CHAPTER 10. WETLAND VEGETATION

by

Palmer Kinser
Sandra Fox
Lawrence Keenan, Ph.D.
Aisa Ceric
Fay Baird
Peter Sucsy, Ph.D.
William Wise, Ph.D., P.E.
Clay Montague, Ph.D.

St. Johns River Water Management District
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WETLAND VEGETATION WORKING GROUP

Name (Organization)	Role
Palmer Kinser (SJRWMD)	Working Group Leader, Author
Sandra Fox (SJRWMD)	Author
Lawrence Keenan, Ph.D. (SJRWMD)	Author
Aisa Ceric (SJRWMD)	Author
Fay Baird (SJRWMD)	Author
Peter Sucsy, Ph.D. (SJRWMD)	Author
William Wise, Ph.D., P.E. (University of Florida, Center for Wetlands, Department of Coastal and Civil Engineering)	Consultant, Author
Clay Montague, Ph.D. (University of Florida, Department of Environmental Engineering Sciences)	Consultant, Author
Ed Lowe, Ph.D. (SJRWMD)	Reviewer
Larry Battoe, Ph.D. (SJRWMD)	Reviewer
Donna Curtis (SJRWMD)	Advisor
William Dunn, Ph.D. (DSV Consulting, LLC)	Consultant, Advisor
Jane Mace (SJRWMD)	Advisor
Marc Minno, Ph.D. (SJRWMD)	Advisor
Kim Ponzio (SJRWMD)	Advisor
Ken Riddick (SJRWMD)	Data collection, field support
Jodi Slater (SJRWMD)	Advisor
Jessie Taft (SJRWMD)	Data collection, field support
Bill VanSickle (SJRWMD)	Advisor
Steve Winkler (SJRWMD)	Advisor

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Acronyms, Abbreviations, and Conversion Factors

µS cm^{-1}	MicroSiemens per centimeter
DEM	Digital elevation model
DM	Deep marsh
dS m^{-1}	DeciSiemens per meter
EFDC	Environmental Fluid Dynamics Code
ESRI	Environmental Systems Research Institute
FAC	Facultative
FACW	Facultative wet
FDEP	Florida Department of Environmental Protection
GIS	Geographic Information Systems
GPS	Global Positioning System
HAP	High Altitude Program
HH	Hydric hammock
IRL	Indian River Lagoon
LiDAR	Light Detection and Ranging
LSJRB	Lower St. Johns River basin
LCLU	Land Cover and Land Use
MFL	Minimum flows and levels
NAVD29	National Geodetic Vertical Datum, 1929
NAVD88	National Geodetic Vertical Datum, 1988
NHAP	National High Altitude Program
NRCS	Natural Resources Conservation Service
OBL	Obligate
R^2	Coefficient of determination
RMSE	Root-mean-square error
SJR	St. Johns River
SJRWMD, District	St. Johns River Water Management District
SM	Shallow marsh
PSS78	Practical salinity Scale 1978
SR	State Road
SSURGO	Soil Survey Geographic database
TOSO	Tosohatchee
TS	Transitional shrub
UPL	Uplands
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geographical Survey
USJRB	Upper St. Johns River basin
WP	Wet prairie
WSIS	Water Supply Impact Study

1 ABSTRACT

In this chapter we examine the potential effects of surface water withdrawals on the floodplain wetland vegetation communities of the St. Johns River in Florida. We focused on whether surface water withdrawals could potentially change the extent or placement of wetlands in the landscape, shift boundaries between wetland types, alter seasonal hydrologic patterns, or cause movement in the freshwater / saltwater interface between community types.

A conceptual model, response functions, and a screening-level assessment to identify river segments with most likelihood for change were developed. Hydrologic analysis and biological analyses of vegetation, soils, and elevation data to assess the effects on wetlands of changes in water levels (stage) and salinity followed. We examined a series of water withdrawal scenarios including those reflecting historic hydrology, encompassing a range of possible future conditions, and representing extreme, although unlikely, conditions.

The portion of river segment 8 from the outlet of Lake Washington through Lake Poinsett was determined to be the area of greatest potential change from the effects of water withdrawals, followed by segment 7, which extended downstream to Lake Harney. For salinity, river segment 2 near Doctor’s Lake and between river km 40 and river km 80, was determined to be the area of greatest concern.

Four transects in the Lake Poinsett study area were analyzed to determine potential changes in placement and extent of wetland plant community types from surface water withdrawals. Under the most extreme scenario, Full1995NN, losses in deep marsh and shallow marsh communities along with substantial gains in wet prairie and upper wet prairie communities were predicted. Effects were progressively less for the Full1995PN and Half1995PN scenarios and virtually absent in the Full2030PN scenario.

A geographic information system application (hydroperiod tool) was used to estimate change in area-wide temporal and spatial patterns of inundation and water depth. Application of the tool required development of an improved digital elevation model from LiDAR data with corrections for the effects of surface-obscuring vegetation. Potential effects were greatest under the Full1995NN scenario, but progressively less for the Full1995PN and Half1995PN scenarios, and largely disappeared with the Full2030PN scenario. The percent of the total study area negatively affected ranged from 27.5% for Full1995NN to 3.82% for Full2030PN scenarios.

Shallow surficial and soil hydrologies were investigated using simple conceptual models and examination of data from shallow floodplain wells. Wetland hydrology was found to decouple from the river when stage was at or below bank level. At high stages, the wetlands and the river act as a single hydrological system and were correctly modeled using the hydroperiod tool. At intermediate levels, when wetlands are shallowly flooded, the effects of many parameters come into play and make prediction of wetland stage difficult.

A second major component in the assessment of potential changes to wetlands from water withdrawals was the analysis of effects from potential upstream movement of salinity isopleths in the lower St. Johns River. The Ortega River, a tributary of the St. Johns River in Duval

County, was used as a model system. Vegetation and soils were sampled and a regression was run between Ortega River water salinity (from modeled data) and soil salinity. Beginning upstream, four environmentally important soil salinity (PSS78) break points were recognized: 0.47, between hardwood swamp and tidal swamp; 1.53 between tidal swamp and lower tidal swamp, 2.44 between lower tidal swamp and intermediate marsh, and 3.41 between intermediate marsh and sand cordgrass marsh. Soil salinity was found to be highly related to river salinity and river salinity was found, in turn, to be highly related to river km. From these relationships, we predicted a movement of breakpoints, and hence of vegetation boundaries of up to 1.13km along the Ortega River. We subsequently applied these relationships to the St. Johns river, where movement of up to 3.34 km under most extreme scenario was projected, but little potential for movement (< .21 km) was seen with the Full2030PS, future scenario.

2 INTRODUCTION

2.1 BACKGROUND

In this chapter, we analyze potential effects to wetlands of the St. Johns River floodplain from water withdrawals. These withdrawals have the potential to affect water quality and the total quantity of water available to support wetland functions. Wetlands perform numerous functions as elements of the landscape: (1) hydrologic functions, such as storage of flood waters, velocity reduction, groundwater discharge and recharge, and contributions to atmospheric processes; (2) water quality functions, such as sediment trapping, absorption or transformation of pollutants, and mediation of biogeochemical processes; (3) habitat functions, such as provision of living space and resources for plant life, and of food, water, shelter, and breeding grounds for fish and wildlife; (4) biological functions, such as maintenance of biodiversity and productivity, including that of economically valuable species, and (5) aesthetic functions (USGS 2005; Mitsch and Gosselink 2007). In this chapter, we focus on wetland plant communities and on those aspects of hydrology that directly affect their persistence and health as functioning elements within the larger landscape.

2.1.1 WETLAND TYPES AND CHARACTERISTICS

A substantial diversity of wetland types—herbaceous and forested, freshwater and saline—occur along the course of the St. Johns River (Table 2–1). More than 50% of the 2,371.5-km^2 St. Johns River floodplain is occupied by wetlands. Shallow marsh (15%), hardwood swamp (15.3%), wet prairie (5.9%), hydric hammock (4.2%), and shrub swamp (3.7%) comprise the greatest area. Several other wetland types, such as tidal marshes of needle rush (*Juncus roemerianus*: 1.4%), saltmarsh cordgrass (*Spartina alterniflora*: 1.3%), and transitional shrub (0.5%), are important locally. Open water (39.3%) and embedded uplands (7.1%) account for most of the remainder of the St. Johns River floodplain (Chapter 2, Appendix 2.B).

The wetlands exhibit a strong geographical pattern along segments of the river (Figure 2–1). Tidally driven salt marshes are found near the mouth of the river in segment 1. Upstream, segment 2 contains few wetlands, but moving south into segments 3 through 5 (extending to Lake Monroe), hardwood swamps become the characteristic wetland type. Further south in segments 6 through 9, herbaceous wetland types become dominant, although hardwood swamps associated with tributary streams frequently encroach into the floodplain (Chapter 2, Appendix 2.B).

Table 2–1. Percent and area of wetlands in the St. Johns River floodplain, by river segment.

River Segment	**Segment Name**	**Open Water**		**Salt Marsh–Tidal Flat**		**Hardwood Swamp**		**Hydric Hammock**		**Transitional Shrub**		**Shrub Swamp**		**Other Wetlands**		**Shallow Marsh**		**Wet Prairie**		**Uplands**		**Total (km^2)**
		km^2	**%**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**	
1	Mill Cove	85.7	45.8	70.8	37.8									13.4	7.1					17.3	9.2	187.2
2	Doctor's Lake	120.5	80.1			16.2	10.8							5.3	3.5					8.5	5.6	150.6
3	Deep Creek	291.7	50.2			164.1	28.2	29.3	5.0					47.3	8.1					48.8	8.4	581.3
4	Lake George	199.6	67.7			38.0	12.9	29.5	10.0					13.7	4.7					13.9	4.7	294.7
5	Lake Woodruff	33.4	15.4			94.3	43.4	15.0	6.9			12.3	5.6	10.6	4.9	45.3	20.9			6.2	2.9	217.0
6	Central Lakes	108.6	54.8			6.8	3.4	9.5	4.8					13.7	6.9	21.1	10.7	30.4	15.4	7.9	4.0	198.0
7	State Road 50	22.7	12.2			6.4	3.5	8.5	4.6	12.6	6.8			6.6	3.6	55.7	30.0	71.3	38.4	2.0	1.1	185.8
8	Chain of Lakes	43.4	14.0			16.6	5.3	7.4	2.4			46.9	15.1	15.5	5.0	119.2	38.3	28.5	9.2	33.4	10.7	310.9
9	Blue Cypress Lake	27.5	11.2			20.4	8.3					28.2	11.4	15.7	6.4	115.4	46.9	8.9	3.6	30.1	12.2	246.2
All Segments		933.1	39.3	70.8	3.0	362.8	15.3	99.1	4.2	12.6	0.5	87.3	3.7	141.9	6.0	356.7	15.0	139.2	5.9	168.2	7.1	2371.5

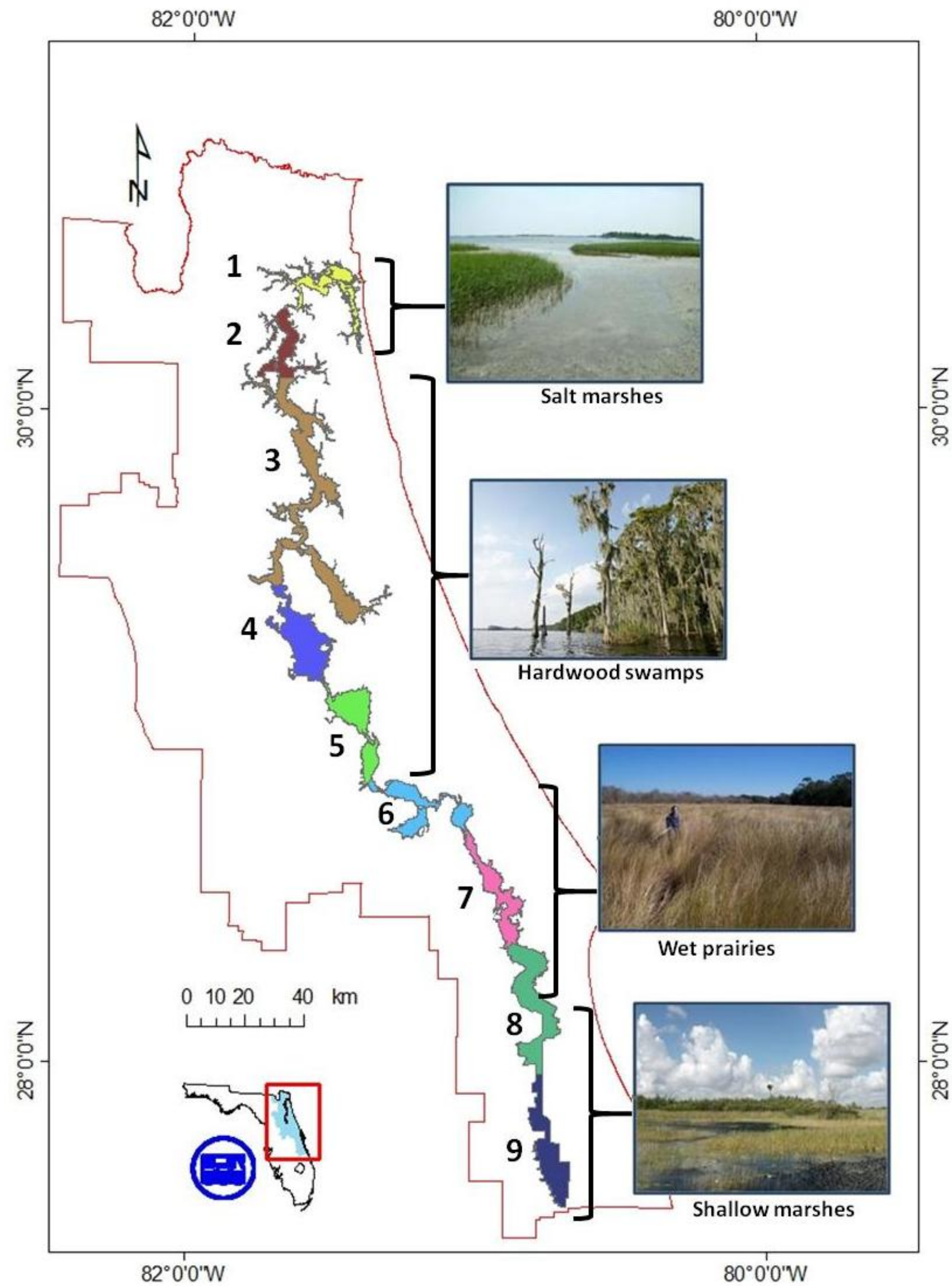

Figure 2–1. General distribution of wetlands along segments of the St. Johns River.

Gradients of tidal amplitude, salinity, and soil texture and composition appear to account for much of the observed pattern of wetland plant community types and composition. At the mouth of the St. Johns River, tidal amplitude averages 1.5 m, which diminishes to 0.34 m at the mouth of the Ortega River. Tidal amplitude then remains relatively constant as far south as Buffalo Bluff, before diminishing again to only a few centimeters in Lake George. The inlet to Lake George is considered to be at the head of tide, and marks the southern boundary of the estuarine portion of the river.

Salinity to some degree follows the same pattern. At the river's mouth, salinity is typically near levels found in seawater (about 32 on the practical salinity scale of 1978 [PSS78]), but at the Fuller-Warren Bridge approximately 40 km from the river's mouth, levels fall to an average of around 5 (PSS78). Levels then fall steadily to an average of less than 1 at the Shands Bridge south of Green Cove Springs (river kilometer 80.6). Further upstream, salinity within the river channel is somewhat variable, particularly under low flow conditions. Levels in adjacent wetlands may be much higher or even hypersaline. Where this occurs, the effect on wetland plant communities is conspicuous.

There is also a gradient of soil textures and compositions along the course of the river. In the lower half of the river, the soils are peats and mucks. In the middle reaches (segments 6 and 7), mineral soils become prominent. In the headwater segments (8 and 9), the soils are again predominantly organic, but less decomposed and, moving south, become increasingly fibric. This also appears to shape community composition.

2.1.2 Wetland Status and Trends

Along much of the river's course, the wetlands are largely intact, but in some areas there have been significant and notable changes over the last 60 years. In segment 1 the dredging of the Intracoastal Waterway, deepening of the main river channel, and other navigational works, as well as sea level rise, have caused a variety of effects. These include retreat of the tree line in many tributaries, changes in drainage patterns, and movement of sediments and salt marsh communities. In segment 2, areas closer to the river appear to have become more saline, and salt-tolerant vegetation has replaced former hardwood swamp communities. Other areas, such as the upstream reaches of contributing tributaries, appear to have become fresher, perhaps from additional runoff from developed land. Here the vegetation has changed from sand cordgrass (*Spartina bakeri*)-dominated salt marsh or intermediate marsh to less saline communities of shrub swamp or hardwood swamp.

Segment 3 has shown little change, other than some encroachment of hardwoods into formerly herbaceous marsh area. The cause of this is unclear. A similar pattern is observed in segment 4, the Lake George segment, where herbaceous, often salt-adapted, marshes have been overtaken to a great extent by shrub and early successional forest vegetation. This has also occurred in segment 5, where additional effects have occurred from logging, channel and canal dredging, the cutting of river meanders for navigation, and deposition of dredge spoil. In segment 6, the effects to wetlands are less apparent, but cattle grazing in floodplain marshes has been prevalent. Segment 7, overall, has shown little change other than local effects from road building and creation of power line corridors. Cattle grazing is also common in segment 7.

In contrast, the floodplain in segment 8 has been reduced substantially by agricultural development. Numerous canals, dug to enhance drainage, have been constructed. Although not subject to the effects of the proposed withdrawals, segment 9 has been greatly altered. Much of the former wetland area has been levied and drained for agricultural development. (Chapter 2, Appendix 2.B).

2.2 OBJECTIVE

The objective of the wetland vegetation analysis was to assess potential changes to wetlands from surface water withdrawals from the St. Johns River and its tributaries. The primary focus of this chapter is on changes to vegetated wetland communities resulting from hydrologic alterations. Indirect effects resulting from water quality changes, specifically alterations in salinity, are also addressed. Potential effects on biogeochemistry (Chapter 7), plankton (Chapter 8) submersed aquatic vegetation (Chapter 9), benthic macroinvertebrates (Chapter 11), fish (Chapter 12), and floodplain wildlife (Chapter 13) were analyzed by other ecological working groups.

Our focus was directed toward determining whether surface water withdrawals could potentially change the extent or placement of wetlands in the landscape, shift the boundaries between wetland types, alter important seasonal hydrologic patterns, or cause movement in boundaries between freshwater ane saltwater wetland types.

2.3 STUDY AREA

The study area for the wetland vegetation analysis included the contiguous waters of the St. Johns River basin, focusing specifically on the floodplain of the river from the outlet of Lake Washington to the salt marshes near the mouth of the river. Minimum flows and levels (MFL) determinations had previously been made at five locations along the river: State Road [SR] 44 (segment 5) (Mace, 2006a), Lake Monroe (segment 6) (Mace 2006b), SR50 (segment 7) (Mace, 2007a), Lake Poinsett (segment 8) (Mace, 2007b), and the St. Johns River downstream of Lake Washington (segment 8) (Hall, 1987). The Ocklawaha River, other tributaries and springs, and lakes beyond the immediate floodplain of the St. Johns River are considered only in the context of their potential influence on the river's floodplain wetlands.

2.4 TASKS

The tasks for the wetland vegetation analysis were as follows:

- Develop a statement of the problem, a conceptual model and response functions expressing linkages between causation and response, research questions and testable hypotheses.
- Perform a screening-level assessment to identify river segments with most likelihood for change.
- Perform hydrologic and biological analysis of MFL transect data, GIS spatial data, and hydrological and water quality data, based on the response functions developed, to assess the effects on wetlands of changes in water levels (stage) and salinity.

2.5 CONCEPTUAL MODEL

A conceptual model was developed to guide exploration of the linkages among hydrology, stage-frequency relationships, salinity, and effects on wetlands (Figure 2–2). In this model, the extent and other characteristics of wetland vegetation are driven by hydrology and salinity. Hydrology is expressed directly as exceedence (i.e., stage frequency), which is the probability that water levels will exceed a specified elevation, or hydroperiod (defined here as "a measure of the time [usually in days per year] that water is at or above the soil surface"; Brown and Starnes 1982).

Salinity is determined by freshwater flow, oceanic influences (tides and sea level), and discharge of relict saline in groundwater. Modeled data sets containing these hydrology and salinity variables for each water withdrawal scenario (see Section 2.8) were obtained from the Watershed Hydrology and River Hydrodynamics working groups (see Chapters 3–6). Historical and data sets combining historical and modeled data (see Appendix 10.A) were obtained from the Bureau of Water Resource Information of the St. Johns River Water Management District (SJRWMD, District). Soil characteristics and processes, which are another set of variables that influence wetlands, were considered in collaboration with the Biogeochemistry Working Group (see Chapter 7). These include soil composition and texture, formation and loss of organic matter, and nutrient dynamics (uptake, storage, and loss of nutrients) and are reported on in Chapter 7.

Functions relating these drivers—hydrology and salinity—to vegetation response were developed. At the community level, wetland vegetation responds to changes in hydrology—in this case, diminished hydration—by changing in composition over time to more nearly resemble those communities better adapted to the altered hydrology. The range of responses (Figure 2–3) may extend from subtle changes in productivity or species composition to replacement of the community by a community characteristic of a distinctly dryer environment or a community that would be considered an upland type. Over time with diminished hydration, community boundaries would be expected to shift downslope as plant species and communities re-establish at elevations best suited to their hydrologic tolerances. A similar range of responses occurs along salinity gradients, from freshwater to oligohaline, brackish, and euryhaline phases. Changes in wetland types and extent lead to effects at other trophic levels and directly influence processes and outcomes analyzed by the Benthic Macroinvertebrates, Fish, and Floodplain Wildlife working groups (Chapters 11–13), and more subtly to outcomes analyzed by the Biogeochemistry, Plankton, and Submersed Aquatic Vegetation working groups (Chapters 7– 9).

2.6 Development of Constraints

A constraint is considered any one of a set of physical, chemical, or biological factors that limit the ability of organisms to reproduce, grow, or survive in an environment. For plants, these include germination site, light, water, salinity, carbon dioxide, nitrogen, phosphorus and other nutrients, herbivory, predation, disease, and mutualistic relationships with other organisms (Schulze and Mooney 1994). We developed constraints for water and salinity. Water operates as a constraint through deficiency and overabundance. For most wetland plants, salinity acts as a constraint through overabundance. Different plant species are constrained at different levels of effect. Although ultimately the response is at the species level, our approach was to consider the various wetland communities from a holistic perspective. For changes in water levels, we used a response function created from scientific literature and unpublished data (CH2MHill 1996; SJRWMD and CH2MHill 1998) that placed constraints and their effects along a gradient from minor shifts in species dominance through conversion of wetlands to uplands. This approach was also used in the District’s assessment of effects to wetlands from groundwater withdrawals (Kinser and Minno 1995). For changes in salinity, we collected data along a gradient of salinity and wetland types to create a response function relating vegetation to soil salinity and soil salinity to open water salinity.

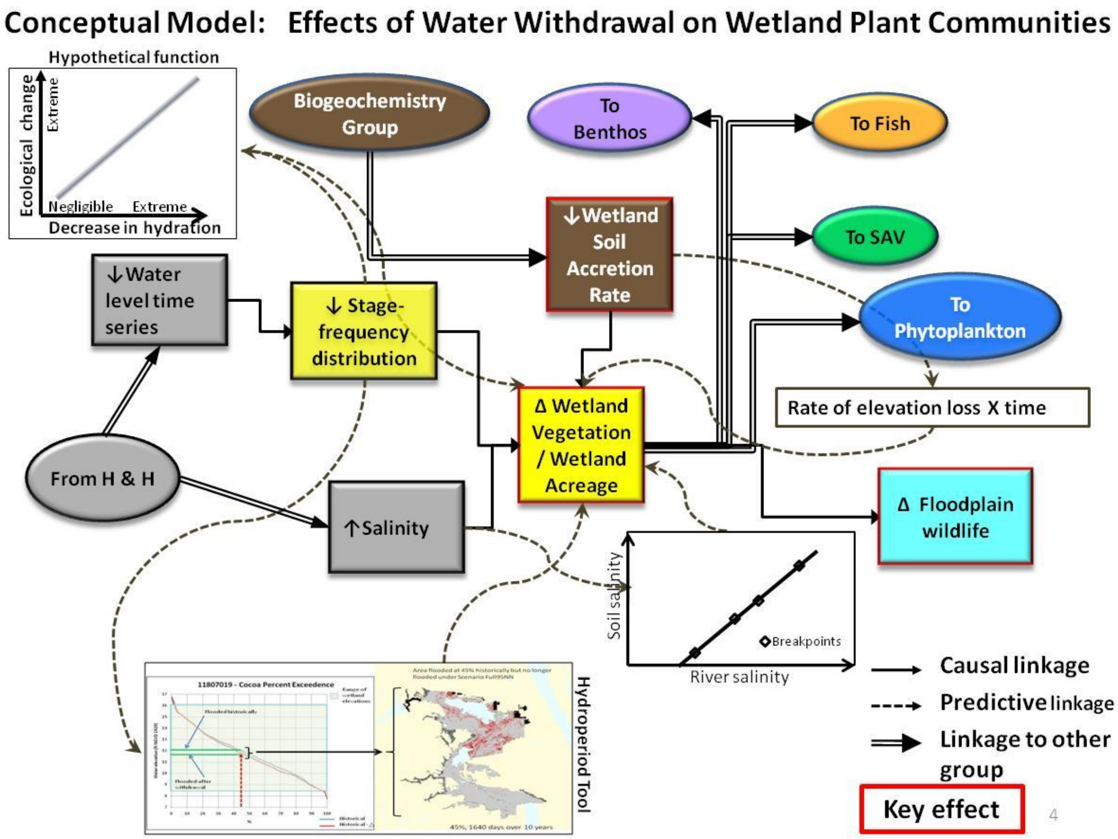

Figure 2–2. Conceptual model for wetland vegetation.

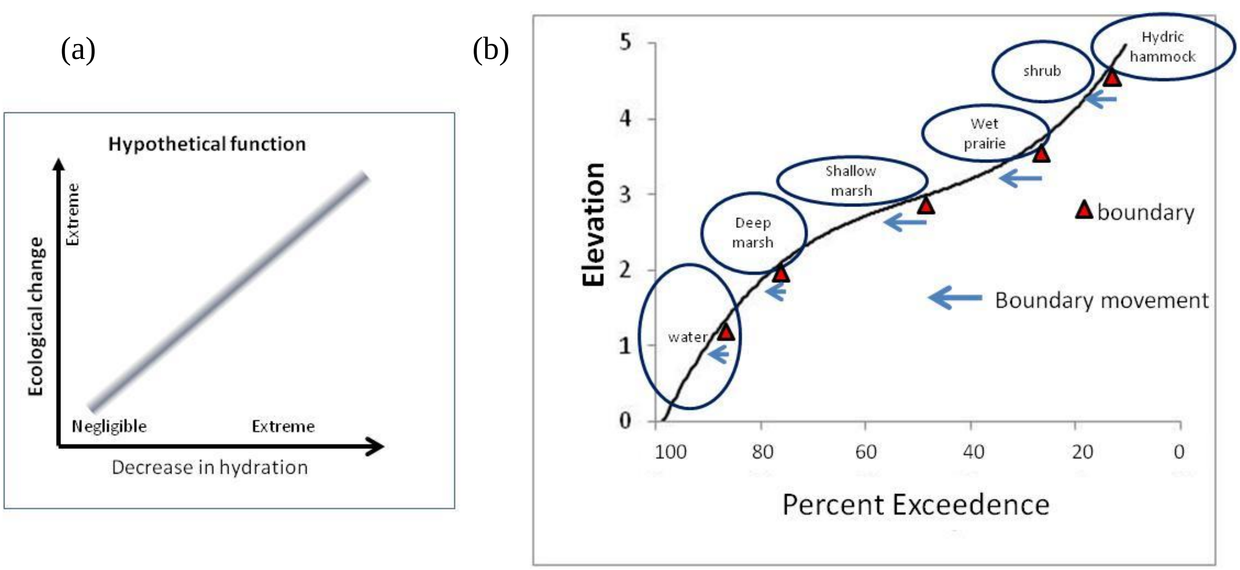

Figure 2–3. Response function showing: (a) expected ecological change with decrease in hydration (modified from CH2MHill 1998 and CH2MHill 1996) and (b) application to a hypothetical wetland transect.

2.7 Potential Effects and Research Questions

Among the potential effects of water withdrawals on wetland plant communities or component species are shifts in wetland plant community types, structure, composition, or boundaries; changes in biomass or productivity; effects on specific target species (e.g., rare or listed); and effects on life cycles and recruitment. Each of these was postulated to be a possible response to changes in stage, stage duration, or timing of hydrologic events. Because of limited available data at the species level, this analysis primarily focused on community boundary shifts, although other potential effects are also addressed.

The Wetland Vegetation Working Group analyzed the following research questions:

1. Would changes in inundation depth and duration change the extent of wetlands in the landscape? To analyze this question, we looked at whether the upper and lower boundaries of wetlands had shifted. The corresponding hydrologic criterion is whether the annual hydroperiod moved outside a range of 10% to 90% exceedence, which is characteristic of wetlands in most landscapes. If the hydroperiod moved below that range, wetlands could potentially move down-slope to occupy areas still hydrated sufficiently for their survival. Upland species would simultaneously colonize newly dewatered habitats at the upper margins of the floodplain (Figure 2–4).

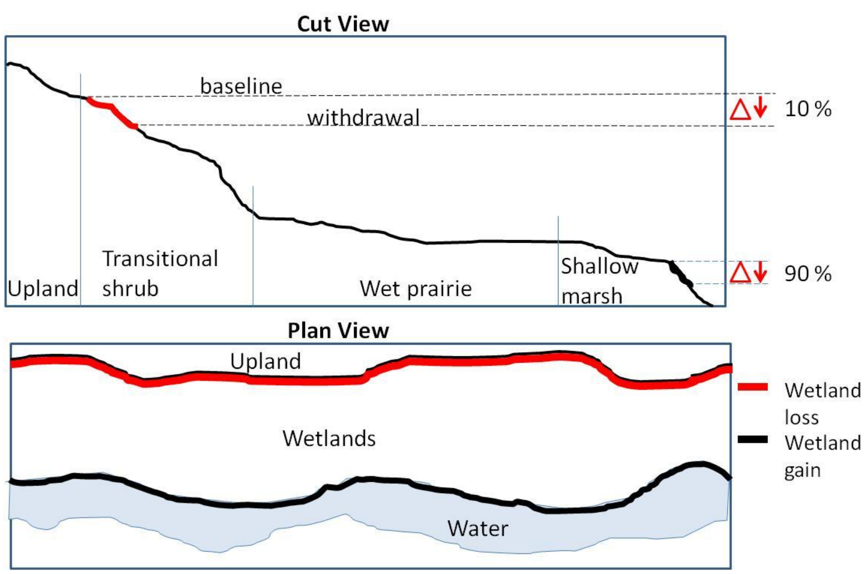

Figure 2–4. Hypothetical movement of upper and lower wetland boundaries in response to surface water withdrawals.

2. Would modeled changes in inundation depth and duration relative to baseline change the extent of wetland plant community types in the landscape? To analyze this question, we examined changes in the boundaries between wetland types (Figure 2–5). The corresponding hydrologic criterion is whether depths and durations of flooding would change sufficiently to promote the replacement of longer hydroperiod wetland plant community types by those more tolerant of dryer conditions resulting in a shift in

proportionality of wetland plant community types. Along a hydrologic gradient, changes in community boundaries would be expected as more drought-tolerant communities expanded waterward and displaced communities requiring wetter conditions.

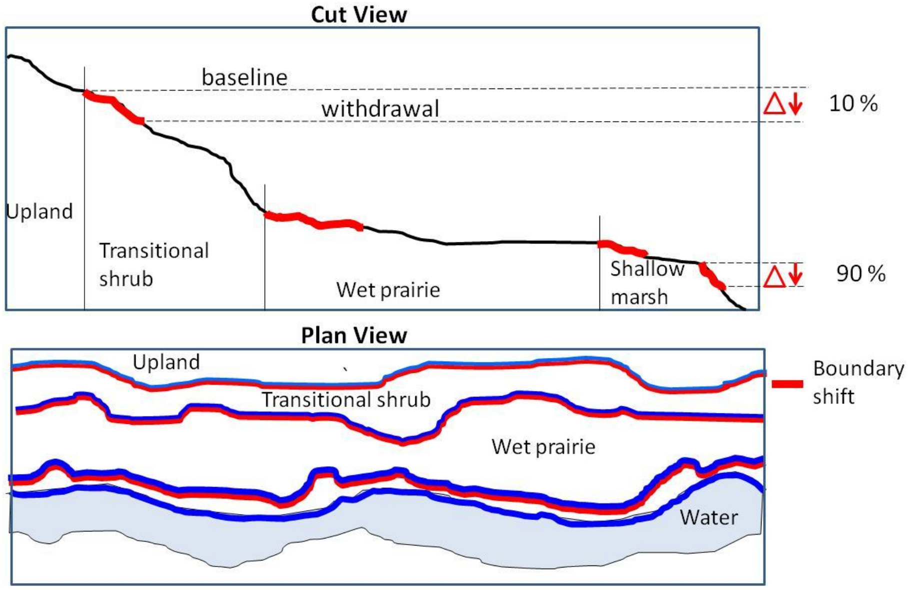

Figure 2–5. Hypothetical movement of wetland boundaries in response to water withdrawals.

3. Would modeled changes in hydrologic seasonality affect wetland plant community types by changing the seasonality of flooding and drying of wetlands? The corresponding hydrologic criterion is whether hydrologic seasonality would be altered sufficiently to change wetland characteristics such as species composition, reproduction, recruitment, mortality, etc. To analyze this question, we determined if a change in seasonal hydrologic events sufficient to alter wetland plant community types and other characteristics would occur (Figure 1-6). Changes in the advent of flooding or of seasonal drawdown significantly outside of the historical range and disruptive of the wetland plant community's normal cycles of growth and reproduction would be expected.

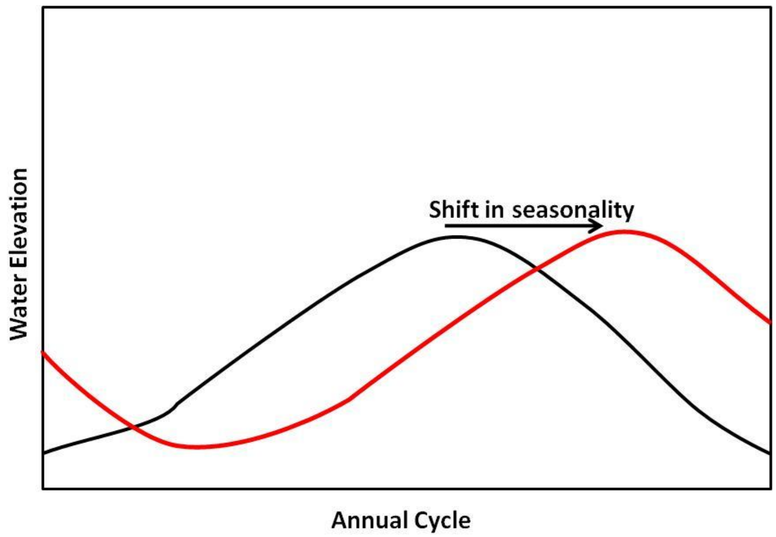

Figure 2–6. Hypothetical change in wetlands hydrologic seasonality due to water withdrawals.

4. Would salinity levels and durations exceed freshwater species tolerances and cause community boundaries to shift? To analyze this question we determined if an increase in salinity levels and durations exceeding the tolerance of freshwater species would occur (Figure 1-7). The corresponding hydrologic criterion is whether changes in salinity levels sufficient to cause shifts in community boundaries would occur. This would be accompanied by adverse effects on communities of freshwater vegetation and an upstream movement of salt-tolerant plant communities.

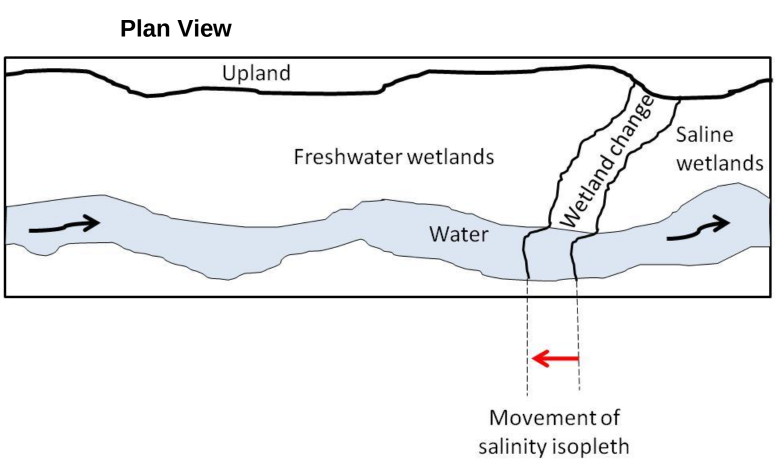

Figure 2–7. Hypothetical movement of salinity isopleths and wetland response.

2.8 Scenarios

The water withdrawal scenarios considered in this study are shown in Table 2–2. With the exception of the baseline historical scenario, the water withdrawal scenarios were developed in cooperation with District management and members of the WSIS team to correctly reflect the past hydrology, encompass a range of possible future conditions, and represent extreme conditions that are unlikely but would stress the system. A full discussion of the scenarios is presented in Chapters 3 through 6.

For the historical baseline south of Lake George, empirical data for water levels were chosen instead of modeled baseline data because the plant communities developed in response to actual water levels events that are recorded at gauged water level monitoring stations. To compare the historical record with the modeled water withdrawal scenarios, it was necessary to develop a series of data sets (historical minus delta) in which the difference (delta) between each modeled water withdrawal scenario and the modeled baseline scenario (Base1995NN) was calculated and subtracted from the empirical historical data. The method developed to create these historical minus delta data sets is described in Appendix 10.A.

The following scenarios were used for the wetland vegetation analysis in the areas south of Lake Harney in the upper St. Johns River: the historical baseline, Base 1995NN, Base1995PN, Full1995NN, Full1995PN, Half1995PN, and Full2030PN scenarios. In the lower St. Johns River, the Base1995NN, Full1995NN, FwOR1995NN, and Full2030PS scenarios were used.

Table 2–2. Scenarios used in the assessment of effects to wetlands from water withdrawals.*

Scenario Name	Description	Application for Wetland Vegetation Analysis
Historical baseline	Empirical data on water surface elevation collected by USGS or SJRWMD, 1 January 1995 to 31 December 2005.	Used as the baseline for hydrologic change in the upper St. Johns River (segments 7 and 8)
Base1995NN	Modeled data, no water withdrawals, 1995 land use, no USJRB projects, and no sea level rise.	Used indirectly for developing a delta to be applied to the historical data set to capture change between scenarios in the upper St. Johns River and directly for assessment of salinity changes in the lower St. Johns River (segments 2, 7, and 8)
Base1995PN	Modeled data, no water withdrawals, 1995 land use, USJRB projects operational, and no sea level rise.	Used in the upper St. Johns River to isolate the effect of water management projects on hydrology (segments 7 and 8)
Full1995NN	Modeled data, full water withdrawal, 1995 land use, no USJRB projects, and no sea level rise.	Used to assess the effect of withdrawals on stage and salinity, without projects (segments 2, 7, and 8)
FwOR1995NN	Modeled data, full water withdrawal, Ocklawaha River withdrawal; no USJRB projects, and no sea level rise.	Used in the Lower St. Johns River to assess the effect of full withdrawals on salinity, without projects (segment 2)
Half1995PN	Modeled data, half water withdrawal, 1995 land use, USJRB projects operational, and no sea level rise.	Used in the Upper St. Johns River to assess effects of half withdrawals and projects on water levels (segments 7 and 8)
Full1995PN	Modeled data, full water withdrawal, 1995 land use, USJRB projects operational, and no sea level rise.	Used in the Upper St. Johns River to assess effects of full withdrawals and projects of water levels (segments 7 and 8)
Full2030PS	Modeled data, full water withdrawal, USJRB projects operational, 2030 land use, and +14 cm of sea level rise.	Used in the Lower St. Johns River to assess the effects of future conditions on salinity, with future sea level rise (segment 2)
Full2030PN	Modeled data, full water withdrawal, USJRB projects operational, 2030 land use, and no sea level rise.	Used in the Upper St. Johns River to assess the effects of future conditions on water levels (segments 7 and 8)

*See Chapter 6. River Hydrodynamics Results for a discussion of the scenarios.

3 METHODS

3.1 DATA SOURCES

3.1.1 MAP DATA

Wetlands

The wetlands data layer (SJRWMD, 2002) is a polygon map layer planned and designed by District staff. It was populated by District staff and consultants with detailed wetland vegetation types (Appendix 10.B) and shows their geographical distribution mapped from aerial photographs taken in the mid-1980s and early 1990s. The features in this layer were grouped to reduce the number of wetland types by merging wetland types that are rare within the St. Johns River basin with similar, but more common, wetland types.

The wetlands can be considered in two alternative but complementary ways: as polygons (closed figures with area) or as edges. Polygons allow the total area of wetland types within the floodplain to be measured. Edges give a measure of habitat availability to species that require contrasting adjacent habitats for their life history or foraging strategies. For this analysis, a simple ratio of shore (edge) length to water body (polygon) area (Rawson 1960) was chosen to represent the extent of one type of edge habitat. A more complicated formula (Hutchinson 1957), which was developed for lakes, was considered but found to be less useful for comparing shoreline development among the diversity of water features within the St. Johns River watershed.

Additionally, wetland polygons from the SJRWMD Land Cover and Land Use 2004 data layer (SJRWMD 2011) and unpublished wetlands map data from the upper St. Johns River Basin program were used for both the digital elevation model (DEM) correction and to determine the area of interest for the areal effects analysis.

Soils

Soils map data were from the Soil Survey Geographic SSURGO Database for SJRWMD and Surrounding Regions data layer (SJRWMD 2007). This spatial layer is the result of a merge of all the individual spatial layers from original Natural Resources Conservation Service (NRCS) data for the region. This data was supplemented with detailed USDA soil series data (Soil Survey Staff). Seventy-seven soil series occur in the floodplain of the St. Johns River (Appendix 10.B).

Aerial Photographs and Images

Aerial photographs and images were used to assess and compare past and present conditions, for planning, and to serve as a backdrop to give context to graphics and spatial analyses. Of particular value were the District’s collection of black-and-white historical photographs from the 1940s (USDA 1938-1944), National High Altitude Program (USGS, 1980 - 1989) and National Aerial Photography Program (USGS 1987 - 2004), and more recent images from 2004 and 2009 (SJRWMD, 2004, 2009).

3.1.2 Elevation Data

Several forms of elevation data were available. The most generally available were U.S. Geological Survey (USGS) contour data (usually 5-ft intervals) processed into DEMs (both native and drainage enforced). LiDAR (Light Detection and Ranging) optical remote sensing data was available for large portions of the river from Lake George to Lake Washington in Brevard County (Figure 3-1). Survey data was available for MFL transects from Lake Dexter to Lake Poinsett. Additional District MFL transect data was available in the area between Lakes Winder and Washington.

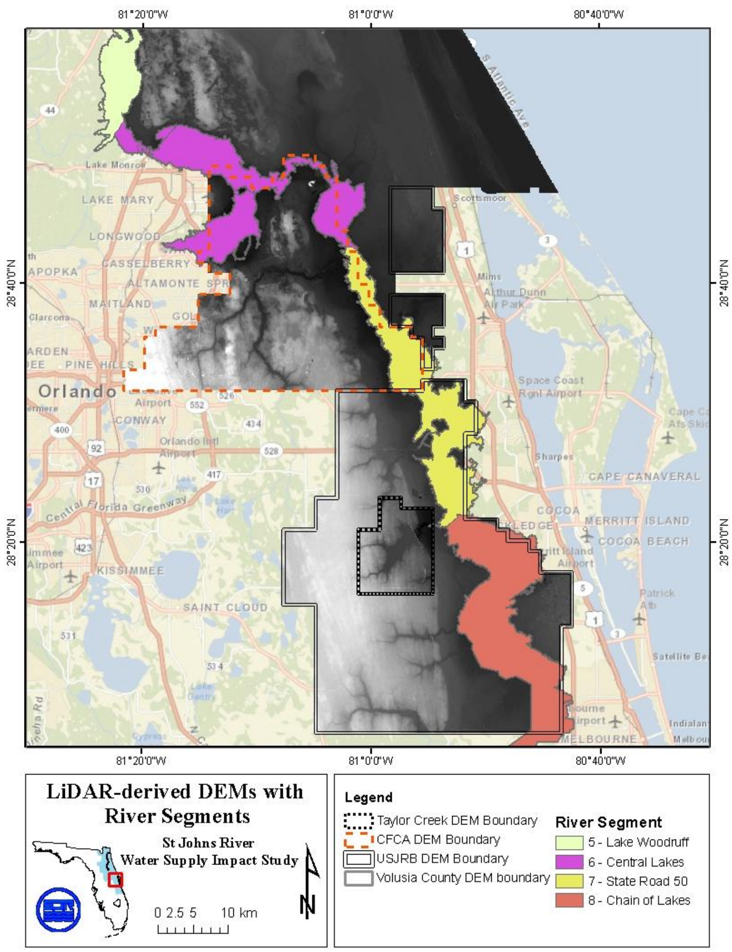

Figure 3–1. LiDAR digital elevation models (DEM) with river segments.

3.1.3 Minimum Flows and Levels Transects

Transects were surveyed and sampled as part of the MFL establishment effort (Mace 2007a, 2007b, 2006a, 2006b). These were located in river segments 5, 6, 7, and 8 (Table 3–1). With few exceptions, each transect extended from the St. Johns River or one of the associated lakes to the adjacent uplands. They ranged in length from 152 to 3,353 m, and each crossed a number of wetland plant community types arranged along the hydrologic gradient. Land surface elevation was measured and vegetation was sampled using a belt transect method, and soils were sampled to determine series and organic matter depth (Hall 2006).

Table 3–1. Minimum flows and levels transects and reference gauges by river segment.

River Segment	MFL Name	Number of Wetland Transects	Transect Names	Reference Gauge Locations
8	Lake Poinsett	4	Buzzard's Roost, I-95, County Line, Mulberry Mound	USGS Station 02232400, St. Johns River near Cocoa at SR 520 Bridge; river kilometer 378
7	St. Johns River at SR 50	7	TOSO-528, Great Outdoors, Tosohatchee North, M-6, Lake Cone, H-1, Ruth Lake	USGS Station 02232500, at SR 50 near Christmas, river kilometer 343
6	St. Johns River at Lake Monroe	7	Transects 1 through 7	USGS Station 02234500; U.S. Highway 17/92 bridge, west lakeshore river kilometer 262
5	St. Johns River at SR 44 near DeLand	8	Pine Island, N. Emanuel Bend - 1, N. Emanuel Bend - 2, Lower Wekiva River, Tick Island, N. Shore Lake Woodruff, Dexter Point East; Dexter Point South	USGS Station 2236000, St. Johns River near DeLand, river kilometer 230

3.1.4 Point Data

Wetlands and soils were sampled at 87 discrete points along the river floodplain (Figure 3–2), in addition to those sampled on MFL transects, to fill in gaps in our knowledge of floodplain features and conditions (Appendix 10.D). Herbaceous, shrubby, and tree-dominated vegetation was sampled within 5 m × 5 m, 10 m × 10 m, and 10 m × 20 m plots, respectively. Field measurements of pore water pH and conductivity were made, and a composite soil sample was collected for lab analysis. Results appear in Chapter 2, Appendix 2.B and in Chapter 7 Biogeochemistry.

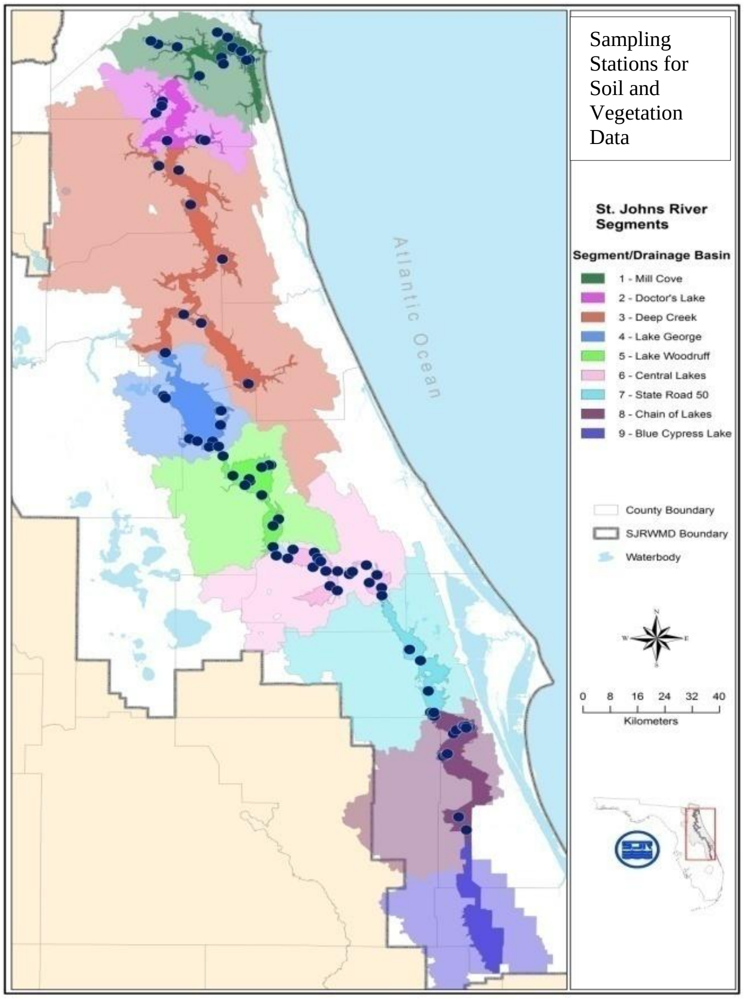

Figure 3–2. Point data sampling stations for soil and vegetation.

3.1.5 WATER ELEVATION DATA

Empirical data was available from 74 historical or modeled USGS and SJRWMD stations located along the course of the river. A subset of these was used in this chapter (Table 3–2). We chose a 10-yr period of record for analysis (1 January 1996 to 31 December 2005).

Table 3–2. Water surface elevation stations.

Surface Water Elevation Station Name	USGS No.	SJRWMD Hydron_ID	River km	Period of Record
St. Johns River at Astor	02236125	70167016	204.4	1931 to 2011
Lake Woodruff National Wildlife Refuge		15493167	217.65	2004 to 2011
St. Johns River near DeLand	02236000	14567018	232.06	1934 to 2011
St. Johns River Marker 88	02235400	28645056	249.1	2008 to 2011
St. Johns River at Sanford	02234500	14477031	262.06	1941 to 2011
St. Johns River at SR 415	02234440	18944193	274.4	2005 to 2011
Lake Jesup outlet	02234435	70417048	279.5	1991 to 2011
Center of Lake Harney		ES054193	304.0	1995 to 2005
St. Johns River above Lake Harney	02234000	70217021	310.07	1941 to 2011
St. Johns River near Christmas	02232500	70207020	343.52	1933 to 2011
St. Johns River near Cocoa (Lake Poinsett)	02232400	11807019	378.08	1953 to 2011
St. Johns River at West Rockledge (Lake Winder)	none	01600751	400.1	1992 to 2011
Lake Washington Weir, Lower (below weir) at Eau Gallie	none	01581076	414.12	1977 to 2011

3.1.6 WELL DATA FOR WETLAND SOIL WATER LEVELS

Well data was available for analysis from 20 shallow wells located along the MFL transects (Table 3–3 and Figure 3–3). These wells were installed to quantify wetland soil water levels. Well construction followed instruction from Morrison (1983).

Table 3–3. Wells used to quantify wetland soil water levels in minimum flows and levels transects.

Well Name	Transect	Hydron ID	River km	Period of Record	Distance from Closest Open Water (m)	Land Surface Elevation at Well (m)
Dexter Point well 1	Dexter Point South	18513772	210	2003 to 2011	104	0.27
Dexter Point well 2	Dexter Point South	18513773	210	2003 to 2011	337	0.20
Tick well 1	Tick Island	18533774	217	2003 to 2011	67	0.43
Pine Island well 1	Pine Island	18433759	245.5	2003 to 2011	178	0.52
Pine Island well 2	Pine Island	18433760	245.5	2003 to 2011	398	0.37
Wekiva well 1	Lower Wekiva	18423758	254	2003 to 2011	78	0.37
Wekiva well 2	Lower Wekiva	18423808	254	2003 to 2011	973	0.63
Monroe well 1	Monroe 4	18563777	270	2003 to 2011	237	0.97
Monroe well 2	Monroe 4	18563778	270	2003 to 2011	1698	0.74
Cone Lake well 1	Cone Lake	18543775	338	2003 to 2011	64	2.26
Cone Lake well 2	Cone Lake	18543776	338	2003 to 2011	675	2.08
Toso North well 1	Toso North	18874162	348	2004 to 2011	320	2.07
Toso North well 2	Toso North	18874163	348	2004 to 2011	1034	2.39
Toso North well 3	Toso North	18874164	348	2004 to 2011	1371	2.73
Mulberry Mound well 1	Mulberry Mound	31193433	379	2010 to 2011	2108	5.12
Mulberry Mound well 2	Mulberry Mound	31193434	379	2010 to 2011	1980	4.63
Mulberry Mound well 3	Mulberry Mound	31193438	379	2010 to 2011	1863	4.42
Mulberry Mound well 4	Mulberry Mound	31193435	379	2010 to 2011	1608	4.21
County Line well 1	County Line	31203436	380.5	2010 to 2011	1146	4.02
County Line well 2	County Line	31203437	380.5	2010 to 2011	844	3.72

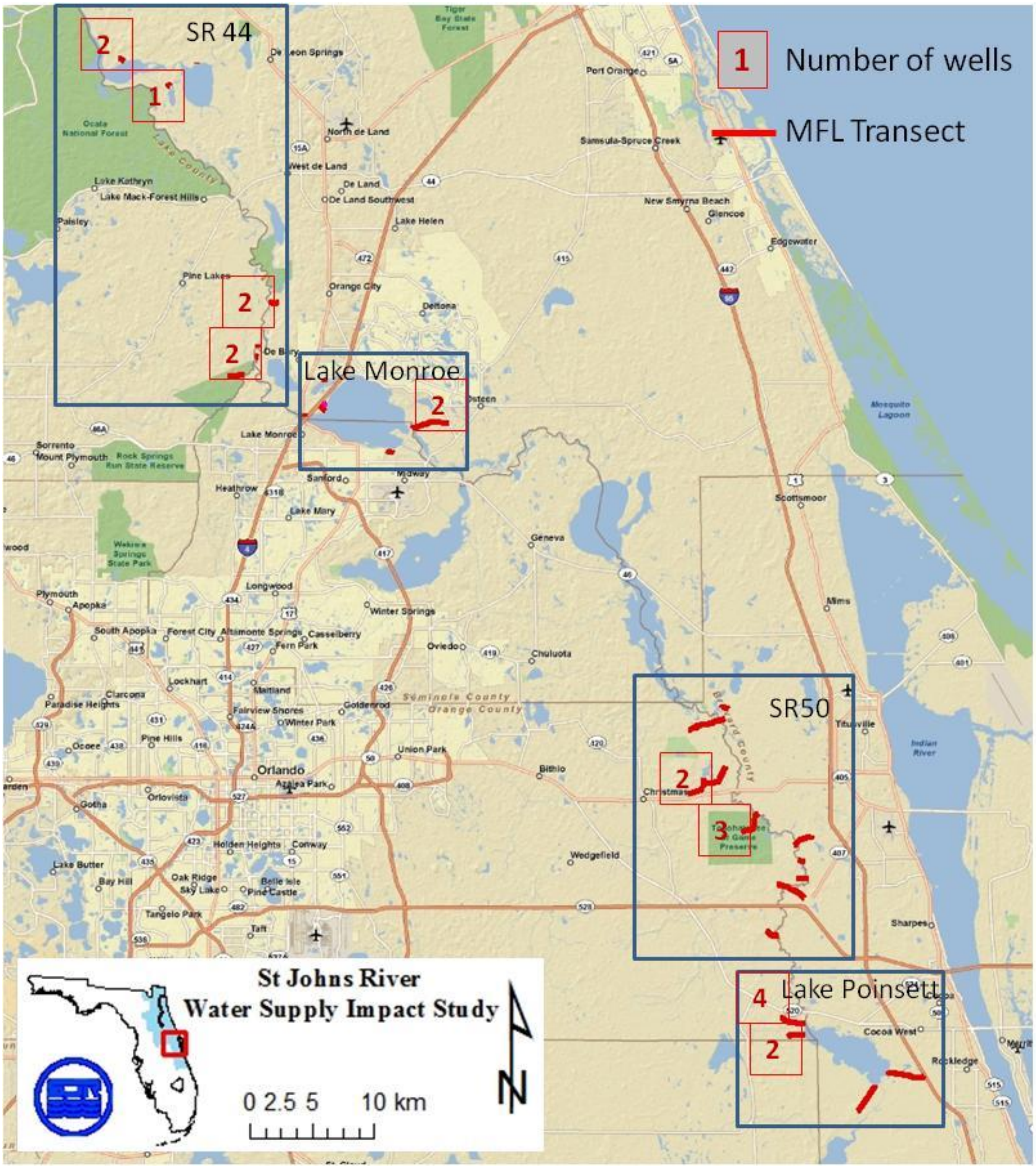

Figure 3–3. Transects and well locations for wetland soil water levels.

3.1.7 Water Quality Data

Water quality data was available from a set of long-term ambient monitoring stations located along the full length of the St. Johns River, as well as from lower St. Johns River project-specific monitoring sites. In addition, modeled data on salinity was available from the Environmental Fluid Dynamics Code (EFDC) hydrodynamic model from Lake George to the mouth of the river. Modeled data were also developed in detail for the Ortega River (Appendix C).

3.2 Screening-Level Assessment to Identify Priority River Segments for Focused Study

Among the first tasks required to analyze the effects of water withdrawal on wetland vegetation was to focus the study on those river segments where the potential for changes in wetland vegetation were greatest. These were selected and prioritized for detailed analysis based on wetland community types, soils, dominant hydrogeomorphology, and modeled changes in average annual water levels and salinities. We used the Full1995NN scenario for this process because it showed the maximum change from the base condition (Base1995NN).

3.3 Minimum Flows and Levels Transect Analysis

Each of the four transects in the Lake Poinsett study area, where potential for change was high, was analyzed to determine potential changes in placement and length of wetland plant community types that would result from surface water withdrawals. The model was driven by water level elevations measured or modeled in the open waters of the river; other sources of water were not considered in the analysis. This analysis made the following assumptions (under a drying scenario):

- Wetland communities shift downslope and re-establish at elevations with hydrologic exceedences similar to those experienced at their previous landscape positions.
- Dryer communities displace more hydrophilic communities through competition for moisture and light.
- Communities are discrete and move as intact units.

The methods for the analysis used the following steps: (1) compile community metrics (elevation, position, and length of transect occupied); (2) look up historical and historical minus delta exceedences and hydroperiods at the minimum elevations for each wetland type (Figure 3–4); (3) look up historical exceedence in the historical minus delta table to find the new matching elevation (Figure 3–5); (4) starting with the community with highest elevation, move the community boundary to the next down-slope point having the correct exceedence (Figure 3–5); (5) record distance moved and linear distance covered by each community

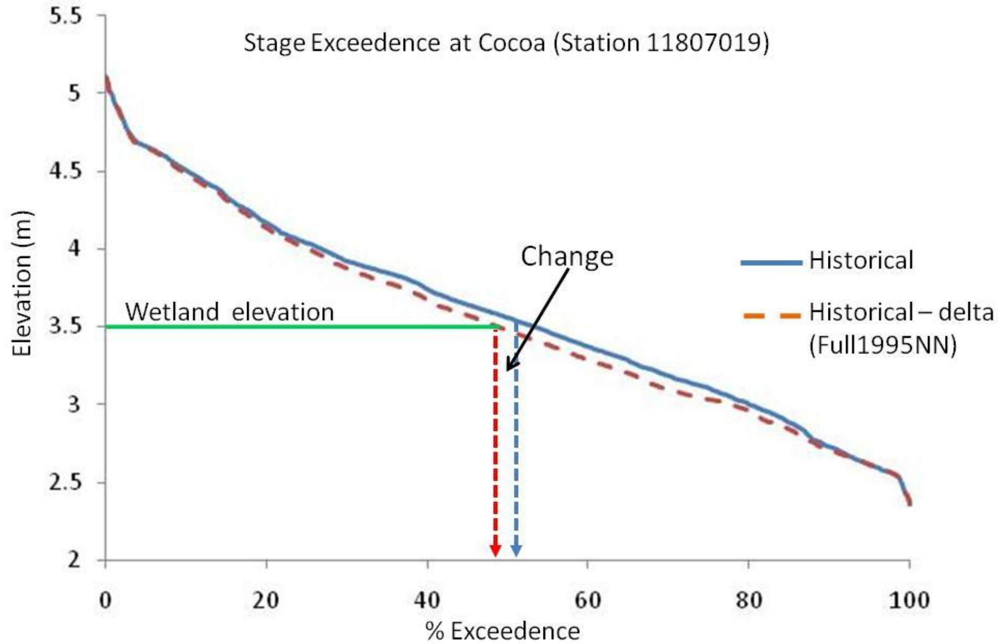

Figure 3–4. Example of process for determining shift in wetland boundary with change in exceedence.

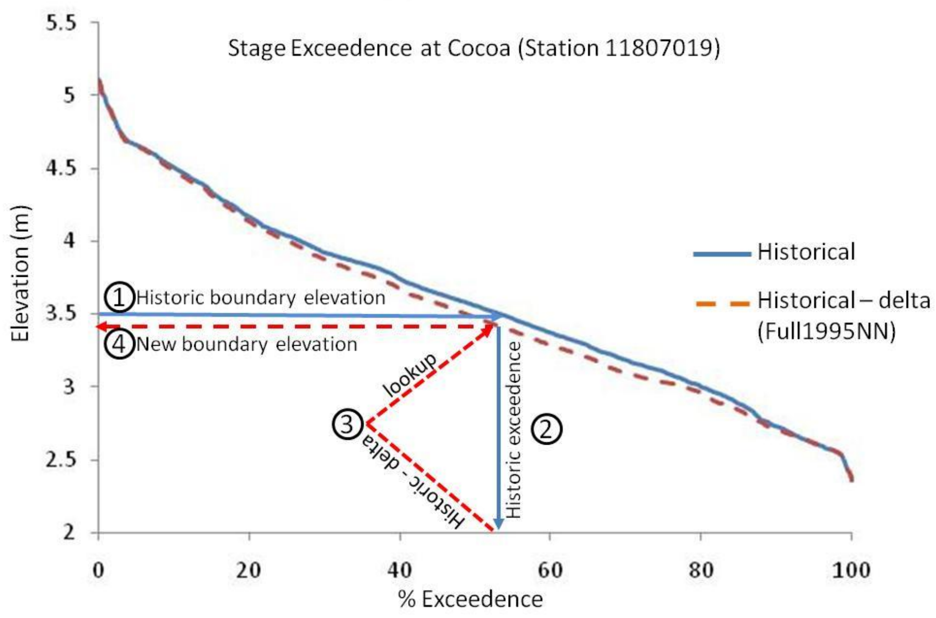

Figure 3–5. Example of process for determining change in wetland elevation with change in exceedence.

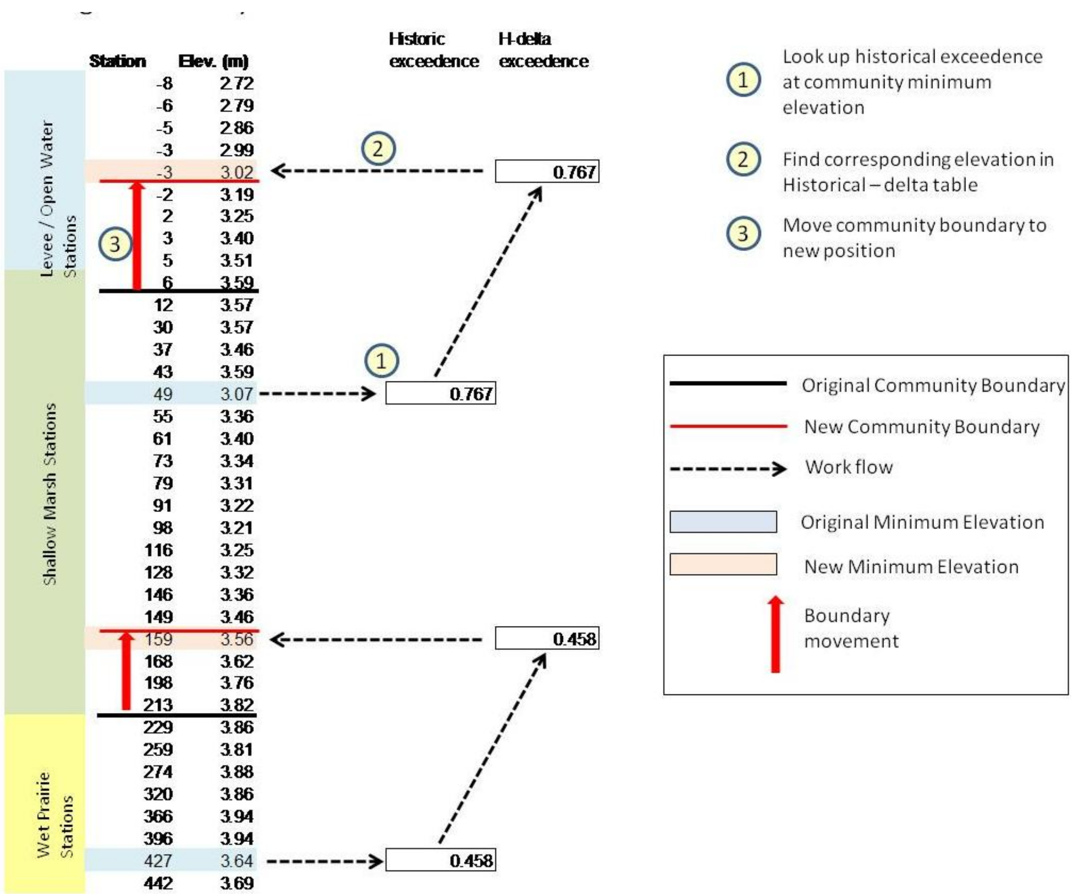

Figure 3–6. Example of process to estimate potential movement of wetland community boundaries with change in exceedence.

3.4 Areal Effects Analysis

The areal extent of potential effects was estimated using a Geographic Information System (GIS) application originally developed for the South Florida Water Management District and modified by SJRWMD for this analysis. The modified GIS application is called the hydroperiod tool. The hydroperiod tool was designed to determine the temporal pattern of inundation over a selected spatial region, accumulate annual and seasonal inundation statistics by wetland plant community type, generate daily ponded depth rasters from time series, and statistically summarize patterns. The District modified the hydroperiod tool to enable change analysis to be performed based on the area of inundation at specific stage exceedence values, with and without surface water withdrawals, and to determine the change in ponded depth for negatively affected areas.

3.4.1 Description of the Hydroperiod Tool

The hydroperiod tool is an extension for Environmental Systems Research Institute's ArcMap and was developed for the South Florida Water Management District to define depth and duration of flood inundation as a function of location in a portion of the restored Kissimmee River floodplain (Sorenson et al. 2004; Sorenson and Maidment 2004; Carlson et al. 2005.)

The hydroperiod tool automates a series of complex and computationally intensive GIS functions

(1) interpolation of water surface from stage data, either for specific conditions (e.g., exceedences) or in time series; (2) intersection of the interpolated water surface with wetland ground elevation (DEM) to produce rasters (grids) representing ponded depth at that water surface elevation, either for specific conditions or in time series; (3) reclassification of the ponded depth rasters, as needed for some analyses; (4) change analyses to identify areas potentially affected (i.e., before and after surface water withdrawals); (5) summarization and statistical analysis for specific wetland types (using zonal statistics) or by grid cell (using cell statistics).

3.4.2 Data and Setup for Running the Hydroperiod Tool

Water elevation data for surface interpolation was from both the St. Johns River historical data and from the EFDC hydrodynamic and HSPF hydrologic models (see Chapters 3–6). Data were compiled with the assistance of District staff in the Bureau of Water Resource Information. Each modeled data set was processed to produce a predicted daily elevation change (delta) by scenario. The delta data sets were then individually applied to the historical data set to produce the historical minus delta data set for each scenario (Appendix 10.A). Statistical analysis of all data sets (historical and historical minus delta) for five scenarios (Full1995NN, Base1995PN, Half1995PN, Full1995PN, Full2030PN; see Table 2–2) was performed to provide water elevation data inputs for the hydroperiod tool.

LiDAR-derived DEMs (Central Florida Coordination Area, Volusia County, Taylor Creek, and USJRB) were available for parts of river segments 5, 6, 7, and 8. Based on the screening-level assessment, it was determined that a portion of segment 8 extending from the Lake Washington weir to the outlet of Lake Poinsett would be the focus of the areal effects analysis since this was the area in which water levels were predicted to show the greatest decline. The USJRB-DEM was prepared to confine analysis to wetland areas and to correct for vegetation obstructed ground surfaces. Wetland polygons from the SJRWMD Land Cover and Land Use (2004) data layer were used to identify the wetland communities potentially affected by each scenario.

3.4.3 LiDAR Data Set

An accurate DEM is an indispensable component of the hydroperiod tool process. LiDAR data was available as DEMs for a substantial portion of the river floodplain (Figure 3-1). LiDAR provides high-resolution elevation data in many terrains, but does not reach the ground in dense vegetation (Figure 3–7) and may produce potentially misleading signals from water surfaces. By October 2011, LiDAR data had become available for almost the entire southern half of the St. Johns River floodplain wetlands study area. The study area extends from the weir at Lake Washington to the outlet of Lake Poinsett, within river segment 8 and is included in the USJRB-DEM. The USJRB LiDAR was collected between 15 and 26 April 2010 using the specifications outlined in the USGS National Geospatial Program Base LiDAR specifications, version 12 (USGS, 2009). The data were acquired to meet 1-ft contour accuracy. The collection parameters used were nominal pulse spacing of 0.7 m, collection under cloud-and-fog free conditions, 50% overlap in flight lines, collection of multiple returns (first, last, intermediate) and intensities, and collection area buffers of 140 m. Use of existing published surveys for ground truth verification was deemed suitable. The LiDAR data set was tested to 0.336-ft vertical accuracy at 95% confidence level, based on consolidated root-mean-square error (RMSE) (0.171ft x 1.960) when compared to 950 Global Positioning System (GPS) kinematic checkpoints. The LiDAR data set was tested to 0.386-ft vertical accuracy at 95% confidence level, based on consolidated RMSE (0.197 ft × 1.960 ft) when compared to nine GPS static check points. The LiDAR data was processed with proprietary software to produce a DEM with a cell size of 10 ft (3 m), National Geodetic Vertical Datum, 1988 (NAVD88). Conversion to NGVD29 was performed by District staff in the Division of Information Technology.

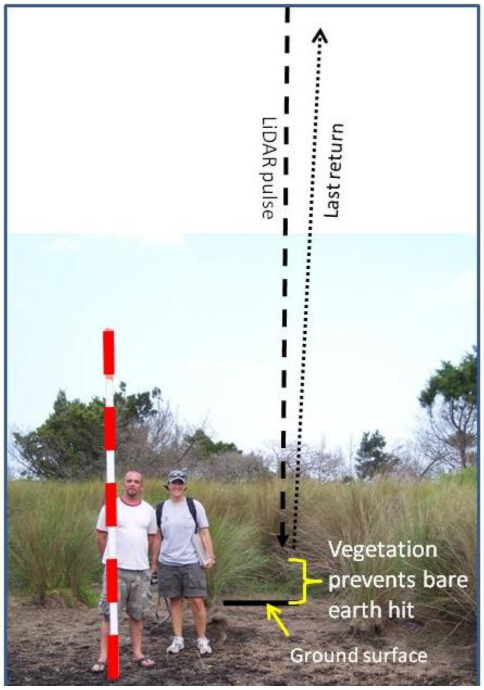

Figure 3–7. Example of obstruction of land surface from LiDAR penetration by dense vegetation.

In order to restrict GIS processing to wetlands hydrologically linked to the river, only a portion of the USJRB-DEM was extracted for analysis. This was accomplished by creating a polygon layer (mask) consisting of the wetlands contiguous with the St. Johns River and Lakes Poinsett, Winder and Washington selected from polygons in the SJRWMD Land Cover and Land Use (2004) layer. The ArcMap Toolbox extract-by-mask function was performed. Additionally, wetland areas identified by as obscured by standing water at the time of LiDAR data collection were removed from further analysis (approximately 800 hectares). The resulting total area of interest was 18,256 hectares.

LiDAR-based Digital Elevation Model Processing and Adjustment

Correction for ground elevation in dense wetland vegetation (Figure 3–7) was accomplished using the four transects from the MFL program within the Lake Poinsett MFL area, including the Buzzard's Roost, County Line, I-95 and Mulberry Mount transects (see Table 3–1). These transects consist of high accuracy elevation data and detailed information on the wetland community. Buzzard's Roost consists of 497 elevation stations, County Line consists of 161 elevation stations, I-95 consists of 531 elevation stations, and Mulberry Mound consists of 291 elevation stations. Elevation at each station was compared to the elevation value of the coincident LiDAR DEM grid cell (Figure 3–8 and Figure 3–9).

The approach to developing DEM correction factors was: (1) to minimize the differences between the new (corrected) DEM and the surveyed MFL elevation at each station; (2) to eliminate bias so that median error between the new DEM and MFL elevations was zero; and (3) to be consistent with field knowledge in each area. Based on vegetation information from the transects and from the SJRWMD Land Cover and Land Use (2004) layer, elevation pairs were placed into the following five wetland categories: woody wetlands, herbaceous wetlands, sparce herbaceous wetlands, dense herbaceous wetlands, and open water. All open water stations were removed from further analysis, since conventional LiDAR signals are reflected by the water surface and do not produce accurate ground surface data. Based on a comparison of elevations, a correction factor for vegetated areas was calculated as the mean of the difference between the DEM and transect elevations for each category (Figure 3–9). This correction factor was further refined by a slight increase in the resulting correction values to achieve a balanced model where the median error equals zero. The correction values were applied to the DEM, a small buffer having been applied to adjacent areas (different vegetation categories) receiving different correction values in order to produce smooth transitions. The correction process was validated using a fifth transect not used in the development of the correction factors (Figure 3–10). The error was also found to be well balanced (median error equaled zero), i.e. there were equal numbers of overestimates and underestimates of surface elevation.

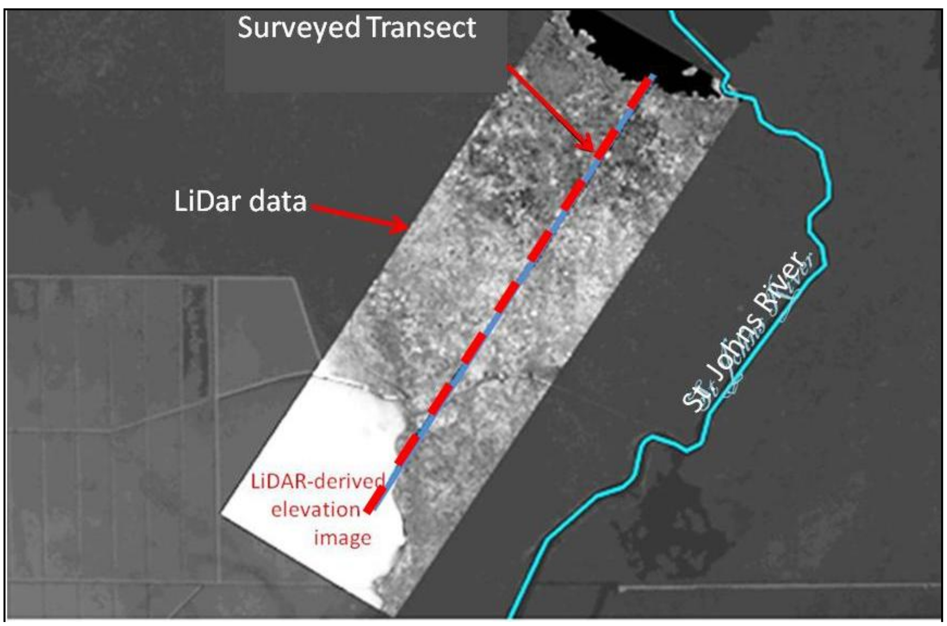

Figure 3–8. Minimum flows and levels transect superimposed on LiDAR data surface.

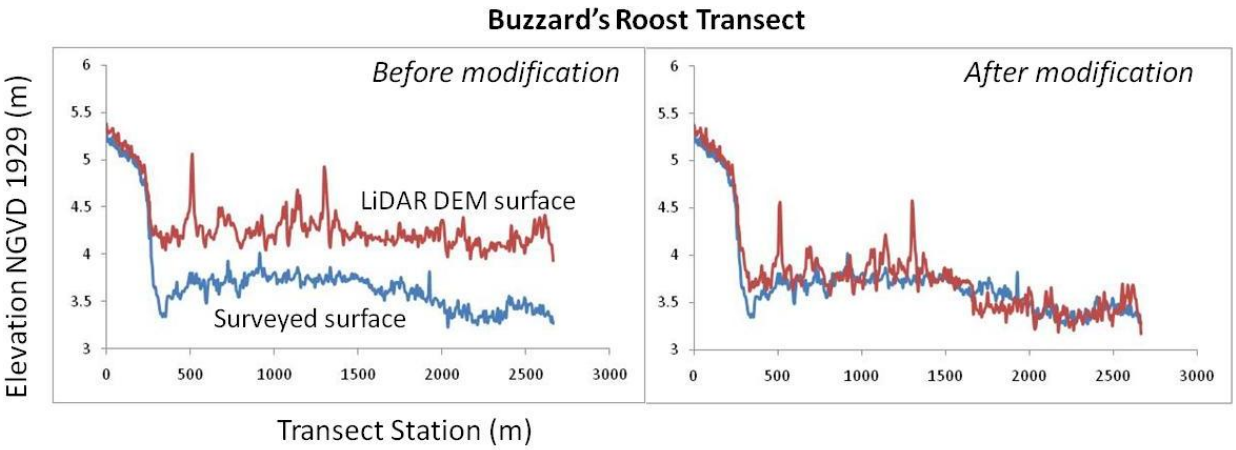

Figure 3–9. LiDAR surface before and after adjustment to fit minimum flows and levels surveyed transect.

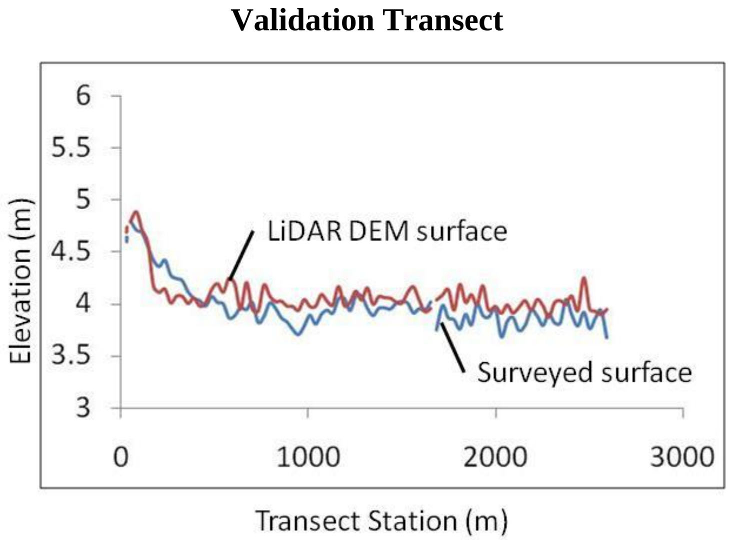

Figure 3–10. Corrected LiDAR surface is well balanced at validation minimum flows and levels transect.

3.4.4 Process and Work Flow for Inundation–Exceedence Analysis

The primary output from the hydroperiod tool is a raster map layer of ponded depth calculated as the difference between the water surface elevation and the land surface elevation from the corrected LiDAR-based DEM. By running the tool in sequence, using the series of 19 water elevations statistically representing the exceedence values in 5% intervals, a series of raster maps representing ponded depth was produced. Each ponded depth layer was then converted or reclassified into a new raster layer of flooded and non-flooded raster cells. This was done for the historical baseline and for each of the five withdrawal scenarios, producing six sets of 19 inundation maps. A change map was produced for each scenario by subtracting the inundation raster map for each scenario (percent exceedence) from the comparable historical raster map. The change maps were characterized by three conditions: no change from historical condition, flooded area not flooded historically, and exposed area that was not exposed historically. (Figure

3–11 and Figure 3–12). Isolating the areas (as polygons) that were historically flooded and are no longer flooded based on each scenario allows additional analyses to be performed, such as determining the change in ponded depth and the categories of wetlands affected using the SJRWMD Land Cover and Land Use (2004) layer or other wetland layer.

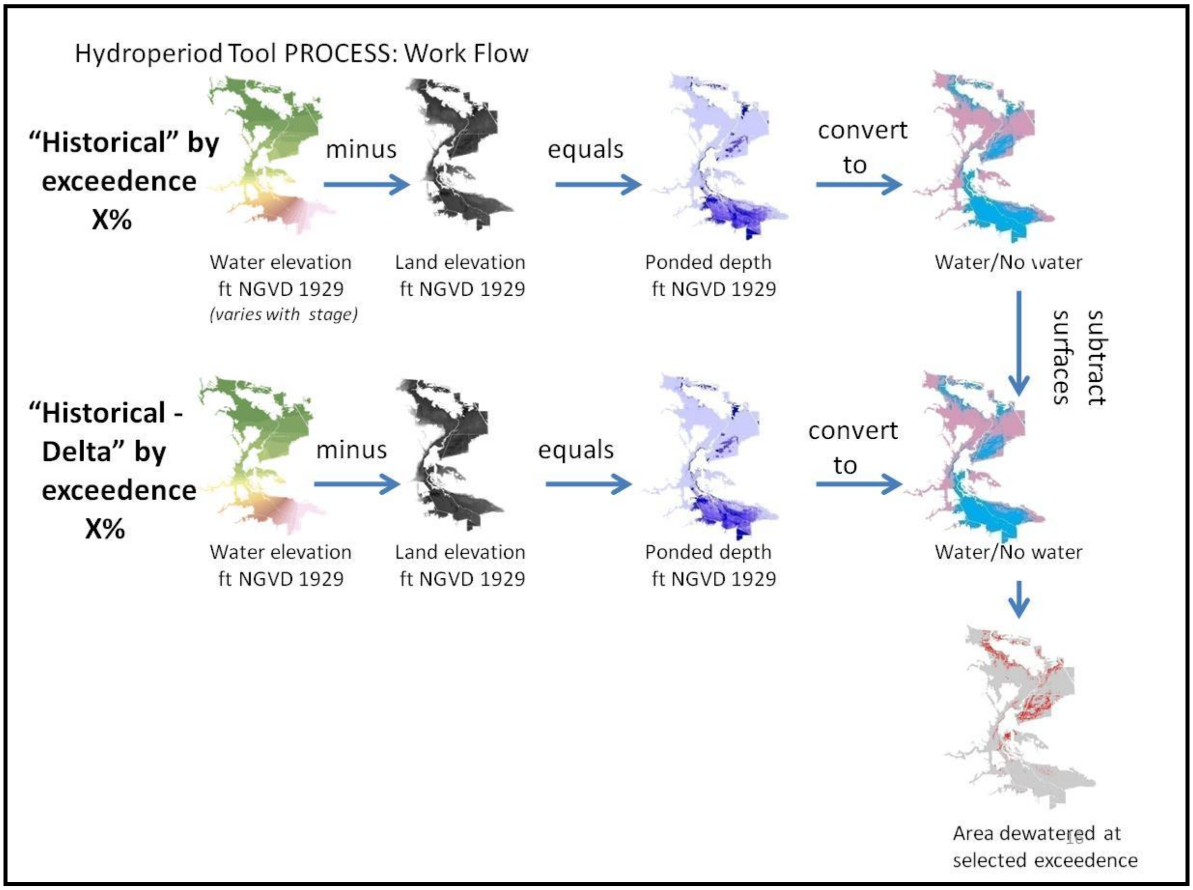

Figure 3–11. Hydroperiod tool process for determining area dewatered.

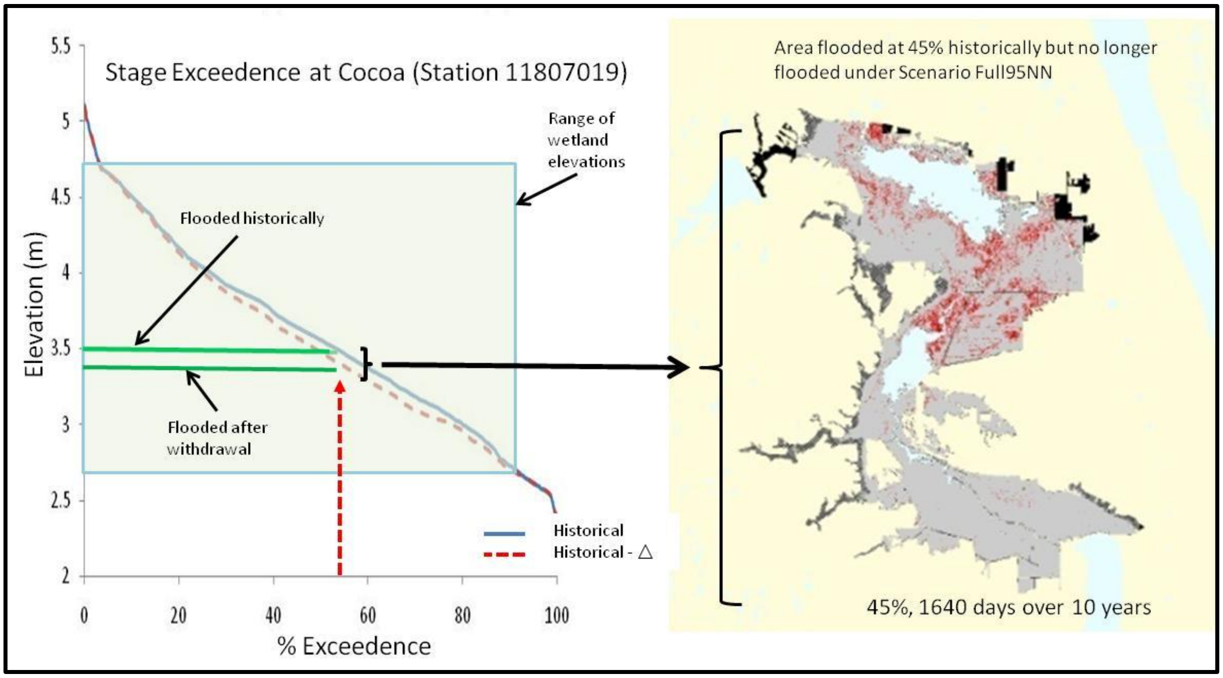

Figure 3–12. Example of how area dewatered is expressed in hydroperiod tool output.

3.5 Assessment of Shallow Surficial and Soil Hydrologies

Early in the study, we recognized that soil moisture adequate to sustain wetland vegetation (and exclude upland species) originated from diverse sources and was not limited to riverine or lacustrine sources. These sources included direct precipitation, runoff, tributary inflow, seepage, and groundwater discharge (Figure 2-13). While not measured directly, their relative importance was investigated through construction of conceptual models and examination of water levels in MFL transect wells previously placed in floodplain wetlands of the St. Johns River (see Figure 3–3). The wells were constructed of PVC material with continuous well screen to 4 in. below the surface and a riser extending above normal high water following the instructions from Morrison (1983).

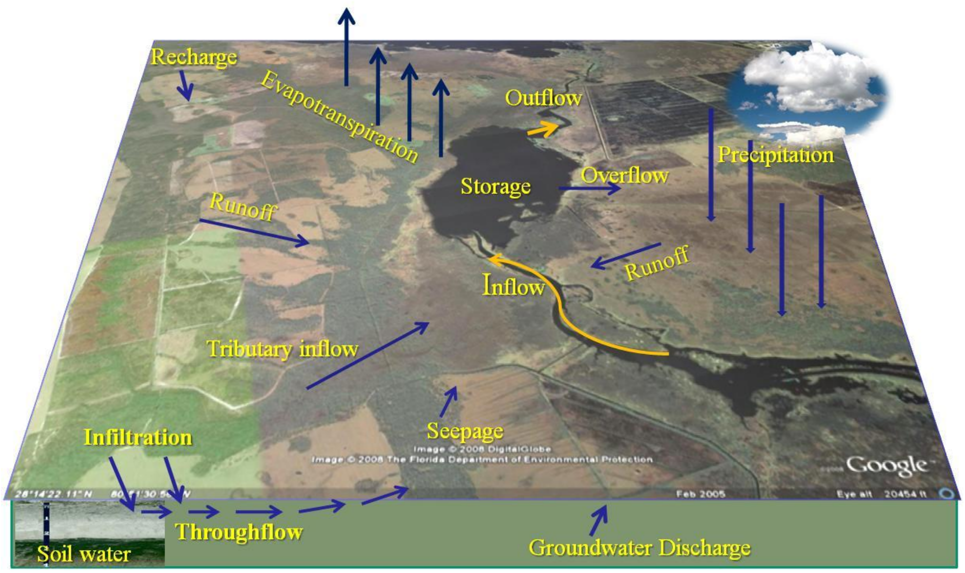

Figure 3–13. Conceptual model of landscape hydrology.

3.6 Assessment of Effects of Changes in Salinity

A second major component in the assessment of potential changes to wetlands from water withdrawals was the analysis of effects from potential upstream movement of salinity isopleths in the lower St. Johns River. Sea level rise and diminished river discharge are known to cause upstream movement of higher salinities in the lower reaches of coastal rivers. These salinity incursions can cause wetland plant communities to change from freshwater to saltwater. Wetland plant communities changes from altered salinity were considered a major concern only in river segment 2.

To assess the nature and extent of possible salinity changes, it was first necessary to further explore the relationships among wetland soil salinities, plant communities, and the adjacent open surface water salinities. The objectives of this analysis were (1) to document how wetland plant community type, structure, species diversity, and species composition change in response to rising salinity; (2) to identify break points at which specific changes occur; (3) to identify and measure other environmental changes that may affect vegetation; (4) to relate changes in soil salinity to changes in surface water salinity; and (5) to predict potential changes in wetlands that might result from salinity changes caused by the water withdrawal scenarios.

This work began with the search for and selection of an extended wetlands gradient covering a broad range of salinities. The intent was to find a model system, similar in general features to the lower St. Johns River, but displaying a complete gradient of salinities and vegetation types from fresh to brackish. There are few systems that meet these criteria in the lower St. Johns River, because the gradient of salinity is steep and little vegetation exists along much of the gradient. The Ortega River, a tributary of the St. Johns River in Duval County, however, was judged to be a suitable model system. Aerial imagery was used to document structural changes in vegetation and to guide sampling design, which ultimately developed into a layout of sampling stations at 0.5-km intervals along the length of the Ortega River from about 0.4 km south of Interstate 295 (I-295) to a point about 1 km upstream of the confluence with Cedar River near Ortega Island

Drive (Figure 3–14). Vegetation types ranged from mature freshwater swamp upstream to sand cordgrass brackish marshes downstream. Beyond that point, the vegetation transitioned into true salt marsh communities of needlegrass rush, although these were patchy and not sampled. Thirty potential sampling sites were located, as matched pairs where possible, on each side of the Ortega River; 14 sites were ultimately sampled.

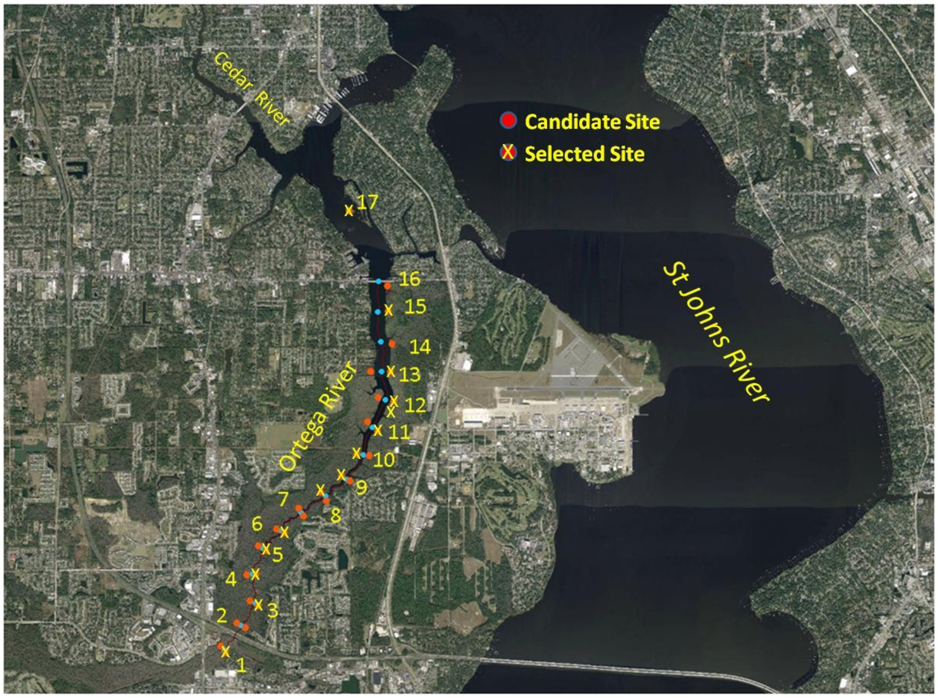

Figure 3–14. Ortega River study area with sampling stations.

We sampled the vegetation using a systematic design in plots placed at a consistent distance of 25 m from the edge of the river channel. Herbaceous, shrub, and forest communities were sampled in 5 m × 5 m, 10 m × 10 m, and 10 m × 20 m plots, respectively. The corners and centers of each plot were sampled with 1-m quadrats to ensure complete documentation of low growing and less conspicuous vegetation, to check for homogeneity of plot conditions, and to guide soil sampling. A species list was made for each plot, and cover values were estimated (Table 3–4).

Soils were also sampled using three techniques. A soil conductivity probe was used to collect relative measures of salinity across the quadrat at the corner and center 1-m plots. These measurements were used to guide collection of two (occasionally more) core samples, generally from the locations showing the highest and lowest readings. These were retained for further laboratory analysis. In addition, salinity and pH of water filling the sampling borehole were measured directly with field probes (if water was present). In the lab, pH was measured again using a 5:1 water to soil mix and salinity was measured using the saturated paste method (Brady. and Weil 2002). Bulk density was also measured and a portion of the sample volume was dried and shipped to an outside lab for further analysis. Parameters and methods are listed in Table 3–5.

Table 3–4. Cover scale for vegetation sampling.

Value	Percent Cover	Description
1	< 1%	Rare
2	2% to 5%	Occasional
3	5% to 25%	Frequent
4	25% to 50%	Common
5	50% to 75%	Abundant
6	75% to 95%	Dominant
7	95% to 100%	Monoculture
9	—	In surrounding community, but not sampled in plot

Table 3–5. Soil parameters, methods, and method detection limits.

Parameter	Method	Method Detection Limit (mg/kg)
Metals digestion	EPA† 3050B	NA*
Aluminum	EPA 6010	0.982
Calcium	EPA 6010	3.4211
Iron	EPA 6010	1.9173
Magnesium	EPA 6010	1.1691
Manganese	EPA 6010	0.0714
Potassium	EPA 6010	0.7433
Sodium	EPA 6010	1.1246
Copper	EPA 6010	0.0475
Sulfur	EPA 6010	50

* EPA = Environmental Protection Agency
† NA = not applicable

Vegetation data was sorted by soil salinity and arranged to create a table of wetland plant communities or associations (Mueller-Dombois and Ellenberg 1974). Break points between distinctive communities were selected and related to soil salinities. Soil salinity break points were determined between each wetland plant community type. These are soil salinities at which one community would be expected to transition into a more salt-tolernat or less salt-tolerant type. Transition points between wetland plant community types were selected and a break point was calculated based on the average salinities of the sites or communities on each side of the selected point. Relationships between number of species and soil parameters were explored through regression analysis. In addition, a regression was run between Ortega River water salinity (from modeled data) and soil salinity. Ultimately, the relationship observed on the Ortega River was transferred to the St. Johns River to predict potential for changes in plant communities in the area of greatest potential effects from water withdrawal scenarios.

4 RESULTS

4.1 SCREENING-LEVEL ASSESSMENT TO IDENTIFY PRIORITY RIVER SEGMENTS FOR FOCUSED STUDY

A screening-level assessment based on vegetation type, soils, dominant hydrogeomorphology, and modeled changes in average annual water levels and salinities revealed those segments where the potential for change in wetland vegetation communities was greatest. (Table 4–1).

Table 4–1. Relative likelihood of effects in river segments from changes in river stage and salinity under the Full1995NN scenario.

River Segment	Dominant Wetland Type	Soils	Dominant Hydrogeo-morphology	Change in Stage (m)	Change in Salinity—Annual Mean (Highest Monthly Mean)	Likelihood of Stage Effects Full1995NN	Likelihood of Salinity Effects Full1995NN
1	Salt marsh	Mucky peat	Estuarine fringe	0.003	0.32 (0.49)	Very low	Low
2	Hardwood swamp	Muck	Estuarine fringe	0.003	0.12 (0.30)	Very low	High
3	Hardwood swamp	Muck	Estuarine fringe	0.003	0.011(0.064)	Very low	Low
4	Hardwood swamp, hydric hammock	Muck; Misc. mineral	Lacustrine fringe	0.006	None	Very low	None
5	Hardwood swamp, shallow marsh	Muck, mucky peat; sandy clay loam	Riverine, Lacustrine fringe	0.008 to 0.015	None	Low	None
6	Wet Prairie, shallow marsh	Misc. mineral; sand, muck	Lacustrine fringe, Riverine	0.029 to 0.033	None	Moderate	None
7	Wet prairie, shallow marsh	Fine sand; muck	Riverine, mineral soil flats	0.04	None	High	None
8	Shallow marsh, shrub swamp	Mucky peat; muck, fine sand	Lacustrine fringe, Organic soil flats	0.05	None	High	None
9	Shallow marsh, shrub swamp	Muck, mucky peat	Organic soil flats, Lacustrine fringe	0.00	None	None	None

4.1.1 Areas of Greatest Potential Change in Stage

Potential change in stage was examined under the Full1995NN scenario, which has full withdrawal with no USJRB Projects and no additional channel deepening. From Lake George to the mouth of the River, modeled changes were minimal owing to the controlling influence of ocean levels. The modeled average annual change in stage was 0.008 m at Astor (segment 4) and increased to 0.015m at DeLand (segment 5), 0.029 m at Sanford (segment 6), 0.033 m at the outlet of Lake Jesup (segment 6), 0.04 m at Christmas (segment 7), and 0.05 m at both Cocoa and Lake Winder (segment 8). Further upstream, at the outlet of Lake Washington (segment 8), there was no modeled change in stage from surface water withdrawals (Figure 4–1). The portion of segment 8 below Lake Washington was considered to be the area of greatest potential change from the effects of water withdrawals based on the magnitude of water level change, the presence of sensitive vegetation (shallow marsh), and organic soils. Change in segment 7 was predicted to be less, but sufficiently high to warrant further investigation (Appendix 10.D).

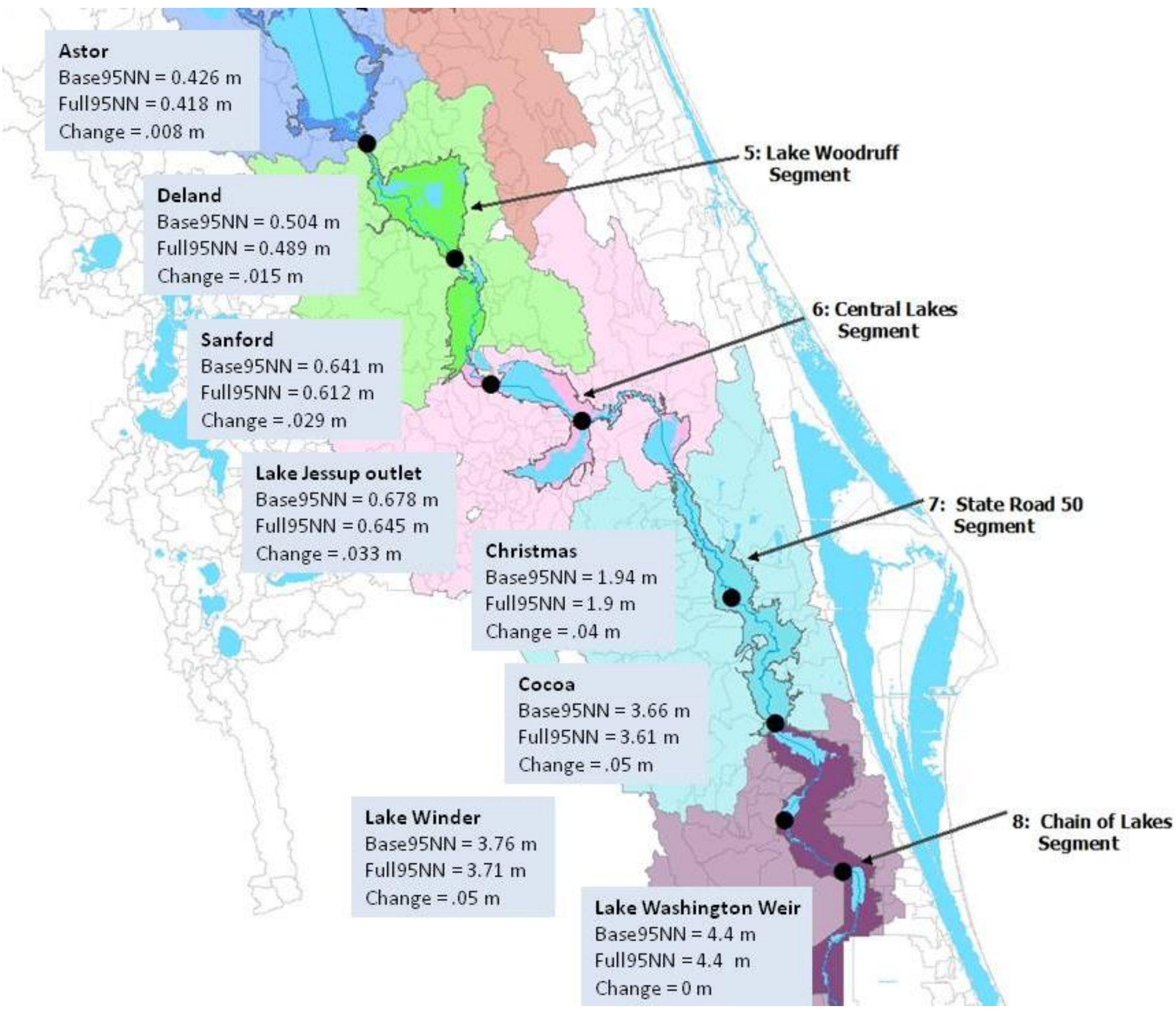

Figure 4–1. Modeled annual average water levels and change in water levels (m) at gauging stations under Base1995NN and Full1995NN scenarios.

4.1.2 AREAS OF GREATEST POTENTIAL CHANGE IN SALINITY

Potential change in surface water salinity was analyzed under the Full1995NN scenario, which has full withdrawal with no USJRB projects and no additional channel deepening. Modeled salinities reached thresholds of concern only in the lower reaches of the river north of river kilometer 80, near Shands Bridge. South of Shands Bridge (further upstream), conditions are generally fresh to very slightly oligohaline and show little change in salinity from water withdrawals. Further downstream, from about river km 40, near the Fuller-Warren Bridge, to the mouth of the river, salinities are sufficiently high and variable under baseline conditions to limit wetlands to salt-tolerant marshes, which are well adapted to salinity increases up to full seawater conditions (Chapter 2, Appendix 2.B). Therefore, the area between river km 40 and river km 80, which corresponds closely with river segment 2, was considered the area of greatest concern.

4.2 MINIMUM FLOWS AND LEVELS (MFLS) TRANSECT ANALYSIS RESULTS

4.2.1 DESCRIPTION OF TRANSECTS IN RIVER SEGMENT 8

Transect analysis was conducted only for River Segment 8, which was judged to be the river segment in which potential changes in wetland vegetation communities were greatest. The four MFL transects in segment 8 at Lake Poinsett—Buzzard’s Roost, County Line, I-95, and Mulberry Mound (Mace, 2007a)—were used in the analysis of the effects of water withdrawal scenarios on wetland vegetation (Figure 4–2).

Figure 4–2. Location of minimum flows and levels (MFL) transects at Lake Poinsett, river segment 8.

Along the four Lake Poinsett (segment 8) MFL transects, 124 plant species were sampled (Table 4-2). These included 12 species of trees, four woody shrubs, two suffrutescent (woody only at the base) shrubs, two perennial subshrubs (dwarf shrubs), four perennial vines, four or five ferns and a diversity of annual to perennial grasses, sedges, and herbs. These fell into one or more of a series of wetland plant community types described by Mace (2007a). The vegetation types correspond closely to those described in Appendix 10.B, but include subcategories and transitional forms among the main types (table 4-3)

Table 4–2. Wetland status and duration and growth habit for vegetation species sampled in Lake Poinsett (segments 8) minimum flows and levels transects.

Common Name	Scientific Name (Wunderlin and Hansen 2008)	FDEP Wetland Status	Duration and Growth Habit (USDA 2011)
Red maple	Acer rubrum	FACW	Woody perennial
Alligator weed	Alternanthera philoxeroides	OBL	Perennial herb
Pigweed	Amaranthus australis	OBL	Annual
Ragweed	Ambrosia artemisiifolia	UPL	Annual herb
Bushy beardgrass	Andropogon glomeratus	FACW	Perennial grass
Bluestem	Andropogon sp.	FAC	Perennial grass
Broomsedge bluestem	Andropogon virginicus	FAC	Perennial grass
Aster	Aster sp.	OBL	Herb
Groundsel tree	Baccharis glomeruliflora	FAC	Woody perennial
Herb-of-grace	Bacopa monnieri	OBL	Perennial herb
Swamp fern	Blechnum serrulatum	FACW	Fern
False nettle	Boehmeria cylindrica	OBL	Perennial herb
Beautyberry	Callicarpa americana	UPL	Woody perennial
Longhair sedge	Carex comosa	OBL	Perennial sedge
Sedge	Carex sp.	OBL	Sedge
Sugarberry	Celtis laevigata	FACW	Woody perennial
Spadeleaf	Centella asiatica	FACW	Perennial herb
Buttonbush	Cephalanthus occidentalis	OBL	Woody perennial
Nuttall's thistle	Cirsium nuttallii	FACW	Perennial herb
Thistle	Cirsium sp.	FACW	Annual, biennial, or perennial herbs
Sawgrass	Cladium jamaicense	OBL	Perennial sedge
Common dayflower	Commelina diffusa	FACW	Annual–Perennial herb
Leavenworth's tickseed	Coreopsis leavenworthii	FACW	Perennial herb
Colombian waxweed	Cuphea carthagenensis	FAC	Annual–Perennial herb
Flatsedge, jointed	Cyperus articulatus	OBL	Perennial sedge
Papyrus flatsedge	Cyperus papyrus	FAC	Perennial sedge
Flatsedge	Cyperus sp.	FAC	Annual or perennial sedges
Needleleaf witchgrass	Dichanthelium aciculare	FACW	Perennial grass
Roundweed witchgrass	Dichanthelium sphaerocarpon	UPL	Perennial grass

Common Name	Scientific Name (Wunderlin and Hansen 2008)	FDEP Wetland Status	Duration and Growth Habit (USDA 2011)
Common persimmon	Diospyros virginiana	FAC	Woody perennial
Coast cockspur-grass	Echinochloa muricata	FAC	Annual grass
Coastal cockspur	Echinochloa walteri	OBL	Annual grass
Water hyacinth	Eichhornia crassipes	OBL	Perennial herb
Fireweed	Erechtites hieraciifolia	FAC	Annual herb
Oakleaf fleabane	Erigeron quercifolius	FAC	Perennial herb
Blue mistflower	Eupatorium coelestinum	FAC	Perennial herb
Dog fennel (alive)	Eupatorium leptophyllum	FAC	Perennial herb
Semaphore thoroughwort	Eupatorium mikanioides	FACW	Perennial herb
Dog fennel	Eupatorium sp.	FACW	Perennial herb
Pinewoods fingergrass	Eustachys petraea	FAC	Perennial grass
forked fimbry	Fimbristylis dichotoma	FACW	Annual–perennial sedge
Carolina ash	Fraxinus caroliniana	OBL	Woody perennial
Stiff marsh bedstraw	Galium tinctorium	FACW	Perennial herb
Water locust	Gleditsia aquatica	OBL	Woody perennial
Orchid	Habenaria sp	FACW	Perennial herb
Swamp rosemallow	Hibiscus grandiflorus	OBL	Suffrutescent shrub
Pennywort	Hydrocotyle umbellata	FACW	Perennial herb
Spiderlily	Hymenocallis sp.	OBL	Perennial herb
Dwarf St. John's-wort	Hypericum mutilum	FACW	Perennial subshrub
Clustered bushmint	Hyptis alata	FACW	Perennial herb
Southern blue-flag	Iris virginica	OBL	Perennial herb
Looseflower waterwillow	Justicia ovata	OBL	Perennial herb
Seashore mallow	Kosteletzkya virginica	OBL	Suffrutescent shrub
Duckweed	Lemna sp.	OBL	Perennial herb
Frog’s bit	Limnobium spongia	OBL	Perennial herb
Winged loosestrife	Lythrum alatum	OBL	Perennial subshrub
Mikania	Mikania scandens	FACW	Perennial vine
Wax myrtle	Myrica cerifera	FAC	Woody perennial
Spatterdock	Nuphar advena	OBL	Perennial herb
Yellow water lily	Nymphaea mexicana	OBL	Perennial herb
Floating hearts	Nymphoides aquatica	OBL	Perennial herb
Wood grass	Oplismenus setarius	UPL	Perennial grass
Royal fern	Osmunda regalis	OBL	Fern
Common yellow woodsorrel	Oxalis corniculata	UPL	Annual–perennial herb
Beaked panicum	Panicum anceps	FAC	Perennial grass
Variable panic grass	Panicum commutatum	FAC	Perennial grass
Fall panicum	Panicum dichotomiflorum	FACW	Annual grass
Savannah panicum	Panicum gymnocarpon	OBL	Perennial grass
Maidencane	Panicum hemitomon	OBL	Perennial grass
Panic grass	Panicum longifolium	OBL	Perennial grass

Common Name	Scientific Name (Wunderlin and Hansen 2008)	FDEP Wetland Status	Duration and Growth Habit (USDA 2011)
Redtop panicum	Panicum rigidulum	FACW	Perennial grass
Panicum sp	Panicum sp.	OBL	Perennial or annual grasses
Egyptian paspalidium	Paspalidium geminatum	OBL	Perennial grass
Knotgrass	Paspalum distichum	OBL	Perennial grass
Early paspalum	Paspalum praecox	OBL	Perennial grass
Common reed	Phragmites australis	OBL	Perennial grass
Turkey tangle fogfruit	Phyla nodiflora	FAC	Perennial herb
Slash pine	Pinus elliottii	UPL	Woody perennial
Water lettuce	Pistia stratiotes	OBL	Perennial herb
Rosy camphorweed	Pluchea baccharis	FACW	Perennial herb
Camphorweed	Pluchea sp.	FACW	Perennial herb
Camphorweed	Pluchea sp. #1	FACW	Perennial herb
Camphorweed	Pluchea sp. #2	FACW	Perennial herb
Smartweed	Polygonum densiflorum	OBL	Perennial herb
Dotted smartweed	Polygonum punctatum	OBL	Perennial herb
Pickerelweed	Pontedaria cordata	OBL	Perennial herb
Sweet everlasting	Pseudognaphalium obtusifolium	UPL	Annual–Biennial herb
Baldrush	Psilocarya nitens	OBL	Annual–Perennial sedge
Mock bishop-weed	Ptilimnium capillaceum	FACW	Annual herb
Sand live oak	Quercus geminata	UPL	Woody perennial
Laurel oak	Quercus laurifolia	FACW	Woody perennial
Starrush whitetop	Rhynchospora colorata	FACW	Perennial sedge
Shortbristle horned beaksedge	Rhynchospora corniculata	OBL	Perennial sedge
Swamp dock	Rumex verticillatus	FACW	Perennial herb
Cabbage palm	Sabal palmetto	FAC	Woody perennial
Largeflower rosegentian	Sabatia grandiflora	OBL	Annual herb
India cupscale	Sacciolepis indica	FAC	Annual grass
American cupscale	Sacciolepis striata	OBL	Perennial grass
Bull arrowhead	Sagittaria lancifolia	OBL	Perennial herb
Carolina willow	Salix caroliniana	OBL	Woody perennial
Water spangles	Salvinia minima	OBL	Annual–Perennial herb
White twinevine	Sarcostemma clausum	FACW	Perennial herb
Lizard's tail	Saururus cernuus	OBL	Perennial herb
Giant bulrush	Schoenoplectus califonicus	OBL	Perennial sedge
Bulrush	Schoenoplectus sp.	OBL	Perennial sedge
Softstem bulrush	Scirpus tabernaemontani	OBL	Perennial sedge
Butterweed	Pakera glabella	OBL	Annual herb
Rattle bush	Sesbania herbacea	FAC	Annual–Perennial subshrub
Sesbania	Sesbania sp.	FACW	Annual–Perennial subshrub

Common Name	Scientific Name (Wunderlin and Hansen 2008)	FDEP Wetland Status	Duration and Growth Habit (USDA 2011)
Giant foxtail	Setaria magna	OBL	Annual grass
Saw greenbrier	Smilax bona-nox	Not rated	Perennial vine
Sand cordgrass	Spartina bakeri	FACW	Perennial grass
Ladiestresses	Spiranthes sp.	FACW	Perennial herb
Bald cypress	Taxodium distichum	OBL	Woody perennial
Wood sage	Teucrium canadense	FACW	Perennial herb
Marsh fern	Thelypteris palustris	FACW	Fern
Maiden fern	Thelypteris sp.	FACW	Fern
Trailing spiderwort	Tradescantia fluminensis	FAC	Perennial herb
Cattail	Typha sp.	OBL	Perennial herb
American elm	Ulmus americana	FACW	Woody perennial
Bladderwort	Utricularia sp	OBL	Perennial herb
Fourleaf vetch	Vicia acutifolia	Not rated	Perennial vine
Muscadine grape	Vitus rotundifolia	Not rated	Perennial vine
Virginia chain fern	Woodwardia virginica	OBL	Fern

FDEP = Department of Environmental Protection
FACW = Facultative wet
OBL = Obligate

Table 4–3. Wetland Plant Community types, subtypes and transitional types on Lake Poinsett (segment 8) minimum flows and levels transects.

Type	Description	Wetlands Type Group
Deep marsh	Deep water wetlands dominated by a mixture of water lilies and deep water emergent species.	Deep marsh
Sawgrass	A subtype of shallow marsh dominated by Sawgrass	Shallow marsh
Shrub swamp	Dominated by willows, buttonbush, or similar appearing vegetation. Hydrology similar to that of cypress, hardwood swamp, or shallow marsh communities.	Shrub swamp
Transitional marsh	A mosaic of sawgrass marsh and sand cordgrass marsh	Shallow marsh
Shallow marsh	Herbaceous or graminoid communities dominated by species such as sawgrass, maidencane, cattails, pickerel weed, arrowhead, or other grasses and broad-leaved herbs.	Shallow marsh

Type	Description	Wetlands Type Group
Shallow marsh–wet prairie	A patchwork of areas dominated by shallow marsh vegetation and by wet prairie vegetation	Shallow marsh
Sand cordgrass marsh	A subtype of wet prairie heavily dominated by sand cordgrass	Wet prairie
Wet prairie	Communities of grasses, sedges, rushes, and herbs typically dominated by sand cordgrass, maidencane, or a mixture of species. Usually on mineral soils that are inundated for a relatively short duration each year, but with prolonged soil saturation.	Wet prairie
Upper wet prairie	A dryer phase of wet prairie, with groundsel tree, wax myrtle, and immature cabbage palm	Wet prairie
Maple swamp	A subtype of hardwood swamp heavily dominated by red maple	Hardwood swamp
Transitional swamp	A dryer phase of maple-dominated hardwood swamp	Hardwood swamp
Transitional shrub	A wetland type dominated by transitional shrubby vegetation near upland margins of wetter community types.	Transitional shrub
Lower palm hydric hammock	A wetter phase of cabbage-palm-dominated hydric hammock	Hydric hammock
Palm hydric hammock	Forested systems dominated by a mixture of broadleaved evergreen and deciduous tree species. Cabbage palmetto may be dominant in some variants of this type.	Palm hydric hammock
Oak–palm hammock	A dryer phase of hydric hammock with sand live oak and laurel oak, in addition to cabbage palm	Hydric hammock
Low flatwoods–palm hydric hammock	A dryer phase of hydric hammock with abundant slash pine, as well as cabbage palm and wax myrtle	Hydric hammock

4.2.2 Community Elevation Ranges

Median, mean, minimum, and maximum elevations were recorded for each community on each MFL transect and compiled to derive overall averages, standard deviations, and medians for each of these measures (Table 4–4). These measures summarize the overall characteristics of the wetlands vegetation at Lake Poinsett and of the inherent variability in the elevations and exceedences at their upper and lower boundaries.

Table 4–4. Plant community statistics for Lake Poinsett minimum flows and levels transects.

Wetland Plant Community Type	Average of Minimums and Standard Deviation (m)	Average of Maximums and Standard Deviation (m)	Median of Minimums (m)	Exceedence at Median of Minimums	Median of Maximums (m)	Exceedence at Median of Maximums
Deep marsh	3.02 (.15)	3.20 (.12)	2.83	.8692	3.14	.7277
Shallow marsh group (a, b, and c)	3.28	3.66	3.23	.6762	3.69	.4239
a. Sawgrass marsh	3.29 (.27)	3.66 (.27)	3.20	.6916	3.78	.3878
b. Shrub swamp	3.32	3.69	3.32	.6308	3.69	.4239
c. Shallow marsh	3.23 (.15)	3.63 (.30)	3.23	.6762	3.57	.4934
Wet prairie	3.63 (.40)	3.93 (.37)	3.63	.4579	4.11	.2167
Hardwood – maple swamp	4.02 (.12)	4.27 (.03)	4.02	.2600	4.27	.1694
Transitional shrub	4.27 (.12)	4.63 (.18)	4.27	.1694	4.63	.0610
Hydric hammock	4.72 (.24)	4.97 (.24)	4.69	.0380	5.12	.0000

4.2.3 Hydrologic Patterns by Scenario

An overview of potential effects can be obtained through examination of stage exceedence curves, daily median annual hydrographs, and maximum and minimum levels for the St. Johns River gauge at Cocoa at SR 520 Bridge (Lake Poinsett) for the period 1996 to 2005. Exceedence curves (Figure 4-4) show the percentage of time (x-axis) water exceeds any given level (y-axis). Higher elevations (upper left of curve) are seldom flooded and so have low exceedences. Lower elevations (lower right of curve) are flooded most of the time and thus have high exceedences. The curve also shows the entire range of flooding (2.36 to 5.11 m or a range of 2.75 m) and the distribution of exceedences within the range. The curve bends sharply at each end, representing extreme floods and droughts. (Note that exceedence can be changed to days of flooding by multiplying the exceedence by the number of days in the period of record. The resulting curve then becomes a stage duration curve).

The daily median hydrograph (Figure 4–4) shows a hypothetical year in which each day is graphed as the median of all values for that date over the period of record. This is useful in that it illustrates the typical seasonal patterns and durations of hydrologic events. Maximum and minimum values also appear on these graphs. They do not show a sequence of events but instead show the range of the values that have occurred on each calendar date. As such, they mark the upper and lower boundaries for all hydrologic events within the period of record. This picture of a typical hydrologic cycle at the Cocoa gauge station (Lake Poinsett) on the St. Johns River shows that stages are generally lowest in late May to early June and rise steeply with the advent of summer storms to reach their highest levels in September and October. They fall off more gradually through the months of winter and spring. High levels may occur anytime from July to May, low levels from December through August.

Full1995NN Scenario

Under the Full1995NN scenario (see Figure 4-4 and Figure 4–4), some change in exceedence may be seen at the lower wetland boundary, but in all other scenarios, this does not occur and there is actually a gain in hydration under the other scenarios. In the Full1995NN scenario there also is a decline in stage over much of the range of exceedences. Minimums decline somewhat during the wet season under the Full1995NN scenario.

From Figure-4, it may be observed that the highest wetland communities are seldom, if ever, watered by the river. Other hydrologic inputs, such as runoff, seepage, direct rainfall, and tributary inflow appear to be responsible for wetland hydration at these elevations. Therefore, no change in the upper wetland boundary (Hydric hammock maximum) is expected under any scenario. The lower wetland boundary (Deep marsh minimum) may potentially shift downslope in the Full1995NN scenario, but in all other scenarios, there are no surface water withdrawal effects on the lower wetland boundary.

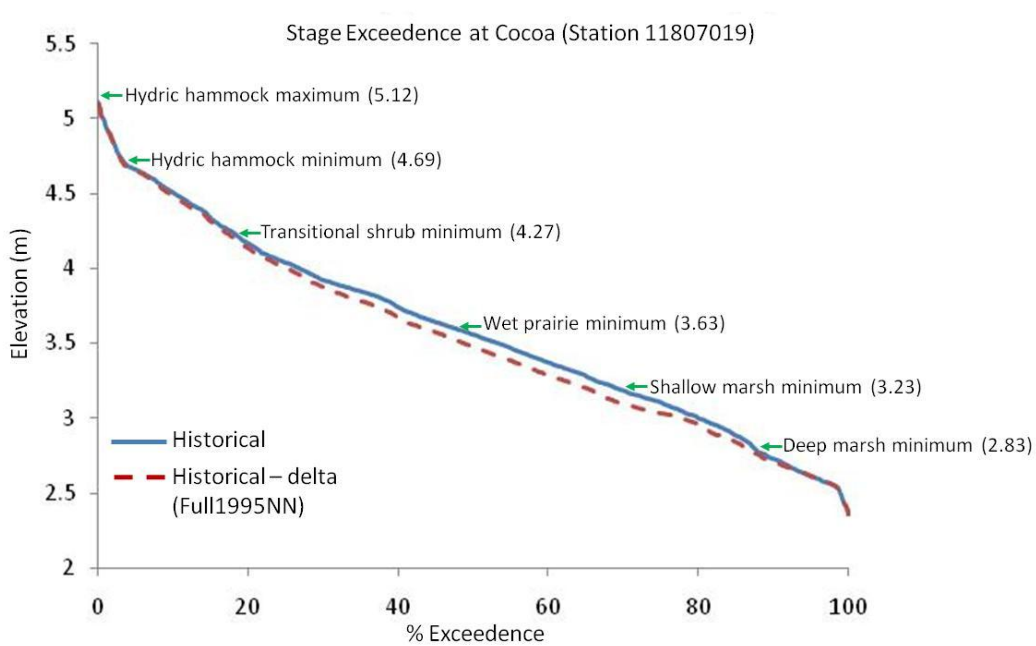

Figure 4–3. Exceedences for Full1995NN Scenario, St. Johns River at Cocoa (Lake Poinsett).

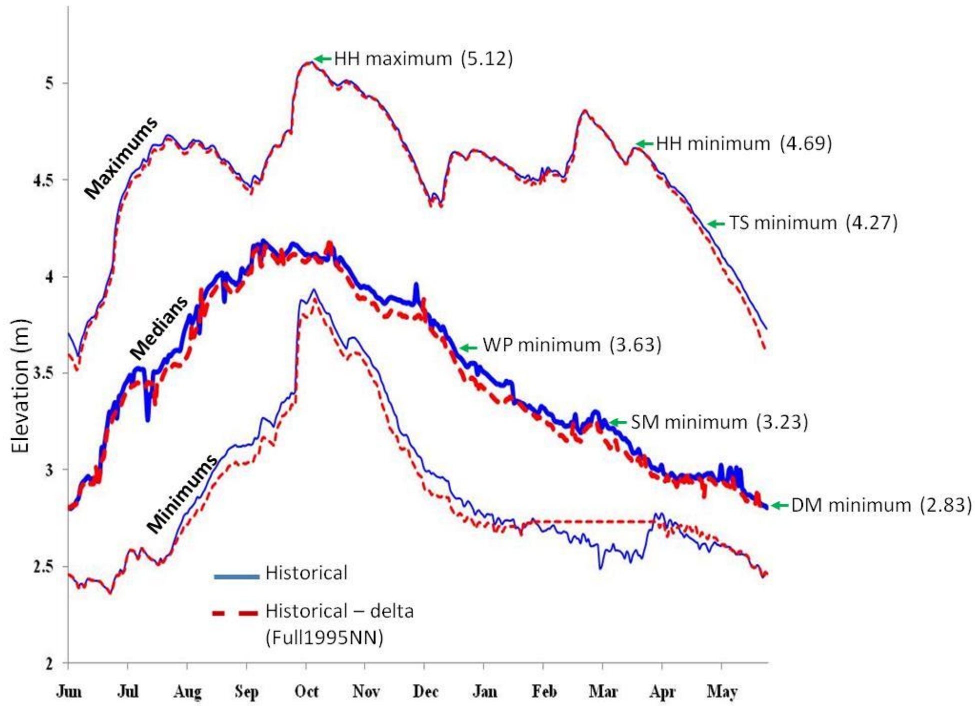

Figure 4–4. Median annual hydrograph with maximums and minimums for Full1995NN Scenario, St. Johns River at Cocoa (Lake Poinsett). HH = hydric hammock, TS = transitional shrub, WP = wet prairie, SM = shallow marsh, DM = deep marsh.

Full1995PN Scenario

Under the Full1995PN scenario (Figure 4–5 and Figure 4–6), stages decline in the midrange of exceedences but increase substantially at higher exceedences (lower elevations) as a result of the USJRB projects. Wet season minimums decline somewhat, but late dry season minimums are higher. Maximum levels also increase slightly under the Full1995PN scenario.

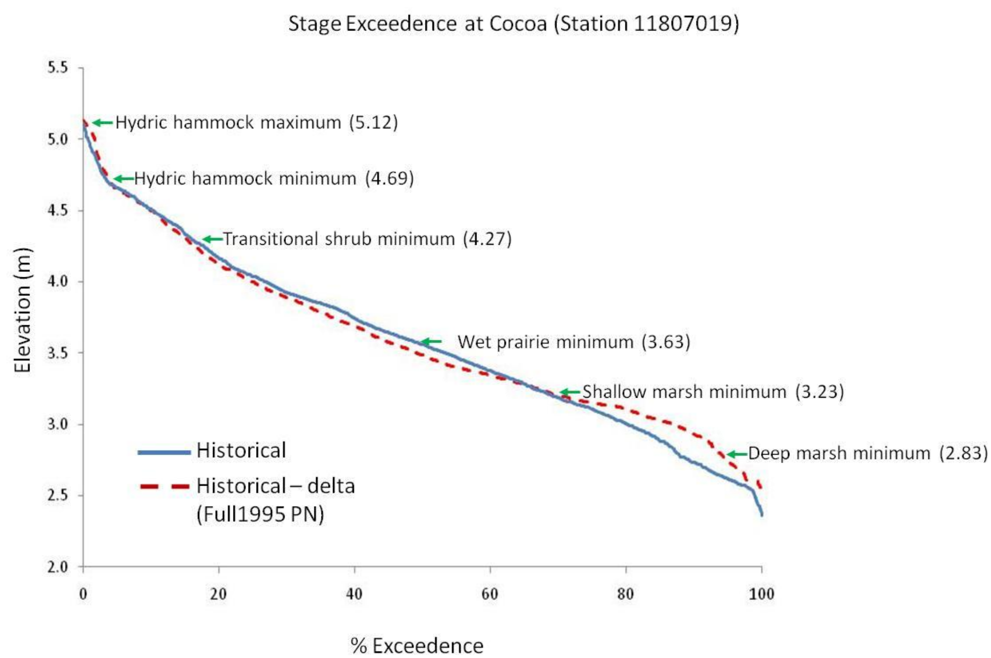

Figure 4–5. Exceedences for Full1995PN scenario, St. Johns River at Cocoa (Lake Poinsett).

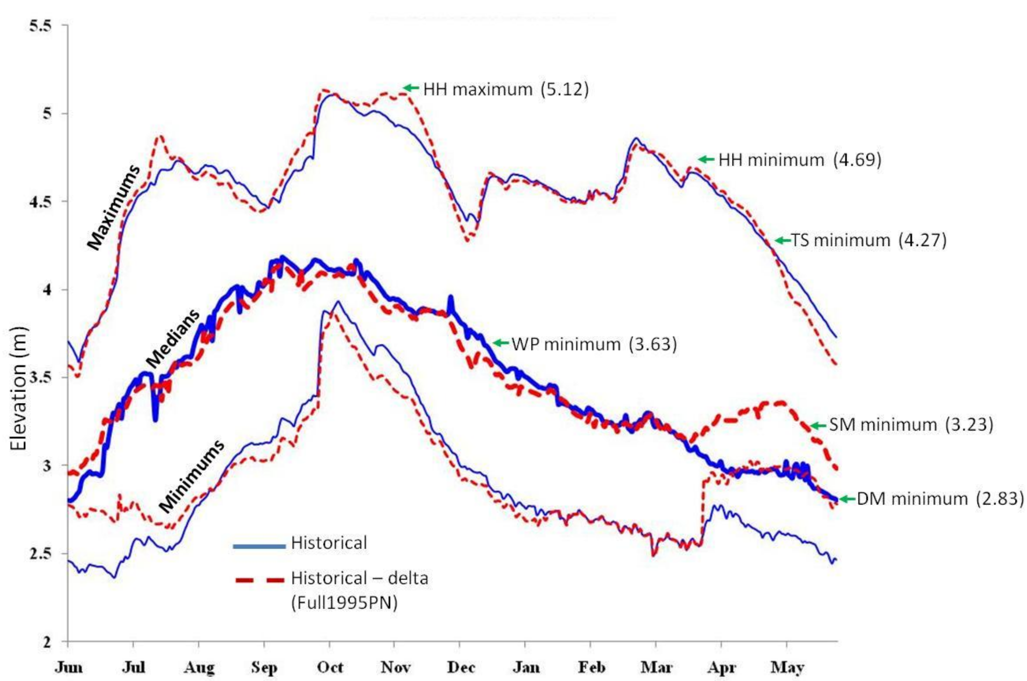

Figure 4–6. Median annual hydrograph with maximums and minimums for Full1995PN scenario, St. Johns River at Cocoa (Lake Poinsett).

Half1995PN Scenario

With the Half1995PN scenario (Figure 4–7 and Figure 4–8), stages drop slightly in the middle section of the range but, as in the Full1995PN scenario, they rise considerably at higher exceedences (lower elevations). Wet season minimums decline somewhat, but late dry season minimums are higher. Maximum levels also increase slightly under the Half1995PN scenario.

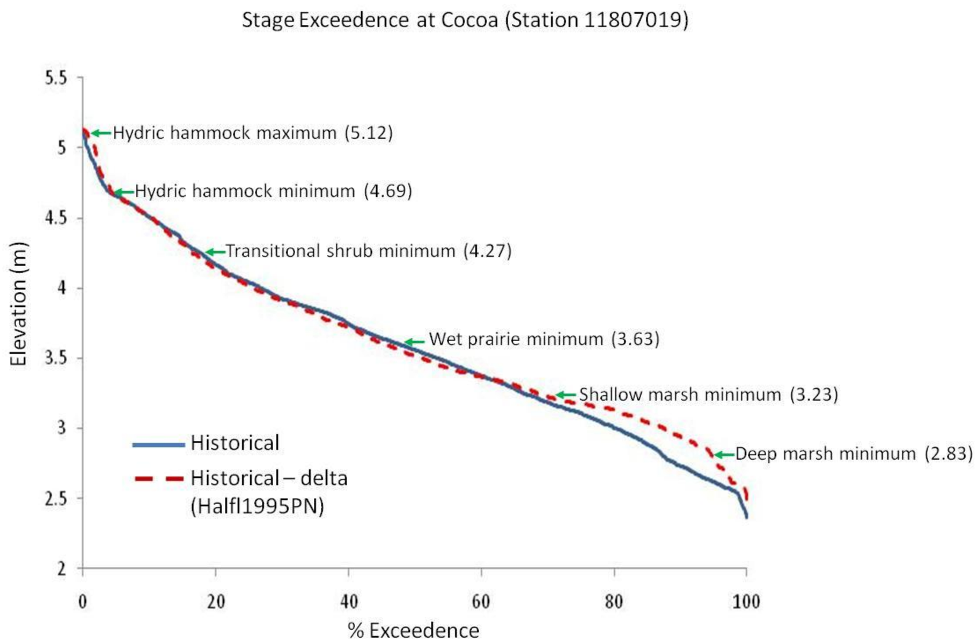

Figure 4–7. Exceedences for Half1995PN scenario, St. Johns River at Cocoa (Lake Poinsett).

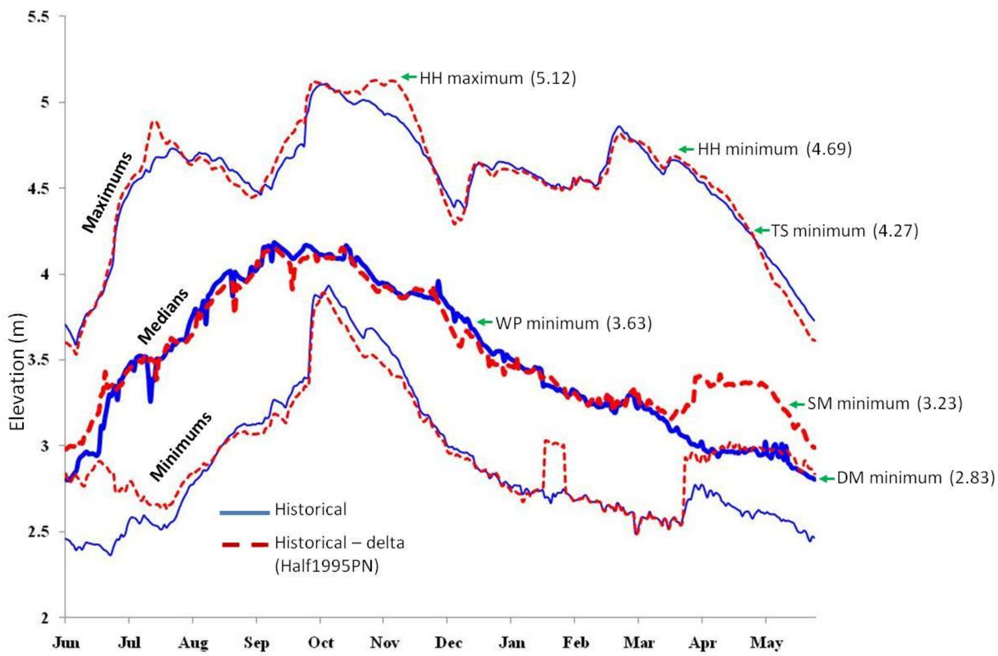

Figure 4–8. Median annual hydrograph with maximums and minimums for Half1995PN scenario, St. Johns River at Cocoa (Lake Poinsett).

<u>Full2030PN Scenario</u>

With the Full2030PN Scenario (Figure 4–9 and Figure 4–10), stages show only a very slight drop in the middle section of the range but, as in the Full1995PN scenario, they rise considerably at higher exceedences (lower elevations). Wet season minimums decline somewhat, but late dry season minimums are higher. Maximum levels also increase slightly under the Full2030PN scenario.

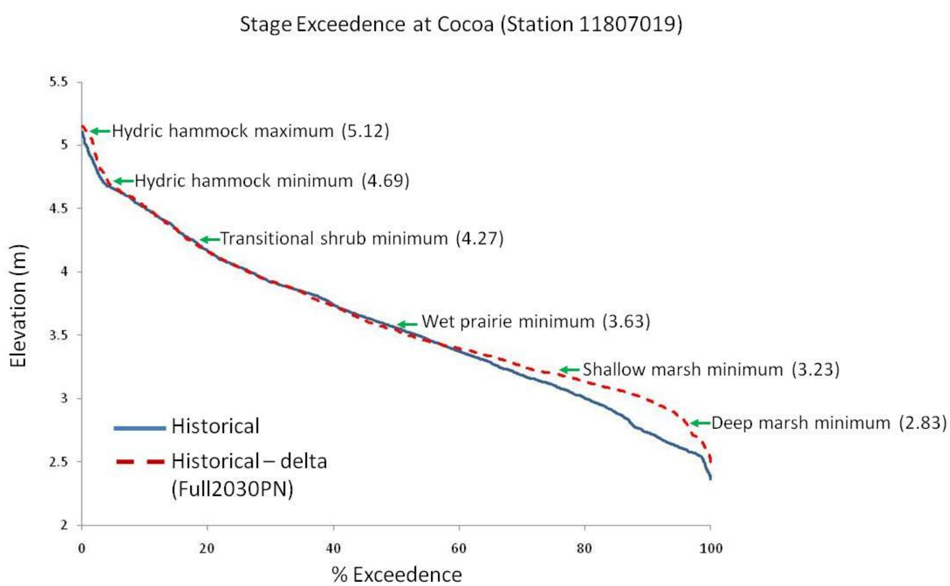

Figure 4–9. Exceedences for Full2030PN scenario, St. Johns River at Cocoa (Lake Poinsett).

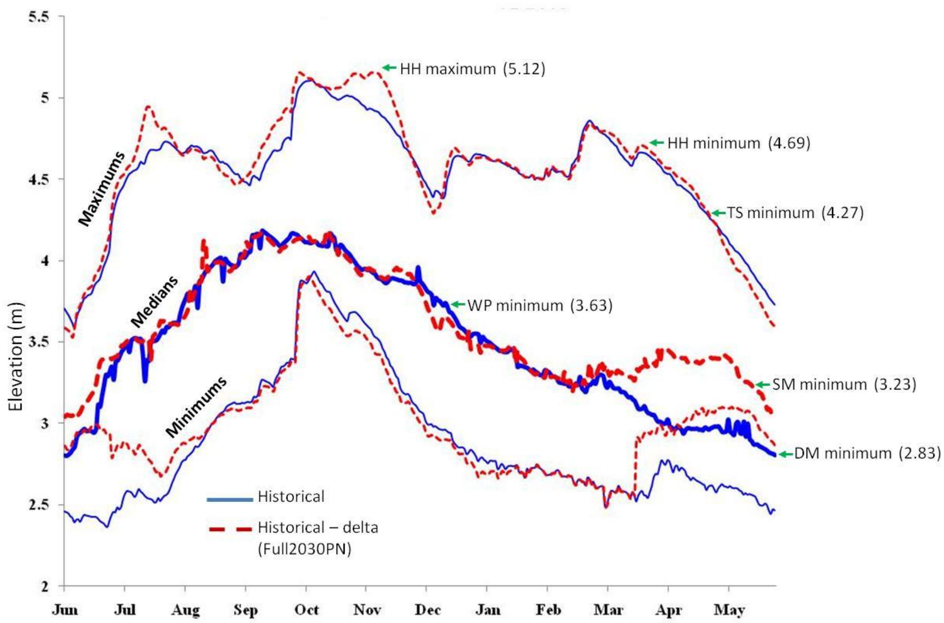

Figure 4–10. Median annual hydrograph with maximums and minimums for Full2030PN scenario, St. Johns River at Cocoa (Lake Poinsett).

The previous figures have shown mean annual hydrographic patterns for the entire period of record. Year to year variability within hydrographic patterns may be striking (Figure 4–11 and Figure 4–12). This pattern of variability reveals the broader spectrum of hydrological conditions under which wetland vegetation communities in river segment 8 exist. In some years very little of the floodplain is flooded and the duration of flooding may be brief. In other years, a substantial portion of the floodplain may be continuously flooded. This variability is important from two perspectives. Some species may need these events for successful reproduction or dispersal. For others these events are harmful extremes, which prevent them from permanently occupying those portions of the floodplain which are in some years either too wet or too dry.

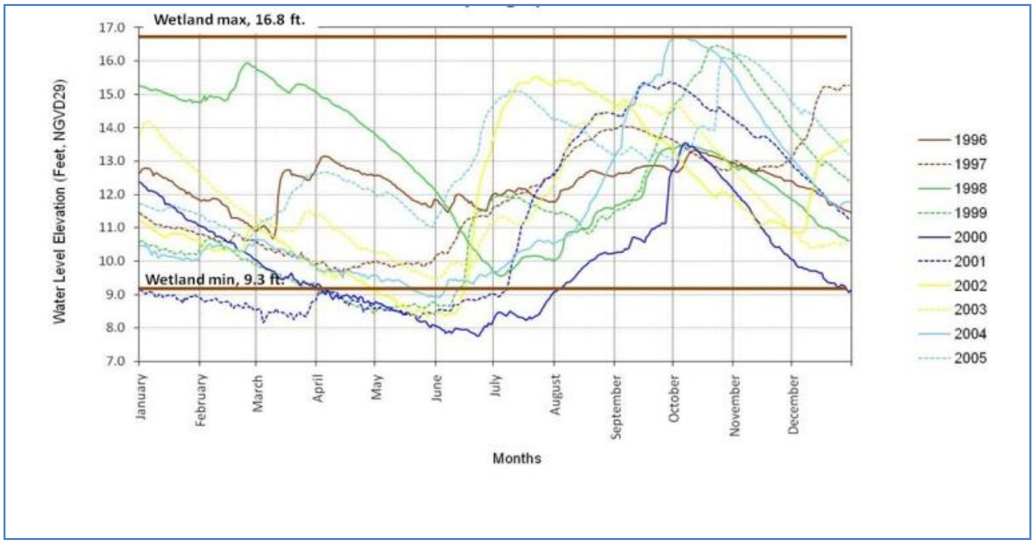

Figure 4–11. Superimposed hydrographs for 1996 to 2005, St. Johns River at Cocoa (Lake Poinsett).

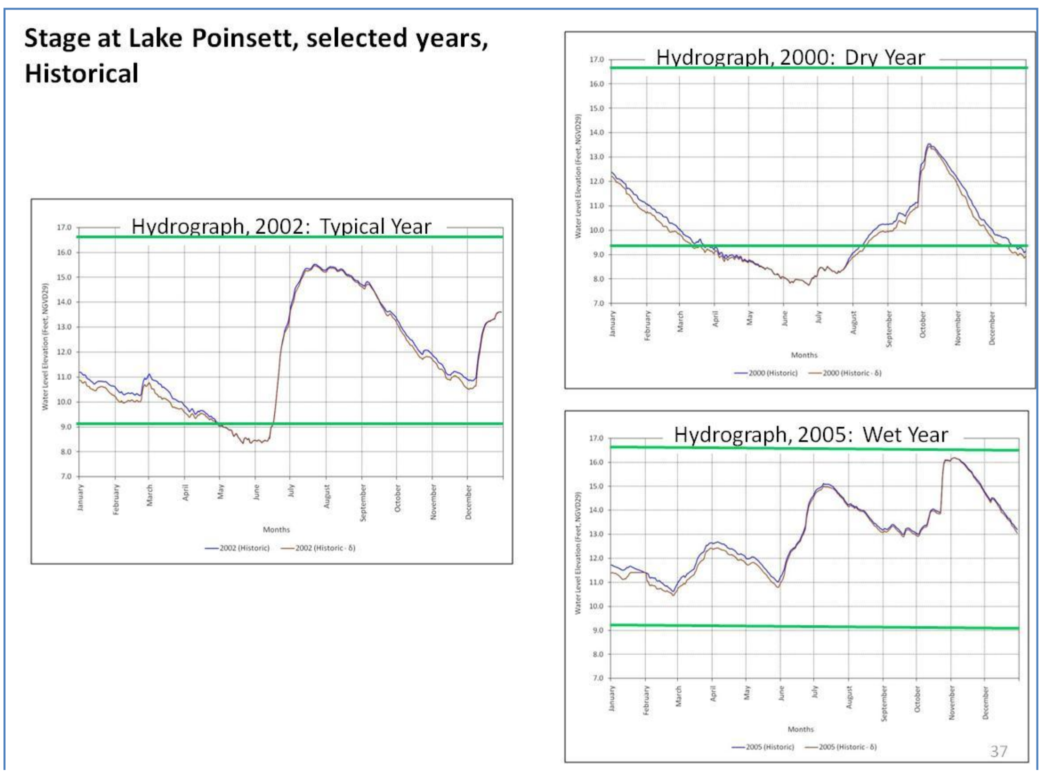

Figure 4–12. Selected years show stage variability, St. Johns River at Cocoa. (Lake Poinsett).

4.2.4 ANALYSIS OF POTENTIAL VEGETATION MOVEMENT ALONG TRANSECTS

Change in exceedence, hydroperiod, potential plant community movement and change in community width varied by transect. The overall pattern shows loss in deep marsh and some loss in shallow marsh communities together with substantial gains in wet prairie and upper wet prairie communities under the Full1995NN scenario. These effects are progressively less prominent for the Full1995PN and Half1995PN scenarios and virtually absent in the Full2030PN scenario.

Full1995NN Scenario

Under the Full1995NN scenario, modeled output indicates a reduction in both exceedence and in days flooded at all but the very lowest and highest community elevations (Table 4–5, Table 4–6, Table 4–7, and Table 4–8). The reduction in exceedence varies from 0% to 6%, in parallel with a reduction in days flooded of 0 to 207 days out of the entire 3,653-day period of record. Most wetland communities show some potential downslope movement, but this varies greatly among transects because of variation in slope and landscape position (Figure 4–13, Figure 4–15, Figure 4–17, Figure 4–19). Overall, there are very large losses in the length of transect occupied by shrub swamp and hardwood swamp, and moderate losses in shallow marsh and deep marsh. The dryer communities of transitional swamp, wet prairie, and upper wet prairies make gains in length along the transects. The greatest change in days of flooding occurs at about the 65% exceedence (Figure 4–14, Figure 4–16, Figure 4–18, Figure 4–20). No change in the upper wetland boundary is expected under the Full1995NN scenario. The lower wetland boundary may potentially shift down slope, resulting in an increase in overall wetland length at some transects.

Mulberry Mound Transect

Table 4–5. Change in community statistics between historical baseline and Full1995NN scenarios, Mulberry Mound transect (Lake Poinsett).

Community	Minimum Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)	Original Length	New Length	Change in Length	Change in length (%)
Shallow marsh	3.07	0.7671	280.2	0.7187	-0.05	262.5	17.7	6.3	212	162	-50	-23.6
Wet Prairie	3.64	0.4579	167.2	0.4157	-0.07	151.8	15.4	9.2	832	860	28	3.4
Upper wet prairie	4.11	0.2189	80.0	0.2096	-0.03	76.6	3.4	4.3	94	200	106	111.7
Maple swamp	4.07	0.2351	85.9	0.2217	-0.04	81.0	4.9	5.7	201	134	-67	-33.5
Hardwood swamp	3.96	0.2882	105.3	0.2701	-0.05	98.7	6.6	6.3	424	113	-311	-73.4
Transitional swamp	4.17	0.2017	73.7	0.1910	-0.04	69.8	3.9	5.3	210	515	305	144.8
Lower palm hydric hammock	4.50	0.1029	37.6	0.0969	-0.02	35.4	2.2	5.9	52	55	3	6.0
Palm hydric hammock	4.68	0.0402	14.7	0.0369	-0.01	13.5	1.2	8.2	177	186	9	5.3

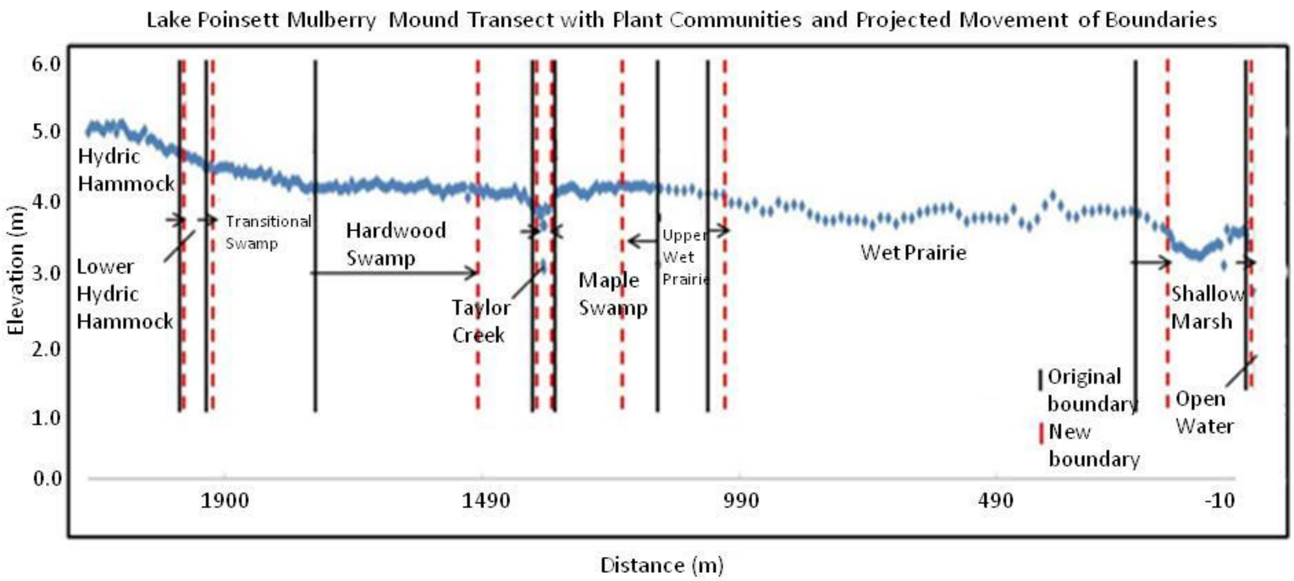

Figure 4–13. Potential movement of community boundaries from historical baseline scenario to Full1995NN scenario, Mulberry Mound transect (Lake Poinsett).

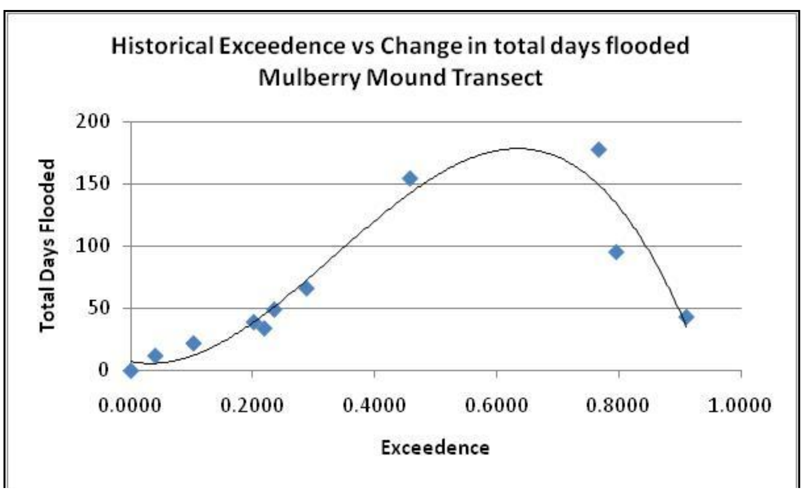

Figure 4–14. Change in days of flooding by exceedence from historical baseline scenario to Full1995NN scenario, Mulberry Mound transect (Lake Poinsett).

County Line Transect

Table 4–6. Change in community statistics between historical baseline and Full1995NN scenarios, County Line transect (Lake Poinsett).

Wetland Plant Community Type	Minimum Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation (m)	New Days Flooded	Reduction in Days Flooded	% Reduction in Flooding	Original Length (m)	New Length (m)	Change in Length (m)	Change in length (%)
Low flatwoods–palm hydric hammock	4.75	0.0307	112.0	0.0296	0.02	108.0	0.02	3.6	79	91	12	15.2
Transitional shrub	4.34	0.1502	548.8	0.1459	0.03	0.03	16.0	2.9	134	124	-10	-7.5
Upper wet prairie	4.12	0.2148	784.7	0.2044	0.04	0.04	38.0	4.8	110	114	4	3.6
Wet prairie	3.40	0.5878	2147.1	0.5441	0.09	1987.2	159.9	7.4	591	1040	449	76.0
Shallow marsh	3.27	0.6568	2399.0	0.6122	0.08	0.08	162.9	6.8	595	182	-413	-69.4
Deep marsh	2.84	0.8675	3168.7	0.8525	0.05	3113.7	55.0	1.7	167	NA	NA	0.0

NA = Surveyed elevation data not available

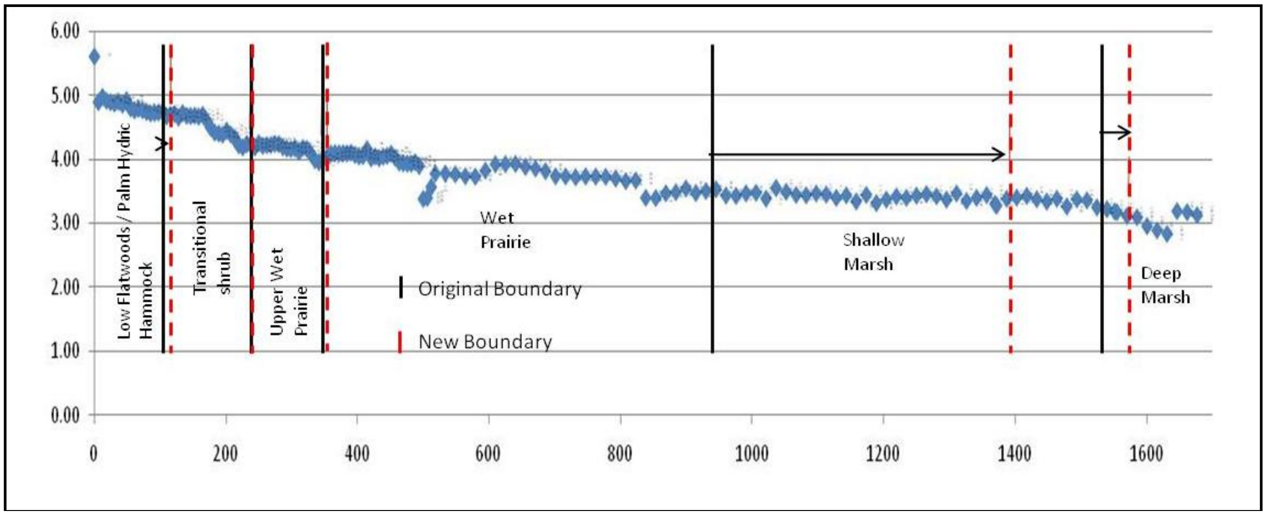

Figure 4–15. Potential movement of community boundaries from historical baseline scenario to Full1995NN scenario, County Line transect (Lake Poinsett).

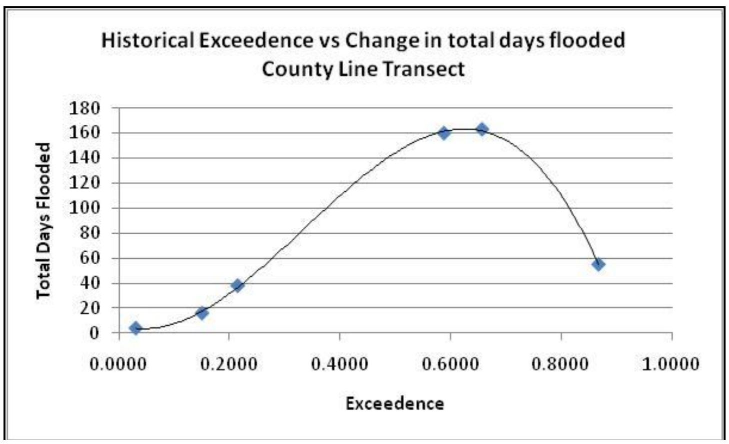

Figure 4–16. Change in days of flooding by exceedence from historical baseline scenario to Full1995NN scenario, County Line transect (Lake Poinsett).

Buzzard's Roost Transect

Table 4–7. Change in community statistics between historical baseline and Full1995NN scenarios, Buzzard's Roost transect (Lake Poinsett).

Community	Minimum Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation (m)	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)	Original Length (m)	New Length (m)	Change in Length (m)	Change in length (%)
Oak-palm hammock	5.11	0.0003	1.0	0.0003	0.00	1.0	0.0	0.0	73.0	73	0	0.0
Palm hydric hammock	4.48	0.1084	395.8	0.1018	0.02	371.8	24.0	6.1	176.8	177	0	0.2
Airboat–jeep trail	3.87	0.3358	1226.5	0.3038	0.07	1109.5	117.0	9.5	24.4	24	0	0.0
Shrub swamp #1	3.35	0.6119	2235.1	0.5673	0.09	2072.1	162.9	7.3	189.0	189	0	0.0
Shallow marsh-wet prairie	3.47	0.5484	2003.2	0.5066	0.21	1850.2	152.9	7.6	1481.3	1572	91	6.1
Shallow marsh	3.23	0.6768	2472.0	0.6357	0.09	2322.0	149.9	6.1	445.0	312	-133	-29.9
Wet prairie	3.38	0.5947	2172.1	0.5531	0.09	2020.2	151.9	7.0	121.9	304	182	149.3
Shrub swamp #2	3.29	0.6475	2365.0	0.5991	0.09	2188.1	176.9	7.5	143.3	25	-118	-82.5
Open water	2.99	0.8093	2955.8	0.7868	0.05	2873.8	82.0	2.8	57.9	37	-21	-36.1

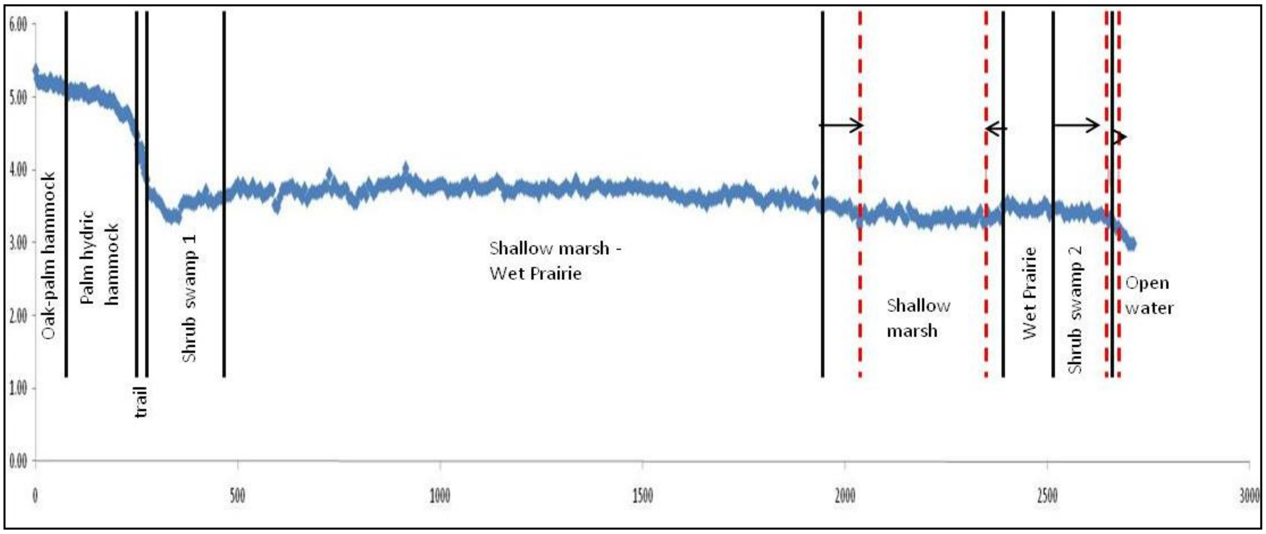

Figure 4–17. Potential movement of community boundaries from historical baseline scenario to Full1995NN scenario, Buzzard's Roost transect (Lake Poinsett).

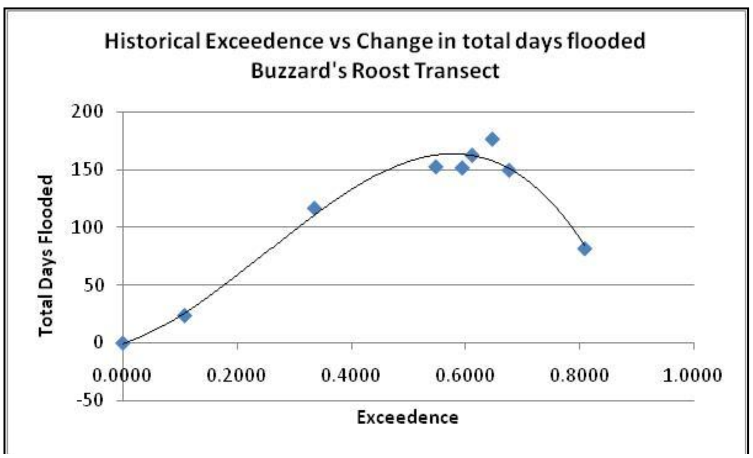

Figure 4–18. Change in days of flooding by exceedence from historical baseline scenario to Full1995NN scenario, Buzzard's Roost transect (Lake Poinsett).

I-95 Transect

Table 4–8. Change in community statistics between historical baseline and Full1995NN scenarios, I-95 transect (Lake Poinsett).

Wetland Plant Community Type	Minimum Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation (m)	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)	Original Length (m)	New Length (m)	Change in Length (m)	Change in length (%)
Sawgrass marsh #1	3.60	0.4789	1749.3	0.4381	0.08	1600.3	148.9	8.5	466	427	-39	-8.4
Spartina marsh #1	3.72	0.4094	1495.4	0.3842	0.08	1403.4	92.0	6.1	262	358	96	36.6
Sawgrass marsh #2	3.20	0.6921	2528.0	0.6533	0.09	2386.0	141.9	5.6	1058	1058	0	0.0
Sawgrass marsh #3	3.11	0.7501	2739.9	0.6935	0.08	2533.0	206.9	7.6	579	579	0	0.0
Transitional marsh	3.11	0.7501	2739.9	0.6935	0.08	2533.0	206.9	7.6	122	122	0	0.0
Spartina marsh #2	3.05	0.7797	2847.8	0.7373	0.05	2692.9	154.9	5.4	195	226	31	15.9
Deep marsh #1	2.96	0.8235	3007.8	0.8041	0.07	2936.8	71.0	2.4	128	97	-31	-24.2
Berm #1	3.14	0.7280	2658.9	0.6771	0.08	2473.0	185.9	7.0	6	6	0	0.0
Historical river channel	2.56	0.9795	3577.5	0.9789	0.00	3575.5	2.0	0.1	19	19	0	0.0
Berm #2	3.11	0.7501	2739.9	0.6935	0.08	2533.0	206.9	7.6	24	24	0	0.0
Deep marsh #2	2.65	0.9330	3407.6	0.9324	0.00	3405.6	2.0	0.1	262	262	0	0.0
Lakeshore berm	2.80	0.8738	3191.7	0.8626	0.03	3150.7	41.0	1.3	55	55	0	0.0
Scattered bulrush	2.59	0.9631	3517.6	0.9625	0.00	3515.6	2.0	0.1	12	12	0	0.0
Open water of Lake Poinsett	2.19	1.0000	3653.0	1.0000	0.00	3653.0	0.0	0.0	43	43	0	0.0

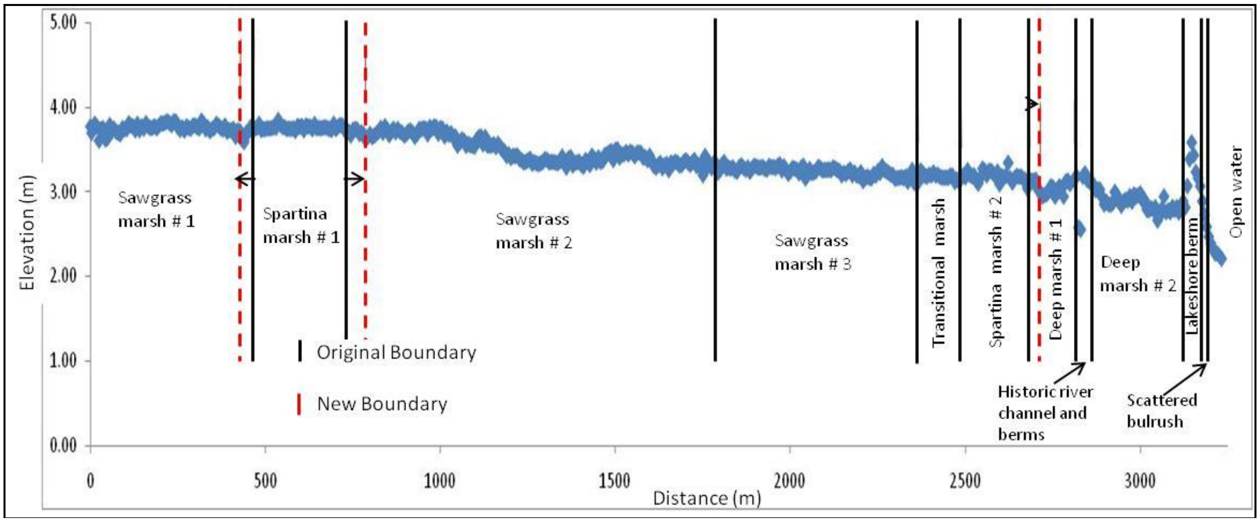

Figure 4–19. Potential movement of community boundaries from historical baseline scenario to Full1995NN scenario, I-95 transect (Lake Poinsett).

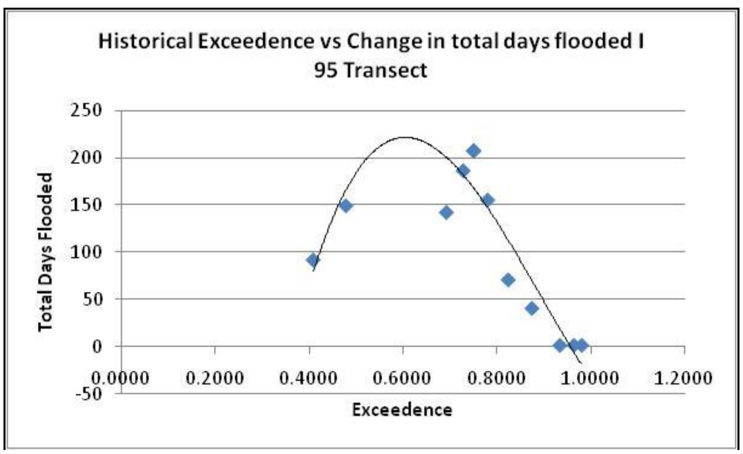

Figure 4–20. Change in days of flooding by exceedence from historical baseline scenario to Full1995NN scenario, I-95 transect (Lake Poinsett).

Full1995PN Scenario

Under the Full1995PN scenario, there is little change or only a slight gain in exceedence and in days flooded at the higher elevation community boundaries. In contrast, exceedences increase by up to 7% at lower elevation community boundaries (Table 4–9, Table 4–10, Table 4–11, and Table 4–12). Communities at midrange elevations show loss in exceedence of up to 4%, corresponding to a loss of up to 157 days of flooding (of 3,653 days in the period of record). The wetter (lower) wetland plant community types, such as deep marsh and shallow marsh, show the potential to move up slope, whereas higher communities, such as wet prairie and upper wet prairie, may move down slope. There are no changes in total wetland length under the Full1995PN scenario.

Table 4–9. Change in community statistics between historical baseline and Full1995PN scenarios, Mulberry Mound transect (Lake Poinsett).

Community	Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)	Original Length (m)	New Length (m)	Change in Length (m)	Change in length (%)
River channel	2.72	0.9108	3327.1	0.9576	0.19	3498.0	-171.0	-5.14	15	6	-9	-60.6
Shallow marsh	3.07	0.7671	2802.2	0.8191	0.06	2992.2	-189.9	-6.78	212	162	-55	-26.0
Wet prairie	3.64	0.4579	1672.5	0.4245	-0.08	1550.6	122.0	7.29	832	860	28	3.4
Upper wet prairie	4.11	0.2189	799.8	0.2061	-0.03	752.8	47.0	5.87	94	200	106	111.7
Maple swamp	4.07	0.2351	858.8	0.2214	-0.04	808.8	50.0	5.82	201	134	-67	-33.5
Taylor Creek	3.02	0.7958	2907.2	0.8591	0.10	3138.1	-230.9	-7.94	46	34	-12	-25.3
Hardwood swamp (without Taylor Creek.)	3.96	0.2882	1052.7	0.2690	-0.05	982.7	70.0	6.65	424	113	-311	-73.4
Transitional swamp	4.17	0.2017	736.8	0.1880	-0.05	686.8	50.0	6.78	210	515	305	144.8
Lower palm hydric hammock	4.50	0.1029	375.9	0.1015	-0.01	370.9	5.0	1.33	52	55	3	6.0
Palm hydric hammock	4.68	0.0402	147.0	0.0432	0.02	158.0	-11.0	-7.48	177	186	9	5.3

* A negative reduction in days flooded or % reduction in flooding is a gain in flooding duration.

Table 4–10. Change in community statistics between historical baseline and Full1995PN scenarios, County Line transect (Lake Poinsett)

Community	Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation (m)	New Days Flooded	Reduction in Days Flooded	% Reduction in Flooding	Original Length (m)	New Length (m)	Change in Length (m)	% Change in length
Low flatwoods–palm hydric hammock	4.75	0.0307	112.0	0.0369	0.03	135.0	-23.0	-20.6	79	73	-6	-7.9
Transitional shrub	4.34	0.1502	548.8	0.1412	-0.03	515.9	32.9	6.0	134	142	8	5.9
Upper wet prairie	4.12	0.2148	784.7	0.2011	-0.04	734.8	49.9	6.4	110	115	5	4.8
Wet prairie	3.40	0.5878	2147.1	0.5512	-0.04	2013.4	133.7	6.2	591	827	236	39.9
Shallow marsh	3.27	0.6568	2399.0	0.6585	0.00	2405.3	-6.3	-0.3	594	321	-273	-46.0
Deep marsh	2.84	0.8675	3168.7	0.9297	0.16	3396.1	-227.4	-7.2	168	198	31	18.3

Table 4–11. Change in community statistics between historical baseline and Full1995PN scenarios, Buzzard's Roost transect (Lake Poinsett).

Community	Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation (m)	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)	Original Length (m)	New Length (m)	Change in Length (m)	Change in length (%)
Oak-palm hammock	5.1206	0.0003	1.0	0.0014	0.01	5.0	4.0	400.1	73	66	-8	-10.5
Palm hydric hammock	4.4806	0.1084	395.8	0.1067	-0.01	389.9	-5.9	-1.5	177	185	8	4.8
Airboat–jeep trail	3.8710	0.3358	1226.5	0.3117	-0.05	1138.7	-87.8	-7.2	24	24	-1	-3.2
Shrub swamp #1	3.3528	0.6119	2235.1	0.5947	-0.03	2172.4	-62.7	-2.8	189	61	-128	-67.7
Shallow marsh-wet prairie	3.4747	0.5484	2003.2	0.5055	-0.07	1846.5	-156.7	-7.8	1481	1691	210	14.2
Shallow marsh	3.2309	0.6768	2472.0	0.6823	0.01	2492.3	20.3	0.8	445	339	-106	-23.8
Wet prairie	3.3833	0.5947	2172.1	0.5662	-0.03	2068.4	-103.7	-4.8	122	250	128	105.1
Shrub swamp #2	3.2918	0.6475	2365.0	0.6426	-0.01	2347.4	-17.7	-0.7	143	40	-104	-72.4
Open water	2.9870	0.8093	2955.8	0.8766	0.10	3202.1	246.3	8.3	58	58	0	0.0

Table 4–12. Change in community statistics between historical baseline and Full1995PN scenarios, I-95 transect (Lake Poinsett).

Wetland Plant Community Type	Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)	Original Length (m)	New Length (m)	Change in Length (m)	Change in length (%)
Sawgrass marsh #1	3.60	0.4789	1749.3	0.4412	-0.07	1611.6	137.7	7.9	466	432	-34	-7.3
Spartina marsh #1	3.72	0.4094	1495.4	0.3834	-0.05	1400.6	94.8	6.3	262	379	117	44.7
Sawgrass marsh #2	3.20	0.6921	2528.0	0.7020	0.01	2564.3	-36.3	-1.4	1058	975	-83	-7.8
Sawgrass marsh #3	3.11	0.7501	2739.9	0.8013	0.04	2927.2	-187.3	-6.8	579	579	0	0.0
Transitional marsh	3.11	0.7501	2739.9	0.8013	0.04	2927.2	-187.3	-6.8	122	122	0	0.0
Spartina marsh #2	3.05	0.7797	2847.8	0.8339	0.08	3046.2	-198.3	-7.0	195	226	31	15.9
Deep marsh #1	2.96	0.8235	3007.8	0.8894	0.11	3249.1	-241.3	-8.0	128	97	-31	-24.2
Berm #1	3.14	0.7280	2658.9	0.7663	0.03	2799.2	-140.3	-5.3	6	6	0	0.0
Historical river channel	2.56	0.9795	3577.5	NA	0.05	NA	NA	NA	19	19	0	0.0
Berm #2	3.11	0.7501	2739.9	0.8013	0.04	2927.2	-187.3	-6.8	24	24	0	0.0
Deep marsh #2	2.65	0.9330	3407.6	0.9735	0.17	3556.0	-148.4	-4.4	262	262	0	0.0
Lakeshore berm	2.80	0.8738	3191.7	0.9360	0.19	3419.1	-227.4	-7.1	55	55	0	0.0
Scattered bulrush	2.59	0.9631	3517.6	NA	0.10	NA	NA	NA	12	8	-4	-33.3
Open water of Lake Poinsett	2.19	NA	NA	NA	NA	NA	NA	NA	43	47	4	9.3

NA = Surveyed elevation data not available

Half1995PN Scenario

Under the Half1995PN scenario, there is little change or only a slight gain in exceedence and in days flooded at the higher elevation community boundaries. In contrast, exceedences increase by up to 8% for lower elevation communities (Table 4-13, Table 4-14, Table 4-15 and Table 4-16). Communities at midrange elevations show loss in exceedence of up to 2%, corresponding to a loss of up to 89 days of flooding (of 3,653 days in the period of record). The wetter (lower) wetland plant community types, such as deep marsh and shallow marsh, show the potential to move up slope, whereas higher communities, such as wet prairie and upper wet prairie, may move slightly down slope. There are no changes in total wetland length under the Half1995PN scenario.

Table 4–13. Change in community statistics between historical baseline and Half1995PN scenarios, Mulberry Mound transect (Lake Poinsett).

Community	Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation (m)	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)
River channel	2.72	0.9108	3327.1	0.9633	0.20	3519.0	-191.9	-5.8
Shallow marsh	3.07	0.7671	2802.2	0.8339	0.09	3046.2	-243.9	-8.7
Wet prairie	3.64	0.4579	1672.5	0.4392	-0.04	1604.6	68.0	4.1
Upper wet prairie	4.11	0.2189	799.8	0.2137	-0.01	780.8	19.0	2.4
Maple swamp	4.07	0.2351	858.8	0.2291	-0.02	836.8	22.0	2.6
Taylor Creek	3.02	0.7958	2907.2	0.8654	0.12	3161.1	-253.9	-8.7
Hardwood swamp (without Taylor Creek)	3.96	0.2882	1052.7	0.2783	-0.02	1016.7	36.0	3.4
Transitional swamp	4.17	0.2017	736.8	0.1918	-0.03	700.8	36.0	4.9
Lower palm hydric hammock	4.50	0.1029	375.9	0.1056	0.00	385.9	-10.0	-2.7
Palm hydric hammock	4.68	0.0402	147.0	0.0438	0.02	160.0	-13.0	-8.8
Palm hydric hammock (max)	5.11	0.0003	1.0	0.0049	#NA	18.0	-17.0	-1700.0

NA = Surveyed elevation data not available

Table 4–14. Change in community statistics between historical baseline and Half1995PN scenarios, County Line transect (Lake Poinsett).

Community	Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation (m)	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)
Low flatwoods–palm hydric hammock	4.75	0.0307	112.0	0.0378	0.04	138.0	-26.0	-23.2
Transitional shrub	4.34	0.1502	548.8	0.1448	-0.02	528.9	20.0	3.6
Upper wet prairie	4.12	0.2148	784.8	0.2074	-0.03	757.8	27.0	3.4
Wet prairie	3.40	0.5878	2147.4	0.5747	-0.02	2099.4	48.0	2.2
Shallow marsh	3.27	0.6568	2399.3	0.6779	0.03	2476.3	-77.0	-3.2
Deep marsh	2.84	0.8675	3169.1	0.9431	0.17	3445.1	-275.9	-8.7

Table 4–15. Change in community statistics between historical baseline and Half1995PN scenarios, Buzzard's Roost transect (Lake Poinsett).

Community	Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)
Oak–palm hammock	5.12	0.0003	1.0	0.0027	NA	10.0	-9.0	-900.0
Palm hydric hammock	4.48	0.1084	395.9	0.1084	0.00	395.9	0.0	0.0
Airboat–jeep trail	3.87	0.3358	1226.7	0.3227	-0.03	1178.7	48.0	3.9
Shrub swamp #1	3.35	0.6119	2235.4	0.6160	0.00	2250.4	-15.0	-0.7
Shallow marsh–wet prairie	3.47	0.5484	2003.5	0.5241	-0.05	1914.5	89.0	4.4
Shallow marsh	3.23	0.6768	2472.3	0.6981	0.04	2550.3	-78.0	-3.2
Wet prairie	3.38	0.5947	2172.4	0.5865	-0.01	2142.4	30.0	1.4
Shrub swamp #2	3.29	0.6475	2365.4	0.6601	0.02	2411.3	-46.0	-1.9
Open water	2.99	0.8093	2956.2	0.8812	0.12	3219.1	-262.9	-8.9

Table 4–16. Change in community statistics between historical baseline and Half1995PN scenarios, I-95 transect (Lake Poinsett).

Community	Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)
Sawgrass marsh #1	3.60	0.4789	1749.5	0.4565	-0.04	1667.5	82.0	4.7
Spartina marsh #1	3.72	0.4094	1495.6	0.4001	-0.02	1461.6	34.0	2.3
Sawgrass marsh #2	3.20	0.6921	2528.3	0.7211	0.04	2634.3	-106.0	-4.2
Sawgrass marsh #3	3.11	0.7501	2740.2	0.8106	0.07	2961.2	-220.9	-8.1
Transitional marsh	3.11	0.7501	2740.2	0.8106	0.07	2961.2	-220.9	-8.1
Spartina marsh #2	3.05	0.7797	2848.2	0.8478	0.11	3097.2	-248.9	-8.7
Deep marsh #1	2.96	0.8235	3008.2	0.8935	0.13	3264.1	-255.9	-8.5
Berm #1	3.14	0.7280	2659.3	0.7950	0.05	2904.2	-244.9	-9.2
Historical river channel	2.56	0.9795	3578.0	NA	0.05	NA	NA	NA
Berm #2	3.11	0.7501	2740.2	0.8106	0.07	2961.2	-220.9	-8.1
Deep marsh #2	2.65	0.9330	3408.1	0.9732	0.20	3555.0	-147.0	-4.3
Lakeshore berm	2.80	0.8738	3192.1	0.9475	0.20	3461.1	-268.9	-8.4
Scattered bulrush	2.59	0.9631	3518.0	NA	0.12	NA	NA	NA
Open water of Lake Poinsett	2.19	NA	NA	NA	NA	NA	NA	NA

NA = Surveyed elevation data not available

Full2030PN Scenario

Under the Full2030PN scenario, there is a slight gain in exceedence and in days flooded at the higher elevation community boundaries. In contrast, exceedences increase by up to 9% at lower, (Table 4-17, Table 4-18, Table 4–19, and Table 4–20). Communities at midrange elevations show losses in exceedence of up to 2%, corresponding to a loss of up to 65 days of flooding (of 3,653 days in the period of record). The wetter (lower) wetland plant community types, such as deep marsh and shallow marsh show the potential to move up slope, whereas higher communities, such as wet prairie and upper wet prairie, may move slightly down slope. There are no changes in total wetland length under the Full2030PN scenario.

Table 4–17. Change in community statistics between historical baseline and Full2030PN scenarios, Mulberry Mound transect (Lake Poinsett).

Community	Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation (m)	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)
River channel	2.72	0.9108	3327.1	0.9718	0.25	3550.0	-222.9	-6.7
Shallow marsh	3.07	0.7671	2802.2	0.8508	0.10	3108.1	-305.9	-10.9
Wet prairie	3.64	0.4579	1672.5	0.4423	-0.04	1615.6	57.0	3.4
Upper wet prairie	4.11	0.2189	799.8	0.2230	0.01	814.8	-15.0	-1.9
Maple swamp	4.07	0.2351	858.8	0.2373	0.00	866.8	-8.0	-0.9
Taylor creek	3.02	0.7958	2907.2	0.8864	0.12	3238.1	-330.9	-11.4
Hardwood swamp (w/o T.C.)	3.96	0.2882	1052.7	0.2865	-0.01	1046.7	6.0	0.6
Transitional swamp	4.17	0.2017	736.8	0.1995	-0.01	728.8	8.0	1.1
Lower palm hydric hammock	4.50	0.1029	375.9	0.1084	0.01	395.9	-20.0	-5.3
Palm hydric hammock	4.68	0.0402	147.0	0.0476	0.04	174.0	-27.0	-18.4
Palm hydric hammock (max)	5.11	0.0003	1.0	0.0071	NA	26.0	-25.0	-2500.0

NA = surveyed elevation data not available

Table 4–18. Change in community statistics between historical baseline and Full2030PN scenarios, County Line transect (Lake Poinsett).

Community	Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation (m)	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)
Low flatwoods–palm hydric hammock	4.75	0.0307	112.0	0.0389	0.06	142.0	-30.0	-26.8
Transitional shrub	4.34	0.1502	548.8	0.1516	0.00	553.8	-5.0	-0.9
Upper wet prairie	4.12	0.2148	784.8	0.2135	-0.01	779.8	5.0	0.6
Wet prairie	3.40	0.5878	2147.4	0.6002	0.01	2192.4	-45.0	-2.1
Shallow marsh	3.27	0.6568	2399.3	0.6946	0.05	2537.3	-138.0	-5.8
Deep marsh	2.84	0.8675	3169.1	0.9548	0.21	3488.0	-318.9	-10.1

Table 4–19. Change in community statistics between historical baseline and Full2030PN scenarios, Buzzard’s Roost transect (Lake Poinsett).

Community	Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation	New Days Flooded	Reduction in Days Flooded	% Reduction in Flooding
Oak-palm hammock	5.12	0.0003	1.0	0.0060	#NA	22.0	-21.0	-2100.0
Palm hydric hammock	4.48	0.1084	395.9	0.1111	0.02	405.9	-10.0	-2.5
Airboat–jeep trail	3.87	0.3358	1226.7	0.3377	0.00	1233.7	-7.0	-0.6
Shrub swamp #1	3.35	0.6119	2235.4	0.6360	0.03	2323.4	-88.0	-3.9
Shallow marsh-wet prairie	3.47	0.5484	2003.5	0.5361	-0.02	1958.5	45.0	2.2
Shallow marsh	3.23	0.6768	2472.3	0.7157	0.06	2614.3	-142.0	-5.7
Wet prairie	3.38	0.5947	2172.4	0.6152	0.02	2247.4	-75.0	-3.5
Shrub swamp #2	3.29	0.6475	2365.4	0.6784	0.05	2478.3	-113.0	-4.8
Open water	2.99	0.8093	2956.2	0.9023	0.13	3296.1	-339.9	-11.5

Table 4–20. Change in community statistics between historical baseline and Full2030PN scenarios, I-95 transect (Lake Poinsett).

Community	Elevation (m)	Historical Exceedence	Original Days Flooded	Historical minus Delta Exceedence	Change in Elevation	New Days Flooded	Reduction in Days Flooded	Reduction in Flooding (%)
Sawgrass marsh #1	3.60	0.4789	1749.5	0.4611	-0.03	1684.5	65.0	3.7
Spartina marsh #1	3.72	0.4094	1495.6	0.4067	-0.01	1485.6	10.0	0.7
Sawgrass marsh #2	3.20	0.6921	2528.3	0.7510	0.07	2743.2	-214.9	-8.5
Sawgrass marsh #3	3.11	0.7501	2740.2	0.8175	0.09	2986.2	-245.9	-9.0
Transitional marsh	3.11	0.7501	2740.2	0.8175	0.09	2986.2	-245.9	-9.0
Spartina marsh #2	3.05	0.7797	2848.2	0.8703	0.12	3179.1	-330.9	-11.6
Deep marsh #1	2.96	0.8235	3008.2	0.9149	0.14	3342.1	-333.9	-11.1
Berm #1	3.14	0.7280	2659.3	0.7978	0.08	2914.2	-254.9	-9.6
Historical river channel	2.56	0.9795	3578.0	NA	0.13	NA	NA	NA
Berm #2	3.11	0.7501	2740.2	0.8175	0.09	2986.2	-245.9	-9.0
Deep marsh #2	2.65	0.9330	3408.1	NA	0.26	NA	NA	NA
Lakeshore berm	2.80	0.8738	3192.1	0.9617	0.23	3513.0	-320.9	-10.1
Scattered bulrush	2.59	0.9631	3518.0	NA	0.20	NA	NA	NA
Open water of Lake Poinsett	2.19	NA	NA	NA	NA	NA	NA	NA

NA = Surveyed elevation data not available

4.2.5 Comparison of Scenarios by Transect

All transects showed similar responses to modeled water withdrawal scenarios (Figure 4–21, Figure 4–22, Figure 4–23,Figure 4–24). Change in elevation corresponds to the loss of flooding depth at the minimum community boundary. Under the Full1995NN scenario, there was some loss in flooding depth for all communities. These losses were greatest for shallow marsh, wet prairie, and deep marsh communities. Under the Full1995PN scenario, there were increases in flooding for deep marsh and many shallow marsh communities, as well as in wetland communities at the highest elevations. Mid-elevation communities still showed some degree of decline in flooding. The Half1995PN scenario showed a similar pattern, but with lesser declines and greater additions in flooding. In the Full2030PN scenario, virtually all declines disappear or are greatly reduced, and gains in flooding at both lower and higher elevations increase.

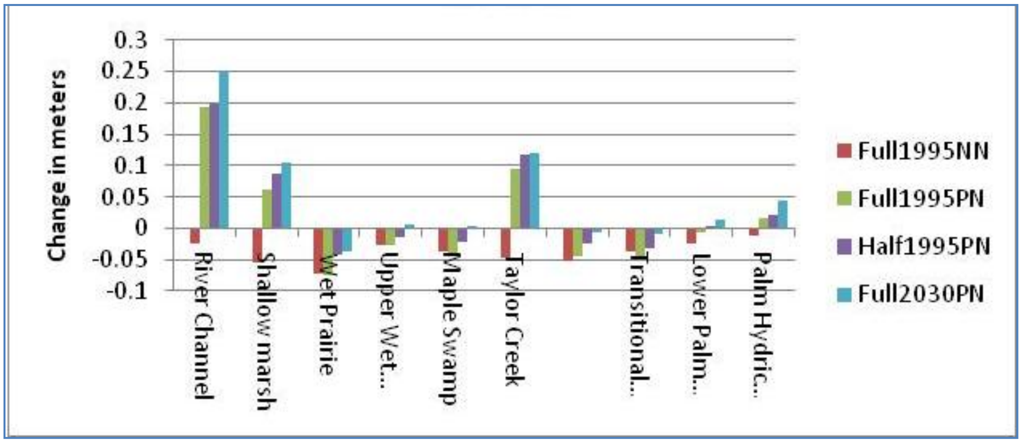

Figure 4–21. Potential reduction in minimum boundary elevations by community, Mulberry Mound transect (Lake Poinsett).

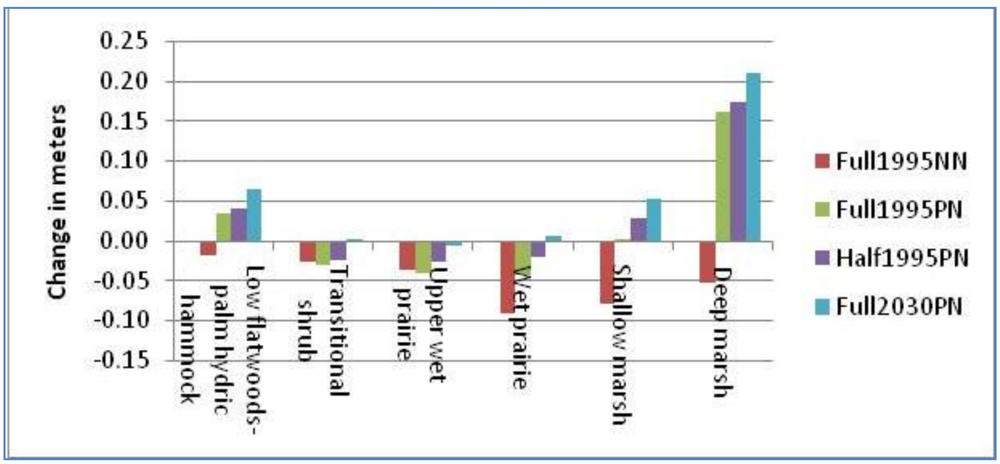

Figure 4–22. Potential reduction in minimum boundary elevations by community, County Line transect (Lake Poinsett).

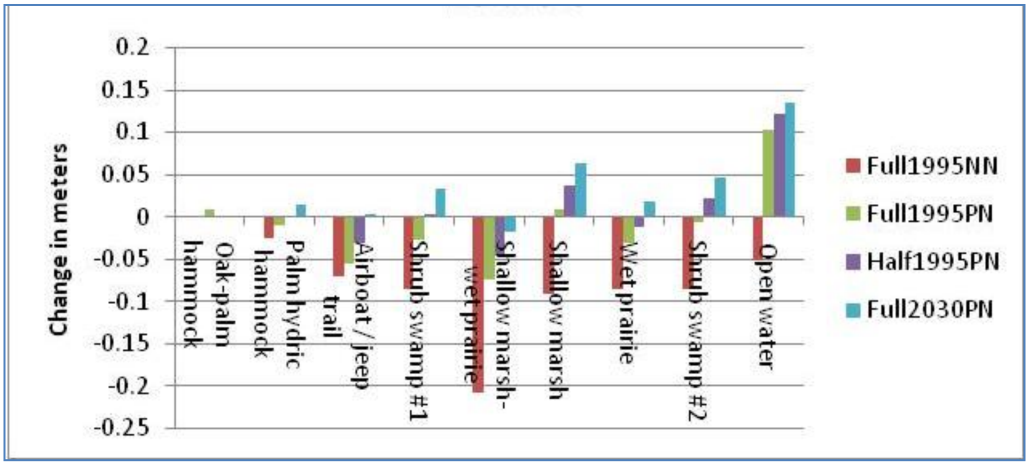

Figure 4–23. Potential reduction in minimum boundary elevations by community, Buzzard's Roost transect (Lake Poinsett).

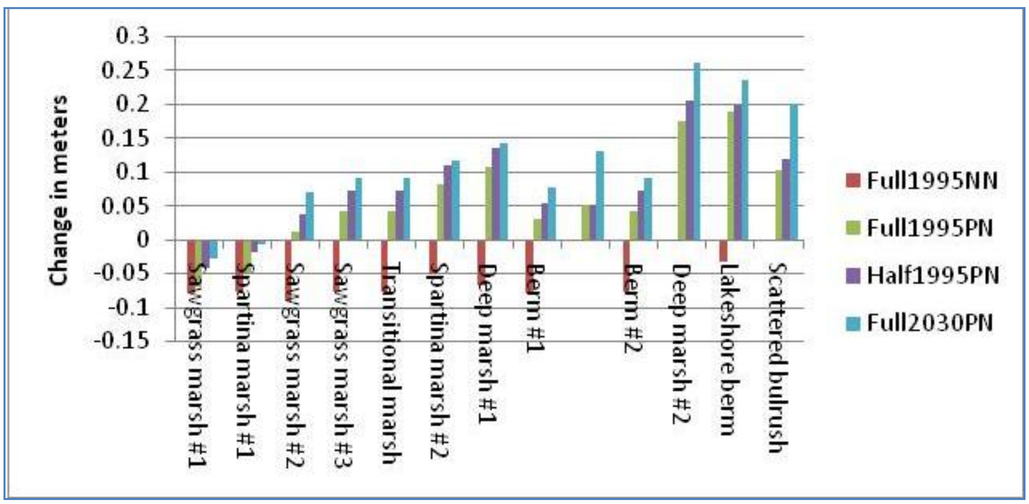

Figure 4–24. Potential reduction in minimum boundary elevations by community, I-95 transect (Lake Poinsett).

4.3 Areal Effects Analysis Results

4.3.1 Inundation and Exceedence Results

Analysis of areal effects with the hydroperiod tool showed a range of results for different scenarios. Potential effects are greatest under the Full1995NN scenario, but are progressively less for the Full1995PN and Half1995PN scenarios, and largely disappear in the Full2030PN scenario. The percent of the total study area (18,256 ha) negatively affected is 27.5% for Full1995NN, 10.04% for Full1995PN, 20.61% for Half1995PN, and 3.82% for Full2030PN. There is also variation in the change in water depth between scenarios. Average depth changes range up to 4 cm for the Full1995NN scenario (Figure 4–25) but fall below 2 cm for the Full2030PN scenario (Figure 4–31). The dominant wetland category affected in all scenarios is freshwater marshes, although there is some effect to most communities (Table 4–21).

Table 4–21. Areal extent of dewatering of wetland plant community types for each of four scenarios.

LCLU code	Wetland Plant Community Type	Total Area (ha)	Full1995NN	Full1995PN	Half1995PN	Full2020PN
6170	Mixed wetland hardwoods	1500.9	25.4	38.1	25.3	11.2
6181	Cabbage palm hammock	798.2	12.5	24.7	18	8.8
6210	Cypress	321.73	63.7	63.2	31.8	13.4
6250	Hydric pine flatwoods	41.36	0	0.2	0.2	0.1
6300	Wetlands forested mixed	336.51	3.3	3	1.4	0.2
6410	Freshwater marshes	5794.76	2713.2	2134.2	1006.6	371.8
6430	Wet prairies	3103.27	767	519	264.3	99.3
6440	Emergent aquatic vegetation	205.61	105.9	88.1	39.9	15.1
6460	Mixed scrub-shrub wetland	3243.16	1063	559.8	237.1	82.4
9999	Restoration areas	2596.3	180.3	288.1	184.1	85.8
	Water	92.67	0	0	0	0
	Other (uplands)	221.9	0	0	0	0
	*Total (ha.)	18256.3	4934.3	3718.4	1808.7	668.1
	*Total wetlands (ha)	17,941.7				
	Total wetlands affected (%)		28%	21%	10%	4%

LCLU = SJRWMD Land Cover and Land Use layer (SJRWMD 2011)
* = Small differences in the totals relative to the following tables are the result of a minor variation in the analytical methods

Full1995NN Scenario

Under the Full1995NN scenario, a total of 5,014 ha of wetlands experience some degree of dewatering (Figure 4–25, Figure 4–26; Table 4–22). The greatest effects fall between the 30% and 70% exceedences, with a peak at 50%, but there is some measurable effect at all exceedences. By far the largest areas affected are in the freshwater marshes wetlands plant community type in the SJRWMD 2004 Land Use and Land Cover (SJRWMD 2011) data layer, with substantial area classified as wet prairie and mixed scrub-shrub wetland also being effected (Table 4–21). Forested wetland types account for little of the change. The affected wetlands are located around and adjacent to Lakes Poinsett and Winder. Much less change is seen toward the Lake Washington weir. The change in ponded depth for selected exceedences is greatest under the Full1995NN scenario, ranging from 1 to 9 cm. The hectare-days (a composite measure expressing the product of area of impact and duration in days of impact) of impact is also greatest under the full1995NN scenario.

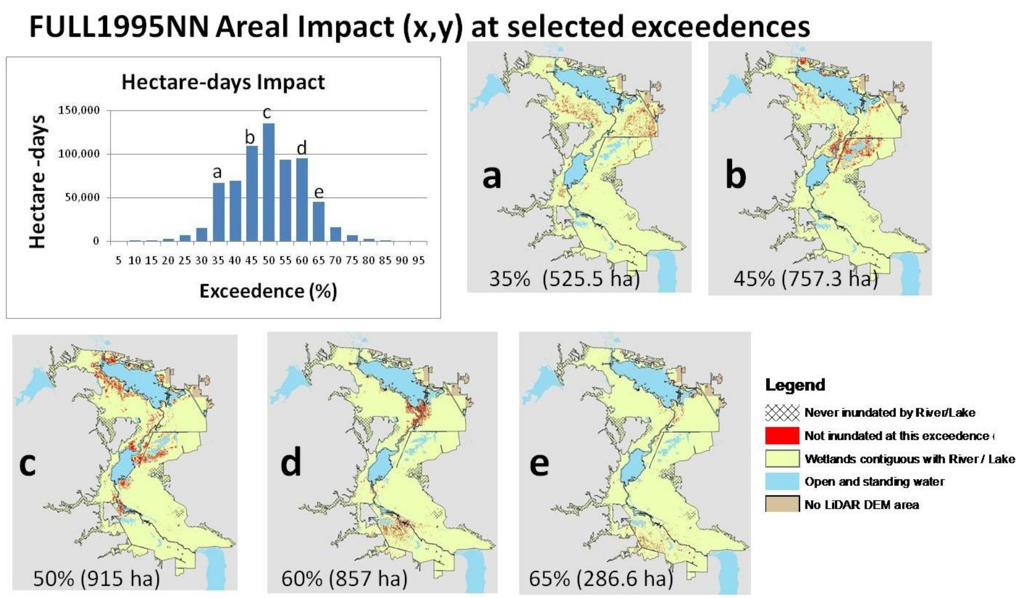

Figure 4–25. Areas dewatered and hectare-days of effect at selected exceedences for the Full1995NN scenario.

Table 4–22. Wetland area of segment 8 affected under the Full1995NN scenario.

Full1995NN Exceedence (%)	Area Impacted (ha)	Reduction in Days Inundated (maximum over 10 yrs)	Area Impacted (percent of total area)	Maximum Hectare-days Impact (over 10 yrs)
5	18.7	11	0.10	206
10	30.9	23	0.17	712
15	37.5	13	0.21	487
20	73.5	32	0.40	2,353
25	128.9	53	0.71	6,830
30	224.3	68	1.23	15,254
35	525.4	127	2.88	66,732
40	666.1	104	3.65	69,273
45	753.6	145	4.13	109,266
50	914.9	148	5.01	135,410
55	600.3	156	3.29	93,653
60	587.0	162	3.22	95,095
65	286.6	157	1.57	44,989
70	107.1	150	0.59	16,066
75	32.9	204	0.18	6,720
80	14.9	151	0.08	2,243

Full1995NN Exceedence (%)	Area Impacted (ha)	Reduction in Days Inundated (maximum over 10 yrs)	Area Impacted (percent of total area)	Maximum Hectare-days Impact (over 10 yrs)
85	6.4	177	0.03	1,125
90	4.3	77	0.02	333
95	1.1	36	0.01	41
Total	5014.5	NA	27.47	NA

NA = Not applicable

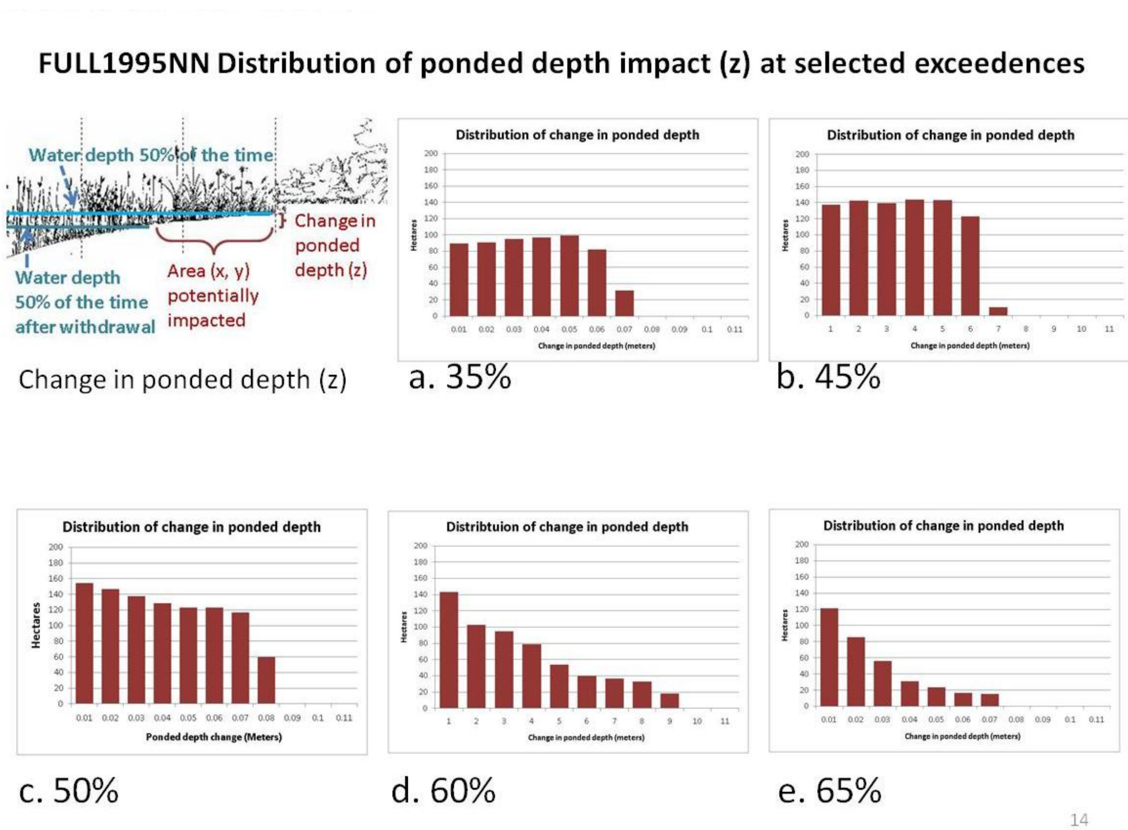

Figure 4–26. Distribution of reduction in ponded depth at selected exceedences under the Full1995NN scenario.

Full1995PN Scenario

In the Full1995PN scenario, potential effects are restricted to the 5 to 60% exceedence range (Figure 4–27 and Figure 4–28, Table 4–23). The greatest effects are at the 45% and 50% exceedences and affect 4.08% and 4.07% of the total wetland area respectively. The total area affected at all exceedence values is 3,763.9 ha, approximately 21% of the total 18,256 ha area. Comparison of hectare-days of effect (Table 4–22 and Table 4–23) indicates that the effect under the Full1995PN scenario is not as great as under the Full1995NN scenario, suggesting that the addition of the USJRB projects reduces the effect of the withdrawals, especially at the lower water elevations and greater exceedences (65% to 95%). Areas around Lakes Poinsett and Winder experience the greatest effects (Figure 4–27). Change in ponded depth (Figure 4–28) is comparable to the Full1995NN scenario, 1 to 8 cm, although the total area affected in hectares (y axes) is less.

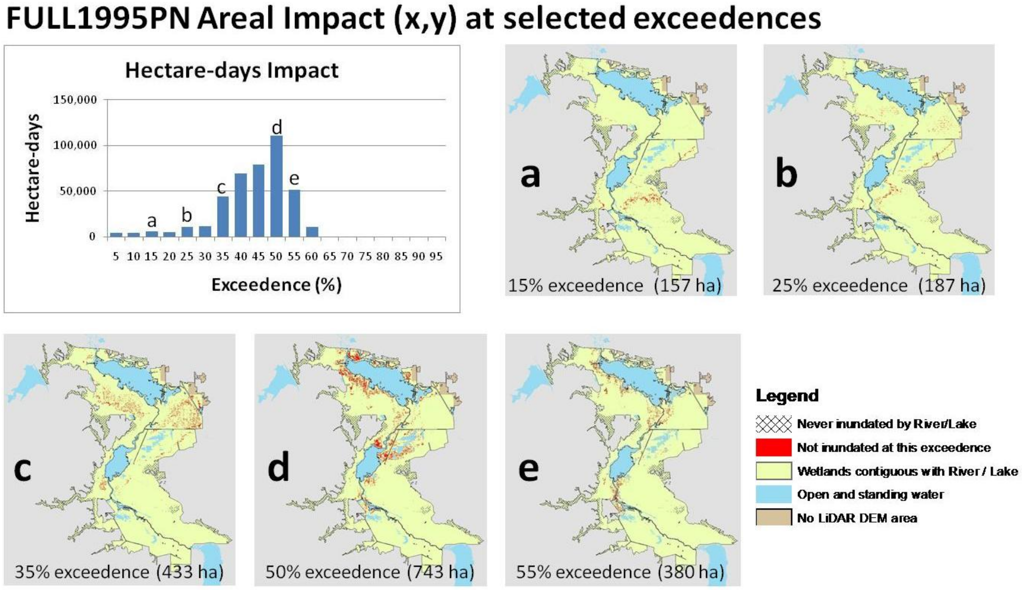

Figure 4–27. Areas dewatered and hectare-days of effect at selected exceedences for the Full1995PN scenario.

Table 4–23. Wetland area of segment 8 affected under the Full1995PN scenario.

FULL1995PN Exceedence (%)	Area Impacted (ha)	Reduction in Days Inundated (maximum over 10 yrs)	Area Impacted (percent of total area)	Maximum Hectare-days Impact (over 10 yrs)
5	60.8	62	0.33	3,768
10	60.1	65	0.33	3,905
15	157.1	35	0.86	5,499
20	104.3	50	0.57	5,213
25	187.1	57	1.02	10,663
30	164.2	71	0.90	11,657
35	433.4	102	2.37	44,206
40	622.0	111	3.41	69,045
45	743.9	106	4.08	78,857
50	743.2	149	4.07	110,734
55	379.3	135	2.08	51,207
60	108.6	98	0.59	10,642
65	0	0	0	0
70	0	0	0	0
75	0	0	0	0
80	0	0	0	0

FULL1995PN Exceedence (%)	Area Impacted (ha)	Reduction in Days Inundated (maximum over 10 yrs)	Area Impacted (percent of total area)	Maximum Hectare-days Impact (over 10 yrs)
85	0	0	0	0
90	0	0	0	0
95	0	0	0	0
Total	3763.9	NA	20.62	NA

NA = Not applicable

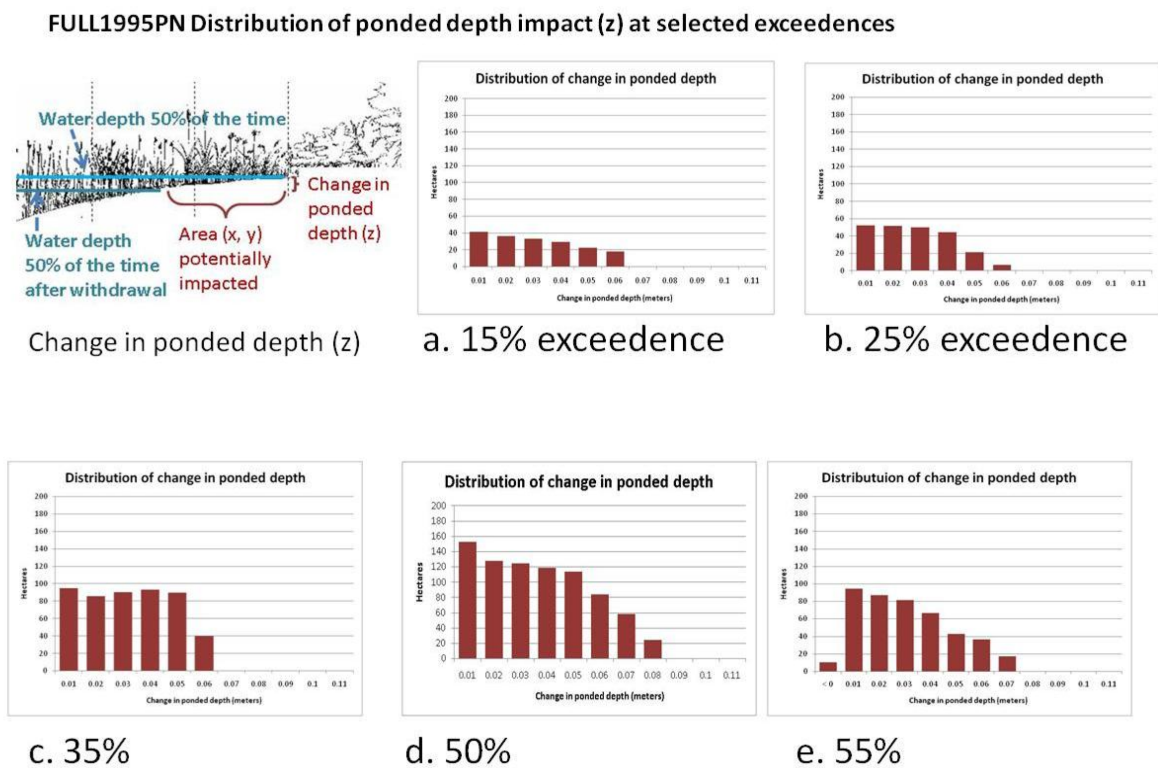

Figure 4–28. Distribution of reduction of ponded depth at selected exceedences under the Full1995PN scenario.

Half1995PN Scenario

In the Half1995PN scenario, potential effects occur in the 5% to 60% exceedence range (Figure 4–29, Figure 4–30; and Table 4–24) in a pattern similar to the Full1995PN scenario. The greatest effects are at the 45% and 50% exceedences and effect 1.9% and 2.06% of the total wetland area, respectively. The total area affected at all exceedence values is 1,831.7 hectares, approximately 10% of the total 18,256 ha study area. Comparison of hectare-days of effect (Table 4–23 and Table 4–24) indicates that the effect under the Half1995PN scenario is far less than half of that under the Full1995PN scenario. Areas around Lake Poinsett experience the greatest effects (Figure 4–29). Change in ponded depth (Figure 4–30) is considerably less than for the Full1995PN scenario, ranging from 1 to 6 cm, with most changes between 1 and 3 cm in depth.

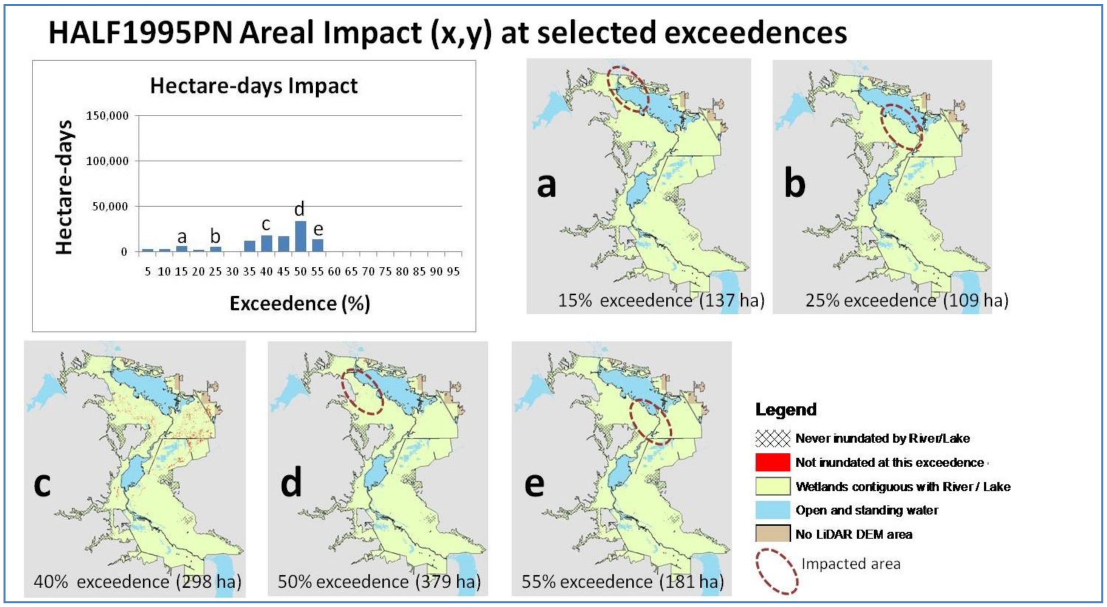

Figure 4–29. Areas dewatered and hectare-days of effect at selected exceedences for the Half1995PN scenario.

Table 4–24. Wetland area of segment 8 affected under the Half1995PN scenario.

HALF1995PN Exceedence (%)	Area Impacted (ha)	Reduction in days Inundated (maximum over 10 yrs)	Area Impacted (percent of total area)	Maximum Hectare-days Impact (over 10 yrs)
5	42.1	64	0.23	2,697
10	45.0	66	0.25	2,967
15	137.4	47	0.75	6,456
20	55.8	33	0.31	1,843
25	109.0	51	0.60	5,559
30	32.7	19	0.18	621
35	192.8	62	1.06	11,954
40	298.1	61	1.63	18,182
45	347.0	50	1.90	17,348
50	377.0	89	2.06	33,550
55	180.6	77	0.99	13,903
60	14.4	28	0.08	402
65	0	0	0	0
70	0	0	0	0
75	0	0	0	0
80	0	0	0	0
85	0	0	0	0
90	0	0	0	0

HALF1995PN Exceedence (%)	Area Impacted (ha)	Reduction in days Inundated (maximum over 10 yrs)	Area Impacted (percent of total area)	Maximum Hectare-days Impact (over 10 yrs)
95	0	0	0	0
Total	1831.7	NA	10.03	NA

NA = Not applicable

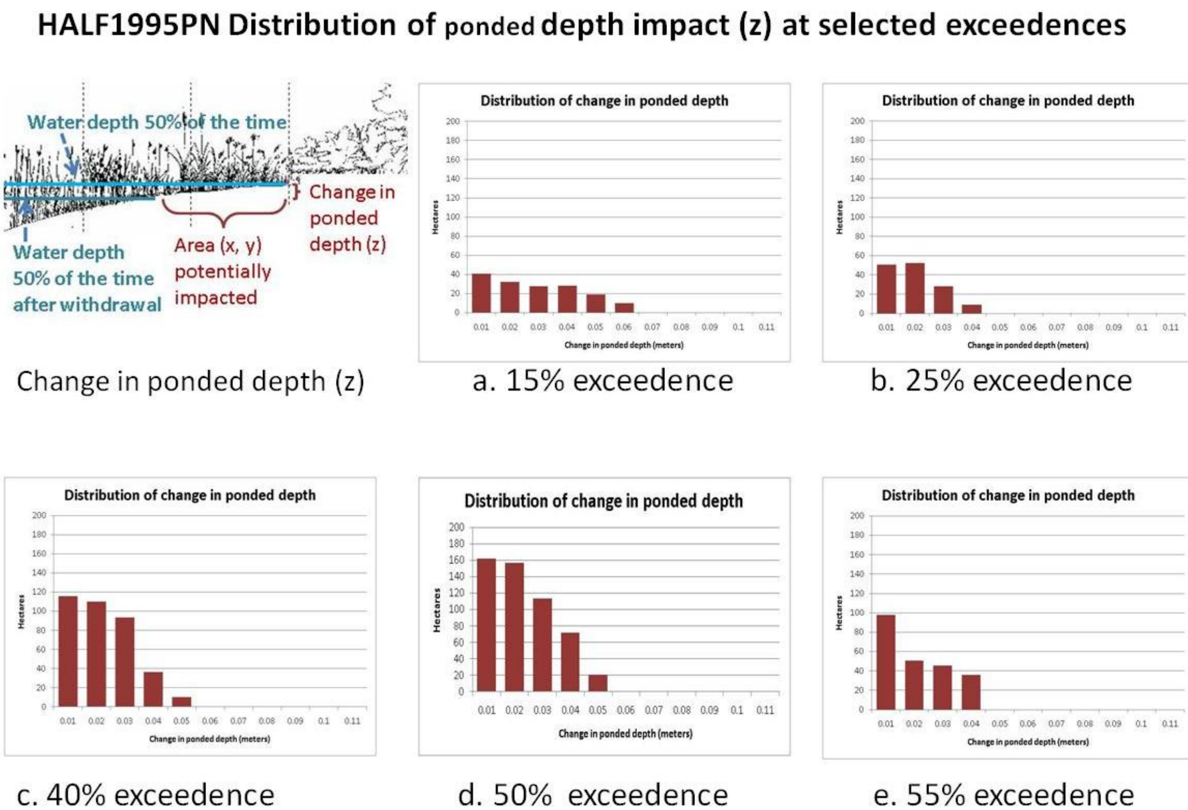

Figure 4–30. Distribution of reduction of ponded depth at selected exceedences under the Half1995PN scenario.

Full2030PN Scenario

In the Full2030PN scenario, potential effects occur in the 5% to 55% exceedence range (Figure 4–31and Figure 4–32, Table 4–25) with no effect at 30%. The greatest effects are at the 40%, 45%, and 50% exceedences and effect 0.77%, 0.90%, and 0.86% of the total wetland area, respectively. The total area affected at all exceedence values is 697.2 ha, approximately 4% of the total 18,256-ha study area. Comparison of hectare-days of effect (Table 4–25) indicates that the effect is small suggesting that not only has the area of effect been reduced substantially, but the duration of the effect has been reduced as well. Areas around Lake Poinsett and Lake Winder experience the greatest effects (Figure 4–31). Change in ponded depth (Figure 4–32) is limited to less than 5 cm, with most of the change amounting to 1 cm.

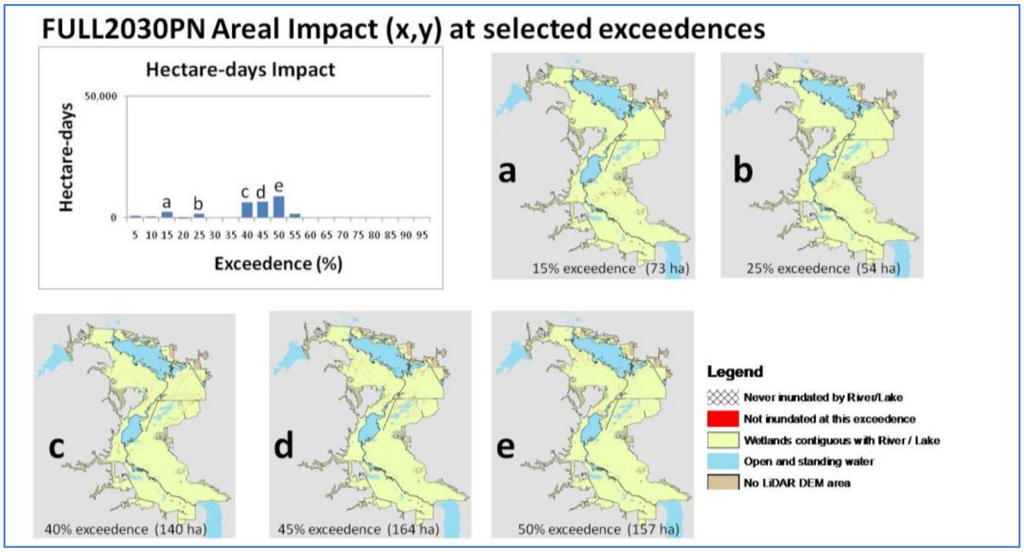

Figure 4–31. Areas dewatered and hectare-days of effect at selected exceedences for the Full2030PN scenario.

Table 4–25. Wetland area of segment 8 affected under the Full2030PN scenario.

FULL2030PN Exceedence (%)	Area Impacted (ha)	Reduction in Days Inundated (maximum over 10 yrs)	Area Impacted (percent of total area)	Maximum Hectare-days Impact (over 10 yrs)
5	19.4	48	0.11	932
10	11.5	46	0.06	527
15	72.9	37	0.40	2,696
20	6.2	10	0.03	62
25	54.5	34	0.30	1,853
30	0	0	0	0
35	25.1	13	0.14	327
40	140.9	46	0.77	6,479
45	164.4	41	0.90	6,739
50	157.3	57	0.86	8,966
55	45.1	36	0.25	1,623
60	0	0	0	0
65	0	0	0	0
70	0	0	0	0
75	0	0	0	0
80	0	0	0	0
85	0	0	0	0
90	0	0	0	0
95	0	0	0	0
Total	697.2	NA	3.82	NA

NA = Not applicable

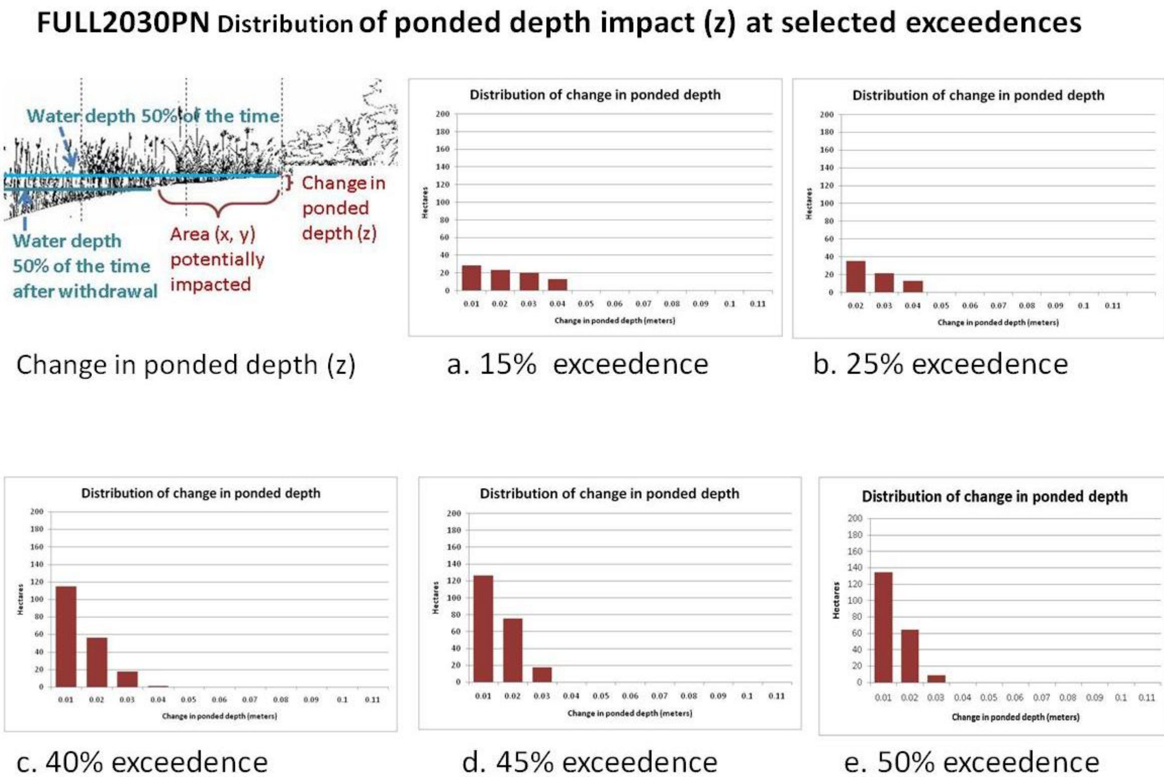

Figure 4–32. Distribution of reduction of ponded depth at selected exceedences under the Full2030PN scenario.

4.3.2 COMPARISON OF SCENARIOS

Maps displaying the area affected by scenario at 35%, 50%, and 65% exceedences are shown in Figure 4–33, Figure 4–34, and Figure 4–35. At the 35% and 50% exceedences (Figure 4–33 and Figure 4–34), the Full1995NN and Full1995PN scenarios are comparable, suggesting that, at these exceedences, the effects of the USJRB projects are not as great as at the higher exceedence values. At exceedence values of 65% and higher, there are no effects from the Full1995PN scenario (Figure 4–35) which indicates that the USJRB projects have compensated for the effects of the withdrawals. At the 35% and 50% exceedences, the effects of the Half1995PN scenario, and especially of the Full2030PN scenario, are difficult to discern. This suggests that the effects of the half withdrawal scenario are minimal and that the anticipated change in land use under the Full2030 PN are likely to compensate for the negative effects of withdrawal.

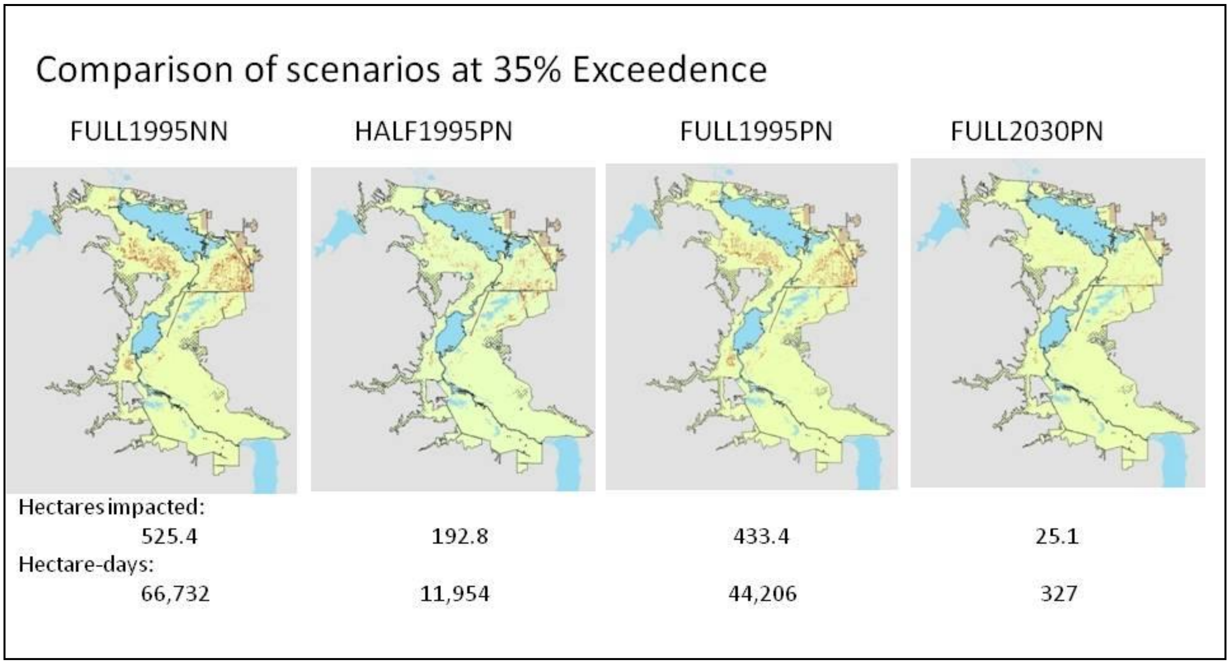

Figure 4–33. Comparison of scenarios at 35% exceedence, with reduction of areal flooding expressed as hectare-days.

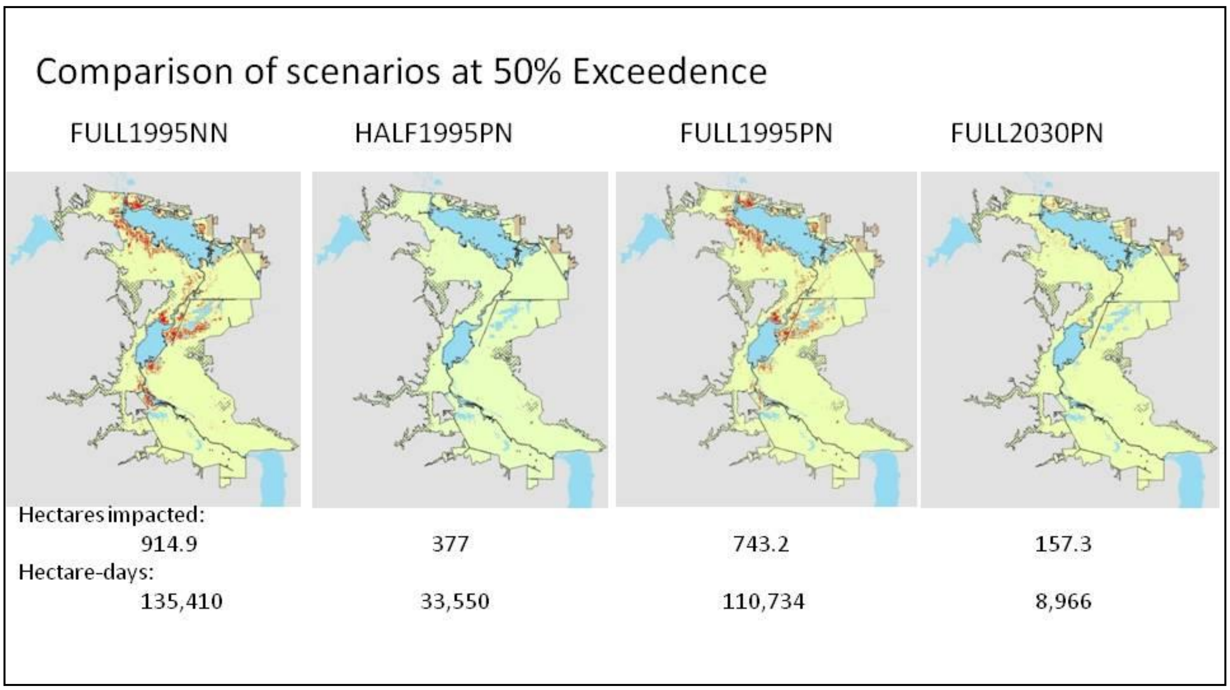

Figure 4–34. Comparison of scenarios at 50% exceedence, with reduction of areal flooding expressed as hectare-days.

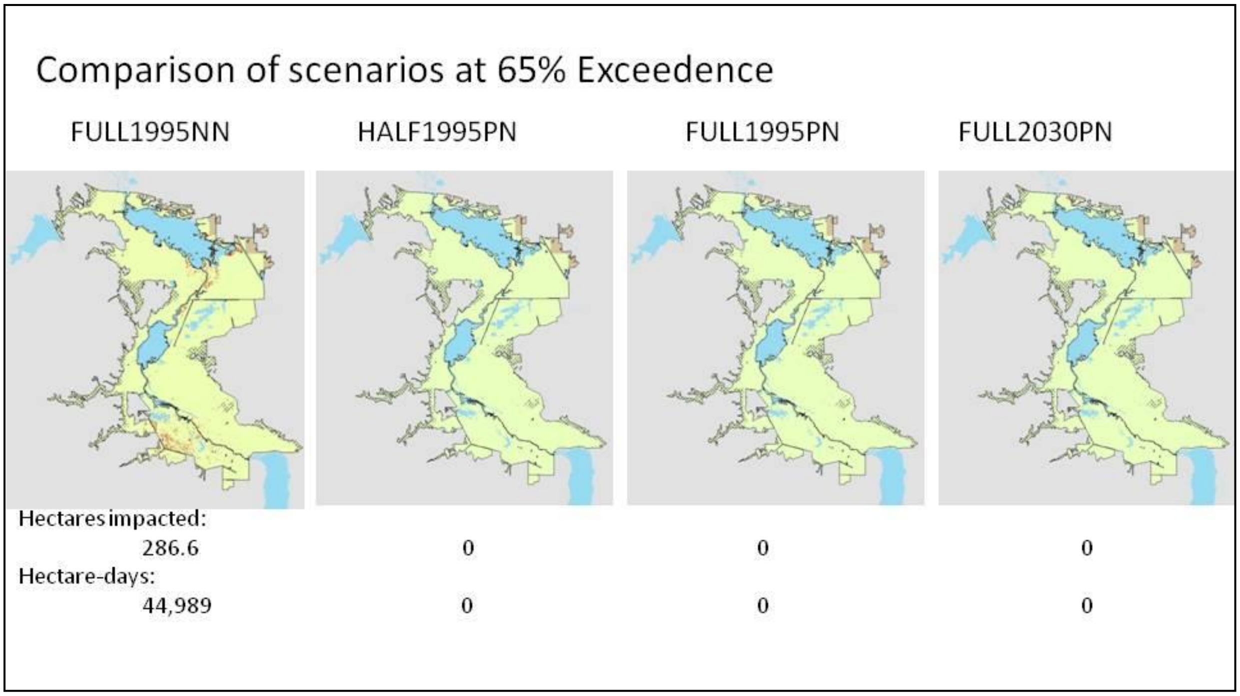

Figure 4–35. Comparison of scenarios at 65% exceedence, with reduction of areal flooding expressed as hectare-days.

4.4 Comparison of Results from Transect and Spatial Approaches

Overall, the results from transect analysis and areal effects analysis for the Full1995NN scenario were quite comparable. The transect analyses showed potential loss of deep marsh and shallow marsh. The areal effects analysis showed loss of water at similar exceedences. Neither analysis showed much change at higher elevations, which are dominated by upper wet prairie and hydric hammock. The transect and areal effects analyses of the other scenarios also produced comparable results, with progressively reduced effects under the Full1995PN, Half1995PN, and Full2030PN scenarios. Some specific wetland types were reduced in area under each scenario. However, loss in total wetland area was not shown under any scenario with any of the analytical approaches used.

4.5 Assessment of Shallow Surficial and Soil Hydrology Results

4.5.1 Topographic Setting

The St. Johns River and adjacent wetlands form an interesting landscape that lies within the confines of a relic lagoon system (Figure 4–36). A complicating factor is that the river alternates between riverine channel and lacustrine segments. The lakes, in particular, provide storage to attenuate downstream pulses during periods in which the streams are flowing below their nominal full stage. During high flow periods, the riparian wetlands also provide storage. Two ridges, which have a significantly higher elevation, typically bound these wetlands, one ridge on each side. Water that infiltrates into the sandy soils of these ridges often forms seepage faces that locally feed either overland flow to or seepage streams through the wetlands. Additionally, these ridges provide sufficient potential energy to drive groundwater up into the wetlands and the river channel through places where confining geological layers are absent or have been breached through karst features such as sinkholes and springs (see Chapter 4. Groundwater Hydrology for a detailed discussion). Furthermore, the relatively gentle downstream gradient of the system allows tides and wind to cause flow reversals for a significant portion of the river, especially during low flows.

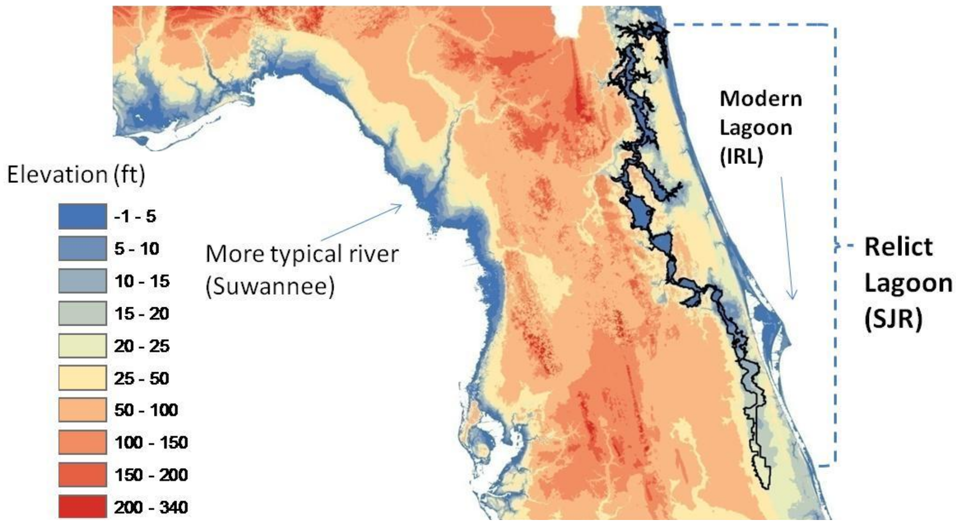

Figure 4–36. Topographic setting of the St. Johns River. IRL = Indian River Lagoon, SJR = St. Johns River.

4.5.2 Conceptual Models of Wetland Hydrology Issues

Three distinct hydrologic conditions may be recognized for the riparian wetlands along the St. Johns River in the context of WSIS:

- Low stages contained within the river or lake bank and completely decoupled from wetland well levels (subsurface drainage)
- High river and wetland stages that are coupled and act as a single system (ponded water with surface flow)
- Intermediate wetland and river stages with moderate decoupling (falling limb of the hydrograph or shallow local flooding)

Low Stages Contained within the River or Lake Bank and Completely Decoupled from Wetland Well Levels

When the river or lake stage is below the elevation of the bank (subsurface drainage; Figure 4–37), the wetlands decouple from the river. This is because the dissipation of energy (friction) through the wetland soil is so great that the vertical transport (infiltration and evapotranspiration) sufficiently exceeds the horizontal flow of water to or from the water body to render the latter negligible. This is easily demonstrated by conservative application of the Dupuit-Forchheimer equation (Fetter 2001) using scales appropriate for the anticipated effects. Therefore, the conceptual model of wetland hydrology at these stages is a vertical, mass balance accounting in which soil storage (including local ponding, if applicable) is added to by infiltration (from precipitation) and subtracted from by evapotranspiration. Some water also may be driven up from the groundwater system due to the ridge effect mentioned previously.

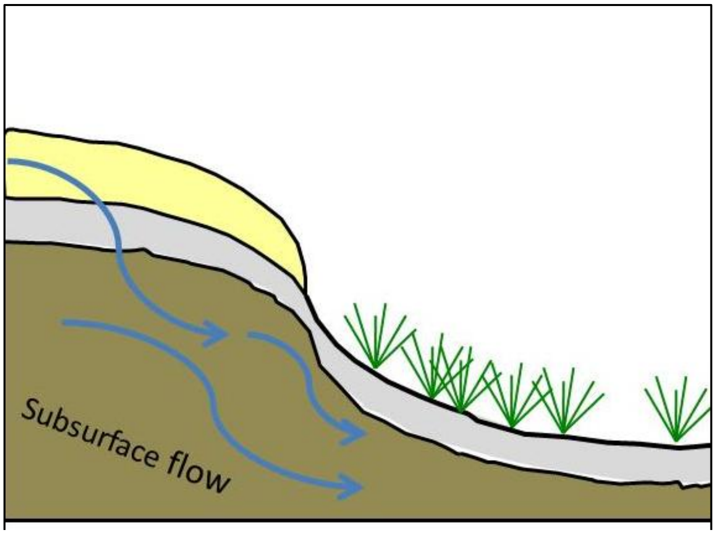

Figure 4–37. Cut view of subsurface wetlands drainage at low stages.

In the cut view (Figure 4–38), water movement is by saturated flow as defined by Equation 3–1 and 3–2. The principal parameters are hydraulic conductivity (K [L/T]), distance to inland boundary condition (L [L]), the depth of the upland groundwater flow with respect to a relatively impermeable layer (h_L [L]), the depth in channel with respect to that same level (h_0 [L]), and the distance to open channel (x) are used to determine the “into the page” flow (Q’ [L^2/T]). Figure 4–39 provides a graphic representation of the flow equation.

Dupuit-Forchheimer Equations

[Eq. 3–1]

Flow: $$Q' = K\frac{\left(h_0^2 - h_L^2\right)}{2L}$$

Phreatic Surface: $$h(x) = \left[h_0^2 - \frac{\left(h_0^2 - h_L^2\right)x}{L}\right]^{\frac{1}{2}}$$

[Eq. 3–2]

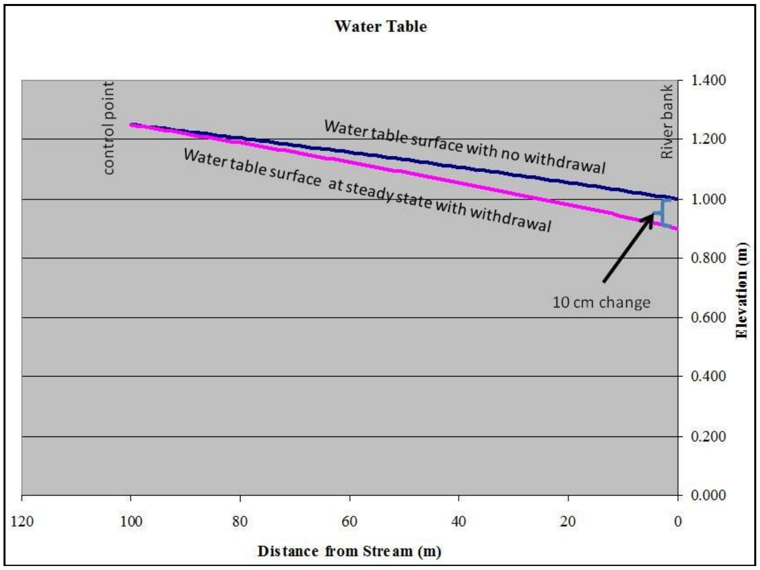

Figure 4–39. Model of wetland subsurface drainage at low stages.

“Residence time” can be conceptualized as the difference between the curves describing the water table surface before and after withdrawals, divided by the flow rate to the river. Using K = 15 m $d^{-1,}$ the residence time is 108 days. This is an approximate measure of the time it would take for the system to reach equilibrium, that is, for the upper curve to evolve to the lower curve. The value of K = 15 m $d^{-1}$is approximately that of a soil of coarse sand texture. A coarse texture soil was chosen to establish an upper limit on the potential for soil drainage. For a loamy sand texture, which is a closer approximation of the texture of upslope soils in the study area, the value would be K = 3 m d^{-1}. For soils with heavier textures, which characterize lower elevations in St. Johns River wetlands, the value is even less.

This conceptual model is supported by well data that decouple, or do not reflect correlation with, stream stage data at the ground elevation of the well. The decoupling is noted for the great majority of, if not all, wells studied. As a result, it may be concluded that lower lows of the river would not have meaningful effects on wetland hydrology in and of themselves. If there is an issue to still be explored in this matter, it would be to extract temporal frequency trends for bank-contained flow.

High River and Wetland Flows that are Coupled

During high flows, the river inundates portions of the wetlands and/or serves as a backwater condition for overland flow through the wetlands toward the channel (Figure 4–40). Here the conceptual model is one in which the river level and the perpendicular wetland transect have the same level, so flow is strictly downstream. The situation is a little more complicated for a meandering system than it would be for a straight one. The details are left to algorithms in the GIS-based hydroperiod tool, which is used to create spatio-temporal models of wetland inundation. Use of the hydroperiod tool is validated by the fact that the well data properly match the channel data during times of high flow. One of the major uses of this approach is to develop a frequency analysis of elevations that are inundated under varying water use scenarios. These results are useful to help bound the potential effect to community structure and ecotone locations for various water withdrawal scenarios.

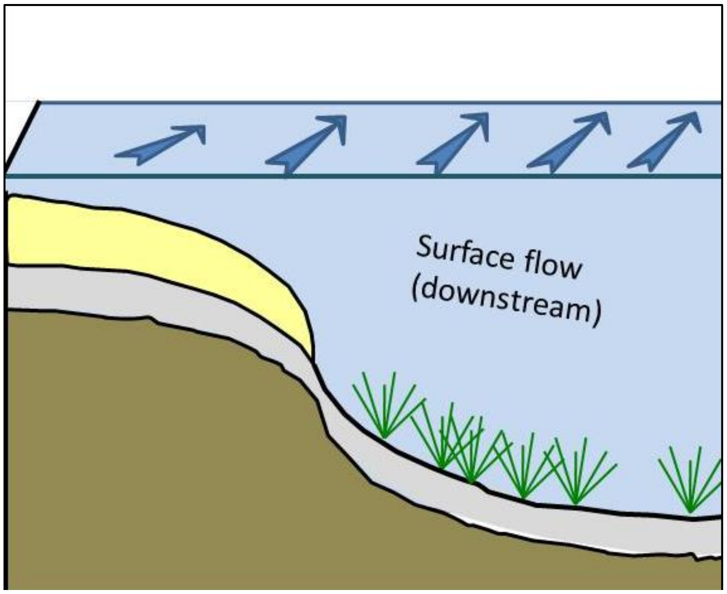

Figure 4–40. Cut view of ponded water at high stages with coupled wetland and river response.

Intermediate Wetland and River Stages with Moderately Decoupling

At intermediate wetland and river stages, shallow water flows off the marsh and to the river. The principal parameters are vegetative resistance, microtopography (surface roughness), slope, the nature and distance to the inland boundary condition, and the degree of change in river hydrology (Figure 4–41).

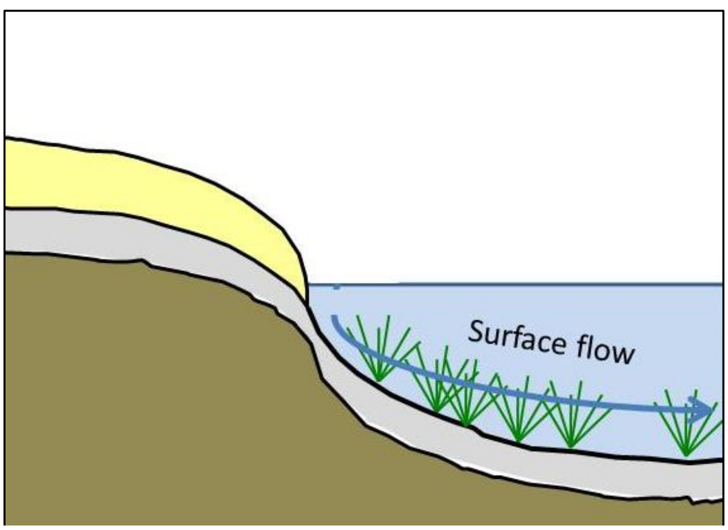

Figure 4–41. Cut view of decoupled intermediate stages for the falling limb of the hydrograph.

Because wetland soils are poorly drained, heavy rain from convective thunderstorms can rapidly produce local flooding conditions in wetlands. The data show that for some places in the St. Johns River basin, water in wetlands rises and stays well above the river stage. These conditions pose a real challenge from a modeling standpoint, because the spatial variation of the rainfall is such that even radar derived data on a 2 km × 2 km grid do not provide sufficient spatial resolution for accurate modeling of individual well levels. Under these conditions, river stages may respond to upstream conditions (including baseflow [sustained flow from groundwater and other sources]), while well levels are responding to potentially very small-scale (local) conditions. No model can overcome the data disparities between watershed processes and local processes, so the data must be evaluated to see if, in fact, cause and effect relationships are anecdotally supported by rainfall, well, and river data. Microtopographic effects, such as subtle ridges in the landscape, can impede water movement toward the channel. Even with the corrected LiDAR-based DEM, these features would be difficult to quantify in any meaningful manner.

4.5.3 Support from Minimum Flows and Levels Well Data

An examination of well data provides insight into the hydrology of St. John River floodplain wetlands. A scatter plot of river stage versus well level for MFL Dexter Point well 1 (see Table 3–3), which is located in a sawgrass–willow marsh (a subtype of shallow marsh dominated by a mixture of sawgrass and willow) 104 m from the shore of Lake Dexter at a surface elevation of 0.27 m, provides a useful example (Figure 4–42). Three areas within the scatter plot may be distinguished. The first is below ground level. In this portion of the graph, there is no predictive relationship between water level in the river and in the well. Well levels may be either higher or lower than river levels. A second area in the graph takes the form of an asymmetrical cone starting at ground level and narrowing with increased water level. In this region, surface roughness and vegetation have their greatest influence on the movement of water. Near the ground surface, the scatter of points is almost as great as that seen below ground level, but with increased water level the effect diminishes and water levels in the well and in the river converge. Above this level surface water levels in the river and in the well function as a single pool.

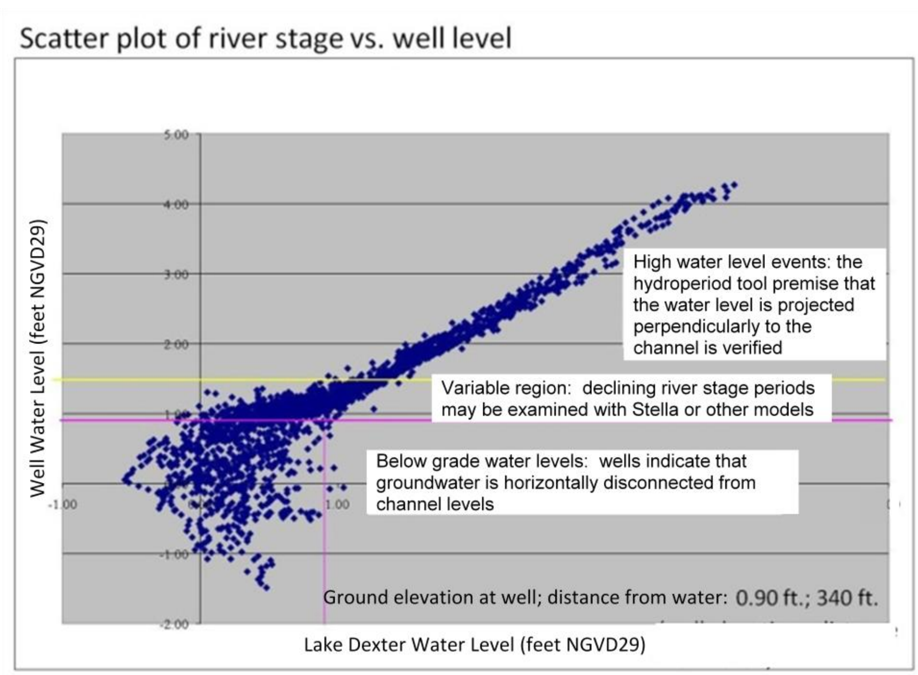

Figure 4–42. Scatter plot of river stage versus well level, Dexter Point South transect well 1.

Another view of the relationship between lake stage and well level is shown in Figure 4–43. At ground level elevation, the exceedence of well water is higher than in the open water of the lake by the equivalent of 37 additional days of flooding annually. The differences narrow towards a level about 10 cm above ground elevation, illustrating the diminishing effects of surface roughness and vegetation. Above this level, the exceedences are essentially coincident, within measurement precision. Below ground level, the exceedences again converge before strongly diverging. This may reflect the effect of evapotranspiration in the wetlands, which results in well levels that are much lower (due to porosity effects) than those seen in the open water of the adjacent lake.

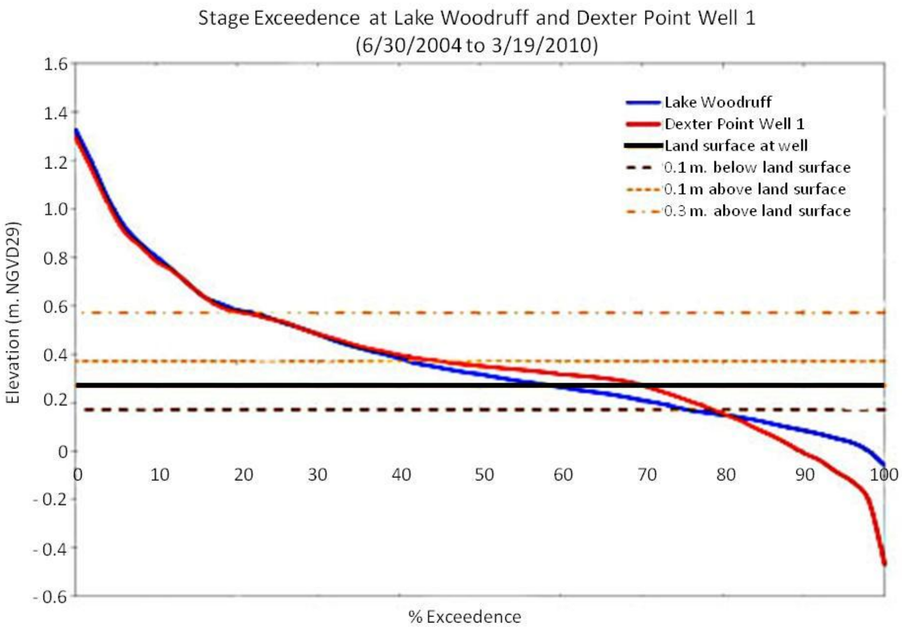

Figure 4–43. Comparison of stage exceedence at Lake Woodruff and Dexter Point well 1. Horizontal lines represent ground level, elevations 10 cm below and above ground level, and 30 cm above ground level.

In the Lake Poinsett study area (segment 8), data from six wells were available. Both time series and scatter plots of well versus lake levels were examined.

The time series for County Line wells (Figure 4–44) show that lake stage elevation and well water levels are coincident when water levels are above ground surface elevation, and they decouple when water levels fall below ground level. When decoupled, well level may be much higher than lake stage or may fall below lake stage. The pattern is probably related to the pattern of precipitation and evapotranspiration. In particular, the steep drop in July and August 2010 is likely the result of low rainfall coupled with high evapotranspiration. Water levels in the higher (upslope) and more distant wells tend to be higher than those in the lower wells by a factor related to their elevation. The scatter plots for the County Line wells show much the same story as that for the Dexter Point wells—complete decoupling below ground level and convergence above ground level.

The period of record for the Mulberry Mound wells (Figure 4–45) was short and covers a dry time interval, so the lake water levels barely exceeded the ground level elevation of the lowest well. The pattern is again a broad scatter of points below and above ground to an elevation about 10 cm above the ground surface.

These findings show that significant dewatering of floodplain soils is unlikely beyond the near vicinity of the lake or river margin as a result of water withdrawals from the river. This finding is also supported by other studies on lateral drainage effects (Phillips et al. 2006) and corroborates the Dupuit-Forchheimer analysis given in Section 3.5.2.

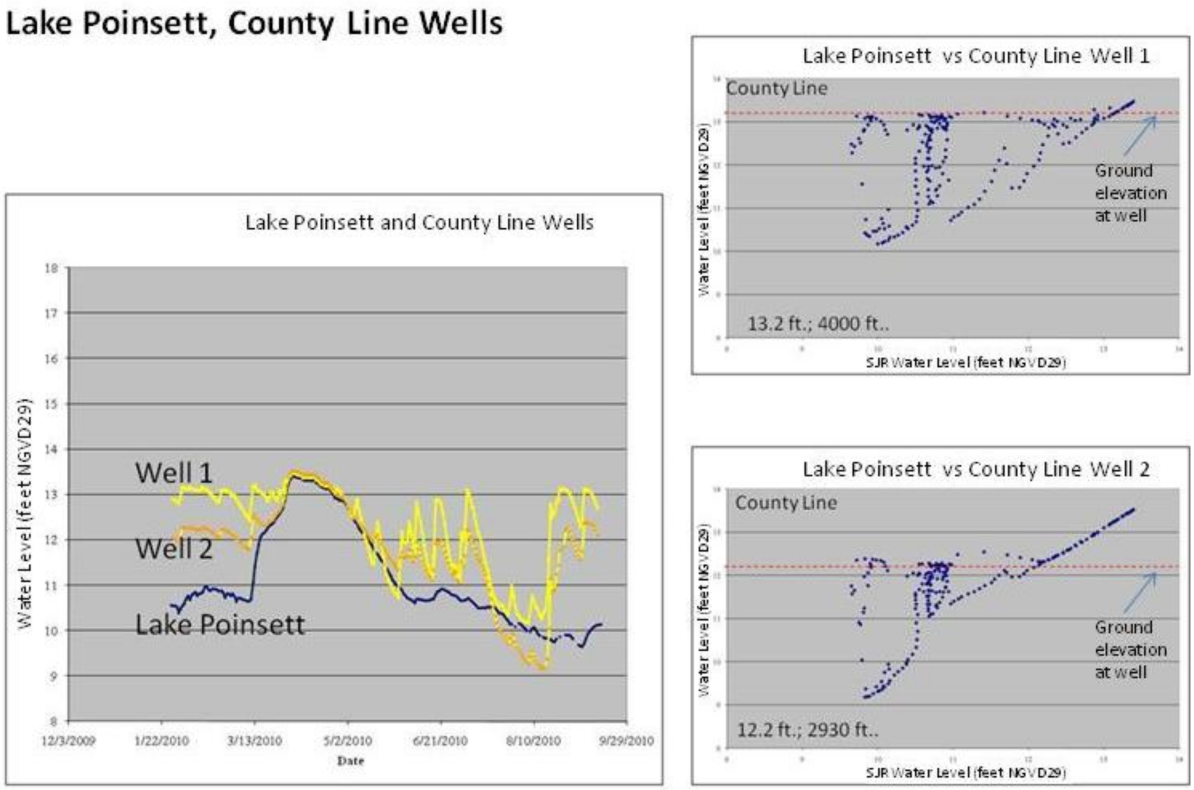

Figure 4–44. Time series of well and lake levels (left) and scatter plots of well versus lake levels (right), County Line wells (Lake Poinsett).

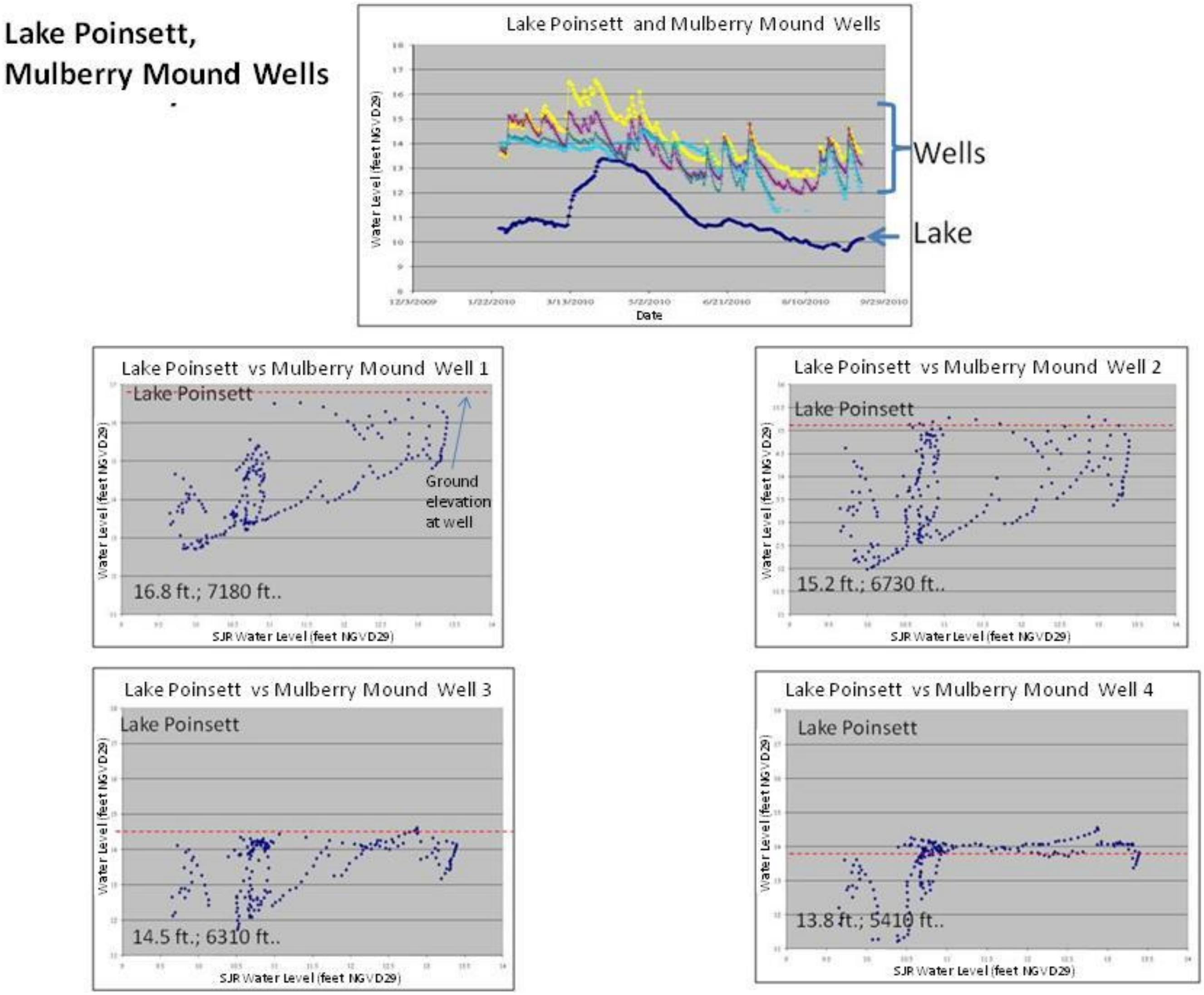

Figure 4–45. Time series of well and lake levels (top) and scatter plots of well versus lake levels (bottom), Mulberry Mound wells (Lake Poinsett).

4.6 Assessment of Effects of Changes in Salinity Results

As discussed earlier, modeled salinities (Full1995NN) reach thresholds of concern only in the lower reaches of the river, north of river km 80 near Shands Bridge. South of Shands Bridge, conditions are generally fresh to very slightly oligohaline and show little change in modeled salinity. In river segment 1 from the Fuller-Warren Bridge (river km 40) north, salinities have become sufficiently high and variable under baseline conditions to limit wetlands to salt-tolerant marshes, which are unlikely to be affected by salinity changes. Therefore, we determined the area of greatest concern to be between river km 40 and river km 80, which corresponds closely with segment 2. Our efforts were first directed to the wetlands of the Ortega River, where we developed a wetland salinity response function. This function was subsequently applied to the remaining portion of segment 2.

4.6.1 Ortega River Criteria Study Area: Distribution of Species by Station and Salinity

Seventy-six distinct taxa were sampled or observed at the 14 stations sampled (Table 4–26). Conductivity (saturated paste method) ranged from a low of 198 microsiemens per centimeter (µS cm^{-1}) to 9,480 µS cm^{-1} and generally increased with distance downstream. Five wetland plant community types were recognized: freshwater swamp, tidal swamp, lower tidal swamp, intermediate marsh, and sand cordgrass marsh (Table 4–27). Most plant species occur in one or two wetland plant community types, but 11 showed wide distributions over the salinity gradient.

Table 4–26. Wetland vegetation species sampled in the Ortega River study area.

Common Name	Scientific Name (Wunderlin and Hansen 2008)	FDEP Status	Duration and Growth Habit (USDA 2011)
Red maple	Acer rubrum	FACW	Woody perennial
Alligator weed	Alternanthera philoxeroides	OBL	Perennial herb
Giant leather fern	Acrostichum danaeifolium	OBL	Fern
Pink redstem	Ammannia latifolia	OBL	Annual herb
Florida hobblebush	Agarista populifolia	FACW	Woody perennial
Bluestem	Andropogon sp.	FAC	Perennial grass
Groundsel tree	Baccharis halimifolia	FAC	Woody perennial
Herb-of-grace	Bacopa monnieri	OBL	Perennial herb
Bluebeech	Carpinus caroliniana	FACW	Woody perennial
Buttonbush	Cephalanthus occidentalis	OBL	Woody perennial
Watersprite	Ceratopteris thalictroides	OBL	Fern
Swamp leather-flower	Clematis crispa	Not rated	Perennial vine
Virginia dayflower	Commelina virginica	FACW	Perennial herb
Swamp dogwood	Cornus foemina	FACW	Woody perennial
String-lily	Crinum americanum	OBL	Perennial herb
Dodder	Cuscuta sp.	Not rated	Perennial vine
Manyspike flatsedge	Cyperus polystachyos	FACW	Annual to perennial sedge
Green flatsedge	Cyperus virens	FACW	Perennial sedge
Climbing hydrangea	Decumaria barbara	Not rated	Perennial vine
Witchgrass	Dichanthelium	FAC to FACW	Perennial grass
Cockspurgrass	Echinochloa	FACW	Annual grass
Rough barnyardgrass	Echinochloa muricata	FACW	Annual grass
Swamp doghobble	Eubotrys racemosa	FACW	Woody perennial

Common Name	Scientific Name (Wunderlin and Hansen 2008)	FDEP Status	Duration and Growth Habit (USDA 2011)
Lateflowering throughwort	Eupatorium serotinum	FAC	Perennial herb
Carolina ash	Fraxinus caroliniana	OBL	Woody perennial
False reinorchid	Habenaria sp	FACW	Perennial herb
Swamp rosemallow	Hibiscus grandiflorus	OBL	Suffrutescent shrub
Pennywort	Hydrocotyle umbellata	FACW	Perennial herb
Yellow stargrass	Hypoxis	FACW	Perennial herb
Dahoon	Ilex cassine	OBL	Woody perennial
Saltmarsh morning-glory	Ipomoea sagittata	Not rated	Perennial vine
Dixie iris	Iris hexagona	OBL	Perennial herb
Virginia willow	Itea virginia	OBL	Woody perennial
Bigleaf sumpweed	Iva frutescens	OBL	Woody perennial
Virginia saltmarsh mallow	Kosteletzkya pentacarpos	OBL	Suffrutescent shrub
Eastern grasswort	Lilaeopsis chinensis	OBL	Perennial herb
Sweetgum	Liquidambar styraciflua	FACW	Woody perennial
Creeping primrosewillow	Ludwigia repens	OBL	Perennial herb
Fetterbush	Lyonia lucida	FACW	Woody perennial
Wand loosestrife	Lythrum lineare	OBL	Perennial herb
Climbing hempvine	Mikania scandens	FACW	Perennial vine
Wax myrtle	Myrica cerifera	FAC	Woody perennial
Royal fern	Osmunda regalis	OBL	Fern
Green arrow arum	Peltandra virginica	OBL	Perennial herb
Swamp bay	Persea palustris	OBL	Woody perennial
Resurrection fern	Pleopeltis polypodioides	UPL	Fern
Sweetscent	Pluchea odorata	FACW	Perennial herb
Dotted smartweed	Polygonum punctatum	OBL	Perennial herb
Pickerelweed	Pontedaria cordata	OBL	Perennial herb
Laurel oak	Quercus laurifolia	FACW	Woody perennial
Buttercup	Ranunculus	FACW	Annual herb
Shortbristle horned beaksedge	Rhynchospora corniculata	OBL	Perennial sedge
Millet beaksedge	Rhynchospora miliacea	OBL	Perennial sedge
Sawtooth blackberry	Rubus pennsilvanicus	FAC	Perennial subshrub
Swamp dock	Rumex verticillatus	FACW	Perennial herb
Dwarf palmetto	Sabal minor	FACW	Woody perennial
Coastal rosegentian	Sabatia calycina	OBL	Perennial herb
American cupscale	Sacciolepis striata	OBL	Perennial grass
Lizard's tail	Saururus cernuus	OBL	Perennial herb
Saltmarsh bulrush	Schoenoplectus robustus	OBL	Perennial herb
Rattlebox	Sesbania punicea	FAC	Perennial subshrub
Bristly greenbrier	Smilax tamnoides	Not rated	Perennial vine
Seaside goldenrod	Solidago sempervirens	FACW	Perennial herb

Common Name	Scientific Name (Wunderlin and Hansen 2008)	FDEP Status	Duration and Growth Habit (USDA 2011)
Sand cordgrass	Spartina bakeri	FACW	Perennial grass
Climbing aster	Symphyotrichum carolinianum	OBL	Perennial subshrub
Bald cypress	Taxodium distichum	OBL	Woody perennial
Eastern poison ivy	Toxicodendron radicans	Not rated	Perennial vine
American elm	Ulmus americana	FACW	Woody perennial
Highbush blueberry	Vaccinium corymbosum	FACW	Woody perennial
Walter's viburnum	Viburnum obovatum	FACW	Woody perennial
Hairypod Cowpea	Vigna luteola	Not rated	Perennial vine
Common blue violet	Viola sororia	FACW	Perennial herb
Florida grape	Vitis cineria var. floridana	Not rated	Perennial vine

Table 4–27. Wetland plant community types and characteristics across soil salinity gradients.

Wetland Plant Community Type	Sites (Figure 2-13)	Canopy and Light at Surface	Understory	Microrelief	Conductivity, Mean and Range (µS cm^{-1})	Salinity (PSS78)
Hardwood Swamp	1, 3, 4, 5	Closed; 80 to 100 ft; heavily shaded	Minimal to sparse	Pronounced	523 (198 to 1080)	.25 (.1 - .53)
Tidal Hardwood Swamp	6, 8, 9	Closed; ca. 70 ft; well shaded	Sparse to moderate	Pronounced	1689 (811 to 3270)	.85 (.40 – 1.71)
Lower Tidal Hardwood Swamp	10, 11, 12-2, 13	Open; 50 – 60 ft; partial shade	Dense	Moderate	3602 (1851 to 5140)	1.89 (.94 – 2.76)
Intermediate Marsh	12-1, 15	Sparse; < 30 feet; full sun	Dense	Minimal	5305 (4050 to 6350)	2.85 (2.14 – 3.46)
Sand Cordgrass Marsh	17	None; full sun	Dense	Minor	6368 (4850 to 9480)	3.5 (2.59 – 5.31)

Change in vegetation was consistently associated with the spatial variation in salinity. Beginning with a typical hardwood swamp assemblage at site 1, the transition to increasingly saline conditions resulted first in the loss of the most sensitive species (e.g., woody shrubs in the Ericaceae, bluebeech [*Carpinus caroliniana*], false reinorchid [*Habenaria* sp.], yellow stargrass [*Hypoxis* spp.]), followed by reduction in canopy closure and height. This allowed proliferation of grasses and herbs of intermediate salt tolerance. This was followed in turn by total loss of canopy species, dominance by increasingly tolerant grasses and herbs, and finally by even more salt-tolerant species, such as sand cordgrass. Data from other wetland plant communities occupying even more saline habitats in the basin show that these would likely be replaced by needle rush, smooth cordgrass, and in some cases saltwort (*Batis maritima*) and perennial glasswort (*Sarcocornia* ambigua)] dominated wetland plant communities (Table 4–27).

The hardwood swamp type exhibited a tall, closed, and diverse canopy, and a diversity of woody plants. The understory was generally sparse but contained some species not found in other types, such as false reinorchid, yellow stargrass, and lizard's tail (*Saururus cernuus*).

The tidal swamp type (sites 6, 8, and 9) differed most notably from lower tidal swamp by the presence of a healthy closed canopy and absence, or near absence, of many grasses and herbs that were common and grew densely under the stunted but open canopy of the lower tidal swamp. No species appeared to be unique to the tidal swamp community. Community composition overlapped broadly with the hardwood swamp type (sites 1, 3, 4, and 5), but a suite of salt intolerant species were absent (lizard's tail, swamp leather-flower [*Clematis crispa*], swamp doghobble [*Eubotrys racemosa*], highbush blueberry [*Vaccinium corymbosum*], Walter's viburnum [*Viburnum obovatum*], bluebeech, and others).

The intermediate marsh (sites 12-1 and 15) differed from lower tidal swamp (sites 10, 11, 12-2, and 13) in the essential absence of canopy-height trees in the former, but were quite similar to each other in floristic composition. Both saltmarsh bulrush (*Schoenoplectus robustus*) and seaside goldenrod (*Solidago sempervirens*) were present in the intermediate marsh, but absent in lower tidal swamp. The lower tidal swamp contains Swamp dock (*Rumex vertillatus*), dodder (*Cuscuta* sp.), giant leather fern (Acrosticum danaeifolium), and Buttercup (*Ranunculus* sp.), all of which are absent from the intermediate marsh. It also contains a variety of stunted trees and other woody species (e.g., Carolina ash [*Fraxinus caroliniana*], wax myrtle [*Myrica cerifera*], dwarf palmetto [*Sabal minor*]) that are absent or sparse in the intermediate marsh type. Alligator weed (*Alternanthera philoxeroides*), shortbristle horned beaksedge (*Rhynchospora corniculata*), American cupscale (*Sacciolepis striata*), pickerelweed (*Pontederia cordata*), dotted smartweed (*Polygonum punctatum*), and *string-lily* (*Crinum americanum*) were present and often abundant in both types.

The sand cordgrass wetland plant community type (site 17) was dominated by sand cordgrass, but contained an additional nine species that were sampled only within this wetland plant community type: (Pink redstem [Ammannia latifolia], herb-of-grace [Bacopa monnieri], late-flowering thoroughwort [Eupatorium serotinum], swamp rosemallow [Hibiscus grandiflorus], saltmarsh morning-glory [Ipomoea sagittata], bigleaf sumpweed [Iva frutescens], eastern grasswort [Lilaeopsis chinensis], climbing hempvine [Mikania scandens], and hairypod cowpea [Vigna luteola]). S*tring-lily* (*Crinum americanum*), rattlebox (*Sesbania punicea*), and saltmarsh bulrush (*Schoenplectus robustus*) were also abundant, but also occurred in other plots as well. Lateflowering throughwort (*Eupatorium serotinum*), swamp rosemallow (*Hibiscus grandiflorus*), saltmarsh morning-glory (*Ipomoea sagittata*), and bigleaf sumpweed (*Iva frutescens*) were not sampled but were conspicuous in the stand.

4.6.2 Ortega River Criteria Study Area: Break Points

Beginning upstream, four break points along the Ortega River were recognized: 952 µS cm^{-1} between hardwood swamp and tidal swamp (midpoint between sites 5 and 6); 2943.6 µS cm^{-1} between tidal swamp and lower tidal swamp (midpoint between sites 9 and 11); 4575.5 µS cm^{-1} between lower tidal swamp and intermediate marsh (midpoint between stations 12-1 and 12-2); and 6266.5 µS cm^{-1} between intermediate marsh and sand cordgrass marsh (midpoint between site 15 and 17). The break point values were converted to practical salinity using the UNESCO International Equation of State (IES 80) as described in Fofonoff (1985). The corresponding break points were practical salinity 0.47, 1.53, 2.44, and 3.41 (PSS78), respectively for the transitions above.

These measures appeared low in relation to the known salinity tolerances of many commonly cultivated crop and landscape plants (Miyamoto et. al. 2004; Maas and Grattan 1999). They may also be compared to the U.S. Salinity Lab scale, which rates tolerances (converted here from decisiemens per meter [dS/m] to µS cm^{-1}) as (1) sensitive (< 3,000 µS cm^{-1}), (2) moderately sensitive (3,000 to 6,000 µS cm^{-1}), (3) moderately tolerant (6,000 to 8,000 µS cm^{-1}), (4) tolerant (8,000 to 10,000 µS cm^{-1}), and (5) highly tolerant (> 10,000 µS cm^{-1}).

Direct comparison may, however, be misleading. Unlike the laboratory values reported in much of the literature, the field measurements taken in the wetlands of the Ortega River represent a single point in time and are not a measure of tolerance. Both lower and higher salinities are expected to have occurred due to freshwater flooding events, rainfall, saline tidal incursions, and evaporation. Additionally, the soils we sampled were saturated. This adds a second stressor that is lacking in the study of crop tolerances, which are generally conducted with container grown plants and freely draining oxygenated soils. Some studies suggest that the combination of water logging and salinity is much more stressful than either alone (Carter et al. 2006).

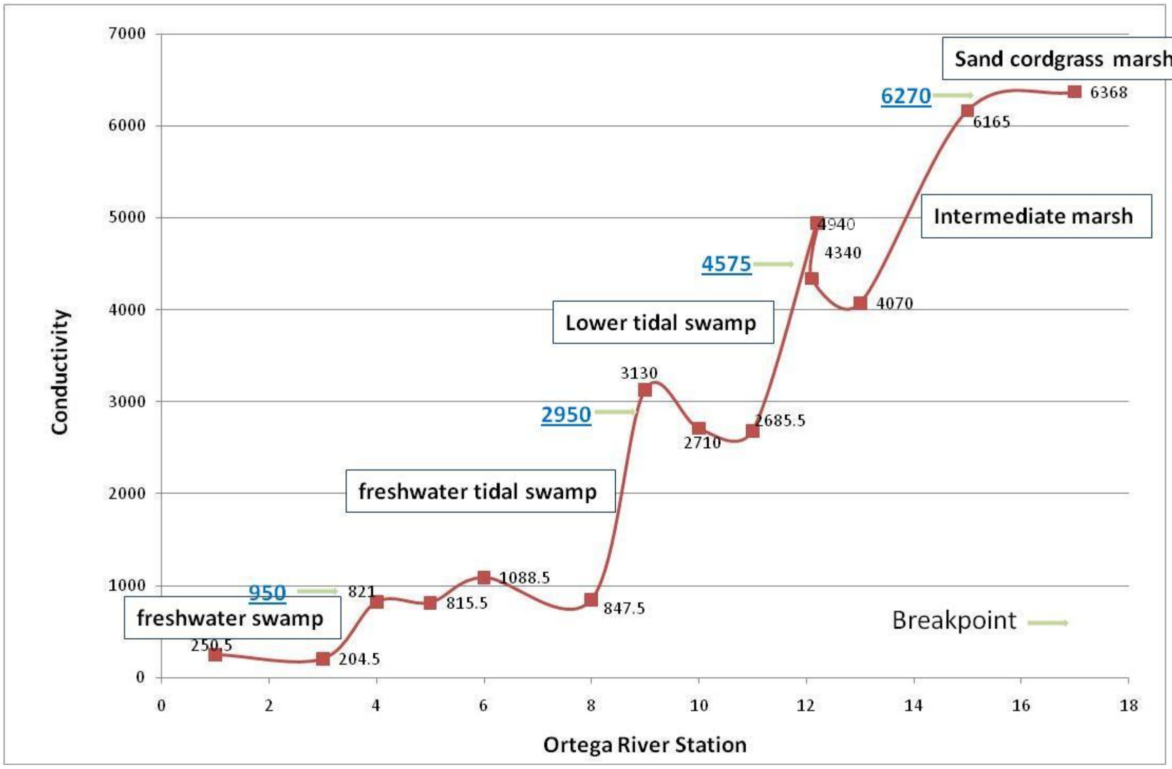

Figure 4–46. Plant communities and break points on the Ortega River.

4.6.3 ORTEGA RIVER CRITERIA STUDY AREA: POTENTIAL MOVEMENT OF ISOPLETHS AND COMMUNITIES

To predict community movement based on surface water withdrawals and subsequent changes in salinity, it was necessary to relate soil salinities to river salinity under the Base 1995NN scenario and then relate river salinity to river km. Soil salinity is the proximate driver for community change, but the ultimate driver is river salinity, which may be altered by various water withdrawal scenarios. A table of salinity statistics by river km for the Ortega River was produced with the EFDC hydrodynamic model by the Hydrodynamics Working Group (Appendix 10.). The 95th percentile was chosen as the measure of salinity because the magnitude of the numbers appeared to be sufficient to drive environmental change, but all of the measures were highly correlated and gave a similar high R^2 when regressed against river km. Soil salinity was found to be highly related to river salinity (Figure 4–47). River salinity was found, in turn, to be highly related to river km (Figure 4–48).

From these relationships, it was possible to predict the position along the river of salinity break points under the Base1995NN scenario (Table 4–28), and then using the same process, the positions of the break points under the Full1995NN scenario (Table 4–29). Potential movement in a geographical context is shown in Figure 4–49.

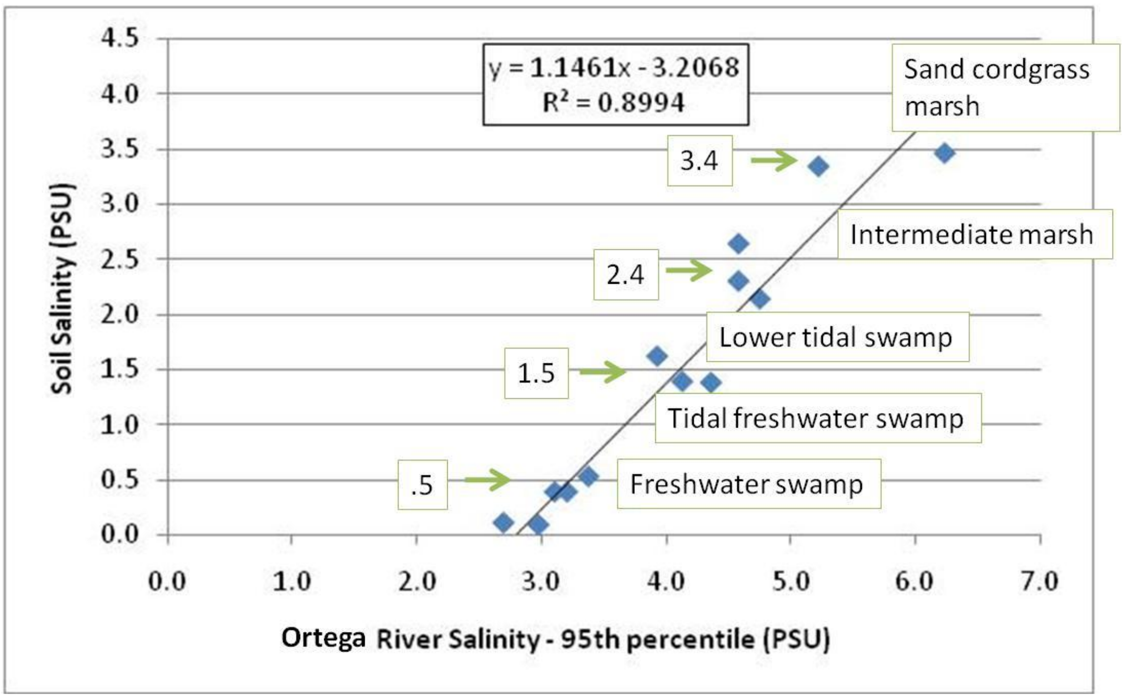

Figure 4–47. Regression of soil salinity on 95th percentile of river salinity.

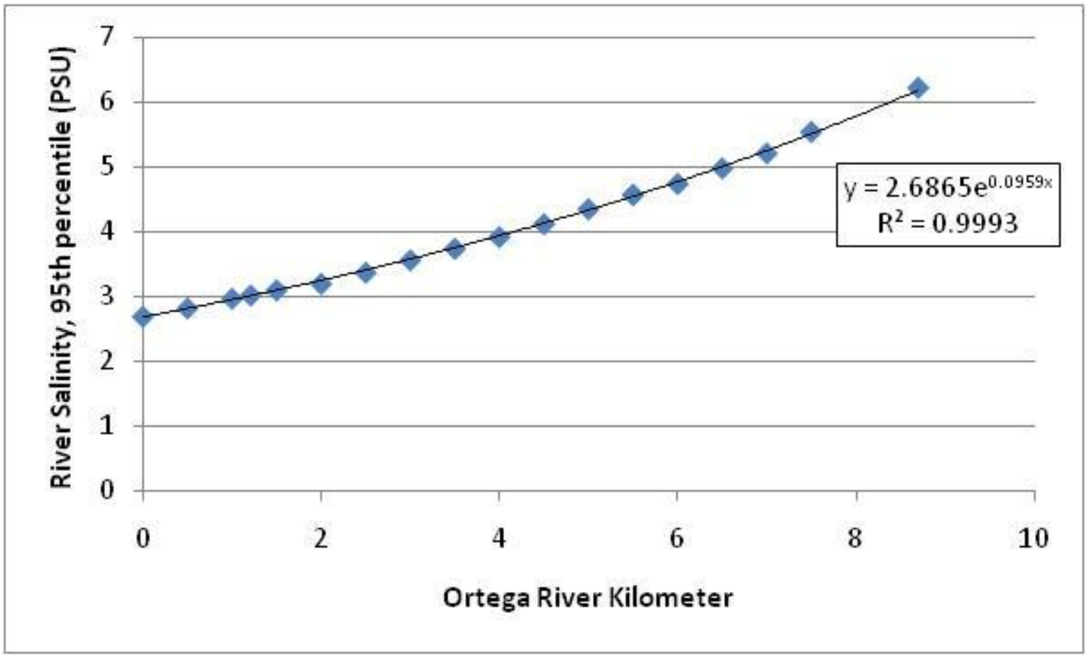

Figure 4–48. Regression of Ortega River salinity by river kilometer.

Table 4–28. Soil salinity break points with corresponding Ortega River salinities and river kilometer.

Soil Salinity Break Point	Corresponding Ortega River Salinity	Ortega River km
0.47	3.218	1.85
1.53	4.13	4.49
2.44	4.93	6.32
3.41	5.77	7.97

Table 4–29. Potential movement of Ortega River soil salinity break points under the Full1995NN scenario.

Soil Salinity Break Point	Corresponding River Salinity	Baseline River km	Full Withdrawal River km	Movement of Break Points (km)
0.47	3.218	1.85	0.74	1.11
1.53	4.13	4.49	3.37	1.12
2.44	4.93	6.32	5.19	1.13
3.41	5.77	7.97	6.84	1.13

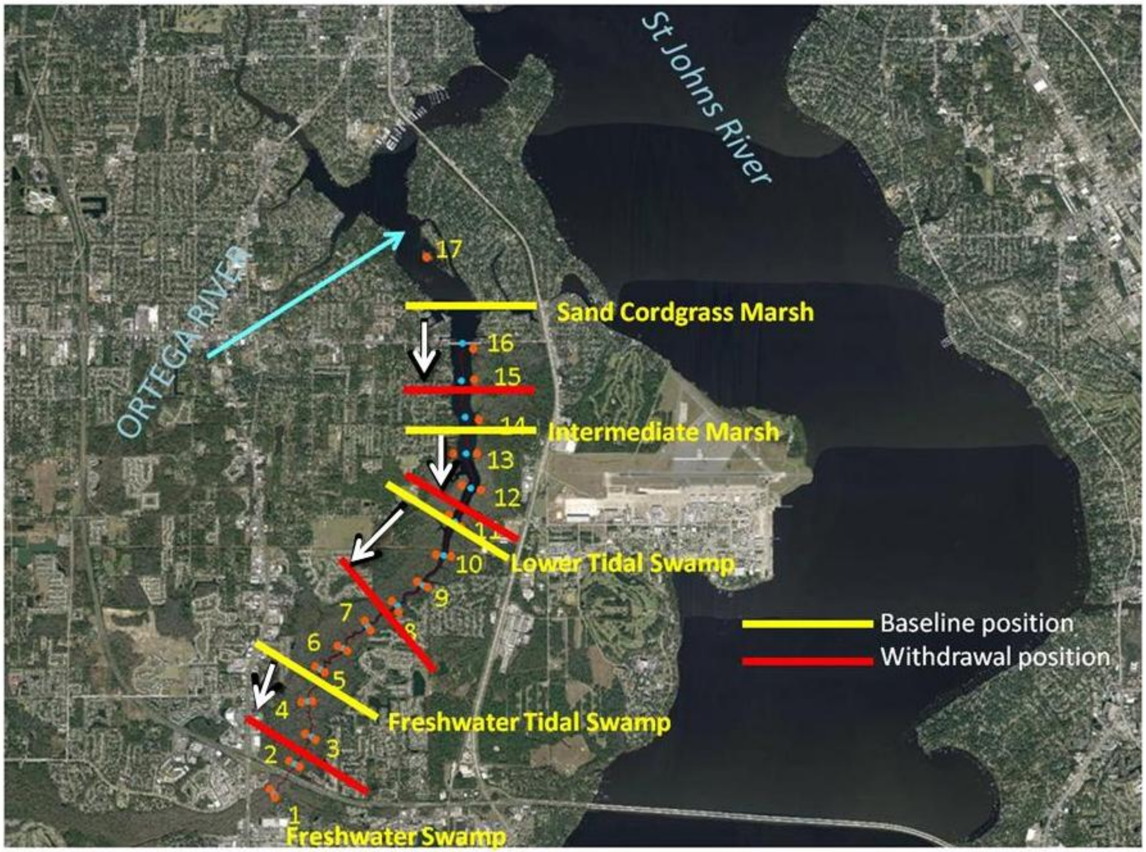

Figure 4–49. Potential movement of Ortega River community boundaries under the Full1995NN scenario.

4.6.4 Application of the Ortega River Analysis to the St. Johns River

To determine movement of communities along the St. Johns River, the relationship we established between river salinity and soil salinity for the Ortega River was applied. We believe this application was appropriate because the two water bodies are in close proximity and have similar vegetation and hydrodynamics. A table of salinity statistics by river km for the St. Johns River was produced from the EFDC hydrodynamic model (Appendix 10.C). River salinities (95%) found to predict soil salinity break points on the Ortega River were taken from the table of values for each scenario and corresponding river km. The greatest potential movement occurred with the FwOR1995NN scenario. With 2030 land use, USJRB projects, and sea level rise future change is less dramatic (Table 4–30).

Table 4–30. Location (in river kilometers) and movement of soil salinity break points under various scenarios.

Soil Salinity Break point	River Salinity Break point	River kilometer (Base 1995NN)	River kilometer (Full 1995NN)	River kilometer (FwOR 1995NN)	River kilometer (Full 2030PS)	Distance moved (km)(Base 1995NN to FwOR 1995NN)	Distance moved (km)(Base 1995NN to Full 1995NN	Distance moved (km)(Base 1995NN to Full 2030PS
0.47	3.21	63.45	64.87	66.28	63.66	2.83	1.42	0.21
1.53	4.13	60.28	61.87	63.38	60.46	3.1	1.59	0.18
2.44	4.93	57.58	59.26	60.88	57.68	3.3	1.68	0.1
3.41	5.77	54.9	56.59	58.24	54.83	3.34	1.69	-0.07

4.6.5 SHIFT OF COMMUNITIES AND ISOPLETHS FOR WATER WITHDRAWAL SCENARIOS

Analysis of river salinity and associated wetland soil salinity and community position along the St. Johns River shows potential shifts of isopleths from a maximum of 3.34 km upstream to a minimum of -0.07 km, corresponding to a slight downstream movement, depending on the water withdrawal scenario (Figure 4–50 and Figure 4–51).

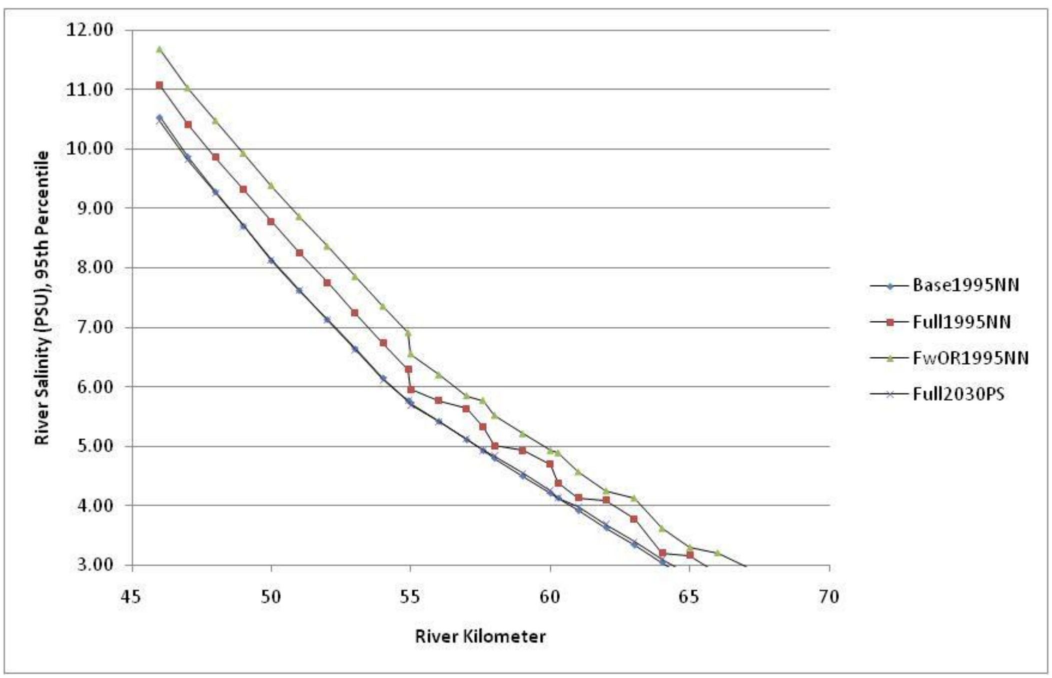

Figure 4–50. Shift in St. Johns River salinity isopleths in relation to river kilometer for four water withdrawal scenarios.

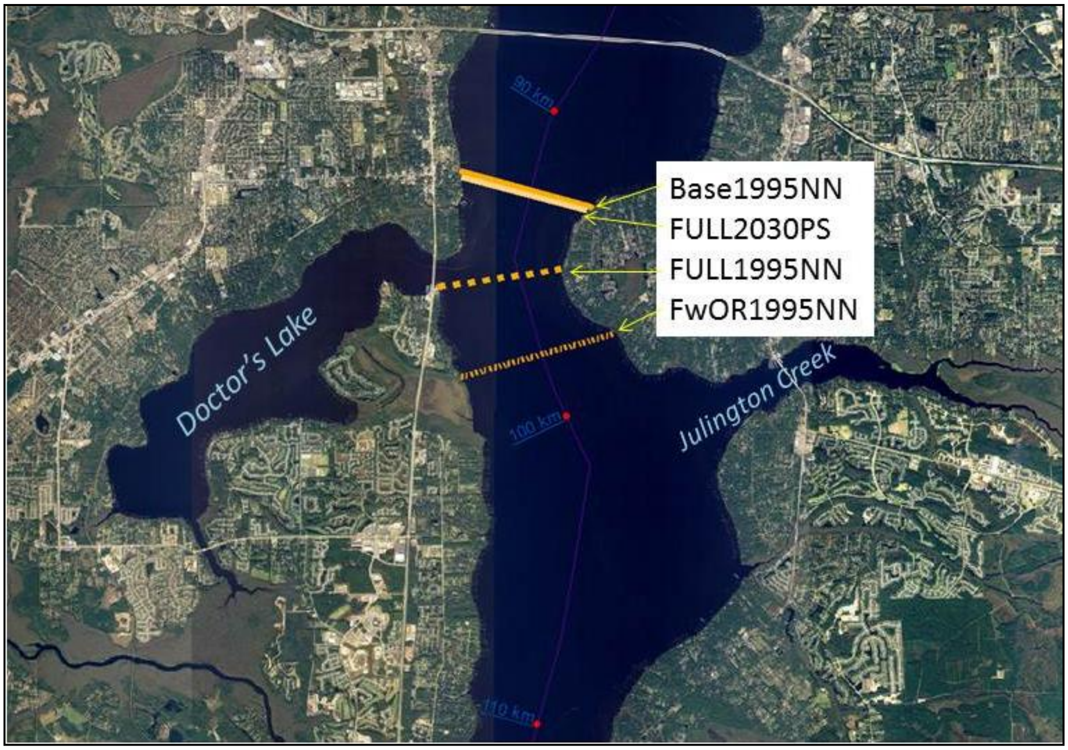

Figure 4–51. Shift in position of the boundary between lower tidal swamp and intermediate marsh due to changes in salinity for four water withdrawal scenarios, St. Johns River.

5 DISCUSSION

This chapter focuses on the effects of surface water withdrawal scenarios on the floodplain wetlands of the St. Johns River and specifically on the potential movement of wetland boundaries, area of wetlands affected by modeled water withdrawal scenarios, and changes in hydrologic seasonality. We concentrated our efforts most intensively on effects to wetlands in segment 8 for changes in water levels (stage) and on the effects to wetlands in segment 2 for changes in salinity.

Segment 8, and in particular that portion of the basin from the outlet of Lake Washington through Lake Poinsett, was chosen for more intensive study due the magnitude of modeled water level changes (an average of 5 cm under the Full1995NN scenario compared to the Base1995NN scenario). Three approaches were used to assess the effects of modeled changes in stage in segment 8: (1) graphical analysis of exceedence and the mean daily annual hydrograph, (2) transect analysis, and (3) areal effects analysis. No analyses for effects (beyond a screening level) from change in stage were done for segments 1 through 4 (the mouth of the St. Johns River through Lake George), because water levels in these segments are largely controlled by sea level (modeled changes in water levels from water withdrawals were less than 1 cm.). Segments 5 and 6 were also analyzed only at a screening level, although we recognize that there is some potential for change under the Full1995NN scenario. Some analysis was done for segment 7 (Appendix 10.D), where the decline in water level under the Full1995NN withdrawal is 4 cm (Table 3-1, Figure 3-1).

Significant change in modeled salinity occurred only in segments 1 and 2. The changes in annual mean and highest monthly mean salinities under the Full1995NN scenario were greatest in segment 1 (0.32 and 0.49 PSS78, respectively). However, these changes were judged to be unlikely to cause significant effects because the vegetation in segment 1 consists primarily of salt marshes, which are able to tolerate wide ranges of salinity. In addition, baseline salinities in segment 1 are greater (the percent change is less) and the natural variability is very high. We therefore focused on segment 2, (Fuller-Warren Bridge to Fleming Island), because the change in annual mean and highest monthly mean salinities were still relatively high (0.12 and 0.30 PSS78, respectively) and extensive areas of freshwater and transitional vegetation were present. Virtually no change in salinity was projected for segments 3 through 8, so no additional analysis was required for those segments.

In this chapter, we have addressed four questions about the effects of modeled hydrologic changes on wetlands:

1. Would changes in inundation depth and duration change the extent of wetlands in the landscape?
2. Would modeled changes in inundation depth and duration relative to baseline change the extent of wetland plant community types in the landscape?
3. Would modeled changes in hydrologic seasonality affect wetland plant community types by changing the seasonality of flooding and drying of wetlands?
4. Would salinity levels and durations exceed freshwater species tolerances and cause community boundaries to shift?

We used a conservative set of assumptions in our assessment: that the wetland plant communities were in a steady state equilibrium with respect to average or median hydrologic conditions, that open water hydrology was the only driver of change, and that plant communities would respond to changes in the central (median) tendency of hydrologic events by moving from past locations and reestablishing at new, hydrologically equivalent landscape positions.

This discussion presents the final assessment for each question under each of the scenarios presented earlier in this report.

5.1 Assessment of Level of Environmental Effect

The significance of any environmental effect can be related to its strength, persistence, and diversity. In our assessment, we related each of these measures to hypothesized changes and created a decision matrix to document the process and to ensure a level of consistency among working groups. Each matrix component (strength, persistence, and diversity) was allowed three states, creating a matrix of 27 combinations:

- The strength component scale contains both an intensity element (magnitude of the effect on populations) and a spatial element (percent of total area affected). The three states for percent reduction or displacement of populations or for area affected were (1) 1% to 25%, (2) 25% to 75%, and (3) 75% to 100%.
- Persistence was given three states: (1) full recovery of populations before additional perturbation has occurred, (2) partial recovery of populations, and (3) little or no recovery of populations.
- The final component of the matrix is diversity, which we define as the percentage of species within the community or the number of community types that are significantly affected at a given level of perturbation. The same scale was used for this component: (1) 1% to 25%, (2) 25% to 75%, and (3) 75% to 100%.

Strength, persistence, and diversity created a matrix of 27 combinations. We subsequently parsed the matrix, using the definitions given in Chapter 2 (Table 5-1). Comprehensive Integrated Assessment, to yield five levels of effects (Figure 5-2)

Table 5–1 Scale for evaluation of the level of ecological importance of an effect (from Chapter 2 —Comprehensive Integrated Assessment)

Level of Effect	Criteria
Extreme	Effect is persistent, strong, and highly diverse; significant change in natural resource values
Major	Effect is persistent & strong, but not highly diverse; significant change in natural resource values
Moderate	Effect is ephemeral or weak or is limited to minor species, no significant change in natural resource values

Level of Effect	Criteria
Minor	Effect is ephemeral and weak; no significant change in any ecosystem attribute
Negligible	No appreciable change in any ecosystem attribute

	Diversity		
Strength/persistence	High (3)	Medium (2)	Low (1)
3,3	3,3,3	3,3,2	3,3,1
3,2	3,2,3	3,2,2	3,2,1
2,3	2,3,3	2,3,2	2,3,1
2,2	2,2,3	2,2,2	2,2,1
3,1	3,1,3	3,1,2	3,1,1
2,1	2,1,3	2,1,2	2,1,1
1,3	1,3,3	1,3,2	1,3,1
1,2	1,2,3	1,2,2	1,2,1
1,1	1,1,3	1,1,2	1,1,1

Legend

- Extreme
- Major
- Moderate
- Minor
- Negligible

Figure 5–2. Decision matrix for levels of effects to wetlands.

5.2 Assessment of Uncertainty

Our assessment of uncertainty addresses only the uncertainty associated with the biological effects covered in this chapter, not that of the hydrologic drivers, which is covered in Chapter 6. River Hydrodynamics Results. The overall approach to uncertainty is described in Chapter 2. Comprehensive Integrated Assessment. Again, we developed a decision matrix (Figure 5–3) to guide our decisions. Here the three components are the strength of the predictive model, the strength of supporting evidence (e.g., studies of similar systems from the scientific literature, corroborative observations, and species tolerance data), and the level of understanding of the underlying mechanism. Each was allowed three states, (1) low, (2) medium, and (3) high. The combinations were parsed to create a range of uncertainties from very low to very high.

Model, Support	Mechanism 3	2	1
3,3	*	**	**
3,2	**	**	***
3,1	**	***	***
2,3	***	***	***
2,2	***	***	****
2,1	***	****	****
1,3	****	****	****
1,2	****	****	*****
1,1	****	*****	*****

*	very low
**	low
***	medium
****	high
*****	very high

Figure 5–3. Decision matrix for levels of uncertainty.

Results for each hypothesized change and each evaluated scenario appear below (Table , and Table). Cells within each table contain values from each of the components of the decision matrix for levels of effects and are shaded to indicate level of effect. Cells representing river segments for which abbreviated analyses were performed, or in which the decision was made deductively, are hatched. Levels of uncertainty are indicated by the number of asterisks. The overall rating follows that of the strongest effect.

5.3 Full1995NN versus Base1995NN

Under the Full1995NN scenario (Table 5-2), no or only very small effects are projected to occur at the upper and lower wetland boundaries. The upper boundaries are unlikely to be affected because they usually lie above the floodplain of the St. Johns River and are hydrated by other sources. In addition, flooding at higher wetland elevations, even within the river floodplain, is little affected by water withdrawals. Since hydrologic change diminishes at the lowest wetland elevations, the lower boundaries of wetlands are the last to experience drying effects and are generally stable. In some areas, where suitable habitat exists, there may be some potential downslope movement of the lower wetland boundary. This would result in an overall expansion in wetlands area, although conditions would be somewhat drier. We gave the effect an overall rating of minor (1, 3, 1) for segment 8 owing to the weak, limited, but persistent effect in segment 8. For other segments, where the effect was projected to be less, we predicted a negligible effect (1, 1, 1).

Most effects under the Full1995NN scenario occur at the boundaries of wetland types, in particular at the lower boundaries of wet prairie and shallow marsh communities, which move down slope. The area of wetland impacted is large (27.5%), and change in ponded depth (about 5 cm) is sizable. For these reasons, we rated the effect on community boundaries as major in segment 8 (2, 3, 3), but somewhat lower in segments 7, 6, and 5—where the magnitude of expected hydrologic changes are progressively lower. Little or no change in modeled water levels occurs in segments 1, 2, 3, and 4, so the potential environmental effects are considered to be negligible.

Moderate effects from changes in salinity on community boundaries are projected to occur in segment 2 under the Full1995NN scenario. Wetland boundaries in segment 2, including those between fresh and saltwater communities, are anticipated to shift 1 to 1.5 km upstream, and communities adapted to saltier conditions are projected to replace those less tolerant of salinity. The effects (2, 3, 2) would be moderate in strength, due to the size of the area affected, high in permanence, and moderate in changes to diversity (populations of some of the more salt-tolerant species would not be affected).

No appreciable change in wetlands hydrologic seasonality in any river segment under this or any of the other scenarios is anticipated, because shifts in median starting and ending dates for wetland flooding are minor and occur within an overall pattern of high interannual variability.

Table 5–1. Summary of effects for the Full1995NN scenario.

River Region	Change in Upper And Lower Wetland Boundaries	Boundaries Between Wetland Types	Wetlands Hydrologic Seasonality	Boundaries Between Freshwater and Saltwater Communities	Overall
1	*1,1,1	* 1,1,1	*1,1,1	*1,1,1	*
2	*1,1,1	* 2,3,2	*1,1,1	*2,3,2	*
3	* 1,1,1	* 1,1,1	*1,1,1	* 1,1,1	*
4	* 1,1,1	*1,1,1	*1,1,1	* 1,1,1	*
5	* 1,1,1	***1,3,1	*1,1,1	* 1,1,1	***
6	* *1,1,1	***1,3,1	*1,1,1	* 1,1,1	***
7	* *1,1,1	***2,3,2	*1,1,1	*1,1,1	***
8	* *1,3,1	** 2,3,3	*1,1,1	*1,1,1	**

Level of Effect	Uncertainty
Negligible	* Very low
Minor	** Low
Moderate	*** Medium
Major	**** High
Extreme	***** Very High

Cross-hatching indicates abbreviated analysis.

5.4 FULL1995PN VERSUS BASE1995NN SCENARIO

Under the Full1995PN scenario (Table 5-3), no water withdrawal effects are projected to occur at the upper wetland boundaries, because they lie above the influence of river hydrologies and are hydrated by other sources. The lower boundaries of wetlands will not experience withdrawal effects since hydroperiods are projected to lengthen.

Some movement of wetland boundaries occurs under the Full1995PN scenario. In segment 8, these shifts primarily occur at the boundaries of wet prairie and shallow marsh communities. The area of wetland impacted (20.6%) is somewhat less than under the Full1995NN scenario, and the change in ponded depth is somewhat less (about 4 cm). For these reasons, we rated the effects as moderate in segment 8 (2, 3, 2), but somewhat lower in segments 7, 6, and 5—where the magnitudes of expected hydrologic change are progressively lower. Effects of changes in water level or salinity on segments 1, 3, and 4 are considered to be negligible.

Effects in segment 2 are projected to remain moderate due to the continued deviation in salinity from historical baseline conditions. The movement of the boundary between fresh and saltwater communities in segment 2 is projected to be somewhat less than under the Full1995NN scenario.

Table 5–2. Summary of effects for the Full1995PN scenario.

River Region	Change in Upper and Lower Wetland Boundaries	Boundaries Between Wetland Types	Wetlands Hydrologic Seasonality	Boundaries Between Freshwater and Saltwater	Overall
1	*1,1,1	*1,1,1	*1,1,1	*1,1,1	*
2	*1,1,1	*2,3,2	*1,1,1	*2,3,2	*
3	*1,1,1	*1,1,1	*1,1,1	*1,1,1	*
4	*1,1,1	*1,1,1	*1,1,1	*1,1,1	*
5	*1,1,1	**1,3,1	*1,1,1	*1,1,1	***
6	*1,1,1	**1,3,1	*1,1,1	*1,1,1	***
7	*1,1,1	**2,3,2	*1,1,1	*1,1,1	***
8	*1,1,1	**2,3,2	*1,1,1	*1,1,1	**

Level of Effect	Uncertainty
Negligible	* Very low
Minor	** Low
Moderate	*** Medium
Major	**** High
Extreme	***** Very High

Cross-hatching indicates abbreviated analysis.

5.5 HALF1995PN VERSUS BASE1995NN SCENARIO

Under the Half1995PN scenario (Table 5-4), the upper wetland boundaries are not projected to move since they lie above the influence of river hydrologies and are hydrated by other sources. The lower boundaries of wetlands will not experience withdrawal effects because hydroperiods are projected to lengthen.

Only slight movement of boundaries between wetland types occurs under the Half1995PN scenario. In segment 8, the area of wetland affected is 10%, and the change in ponded depth is small (about 2.5 cm). For these reasons, we rated the effects as minor in segment 8 (1, 3, 1) and negligible in all other segments.

From the small changes in baseline salinities, we project that the movement of the boundary between fresh and saltwater communities in segment 2 would be minor (1, 3, 1) under the Half1995NN scenario.

Table 5–3. Summary of effects for the Half1995PN scenario.

River Region	Change in Upper and Lower Wetland Boundaries	Boundaries Between Wetland Types	Wetlands Hydrologic Seasonality	Boundaries Between Freshwater and Saltwater	Overall
1	*1,1,1	* 1,1,1	*1,1,1	*1,1,1	*
2	*1,1,1	* 1,3,1	*1,1,1	*1,3,1	*
3	* 1,1,1	* 1,1,1	*1,1,1	* 1,1,1	*
4	* 1,1,1	*1,1,1	*1,1,1	* 1,1,1	*
5	* 1,1,1	***1,1,1	*1,1,1	* 1,1,1	***
6	* *1,1,1	***1,1,1	*1,1,1	* 1,1,1	***
7	* *1,1,1	***1,1,1	*1,1,1	*1,1,1	***
8	* *1,1,1	**1,3,1	*1,1,1	*1,1,1	**

Level of Effect	Uncertainty
Negligible	* Very low
Minor	** Low
Moderate	*** Medium
Major	**** High
Extreme	***** Very High

Cross-hatching indicates abbreviated analysis.

5.6 FULL2030PN AND FULL2030PS VERSUS BASE1995NN SCENARIO

Under the Full2030PN and Full2030PS scenarios (Table 5-5), no withdrawal effects are projected to occur either at the upper or lower wetland boundaries.

Only very slight changes are projected to occur between the boundaries of wetland types under the Full2030PN and Full2030PS scenarios. In segment 8, the area of wetland affected is slight (3.8%), and the change in ponded depth is very small (about 1.5 cm). For these reasons, we rated the effects as minor in segment 8 (1, 3, 1) and negligible in all other segments.

Salinity effects in segment 2 are projected to be minor based on boundary movements of less than 0.2 km. From changes in baseline salinities, we project that the upstream movement of the boundary between fresh and saltwater communities in river segment 2 to be minor (1, 3, 1) under the Full2030PN and Full2030PS scenarios.

Table 5-4. Summary of effects for the Full2030PN and Full2030PS scenarios.

River Region	Change in Upper and Lower Wetland Boundaries	Boundaries Between Wetland Types	Wetlands Hydrologic Seasonality	Boundaries Between Freshwater and Saltwater	Overall
1	1,1,1	* 1,1,1	*1,1,1	*1,1,1	*
2	1,1,1	* 1,3,1	*1,1,1	*1,3,1	*
3	*1,1,1	* 1,1,1	*1,1,1	* 1,1,1	*
4	* 1,1,1	*1,1,1	*1,1,1	* 1,1,1	*
5	* 1,1,1	***1,1,1	*1,1,1	* 1,1,1	***
6	* *1,1,1	***1,1,1	*1,1,1	* 1,1,1	***
7	* *1,1,1	***1,1,1	*1,1,1	*1,1,1	***
8	* *1,1,1	**1,3,1	*1,1,1	*1,1,1	**

Level of Effect	Uncertainty
Negligible	* Very low
Minor	** Low
Moderate	*** Medium
Major	**** High
Extreme	***** Very High

Cross-hatching indicates abbreviated analysis.

The greatest negative effect from change in stage was observed under the Full1995NN scenario, and diminishing effects were seen under the Full1995PN, Half1995PN, and Full2030PN scenarios. We consider effects under the Full2030PN scenario to be minor. Only those effects resulting from surface water withdrawals were considered in this analysis.

Effects from changes in salinity follow the same pattern. The greatest effects were with the FwOR1995NN scenario, lesser effects with the Full1995NN scenario, and only minor effects with the Full2030PN scenario. Scenarios Full1995PN and Half1995PN were not analyzed, but were projected to have effects proportionate to the modeled changes in salinity in both of these scenarios.

Our uncertainty is low or very low in those segments of the river where modeled changes in the driver (i.e. water level or salinity) are insufficient to create a biological response. In areas where the drivers are sufficient to cause change, uncertainty is somewhat greater, but does not exceed a moderate level. We believe the close agreement between a variety of methods, sound models, and well-understood causal mechanisms support these levels of confidence.

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8 APPENDICES

Appendix A: Description of Method for Historical – Delta Calculation

Appendix B. Wetland and Soil Types in the Floodplain of the St. Johns River

Appendix C. Estimation of Salinity in the Ortega River

Appendix D. Hydroperiod Tool analysis of St. Johns River Segment 7