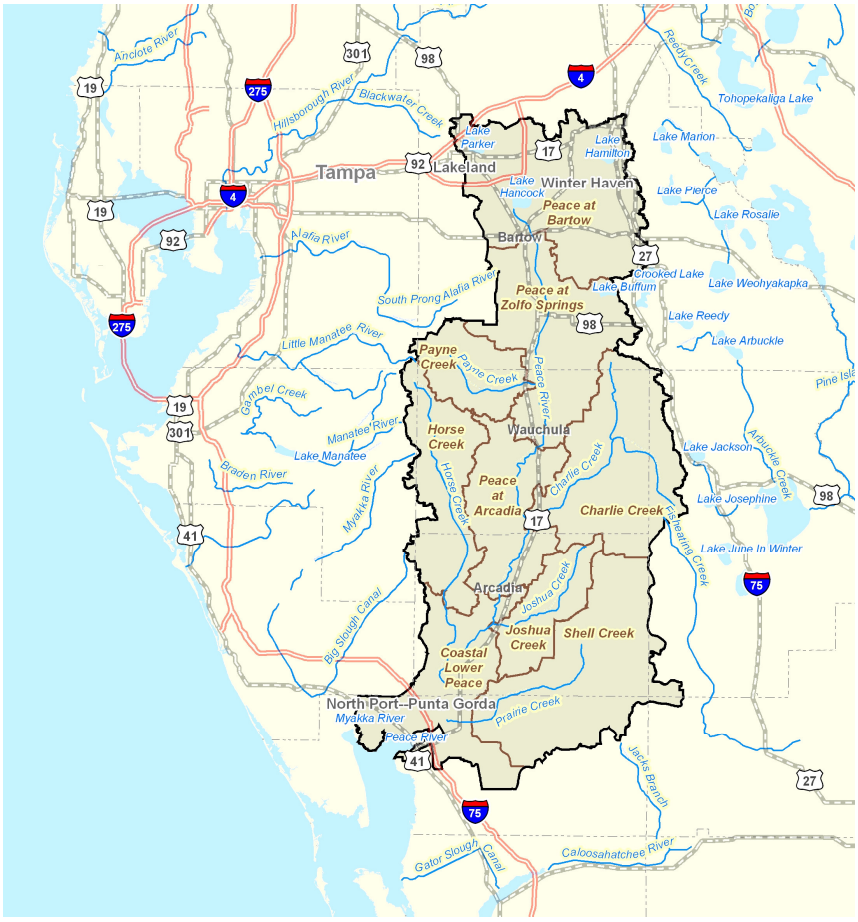
1.0 Introduction

1.1 Study Setting

The Peace River flows in a southerly direction about 105 miles from the confluence of the Peace Creek Drainage Canal and Saddle Creek in central Polk County to Charlotte Harbor. The Peace River watershed is approximately 2,350 square miles in area and includes large portions of Polk, Hardee, DeSoto, and Charlotte counties, and smaller portions of Hillsborough, Manatee, Highlands, Sarasota, and Glades counties (Figure 1.1). The Gulf Coastal Lowlands, the DeSoto Plain, and the Polk Upland are the three major physiographic provinces represented in the watershed. The headwaters region of the watershed lies within the Polk Uplands and is characterized by an upland, internally drained lake region that transitions to a poorly drained upland that extends south into Hardee County. The watershed gently slopes south through the DeSoto Plain in central Hardee and northern DeSoto counties, where surface drainage features are well developed. The Gulf Coastal Lowlands province dominates the watershed in central DeSoto County and Charlotte County. As in several previous studies, the Peace River Cumulative Impact Study (CIS) divides the watershed into nine basins.

Figure 1.1. Location of the Peace River Watershed in Southwest Florida



1.2 Importance of the Watershed and Estuarine System

The Peace River watershed and Charlotte Harbor estuary support a number of activities that contribute to the overall economy of the region. These include agriculture, urban development, phosphate mining, and tourism, as well as both recreational and commercial fishing. Regional economic assets also include natural habitats that provide direct and indirect economic benefits and represent significant regional environmental resources.

The diverse natural uplands, wetlands, and riverine and estuarine habitats in the Peace River watershed support a wide variety of flora and fauna as well as critical or essential habitat for a federally and state listed endangered and threatened species. The lower Peace River/Charlotte Harbor estuarine system is also important habitat for the larval, juvenile, and adult stages of a wide variety of recreationally and commercially important fish and invertebrates such as crabs and shrimp.

However, expanding populations and development continue to present challenges at the local, regional, and state level to addressing impacts to these resources and developing management alternatives to reduce future threats and protect the current uses of these resources. Management goals include reducing future native wildlife habitat losses, reducing the impacts of point and nonpoint pollutants from growing development, securing additional water sources and improving the efficiency of freshwater use, protecting wetland areas for water storage, and maintaining ground water recharge.

In 1995 the U.S. Environmental Protection Agency (EPA) identified the Charlotte Harbor estuary and associated watershed as a system of national significance threatened by pollution, development, or overuse, and joined with local, regional, and state agencies to establish the Charlotte Harbor National Estuary Program (CHNEP). In addition, the Management conferences to develop Comprehensive Conservation and Management Plans (CCMPs) were convened under Section 320 of the Water Quality Act of 1987. The CHNEP is one of only 28 similar programs in the nation and represents the only program designated as "maintenance" rather than "restoration". To maintain the estuarine systems unique to Charlotte Harbor, the CHNEP has identified three priority problems that can be viewed as symptoms or consequences of more basic, causal processes.

1. **Hydrologic Alterations** – Adverse changes to volumes, locations, and timing of freshwater flows, the hydrologic function of floodplain systems, and natural river flows.

2. **Water Quality Degradation** – Including, but not limited to, pollution from agricultural and urban runoff, point source discharges, septic tank system loadings, atmospheric deposition, and ground water.

3. **Fish and Wildlife Habitat Loss** – Degradation and elimination of headwater streams and other habitats caused by development, conversion of natural shorelines, cumulative impacts of docks and boats, invasion of nonnative species, and cumulative and future impacts.

1.3 Peace River Watershed Cumulative Impact Study (CIS)

Natural land cover in many portions of the Peace River watershed has undergone considerable alterations by both historic and current agriculture, phosphate mining, and urban development. In addition, considerable volumes of ground water, and to a lesser extent surface water, are withdrawn each day to support these anthropogenic land uses. It has become evident that these changes in both land and water uses have cumulatively impacted both the hydrology and ecology of the Peace River watershed.

In recognition of these impacts, the Florida Legislature enacted Senate Bill 18-E during the 2003 legislative session. The bill directed the Florida Department of Environmental Protection (FDEP) to conduct a Cumulative Impact Study (CIS) and prepare a Resource Management Plan for the Peace River watershed. The purpose of this study was to conduct an objective assessment of the individual and cumulative impacts of certain anthropogenic and natural stressors in the Peace River watershed with respect to historical changes in stream flow, ambient water quality, and various ecological indicators. The stressors specifically assessed in this study include:

- Urban development
- Phosphate mining
- Agriculture
- Climate variability

The Resource Management Plan prepared by FDEP will identify regulatory and non-regulatory means to minimize future impacts and mitigate past impacts to the Peace River watershed. In support of the Resource Management Plan, the primary goal and specific task of the CIS was to document and evaluate the historic hydrologic and land use changes in the Peace River watershed. The CIS objectives presented below were established to evaluate the potential cumulative impacts of the observed changes on the natural resources of the watershed and downstream estuarine system.

- Assess historical changes in the watershed with respect to the following indicators:
    - Acres of wetlands lost
    - Acres of native upland habitats lost
    - Miles of streambed lost
    - Changes in rainfall
    - Changes in stream flows
    - Changes in ground water elevations
    - Changes in the concentrations of indicator water quality constituents
    - Changes in the abundance, distribution, and diversity of indicator fish communities.

- Discern, and quantify where possible, the relative and absolute contribution of each of the four stressors to documented historical changes in each of the nine major basins in the Peace River watershed.

- Develop a scientific foundation for the subsequent preparation and adoption of a Resource Management Plan for the Peace River watershed.

Time periods used for comparisons among indicators varied, depending on data available. For example, the benchmark time period for land use data was circa-1940s based on the availability of quality high-resolution aerial photography. Spatial data were analyzed for three additional incremental time periods including circa 1979, 1990, and 1999. The absence of 1940s aerial photography in some counties precluded land use comparisons between years and accounts for "missing" data at the edge(s) of some basins. Similarly, analyses of trends were conducted for incremental time steps appropriate to water quality and stream flow data. Data for these analyses (e.g. daily flows and rainfall, monthly water quality, quarterly ground water elevations, etc.) spanned the period-of-record through 2004. Additional data were obtained from the mining industry to better differentiate among mining operations, e.g. mandatory and nonmandatory reclaimed lands.

A variety of analytical techniques was used to determine and quantify, where feasible, the relative cause and effect relationships between the primary stressors and key indicators. Temporal changes in land uses and cover types associated with the anthropogenic stressors were directly assessed and quantified using various GIS spatial analytical methods. Temporal changes in hydrology attributable to the anthropogenic stressors and recent climate variability were assessed and quantified where possible using appropriate multivariate statistical procedures and modeling techniques.

An historical timeline of policy and regulatory programs implemented in the Peace River watershed from the benchmark period to the present was prepared. An attempt was made to relate historical changes in state and water management district policy and regulatory programs with documented temporal changes in key watershed indicators. From this analysis, inferences were developed regarding the effectiveness of current policy and regulatory programs. In addition, proposed changes to current regulatory and management programs were developed to reduce or reverse documented cumulative impacts.

1.4 Overview of CIS Final Report

An overview of the integrated format for the Peace River CIS report, its associated technical appendices, and the additional accompanying portfolio of GIS based figures are provided below. The goal of the CIS report is to summarize the major findings of the study in a manner that will provide a comprehensive overview to a wide audience. The general findings and conclusions presented in the report are then supported through a series of technical appendices constructed around specific project tasks.

Chapter 1 – Introduction

The objective of this introductory section is to provide the reader with a brief overview of the items outlined below.

- The need for the study
- The study's primary objectives and goals
- The report organization and structure

Chapter 2 –Watershed Stressors and Key Indicators of Change

This section provides general descriptions of the primary stressors identified as causes of long-term changes in important ecosystem components in the Peace River watershed. In addition, the manner in which the key indicators of change are used in the study to assess the historic and cumulative impacts of the stressors are presented.

Stressors – The primary mechanisms of the influence of individual stressors and the characteristics of principal stressors associated with historic hydrologic alterations, changes in water quality, and lost of natural habitats within the Peace River watershed are reviewed. Stressors specifically addressed in this study include:

- Natural variability in long-term climate patterns
- Urban development
- Phosphate mining activities
- Agricultural conversions from more passive to intense practices

Indicators of Change – A discussion of the applicability of selected indicators to assessing long-term changes in key watershed characteristics is presented.

Chapter 3 – The Peace River Basins

This chapter of the report summarizes the primary findings of the CIS for each of the nine watershed basins, listed below.

- Peace River at Bartow
- Peace River at Zolfo Springs
- Payne River Creek
- Peace River at Arcadia
- Charlie Creek
- Joshua Creek
- Horse Creek
- Shell Creek
- Coastal Lower Peace

The general topics addressed for each of the basins include:

- Topography and geology
- Primary hydrologic features
- Time series changes in:
  - Rainfall
  - Stream flows
  - Water quality characteristics
  - Ground water levels
  - Land use - summary of change analyses and comparisons among the 1940s, 1979, and 1999 Peace River watershed GIS land use layers:
    - Agriculture activities and intensity
    - Urbanization
    - Mining activities and reclamation
    - Changes in extent of native upland habitats
    - Wetland losses
    - Losses of natural stream and river channels
- Overview of basin specific hydrologic water budget and differences between the 1940s, 1979, 1990 and 1999 reference periods.

Chapter 4 –Cumulative Impacts to Peace River Watershed

The primary objective of this chapter is to evaluate cumulative impacts at the watershed level with regard to previously presented historic changes in:

- Hydrology
- Water quality
- Wetland and in-stream habitat
- Native upland habitat

Relevant information and analyses from additional sources are also presented and used to examine possible linkages and/or causal relationships among and between anthropogenic and natural stressors, as well as the key indicators of change. In addition, the relative magnitude of influence of each of the key identified watershed stressors is ranked.

Chapter 5 – Overview of History and Evaluation of Regulatory Effectiveness

The primary objectives of this section of the report are to summarize conclusions regarding the effectiveness of both historical and current governmental policies and regulatory programs. Potential changes to those programs, and/or new programs to enhance protection of key watershed ecological components in the future are also proposed.

An historical timeline dating back to the study benchmark period is presented that documents the long-term history of both governmental policies and regulatory programs implemented in the Peace River watershed. Based on previously described long-term changes in the watershed resources, regulatory effectiveness is assessed through comparisons of historical implementation

of regulatory policies and programs, and documented changes in the selected watershed indicators. The report assesses "gaps" between actual current and future desired conditions in these indicators.

The chapter also presents inferences regarding the historical and current effectiveness of policy and regulatory programs, as well as proposes potential proposed changes to those programs. In addition, the assessment of potential policy and/or regulatory changes is presented centering on the potential benefits of floodplain buffers for maintaining water quality, moderating stream flow extremes, and protecting the habitat of water-dependent wildlife. The chapter presents an evaluation with regard to the specific applications and prescribed uses of floodplain buffers as mitigation under applicable permitting programs, and provides an economic assessment of such implementation.

Peace River Cumulative Impact Study Technical Appendices

Detailed technical information use in the Peace River Cumulative Impact Study is contained in a series of technical appendices. The technical appendices provide comprehensive summaries of the information, methods, and analyses implemented for the CIS tasks. As such, these appendices provide the technical background information supporting the summary conclusions contained in the main chapters of the document outlined above.

Appendix A, Literature Review – This appendix summarizes the methodology used in developing the CIS literature database and details the use of various aspects of the developed Access™ reference/literature database.

Appendix B, Hydrologic and Water Quality Data – Appendix B provides descriptions of data sources used in synthesizing the hydrology and water quality data that were analyzed in the report and provides descriptions of each database.

Appendix C, Arc/GIS Project File – Appendix C describes the CIS ArcView project file, the standardized GIS projections, and includes a description of the appropriate meta data file structure.

Appendix D, Time Series Analyses of Trends in Hydrologic Information – This appendix provides an overview and comparison of the statistical methods used to test for statistically significant, progressive changes (or trends) in each of the key hydrologic indicators (listed below).

- Rainfall
- Surface water flows
- Rainfall / flow interactions
- Ground water elevations

The appendix also includes results, including summary graphics and tables, of all analyses for each of the nine watershed basins.

Appendix E, Time Series Analyses of Trends in Water Quality Parameters – The specific methodologies used to analyze the status and changes in water quality in each of the watershed basins are presented. This appendix also include the results, in graphical and tabular formats, of statistical and other procedures used to characterize changes in both surface and ground water quality measurements.

Appendix F, Development of 1940s Baseline GIS Land Use Layer – The appendix presents a brief overview of the technical issues related to the development of circa 1940s benchmark land use GIS layer. Topics include the availability, quality, and resolution of watershed aerial photography covering the 1940s reference period, as well as compatibility and comparability issues associated with more recent GIS land use layers developed by SWFWMD.

Appendix G, Application of Change Analyses Methodologies in Comparisons of 1940s, 1979, 1990, and 1999 Peace River Watershed GIS Land Use Layers – This appendix addresses the methods applied to change analyses among the available historical Peace River watershed GIS land use layers. This section also provides tabular summaries for each of the nine basins for specific indicators of land use changes.

Appendix H, Basin Water Budgets and Watershed Conceptual Models – This appendix details the methods and rationale used to develop conceptual water budget models for the watershed basins. Conceptual models were developed and used to relate all flow related mechanisms in each basin systems. Each of these analytical water budgets included primary components accounting for the channel, overland, and subsurface budgets. These components were computed from measured rainfall, stream flow, and ground water elevations, as well as estimates of annual fluxes between these components and their respective changes in storage. The developed water budgets included representations accounting for both temporal and spatial basin processes. Similarities and differences among the key hydrologic processes and specific observed responses among the basins were assessed and discussed. These comparisons were then used to develop conceptual models for the surface water and ground water systems in the Peace River watershed.

Appendix I, Background Information Associated with Evaluation of Regulatory Effectiveness – This appendix provides supporting information for the each of the primary topics discussed in Chapter 5 of the CIS report.

Appendix J, Evaluation of Historical Changes in Fish Species Composition and Abundance – This appendix details the technical findings of the review of historical fish studies in the Peace River watershed. The report examines historical changes in fish species composition and abundance. Where data were available, comparisons were made among tributaries in the Peace River watershed. Species richness and abundance were examined by computed incidence based curves and/or on sample based curves. Historical changes in the abundance and distribution of key indicator species were quantified by tributary or river basin. Based on the available data, inferences were drawn relative to potential causes of apparent historical changes in the abundances and distributions of fish species in the Peace River watershed.

1.5 Data Sources

The results and conclusions presented in the Peace River CIS were based on analyses of data compiled from a number of sources. An overview of the primary data sources used in the study is presented here. Specific details with regard to the data used in the various analyses for the study are presented in the series of report technical appendices outlined above

Land Use

- 1940s land use Graphical Information System (GIS) mapping in the watershed – this layer was developed as part of the CIS by Avineon, Inc. FDEP contracted directly with Pickett, Inc. to have prints of photographs from the U.S. National Archives scanned and digitized into a GIS compatible format. Uniform, synoptic aerials for the entire watershed for the same time period were not available, and the information compiled by Pickett covered a period from the early 1940s to approximately 1951. Avineon then digitally rectified these aerials developed a 1940s baseline land use GIS layer using the same methods they applied in developing the 1979 SWFWMD land use GIS layer.

- 1979 land use GIS mapping – this recently developed layer was provided by SWFWMD.

- 1990 land use GIS mapping – this older layer was also provided by SWFWMD. It was developed by the District from U.S. Geological Survey (USGS) Quadrangle maps, rather than directly from aerial photographs. As a result, Avineon was unable to include accurate, direct comparisons between this 1990 land use information and from the 1940s, 1979, and 1999 time periods as part of the change analyses. The 1990 land use information was, however, used to develop the watershed basin water budgets presented in the CIS.

- 1999 land use GIS mapping – data were also provided by SWFWMD. Avineon then coordinated with District staff to resolve issues with the more recent 1979 layer developed by Avineon for the District.

- Phosphate mining GIS mapping – a number of sources were used in compiling the historic and current information presented in the CIS. GIS layers were obtained from SDI, Inc., the phosphate mining industry, and FDEP Bureau of Mine Reclamation.

- Avineon then used GIS software to prepare the tabular comparisons of changes in land use between the 1940s, 1979, and 1999 GIS layers presented in the CIS.

Stream and River Channel Lengths

Members of the PBS&J GIS and sciences staff used the 1940s digitally rectified aerial photographs to develop a digitized layer of the natural stream channels in each of the nine CIS watershed basins. These 1940s aerials indicated that even at this early period, extensive channelization had already occurred in many areas throughout the watershed. However, the objective of the CIS was to include only those 1940s stream channels that appeared to have

retained their natural characteristics during this baseline period. In addition, stream channels were not included in sloughs or other continuous wetland systems where no definitive stream channel could be identified from the aerials. Consequently, estimates of first and second order streams may have been conservative and therefore underestimated due to the limits of the 1940s aerial photography. The 1940s GIS stream layer was then compared with the 1999 District aerials, and the new 1999 layer included stream segments identified in the 1940s that had been channelized, filled, or were otherwise no longer apparent. The difference between the 1940s and 1999 natural stream segments was then compared with the 1999 land use layer to provide an indication of potential causes for the observed losses. IIn many instances, the actual underlying cause of the stream loss may have been due to changes which preceded the 1999 land use.

Hydrologic Data

- Stream flow – data were obtained directly from the Tampa USGS web site.

- Ground water levels – data were compiled from the USGS ground water level monitoring and ambient water quality monitoring web sites, as well as from available SWFWMD monitoring programs.

- Rainfall – data were compiled from long-term recorders at the USGS stream flow gages, the National Oceanographic and Atmospheric Administration (NOAA) network, and the SWFWMD watershed rainfall monitoring sites.

- NPDES Discharges – data were obtained from FDEP.

- NPDES Water Quality – data were obtained from FDEP.

Water Quality Data

- Surface Water – period-of-record water quality data from watershed stream flow gaging sites were obtained directly from the USGS web site. STORET water quality data compiled by FDEP were obtained from the Total Maximum Daily Load Program. SWFWMD surface water quality data were provided by the District's surface water ambient monitoring program, and long-term water quality data for the lower Peace River/upper Charlotte Harbor estuary were acquired from the Peace River/Manasota Regional Water Supply Authority and City of Punta Gorda's Hydrobiological Monitoring Programs (HBMPs).

- Ground Water – data were obtained directly from the USGS ground water monitoring data web site, and from the SWFWMD database.

Relevant Literature – both the Peace River CIS and the accompanying technical appendices extensively site relevant literature in support of statements made beyond particular findings derived directly from the study. Where applicable, the report directs readers back to specific technical appendices in support of conclusions drawn from relevant analyses conducted as part of the CIS. In addition, an extensive Access™ database was developed as part of this study and

includes additional references that may be of both specific and general interests with regard to assessing potential impacts to the Peace River watershed and the Charlotte Harbor estuary.

Background Information – copies of extensive background information and data, as well as materials compiled and summarized as part of various recent legal proceedings were provided by Charlotte County and its consultants, the FDEP Bureau of Mine Reclamation, and SWFWMD staff.