Special Publication SJ97-SP8

Water Management Alternatives: Effects on Lake Levels and Wetlands in the Orange Creek Basin

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WATER MANAGEMENT ALTERNATIVES: EFFECTS ON LAKE LEVELS AND WETLANDS IN THE ORANGE CREEK BASIN

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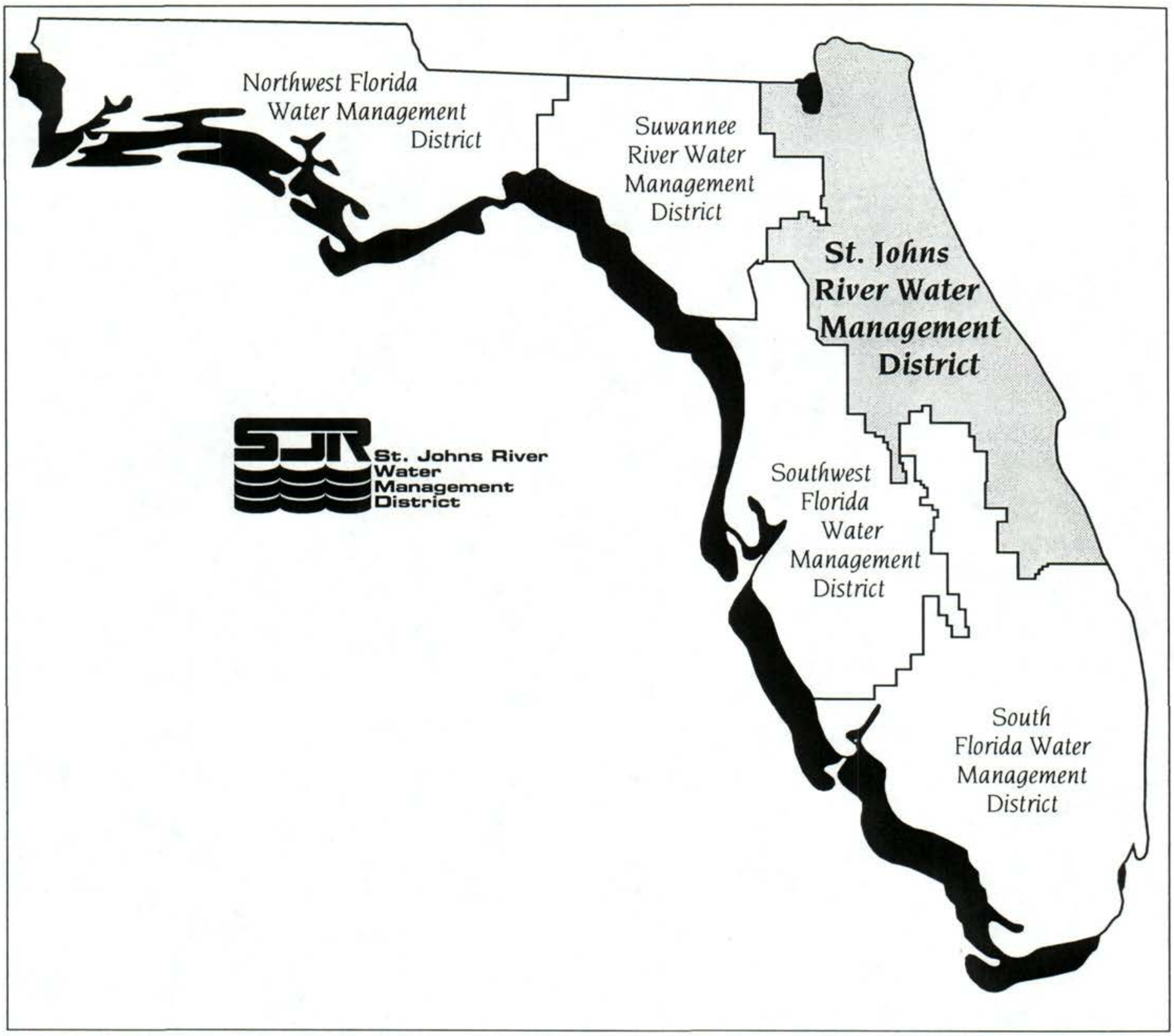

The **St. Johns River Water Management District** (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 19 counties in northeast Florida. The mission of SJRWMD is to manage water resources to ensure their continued availability while maximizing environmental and economic benefits. It accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; operation and maintenance of water control works; and land acquisition and management.

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EXECUTIVE SUMMARY

The Orange Creek Basin (OCB), located in north-central Florida, is part of the lower Ocklawaha River watershed. Lakes Orange, Lochloosa, and Newnans are the major water bodies of OCB; Paynes Prairie is also part of OCB. These water bodies are recognized for their considerable ecological and economic significance. Paynes Prairie, Orange Lake, and Lochloosa Lake have been designated as Outstanding Florida Waters. OCB supports a diverse and productive wildlife community, including populations of many threatened and endangered species. Economic and recreational values center around the reputation of the major lakes for excellent sportfishing. Paynes Prairie State Preserve is an area for passive recreation. OCB has traditionally attracted many sportsmen, naturalists, and tourists annually.

Hydraulic alterations within OCB have changed the natural hydrology of the lakes and Paynes Prairie and have been suspected causes of ecological degradation. Concerns have increased regarding both the ecology and the economics of OCB. Drought-induced low water levels, stabilization of water levels through the construction of weirs, excessive growth of nuisance aquatic plants, water quality degradation, and increased accumulation of sediments are problems that have been addressed in scientific studies. Recreational fishing has declined throughout OCB, probably because of drought-induced low lake levels and reduced lake access.

In response to these issues and to address additional surface water management concerns expressed by state and local governments and citizen groups, the St. Johns River Water Management District initiated a study to evaluate the ecological effects of different surface water management alternatives on OCB. This report documents the development of the biohydrologic criteria and methods used to evaluate these water management alternatives. The study upon which the report is based had five objectives:

- To evaluate the surface water hydrology of the watershed based on a hydrologic model for each lake and Paynes Prairie

- To develop biohydrologic criteria for water levels to evaluate the restoration and conservation potential of alternative surface water management plans

- To develop alternative surface water management plans and to evaluate each with respect to the biohydrologic criteria

- To assess the water management alternatives from the perspectives of hydrology and wetland ecology

- To identify those water management alternatives that require more specialized study (e.g., hydrogeologic, ecologic, or economic studies)

Lake and wetland ecosystems require a range of surface water fluctuations for their conservation. This range of water levels constitutes a fluctuation regime that consists of (1) high water levels due to temporary and seasonal floods, (2) a suitable middle level, and (3) low water levels that coincide with mild droughts and infrequent extensive droughts. Water management measures can negatively affect the range of water level fluctuation of these ecosystems.

The biohydrologic criteria were created to accommodate a range of surface water fluctuations. These criteria are Infrequent High, Frequent High, Middle, Frequent Low, and Infrequent Low water levels. These criteria define periods of inundation that preserve the ecological processes of the lake and floodplain biological communities. Hydrologic conditions for each management alternative were derived from daily lake levels simulated by the Streamflow Synthesis and Reservoir Regulation (SSARR) mathematical model for a 50-year period of rainfall record. Summary statistics in the form of probability tables and stage-duration curves were generated from these data.

Each criterion describes a duration (the number of consecutive days an average water level is maintained) and a recurrence interval (the frequency in years, on the average, that a water level is equalled or exceeded). The duration and recurrence intervals were formulated by project biologists after examining the physical and biological features of the floodplain wetland and/or lake littoral zone communities and were supported by other research done by the St. Johns River Water Management District and by scientific literature.

The duration and recurrence interval associated with each criterion statistically specify a particular water elevation that is expected to occur under a particular management alternative. For example, a flood event with a duration of at least 60 consecutive days and recurring once every 2 years would occur at 57 feet (ft) under the "Existing Conditions" alternative. Under a different water management alternative, a flood event with the identical duration and recurrence interval might occur at 56 ft. The comparison of changes in water elevation under different management scenarios to the elevations of key biological attributes is the basis for evaluating the effects of different water management alternatives on the lake and floodplain wetland communities.

Twenty-three water management alternatives were evaluated for potential ecological impacts to the major water bodies. Two of these 23 would affect Newnans Lake, 7 would affect Paynes Prairie, and 22 would affect Orange and Lochloosa lakes. The fluctuation regimes predicted by the SSARR hydrologic model for each alternative were evaluated for potential ecological impacts to the major water bodies. These ecological evaluations compared the new water level fluctuation regimes predicted by the SSARR hydrologic model to key environmental attributes of each water body. These comparisons provided a systematic means to determine which water management alternatives were likely to maintain the hydroperiods needed by the biological communities.

Management Alternatives—Newnans Lake

The floodplain swamps have been impacted by maintaining artificially high water levels with a weir at the outlet of Newnans Lake. With the weir in place, median water levels for the "Existing Conditions" alternative are predicted by the SSARR model to be approximately 0.8 ft higher than under pre-weir conditions, resulting in significantly higher inundation frequencies over hundreds of acres of the floodplain swamp. Concomitantly, there is little recent regeneration of the cypress fringe community on Newnans Lake. Weir removal would result in a 27% increase in emergent wetland vegetation (235 acres).

"Remove Newnans Lake Weir" appears to be the most ecologically sound management alternative for Newnans Lake. Weir removal results in a greater range of lake level fluctuations, increasing the amount of time a given elevation is exposed. Removal of the weir would also occasionally allow nearly complete dewatering of the lower floodplain near the present cypress/lake ecotone. This dewatering will create a hydrologic regime more favorable for the rejuvenation of the floodplain wetlands and the upper littoral zone of the lake. Weir removal also should increase the flushing of nutrients and sediments from the lake.

Management Alternatives—Paynes Prairie

Seven water management alternatives were evaluated for Paynes Prairie. Either the "Existing Conditions" alternative or the "Remove Newnans Lake Weir" alternative appears to be the most ecologically sound management practice for Paynes Prairie and OCB, given present conditions. These alternatives maximize the emergent wetland acreage and maintain the surface water sheetflow across the eastern lobe of the prairie that is so important to the maintenance of the biology of the prairie. Additionally, these alternatives have little effect on the average surface water levels of Orange and Lochloosa lakes.

In our opinion, the five remaining alternatives should not be considered for implementation because of the potential environmental impacts to Paynes Prairie or to Orange and Lochloosa lakes. These alternatives are "Complete Restoration of Prairie Creek Flow to Paynes Prairie," "Complete Diversion of Prairie Creek Flow to Orange Lake," "Reduction in Paynes Prairie Inflow/Outflow Structure Capacity by 50%," "Lake Level Threshold Management of the Camps Canal Structure," and "Use Sweetwater Branch Inflow to Replace Prairie Creek Inflow."

Management Alternatives—Orange and Lochloosa Lakes

Twenty-two water management alternatives were evaluated for Orange and Lochloosa lakes. In our opinion, either the "Existing Conditions" alternative or the "Remove Newnans Lake Weir" alternative should be considered for implementation. However, there are two additional alternatives that have relatively small wetland losses: "Fixed Crest Weir around Orange Lake Sinkholes, 54 ft" and "Fixed Crest Weir around Orange Lake Sinkholes, 55 ft." More specialized study is required to assess the environmental impacts of these two alternatives to determine impacts to nutrient loading of the lakes and potential hydrogeological impacts to the subterranean geology and the Floridan aquifer system. These alternatives have little effect on access to the lakes.

The remaining 18 alternatives have one or more of the following characteristics:

- Minimal hydrologic effects
- Significant wetland losses
- Detrimental hydrological effects in other subbasins in OCB
- Potential hydrogeologic impacts

The alternatives impacting Paynes Prairie are

- "Complete Diversion of Prairie Creek Flow to Orange Lake"
- "Reduction in Paynes Prairie Inflow/Outflow Structure Capacity by 50%"
- "Lake Level Threshold Management of the Camps Canal Structure"

The alternatives impacting Orange and Lochloosa lakes are

- "Complete Restoration of Prairie Creek Flow to Paynes Prairie"
- "Fill Low-Flow Notch in Orange Lake Weir"
- "Remove Orange Lake Weir"
- "Dredge Cross Creek 3 ft"
- "Plug Orange Lake Sinkholes 50%"
- "Plug Orange Lake Sinkholes 100%"

- "Fixed Crest Weir around Orange Lake Sinkholes, 56 ft"
- "Gated Weir around Orange Lake Sinkholes, Gates Closed at 54 ft, Opened at 58 ft"
- "Gated Weir around Orange Lake Sinkholes, Gates Closed at 55 ft, Opened at 58 ft"
- "Gated Weir around Orange Lake Sinkholes, Gates Closed at 56 ft, Opened at 58 ft"
- "Fixed Crest Weir around Orange Lake Sinkholes at 55 ft, Remove Orange Lake Weir"
- "Plug Orange Lake Sinkholes 50%, Remove Orange Lake Weir"
- "Plug Orange Lake Sinkholes 100%, Remove Orange Lake Weir"
- "Complete Restoration of Prairie Creek Flow to Paynes Prairie, Plug Sinkholes 50%, Remove Orange Lake Weir"
- "Complete Restoration of Prairie Creek Flow to Paynes Prairie, Plug Sinkholes 100%, Remove Orange Lake Weir"

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INTRODUCTION

The Orange Creek Basin (OCB), located in north-central Florida (Figures 1 and 2), is part of the lower Ocklawaha River watershed. Orange Lake, Lochloosa Lake, and Newnans Lake are the major surface waters within OCB; Paynes Prairie is also part of OCB (Figure 3). These areas are recognized for their considerable ecologic and economic significance. Paynes Prairie, Orange Lake, and Lochloosa Lake have been designated as Outstanding Florida Waters. OCB supports a diverse and productive wildlife community, including reproducing populations of many threatened and endangered species. Economic and recreational values center around the reputation of the major lakes for excellent sportfishing. Paynes Prairie State Preserve is an area for passive recreation. OCB has traditionally attracted many sportsmen, naturalists, and tourists annually. Paynes Prairie State Preserve is registered as a National Natural Landmark by the U.S. Department of the Interior. In addition, Cross Creek and the Marjorie Kinnan Rawlings State Historic Site are important cultural and historical resources.

During the past several decades, concerns developed regarding both the ecology and the economics of OCB. Drought-induced low water levels, stabilization of water levels through the construction of weirs, excessive growth of aquatic plants (primarily hydrilla, *Hydrilla verticillata*), water quality degradation, and increased accumulation of sediments are problems that have been addressed in scientific studies (Gottgens and Montague 1987a, 1987b, 1988). Recreational fishing declined throughout OCB, probably because of drought-induced low lake levels and reduced lake access.

Hydraulic alterations to OCB, in an attempt to exploit the water resources, changed the natural hydrology of the lakes and Paynes Prairie and are suspected causes of ecological degradation. A canal (Camps Canal) was constructed in the 1920s to divert water from Paynes Prairie to Orange Lake. Weirs placed at lake outlets reduced seasonal water level fluctuations. The shallow depth of the lakes and the small elevation gradients in OCB suggest that a reduction in

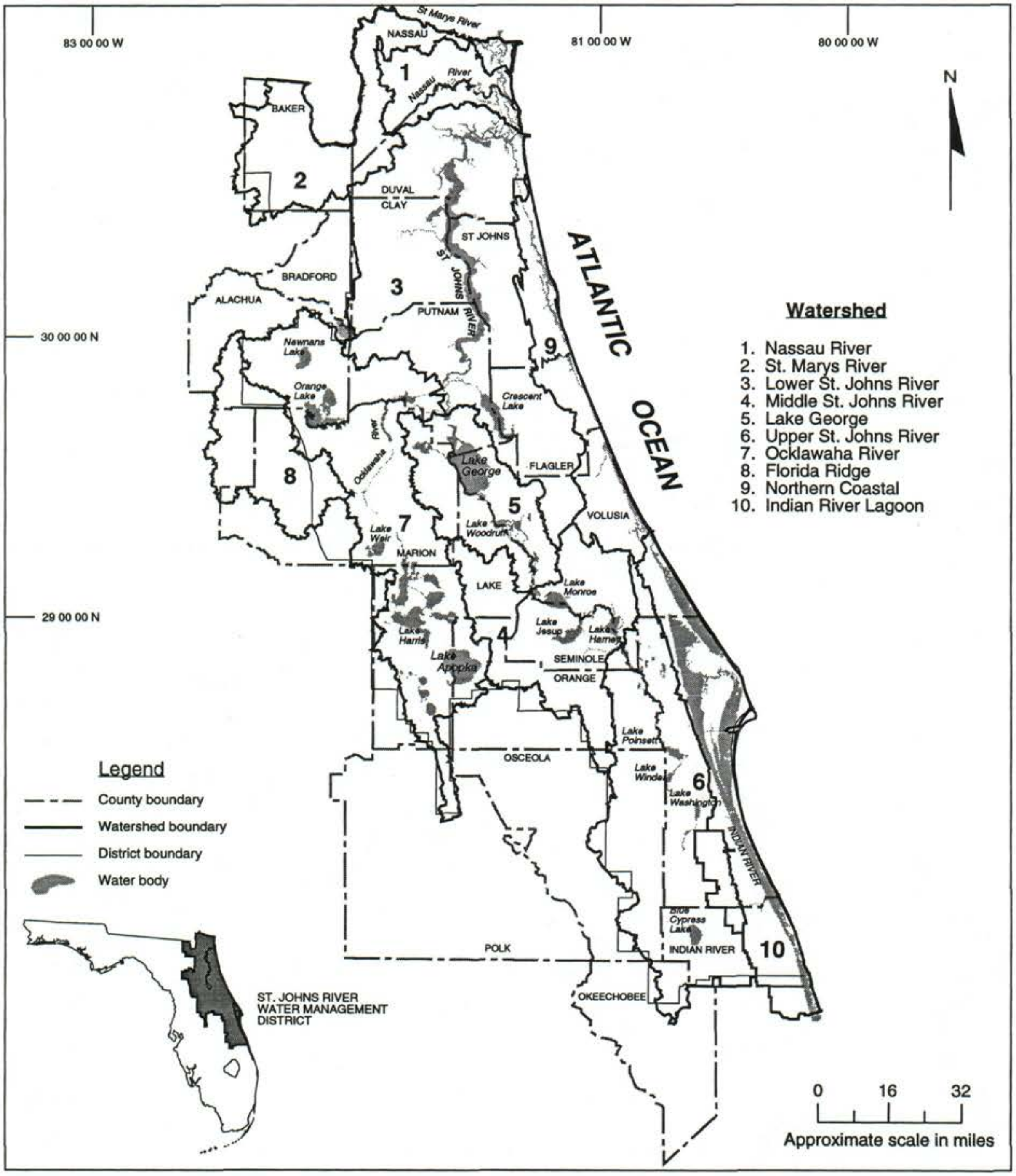

Figure 1. Major watersheds of the St. Johns River Water Management District

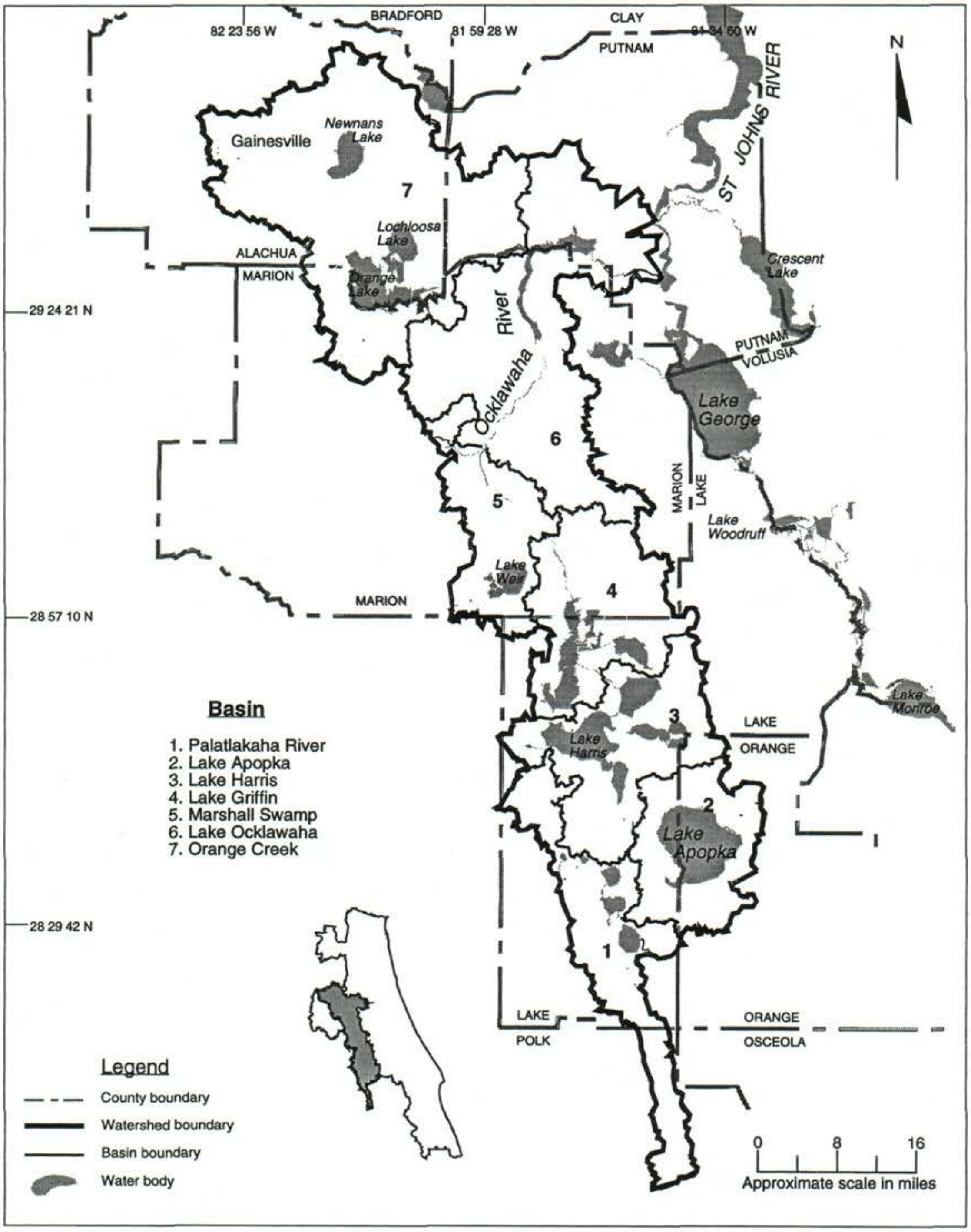

Figure 2. Basins within the Ocklawaha River watershed

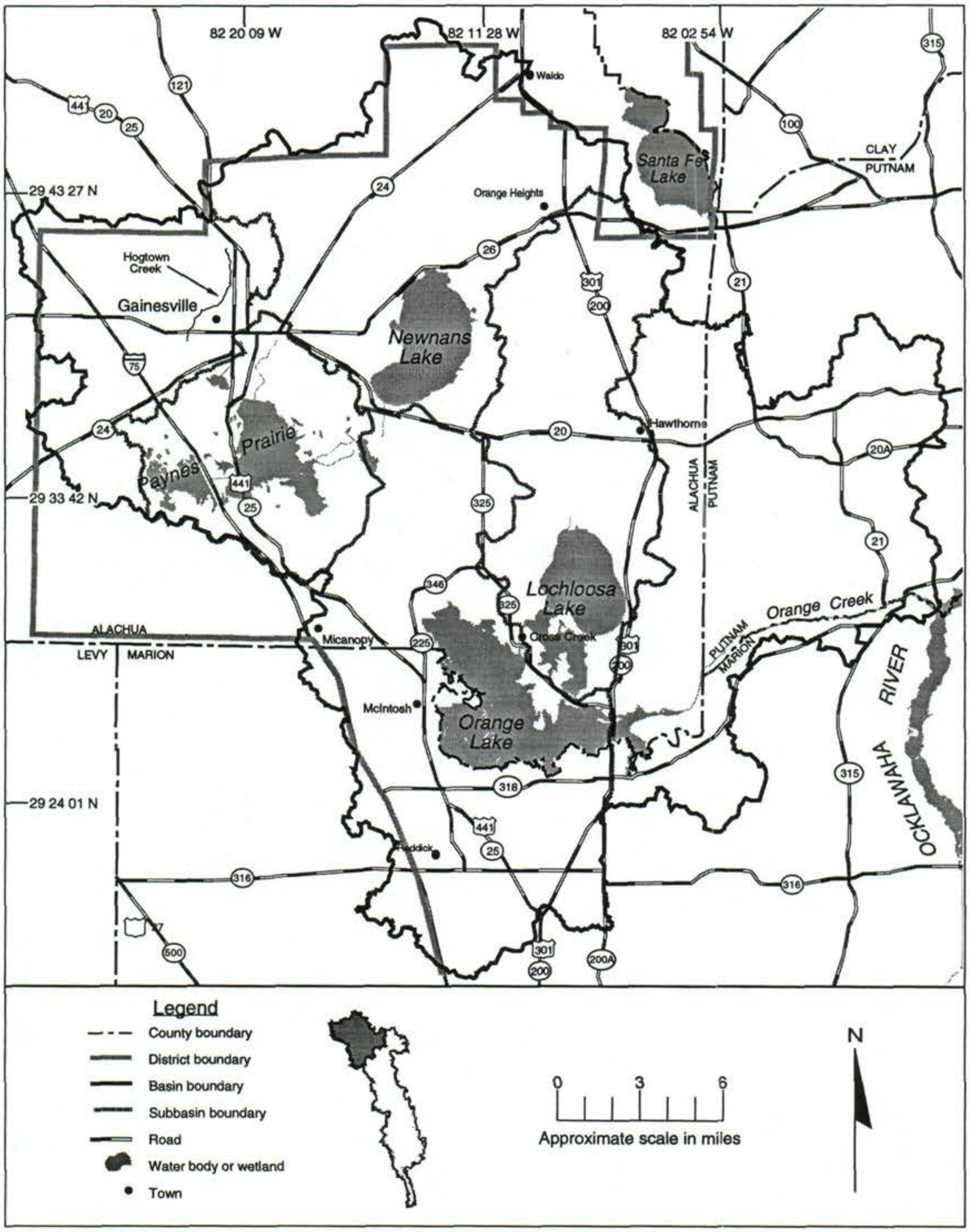

Figure 3. Orange Creek Basin, lower Ocklawha River watershed

water level fluctuation has long-term negative consequences for the lake ecosystems (Gottgens and Montague 1987b).

A case in point is Newnans Lake. Twenty years of lake level stabilization have had a pronounced effect on the lake ecology. Vaughn (1972) compared pre- and post-weir fish populations in Newnans Lake. He noted an increase in the post-weir standing crop of fish, but a stabilization of the bass population, and concluded that the changes in the fish community followed the classic pattern of a lake affected by accelerated eutrophication. These changes appear to be related to increased accumulation of flocculent sediments in spawning areas, resulting in part from lake level stabilization. Since construction of the weir, concentrations of nutrients (nitrogen and phosphorus) have increased in sediments (Gottgens and Crisman 1993). At the same time, bulk densities of lake bottom sediments have decreased. Sediments are becoming more unconsolidated and are easily resuspended, thus increasing nutrient concentrations and biological oxygen demands in the water column (Gottgens and Crisman 1993).

Weirs and dams can reduce the hydraulic flushing of lakes, thereby increasing the rates of accumulation of organic detritus and unconsolidated sediments. Gottgens and Montague (1987b) postulated that sediment accumulation caused the disappearance of a true deep open-water area in Orange Lake, as average water column depth decreased and hydrilla invasion increased. In addition, attenuated water level fluctuations could have reduced wetland habitat and reduced waterfowl and wading bird populations that are dependent on naturally fluctuating water levels (Kadlec 1962; Harris and Marshall 1963). Seasonal fluctuations in lake water levels also have a significant impact on nutrient cycling and play an important role in periodic rejuvenation of these aquatic systems.

The St. Johns River Water Management District (SJRWMD) initiated a study to evaluate the ecological effects of different surface water management alternatives for OCB in response to these environmental issues and additional surface water management concerns expressed by state and local governments and citizen groups (Table 1). This report documents the development of the biohydrologic criteria and

Table 1. Summary of major surface water management issues in the Orange Creek Basin

Location	Issue(s)
Newnans Lake	Degradation of floodplain wetlands and in-lake resources
Paynes Prairie	Optimization of wetland restoration and management
	Water levels in relation to U.S. 441
	Impacts of the restoration of surface water flow to Paynes Prairie on water levels in Orange and Lochloosa lakes
	Effects of Sweetwater Branch inflows to the prairie ecology
Orange Lake sinkhole area	Effects on lake water levels and recreational access
	Effects of water levels on floodplain wetland communities and in-lake aquatic resources
Orange Lake weir	Effects of water levels on floodplain wetland communities and in-lake aquatic resources
	Effects on recreational access
Cross Creek	Effects of dredging on floodplain wetland communities and in-lake aquatic resources
	Effects of dredging on recreational access

methods used to evaluate the water management alternatives. This study had five objectives:

- To evaluate the surface water hydrology of the watershed based on a hydrologic model for each lake and Paynes Prairie
- To develop biohydrologic criteria for water levels to evaluate the restoration and conservation potential of alternative surface water management plans
- To develop alternative surface water management plans and to evaluate each with respect to the biohydrologic criteria
- To assess the water management alternatives from the perspectives of hydrology and wetland ecology

- To identify those water management alternatives that require more specialized study (e.g., hydrogeologic, ecologic, or economic studies)

ORANGE CREEK BASIN

OCB covers approximately 600 square miles (mi^2) in Alachua, Putnam, and Marion counties. Orange Creek is a major tributary of the lower Ocklawaha River, which ultimately flows to the St. Johns River (Figures 2 and 3). This section includes a discussion of the following:

- Physiography
- Soils
- Land use
- Drainage subbasins
- Water control structures
- Chronology of important management events

PHYSIOGRAPHY

OCB is generally located within the Central Lowlands topographic region, described as an area of karst topography characterized by shallow, flat-bottomed lakes; level prairies; irregular drainage patterns; sinkholes; and other solution features (Sellards 1910). The geomorphology of OCB is dominated by the Hawthorn Group, a marine deposit of Miocene age (25 million years ago). This formation is relatively impermeable compared with the underlying Ocala Limestone Formation, and it is the main confining layer in this region. It consists of phosphate-rich sands, clays, and limestones that are exposed in the central and eastern parts of OCB (Pirkle and Brooks 1959). The underlying Ocala Limestone Formation consists of porous and permeable limestones of Eocene age (60 million years ago), characterized by solution caverns and underground streams. The Ocala Limestone Formation constitutes the main part of the Floridan aquifer system, and its erosional structure dictates the regional surface relief. Outcrops of this formation are exposed at the southern parts of OCB. Both of these formations are highly eroded and mineralized within the region. As a result, the lakes, wetlands, and many upland areas in OCB are naturally nutrient enriched and highly productive.

OCB can be divided into two major land features, a northern upland plateau, which includes most of northeastern Alachua County, and a central and southern transitional area, which includes the lake subbasins and the Paynes Prairie subbasin (Sellards 1910; White 1970). The upland plateau, located north of the City of Gainesville, is nearly level, sloping gently to the west, north, and east. Elevations range from 135 to 180 feet (ft) above sea level. In this plateau region, the Floridan aquifer system is confined where it is overlain by the Hawthorn Group, but artesian conditions do exist. Natural ground water discharges occur where the confining layer is thin or absent, such as at Iron and Magnesia springs to the north of Lochloosa Lake. The central and southern transition area is characterized by flat-bottomed lakes, prairies, small streams, and erosional remnants of the plateau. The elevations are typically at or below 65 ft above sea level, and the piezometric surface of the Ocala Limestone Formation generally corresponds with the level of depressions and lakes (Pirkle and Brooks 1959).

SOILS

Surface soils of the region are nearly level to strongly sloping. The U.S. Department of Agriculture, Soil Conservation Service (SCS 1979, 1985, 1990), identified 13 general soil associations within OCB (Table 2). Drainage characteristics vary from well-drained, droughty soils of uplands to poorly drained, often flooded soils associated with creeks, lakes, and wetlands (Table 2, Figure 4).

Excessively drained soils of strongly sloping to nearly level upland areas (Soil Association 1, Table 2) and well-drained, nearly level to sloping upland soils (Soil Associations 2–6, Table 2) are generally confined to sand ridges in the west-central portion of OCB. Collectively these soils comprise approximately 37% of the watershed area. The majority of the watershed, approximately 44%, has soils that are characterized as moderately to poorly drained and not subject to flooding (Soil Associations 7–10, Table 2). Soils characterized as poorly drained to very poorly drained and subject to flooding dominate flatwoods areas, Paynes Prairie, depressional wetlands, and the floodplain area of lakes and streams (Soil Associations 11–13, Table 2).

Table 2. Major soil associations of the Orange Creek Basin: drainage characteristics and percentage of basin area

Soil Drainage Characteristics and Soil Associations (1–13)	Percent of Basin Area*
Excessively drained, nearly level to strongly sloping soils of the uplands	6
1. Candler-Apopka	
Well-drained, nearly level to sloping soils of uplands	31
2. Arredondo-Gainesville-Millhopper	
3. Kendrick-Arredondo-Bonneau	
4. Arredondo-Jonesville-Lake	
5. Millhopper-Bonneau-Arredondo	
6. Blichton-Lochloosa-Bivans	
Moderately well-drained to somewhat poorly drained, nearly level to sloping soils of uplands and flatwoods	44
7. Millhopper-Lochloosa-Sparr	
8. Chipley-Tavares-Sparr	
9. Pelham-Mulat	
10. Pomona-Wauchula-Newnan	
Poorly drained to very poorly drained soils of flatwoods and floodplains	14
11. Monteocha-Surrency	
12. Ledwith-Wauberg	
13. Shenks-Terra Ceia-Okeechobee	

*Approximately 5% of the basin is open water

Source: SCS 1979, 1985, 1990

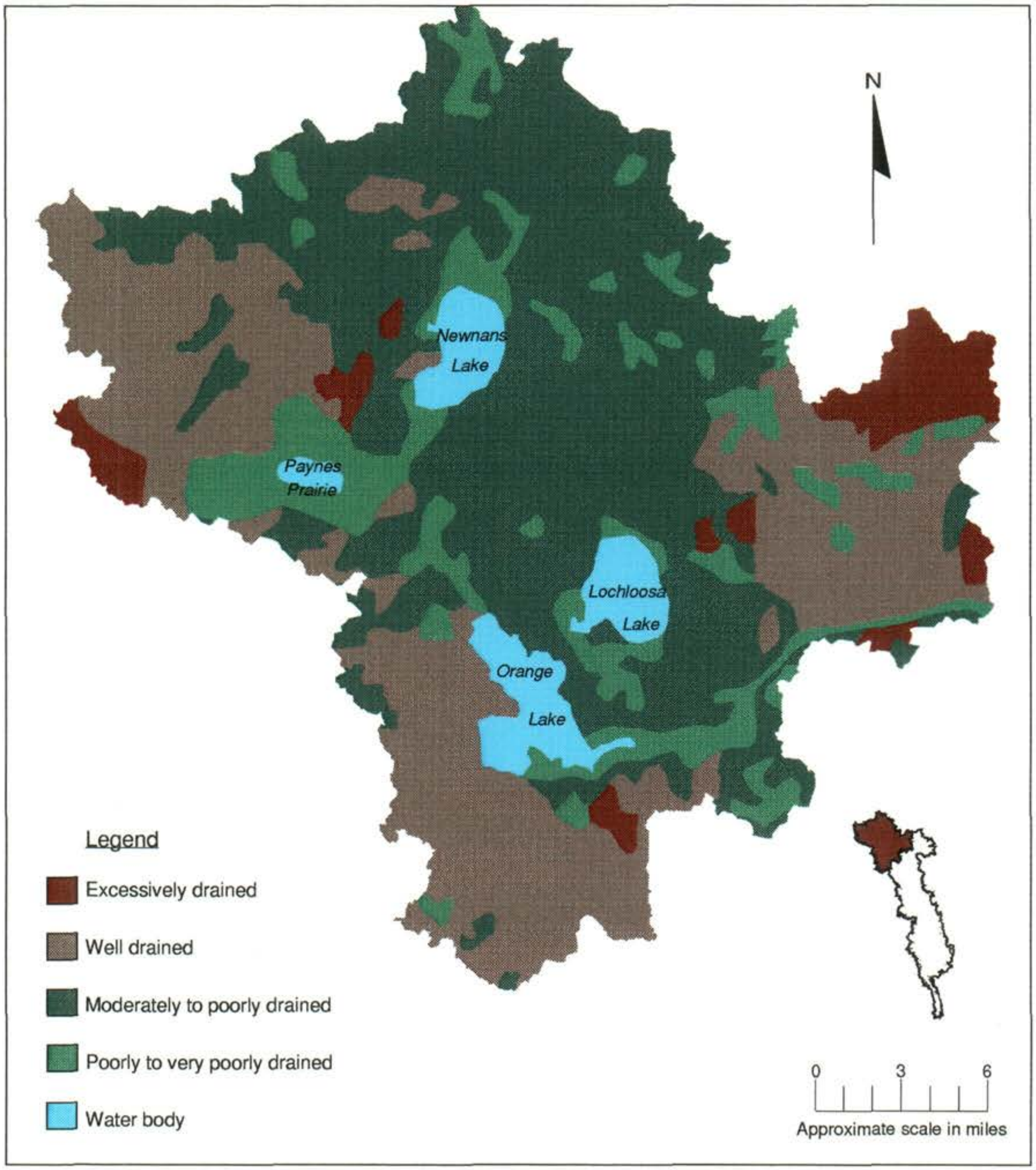

Figure 4. Major soil associations of the Orange Creek Basin (modified from SCS 1979, 1985, 1990)

LAND USE

OCB is primarily rural with the most prevalent land uses including upland forests (40%), wetlands and open water (27%), agriculture and rangeland (17%), and urban development (14%) (Table 3, Figure 5). Commercial pineland plantations and mixed hardwood

Table 3. Summary of major land uses within the Orange Creek Basin

Code	Classification	Newnans Lake Subbasin	Paynes Prairie Subbasin	Orange Lake Subbasin	Lochloosa Lake Subbasin	Hogtown Creek Subbasin	Orange Creek Subbasin	Basin Total
1000	Urban	7,600 (10)	7,371 (18)	7,580 (9)	2,740 (5)	15,681 (56)	11,637 (13)	52,609 (14)
2000	Agriculture	4,397 (6)	5,787 (14)	27,408 (34)	6,143 (11)	2,320 (8)	13,130 (15)	59,185 (16)
3000	Rangeland	1,235 (2)	312 (<1)	536 (<1)	455 (1)	260 (1)	660 (<1)	3,458 (1)
4000	Upland forest	39,952 (55)	11,748 (29)	22,759 (28)	28,181 (51)	7,315 (26)	37,306 (42)	147,261 (40)
5000	Open water	6,086 (8)	746 (2)	7,066 (9)	5,843 (11)	249 (1)	4,283 (5)	24,273 (7)
6000	Wetlands	12,632 (17)	14,504 (35)	15,232 (19)	11,345 (21)	1,505 (5)	21,417 (24)	76,635 (20)
7000	Barren land	0	20 (<1)	44 (<1)	11 (<1)	64 (<1)	173 (<1)	312 (<1)
8000	Transportation	1,432 (2)	665 (2)	622 (1)	421 (<1)	609 (2)	156 (<1)	3,905 (1)
Total		73,334 (20)	41,153 (11)	81,247 (22)	55,139 (15)	28,003 (8)	88,762 (24)	367,638 (100)

Note: All units are acres; values in parentheses are percentages

forests dominate the upland plant communities. Vast natural pinelands and mixed hardwood and cypress swamps occur on wetter soils. Extensive urban development occurs in the western portion of OCB (Figures 3 and 5), associated with the City of Gainesville. Lower density development occurs in the eastern and southern regions of OCB. Many smaller towns are located within the watershed, including Micanopy, Hawthorne, Waldo, Reddick, and McIntosh. Open surface water, primarily associated with the major lakes of OCB, accounts for approximately 7% of the surface area. Agriculture is the predominant land use in the southern region of OCB.

The Paynes Prairie subbasin is unique in that significant areas are in contrasting land uses. Approximately 18,000 acres (44%) of the subbasin area is contained in the Paynes Prairie State Preserve, one of the largest contiguous wetlands in the Southeast. Urban development, about 18% of the subbasin area, is expanding and has created conflicting surface water management objectives.

DRAINAGE SUBBASINS

The study area is divided into six surface water subbasins: Orange Lake, Lochloosa Lake, Paynes Prairie, Newnans Lake, Orange Creek, and Hogtown Creek. With the exception of the Hogtown Creek and Paynes Prairie subbasins, which are closed watersheds, all the subbasins contribute runoff to Orange Creek, which is a tributary of the Ocklawaha River. The direction of flow within the watershed is from Newnans Lake into Paynes Prairie and Orange Lake, from Lochloosa Lake into Orange Lake, and from Orange Lake into Orange Creek (Figure 3). The major hydrologic features of each lake subbasin and the Paynes Prairie subbasin follow.

The Hogtown Creek subbasin is not discussed further because it has no surface water connection to OCB proper.

Newnans Lake Subbasin

The Newnans Lake subbasin (Figure 6) covers approximately 114 mi^2. The main sources of inflow to Newnans Lake are Hatchet Creek and Little Hatchet Creek. Hatchet Creek has many tributaries and drains large areas of undeveloped land such as Buck Bay, the Austin Cary Memorial Forest, and Saluda Swamp, to the northeast and northwest of Newnans Lake. Little Hatchet Creek discharges into Newnans Lake through Gum Root Swamp. It drains rural lands

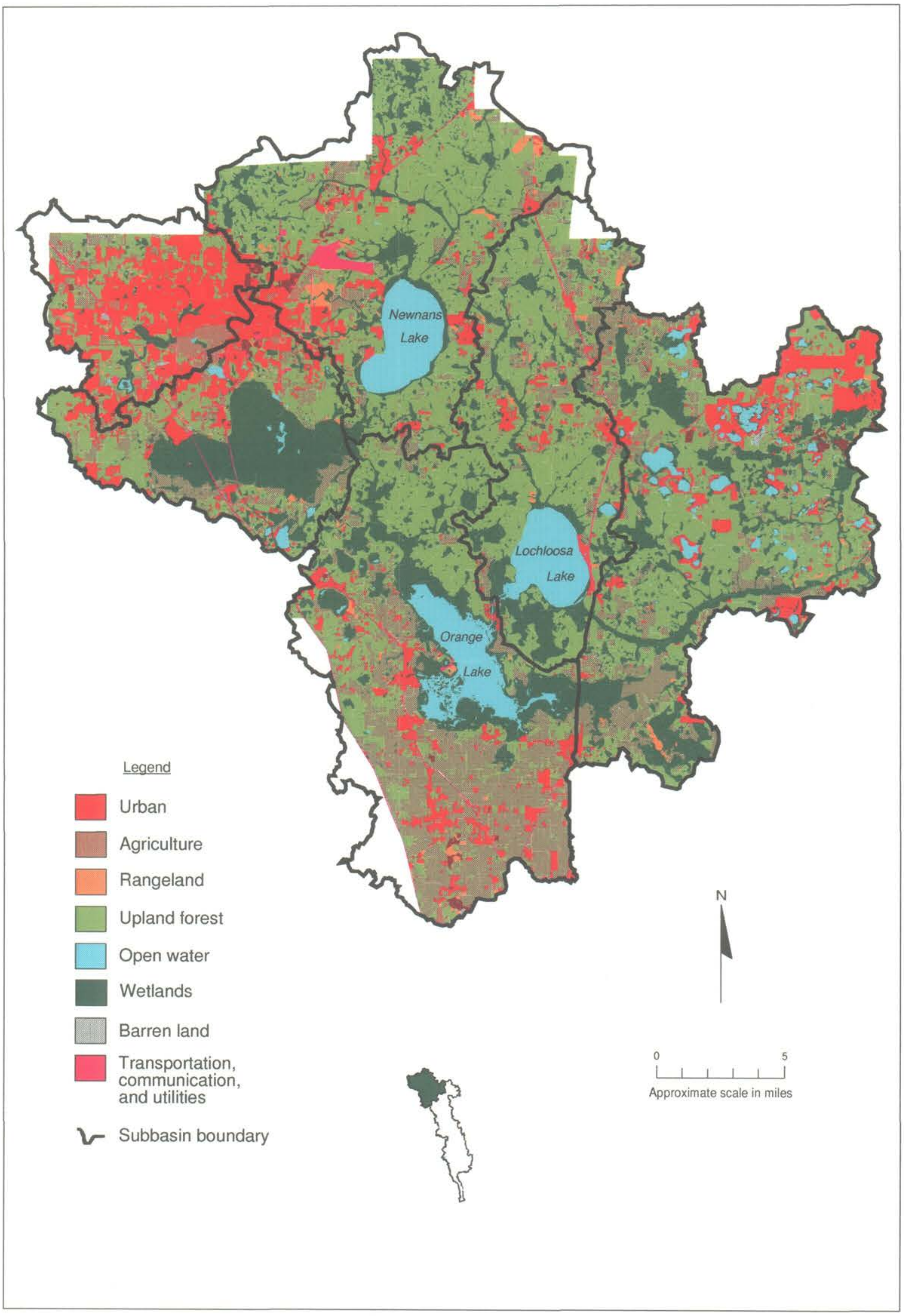

Figure 5. Major land uses within the Orange Creek Basin

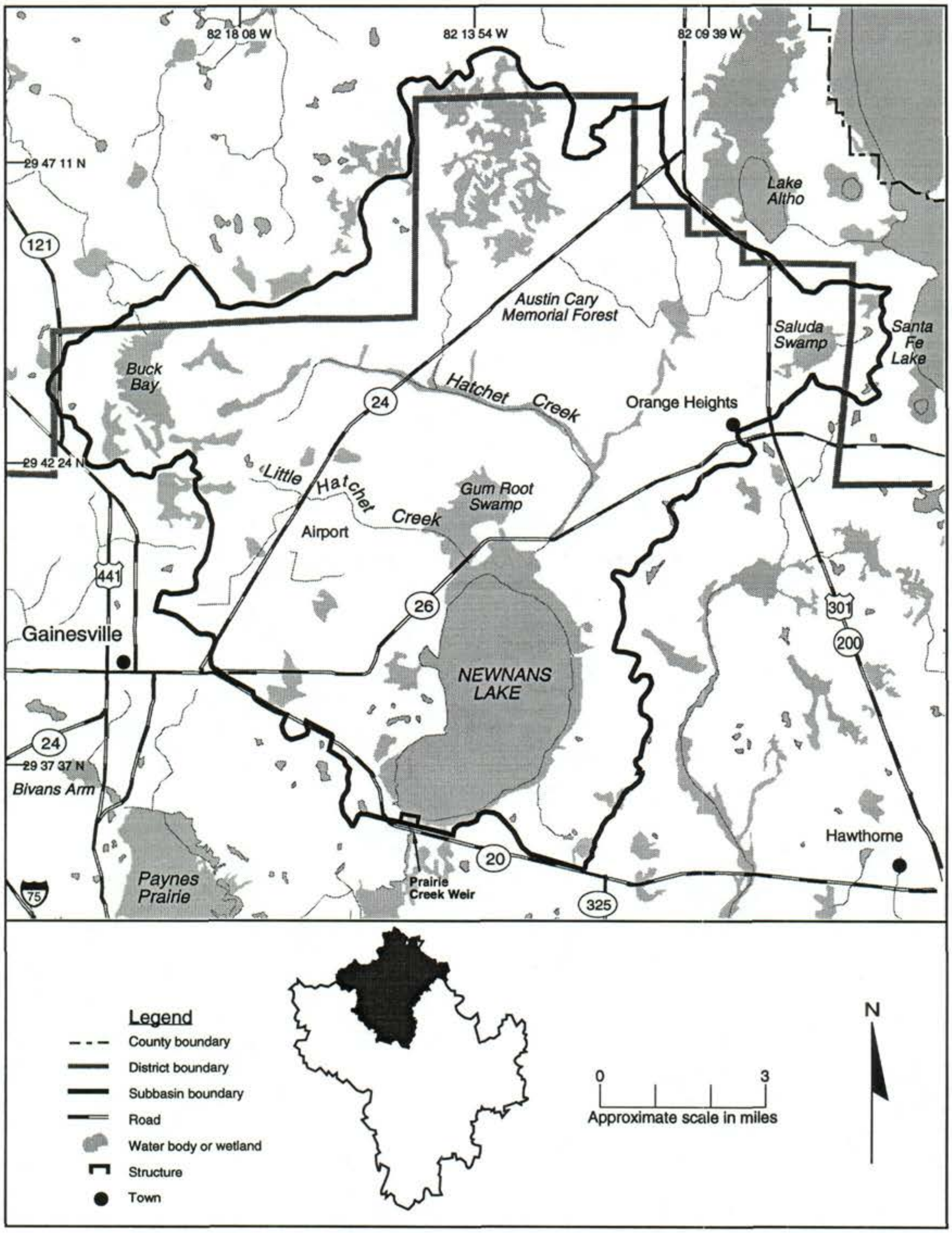

Figure 6. Newnans Lake subbasin

to the north and east of the City of Gainesville and receives runoff from portions of northeast Gainesville, including the regional airport.

Paynes Prairie Subbasin

The Paynes Prairie subbasin (Figure 7) covers an area of approximately 56 mi^2. A large part of the subbasin lies within the Paynes Prairie State Preserve, an area managed by the Florida Department of Environmental Protection (FDEP) to restore and maintain the water resources as representative of Florida's original natural systems.

Paynes Prairie receives runoff from areas of the City of Gainesville which have little stormwater storage and, therefore, high peak discharges and poor water quality. Sweetwater Branch, the only major creek within the subbasin (Figure 7), drains approximately 3 mi^2 of eastern Gainesville, including treated effluent from the Gainesville Main Street Sewage Treatment Plant. An earthen levee segregates runoff from the creek to a small area of Paynes Prairie before discharging into Alachua Sink. Boulware Springs is also within the Paynes Prairie subbasin; however, its discharges are also segregated by the Sweetwater Branch levee. Bivans Arm, a small surface water inflow to Paynes Prairie, drains urbanized areas to the south and southeast of Gainesville.

Additional surface water inflows enter Paynes Prairie from Prairie Creek through gated culverts controlled by FDEP (Figure 7). This structure conveys only a portion of the flow from Prairie Creek. Historically, all the flow from Prairie Creek meandered across the prairie before discharging into Alachua Sink. In the 1920s, Camps Canal was constructed to dewater Paynes Prairie for conversion to rangeland. FDEP restored partial flows from Prairie Creek to Paynes Prairie during 1975 by breaching Camps Canal levee at the point where Prairie Creek originally entered Paynes Prairie.

Alachua Sink, a natural sinkhole located on the northeastern boundary of Paynes Prairie (Figure 7), is the only drainage outlet for this subbasin. It receives inflow from Paynes Prairie, Boulware Springs, and Sweetwater Branch. Discharges from Paynes Prairie to

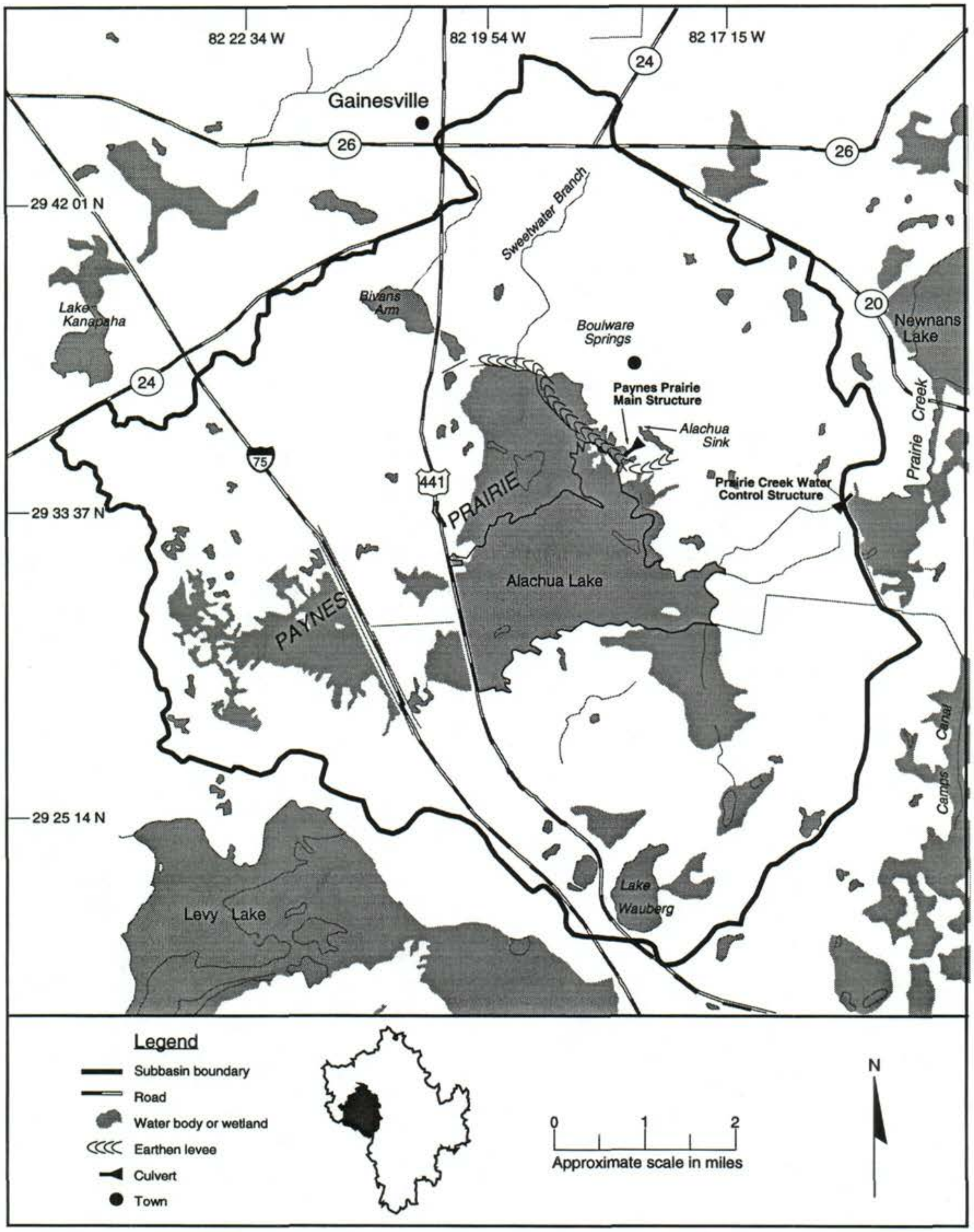

Figure 7. Paynes Prairie subbasin

Alachua Sink are regulated by a gated control structure operated by FDEP.

Lochloosa Lake Subbasin

The Lochloosa Lake subbasin (Figure 8) covers an area of approximately 88 mi^2. The major drainage feature of the subbasin is Lochloosa Creek, which drains a 51-mi^2 area of rural lands to the north of the lake. Magnesia Spring discharges into the creek. A dendritic system of spring-fed streams drains flatwoods to the northeast of the lake and receives runoff from the City of Hawthorne and the area south along U.S. Highway 301 (U.S. 301). Iron Spring and Sulphur Spring in the City of Hawthorne flow into this watershed. The main outflow of the subbasin is through Cross Creek to Orange Lake. During high lake stages, Lochloosa Slough conveys flow eastward from Lochloosa Lake to the Orange Creek subbasin.

Orange Lake Subbasin

The Orange Lake subbasin (Figure 9) covers an area of approximately 141 mi^2. The main surface water inflows to the subbasin are through Cross Creek and Camps Canal, through the River Styx. These two conveyances connect the Lochloosa Lake and Newnans Lake subbasins to Orange Lake.

Historically, runoff from the River Styx, which drained swamps and sloughs north of Orange Lake, and Cross Creek were the only surface water sources to the lake. Orange Lake received additional water when Prairie Creek flow was diverted from Paynes Prairie to the lake by construction of the Camps Canal and levee system in the 1920s. FDEP restored partial flows from Prairie Creek to Paynes Prairie during 1975.

The subbasin discharges through Orange Creek to the Ocklawaha River. Additional surface water outflows are to the Floridan aquifer system through lake bottom seepage. Most of the seepage outflow probably occurs at a sinkhole area located along the southwestern shore of the lake, near the town of Orange Lake. Average seepage

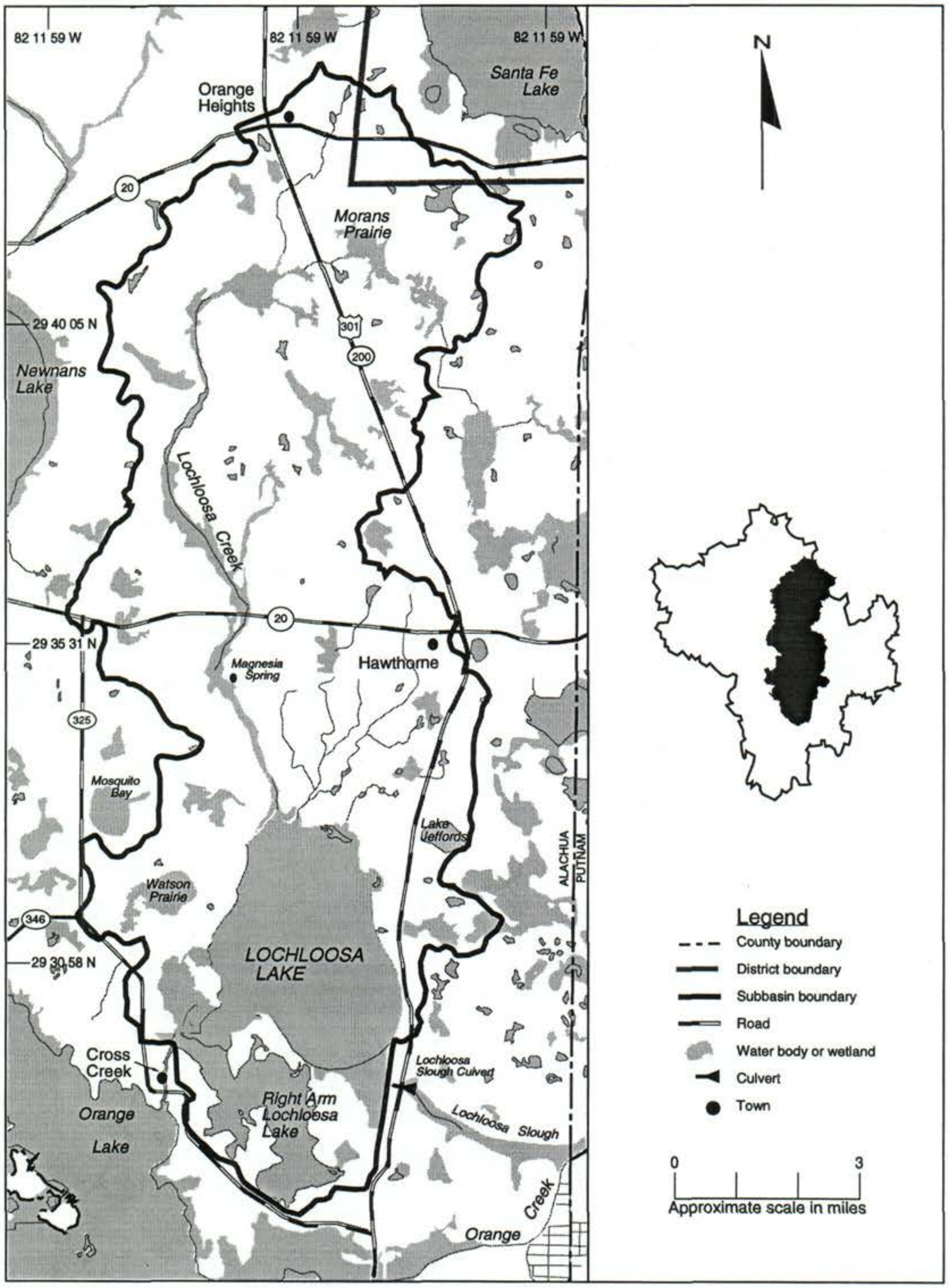

Figure 8. Lochloosa Lake subbasin

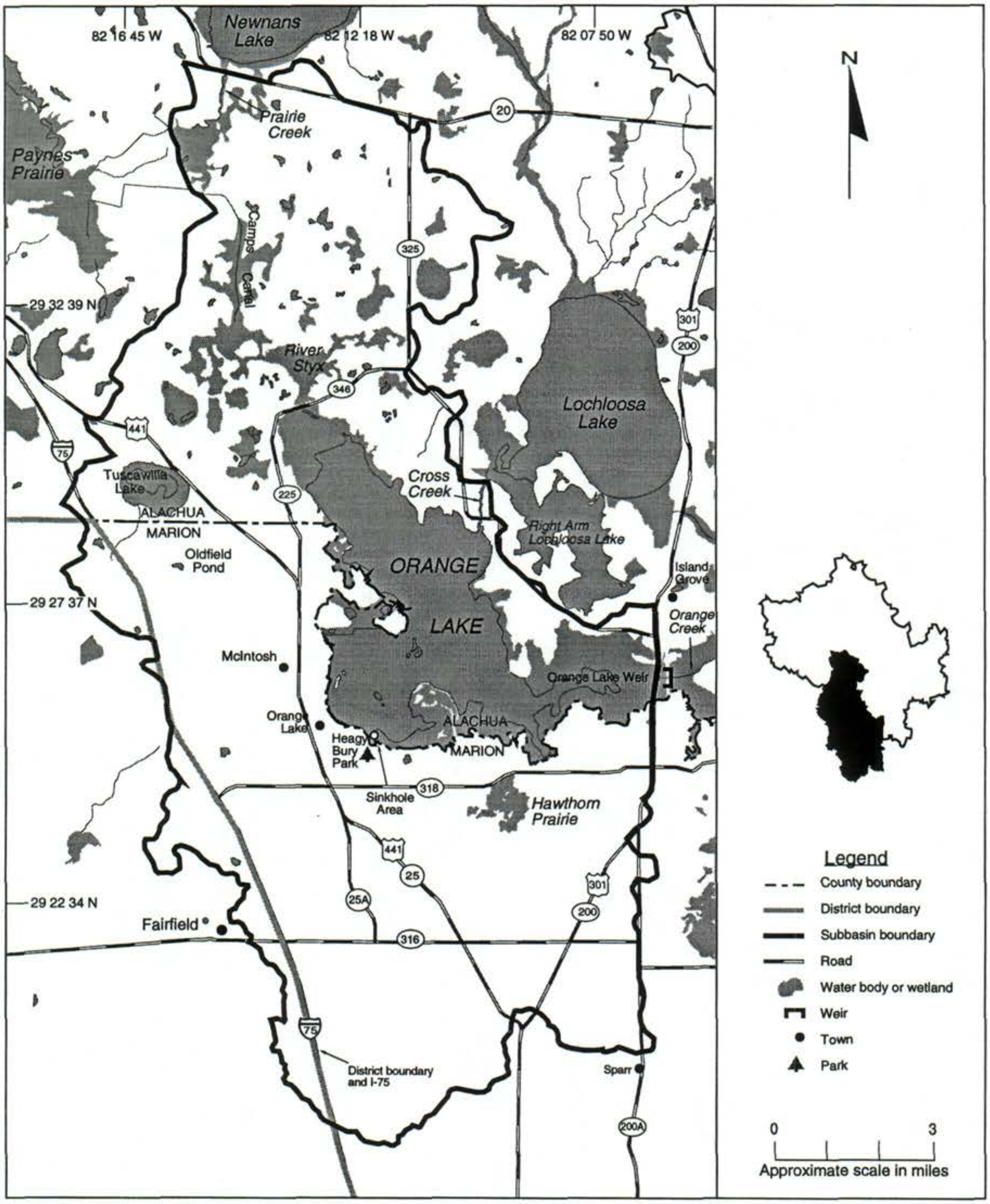

Figure 9. Orange Lake subbasin

rates for the entire lake have been estimated by SJRWMD to be 44 cubic feet per second (cfs) (28 million gallons per day [mgd]). The Center for Aquatic Plants at the University of Florida estimated seepage flows through the sinkhole area at 37 cfs from direct flow measurements taken on 12 November 1992. Roland (1957) gave a detailed account of the sinkhole area and of searches for other sinkholes within Orange Lake. Local property owners attempted to curtail the seepage loss by sandbagging and plugging the sinkhole area with debris during the 1950s and 1960s (Jessen 1972). These actions appear to have had only short-term influences.

Orange Creek Subbasin

The Orange Creek subbasin (Figure 10) has a drainage area of approximately 139 mi^2. The major drainage feature of this subbasin is Orange Creek. The creek provides the sole drainage outlet for all the other subbasins and connects them to Rodman Reservoir, east of the town of Orange Springs. Orange Creek has only two main tributaries, Lochloosa Slough and Little Orange Creek. Lochloosa Slough, a cypress-mixed swamp depression, drains lands to the southeast of Lochloosa Lake and provides an overflow outlet for the lake when the lake stage exceeds approximately 57.5 ft. Little Orange Creek drains lands in the extreme eastern portion of the subbasin and discharges to Orange Creek approximately 1 mile upstream of the confluence of Orange Creek and Rodman Reservoir.

WATER CONTROL STRUCTURES

There are five principal water control structures within the watershed. A fixed crest weir is located at the outlet of Orange Lake, Newnans Lake has an adjustable weir, and gated culverts control water flow at the Prairie Creek structure and the Alachua Sink within Paynes Prairie (Figures 6, 7, and 9). A box culvert controls water flow from Lochloosa Lake to Orange Creek through Lochloosa Slough at high lake levels (Figure 8).

The Orange Lake weir was constructed at the U.S. 301 bridge crossing in 1963, under authority of the Alachua County Recreation and Water Conservation and Control Authority (ACRWCCA). This

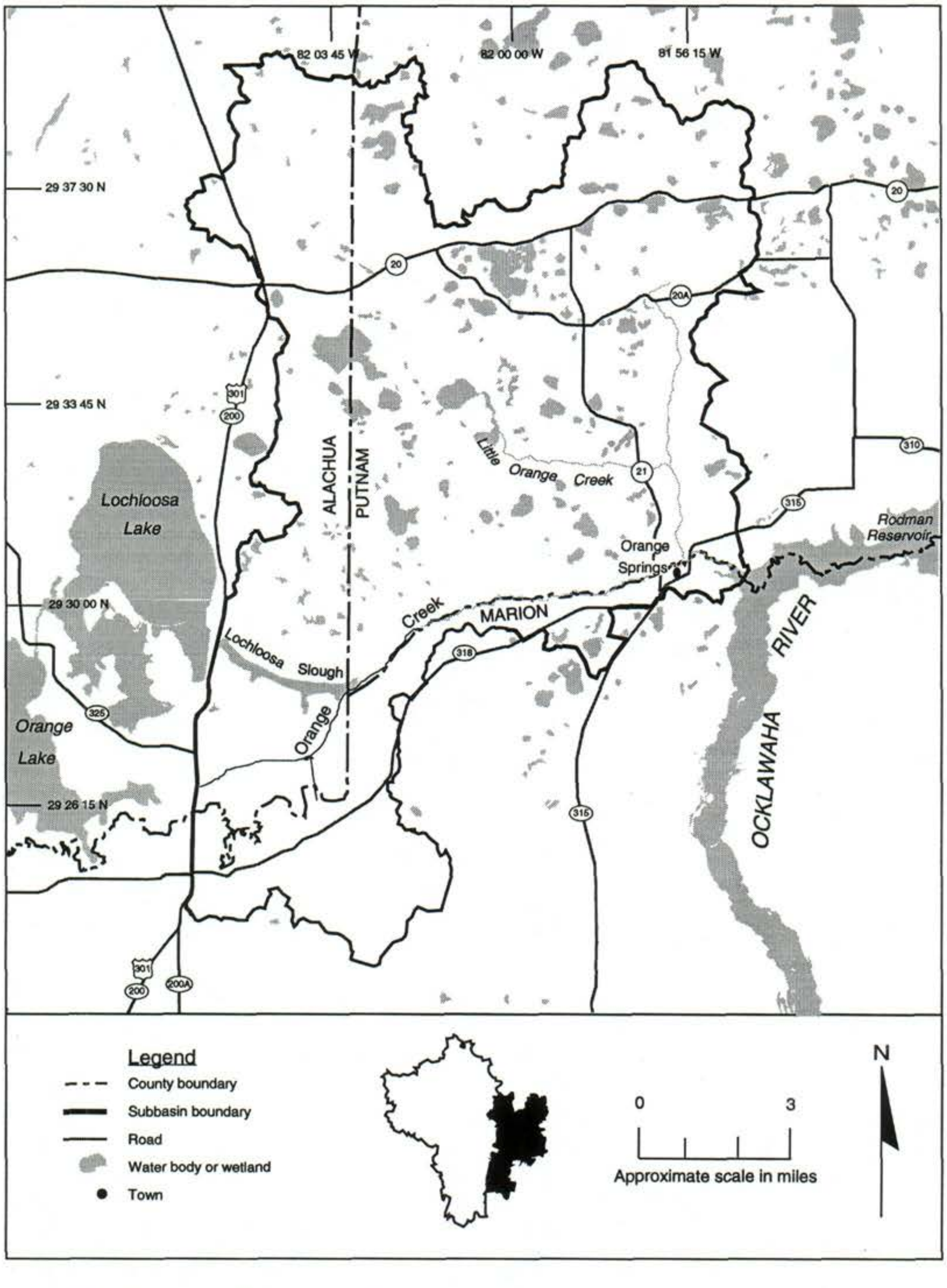

Figure 10. Orange Creek subbasin

structure was intended to prevent the recurrence of the low lake levels prevalent in the mid-1950s. The weir is constructed of 24-inch (in.)-thick, concrete-filled sheetpiles with a fixed crest elevation of 58 ft. A small discharge notch constructed in the center of the weir allowed downstream flows when lake levels exceeded 55.5 ft. The low-flow notch was illegally filled with concrete during 1990. ACRWCCA authorized the construction of a control weir at the outlet to Newnans Lake in 1966. In 1976, the Florida Game and Fresh Water Fish Commission (FGFWFC) was given authority to operate this structure. FGFWFC modified the weir to allow the crest height to be adjusted using stoplogs. The crest of the weir is at an elevation of 66.8 ft.

During the early 1970s, the State of Florida purchased Camps Ranch to restore Paynes Prairie, and FDEP began restoration efforts. A gated culvert structure was constructed at the inlet of Alachua Sink to control water levels in Paynes Prairie. In 1975, flow from Prairie Creek to Paynes Prairie was partially restored by breaching the Camps Canal levee. FDEP installed flashboard culverts in the levee breach in 1979; the culverts were renovated and control gates added in 1988.

Many excavated channels and drainage canal systems have been constructed within OCB. Camps Canal is perhaps the most notable. The original purpose of this canal was to dewater Paynes Prairie to create rangeland. This canal system was constructed during the 1920s and diverted the flow of Prairie Creek from Paynes Prairie into the River Styx (Figure 9). In addition, canals and levees were constructed within Paynes Prairie to convey runoff to the Alachua Sink and to a currently inactive pump station that discharged to Camps Canal. These levees and canals continue to artificially divide the prairie into drainage basins and interrupt the natural flow patterns and sheetflow.

Chronology of Important Management Events

In OCB, there is a long history of events that lead to the existing issues and problems. A chronology of water resource-related events in OCB is shown in Table 4.

Table 4. Chronology of significant events in the study area

Year(s)	Event(s)
Pre-1871	Paynes Prairie existed as a shallow marsh/lake
1871	Alachua Sink closed naturally; Paynes Prairie became a lake
1891	Alachua Sink opened; Paynes Prairie became a shallow marsh/lake
1918	Railroad bridge constructed across outlet to Orange Lake
1920s	U.S. 301 constructed across outlet to Orange Lake
1927	Paynes Prairie dewatered to create Camps Ranch; Prairie Creek was diverted to Camps Canal and Orange Lake
	U.S. 441 completed across Paynes Prairie
1930s	Shands Dike and Shands Canal constructed downstream from Orange Lake to provide farming access
1950	Sweetwater Canal dredged
1955	Orange Lake Watershed Association organized to address low water levels in Orange Lake
1957	Attempt to isolate sinkhole area in Orange Lake made by building a berm between the sinkhole area and the rest of the lake
	ACRWCCA created to study and implement lake level stabilization; replaced Orange Lake Watershed Association
1958	Dam of earth and concrete rubble placed across Orange Lake outlet to increase water levels
1960s	U.S. 301 expanded to four lanes across outlet to Orange Lake
	U.S. 441 expanded to four lanes across Paynes Prairie
1961	Paynes Prairie established as a wildlife sanctuary
1963	Orange Lake weir constructed by ACRWCCA to increase lake levels
1964	Attempt to plug sinkholes in Orange Lake made by filling in sinkholes with debris
1964	I-75 completed across Paynes Prairie
1966	Newnans Lake weir constructed by ACRWCCA to increase water levels
Early 1970s	FDNR (now FDEP) bought Camps Ranch to restore Paynes Prairie
	Sweetwater Canal re-dredged
1974	Paynes Prairie designated as a National Natural Landmark by the U.S. Department of the Interior
1975	Flow to Paynes Prairie from Prairie Creek partially restored by breaching Camps Canal levee
1976	Newnans Lake weir altered by FGFWFC to include removable boards for lake management purposes
1979	FDEP installed flashboard riser culverts in breach in Camps Canal levee

Table 4—*Continued*

Year(s)	Event(s)
1987	Orange Lake, River Styx, Cross Creek, and Lochloosa Lake designated as Outstanding Florida Waters
1988	FDEP replaced flashboard riser culverts in Camps Canal levee with gated culverts
1989	Orange Lake Dam Task Force formed to address lake levels in Orange Lake
	Boards removed from Newnans Lake weir for 5 months to increase lake level fluctuations
1990	Newnans Lake Task Force formed to develop a lake management and restoration plan
	Low-flow notch in Orange Lake weir illegally obstructed
1991	Boards removed from Newnans Lake weir to increase lake level fluctuation
1994	SJRWMD Governing Board established Orange Creek Basin Advisory Council
	SJRWMD Governing Board passed Rule 40C 2.302, *Florida Administrative Code*: Reservation of water from use for Paynes Prairie State Preserve
1996	Orange Creek Basin Advisory Council and SJRWMD Governing Board approve the surface water management plan for Orange Creek Basin

Note: ACRWCCA = Alachua County Recreation and Water Conservation and Control Authority
FDEP = Florida Department of Environmental Protection
FDNR = Florida Department of Natural Resources
FGFWFC = Florida Game and Fresh Water Fish Commission
SJRWMD = St. Johns River Water Management District

METHODS

This section describes the surveying, hydrologic, and environmental methods used to collect data and perform various calculations and analyses during this study.

SURVEYING METHODS

Surveying methods used in this study included

- Photogrammetric aerial contour mapping of Paynes Prairie
- Hydrographic mapping of lakes
- Determination of floodplain elevation transects

Photogrammetric Aerial Contour Mapping of Paynes Prairie

One-foot contours (Figure A4, Appendix A) for the vast majority of Paynes Prairie were determined by photogrammetric methods under contract with Continental Aerial Surveys. Aerial photographs were taken at a scale of 1 in. equals 200 ft. Ground control surveys were conducted by registered land surveyors and correlated with aerial photographs. All project work was supervised by a certified photogrammetrist. Horizontal locations were referenced to the State Plane Coordinate System, Florida North Zone, North American Datum 1983 (adjustment 1990), based on final published values for the National Geodetic Survey, High-Precision Network Station FLNRC 1-1987, and Alachua County global positioning system (GPS) stations A095, A067, A061, and A092 AZ (azimuth reference station). Elevations were referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

The contours of areas not covered by the aerial photography (1%–2%) were estimated by comparison to elevations on U.S. Geological Survey (USGS) 7½-minute quadrangle maps. Elevation contours were digitized, processed, analyzed, and mapped using the ARC/INFO geographical information systems (GIS) computer software (ESRI 1993).

Hydrographic Mapping of Lakes

Hydrographic surveys of Newnans, Orange, and Lochloosa lakes (Figures A1–A3, Appendix A) were contracted to Bennett R. Wattles and Associates. The surveys were completed using a fully automated hydrographic system, which consisted of a digital fathometer, a trisponder microwave navigation system, and a data acquisition and reduction software system. Horizontal control for the establishment of the trisponder navigation network was determined using GPS receivers. Depth data were collected along tracklines spaced at 500-ft intervals. The data were edited and reduced for water elevation, corrected for squat (vertical displacement of a boat due to forward movement under power), contoured, and plotted. Elevations were referenced to NGVD 29. Horizontal locations are referenced to the state plane coordinate system for 1990 (SPCS-90), based on final published values for Alachua County GPS stations A003, A009, and A053.

Determination of Floodplain Elevation Transects

The professional survey firm Bennett R. Wattles and Associates was contracted to determine elevations on floodplain transects located at selected points on each lake (Figures 11–13). In general, these transects were (1) perpendicular to the water body, (2) relatively undisturbed, (3) representative of the general vegetative conditions of the lakes, and (4) extended from the lake or deeper marsh areas landward into definite upland areas.

The purpose of these transects was to typify the vegetative communities and the elevations over which they occur. Bennett R. Wattles and Associates used traditional survey traverse methods; land-based survey control was from existing Alachua County GPS stations A003, A005, A007, A009, A011, A053, A065, A067, and A071. Transects selected for vegetation analyses on each lake were recovered later by the SJRWMD Division of Surveying, and vertical control was verified to NGVD 29.

Elevation transects in Paynes Prairie (Figure 14) were determined by the SJRWMD Division of Surveying, using traditional survey traverse

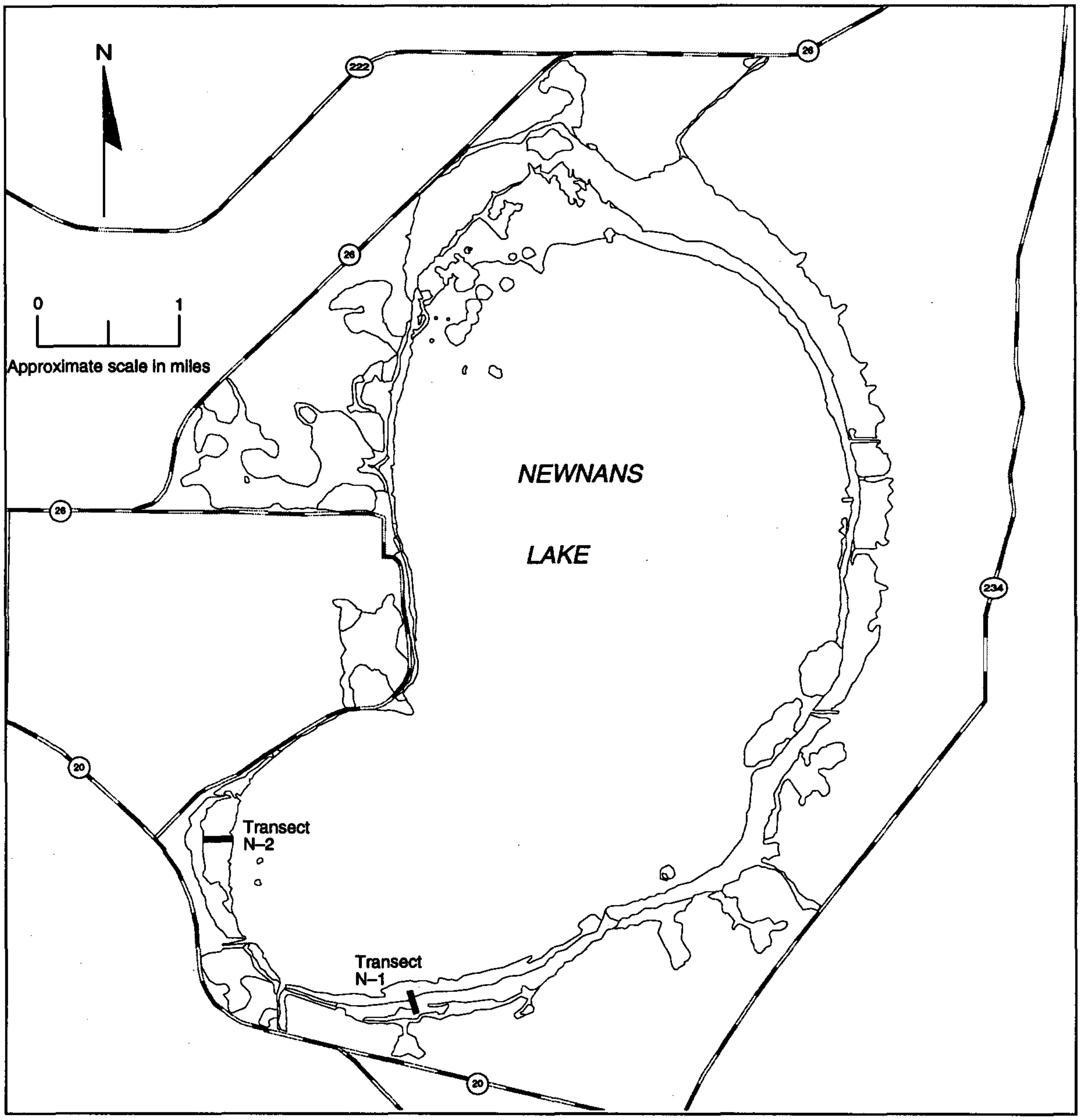

Figure 11. Location of elevation transects used to develop biohydrologic criteria for the Newnans Lake floodplain

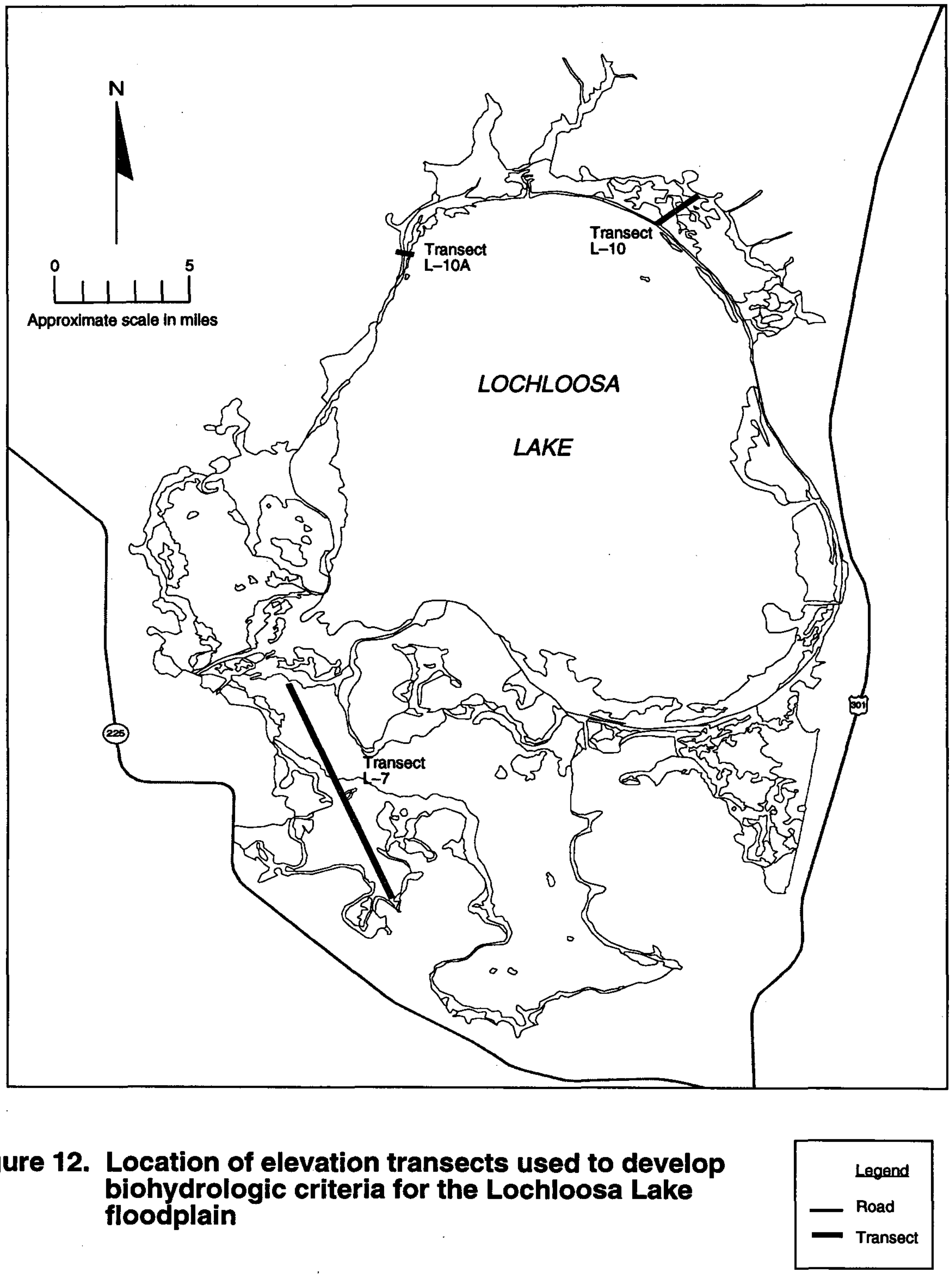

Figure 12. Location of elevation transects used to develop biohydrologic criteria for the Lochloosa Lake floodplain

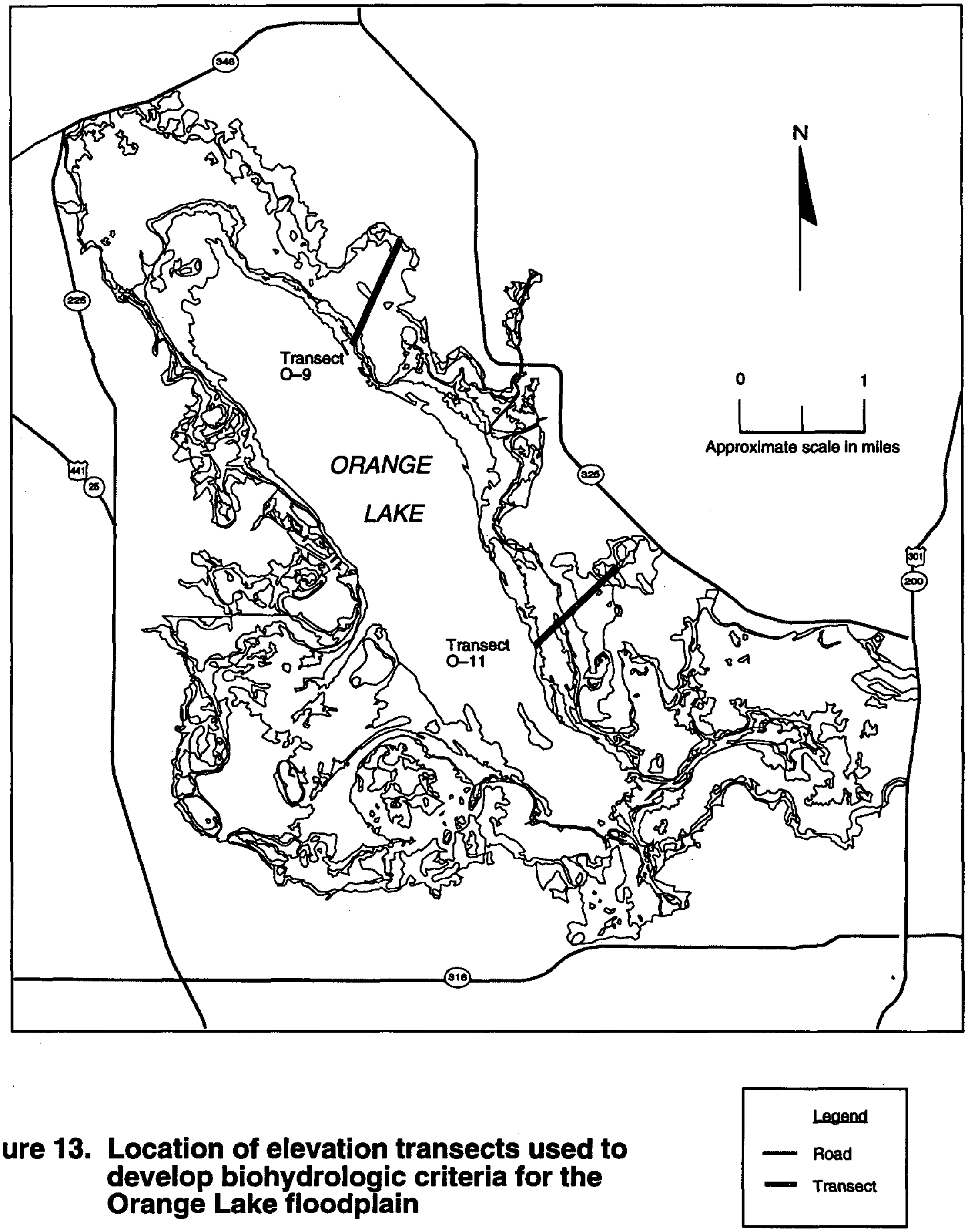

Figure 13. Location of elevation transects used to develop biohydrologic criteria for the Orange Lake floodplain

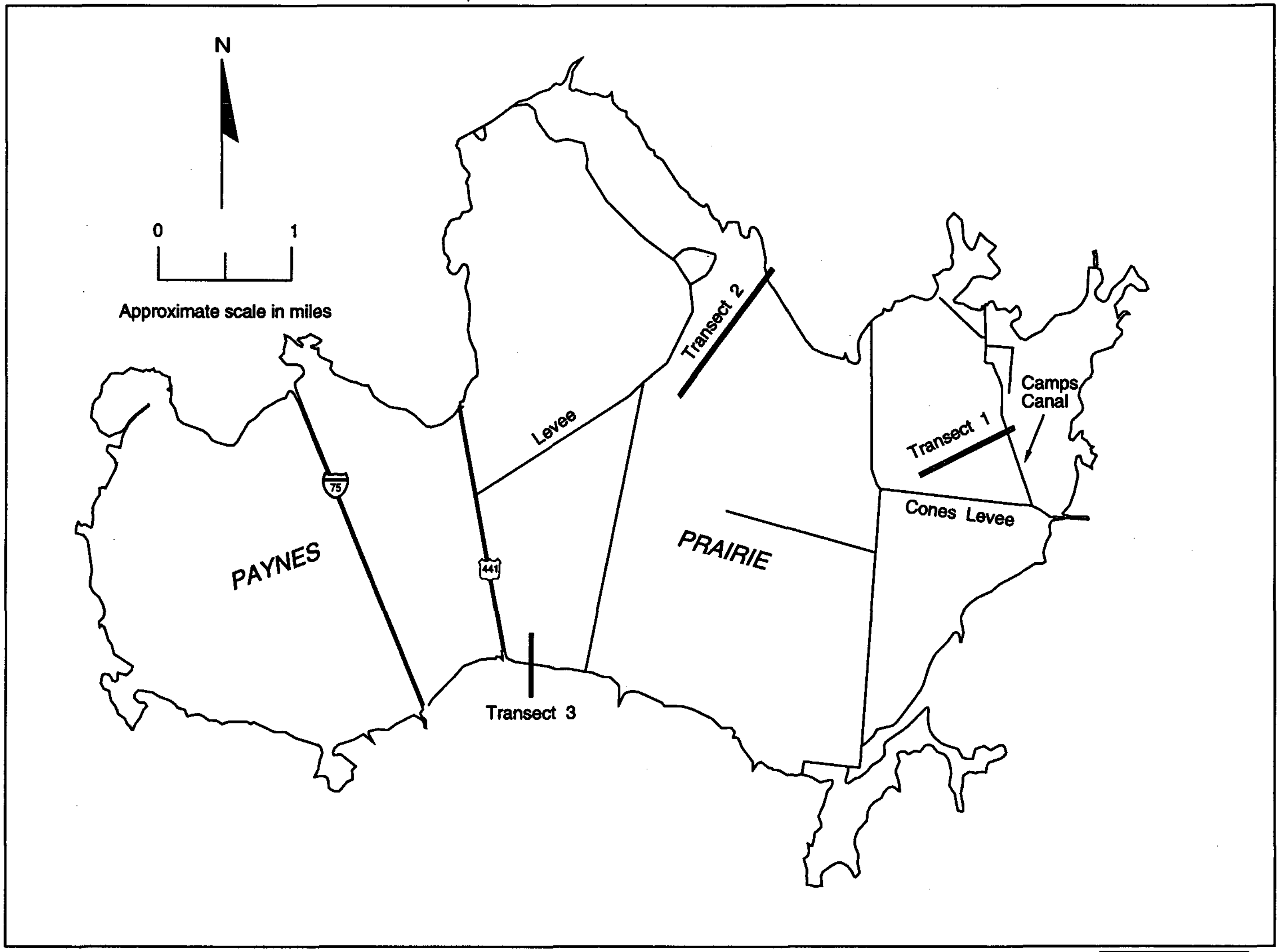

Figure 14. Location of elevation transects used to develop biohydrologic criteria for the Paynes Prairie floodplain

Legend
— Road
▬ Transect

methods. Elevations were referenced to NGVD 29. Horizontal locations were referenced to the SPCS-90, based on final published values for FLNRC 1-87, and Alachua County GPS stations A095, A067, A061, and A092 AZ.

HYDROLOGIC METHODS

Hydrologic methods used in this study involved

- A hydrologic model
- Modeling assumptions
- Calibration and verification
- Ground water levels used for long-term simulations

Model Description

The Streamflow Synthesis and Reservoir Regulation (SSARR) mathematical model, a rainfall-runoff-routing model developed by the Portland District of the U.S. Army Corps of Engineers (USACE 1986; Ponce 1989), was used to simulate elevations and discharges for Newnans Lake, Orange Lake, Lochloosa Lake, and Paynes Prairie. The model simulated the hydrologic conditions of drainage basins surrounding each lake. The model also was used to simulate discharge through Orange Creek.

SSARR comprises a watershed sub-model and a river system sub-model. The watershed sub-model simulates rainfall-runoff and accounts for interception, evapotranspiration, baseflow infiltration, and routing of runoff into the stream network. It also accounts for ground water flow through the local water table but not for flow through the regional water table, the intermediate aquifer, or the Floridan aquifer system.

The basic routing method used in the watershed model is a cascade of reservoirs technique (USACE 1986; Ponce 1989). A watershed is represented as a series of lakes, which conceptually simulates the natural delay of runoff.

The river system sub-model routes streamflows from upstream to downstream points through lake storage. The river system sub-model also uses the cascade of reservoirs technique to simulate channel routing. Lake routing is accomplished by an iterative solution of an equation involving inflow, outflow, and storage. The model accounts for evaporation from and rainfall to each of the lakes.

The SSARR User Manual (USACE 1986) contains a complete description of the model. Ponce (1989) also provides a description of SSARR.

Input data needed to operate SSARR include the following:

- Constant characteristics
- Initial conditions data
- Time series data
- Job control parameters

Constant Characteristics. The constant characteristics of a watershed are physical features such as drainage area, characteristics affecting runoff, hydrograph shape, lake storage and rating curves, drainage system configuration, and so on.

The constant characteristics discussed in detail here are the soil moisture-runoff relationships, drainage areas, the relationship of lake storage to lake elevation, lake outlet rating curves, and Floridan aquifer system seepage curves.

<u>Soil Moisture-Runoff Relationships</u>. The Soil Moisture Index (SMI), measured in inches, is an indicator of relative soil wetness and, consequently, of watershed runoff potential. Rainfall input is divided by SSARR into runoff and soil moisture increases. The percentage of rainfall available for runoff (runoff percentage, or ROP) is based on an empirically derived relationship between soil moisture and intensity of rainfall (I) (Figures 15 and 16). This relationship determines the runoff percentage; rainfall that is not converted by the model into runoff is added to the SMI.

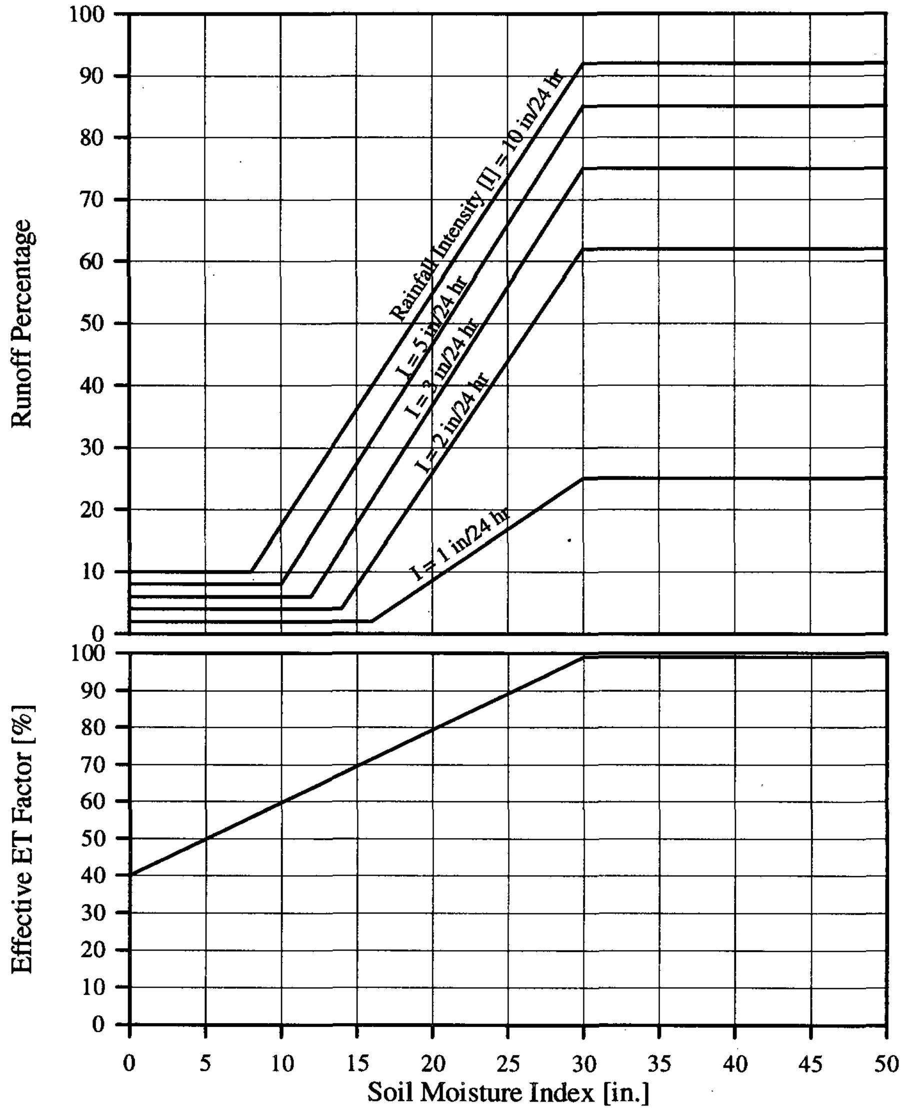

Figure 15. Soil moisture relationships for the Orange Creek Basin (except Paynes Prairie subbasin) using the hydrologic model SSARR. *(Top) Runoff percentage versus soil moisture index curves. (Bottom) Evapotranspiration reduction factor versus soil moisture index curve. These curves were developed during model calibration.*

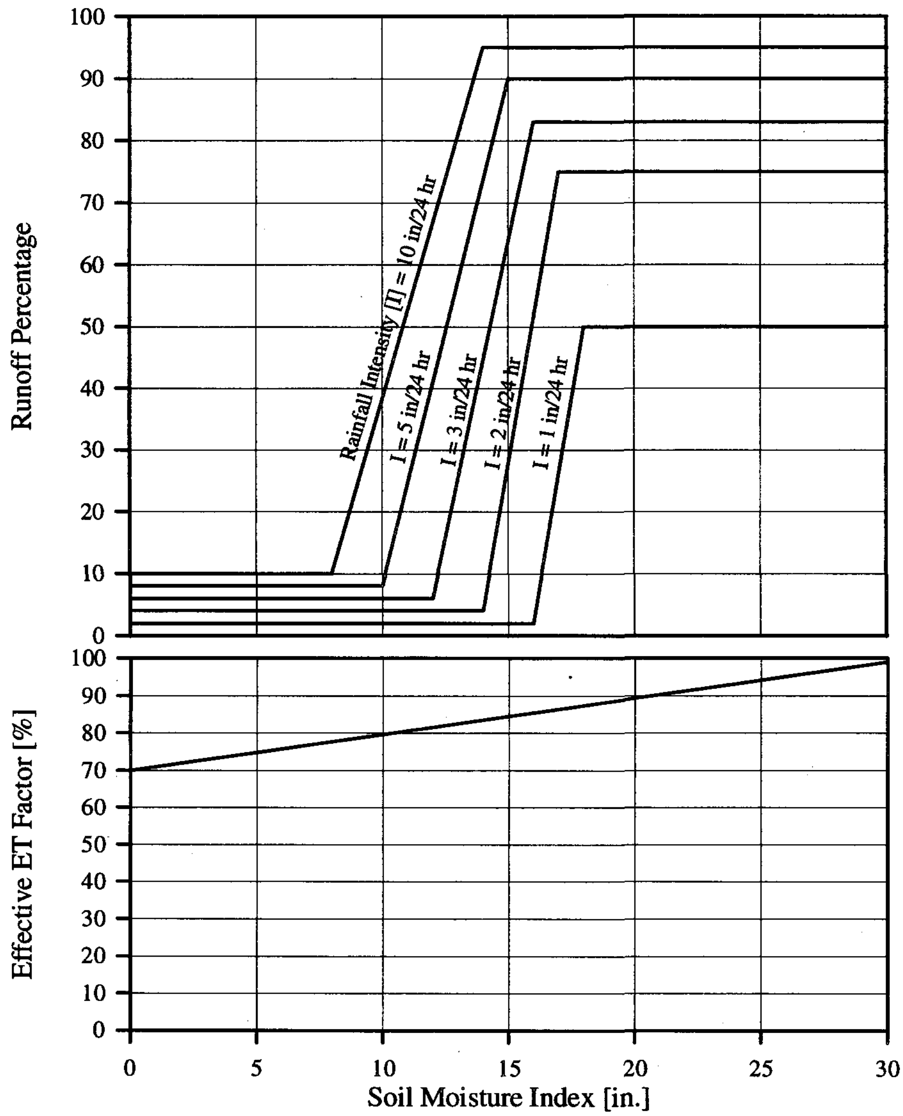

Figure 16. Soil moisture relationships for the Paynes Prairie subbasin using the hydrologic model SSARR. *(Top) Runoff percentage versus soil moisture index curves. (Bottom) Evapotranspiration reduction factor versus soil moisture index curve. These curves were developed during model calibration.*

Soil moisture (the SMI) in SSARR is depleted only by evapotranspiration (ET). ET losses, measured in inches, include transpiration of moisture by vegetation, interception losses, and direct evaporation of water from the ground to the atmosphere. The total of these losses is referred to as *potential* ET (Ponce 1989). The potential ET can be approximated by using a set percentage of the pan evaporation (Ponce 1989; Linsley et al. 1982), which is determined during model calibration. The monthly pan evaporation at the Gainesville weather station was converted to daily potential ET.

The actual amount of ET, referred to as *effective* ET, changes with changing soil moisture conditions. The amount of water that evaporates from the ground decreases as the soil dries out. Thus the potential ET is multiplied by a reduction factor, based on the SMI, to obtain the effective ET (Figures 15 and 16). SSARR determines the effective ET and reduces the SMI by the effective ET before calculating discharge.

The different soil characteristics of Paynes Prairie (Figure 4) mean different soil moisture-runoff relationships (Figure 16) than for the rest of OCB. Poorly drained soils in Paynes Prairie mean that a greater percentage of rainfall becomes runoff than for the rest of OCB.

Drainage Areas. Drainage areas were determined based on elevation contours from USGS quadrangle maps of the area. The drainage areas are 105 mi^2 for the Newnans Lake subbasin (Figure 6); 49 mi^2 for the Paynes Prairie subbasin (Figure 7); 72 mi^2 for the Lochloosa Lake subbasin (Figure 8); 54 mi^2 for the Orange Lake subbasin (Figure 9); and 75 mi^2 for the Orange Creek subbasin, downstream of the Orange and Lochloosa lakes outlets (Figure 10). These values differ from published values (USGS 1991; Adkins and Rao 1995) because non-contributing areas have been removed.

Capacity Curves. The relationship of storage capacity to elevation (Appendix B) is based on contour maps of each lake and Paynes Prairie (Figures A1–A4, Appendix A).

Lake Outlet Rating Curves. Outlet rating curves for each lake (Figures C1–C3, Appendix C) were developed with existing lake elevation and discharge data. The rating curves relate elevation to discharge.

Rating curves for Cross Creek (Figure C4, Appendix C) were developed with hydraulic analysis assuming uniform, subcritical flow and a width of 30 ft (Chow 1959). No field measurements were made to verify these curves.

The rating curve for the Camps Canal structure (Figure C5, Appendix C) was developed using a combination of discharge measurements at the structure, USGS discharge measurements at the Camps Canal gage, and USGS discharge measurements at the Prairie Creek gage.

The rating curves for the Main Structure of Paynes Prairie (Figure C6, Appendix C) were based on field measurements when possible. The outside envelope was calculated assuming inlet control at the culverts (Departments of the Army and the Air Force 1983). These curves were developed with the assumption that flows are determined by two variables: elevations on the prairie and elevations on Alachua Sink. A probable further complicating factor for these curves are stages in Sweetwater Branch, just downstream of the culverts.

Paynes Prairie is divided into eight different cells (Figure A4, Appendix A). To model Paynes Prairie with SSARR, rating curves are needed between each adjacent cell (a typical example is shown in Figure C7, Appendix C). No field discharge measurements exist for these rating curves, so approximate curves were developed assuming inlet control on culverts, open channel flow, and weir flow where appropriate.

Floridan Aquifer System Seepage Curves. Seepage from Orange Lake to the Floridan aquifer system was calculated based on a three-variable relationship among the elevation of Orange Lake, the potentiometric surface level of the Floridan aquifer system, and the flow from the lake to the aquifer (Figure 17). The initial general form

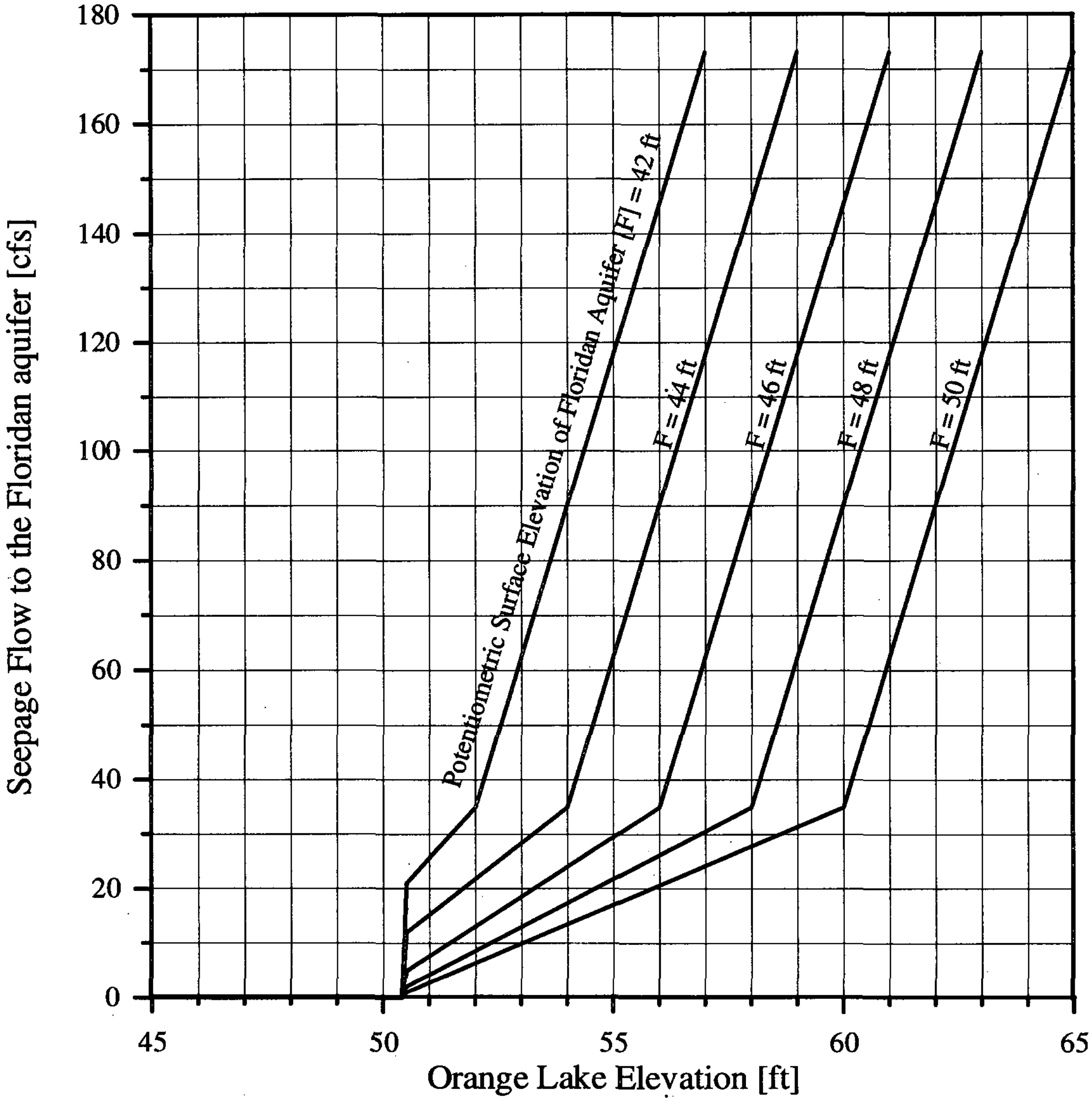

Figure 17. Seepage curves for the Floridan aquifer system, Orange Lake. *These curves were developed during model calibration to relate lake elevation, the potentiometric surface of the Floridan aquifer system (F), and seepage from the lake to the aquifer.*

of the curves was loosely based on the assumption of a submerged orifice (Brater and King 1976). Basically, the higher the elevation of Orange Lake, the higher the flow to the Floridan aquifer system. Likewise, the lower the potentiometric surface level of the Floridan aquifer system, the higher the flow from the lake to the aquifer. The final form of this family of seepage curves was developed during model calibration.

Initial Conditions Data. Initial conditions specify the watershed parameters on the starting day of simulation. These parameters include the current value of the SMI; the initial discharge from each drainage basin; and the initial storage, elevation, and outflow for each lake. The model automatically saves initial conditions calculated for any given time to be used in subsequent simulations.

Time Series Data. SSARR can use a number of time series as input. Rainfall, evaporation, lake elevation, potentiometric surface levels of the Floridan aquifer system, and discharge data were used for the Orange Creek model.

Rainfall. Because few on-site rainfall data are available for the period of study, the simulations were based on the nearest rainfall recording stations (Table 5). If rainfall records were available at more than one station at a given time, then rainfall was distributed by subbasin according to the station nearest to that subbasin.

Rainfall data were collected from six stations in and around Paynes Prairie (Table 5). However, rainfall data for the Paynes Prairie District Office were used for all of Paynes Prairie for two principal reasons:

1. Other Paynes Prairie rainfall records had gaps in them.

2. Limited discharge and stage measurements in the prairie's interior mean that increased detail in modeling (including rainfall) would not have added significantly to the accuracy of modeling results.

Table 5. Rain gages in and near the Orange Creek Basin

Station	Location	Period of Record	Frequency of Measurement
Gainesville	Gainesville Weather Station, Alachua County	1954–present	Daily
Island Grove	Island Grove, Alachua County	1958–84	Daily
Gainesville airport	Gainesville airport	1956–82; 1989–present	Daily
University	University of Florida	1903–63	Daily
District office	Paynes Prairie	1980–present	Daily
Ranger station	Paynes Prairie	1980–present	Daily
U.S. 441	Paynes Prairie	1988–present	Daily
Lake Wauberg	Paynes Prairie	1989–present	Daily
Bridge	Paynes Prairie	1988–present	Daily
West Prairie	Paynes Prairie	1980–present	Daily

Evaporation. Lake evaporation was assumed to be a fixed percentage of daily pan evaporation at Gainesville (Linsley et al. 1982).

For calculating evapotranspiration losses from the remaining watershed, a set percentage of daily pan evaporation was used as the potential daily ET (Ponce 1989; Linsley et al. 1982). SSARR reduces the potential ET to obtain the effective ET (Figures 15 and 16).

Lake Elevations and Floridan Aquifer System Potentiometric Surface Levels. USGS lake elevation data for Newnans Lake, Orange Lake, and Lochloosa Lake were used to calibrate and verify the model (Table 6). USGS also published well data from 1978 to the present for a Floridan aquifer system well located in Sparr, some 4 miles to the south of Orange Lake. SJRWMD has operated the well since 1985.

Table 6. Water level gages in the Orange Creek Basin

Station	USGS Number	Period of Record	Frequency of Measurement	Type of Measurement
Newnans Lake	02240900	1943–present	Approximately weekly	Lake elevation
Orange Lake	02242450	1942–present	Daily	Lake elevation
Lochloosa Lake	02242400	1942–present	Approximately weekly	Lake elevation
Floridan aquifer system	NA	1978–present	Approximately bimonthly	Potentiometric surface level
Prairie Creek	02240902	1978–present	Daily	Discharge
Camps Canal	02241000	1978–present	Daily	Discharge
Orange Lake outlet	02242451	1947–55; 1983–present	Daily	Discharge
Lochloosa Slough	02242500	1947–55; 1982–present	Daily	Discharge
Orange Creek	02243000	1942–52; 1955–present	Daily	Discharge
Paynes Prairie: Main Structure	NA	1979–present	Daily, with gaps	Stage
Alachua Sink	NA	1987–present	Daily, with gaps	Stage

Note: NA = not applicable

Discharge Data. USGS discharge data for Prairie Creek, Camps Canal, Orange Creek (at both Citra and Orange Springs), and Lochloosa Slough were used to calibrate and verify the model (Table 6).

Job Control Parameters. Job control parameters used by SSARR include the total simulation period, time intervals for the data (daily, hourly, etc.), and output options.

Modeling Assumptions

No model can include all factors that affect the hydrologic cycle. Therefore, any study has to include simplifying assumptions. In analyzing the final product of the model, a judgment is made as to the sufficiency of the assumptions. In particular, including ground water movement between lakes is beyond the scope of this study. The following assumptions were made for simulating the lakes in OCB:

- Over the long run, there is no net loss (or gain) from any of the lakes or Paynes Prairie to the surficial or the intermediate aquifers. This assumption implies that the same amount of ground water flows into each lake as flows out.
- Based on the small range of elevation on Newnans Lake relative to that of Orange Lake, losses to the Floridan aquifer system from Newnans Lake are negligible.
- When Lochloosa Lake reaches the level of Cross Creek, it declines much more slowly than does Orange Lake. Based on this fact, losses from Lochloosa Lake to the Floridan aquifer system are negligible.
- Losses from Orange Lake to the Floridan aquifer system are concentrated in one area near Heagy Burry Park; the rest of Orange Lake is impervious.
- Backwater effects of Orange Lake on Newnans Lake and the Camps Canal structure are negligible.
- Rating curves do not change on a seasonal basis.

General Model Calibration and Verification

Calibration and verification of a hydrologic model are standard procedures in which calculated or simulated values are compared with measured or gaged values. Either discharge values or elevation values (or both) can be used in this comparison.

Fit of Calculated Values. Transformation of rainfall into runoff in OCB is controlled by various basin characteristics. SSARR simulates hydrologic processes that, with input of observed data such as rainfall and evaporation, replicate to some degree other observed data such as streamflows or lake elevations. Calibration is the manipulation of various model parameters to optimize the *fit* of calculated data to observed data.

Several factors affect closeness of fit:

- Availability of rainfall data
- Density of the rain gage network
- Availability of USGS lake elevation data
- Availability of USGS discharge data
- Frequency of lake elevation measurements

Availability of Rainfall Data. The most complete available rainfall data were from the National Weather Service stations at Gainesville, the Gainesville airport, and Island Grove (Table 5). For the period 1989–91, data were available from stations in Paynes Prairie. So although the long-term statistics of the rainfall records will tend to be similar, on a day-to-day basis they might differ substantially and might affect model performance.

Density of the Rain Gage Network. Rainfall is spatially and temporally variable. Therefore, the more dense a monitoring network, the more accurately the true amount and location of rainfall over a basin will be represented. For this model, only three or four gages at most were used to cover a basin of approximately 300 mi^2. Especially for the long-term simulations, data from only one station were available for extended periods of time.

Availability of USGS Lake Elevation Data. Some of the gage records have large gaps in data. The lake elevation data for Orange Lake, Newnans Lake, and Lochloosa Lake cover the period of study between 1943 and 1991, although somewhat sporadically at times. For instance, gages for Newnans Lake and Lochloosa Lake had been discontinued during the extended drought of the mid-1950s, so an important part of the record (extreme low lake levels) is missing.

Availability of USGS Discharge Data. Some of the gage records have large gaps, and others have only a few years of data.

Frequency of Lake Elevation Measurements. Some events, especially high water events, are missed when lake level measurements are not recorded daily.

All these factors combined to make calibration and verification difficult. However, a long period of time was simulated, which should make possible a meaningful comparison of observed and calculated values and thus a meaningful assessment of model performance.

Verification. The verification process in general indicates how well the model is performing, as well as how appropriate any assumptions might have been. Verification involves using data not used in model calibration with SSARR. The results of SSARR are compared to measured lake levels or discharges to evaluate "goodness of fit."

Calibration and Verification for the Orange Creek Basin

SSARR was calibrated for OCB using observed lake elevation measurements for Newnans Lake, Orange Lake, Lochloosa Lake, and Paynes Prairie. Discharge measurements for Prairie Creek, Camps Canal, Orange Creek at Orange Lake, Lochloosa Slough, and Orange Creek at Orange Springs also were used. Calibration of SSARR involved a series of trial and error runs to obtain the best fit with observed values, adjusting some model parameters while maintaining others fixed. The following model parameters were adjusted:

- The SMI versus ROP curves and the SMI versus effective ET curves (Figures 15 and 16)
- The Orange Lake-Floridan aquifer system seepage function (Figure 17)
- SSARR factors affecting the shape of hydrographs

- SSARR factors affecting division of runoff into base, subsurface, and surface flows

- The ratio of lake evaporation to pan evaporation

- The ratio of potential ET to pan evaporation

The following model parameters were constant:

- Drainage areas
- Capacity curves
- Outlet rating curves

The Orange Creek Basin was divided into four different parts, and each part was calibrated as a separate unit:

- Newnans Lake and surrounding drainage basins to the Prairie Creek gage

- Orange and Lochloosa lakes and surrounding drainage basins from the Camps Canal gage to the outlets of both lakes

- Orange Creek and surrounding drainage basins from the outlets of Orange and Lochloosa lakes to the gage at Orange Springs

- Paynes Prairie and surrounding drainage basins, including the Camps Canal structure and the outlet at Alachua Sink

(See Adkins and Rao 1995 for locations of gages.)

The contributing area between the Prairie Creek and Camps Canal USGS gages is relatively small (about 2 mi^2). Discharge measurements at the Camps Canal gage reflect management activities at the Camps Canal structure (opening and closing gates). These activities have not been documented. For these reasons, Camps Canal discharges were not used for calibration and verification activities, except as Orange Lake inflows.

Because rain gage data were relatively sparse for such a large area, the basic strategy for all these parts was to calibrate and verify the model with data from relatively long periods. Calibration was done with data from 1987 through 1991 and verification with data from 1982 through 1986. The period between 1987 and 1991 was used because it covered a variety of hydrologic conditions. For the sake of simplicity, two comparisons were made: one on start-of-month elevations for the lakes, the other on average monthly flow for the discharge points. Because there was very little data for the Paynes Prairie subbasin, a much shorter period of time was used for the calibration and verification of SSARR for the Paynes Prairie subbasin than for the rest of OCB.

In SSARR, the amount of runoff from a basin is determined by the SMI versus ROP curves and the SMI versus effective ET curves (Figures 15 and 16). Without extensive rain and stream gage networks, creation of an elaborate classification of drainage basins cannot be justified. Of course, each lake had its own drainage basins. For OCB, six different general types of drainage basins were used:

- Most of the Newnans Lake, Orange Lake, Lochloosa Lake, and Orange Creek drainage basins were lumped into one classification (Figure 15).
- Most of the Paynes Prairie subbasin was lumped into a separate classification because of its soil characteristics (Figure 16).
- Some drainage basins at the margin of OCB (for example, Buck Bay to the north of Newnans Lake [Figure 6]) have significant detention storage.
- The Lake Wauberg drainage basin (Figure 7) has significant detention storage.
- Parts of the Newnans Lake and Paynes Prairie subbasins (Figures 6 and 7) are impervious.
- Some drainage basins, especially around Orange Lake (Figure 9), were classified as non-contributing and so were not included in the analysis.

Newnans Lake. The model for Newnans Lake was calibrated with data from 1987 through 1991. Calculated start-of-month elevations were generally within about 0.5 ft of USGS elevations (Figure 18). General up-and-down trends were replicated well. General trends also were replicated for the Newnans Lake outlet (Prairie Creek) discharge measurements (Figure 19). The average of calculated values over the 5 years of calibration was 55 cfs; measured values were somewhat lower at 52 cfs.

The Newnans Lake model was verified with data from 1982 through 1986 (Figures 18 and 19). Elevations were replicated fairly well except for the first half of 1985, where the model projects elevations more than 1 ft lower than the USGS elevations. Orange Lake elevations showed the same tendency during this time, so the available rainfall data may not be representative of this particular time. Discharges also were replicated well during verification. For the 10-year period of calibration and verification, the average calculated flow was 68 cfs, compared to 67 cfs for the USGS data.

Orange and Lochloosa Lakes. The models for Orange and Lochloosa lakes were calibrated with data from 1987 through 1991. To eliminate one source of error, USGS gage values for Camps Canal (Table 6) were used as input for Orange Lake.

Included in the Orange Lake model was a function (Figure 17; see Assumptions section, p. 43) establishing the relationship between the level of Orange Lake, the piezometric level of the Floridan aquifer system, and the seepage to this aquifer. This seepage is an important part of the water budget for Orange Lake. With- and without-seepage simulations of Orange Lake for 1990 showed a difference of more than 3 ft by the end of the year (Figure 20).

The eventual calibrated elevations for Orange Lake were good (Figure 21) except for brief times in 1988 and 1991. The model successfully simulated the range of approximately 8 ft during the

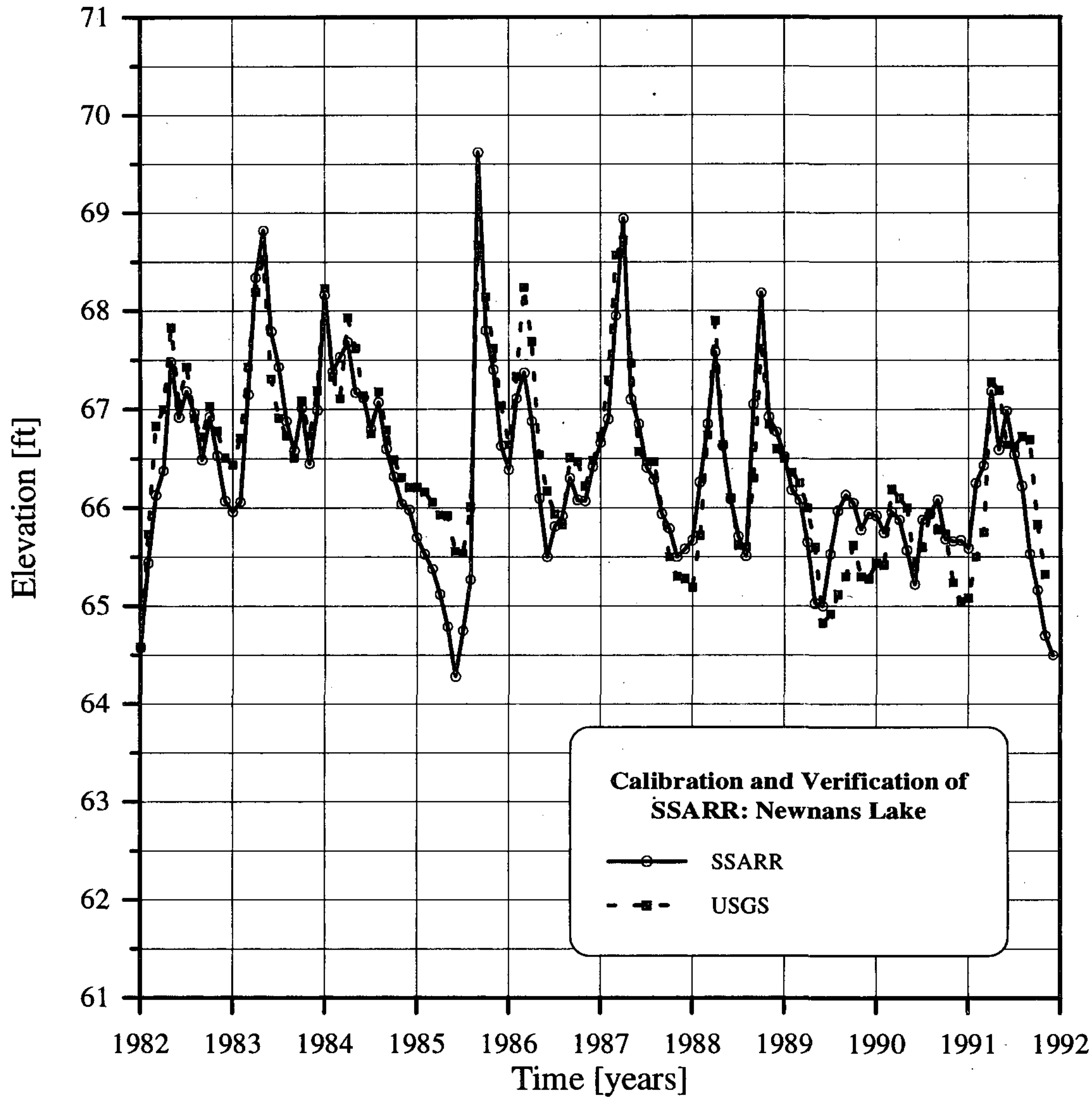

Figure 18. Calibration and verification of the SSARR model for Newnans Lake. *Calibration covered the years from 1987 through 1991; verification covered the years from 1982 through 1986.*

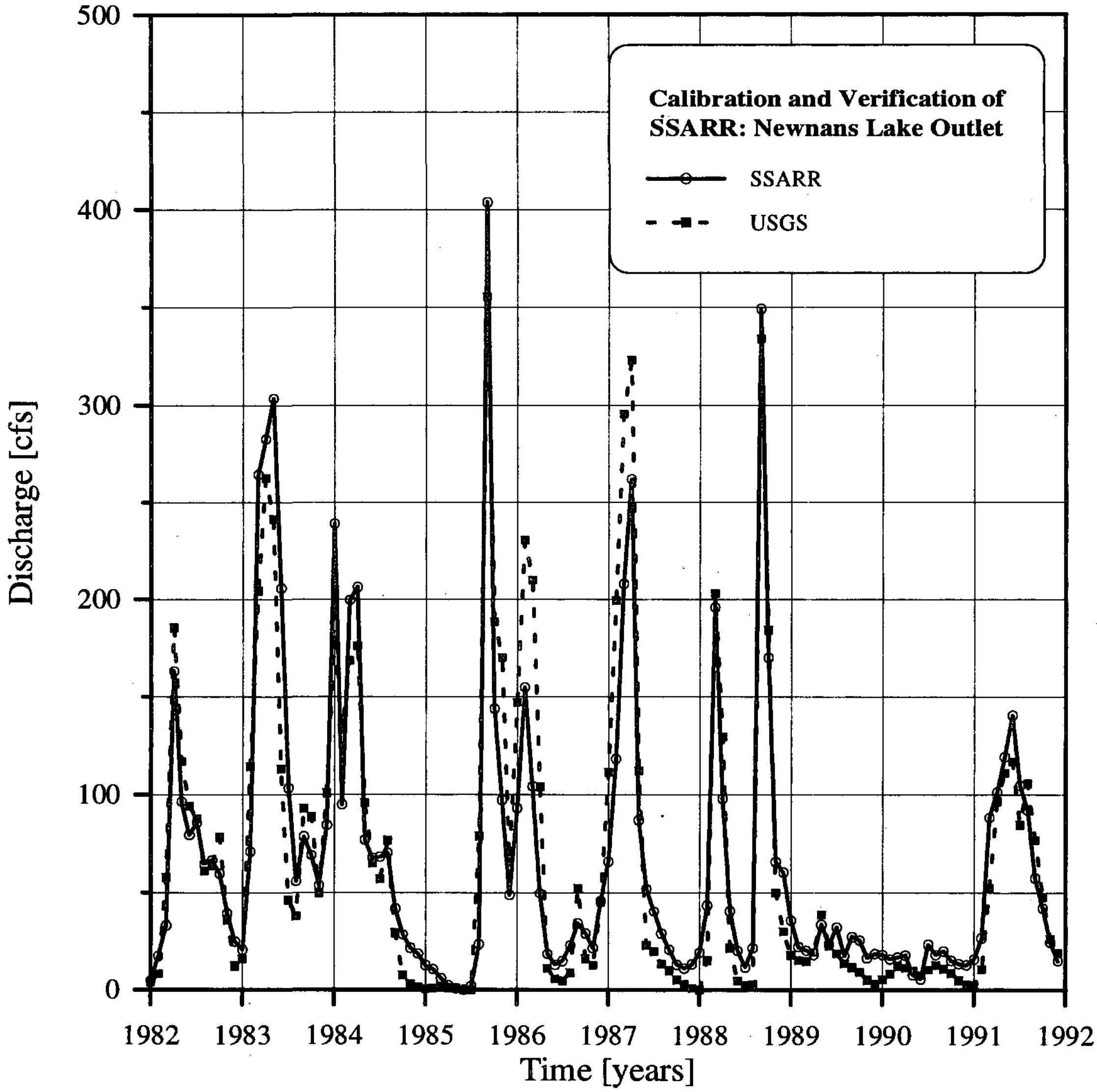

Figure 19. Calibration and verification of the SSARR model for the Newnans Lake outlet. *Calibration covered the years from 1987 through 1991; verification covered the years from 1982 through 1986.*

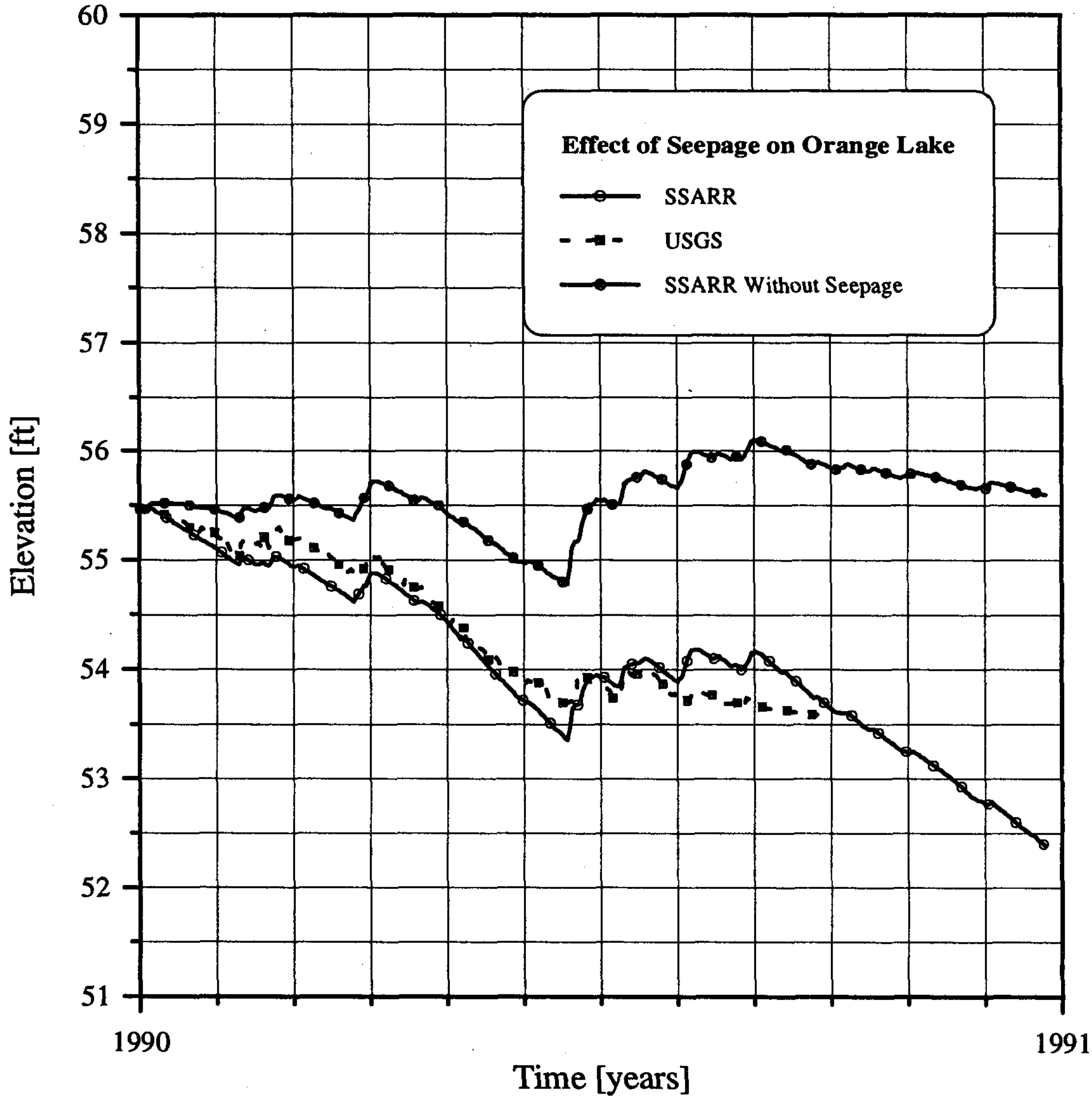

Figure 20. Effect of seepage on Orange Lake, 1990

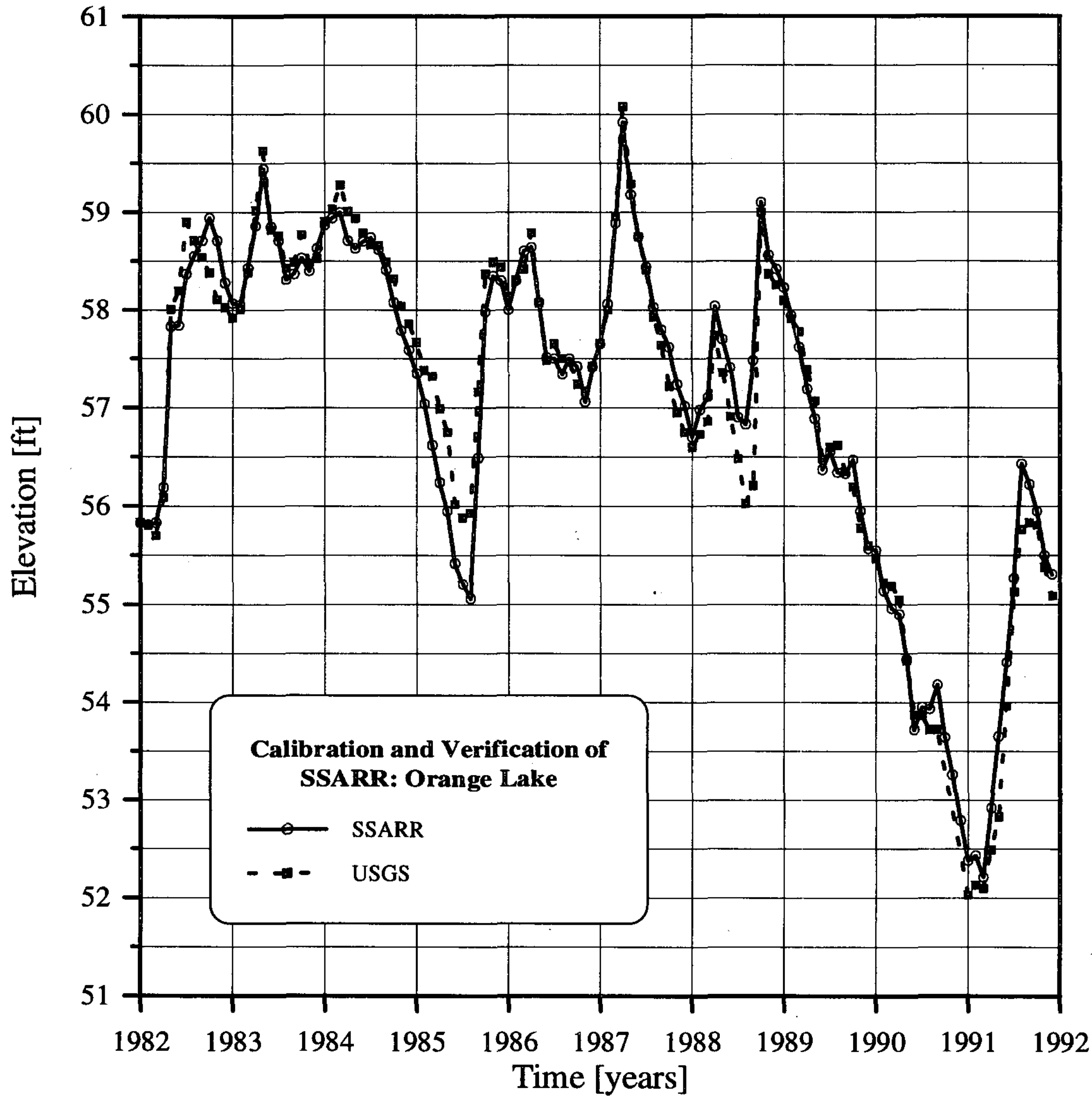

Figure 21. Calibration and verification of the SSARR model for Orange Lake. *Calibration covered the years from 1987 through 1991; verification covered the years from 1982 through 1986.*

calibration years. The average flow during the calibration years was 45 cfs; the measured flow averaged 39 cfs during those years (Figure 22).

Calibrated elevations for Lochloosa Lake (Figure 23) were within 0.5 ft except for times in 1988 and 1989. The replication of overall trends was quite good, although there was a tendency for the model to be high until about mid-1989.

Flows through Lochloosa Slough (Figure 24) were so small when compared, for example, to the Orange Lake outlet (Figure 22), that comparisons were not too significant. Replication of the action was quite good; a slight change in the rating curve (Figure C3, Appendix C) would cause the two amounts to agree much more closely. Average flow for the calibration years for Lochloosa Slough was 5 cfs; the average flow for USGS measurements for the same period was 3 cfs.

The SSARR model for Orange and Lochloosa lakes was verified with data from 1982 through 1986. Calculated elevations for Orange Lake (Figure 21) were close to measured elevations except for a period in 1985. The model for Newnans Lake (Figure 18) exhibited a similar deviation, so the measured rainfall might not be representative for this particular period. Average flows for the 10 years of calibration and verification (Figure 22) were calculated by SSARR to be 67 cfs; USGS measurements over the same period averaged 68 cfs.

Calculated elevations for Lochloosa Lake (Figure 23) tended to be high for the verification years. Calculated flows for Lochloosa Slough for the verification years (Figure 24) were systematically high, indicating again that the rating curve for Lochloosa Slough in SSARR might be too low. Over the 10 years of calibration and verification, SSARR calculated the flow from Lochloosa Slough to be approximately 7 cfs; the average USGS discharge over the same period was about 3 cfs.

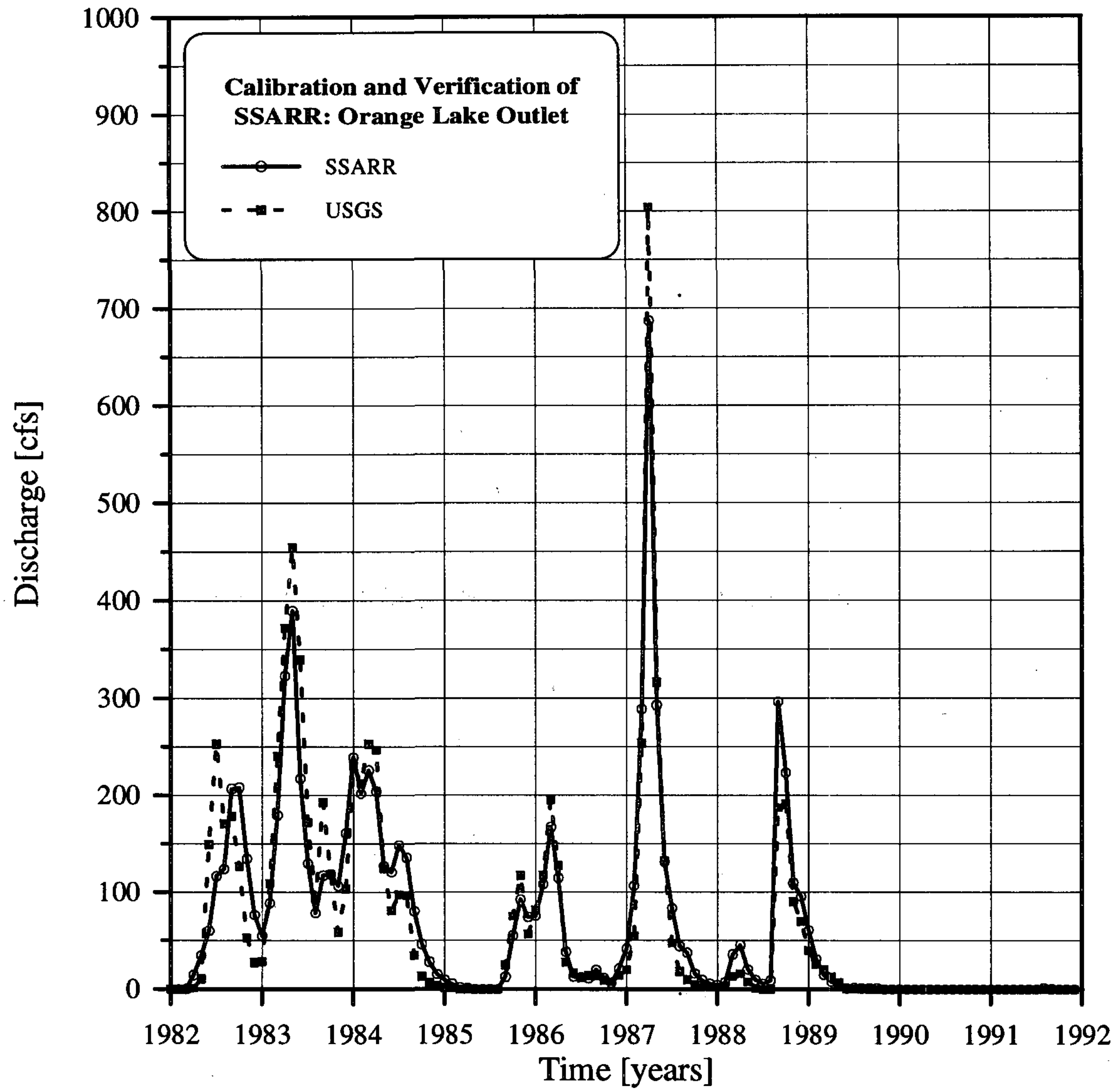

Figure 22. Calibration and verification of the SSARR model for the Orange Lake outlet. *Calibration covered the years from 1987 through 1991; verification covered the years from 1982 through 1986.*

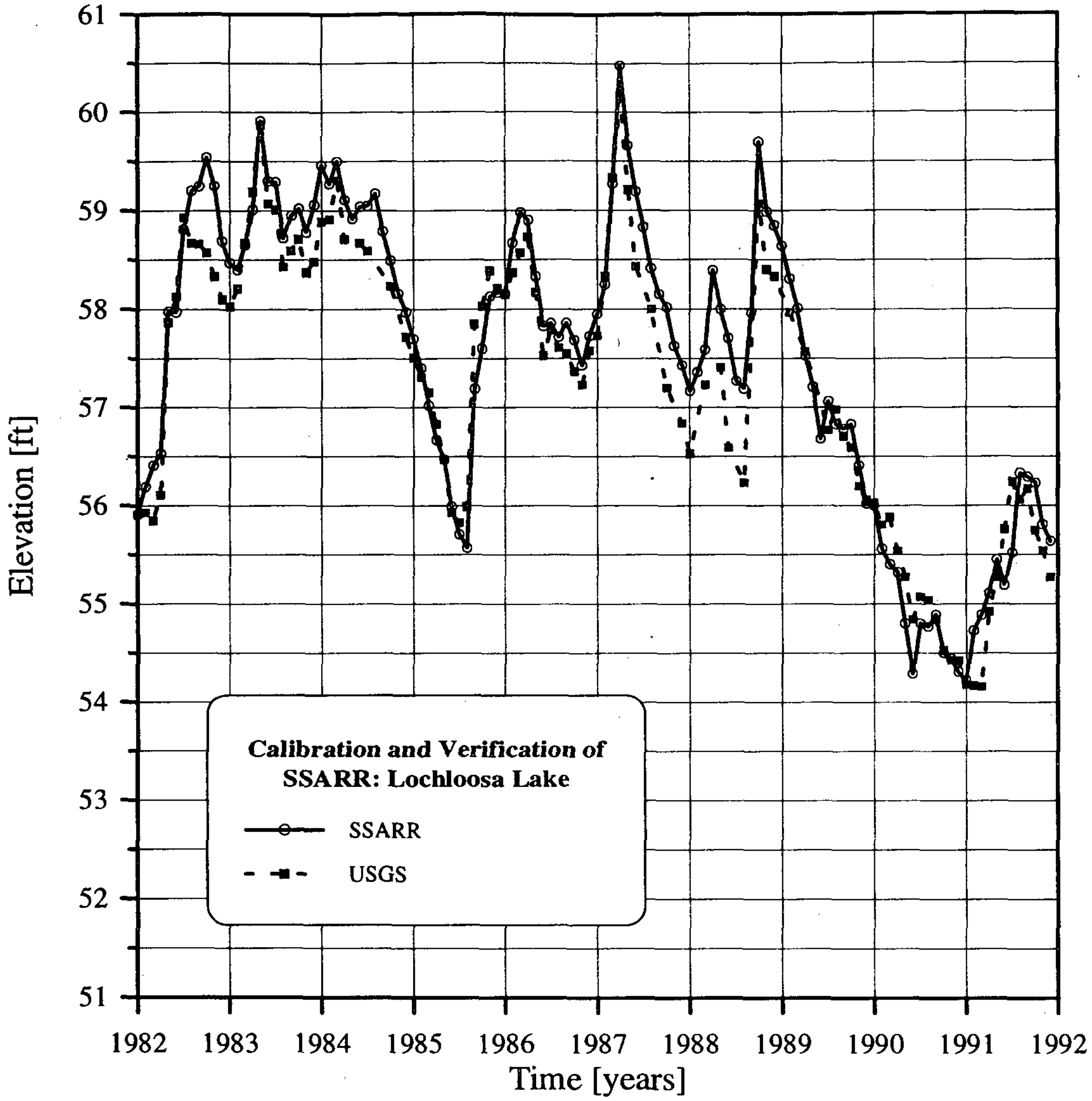

Figure 23. Calibration and verification of the SSARR model for Lochloosa Lake. *Calibration covered the years from 1987 through 1991; verification covered the years from 1982 through 1986.*

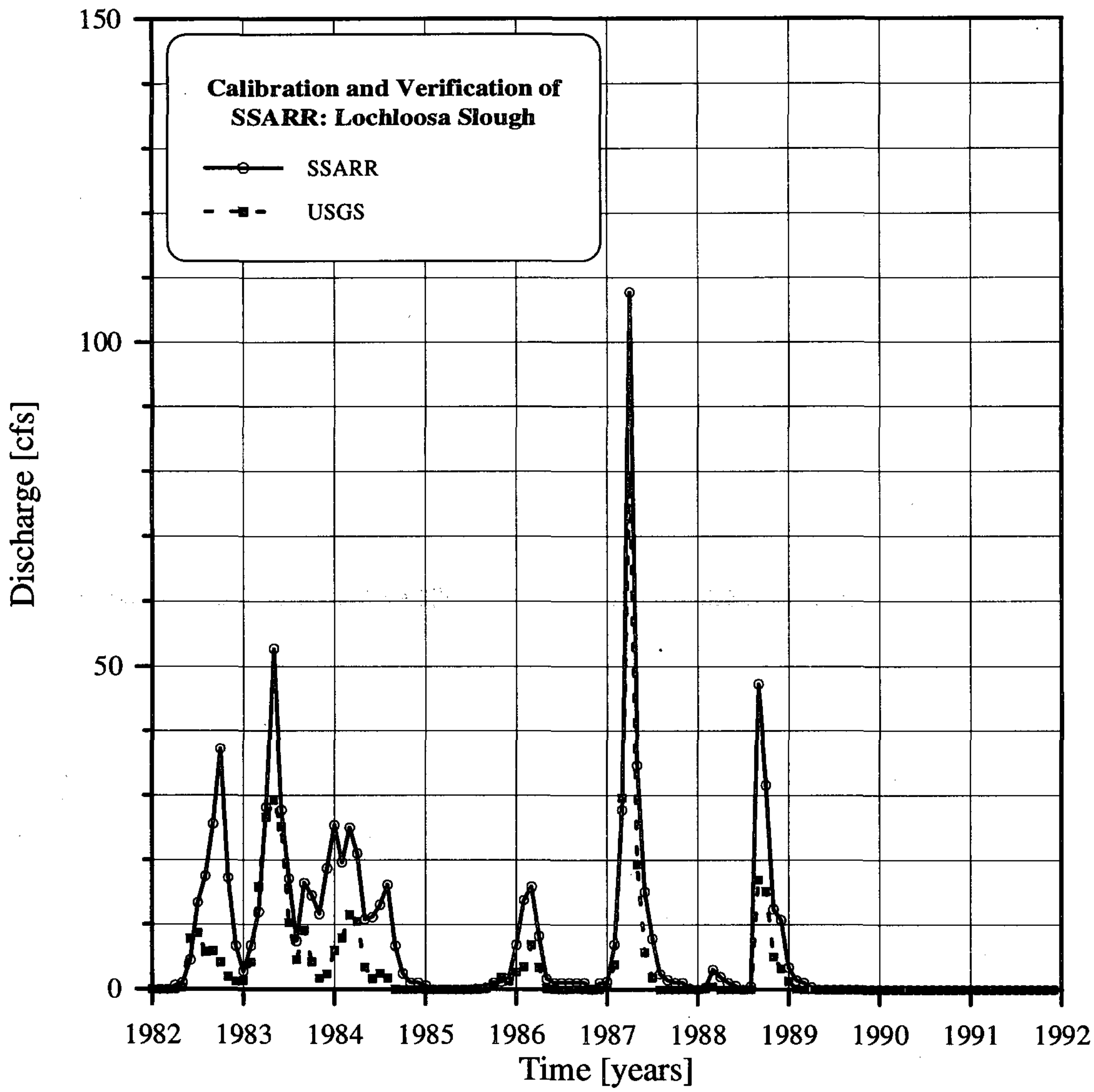

Figure 24. Calibration and verification of the SSARR model for Lochloosa Slough. *Calibration covered the years from 1987 through 1991; verification covered the years from 1982 through 1986.*

SSARR calculated the combined flow from Orange Lake and Lochloosa Slough to be 74 cfs over the 10 years of calibration and verification. The average USGS discharge over the same period from the two sources was about 71 cfs.

Orange Creek at Orange Springs. The model for the watershed between Orange Lake and the USGS gage on Orange Creek at the town of Orange Springs (Table 6) was calibrated along with the Newnans Lake and the Orange and Lochloosa lakes parts of the model. To eliminate two sources of error, the model used USGS-measured discharges at Orange Lake (Table 6) and at Lochloosa Slough as upstream inputs. The model was calibrated with data from 1987 through 1991. The calculated discharge for this period tended to be higher than the USGS measurements (Figure 25). Results for April 1987 and September 1988 were especially high and tended to skew the final results. These results may indicate that the rainfall for these two very short periods was not representative of that which fell over the subbasin.

It is very difficult to establish the drainage patterns within this subbasin. Likewise, it is difficult to establish exactly how much area contributes to the discharge at this gage. These differences might account for a systematically high calculated value. The average calculated flow for the calibration years was 82 cfs; the average measured flow for the same period was 54 cfs.

Simulation for the verification years (from 1982 through 1986) appeared to be better than for the calibration years (Figure 25). For the entire 10-year period of calibration and verification, the average calculated discharge for this location was 108 cfs; the average measured discharge was 97 cfs.

Paynes Prairie. The soils for Paynes Prairie (Adkins and Rao 1995) are quite different from those which predominate in the other subbasins. Thus, different SMI versus ROP curves (Figure 16) were used for Paynes Prairie than for the rest of OCB. The soils around Paynes Prairie contribute much more runoff from a given rainfall event, which was reflected in the final SMI versus ROP curves.

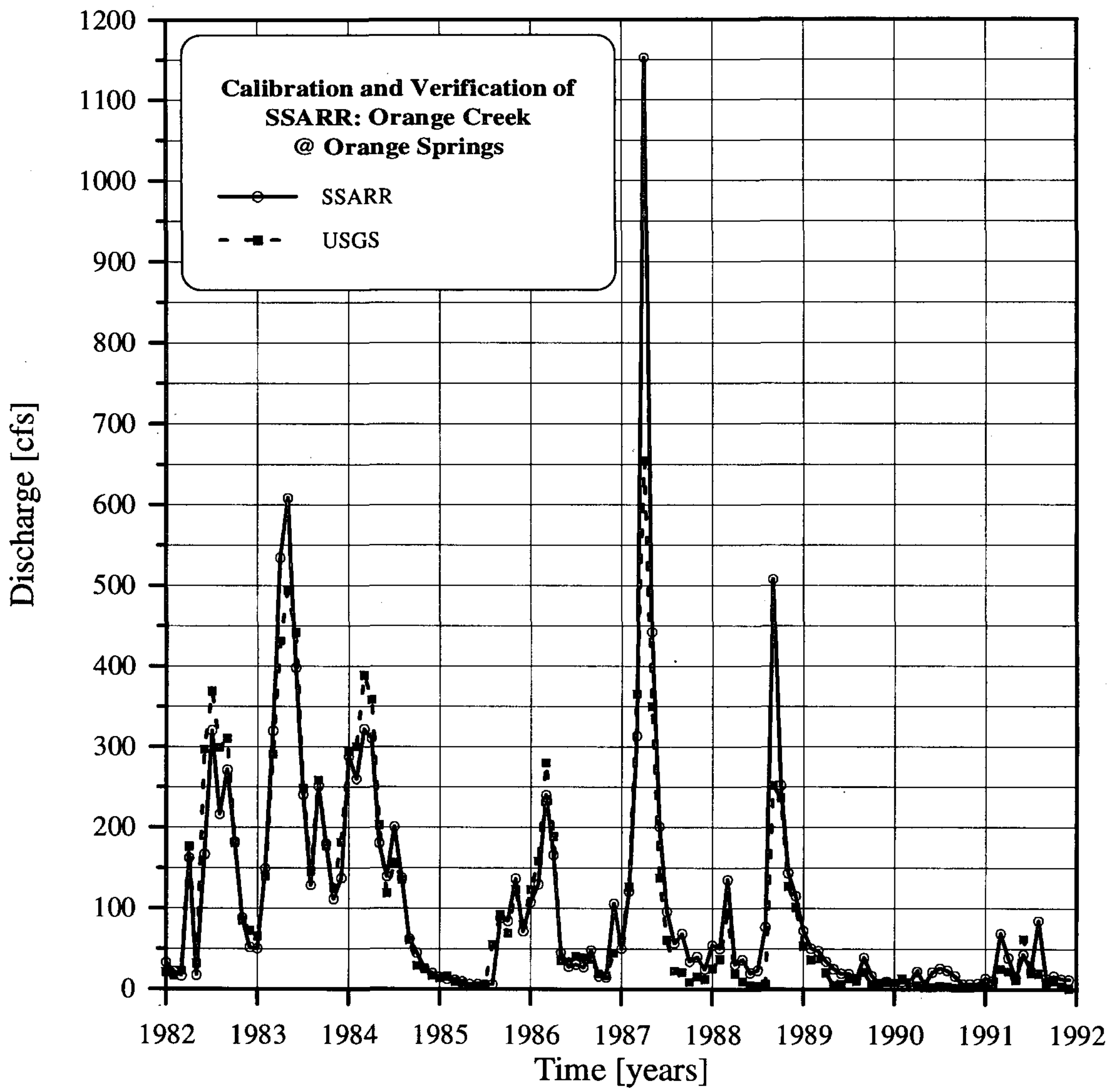

Figure 25. Calibration and verification of the SSARR model for Orange Creek at Orange Springs. *Calibration covered the years from 1987 through 1991; verification covered the years from 1982 through 1986.*

Paynes Prairie, as presently configured, is an extremely complex hydraulic system. Paynes Prairie is divided into eight cells by highways, canals, and levees (Figure A4, Appendix A).

To minimize error at the Camps Canal structure, discharges at the Prairie Creek and Camps Canal USGS gages (Table 6) were used. It was assumed that the difference between the two gages constituted flow into Paynes Prairie. Calibration was performed using data from 1988, principally because 1988 provided a variety of hydrologic conditions. The model was verified with data from 1989 and 1990.

The final calibration simulation of overall trends for 1988 was quite good (Figure 26). Differences between simulated and measured elevations were rather significant at times. The same comments are applicable to verification simulations of 1989 and 1990. The following factors explain some of the discrepancies.

- Discrepancies in 1988 (June) and 1989 (April) may be due to problems with the rating curve at the Main Structure (Figure C6, Appendix C). This rating curve will be a complex function of prairie elevations, sinkhole elevations, and stage and flow levels coming into the Alachua Sink from Sweetwater Branch. Most discharge measurements for the rating curve just happened to occur during a long-term drought, so the full range of conditions was not obtained.

- At times, in all three simulations, the model does not adequately simulate quick rises and falls of elevation on the prairie. These abnormalities may be due in part to the limitations of the rating curve. Although backflow into Paynes Prairie has rarely been seen (James Weimer, FDEP, pers. com., January 1993), the rapid rise might be an indication of a rapid rise in Sweetwater Branch and subsequent backflow into the prairie. Sweetwater Branch is subject to frequent rapid rises due to stormwater runoff.

- The model does not adequately simulate the extremely low elevations experienced during 1990. The decline in water levels during May, June, September, October, and November is too rapid to attribute to direct evaporation alone. On the other hand,

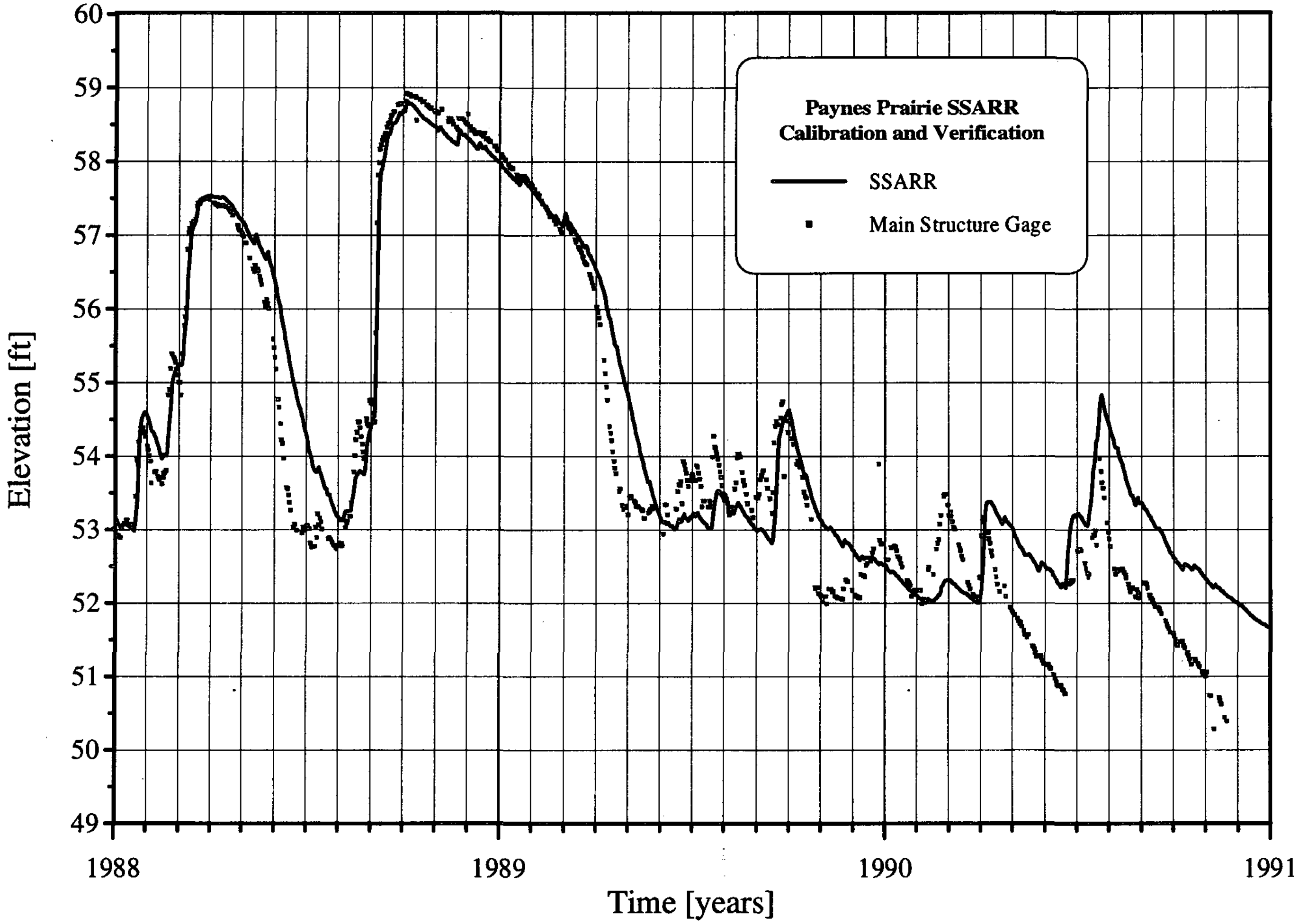

Figure 26. Calibration and verification of the SSARR model for Paynes Prairie. *Calibration covered 1988; verification covered 1989 and 1990.*

the rapidity of decline plus the fact that the rates are similar would be consistent with significant ground water losses.

Ground Water Levels Used for Long-Term Simulations

Ground water levels can be an important factor when sinkholes are part of a hydrologic system or its model. Unfortunately, ground water records are often of short-term duration or are measured at a considerable distance from the sinkhole in question. To model these systems, it is often necessary to artificially extend the record or generate it from other hydrologic data. Such methods were used to model both Orange Lake and Paynes Prairie.

Calculation of Orange Lake Seepage. The ground water level is one of the two variables needed to determine seepage from Orange Lake (Figures 9 and 17). Data from a ground water well near Sparr (Table 6), 4 miles south of Orange Lake, was used for calibration and verification of the Orange Lake model. However, this well has been monitored only since 1978; an extension of this record was needed to perform long-term simulations of Orange Lake. Analysis of ground water levels at Sparr and Orange Lake elevations showed a relationship between the two (Figure 27). This relationship was used to estimate periodic ground water level values based on trends in historical elevations of Orange Lake.

Calculation of Paynes Prairie Discharge. The water surface elevation in Alachua Sink is one of the two variables needed to determine flows through the Main Structure in Paynes Prairie (Figure C6, Appendix C). However, the gage at Alachua Sink has been monitored only since 1988; an extension of this record was needed to perform long-term simulations of Paynes Prairie water levels. Analysis of water surface elevations at Alachua Sink and ground water levels at Sparr showed a significant relationship (Figure 28). This relationship was used to convert the outlet rating curves for the Main Structure from Alachua Sink elevations to Sparr ground water elevations. This new rating curve was used with the long-term time series of Sparr ground water elevations used for calculating seepage losses from Orange Lake.

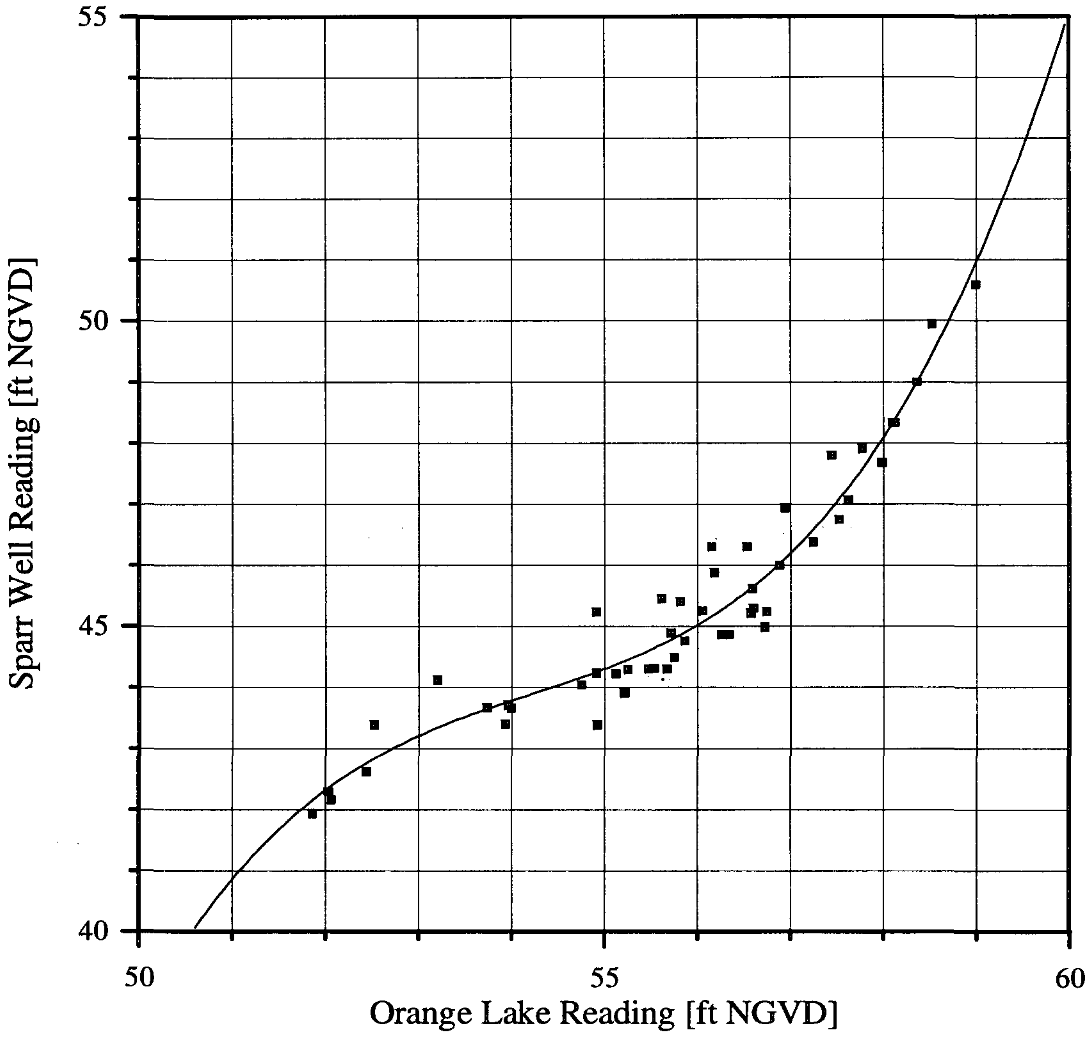

Figure 27. Relationship between Orange Lake gage reading and potentiometric levels at the Sparr ground water well

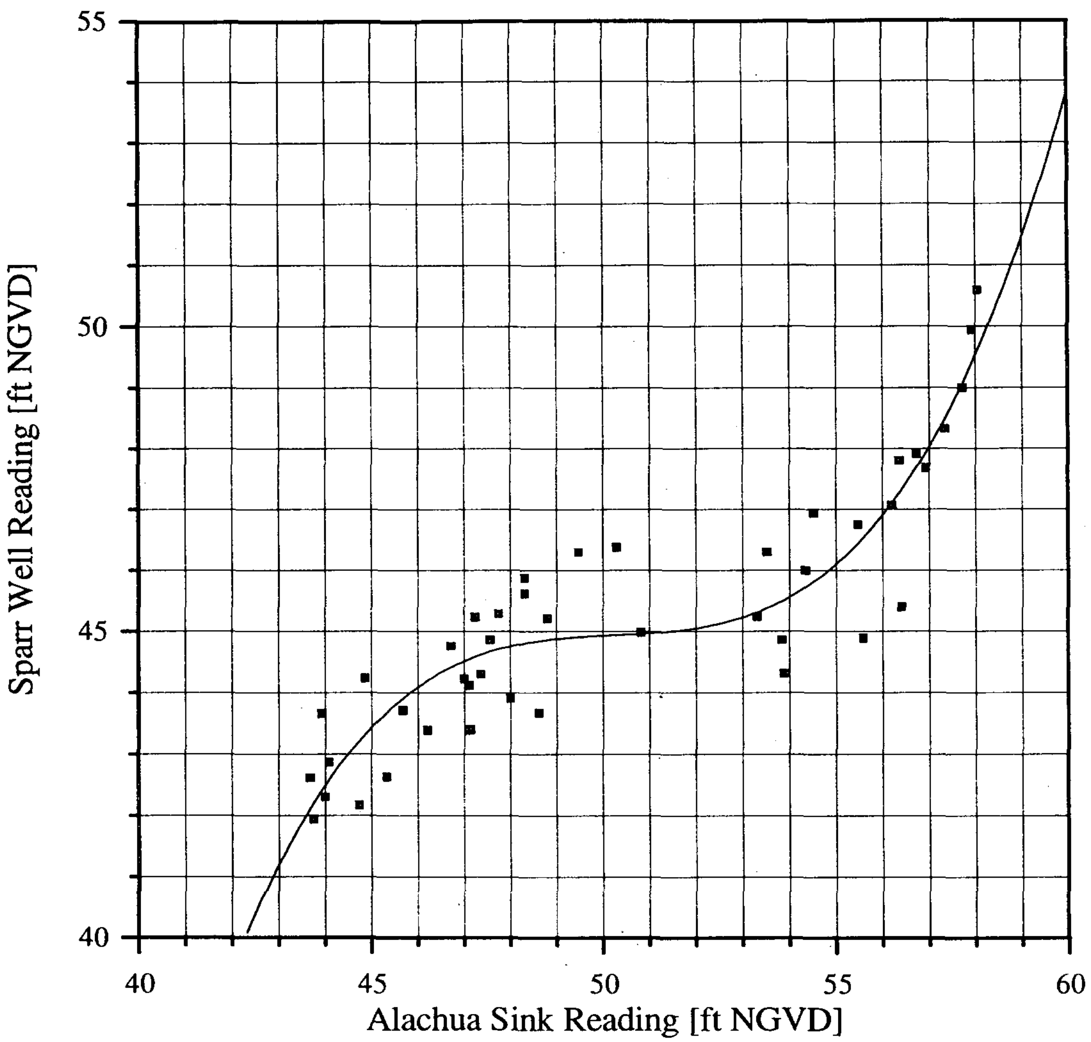

Figure 28. Relationship between Alachua Sink gage reading and potentiometric levels at the Sparr ground water well

Simulations of Paynes Prairie (at the Main Structure) using Sparr ground water data tended to be somewhat lower than simulations using Alachua Sink elevations (Figure 29). Overall performance, including trends, highs, and lows, was good.

ENVIRONMENTAL METHODS

Environmental methods used in this study include the following:

- Assessment of wetland vegetation
- Determination of the acreage of emergent floodplain wetlands
- Derivation of cumulative floodplain acreage tables
- Estimation of nutrient loading to Paynes Prairie
- Development of biohydrologic criteria for surface water management
- Evaluation of the ecological effects of water management alternatives

Assessment of Wetland Vegetation

Wetland vegetation was interpreted using color-infrared aerial photographic transparencies (scale 1:24,000). The dates of the photography varied by county: Marion, 1985–86; Alachua and Putnam, 1990. Transparencies were viewed using a high-intensity light table with stereo-optics. Vegetation types were delineated on high transmissivity mylar film using india ink pens, according to the wetland categories defined in Appendix D. Vegetation polygons were digitized and entered into GIS. Digitized polygons were analytically adjusted for spatial distortions due to aircraft movements using an in-house computerized photorectification process (Woodard 1990). Acreages of wetland vegetation cover types were calculated by GIS, and maps were plotted using an electrostatic plotter.

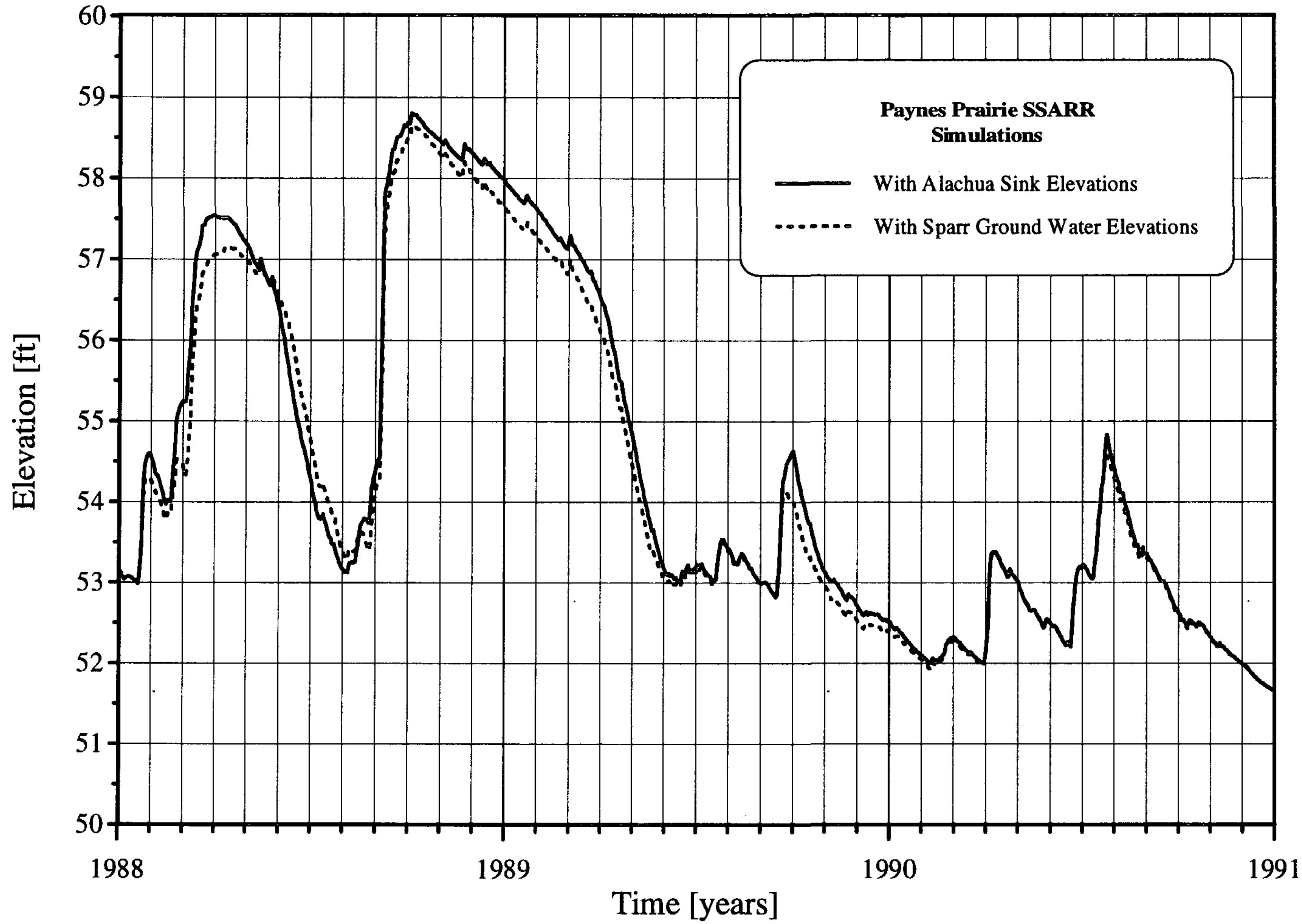

Figure 29. Simulation of Paynes Prairie Main Structure elevations using Sparr ground water elevations in the SSARR model

Determination of the Acreage of Emergent Floodplain Wetlands

Emergent wetlands were defined to occur between elevations that are expected to be flooded from 10% to 90% of the time. The elevation that experiences a 10% flooding duration occurs approximately at the upland-wetland intersection; the elevation that experiences a 90% flooding duration occurs approximately at the transition from emergent wetlands to floating-leaved or submersed aquatic plants. Elevations that correspond to the 10% and 90% flooding durations were determined by referring to stage-duration tables generated by the SSARR hydrologic model for each water management alternative. Table E1 (Appendix E) is an example of such output.

The elevations defined from the stage-duration tables were used to determine the acreage of wetlands that occur between the elevations, using cumulative acreage tables (see Appendix F). Figure B1 (Appendix B) is an example of the graphical representation of a cumulative acreage table. The acreage of wetlands for each alternative was determined by subtracting the cumulative acreage figure for the 90% flooding duration from the acreage figure for the 10% flooding duration.

Paynes Prairie wetland acreage determinations for alternatives that allow flow through the Camps Canal structure include additional wetland acres from cells 7 and 8 (Figure A4, Appendix A) not included in the 10%–90% stage-duration analysis. These cells are at relatively high elevations and are not inundated by the central pool (Alachua Lake) except under flood conditions (>58 ft), but are maintained by surface water sheetflow from Prairie Creek. The extent of wetlands above the elevation of the 10% inundation contour changes according to the quantity of flow through the Prairie Creek structure. These differences must be included in a determination of the total acreage of emergent wetlands for each water management alternative.

The extent of wetlands in cells 7 and 8 directly influenced by sheetflow from Prairie Creek was estimated for the "Existing Conditions" and the "Complete Restoration of Prairie Creek Flow to Paynes Prairie" ("All to Prairie") alternatives from 1990 and 1937 aerial photography, respectively, and processed using GIS. The 1937 photography was used for the "All to Prairie" alternative because it was the earliest available photography. Boundaries were determined using the existing OCB morphometry. Wetlands directly influenced by the flow from Prairie Creek for both the "Existing Conditions" and "All to Prairie" alternatives include contiguous herbaceous wetlands that transition to a solid shrub community or managed area and/or contiguous herbaceous wetlands that appear to be in standing water. Under the "Complete Diversion of Prairie Creek Flow to Orange Lake" alternative, no wetlands in cells 7 and 8 would be directly influenced by sheetflow from Prairie Creek.

The data from these three alternatives were used to develop a graph that relates percentage of total Prairie Creek flow to wetland acreage. This graph was then used to interpolate wetlands acreage for the "Reduction in Paynes Prairie Inflow/Outflow Structure Capacity by 50%" ("½ In- & ½ Outflow") alternative. Under the "½ In- & ½ Outflow" alternative, Prairie Creek flow into Paynes Prairie is half of that under "Existing Conditions." The extent of wetlands directly influenced by sheetflow for the "Lake Level Threshold Management of the Camps Canal Structure" alternative was assumed to equal that of the "Existing Conditions" alternative because changes in flow rates were of relatively short duration.

The 1-ft elevation contour map of Paynes Prairie (Figure A4, Appendix A) was superimposed on these wetland delineations using GIS. Areas above the contour of the 10% flooding duration elevation were calculated and added to the 10%–90% wetland acreage calculation estimates for each alternative.

Derivation of Cumulative Floodplain Acreage Tables

Cumulative floodplain acreage tables for Orange, Lochloosa, and Newnans lakes (Tables F1–F3, Appendix F) were derived from (1) hydrographic maps of lake bottom contours by Bennett R. Wattles and Associates, (2) floodplain transects prepared by Bennett R. Wattles and Associates and SJRWMD staff, (3) analysis of the elevation gradient of plant communities and water levels by SJRWMD staff, and (4) USGS quadrangle maps. Acreages that occur between 1-ft contours were interpolated using in-house computer programs.

Cumulative floodplain acreage tables for Paynes Prairie (Table F4, Appendix F) were derived from the photogrammetric analysis of 1-ft elevation contours of Paynes Prairie prepared by Continental Aerial Surveys.

Estimation of Nutrient Loading to Paynes Prairie

The effects on water quality of reducing flow from Prairie Creek to Paynes Prairie were predicted using the Vollenweider mathematical model. This model predicts a phosphorus concentration in a water body from data on total phosphorus load, flow rate, area, mean depth, water retention time, and a phosphorus loss term called the sedimentation coefficient. Of the many mathematical models dealing with nutrient loading, the Vollenweider model has the strongest confirmation support (Reckow and Chapra 1983).

In many water bodies, much of the phosphorus input is deposited in the sediments. The Vollenweider model differs from other models in that phosphorus sedimentation is made a function of water body concentration, as opposed to other variables. The Vollenweider model also assumes that water body and outflow phosphorus concentrations are identical. Expressed as a formula, the Vollenweider model is as follows:

$$P = \frac{W}{Q+V} = \frac{L}{z\left(\frac{1}{T_w} + \sigma\right)} \qquad (1)$$

where:

P = water body phosphorus concentration
W = annual mass rate of phosphorus loading
Q = annual volume rate of water inflow
V = water body volume
L = W/As = annual areal phosphorus loading

As = water body surface area
z = water body mean depth
T_w = hydraulic retention time
σ = sedimentary loss coefficient

The following assumptions were used to model the effects of the "½ In- & ½ Outflow" water management alternative on the phosphorus loading of Paynes Prairie:

- Two areas: (1) area of standing water (Alachua Lake), approximately 1,000 acres (ac) (405 hectares) and (2) entire Paynes Prairie, approximately 11,000 ac (4,452 hectares)
- Flow rate for Prairie Creek at 17.5 cfs ("½ In- & ½ Outflow") and 35 cfs ("Existing Conditions")
- Phosphorus concentration of 0.2 milligrams per liter at Prairie Creek spillway (Best et al. 1995)
- Total load calculated as the sum of atmospheric load (assumed to be 0.1 grams per square meter per year) and inflow load (SFWMD 1992)
- Mean depth at 0.5 meters
- Sedimentation coefficients adjusted to calibrate the model to predict the existing phosphorus concentrations (Best et al. 1995)

Development of Biohydrologic Criteria for Surface Water Management

Lake and wetland ecosystems require a range of surface water fluctuations for conservation. This range of water levels constitutes a fluctuation regime that consists of (1) high water levels due to temporary and seasonal floods, (2) maintenance of a suitable middle water level, and (3) low water levels that coincide with mild droughts and infrequent extensive droughts. Water management measures can increase or decrease the range of water level fluctuation of these ecosystems.

Twenty-three surface water management alternatives were evaluated in this report. The surface water fluctuation regime predicted by the SSARR hydrologic model for each alternative was evaluated for potential ecological impacts to the major water bodies. To accomplish this calculation, five biohydrologic criteria were developed that allowed a comparison of the new water level fluctuation regimes to key environmental attributes of each body of water. The criteria developed provided a systematic means to determine which water management alternatives were likely to maintain the hydroperiods needed by the biological communities.

The five biohydrologic criteria were created to accommodate a range of surface water fluctuations. These criteria are the (1) Infrequent High Water Level, (2) Frequent High Water Level, (3) Middle Water Level, (4) Frequent Low Water Level, and (5) Infrequent Low Water Level. These criteria define periods of inundation that preserve the ecological processes of the lake and floodplain biological communities.

Each criterion describes a duration (the number of consecutive days that an average water level is maintained) and a recurrence interval (the frequency in years, on average, that a water level is equalled or exceeded). The duration and recurrence intervals were formulated by project biologists after examining the physical and biological features of the floodplain wetland and/or lake littoral zone communities and were supported by other SJRWMD research (Brooks and Lowe 1984; Hall 1987; Hupalo et al. 1994) and the scientific literature (Stephens 1974; Duever et al. 1978; Guillory 1979; Huffman 1980; Ross and Baker 1983; McArthur 1989).

The duration and recurrence interval associated with each criterion statistically specify a particular water elevation that is expected to occur under a particular management alternative. For example, under "Existing Conditions" a flood event occurring for a duration of at least 60 consecutive days and recurring once every 2 years would occur at 57 ft. Under a different water management alternative, a flood event with the identical duration and recurrence interval might occur at 56.4 ft. Comparing changes in water elevation under different management alternatives to the elevations of key biological attributes is the basis for evaluating the effects of different water management alternatives on the ecology of the lakes and the floodplain biological communities.

The following subsections provide a conceptual rationale for each biohydrologic criterion and a description of the ecological functions each criterion is intended to conserve.

Need for High Water Levels. Inundation of the floodplain is necessary for the exchange of particulate organic matter and nutrients (McArthur 1989). Flooding of wetlands and upland fringes redistributes and concentrates organic particulates (decomposing plant and animal parts, seeds, etc.) across the floodplain (McArthur 1989). This organic matter is assimilated by both bacteria and invertebrate populations (Cuffney 1988). These populations, in turn, serve as food for larger fish. Reductions in the supply of organic matter, through changes in flood regimes, will ultimately impact fish populations by first affecting the food source.

Aquatic fauna rely upon these high waters to provide periodic access to feeding, spawning, and refugia habitat across the floodplain (Guillory 1979; Ross and Baker 1983). The life cycles of many fishes are related to seasonal water level fluctuations, particularly annual flood patterns (Guillory 1979). Stabilization of water levels was implicated as the reason for low densities or absences of flood-exploitive fish species in an altered stream reach (Finger and Stewart 1987). Two to three months of flooding should be provided to ensure fish access to the floodplain (Knight et al. 1991). This period may be exceeded during wet years, and in dry years it may not occur; fish are adapted to year-to-year variation of the natural hydrologic regime.

High water also influences the composition and survival of wetland forests adjacent to the lakes. The species composition and structural development of floodplain communities are influenced by the timing and duration of floods that occur during the growing season (Huffman 1980). The proper timing and duration of floods enhance seed dispersal and permit germination. The forest community will be able to reseed itself periodically under a suitable flood regime.

The following biohydrologic criteria are recommended to meet the ecological requirements of the floodplain provided by temporary and seasonal floods.

Infrequent High Water Level. A high water condition that occurs on average once every 5 years for a duration of 30 consecutive days (1:5 years, 30 days).

Objectives:

- To inundate the entire floodplain wetland and prevent the encroachment of upland species into the upper wetland area
- To facilitate seed dispersal
- To transport organic matter between the floodplain wetlands and the lake
- To provide spawning, refugia, and foraging habitat for fish

Frequent High Water Level. A high water condition that occurs on average once every 2 years for a duration of 60 consecutive days (1:2 years, 60 days).

Objectives:

- To maintain lower swamp and shallow marsh habitats
- To transport organic matter between the floodplain wetlands and the lake
- To provide spawning areas and refugia for small forage fish
- To provide additional foraging areas for other aquatic organisms, particularly gamefish
- To facilitate seed dispersal

Need for a Middle Water Level. An appropriate middle water level is necessary to maintain the plant species composition of existing wetlands and also to conserve the hydric soils of the floodplain. Wetland communities are maintained by a combination of inundation and saturation. Wetlands must remain wet long enough to exclude upland plants, yet be sufficiently dry for a period to allow the germination of wetland species. In the Corkscrew Swamp region of the Everglades, wetland plant communities occur where the average annual hydroperiod is greater than 219 days per year, or approximately 60% of each year (Duever et al. 1978). Twenty wetland sites, including marshes, cypress swamps, and willow swamps, had hydroperiods that averaged between 224 and 296 days per year during a 14-year period (Duever et al. 1978).

Conserving the hydric nature of floodplain soils is also necessary. Low water levels for extended periods allow the oxidation of organics present in hydric soils, which ultimately results in subsidence. Stephens (1974) reported that the oxidation of Everglades peat soils occurs when water levels are more than 0.25 ft below the wetland surface for extended periods of time. Studies of marshes in the Upper St. Johns River Basin of the St. Johns River (Brooks and Lowe 1984; Hall 1987) correlated this 0.25-ft depth to a water level exceeded approximately 60% of the time. Studies of the Wekiva River system found that this hydrologic condition also can be expressed as the mean low stage occurring, on the average, 1 in 2 years with a duration of less than or equal to 180 days (Hupalo et al. 1994).

The following biohydrologic criterion is recommended to meet the ecological requirements of the floodplain provided by middle water conditions.

Middle Level is a low water condition that occurs on average once every 2 years for a duration of 180 consecutive days (1:2 years, 180 days).

Objectives:

- To maintain hydric soils of the floodplain by preventing oxidation and subsidence
- To exclude colonization by terrestrial plants
- To maintain sufficient water depth in the lake littoral zone for aquatic wildlife

Need for Low Water Levels. Low water levels, which occur during droughts, allow the lower areas of floodplain wetlands to reseed themselves. Seeds of many wetland plant species require saturated soils (no standing water) to germinate. Exposing the floodplain and the upper littoral zone of the lake for suitable durations allows a wetland to maintain a diversity of emergent plant species.

Low water levels also allow for the breakdown and/or compaction of flocculent organic sediments. Aerobic microbial breakdown of the sediment begins with receding water levels. Sunlight also heats, dries, and compacts the sediment into a firm, not flocculent, substrate. Sediment compaction provides improved fish-nesting and seed germination substrates.

The following biohydrologic criteria are recommended to meet the ecological conditions of the floodplain resulting from both frequent and infrequent droughts.

<u>Frequent Low Water Level</u>. A low water condition that occurs on average once every 5 years for a duration of 180 consecutive days (1:5 years, 180 days).

Objectives:

- To rejuvenate the floodplain and lake littoral zone by allowing seed germination and growth of wetland plant species
- To increase the rate of decomposition of organic sediments, allowing aerobic microbial breakdown

Infrequent Low Water Level. A low water condition that occurs on average once every 50 years for a duration of 360 consecutive days (1:50 years, 360 days).

Objectives:

- To allow consolidation and compaction of organic sediments in fish spawning habitat
- To rejuvenate the floodplain wetlands and the upper littoral zone of the lakes by allowing seed germination and growth of wetland species

Evaluation of the Ecological Effects of Water Management Alternatives

We evaluated 2 surface water management alternatives for Newnans Lake, 7 alternatives for Paynes Prairie, and 22 alternatives for Orange and Lochloosa lakes. Daily lake levels for a 50-year period of rainfall record were predicted for each management alternative by the SSARR hydrologic computer model. Summary statistics consisting of recurrence interval analyses of mean high and mean low stages and duration analyses were generated for each water management alternative (e.g., Tables E15 and E17, Appendix E).

The summary statistics generated for each water management alternative were used to determine surface water elevations that corresponded to the durations and recurrence intervals defined by the five biohydrologic criteria. The tables reporting the highest mean water levels were used to determine the Infrequent High and Frequent High water levels, and the tables reporting the lowest mean water levels were used to determine the Middle, Frequent Low, and Infrequent Low water levels.

For example, under "Existing Conditions" for Orange Lake, a flood level that occurs for a minimum of 60 consecutive days on an average of once every 2 years (1:2 years) was chosen as the Frequent High water level biohydrologic criterion. Using Table E15 (Appendix E), we located the Weibull probability of .50, which corresponds to a 1:2 years recurrence interval. Then we moved across the table until we located the column that corresponded to a duration of 60 consecutive days and read the elevation 58.51 ft. This process was repeated from the appropriate table for each of the five biohydrologic criteria for each water management alternative. Together, the series of five water elevations and their associated durations and recurrence intervals defined a surface water fluctuation regime for each management alternative that was evaluated with respect to the elevations of important biological features of each major water body (e.g., see Figure 39A, p. 115).

Hydrologic Assessment

This chapter discusses the results of the hydrologic assessment of the different water management alternatives for OCB.

Evaluations of the surface water management alternatives are presented for each of the major water bodies: Newnans Lake, Paynes Prairie, and Orange and Lochloosa lakes. Twenty-three water management alternatives were evaluated—2 of these would affect Newnans Lake, 7 would affect Paynes Prairie, and 22 would affect Orange and Lochloosa lakes (Table 7).

Summary of Hydrologic Simulation Statistics

The SSARR model was used to predict the hydrologic conditions that would result from each water management alternative. A series of analyses was performed on SSARR-generated hydrographs to obtain hydrologic statistics for each of the alternatives. Hydrologic statistics provide a convenient method of comparison between alternatives. Hydrologic statistics characterize the response of a water body, given such hydrologic influences as

- Rainfall
- Evaporation
- Evapotranspiration
- Runoff
- Seepage
- Hydraulic structures (such as weirs and culverts)
- Land use changes
- Water management changes

Different statistics often are important for different uses of a water body. For example, although a minimum of fluctuation on a lake might be desirable from the point of view of access, stabilization may adversely affect the system biologically.

Table 7. Water management alternatives for the Orange Creek Basin

Water Body	Water Management Alternative	Short Title
Newnans Lake	Existing conditions	Existing conditions
	Remove Newnans Lake weir	Remove Newnans Lake weir
Paynes Prairie	Existing conditions	Existing conditions
	Remove Newnans Lake weir	Remove Newnans Lake weir
	Complete restoration of Prairie Creek flow to Paynes Prairie	All to prairie
	Complete diversion of Prairie Creek flow to Orange Lake	None to prairie
	Reduction in Paynes Prairie inflow/ outflow structure capacity by 50%	½ in- & ½ outflow
	Lake level threshold management of the Camps Canal structure	Newnans Lake=66 ft, Orange Lake=56 ft
	Use Sweetwater Branch inflow to replace Prairie Creek inflow	Use Sweetwater
Orange and Lochloosa lakes	Existing conditions	Existing conditions
	Remove Newnans Lake weir	Remove Newnans Lake Weir
	Complete restoration of Prairie Creek flow to Paynes Prairie	All to prairie
	Complete diversion of Prairie Creek flow to Orange Lake	None to prairie
	Reduction in Paynes Prairie inflow/ outflow structure capacity by 50%	½ in- & ½ outflow
	Lake level threshold management of the Camps Canal structure	Newnans Lake=66 ft, Orange Lake=56 ft
	Fill low-flow notch in Orange Lake weir	Fill Orange Lake notch
	Remove Orange Lake weir	Remove Orange Lake weir
	Dredge Cross Creek 3 ft	Dredge 3 ft
	Plug Orange Lake sinkholes 50%	Plug 50%
	Plug Orange Lake sinkholes 100%	Plug 100%
	Fixed crest weir around Orange Lake sinkholes, 54 ft	Sinkhole weir at 54 ft
	Fixed crest weir around Orange Lake sinkholes, 55 ft	Sinkhole weir at 55 ft

Table 7—*Continued*

Water Body	Water Management Alternative	Short Title
Orange and Lochloosa lakes—*continued*	Fixed crest weir around Orange Lake sinkholes, 56 ft	Sinkhole weir at 56 ft
	Gated weir around Orange Lake sinkholes, gates closed at 54 ft, opened at 58 ft	Close 54 ft/open 58 ft
	Gated weir around Orange Lake sinkholes, gates closed at 55 ft, opened at 58 ft	Close 55 ft/open 58 ft
	Gated weir around Orange Lake sinkholes, gates closed at 56 ft, opened at 58 ft	Close 56 ft/open 58 ft
	Fixed crest weir around Orange Lake sinkholes at 55 ft, remove Orange Lake weir	Sinkhole weir at 55 ft, remove Orange Lake weir
	Plug Orange Lake sinkholes 50%, remove Orange Lake weir	Plug 50%, no weir
	Plug Orange Lake sinkholes 100%, remove Orange Lake weir	Plug 100%, no weir
	Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 50%, remove Orange Lake weir	All to Prairie, plug 50%, no weir
	Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 100%, remove Orange Lake weir	All to Prairie, plug 100%, no weir

Note: ft = feet

Key statistics from simulations of different water management alternatives are summarized in Tables 8–11. These statistics were obtained from data appearing in the appendixes to this report. Other statistics can be easily obtained from the appendixes. Tables 8–11 list a number of statistics of general interest with respect to water management issues. A brief description follows of each statistic that appears in the tables.

Table 8. Summary of SSARR simulations for Newnans Lake (all elevations in feet)

Water Management Alternative	50% Inundation	50-year, 1-day Maximum	10-year, 1-day Maximum	50-year, 1-day Minimum	10-year, 1-day Minimum	Average Difference* (ft)	Maximum Difference* (ft)
Existing conditions (Appendix E)	66.45	70.55	69.62	64.18	64.85	NA	NA
Remove Newnans Lake weir (Appendix G)	65.68	70.40	69.03	63.20	63.93	−0.73	−1.14

Note: NA = not applicable
SSARR = Streamflow Synthesis and Reservoir Regulation [model]

*Difference from "Existing Conditions" over 50-year simulation

Table 9. Summary of SSARR simulations for Orange Lake (all elevations in feet)

Water Management Alternative	50% Inundation	Boater Access at 56 ft	50-year, 1-day Maximum	10-year, 1-day Maximum	50-year, 1-day Minimum	10-year, 1-day Minimum	Average Difference* (ft)	Maximum Difference* (ft)	Zero Flow to Orange Creek
Existing conditions (Appendix E)	57.67	81.6%	60.12	59.52	50.90	53.64	NA	NA	18.6%
Remove Newnans Lake weir (Appendix G)	57.67	81.6%	60.08	59.48	50.95	53.69	0.00	−0.27	18.6%
Complete restoration of Prairie Creek flow to Paynes Prairie (Appendix H)	57.19	72.8%	59.63	58.99	49.85	52.14	−0.63	−2.89	27.8%
Complete diversion of Prairie Creek flow to Orange Lake (Appendix I)	57.91	84.2%	60.32	59.70	51.04	53.86	0.25	1.44	16.3%
Reduction in Paynes Prairie inflow/outflow structure capacity by 50% (Appendix J)	57.79	82.8%	60.23	59.62	50.99	53.78	0.14	0.84	17.3%
Lake level threshold management of the Camps Canal structure (Appendix K)	57.69	82.6%	59.94	59.52	51.03	53.62	0.03	0.64	17.6%
Fill low-flow notch in Orange Lake weir (Appendix L)	58.01	83.5%	60.22	59.66	51.02	53.79	0.25	0.45	44.4%
Remove Orange Lake weir (Appendix M)	56.69	70.7%	59.79	59.18	50.62	53.24	−0.76	−1.18	16.2%
Dredge Cross Creek 3 ft (Appendix N)	57.67	81.3%	60.12	59.52	51.70	53.79	0.01	0.79	18.8%
Plug Orange Lake sinkholes 50% (Appendix O)	57.90	90.2%	60.18	59.60	52.93	55.02	0.43	2.24	10.3%
Plug Orange Lake sinkholes 100% (Appendix P)	58.13	100%	60.30	59.74	56.73	56.73	0.90	5.63	0.0%

Table 9—*Continued*

Water Management Alternative	50% Inundation	Boater Access at 56 ft	50-year, 1-day Maximum	10-year, 1-day Maximum	50-year, 1-day Minimum	10-year, 1-day Minimum	Average Difference* (ft)	Maximum Difference* (ft)	Zero Flow to Orange Creek
Fixed crest weir around Orange Lake sinkholes, 54 ft (Appendix Q)	57.67	82.3%	60.12	59.52	53.07	53.86	0.09	2.29	17.8%
Fixed crest weir around Orange Lake sinkholes, 55 ft (Appendix R)	57.67	83.2%	60.12	59.52	53.79	54.67	0.17	3.16	17.1%
Fixed crest weir around Orange Lake sinkholes, 56 ft (Appendix S)	57.70	87.1%	60.14	59.52	54.69	55.54	0.31	4.10	14.1%
Gated weir around Orange Lake sinkholes, gates closed at 54 ft, opened at 58 ft (Appendix T)	57.73	85.1%	60.16	59.52	53.09	54.28	0.19	3.97	15.2%
Gated weir around Orange Lake sinkholes, gates closed at 55 ft, opened at 58 ft (Appendix U)	57.72	87.2%	60.23	59.52	54.18	54.94	0.30	4.85	13.0%
Gated weir around Orange Lake sinkholes, gates closed at 56 ft, opened at 58 ft (Appendix V)	57.77	90.3%	60.20	59.52	54.92	55.47	0.40	5.06	10.2%
Fixed crest weir around Orange Lake sinkholes at 55 ft, remove Orange Lake weir (Appendix W)	56.72	73.0%	59.79	59.18	53.72	54.64	−0.55	3.15	12.4%
Plug Orange Lake sinkholes 50%, remove Orange Lake weir (Appendix X)	56.92	77.8%	59.87	59.26	52.31	54.29	−0.42	1.67	8.8%
Plug Orange Lake sinkholes 100%, remove Orange Lake weir (Appendix Y)	57.18	89.3%	59.97	59.32	54.79	55.48	−0.04	4.28	0.5%
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 50%, remove Orange Lake weir (Appendix Z)	56.39	63.7%	59.11	58.47	51.12	52.95	−1.05	−1.95	17.6%
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 100%, remove Orange Lake weir (Appendix AA)	56.66	78.5%	59.23	58.64	54.00	54.72	−0.53	3.52	3.6%

Note: NA = not applicable
SSARR = Streamflow Synthesis and Reservoir Regulation [model]

*Difference from "Existing Conditions" over 50-year simulation

Table 10. Summary of SSARR simulations for Lochloosa Lake (all elevations in feet)

Water Management Alternative	50% Inundation	Cross Creek Boater Access at 56.5 ft	50-year, 1-day Maximum	10-year, 1-day Maximum	50-year, 1-day Minimum	10-year, 1-day Minimum	Average Difference* (ft)	Maximum Difference* (ft)	Zero Flow to Lochloosa Slough
Existing conditions (Appendix E)	58.00	80.0%	61.17	60.26	53.43	54.29	NA	NA	33.9%
Remove Newnans Lake weir (Appendix G)	58.00	80.1%	61.15	60.24	53.43	54.31	0.00	-0.12	33.9%
Complete restoration of Prairie Creek flow to Paynes Prairie (Appendix H)	57.57	71.4%	60.95	59.96	53.32	54.10	-0.45	-2.22	45.6%
Complete diversion of Prairie Creek flow to Orange Lake (Appendix I)	58.19	82.7%	61.32	60.45	53.46	54.39	0.20	1.35	29.2%
Reduction in Paynes Prairie inflow/outflow structure capacity by 50% (Appendix J)	58.10	81.8%	61.25	60.37	53.44	54.33	0.11	0.76	31.2%
Lake level threshold management of the Camps Canal structure (Appendix K)	58.02	81.3%	60.99	60.27	53.48	54.23	0.02	0.54	34.8%
Fill low-flow notch in Orange Lake weir (Appendix L)	58.27	82.1%	61.27	60.40	53.48	54.38	0.21	0.41	28.6%
Remove Orange Lake weir (Appendix M)	57.13	67.5%	60.78	59.90	53.31	54.10	-0.67	-1.19	58.3%
Dredge Cross Creek 3 ft (Appendix N)	57.97	97.1% (at 53.5)	61.16	60.25	51.90	54.05	-0.11	-1.95	34.8%
Plug Orange Lake sinkholes 50% (Appendix O)	58.19	88.2%	61.27	60.43	53.91	55.24	0.32	1.39	26.1%
Plug Orange Lake sinkholes 100% (Appendix P)	58.40	99.4%	61.49	60.60	56.17	56.87	0.73	3.38	12.1%
Fixed crest weir around Orange Lake sinkholes, 54 ft (Appendix Q)	58.00	81.0%	61.17	60.26	53.47	54.31	0.02	0.64	33.5%
Fixed crest weir around Orange Lake sinkholes, 55 ft (Appendix R)	58.00	82.1%	61.17	60.26	53.96	54.71	0.08	1.18	33.1%
Fixed crest weir around Orange Lake sinkholes, 56 ft (Appendix S)	58.03	85.0%	61.27	60.26	54.63	55.51	0.21	1.78	31.0%
Gated weir around Orange Lake sinkholes, gates closed at 54 ft, opened at 58 ft (Appendix T)	58.05	84.3%	61.28	60.27	53.53	54.30	0.11	2.61	32.7%

Table 10—*Continued*

Water Management Alternative	50% Inundation	Cross Creek Boater Access at 56.5 ft	50-year, 1-day Maximum	10-year, 1-day Maximum	50-year, 1-day Minimum	10-year, 1-day Minimum	Average Difference* (ft)	Maximum Difference* (ft)	Zero Flow to Lochloosa Slough
Gated weir around Orange Lake sinkholes, gates closed at 55 ft, opened at 58 ft (Appendix U)	58.04	85.8%	61.40	60.38	54.29	55.07	0.18	2.79	30.7%
Gated weir around Orange Lake sinkholes, gates closed at 56 ft, opened at 58 ft (Appendix V)	58.08	87.2%	61.37	60.47	54.87	55.66	0.27	2.95	28.9%
Fixed crest weir around Orange Lake sinkholes at 55 ft, remove Orange Lake weir (Appendix W)	57.16	69.7%	60.78	59.90	53.92	54.61	−0.57	−1.19	57.9%
Plug Orange Lake sinkholes 50%, remove Orange Lake weir (Appendix X)	57.33	74.7%	60.85	59.96	53.54	54.52	−0.43	−0.95	53.0%
Plug Orange Lake sinkholes 100%, remove Orange Lake weir (Appendix Y)	57.56	82.9%	60.92	60.04	54.71	55.54	−0.10	2.26	43.2%
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 50%, remove Orange Lake weir (Appendix Z)	56.86	61.1%	60.46	59.46	53.33	54.11	−0.94	−1.77	67.8%
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 100%, remove Orange Lake weir (Appendix AA)	57.11	72.4%	60.56	59.58	54.12	54.83	−0.55	−1.51	60.8%

Note: NA = not applicable
SSARR = Streamflow Synthesis and Reservoir Regulation [model]

*Difference from "Existing Conditions" over 50-year simulation

Table 11. Summary of SSARR simulations for Paynes Prairie (all elevations in feet)

Water Management Alternative	50% Inundation	50-year, 1-day Maximum	10-year, 1-day Maximum	50-year, 1-day Minimum	10-year, 1-day Minimum	Average Difference* (ft)	Maximum Difference* (ft)	Effect on U.S. 441, Elevation >60 ft
Existing conditions (Appendix E)	56.67	61.22	60.26	51.22	51.39	NA	NA	1.5%
Remove Newnans Lake weir (Appendix G)	56.70	61.23	60.23	51.23	51.41	0.02	0.30	1.5%
Complete restoration of Prairie Creek flow to Paynes Prairie (Appendix H)	57.14	61.87	61.05	51.43	51.81	0.46	1.65	4.0%
Complete diversion of Prairie Creek flow to Orange Lake (Appendix I)	55.52	60.48	59.52	51.22	51.37	−0.65	−2.46	0.1%
Reduction in Paynes Prairie inflow/outflow structure capacity by 50% (Appendix J)	56.68	61.42	60.52	51.51	51.82	0.22	1.40	2.6%
Lake level threshold management of the Camps Canal structure (Appendix K)	56.62	61.22	60.26	51.22	51.40	−0.03	−0.69	1.5%
Use Sweetwater Branch inflow to replace Prairie Creek inflow†	NA	NA	NA	NA	NA	NA	NA	NA

Note: NA = not applicable
SSARR = Streamflow Synthesis and Reservoir Regulation [model]

*Difference from "Existing Conditions" over 50-year simulation
†No hydrologic modeling was done for this alternative; therefore, no data exist for comparative purposes

- 50% Inundation (Tables 8–11). An elevation-duration curve provides the frequency of occurrence for a given lake level. The "50% Inundation" value identifies the elevation for a given lake and water management alternative that is dry 50% of the time and is inundated (flooded) 50% of the time.

- Boater Access at 56 ft (Table 9). There is no uniform elevation at which fishing access is assured at all locations in Orange Lake. However, examination of topographic profiles indicates that most fish camps have some access at about 56 ft, so the percentage of time above this elevation is included in Table 9. If other elevations are considered more appropriate, then their statistics can be found in the appendixes to this report.

- Cross Creek Boater Access at 56.5 ft (Table 10). The controlling hydraulic invert of Cross Creek is at approximately 54.5 ft; in other words, there is no flow into Orange Lake from Lochloosa Lake once Lochloosa Lake falls below 54.5 ft. Assuming a minimum depth of 2 ft of water for boating access and adding this 2 ft to the 54.5 ft, an elevation of 56.5 ft is obtained; the percentage of time Lochloosa Lake is above this elevation is included in Table 10.

- 50-year/10-year, 1-day Maximum (Tables 8–11). Each year of simulation has a 1-day maximum elevation. This series of elevations is ranked and sorted and given a probability of occurrence based on the Weibull formula:

$$p = \frac{m}{(n+1)} \qquad (2)$$

  where:

  p = probability of occurrence
  m = rank of a given event
  n = number of events

  The return period (average recurrence interval) is defined as the inverse of this probability. Thus, p=.02 corresponds to a return period of 50 years.

- 50-year/10-year, 1-day Minimum (Tables 8–11). Probabilities and return periods are obtained in the same manner as the maximum elevations, except that they are sorted inversely.

- Average Difference (Table 8–11). The hydrograph corresponding to a given water management alternative for any given water body is compared to the "Existing Conditions" hydrograph of the water body. The value for each time increment on the hydrograph is subtracted from the corresponding point on the "Existing Conditions" hydrograph to obtain the difference. This difference is then averaged over the entire period of record. This statistic provides an idea of the relative effect of a given water management alternative when compared to "Existing Conditions."

- Maximum Difference (Tables 8–11). The hydrograph corresponding to a given water management alternative for any given water body is compared to the "Existing Conditions" hydrograph of that water body. The value for each time increment on the hydrograph is subtracted from the corresponding point on the "Existing Conditions" hydrograph to obtain the difference. Then the maximum of the differences is determined. This statistic indicates the maximum effect a water management alternative might have from a water level perspective.

- Zero Flow to Orange Creek (Table 9). A discharge-duration curve indicates the frequency with which a given discharge occurs at a given location. This column describes the percentage of time for which there is zero flow at the outlet from Orange Lake to Orange Creek.

- Zero Flow to Lochloosa Slough (Table 10). A discharge-duration curve indicates the frequency with which a given discharge occurs at a given location. This column describes the percentage of time for which there is zero flow at the outlet from Lochloosa Lake to Lochloosa Slough.

- Effect on U.S. 441, Elevation >60 ft (Table 11). The lowest crown elevation of U.S. 441 through Paynes Prairie is approximately 62 ft; however, the highway would begin to be affected by the water at lower elevations. The elevation of the edge of pavement is approximately 61.5 ft. Allowing about 1 ft for pavement thickness and 0.5 ft freeboard, the elevation at which water begins to affect the road would be about 60 ft. The percentage of time above 60 ft is included in Table 11. The duration of any other elevation deemed more appropriate can be found in the appendixes to this report. If a larger freeboard is deemed necessary, the corresponding modeling results can be found in Appendixes E and G–K.

Hydrologic Modeling of Water Management Alternatives

Part of the evaluation of management alternatives consisted of comparing elevations and statistics for simulation of "Existing Conditions" with those of the management alternative in question. A brief description which details hydrologic modeling parameters for each management alternative follows.

Newnans Lake

Two of the 23 water management alternatives (Table 7) would affect Newnans Lake.

Existing Conditions. For purposes of this study, "Existing Conditions" at Newnans Lake assumed that the outlet weir was in place.

A set of graphs and tables corresponding to the SSARR simulation of "Existing Conditions" appears in Appendix E. Some graphs for the "Existing Conditions" simulations will appear when they are compared with different management alternatives. Hydrologic statistics for this alternative are summarized in Table 8.

Remove Newnans Lake Weir. Removal of the Newnans Lake weir was simulated by replacing the "Existing Conditions" rating curve—with weir—with one corresponding to the case without the weir (Figure C1, Appendix C). A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix G. A summary of hydrologic statistics for this alternative appears in Table 8.

Paynes Prairie

Seven of the 23 water management alternatives (Table 7) would affect Paynes Prairie. The "Use Sweetwater Branch Inflow to Replace Prairie Creek Inflow" alternative was not modeled because of engineering logistical problems (e.g., long-distance water piping or pumping) and questionable water quality.

Existing Conditions. For purposes of this study, "Existing Conditions" for Paynes Prairie consisted of the Newnans Lake weir in place, gates on the Camps Canal structure completely open at all times, and gates at the Alachua Sink structure (Main Structure) completely open at all times.

A set of graphs and tables corresponding to the SSARR simulation of "Existing Conditions" appears in Appendix E. Some graphs for the "Existing Conditions" simulations will appear when they are compared with different management alternatives. Hydrologic statistics for this alternative are summarized in Table 11.

Remove Newnans Lake Weir. Because removal of the weir affects the distribution of flow out of Newnans Lake, this alternative will have an effect on Paynes Prairie. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix G. The hydrologic effects of this alternative on Paynes Prairie are summarized in Table 11.

Complete Restoration of Prairie Creek Flow to Paynes Prairie. At one extreme of many possible restoration alternatives for Paynes Prairie is the complete restoration of Prairie Creek flow to the prairie. This alternative was simulated by replacing the "Existing Conditions" rating curve at the Camps Canal structure with one that routes all flows at this point into Paynes Prairie. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix H. The hydrologic effects of this alternative on Paynes Prairie are summarized in Table 11.

Complete Diversion of Prairie Creek Flow to Orange Lake. At the other extreme from complete restoration of Prairie Creek flow to Paynes Prairie is the complete diversion of Prairie Creek flow by closing the gates at the Camps Canal structure and cutting off all flow from Prairie Creek into Paynes Prairie. This alternative was simulated by replacing the "Existing Conditions" rating curve at the Camps Canal structure with one that routes all flows at this point into Orange Lake. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix I. The hydrologic effects of this alternative on Paynes Prairie are summarized in Table 11.

Reduction in Paynes Prairie Inflow/Outflow Structure Capacity by 50%. One general category of management alternatives for Paynes Prairie would be to alter the management practices at the Camps Canal structure and/or the Alachua Sink structure (Main Structure). These changes would involve the operation of one or more gates on either or both structures. At least conceptually, the ideal situation is to minimize active management and leave the system to operate largely on its own.

There is virtually an infinite number of management combinations between the two structures. This particular management alternative was simulated because it represents a simple combination.

This alternative was simulated by replacing the "Existing Conditions" rating curve at the Camps Canal structure (Figure C5, Appendix C) with one that reduces the flow to Paynes Prairie by one-half. The final effect will be to halve the amount of water going to the prairie from Camps Canal.

The "Existing Conditions" rating curve at the Paynes Prairie Main Structure (Figure C6, Appendix C) was replaced by one that had half of the existing capacity at each elevation.

A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix J. The hydrologic effects of this alternative on Paynes Prairie are summarized in Table 11.

Lake Level Threshold Management of the Camps Canal Structure. There are many options for operating the Camps Canal structure gates, depending on hydrologic conditions in Orange Lake and/or Paynes Prairie. In this particular case, the following criteria were simulated (any combination of elevations can be used):

- If Orange Lake is above 56 ft, then the gates of the Camps Canal structure are kept completely open (as in "Existing Conditions").
- If Newnans Lake is below 66 ft, then the gates of the Camps Canal structure are kept completely open (as in "Existing Conditions").

- If Orange Lake is below 56 ft and Newnans Lake is above 66 ft, then the flow through the Camps Canal structure is reduced by half.

This alternative would provide some additional recreational access on Orange Lake when Camps Canal flows are high and the effects on Orange Lake water levels are most pronounced. It also would ensure low flow across the eastern prairie wetlands (Figure A4, Appendix A) in times of drought, when flow into Paynes Prairie is low and the effect on Orange Lake is minimal.

A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix K. The hydrologic effects of this alternative on Paynes Prairie are summarized in Table 11.

Orange and Lochloosa Lakes

Twenty-two of the 23 water management alternatives would affect Orange and Lochloosa lakes.

Existing Conditions. For purposes of this study, "Existing Conditions" for Orange and Lochloosa lakes consisted of Newnans Lake weir in place, gates on the Camps Canal structure completely open at all times, and Orange Lake weir in place with the low-flow notch as originally configured.

A set of graphs and tables corresponding to the SSARR simulation of "Existing Conditions" appears in Appendix E. Some graphs for the "Existing Conditions" simulation will appear when they are compared with different management alternatives. Hydrologic statistics for the "Existing Conditions" simulation of Orange and Lochloosa lakes are summarized in Tables 9 and 10, respectively.

Remove Newnans Lake Weir. Because removal of the weir affects the distribution of flow out of Newnans Lake, this alternative will have an effect on Orange and Lochloosa lakes. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix G. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Complete Restoration of Prairie Creek Flow to Paynes Prairie. This alternative was simulated by replacing the "Existing Conditions" rating curve at the Camps Canal structure with one that routes all flows at this point into Paynes Prairie. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix H. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Complete Diversion of Prairie Creek Flow to Orange Lake. This alternative was simulated by replacing the "Existing Conditions" rating curve at the Camps Canal structure with one that routes all flows at this point into Orange Lake. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix I. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Reduction in Paynes Prairie Inflow/Outflow Structure Capacity by 50%. This alternative was simulated by replacing the "Existing Conditions" rating curve at the Camps Canal structure (Figure C5, Appendix C) with one that cut the capacity at each Prairie Creek structure in half. The final effect will be to halve the amount of water going to the prairie from Camps Canal.

A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix J. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Lake Level Threshold Management of the Camps Canal Structure. There are many options for operating the Camps Canal structure gates, depending on hydrologic conditions in Orange Lake and/or Paynes Prairie. In this particular case, the following criteria were simulated (any combination of elevations can be used):

- If Orange Lake is above 56 ft, then the gates of the Camps Canal structure are kept completely open (as in "Existing Conditions").
- If Newnans Lake is below 66 ft, then the gates of the Camps Canal structure are kept completely open (as with "Existing Conditions").
- If Orange Lake is below 56 ft and Newnans Lake is above 66 ft, then the flow through the Camps Canal structure is reduced by half.

This alternative would provide some additional recreational access on Orange Lake when Camps Canal flows are high and the effects on Orange Lake water levels are most pronounced. It also would ensure low flow across the eastern prairie wetlands (Figure A4, Appendix A) in times of drought, when flow down Camps Canal is low and the effect on Orange Lake water levels of flow into Paynes Prairie is minimal.

A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix K. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Fill Low-Flow Notch in Orange Lake Weir. The low-flow notch in the Orange Lake weir was illegally filled in with concrete in 1990, most likely in the belief that it would have a dramatic effect on alleviating low lake levels. Filling the notch had been suggested as a possible management alternative that would improve boating access on Orange Lake and through Cross Creek. The SSARR model for the Orange Lake subbasin was run to determine the effect on water levels in Orange Lake by filling the low-flow notch. This simulation consisted of replacing the rating curve for the existing Orange Lake weir (Figure C2, Appendix C) with a rating curve for the weir with the low-flow notch filled.

A set of graphs and tables that corresponds to the SSARR simulation of this management alternative appears in Appendix L. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Remove Orange Lake Weir. This alternative was simulated by replacing the "Existing Conditions" rating curve for Orange Lake (Figure C2, Appendix C) by one corresponding to the without-weir alternative. A set of graphs and tables that corresponds to the SSARR simulation of this management alternative appears in Appendix M. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Dredge Cross Creek 3 ft. During times of drought, boat access through Cross Creek (between Orange and Lochloosa lakes) is a problem. This problem affects residents of the town of Cross Creek, some Cross Creek businesses, and people who want to boat from one lake to the other. One possible solution to this problem is to dredge the creek channel.

Dredging Cross Creek was simulated with SSARR by essentially lowering the sill elevation between the two lakes. Because Lochloosa Lake is generally higher than Orange Lake, this analysis concentrated on the elevation of Lochloosa Lake. Cross Creek goes dry when Lochloosa Lake drops to an elevation of approximately 54.5 ft. To simulate the effects of dredging, the "Existing Conditions" rating curves for Cross Creek (Figure C4, Appendix C) were replaced by curves for lower sill elevations. Although this analysis is for a 3-ft-deep dredge, similar analyses can be made for other levels of dredging.

To simulate the effects of a 3-ft dredge, the sill elevation for the "Existing Conditions" Cross Creek rating curves was lowered from 54.5 ft to 51.5 ft. A set of graphs and tables that corresponds to the SSARR simulation of this management alternative appears in Appendix N. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Plug Orange Lake Sinkholes 50%. Conceptually, there are two ways to reduce the flows to the Floridan aquifer system: (1) the sinkholes in Orange Lake can be partially or completely plugged or (2) the water flowing to the sinkholes can be controlled with some sort of weir, with or without gates.

Plugging the sinkholes has been found to be feasible from an engineering standpoint (BCI 1994). Attempts at plugging the sinkholes were made during the 1950s and 1960s, although it appears that seepage through the sinkholes returned to similar levels after a short time (see discussion on p. 101). The following assumptions are necessary to this analysis:

- Virtually all seepage is concentrated around the Heagy Burry Park area.
- Once the location and magnitude of seepage can be ascertained, part or all of the loss can be cut off by filling in the sinkholes.
- Any measures to plug the sinkholes are permanent.
- New sinkholes will not form.

A 50% reduction of seepage does not refer to the volume of seepage but to the size or number of sinkholes. Thus, if one assumes that there are 10 sinkholes of identical capacity and rating, then a 50% reduction means that five remain. Because lake levels increase, hydraulic head increases and the seepage by volume would actually be greater than 50%.

This alternative was simulated by replacing the "Existing Conditions" family of seepage curves (Figure 17) with one where the seepage at every point is 50% of that under "Existing Conditions." Thus, for example, at an Orange Lake elevation of 60 ft and a potentiometric level of 48 ft, seepage under "Existing Conditions" would be about 90 cfs. For this alternative, that particular combination of elevations results in seepage of about 45 cfs.

A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix O. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Plug Orange Lake Sinkholes 100%. This alternative was simulated by removing the "Existing Conditions" seepage curves (Figure 17) from the SSARR model of Orange Lake. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix P. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Fixed Crest Weir around Orange Lake Sinkholes, 54 ft. Building some sort of structure around the sinkhole complex (e.g., a pile structure) has been found to be feasible from an engineering standpoint (BCI 1994). Although this structure can include some sort of gate to provide for operation, the following alternatives assume a fixed crest weir.

This alternative was simulated by replacing the "Existing Conditions" family of seepage curves (Figure 17) with one that cuts off seepage if Orange Lake goes below 54 ft. In other words, Orange Lake was simulated above 54 ft as if there was no weir around the sinkhole area. A set of graphs and tables that corresponds to the SSARR simulation of this management alternative appears in Appendix Q. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Fixed Crest Weir around Orange Lake Sinkholes, 55 ft. This alternative was simulated by replacing the "Existing Conditions" family of seepage curves (Figure 17) with one that cuts off seepage if Orange Lake goes below 55 ft. In other words, Orange Lake was simulated above 55 ft as if there was no weir around the sinkhole area. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix R. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Fixed Crest Weir around Orange Lake Sinkholes, 56 ft. This alternative was simulated by replacing the "Existing Conditions" family of seepage curves (Figure 17) with one that cuts off seepage if Orange Lake goes below 56 ft. In other words, Orange Lake was simulated above 56 ft as if there was no weir around the sinkhole area. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix S.

The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Gated Weir around Orange Lake Sinkholes, Gates Closed at 54 ft, Opened at 58 ft. Building some sort of structure around the sinkhole complex has been found to be feasible from an engineering standpoint (BCI 1994). This structure can include a gate to provide for operation.

This alternative was simulated by replacing the "Existing Conditions" family of seepage curves (Figure 17) with one that cuts off seepage if Orange Lake goes below 54 ft. Once Orange Lake reaches 58 ft, the normal seepage curves are reinserted. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix T. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Gated Weir around Orange Lake Sinkholes, Gates Closed at 55 ft, Opened at 58 ft. This alternative was simulated by replacing the "Existing Conditions" family of seepage curves (Figure 17) with one that cuts off seepage if Orange Lake goes below 55 ft. Once Orange Lake reaches 58 ft, the normal seepage curves are reinserted. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix U. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Gated Weir around Orange Lake Sinkholes, Gates Closed at 56 ft, Opened at 58 ft. This alternative was simulated by replacing the "Existing Conditions" family of seepage curves (Figure 17) with one that cuts off seepage if Orange Lake goes below 56 ft. Once Orange Lake reaches 58 ft, the normal seepage curves are reinserted. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix V. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Fixed Crest Weir around Orange Lake Sinkholes at 55 ft, Remove Orange Lake Weir. There is an almost infinite variety of combinations that use two or more management alternatives. This simulation consisted of replacing the rating curve for the existing Orange Lake weir (Figure C2, Appendix C) with one that corresponds to the case without the weir. Additionally, the "Existing Conditions" family of seepage curves (Figure 17) was replaced with one that cuts off seepage if Orange Lake goes below 55 ft. In other words, Orange Lake is simulated above 55 ft as if there were no weir around the sinkhole area. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix W. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Plug Orange Lake Sinkholes 50%, Remove Orange Lake Weir. This simulation consisted of replacing the rating curve for the existing Orange Lake weir (Figure C2, Appendix C) with one that corresponds to the case without the weir. Additionally, the "Existing Conditions" family of seepage curves (Figure 17) was replaced with one that corresponds to a 50% cut in seepage. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix X. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Plug Orange Lake Sinkholes 100%, Remove Orange Lake Weir. This simulation consisted of replacing the rating curve for the existing Orange Lake weir (Figure C2, Appendix C) with one that corresponds to the case without the weir. Additionally, the "Existing Conditions" family of seepage curves (Figure 17) was removed. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix Y. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Complete Restoration of Prairie Creek Flow to Paynes Prairie, Plug Sinkholes 50%, Remove Orange Lake Weir. This simulation consisted of replacing the rating curve for the existing Orange Lake weir (Figure C2, Appendix C) with one that corresponds to the case without the weir. Additionally, the "Existing Conditions" family of seepage curves (Figure 17) was replaced with one corresponding to a

50% cut in seepage. Finally, the "Existing Conditions" Camps Canal rating curve was replaced by one that allows all flow to Paynes Prairie. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix Z. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Complete Restoration of Prairie Creek Flow to Paynes Prairie, Plug Sinkholes 100%, Remove Orange Lake Weir. This simulation consisted of replacing the rating curve for the existing Orange Lake weir (Figure C2, Appendix C) with one that corresponds to the case without the weir. Additionally, the "Existing Conditions" family of seepage curves (Figure 17) was removed. Finally, the "Existing Conditions" Camps Canal rating curve was replaced by one that allows all flow to Paynes Prairie. A set of graphs and tables corresponding to the SSARR simulation of this management alternative appears in Appendix AA. The hydrologic effects of this alternative on Orange and Lochloosa lakes are summarized in Tables 9 and 10.

Additional Hydrologic Modeling Analyses

In addition to modeling water management alternatives, SSARR was used to examine different aspects of OCB from a hydrologic perspective. These analyses help us to understand the dynamics of the system and can provide insight into understanding how best to approach water management in the basin.

Water Budgets for Existing Conditions in the Orange Creek Basin

A water budget identifies the source and destination of water in a basin. It can provide insight into the relative importance of different sources of water and provide clues into the relative effect of different management alternatives. A water budget for the "Existing Conditions" simulation of each subbasin in OCB is included in Appendix E (Tables E43–E49).

Newnans Lake. Over the 50 years of simulation, runoff from surrounding drainage basins accounted for an average of 65% (55,800 acre-feet per year [ac-ft/yr]) of inflows to Newnans Lake

(Table E43, Appendix E). Direct rainfall to the lake provided the remaining 35% (29,700 ac-ft/yr) of inflows.

Flow to Prairie Creek accounted for an average of 66% (56,500 ac-ft/yr) of outflows from Newnans Lake. Direct evaporation from the lake provided the remaining 34% (29,200 ac-ft/yr) of outflows.

Camps Canal Structure. Over the 50 years of simulation, runoff from the contributing drainage basin between Newnans Lake and the Camps Canal structure accounted for an average of only 1% (800 ac-ft/yr) of inflows at the structure (Table E44, Appendix E). Outflow from Newnans Lake provided the remaining 99% (56,500 ac-ft/yr) of inflows.

Inflow to Paynes Prairie accounted for an average of 45% (25,800 ac-ft/yr) of outflows at the Camps Canal structure. Flow to Orange Lake accounted for 55% (31,400 ac-ft/yr) of outflows.

According to the SSARR simulation, an average of 36 cfs (23 mgd) went to Paynes Prairie and 43 cfs (28 mgd) went to Orange Lake. The maximum annual flow to Paynes Prairie from Prairie Creek was 57,500 ac-ft/yr (94 cfs or 61 mgd). The minimum annual flow to Paynes Prairie from Prairie Creek was 900 ac-ft/yr (1.3 cfs or 0.81 mgd).

Orange Lake. Over the 50 years of simulation, runoff from surrounding drainage basins accounted for an average of 16% (20,400 ac-ft/yr) of inflows to Orange Lake (Table E45, Appendix E). Flow from Camps Canal, flow from Lochloosa Lake, and direct rainfall provided 24% (31,700 ac-ft/yr), 19% (24,900 ac-ft/yr), and 41% (53,300 ac-ft/yr), respectively, of inflows to Orange Lake. (The inflow from Camps Canal [31,700 ac-ft/yr] is slightly different from outflows at the Camps Canal structure [31,400 ac-ft/yr; Table E44, Appendix E] because of rounding errors.)

Flow to Orange Creek accounted for an average of 35% (46,000 ac-ft/yr) of outflows from Orange Lake. Direct evaporation and losses to the Floridan aquifer system provided 41%

(53,300 ac-ft/yr) and 24% (31,900 ac-ft/yr), respectively, of outflows from Orange Lake. According to the SSARR simulation, the average seepage to the Floridan aquifer system was 44 cfs (29 mgd). The maximum annual seepage was 52,100 ac-ft/yr (72 cfs or 46 mgd), and the minimum annual seepage was 18,200 ac-ft/yr (25 cfs or 16 mgd).

Lochloosa Lake. Over the 50 years of simulation, runoff from surrounding drainage basins accounted for an average of 46% (30,100 ac-ft/yr) of inflows to Lochloosa Lake (Table E46, Appendix E). Direct rainfall to Lochloosa Lake provided the remaining 54% (36,100 ac-ft/yr) of inflow.

Flow to Lochloosa Slough accounted for an average of only 8% (5,600 ac-ft/yr) of outflows from Lochloosa Lake. Direct evaporation and flow to Orange Lake provided 54% (35,900 ac-ft/yr) and 38% (24,900 ac-ft/yr), respectively, of outflows from Lochloosa Lake.

Orange Creek at Orange Springs. Over the 50 years of simulation, runoff from contributing drainage basins between the outlets of Orange and Lochloosa lakes and Orange Creek at Orange Springs accounted for an average of 36% (29,000 ac-ft/yr) of inflows at the USGS gage on Orange Creek (Table E47, Appendix E). Outflows from Lochloosa Slough and Orange Lake provided 7% (5,800 ac-ft/yr) and 57% (46,200 ac-ft/yr), respectively, of the inflows at this location.

Paynes Prairie at the Main Structure. Paynes Prairie is an extremely complex hydrologic system (Figure A4, Appendix A). The water budget at the Main Structure (cell 6a, Figure A4, Appendix A and Table E48, Appendix E) consequently is made up of numerous components. Over the 50 years of simulation, runoff from surrounding drainage basin accounted for an average of 7% (3,600 ac-ft/yr) of inflow at the Main Structure. The area around U.S. 441 (including cells 1, 2, and 3) provided 17% (8,300 ac-ft/yr) of inflow at the Main Structure. The Bivans Arm area (cell 4) provided 12% (5,700 ac-ft/yr) of inflow at the Main Structure. Flow from the area west of the Camps Canal structure included discharge from the structure and runoff from the surrounding drainage basin (cell 8) and provided 54% (26,700 ac-ft/yr) of inflow at the Main Structure.

The area southeast of the Main Structure (including cell 6b and Lake Wauberg) provided 10% (4,700 ac-ft/yr) of the inflow at the Main Structure. Finally, the difference between direct rainfall and direct evaporation provided just 0.5% (200 ac-ft/yr) of inflow at the Main Structure. (The difference between direct rainfall and direct evaporation was used to simplify the hydrologic model and make it as small as possible.)

Orange Lake Seepage

Seepage is an important part of the water budget for Orange Lake (Table E45, Appendix E). The presence of this seepage has been documented in two instances in recent years. In the mid-1950s, Orange Lake reached its lowest recorded level; seepage around Heagy Burry Park was obvious at this time, and a number of attempts were made to stop it. In November 1992, this same area was isolated and the seepage measured at 37 cfs.

Other than these two instances, it is not known whether or not this ground water seepage has decreased and increased over the years. Although it is impossible to verify the magnitude of seepage without direct measurements, hydrologic analysis perhaps can provide clues.

One method of analyzing model performance or detecting inconsistencies within gaging records is with double-mass curves. The upper part of Figure 30 shows a curve comparing modeled and gaged discharges at the USGS gage on Orange Creek at Orange Springs. If the model is accurately simulating the hydrology, then this curve should be close to the line of equality. There is a noticeable divergence of the double-mass curve from the line of equality. The divergence means either that the model did not simulate the hydrology of Orange Lake very well, or that some hydrologic change had occurred and showed up as a divergence. The double-mass curve does end up more or less parallel to the line of equality.

The lower part of Figure 30 shows a graph of the difference between the double-mass curve and the line of equality. For a properly performing model, of course, this difference curve should hover

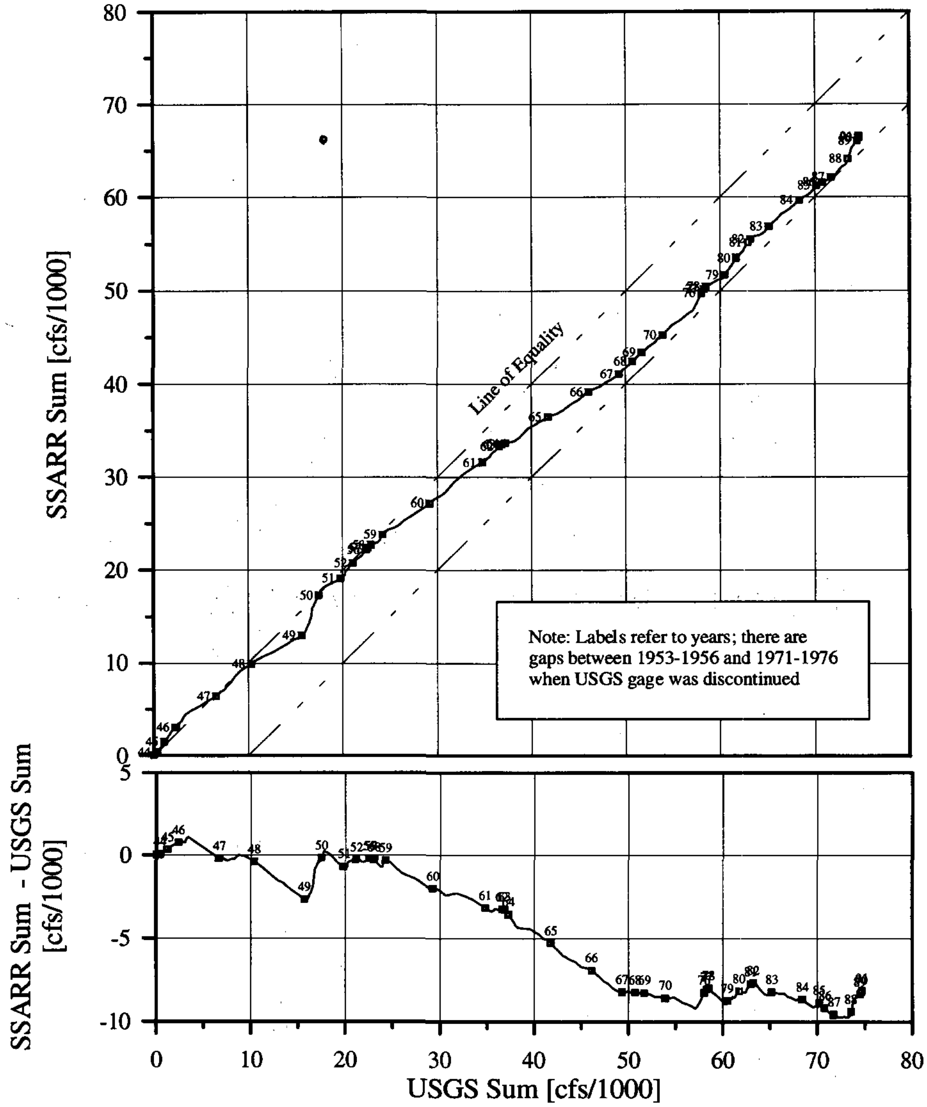

Figure 30. Orange Creek at Orange Springs double-mass curve (top) and difference curve (bottom) for historical conditions (1942–91)

around zero. The divergence of the double-mass curve and line of equality appears as a divergence from a horizontal line at zero. It is quite possible that the divergence is caused by the activity that surrounded the sinkhole area following the drought in the 1950s. The divergence starts around 1958 and stops at the end of 1966, as the difference curve becomes more or less horizontal. During 1957, several unsuccessful attempts were made to construct a berm that would isolate the sinkhole area. The berm was finally built around August 1957. According to the Jessen report (1972, p. 307):

> The lake began rising after a tropical storm in June. Scattered convectional rains during the summer brought the lake level up to 56 feet by the end of 1957. As the lake continued to rise, great chunks of the dike slumped into the sink. By the end of March 1958, the remains of the dike lay beneath the waters.

The berm material (including that from the unsuccessful attempts at building the berm) actually might have succeeded in plugging the principal sinkholes, thus the divergence of the difference curve.

According to Jessen (1972, p. 319):

> The continuation of the drought through 1963 kept the lake level low. A reading of just below 55 feet occurred on January 1, 1964. ... A determined effort was made to plug the sinkhole. ... The sink was filled to approximately 5 feet above normal water level.

The divergence of the difference curve continues until the end of 1966. After 1966, the difference curve becomes more or less horizontal, indicating that the model is again simulating correctly. Thus it appears that the plugging of the sinkholes was successful until the lake "started leaking" again around the end of 1966.

In summary, therefore, there is no reason to believe that this significant seepage, or "sinkhole," has not been active, at least since 1942. Also, in times of drought the sinkholes become more of an issue because the effect is more visible. Although attempts to plug the sinkholes appeared to have succeeded, that success lasted only 8 or 9 years.

ENVIRONMENTAL ASSESSMENT

This chapter describes the results of the environmental assessment of the different water management alternatives for OCB and the results of the wetland vegetation mapping for each of the major water bodies.

Evaluations of the surface water management alternatives are presented for each of the major water bodies: Newnans Lake, Paynes Prairie, and Orange and Lochloosa lakes. Twenty-three distinct management alternatives were evaluated—2 for Newnans Lake, 7 for Paynes Prairie, and 22 for Orange and Lochloosa lakes (Table 7).

WETLAND VEGETATION MAPPING

The following sections describe the major wetland communities contiguous to each lake and Paynes Prairie. Appendix D contains a description of the dominant plant species comprising the different wetland categories referenced in the text.

Newnans Lake

Newnans Lake has a surface area of approximately 5,980 ac consisting of 5,441 ac of open water and 539 ac of littoral zone (Table 12). The littoral zone is dominated by deep marsh communities (263 ac), submerged aquatic beds (272 ac), and floating marsh (4 ac) (Figure 31). The emergent wetlands surrounding the lake are comprised primarily of cypress swamp (173 ac) and mixed hardwood swamp (830 ac), shifting to bayhead (122 ac) and hydric hammock (394 ac) with increasing floodplain elevation.

Paynes Prairie

Paynes Prairie contains approximately 7,117 ac of shallow marsh bordered at higher elevations by shrub swamp (2,255 ac), wet prairie (2,553 ac), and transitional shrub communities (953 ac) (Table 12). Deep marsh (123 ac) and floating marsh (52 ac) communities occur

Table 12. Wetland vegetation by type and major water body (in acres; values in parentheses are percentages)

Wetland Type	Newnans Lake	Paynes Prairie	Orange Lake	Lochloosa Lake
Bayhead	122.3 (6)	7.2 (<1)	14.1 (<1)	59.9 (1)
Bottomland hardwoods	7.1 (<1)	NA	NA	40.3 (<1)
Cypress swamp	172.9 (8)	17.5 (<1)	59.9 (<1)	193.3 (4)
Deep marsh	263.1 (13)	122.9 (<1)	1,486.4 (14)	149.3 (3)
Floating marsh	3.6 (<1)	52.3 (<1)	408.1 (4)	101.8 (2)
Forested depressions	NA	NA	18.6 (<1)	142.3 (3)
Hardwood swamp	830.4 (40)	75.8 (<1)	662.9 (6)	853.3 (18)
Hydric hammock	393.8 (19)	55.4 (<1)	602.2 (6)	217.2 (4)
Shallow marsh	1.7 (<1)	7,117.1 (54)	3,536.4 (34)	1,623.7 (34)
Shrub swamp	NA	2,255.3 (17)	1,520.2 (15)	174.0 (4)
Shrub bog	9.8 (<1)	37.8 (<1)	NA	14.4 (<1)
Submerged aquatic beds	271.7 (13)	NA	1,040.3 (10)	593.1 (12)
Transitional shrub	11.1 (<1)	952.7 (7)	345.3 (3)	132.0 (3)
Wet prairie	NA	2,552.6 (19)	564.0 (6)	481.0 (10)
Total wetlands	2,087.5 (100)	13,246.6 (100)	10,258.4 (100)	4,775.6 (100)
Open water	5,441.1	2,552.7	4,214.5	4,779.6
Total lake surface area*	5,979.5	NA	7,149.3	5,623.8

Note: NA = not applicable

*Calculated by combining acreages of open water, submerged aquatic beds, floating marsh, and deep marsh

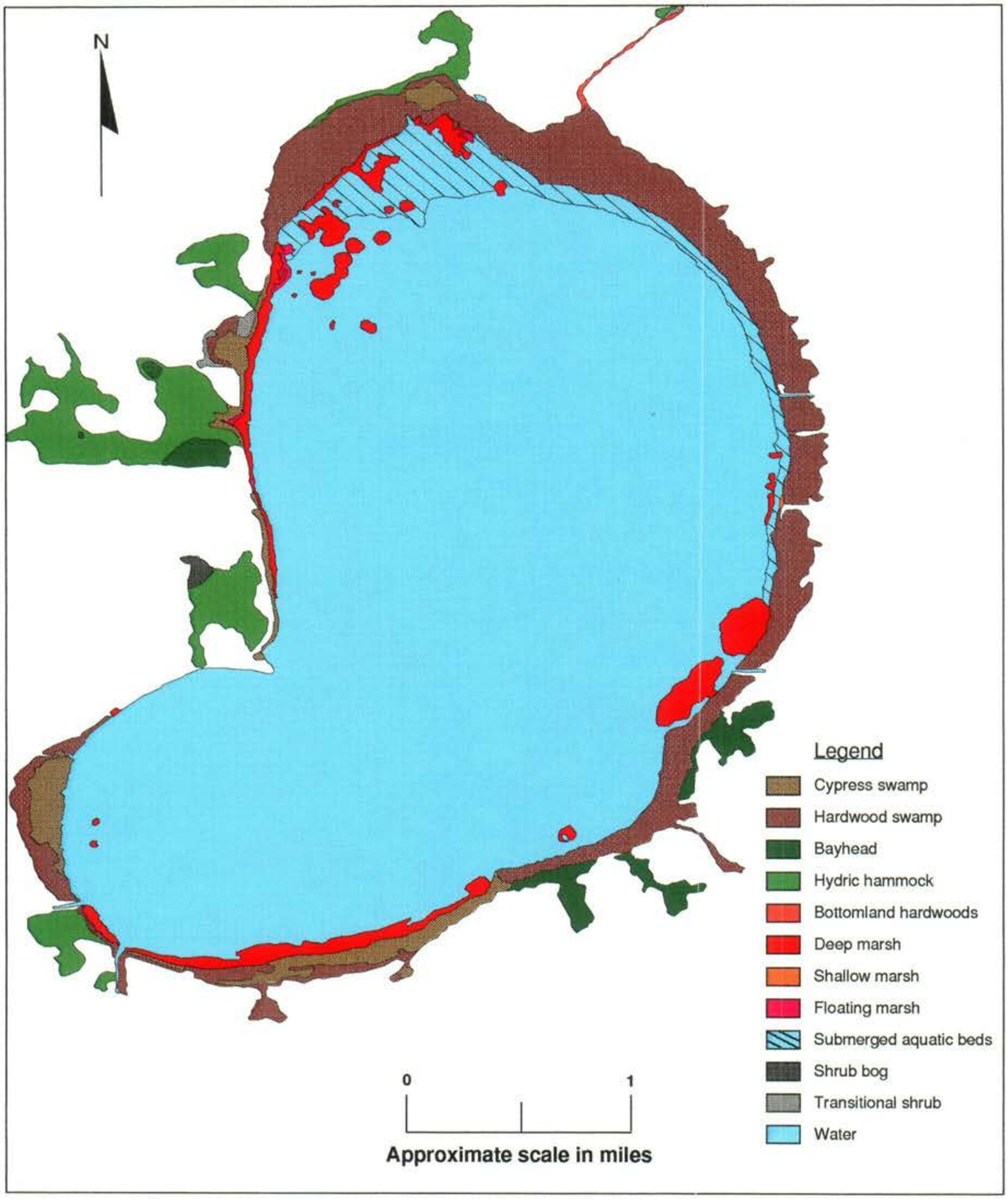

Figure 31. Wetland vegetation map of Newnans Lake

primarily in Alachua Lake and the Prairie Creek channel (Figures 7 and 32). Cypress swamp (18 ac) occurs only in the eastern lobe of Paynes Prairie along the Prairie Creek channel. Other types of forested wetlands are rare around the prairie.

Orange Lake

Orange Lake has a surface area of approximately 7,149 ac (Table 12). Much of the surface area is occupied by deep marsh (1,486 ac), submerged aquatic beds (1,040 ac), and floating marsh (408 ac) (Figure 33). The lake is surrounded by vast expanses of contiguous shallow marsh (3,536 ac). Shrub swamp (1,520 ac) has become a major plant community around the lake, primarily displacing shallow marsh community. Small areas of forested wetlands are scattered around the periphery of the lake at higher elevations. Cypress swamp (60 ac) is located to the northeast along the River Styx (Figures 9 and 33).

Lochloosa Lake

Lochloosa Lake has a surface area of approximately 5,624 ac, consisting of 4,780 ac of open water and 844 ac of littoral zone (Table 12). At times, much of the open water habitat of the lake is occupied by submerged aquatic beds (primarily hydrilla). The littoral zone is dominated by submerged aquatic beds (593 ac), deep marsh (149 ac), and floating marsh (102 ac) (Figure 34). Shallow marsh vegetation is by far the most prevalent plant community around the lake, accounting for 1,624 ac (34%) of the total wetland acreage. The shallow marsh forms vast contiguous expanses in the southern and southwestern portions of the lake. Forested wetland communities, dominated by cypress swamp (193 ac) and hardwood swamp (853 ac), occur in the northern, western, and southeastern portions of the lake.

Environmental Evaluation of Management Alternatives

The following sections describe the results of the environmental assessment of different water management alternatives for each of

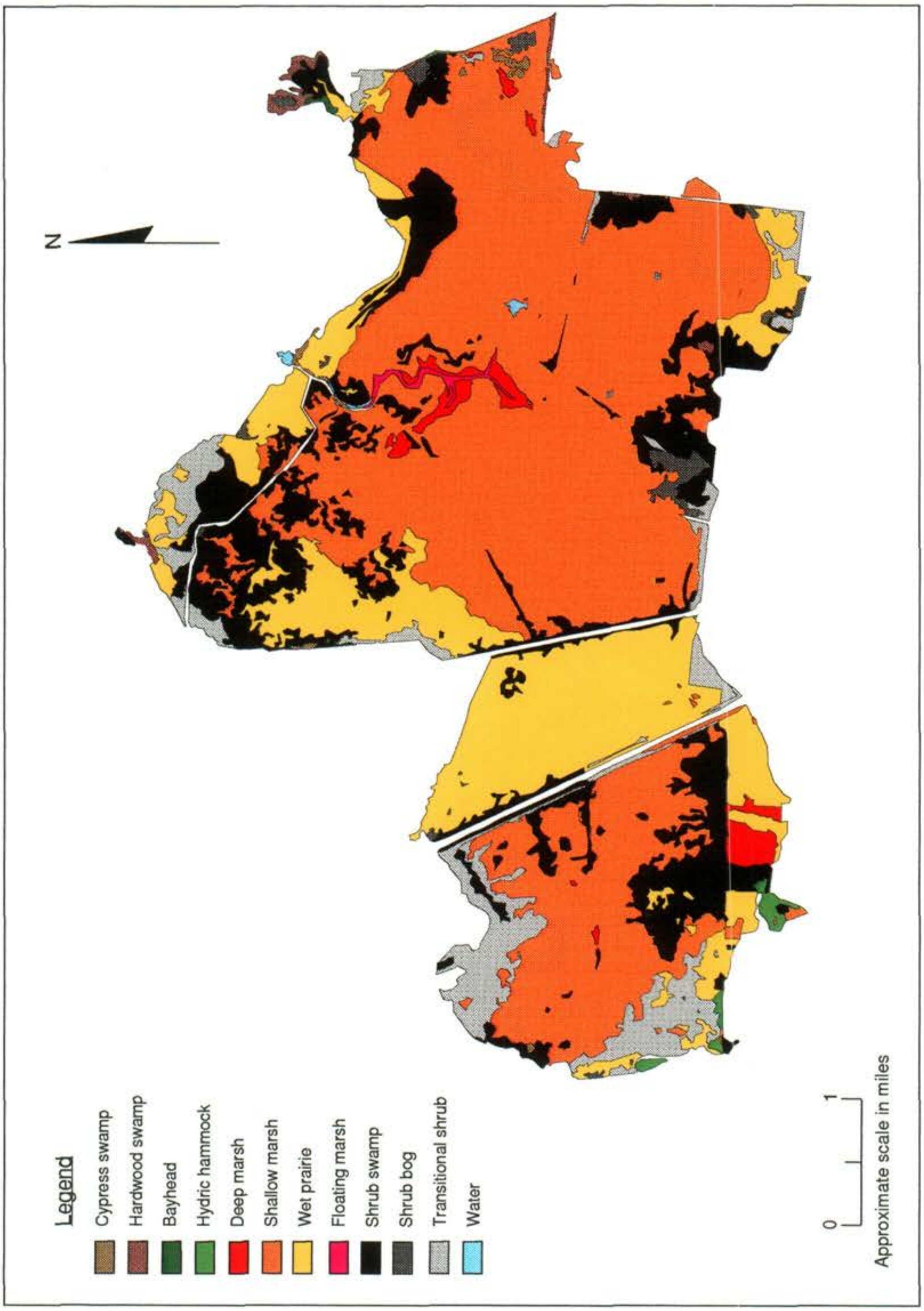

Figure 32. Wetland vegetation map of Paynes Prairie

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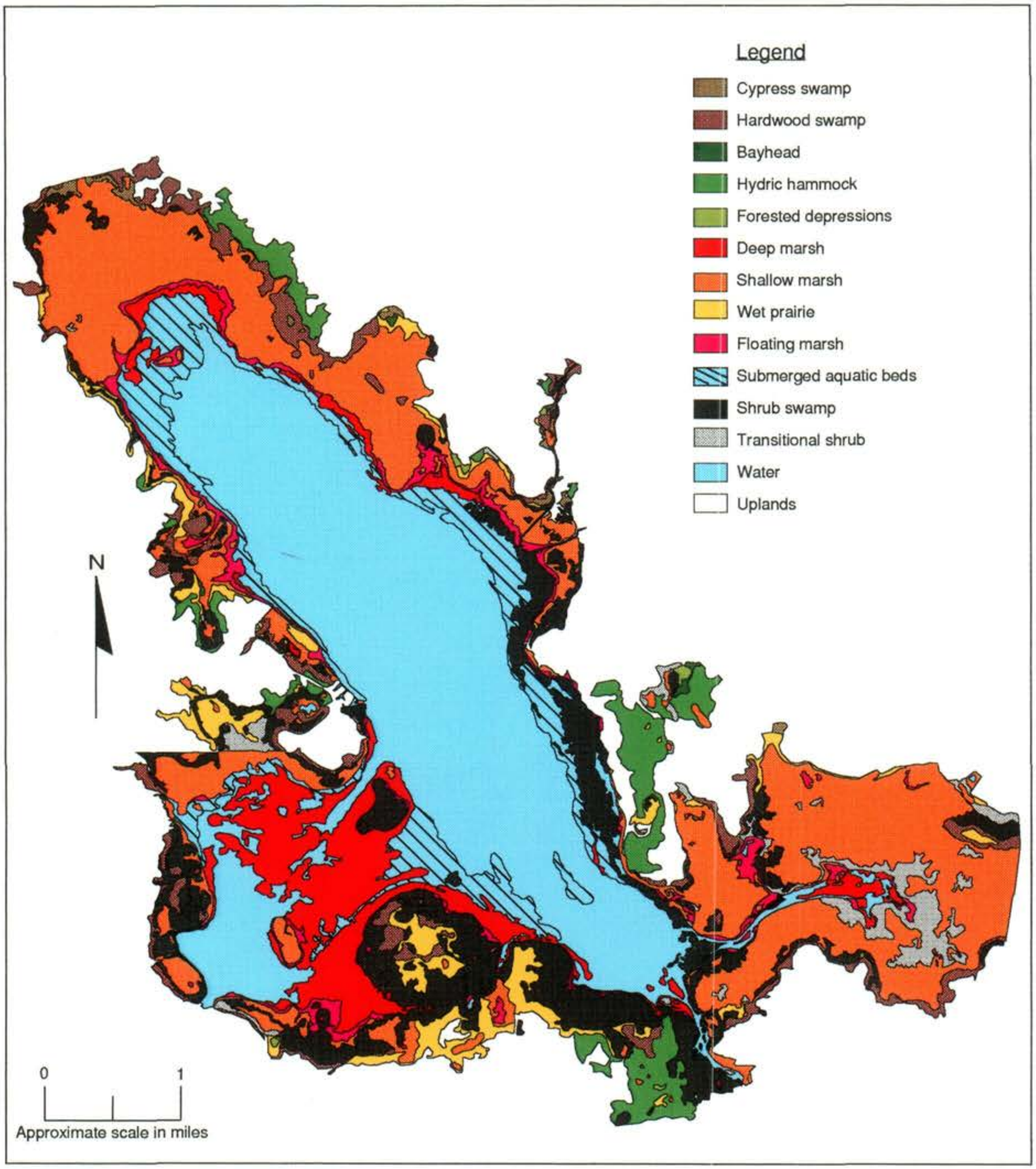

Figure 33. Wetland vegetation map of Orange Lake

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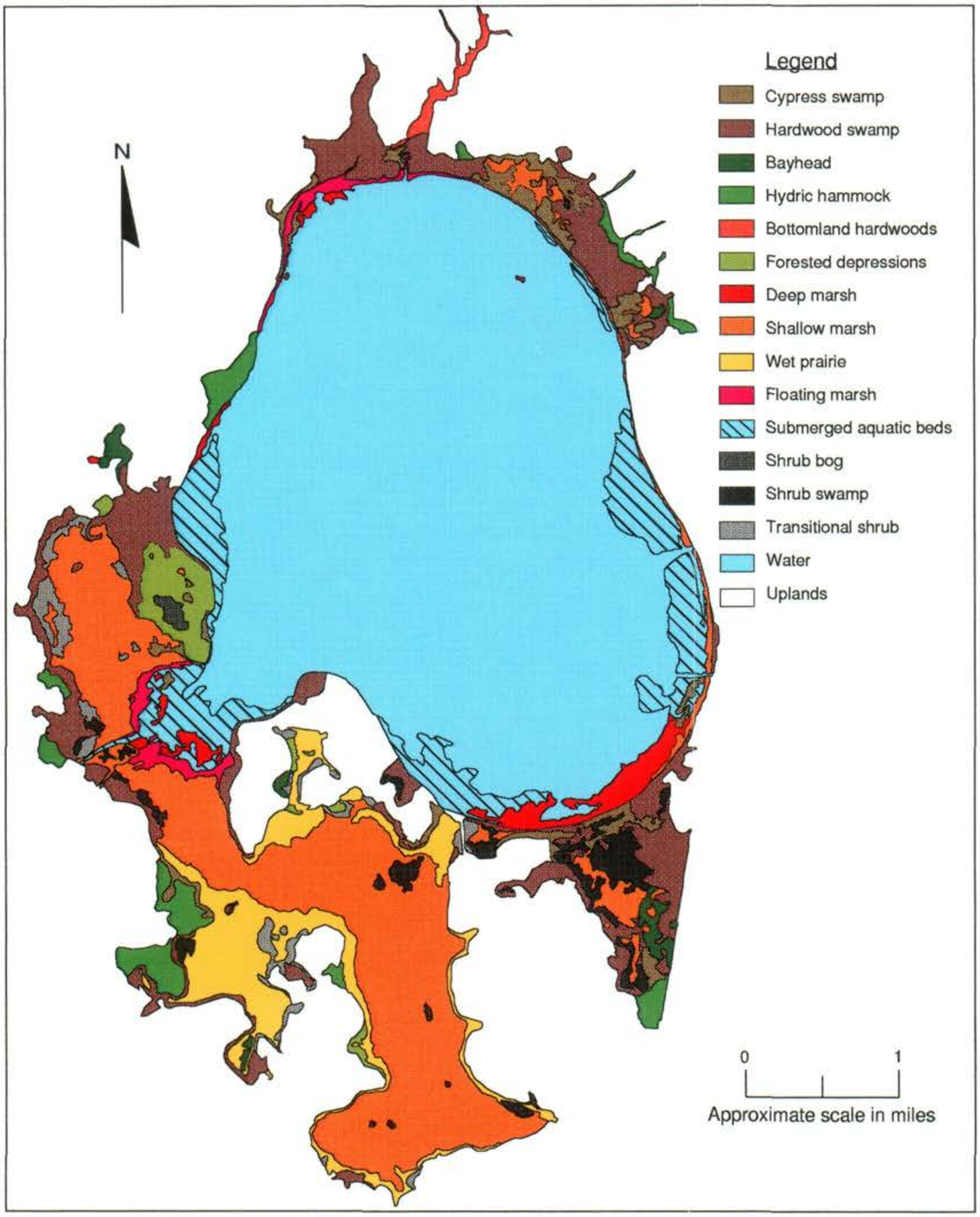

Figure 34. Wetland vegetation map of Lochloosa Lake

the major surface water bodies of OCB: Newnans Lake, Paynes Prairie, Orange Lake, and Lochloosa Lake.

Newnans Lake

A weir was constructed at the outlet to Newnans Lake in 1967, stabilizing surface water levels at approximately 67–68 ft (Vaughn 1972). Prior to weir construction, the lake fluctuated between 64 and 68 ft (Vaughn 1972), which seasonally exposed the floodplain forests and littoral areas of the lake bottom. Modifications to the weir in 1976 reintroduced limited water level fluctuation (2–2.5 ft) in an effort to improve control of nuisance aquatic plants and lake flushing.

The SSARR model results indicate that with the weir in place, median water levels (50% inundation) would be approximately 0.8 ft higher than under pre-weir conditions (Table 8). An increased water level would result in significantly higher inundation frequencies over hundreds of acres of the floodplain swamp. Concomitantly, there has been little recent regeneration of the cypress fringe community, which is defined as trees growing below 66 ft on Newnans Lake.

Field investigations along two elevation transects indicated that of 91 cypress individuals growing at elevations of approximately 64.5–66.0 ft, 71 have a diameter at breast height (dbh) of 5 in. or greater (Table 13). Twenty cypress trees had a dbh of less than 5 in., and no cypress trees were observed with a dbh smaller than 1 in. Typical cypress tree growth has been measured at 0.04–0.13 in. of diameter per year (Mitsch and Ewel 1979). Attaining a girth of 5 in. takes many years, and the lack of smaller trees indicates little recent seedling establishment.

Cypress communities require occasional extended periods of low water for seed germination and seedling establishment. Cypress seeds germinate only when low water exposes the soil, and the seeds survive only if they grow faster than ascending waters when the swamp refloods. Seeds will not germinate underwater. Seedlings in swamps often reach heights of 8–30 in. in 1 year. Seedling growth is checked by complete flooding, and prolonged flooding will kill

Table 13. Size classes of cypress individuals growing at elevations of approximately 64.5–66.0 feet on two elevation transects at Newnans Lake

Cypress Size Class (Diameter at breast height, in inches)	Number of Trees	Percent of Total Number of Trees
≥25	2	2.2
≥20 <25	10	11.0
≥15 <20	14	15.4
≥10 <15	19	20.8
≥5 <10	26	28.6
<5	20	22.0
Total	91	100.0

seedlings (Burns and Honkala 1990). We estimate that a minimum of 12 consecutive months of soil exposure is needed for a cohort of seedlings to become established. In our opinion, the lack of regeneration has resulted primarily from the maintenance of artificially higher water levels due to the construction of the Newnans Lake weir in 1967.

To evaluate what effect the weir might have on the occurrence of extended low water levels (water levels below 66 ft for at least 12 consecutive months), the "Existing Conditions" and "Remove Newnans Lake Weir" alternatives were compared for the period 1942–91 using the SSARR hydrologic model (Table 14). With the weir in place, water falls below 66 ft for a minimum of 12 consecutive months during three periods. Without the weir, there are eight periods of extended low water. The average length of the low water periods for the "Existing Conditions" and "Remove Newnans Lake Weir" alternatives is 17 and 23 months, respectively.

Table 14. Periods when Newnans Lake water levels would be below 66 feet for at least 12 consecutive months (SSARR simulation for the period 1942–91)

Period	Number of Months	
	Existing Conditions Alternative	Remove Newnans Lake Weir Alternative
5/42–4/44	0	24
5/52–4/53	0	12
4/54–7/57	19	40
11/61–1/64	18	27
11/76–2/78	0	16
5/80–4/82	0	24
8/84–7/85	0	12
1/89–3/91	15	27

Note: SSARR = Streamflow Synthesis and Reservoir Regulation [model]

The mean elevation of the cypress/lake ecotone, approximately 64.5 ft (Figure 35), is predicted to be dewatered for only 60 consecutive days, once every 50 years (Table E9, Appendix E). Longer exposures (270 to 360 days) are likely to occur at much less frequent intervals (once every 200 years or more; Figure E5, Appendix E). Such short exposure durations or long return intervals would limit the opportunities for regeneration of cypress and hardwood swamp species. Regeneration of cypress requires a well-defined set of hydrologic conditions and becomes even more restrictive when variability and seasonality of seed production are considered. The amount of seed produced varies from year to year, with bumper crops believed to be produced every 3 years (Brandt and Ewel 1989). Lost hydrologic opportunity coupled with irregular seed production could cause these habitats to be converted to open water habitat as the senescent cypress trees die.

The weir also reduces the total acreage of wetland communities that surround Newnans Lake. Total wetlands acreage with the weir in (assuming that emergent wetlands occur between the elevations that

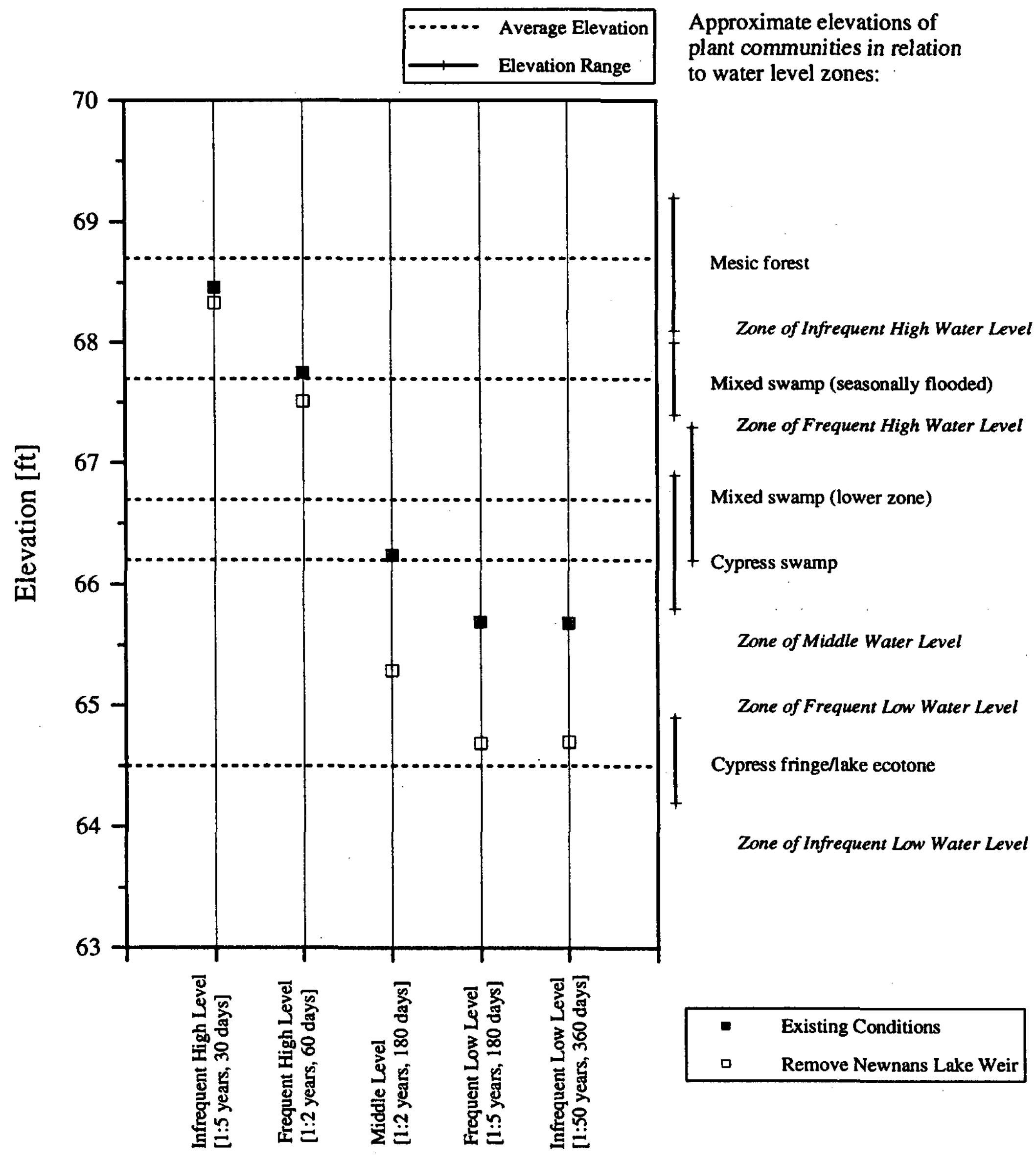

Figure 35. Surface water levels generated by the SSARR model for water management alternatives plotted against the elevations of major plant community ecotones at Newnans Lake (See Table 15 for specific elevations)

are flooded 10%–90% of the time) is estimated to be 861 ac. Total wetlands acreage with the weir out is estimated to be 1,096 ac. Removal of the weir would increase (restore) wetlands acreage by 235 ac, or 27.3%.

Construction of the weir has limited the regeneration of tree species at lower elevations of the floodplain swamps and reduced the total acreages of emergent wetlands. Therefore, removal of the weir appears to be the most ecologically sound management practice for the lake. Weir removal will result in lower water levels, increasing the amount of time a given elevation is exposed. Occasionally, a nearly complete dewatering of the average floodplain elevation of the present cypress/lake lower ecotone would occur (Table 15, Figure 35). Removal of the weir will create a hydrologic regime more

Table 15. Surface water fluctuation regimes generated by the SSARR model for water management alternatives in Newnans Lake

Management Alternative	Biohydrologic Criteria				
	Infrequent High Water Level (feet)	Frequent High Water Level (feet)	Middle Water Level (feet)	Frequent Low Water Level (feet)	Infrequent Low Water Level (feet)
Existing conditions	68.46	67.75	66.24	65.70	65.68
Remove Newnans Lake weir	68.33/−0.13*	67.51/−0.24	65.29/−0.95	64.69/−1.01	64.70/−0.98

Note: Infrequent High Water Level = event occurs once every 5 years for 30 days
Frequent High Water Level = event occurs once every 2 years for 60 days
Middle Water Level = event occurs once every 2 years for 180 days
Frequent Low Water Level = event occurs once every 5 years for 180 days
Infrequent Low Water Level = event occurs once every 50 years for 360 days
SSARR = Streamflow Synthesis and Reservoir Regulation [model]

*Change (in feet) between the elevation predicted by the SSARR model for "Existing Conditions" and the elevation for "Remove Newnans Lake Weir" for the respective biohydrologic criteria

favorable for the rejuvenation of the floodplain wetlands and the upper littoral zone of the lake (mean low water levels of 64.7 ft, for 360 days, on average, once every 50 years; Table G5, Figure G12, Appendix G). Also, favorable hydrologic conditions for an estimated

235 ac of emergent wetlands will be restored due to increased water fluctuations.

Paynes Prairie

This section describes the results of the environmental assessment of the seven water management alternatives for Paynes Prairie.

Existing Conditions. "Existing Conditions" allows a more or less equal sharing of water between Paynes Prairie and Orange Lake. Over the long term, an average of approximately 45% of Prairie Creek flow would go to Paynes Prairie through the Camps Canal structure and 55% would go to Orange Lake (Table E44, Appendix E). The predicted Middle Water Level of the prairie under "Existing Conditions" would be only about 0.3 ft lower than the level expected if all of Prairie Creek flow was restored to Paynes Prairie (i.e., in a predevelopment condition) (Table 16, Figures 36A and 36B). The range of surface water fluctuations would be similar to the simulated historic conditions. Middle and low water levels are predicted to be 0.3 to 0.8 ft lower than the conditions for "Complete Restoration of Prairie Creek Flow to Paynes Prairie" and high water levels to be between 0.5 and 1.0 ft lower (Table 16).

Total wetlands acreage for Paynes Prairie for "Existing Conditions" is estimated to be 11,721 ac. This acreage includes 11,599 ac between the 10%–90% frequency of inundation elevations and 122 ac of sheetflow wetlands above the 10% frequency of inundation elevation (Table 17). An estimated 612 ac of wetlands would be directly influenced by flow from the Camps Canal structure (Table 18, Figure 37).

"Existing Conditions" involves little active management of structures. Adjustments to the water control structures are made only during extremely high water or for short-term management goals.

Table 16. Surface water fluctuation regimes generated by the SSARR model for various water management alternatives in Paynes Prairie

(A) Main Structure

Management Alternative*	Biohydrologic Criteria				
	Infrequent High Water Level (feet)	Frequent High Water Level (feet)	Middle Water Level (feet)	Frequent Low Water Level (feet)	Infrequent Low Water Level (feet)
Existing conditions	59.36	57.92	55.42	52.32	52.02
Remove Newnans Lake weir	59.33/−0.03[†]	58.03/+0.11	55.43/−0.01	52.35/+0.03	52.04/+0.02
Complete restoration of Prairie Creek flow to Paynes Prairie	60.31/+0.95	58.45/+0.53	55.74/+0.32	52.95/+0.63	52.81/+0.79
Complete diversion of Prairie Creek flow to Orange Lake	58.86/−0.50	56.86/−1.06	54.41/−1.01	52.26/−0.06	51.85/−0.17
Reduction in Paynes Prairie inflow/outflow structure capacity by 50%	59.62/+0.26	57.89/−0.03	55.73/+0.31	52.84/+0.52	52.36/+0.34
Lake level threshold management of the Camps Canal structure	59.36/−0.00	57.91/−0.01	55.43/+0.01	52.33/+0.01	52.00/−0.02
Use Sweetwater Branch inflow to replace Prairie Creek inflow[‡]	NA	NA	NA	NA	NA

(B) East of U.S. 441

Management Alternative	Biohydrologic Criteria				
	Infrequent High Water Level (feet)	Frequent High Water Level (feet)	Middle Water Level (feet)	Frequent Low Water Level (feet)	Infrequent Low Water Level (feet)
Existing conditions	59.47	57.97	55.49	52.69	52.51
Remove Newnans Lake weir	59.46/−0.01[†]	58.07/+0.10	55.51/+0.02	52.70/+0.01	52.51/0.00
Complete restoration of Prairie Creek flow to Paynes Prairie	60.41/+0.94	58.36/+0.39	55.81/+0.32	53.04/+0.35	52.89/+0.38

Table 16—*Continued*

Management Alternative	Biohydrologic Criteria				
	Infrequent High Water Level (feet)	Frequent High Water Level (feet)	Middle Water Level (feet)	Frequent Low Water Level (feet)	Infrequent Low Water Level (feet)
Complete diversion of Prairie Creek flow to Orange Lake	58.97/−0.50	56.89/−1.08	54.43/−1.06	52.62/−0.07	52.41/−0.10
Reduction in Paynes Prairie inflow/outflow structure capacity by 50%	59.70/+0.31	57.85/−0.12	55.74/+0.25	53.02/+0.33	52.64/+0.13
Lake level threshold management of the Camps Canal structure	59.47/0.00	57.96/−0.01	55.50/−0.01	52.69/0.00	52.49/−0.02
Use Sweetwater Branch inflow to replace Prairie Creek inflow‡	NA	NA	NA	NA	NA

Note: Infrequent High Water Level = event occurs once every 5 years for 30 days
Frequent High Water Level = event occurs once every 2 years for 60 days
Middle Water Level = event occurs once every 2 years for 180 days
Frequent Low Water Level = event occurs once every 5 years for 180 days
Infrequent Low Water Level = event occurs once every 50 years for 360 days
NA = not applicable
SSARR = Streamflow Synthesis and Reservoir Regulation [model]

*See Table 7 for short title
†Change (in feet) between the elevation predicted by the SSARR model for "Existing Conditions" and the elevations for the other water management alternatives for the respective biohydrologic criteria
‡No hydrologic modeling was done for this alternative; therefore, no data exist for comparative purposes

Remove Newnans Lake Weir. The hydrologic regime for "Remove Newnans Lake Weir" is very similar to that for "Existing Conditions" (Table 16, Figures 36A and 36B). The water levels needed to meet the five biohydrologic criteria vary 0.11 ft and less. In general, the Prairie receives slightly more flow under "Remove Newnans Lake Weir."

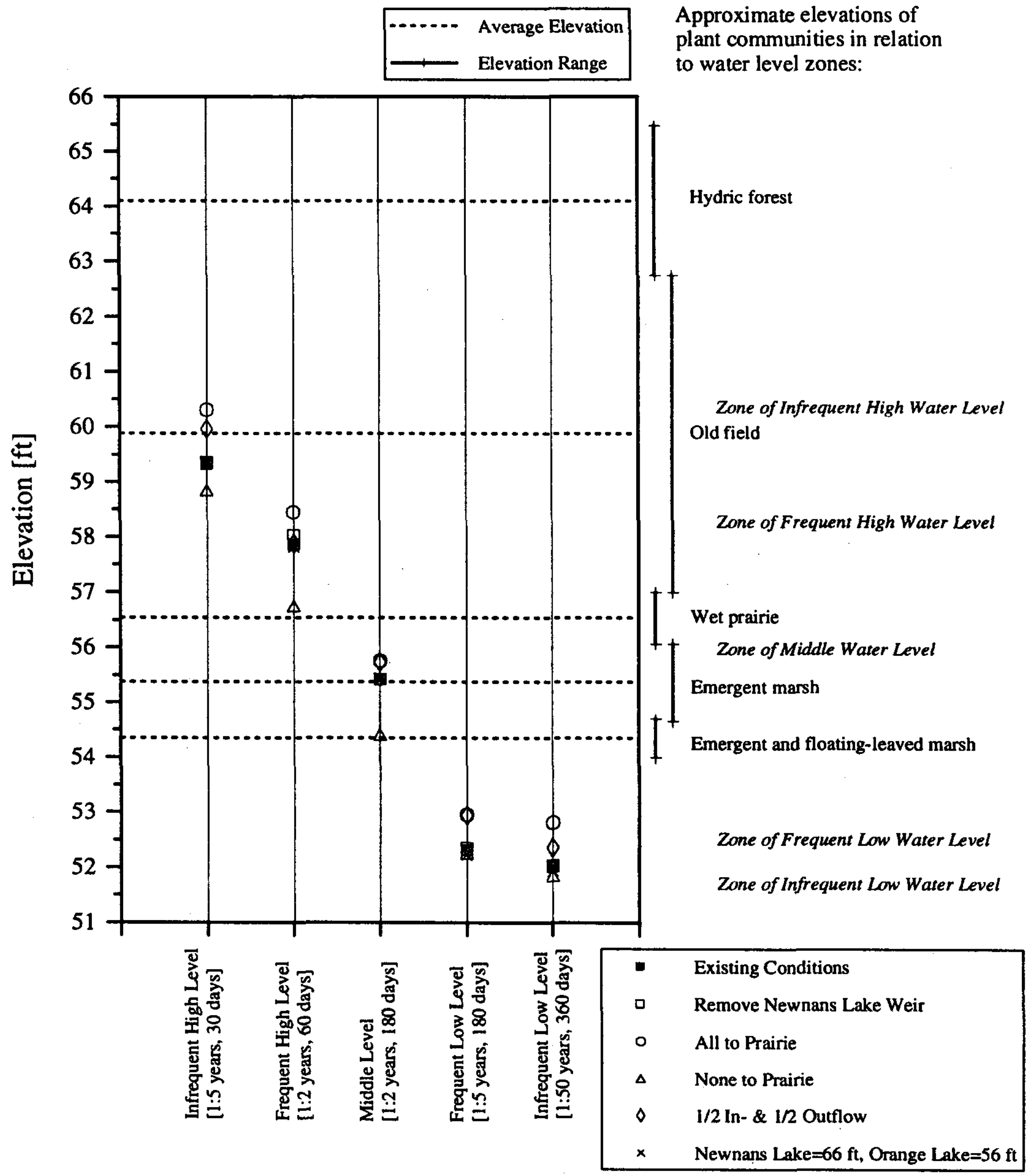

Figure 36A. Surface water levels generated by the SSARR model for water management alternatives plotted against the elevations of major plant community ecotones at the Main Structure in Paynes Prairie (See Table 16 for specific elevations)

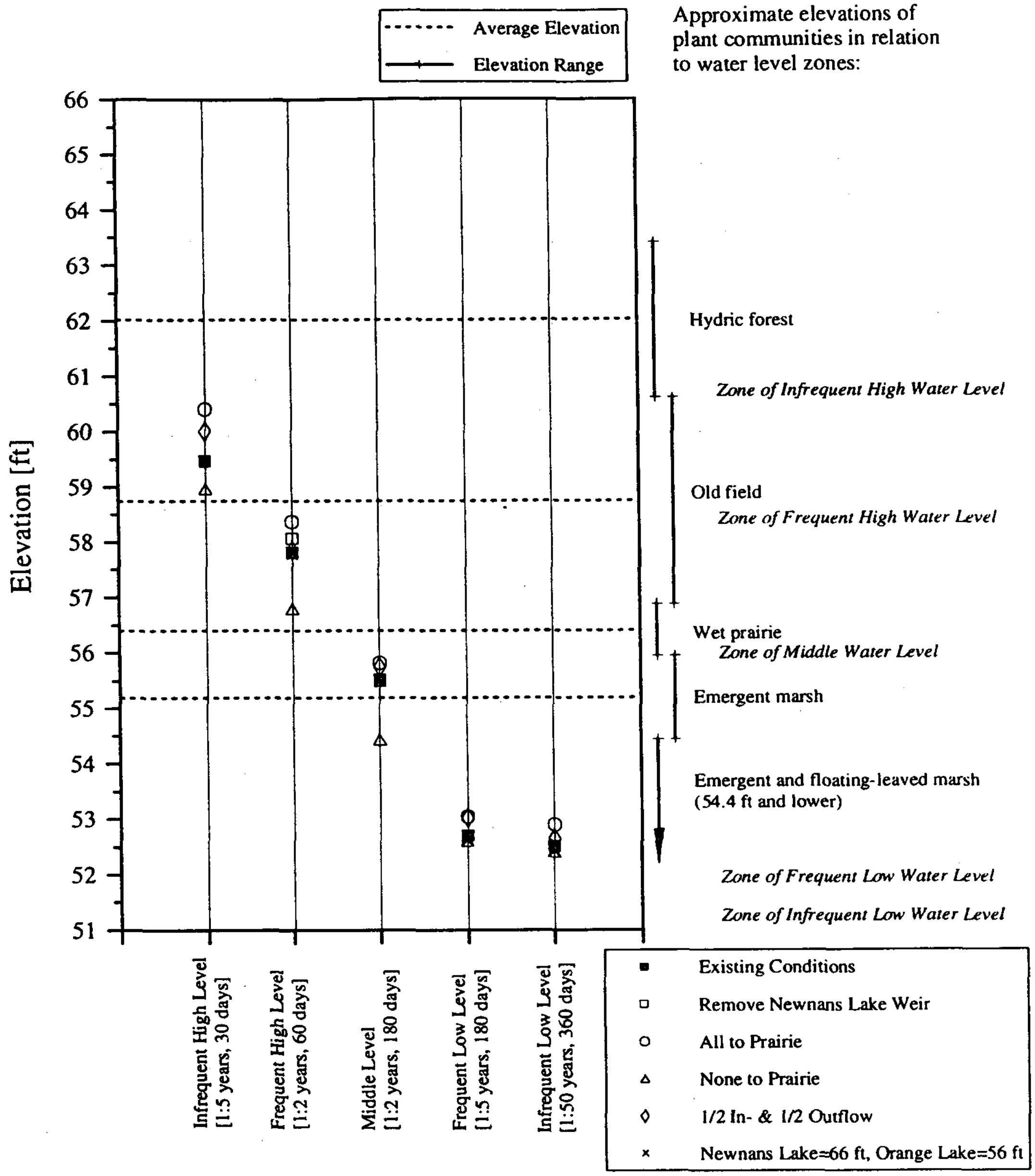

Figure 36B. Surface water levels generated by the SSARR model for water management alternatives plotted against the elevations of major plant community ecotones east of U.S. 441 in Paynes Prairie (See Table 16 for specific elevations)

Table 17. Total acreage, change in acreage, and percent change in acreage of Paynes Prairie wetlands for various water management alternatives*

Management Alternative	Paynes Prairie Wetlands (10%–90% Frequency of Inundation)				
	Acres between 10% and 90% Frequency of Inundation	Acres between 0% and 10% Frequency of Inundation	Total Emergent Wetlands Acreage	Change in Acreage†	Percent Change in Acreage
Existing conditions	11,599	122	11,721	NA	NA
Remove Newnans Lake weir	11,599	122	11,721	0	0
Complete restoration of Prairie Creek flow to Paynes Prairie	10,993	101	11,094	−627	−5.3%
Complete diversion of Prairie Creek flow to Orange Lake	11,334	0	11,334	−387	−3.3%
Reduction in Paynes Prairie inflow/outflow structure capacity by 50%	11,269	98	11,367	−354	−3.0%
Lake level threshold management of the Camps Canal structure	11,599	137	11,736	+15	<+0.1%
Use Sweetwater Branch inflow to replace Prairie Creek inflow‡	NA	NA	NA	NA	NA

Note: NA = not applicable

*For additional information, see Appendixes E–K

†Change equals total emergent wetlands acreage for the respective management alternative minus total emergent wetlands acreage for the "Existing Conditions" alternative

‡No hydrologic modeling was done for this alternative; therefore, no data exist for comparative purpose

Table 18. Estimates of Paynes Prairie wetland acres directly influenced by sheetflow from Prairie Creek under various water management alternatives

Management Alternative	Wetland Acres Directly Influenced by Sheetflow
Existing conditions	612
Remove Newnans Lake weir	612
Complete restoration of Prairie Creek flow to Paynes Prairie	984
Complete diversion of Prairie Creek flow to Orange Lake	0
Reduction in Paynes Prairie inflow/outflow structure capacity by 50%	394
Lake level threshold management of the Camps Canal structure	612
Use Sweetwater Branch inflows to replace Prairie Creek inflow	0

Total wetlands acreage for "Remove Newnans Lake Weir" is estimated to be 11,721 ac, the same as for "Existing Conditions" (Table 17). This acreage includes 11,599 ac between the 10%–90% frequency of inundation elevations and 122 ac contributed by sheetflow wetlands above the 10% frequency of inundation elevation (Table 17). An estimated 612 ac of wetlands would be directly influenced by flow from the Camps Canal structure (Table 18, Figure 37).

"Remove Newnans Lake Weir" involves no additional active management of Paynes Prairie structures. Adjustments to the water control structures are made only during extremely high water or for short-term management goals, as for "Existing Conditions."

Complete Restoration of Prairie Creek Flow to Paynes Prairie ("All to Prairie"). One of the FDEP goals is to restore Paynes Prairie to pre-European settlement conditions (White 1975; Appendix BB). This

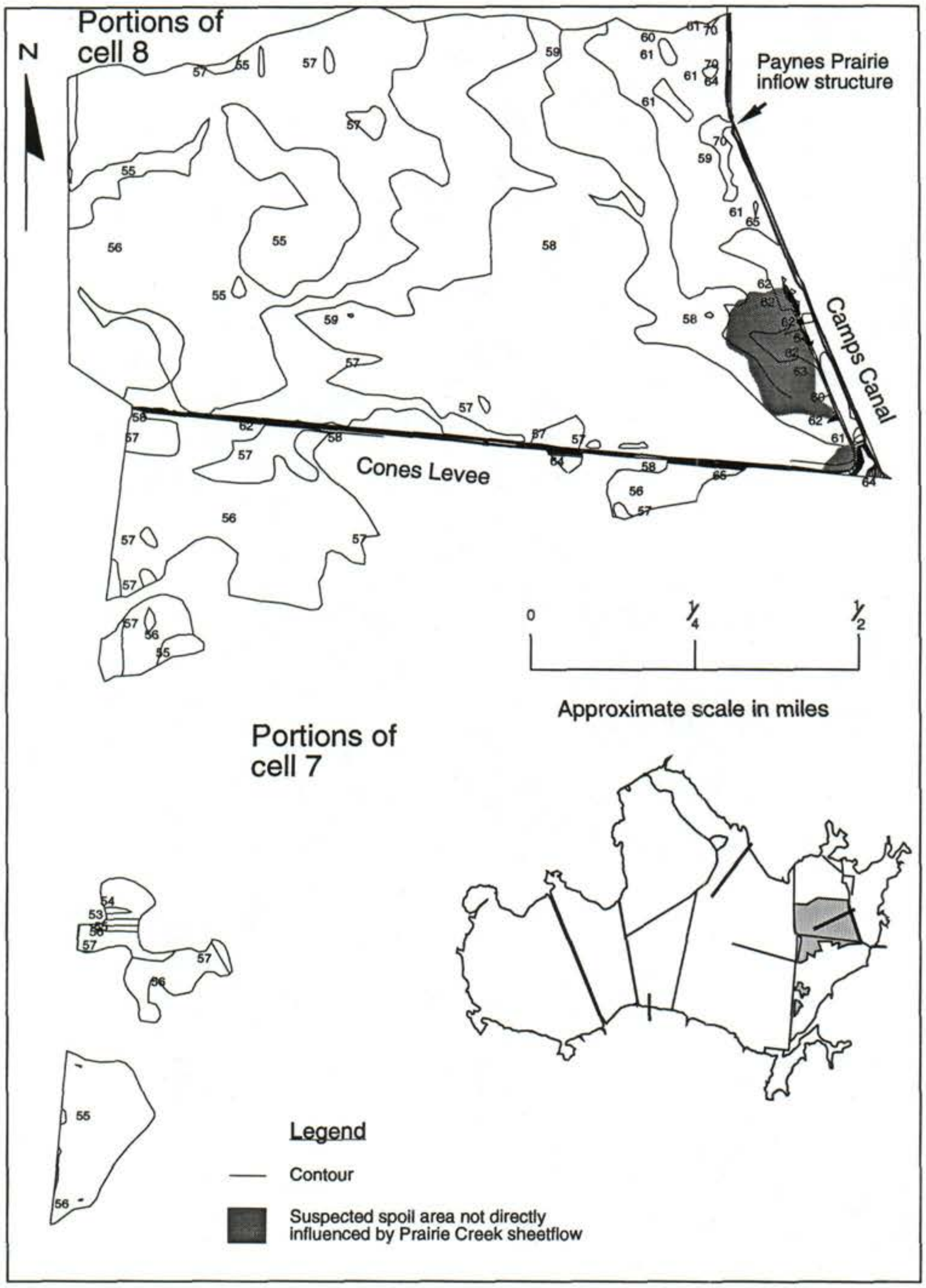

Figure 37. Herbaceous wetlands of the eastern lobe of Paynes Prairie directly influenced by the surface water sheetflow from Prairie Creek for the "Existing Conditions" water management alternative (portions of cells 7 and 8; see Figure A4, Appendix A)

goal could include complete restoration of Prairie Creek flow to Paynes Prairie. However, U.S. 441 now bisects the western half of the prairie (Figure 7), perhaps limiting the restoration effort due to concerns for road flooding. In addition, construction costs would be incurred to increase the flow capacity into Paynes Prairie from Prairie Creek and to build a structure or install earthen plugs in Camps Canal.

Under this alternative, flood levels in Paynes Prairie would be 0.6–0.8 ft higher than those predicted for "Existing Conditions," increasing the possibility of direct flooding of U.S. 441 or damage to the underlying roadbed (Table 11). The Infrequent High Water Level is predicted to be 60.4 ft as compared to 59.5 ft under "Existing Conditions" (Table 16(B), Figure 36B). Active management of the Camps Canal structure might reduce flooding to levels that would not adversely affect roadbeds.

The range of water level fluctuations would increase under this management alternative; however, the total acreage of emergent wetlands would actually decrease (relative to "Existing Conditions") as emergent marshlands are converted to open water habitat. Total wetlands acreage for "All to Prairie" is estimated to be 11,094 ac (Table 17). This acreage includes 10,993 ac between the 10%–90% frequency of inundation elevations and 101 ac contributed by sheetflow wetlands above the 10% frequency of inundation elevation. The implementation of this alternative would cause 627 ac (–5.3%) of wetlands loss (relative to "Existing Conditions"). An estimated 984 ac of wetlands would be directly influenced by flow from the Camps Canal structure (Table 18, Figure 38).

Complete Diversion of Prairie Creek Flow to Orange Lake ("None to Prairie"). Eliminating the flow of Prairie Creek into Paynes Prairie would be detrimental to the biology of the prairie. The predicted Frequent High and Middle water levels at the Main Structure would be significantly lower (–1.1 ft and –1.0 ft, respectively) than for "Existing Conditions" (Table 16(A), Figure 36A). Acres inundated at the Middle Water Level would be reduced by approximately 2,800 ac (or 38% of the total inundated acreage), as compared to "Existing Conditions." This acreage estimate was obtained by comparing the

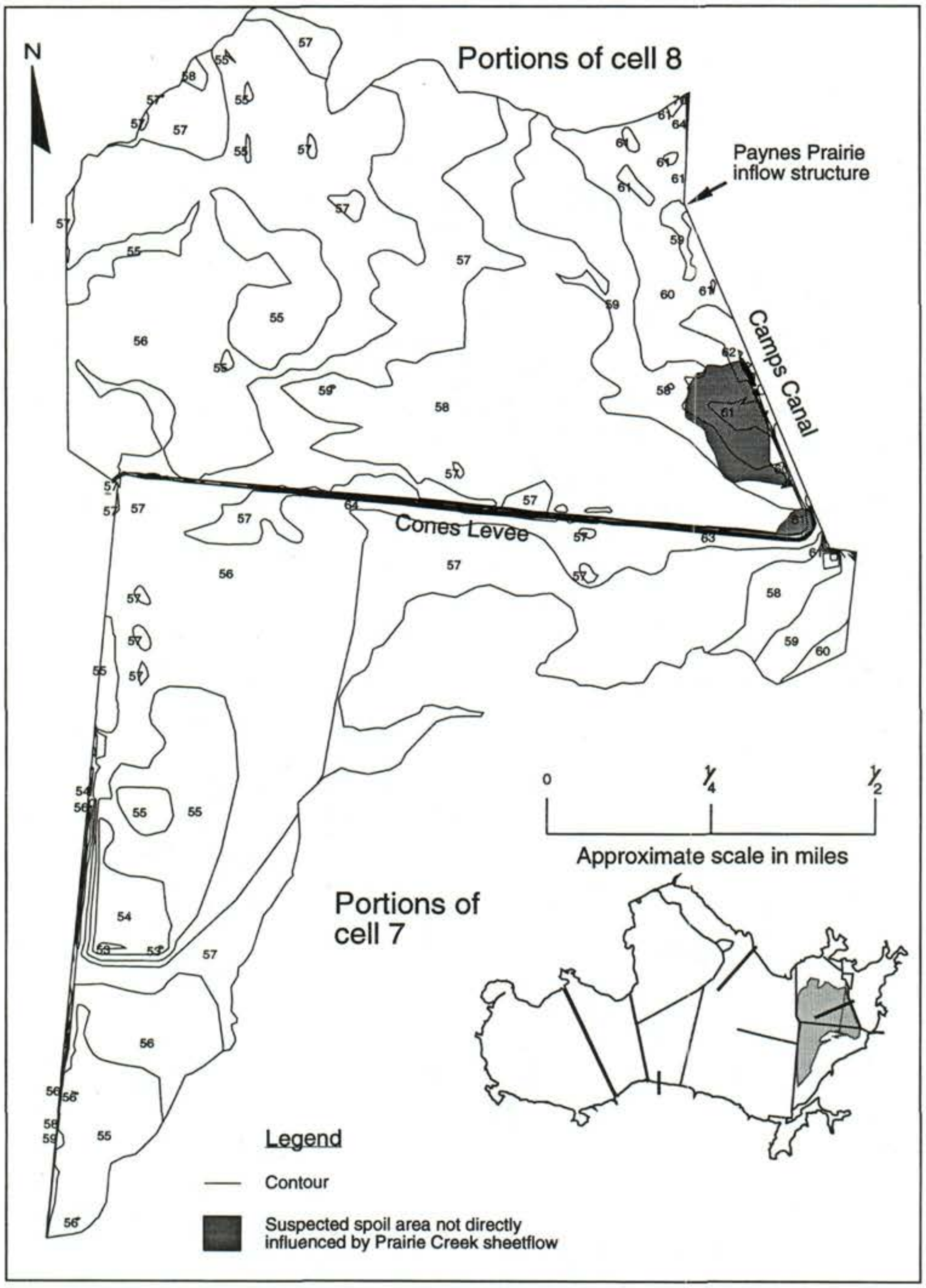

Figure 38. Herbaceous wetlands of the eastern lobe of Paynes Prairie directly influenced by surface water sheetflow from Prairie Creek for the "Complete Restoration of Prairie Creek Flow to Paynes Prairie" water management alternative (portions of cells 7 and 8; see Figure A4, Appendix A)

total acreage at 55.5 ft (Middle Water Level, "Existing Conditions") to the total acreage at 54.4 ft (Middle Water Level, "None to Prairie") (Table F4, Appendix F). This acreage estimate is low because it does not fully reflect loss of wetlands in the eastern lobe caused by the cessation of sheetflow from Prairie Creek. Wetland-dependent wildlife habitat would be reduced significantly.

Total wetlands acreage for Paynes Prairie for the "None to Prairie" alternative is estimated to be 11,334 ac (Table 17). This acreage includes 11,334 ac between the 10%–90% frequency of inundation elevations. There are no acres contributed by sheetflow wetlands above the 10% frequency of inundation elevation. Wetlands are not directly influenced by flow from the Camps Canal structure because all water from Prairie Creek is diverted to Orange Lake (Table 18). As a result, the frequency of inundation on approximately 612 ac would be markedly lowered.

Under this alternative, approximately 387 ac (−3.3%) of the total wetlands would be lost at higher elevations due to reduced inundation from the central pool (Alachua Lake) and loss of Prairie Creek inflow. As the upper rim of Paynes Prairie dries, widespread colonization by upland and transitional species would occur. Prescribed fire would become the primary tool to control the spread of xerophytic woody species in order to retain the open characteristics of Paynes Prairie.

Reduction in Paynes Prairie Inflow/Outflow Structure Capacity by 50% ("½ In- & ½ Outflow"). This water management alternative (Table 16A, Figure 36A) would reduce the average percentage of flow from Prairie Creek into Paynes Prairie from 45% to 22.5% (Table E44, Appendix E). As a result, flow to the Alachua Sink (outflow) would be reduced by approximately 26% (Tables E44 and E48, Appendix E), as more water would be diverted to Orange Lake.

SSARR simulations indicate that water levels are actually increased in Paynes Prairie over the existing levels and approach predevelopment conditions (Table 16A, Figure 36A; Figures J3 and J5, Appendix J). Most water levels predicted to meet the biohydrologic criteria would be approximately 0.3 ft higher using this management alternative.

Total wetlands acreage for Paynes Prairie for the "½ In- & ½ Outflow" alternative is estimated to be 11,367 ac (Table 17). This acreage includes 11,269 ac between the 10%–90% frequency of inundation elevations and 98 ac contributed by sheetflow wetlands above the 10% frequency of inundation elevation. The implementation of this alternative would cause 354 ac (-3.0%) of wetlands loss (relative to "Existing Conditions") (Table 17). Wetlands directly influenced by flow from the Camps Canal structure are estimated to be 394 ac (Table 18).

The "½ In- & ½ Outflow" alternative may introduce a new set of environmental problems. Although the flow from Prairie Creek would be reduced by 50%, the amount going down Alachua Sink also would be reduced. The impact of less flow to the aquifer and less dilution of Sweetwater Branch flow is unknown. The "½ In- & ½ Outflow" hydrologic regime also would increase the residence time of water in Paynes Prairie (the flow from Prairie Creek to Alachua Sink is slower) and would decrease the total nutrient load entering Paynes Prairie from Prairie Creek.

Phosphorus concentrations of the inflow from Prairie Creek are lower than internal concentrations (Best et al. 1995). These data suggest that Paynes Prairie is a net source of phosphorus. Vollenweider nutrient models (Dr. Lawrence Keenan, SJRWMD, pers. com., July 1993) predict that internal phosphorus concentrations actually increase as the inflows from Prairie Creek are decreased.

Simulations of phosphorus equilibrium concentration by a model based on the Vollenweider equations (Dr. Lawrence Keenan, SJRWMD, pers. com., July 1993) were performed using a wide variety of model assumptions (see p. 68). All model results reflect the same trend of increasing phosphorus concentration with decreased flow (i.e., nutrient retention). Nitrogen also may follow this trend, although the data are equivocal, which suggests different interpretations depending on the set of data reviewed. Therefore, under this hydrologic regime, general water quality in Paynes Prairie could deteriorate. Poorer water quality may adversely impact the vegetation of Paynes Prairie by favoring nuisance and exotic species instead of a natural prairie (Best et al. 1995).

Reducing water flow from Prairie Creek critically affects the wetlands of the prairie's eastern lobe (cell 8, Figure A4, Appendix A). The eastern lobe is higher in elevation than the central part of the prairie, and its wetlands are not maintained by the central pool of water. Eastern-lobe wetlands depend upon downhill sheetflow from Prairie Creek. Decreasing this downhill sheetflow reduces available water and may result in the loss of wetlands.

Achieving the "½ In- & ½ Outflow" management alternative may involve constant active management of the inflow and outflow structures.

Lake Level Threshold Management of the Camps Canal Structure ("Newnans Lake=66 ft, Orange Lake=56 ft"). Under this alternative, the flow to Paynes Prairie would be reduced by 50% under certain circumstances to allow more water to go to Orange Lake. These conditions are (1) Orange Lake levels must be *below* 56 ft and (2) Newnans Lake levels must be *above* 66 ft. When Orange Lake is above 56 ft, there is recreational access. When Newnans Lake is below 66 ft, Prairie Creek flows are low and would not significantly affect Orange Lake levels. Management requires monitoring of lake levels and periodic adjustment of the Camps Canal structure.

The hydrologic regime of Paynes Prairie under this alternative would be very similar to that under "Existing Conditions" (Table 16, Figure 36A; Figures K3 and K5, Appendix K). However, the prairie would receive less water during some periods of naturally high flows. Reducing wet season flows could reduce the duration and frequency of inundation of the eastern lobe wetlands (cell 8, Figure A4, Appendix A) and, therefore, negatively impact wildlife dependent on seasonal high flows.

This management alternative would have little impact on the wetlands acreage of Paynes Prairie. Total wetlands acreage for Paynes Prairie for the "Newnans Lake=66 ft, Orange Lake=56 ft" management alternative is estimated to be 11,736 ac, representing a

15-ac (<1%) increase over "Existing Conditions" (Table 17). This acreage includes 11,599 ac between the 10%–90% frequency of inundation elevations and 137 ac contributed by sheetflow wetlands above the 10% frequency of inundation elevation (Table 17). An estimated 612 ac of wetlands would be directly influenced by flow from the Camps Canal structure (Table 18).

Use Sweetwater Branch Inflow to Replace Prairie Creek Inflow ("Use Sweetwater"). Using alternative sources of water for Paynes Prairie has been considered as a management option. Sweetwater Branch drains portions of the City of Gainesville and the Main Street Sewage Treatment Plant. Sweetwater Branch flows directly to Alachua Sink and is separated from Paynes Prairie by a canal and levee system. Substituting Sweetwater Branch flow for Prairie Creek flow is seen by some as a means to divert more water to Orange Lake. The quantity of water contributed to Paynes Prairie by Sweetwater Branch is much less than that contributed by Prairie Creek. According to the SSARR simulations, Sweetwater Branch contributes an average of 9,300 ac-ft/yr to the water budget at Alachua Sink (Table E49, Appendix E). Prairie Creek contributes an average of 25,800 ac-ft/yr (Table E44, Appendix E), nearly three times as much as Sweetwater Branch. Removing Prairie Creek as a source of inflow to the prairie would lower the central pool (Alachua Lake) and impact wetlands.

Flow from Sweetwater Branch is not a replacement for flow from Prairie Creek. It is of insufficient volume and enters the prairie in the wrong location to inundate wetlands on the eastern slope of Paynes Prairie. These wetlands are 2–3 ft higher in elevation than the central part of OCB (Figure A4, Appendix A) and depend on sheetflow from Prairie Creek. This portion of Paynes Prairie only begins to be inundated by the central pool (Alachua Lake) when water levels approach 56 ft.

The water quality of Sweetwater Branch contains more nutrients than the waters of Paynes Prairie (Best et al. 1995; Table 19). The concentrations of NO_2/NO_3 (nitrite/nitrate nitrogen) and TP (total phosphorus) from Sweetwater Branch are much higher than those in

Table 19. Average monthly background water quality parameters for Paynes Prairie and vicinity, July 1991–February 1992 (in milligrams per liter)

Station	Ammonium (NH_{4+})	Nitrite/Nitrate (NO_2/NO_3)	Total Kjeldahl Nitrogen (TKN)	Total Phosphorus (TP)
Main Canal	0.16	0.22	2.72	0.33
Wetlands stations (Paynes Prairie)	0.35	0.33	2.42	0.49
Prairie Creek	0.22	0.05	2.93	0.17
Bivans Arm	1.16	0.26	2.13	0.23
Sweetwater Branch at Main Canal	0.09	8.17	1.32	1.25

Source: Best et al. 1995

Paynes Prairie, Prairie Creek, or Bivans Arm (Best et al. 1995). Inundating Paynes Prairie with higher-nutrient water would likely change the vegetative community. Native aquatic vegetation adapted to lower nutrient conditions is likely to be replaced by nuisance species that thrive in eutrophic situations. Best et al. (1995) comment on the discharge of Sweetwater Branch flow onto Paynes Prairie and the detrimental effects on restoration:

> Specifically, the nutrient enriched, sediment-laden waters have apparently facilitated invasion of terrestrial plant species (Southern willow [*Salix caroliniana*] and elderberry [*Sambucus canadensis*]), exotics (air potato [*Dioscorea bulbifera*], elephant ear [*Colocasia esculenta*], and waterhyacinth [*Eichhornia crassipes*]), and nuisance species (specifically, cattail [*Typha* spp.]). These impacts conflict with the main management objective of FDNR, which is "to restore, as nearly as possible, the conditions that existed on and around the basin during Bartram's visit" (FDNR 1986).

The "Use Sweetwater" alternative will cause environmental impacts to Paynes Prairie. The lowering of the central pool, introduction of lower-quality water, and impacts to eastern lobe wetlands eliminate this alternative as a viable option. As a result, no hydrologic analyses were performed.

Orange and Lochloosa Lakes

This section describes the results of the environmental evaluation of 22 water management alternatives for Orange and Lochloosa lakes. The SSARR model generated water levels for the biohydrologic criteria for each of these alternatives (Figures 39A–39D and 40A–40D).

Existing Conditions. The SSARR simulations indicate that over the long term an average of 45% of Prairie Creek flow goes to Paynes Prairie through the Camps Canal structure and 55% goes to Orange Lake (Table E44, Appendix E). The SSARR model simulated water levels for the five biohydrologic criteria (Tables 20 and 21, Figures 39A and 40A). The acreage of emergent wetlands for Orange and Lochloosa lakes is 9,055 ac (Table 22).

Remove Newnans Lake Weir. Surface water levels of Orange and Lochloosa lakes predicted by the SSARR model for this alternative are very similar to those for "Existing Conditions" (Tables 20 and 21, Figures 39B and 40B). The five biohydrologic criteria vary less than 0.05 ft for both lakes. The acreage of emergent wetlands for Orange and Lochloosa lakes for this alternative is 9,055 ac (Table 22), the same as for "Existing Conditions."

Complete Restoration of Prairie Creek Flow to Paynes Prairie ("All to Prairie"). Reconnecting the historical flow of Prairie Creek to Paynes Prairie is a possible restoration strategy for Paynes Prairie. However, this alternative would further lower water levels of Orange Lake and increase the duration in low water levels to a degree that would alter existing biological features (Tables 20 and 21, Figures 39A and 40A; Figures H1 and H2, Appendix H). This alternative might result in the flooding of highway U.S. 441 in Paynes Prairie (Table 11).

Surface water levels of Orange and Lochloosa lakes predicted by the SSARR model for each of the biohydrologic criteria are markedly lower than the corresponding levels for "Existing Conditions" (Tables 20 and 21, Figures 39A and 40A). In particular, the lower Middle Water Level for both lakes may result in soil oxidation and subsidence of the floodplain. This hydrologic condition also may

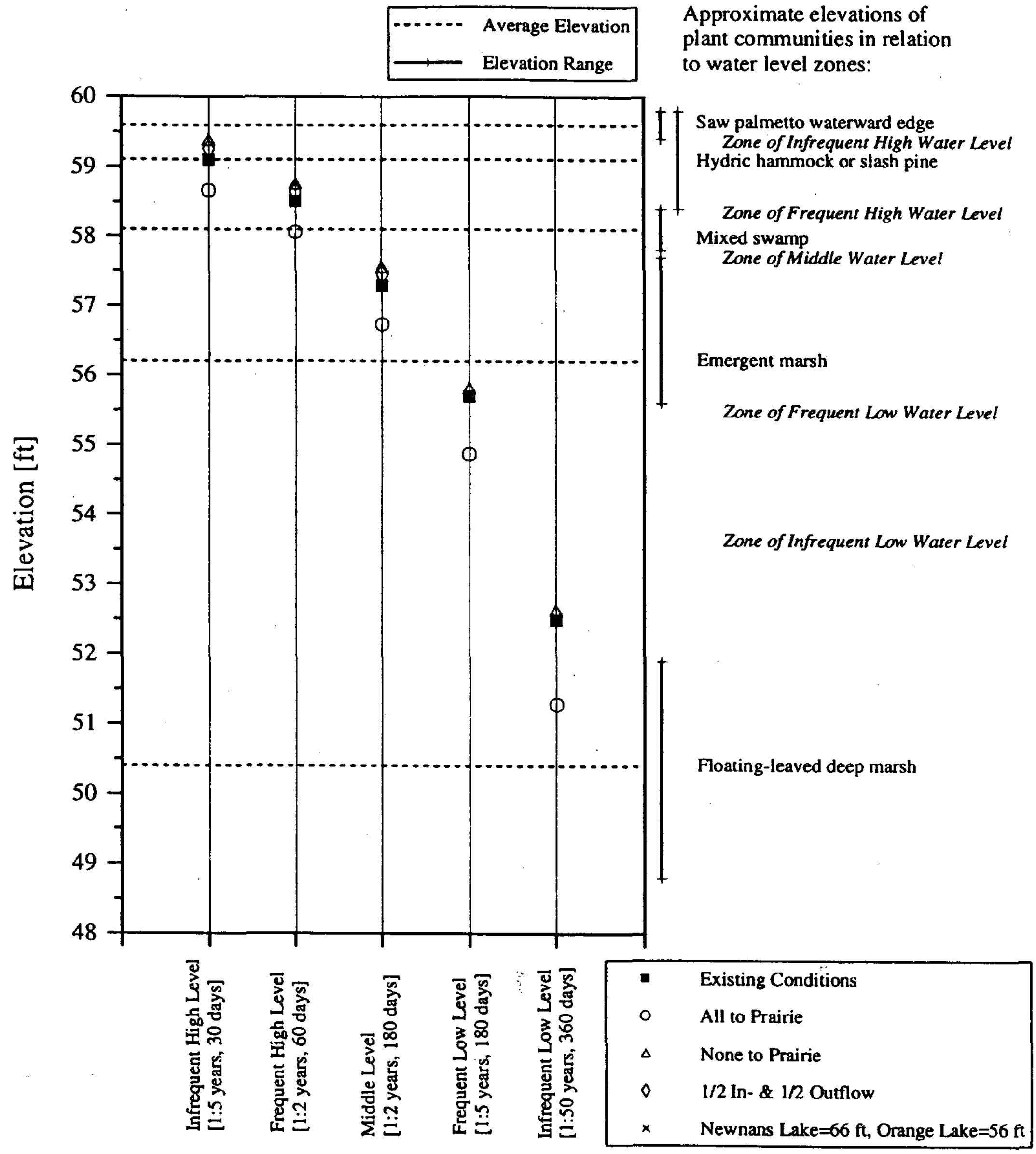

Figure 39A. Surface water levels generated by the SSARR model for water management alternatives (related to Paynes Prairie) plotted against the elevations of major plant community ecotones at Orange Lake (See Table 20 for specific elevations)

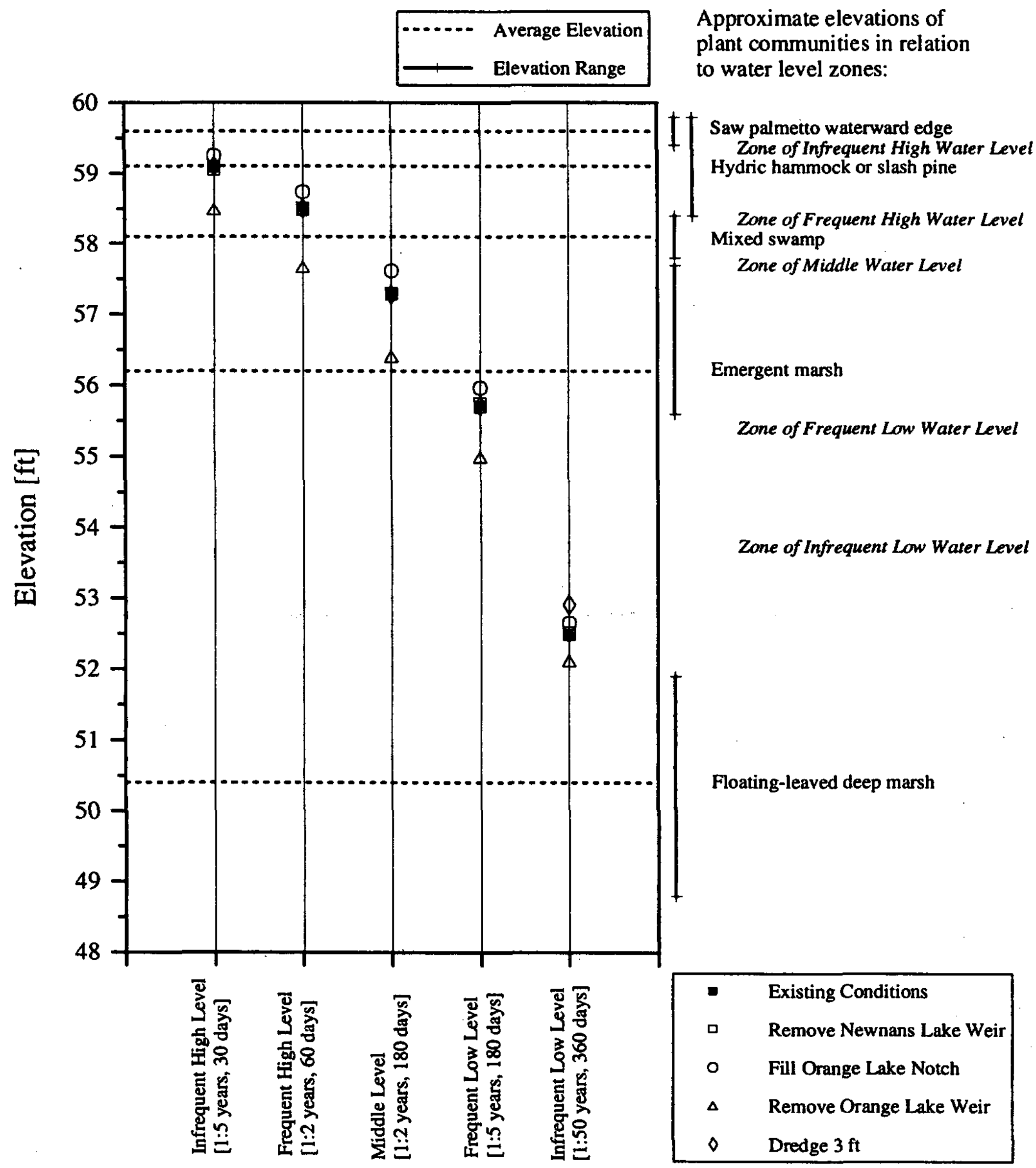

Figure 39B. **Surface water levels generated by the SSARR model for water management alternatives (miscellaneous) plotted against the elevations of major plant community ecotones at Orange Lake (See Table 20 for specific elevations)**

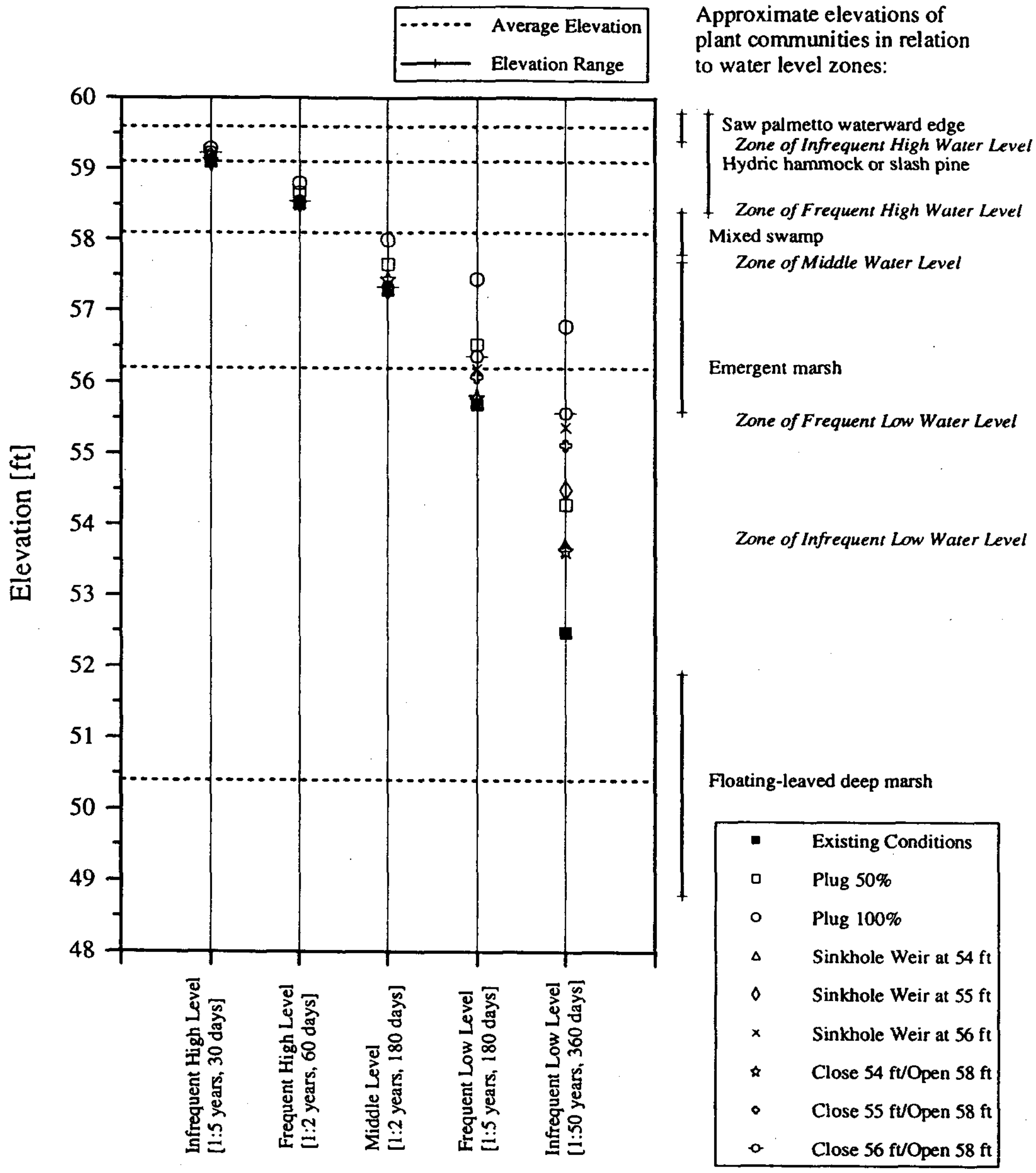

Figure 39C. Surface water levels generated by the SSARR model for water management alternatives (related to Orange Lake sinkholes) plotted against the elevations of major plant community ecotones at Orange Lake (See Table 20 for specific elevations)

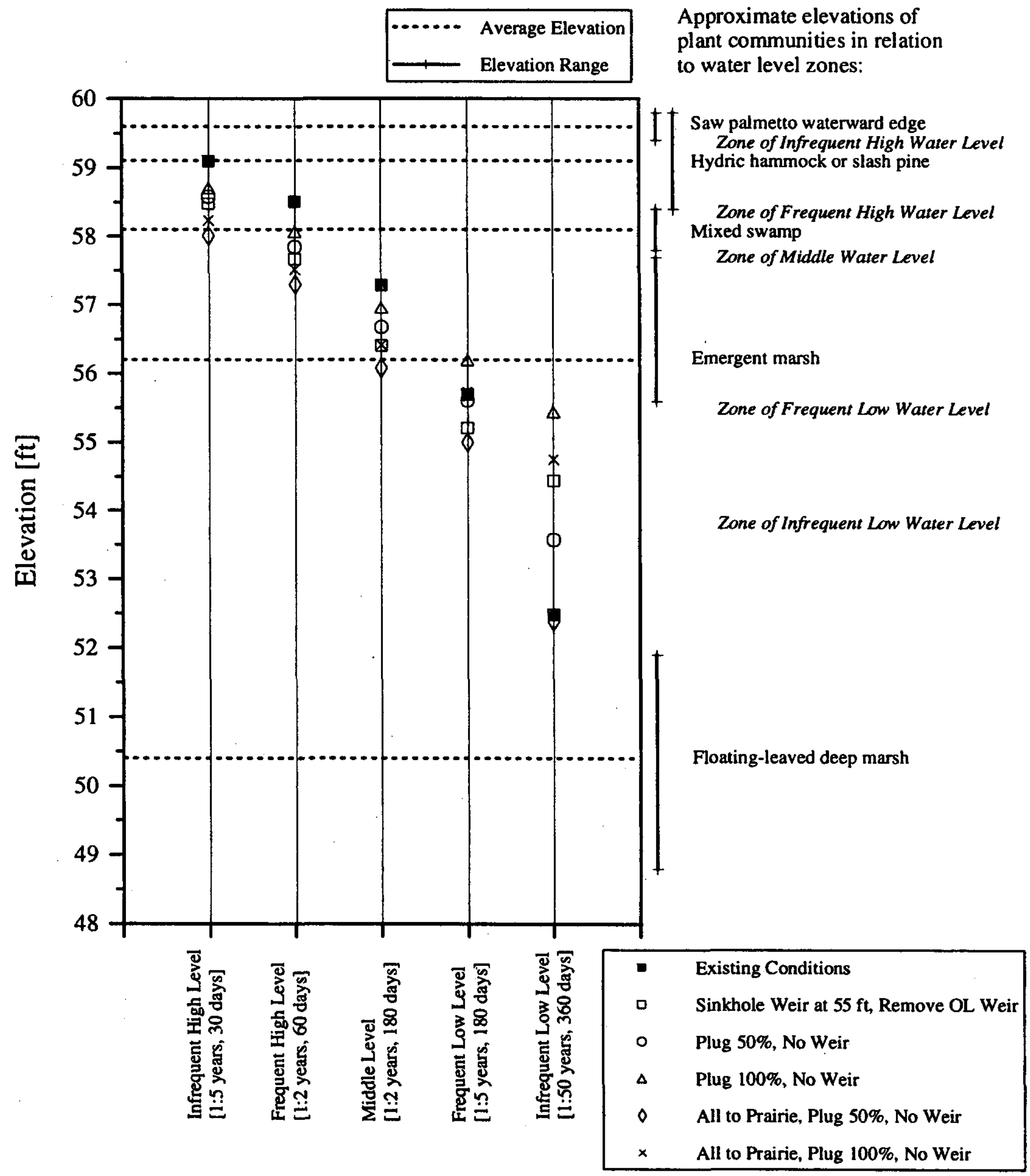

Figure 39D. Surface water levels generated by the SSARR model for water management alternatives (combinations) plotted against the elevations of major plant community ecotones at Orange Lake (See Table 20 for specific elevations)

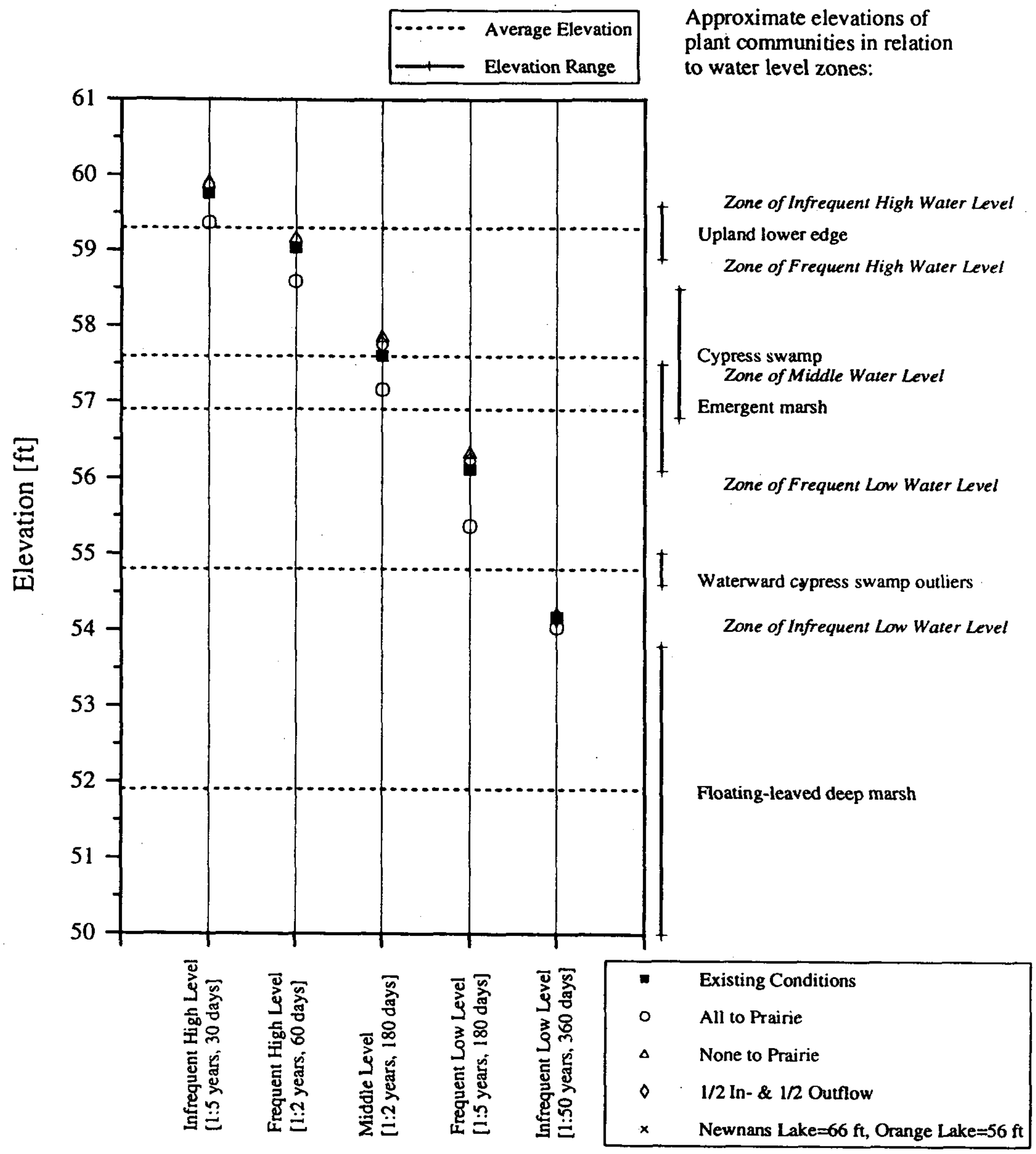

Figure 40A. Surface water levels generated by the SSARR model for water management alternatives (related to Paynes Prairie) plotted against the elevations of major plant community ecotones at Lochloosa Lake (See Table 21 for specific elevations)

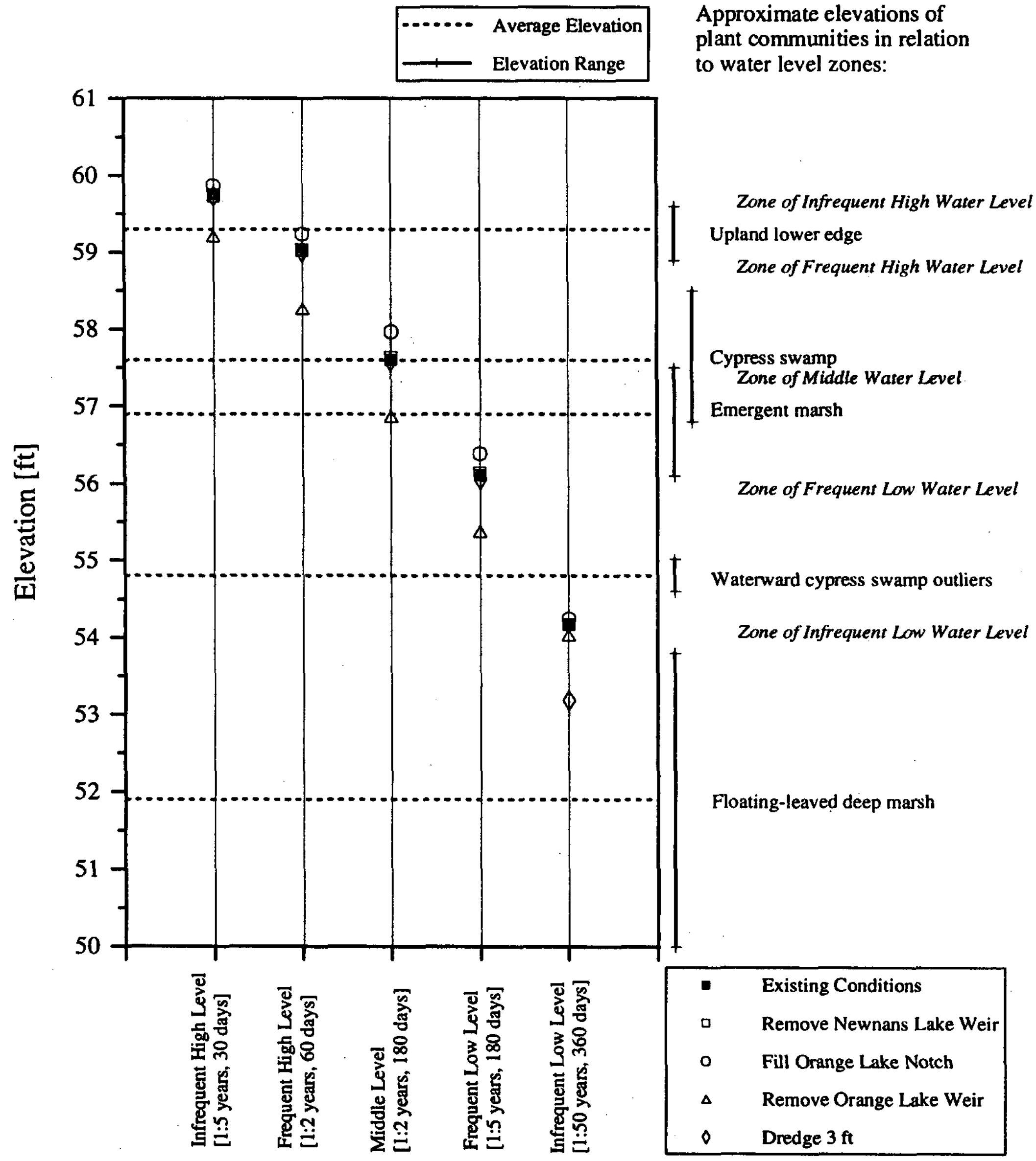

Figure 40B. Surface water levels generated by the SSARR model for water management alternatives (miscellaneous) plotted against the elevations of major plant community ecotones at Lochloosa Lake (See Table 21 for specific elevations)

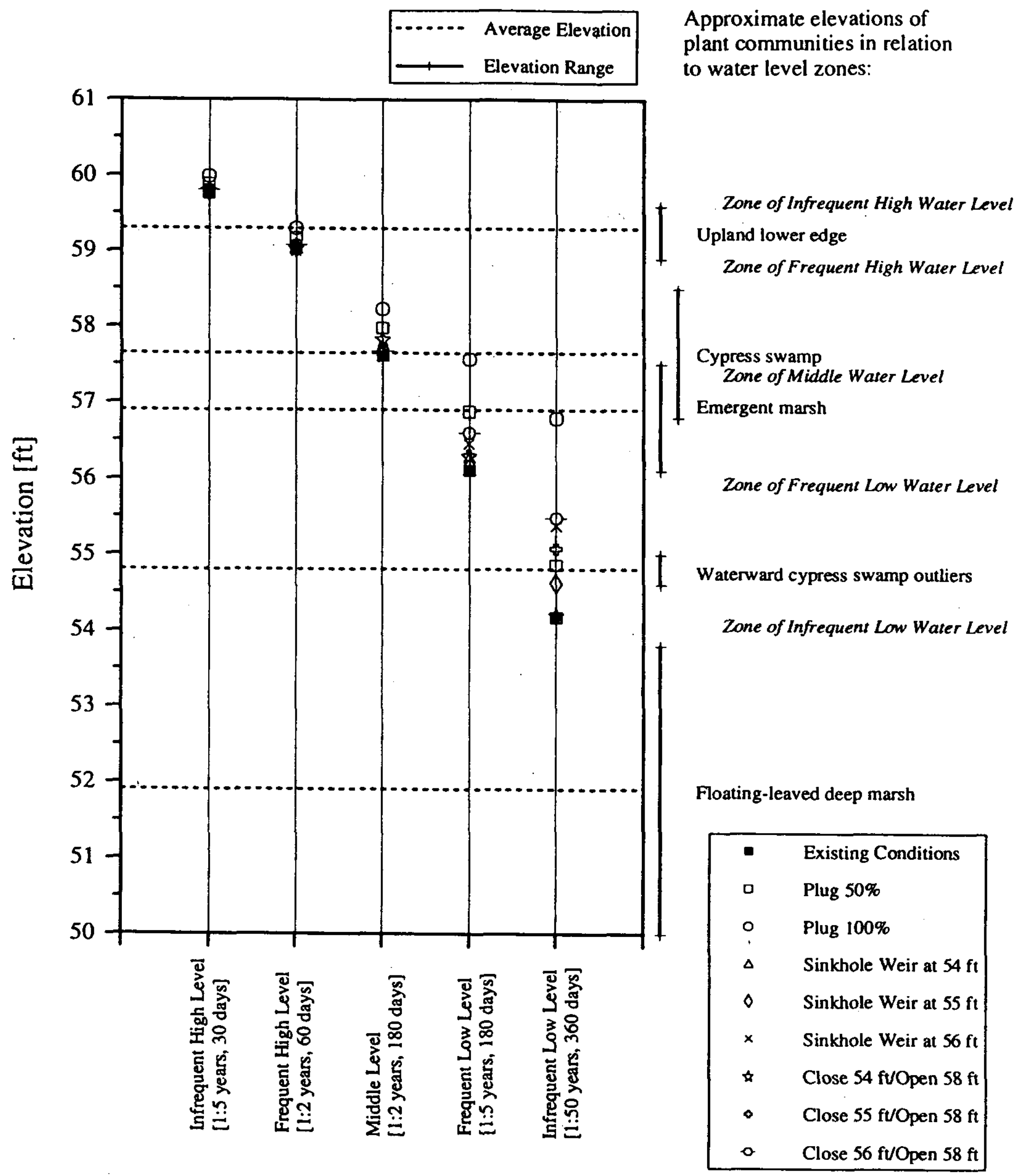

Figure 40C. Surface water levels generated by the SSARR model for water management alternatives (related to Orange Lake sinkholes) plotted against the elevations of major plant community ecotones at Lochloosa Lake (See Table 21 for specific elevations)

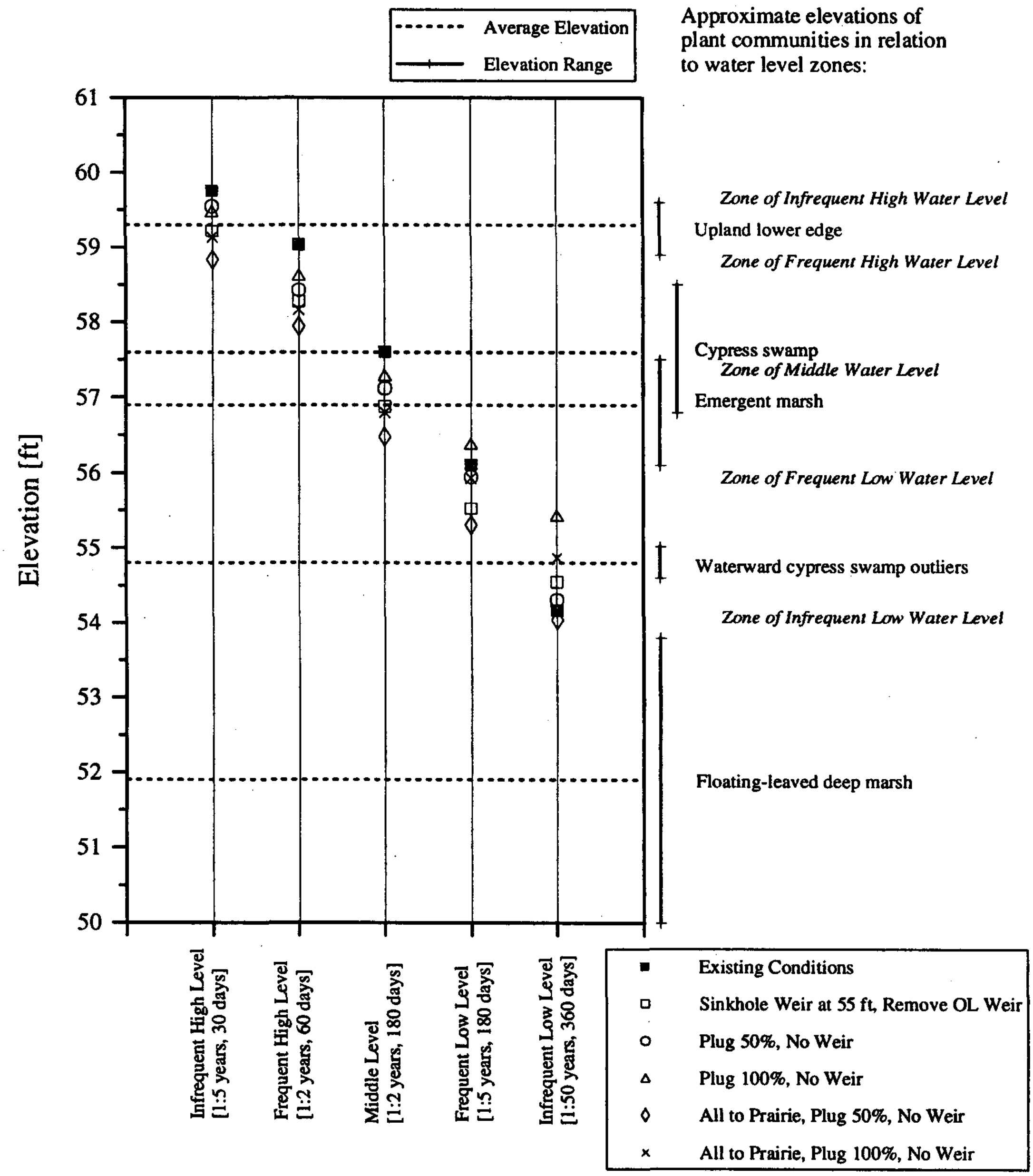

Figure 40D. Surface water levels generated by the SSARR model for water management alternatives (combinations) plotted against the elevations of major plant community ecotones at Lochloosa Lake (See Table 21 for specific elevations)

Table 20. Surface water fluctuation regimes generated by the SSARR model for water management alternatives in Orange Lake

Management Alternative*	Biohydrologic Criteria				
	Infrequent High Water Level (feet)	Frequent High Water Level (feet)	Middle Water Level (feet)	Frequent Low Water Level (feet)	Infrequent Low Water Level (feet)
Existing conditions	59.10	58.51	57.29	55.73	52.49
Remove Newnans Lake weir	59.05/−0.05[†]	58.48/−0.03	57.30/+0.01	55.74/+0.01	52.52/+0.03
Complete restoration of Prairie Creek flow to Paynes Prairie	58.66/−0.44	58.06/−0.45	56.73/−0.56	54.87/−0.86	51.28/−1.21
Complete diversion of Prairie Creek flow to Orange Lake	59.39/+0.29	58.77/+0.26	57.56/+0.27	55.82/+0.09	52.64/+0.15
Reduction of Paynes Prairie inflow/ outflow structure capacity by 50%	59.26/+0.16	58.64/+0.13	57.45/+0.16	55.76/+0.03	52.57/+0.08
Lake level threshold management of the Camps Canal structure	59.12/+0.02	58.52/+0.01	57.31/+0.02	55.79/+0.01	52.54/+0.05
Fill low-flow notch in Orange Lake weir	59.25/+0.15	58.74/+0.23	57.62/+0.33	55.99/+0.26	52.65/+0.16
Remove Orange Lake weir	58.49/−0.61	57.67/−0.84	56.41/−0.88	54.99/−0.74	52.12/−0.37
Dredge Cross Creek 3 ft	59.10/0.00	58.51/0.00	57.28/−0.01	55.74/+0.01	52.91/+0.42
Plug Orange Lake sinkholes 50%	59.16/+0.06	58.67/+0.16	57.66/+0.37	56.54/+0.81	54.29/+1.80
Plug Orange Lake sinkholes 100%	59.28/+0.18	58.80/+0.29	58.00/+0.71	57.45/+1.72	56.79/+4.30
Fixed crest weir around Orange Lake sinkholes, 54 ft	59.10/0.00	58.52/+0.01	57.30/+0.01	55.74/+0.01	53.73/+1.24
Fixed crest weir around Orange Lake sinkholes, 55 ft	59.10/0.00	58.52/+0.01	57.30/+0.01	55.77/+0.04	54.50/+2.01
Fixed crest weir around Orange Lake sinkholes, 56 ft	59.10/0.00	58.53/+0.02	57.36/+0.07	56.20/+0.47	55.38/+2.89
Gated weir around Orange Lake sinkholes, gates closed at 54 ft, opened at 58 ft	59.12/+0.02	58.52/+0.01	57.45/+0.16	55.80/+0.07	53.64/+1.15

Table 20—*Continued*

Management Alternative*	Biohydrologic Criteria				
	Infrequent High Water Level (feet)	Frequent High Water Level (feet)	Middle Water Level (feet)	Frequent Low Water Level (feet)	Infrequent Low Water Level (feet)
Gated weir around Orange Lake sinkholes, gates closed at 55 ft, opened at 58 ft	59.19/+0.09	58.52/+0.01	57.30/+0.01	56.08/+0.35	55.13/+2.64
Gated weir around Orange Lake sinkholes, gates closed at 56 ft, opened at 58 ft	59.23/+0.13	58.55/+0.04	57.34/+0.05	56.37/+0.64	55.58/+3.09
Fixed crest weir around Orange Lake sinkholes at 55 ft, remove Orange Lake weir	58.48/−0.62	57.67/−0.84	56.41/−0.88	55.21/−0.52	54.44/+1.95
Plug Orange Lake sinkholes 50%, remove Orange Lake weir	58.58/−0.52	57.85/−0.66	56.68/−0.61	55.61/−0.12	53.58/+1.09
Plug Orange Lake sinkholes 100%, remove Orange Lake weir	58.71/−0.39	58.07/−0.44	56.96/−0.33	56.20/+0.47	55.44/+2.95
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 50%, remove Orange Lake weir	58.01/−1.09	57.30/−1.21	56.08/−1.21	55.00/−0.73	52.39/−0.10
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 100%, remove Orange Lake weir	58.24/−0.86	57.52/−0.99	56.42/−0.87	55.73/+0.00	54.75/+2.26

Note: Infrequent High Water Level = event occurs once every 5 years for 30 days
Frequent High Water Level = event occurs once every 2 years for 60 days
Middle Water Level = event occurs once every 2 years for 180 days
Frequent Low Water Level = event occurs once every 5 years for 180 days
Infrequent Low Water Level = event occurs once every 50 years for 360 days
SSARR = Streamflow Synthesis and Reservoir Regulation [model]

*See Table 7 for short title

†Change (in feet) between the elevation predicted by the SSARR model for "Existing Conditions" and the elevations for the other water management alternatives for the respective biohydrologic criteria

Table 21. Surface water fluctuation regimes generated by the SSARR model for water management alternatives in Lochloosa Lake

Management Alternative*	Biohydrologic Criteria				
	Infrequent High Water Level (feet)	Frequent High Water Level (feet)	Middle Water Level (feet)	Frequent Low Water Level (feet)	Infrequent Low Water Level (feet)
Existing conditions	59.76	59.04	57.61	56.17	54.17
Remove Newnans Lake weir	59.73/−0.03[†]	59.02/−0.02	57.64/+0.03	56.20/+0.03	54.17/0.00
Complete restoration of Prairie Creek flow to Paynes Prairie	59.37/−0.39	58.59/−0.45	57.16/−0.45	55.44/−0.73	54.04/−0.13
Complete diversion of Prairie Creek flow to Orange Lake	59.91/+0.15	59.18/+0.14	57.87/+0.26	56.34/+0.17	54.21/+0.04
Reduction in Paynes Prairie inflow/ outflow structure capacity by 50%	59.88/+0.12	59.13/+0.09	57.75/+0.14	56.22/+0.05	54.18/+0.01
Lake level threshold management of the Camps Canal structure	59.78/+0.02	59.03/−0.01	57.67/+0.06	56.21/+0.04	54.18/+0.01
Fill low-flow notch in Orange Lake weir	59.87/+0.11	59.24/+0.20	57.97/+0.36	56.43/+0.26	54.24/+0.07
Remove Orange Lake weir	59.21/−0.55	58.27/−0.77	56.87/−0.74	55.38/−0.79	54.03/−0.14
Dredge Cross Creek 3 ft	59.73/−0.03	59.00/−0.04	57.58/−0.03	56.11/−0.06	53.18/−0.99
Plug Orange Lake sinkholes 50%	59.89/+0.13	59.18/+0.14	57.98/+0.37	56.88/+0.71	54.86/+0.69
Plug Orange Lake sinkholes 100%	59.99/+0.23	59.30/+0.26	58.23/+0.62	57.57/+1.40	56.79/+2.62
Fixed crest weir around Orange Lake sinkholes, 54 ft	59.78/+0.02	59.04/0.00	57.68/+0.07	56.19/+0.02	54.20/+0.03
Fixed crest weir around Orange Lake sinkholes, 55 ft	59.78/+0.02	59.04/0.00	57.68/+0.07	56.22/+0.05	54.62/+0.45
Fixed crest weir around Orange Lake sinkholes, 56 ft	59.79/+0.03	59.05/+0.01	57.69/+0.08	56.46/+0.29	55.38/+1.21
Gated weir around Orange Lake sinkholes, gates closed at 54 ft, opened at 58 ft	59.80/+0.04	59.03/−0.01	57.83/+0.22	56.30/+0.13	54.20/+0.03

Table 21—*Continued*

Management Alternative*	Biohydrologic Criteria				
	Infrequent High Water Level (feet)	Frequent High Water Level (feet)	Middle Water Level (feet)	Frequent Low Water Level (feet)	Infrequent Low Water Level (feet)
Gated weir around Orange Lake sinkholes, gates closed at 55 ft, opened at 58 ft	59.80/+0.04	59.03/−0.01	57.67/+0.06	56.31/+0.14	55.08/+0.91
Gated weir around Orange Lake sinkholes, gates closed at 56 ft, opened at 58 ft	59.81/+0.05	59.08/+0.04	57.67/+0.06	56.60/+0.43	55.48/+1.31
Fixed crest weir around Orange Lake sinkholes at 55 ft, remove Orange Lake weir	59.22/−0.54	58.28/−0.76	56.88/−0.73	55.53/−0.64	54.55/+0.38
Plug Orange Lake sinkholes 50%, remove Orange Lake weir	59.35/−0.41	58.43/−0.61	57.12/−0.49	55.95/−0.22	54.31/+0.14
Plug Orange Lake sinkholes 100%, remove Orange Lake weir	59.49/−0.27	58.63/−0.41	57.30/−0.31	56.39/+0.22	55.44/+1.27
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 50%, remove Orange Lake weir	58.84/−0.92	57.95/−1.09	56.48/−1.13	55.31/−0.86	54.04/−0.13
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 100%, remove Orange Lake weir	59.14/−0.62	58.17/−0.87	56.80/−0.81	55.93/−0.24	54.87/+0.70

Note: Infrequent High Water Level = event occurs once every 5 years for 30 days
Frequent High Water Level = event occurs once every 2 years for 60 days
Middle Water Level = event occurs once every 2 years for 180 days
Frequent Low Water Level = event occurs once every 5 years for 180 days
Infrequent Low Water Level = event occurs once every 50 years for 360 days
SSARR = Streamflow Synthesis and Reservoir Regulation [model]

*See Table 7 for short title

†Change (in feet) between the elevation predicted by the SSARR model for "Existing Conditions" and the elevations for the other water management alternatives for the respective biohydrologic criteria

Table 22. Total acreage, change in acreage, and percent change in acreage for Orange and Lochloosa lakes wetlands for various water management alternatives*

Management Alternative	Orange and Lochloosa Lakes Wetlands (10%–90% frequency of inundation)		
	Total Acreage	Change in Acreage[†]	Percent Change in Acreage
Existing conditions	9,055	NA	NA
Remove Newnans Lake weir	9,055	0	0
Complete restoration of Prairie Creek flow to Paynes Prairie	10,307	+1,252	+13.8
Complete diversion of Prairie Creek flow to Orange Lake	8,993	-62	-0.7
Reduction in Paynes Prairie inflow/outflow structure capacity by 50%	8,859	-196	-2.2
Lake level threshold management of the Camps Canal structure	8,857	-198	-2.2
Fill low-flow notch in Orange Lake weir	9,259	+204	+2.3
Remove Orange Lake weir	8,458	-597	-6.6
Dredge Cross Creek 3 ft	9,320	+265	+2.9
Plug Orange Lake sinkholes 50%	7,029	-2,026	-22.4
Plug Orange Lake sinkholes 100%	4,480	-4,575	-50.5
Fixed crest weir around Orange Lake sinkholes, 54 ft	8,656	-399	-4.4
Fixed crest weir around Orange Lake sinkholes, 55 ft	8,244	-811	-9.0
Fixed crest weir around Orange Lake sinkholes, 56 ft	7,146	-1,909	-21.1
Gated weir around Orange Lake sinkholes, gates closed at 54 ft, opened at 58 ft	7,913	-1,142	-12.6
Gated weir around Orange Lake sinkholes, gates closed at 55 ft, opened at 58 ft	7,606	-1,449	-16.0
Gated weir around Orange Lake sinkholes, gates closed at 56 ft, opened at 58 ft	6,984	-2,071	-22.9
Fixed crest weir around Orange Lake sinkholes at 55 ft, remove Orange Lake weir	7,658	-1,397	-15.4
Plug Orange Lake sinkholes 50%, remove Orange Lake weir	7,568	-1,487	-16.4
Plug Orange Lake sinkholes 100%, remove Orange Lake weir	6,114	-2,941	-32.5
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 50%, remove Orange Lake weir	7,588	-1,467	-16.2
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 100%, remove Orange Lake weir	6,016	-3,039	-33.6

Note: NA = not applicable

*For additional information, see Appendixes E–AA

[†]Change equals the total acreage for the respective management alternative minus the total acreage for the "Existing Conditions" alternative

permit invasion of the upper floodplain (swamp and upper emergent marsh) by upland and transitional plants, because the frequency of inundation would decrease (Figure H4, Appendix H). A lower Infrequent Low Water Level in Orange Lake (51.28 ft, Table 20) would result in shallower water and decreased lake volume. Shallower water could result in greater resuspension of bottom sediments and, therefore, in more internal nutrient loading, higher water temperatures, decreased oxygen concentrations, stimulated production and proliferation of nuisance aquatic plants such as cattail and hydrilla, and loss of fish habitat and refugia. Water levels in Lochloosa Lake would be only slightly lower at the Infrequent Low water level compared with "Existing Conditions" (Table 21, Figure 40A).

The acreage of emergent wetlands for Orange and Lochloosa lakes would be 10,307 ac, a 1,252-ac (+13.8%) increase over "Existing Conditions" (Table 22). With the "All to Prairie" alternative, the range of water level fluctuation would be increased by 0.6 ft for Orange Lake but decreased by 0.2 ft for Lochloosa Lake (Tables 23 and 24). The range is the difference between the maximum and minimum fluctuations of an alternative relative to the range for "Existing Conditions."

Complete Diversion of Prairie Creek Flow to Orange Lake ("None to Prairie"). Diverting all the Prairie Creek flow to Orange Lake raises the water levels of the lakes (Figures I1, I2, and I4, Appendix I). The effects on the biohydrologic criteria are a 0.09–0.29-ft increase for Orange Lake and a 0.04–0.26-ft increase for Lochloosa Lake (Tables 20 and 21, Figures 39A and 40A). However, this alternative would adversely affect the flora and fauna of Paynes Prairie (see discussion on p. 127).

The acreage of emergent wetlands occurring in Orange and Lochloosa lakes would be decreased by only 62 ac (−0.7%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations would be unchanged for Lochloosa Lake (Table 24) but increased by 0.1 ft for Orange Lake (Table 23).

Table 23. Effects of different water management alternatives on the Orange Lake fluctuation regime (all measurements in feet)

Management Alternative	Orange Lake Fluctuation Regime			
	Maximum	Minimum	Range	Change*
Existing conditions	60.1	50.9	9.2	NA
Remove Newnans Lake weir	60.1	50.9	9.2	0.0
Complete restoration of Prairie Creek flow to Paynes Prairie	59.6	49.8	9.8	+0.6
Complete diversion of Prairie Creek flow to Orange Lake	60.3	51.0	9.3	+0.1
Reduction in Paynes Prairie inflow/outflow structure capacity by 50%	60.2	51.0	9.2	0.0
Lake level threshold management of the Camps Canal structure	60.1	51.0	9.1	-0.1
Fill low-flow notch in Orange Lake weir	60.2	51.0	9.2	0.0
Remove Orange Lake weir	59.8	50.6	9.2	0.0
Dredge Cross Creek 3 ft	60.1	51.7	8.4	-0.8
Plug Orange Lake sinkholes 50%	60.2	52.9	7.3	-1.9
Plug Orange Lake sinkholes 100%	60.3	56.2	4.1	-5.1
Fixed crest weir around Orange Lake sinkholes, 54 ft	60.1	53.1	7.0	-2.2
Fixed crest weir around Orange Lake sinkholes, 55 ft	60.1	53.8	6.3	-2.9
Fixed crest weir around Orange Lake sinkholes, 56 ft	60.1	54.7	5.4	-3.8
Gated weir around Orange Lake sinkholes, gates closed at 54 ft, opened at 58 ft	60.2	53.1	7.1	-2.1
Gated weir around Orange Lake sinkholes, gates closed at 55 ft, opened at 58 ft	60.2	54.2	6.0	-3.2
Gated weir around Orange Lake sinkholes, gates closed at 56 ft, opened at 58 ft	60.2	54.9	5.3	-3.9
Fixed crest weir around Orange Lake sinkholes at 55 ft, remove Orange Lake weir	59.8	53.7	6.1	-3.1
Plug Orange Lake sinkholes 50%, remove Orange Lake weir	59.9	52.3	7.6	-1.6
Plug Orange Lake sinkholes 100%, remove Orange Lake weir	60.0	54.8	5.2	-4.0
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 50%, remove Orange Lake weir	59.1	51.1	8.0	-1.2
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 100%, remove Orange Lake weir	59.2	54.0	5.2	-4.0

Note: NA = not applicable

*Change equals the range for the respective management alternative minus the range for the "Existing Conditions" alternative

Table 24. Effects of different water management alternatives on the Lochloosa Lake fluctuation regime (all measurements in feet)

Management Alternative	Lochloosa Lake Fluctuation Regime			
	Maximum	Minimum	Range	Change*
Existing conditions	61.2	53.4	7.8	NA
Remove Newnans Lake weir	61.2	53.4	7.8	0.0
Complete restoration of Prairie Creek flow to Paynes Prairie	60.9	53.3	7.6	−0.2
Complete diversion of Prairie Creek flow to Orange Lake	61.3	53.5	7.8	0.0
Reduction in Paynes Prairie inflow/outflow structure capacity by 50%	61.2	53.4	7.8	0.0
Lake level threshold management of the Camps Canal structure	61.2	53.5	7.7	−0.1
Fill low-flow notch in Orange Lake weir	61.3	53.5	7.8	0.0
Remove Orange Lake weir	60.8	53.3	7.5	−0.3
Dredge Cross Creek 3 ft	61.2	51.9	9.3	+1.5
Plug Orange Lake sinkholes 50%	61.3	53.9	7.4	−0.4
Plug Orange Lake sinkholes 100%	61.5	56.2	5.3	−2.5
Fixed crest weir around Orange Lake sinkholes, 54 ft	61.2	53.5	7.7	−0.1
Fixed crest weir around Orange Lake sinkholes, 55 ft	61.2	54.0	7.2	−0.6
Fixed crest weir around Orange Lake sinkholes, 56 ft	61.3	54.6	6.7	−1.1
Gated weir around Orange Lake sinkholes, gates closed at 54 ft, opened at 58 ft	61.3	53.5	7.8	0.0
Gated weir around Orange Lake sinkholes, gates closed at 55 ft, opened at 58 ft	64.4	54.3	7.1	−0.7
Gated weir around Orange Lake sinkholes, gates closed at 56 ft, opened at 58 ft	61.4	54.9	6.5	−1.3
Fixed crest weir around Orange Lake sinkholes at 55 ft, remove Orange Lake weir	60.8	53.9	6.9	−0.9
Plug Orange Lake sinkholes 50%, remove Orange Lake weir	60.8	53.5	7.3	−0.5
Plug Orange Lake sinkholes 100%, remove Orange Lake weir	60.9	54.7	6.2	−1.6
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 50%, remove Orange Lake weir	60.5	53.3	7.2	−0.6
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 100%, remove Orange Lake weir	60.6	54.1	6.5	−1.3

Note: NA = not applicable

*Change equals the range for the respective management alternative minus the range for the "Existing Conditions" alternative

Reduction in Paynes Prairie Inflow/Outflow Structure Capacity by 50% ("½ In- & ½ Outflow"). This alternative has essentially no effect on the wetlands of Orange and Lochloosa lakes and relatively little effect on the existing lake levels (Tables 20 and 21, Figures 39A and 40A; Figures J1, J2, and J4, Appendix J). The surface water elevations predicted by the SSARR hydrologic model that meet the biohydrologic criteria would be increased generally less than 0.2 ft. The Frequent Low and Infrequent Low water levels for Orange Lake would be increased less than 0.1 ft (Table 20).

The acreage of emergent wetlands for Orange and Lochloosa lakes would be decreased by 196 ac (-2.2%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for both Orange Lake (Table 23) and Lochloosa Lake (Table 24) would be unchanged.

Lake Level Threshold Management of the Camps Canal Structure ("Newnans Lake=66 ft, Orange Lake=56 ft"). Under certain conditions, the flow to Paynes Prairie from Prairie Creek would be reduced by 50% to allow more water to go to Orange Lake. These conditions are (1) Orange Lake levels must be *below* 56 ft and (2) Newnans Lake levels must be *above* 66 ft. When Orange Lake is above 56 ft, there is recreational access. When Newnans Lake is below 66 ft, Prairie Creek flows are low and would not significantly affect Orange Lake levels.

Implementation of this alternative during these hydrologic conditions is predicted to increase water levels in Orange and Lochloosa lakes (Tables 20 and 21, Figures 39A and 40A; Figures K1, K2, and K4, Appendix K). The range of water level fluctuations for both Orange and Lochloosa lakes would be decreased by 0.1 ft (Tables 23 and 24). The acreage of emergent wetlands for Orange and Lochloosa lakes would be decreased by 198 ac (-2.2%) as compared to "Existing Conditions" (Table 22).

Fill Low-Flow Notch in Orange Lake Weir ("Fill Orange Lake Notch"). This alternative increases lake levels an average 0.2 ft (Tables 9 and 10). However, it would eliminate the base flow contribution of Orange Lake to Orange Creek at lake levels below

58 ft (crest elevation of the weir) and would reduce the overall duration of downstream flow. This base flow is very important to downstream aquatic fauna during drought conditions. Under "Existing Conditions," there is some flow across the weir 81% of the time (Table E42, Appendix E; Figure L6, Appendix L). With the low-flow notch filled, there is some flow across the weir only 56% of the time (Table L10 and Figure L6, Appendix L).

In addition, the acreage of emergent wetlands for Orange and Lochloosa lakes would be increased by 204 ac (2.3%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would be unchanged (Tables 23 and 24).

Remove Orange Lake Weir. Removal of the Orange Lake weir may aid in flushing organic sediments from the lake and decreasing lake hydraulic residence time. It also would benefit the stream biota of Orange Creek by increasing base flows during droughts. However, this alternative would lower lake levels by approximately 0.8 ft (Tables 20 and 21, Figures 39B and 40B; Figures M1–M3, Appendix M). The water levels for both lakes predicted by the SSARR hydrologic model to correspond with the biohydrologic criteria would be markedly reduced relative to "Existing Conditions" (Tables 20 and 21). Significant reductions in the predicted high and middle water conditions would allow upland and transitional plant species to invade the existing wetland swamp and allow wetland tree and shrub species to invade the emergent marsh (Tables 20 and 21, Figures 39B and 40B).

The acreage of emergent wetlands for Orange and Lochloosa lakes would be decreased by 597 ac (−6.6%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange Lake would remain the same; Lochloosa Lake would decrease by −0.3 ft (Tables 23 and 24).

Dredge Cross Creek 3 ft ("Dredge 3 ft"). Dredging Cross Creek would improve low water access and enhance navigation between Orange and Lochloosa lakes. However, this alternative lowers Lochloosa Lake levels during a significant drought (Table 21,

Figure 40B; Figures N2 and N3, Appendix N). The effects of extreme droughts on Lochloosa Lake would be exacerbated because the water level corresponding to the Infrequent Low criterion would decrease by approximately 1 ft (Table 21, Figure 40B). This alternative also would cause environmental impacts due to dredge spoil dewatering, turbidity during construction, and elimination of eelgrass (*Vallisneria*) and other fish habitat in the creek channel. This alternative does not alleviate the problems within Orange Lake associated with extreme low water levels (e.g., sediment resuspension, low dissolved oxygen, loss of habitat, and nuisance aquatic plant problems).

The acreage of emergent wetlands for Orange and Lochloosa lakes would be increased by 265 ac (2.9%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations would decrease by 0.8 ft for Orange Lake and increase by 1.5 ft for Lochloosa Lake (Tables 23 and 24).

Plug Orange Lake Sinkholes 50% ("Plug 50%"). Curtailing flow to the sinkhole area by 50% would augment middle and low water levels. The water level predicted to meet the Infrequent Low criterion for Orange Lake is 1.8 ft higher (52.49 to 54.29 ft) than the corresponding level for "Existing Conditions" (Table 20, Figure 39C). Similarly, the Infrequent Low Water Level in Lochloosa Lake would be increased by approximately 0.7 ft (Table 21, Figure 40C).

Restricting water flow to the sinkholes could create new problems. Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study.

Augmented low water levels attained by this alternative (Figures O1–O3, Appendix O) would significantly decrease exposure of the lower floodplain to drawdown. Reseeding of the wetland plant communities and the oxidation and compaction of organic sediments would be greatly curtailed. Augmentation of low water levels would not result in aerobic conditions or exposure of the seed bank at elevations below the average elevation of the emergent marsh surrounding the lake (Tables 20 and 21, Figures 39C and 40C). Prolonged inundation of much of the marsh would likely result in conversion to deep marsh. The existing biology of the lakes would be changed.

In addition, the acreage of emergent wetlands for Orange and Lochloosa lakes would be decreased by 2,026 ac (−22.4%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would be decreased by 1.9 ft and 0.4 ft, respectively (Tables 23 and 24).

Plug Orange Lake Sinkholes 100% ("Plug 100%"). Curtailing all flow to the sinkhole area would significantly increase the middle and low water levels in the lakes (Tables 20 and 21, Figures 39C and 40C; Figures P1–P3, Appendix P). However, this hydrologic regime would interfere with existing biological functions in Orange Lake.

Augmented water levels predicted to correspond with the Frequent Low and Infrequent Low biohydrologic criteria would decrease exposure of the lower floodplain. Reseeding of the wetland and the oxidation and compaction of organic sediments would be greatly curtailed. This area would convert from emergent marsh to aquatic or deep marsh habitat. Fish-spawning substrate that currently exists in this area would be reduced. The Middle Water Level of Orange Lake would become so high that a portion of the forested wetland would be replaced by marsh habitat. The water level predicted for the Frequent Low criterion would be considerably above the average elevations of the marsh of Lochloosa and Orange lakes (Tables 20 and 21, Figures 39C and 40C). These elevated water levels would result in an adverse impact to the fishery because the range of fluctuation would be greatly curtailed.

Restricting water flow to the sinkholes could create new problems. Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study.

The acreage of emergent wetlands for the lakes would be decreased by 4,575 ac (−50.5%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would decrease by 5.1 ft and 2.5 ft, respectively (Tables 23 and 24).

Fixed Crest Weir around Orange Lake Sinkholes, 54 ft ("Sinkhole Weir at 54 ft"). Curtailing flow to the sinkhole area when water levels decline below 54 ft would augment low water levels in Orange Lake without causing discernible surface water impacts at high lake levels (Table 20, Figure 39C; Figures Q1–Q3, Appendix Q). Middle and high water conditions would be unaffected. Likewise, the hydrologic regime of Lochloosa Lake would be essentially unaltered (Table 21, Figure 40C).

We expect that the ecotone between the lower emergent marsh and deep marsh of Orange Lake would shift upward from 52 ft to near 54 ft. This upward shift in the ecotone would result in more acreage of deep marsh and approximate the ecotone elevation of these marsh communities on Lochloosa Lake (Tables 20 and 21, Figures 39C and 40C).

However, constructing a weir around the sinkholes may create new problems. Lake flow to the aquifer would be reduced, and the frequency and duration of no flow to the sinkholes would increase over "Existing Conditions" (Table 25). Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. Raising the Infrequent Low Water Level would also reduce consolidation of organic sediments. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study. Finally, the acreage of emergent

Table 25. Frequency and duration of reduced seepage from Orange Lake sinkholes for various water management alternatives

Management Alternative	Percentage of Time that Seepage is Eliminated*	Duration of Time that Seepage is Eliminated (days)	Return Period (years)
Existing conditions (at 50.5 ft)	0	NA	NA
Fixed crest weir around Orange Lake sinkholes, 54 ft (Appendix Q)	4	1	8
		30	10
		274	50
Fixed crest weir around Orange Lake sinkholes, 55 ft (Appendix R)	7	1	6
		90	10
		365	50
Fixed crest weir around Orange Lake sinkholes, 56 ft (Appendix S)	13	1	4
		120	10
		365+	50

Note: NA = not applicable

*Interpolated value based on data in Table E1 (Appendix E), Table Q1 (Appendix Q), Table R1 (Appendix R), Table S1 (Appendix S), respectively

wetlands for the lakes would be decreased by 399 ac (–4.4%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would decrease by 2.2 ft and 0.1 ft, respectively (Tables 23 and 24).

Fixed Crest Weir around Orange Lake Sinkholes, 55 ft ("Sinkhole Weir at 55 ft"). This alternative would produce a hydrologic regime in both lakes similar to the "Sinkhole Weir at 54 ft" option (see preceding discussion; Figures Q1–Q3, Appendix Q; Figures R1–R3, Appendix R). The water level predicted to meet the Infrequent Low criterion for Orange Lake would be 54.5 ft. The water levels in both lakes that are predicted to meet the other biohydrologic criteria would be similar to those for "Existing Conditions." However, the frequency and duration of no flow to the sinkholes would be further increased over the "Sinkhole Weir at 54 ft" alternative (Table 25).

Restricting water flow to the sinkholes could create new problems. Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study.

The acreage of emergent wetlands for the lakes would be decreased by 811 ac (−9.0%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would decrease by −2.9 ft and −0.6 ft, respectively (Tables 23 and 24).

Fixed Crest Weir around Orange Lake Sinkholes, 56 ft ("Sinkhole Weir at 56 ft"). Curtailing flow to the sinkhole area when water levels descend below 56 ft augments low water levels in the lakes (Tables 20 and 21, Figures 39C and 40C; Figures S1–S3, Appendix S). However, this hydrologic regime would interfere with existing biological functions. In addition, the frequency and duration of no flow to the sinkholes would be further increased over the "Sinkhole Weir at 55 ft" alternative (Table 25).

The augmented water levels predicted to meet the Frequent Low and Infrequent Low biohydrologic criteria would significantly decrease exposure of the lower floodplain to drawdown. Reseeding of the wetland plant communities and the oxidation and compaction of organic sediments would be greatly curtailed. This management alternative has a greater negative impact on Orange Lake than on Lochloosa Lake. The elevation of the Frequent Low Water Level criterion would not result in aerobic conditions or exposure of the seed bank at elevations below the average elevation of the emergent marsh surrounding the lake (Table 20, Figure 39C). Prolonged inundation of much of the marsh would likely result in conversion to deep marsh. In Lochloosa Lake, the lowest elevations occupied by cypress seldom would be exposed, thus preventing germination and establishment of seedlings. This forested habitat ultimately would be replaced by aquatic habitat.

Restricting water flow to the sinkholes could create new problems. Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study.

The acreage of emergent wetlands for the lakes would be decreased by 1,909 ac (−21.1%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would decrease by 3.8 ft and 1.1 ft, respectively (Tables 23 and 24).

Gated Weir around Orange Lake Sinkholes, Gates Closed at 54 ft, Opened at 58 ft ("Close 54 ft/Open 58 ft"). Curtailing flow to the sinkhole area when Orange Lake levels reach 54 ft, then opening the sinkhole gates when lake levels reach 58 ft would augment low water levels in Orange Lake (Table 20, Figure 39C; Figures T1–T3, Appendix T). Middle and high water conditions would be unaffected. Likewise, the hydrologic regime of Lochloosa Lake would be generally unaltered (Table 21, Figure 40C).

This alternative raises the existing Infrequent Low Water Level of Orange Lake 1.2 ft, from 52.49 to 53.64 ft (Table 20, Figure 39C). This change in the Infrequent Low Water Level would cause the ecotone between the lower emergent marsh and deep marsh of Orange Lake to shift from 52 ft to near 54 ft. This shift would result in more acreage of deep marsh and approximate the ecotone elevation of these communities on Lochloosa Lake (Figures 39C and 40C). Constructing a weir around the sinkholes may create new problems. Lake flow to the aquifer would be reduced, and the frequency and duration of no flow to the sinkholes would increase over "Existing Conditions." Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study.

Raising the Infrequent Low Water Level would decrease the acreage of emergent wetlands for the lakes by 1,142 ac (−12.6%) as compared to "Existing Conditions" (Table 22). The Frequent Low Water Levels of Orange and Lochloosa lakes also are increased slightly, thus reducing acreages of emergent marsh exposed during low water periods. Ultimately, the total acreage of emergent wetlands would decrease because of the lack of reseeding.

The range of water level fluctuations would decrease by 2.1 ft for Orange Lake and remain unchanged for Lochloosa Lake (Tables 23 and 24).

Gated Weir around Orange Lake Sinkholes, Gates Closed at 55 ft, Opened at 58 ft ("Close 55 ft/Open 58 ft"). Curtailing flow to the sinkhole area when Orange Lake levels reach 55 ft and opening the sinkhole gates when water levels reach 58 ft would augment low water levels in the lakes (Tables 20 and 21, Figures 39C and 40C; Figures U1–U3, Appendix U). However, this hydrologic regime would interfere with existing biological functions of Orange Lake. In addition, the frequency and duration of no flow to the sinkholes would be further increased over the "Close 54 ft/Open 58 ft" alternative.

The augmented water levels predicted to meet the Frequent Low (+0.35 ft for Orange Lake, +0.14 ft for Lochloosa Lake) and Infrequent Low (+2.64 ft for Orange Lake, +0.91 ft Lochloosa Lake) biohydrologic criteria would significantly decrease exposure of the lower floodplain to drawdown. Reseeding of the wetland plant communities and the oxidation and compaction of organic sediments would be greatly curtailed. In Orange Lake, the elevation of the Frequent Low Water Level criterion would not result in aerobic conditions or exposure of the seed bank at elevations below the average elevation of the emergent marsh surrounding the lake (Table 20, Figure 39C). Prolonged inundation of much of the marsh would likely result in conversion to deep marsh. In Lochloosa Lake, the lowest elevations occupied by cypress seldom would be exposed, thus preventing germination and establishment of seedlings. This forested habitat would ultimately be replaced by aquatic habitat.

Restricting water flow to the sinkholes could create new problems. Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study.

The acreage of emergent wetlands for the lakes would be decreased by 1,449 ac (−16.0%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would decrease by 3.2 ft and 0.7 ft, respectively (Tables 23 and 24).

Gated Weir around Orange Lake Sinkholes, Gates Closed at 56 ft, Opened at 58 ft ("Close 56 ft/Open 58 ft"). Curtailing flow to the sinkhole area when Orange Lake levels reach 56 ft and opening the sinkhole gates when the lake levels reach 58 ft would augment low water levels in the lakes (Tables 20 and 21, Figures 39C and 40C; Figures V1–V3, Appendix V). However, this hydrologic regime would interfere with existing biological functions. In addition, the frequency and duration of no flow to the sinkholes would be further increased over the "Close 55 ft/Open 58 ft" alternative.

Water levels predicted to correspond with the Frequent Low (+0.64 ft for Orange Lake, +0.43 ft for Lochloosa Lake) and Infrequent Low (+3.09 ft for Orange Lake, +1.31 ft for Lochloosa Lake) biohydrologic criteria would significantly decrease exposure of the lower floodplain to drawdown. Reseeding of the wetland plant communities and the oxidation and compaction of organic sediments would be greatly curtailed. In Orange Lake, the elevation of the Frequent Low Water

Level would not result in aerobic conditions or exposure of the seed bank at elevations below the average elevation of the emergent marsh surrounding the lake (Table 20, Figure 39C). Prolonged inundation of much of the marsh would likely result in conversion to deep marsh. In Lochloosa Lake, the lowest floodplain elevations occupied by cypress seldom would be exposed, thus preventing germination and establishment of seedlings. This forested habitat would ultimately be replaced by aquatic habitat.

Restricting water flow to the sinkholes could create new problems. Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study.

The acreage of emergent wetlands for the lakes would be decreased by 2,071 ac (-22.9%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would decrease by 3.9 ft and 1.3 ft, respectively (Tables 23 and 24).

Fixed Crest Weir around Orange Lake Sinkholes at 55 ft, Remove Orange Lake Weir ("Sinkhole Weir at 55 ft, Remove Orange Lake Weir"). This alternative involves removing the Orange Lake weir and eliminating flow to the sinkhole area when Orange Lake levels reach 55 ft. This combination could aid in flushing organic sediments and also augment low water levels. However, this alternative would affect middle to high lake levels virtually the same as the "Remove Orange Lake Weir" alternative, thus causing similar impacts (Tables 20 and 22, Figures 39B, 39D, 40B, and 40D). The effects of extreme droughts on Orange Lake would be moderated because the water level that is predicted to meet the Infrequent Low criterion would increase by 1.95 ft (Table 20, Figure 39D).

Restricting water flow to the sinkholes could create new problems. Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study.

The acreage of emergent wetlands for the lakes would be decreased by 1,397 ac (−15.4%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would decrease by 3.1 ft and 0.9 ft, respectively (Tables 23 and 24).

Plug Orange Lake Sinkholes 50%, Remove Orange Lake Weir ("Plug 50%, No Weir"). This alternative attempts to increase the flushing of organic sediments from Orange Lake by removing the Orange Lake weir and to augment low water levels by partial plugging of the Orange Lake sinkholes. Removal of the weir also will help to maintain base flows in Orange Creek during times of drought, thereby benefiting stream biota. As a result, high water levels in the lakes would be reduced by approximately 0.7 ft in Orange Lake and 0.6 ft in Lochloosa Lake (Tables 20 and 21). The Middle Water Level would be reduced by approximately 0.6 ft in Orange Lake and 0.5 ft in Lochloosa Lake.

Water levels predicted to correspond with the Infrequent High, Frequent High, and Middle criteria of this alternative are significantly below the corresponding levels of "Existing Conditions" (Tables 20 and 21, Figures 39D and 40D). The Infrequent High and Frequent High water levels result in less frequent prolonged flooding in upper portions of the forest floodplain. The Middle Water Level may result in soil oxidation and subsidence upon the floodplain. It also may cause an expansion of wetland shrub and forest acreage that replaces the upper portion of the emergent marsh.

Restricting water flow to the sinkholes may create new problems. Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study.

The acreage of emergent wetlands for the lakes would be decreased by 1,487 ac (−16.4%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would be decreased by 1.6 ft and 0.5 ft, respectively (Tables 23 and 24).

Plug Orange Lake Sinkholes 100%, Remove Orange Lake Weir ("Plug 100%, No Weir"). This alternative attempts to increase the flushing of organic sediments from Orange Lake by removing the Orange Lake weir and to augment low water levels by plugging the sinkholes. Removal of the weir also will help to maintain base flows in Orange Creek during times of drought, thus benefiting stream biota. As a result, high and middle water levels in the lakes would be reduced, whereas low water levels would be augmented (Tables 20 and 21; Figures Y1–Y3, Appendix Y).

In particular, the water levels predicted to correspond with the Infrequent High, Frequent High, and Middle criteria for this alternative are below the corresponding levels of "Existing Conditions" (Tables 20 and 21, Figures 39D and 40D). The lower Infrequent High and Frequent High water levels result in less frequent prolonged flooding in upper portions of the forest floodplain. A lower Middle Water Level may result in soil oxidation and subsidence upon the floodplain. It also may cause an expansion of wetland shrub and forest acreage that replaces the upper portion of the emergent marsh.

The water levels corresponding to the Frequent Low and Infrequent Low criteria for this alternative are significantly higher than the corresponding levels of "Existing Conditions" (Tables 20 and 21, Figures 39D and 40D). The augmented Frequent Low and Infrequent Low water levels would significantly decrease exposure of the lower floodplain to drawdown. Reseeding of the wetland plant communities and the oxidation and compaction of organic sediments would be greatly curtailed. The Frequent Low Water Level would not result in aerobic conditions or exposure of the seed bank at elevations below the average elevation of the emergent marsh surrounding the lake. Prolonged inundation of much of the marsh would likely result in conversion to deep marsh. In Lochloosa Lake, the lowest elevations occupied by cypress seldom would be exposed, preventing germination and establishment of seedlings.

Restricting water flow to the sinkholes may create new problems. Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study.

The acreage of emergent wetlands for the lakes would be decreased by 2,941 ac (−32.5%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would be decreased by 4.0 ft and 1.6 ft, respectively (Tables 23 and 24).

Complete Restoration of Prairie Creek Flow to Paynes Prairie, Plug Sinkholes 50%, Remove Orange Lake Weir ("All to Prairie, Plug 50%, No Weir"). This alternative completes the restoration of flow to Paynes Prairie, attempts to increase the flushing of organic sediments from Orange Lake by removing the Orange Lake weir, and augments low water levels by plugging the sinkholes by 50%. Removal of the weir will maintain base flows in Orange Creek during times of drought, benefiting stream biota.

However, the water levels predicted to correspond with the biohydrologic criteria of this alternative are significantly below the corresponding levels of "Existing Conditions" (Tables 20 and 21, Figures 39D and 40D; Figures Z1–Z3, Appendix Z). The lower Infrequent High and Frequent High water levels result in less frequent prolonged flooding in upper portions of the forest floodplain. A lower Middle Water Level may result in soil oxidation and subsidence upon the floodplain. It also may cause an expansion of wetland shrub and forest acreage that replaces the upper portion of the emergent marsh. The Infrequent Low Water Levels of the lakes are essentially unchanged.

Restricting water flow to the sinkholes may create new problems. Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study.

The acreage of emergent wetlands for the lakes would be decreased by 1,467 ac (−16.2%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would be decreased by 1.2 ft and 0.6 ft, respectively (Tables 23 and 24).

Complete Restoration of Prairie Creek Flow to Paynes Prairie, Plug Sinkholes 100%, Remove Orange Lake Weir ("All to Prairie, Plug 100%, No Weir"). This alternative completes the restoration of flow to Paynes Prairie, attempts to increase the flushing of organic sediments from Orange Lake by removing the Orange Lake weir, and augments low water levels by plugging the sinkholes. Removal of the weir will maintain base flows in Orange Creek during times of drought, benefiting stream biota. As a result, high and middle water levels in Orange and Lochloosa lakes would be reduced, whereas extreme low water levels in Orange Lake would be augmented.

The water levels predicted to correspond with the Infrequent High, Frequent High, and Middle criteria of this alternative are significantly below the corresponding levels of "Existing Conditions" (Tables 20 and 21, Figures 39D and 40D; Figures AA1–AA3, Appendix AA). The Infrequent High and Frequent High water levels result in less frequent prolonged flooding in upper portions of the forest floodplain. The Middle Water Level may result in soil oxidation and subsidence upon the floodplain. It also may cause an expansion of wetland shrub and forest acreage that replaces the upper portion of the emergent marsh.

The water level corresponding to the Infrequent Low criterion for this alternative for Orange Lake is +2.26 ft higher than the corresponding levels of "Existing Conditions" (Table 20 and Figure 39D). Restricting water flow to the sinkholes may create new problems. Reducing water flow to the aquifer, particularly during times of drought, may affect aquifer water levels, reduce support to underlying limestone geologic structures, and reduce the total export of nutrients from the lake. In addition, construction activities around the lake bottom could increase the likelihood of new sinkholes forming. However, concerns would have to be addressed by further study.

The acreage of emergent wetlands for the lakes would be decreased by 3,039 ac (−33.6%) as compared to "Existing Conditions" (Table 22). The range of water level fluctuations for Orange and Lochloosa lakes would be decreased by 4.0 ft and 1.3 ft, respectively (Tables 23 and 24).

SUMMARY AND CONCLUSIONS

This section summarizes the wetland and hydrologic effects that would be expected to occur from the implementation of the different water management alternatives discussed in this report. A table of pertinent wetland and hydrologic data relevant to issues of OCB is provided for each major water body. This synopsis, where appropriate, includes the following:

- Change in wetland acreage (acres and percentage) relative to the "Existing Conditions" alternative
- Advantages and disadvantages of water management alternatives
- Wetland areas directly influenced by Prairie Creek inflows
- Effects on other water bodies
- Need for specialized studies
- Changes in range of water fluctuation
- Changes in recreational boating access

The reader is referred to the Hydrologic Assessment and Environmental Assessment sections of the report (pp. 77, 105) for more detailed analyses of each water management alternative.

NEWNANS LAKE

Two water management alternatives were evaluated for Newnans Lake: "Existing Conditions" and "Remove Newnans Lake Weir."

The floodplain swamps have been impacted by maintaining artificially high water levels with a weir at the outlet of Newnans Lake. A hydrologic model (SSARR) predicted that the weir would increase median water levels by approximately 0.8 ft over pre-weir conditions. The increase in water levels would result in significantly higher inundation frequencies over hundreds of acres of the floodplain swamp. Concomitantly, there is little recent regeneration of the cypress fringe community on Newnans Lake. Weir removal would result in a 27% (235 ac) increase in emergent wetland vegetation (Table 26).

Table 26. Summary of wetland and hydrologic effects of surface water management alternatives for Newnans Lake

Management Alternative	Change in Wetland Acres	Advantages for Newnans Lake	Disadvantages for Newnans Lake
Existing conditions	0	None	Decreases range of lake level fluctuations Deters regeneration of lake cypress fringe
Remove Newnans Lake weir	+235 (+27.3%)	Increases range of lake level fluctuations Allows regeneration of lake cypress fringe Increases emergent wetlands acreage by 27% (235 acres)	Reduces median water levels by 0.8 ft, reducing fishing access to swamp

Findings from this study indicated that construction of the weir has (1) limited regeneration of tree species at the lower elevations of the floodplain swamps and (2) reduced the total acreages of emergent wetlands. Therefore, removal of the weir appears to be the most ecologically sound management practice for Newnans Lake (Table 26).

PAYNES PRAIRIE

Seven water management alternatives were evaluated for Paynes Prairie. The "Existing Conditions" or "Remove Newnans Lake Weir" alternatives appear to be the most ecologically sound management practices for Paynes Prairie and OCB, given the present morphometry. These alternatives maximize the emergent wetlands acreage and maintain the surface water sheetflow across the eastern lobe of Paynes Prairie that is so important to the maintenance of OCB biology. They minimize direct flooding of the U.S. 441 roadway and damage to the underlying roadbed. Additionally, these alternatives have little effect on the average surface water levels of Orange and Lochloosa lakes.

Under these two alternatives, approximately 45%, on average, of Prairie Creek flow enters the eastern lobe of Paynes Prairie. Downhill sheetflow from the Camps Canal structure creates some wetlands by supplying water to areas not inundated by the central pool.

However, the major effect of Prairie Creek flow is to produce higher inundation frequencies for the vast majority of eastern lobe wetlands. The extent of this direct influence on wetlands varies with flow through the Camps Canal structure. Estimates for acres of direct influence range from 984 ac for the "Complete Restoration of Prairie Creek Flow to Paynes Prairie" alternative to 0 ac for the "Complete Diversion of Prairie Creek Flow to Orange Lake" alternative. Prairie Creek flow also indirectly influences areas through occasional inundation or soil saturation. These indirectly influenced areas cannot be directly measured, but they could be extensive. The extent of wetlands directly and indirectly influenced by Prairie Creek flow and its contribution to the biology of Paynes Prairie State Preserve must be considered when choosing a water management alternative.

In our opinion, the five remaining alternatives should not be considered for implementation because of the potential environmental impacts to Paynes Prairie or to Orange and Lochloosa lakes (Table 27).

Table 27. Summary of wetland and hydrologic effects of surface water management alternatives for Paynes Prairie

Management Alternative	Change in Wetland Acres*	Wetland Acres Directly Influenced by Prairie Creek Inflow†	Advantages for Paynes Prairie	Disadvantages for Paynes Prairie
Existing conditions	NA	612	Minimizes active water management emergent wetlands acreage of Paynes Prairie	None
Remove Newnans Lake weir	0	612	Minimizes active water management; maximizes emergent wetlands acreage of Paynes Prairie	None
Complete restoration of Prairie Creek flow to Paynes Prairie	−627 (−5.3%)	984	Restores historical hydrologic conditions to Paynes Prairie	Emergent wetlands loss Increases potential flooding of U.S. 441
Complete diversion of Prairie Creek flow to Orange Lake	−387 (−3.3%)	0	None	Affects the hydrology of emergent wetlands throughout Paynes Prairie Loses wetlands of eastern lobe of Paynes Prairie
Reduction in Paynes Prairie inflow/outflow structure capacity by 50%	−354 (−3.0%)	394	None	Exacerbates prairie water quality problems
Lake level threshold management of the Camps Canal structure	+15 (<+0.1%)	612	None	Reduces seasonal high flows to Paynes Prairie from Prairie Creek
Use Sweetwater Branch inflow to replace Prairie Creek inflow	not available	0	None	Decline in prairie water quality Affects the hydrology of emergent wetlands throughout Paynes Prairie Loses wetlands of eastern lobe of Paynes Prairie

Note: NA = not applicable

*From Table 17
†From Table 18

Orange and Lochloosa Lakes

Twenty-two water management alternatives were evaluated for Orange and Lochloosa lakes. In our opinion, the "Existing Conditions" alternative or "Remove Newnans Lake Weir" alternative should be considered for implementation. However, there are two additional alternatives that have relatively small wetlands loss: "Fixed Crest Weir around Orange Lake Sinkholes, 54 ft" and "Fixed Crest Weir around Orange Lake Sinkholes, 55 ft" (Table 28). These water management alternatives require more specialized study to assess their environmental impacts to Orange and Lochloosa lakes. The two fixed crest weir alternatives would augment extreme low lake levels but would require further study to determine adverse effects to nutrient loading of the lakes, the subterranean geology, and the Floridan aquifer system. These alternatives have little effect on access.

The remaining 18 alternatives have one or more of the following characteristics:

- Minimal hydrologic effects
- Significant wetland losses
- Detrimental hydrological effects in other subbasins in OCB
- Potential hydrogeologic impacts

Table 28. Summary of wetland and hydrologic effects of surface water management alternatives for Orange and Lochloosa lakes

Management Alternative	Geological Analysis Required	Change* in Wetland Acres	Change† in Surface Water Fluctuation Range (feet)		Change‡ in Boater Access at 56 ft	Advantages for Orange and Lochloosa Lakes	Disadvantages for Orange and Lochloosa Lakes
			Orange Lake	Lochloosa Lake			
Existing conditions	No	NA	NA	NA	NA	Maintains existing hydrologic regime	Maintains a large range of water level fluctuations that may impair boater access under low waters
Remove Newnans Lake weir	No	0	0.0	0.0	0	Maintains existing hydrologic regime	Maintains a large range of water level fluctuations that may impair boater access under low waters
Complete restoration of Prairie Creek flow to Paynes Prairie	No	+1,252 (+13.8%)	+0.6	-0.2	-8.8%	None	Lowers extreme low water levels and increases duration of extreme low water levels
Complete diversion of Prairie Creek flow to Orange Lake	No	-62 (-0.7%)	+0.1	0.0	+2.6%	Increases lake levels in the short term	None
Reduction in Paynes Prairie inflow/outflow structure capacity by 50%	No	-196 (-2.2%)	0.0	0.0	+1.2%	Increases lake levels in the short term	None
Lake level threshold management of the Camps Canal structure	No	-198 (-2.2%)	-0.1	-0.1	+1.0%	Increases lake levels in the short term	None
Fill low-flow notch in Orange Lake weir	No	+204 (+2.3%)	0.0	+0.0	+1.9%	Increases average lake levels	Eliminates base flow to Orange Creek during droughts
Remove Orange Lake weir	No	-597 (-6.6%)	0.0	-0.3	-10.9%	Increases potential for flushing organic sediments	Decreases average water levels
Dredge Cross Creek 3 ft	No	+265 (+2.9%)	-0.8	+1.5	-0.3%	Improves low water access between lakes	Lowers Lochloosa Lake during droughts Impacts water quality

Table 28—*Continued*

Management Alternative	Geological Analysis Required	Change* in Wetland Acres	Change† in Surface Water Fluctuation Range (feet)		Change‡ in Boater Access at 56 ft	Advantages for Orange and Lochloosa Lakes	Disadvantages for Orange and Lochloosa Lakes
			Orange Lake	Lochloosa Lake			
Plug Orange Lake sinkholes 50%	Yes	-2,026 (-22.8%)	-1.9	-0.4	+8.6%	Increases boater access during droughts	Decreases emergent wetlands significantly
Plug Orange Lake sinkholes 100%	Yes	-4,575 (-50.5%)	-5.1	-2.5	+18.4%	Increases boater access during droughts	Decreases emergent wetlands significantly Causes potential hydrogeological impacts
Fixed crest weir around Orange Lake sinkholes, 54 ft	Yes	-399 (-4.4%)	-2.2	-0.1	+0.7%	Increases boater access during droughts	Reduces emergent wetlands by 4% Causes potential hydrogeological impacts
Fixed crest weir around Orange Lake sinkholes, 55 ft	Yes	-811 (-9.0%)	-2.9	-0.6	+1.6%	Increases boater access during droughts	Reduces emergent wetlands by 9% Causes potential hydrogeological impacts
Fixed crest weir around Orange Lake sinkholes, 56 ft	Yes	-1,909 (-21.1%)	-3.8	-1.1	+5.5%	Increases boater access during droughts	Decreases emergent wetlands significantly Causes potential hydrogeological impacts
Gated weir around Orange Lake sinkholes, gates closed at 54 ft, opened at 58 ft	Yes	-1,142 (-12.6%)	-2.1	+0.0	+3.5%	Increases boater access during droughts	Decreases emergent wetlands significantly Causes potential hydrogeological impacts

Table 28—*Continued*

Management Alternative	Geological Analysis Required	Change* in Wetland Acres	Change† in Surface Water Fluctuation Range (feet)		Change‡ in Boater Access at 56 ft	Advantages for Orange and Lochloosa Lakes	Disadvantages for Orange and Lochloosa Lakes
			Orange Lake	Lochloosa Lake			
Gated weir around Orange Lake sinkholes, gates closed at 55 ft, opened at 58 ft	Yes	-1,449 (-16.0%)	-3.2	-0.7	+5.6%	Increases boater access during droughts	Decreases emergent wetlands significantly Causes potential hydrogeological impacts
Gated weir around Orange Lake sinkholes, gates closed at 56 ft, opened at 58 ft	Yes	-2,071 (-22.9%)	-3.9	-1.3	+8.7%	Increases boater access during droughts	Decreases emergent wetlands significantly Causes potential hydrogeological impacts
Fixed crest weir around Orange Lake sinkholes at 55 ft, remove Orange Lake weir	Yes	-1,397 (-15.4%)	-3.1	-0.9	-8.6%	Increases potential for flushing organic sediments	Decreases average water levels Decreases emergent wetlands significantly Causes potential hydrogeological impacts
Plug Orange Lake sinkholes 50%, remove Orange Lake weir	Yes	-1,487 (-16.4%)	-1.6	-0.5	-3.8%	Increases potential for flushing organic sediments	Decreases average water levels Decreases emergent wetlands significantly Causes potential hydrogeological impacts
Plug Orange Lake sinkholes 100%, remove Orange Lake weir	Yes	-2,941 (-32.5%)	-4.0	-1.6	+7.7%	Increases potential for flushing organic sediments Increases lake levels during droughts	Decreases average water levels Decreases emergent wetlands significantly Causes potential hydrogeological impacts

Table 28—*Continued*

Management Alternative	Geological Analysis Required	Change* in Wetland Acres	Change† in Surface Water Fluctuation Range (feet)		Change‡ in Boater Access at 56 ft	Advantages for Orange and Lochloosa Lakes	Disadvantages for Orange and Lochloosa Lakes
			Orange Lake	Lochloosa Lake			
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 50%, remove Orange Lake weir	Yes	−1,467 (−16.2%)	−1.2	−0.6	−17.9%	Increases potential for flushing organic sediments	Decreases average water levels significantly Decreases emergent wetlands significantly Causes potential hydrogeological impacts
Complete restoration of Prairie Creek flow to Paynes Prairie, plug sinkholes 100%, remove Orange Lake weir	Yes	−3,039 (−33.6%)	−4.0	−1.3	−3.1%	Increases potential for flushing organic sediments	Decreases average water levels significantly Decreases emergent wetlands significantly Causes potential hydrogeological impacts

Note: NA = not applicable

*From Table 22
†Orange Lake from Table 23, Lochloosa Lake from Table 24
‡From Table 9; change in boater access between "Existing Conditions" and the other water management alternatives

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