3.0 Cumulative Impacts to Water Resources

PBS&J and several sub-contractors conducted a literature review and collected data to document historical changes that had occurred in the Peace River basin for the period from the early 1940s through 1999, some of which is reflected in the sub-basin summaries in the previous chapter. Rainfall patterns, water quality, consumptive surface water and groundwater use, and land use changes were among the factors studied. More detailed discussions are provided in the *Peace River Cumulative Impact Study*.

The analyses conducted by PBS&J were used to systematically identify changes to surface waters, groundwaters, wetlands, fisheries, aquatic habitats, and water supplies. Individual and cumulative impacts of certain man-induced and natural causes of stress in the Peace River basin were assessed relative to historical changes in stream flow, ambient water quality, and various ecological indicators. Identified impacts were also identified in relation to the four major sources of stress: urbanization, agriculture, phosphate mining, and climate variability.

The *Peace River Cumulative Impact Study* identified 22 major impacts to water resources, summarized in the table below. Note that agricultural land uses today comprise approximately 80% of the Peace River basin while urban and mining land uses each cover roughly 10%.

Table 3.1 Identified impacts to water resources of the Peace River basin in relation to sources of stress

Water Resources and Impacts		Source of Stress			
		Agriculture	Mining	Urbanization	Climate
Surface Waters					
1	Loss of 343 miles of streams and associated floodplains	*	*	*	
2	Increased mineralization of surface waters in southern sub-basins (Joshua, Shell/Prairie, and Lower Horse creeks)	*			
3	Increased conductivity levels (essentially, a reflection of dissolved solids) in Payne Creek	*	*		
4	Reduced base flow in northern sub-basins	*	*	*	*
5	Loss of base flow to river in northern sub-basin (Kissengen Spring)	*	*	*	
6	Increased color in upper basin causing reduced water clarity	*	*	*	
7	Alteration of natural drainage patterns in watershed	*	*	*	
8	Post-regulation water quality improved in upper basin, but nutrients in Lake Hancock contribute to poor water quality downstream		*	*	
9	Many surface water segments in the basin have been verified by DEP to be "impaired" (not meeting water quality criteria) for at least one pollutant or condition	*	*	*	
Ground Waters					
10	Decline of 20 to 50 feet in Floridan aquifer level	*	*	*	*
5	Loss of base flow to river in northern sub-basin (Kissengen Spring)	*	*	*	
Wetlands					
11	Loss of 136,000 acres of original 355,000 acres of wetlands in total basin during study period (majority pre-regulation)	*	*	*	
12	Continuing loss of wetlands (31,000 acres) after 1979 despite regulations, but at slower rate	*	*	*	

Water Resources and Impacts		Sources of Stress			
		Agriculture	Mining	Urbanization	Climate
Fisheries					
13	Increasing number of exotic fishes and fish species			*	
14	Loss of spring fish species	*	*	*	
15	Shifts in fish species due to mineralization	*			
16	Fish population losses due to loss of stream habitats	*	*	*	
Aquatic Habitats					
1	Loss of 343 miles of streams and associated floodplains	*	*	*	
17	Loss of spring habitat	*	*	*	
18	Reduction in the amount of time wetted stream channel occurs in upper basin	*	*	*	*
11	Loss of 136,000 acres of wetlands	*	*	*	
19	Increase of man-made waterbodies	*	*	*	
Water Supplies					
20	Peace River Water Supply – changes to seasonal hydroperiod that might cause more days of low river flow	*	*	*	*
21	Impact of mineralization of Shell/Prairie creeks on Punta Gorda water supply	*			
22	Limitations on ground water supplies in Southern Water Use Caution Area	*	*	*	*

As seen in Table 3.1, some impacts affect more than one water resource. For clarity of the following discussion and consistency with the *Cumulative Impact Study*, impacts have been grouped into the following general categories:

- Loss of Streams and Floodplains – Impacts of ditching, canalization, channelization, and mining
- Loss of Wetlands – Conversion of wetlands both pre- and post-regulation
- Alteration of Drainage Patterns – Hydrologic changes to the basin caused by changes to land use and landforms
- Fisheries – Changes in fish populations caused by introduction of non-native species and loss of habitat
- Reduced Base Flow – Combined effects that produced loss of flow from Kissengen Spring and changes in its water quality, with related loss of spring habitat and fishes
- Reduction in Aquifer Levels – Combined impacts of extensive groundwater withdrawals for agriculture, industry, phosphate mining, and public supply
- Mineralization – Increases in surface water conductivity (essentially, a reflection of dissolved solids) due to discharge of mineralized groundwater
- Water Quality – Influences due to nutrient inputs from Lake Hancock and accidental or permitted discharges to the river
- Water Supply – Changes in the water quality and quantity of public supplies

3.1 Loss of Streams and Floodplains

- **Impact 1: Loss of 343 miles of streams and associated floodplains**

The first- and second-order streams in the basin associated with natural flatwoods drainage typically exhibited a discharge pattern in which the flow was highest during the summer rainy season, rapidly decreased as the rains ended to form separated pools, and then totally dried up by late winter. (First-order streams are those with no tributaries; second-order streams result from the confluence of two first-order streams.) Often these small streams existed between a series of wetland systems (interrupted streams) prior to becoming more incised (defined) and continuous lower in the watershed. First-order streams associated with seepage areas (bayhead wetlands) had more extended discharges, often well into the early spring, and some were probably perennial. During the occasional rainy winter, a phenomenon now known to be associated with the El Niño weather pattern, the first-order streams often flowed until the following dry season.

Faced with all this water, agricultural operations historically removed it, primarily through the construction of drainage ditches and canals and canalization of small- to mid-sized streams. This increased rate of drainage further shortened the flow patterns of the first-order streams. Eventually the combination of drainage and natural periods of dry weather caused many of smallest first-order streams to be eliminated or reduced to straight ditches as agricultural land practices became more intensive. Agricultural drainage modifications were not limited to the smaller streams and wetlands. Some of the most extensive agricultural drainage of wetlands that occurred in the upper basin was associated with large marshes and prairies west and southwest of Lake Wales. By 1915, Peace Creek was canalized nearly to the junction with Saddle Creek in order to receive the outfall of this wetland drainage. Saddle Creek below Lake Hancock has been canalized since at least 1929.

Mining in the basin has also resulted in elimination and canalization of streams. Most streams lost to mining were first- and second-order systems. On the east side of the Peace River between Peace Creek canal in the north and Rocky Branch to the south, an extensive series of Peace River tributary streams and headwater bayhead wetlands that formerly existed along the west side of the Winter Haven Ridge were totally eliminated and replaced mostly by clay settling areas (Figure 3.1). Saddle Creek north of Lake Hancock was channelized to facilitate mining operations as they expanded northward along the western side of the creek floodplain (Figures 3.2 through 3.7).

Phosphate mining caused the loss of some larger streams in the basin as well as the numerous smaller ones. The elimination of the entire Six Mile Creek drainage area and the majority of Bear Creek as natural systems (Figures 3.8 and 3.9) are dramatic examples of the loss of larger order stream channels and associated floodplains. Other larger order stream impacts have occurred in the Payne Creek sub-basin where substantial lengths of Little Payne Creek and smaller portions of upper Payne Creek were eliminated and replaced by ditches or re-routed ditch drainage (Figure 3.10). Table 3.2 details the loss of stream miles and associated floodplains in each of the nine sub-basins of the Peace River watershed from the 1940s through 1999.

Table 3.2 Loss of miles of streams and associated floodplains from 1940s through 1999

Sub-Basin	Length (miles) 1940s	Length (miles) 1999	Approximate Loss (miles)	Approximate Loss (%)
Peace River at Bartow	95.9	38.1	58	60.3
Peace River at Zolfo Springs	290.0	240.6	49	17.0
Payne Creek	128.7	61.7	67	52.1
Peace River at Arcadia	133.6	115.7	18	13.4
Charlie Creek	185.6	175.7	10	5.4
Horse Creek	170.7	140.1	31	17.9
Coastal Lower Peace River	397.7	320.2	77	19.5
Joshua Creek	57.9	44.2	14	23.7
Shell Creek	93.0	74.1	19	20.3
Total	**1,553.2**	**1,210.5**	**343**	**22.1**

Peace River Cumulative Impact Study (PBS&J, 2007)

Historically, regulation of the mining industry focused exclusively on reclamation and failed to consistently include stream restoration. Unquestionably, some stream reclamation has been accomplished but most efforts under reclamation standards produced slough-like wetlands, not functional stream channels. In 2006, the DEP completed a revision of the reclamation rules to specifically require stream restoration when a natural stream has been mined.

In the Coastal Lower Peace River sub-basin, stream loss was most directly related to the practice of eliminating first- and second-order streams through extensive canal networks designed to sufficiently lower the water table to allow the widespread use of septic tank wastewater treatment systems in subdivisions. The largest single loss of stream channels in all the sub-basins, 77 miles of mostly first-order streams in the Coastal Lower Peace River sub-basin, was the result of a combination of urban and agricultural land use practices (Table 3.2).

In the upper Peace River basin, the increase of urban areas since the 1940s exacerbated existing land use changes previously initiated by agriculture or mining. The Peace River at Bartow, Peace River at Zolfo Springs, and Payne Creek sub-basins had a total loss of 58, 49, and 67 miles, respectively, of streams and associated floodplains through 1999 (Table 3.2). This 174-mile loss is more than 50% of the total stream miles lost in the entire Peace River watershed; together with the 77 miles of stream lost in the Coastal Lower Peace River sub-basin, these losses accounted for approximately 73% of the total streams and associated floodplains lost within the Peace River basin during the study period.

3.2 Loss of Wetlands

- **Impact 11: Loss of 136,000 acres of original 355,000 acres of wetlands during study period from 25.4% to 15.6% of total basin (majority pre-regulation)**
- **Impact 12: Continuing loss of wetlands (31,000 acres) after 1979 despite regulations, but at a slower rate**

The historic conversion of a significant amount of wetland acreage in the Peace River basin to other land uses in the early 1900s reflects the thinking at the time that wetlands were of little value, economic or otherwise. It was common practice in the 1940s to drain property to increase crop production; create more upland pastures for increased beef cattle production; prepare land for residential, industrial, and commercial development; strip mine an area for phosphate; and control mosquitoes. Extensive wetland drainage in the upper sub-basin is documented as early as 1915. Following World War II, agricultural expansion accelerated throughout the watershed. Examples of more recent agricultural land use impacts on wetlands that have occurred in the Peace River basin are shown in Figures 3.11 and 3.12.

Since the 1940s, the Peace River basin has sustained a 38.5% reduction in wetland acres. This loss does not account for the earlier land use conversion in the upper sub-basin described above. Table 3.2 reflects that 343 miles of streams and associated floodplains were eliminated or canalized in the Peace River basin through 1999. As shown in Table 3.3, wetland acreage in the Peace River watershed from the 1940s to 1979 was reduced from approximately 354,700 acres to 249,300 acres. Regulation of the filling or draining of freshwater wetlands did not become widespread until the mid-1980s, but even after that, wetland acreage in the basin decreased from 249,300 acres to 218,200 acres, creating a total loss of approximately 10% of the total watershed coverage during the study period. Native uplands suffered an even more drastic reduction, decreasing from 834,300 acres in the 1940s to 242,900 acres in 1999, a reduction from 60% to 17% of the total land use in the approximately 1.4 million-acre basin (PBS&J, 2007). During this same period, developed land uses increased from 12% of the watershed in the 1940s to 64% by 1999.

Table 3.3 Land use (acres and %) within the Peace River basin: 1940s to 1999

Land Use	Acres and Percents in Land Use Class		
	1940s	**1979**	**1999**
	Acres (%)	**Acres (%)**	**Acres (%)**
Developed			
Improved Pasture	39,640 (2.8)	356,925 (25.6)	379,346 (27.2)
Intensive Agriculture	107,115 (7.7)	191,496 (13.7)	229,832 (16.5)
Mined Lands	7,495 (0.5)	64,437 (4.6)	143,487 (10.3)
Urban Land	14,659 (1.0)	73,049 (5.2)	133,571 (9.6)
Subtotal	**168,909 (12.0)**	**685,907 (49.1)**	**886,236 (63.6)**
Undeveloped			
Native Uplands	834,311 (59.7)	419,449 (30.0)	242,849 (17.4)
Wetlands	354,674 (25.4)	249,255 (17.8)	218,232 (15.6)
Subtotal	**1,188,985 (85.1)**	**668,704 (47.8)**	**461,081 (33.0)**

Peace River Cumulative Impact Study (PBS&J, 2007)

The analysis of landform changes performed in the *Peace River Cumulative Impact Study* was developed around three sets of aerial photographs from the 1940s, 1979, and 1999. These photographs provided snapshots of empirical evidence about land uses at those times. While the 1940s aerials represent the earliest available baseline and the 1999 aerials represent a reasonably recent view, the 1979 aerials fall into a period when many regulations were still in the developmental stage. Protection of isolated wetlands in general only became effective in 1987 and those affected by phosphate mining were not protected until 1995.

The *Cumulative Impact Study* indicates that during this period, phosphate mining, agriculture, and urban land uses apparently contributed to the net loss of approximately 13,400 acres, 13,100 acres, and 4,100 acres, respectively—a total net loss of approximately 31,000 acres (PBS&J, 2007). The apparent loss of more than 31,000 acres of wetlands during this period when regulation of wetland impacts was evolving must be critically reviewed. There are a number of possibilities:

a) Permitted wetland loss without effective offsetting mitigation;
b) Rules for protection of isolated wetlands not in effect until 1987;
c) Delayed effects of drainage not previously regulated;
d) Illegal activities not detected by enforcement;
e) Use of the agricultural exemption before urban development; and
f) Incorrect aerial interpretation of wetlands in early stages of reclamation and restoration.

3.3 Alteration of Drainage Patterns

- **Impact 7: Alteration of natural drainage patterns in watershed**

Urban development, mining, and agriculture have all adversely affected the hydrology, water quality, and natural habitats in the Peace River basin. Comparisons of land use between the 1940s, 1979, and 1999 indicate the expansion of developed lands throughout the watershed. Results of the *Cumulative Impact Study* indicate that these land use changes have altered natural drainage patterns, affected surface water runoff and infiltration rates, and lowered groundwater levels (PBS&J, 2007). The expansion of agriculture throughout most of the watershed, phosphate mining operations primarily in the three northern sub-basins, and urbanization in the northernmost and southernmost sub-basins have resulted in large losses of wetlands and native upland habitats.

Wetlands drained by ditching and canal construction for agriculture practices result in decreased surface water storage and increased surface water conveyance in the watershed, leading to a decline in water table elevations. Agricultural practices lead to changes in vegetation in floodplains, subsequently altering the historical hydraulic characteristics that may eventually lead to changes in the flood regime. Different crop types can also alter the water budget and affect flow rates during periods of low flow. Agricultural fields in a catchment area may retain floodwaters and reduce downstream flood peaks, but the loss of forest cover may lead to increased surface water runoff. The direction and magnitude of a hydrologic response to agricultural practices is a function of prior and existing land uses as well as soil types and, as a result, the response of a watershed or sub-basin to agricultural practices can be difficult to accurately predict (PBS&J, 2007).

Early phosphate mining in the upper Peace River watershed altered surface drainage patterns and the surface water/groundwater relationships of the river and its tributaries. Although most of the mining in the watershed has occurred since the 1940s, phosphate pebble was mined from the channel of the Peace River during the late 1800s (Figures 3.13 and 3.14) and many lands were mined before Florida first required land reclamation in 1975.

Figure 3.13 Early 1900s Phosphate Dredge on Upper Peace River (Florida Archives)

Figure 3.14 1890s Phosphate Mine in Ft. Meade (Florida Archives)

Reclamation philosophies and techniques have evolved considerably during the last two decades with current reclamation efforts now attempting to mimic the pre-mining hydrology. As a result of historical mining and reclamation practices, however, the upper sub-basins now contain a complex mosaic of reclaimed lands with differing hydrologic characteristics (DEP-DWRM, 2006).

Historical phosphate mining activities also altered surface and groundwater hydrology by changing soil and land surface composition and structure, altering the way water flows over and through the land and subsequently affecting the relationship of rainfall to stream flow. These activities have further affected runoff, surface water storage, aquifer recharge, and evapotranspiration (loss of water to the atmosphere). Clay settling areas (Figure 3.15), while initially increasing seepage runoff, can over time alter the hydrology of mined and adjacent lands by acting as holding ponds, decreasing flows to stream channels, and replacing native wetlands and uplands that may act as natural recharge areas. Historical groundwater withdrawals for mining processes and fertilizer manufacturing facilities (Figure 3.16) have been implicated as an initial cause of altered base flows in the upper Peace River but recent water conservation efforts and changes in mining practices have dramatically reduced groundwater withdrawals (PBS&J, 2007).

Vegetation removal, soil displacement, and site grading prior to the creation of large areas of impervious surfaces in urban developments eliminate much of the natural storage capacity and increase stormwater runoff. Development can dramatically alter the hydrologic regime of an area, increasing impervious surfaces, decreasing rainfall percolation into the ground and subsequently increasing the runoff volume, which may then require the construction of additional impervious surfaces (culverts, curbs, gutters, storm sewers, or lined channels) to convey the excess runoff off-site. Drainage of wetlands by ditching and canal construction for urban development decreases surface water storage and increases surface water conveyance in the watershed, leading to a decline in water table elevations (PBS&J, 2007). Major roadways in the watershed, such as Interstate 4 that extends in an east-west direction through the southern portion of the Green Swamp, or U.S. Highway 17 that stretches in a north-south direction through the basin near the Peace River, interfere with the natural drainage patterns of the watershed. Highways bridges that cross the Peace River can create potential dams if floating vegetation jammed against pilings impedes or halts the flow of water down the river. Two tributaries have flows that are intentionally regulated, including a control structure (P-11) on Saddle Creek south of Lake Hancock and a dam at the city of Punta Gorda's water supply reservoir on Shell Creek. Water withdrawals are made at the Peace River Manasota Regional Water Supply Authority water plant south of Arcadia (DEP-DWRM, 2006).

- **Impact 19: Increase in man-made waterbodies**

The *Peace River Cumulative Impact Study* cites an increase in man-made lakes during the 1940s through 1999, with an increase of nearly 10,000 acres in the Lakes and Open Water Land Use class. Approximately 6,000 of these 10,000 acres were created primarily by mining activities in the Peace at Bartow, Peace at Zolfo Springs, and Payne Creek sub-basins and about 1,200 acres were due to increases in agricultural activities in the Shell Creek sub-basin (PBS&J, 2007). These waterbodies are being used in a variety of applications: the Shell Creek in-stream reservoir used by Punta Gorda for its potable water supply; power plant cooling reservoirs; and impoundments created or left as a result of historical phosphate mine reclamation practices, for example. Often these impoundments have been used for residential housing developments or as fish management areas such as the Tenoroc Fish Management Area near Lakeland.

3.4 Fisheries

- **Impact 13: Increasing numbers of exotic fishes and fish species**

Fish collection records show that historically there were approximately 142 native freshwater or estuarine/marine species present in the Peace River (Fraser, 2006). Overall, fish fauna data for the Peace River watershed have shown a decline in species based on a habitat index. However, the data also show that at least six exotic fishes have become established and are reproducing in the Peace River basin (PBS&J, 2007).

Florida has experienced the introduction of numerous foreign fish species. Common methods of introduction include intentional and accidental stocking, release of bait fish, release of unwanted aquarium fish, escape from aquaculture facilities, and discharge of ballast water (USDI, 2002). The introduction of exotic fishes in southwest Florida has occurred primarily because of the tropical fish farm industry that raises foreign fish species; the sub-tropical climate has allowed several of these species to survive once they have escaped or been released. While the aquarium trade is perhaps the greatest source of released exotics, the general public also contributes to the increasing numbers of exotic fish species in the watershed, although the public rarely releases enough individuals of the same species simultaneously to allow successful establishment of the species. The State of Florida has also released some exotic fishes, primarily for nuisance and exotic aquatic plant species control but also through accidental releases. Existing and potential impacts resulting from the introduction and establishment of exotic fish species include competition with native species for food and habitat, reduction of natives by predation, transmission of disease or parasites, and habitat alteration (USDI, 2002). The increasing number of exotic fishes and species goes on with no solution in sight (USDI, 2002; Fraser; 2006).

- **Impact 16: Fish population losses due to loss of stream habitats**
- **Impact 18: Reduction in amount of time wetted stream channel occurs in upper basin**

As already noted, available fish collection data for the Peace River basin show that historically there were approximately 142 native fish species, 45 native freshwater species throughout the river and approximately 97 native estuarine/marine species in the tidal areas (Fraser, 2006). The presence of these species varied spatially and temporally throughout the river system. There were more species recorded in past fish collections for the upper Peace River when compared to recently collected data sets. The data show that the number of native fish species has declined in the Payne Creek sub-basin and, indirectly, for Whidden Creek. By comparison, the native fish fauna appear to have been relatively stable in both the Horse Creek and Lower Peace River sub-basins since 1976. Tidal Peace River native fish fauna data show a decline in the number of species between 1976 and more recent data collections (PBS&J, 2007).

The loss of native fish populations has resulted from the alteration and elimination of native habitats in the watershed. Studies have shown that stressed stream habitats result in a reduction of the number of species. In addition to the changes that resulted from the discharge of mineralized groundwater, habitat alteration in the watershed has also occurred due to the accidental or conscious introduction of exotic flora and fauna, the removal of woody debris from the channel for navigational purposes, the elimination of mangrove shorelines, the construction of dams for water supply purposes, and the increase in sedimentation due to construction activities in adjacent uplands, among other reasons. These alterations likely stressed some fish populations to the extent of elimination.

The loss of first- and second-order streams due to mining, agriculture, and urbanization were definite causal factors in the elimination of fish populations in various tributaries of the river. The loss of an estimated 343 miles of natural streams and associated floodplains through anthropogenic actions either totally eliminated habitat or removed the essential components of it for many plant and animal species that previously existed there.

In addition to the elimination of spring habitats due to the loss of base flow, the quantity of stream habitat in the upper basin was also adversely affected. The wetted perimeter method for evaluating stream flows—the distance along the streambed and banks at a cross section where there is contact with water—can determine the point at which the water surface recedes from stream banks and fish habitat is lost at an accelerated rate.

The wetted perimeter approach was one of two approaches applied to determine a minimum low flow threshold for the upper Peace River. The other approach was determination of the flow needed to allow for passage or movement of fish across shoals or high points in the stream profile. Maintenance of fish passage flows is expected to ensure continuous flows with the channel or river segment, allow for recreational navigation, improve aesthetics, and avoid or lessen potential negative effects associated with pool isolation, such high water temperatures, low dissolved oxygen concentrations, localized phytoplankton blooms, and increased predatory pressure resulting from loss of habitat or cover. In setting a low flow threshold, the Water Management District uses a conservative approach and selects the higher of the wetted perimeter inflection point or fish passage flow. On the upper Peace River, the wetted perimeter inflection point determined the low flow threshold at the Bartow gage (a 95% exceedance flow of 17 cubic feet per second); while fish passage depth determined the low flow thresholds at the Fort Meade and Zolfo Springs gages (95% exceedance flows of 27 and 45 cubic feet per second, respectively).

Annual 95% exceedance flows have fallen below the wetted perimeter value beginning in the early 1980s at the Bartow stream flow station and below the fish passage threshold during the entire period of record at the Fort Meade station since 1975. This is mostly due to the loss of base flow contribution from the intermediate and upper Floridan aquifers as a result of historic groundwater withdrawals and the large reduction in augmented base flow from mining and domestic wastewater discharges to the river since the early 1980s.

3.5 REDUCED BASE FLOW

- **Impact 4: Reduced base flow in northern sub-basins**
- **Impact 5: Loss of base flow to river in northern sub-basin (Kissengen Spring)**
- **Impact 6: Increased color in upper Peace River which results in reduced water clarity**
- **Impact 14: Loss of spring fish species**
- **Impact 17: Loss of spring habitat**

Historically, free-flowing (artesian) conditions within the underlying aquifers occurred in the upper Peace River basin and the dry season potentiometric head (pressure) in the Peace River basin was higher than the riverbed. Groundwater flowed into the river channel even during the dry season, resulting in the upper river having base flow all year long. Groundwater use associated with urbanization, mining, and agriculture has, however, lowered the potentiometric surface of the upper Floridan aquifer by 20 to 50 feet since the early 1930s in the northern sub-basins. Cessation of continuous flow from Kissengen Spring in 1950 is generally attributed to a decline in the hydraulic potential of the underlying confined aquifers (Kauffman, 1967). The hydraulic potentials of the aquifers, once observed above the riverbed, are now generally tens of feet below the riverbed. This decline, due to increasing groundwater withdrawals, now allows surface flows along a five-mile stretch of riverbed between Bartow and Homeland to drain into the ground during dry periods, a result of the underlying karst geology providing direct connections between the river and the underlying intermediate and upper Floridan aquifers. The Unites States Geologic Survey estimates that dry season river losses to groundwater range from six to 30 cubic feet per second and average 17 cubic feet per second.

Data indicate that historical discharges from activities related to mining and urbanization (discharges from domestic wastewater facilities) significantly augmented river base flow in the upper Peace River sub-basins through the early 1980s (PBS&J, 2007). This supplementary base flow masked the declines of natural spring discharges that followed reductions in groundwater levels due to increased pumping from the upper Floridan aquifer. It also obscured the impacts caused by the below-average rainfall during that period. The impacts due to loss of base flow on the Peace River between Bartow to Homeland became apparent in the 1985 drought with the loss of perennial flow during the dry season. These impacts became even more apparent during the severe drought of 1999-2001.

Increasing development in the upper basin, with its associated wetland drainage, canal construction, and replacement of natural areas with impervious surfaces, resulted in decreased surface water storage and increased surface water conveyance. This caused a decline in water table elevations and reduced base flows in the upper Peace River. The combination of land use changes in the upper sub-basins all contributed to the decline of groundwater levels. Urban water usage in the upper Peace River sub-basins is higher than in any of the other sub-basins in this watershed. SWFWMD (2004a) estimated that 79.8 million gallons per day was used for public and domestic supply and another 10.0 million gallons per day was used for recreational and aesthetic uses in Polk County in 1999 (Table 3.4).

Table 3.4 Estimated groundwater use (million gallons per day) by stressors in several counties within the Peace River watershed in 1998 and 1999

County	Agriculture		Public and Domestic Supply	
	1998	1999	1998	1999
Charlotte	13.8	17.5	16.5	16.6
DeSoto	70.0	75.3	2.9	3.0
Hardee	60.4	63.2	2.3	2.2
Highlands	53.7	53.9	10.4	9.4
Polk	122.4	121.1	80.3	79.8
County	**Industry and Mining**		**Recreational/Aesthetic**	
	1998	**1999**	**1998**	**1999**
Charlotte	1.4	1.1	2.8	3.3
DeSoto	0.2	0.2	0.5	0.4
Hardee	0.5	4.1	0.2	0.2
Highlands	0.9	0.3	4.0	4.5
Polk	98.2	81.4	8.2	10.0

Southwest Florida Water Management District (SWFWMD, 2004a)

The early loss of base flows in the upper reaches of the Peace River in Polk County reflected historical groundwater withdrawals from the upper Floridan aquifer system predominantly associated with mining. As agriculture, public supply, and mining expanded in the upper watershed, total groundwater withdrawals in Polk County peaked slightly above 400 million gallons per day in the mid-1970s (Basso, 2003). Peek (1951) estimated that groundwater withdrawals for phosphate mining in southwest Polk County were about 22 million gallons per day in the early 1930s. By the mid-1940s, withdrawals had increased to 68 million gallons per day and by 1950 were approximately 90 million gallons per day (Basso, 2003). Stewart (1966) estimated that mining withdrawals comprised approximately 80% of total groundwater use in Polk County in 1959. By 1966, total groundwater withdrawn in Polk County had increased to more than 340 million gallons per day and peaked at 410 million gallons per day in the mid-1970s. By the mid- to late-1990s, groundwater withdrawals in Polk County were about 275 million gallons per day, reflecting water conservation practices instituted over the past 25 years by agricultural and phosphate mine users (Basso, 2003). Groundwater consumption in Polk County in 1999 was estimated to be less than 300 million gallons per day (SWFWMD, 2004a). However, other anthropogenic uses in this and other sub-basins have expanded in recent years.

Groundwater withdrawal volumes during 1997-1999 were estimated to be 151 million gallons per day and 95 million gallons per day in the Peace River at Bartow and Peace River at Zolfo Springs sub-basins, respectively, while in the Lower Coastal sub-basin during that same period only 26 million gallons per day were estimated to have been withdrawn (Table 3.5).

Table 3.5 Estimated groundwater use (million gallons per day) by sub-basin for four time periods

Sub-Basin	1941-1943	1976-1978	1989-1991	1997-1999
Peace River at Bartow	63	176	156	151
Peace River at Zolfo Springs	34	102	100	95
Peace River at Arcadia	7	30	37	40
Payne Creek	7	24	24	24
Charlie Creek	11	49	57	62
Horse Creek	6	27	34	37
Joshua Creek	9	27	33	36
Shell Creek	13	44	54	55
Coastal Lower Peace River	5	20	25	26

Peace River Cumulative Impact Study (PBS&J, 2007)

These groundwater withdrawals have had significant impacts on the aquifers within the Peace River basin. Spring-fed streams are distinguished from other Florida streams by more constant flow, higher pH (a measure of acidity), more submerged aquatic vegetation, naturally low dissolved oxygen and nutrients, high calcium levels, and remarkable clarity. The plants and animals that comprise the biological communities in springs are adapted to these unique conditions (FSTF, 2000). The populations of some species that exist in springs are particularly vulnerable to changes in water quantity and quality, as well as to natural and man-made catastrophes. The groundwater that feeds the springs that many of these plant and animal species rely upon is also increasingly in demand, with significant withdrawals leading to reductions in spring discharge. Land uses within recharge areas can result in altered spring water quality and a change in the type of plants growing in the springs. Declines in water levels in the upper Floridan aquifer reduced the potentiometric surface enough so that the flows from Kissengen Spring were reduced from the original average discharge of 30 cubic feet per second to only intermittent discharge in the early 1950s and elimination by 1960 (Basso, 2003). This loss of spring flow and spring-fed aquatic habitat has resulted in both water quality changes and adverse biological consequences.

Water color in the spring-fed reaches of the upper basin was historically low, typically during the dry season. Data analyses suggest that loss of aquifer base flow contributed to changes in the average water color in the upper Peace River sub-basins by allowing a greater influence from naturally tannic surficial runoff. Data comparisons from the river monitoring sites at Bartow, Fort Meade, and Zolfo Springs indicate that the marked increases in water color followed reductions of the historical natural groundwater discharges upstream at Bartow (PBS&J, 2007). Anthropogenic impacts, primarily the discharge of groundwater from agriculture and mining and water from sewage treatment facilities into the upper reaches of the Peace River, further colored the historically clear waters of the river in this portion of the basin.

One of the principal biological impacts in the upper sub-basins has been the loss of eelgrass (*Vallisneria americana*) beds. This native aquatic plant requires clear water and flourishes under spring-fed conditions. Eelgrass beds provide habitat for numerous fish and other aquatic life. The reduction in water clarity and the direct loss of perennial flow has dramatically restricted the amount of eelgrass in the Peace River, which has in turn reduced the presence of dependent aquatic life.

The combination of the steady decline in flows, the change in water quality parameters, and the increasing conversion from native habitats to developed lands within the upper basin eventually led to the destruction of Kissengen Spring and the reduction or elimination of the species dependent on the karstic, clear-water flows at the spring.

3.6 Reduction in Aquifer Levels

- **Impact 10: Decline of 20-50 feet in Floridan aquifer level**
- **Impact 22: Limitations on groundwater supplies since Southern Water Use Caution Area rules implemented**

The progressive decline of the potentiometric surface of the Floridan aquifer system as a result of groundwater withdrawals in the Peace River basin is well documented by Peek (1951), Hammett (1990), and Basso (2003). Groundwater withdrawals for agriculture, industry, phosphate mining, public supply, and recreational uses have lowered the potentiometric surface of the upper Floridan aquifer more than 30 feet since the 1930s over much of the Southern West-Central Florida Groundwater Basin, which includes portions of Hardee, Hillsborough, Manatee, and Polk counties.

These declines have resulted in several detrimental impacts to the water resources of the area:

a) Peek (1951) linked these withdrawals to cessation of flow of Kissengen Spring;
b) Geraghty and Miller, Inc. (1980) described the effect of the declining levels on lake levels in the Lake Wales Ridge area, a major recharge area for the groundwater basin that includes the northeastern part of the Peace River watershed;

c) Hammett (1990) attributed withdrawals to some of the reduction in Peace River flows; and
d) Southwest Florida Water Management District (1993) described how the declines contributed to concerns of saltwater intrusion in the coastal areas of Hillsborough, Manatee, and Sarasota counties.

In response to growing demands from public supply, agriculture, mining, power generation, and recreational uses (Tables 3.4 and 3.5), as well as to impacts from climate variation, groundwater withdrawals steadily increased for nearly a century before peaking in the mid-1970s. These withdrawals resulted in declines in aquifer levels throughout the groundwater basin, which in some areas exceeded 50 feet. Although groundwater withdrawals have since stabilized as a result of management efforts, depressed aquifer levels continue to cause saltwater intrusion and contribute to reduced flows in the upper Peace River and lowered lake levels of some of the lakes in the upland areas of Polk and Highland counties (SWFWMD, 2006).

Following intensive studies of water resources and ecology in the areas of greatest concern in its jurisdiction, the Southwest Florida Water Management District Governing Board established the Southern Water Use Caution Area (SWUCA) in 1992 to manage the water resources in the Southern West-Central Florida Groundwater Basin in a comprehensive manner. The SWUCA encompasses approximately 5,100 square miles, including all or part of eight counties in the southern portion of the District (Figure 3.17). Almost the entire Peace River basin lies with the SWUCA.

Nearly all minimum flows and levels being proposed for the SWUCA are not currently being met. This circumstance has necessitated the development of a Recovery Strategy, consistent with section 373.0421, Florida Statutes. The Recovery Strategy is designed to restore minimum flows to the upper Peace River, reestablish minimum levels to priority lakes in Highlands and Polk counties, and slow the inland movement of saltwater intrusion such that withdrawal infrastructure will be at minimal risk of water quality deterioration over the next 50 years. Consistent with statutory direction, the Recovery Strategy ensures that there is sufficient water supply for all existing and projected reasonable and beneficial uses in this eight-county area (SWFWMD, 2006).

There are two major components to the Recovery Strategy: (1) management of groundwater withdrawals throughout the SWUCA such that the Floridan aquifer saltwater intrusion minimum aquifer level can be achieved and sustained; and (2) implementation of a series of water resource development projects that restore minimum flows to the upper Peace River and minimum levels to priority lakes in the Lake Wales Ridge area. Ultimately, these two components are interconnected in that the management of groundwater withdrawals to protect against saltwater intrusion will lessen the extent of water resource development projects needed to reestablish perennial flow in the upper Peace River and lake levels in the Ridge area. Conversely, the water resource development projects will not only improve river flows and lake levels but will enhance recharge to the Floridan aquifer, thereby having a positive impact on management of saltwater intrusion (SWFWMD, 2006).

Table 3.5 depicts the estimated groundwater withdrawal volumes in each of the nine sub-basins of the Peace River watershed during four time periods beginning in the early 1940s through 1999 (PBS&J, 2007). Over the past 20 years, the long-term average annual groundwater withdrawals in the SWUCA have been about 650 million gallons per day, of which nearly 90% is from the Floridan aquifer. Based on the existing distribution of withdrawals, the District has estimated that long-term average annual withdrawals from the Floridan aquifer need to be reduced by 50 million gallons per day to ensure the saltwater intrusion minimum aquifer level is met. If withdrawals were more optimally distributed (i.e., declines in the most impacted areas and increases in the least impacted areas), the required reduction would be significantly less than 50 million gallons per day. As previously discussed, minimum flows for the upper Peace River and minimum levels for the Lake Wales Ridge area lakes will be primarily achieved through water resource restoration projects. However, a reduction of up to 50 million gallons per day in withdrawals from the Floridan aquifer will enhance restoration efforts for the upper Peace River and the eight minimum level Lake Wales Ridge area priority lakes (SWFWMD, 2006).

Most of the projected water use increases in the SWUCA are for public supply. Fortunately, alternative supplies and additional demand management plans are expected to be able to meet most of these increases. In areas where utilities have limited opportunities to develop alternative supplies, significant quantities needed for growth are anticipated to be met as urban areas expand and use some of the groundwater permitted to the land use they have displaced. The District is undertaking a series of water resource development projects that are anticipated to enhance Floridan aquifer levels. For example, there are a series of projects to provide perennial flow to the upper Peace River. Because the upper river is well connected to the aquifers, a significant percentage of the flow is anticipated to recharge the aquifers. Additionally, there are several potable water aquifer storage and recovery systems in the basin that store water in the Floridan aquifer. As these systems build up reserves, there will be some benefit to the aquifer systems. Several of the projects described above will result in a net benefit in terms of reducing Floridan aquifer groundwater withdrawals. In addition, there are a number of possible projects and activities that can result in a net benefit, including the capturing of high surface water flows to recharge the aquifer with potable-quality water during the wet season and recovering a percentage of that use in the dry season. Net benefit activities are anticipated to play a major role in solving water resource issues in the SWUCA (SWFWMD, 2006).

3.7 Mineralization

- **Impact 2: Increased mineralization of surface waters in southern basins (Joshua, Shell/Prairie, and Lower Horse creeks)**
- **Impact 3: Increased conductivity levels in Payne Creek**
- **Impact 15: Shifts in fish species due to mineralization**
- **Impact 21: Impact of mineralization of Shell/Prairie Creeks on Punta Gorda water supply**

Specific conductance, or conductivity, is a measure of the capacity of water to conduct electricity and is directly related to the amount of dissolved salts in the water. Changes in conductivity over time typically indicate changes in the mineral content of water. Increases in surface water conductivity measurements are often linked to the increased presence and influence of groundwater from the mineralized aquifers.

The largest documented single change in land use throughout the entire Peace River basin, including the three sub-basins in the southernmost portion, has been the conversion of native upland habitats to improved pasture. The Peace River watershed included 834,311 acres of native upland habitat in the 1940s but by 1999 only 242,849 acres of native upland habitat remained—a loss of almost 600,000 acres. Over 300,000 acres of native uplands were converted to improved pasture and intense agriculture during this time period (PBS&J, 2007). In many instances, improved pasture is converted further to intensive agriculture, mining, or urban land uses. In the lower Peace River sub-basins, excluding the urbanized portion of the Coastal Lower Peace River sub-basin, the conversions were mainly to intensive agriculture, primarily citrus production.

More intensive agricultural activities typically require the use of more water. The source for the increased demand in the lower Peace River sub-basins has been groundwater. Historical groundwater data collected from monitoring wells near Shell, Prairie, and Joshua creeks in southeastern DeSoto and central Charlotte counties indicate that water quality degrades with depth (SWFWMD, 2004b). This condition is naturally occurring and inherent to the region. Groundwater investigations in the Shell/Prairie Creek sub-basin indicate that mineralized concentrations increase rapidly below depths of 1,200 feet (below land surface) and often exceed specific conductance concentrations of 1,000 microsiemens per centimeter. A review of irrigation well construction records within the sub-basins indicates that approximately 195 wells in the Prairie Creek portion of the sub-basin exceed 1,200 feet in total depth. In the Shell Creek portion of the sub-basin, high mineral concentrations can occur at depths in excess of 450 feet below land surface.

Groundwater withdrawals from mineralized zones used for irrigation contribute to surface water systems through direct runoff or leaching. Typical farming practices for flatwoods soils may help facilitate these contributions. In addition, the use of mineralized groundwater can stress crops and require additional irrigation to overcome evaporative concentrations of salts in soils (Basso, 2003). The lands around Joshua, Shell, and Prairie creeks have little urbanization and no phosphate mining. In Horse Creek, the portion most affected is well downstream from any mining activities. The data are persuasive that the increases in conductivity in these sub-basins are due to the use of mineralized groundwater associated with agricultural land uses.

Mineralized groundwater used for irrigation and freeze protection inevitably entered the surficial aquifer and surface waters, as evidenced by the water chemistry data reported in the *Cumulative Impact Study* (PBS&J, 2007) in the lower Peace River watershed. Depending on the sub-basin, available long-term water quality data indicate increases in levels of conductivity, pH, total dissolved solids, calcium, magnesium, sodium, potassium, chloride, silica, and sulfate (PBS&J, 2007). Concentrations of many of these water quality parameters were at or near historical highs during the severe 1999-2001 drought. In locations such as Horse Creek at Arcadia and Joshua Creek at Nocatee, trends over time indicate conductance has increased over 50%.

While these reported values are still either entirely (Horse Creek) or predominantly (Joshua Creek) below Florida's water quality standard for the vast majority of surface waters (Class III) of 1,275 microsiemens per centimeter (Rule 62-302.530, Florida Administrative Code, Surface Water Quality Criteria), these dramatic increases are still indicative of developing problems. The specific conductance level has been exceeded on numerous occasions at a number of locations in Joshua, Prairie, and Shell creeks. While only three stream segments to date have been listed by the DEP as "verified impaired" as not meeting water quality standards (DEP-BMR, 2006b), additional segments are under consideration for such listing in the Peace River watershed. Preliminary indications are that while high specific conductance values in Joshua Creek do not affect Class I waters (potable supplies) they are actually representative of exceedingly high levels of other constituents like chlorides and total dissolved solids (PBS&J, 2007).

Contributions of mineralized groundwater from the Shell and Prairie creek areas are directly affecting the ability of Punta Gorda's surface water treatment facility to meet secondary (aesthetic) drinking water standards for chloride, sulfate, and total dissolved solids during the dry season. Punta Gorda withdraws water from the Shell Creek Reservoir for public water supply. Section 62-550.320, Florida Administrative Code, establishes maximum levels for secondary drinking water standards for "community water systems" like Punta Gorda's. In April 2001, the DEP authorized an Emergency Final Order (OGC Case No. 01-0467) that allowed Punta Gorda to temporarily exceed secondary drinking water standards in water withdrawn for the reservoir as a result of severe drought conditions.

Increases in surface water conductivity are also observed farther north in the Peace River and long-term changes in water quality in the Payne Creek sub-basin include a significant increase in specific conductance. In this sub-basin, the base flow of Payne Creek also appears to be augmented by groundwater discharges. However, because the water quality of the groundwater is less mineralized, the magnitude of the changes is less than that in the lower sub-basins. In addition, there are potential sources of the groundwater augmentation other than those produced by agriculture.

The Payne Creek sub-basin is unique due to the extent of phosphate mining in the area. Mining activities in the Payne Creek area dominate the land use practices; by 1999, approximately 63% of the Payne Creek sub-basin had been impacted by mining and mining-related activities. The second smallest of the nine sub-basins, this sub-basin includes 41%, or more than 50,000 acres, of the lands that have been mined for phosphate within the Peace River watershed. Only the Peace River at Zolfo Springs sub-basin has more, with over 65,000 acres impacted by mining and mining-related activities (PBS&J, 2007).

Water from Payne Creek enters the Peace River upstream of Wauchula and there is a single long-term U.S. Geological Survey/Southwest Florida Water Management District water quality monitoring station near Bowling Green in the Payne Creek sub-basin. The water quality data from this location indicate comparatively large historical increases in levels of measured total alkalinity, total dissolved solids, sodium and sulfate since the 1940s. Since the 1980s, both total phosphorus and orthophosphate levels in Payne Creek have increased.

Augmentation to Payne Creek appears to occur mainly in the dry seasons, yet permitted discharges from phosphate mining operations and power generation facilities typically occur only during the wet season. Agriculture makes up only 18% of the land use in the Payne Creek sub-basin but averaged 4.83 million gallons per day of groundwater withdrawals compared to the 3.82 million gallons per day used by phosphate mining operations in 2002 (Basso, 2006). The limited data indicate that the increase in conductivity may be due to the increase in agricultural groundwater pumping for irrigation during the spring and for freeze protection during the winter.

Another possible cause for the higher levels of conductivity may be attributed to the geology of the area. Most of Florida was underwater for millions of years and thousands of feet of sedimentary rock deposits (composed of various marine creatures, their excrement, and their remains) accumulated on top of the underlying igneous and metamorphic rocks to build up the land that now exists. One of the ways in which Florida's phosphate rock deposits are believed to have originated is "precipitation," a process in which conditions in the seawater caused dissolved phosphate to solidify (precipitate) and settle to the bottom of the shallow coastal waters, becoming part of the sedimentary layers that eventually formed the material, along with the sea life and its remains, that is mined today (FIPR, 2004). During phosphate mining, this sedimentary material is excavated, the phosphatic material removed, and the overburden and sand tailings used to fill the excavation areas as part of the reclamation process. It is thought that the actual mining process itself may cause a portion of the increased conductivity levels in the surface waters in the Payne Creek sub-basin through this disturbance of the soils. In the Peace River watershed, conductivity values have decreased over time at some locations in the upper Peace River (e.g., Saddle Creek, Peace River at Bartow, Peace River at Fort Meade, and Peace River at Zolfo Springs), while increasing in Payne Creek (PBS&J, 2007). This trend may be due to the reduction in mining activities in most of these locations, which allows materials in previously mined areas to settle and age (leach), while in the Payne Creek sub-basin phosphate mining continues as a major land use.

Changes in the mineral content of the surface water system appear also to have biological implications. Many freshwater fishes in low-order streams in the Peace River watershed are adapted to conditions of very low levels of total dissolved solids (low conductivity) and very low (acidic) pH levels. These conditions posed a barrier to other fish species that required higher conductivity and pH levels. At least 15 fish species in the Peace River appear to prefer conductivities less than the present State standard of 1,275 microsiemens per centimeter and may be susceptible to the higher levels (PBS&J, 2007).

Depending on the basin and availability of data, long-term increases in conductivity, pH, total dissolved solids, calcium, magnesium, sodium, potassium, chloride, silica, and sulfate have been reported in all nine sub-basins in the Peace River watershed, water quality changes that are attributable to mineralized groundwater discharges to the surface waters (PBS&J, 2007). Following the implementation of regulatory measures and changes in phosphate mining practices that eliminated or reduced the discharge of groundwater to surface waters, decreases in the upper river were reported in the levels of specific conductivity, total dissolved solids, calcium, magnesium, sulfate, silica, total phosphate, orthophosphate, fluoride, and strontium. In the lower Peace River watershed, however, elevated concentrations are still being reported in the Joshua, Shell, Horse, and Charlie creek sub-basins. Concentrations of many of these parameters were at or near historical highs during the recent 1999-2001 drought (PBS&J, 2007). Based on the known distribution patterns with conductivity/salinity, it is possible that many of the 15 susceptible fish species may have suffered decreases in populations or disappeared from the creek systems that received these groundwater discharges. In turn, the barrier to some secondary freshwater and marine fishes that was provided by the very low conductivity and acidic pH levels appears to have been removed by the augmentation of mineralized groundwaters to the surface waters, thus allowing the invasion of species more tolerant of mineral content (Fraser, 2006; PBS&J, 2007).

3.8 Water Quality

- **Impact 8: Post-regulation water quality improved in upper basin, but poor water quality (nutrients) in Lake Hancock contributes to poor water quality downstream**

The two main influences on water quality in the northern portion of the Peace River watershed have historically been due to accidental and permitted discharges to the river from phosphate mining and processing and nutrient inputs, primarily from municipal and industrial sources, from the highly eutrophic (rich in minerals and organic materials) Lake Hancock. The Peace River has a naturally high concentration of phosphate due to the presence of phosphorus-enriched sediments in the riverbed. Large areas of the river bottom in the northern sub-basins were directly mined for pebble phosphate during the late 1800s (FIPR, 2004). By the 1940s, expansion of phosphate strip mining in the uplands had expanded into the upper Peace River watershed. Over time, phosphate mining continued to move south as the phosphate ore reserves in the upper portion of the watershed were reduced (PBS&J, 2007).

Sporadic discharges of materials, sometimes quite substantial, from failures of clay settling area dams, pipeline spills, breaks in perimeter ditches and berms, and failures of erosion control devices resulted in degraded water quality and catastrophic losses of fish and aquatic life downstream. However, increasingly effective environmental regulations dramatically reduced both the frequency and severity of these occurrences. As a result, while dissolved inorganic phosphorus concentrations in the Peace River and upper Charlotte Harbor are high relative to most other rivers and estuaries, peak levels have declined by as much as an order of magnitude since the early 1980s (PBS&J, 2007).

Lake Hancock is a large, shallow, hypereutrophic lake in Polk County that contributes an average of 52 cubic feet per second of flow to the upper Peace River. The current water control structure on Lake Hancock was constructed in the early 1960s and flows from the lake have been regulated ever since. Outflows from the lake currently degrade water quality in the Peace River. The Peace Creek Canal was excavated in the early 1900s to drain wetlands in Polk County as far east and north as Lake Wales and Lake Hamilton. Development in the low areas near the canal has created problems with seasonal flooding, when large areas of standing water may be present for several months during some years. Water control structures on Lake Lulu and Lake Hamilton also affect flows to the Peace Creek Canal and the upper Peace River (DEP-DWRM, 2006).

Eutrophication (and the associated accumulations of organic detrital material) driven by excessive nutrient loadings is the most serious water quality problem in the Peace River at Bartow sub-basin. In addition to Lake Hancock, there are a number of hypereutrophic waterbodies in this sub-basin, including Lake Parker, Banana Lake, Saddle Creek, Stahl Canal, Banana–Hancock Canal, and Lake Lena Run. Natural environmental factors and human activities have combined to produce extremely large phosphorus loadings to surface waters in the Peace River watershed. From 1990 to 1995, the average annual total phosphorus concentration measured at the USGS monitoring site on Saddle Creek at Structure P-11 (immediately south of Lake Hancock) exceeded 0.4 milligrams per liter of phosphorus, placing water quality in this stretch of the river among the poorest 25% of Florida streams. During the same period, the average total nitrogen concentration exceeded 5.2 milligrams per liter of nitrogen, among the poorest 10% of Florida streams. Several other lakes in this sub-basin have received excessive nutrient loadings over several decades and in response have developed extensive deposits of nutrient-enriched organic sediments (DEP-DWRM, 2006).

Reduced point source discharges and recent restoration efforts implemented by the Water Management District, the DEP, and local governments have produced water quality improvements in Lake Parker and Banana Lake. Despite these improvements, however, both waterbodies remain highly eutrophic. At times, Lake Hancock can discharge extremely poor quality water, characterized by high concentrations of phytoplankton and other sources of biological oxygen demand, to Saddle Creek and upper Peace River, which has caused faunal mortality and long-term water quality impacts that extend many miles downstream along the river's main stem.

These discharges are also a potential factor in the water quality problems experienced periodically at the Peace River Manasota Regional Water Supply Authority drinking water facility on the Lower

Peace River. Elevated dissolved inorganic phosphate concentrations and low ratios of dissolved inorganic nitrogen to dissolved inorganic phosphate contribute to the development of nuisance cyanobacterial (blue-green algae) blooms in fresh waters. These blooms are most likely to occur in lakes and floodplain sloughs, where a combination of high nutrient concentrations and low current velocities allow dense phytoplankton populations to develop and persist. The frequent development of cyanobacterial blooms in many surface waters in the Peace River watershed and episodic complaints of unpleasant tastes and odors in the public water supplies provided by the Peace River Manasota Regional Water Supply Authority are often associated with unnaturally high phosphorus concentrations in the system (DEP-DWRM, 2006).

The degradation of Lake Hancock is attributed to flows from its tributaries, which have received elevated nutrient loadings over several decades from a number of industrial and domestic point sources. Although still extremely high, phosphorus concentrations have shown improving trends in recent decades in some portions of the Peace River watershed. Concentrations of dissolved inorganic phosphate and total phosphate have declined at several long-term U.S. Geological Survey monitoring sites. These improvements appear due to increased oversight by regulatory agencies and increased compliance by regulated industries and local governments, leading to reduced phosphorus loadings from a number of phosphate mining and processing facilities, food processing facilities, and municipal wastewater treatment plants. Despite these trends, however, average annual total phosphate concentrations measured at the Bartow, Homeland, Fort Meade, Zolfo Springs, and Arcadia U.S. Geological Survey gage sites from 1990 to 1995 exceeded 1.0 milligram per liter.

- **Impact 9: Numerous waterbodies or waterbody segments in upper basin verified impaired for at least one water quality parameter, per Rule 62-303, F.A.C.**

Water quality in the upper Peace River watershed has been affected by a number of anthropogenic activities. Historically, these have included point and non-point source discharges from phosphate mining and processing facilities near Lakeland and Bartow, point source municipal and industrial effluents from the cities of Lakeland, Bartow, and Fort Meade, and non-point runoff from urbanized areas and lands used for intensive agriculture, especially in areas in the eastern portion of the upper Peace River watershed.

Lake Hancock water quality has been characterized as "poor" based on the Florida Trophic State Index since at least 1970 and water quality in the lake became a concern as early as the 1950s. The DEP has verified the impaired condition of the lake; its levels of total phosphorus, total nitrogen, and biological oxygen demand all significantly exceeded the State threshold screening values. Until recently, Lake Hancock received nutrient-laden effluent directly from a number of industrial and municipal sources. As a result, the water leaving Lake Hancock is typically characterized by elevated concentrations of blue-green algae, turbidity, and elevated organic content that lead to low dissolved oxygen concentrations in the receiving waters of Saddle Creek and ultimately the Peace River.

Fully 20% of the waterbody segments in the upper Peace River basin are impaired—verifiably not meeting water quality standards—for at least one water quality parameter (Singleton, 2006; Petrus, 2006). Most of the impairments are for Trophic State Indices (nutrients: nitrogen, phosphorus) or dissolved oxygen in lakes located in the Lake Hancock watershed and the Winter Haven Chain of Lakes. There also are impairments related to fecal coliform bacteria in the Peace Creek drainage canal, the Wahneta Farm drain, and the Peace River above Bowlegs Creek (DEP-DWRM, 2006).

For impaired waterbodies that are not meeting their designated uses—whether for drinking water, recreation, or shellfish harvesting, for example—the DEP must develop Total Maximum Daily Load (TMDL) determinations. A TMDL represents the maximum amount of a given pollutant that a waterbody can assimilate and still remain healthy so that all its designated uses are met. Multiple TMDLs have been developed for waters in the Peace River basin and will be adopted in the near future. A TMDL sets pollutant reduction objectives that must be implemented to clean up impaired waterways.

Progress has been made in addressing the water quality impairments identified in the Peace River basin. Some projects are already underway, in advance of TMDL implementation, including:

- Lake Hancock lake level modification and outfall treatment projects, including major land acquisitions;
- Restoration projects in the Lake Hancock watershed, including lakes Parker and Hollingsworth and Banana Lake and canal;
- Restoration projects in the Winter Haven Chain of Lakes, including lakes Howard, Conine, and Smart; and
- The Peace Creek Drainage Canal watershed restoration plan, which will lead to the acquisition of up to 3,000 acres of conservation lands.

A number of other water quality measures in the upper Peace River have improved significantly since the 1960s and 1970s following the implementation of regulatory measures and changes in phosphate mining and processing practices. These measures eliminated direct processing discharges and reduced other phosphate mining-related discharges to surface waters. These changes have resulted in improved water quality, especially concentrations of phosphorus and orthophosphate, in the upper river. The significant reductions in inputs of phosphorus-rich waters directly into the upper river have resulted in significant declines in peak levels of these parameters.

3.9 Water Supply

- **Impact 20: Peace River Water Supply – changes for seasonal hydroperiod patterns and volumes that might result in increased number of days of low river flow**

While groundwater has historically provided the majority of consumptive uses of water in the basin, surface water for public supply has become increasingly important in the southern part of the basin. The declining flows during the drought periods have at times impeded public supply demands. The Peace River Facility is owned and operated by the Peace River Manasota Regional Water Supply Authority, a wholesale provider of drinking water to Charlotte, DeSoto, Manatee and Sarasota counties and the City of North Port. The Peace River Facility is located in the lower Peace River basin about 19 miles from the mouth of the river. This public potable water source supplies about 400,000 citizens and is anticipated to provide additional supply for growth in the future (Coates and Stone, 2006). Due to the facility's downstream location, most activities in the basin that impact water quality or the natural timing and volume of river flow have the potential to impact the viability of this important regional surface water supply, making water quality another critical factor for water supply. Most water treatment facilities are designed to treat the quality of water expected from the supply source; changes in water quality in the streams that provide source water to public water supply systems can be a threat to public water supplies (PBS&J, 2007).

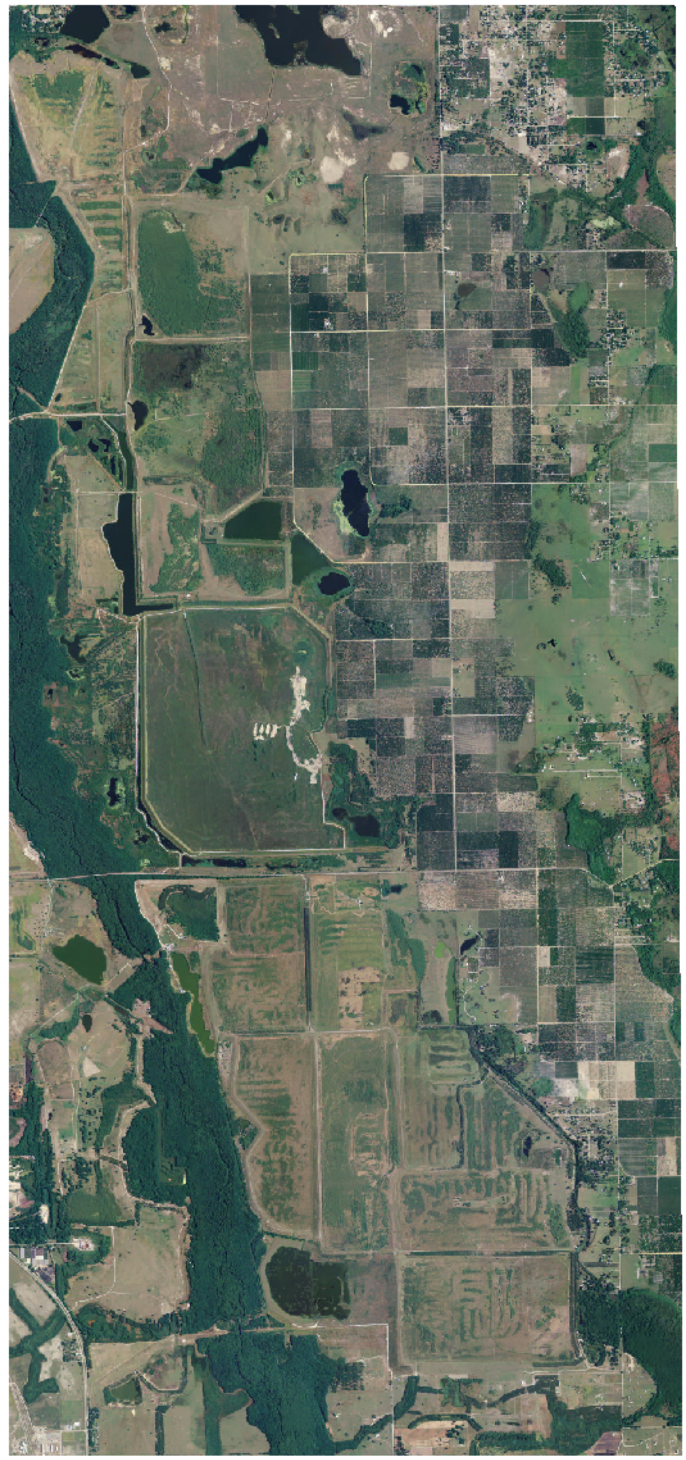
At present, the Peace River Facility is operating at a 24-million gallon per day capacity. The Peace River Manasota Regional Water Supply Authority is presently permitted to withdraw an average of 32.7 million gallons per day of water from the Peace River. Expansion of treatment capacity at the Peace River Facility to 48 million gallons per day and construction of a 6-billion gallon above ground reservoir is scheduled for completion in 2009. Expansion of the Peace River Facility, within environmentally sustainable limits, may be proposed in the future to meet growing regional water supply needs and aid in regional recovery from over-pumping of groundwater in the Southern Water Use Caution Area (Coates and Stone, 2006).

The four stressors identified in the *Peace River Cumulative Impact Study* (PBS&J, 2007) are agriculture, mining, urbanization and climate. The stressors within some measure of human control (agriculture, mining, and urbanization) each have potential to adversely affect water quality in the Peace River and change the timing and quantity of water available to meet public water demands. Deterioration in water quality may require the Peace River Facility to modify treatment processes or potentially treat water only at certain times of the year or under certain flow conditions. Changes in the timing of flow, such as increased peak discharge rates at the expense of the duration of discharge events, may require construction of additional intake, storage and treatment capacity to enable harvest of environmentally sustainable quantities while available. In addition to the environmental consequences of water quality deterioration and man-induced changes in flow regime, these impacts may reduce the ability of the Peace River Facility to meet regional drinking water needs and necessitate the development of new drinking water supplies earlier than otherwise required, resulting in an additional cost burden to water customers.

East of Peace River between Bartow and Fort Meade Comparison

1940s Aerial

2004 Aerial



Historical Aerials obtained from the National Archives.

Author: Levi Sciara
Date: December 20, 2006
Path: P:\Projects\ArcGIS\Production\ERS\Studies\PeaceRiver_AerialsComp.mxd

Figure 3.1

1941 Aerial

Figure 3.2

1941 - North Lake Hancock/Unimpacted South-Central Saddle Creek

Autho r: Levi Sciara and Braulio Fernandez.
Date: January 9, 2007
Path: P:\Projects ArcGIS Produc ion\ERS\PeaceRive rBasin\PeaceRiverStudy\19 1LakeHancockAerial.mxd

1952 Aerial

1952 - North Lake Hancock/Channelized South-Central Saddle Creek/Mining

Autho r: Levi Sciara and Braulio Fernandez.

Date: Janua y 9, 2007
Path: P:\Projects\ArcGIS\Production\ERS\PeaceRiverBasin\PeaceRiverStudy\1952LakeHancockAerial.mxd

1958 Aerial

1958 - North Lake Hancock/Channelized South-Central Saddle Creek/Mining/Turbidity Plume

Author: Levi Sciara and Braulio Fernandez.

Date: January 9, 2007
Path: P:\Projects\ArcGIS\Production\ERS\PeaceRiverBasin\PeaceRiverStudy\1958LakeHancockAerial.mxd

1968 Aerial

1968 - North Lake Hancock/Channelized South-Central Saddle Creek/Mining/State Road 540

Autho r: Levi Sciara and Braulio Fernandez.
Date: Janua y 9, 2007
Path: P:\Projects\ArcGIS\Production\ERS\PeaceRive rBasin\PeaceRiverStudy\1968a_LakeHancockAerial.mxd

1968 Aerial

Figure 3.6

1968 - Channelized North-Central Saddle Creek/Mining

Author: Levi Sciara and Braulio Fernandez.

Date: Janua y 9, 2007
Path: P:\Projects\ArcGIS\Production\ERS\PeaceRiverBasin\PeaceRiverStudy\1968b_LakeHancockAerial.mxd

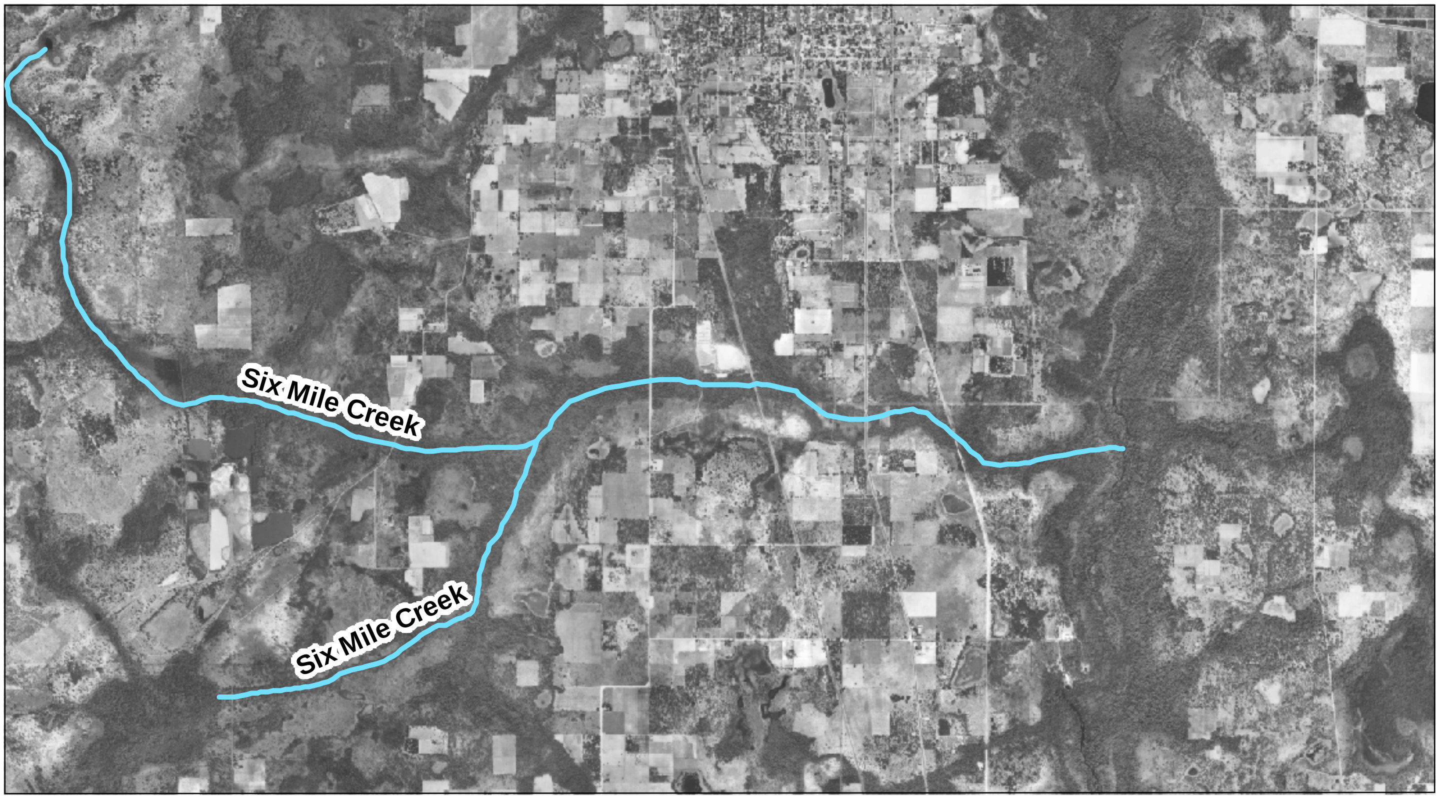
1968 Aerial

1968 - Channelized Northern Saddle Creek/ Mining in Lower Tenoroc Mine

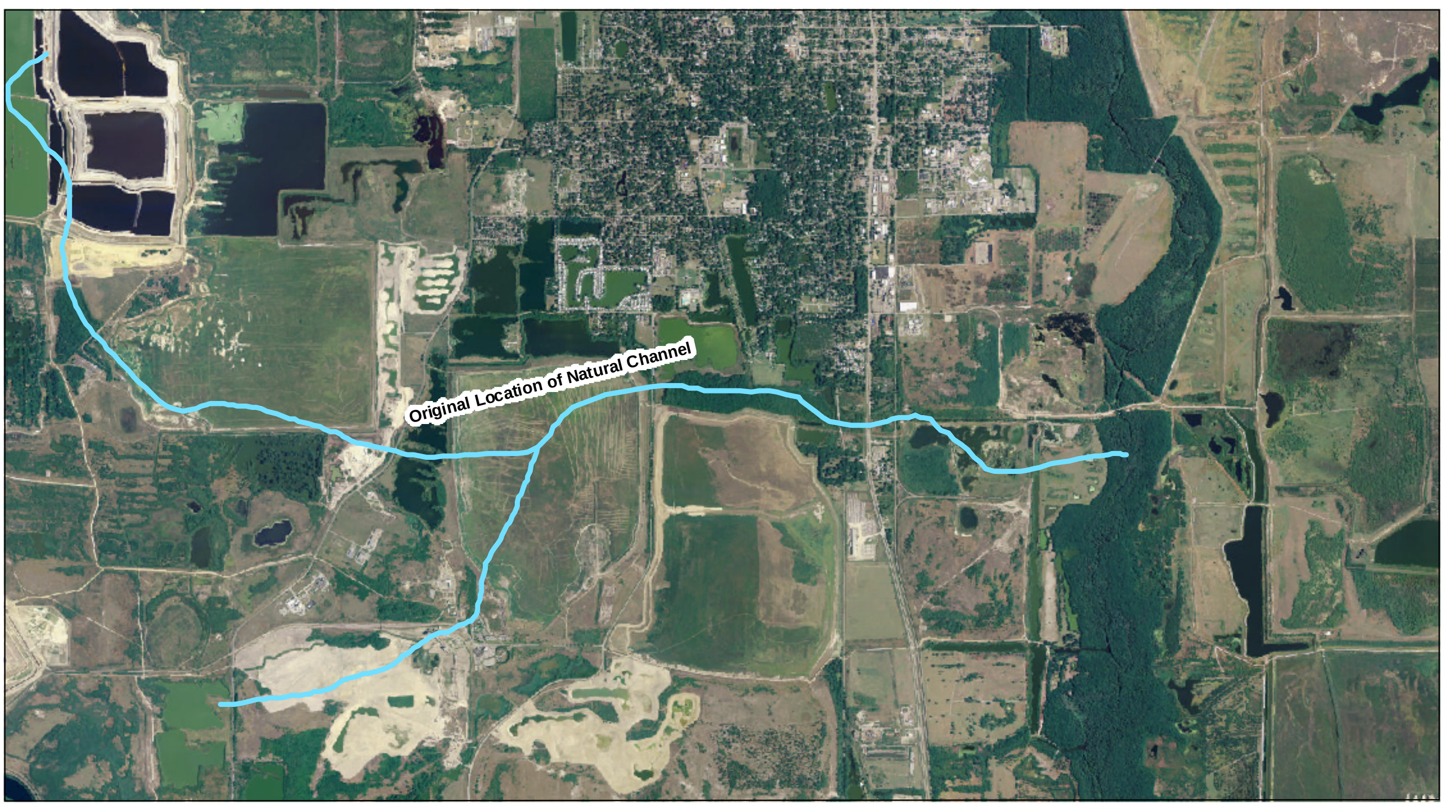
Author: Levi Sciara and Braulio Fernandez.
Date: Janua y 9, 2007
Path: P:\Projects\ArcGIS\Production\ERS\PeaceRiverBasin\PeaceRiverStudy\1968c_LakeHancockAerial.mxd

Six Mile Creek Wetlands Comparison

1940s Aerial



2004 Aerial



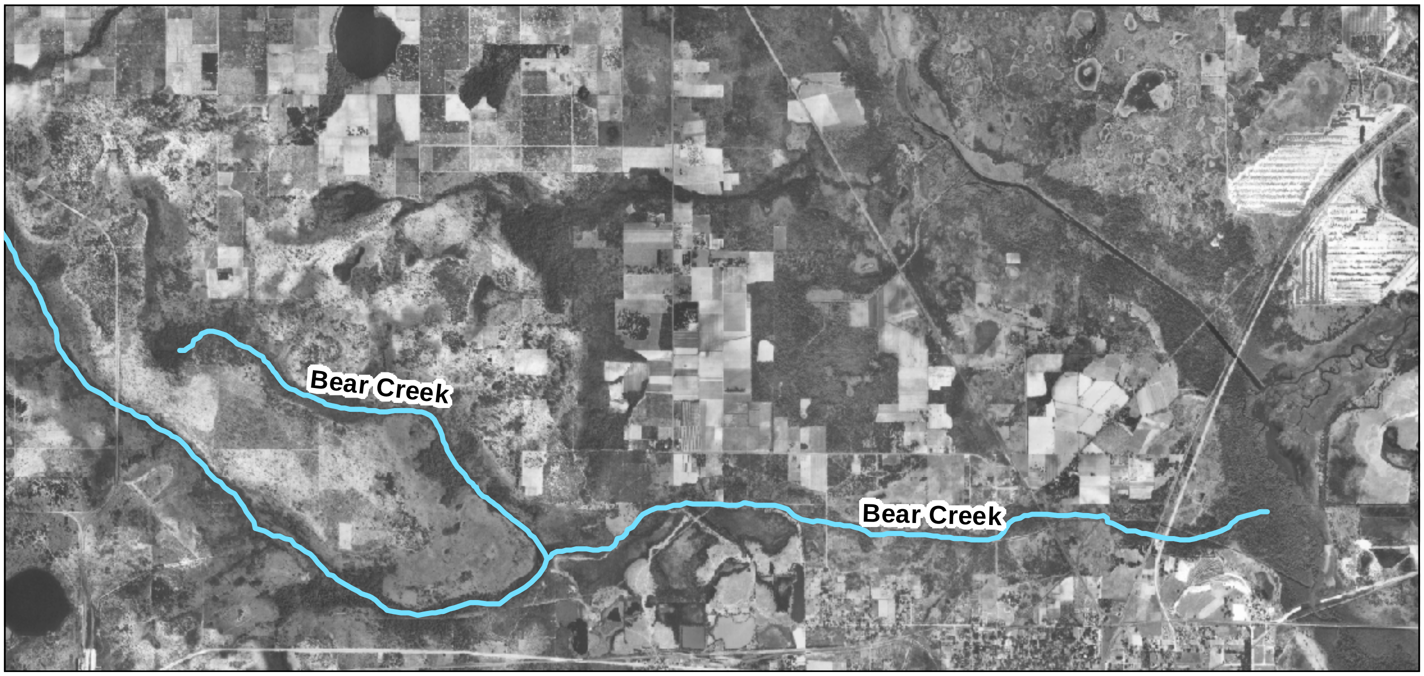
Historical Aerials obtained from the National Archives.

Author: Levi Sciara
Date: November 6, 2006
Path: P:\Projects\ArcGIS\Production\ERS\Studies\SixMileCreekWetland_AerialsComp.mxd
Layout View: 16000

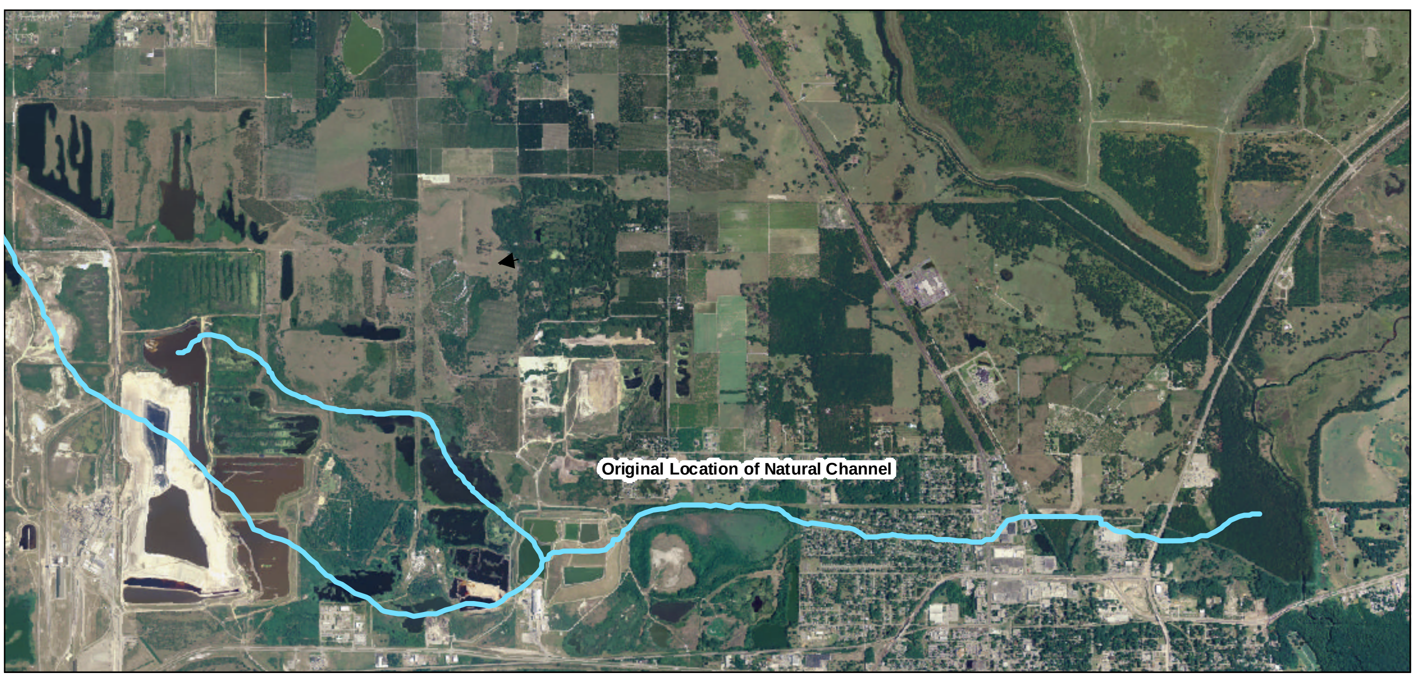
Figure 3.8

Bear Creek Wetlands Comparison

1940s Aerial



2004 Aerial



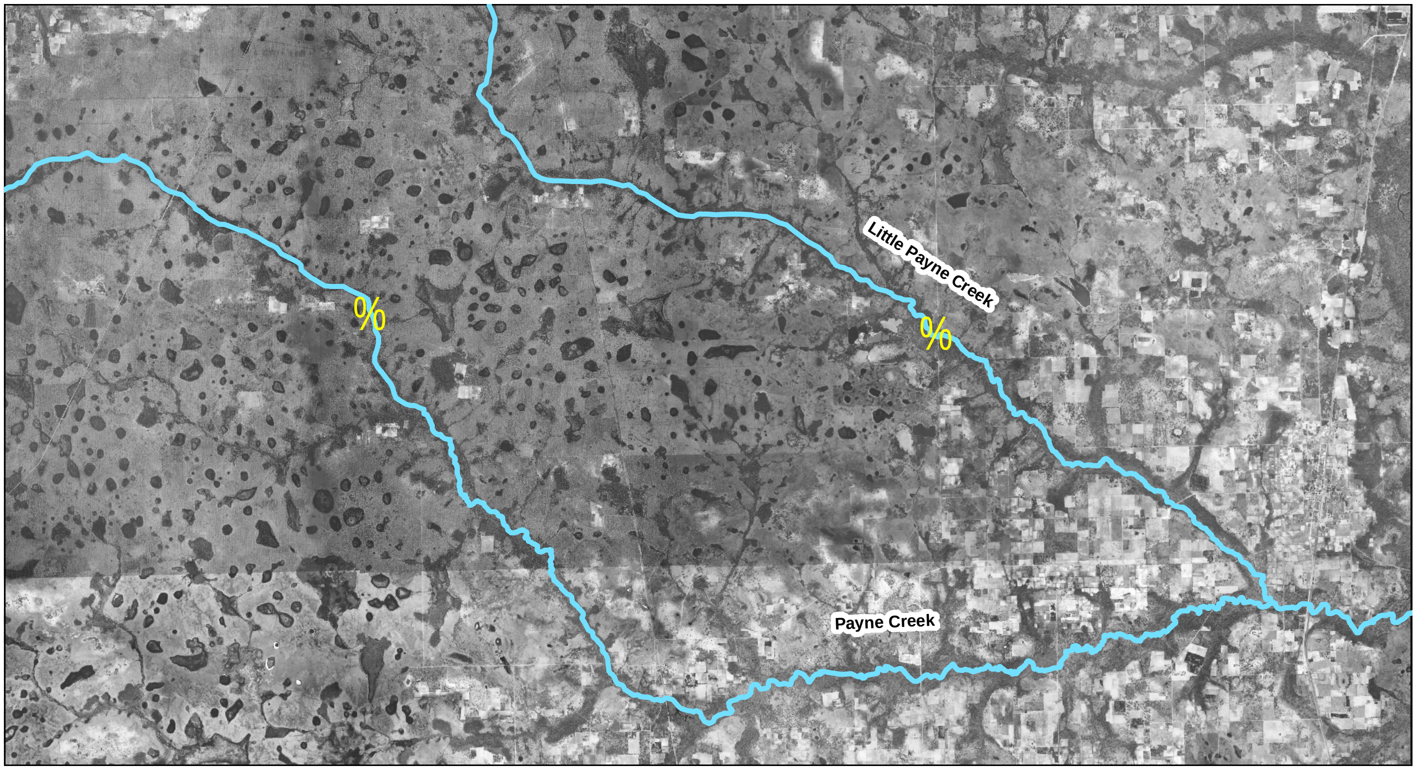
Historical Aerial obtained from the National Archives.

Author: Levi Sciara
Date: November 6, 2006
Path: P:\Projects\ArcGIS\Production\ERS\Studies\BearCreekWetland_AerialsComp mxd
Layout View: 15,443

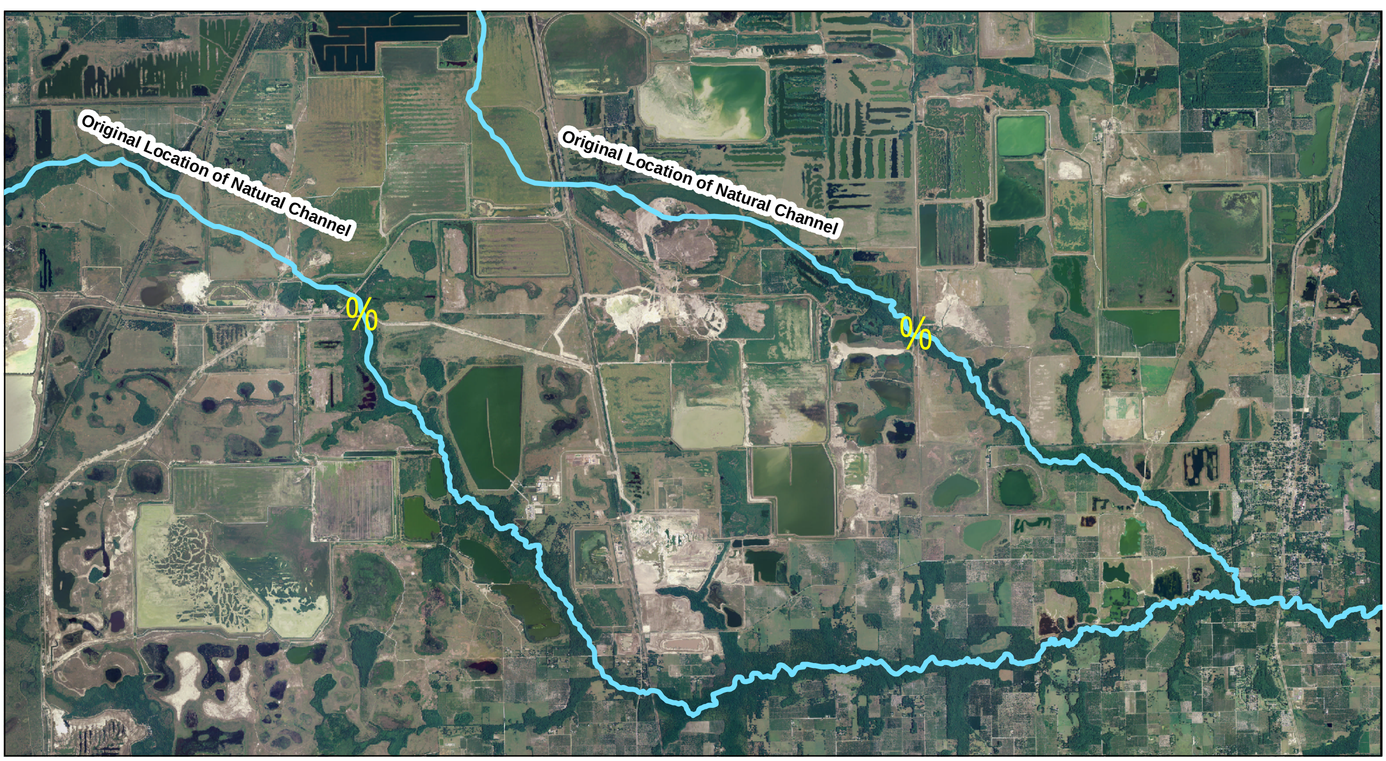
Figure 3.9

Payne Creek Wetlands Comparison

1940s Aerial



2004 Aerial



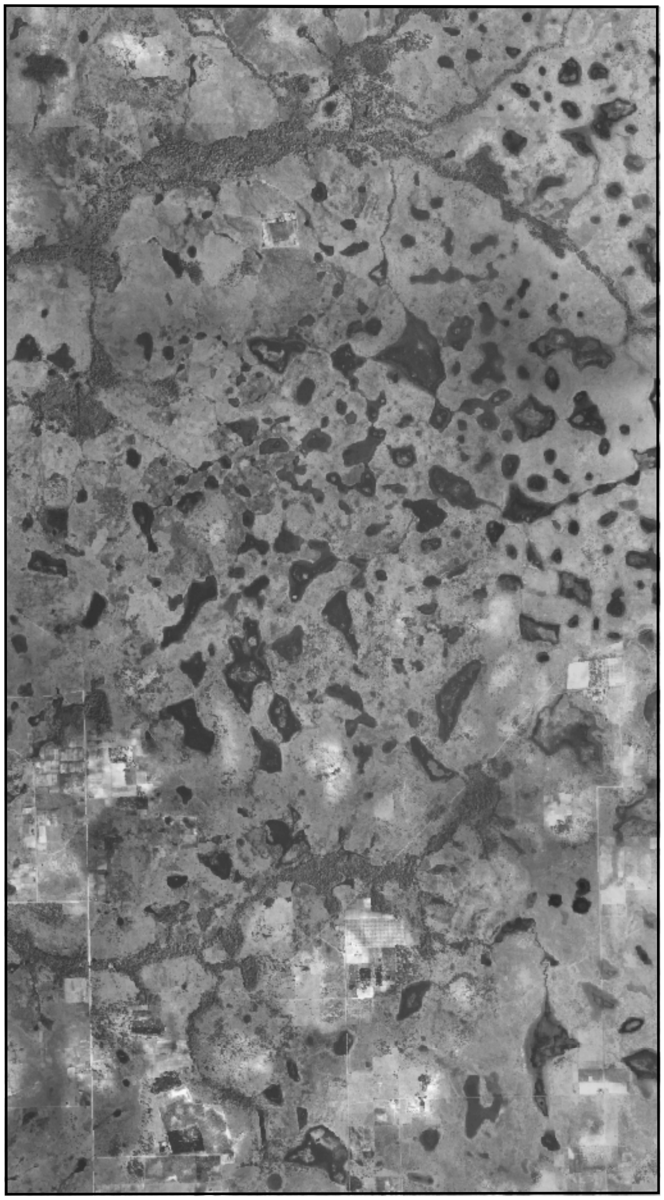
Historical Aerials obtained from the National Archives.

Author: Levi Sciara
Date: October 30, 2006
Path: P:\Projects\ArcGIS\Production\ERS\Studies\PayneCreekWetland_AerialsComp.mxd
Layout View: 34,334

Figure 3.10

South Fort Meade Wetlands Comparison

1940s Aerial



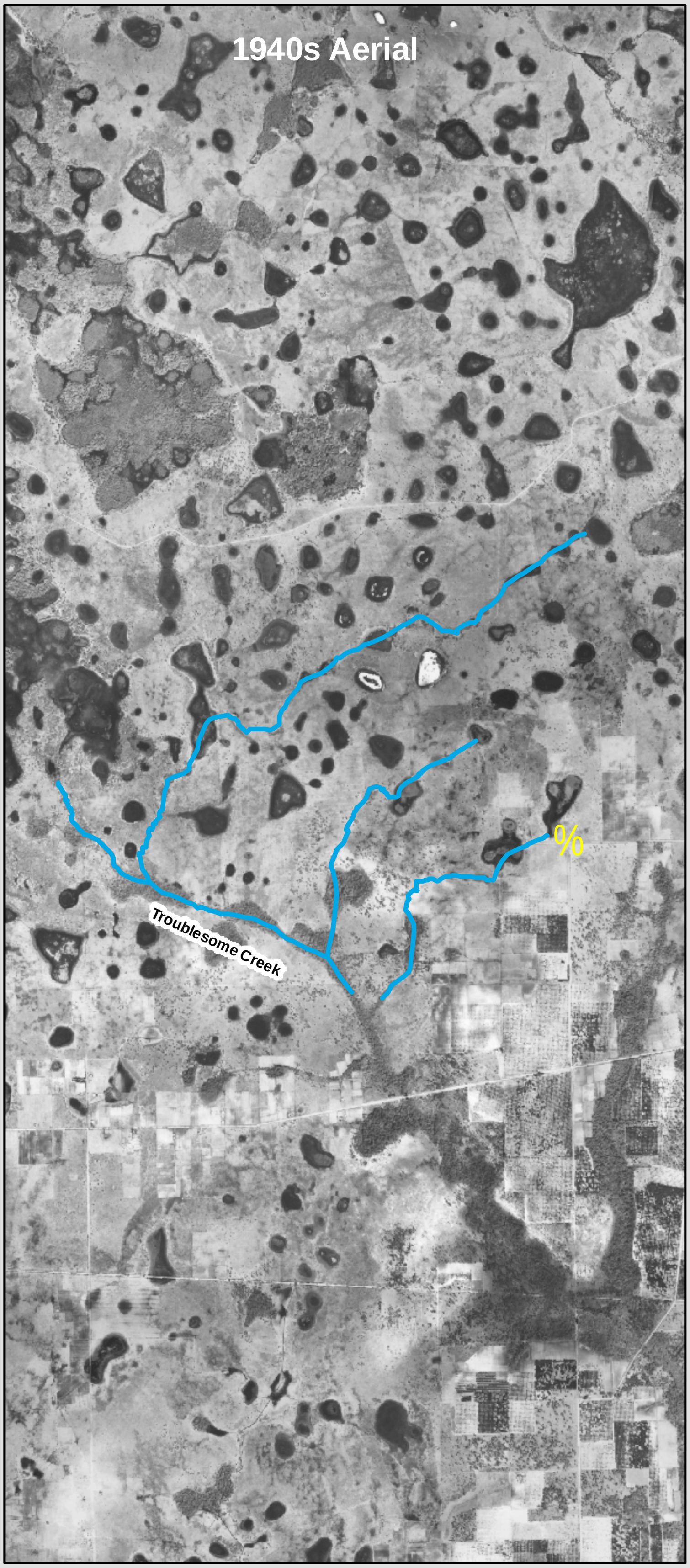
2004 Aerial

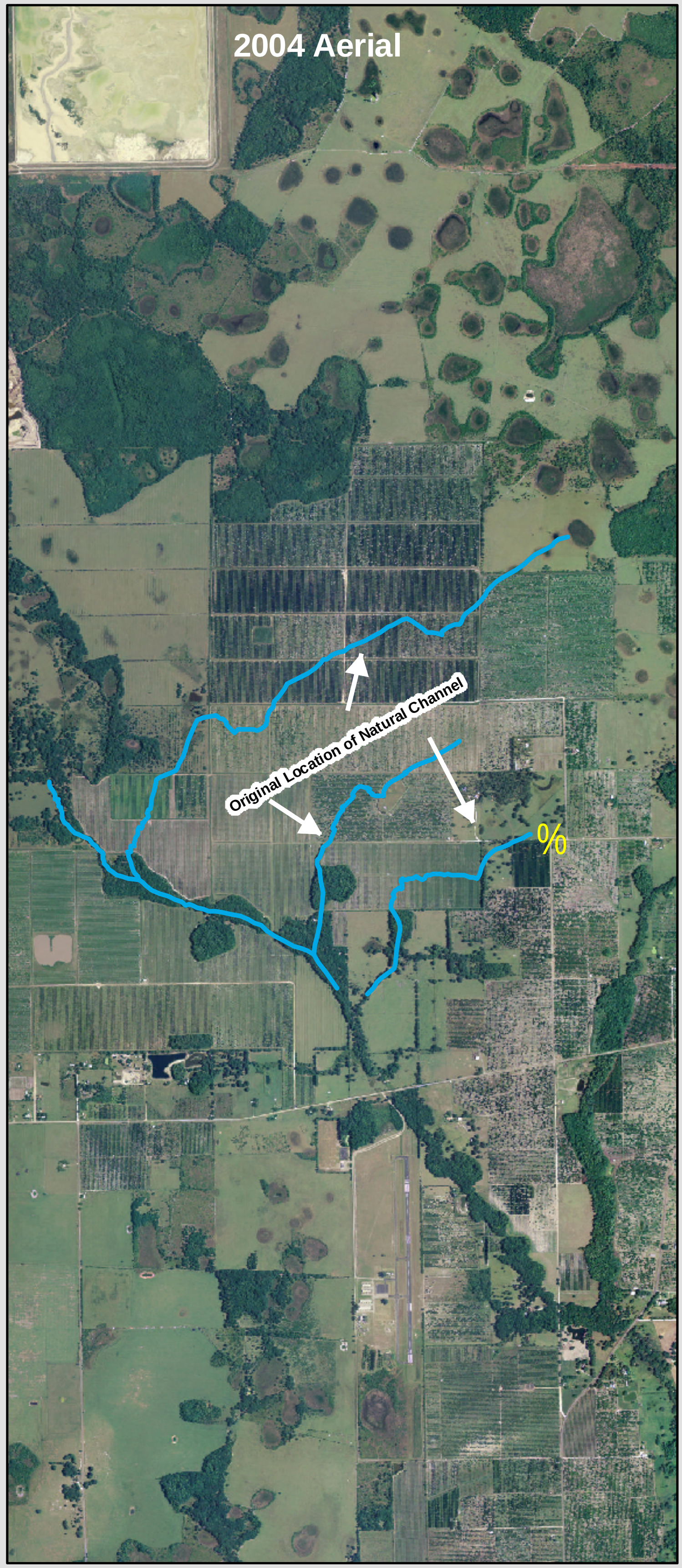
Historical Aerial obtained from the National Archives.

Author: Levi Sciara
Date: October 30, 2006
Path: P:\Projects\ArcGIS\Production\ERS\Studies\SouthFortMeadeWeland_AerialsComp.mxd
Layout View: 14,500

Figure 3.11

Hardee Wetlands Comparison





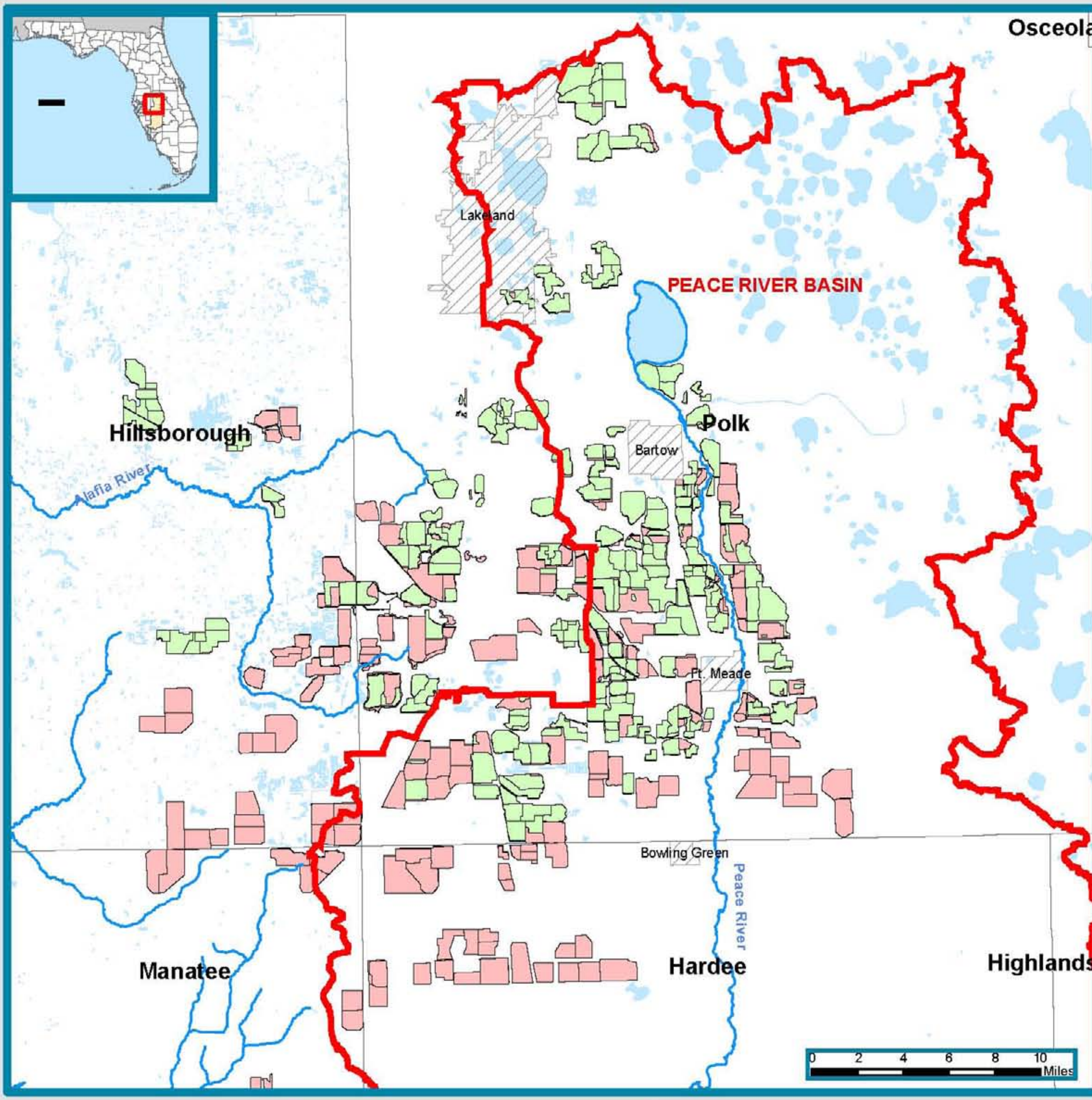
Historical Aerials obtained from the National Archives.

Author: Levi Sciara
Date: October 30, 2006
Path: P:\Projects\ArcGIS\Production\ERS\Studies\Hardee_AerialsComp mxd
Layout View: 10,168

Figure 3.12

MANDATORY AND NONMANDATORY CLAY SETTLING AREAS

Department of Environmental Protection
Bureau of Mine Reclamation



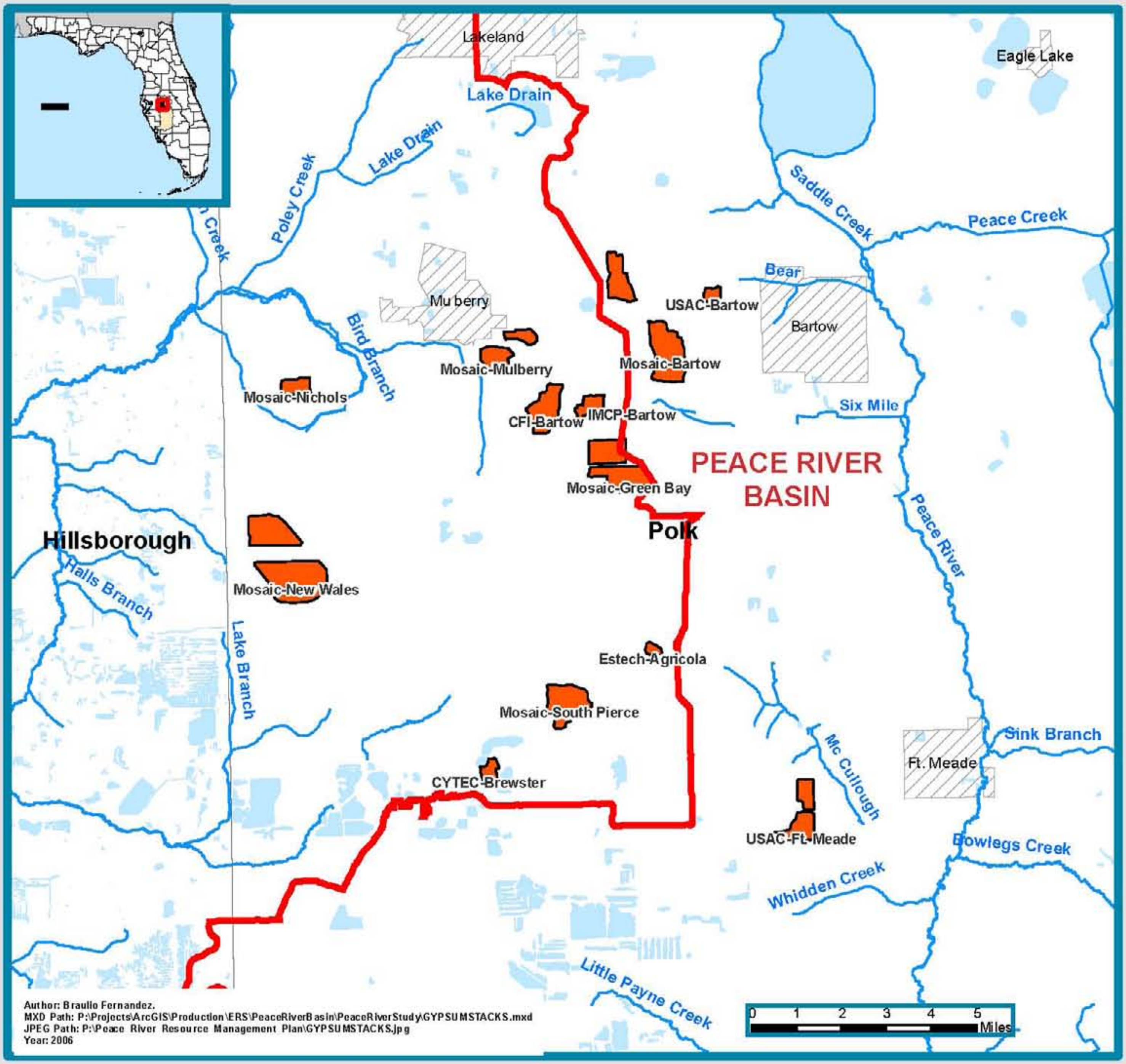
- Peace River Basin
- Nonmandatory Clay Settling Areas
- Mandatory Clay Settling Areas
- Counties
- Cities
- Rivers and Streams
- Lakes

Author: Braulio Fernandez.
MXD Path: P:\Projects\ArcGIS\Production\ERS\PeaceRiverBasin\PeaceRiverStudy\CSA.mxd
JPEG Path: P:\Peace_River_Resource_Management_Plan\CSA.jpg
Year: 2006

Figure 3.15

CENTRAL FLORIDA PHOSPHATE GYPSUM STACKS

Department of Environmental Protection
Bureau of Mine Reclamation



- Peace River Basin
- Phosphate Gypsum Stacks
- Rivers and Streams
- Counties
- Cities
- Lakes

Figure 3.16

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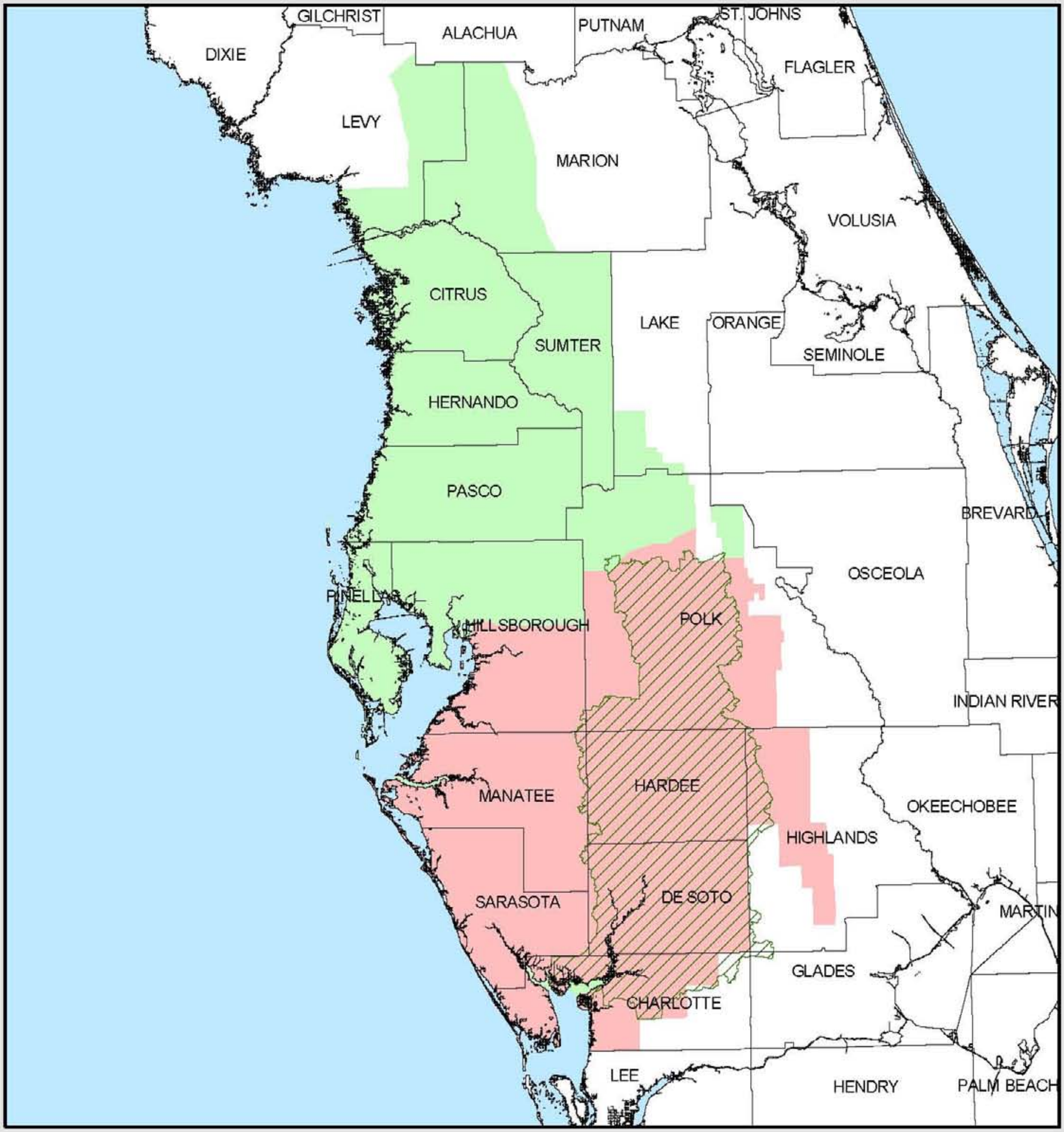
SWFWMD/SWUCA/ Peace River Basin Boundaries Comparison



Peace River Basin
SWUCA Boundary
SWFWMD Boundary

Author: Levi Sciara
Date: December 5, 2006
Path: P:\Projects\ArcGIS\Production\ERS\PeaceRiverBasin\SWUCAvsPRBvsSWFWMD.mxd

Figure 3.17

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