchee River collected from two stations (Figure 3-1) were obtained from the SRWMD’s biological database. These stations correspond to locations where water quality data were collected. SRWMD Station STN040C1 had only one sampling date (11/27/2007) where benthic taxonomic data were reported. Data from Station STN031C1 were available from November 1992 through August 2010. Benthic data from these stations were analyzed to identify the most abundant (total number of a species in the sample, Table 3-7) and most commonly found (number of samples where a species occurs) taxa (Table 3-8).

The greatest number of individuals of any species (most abundant) were the amphipod crustacean *Hyalella azteca* (Table 3-7), and this was also the second-most common species (Table 3-8) captured by SRWMD monitoring. The most commonly found species was the

eastern grass shrimp, *Palaemonetes paludosus*, which was also had the third greatest abundant of individuals found. Other abundant and commonly found benthic species included the Dipteran *Rheotanytarsus exiguus* group and the gastropod Rasp Elimia (*Elimia floridensis*).

Table 3-7. Ten most abundant benthic taxa collected by SRWMD from stations identified in the study area.

Scientific Name	Total Number	Rank
<i>Hyalella azteca</i>	666	1
<i>Rheotanytarsus exiguus</i> group	487	2
<i>Palaemonetes paludosus</i>	331	3
<i>Elimia floridensis</i>	271	4
<i>Amnicola</i> sp.	184	5
<i>Chironomus</i> sp.	174	6
<i>Caecidotea racovitzai</i>	162	7
<i>Polypedilum flavum</i>	156	8
<i>Simulium</i> sp.	142	9
<i>Planorbella trivolvis</i>	134	10

Table 3-8. Ten most commonly found benthic taxa collected by SRWMD from stations identified in the study area.

Scientific Name	# of Samples	Rank
<i>Palaemonetes paludosus</i>	47	1
<i>Hyalella azteca</i>	41	2
<i>Elimia floridensis</i>	40	3
<i>Planorbella trivolvis</i>	24	5
<i>Polypedilum flavum</i>	24	5
<i>Rheotanytarsus exiguus</i> group	24	5
<i>Caenis diminuta</i>	23	7.5
<i>Enallagma</i> sp.	23	7.5
<i>Caecidotea racovitzai</i>	22	9
<i>Musculium lacustre</i>	21	10.5

FDEP initiated a nutrient longitudinal study (FDEP 2016) in 2008 to evaluate downstream biological responses to naturally high upstream phosphorus levels. As part of this study, samples were collected in August 2008 and January 2009 to compute habitat assessment and stream condition index (SCI) scores for freshwater biological sites from the Steinhatchee River (Figure 3-33 and Table 3-9).

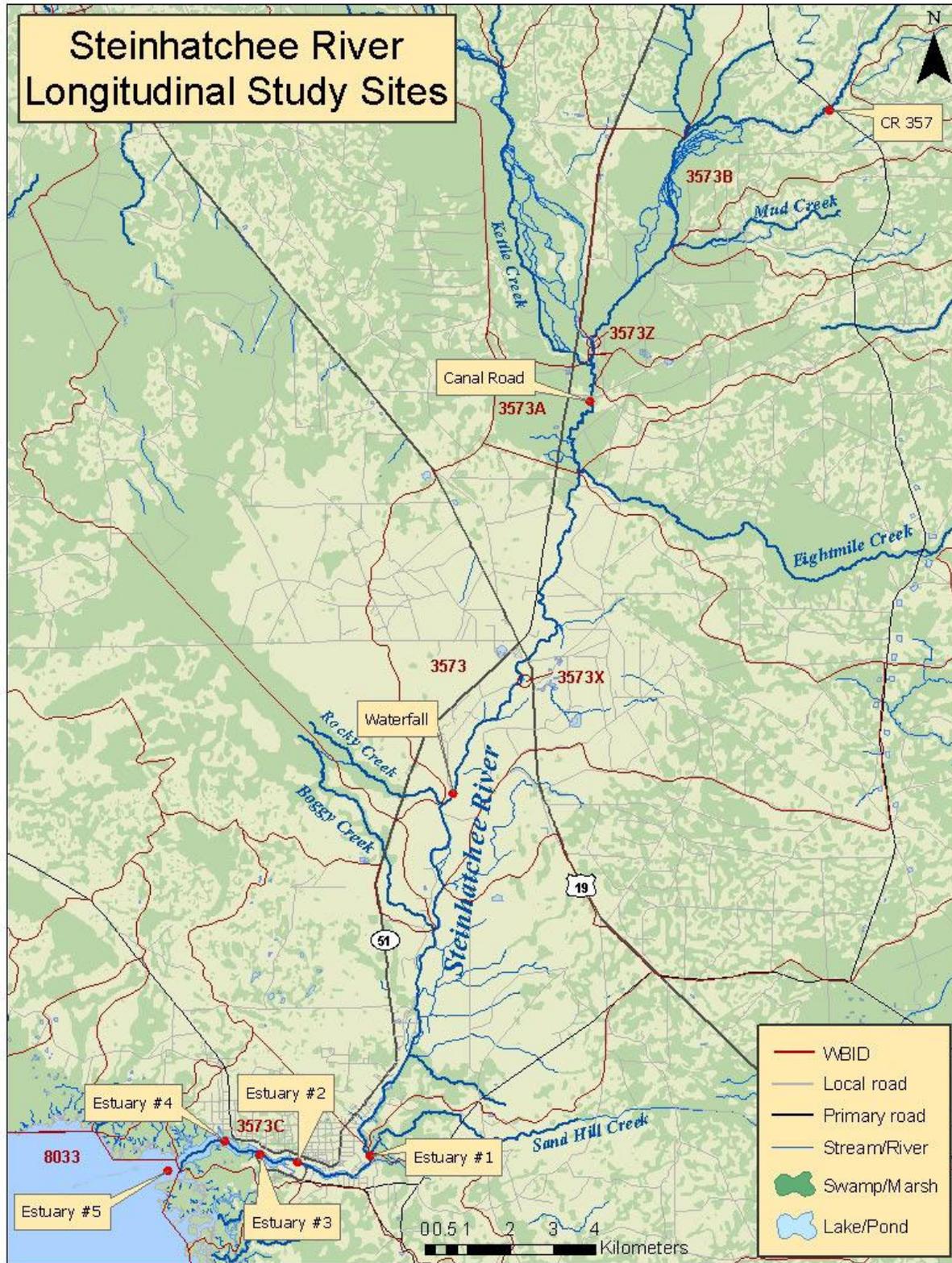


Figure 3-33. Locations of the longitudinal study sampling stations on the Steinhatchee River. (Source: FDEP)

Table 3-9. Qualitative periphyton sampling results from the Steinhatchee River as reported in the FDEP Nutrient Longitudinal Study (FDEP 2016).

Periphyton	CR 357	Canal Rd
% Bacillariophyta	76.5	63.8
% Chlorophycota	5.7	9.3
% Cyanophycota	17.7	26.3
% Euglenophycota	0.2	0.0
% Cryptophycophyta	0.0	0.2
Total # Taxa	56	63

Average habitat assessment scores were in the “optimal” range. SCI scores from one of two Steinhatchee sites (Canal Road) were above the impairment threshold of 40, while one score in August at the second site (CR 357) was below this threshold, with a score of 20 (FDEP 2016). However, the study report indicates that the CR 357 site was experiencing low flow conditions at the time of sampling and the lower SCI score was probably due to hydrologic conditions. By the January sampling, flow had increased, and the SCI score improved to 53 (FDEP 2016). The report also indicated that the lower SCI scores relative to a second river studied, despite high habitat assessment scores, might be due to the naturally higher specific conductance in the Steinhatchee River, most likely due to influences from the limestone substrate (FDEP 2016).

As part of the longitudinal study, FDEP collected periphyton for taxonomic identification from natural substrates at the two freshwater sites evaluated for habitat assessment and SCI scores. The periphyton community was dominated by diatoms (Bacillariophyta, 76.5 percent and 63.8 percent at CR 357 and Canal Road, respectively), as indicated by the qualitative periphyton sampling results (Table 3-9, FDEP 2016). The report indicated that the majority of periphyton observed was less than 0.5 mm long or non-visible. The Canal Road site had filamentous algae growing on a section of rocky limestone within the assessment area, however, the algal growth did not adversely affect the macroinvertebrate community, as evidenced by the average SCI score of 51.5 (FDEP 2016).

4.0 CONCEPTUAL MODEL AND APPROACH TO MFL ESTABLISHMENT

To be an effective water resource management tool, the establishment of MFLs must consider protection of the entire flow regime and not strictly low flow conditions. Thus, in some ways, the term “minimum flow and level” may be a misnomer.

The importance of protecting the full flow regime has been recognized by others and is reflected in multiple MFLs being set for various waterbodies. This became most apparent in cases where inline reservoirs could significantly affect both the low flow and high flow extremes. Richter et al. (1996) concluded that both intra- and inter-annual variations in flow should be protected, thus mimicking the natural flow regime. Postel and Richter (2003) also emphasized the critical nature of flood events in terms of both frequency and duration.

Stalnaker (1990) discussed the influence of flows on physical processes (e.g., sediment transport, channel formation), which, in turn, affect biological resources. This linkage was also apparent to Hill et al. (1991), who identified four types of flows that should be considered when examining river flow requirements, both for in-stream and out-of-bank floodplain habitat:

- Flood flows that determine the boundaries and shape of floodplain and valley features
- Overbank flows that maintain riparian habitats
- In-channel flows that keep immediate streambanks and channels functioning
- In-stream flows that meet critical biota requirements

Therefore, establishment of MFLs considers broad ecological functions. As stated in Section 1.0, of the State Water Resources Implementation Rule regarding MFLs (Chapter 62-40.473, F.A.C.) “...consideration shall be given to natural seasonal fluctuations in water flows or levels, non-consumptive uses, and environmental values associated with coastal, estuarine, aquatic, riverine, spring, aquatic and wetlands ecology...” These environmental values and water resource values (WRVs) include:

- Recreation in and on the water
- Fish and wildlife habitats and the passage of fish

- Estuarine resources
- Transfer of detrital material
- Maintenance of freshwater storage and supply
- Aesthetic and scenic attributes
- Filtration and absorption of nutrients and other pollutants
- Sediment loads
- Water quality
- Navigation

The following sections discuss each of these WRVs and their relationship to the Steinhatchee River.

4.1 RECREATION IN AND ON THE WATER (WRV 1)

Recreation is an important use of the Steinhatchee River. Recreational use of the freshwater portion of the river and associated lands is at greater risk from flow reduction than the tidally-controlled estuary. This is because the water level conditions in the lower reaches are driven by tidal conditions rather than freshwater inflow.

An estimated eight or more charter boat companies or marinas are located within 3 miles of the mouth of the river. Motor boats make frequent use of this 3-mile stretch of the river because of easy access to the Gulf of Mexico. In addition to the typical seasonal fish that the Gulf of Mexico offers, the river and surrounding Gulf waters also support a robust scalloping industry. Charter boat businesses experience an increase in business during scalloping season, as do the local businesses that surround the river.

Motor boat activity is less common upstream of the Steinhatchee Landing Resort, located about 3 miles upriver of the mouth. Kayaking and canoeing are popular from this point and farther upriver because of the infrequent human presence on the river. Local officials recently were successful in having the Steinhatchee River designated one of the 50 rivers in Florida that comprise Florida's Designated Paddling Trails, managed under FDEP's Greenways & Trails program. As defined by 260.013 F.S., this designation grants FDEP legal authority to limit motorboat use in parts of the river. The act also allows FDEP to provide public access to the greatest extent possible while avoiding unnecessary impacts to

sensitive environments such as wetlands or animal habitats, wherever encountered. Thus, the river gains moderate legislative protection under this designation.

While the river has always been popular for sport fishing, the area also attracts nature lovers due to its low population density, natural scenic beauty, and old-Florida ambiance, and efforts are underway to increase eco-tourism. The river has many eco-tourism attractions, but the most popular is kayaking various stretches of the system both upstream and downstream of Steinhatchee Falls. Steinhatchee Falls is a 3-foot waterfall formed by a limerock outcropping in the river (Figure 3-21). The falls and adjacent public park serve as an important scenic stopping point along the paddling trail.

4.2 FISH AND WILDLIFE HABITATS AND THE PASSAGE OF FISH (WRV 2)

Freshwater fish and wildlife are important factors in the Steinhatchee River's appeal to the public. Instream fish habitat can be characterized by water depth, velocity, and suitable substrate, all three of which may be adversely affected by flow reduction. Freshwater fish passage also can be adversely affected by flow reductions as might occur during low-flow conditions.

Of the 32 birds the federal government or State of Florida lists as threatened, endangered or of special concern (FWC 2017), at least 10 are wading birds (e.g., wood stork) or birds with foraging strategies similar to wading birds (FWC 2013), any of which may be observed along the Steinhatchee. Colonial nesting water bird breeding success is generally correlated to high water levels that trigger the life cycles of aquatic invertebrates and fishes. This is followed by a draw-down in prairie ponds, marshes, streams, and rivers, where fish prey are trapped in pools, ponds, temporarily isolated marshes, and sloughs of varying sizes and depths as water levels decline across the landscape, and become easily available to foraging birds. Thus, any proposed reduction in flow must take into consideration the potential impact on the inter-dependency of species and prey with historical water level cycles.

For some WRVs, best available data may provide evidence that a threshold flow (or stage) magnitude must persist for some finite duration and occur with some minimum (or maximum) frequency to protect the WRV from degradation. Lower flood depths maintained continuously for a period of 14 days that occur every 2 to 5 years were determined to be

important descriptors of general flood conditions affecting tree regeneration in riverine floodplain forests (Light et al. 2002). These floods restrict regeneration in wetland forests by limiting seedlings of exotic invasive species and opportunistic hardwoods to gain enough height during the period to survive the next flood. Floods greater in magnitude occur less frequently, thus allowing more time for young trees to reach heights that exceed flood depths. Note that the metric used for evaluating the WRV is the time between the flood events that restricts the growth of invasive plant species.

4.3 ESTUARINE RESOURCES (WRV 3)

Estuarine resources are the flora and fauna that inhabit brackish water with salinity between 0.5 and 30 ppt. Salinity reflects a blend of freshwater with a saline (greater than 30 ppt) source like the Gulf of Mexico. The salinity regime at any location is inversely proportional to freshwater flow, such that higher salinity is associated with lower freshwater flow. In terms of spatial distribution, diminished freshwater flows can result in an isohaline movement upriver. This WRV is clearly associated with the use of the Steinhatchee estuary for recreational scalloping and fishing. In the estuarine portion of the river, low salinity fauna may experience habitat loss due to increased salinity as freshwater inflow to the estuary is reduced by withdrawals. The biota typically found in the estuarine portion of the river will have relatively wide salinity tolerances. These can include vegetation, benthic organisms, and fishes. However, if salinity responses to changes in river flows result in salinity conditions outside their tolerances, shifts in the distributions of the biota can be expected to occur. In addition, the habitat available for biota is critical to the maintenance of ecosystem function in the estuarine portions of waterbodies such as the Steinhatchee and the Big Bend Seagrass Aquatic Preserve; the latter has been afforded legislated protection per Chapter 62-302.700, F.A.C. Therefore, consideration of estuarine resources in the establishment of the Steinhatchee MFL is essential.

4.4 TRANSFER OF DETRITAL MATERIAL (WRV 4)

Detrital material is a food source for detritivores that obtain nutrients by consuming decomposing plant and animal material. These primary consumers are crucial to benthic ecosystems. There is an ample supply of organic matter from the headwaters of the Steinhatchee River along the length of the riparian corridor (i.e., to San Pedro Bay and Mallory Swamp). While flow reduction could reduce the downstream transfer of this organic energy, this WRV is concluded to be less important for the Steinhatchee River than the

three previously addressed WRVs. Additionally, there are no data available to assess this WRV.

4.5 MAINTENANCE OF FRESHWATER STORAGE AND SUPPLY (WRV 5)

Maintaining freshwater storage is a relevant WRV that involves the protection of an amount of freshwater supply for permitted users at the time of MFLs determination. The direct withdrawal of surface water or an indirect flow reduction associated with groundwater withdrawals will reduce streamflow to one degree or another. These facts are supported by the statewide regulation of water use and provisions for reviewing water use applications where MFLs have been established in Chapter 373.22, F.S.

The permitted uses of water can range from public supply to environmental restoration. For example, in 2013, SRWMD completed the Steinhatchee Rise Dispersed Water Storage Project (DWSP). The objective of this project is to help return the property to its natural conditions by allowing more than 8 million gallons of freshwater to flood 50 acres of adjacent SRWMD-owned wetlands. While the primary goal of the project is to reconnect storage capacity and return this section of land to its historical state, it also is intended to improve the water quality of the river and estuary and reduce downstream flooding impacts.

4.6 AESTHETIC AND SCENIC ATTRIBUTES (WRV 6)

WRV 6 refers to features of a natural or modified waterscape usually associated with passive uses, such as sightseeing, hiking, photography, contemplation, and other forms of relaxation. The most prevalent aesthetic attribute is Steinhatchee Falls. Generally, there is little quantitative information linking aesthetics and flow suitable for the establishment of MFL criteria. In this case, consideration may be given to the nature of Steinhatchee Falls as it relates to river flows.

4.7 FILTRATION AND ABSORPTION OF NUTRIENTS AND OTHER POLLUTANTS (WRV 7)

This WRV refers to the attenuation of nutrients and other pollutants through the process of filtration and absorption (i.e., removal of suspended and dissolved materials) as these substances move through the water column, soil or substrate, and associated organisms. These processes are different from assimilation, a process in which inorganic nutrients and organic matter are integrated into living matter.

4.8 SEDIMENT LOADS (WRV 8)

Sediment loads refer to the transport of inorganic material, suspended in water, which may settle or rise. A load, by definition, is the product of discharge and sediment concentration; thus, flow reductions would likely reduce sediment loads. The river bottom is largely composed of limerock, and the smaller sediments are relatively less common. Maintaining the river's limestone and gravel streambed and avoiding the gradual coverings of rocks with silt is important to the river's viability as a habitat for benthic ecosystems.

This WRV is less important to this river, particularly in the freshwater portion, due to the absence of high concentrations of silt and coarser particulate suspended sediment (HSW 2014). Meanders with sandbars on the inside bend are not apparent in aerial images of the river (Google Earth 2014). Historically, total dissolved solids (TDS) have ranged below the minimum standard of ≤ 500 mg/L, as a monthly average, or a maximum of $\leq 1,000$ mg/L for Class I waters, per Rule 62-302.530, F.A.C. (Figure 4-1). The rule does not specify a limit for Class III waters. Low sediment loads are characteristic of forested land uses, particularly as compared to urban and agricultural land use (Lenat and Crawford 1994). A modest negative correlation occurs between the low silt load, expressed as TDS, and discharge for the Steinhatchee (Pearson Correlation Coefficient = -0.49; $p < 0.0001$; Discharge range = 2.1-1,850 cfs) for the data illustrated in Figure 4-1.

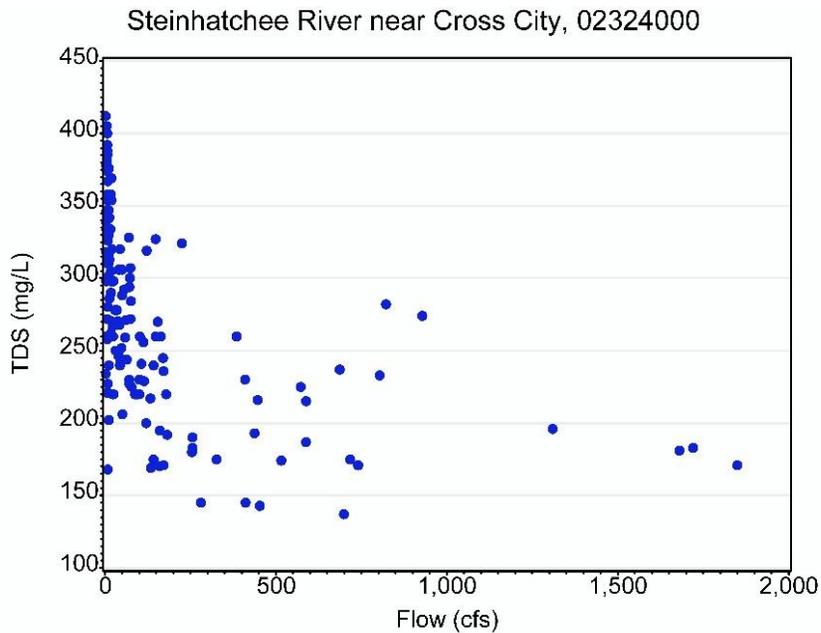


Figure 4-1. Total dissolved solids versus flow from the USGS gage Steinhatchee River near Cross City (02324000) between February 12, 1990 and September 16, 2009.

4.9 WATER QUALITY (WRV 9)

Water quality refers to the chemical and physical properties of water not included in WRV 7. The association of water quality with freshwater flows is likely complex. For example, lower flows are associated with lower velocities, longer residence time, and an increased biological assimilation of organic matter to the extent that DO regimes are affected. Some data exist that indicate water quality may degrade with lower flows.

FDEP presently maintains lists of the impairment status of waterbodies throughout the State of Florida. For the Steinhatchee River, FDEP has broken the waterbody into two segments (WBIDs – Water Body IDs) for the water quality impairment analyses. The segments are the marine portions of the Steinhatchee (WBID 3673C), and the freshwater portion (WBID 3573B). Based upon the most recent impairment assessment for these segments, neither the freshwater portion nor the marine portion are impaired for nutrients, Chl a or dissolved oxygen. These are the primary parameters generally impacted by changes in residence time due to flow reductions. Presently, the freshwater portion of the system is impaired for fecal coliforms. The estuarine portion was previously listed as impaired for fecal coliforms but was recently taken off the impaired list for this parameter based upon the determination that the original impairment was based on faulty data analyses.

4.10 NAVIGATION (WRV 10)

While navigation in the upper river is directly impacted by changes in flow, navigation is not a relevant WRV for the Steinhatchee River because minimum water depth in the Federal ship channel is controlled by tide stage not river flow. Small boat traffic and commercial guide operations upstream of the Federal channel will be protected under WRV 1 (Recreation In and On the Water).

4.11 PRELIMINARY SCREENING AND IDENTIFICATION OF RELEVANT WRVS

A qualitative evaluation of risk and value was performed to identify WRVs most relevant to that system (HSW and Janicki Environmental 2015). This evaluation was based on review of available information and assessment of outcomes that potentially could result under a flow-reduction scenario. The 10 WRVs were scored on a nine-point scale for relevance from low (1 point) to high (9 points) by considering the risk of adverse consequences attributable to a flow reduction, the intrinsic value of the WRV, and existence of legislated protection (Table 4-1). A WRV that would be adversely impacted by a flow reduction is scored higher than one

that would be impacted to a lesser degree or not at all. Intrinsic value is a measure of how essential the WRV is perceived to be to the public and water managers. The legislated protection factor is a measure of a WRV's perceived value as evidenced by special legislation that protects the water resource.

Table 4-1. Steinhatchee River water resource values screening summary.

WRV	Water Resource Value	Scoring for Relevance*			Total Score
		Risk to Flow Reduction	Overall Intrinsic Value	Legislated Environmental Protection	
1	Recreation in/on water	2	3	2	7
2**	Fish/wildlife habitat and fish passage	3	3	2	8
3**	Estuarine resources	3	3	2	8
4	Transfer of detrital material	2	1	1	4
5	Maintain freshwater storage	2	1	2	5
6	Aesthetic/scenic attributes	2	3	1	6
7	Filtration/absorption of nutrients/other pollutants	2	2	1	5
8	Sediment loads	2	1	1	4
9	Water quality	2	3	2	7
10	Navigation	1	2	1	4

*Scoring factors for relevance are 1 for low, 2 for medium, and 3 for high. Adapted from HSW, Inc. and Janicki Environmental (2015).

**The WRVs evaluated in this MFL have been highlighted.

4.12 SUMMARY OF STEINHATCHEE RIVER WATER RESOURCE VALUES

A collection of human activities, hydrogeomorphic processes, and/or the health and sustainability of floral and faunal characteristics of the Steinhatchee River may be used as WRV indicators for the river. For example, a key indicator used to assess the recreational viability of a river would be access to the river by boaters and paddlers. WRV indicator metrics are surrogate measures of water resource values that may be related to the discharge of the river. The association between flow and a WRV metric is referred to as a response function.

WRV metrics can be expressed in terms of time, distance, area, or other meaningful characteristics. For instance, kayakers and other recreational users of the river are more

likely to relate to a flow reduction and the associated change in the number of days available for river access for paddling or boating than they would to a change in navigable distance that a flow reduction might cause. Likewise, the natural life cycle of a certain animal species (e.g., scallops) may require some minimum hydrologic condition sufficient for spawning that must be maintained frequently enough and for a minimum duration to sustain the population and allow commercial or recreational harvesting.

Specific WRV indicators that could be used to determine MFLs for consideration by SRWMD also are listed in Table 4-2. WRVs 1, 2, 3, and 9 can cover a wide range of flow conditions and thus are sufficient for developing MFLs that would be protective of the remaining WRVs as well.

4.13 APPROACH TO MFL DEVELOPMENT

As discussed in Chapter 1, the goal of an MFL determination is to protect the resource from significant harm due to water withdrawals and was broadly defined in the enacting legislation as "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." However, as previously shown, significant harm is rarely depicted as a "bright line," as habitat loss typically varies monotonically (without a clear inflection or break point) with flow (SWFWMD 2005b). Thus, there is a need for an operationally defined threshold that protects the WRVs used to establish the MFL.

The allowable flow reductions associated with MFLs generally are associated with reductions in habitat area, the number of days of floodplain inundation or days available for fish passage. SWFWMD (2005b) has implemented a 15 percent loss of habitat or other flow-dependent resource as a threshold for significant harm that limits the withdrawal of water from freshwater ecosystems. Instream flow determinations in other areas have been based on percent changes in habitat that ranged from 10 percent to 33 percent (Jones Edmunds and Associates 2012). In its review of a SWFWMD MFL, Cichra et al. (2005), stated:

Table 4-2. Indicators, response functions, and MFL assessment metrics for WRVs relevant to the Steinhatchee River*.

WRV	Indicator	Relevance	Response Function	Metric	Key Source	Example	
1	Recreation In and On the Water	River access	Many recreational activities involve boat access to the river.	Relationship between freshwater flow and river depth.	Depth of the river at access locations and for boating.	Personal communications with local marinas and outfitters.	Viable stage for kayaking / canoeing ≥ 1.5 feet (Broksma and Roelse 2011). Viable stage for boating ≥ 2 feet (average shaft length of short and long-shaft engines (HSW 2016).
2	Fish Passage / Fish and Wildlife Habitat	Habitat	Different animal species require minimum water depths, velocities, substrate, and temperatures to thrive.	Relationship between freshwater flow and river depth and velocity, and floodplain wetland inundation.	Extent of time with adequate depth for fish passage. In-stream flow maintenance for relevant biological guilds. Number of days the floodplain is inundated.	SRWMD 2014.	Frequency of flows that allow fish passage in Lower Santa Fe and Ichetucknee Rivers (SRWMD 2014).
3	Estuarine Resources	Flora and fauna located in water with salinity ranging between 0 and 35 ppt	Many commercial and public interests are associated with sports fishing and scalloping within three miles of the coast.	Relationship between freshwater flow, salinity and isohaline locations.	Estuary volume, bottom area and shoreline length.	FDEP 2014.	Relative amount of time that desirable salinities can be found.
9	Water Quality	Concentrations of primary water quality parameters	Healthy scallop beds and fish populations depend on sufficient levels of dissolved oxygen and absence of elevated levels of pollutants, including nutrients.	Relationship between freshwater flow and water quality.	Compliance with state water quality standards.	Rules 62-302.530, and 62-530.531, F.A.C.	Increase in the number of years of non-compliance with state water quality standards.

* From HSW, Inc. and Janicki Environmental (2015).

“...the peer review panel for the Middle Peace found that use of the 15% threshold is reasonable and prudent (Shaw et al. 2005), especially given the absence of clear guidance in statute or in the scientific literature on levels of change that would constitute significant harm. We acknowledge that percentage changes reported in the literature have ranged from 10-33% in other applications designed to prevent significant harm. The present panel affirms the use of the 15% threshold in the Alafia and Myakka rivers for similar reasons.”

Jones Edmunds and Associates (2012) conducted a literature review to allow examination of the 15 percent habitat loss criterion. The literature search resulted in the review and documentation of 366 articles. JEA concluded:

“In examining the literature, we have drawn several broad conclusions that are consistent with previous observations made by the water management districts of Florida in various MFL documents. Minimum flow recommendations should address a range of processes and the flow events that influence each process. Many programs employ assessment methods that rely heavily on the input of scientific experts to define flow-ecology relationships. To increase transparency and community acceptance, some programs have supplemented scientific expertise with input from local stakeholders through a workshop approach. The coupling of scientific experts and local stakeholders to arrive at a recommended flow regime is commonly referred to as a holistic method or approach.”

The 15 percent threshold has been applied in many of the MFLs analyses performed in the State of Florida for MFL rule development (e.g., Munson and Delfino 2007, SRWMD 2005, SWFWMD 2010b, 2011). The 15 percent threshold also was applied in the recent MFLs developed for the Aucilla-Wacissa and Econfina River Rivers MFLs (SRWMD 2016a and SRWMD 2016b, respectively).

The approach to the development of the Steinhatchee River MFLs is a weight-of-evidence approach, where the analysis depends upon the specific WRV being protected and the

availability of defensible data and information. In general, the MFLs can be expressed as either in-channel or out-of-channel.

The in-channel MFL metrics, mid- or low-flow MFLs include fish passage, wetted perimeter, physical habitat suitability, and salinity distributions. The MFLs associated with the fish passage and wetted perimeter metrics will be estimated by a 15 percent reduction from the number of days in the POR when the critical flow for that metric is exceeded. The MFLs associated with the physical habitat suitability and salinity distributions are based on an allowable 15 percent loss of habitat area.

The out-of-channel MFL is often expressed as a high-flow MFL and is based on the distribution of the floodplain swamp relative to the river channel and the water surface elevations that vary with river flow. The MFL is estimated by a 15 percent reduction from the number of days of inundation in the POR. In general, Munson and Delfino (2007) found the reduction-in-time method to be more conservative than a reduced-area method.

The general approach taken in the development of the Steinhatchee River MFLs includes the following steps:

- Set a goal (for this MFL, protection from significant harm)
- Identify the resources of interest to be protected (WRVs)
- Define a unit of measure (e.g., flow in cubic feet per second, percent reduction in flow)
- Define a baseline flow regime from the POR data
- Define a protection standard statistic (e.g., a prescribed percent reduction)

The following sections of this report present this approach in greater detail.

5.0 METHODOLOGY AND APPROACH FOR THE ESTABLISHMENT OF THE STEINHATCHEE RIVER MFL

The establishment of MFLs ultimately depends upon the quantitative relationship between river and spring flows and the WRVs of concern. The following analyses use the best available data to derive the MFLs for the Steinhatchee River.

The proposed MFL for the Steinhatchee River is based on the relationships between river flow (including spring flow contribution) and the following:

- Salinity distributions in the tidal portion of the river,
- Out-of-bank flows within the freshwater portions of the river above Steinhatchee Falls. This is the portion of the river that inundates floodplains and provides access to floodplain habitat.
- In-channel flows that provide for the following;
 - fish passage within the freshwater portions of the river above Steinhatchee Falls.
 - evaluation of in-stream habitat within the freshwater portions of the river above Steinhatchee Falls.

5.1 STEPS IN THE DEVELOPMENT OF THE STEINHATCHEE RIVER MFL

The general approach taken in the development of the Steinhatchee River MFL includes the evaluation of the relationships defined above. The specific results from the evaluation of these relationships for the Steinhatchee River include:

- MFL Goal - The goal for the Steinhatchee River MFL is a given – protection from significant harm due to water withdrawals.
- Resources of Interest – The WRVs associated with the resources of interest include WRV 2 Fish Passage / Fish and Wildlife Habitat and WRV 3 Estuarine Resources. WRV 1 Recreation in and on the Water and WRV 5 Freshwater Supply are applicable but not included due to the lack of data. While there is a general lack of data for both WRV 1 and WRV 5, these WRVs can be expected to be protected by the flows that protect WRV 2 and WRV 3. The relevant aspect of WRV 9 Water

Quality is implicitly addressed by evaluating the relationship between river flow and salinity.

- MFL Metrics and Unit of Measure - An MFL metric has been identified for each WRV where adequate data exist for the development of an MFL. A critical flow, i.e., the flow that is the threshold for a given MFL metric, has been defined for each metric. The MFL for a given metric is the flow that considers modifications to the baseline flow time series. The unit of measure by which the Steinhatchee River MFL is to be expressed is a percent reduction in flow from the baseline.
- Baseline Flow Regime - the baseline flow regime for the Steinhatchee River MFL comes from the flow data generated by the U.S. Geological Survey at the gage on the Steinhatchee River near Cross City (02324000). The POR at this gage includes WYs 1951-2015 and is characterized by a wide range of meteorological conditions and the resulting wide range of river flows. There is little water use in the Steinhatchee River watershed and as a result the river flows can be viewed as relatively unaffected by water withdrawals.
- Protection Standard Statistic for Steinhatchee River MFL – The protection standard statistic is 15 percent, i.e., the critical flow will not allow more than a 15% change in the metric for any MFL WRV.

The following discusses the evaluations conducted for each of the WRVs.

5.2 ESTUARINE RESOURCES (WRV 3)

Salinity is one of the major determinants of the composition and distribution (both spatial and temporal) of the biotic communities in tidal waters. The general behavior of salinity response to changes in freshwater inflow are well-known. Established MFLs for other similar systems along the Florida Gulf Coast considered how freshwater inflows affected salinity; these include the Lower Hillsborough River (SWFWMD 2006), Lower Peace River (SWFWMD 2010a), Lower Alafia River (SWFWMD 2008a), Weeki Wachee River (SWFWMD 2008b), Anclote River (SWFWMD 2010b), Lower Myakka River (SWFWMD 2011), Lower Suwannee River (WRA et al. 2005), Waccasassa River (WRA et al. 2006), Econfinia River (SRWMD 2015), and the Aucilla River (SRWMD 2016a).

Salinity varies in the lower reaches of these rivers along the Florida Gulf Coast in response to changing freshwater inflow in an inverse fashion - higher river flow results in lower salinity

in the upper tidal zones of the rivers and lower river flow results in higher salinity in those same areas. Due to the higher density of saline waters, salinity concentrations are often lower near the water surface and higher near the bottom of the water column at any particular location in the lower river. A high degree of variation in salinity is expected due to freshwater inflows and the influences of tide, wind, and vertical stratification. Salinity can vary significantly over the course of each day as the tide moves upstream and downstream. Lateral variation in salinity depends upon the morphometry of the river.

Salinity tolerances have been described for many common fish and invertebrate taxa such as in the Lower Suwannee River (Heard 1982; Gosner 1978). Based on Rogers et al. (1984), salinities of <10 ppt may be critical for recruitment of many fish taxa. Additionally, creeks in very low-salinity areas (< 5 ppt) are important nursery habitat for commercial and recreational fishery species (Rozas and Hackney 1983).

A critical step in establishing the MFL that is protective of estuarine resources is the definition of important salinities and salinity ranges. From the multivariate analysis described in WRA et al. (2005), a critical salinity of <5 ppt was chosen as a salinity limit which may be most sensitive to changes in flow regime and salinity patterns. This category represented the classic "oligohaline" zone for estuarine environments and exhibited a fairly narrow range indicating potential for a high degree of sensitivity to habitat alterations. This critical salinity is also supported by several other lines of evidence. Oligohaline river habitats with salinities less than 5 ppt have been disproportionately lost throughout the Gulf Coast (Beck et al. 2000). Analysis of fish community structure in the several rivers along the Florida Gulf Coast suggests break points for distinct groups of these organisms at approximately 0, 2, and 5 ppt (SWFWMD 2006, 2010a, 2008a, 2008b, 2011; WRA et al. 2005, 2006). The MFL for Sulphur Springs (SWFWMD 2004) and Lower Hillsborough River MFL reevaluation (SWFWMD 2006) both had the goal of maintaining low salinity (less than 5 ppt) habitat in the Lower Hillsborough River. There is an opportunity to maintain such habitats in the Steinhatchee River given appropriate minimum flows.

Freshwater is typically viewed as having a salinity of 0 ppt while others have used 0.5 ppt as the criterion. The 0 ppt threshold is protective of the biotic communities that are classified as freshwater. Therefore, for the analyses that support the MFL for the Steinhatchee River, a threshold of 0 ppt is used. A series of shoals composed of limestone outcroppings create a

physical barrier to salinity between RM 6.5 and 7.0. The shoal elevation is estimated near 0 feet NGVD. Although river levels may exceed this elevation at high tide, the salinity does not propagate past this point. Therefore, the analyses of the salinity habitat were isolated to all the model cells below this location.

A critical salinity ≤ 2 ppt is supported by several pieces of evidence. Jassby et al. (1995) use the 2 ppt isohaline (an area of similar salinities) as an indicator of overall ecosystem productivity in the Sacramento - San Joaquin estuary system. Fish studies on many Florida Gulf Coast rivers showed that many freshwater fish and invertebrates have mean salinity of capture of less than 2 ppt; and the Lower Suwannee River MFL was based on "average salinities of high tide waters flooding the swamps should be kept < 2 ppt, with briefer periods of higher salinity tolerable." (Mattson 2002, WRA et al. 2005).

In addition to the salinity isohalines discussed above, critical habitats relative to changes in salinity (as discussed earlier) in the Steinhatchee River are the scallop habitats located in the offshore areas. These species are of critical ecologic as well as economic importance. For the scallops, the optimal range for evaluation of changes in salinity is 23 to 26 ppt (Tettelbach and Rhodes 1981) and applies exclusively to the bottom area, being most important during the critical period from October to December. A separate analysis related to the offshore habitat areas is presented along with the isohalines outlined above.

5.2.1 EFDC MODEL

The Environmental Fluid Dynamics Code (EFDC) model was used to simulate salinity in the Steinhatchee River. A description of the model and its application is presented in this section, and a more comprehensive description of the specific model application to the Steinhatchee River can be found in Appendix B.

The EFDC model is a general-purpose modeling package for simulating two- and three-dimensional flow, transport and biogeochemical processes in surface water systems, including rivers, lakes, estuaries, reservoirs, wetlands, and nearshore to shelf-scale coastal regions. The EFDC model was developed by Dr. John Hamrick at the Virginia Institute of Marine Science and is considered public domain software. EFDC is currently supported by the U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD), EPA Region 4, and EPA Headquarters. Additionally, the Florida Department of

Environmental Protection (FDEP) and the Water Management Districts (WMD) throughout the state have used this model extensively.

The spatial domain of the model includes the nearshore area of the Gulf of Mexico to approximately three miles offshore of the mouth of the river. The model extends along the Gulf shore for approximately two miles to the north and 1 mile to the south and extends upriver approximately 10 miles to Steinhatchee Falls.

The model grid (Figure 5-1) was developed utilizing available LiDAR data for elevations from 0.15 feet and greater referenced to the North American Vertical Datum of 1988 (NAVD88) to develop a river shoreline at the 1-foot level. The LiDAR data were combined with the bathymetric data collected in the river from outside the mouth upstream to RM 5 to develop the river bathymetry. Upstream of the upper extent of the bathymetric data collection, data from available HEC-RAS cross-sections were utilized to define the grid depths. Additionally, sill locations were identified, based upon site reconnaissance and aerial photography, and were input to the model. The bathymetry for the model grid in the offshore region (outside of the area included in the bathymetric data collection) was created utilizing the USGS bathymetry coverage developed for the Florida Shelf Habitat (FLaSH) study (Robbins et al. 2007). Boundary conditions necessary to run the model include the offshore water surface elevations and salinity, upstream freshwater inflows, and meteorological data (wind speed and direction).

It was determined during the model calibration that it was necessary to incorporate some representative storage areas along the main stem of the river to accurately simulate the tidal prism moving through the system. These storage areas were roughly based on the area of inundation along tidal creeks, with the volumes of these areas adjusted so the modeled flows could be calibrated to observed flows collected during the calibration period.

To evaluate the likely effects of reductions in freshwater inflows on salinity regimes in the Lower Steinhatchee River, it is important to select a period for model application that includes a distribution of flows representative of the long-term record or baseline period (WYs 1951-2015). This allows the impacts of flow reductions to be evaluated over the entire range of flows experienced in the river utilizing only a relatively small portion of the available flow record.

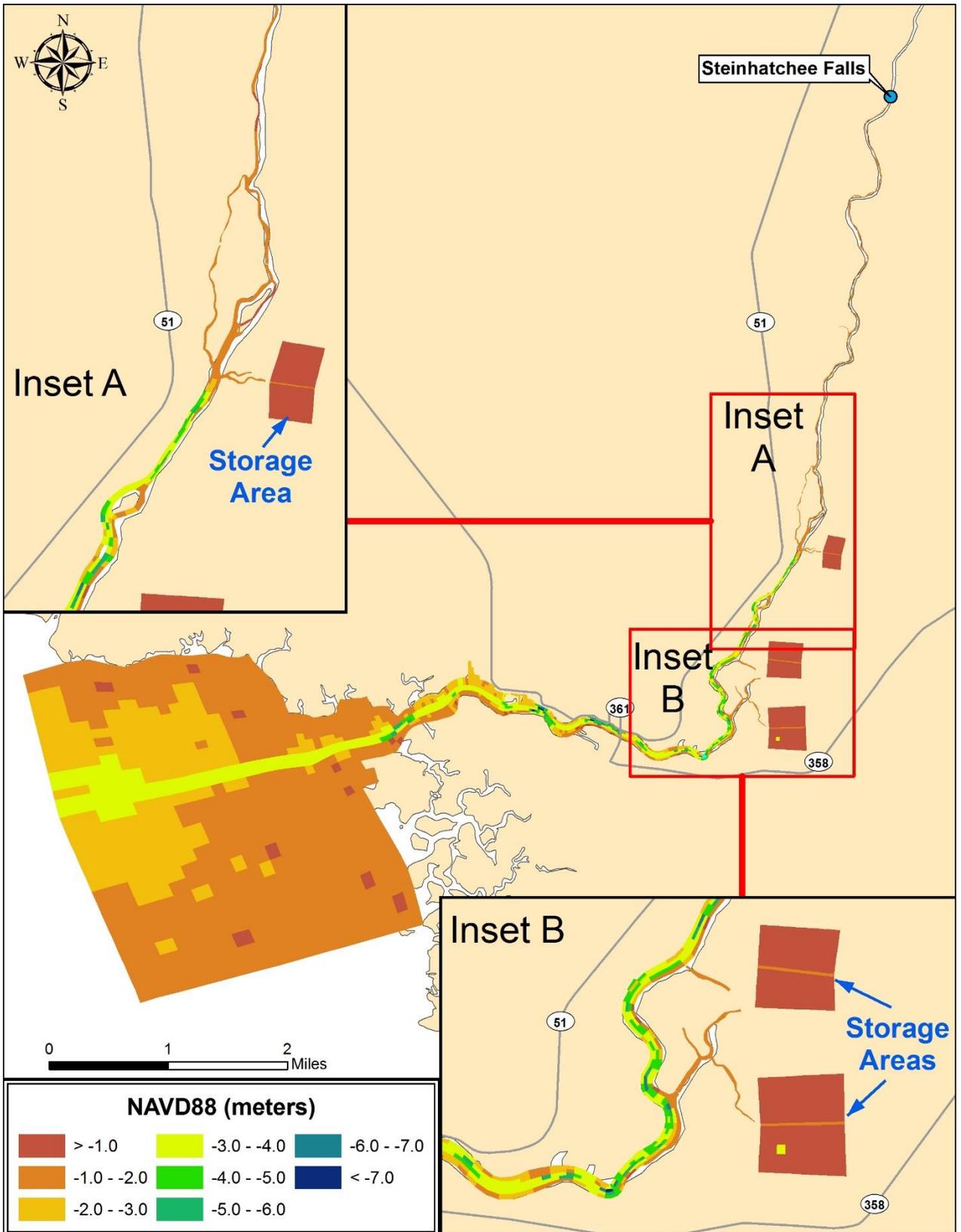


Figure 5-1. EFDC model grid and bathymetry

Constraints in selecting a model period included the length of the period to be evaluated (a function of model run time) and the availability of boundary condition data during the selected period. Evaluation of the entire baseline historic flow record against various shorter periods defined the time-period of the model scenarios. Additionally, it was necessary to choose a time-period when boundary forcing conditions were available from the previously completed Gulf Coast Shelf Model (GCSM) runs for the period 1995-2002.

A comparison of the distribution of the baseline daily flows (WYs 1951-2015) and the distribution of flows during the shorter period for which GCSM output existed indicated that the flow distribution for the period October 1, 1995 – October 1, 1999 (WYs 1995-1999) was an appropriate match for the POR distribution. Figure 5-2 provides a graphic comparison of statistics from the full baseline flow period, and a set of sequential four-year (water year) periods between 1995 and 2015. The goal was to choose a period where the baseline (straight lines without symbols) line up with the three statistical points from the discrete 4-year periods (lines with symbols). Looking at Figure 5-2 this occurs in 1999. As the symbols are located at the end of the 4-year periods, if 1999 lines up that means the period is from WYs 1996-1999. Based on this evaluation, the 4-year period selected was October 1, 1995 - September 30, 1999. Figure 5-3 provides a graphical display of the distributions of flows for the October 1, 1995 - September 30, 1999 period and flows for the complete POR, and Table 5-1 provides comparison of the flow distribution statistics for the POR to those for the 4-year period (October 1, 1995 - September 30, 1999). The October 1, 1995 to September 30, 1999 period will be referred to as the model period.

Contributing freshwater inflows to the model domain were developed based on the relationship between the measured net flow within the tidal river, collected from September of 2015 through May of 2016, and the flow at the USGS gage 02324000, upstream of the model domain, during the same dates. Details of the development of the freshwater inflow time series for the scenarios are presented in Appendix B. The flows into the model were parsed into four inflow points. The location of the flow inputs is presented in Appendix B. The points are as follows:

- Upstream-most extent of the EFDC model at Steinhatchee Falls
- Three locations downstream of Steinhatchee Falls based upon locations of tributary inflows

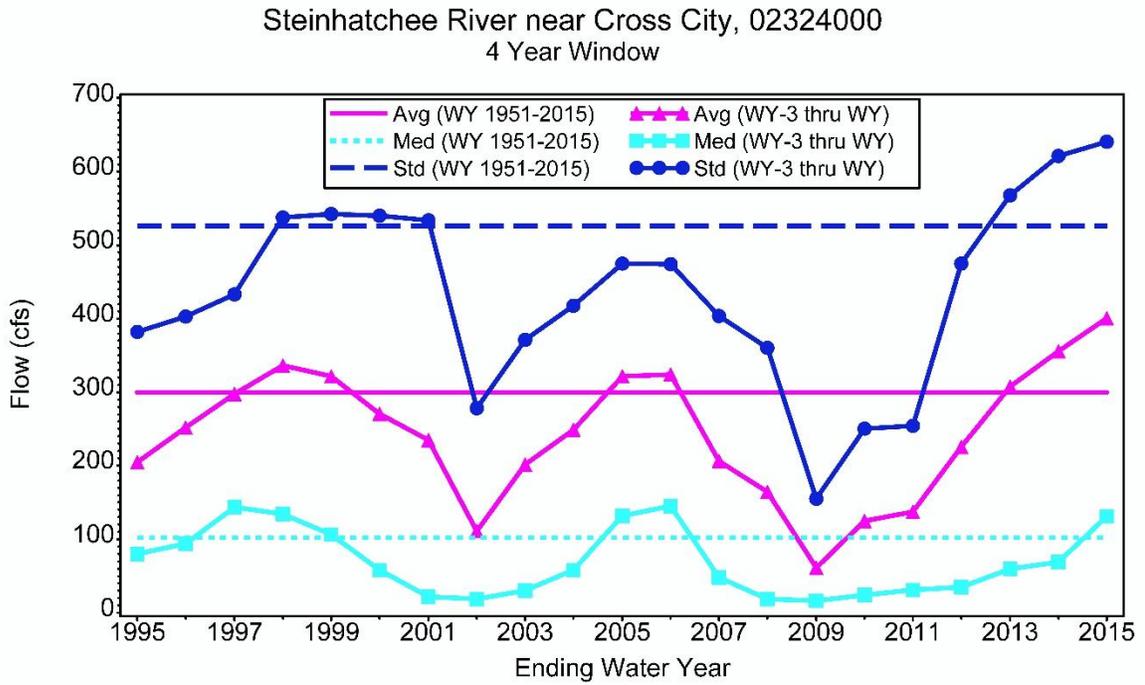


Figure 5-2. Comparison of flow statistics (average, median, and standard deviation) for the POR and moving 4-year periods between WYs 1995-2015.

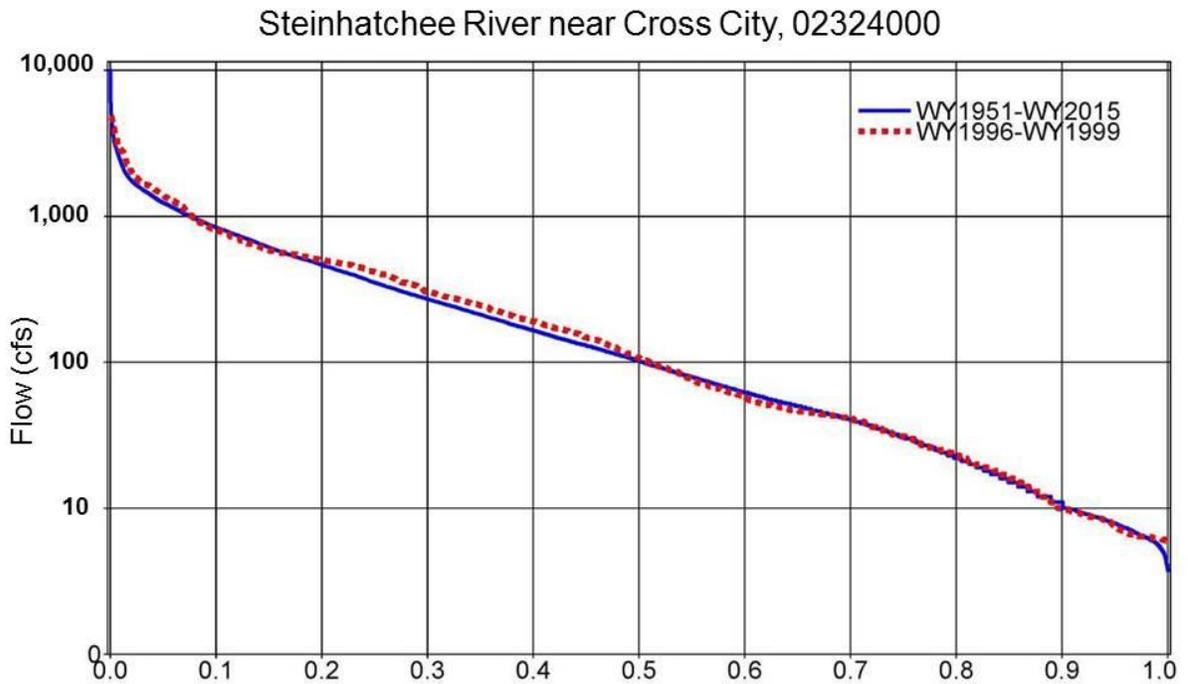


Figure 5-3. Comparison of flow distributions for POR (October 1, 1950 - September 30, 2015) and the selected 4-year model period (October 1, 1995 - September 30, 1999).

Table 5-1. Comparison of flow distribution statistics for the POR (October 1, 1950 - September 30, 2015) and 4-year model period (October 1, 1995 - September 30, 1999).

Flow percentile	Baseline Flow (cfs)	Model Period Flow (cfs)
5 th	6.2	5.3
25 th	31.0	31.0
50 th (median)	102.0	106.0
75 th	350.0	414.0
95 th	1,240.0	1,380.0
Mean	526.0	542.6

The EFDC model scenario runs included the following:

- 0 percent flow reduction – existing conditions during the model period October 1995 - September 1999
- 5 percent flow reduction – daily flows above Steinhatchee Falls reduced by 5 percent
- 10 percent flow reduction – daily flows above Steinhatchee Falls reduced by 10 percent
- 20 percent flow reduction – daily flows above Steinhatchee Falls reduced by 20 percent
- 30 percent flow reduction – daily flows above Steinhatchee Falls reduced by 30 percent

The flows entering the model domain below Steinhatchee Falls were not reduced for the scenario runs as the MFL is established based upon the upstream gage USGS 02324000.

An additional model run simulated the effects of a sea level rise of 5.1 inches which is an estimate of the potential sea level rise for 2035. The results of this model run can be found in Appendix E.

5.2.2 ANALYSES OF MODEL SIMULATIONS

To estimate the amount of available habitat that meets the biologically-relevant salinities discussed above under various flow conditions, the following metrics have been used as surrogates for habitat in establishing the MFLs for the Lower Peace River (SWFWMD 2010a), Dona Bay (SWFWMD 2009), Lower Hillsborough River (SWFWMD 2006), Econfina River (SRWMD 2016b), and Aucilla River (SRWMD 2016a):

- The volume of water in the system less than a given salinity, since the fish generally utilize the entire water column
- The bottom area in the system less than a given salinity, since the benthic macroinvertebrates inhabit the bottom substrate
- The shoreline length in the system less than a given salinity, since this metric best defines the amount of shoreline vegetation habitat available in the system

In the application of these three MFL metrics to the Steinhatchee River, the location of the 0, 2, and 5 ppt isohalines during the 0 flow reduction run were simulated. These isohalines were then simulated under altered flow conditions, i.e. a series of flow reductions (5 percent, 10 percent, 20 percent and 30 percent). As described earlier, based upon shoals above RM 6.5, the salinity habitat analyses only include the cells in the model below RM 6.0.

The potential MFL flows were estimated by comparing the available habitat modeled from the series of percent flow reductions to that available per the 0 flow reduction model results. The critical flow for each MFL metric is defined as that flow reduction that results in a 15 percent reduction in habitat extent or isohaline location. The most restrictive of the critical flows associated with the habitat extent and isohaline locations was identified as the MFL for the estuarine resource WRV.

5.3 FISH PASSAGE/FISH AND WILDLIFE HABITAT (WRV 2)

Under WRV 2, Fish Passage and Fish and Wildlife Habitat, the following three flow-based metrics were utilized to support the development of the MFL for the Steinhatchee River:

- Fish Passage
- Instream Habitat (Habitat Suitability)
- Floodplain Habitat

The wetted perimeter metric was examined and is typically used to define a low flow cutoff, which is a flow below which no withdrawals are permitted. This is a useful concept in rivers where flow reductions due to direct withdrawals are used to provide the water demand. However, this concept is moot in the case of the Steinhatchee Basin where predominant

water withdrawals result from groundwater withdrawals. As such, this metric is not utilized in the definition of the MFL.

For the assessment of the impacts of flow reduction on these metrics, a HEC-RAS model was utilized. The model was developed to represent the flow and stage characteristics of the Steinhatchee River with specific focus on freshwater areas above Steinhatchee Falls. Below the Falls, the stage conditions are driven primarily by tides and, therefore, the water levels, and ultimate metrics listed, are not limited by flow. The following provides a summary of the HEC-RAS model followed by the data types and methodologies utilized to assess the impacts of flow reduction for each of the four metrics.

5.3.1 HEC-RAS MODEL

A modified steady-state HEC-RAS model was developed for the Steinhatchee River to support MFL development and ecological modeling. The Steinhatchee River is delineated in the model as the 20-mile-long stretch of river that begins in Lafayette County and extends to the Gulf of Mexico. Figure 5-4 shows the extent of the HEC-RAS model and the cross-sections utilized in the model development.

The HEC-RAS model for the Steinhatchee utilized best available information from an existing HEC-RAS model of the Steinhatchee River along with new survey data. SRWMD provided digital elevation model (DEM) data that were combined with the existing and newly surveyed cross-sectional data to develop cross-sections for the HEC-RAS model. USGS flow and water level data were used in model updates and calibration. The model was calibrated to observed stages and flows. HEC-RAS-simulated measurements of depths, velocities, water surface elevations, and other hydraulic output data were utilized for the analyses discussed in the following sections. A detailed account of the model development, calibration and application is included as a separate report in Appendix A.

5.3.2 FISH PASSAGE

Under low-flow conditions, water depth can be a limitation to the longitudinal passage of fish. The ability to move up and down a river is important for many fish species to escape predation or undesirable conditions or to find food sources or spawning habitat. MFL development should consider the maintenance of longitudinal connectivity along a river corridor to the extent that this connectivity has historically occurred.

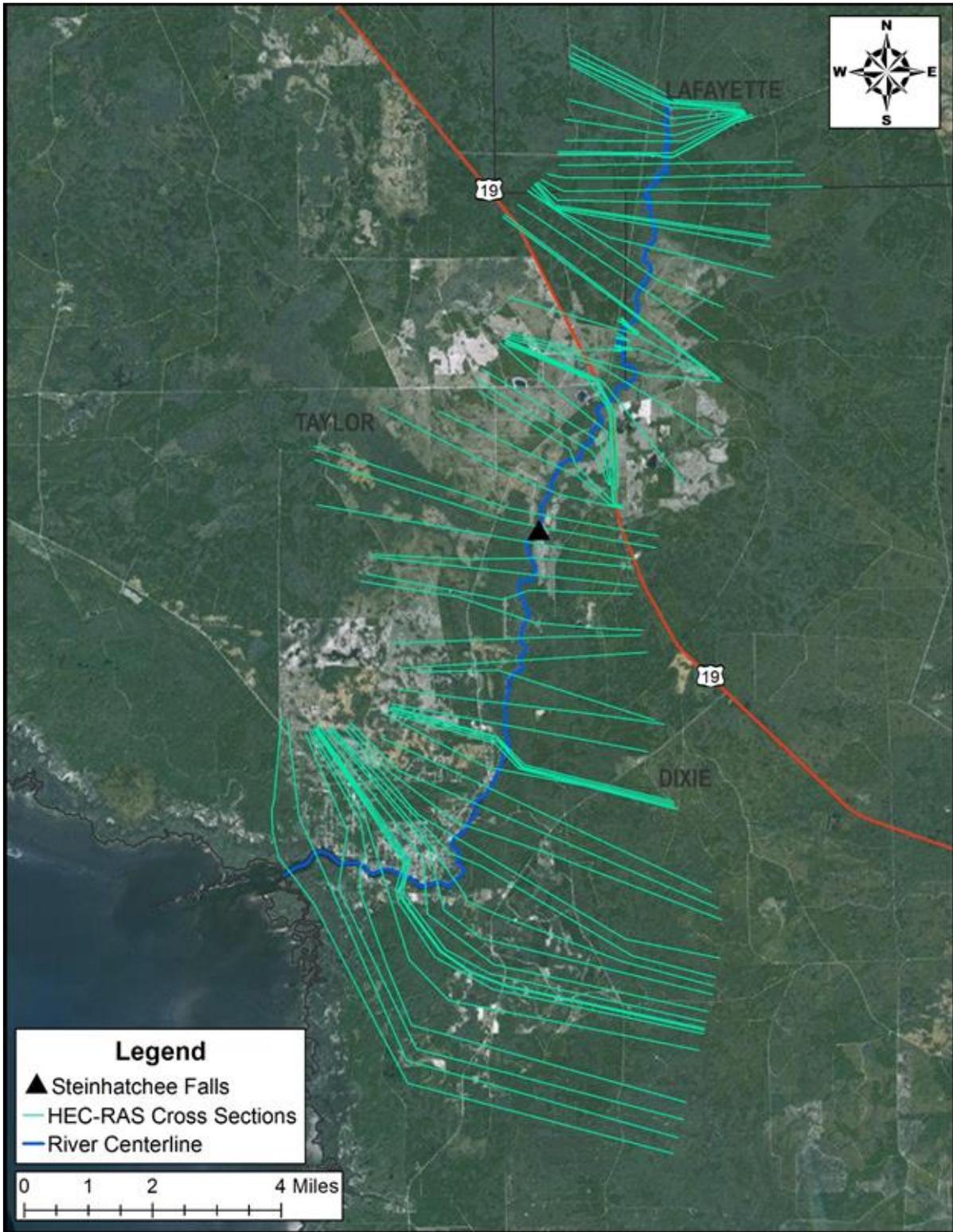


Figure 5-4. Base model for the modified HEC-RAS model for the Steinhatchee River MFL.

Information used to examine the potential for limited fish passage under baseline and altered river flow conditions was obtained from the HEC-RAS model described in Appendix A and summarized in Section 5.3.1. The fish passage analysis required that the point of lowest elevation at each model cross-section along the longitudinal axis of the river be identified. This is often referred to as the thalweg. The river water level (stage) at each cross-section in the model was compared to the thalweg elevation across a range of flow conditions. Flows necessary for fish passage at each of the cross-sections were identified using the output from multiple runs of the HEC-RAS model. The flows were determined by using a 0.8-ft depth fish passage criterion.

This depth for fish passage criterion is based on Thompson's (1972) study on minimum depth criteria (0.6 ft – 0.8 ft). This criterion has been used throughout Florida for MFL evaluation and development, including for the Peace River (SWFMWD 2002, 2005c), the Myakka River (SWFWMD 2005a), the Hillsborough River (SWFWMD 2005d), the Lower Santa Fe and Ichetucknee rivers (SRWMD 2014), the Aucilla River (SRWMD 2016a), and the Econfina River (SRWMD 2015).

The 0.8-ft depth was added to the lowest spot in the channel and the flow necessary to achieve the resultant elevations was determined. The critical flow, the flow at which one of the cross-sections in the model reached the critical elevation, was defined. The frequency of occurrence of these critical flows during the baseline period was then estimated using output from the HEC-RAS model. The reduction in the frequency of the critical flow was estimated by simulating a series of flow reductions (from 0 percent to 100 percent). The MFL for the fish passage metric was the percent reduction in flow that resulted in a 15 percent reduction in the frequency of the critical flow.

5.3.3 IN-STREAM HABITAT (HABITAT SUITABILITY)

SRWMD conducted an in-stream habitat assessment in 2016 to support the MFL development for the Steinhatchee River. The assessment utilized output from the HEC-RAS model described in Section 5.3.1 as input to the System for Environmental Flow Analysis (SEFA) Software. SEFA is a Windows-based program that was developed as a tool for use in studies that utilize the Instream Flow Incremental Methodology (IFIM) (Aquatic Habitat Analysts, Inc. 2012). It contains hydraulic, instream habitat, and time series models, and

can be used in the development of flow recommendations. The program allows for the alteration of flows to demonstrate the effects on the availability of habitat [shown as area-weighted suitability (AWS)] for species of interest in a body of water (Jowett et al. 2014). The SRWMD report summarizing the instream assessment is provided in Appendix C.

The study area encompassed a 0.6-mile stretch of the Steinhatchee River above the sink between RMs 14.15 and 14.80. Fourteen sites were chosen in early 2016 based on characteristic representation, ease of access, and diversity of habitat in the river. Figure 5-5 shows the locations of the sites. No data collection occurred at these sites, with the exception of supplemental in-channel bathymetry for the HEC-RAS model, which was used in calibration of the SEFA model. HEC-RAS data were incorporated into the hydraulic, instream habitat, and time series models of the river.

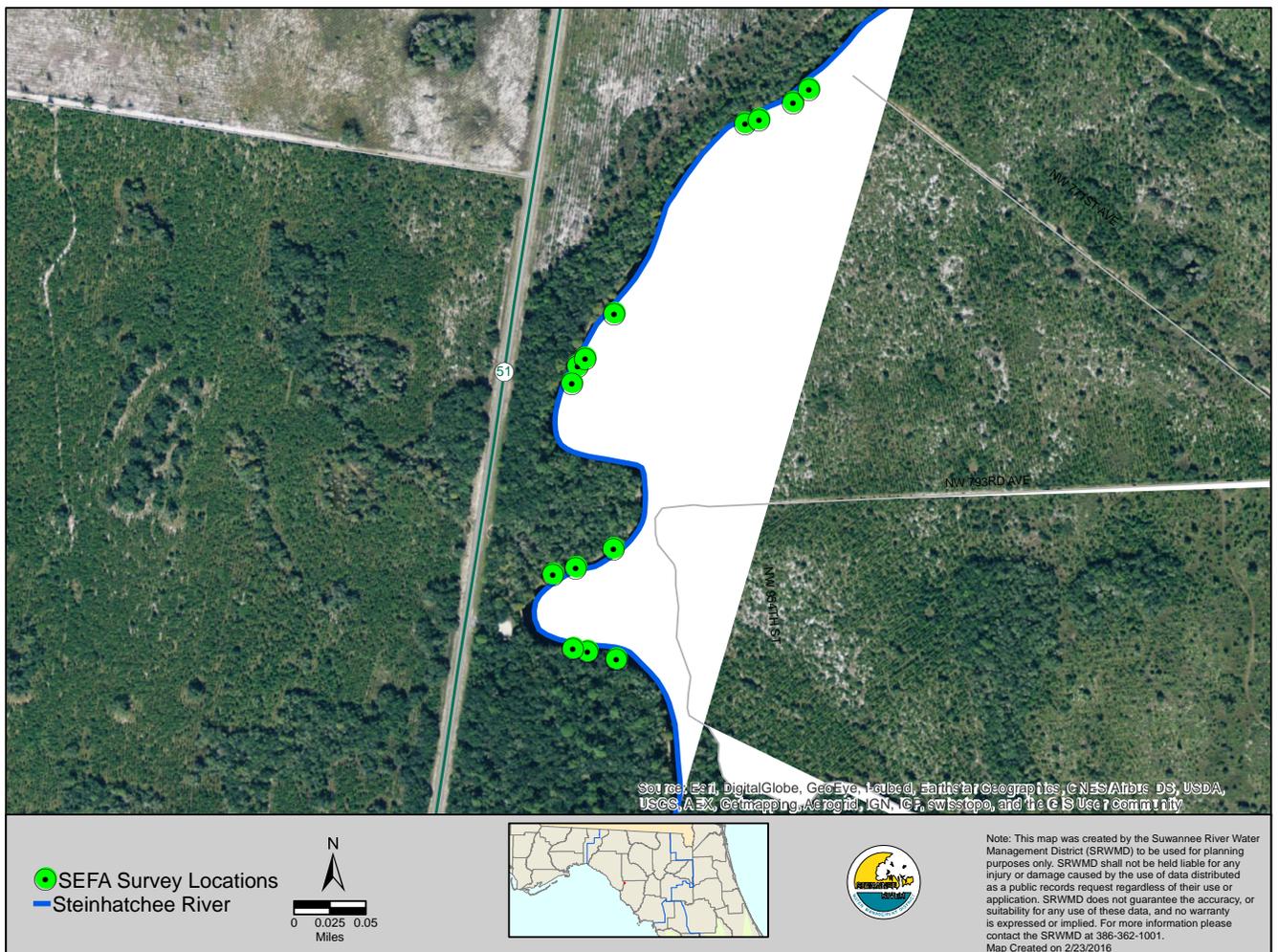


Figure 5-5. Map of the Steinhatchee River SEFA study area with surveyed transect locations.

The HEC-RAS model provided the stage/discharge relationships over six different flow scenarios, along with the velocities at specific points across each transect under the highest flow regime. These model output values were used to establish log-log rating relationships for each transect in the SEFA program. The rating curves were each calculated with Instream Flow Group model 4 (IFG4) emulation, the same method applied by the Physical Habitat Simulation model (PHABSIM) (Jowett et al. 2014; Milhous and Waddle 2001). Since no in-situ data were collected, the substrate index codes were absent in the final calculation of the AWS for each species and life stage.

Forty habitat suitability curves of various species and life stages were incorporated into the instream habitat model (Table 5-2). All of these curves have been applied in previous MFL analyses. Only the velocity and depth criteria for each species and life stage were considered in the calculation of preference habitat.

Table 5-2. Habitat Suitability Curves used in the MFL analysis.

Species or Group	Life Stage
Suwannee Bass	Adult, Juvenile
Redbreast Sunfish	Adult, Juvenile, Spawning, Fry
Habitat Guilds	Shallow/Slow, Shallow/Fast, Deep/Slow, Deep/Fast
Channel Catfish	Adult, Juvenile, Juvenile (spring, summer, fall, warmwater), Spawning, Fry
Darters	Generic, Blackbanded
Macroinvertebrates	Ephemeroptera, Plecoptera, Trichoptera, EPT Total, <i>Pseudocloeon ephippiatum</i> , Hydropsychidae - Total, <i>Tvetenia vitracies</i>
Largemouth Bass	Adult, Juvenile, Spawning, Fry
Bluegill	Adult, Juvenile, Spawning, Fry
Spotted Sunfish	Adult, Juvenile, Spawning, Fry
Cyprinidae	Adult

Discharge data from the USGS gage 02324000 (Steinhatchee River near Cross City) were utilized in the time series analysis portion of the SEFA program. The range of flows used in this analysis dated between October 1, 1950 and September 30, 2015 which corresponds to the POR for the HEC-RAS model. Figure A1 in Appendix C contains the flow duration curve, along with the associated percent reductions to the flow record at the USGS gage.

The determination of the MFL involved a straight percent reduction of each discharge measurement value in the historical POR. Reductions used in the discharge record ranged from 5 percent to 30 percent. Flows were reduced by ascending stepwise percentages until the difference between the reduced and historical discharge records revealed a less than 15 percent reduction in the calculated mean of the AWS.

5.3.4 RIPARIAN BANK HABITAT (WETTED PERIMETER)

Wetted perimeter is used as an estimate of the amount of habitat available to aquatic organisms under different flow conditions. Generally, greater extents of wetted perimeter in a stream or river are associated with increased habitat availability for fish and macroinvertebrates. The wetted perimeter of a stream transect is the linear extent to which water in the stream is in contact with its channel bed (Parker and Armstrong 2002). As such, changes in stream morphometry determine how alterations in stream flow affect the wetted perimeter of the stream (Parker and Armstrong 2002). For example, given two reaches of a stream of equal depth but different channel widths, the wetted perimeter in the reach with the narrower channel will be more responsive to changes in flow than the reach with the wider channel (Parker and Armstrong 2002).

In theory, as the flow increases, there should be a stream flow at which the rate of change in wetted perimeter decreases dramatically (i.e., an inflection point) (Parker and Armstrong 2002). This inflection point or threshold demarcates a “critical” minimum flow, for in-channel flow regimes (Gippel and Stewardson 1998, Parker and Armstrong 2002). In practice, such inflection points are not always clearly defined or there can be multiple inflection points (Parker and Armstrong 2002). The identification of the critical flow can be subjective, although there are more rigorous mathematical solutions to identify the inflection point (Gippel and Stewardson 1998). Expert knowledge of the system is often used to identify the most meaningful inflection point.

The wetted perimeter technique has been used, in conjunction with other methods, to establish MFLs in rivers of the SWFWMD, including the Alafia (SWFWMD 2005b), Myakka (SWFWMD 2005a) and Peace Rivers (SWFWMD 2002). Wetted perimeter has also been used to evaluate fisheries habitat in the western United States (Swift 1976; Leathe and Nelson 1989) and has been applied in concert with other methods to estimate available habitat in Australian rivers (Tunbridge 1988, Tunbridge and Glenane 1988, Anderson and

Morison 1989) (Figure 5-6). The application of this technique requires the assumption that wetted perimeter is a valid measure of available habitat for fish and macroinvertebrates (Annear and Conder 1984, Arthington and Zalucki 1998). For the establishment of an MFL, wetted perimeter was calculated with data produced by the HEC-RAS model of the Steinhatchee River as discussed in Appendix A. While the analyses for wetted perimeter were performed, they were not utilized in the definition of the MFL.

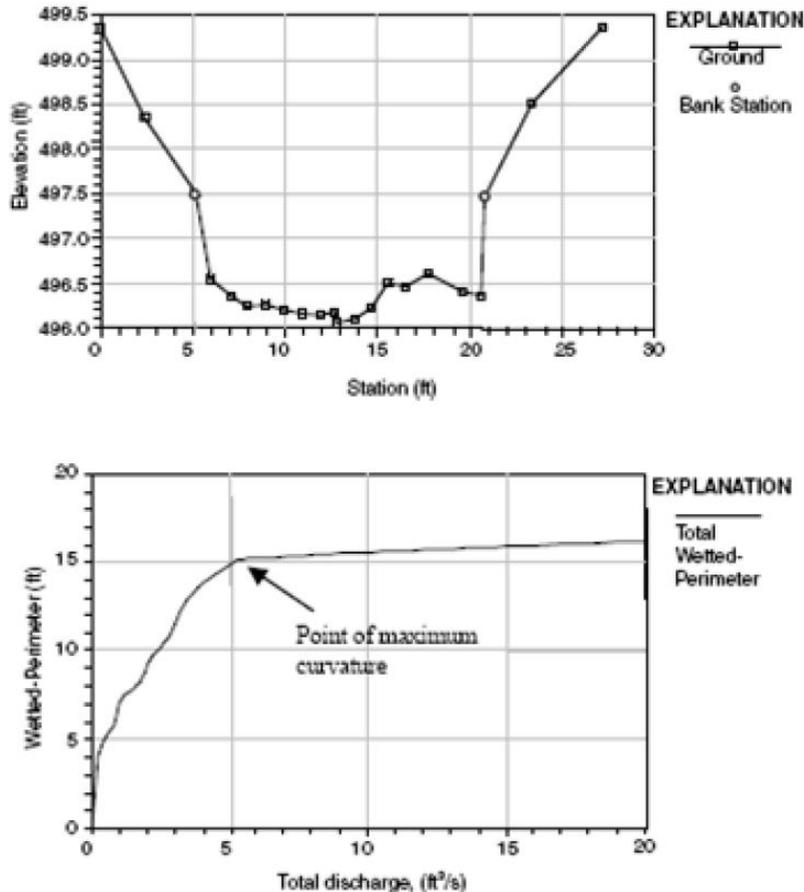


Figure 5-6. Examples of a stream cross-section (top) and the relationship between stream flow and wetted perimeter (Source: Tunbridge and Glenane 1988).

5.3.5 FLOODPLAIN HABITAT

As presented in Section 3, the CLC map identifies different vegetation habitats and land cover for the entire state of Florida. The floodplain swamp habitat adjacent to Steinhatchee River was identified from the CLC. Using the HEC-RAS transects in conjunction with the CLC, areas where the floodplain swamp occur were identified (Figure 5-7).

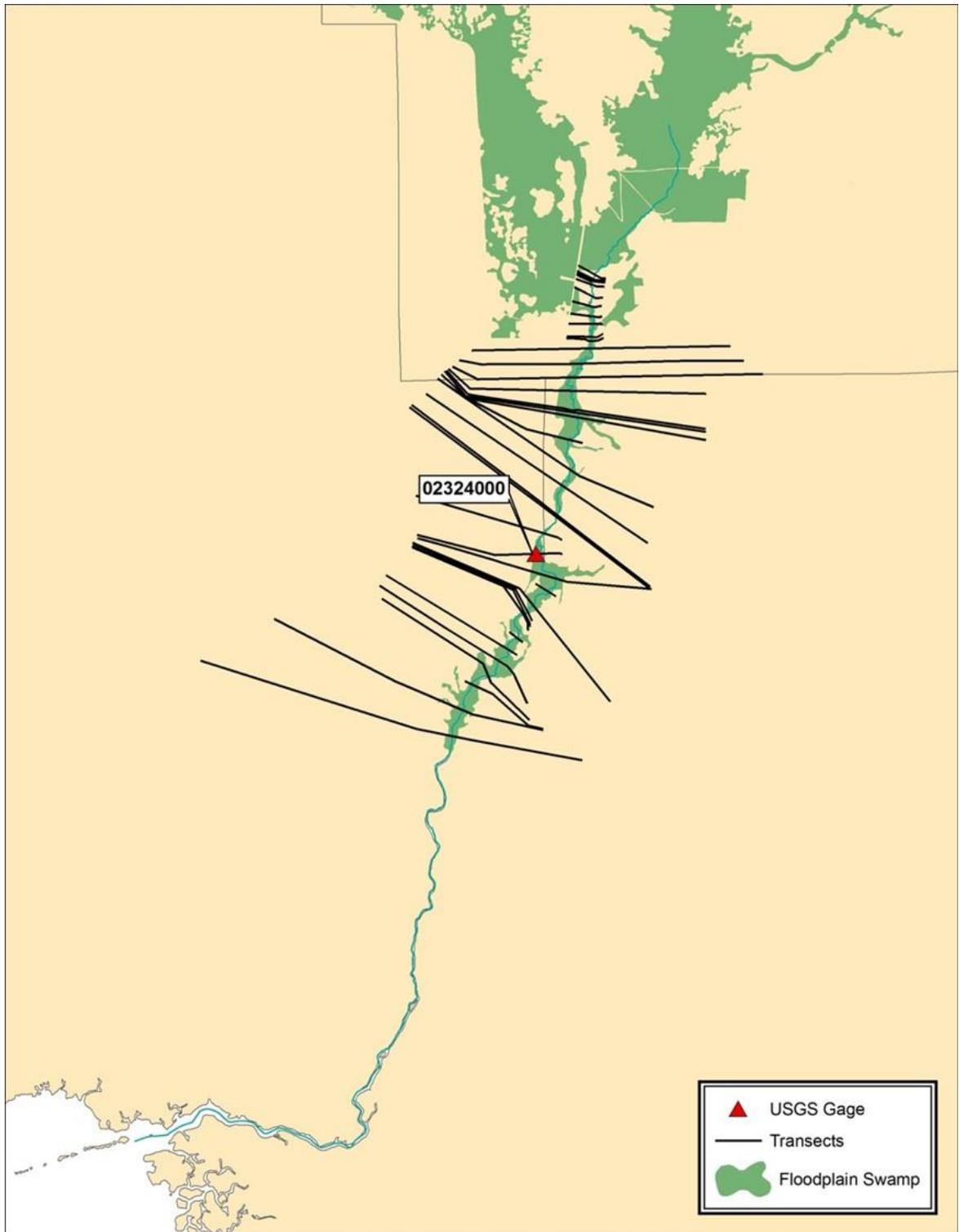


Figure 5-7. The Steinhatchee River floodplain swamp habitat along with the transects used to perform the vegetation analysis.

Using the HEC-RAS model allows a relationship to be developed between the transect water surface elevation and flow measured at the USGS gage. The HEC-RAS transects that intersect the floodplain swamp were clipped using geo-statistical software (ESRI 2014) to include only the areas where the floodplain swamp land cover occurred. The clipped HEC-RAS transects were then used to extract elevation data from the DEM coverage of the Steinhatchee watershed. SRWMD created the DEM coverage from LiDAR data for use in this project. The mean elevation extracted from the DEM coverage was then determined to represent the height the water surface at each transect necessary to inundate 50 percent the floodplain swamp. This is the critical elevation.

Using the mean elevation of the floodplain swamp at each transect and transect-specific water surface elevations from the HECRAS model output, a water surface elevation was determined for each transect where the floodplain swamp critical elevation would become inundated. Each of the transects' water surface elevations are related to a percent exceedance, which was related back to the percent exceedance at the USGS gage. The percent exceedance at the USGS gage represents a percentile flow of the gage. A mean of these percentile flows was taken to create the floodplain swamp critical flow at the gage.

Using the POR for the Steinhatchee USGS gage, a count was taken of the number of days in which the daily flow records exceeded the critical flow. The daily flow record was then repeatedly reduced by 1 percent and compared to the critical flow and the numbers of days were again tabulated. Once the number of days in which the critical flow was not met was greater than 15 percent of the unimpacted days, the allowable flow reduction is determined.

6.0 PROPOSED STEINHATCHEE RIVER MFL

As discussed in Section 5, an application of the EFDC model described in Appendix B was used to examine the relationships between river flow reductions and the response in the salinity distributions. Additionally, output from a HEC-RAS model, described in Appendix A, was used to examine the relationships between river flow reductions and responses in fish passage, instream habitat, riparian habitat, and floodplain habitat. The freshwater habitat assessments were performed in the reaches above Steinhatchee Falls (RM 10.25), the estuarine assessments were performed in the lower portions of the river below areas of shoaling (RM 6.5 to 7.0). These metrics relate to the two WRVs – Fish Passage / Fish and Wildlife Habitat (WRV-2) and Estuarine Resources (WRV-3). These WRVs have been selected for the establishment of the Steinhatchee River MFL.

6.1 SALINITY HABITAT

6.1.1 RESPONSES IN SALINITY TO VARIATIONS IN RIVER FLOWS

The relationship between salinity and river flow is the most important relationship that is simulated by the EFDC model. Figures 6-1 and 6-2 present plots of the mean daily bottom and surface salinities versus flow as simulated by the model under the model period 0 flow reduction scenario. This relationship varies longitudinally along the river as well as from the bottom to the surface of the water column. The results are presented for RM 1.5 and RM 4.5. Appendix D presents a full set of plots for various river miles.

Plots of the daily average salinity at the bottom and surface are presented for two flow ranges. The river miles represent conditions near to the mouth (RM 1.5) and upstream (RM 4.5), below where the system braids out and the first sill is encountered. The first range (less than 838 cfs) represents the flows that are below the 90th percentile over the full record. This eliminates some of the extreme events from the analyses. The second range (less than 102 cfs) represents flows below the median for the long-term record. This provides an evaluation of the behavior under the lower flow conditions.

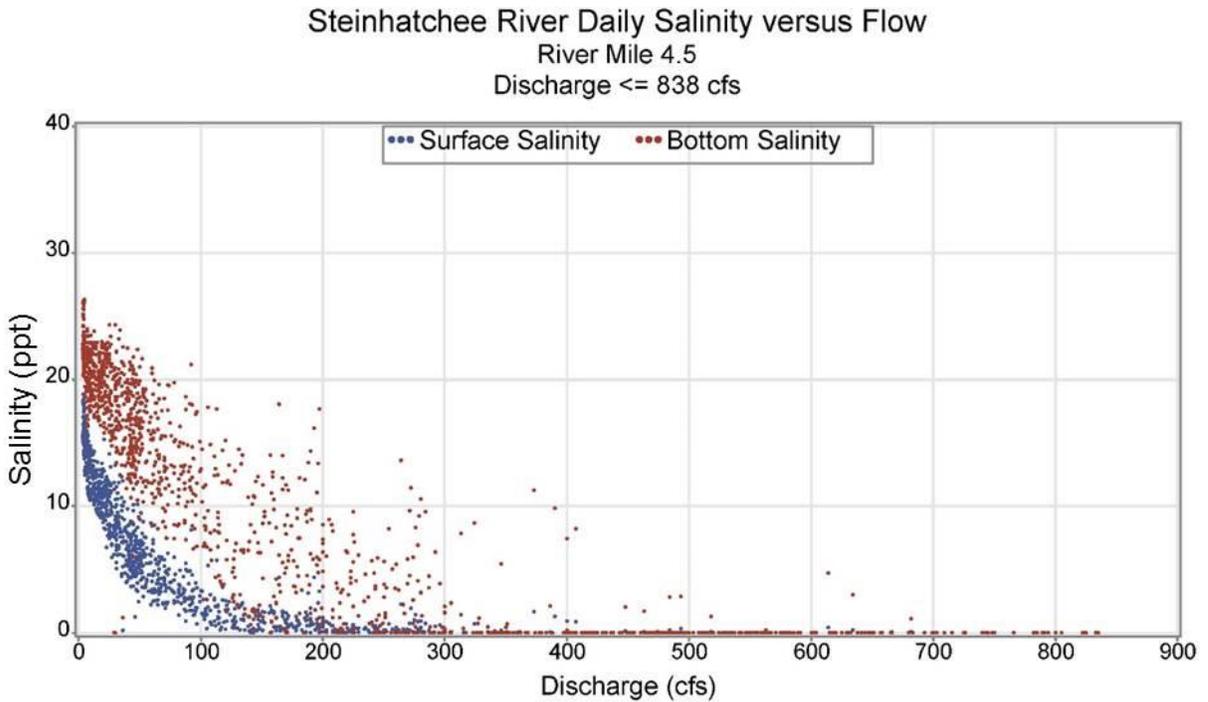
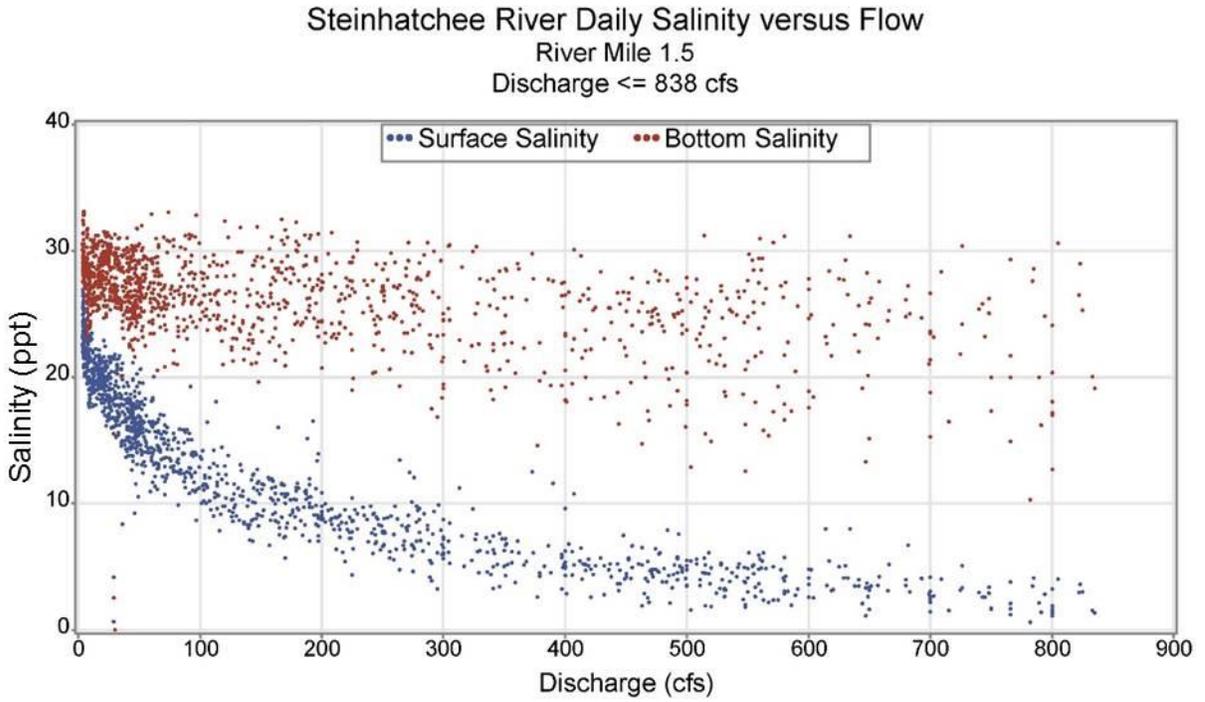


Figure 6-1. Daily mean surface and bottom salinities versus flow (<90th percentile flow) for RM 1.5 and RM 4.5.

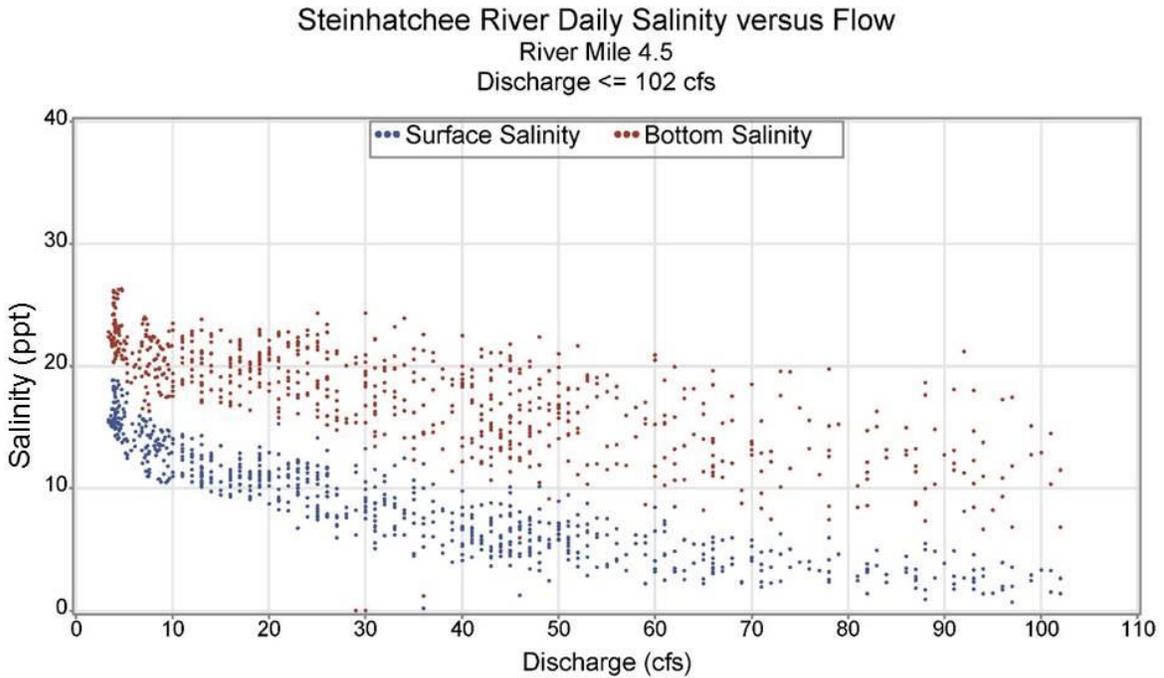
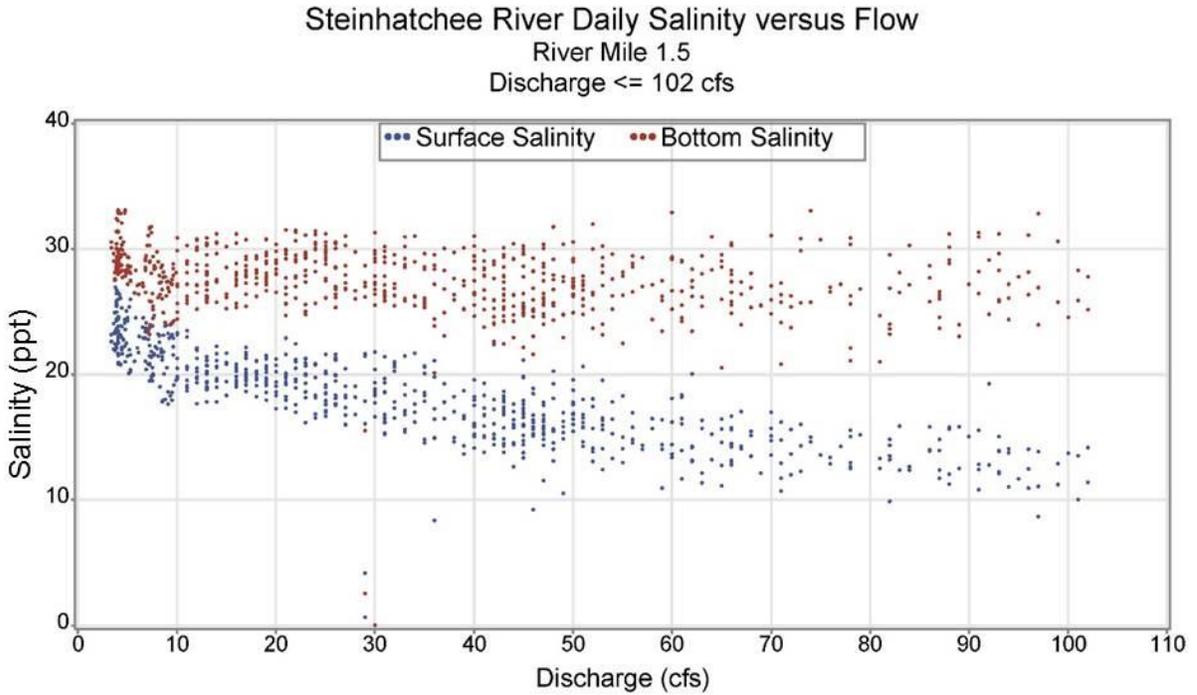


Figure 6-2. Daily mean surface and bottom salinities versus flow (<median flow) for RM 1.5 and RM 4.5

Examination of the figures above and those in Appendix D identifies some key properties of how the system behaves in relation to the freshwater inflow. The degree of response or change due to increased flows for both the bottom and surface salinities increases as moving upstream, i.e., the upstream areas are more responsive to the flow reductions. Additionally, the surface salinities tend to be more responsive to flow changes than the bottom salinities. Finally, it is interesting to note that the response of the bottom salinities near the mouth is nearly flat, i.e., non-responsive to flow increases. This is seen in both ranges of flow.

6.1.2 OFFSHORE SCALLOP HABITAT

As identified in earlier sections, a key habitat identified for protection is the offshore or estuarine scallop habitats. The critical salinity range identified for protection was from 23 ppt to 26 ppt (Arnold 2009; Tettelbach and Rhodes 1981). Additionally, it was identified that the critical time period for protection was October to December. As scallops generally reside in bottom waters, the bottom area for salinity was identified as the criteria for protection.

Figure 6-3 present maps showing the mean bottom salinities in the offshore area of the model grid for the model period. Scallop habitats, as defined in previous sections, are exclusively located offshore of the river mouth, so the evaluation of these grids is critical. Looking at the plots shows that even under the 30 percent reduction in flows, there is negligible change in the bottom salinities in the offshore area, regardless of season.

As a secondary look, impacts of flow withdrawal on the defined habitat and time period for scallops was done by looking at bottom habitat area changes during the months of October to December for the range of salinity between 23 ppt and 26 ppt. It is important to note that this analysis considers all habitat areas, including those inside of the mouth. This includes all of the model grid up to RM 6.0. This provides a highly conservative evaluation of the potential impacts of flow reduction. Figures 6-4 and 6-5 present time series and cumulative distribution functions (CDFs) for the model period under 0 flow reduction and the various percent flow reductions. The CDF plots are for the October to December season. The data show that scallop habitat will not drive the MFL determination.

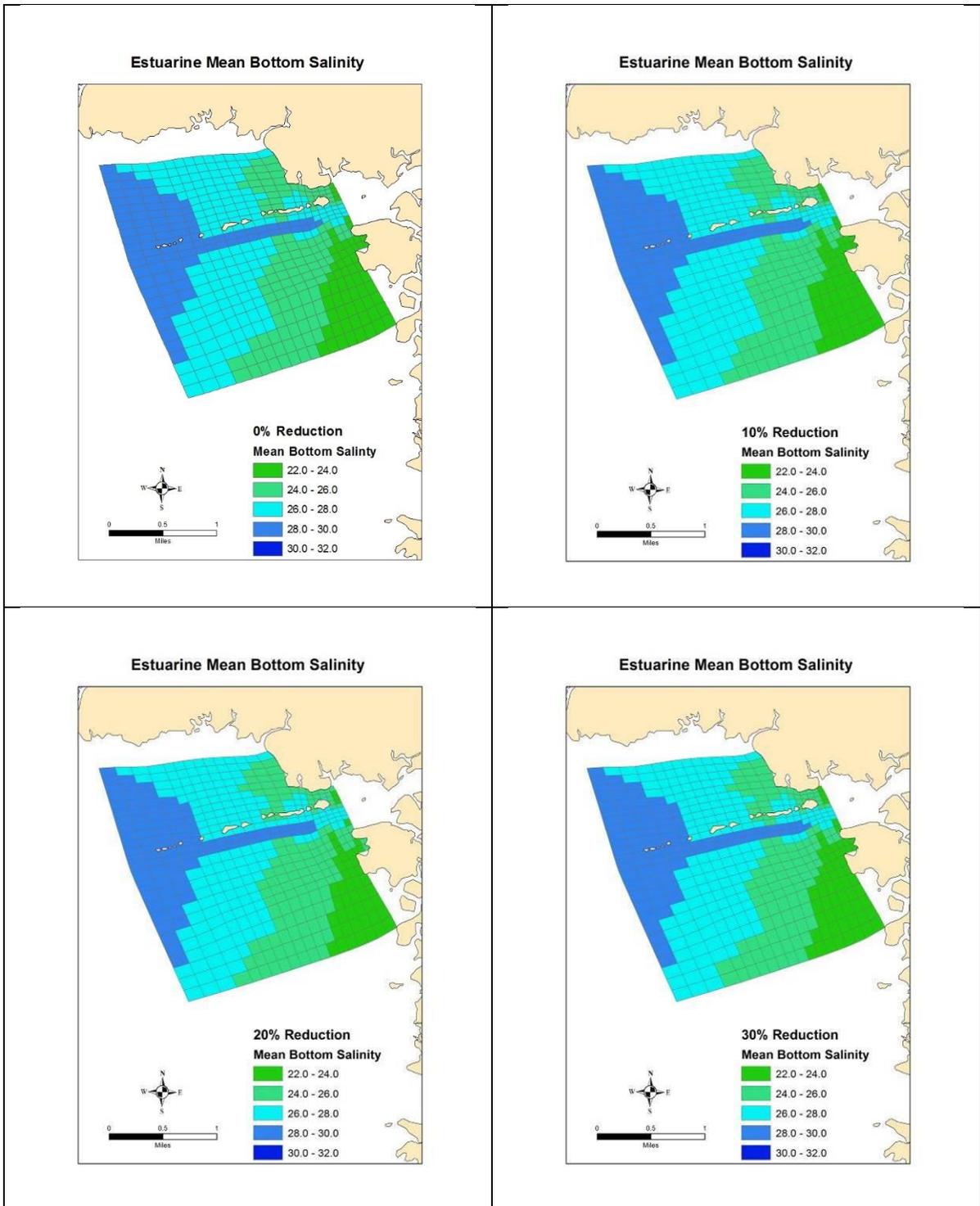


Figure 6-3. Mean bottom salinities in offshore area under varying flow reductions.

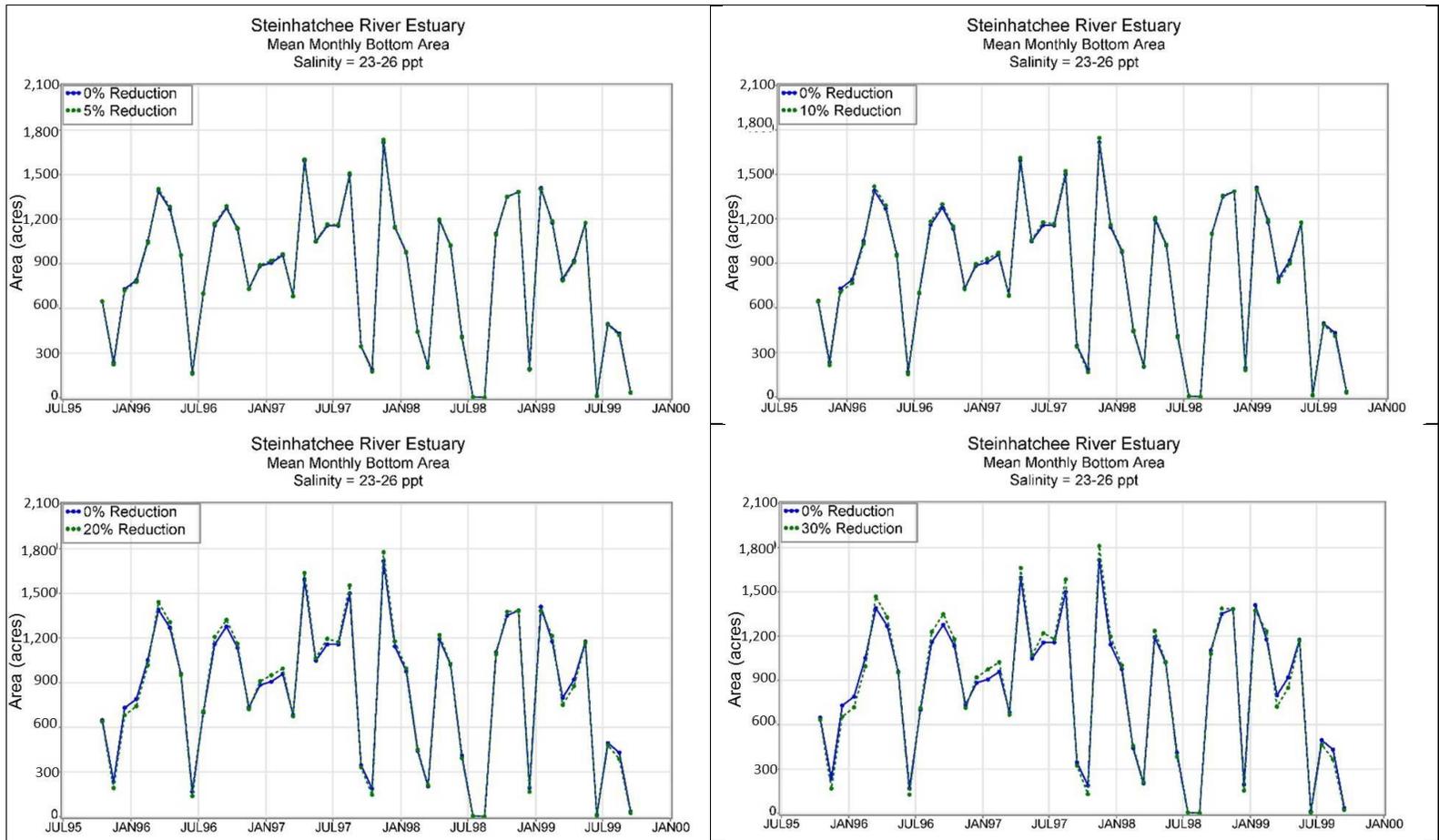


Figure 6-4. Time series of mean bottom area compared to 0 percent flow reduction (23 to 26 ppt range).

Steinhatchee River Estuary
 Mean Daily Bottom Area with Salinity = 23-26 ppt
 October-December

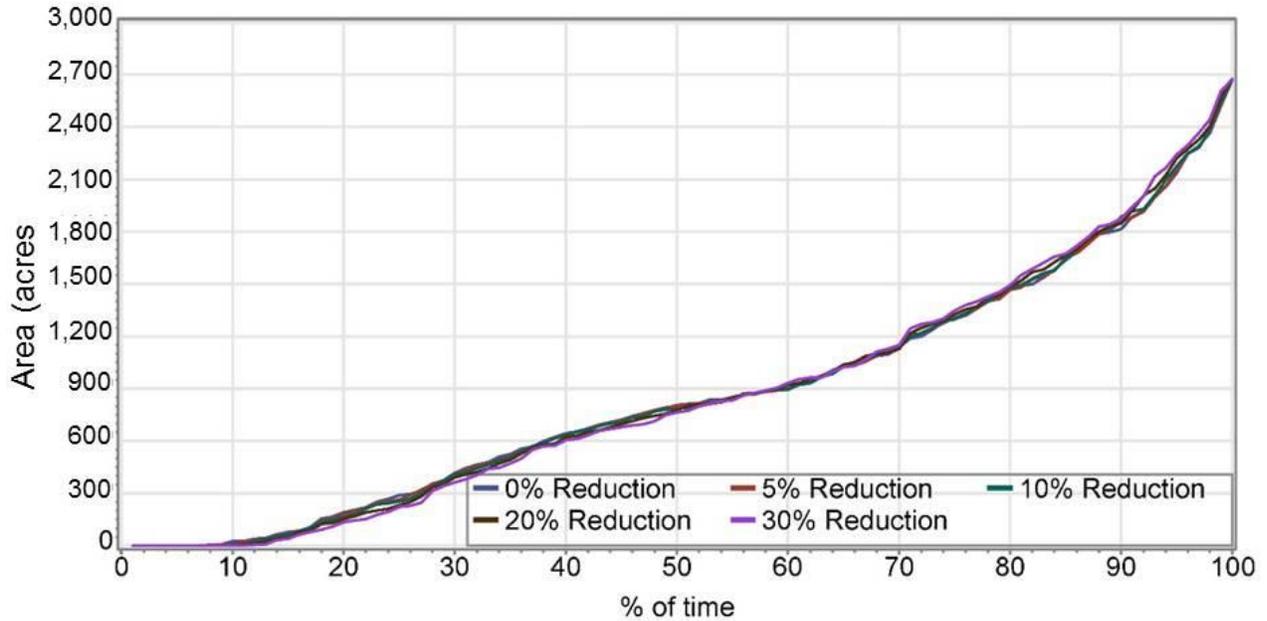


Figure 6-5. Cumulative distribution function of mean bottom area compared to 0 percent flow reduction (23 to 26 ppt range).

6.1.3 RIVER/ESTUARINE HABITAT

The establishment of the Steinhatchee River MFL for salinity will be based on the responses in the river as indicated by the output from the model runs for a series of flow reductions (5 percent, 10 percent, 20 percent, and 30 percent) and the estimated differences from the base model scenario. The responses include the bottom habitat (area), the estuarine water column habitat (volume), and shoreline habitat (river miles). The analyses presented below are based on all grids within the model below RM 6.0.

Figure 6-6 presents a time series of mean monthly river bottom area with salinity ranging from 0 to 5 ppt, comparing the 0 percent flow reduction to the four percent flow reduction scenarios (5 percent, 10 percent, 20 percent, and 30 percent). Appendix D presents the full set of plots including the 0 ppt and 0 to 2 ppt ranges. In all cases, the acres of bottom habitat for each of the salinity ranges decreased with decreasing flow. Under the 5 percent reduction, this change is very small, but at the 30 percent reduction level, these can be substantial.

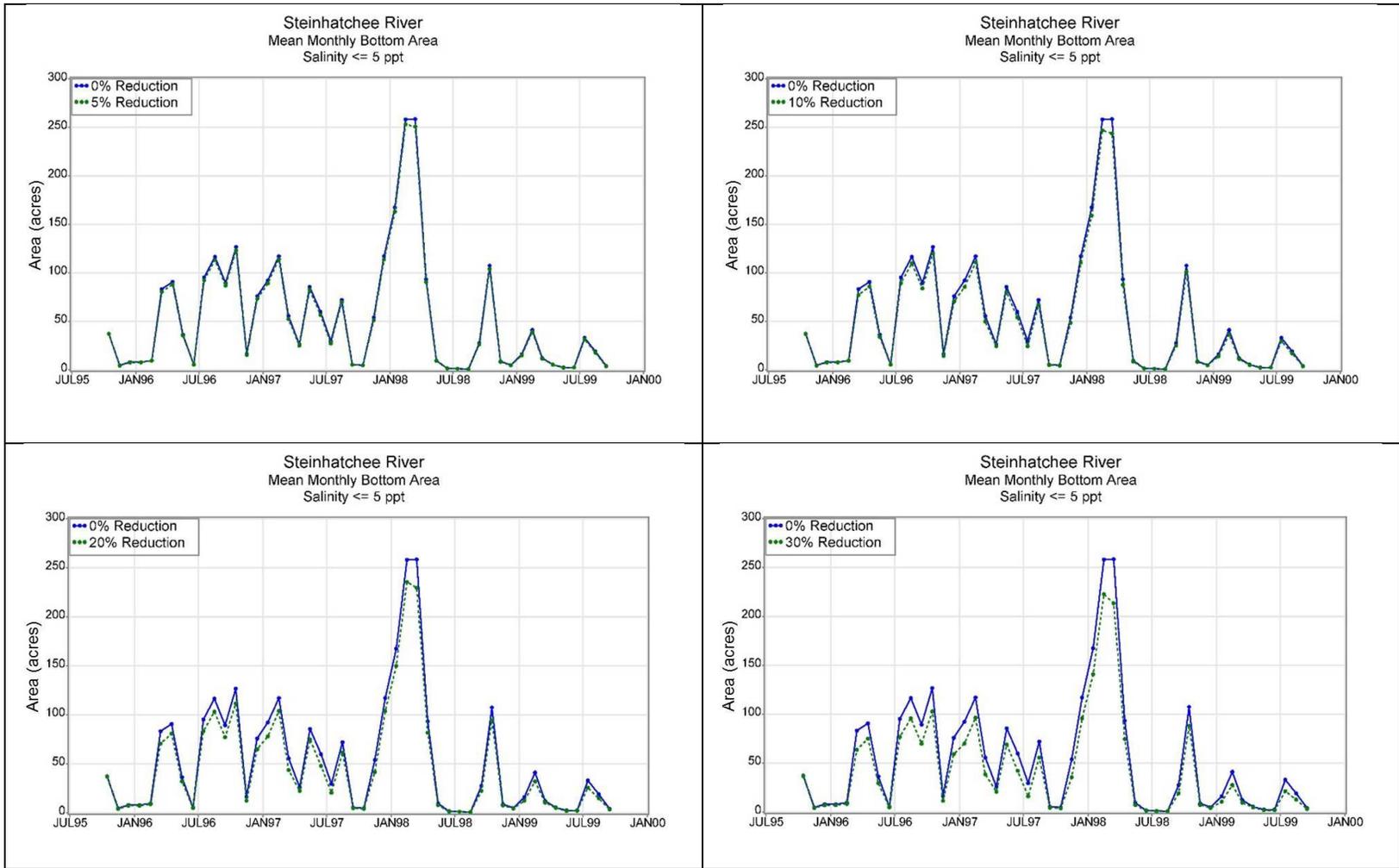


Figure 6-6. Time series of bottom area compared to 0 percent flow reduction (<=5 ppt).

Figure 6-7 presents a time series of mean monthly water column volume with salinity ranging from 0 to 5 ppt, comparing the 0 percent flow reduction to the four percent flow reduction scenarios (5 percent, 10 percent, 20 percent, and 30 percent). Appendix D presents the full set of plots including the 0 ppt and 0 to 2 ppt ranges. As with the bottom area, the habitat volumes are reduced with decreasing flow. Again, the 5 percent changes are relatively small but become more substantial moving up to the 30 percent reduction. Of the three criteria, the volumes appear to be the most sensitive to flow reductions.

Figure 6-8 presents a time series of mean monthly shoreline length with salinity ranging from 0 to 5 ppt, comparing the 0 percent flow reduction to the four percent flow reduction scenarios (5 percent, 10 percent, 20 percent, and 30 percent). Appendix D presents the full set of plots including the 0 ppt and 0 to 2 ppt ranges. The results are again proportional to the flow reductions, with little difference at the 5 percent reduction and becoming more substantial moving toward the 30 percent reduction. Shoreline length appears to show the least sensitivity to the flow of the three criteria.

The responses in the river volume, bottom area, and shoreline length at the three critical salinity ranges to the simulated reductions in river flow were also examined by plotting the cumulative distribution functions of the 0 percent flow reduction with the results from each of the four different percent reductions in river flow.

Figure 6-9 presents the comparisons of the cumulative distribution functions of the mean monthly bottom area for the 0 to 5 ppt salinity range. Appendix D presents the full set of plots including the 0 ppt and 0 to 2 ppt ranges. As with the time series, the changes are proportional to the amount of flow reduction, but only 50 percent of the time (upper 50 percent) shows changes. The lower 50 percent of the time, when the areas of habitat are small, there is little change.

Figure 6-10 presents the comparisons of the cumulative distribution functions of the mean monthly water column volume for the 0 to 5 ppt salinity range. Appendix D presents the full set of plots including the 0 ppt and 0 to 2 ppt ranges. As with the bottom area, the changes are proportional to the amount of flow reduction, but again only 50 percent of the time (upper 50 percent) shows changes. Volume appears to show the greatest degree of change with the flow reductions.

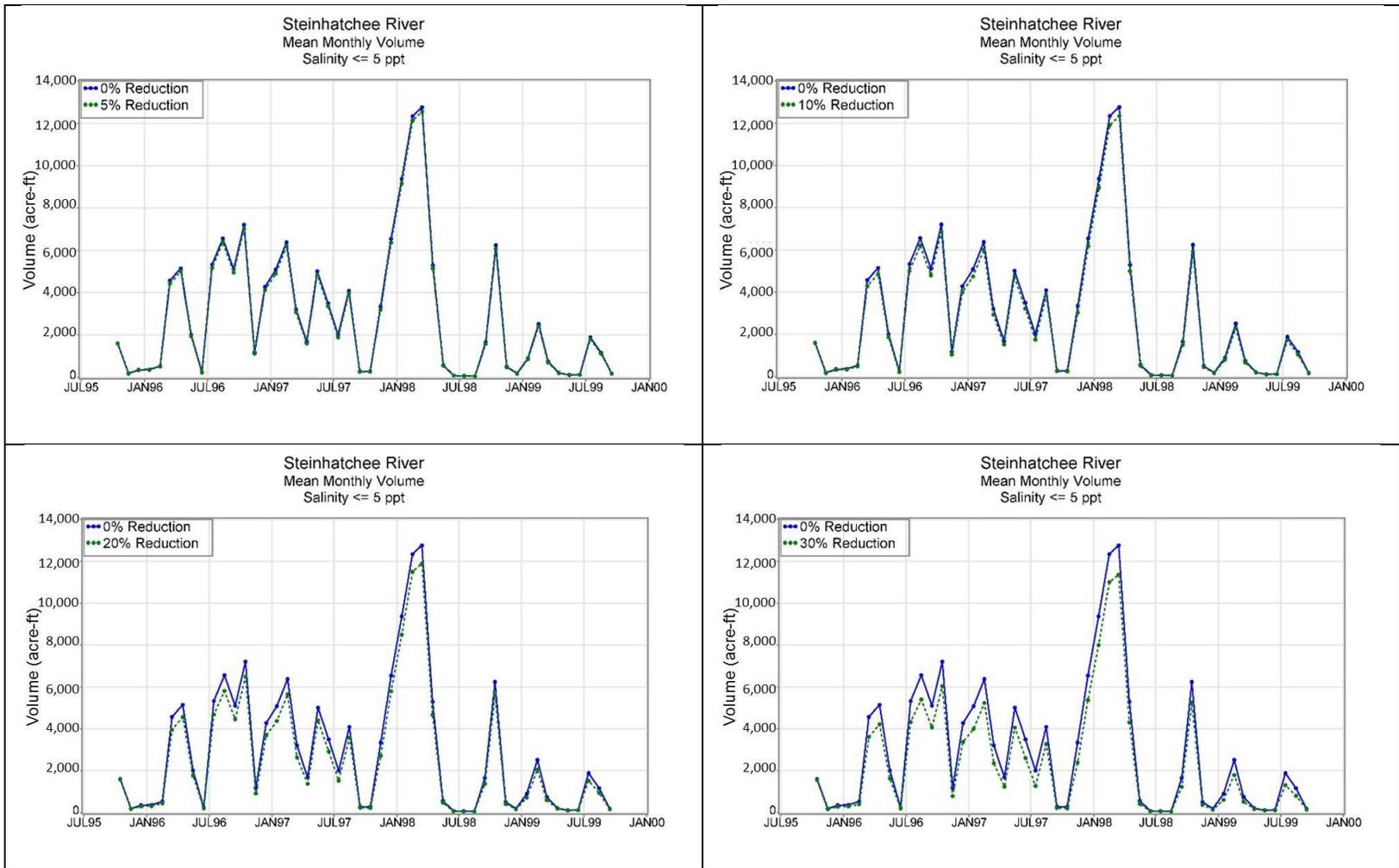


Figure 6-7. Time series of habitat volume compared to 0 percent flow reduction (<=5 ppt).

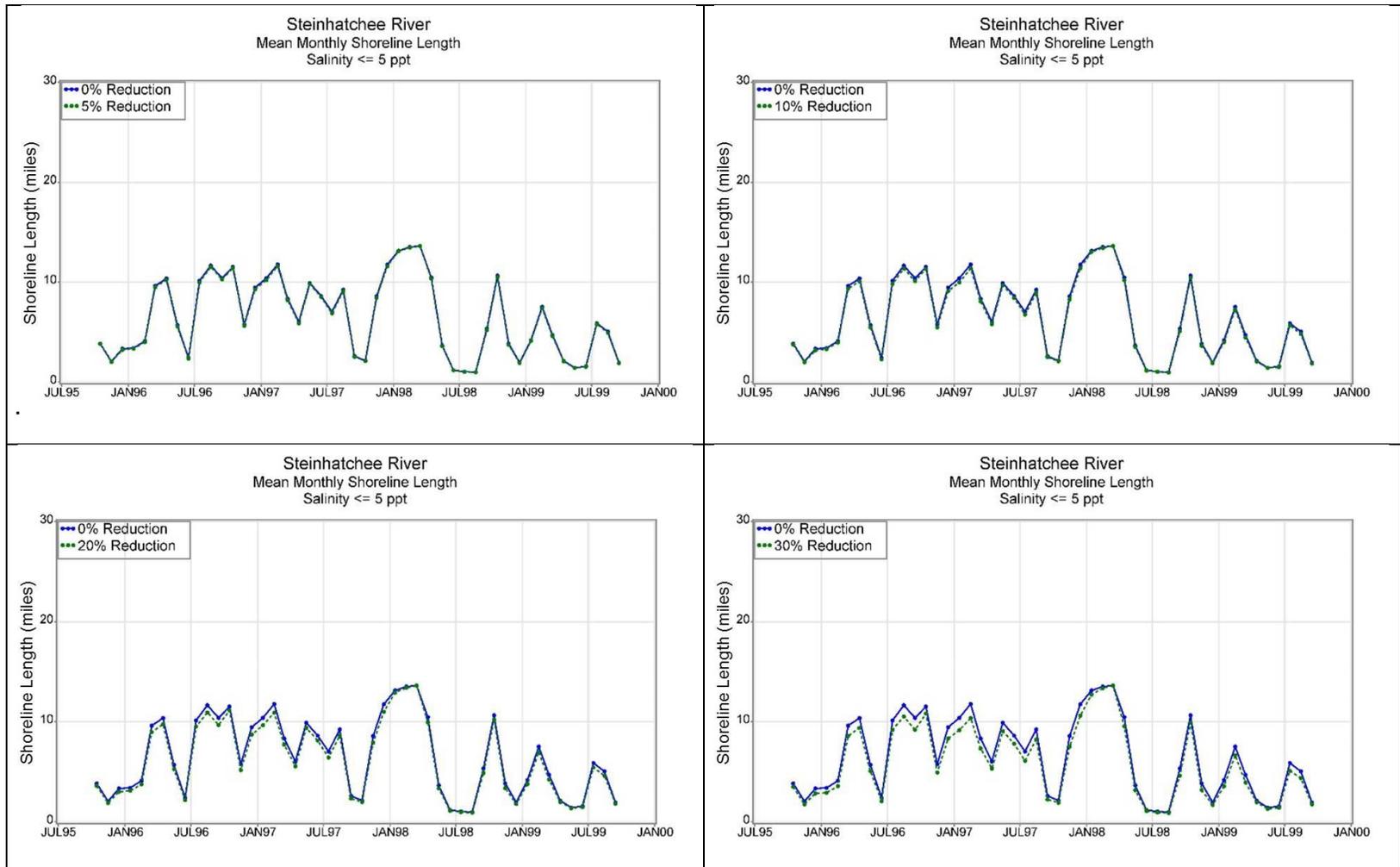


Figure 6-8. Time series of shoreline length compared to 0 percent flow reduction (<=5 ppt).

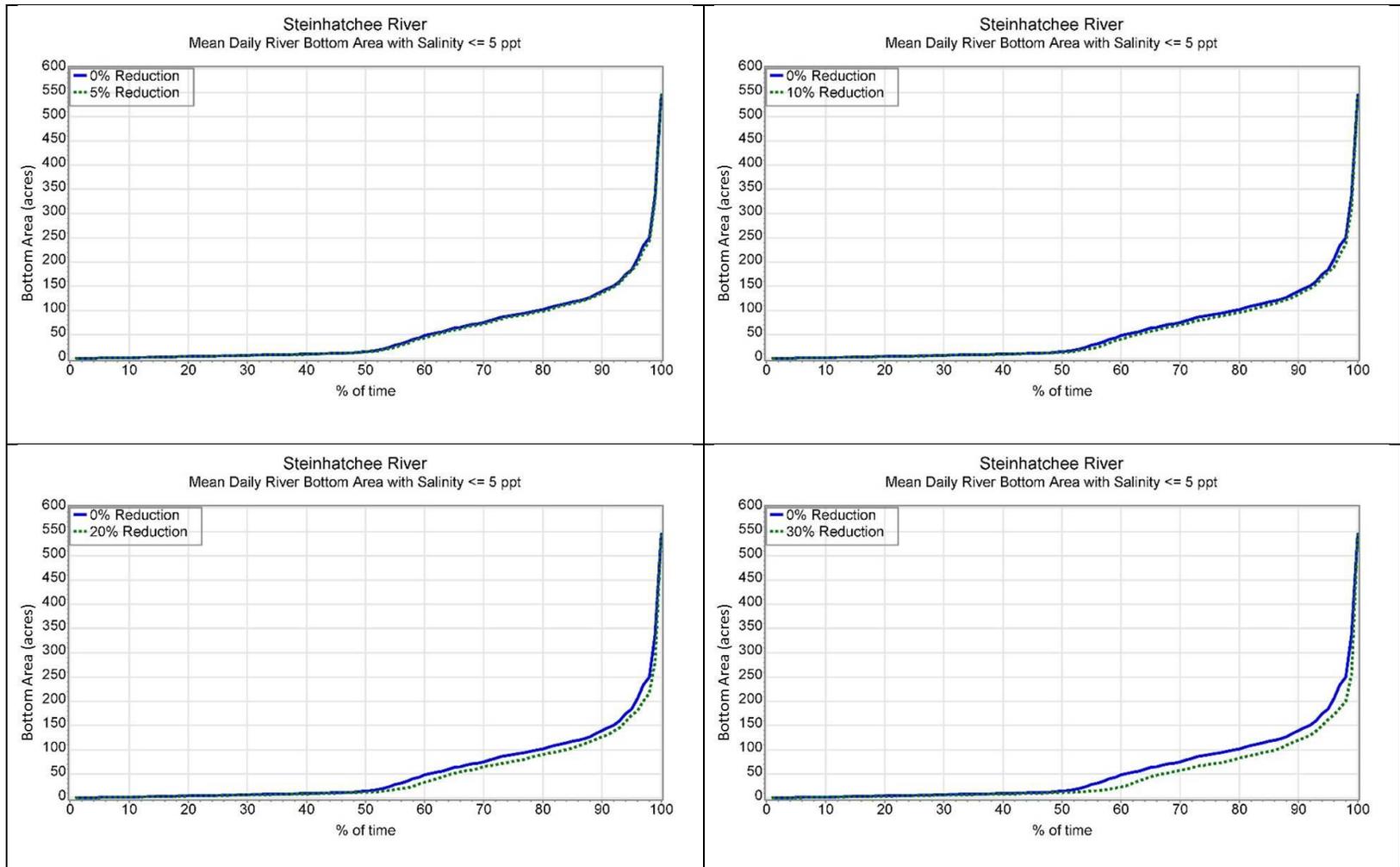


Figure 6-9. CDF of bottom area compared to 0 percent flow reduction (≤ 5 ppt).

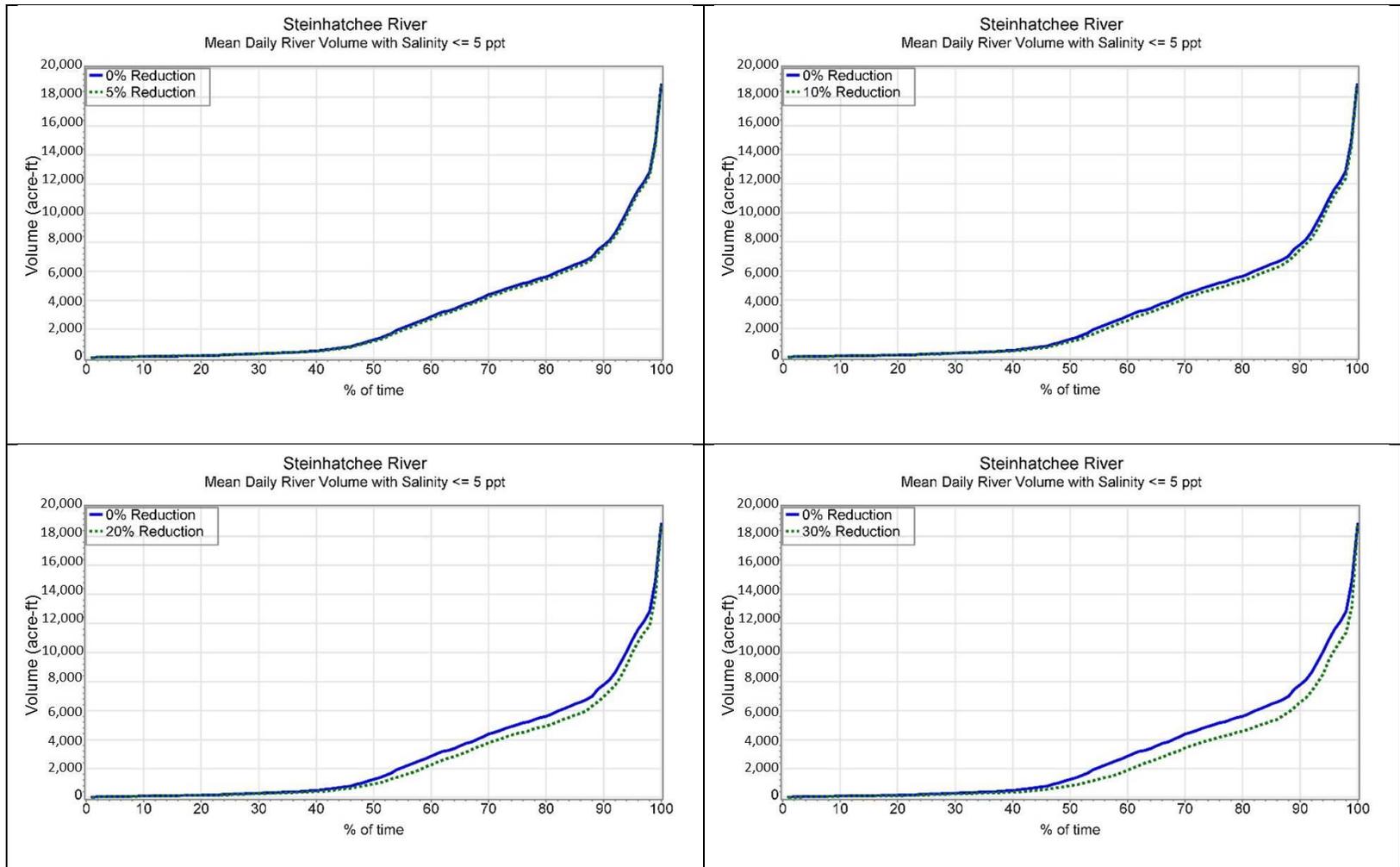


Figure 6-10. CDF of habitat volume compared to 0 percent flow reduction (<=5 ppt).

Figure 6-11 presents the comparisons of the cumulative distribution functions of the mean monthly shoreline length for the 0 to 5 ppt salinity range. Appendix D presents the full set of plots including the 0 ppt and 0-2 ppt ranges. As with the other two criteria, the changes are proportional to the amount of flow reduction, but again, only 50 percent of the time (upper 50 percent) shows changes.

Tables 6-1 through 6-3 present a summary of the comparisons of the median river volume, bottom area, and shoreline length between the 0 percent flow reduction and the four percent reduction scenarios. For example, the statistics compared in these tables were calculated by estimating the daily river volume for a given salinity or salinity range for each day in the simulation period and deriving the median of those values for each model scenario. The differences between the medians for each of the percent reduction scenarios and the median for the 0 percent flow reduction condition are calculated as a percent difference. The objective is to estimate the percent flow reduction that corresponds to a 15 percent difference from the 0 percent flow reduction.

With respect to both the bottom area (Table 6-2) and shoreline length (Table 6-3) the only times that the percent changes rise above the 15 percent threshold are at the higher flow reductions, i.e., 20 percent and 30 percent. Table 6-1 presents the changes in the volume of salinity habitat. Examination of this table shows that the greatest changes occur in the 0-5 ppt salinity range for the water column volume habitat. Looking at the point where the percent change is equal to 15 percent the associated flow reduction for this metric is 11.5 percent. This is the critical percent flow reduction for the salinity habitat.

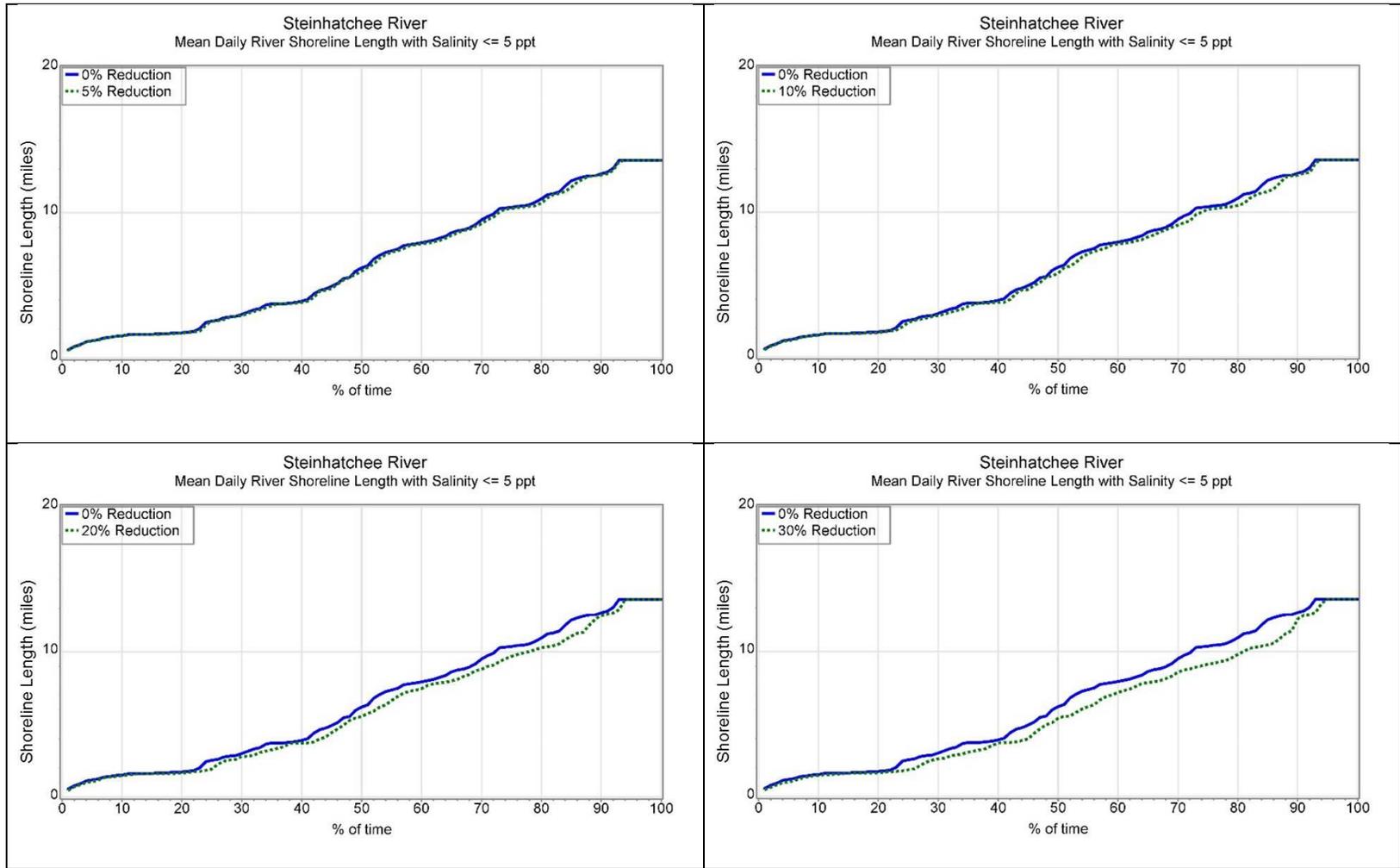


Figure 6-11. CDF of shoreline length compared to 0 percent flow reduction (<=5 ppt).

Table 6-1. Comparison of median 0 percent flow reduction volume to the median volumes by critical salinity for each of the four (4) percent reduction scenarios.

Scenario	Statistic	0 ppt	0-2 ppt	0-5 ppt
0% Reduction	Volume (acre-ft)	173	505	1,246
5% Reduction	Volume (acre-ft)	168	476	1,160
	% Difference from 0% Reduction	-3.3%	-5.7%	-6.9%
10% Reduction	Volume (acre-ft)	160	455	1,082
	% Difference from 0% Reduction	-7.6%	-10.0%	-13.2%
20% Reduction	Volume (acre-ft)	150	361	819
	% Difference from 0% Reduction	-13.3%	-20.2%	-24.4%
30% Reduction	Volume (acre-ft)	138	361	819
	% Difference from 0% Reduction	-20.5%	-28.5%	-34.3%

Table 6-2. Comparison of median 0 percent flow reduction bottom area to the median bottom areas by critical salinity for each of the four (4) percent reduction scenarios.

Scenario	Statistic	0 ppt	0-2 ppt	0-5 ppt
0% Reduction	Bottom Area (acres)	8.59	10.98	14.4
5% Reduction	Bottom Area (acres)	8.26	10.90	13.81
	% Difference from 0% Reduction	-3.9%	-0.8%	-4.1%
10% Reduction	Bottom Area (acres)	7.95	10.66	12.75
	% Difference from 0% Reduction	-7.5%	-2.9%	-11.5%
20% Reduction	Bottom Area (acres)	7.51	10.25	11.75
	% Difference from 0% Reduction	-12.6%	-6.7%	-18.4%
30% Reduction	Bottom Area (acres)	6.95	9.25	11.34
	% Difference from 0% Reduction	-19.1%	-15.8%	-21.2%

Table 6-3. Comparison of median 0 percent flow reduction shoreline length to the median shoreline lengths by critical salinity for each of the four (4) percent reduction scenarios.

Scenario	Statistic	0 ppt	0-2 ppt	0-5 ppt
0% Reduction	Shoreline Length (miles)	1.24	3.91	6.19
5% Reduction	Shoreline Length (miles)	1.20	3.77	5.98
	% Difference from 0% Reduction	-3.3%	-3.5%	-3.3%
10% Reduction	Shoreline Length (miles)	1.17	3.73	5.77
	% Difference from 0% Reduction	-5.1%	-4.6%	-6.7%
20% Reduction	Shoreline Length (miles)	1.14	3.59	5.55
	% Difference from 0% Reduction	-8.3%	-8.0%	-10.3%
30% Reduction	Shoreline Length (miles)	1.04	3.38	5.40
	% Difference from 0% Reduction	-16.3%	-13.5%	-12.8%

6.2 FISH PASSAGE

As discussed in Section 5, fish passage is assumed to be precluded at water depths less than 0.8 ft (Thompson 1972). The water depths along the thalweg of the river were estimated based on runs of the HEC-RAS model over the full simulation period (WYs 1951-2015), and a critical flow was identified. Figure 6-12 presents a plot showing the critical depth, (Z) which represents the difference between the thalweg depth and the critical depth (0.8 ft), plotted against river mile for a specified flow exceedance. The red dot represents the cross-section where the critical depth was reached. This occurred at a 56 percent flow exceedance value which was equivalent to 78 cfs. For the POR of the simulations, Figure 6-13 presents the number of days that the critical flow was exceeded under the baseline condition (blue line). The simulations were then performed under varying flow reductions and the number of days of percent exceedance were plotted against the flow reduction (Figure 6-14). The red line in Figure 6-14 represents a 15 percent change in the number of days of exceedance of the critical flow (from near 13,000 days over the full POR down to near 11,000 days). This occurred at a flow reduction of between 32 and 34 percent. The green line on Figure 6-13 then shows the revised annual flow conditions over the POR.

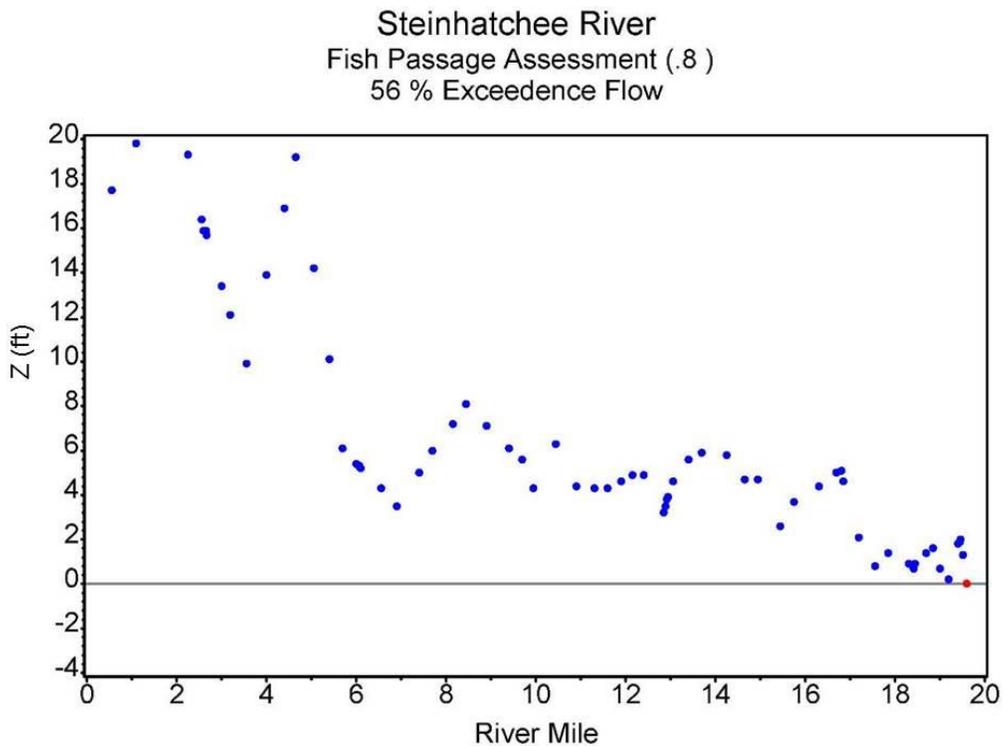


Figure 6-12. Critical depth versus river mile for 56 percent flow exceedance.

Steinhatchee River near Cross City
 Fish Passage Assessment (0.8 ft)
 Critical Q = 78 cfs

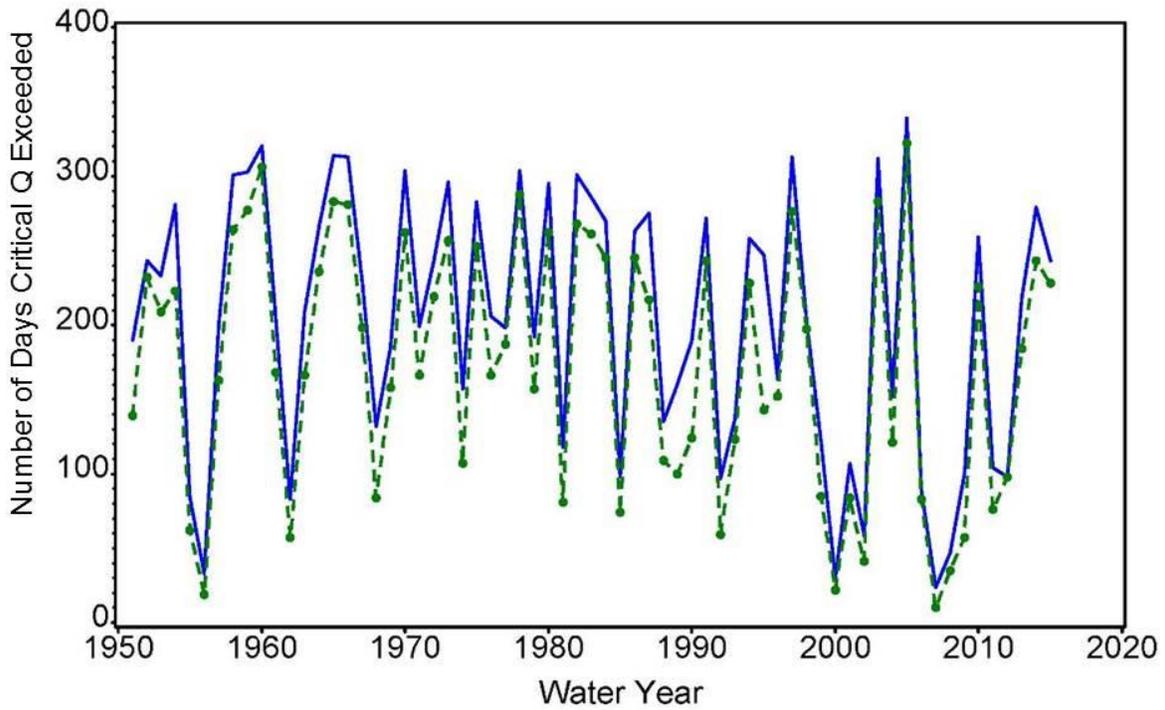


Figure 6-13. Number of days critical flow exceeded over POR.

Steinhatchee River near Cross City
 Fish Passage Assessment (0.8 ft)
 Critical Q = 78 cfs Transect=101643.7 RM=19.6

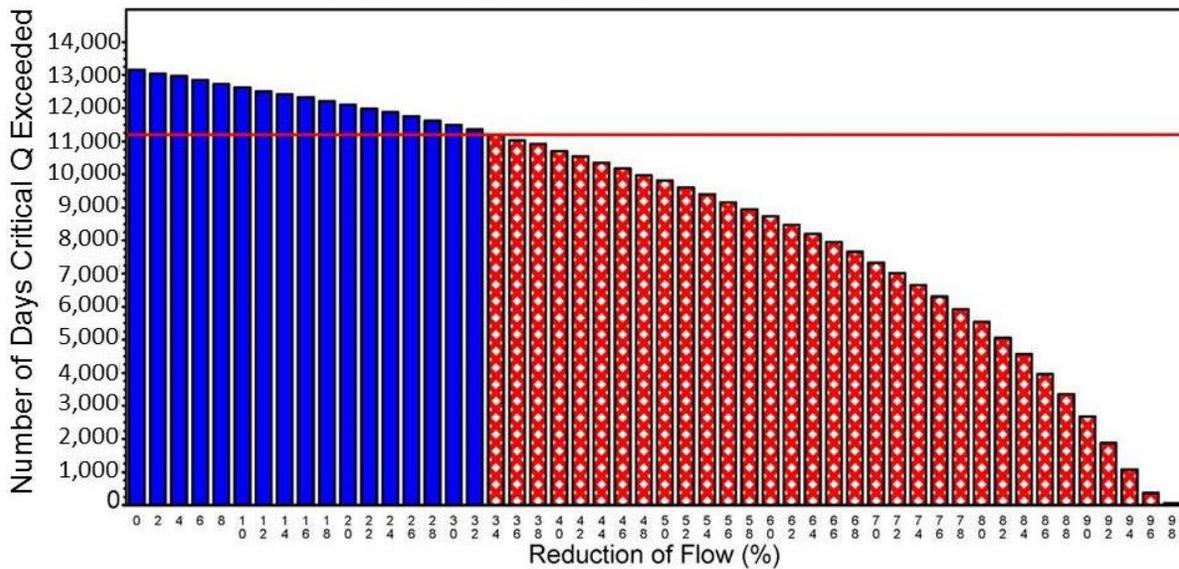


Figure 6-14. Number of days critical flow exceeded versus percent flow reduction.

6.3 IN-STREAM HABITAT

As stated in Section 5.3.3 incremental flow reductions were applied to each discharge measurement value in the historic POR over a range of 5 percent to 30 percent. For the species evaluated, percent changes in the Area Weighted Suitability (AWS) were evaluated to determine the flow reduction that caused a reduction in the AWS greater than 15 percent.

Channel catfish (*Ictalurus punctatus*) juvenile along with spotted sunfish (*Lepomis punctatus*) juvenile, spawning, and fry are all deemed critical species in this study (Table 6-4). Duration curves containing the area weighted suitability and percent reductions across the historic flow record are presented in Figures 6-15a through 6-15d.

Table 6-4. Summary of critical species and maximum allowable reduction in flow.

Species / Life Stage	Reductions					
	5%	10%	15%	20%	25%	30%
Channel Catfish - Juvenile	-2.44	-4.27	-7.32	-9.76	-12.20	-15.24
Spotted Sunfish - Juvenile	-2.44	-4.27	-7.32	-9.76	-12.20	-15.24
Spotted Sunfish - Spawning	-2.42	-4.85	-7.27	-9.70	-12.73	-15.76
Spotted Sunfish - Fry	-2.26	-4.51	-6.77	-9.77	-12.03	-15.04

* Red type denotes a reduction in the AWS of greater than 15 percent.

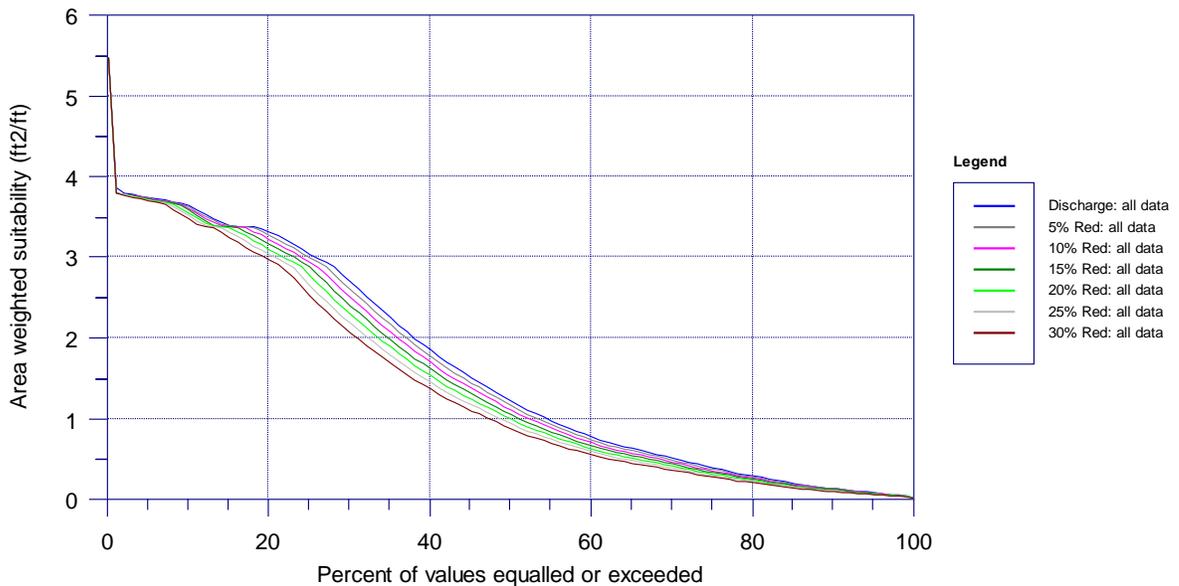


Figure 6-15a. Area weighted suitability duration curves with 0 percent flow reduction discharge including the various percent reductions for channel catfish-juvenile.

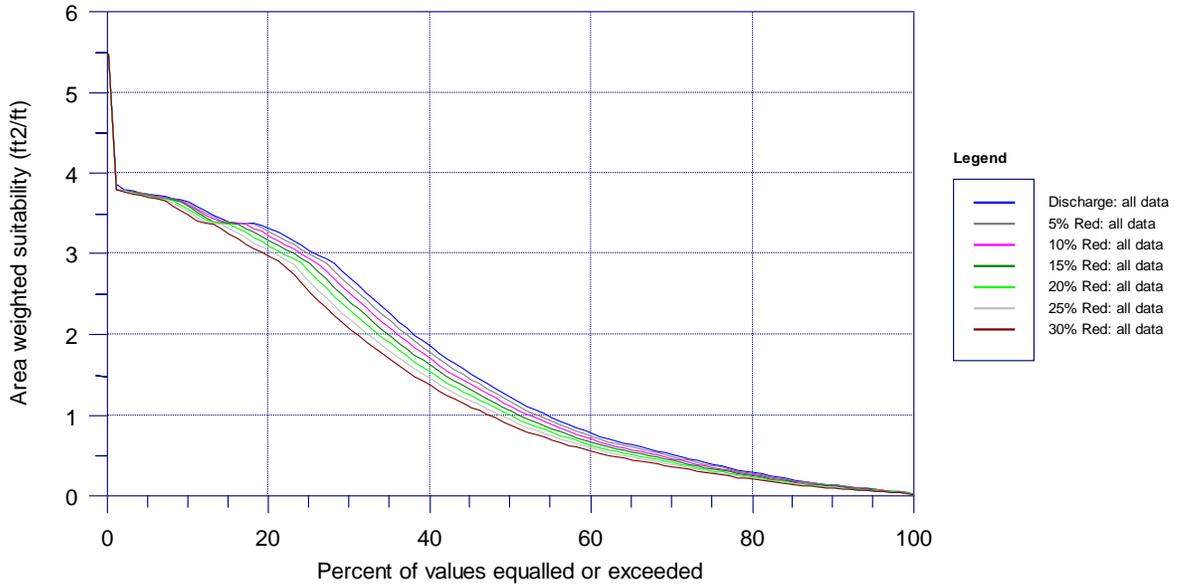


Figure 6-15b. Area weighted suitability duration curves with 0 percent flow reduction discharge including the various percent reductions for spotted sunfish juvenile.

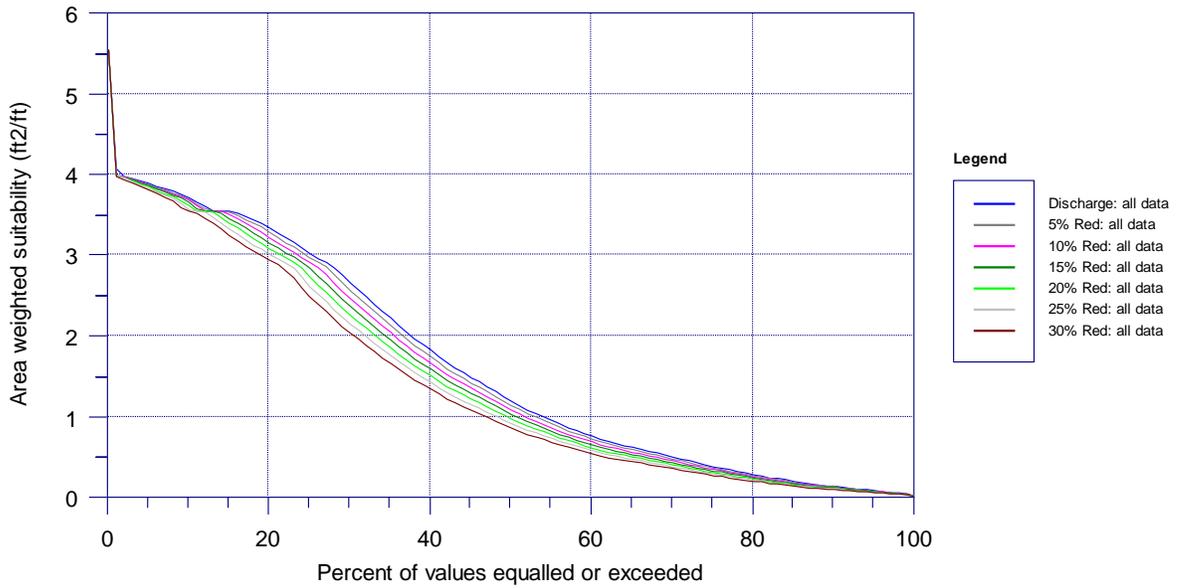


Figure 6-15c. Area weighted suitability duration curves with 0 percent flow reduction discharge including the various percent reductions for spotted sunfish spawning.

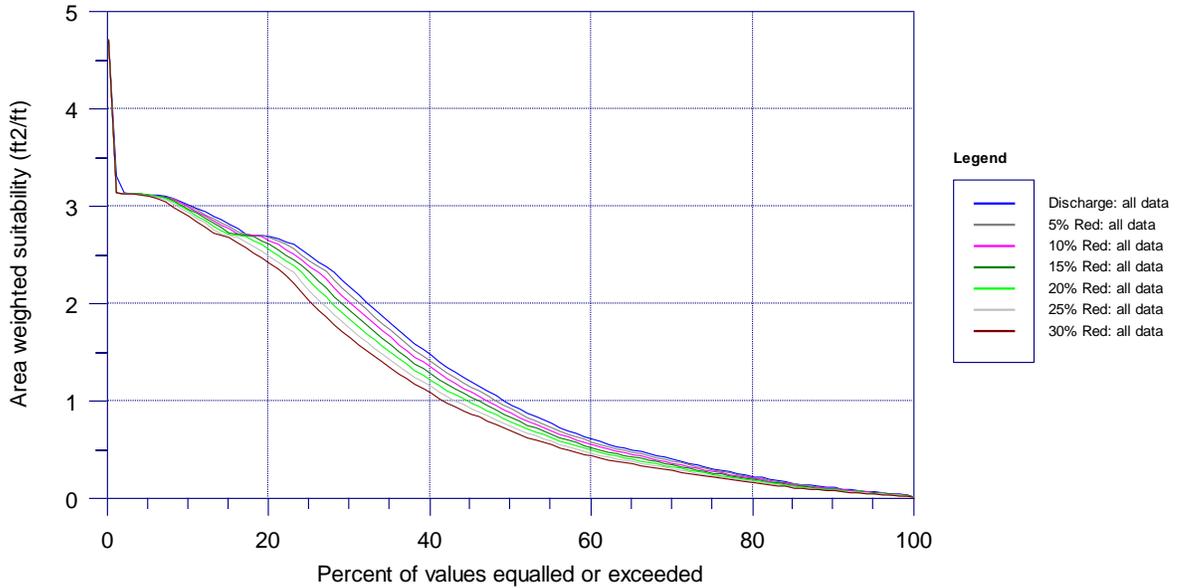


Figure 6-15d. Area weighted suitability duration curves with 0 percent flow reduction discharge including the various percent reductions for spotted sunfish fry.

The use of linear interpolation on flow reductions between 25 to 30 percent indicated that spawning spotted sunfish are the most restrictive species and life stage, with the most deleterious effects to habitat occurring at the 29 percent flow reduction scenario. Thus, any flow reduction greater than 28 percent would cause a greater than 15 percent reduction in the species' habitat.

6.4 RESPONSES IN RIPARIAN HABITAT TO REDUCTIONS IN FLOWS

Wetted perimeter plots (wetted perimeter versus flow at the Steinhatchee gage) were developed for each HEC-RAS cross-section of the Steinhatchee River. For the freshwater non-tidal portions of the system (above Steinhatchee Falls), plots of the wetted perimeter versus flow are presented in Appendix D. As discussed in Section 5.3.4, the determination of a "critical" minimum flow is identified through the identification of inflection points or points where the wetted perimeter changes significantly. In the plots presented in Appendix D, the inflection points are where significant changes in slope are identified. The "critical" inflection point is that at the lowest flow identified. For the results from the cross-sections presented, a critical flow of from 10 to 20 cfs was identified based upon visual examination of the plots. This becomes the critical minimum flow for the system. While the results of the wetted perimeter analysis are presented for informational purposes, this metric was not utilized in the definition of the MFL.

6.5 RESPONSES IN FLOODPLAIN HABITAT TO REDUCTIONS IN FLOWS

As was outlined in Section 5.3.5, a critical flow was identified that represented the median floodplain inundation condition. Using the POR for the Steinhatchee USGS gage, a count was taken of the number of days in which the daily flow records exceeded the critical flow. The daily flow record was then repeatedly reduced by 1 percent. Figure 6-16 presents the number of days the critical flow is exceeded under the baseline and repeated 1 percent reductions in flow. The percent reduction in flow that represents a 15 percent reduction in the number of days the critical flow is exceeded is shown on the graph as the point of transition from the blue to red. This is a reduction in the number of days from near 450 down to near 382. This is between a 5 and a 6 percent reduction in flow. For the purposes of the MFL recommendations in Section 6.6, a 5.5 percent flow reduction is identified as the allowable to maintain the floodplain habitat.

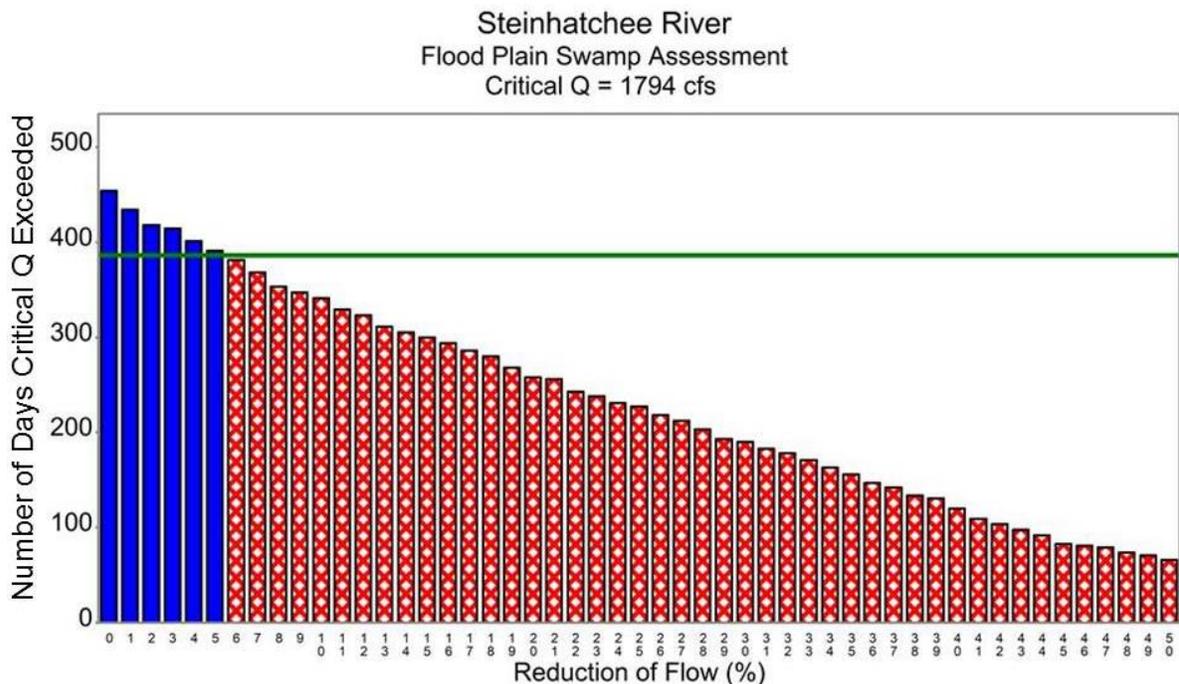


Figure 6-16. The reduction of flow which results in a 15 percent decrease in days of inundation of the floodplain swamp adjacent the Steinhatchee River.

6.6 MFL RECOMMENDATIONS

The baseline flow regime was developed as described in Section 2.3. The baseline flow regime is comprised of daily flows for the period encompassing WYs 1951-2015. Figure 6-17 presents the baseline flow duration curve (FDC).

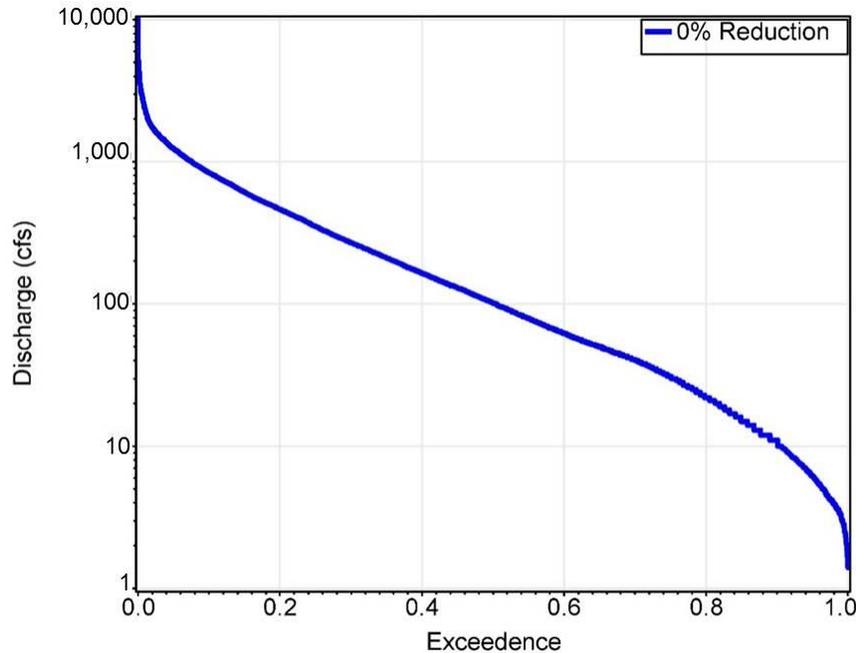


Figure 6-17. 0 percent flow reduction flow duration curve.

The critical flows for each of the MFL metrics examined were presented in Sections 6.1 through 6.5. Allowable shifts in the critical flow for each metric were also determined. Table 6-5 presents a summary of these habitat responses, critical flows, and allowable percent flow reductions for each metric.

Table 6-5. Summary of MFL metrics, habitat responses and allowable percent flow reductions.

MFL Metric	Habitat Response	Flow / % Reduction
Salinity Habitat	15% Volume Change (0 – 5 ppt Oligohaline zone)	11.5%
Fish Passage	15% Percent Exceedance (Critical Flow = 78 cfs)	33.5%
Flood Plain Inundation	15% Percent Exceedance (Critical Flow = 1,794 cfs)	5.5%
Habitat Suitability	Area Weighted Suitability	28%

6.6.1 MAIN STEM STEINHATCHEE MFL

Based on these results, the main stem of the Steinhatchee will have two protective flow metrics which apply to different flow ranges. The most protective MFL metric, representing the MFL metric with the lowest allowable flow reduction, is the Flood Plain Inundation, but this metric only applies at higher flow regimes when the flow goes over bank. The critical flow for the Flood Plain Inundation metric was defined as 1,794 cfs. When considered

solely, the most protective metric relative to the full flow range is the Salinity Habitat, but this metric is applied to flows below 1,794 cfs for a conservative regulation of withdrawals for the entire range of potential flows.

The wetted perimeter metric was examined and is typically used to define a low flow cutoff, which is a flow below which no withdrawals are permitted. This is a useful concept in rivers where flow reductions due to direct withdrawals are used to provide the water demand. However, this concept is moot in the case of the Steinhatchee Basin where predominant water withdrawals result from groundwater withdrawals. As such, this metric is not utilized in the definition of the MFL.

To evaluate the allowable flow reductions, a withdrawal schedule was developed for each of the metrics and plotted on a single graph. Figure 6-18 presents plots of the various metrics and where they apply over a range or at a point. To define an implementable withdrawal schedule where withdrawal amounts do not decrease over any range of increasing flows, a withdrawal line was established that combined the allowable flow reduction for salinity over a range of flow, and transitions to the more restrictive percent reductions defined at the higher critical flows. The dotted line in Figure 6-18 represents the withdrawal schedule that is protective of all the Salinity Habitat metric at all flows. Two critical control points exist in this analysis. The first represents the critical flow for the Flood Plain Inundation (1,794 cfs). The second represents the Salinity Habitat withdrawal rate corresponding to that of Flood Plain Inundation at 1,794 cfs, that point is at 858 cfs. Below 858 cfs the salinity metric drives the allowable withdrawal. Above that point the allowable withdrawal is based on the Flood Plain Inundation withdrawal of 5.5 percent. Table 6-6 presents a final table that defines the allowable withdrawals.

Figure 6-19 presents the resulting FDC for the proposed MFL flow regime. The two control points are shown on the plots. The differences in the two FDCs estimate the allowable flow reductions consistent with the proposed MFL. The difference is 11.5 percent of the baseline flow up to the control point at 858 cfs. At flows greater than 1,794 cfs, the difference is 5.5 percent.

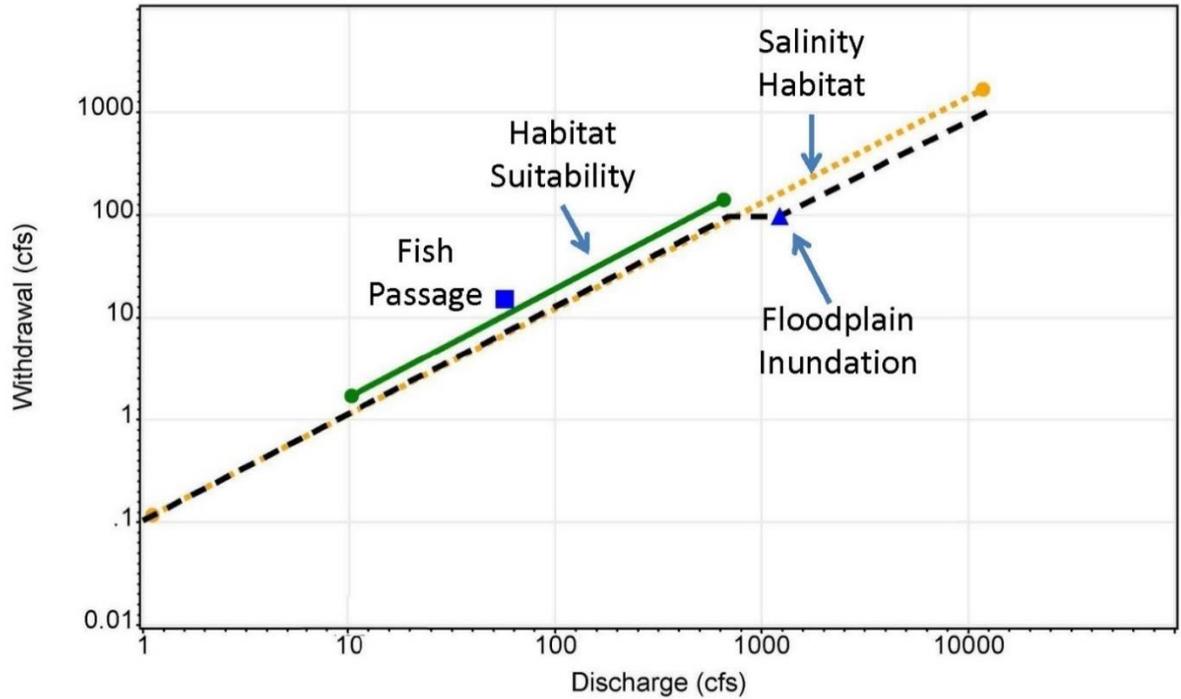


Figure 6-18. Withdrawal schedule based on the combined metrics.

Table 6-6. Withdrawal schedule based on the combined metrics

WRV Metrics	Flow Range	Withdrawal Rate	Final MFL Criteria		
			Percent Time MFL is Applicable	Range of Flow Available for Withdrawal (cfs)	Flow Reduction (%)
Salinity Habitat	$Q \leq 858$	$0.115 \times Q$	88	< 98.7	11.5
Floodplain Inundation	$858 < Q \leq 1,794$	98.7	2	98.7	5.5 – 11.5
	$Q > 1,794$	$0.055 \times Q$	10	> 98.7	5.5

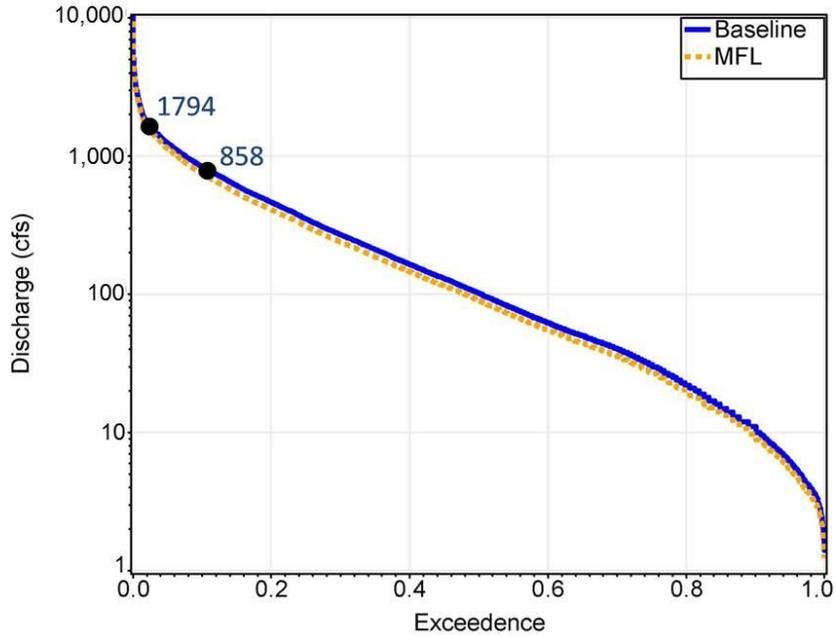


Figure 6-19. Flow duration curves for the 0 percent flow reduction and MFL flow regimes.

Figure 6-20 provides a summary of the available water based on the withdrawals displayed in Figure 6-18. This provides a useful tool during the evaluation of the water use permits application. The results show that the median amount of available water is approximately 10 cfs. Approximately 100 cfs of available water occurs only 10 percent of the time.

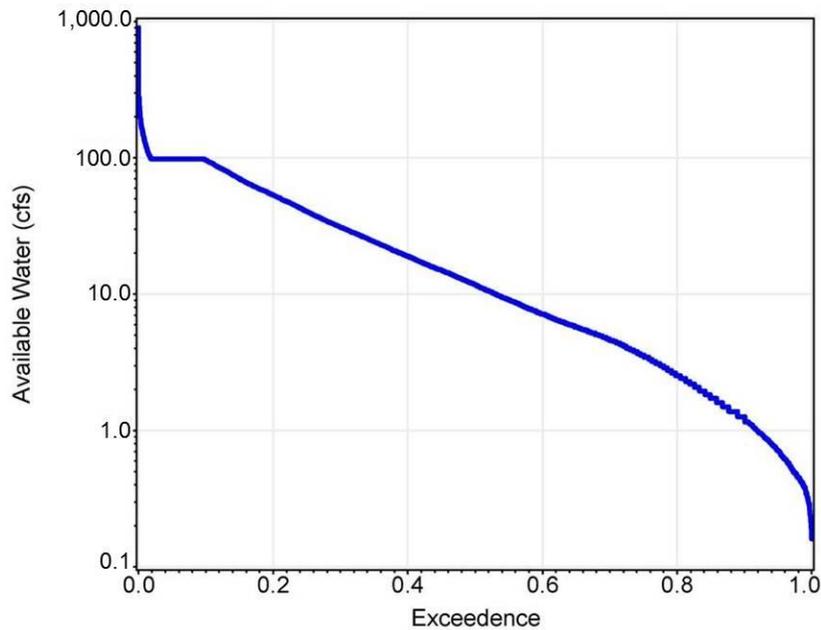


Figure 6-20. Allowable withdrawals as a function of river discharge and the critical flows and percent flow reduction for each of the MFL metrics examined.

6.6.2 SPRING MFLS

Two Priority Springs are located within the Steinhatchee River Basin. As described previously, these are the Steinhatchee River Rise and Beaver Creek Spring. The MFLs for these springs are defined using the same criteria as those defined for the main stem without consideration of the flow reduction restrictions associated with the overbank flow (floodplain habitat). Using the criteria and flow conditions defined under Section 6.6.1 the allowable percent reduction for the springs would be the 11.5 percent reduction defined for protection of the estuarine resource. This defines the MFLs for the two springs.

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