HERBERT HOOVER DIKE DAM SAFETY MODIFICATION STUDY
GLADES, HENDRY, MARTIN, OKEECHOBEE AND PALM BEACH COUNTIES, FLORIDA

ENVIRONMENTAL IMPACT STATEMENT
June 2016

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Cover Sheet

FINAL ENVIRONMENTAL IMPACT STATEMENT

HERBERT HOOVER DIKE
DAM SAFETY MODIFICATION STUDY
Glades, Hendry, Martin, Okeechobee, and Palm Beach Counties, FL

Lead Agency: **Department of Army**
U.S. Army Corps of Engineers, Jacksonville District

Abstract:
The purpose of the Herbert Hoover Dike (HHD) Dam Safety Modification Study (DSMS) is to identify and recommend a cost effective alternative risk management plan (RMP) that supports the expeditious reduction of risk at HHD. While the primary purpose of the remediation of HHD is to ensure public safety, objectives of the project also include lowering the probability of experiencing a breach and incurring impacts on ecological, cultural, and aesthetic resources, including these resources in the Everglades resulting from a breach. Species and habitats directly on the dike and within the path of the water due to a breach would be negatively impacted, and snail kite critical habitat could be negatively impacted due to lower lake levels. Further, if a breach were to occur along the southern perimeter of HHD, flooding would occur within the Everglades Agricultural Area (EAA) and further south, through the Water Conservation Areas (WCAs) and eventually to Everglades National Park. There are many state and federally protected species within south Florida that would be negatively impacted due to a loss of habitat from flooding resulting from a breach of HHD.

The comparison of the final array of alternatives has resulted in the identification of the economically, environmentally, and socially efficient alternative as the plan being recommended to reduce the overall risks attributed to a breach associated with the Herbert Hoover Dike. Alternative 3 has been identified as the Recommended Plan. The Recommended Plan consists of cost-effective structural measures that work in unison to reduce the likelihood of a breach at HHD and achieves the primary objective of protecting public safety. The Recommended Plan includes construction of risk reduction measures around the southern half of HHD and limited areas in the northwest sides of the dam, greatly reducing the potential for breach-related damages to the nationally significant agricultural industry in the Everglades Agricultural Area, and the nationally and internationally significant Everglades ecosystem. The probability of experiencing a breach and incurring substantial impacts on ecological, cultural, and aesthetic resources would be greatly reduced with the implementation of the Recommended Plan. Adverse effects associated with implementing the Recommended Plan are expected to be minimal to moderate. Many effects, such as impacts to recreation and noise levels would be temporary during construction activities.

Send your comments by:
July 1, 2016

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EXECUTIVE SUMMARY

Background

Authorization: The HHD is a component of the Central and Southern Florida (C&SF) Project for Flood Control and Other Purposes. It is generally understood that the birth of the C&SF Project began with the Flood Control Act of 1948; however, Federal participation in local flood control efforts in the Lake Okeechobee area started much earlier in response to the disastrous hurricanes of 1926 and 1928. The Rivers and Harbors Act of 1930 authorized the construction of levees for protection from storm surge-induced flooding along the north and south shores of Lake Okeechobee. The 1948 Act created the C&SF Project and included authorization for enlargement of the existing levees and construction of additional levees along the northeast and northwest shores. The Flood Control Act of 1960 authorized the name of all levees around the shore of Lake Okeechobee to be "Herbert Hoover Dike", in honor of the former President and his role in implementing levee construction.

Purpose: The Herbert Hoover Dike (HHD), surrounding Lake Okeechobee, is currently recognized as requiring urgent repairs to minimize risks to public safety and to provide a tolerable level of economic, societal and environmental security in the region. The objective of the HHD Dam Safety Modification Study (DSMS) and Final Environmental Impact Statement (EIS) is to identify and recommend a cost effective alternative risk management plan (RMP) that supports the expeditious reduction of risk from a breach of HHD.

While the primary purpose of the remediation of HHD is to reduce risk to public safety, objectives of the project also include lowering the probability of experiencing a breach and incurring impacts on ecological, cultural and aesthetic resources and these same resources within the Everglades resulting from a breach. If a breach were to occur, both federally and state listed species, and habitats directly on the dike and within the path of the water due to a breach would be negatively impacted. Snail kite critical habitat in the southern portion of HHD could be negatively impacted due to lower lake levels. Further, if a breach were to occur along the southern perimeter of HHD, flooding would occur within the EAA and further south, through the Water Conservation Areas (WCAs) and eventually to Everglades National Park, negatively impacting species due to loss of foraging and nesting habitat. If a breach were to occur along the northern perimeter of HHD, flooding would be more localized due to the topography of the area; however, minimal effects would occur.

Alternatives

The Corps analyzed 11 alternatives for the HHD Dam Safety Modification Study (see Section 2 for more detailed description and figures). This Final Environmental Impact Statement (EIS) analyzes the environmental effects of (1) the No-Action Alternative; and (2) four alternatives with various cutoff wall locations and depths, and downstream armoring and floodwalls in select areas of low crest elevation (one of which has been selected as the Recommended Plan). In accordance with ER-1105-100, the socioeconomic impacts of the alternatives must be considered in plan formulation and evaluation. Typically, economic impacts are measured by National Economic Development (NED). In the case of the DSMS, the impacts also address public safety. The HHD DSMS, NED impacts are measured as reduced economic risk. Changes in economic risk are documented in Section 4 of the main report. However, Regional Economic Development (RED) and Other Social Effects (OSE) should also be considered. RED considers regional economics, such as benefits of employment during construction or recreational

features gained or lost, rather than on a national level. OSE include environmental justice, prime and unique farmlands, protection of children, health and safety, and recreation. The comparison of the final array has resulted in the identification of the economically, environmentally, and socially efficient alternative as the plan being recommended to reduce the overall risks attributed to a breach associated with Herbert Hoover Dike. All alternatives were analyzed under the current operations schedule, Lake Okeechobee Regulation Schedule (LORS) 2008. A new regulation schedule would be a separate, collaborative effort under NEPA and would have many competing interests and objectives. Alternative 3 has been identified as the Recommended Plan. The Recommended Plan is a cost-effective plan consisting of structural measures that work in unison to reduce risk, achieving the primary objective of protecting public safety. The Recommended Plan includes constructing risk reduction measures along most of the southern half of HHD and in limited areas of the northwestern perimeter of HHD, greatly reducing the potential for breach-related damages to the communities surrounding HHD, the nationally significant agricultural industry in the Everglades Agricultural Area, and the nationally and internationally significant Everglades ecosystem.

Description of the Recommended Plan:

A cutoff wall was determined to be the least costly, technically acceptable risk reduction measure for remediation of the HHD embankment in areas that have been identified as high risk due to internal erosion failure modes (erosion of the internal structure of the embankment due to seepage forces). This alternative includes a cutoff wall around the southern perimeter of HHD, extending the previously constructed cutoff wall from the end of Belle Glade to just north of Moore Haven, terminating at the intersection of HHD and interceptor Levee 41. The Recommended Plan also includes a cutoff wall along the northwest perimeter of HHD in the vicinity of Lake Port. Lastly, the Recommended Plan includes isolated areas of downstream armoring on the abutments of SR 78 Bridge over Harney Pond Canal and floodwall around S71 and S72 at the northern terminus of HHD on Harney Pond Canal and Indian Prairie Canal, respectively. These areas were identified as low points in the crest of HHD that were considered excessively vulnerable to overtopping under combined loading events of elevated lake stages and tropical cyclone impact. Additional coordination is needed with the non-Federal sponsor (Florida Department of Transportation) to identify the need to raise the SR78 Bridges over Harney Pond, Indian Prairie, and the Kissimmee River to match adjacent embankment crest elevations. This work is recommended to be completed as the infrastructure reaches the end of the design surface life or becomes scheduled for replacement for other reasons. Due to the remote combination of loading conditions that could cause overtopping at these locations, only one of these structures was estimated to pose sufficient risk to warrant some level of interim risk reduction prior to bridge replacement.

The environmentally preferred alternative is also Alternative 3 (the Recommended Plan). Constructing a cutoff wall would significantly decrease the likelihood of failure of the embankment and therefore reduce likelihood of life safety, economic, and environmental damages from breach. The No Action Alternative does not address the imminent need for public safety according to current dam safety standards.

Environmental Consequences of the Recommended Plan

The probability of experiencing a breach and incurring substantial impacts on ecological, cultural, and aesthetic resources would be greatly reduced with the Recommended Plan. Adverse effects associated with implementing any of the alternatives are expected to be minimal to moderate (defined in Section 4). Many effects, such as recreation and noise levels would be temporary during construction activities. Moderate effects to aesthetics would be expected. The Recommended Plan is not expected to adversely

affect historic properties listed or eligible for listing in the National Register of Historic Places due to the location of the project area within the previously disturbed Federal right-of-way. Any actions outside of the Federal right-of-way may have the potential to affect historic properties. HHD rehabilitation as a whole would not be expected to significantly affect protected species. The Recommended Plan may affect, but is not likely to adversely affect, the threatened and endangered species and their critical habitat in the project area. Species would not be directly affected by construction of a cutoff wall or internal drainage system; however, there is potential for disturbance to the species during construction activities. The action may produce noise above ambient levels, however, mufflers and sound dampening equipment would be required during construction, along with preconstruction surveys. While small foraging or nesting areas utilized by the gopher tortoise and burrowing owl may be temporarily affected by this project, the Recommended Plan is not likely to adversely affect protected State listed species or other wildlife.

Areas of Controversy

There are no known conflicts or controversy over the HHD rehabilitation itself. Indirectly related to the rehabilitation efforts is the potential for revisions to LORS 2008 for operations of Lake Okeechobee. This EIS, in support of the HHD DSMS, does not propose to change LORS 2008 as part of the rehabilitation efforts. This DSMS utilized the assumption that the Lake Okeechobee Regulation Schedule would be the operating critieria for lake levels. A study for a new regulation schedule could be undertaken concurrently while risk reduction features identified in the DSMS are constructed. A new regulation schedule would be a separate, collaborative effort under NEPA and would have many competing interests and objectives.

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1.0 PROJECT PURPOSE AND NEED

1.1 INTRODUCTION

The Herbert Hoover Dike (HHD) was constructed around Lake Okeechobee, a 724-square-mile freshwater lake in south central Florida (**Figure 1-1**) for the purposes of flood risk management, navigation, agricultural and municipal water supply, prevention of saltwater intrusion, recreation, and the enhancement of environmental resources. The U.S. Army Corps of Engineers (Corps), Jacksonville District, has operated and maintained the HHD for over 75 years, its highest priority being the continued safety of the communities surrounding the HHD. Internal erosion (piping) can result when seepage forces through an earthen embankment become strong enough to begin eroding the soil particles used to construct the embankment and/or foundation of the dam. Evidence of this failure mode initiating has been observed in certain areas of HHD during high water events. The likelihood of initiation of a piping failure mode and the rate at which piping occurs is dependent upon lake elevations. The seepage volume and distress indicators in certain reaches of the embankment begin to become more prevalent at lake elevations above 17 feet North American Vertical Datum 1988 (NAVD88) and are cause for increasing concern when operating at or above these levels for any significant period. Major remediation is necessary to prevent a breach in the dike and consequent significant adverse effects on public safety.

The HHD is approximately 143 miles long and spans the following five counties around the perimeter of Lake Okeechobee: Glades, Hendry, Martin, Okeechobee, and Palm Beach. In 1993, the Corps established priorities to address structural problems at individual sections of the dike according to the perceived risk of dike failure at that time (USACE, 1993); these sections were classified as Reaches **(Figure 1-2**). Reach 1 was previously assigned the highest priority and rehabilitation efforts are nearing completion based on designs from the 2005 Supplemental MRR and EIS and subsequent Environmental Assessments (EA), including the most recent Supplemental MRR in 2015. The implied order of priority (Reaches designated 1 through 8 in descending order of priority) by reach numbering is no longer valid as recent repairs, additional data, and additional analysis have changed the priority. The current construction of the cutoff wall should be considered successful at reducing the probability of failure throughout Reach 1, and a step forward in reducing the Damn Safety Action Classification (DSAC) rating of the dam.

Within the Dam Safety Modification Study and for this Final EIS, the use of 8 Reaches to delineate HHD has been substituted with seven Common Inundation Zones (CIZ) (**Figure 1-3**). These seven CIZs reflect downstream areas where similar inundation or flooding would occur from a breach anywhere within that zone.

The Corps has undertaken a major rehabilitation program for the HHD that has been endorsed by local, national, and international experts. This Final Environmental Impact Statement (EIS) assesses the environmental effects of rehabilitation of the HHD as part of the Dam Safety Modification Study (DSMS).

Figure 1-1. Herbert Hoover Dike Location Map, Herbert Hoover Dike Surrounds Lake Okeechobee

Figure 1-2. Herbert Hoover Dike Original Designation of Reaches

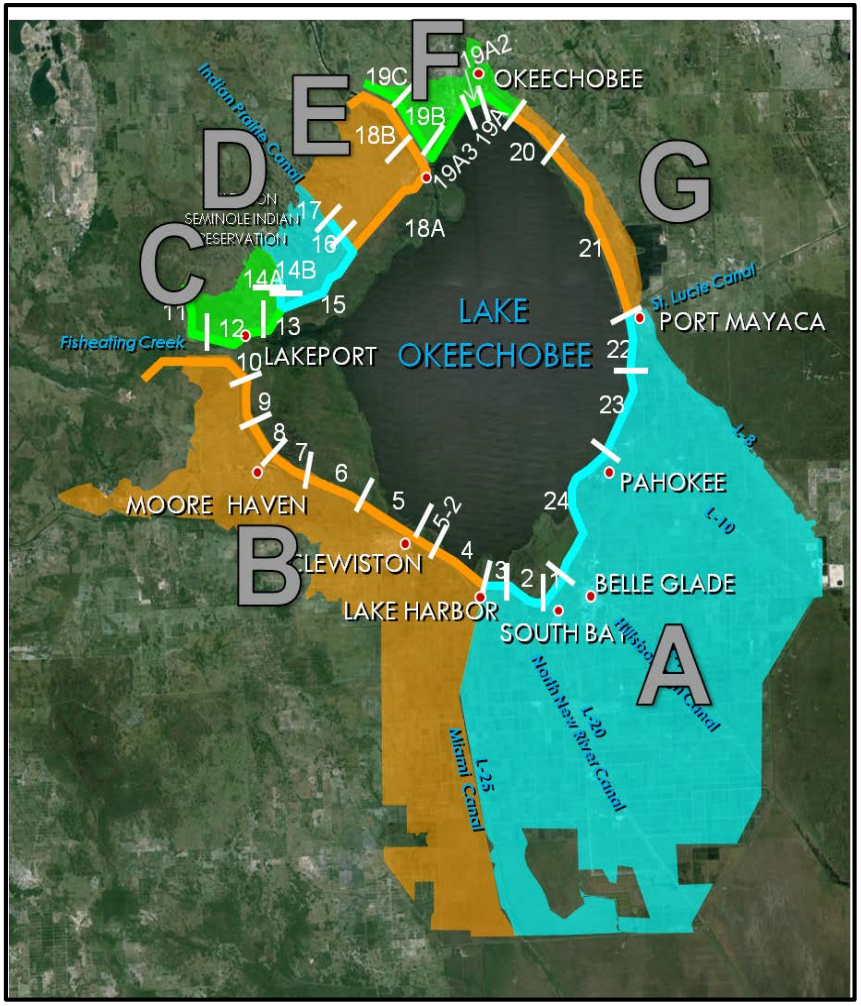

Figure 1-3. Common Inundation Zones with Segments for HHD

1.2 PROJECT NEED AND OPPORTUNITY

Since the early 1980s, the Corps and independent technical reviewers have studied and documented the potential for catastrophic failure of the HHD during high water stages, particularly in CIZ A. The primary causes for concern are seepage and piping. Seepage occurs when water travels from the lake through the foundation and embankment of the dike. The seepage can carry material (mostly sands) with it, eventually eroding a water flow path through the HHD embankment and foundation. This causes a damaging mechanism of internal erosion or piping through the embankment or foundation. Underground seepage and internal erosion are made possible by the permeable nature of the materials of which the dike is constructed, including sand, gravel, shell, and limestone, and by the variable geology comprising the foundation of the dike system.

There are three phases of the piping erosion process: initiation, continuation and progression. Piping typically initiates at the toe or in the ditch at the toe of the HHD embankment (also referred to as the toe ditch) and is the point at which the seepage flows first become sufficient to erode the surface soils at the toe. In the continuation phase, the seepage flows are sufficientto continue erosion up-gradient toward the water source where erodible materials in the embankment or foundation are continuous and not interrupted by less erodible layers. In the erosion progression phase of piping, the seepage volumes and erosion increase, and layers within the embankment or foundation acts like a roof that allows the pipe to progress toward the lake. The final stage of the piping process results in an open conduit ("pipe") between the lake and landside toe that can rapidly cause a breach of the embankment (**Figure 1-4**).

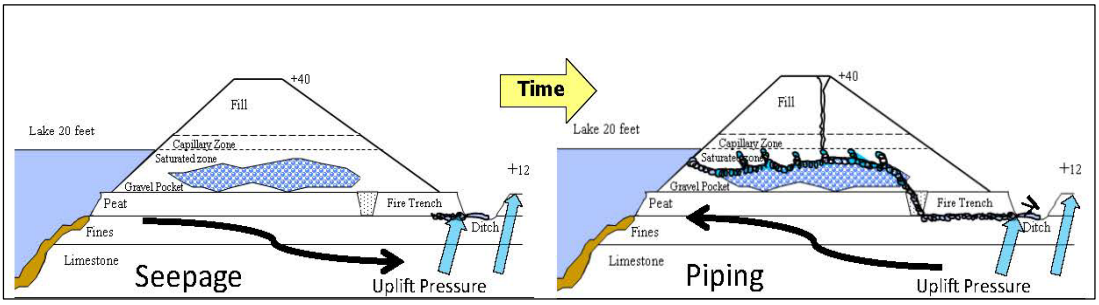

Figure 1-4. Dike Failure Cross-Section Depicting Seepage and Piping.

Symptoms of serious seepage and piping include sand boils--concentrated vertical discharge of water mixed with sand on the landside of the dike, and/or horizontal discharge of seepage with deltas of sand being deposited around the discharge location. Piping can create tunnels and cavities, causing instability and sinkholes on the dike. Seepage and piping are the failure modes of greatest concern due to the high potential for their occurrence and evidence of this failure mode was observedduring past high water events (sinkholes, sand boils, and deltas of sand deposited in the landside toe ditch observed during high water events are evidence that the piping process has initiated or could initiate at slightly higher lake levels in some areas).

Water managers are unable to maintain safe water levels following sustained high rainfall events or water patterns because the outlet capacity to release lake water is limited. The outlet capacity (released via the St. Lucie and Caloosahatchee canals) is about one-sixth of the potential inflow capacity (USACE 2007b).

Another failure mode identified at HHD is overwash/overtop. The potential for HHD to overwash/overtop is possible in some areas under various combinations of still water reservoir elevation and tropical cyclone wind (with the magnitude of the wind event needed to initiate this failure mode decreasing with increasing still water reservoir levels). If the still water elevation, plus the hurricane setup elevation (storm surge) exceeds the crest of the embankment, overtopping would then occur for some duration of the wind/setup event. The other component of this failure mode is overwash. Overwash occurs prior to overtopping when waves break on the interior of the dam and run up and over the back side of the embankment. Both overtopping and overwash result in erosion of the embankment. Sustained overtopping or overwash of sufficient intensity and duration could erode sufficient soil to result in a breach. The wind driven overtopping/overwash failure mode can be described as follows: 1) the pool rises to some still water elevation based on wet season fluctuations, 2) Lake Okeechobee then struck by a tropical cyclone which adds a wind load on the lake, 3) the wind results in waves and wind set up (storm surge), 4) the combination of the stillwater lake stage and wind intensity is sufficient to cause overwash or overtopping of the embankment, and 5) the duration of the overwash/overtopping event is sufficient to result in failure of the embankment.

Based on the above described failure modes, in 2007, the Corps ranked the HHD an "Urgent and Compelling (Unsafe)" water control system and "critically near failure or extremely high risk" (USACE 2007a); this considered the fact that seepage and internal erosion have occurred during high reservoir events and limited outflow capacity of the system does not allow the Corps to prevent extreme reservoir levels from occurring. Failure here means an uncontrolled release of water resulting from a catastrophic breach of some portion of the HHD system. This classification and characterization was validated through an external peer review in 2007 (USACE 2007b).

A failure of the dike could result in human suffering, immense property damage, destruction of the natural habitat, and loss of human life. This project represents an opportunity to avoid a catastrophic failure by implementing an effective, comprehensive rehabilitation solution.

1.3 PROJECT PURPOSE

The objective of the Hebert Hoover Dike Dam Safety Modification Study (DSMS) and Final EIS is to identify and recommend a cost effective alternative risk management plan (RMP) that supports specific actions to expeditiously reduce dam safety risks to tolerable levels for public safety and economic, environmental, and social resources. For HHD to be considered tolerable there should be an expectation of less than 0.001 lives lost on an average annual basis. Additionally, the Annual Probability of Failure (APF) should be less than a 1 in 10,000 chance of occurring when economic, social, or environmental consequences of a breach are significant. Reduction of risk to these threshold values will make HHD no greater risk than other facilities of its type and pose no greater risk to the public than incurred by other normal daily encounters. The purpose of this project is not to change the Lake Okeechobee Regulation Schedule, it is to expeditiously reduce dam safety risks to tolerable levels for public safety and economic, environmental, and social resources. Therefore, alternatives discussed in this EIS were developed to provide risk reduction measures to the physical embankment specifically, which would not alter water management operations to the estuaries. The risk reduction measures to improve the embankment would allow a future or concurrent study to evaluate alternatives in relation to a revised regulation schedule upon approval of the Dam Safety Modification Study.

1.4 BACKGROUND

The HHD was constructed in stages around the lake to provide flood risk management to surrounding agricultural areas and communities. The first levees around Lake Okeechobee were constructed by local interests between 1910 and 1920 along the southern portion of Lake Okeechobee. The height of these first levees ranged from five to nine feet and were largely composed of muck excavated from adjacent borrow canals.

During the 1930s, a Federal interest to reconstruct and lengthen the dike for flood risk management was initiated after hurricane storm surge in 1926 and 1928 overtopped the original embankment and caused over 2,600 deaths. The Rivers and Harbors Act, approved July 3, 1930, authorized the construction of 67.8 miles of levee along the south shore of Lake Okeechobee and 15.7 miles of levee along Lake Okeechobee's north shore. The USACE constructed these reaches between 1932 and 1938, and the typical crest height of these levees ranged from about 31 to 34 feet (NAVD88).

A major hurricane in 1947 prompted the need for additional flood risk management in Florida. In response, Congress passed the Flood Control Act of 1948 authorizing the first phase of a comprehensive plan for flood risk management and other water control benefits called the Central and Southern Florida (C&SF) Project. As part of the C&SF project, in the early 1960s, the HHD was extended to encircle Lake Okeechobee and raised to its present height (ranging from about 31 to 45 feet NAVD88). Major culvert modifications, for water supply and flood risk management, were then accomplished in the 1970s.

In recent years, the HHD has experienced a high quantity of seepage through its embankment and foundation during periods of high reservoir elevations. This has required emergency remediation in some areas along the southeastern perimeter of the dike. The cause of the seepage and erosion is related to the materials and methods used in the construction of the dike and to the variable geology comprising the foundation of the dike system. The Corps, Jacksonville District, began reporting areas of vulnerability in the HHD in the mid-1980s. The primary compilation of information and documentation of the condition of the dike was prepared in the *HHD Major Rehabilitation Evaluation Report (MRR)* (USACE 2000). While the MRR analyzed the entire dike system to determine whether rehabilitation measures related to seepage and stability problems were warranted, it provided more detailed, site-specific information for the engineering analysis of Reach 1. The report recommended that while detailed plans and specifications to rehabilitate Reach 1 were being prepared, an MRR for reaches 2 and 3 should be initiated as a first step in addressing severe seepage and stability problems.

Upon receiving approval for the 2000 MRR from the Corps South Atlantic Division, a plan for rehabilitating the HHD in Reach 1 was developed, and construction began in December 2005. However, the plan for Reach 1 was developed before Hurricane Katrina's devastating impact on levees in New Orleans in August 2005. Even though construction had begun, it was concluded by the Corps that the lessons learned in Katrina's aftermath should be used to ensure that the HHD would continue to protect lakeside communities. Construction was halted, and Independent Technical Review (ITR) panels convened in 2006 and 2007 to further evaluate the rehabilitation design. Construction of the Reach 1 cutoff wall is almost complete, with the existing gaps between the wall and existing structures.

A Draft MRR and accompanying Supplemental EIS for the HHD, Reaches 2 and 3 was prepared and coordinated with the public in 2006. The MRR design concept included a cutoff wall in the center of the dike and a seepage berm that would incorporate lands outside of the existing HHD right of way. The plan was to be constructed in two phases, with the 2006 Draft Supplemental EIS addressing only Phase 1. However, as preliminary designs indicated, constructing the required seepage berm would have significant impacts on residential and commercial property, transportation networks, and would incur excessive real estate and construction costs. Therefore, the 2006 Draft Supplemental EIS for the MRR, Reaches 2 and 3, was halted to allow the project team to develop and analyze other rehabilitation designs that would meet all safety and engineering criteria while avoiding significant impacts to the greatest extent possible. Another risk reduction measure implemented was replacing or removing the 32 Federal culverts within HHD. This action had a signed Finding of No Significant Impact (FONSI) in 2010.

Because of the multiple investigations and rehabilitation efforts over the past 15 years, a holistic description of the overall level of risk, the complete scope of repairs and the resulting total project cost was unavailable. As a result, the Corps has focused study efforts since 2011 on completing a comprehensive evaluation of the entire HHD system, known as a Dam Safety Modification Study (DSMS). The DSMS effort has focused on updating hydrology, geology, geotechnical investigations, risk assessments, and consequence evaluations for the entire HHD to more comprehensively identify an overall risk picture, scope, and cost for remediating the entire HHD. This current Final EIS assesses the environmental effects of the rehabilitation of the HHD as developed in the DSMS.

As work on the DSMS has progressed, it became evident that the work that has been completed for Reach 1, while providing protection for lives and public safety did not fully reduce the risks of economic or social impacts in Reach 1. Modeling demonstrated that a breach in Reach 3 would inundate large portions of Reach 1. These areas together make up what is referred to as CIZ A in the DSMS. In lieu of waiting for the approval of the DSMS, and in order to expeditiously reduce risk for the public in Reach 1, a Supplement to the Reach 1 MRR and an associated EA/FONSI (2015) identified an additional 6.8 miles of cutoff wall in which to accelerate construction in 2017, therefore providing risk reduction measures to the community and environment.

1.5 PROJECT AUTHORITY

The Herbert Hoover Dike (HHD) is a component of the Central and Southern Florida (C&SF) Project for Flood Control and Other Purposes, and was constructed based on multiple authorizations and numerous associated construction contracts. Authorizations include the Rivers and Harbors Acts of 1930 and 1935, and Flood Control Acts of 1948, 1954, 1958, and 1968.

The River and Harbor Act of 1930, Public Law 71-520, authorized the construction of levees and other features, for protection from storm surge-induced flooding, along the north and south shores of Lake Okeechobee. Components authorized included:

- Improvements to the Caloosahatchee River and Canal from Lake Okeechobee to the Gulf of Mexico, to provide a 2,500 cubic feet per second (cfs) capacity outlet from Lake Okeechobee, and a 6 foot minimum water depth navigation channel.
- Improvements to Taylor Creek to provide a 6 foot minimum water depth channel from Okeechobee City to Lake Okeechobee.

- Protection works in the St. Lucie Canal for erosion control.

The River and Harbor Act of 1935, Public Law 74-409, authorized the Corps construction of multiple drainage structures in the levees and provided that the United States would be responsible for operation and maintenance of the levees and drainage structures.

The Flood Control Act of 1948, Public Law 80-585, created the C&SF Project and included authorization for the initial phase of the C&SF Project that included raising the existing levees and construction of additional levees along the northeast and northwest shores. Additional provisions included agricultural and municipal water supply, additional flood control, the preservation of fish and wildlife, regional groundwater control, salinity control, and navigation. Components included:

- Construction of levees, channels, and control works for Lake Okeechobee.
- Construction of major drainage of the Everglades Agricultural Area.
- Conservation of water for control of regional groundwater supplies.
- Protection of east coast urban areas from overflow from the Everglades.
- Flood and water control for salinity control in the existing east coast urban areas.
- Construction of main outlets for the water conservation areas.

The Flood Control Act of 1948 also required the United States to operate and maintain the levees, channels, locks, and control works of the St. Lucie Canal, Lake Okeechobee, and Caloosahatchee River and the main spillways of the conservation areas.

The Flood Control Act of 1954, Public Law 83-780, authorized the remainder of the C&SF project. These elements included:

- Additional flood control, water conservation, and navigation projects in the Upper St. Johns and Kissimmee River Watershed Basins.
- An increase in the outlet capacity of the Caloosahatchee River from Lake Okeechobee.
- Construction of the remaining levees for the Everglades Agricultural and Water Conservation Areas.
- Construction of the remaining salinity barrier in south Dade County.

The Flood Control Act of 1958, Public Law 85-500, provided additional authorization and modified the comprehensive plan to provide that the second phase of the project authorized by the Flood Control Act of 1954, non-Federal interests be required to contribute 20 percent toward the cost of contracts for construction plus supervision and administration thereof, to provide the necessary lands and relocations, to bear the cost of maintenance and operation of all works except those having to do with the regulation of Lake Okeechobee, and to hold and save the Federal Government free from damages resulting from project construction and operation.

The Flood Control Act of 1960, Public Law 86-645, authorized the name of all levees around the shore of Lake Okeechobee to be “Herbert Hoover Dike”, in honor of the former President and his role in implementing levee construction.

The Flood Control Act of 1968, Public Law 90-483, further authorized construction projects around the lake. Some of the components included:

- Construction of an interrelated system of canals, levees, pump stations, and other structures necessary to supply irrigation water, provide flood protection to St. Lucie and Martin Counties, and to maintain optimum water-control levels.
- Provisions to meet the long-term needs of urban and agricultural water users.
- Conservation and conveyance of additional water supply for the Everglades National Park (recreation and allied purposes) to include:

    1. Facilities for pumping excess water from east coast areas into storage component of Lake Okeechobee and water conservation areas.
    2. Construction of interrelated canals, levees, pump stations, and control structures for conveyance and distribution of water to demand areas.
    3. Deepening the navigation channel across Lake Okeechobee.
    4. Construction of recreation facilities.
    5. Raising Lake Okeechobee levees to increase the water levels 4 feet in regulation stage.
    6. Deletion of deepening of the St. Lucie Canal.
    7. Construction of a small craft locks at the Buttonwood Canal.

The Flood Control Act of 1968 authorized the raising of the Herbert Hoover Dike regulation schedules to increase the water levels 4 feet in regulation stage as described in House Document 369, Ninetieth Congress, 1968. House Document 369 used the criteria set forth in the Design Memoranda and the 1959 General Design Memorandum to determine the revised design levee heights for the Herbert Hoover Dike. The levees were never raised pursuant to this authorization.

Other Relevant Authorities Related to Dam and Levee Safety include:

- National Dam Safety Inspection Act of 1972, Public Law 92-367
- Water Resources Development Act of 1986, Title XII, National Dam Act of 1986, Public Law 99-662
- Water Resources Development Act of 1992, Public Law 102-580
- Water Resources Development Act of 1996, Public Law 104-303
- Dam Safety and Security Act of 2002, Public Law 107-310
- Dam Safety Act of 2006, Public Law 109-460
- Water Resources Development Act of 2007, Title IX National Levee Safety Program, Public Law 110-114

A more extensive discussion of authorities are presented in Appendix B – Authorities.

Design Memoranda

The plan of improvement authorized by the Flood Control Act of 1948 as described in House Document 643 Eightieth Congress, 1948, was very generic and conceptual and provided that the Chief of Engineers and the Secretary of the Army could make such modifications as in the discretion of the Secretary of the Army and the Chief of Engineers was advisable.

After approval of the C&SF Comprehensive Plan, Phase 1 in 1948, a series of Design Memorandums (DM), General Design Memorandums and Detailed Design Memorandums were completed by the Jacksonville District for the approval of various components of the Comprehensive Plan including for the Lake Okeechobee Regulation Schedule, the design heights and grades of the Herbert Hoover Dike levees, as well as Detailed Design Memorandum for each of the Structures which penetrate the HHD. The following are the Design Memorandums, General Design Memorandums, and Detailed Design Memorandums related to the Herbert Hoover Dike levees as approved by the Chief of Engineers authority pursuant to the 1948 Act (more detail is contained in Appendix B-Authorities).

Dated October 13, 1953 Part IV Supplement 2, Section 1 Storage Level In Lake Okeechobee At Beginning Of Critical Hurricanes, this DM sets forth the problems with accurate determination of the heights of the Lake Okeechobee levees and erosion protection to withstand the most severe combination of lake storage levels, wind tides, and wave action that is expected which included - accurate determination of the height required and erosion protection needed for Lake Okeechobee levees is of prime importance in project design. The factors governing the heights of levees required to contain Lake Okeechobee waters during critical periods were:

(1) Storage level of Lake Okeechobee at the beginning of critical hurricanes.
(2) Hurricane winds coincident with lake levels produced by severe floods.
(3) Wind tides produced by hurricanes.
(4) Wave action coincident with wind tides.
(5) Lake-regulating facilities.
(6) Resistance of levees to wave erosion.
(7) Critical combination of hydrologic and hydraulic factors affecting height of Lake Okeechobee levees.

The Chief of Engineers determined that a routing of the flood based on 125 percent of the 100-year rainfall be added in order that the information will be available for consideration when combinations of hydrologic events governing the Lake Okeechobee levee grades are selected.
The factors governing the heights of levees were further evaluated in the following DMs:

- Dated December 31, 1953 Part IV Supplement 2, section 2 Hurricane Winds Over Lake Okeechobee
- Dated January 12, 1954 Part IV Supplement 2, section 5 Lake-Regulating Facilities
- Dated August 12, 1954 Part IV Supplement 2, section 6 Resistance Of Levees To Wave Erosion
- Dated March 28, 1955 Part IV Supplement 2, section 5A Additional Lake-Regulating Facilities
- Dated July 26, 1956 Part IV Supplement 2, section 3 Wind Tides Produced By Hurricanes (Revised)
- Dated July 27, 1956 Part IV Supplement 2, section 4 Wave Action Coincident With Wind Tides (Revised)

The conclusions and recommendations contained in these DMs were then combined into General Design Memorandum entitled Part IV Supplement 2, section 7 Combinations of Hydrologic and Hydraulic Factors Affecting Height of Levees.

The 1959 General Design Memorandum (USACE, 1959-SUPPLEMENT 2, Section 7 entitled Combinations Of Hydrologic And Hydraulic Factors Affecting Height Of Levees) concluded that if Lake Okeechobee is to be operated as a multipurpose reservoir, a levee system which would protect developed areas and provide sufficient outlet capacity to permit the lake to be regulated within safe limits must be provided. It also discussed the hydrologic and hydraulic factors which are important in the design of lake levees and outlet channels are as follows:

a. Conservation storage needed to meet the water-supply requirements of the area with expected development.
b. Effect of existing and proposed outlets on lake levels during the floods of record, 100-year flood, and standard project flood.
c. Height of levees required to protect developed areas from wind tides, waves, and wave run up which could be expected if a major hurricane should occur.

The plan of improvement included construction of levees on the northwest and northeast shores of Lake Okeechobee and raising of existing levees. It was recommended that the design of project works be based on the following hydraulic conditions: probable maximum hurricane on a 17.5-ft pool, standard project hurricane on a 21.6-ft pool (the 30-day average 100-year flood stage at that time), and moderate hurricane on a 23.5-ft pool (the 30-day average Standard Project Flood stage at that time). All elevations are in the National Geodetic Vertical Datum 29 (NGVD 29) throughout this report unless otherwise noted.

1.6 LAKE OKEECHOBEE REGULATION SCHEDULES

Regulation of Lake Okeechobee from the early 1900s up through the authorization of the Central and Southern Florida Project (C&SF) in 1948 attempted to maintain the lake at water levels between elevation 12.56 to 15.56 ft., NGVD29 (11.26 to 14.26 ft., NAVD88). The 1948 C&SF project authorization did not specify what lake regulation schedule should be adopted. As agricultural development south of the lake and population growth along Florida's southeast coast burgeoned in the 1950s and 1960s, an increased reliance and draw on the lake for water supply encouraged water managers and decision makers to attempt to store more water in the lake by raising the lake regulation schedule. Incorporating additional hurricane studies and the effects of wind setup/wave run-up, design, and construction of the full-height HHD in the 1960s also influenced the decision to increase the water levels in Lake Okeechobee with a revised lake regulation schedule. In 1974, the regulation schedule was increased with operating ranges between 14.5 to 16 ft., NGVD29 (13.2 to 14.7 ft., NAVD88) and then again in 1978, with operating ranges between 15.5 to 17.5 ft., NGVD29 (14.2 to 16.2 ft., NAVD88). The RUN25 and Water Supply and Environmental (WSE) lake regulation schedules were implemented in 1994 and 2000, respectively, with the WSE formally incorporating forecast information such as tributary inflows and climate outlooks into the lake management process. The top of the flood storage pool varied between 17 ft., NGVD29 (15.7 ft., NAVD88) up to 18.5 ft., NGVD29 (17.2 ft., NAVD88) for both the RUN25 and WSE lake regulation schedules.

The current regulation schedule implemented in April, 2008 is called the Lake Okeechobee Regulation Schedule (LORS). Lake regulation schedules influence the stage-duration on the lake which has the most effect on antecedent lake stages prior to episodic flood events. One purpose of LORS implementation was as an interim HHD risk-reduction measure by attempting to maintain lower lake levels. LORS attempts to limit maximum stages on Lake Okeechobee to elevation 17.25

ft., NGVD29 (15.95 ft., NAVD88) as opposed to previous schedules which limited maximum stages to 18.5 ft., NGVD29 (17.2 ft., NAVD88).

A variety of lake regulation schedules have been utilized on Lake Okeechobee since authorization of the C&SF project in 1948. These regulation schedules have been summarized within Appendix B.

1.7 HHD ENVIRONMENTAL AND RELATED DOCUMENTS

Since 1999, numerous engineering designs and interim risk reduction measures have been proposed for rehabilitating the dike in Reaches 1, 2, and 3. Each one has been accompanied by an Environmental Assessment (EA) or an EIS. **Table 1-1** provides a summary of all NEPA documents that have been prepared for the HHD project. Each of the actions described in the NEPA documents have independent utility.

Table 1-1. Previous NEPA Documents for HHD Rehabilitation.

Type	Project	Title	Recommended Action	Decision
Draft EIS	Reach 1	Draft EIS for the Major Rehabilitation Report, HHD, Reach 1 (USACE, 2000)	Installation of a seepage berm with relief trench along the landward toe of the embankment.	Approved in 2000 contingent on economic revisions
Final EIS	Reach 1	Final EIS for the HHD Major Rehabilitation Report, Reach 1 (USACE, 2005)	Installation of a seepage cutoff wall on the landward side of the dike slope and a relief trench and relief berm at the toe of the dike, all within the current right of way.	Record of Decision signed on September 23, 2005
Draft EIS	Reaches 2 and 3	Draft EIS for the Major Rehabilitation Report, Phase 1, HHD Reaches 2 and 3 (USACE, 2006)	Installation of a partial cutoff wall at crest of dike and construction of a seepage berm within existing right of way	Cancelled by Notice in Federal Register (78 FR 8119) February 5, 2013
EA	Reaches 1, 2, and 3	EA of Modified Design in Reach 1 and Priority Toe Ditch Repairs in Reaches 1, 2, and 3 (USACE, 2007c)	(1) Installation of a cutoff wall at crest of dike, a partial seepage berm within existing right of way, and a drainage swale at toe of berm. (2) Backfill toe ditch for immediate repairs in the most critical areas. This document only assessed impacts within the existing right of way. A future NEPA document would assess impacts of the full seepage berm, which would extend outside of the existing right of way.	Finding of No Significant Impact, January 12, 2007

Type	Project	Title	Recommended Action	Decision
EA	Reach 1 and Sub-reach 1A	EA of Reach 1 Seepage Berm and Reach 1A Test Cutoff Wall (USACE, 2007e)	Installation of a demonstration cutoff wall at the crest of the dike in Reach 1A and a partial seepage berm within the existing right of way. A future NEPA document would assess impacts of the full seepage berm.	Finding of No Significant Impact, May 3, 2007
EA	Reach 1 and Sub-reaches 1B, C, and D	EA of Reach 1 Cutoff Wall with Addendum (Quarry) (USACE, 2008a)	Installation of a cutoff wall at crest of dike in Reach 1B, C, & D.	Finding of No Significant Impact, February 11, 2008
EA	Reaches 1 and 2	EA for Partial Reach 1 and 2 Ditch Backfill and Culvert 14 Removal (USACE, 2008b)	In Reach 1, assesses the impacts of removing Culvert 14 and filling the toe ditch in Focus Areas 1 and 6. In Reach 2, assesses impacts of filling in 9.5 acres of toe ditch.	Finding of No Significant Impact, August 28, 2008
Draft Supple-mental EIS	Reach 1A	Draft Supplemental EIS for the Major Rehabilitation Project, HHD Reach 1A (USACE, 2010)	Installation of a seepage berm, drainage swale, and relief wells outside of the existing right of way. Removal of Culvert 11 and replacement of Culvert 16.	Cancelled by Notice in Federal Register (78 FR 8118) February 5, 2013
EA	HHD Federal Culverts	EA for HHD Culvert Replacement and Removal	Replacement of 28 Federal culverts and removal of 4 Federal culverts.	Finding of No Significant Impact, May 13, 2011
EA	HHD Pilot Test	EA for HHD Alternative Rehabilitation Plan Pilot Test	To perform a pilot test to determine constructability and efficacy of alternative seepage collection systems and comparison to cutoff wall currently installed in Reach 1.	Finding of No Significant Impact, February 7, 2012
EA	Reach 3	EA for HHD Supplemental Major Rehabilitation Report	To perform maintenance on an existing Federal project and construction would occur within the Federal right of way.	Finding of No Significant Impact, June 15, 2015

1.8 RELATED PROJECTS

Comprehensive Everglades Restoration Plan (CERP), April 1999

The $10.9 billion CERP takes a watershed approach that builds upon and works with other state and Federal efforts to revitalize the wetlands, lakes, bays, and estuaries of south Florida. Considered the largest environmental restoration program in history, CERP is largely based upon a series of projects that would address four major characteristics of freshwater flow: quantity, quality, timing, and distribution.

The complex, multi-year undertaking has two distinct levels of activity:

- Program-level coordination fosters productive working relationships and understanding among the various Federal, state, local, tribal, and stakeholder partners involved in CERP implementation. In addition, other key activities that span the life of CERP include ongoing efforts such as data collection, computer modeling, studying the response of the natural environment to CERP activities, addressing recreational opportunities, and science, outreach, and economic issues.

- Project-level activities are the land acquisition, planning, designing, and constructing of more than 50 individual projects.

Once fully implemented, CERP would allow water deliveries and overland flow to follow patterns that are more natural throughout the south Florida ecosystem. The CERP reservoirs would store excess water from Lake Okeechobee, receive flood control releases that would otherwise go to the estuaries, and collect stormwater runoff from developed areas. The stored water would then improve high and low water levels in Lake Okeechobee; help meet environmental targets in the estuaries, Everglades, and other natural areas; and supplement urban and agricultural water supply. The integrity of the HHD could affect future lake levels and Lake Okeechobee's ability to store water for Everglades restoration.

Final Supplemental EIS on Lake Okeechobee Regulation Schedule (LORS), Lake Okeechobee, Florida, 2008

The LORS was approved by the Corps on April 28, 2008. This regulation schedule represents the best balance of project goals, including improving the environmental health of certain major ecosystems while providing for public health and safety. High lake stages approved under the previous schedule, called the Water Supply and Environment schedule, threatened the integrity of the HHD in its current condition. To avoid stressing the HHD when lake stages are high, large volumes of lake water have been released to Lake Okeechobee's two major outlets, the St. Lucie and Caloosahatchee estuaries, contributing to adverse effects in these ecosystems. Extended periods of high water levels in Lake Okeechobee have also resulted in significant losses of valuable habitat in Lake Okeechobee's littoral zone and marsh communities, including habitat for the endangered Everglade snail kite (*Rostrhamus sociabilis*). The LORS allows for quick response and operational flexibility to changing lake conditions and tributary inflows. The schedule improves the rates of flow to the coastal estuaries by allowing low rates of flow to begin earlier as the lake rises, which in turn helps reduce the need for higher flows later in the year. The LORS also improves the environmental health of Lake Okeechobee by reducing the frequency and duration of high lake elevations that affect Lake Okeechobee's shore zones and HHD stability.

South Florida Water Management District (SFWMD) Restoration Strategies Project

The SFWMD is required to meet a numeric discharge limit, referred to as the WQBEL, which is contained in the National Pollutant Discharge Elimination System (NPDES) permit for discharges from the stormwater treatment areas (STAs) into the ENP. The WQBEL was developed to assure that such discharges do not cause or contribute to exceedances of the 10 parts per billion (ppb) total phosphorus (TP) criterion (expressed as a long-term geometric mean [LTGM]) established under 62-302.540, Florida Administrative Code (F.A.C.). The TP criterion is measured at a network of stations across the ENP marsh and is intended to prevent imbalances of aquatic flora and fauna. The WQBEL is measured at the discharge points from each STA and requires that the total phosphorus concentration in STA discharges shall not exceed: 1) 13 ppb as an annual flow

weighted mean in more than three out of five water years on a rolling basis; and 2) 19 ppb as an annual flow-weighted mean in any water year. Excess phosphorus discharged into the ENP has caused ecological impacts within the Everglades.

To address water quality concerns associated with existing flows to the ENP, the SFWMD, FDEP, and USEPA engaged in technical discussions starting in 2010. The primary objectives were to establish a WQBEL that would achieve compliance with the State of Florida's numeric phosphorus criterion in the ENP and to identify a suite of additional water quality projects to work in conjunction with the existing Everglades STAs to meet the WQBEL. Based on this collaborative effort, a suite of projects has been identified that would achieve the WQBEL. The Restoration Strategies Regional Water Quality Final Plan (SFWMD 2012) describes those resulting projects and the evaluation tools and assumptions that were utilized in the technical evaluation. The projects have been divided into three flow paths (Eastern, Central, and Western), which are delineated by the source basins that are tributary to the existing Everglades STAs. The identified projects primarily consist of flow equalization basins (FEBs), STA expansions, and associated infrastructure and conveyance improvements. The primary purpose of FEBs is to attenuate peak stormwater flows prior to delivery to STAs and provide dry season benefits, while the primary purpose of STAs is to utilize biological processes to reduce phosphorus concentrations in order to achieve the WQBEL. The Eastern Flow Path contains STA-1E and STA-1W. The additional water quality projects for this flow path include an FEB in the S-5A Basin with approximately 45,000 acre-feet (ac-ft.) of storage and an STA expansion of approximately 6,500 acres (5,900 acres of effective treatment area) that would operate in conjunction with STA-1W. The Central Flow Path contains STA-2, and STA-3/4. The additional project is an FEB with approximately 60,000 ac-ft. of storage that would attenuate peak flows to STA-3/4, and STA-2. The Western Flow Path contains STA-5, Compartment C and STA-6. An FEB with approximately 11,000 ac-ft. of storage and approximately 800 acres of effective treatment area (via internal earthwork) within STA-5 are being added to the Western Flow Path. Based on the CEPP project objectives, only the Central Flow Path features are included in the CEPP modeling representation of the FWO project conditions. The FEB located within the Central Flow Path would be located on the A-1 Talisman site.

Central Everglades Planning Project (CEPP), 2015

The purpose of CEPP is to assess Federal and non-Federal interest in implementing components of CERP, which was authorized as a framework for restoring the south Florida ecosystem while providing for other water related needs of the region in the 2000 Water Resources Development Act (WRDA). Since CERP was approved, three projects were authorized in the 2007 WRDA and proceeded into construction (Indian River Lagoon-South, Picayune Strand, and Site 1 Impoundment) and a fourth project, Melaleuca and Other Exotic Plants Biological Controls, was implemented under the programmatic authority in WRDA 2000. Despite this progress, ecological conditions and functions within the central portion of the Everglades ridge and slough community continue to decline due to lack of sufficient quantities, timing, and distribution of freshwater flow into the central Everglades. Planning goals for CERP projects include enhancing ecological values and enhancing economic values and social well-being. Both goals were considered during the formulation of CEPP alternative plans, and project-specific objectives and constraints were established to evaluate the plans. In general, ecosystem restoration objectives focused on providing additional water to the Everglades by capturing freshwater discharges from Lake Okeechobee to the St. Lucie and Caloosahatchee Estuaries. Timing of deliveries and distribution of flows to the Everglades and improvements to water supply for municipal, agricultural, and Tribal use were also evaluated.

Kissimmee River Restoration and Headwaters Revitalization (in progress)
Acquisition of more than 100,000 acres of land needed for Kissimmee River Restoration and Headwaters Revitalization is complete. This project is scheduled to be complete in 2019. Once restoration construction is complete, 40 square miles of Kissimmee River and floodplain ecosystem would be restored including almost 63,000 acres of wetlands (38,000 acres of riverine floodplain and 25,000 acres of lake littoral zone) and 40 miles of historic river channel. The Kissimmee River Restoration project will allow more water to be stored in the Headwaters Lakes and will increase the frequency of out-of-bank, shallow sheet flow within the restored riverine floodplain. These features will affect the timing and duration of Kissimmee Basin flows to Lake Okeechobee, but the overall inflow volume to Lake Okeechobee will not change significantly.

1.9 APPROVALS

The proposed HHD repairs are subject to Section 401 of the Clean Water Act and would require Water Quality Certification (WQC) from the Florida Department of Environmental Protection (FDEP). This WQC will be obtained when more specific designs are completed. The proposed construction activity will require an Environmental Resource Permit (ERP) to be obtained from the Department, under the authority of Part IV of Chapter 373, Florida Statutes (F.S.).The proposed work also requires a Coastal Zone Management Act consistency evaluation (Appendix D). A Section 402 NPDES permit is required for construction activities disturbing more than one acre of land. All permits would be acquired prior to construction. Drainage connections and utilities will be coordinated with the Florida Department of Transportation (FDOT), as appropriate.

1.10 DECISION TO BE MADE

This Final EIS assesses the environmental impacts of the Recommended Plan for the DSMS for rehabilitating the HHD. The Recommended Plan is a combination of structural and non-structural features with varying design across segments based on specific failure modes. The Recommended Plan includes remediation focused on segments exhibiting intolerable probability of failure and significant consequences of a breach as discussed in Section 2. Other alternatives considered during the plan formulation process included the following: no action, dam (HHD) removal, dam replacement, and a spillway. These alternatives are discussed in Section 2. The environmental effects of the No Action (future without project) Alternative and the Action Alternatives will be discussed in Sections 4 and 5 respectively.

2.0 ALTERNATIVES

2.1 PAST PLAN FORMULATION FOR HERBERT HOOVER DIKE (HHD) REHABILITATION

In the evolution of this project, many alternatives to modify, upgrade, and rehabilitate the HHD have been developed and evaluated. Previous HHD NEPA documents (see **Table 1-1**), have outlined the plan formulation process and that information is incorporated by reference into this document. Most recently, a summary of the plan formulation effort and previous alternatives considered has been summarized in the Draft EIS for Reach 1A (USACE 2010). This summary is incorporated by reference into the current Final EIS. This section summarizes the alternatives for rehabilitating the HHD that have been developed through the DSMS. The concepts and lessons learned in the development of rehabilitation designs for Reach 1 (the first of the HHD reaches to receive comprehensive evaluation) have been used to develop alternative designs for the remainder of HHD.

Past HHD studies divided the HHD into eight reaches. The DSMS, using geology of the HHD, divided the HHD into 32 segments for analysis (**Figure 2-1**). These segments were then combined to create common inundation zones (CIZ) for use in formulating the Recommended Plan (**Figure 2-2**).

2.2 CURRENT PLAN FORMULATION FOR HHD REHABILITATION

HHD risk management plan formulation was conducted to identify Alternatives that meet or partially meet the objectives of the study, avoid violating identified concerns and arrive at an efficient solution to failure modes that pose unacceptable risks to the public. Risk Management Plans (RMPs) are composed of structural and non-structural risk management measures that address one or more significant failure modes. During formulation, multiple risk management measures were considered and evaluated to identify a subset of efficient and effective measures as described in the following section.

The formulation, evaluation, and comparison of alternative RMPs progressed in a systematic approach aimed at identifying and screening a wide suite of preliminary risk management measure solutions, molding the retained risk management measures into an initial suite of alternatives, the initial array to identify the final array of alternatives, and evaluating and comparing the final array to identify a Preferred Alternative, also referred to as the Recommended Plan (Recommended Plan) throughout this report. As formulation progressed, the evaluation criteria increased in complexity and transitioned from qualitative analysis to quantitative analysis.

Multiple risk management measures (measures) were considered and screened to identify a subset of efficient and effective measures that serve as the building block of alternative RMPs. These measures were identified as a means to reduce risk by either:

- reducing the loading on the dike
- reducing the likelihood that the dike would fail
- reducing the consequences if a breach occurs

The initial suite of alternative RMPs for HHD are composed of combinations of retained structural and/or non-structural measures that address each significant failure mode. Alternative RMPs (alternatives) are broadly categorized into three different concepts that adopt retained measures

to form an initial array of Alternative RMPs that provide holistic risk solutions. Formulation of alternatives follows these three concepts as described in the following section:

I. System-wide structural remediation
II. System-wide non-structural solutions
III. Segmental structural and non-structural solutions

Risk assessment, risk reduction, and the formulation of structural remediation alternatives for HHD were analyzed for the 32 identified segments delineated by similar geologic conditions and embankment configurations, ground surface elevations and downstream consequences. Common Inundation Zones (CIZ; **Figure 2-2**) were also assembled based on combining segments (**Table 2-1**) that share similar inundation patterns following a breach, which lead to common economic, social and environmental consequences.

The initial array of Alternative Risk Management Plans was evaluated using both qualitative and quantitative screening criteria, and alternatives were eliminated from further consideration based on their ability to meet tolerable risk guidelines, cost effectiveness, economic and environmental impacts, and excessive implementation time. The results of this evaluation are the final array of alternatives.

The final array of Alternative Risk Management Plans (Alternatives) was then evaluated and compared based on cost, cost-effectiveness, reduction in risk, essential USACE guidelines, and meeting DSAC V objectives (tolerable residual risk and meeting essential USACE guidelines) to identify the recommended plan.

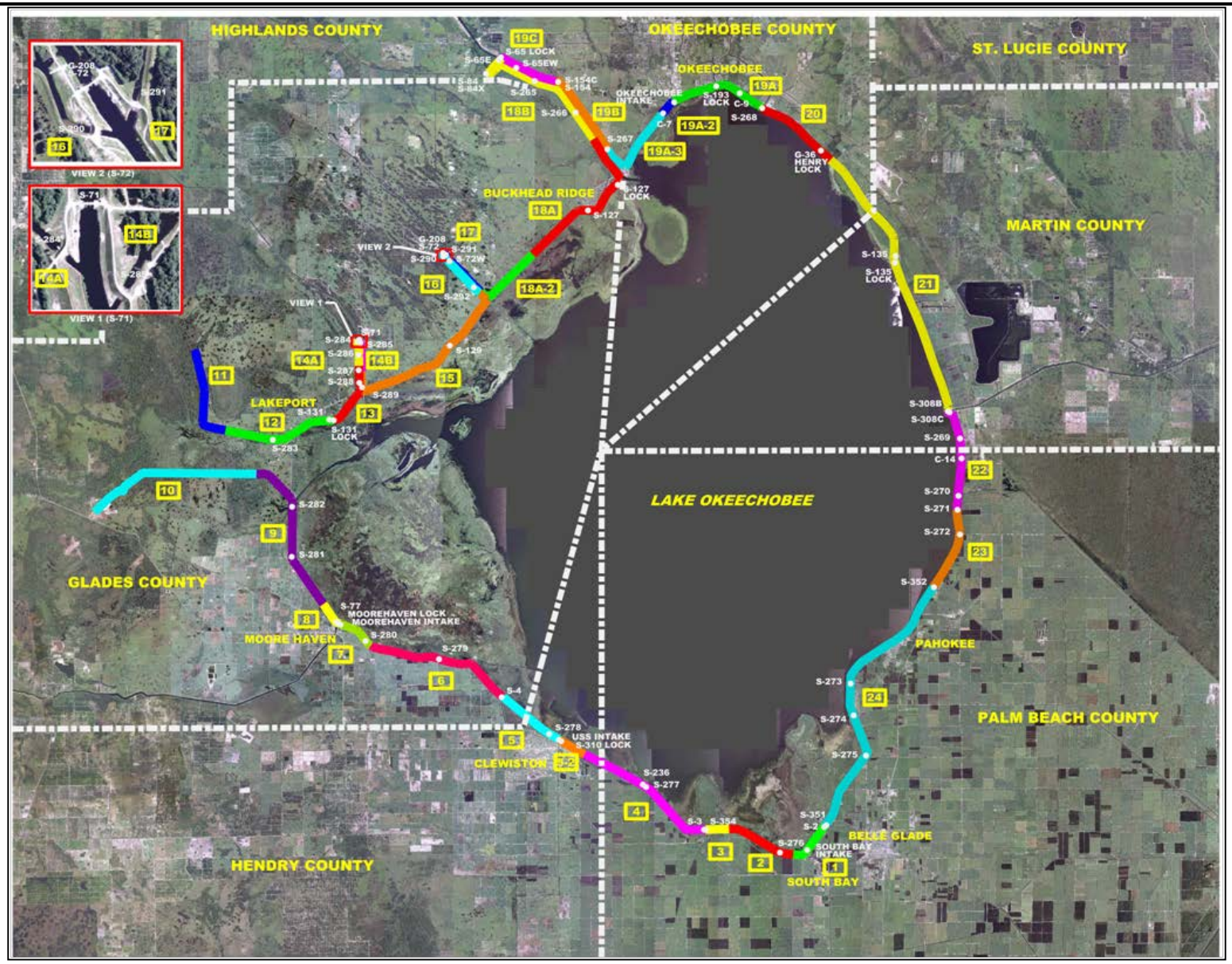

Figure 2-1. HHD Segment Map

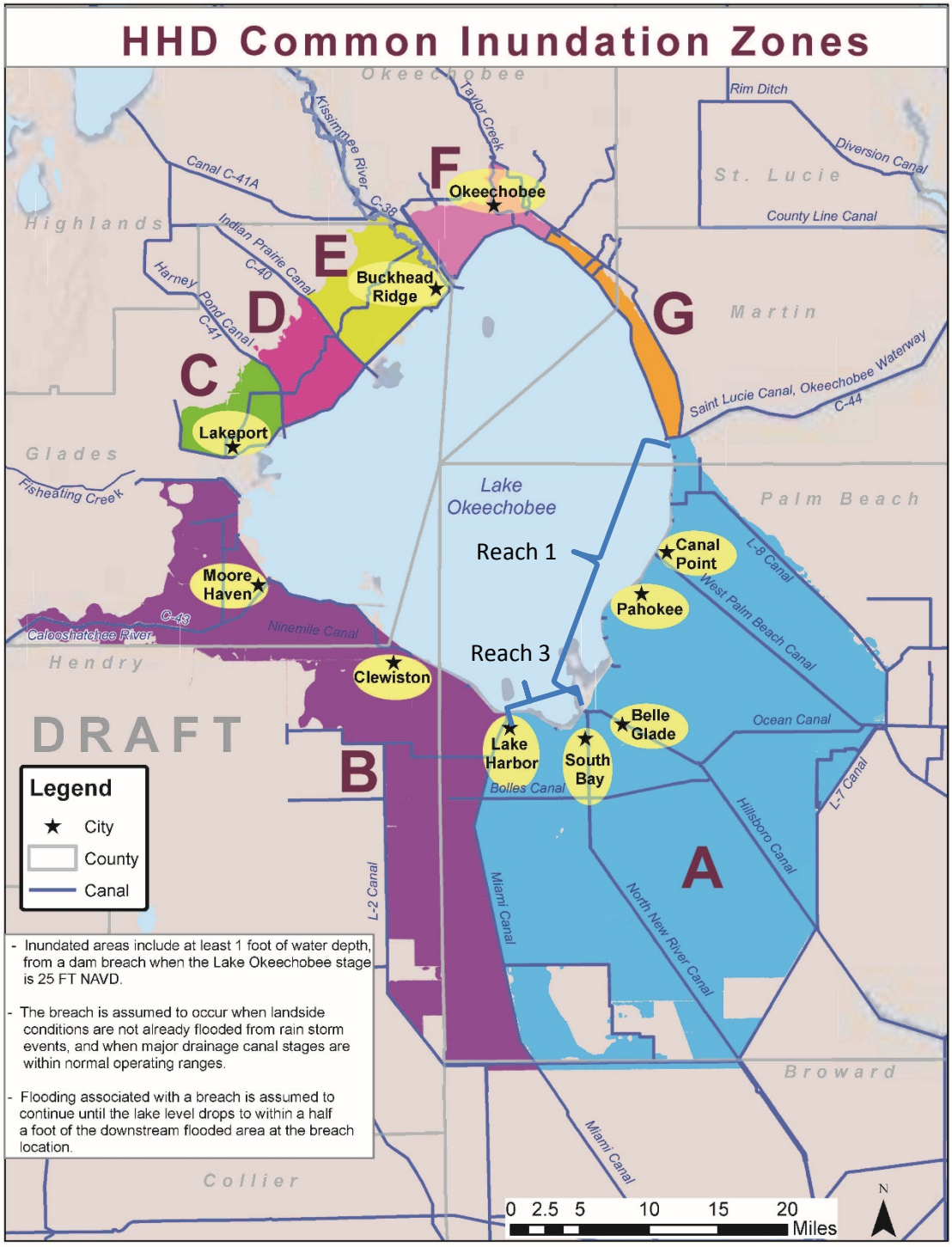

Figure 2-2. Common Inundation Zones for Economic and Environmental Impacts for Lake Stages at 25ft NAVD

Table 2-1. Common Inundation Zones (Zone) and Segments with HHD Reaches.

Zone	Segment	Reach
A	22, 23, 24, 1, 2, 3	1, 3
B	4, 5, 5-2, 6, 7,8, 9, 10	2, 4
C	11, 12, 13, 14A	6
D	14B, 15, 16	6
E	17, 18A, 18A-2, 18B	8
F	19A, 19A2, 19A3, 19B, 19C	5
G	20, 21	7

2.3 ALTERNATIVES

An initial array of alternatives was established by combining retained management measures with the intent of meeting three overarching concepts established for plan formulation:

I. System-wide structural solutions to reduce loading on the dike
II. System-wide solutions that are non-structural in nature
III. Structural and non-structural solutions at the segment level

The initial array of alternatives includes the five required alternatives specified in Engineering Regulation (ER) 1110-2-1156. Additional plans were developed to ensure that economically, socially, and environmentally justified alternatives were identified. The required alternatives include the following:

- No Action
- Reducing risks to tolerable levels and meeting applicable essential USACE guidelines (To meet USACE essential guidelines means to correct for all deficiencies from current state of the practice design guidance in the areas recommended for remediation.)
- Reducing risks to tolerable levels
- Remove Structures
- Replace Structures

Figure 2-3 displays the initial suite of alternatives considered for remediating HHD. The alternatives shaded in green represent the five required plans and the alternatives shaded in white were additional alternatives identified.

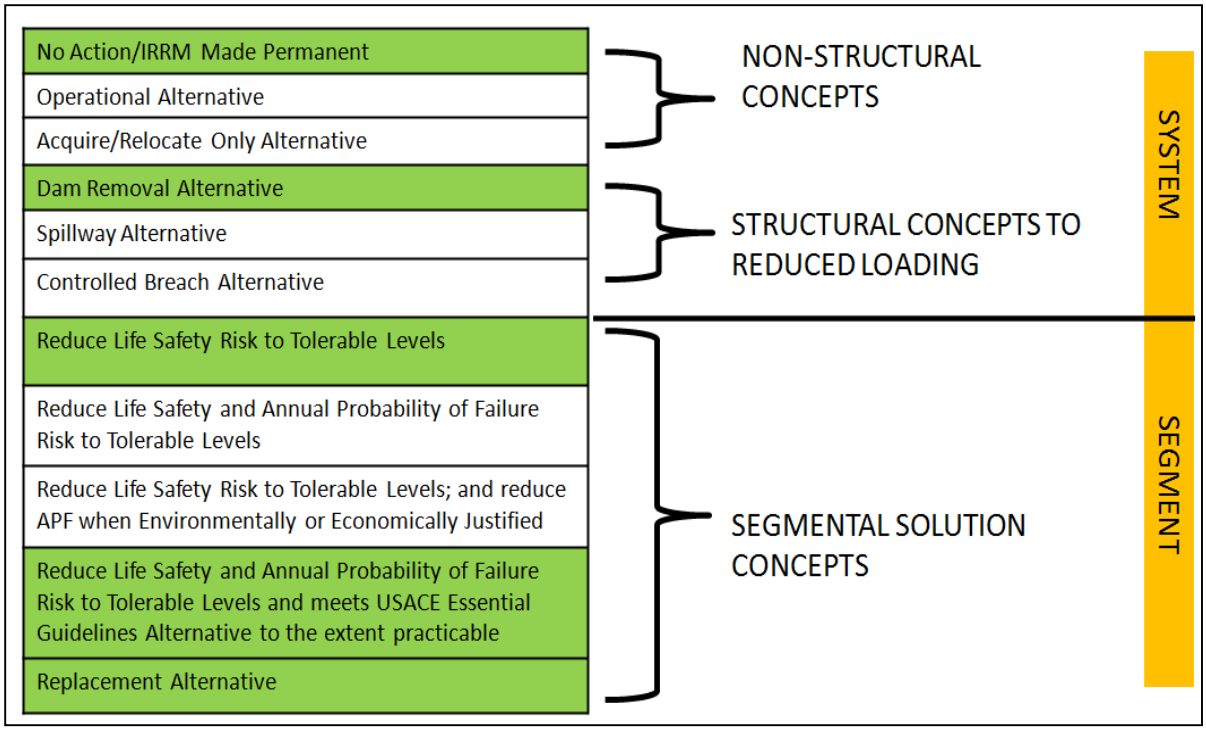

Figure 2-3. Overview of Initial Array of Alternatives

2.3.1 No Action Alternative

Evaluation of the No Action Alternative, also known as the future without project condition, is a requirement of NEPA regulations. The No Action Alternative is defined as not taking actions to improve the existing system. This alternative assumes the lake is operated according to the current regulation schedule (Lake Okeechobee Regulation Schedule, LORS 2008). The schedule is intended to contain the lake stage within a band that best satisfies the C&SF Project flood damage reduction, water supply, navigation, and environmental objectives, while reducing the likelihood of a lake stage that could cause dam failure. The baseline risk assessment demonstrated that, even with the loading restrictions imposed by the current regulation schedule, the existing risk is still well above tolerable risk guidelines. This plan offers no opportunity to restore authorized project benefits or reduce risk to tolerable levels.

Without improvements to the HHD embankment, the safety of the surrounding human and natural environment may be severely impacted with subsequent effects upon the local and regional economies. The No Action Alternative does not provide a long-term solution to the potential for internal erosion throughout the system. Under this alternative, the continued occurrence of seepage and piping would increase the likelihood of a dike failure. The term "dike failure" implies a catastrophic breaching of some portion of the HHD system. This would result in widespread flooding as waters from Lake Okeechobee pass through the breach and onto adjacent lands. A failure could be initiated by the continuous uncontrolled seepage of water from one side of the dike to the other. If seepage increases to a rate that displaces material from the dike or its foundation, piping could eventually create large voids through the dike embankment or foundation. If the voids become large enough, the dike would weaken, and sections of the embankment could collapse. Such a collapse would reduce the embankment crest elevation in

the immediate area to a point where lake water would overtop the dike. At that point, lake water flowing through the breach would be uncontrollable, levee erosion would continue, and adjacent areas would flood. In the event of a total breach, significant impacts to human life, wildlife, agriculture, property, vegetation, and water resources would result. The No Action Alternative would not provide an acceptable level of flood risk management for nearby communities. Additional expectations in the future without project condition include: limited changes in land use and structure inventories, enhanced warning systems as a local responsibility, greater public awareness and education, and more effective evacuation planning. The No Action alternative is retained for further analysis in this DSMS and used as a baseline of comparison among the other alternatives.

2.3.2 System-Wide Structural Alternatives

Three of the following system-wide structural alternatives focus on reducing the loading on the dike. The fourth system-wide alternative does not change the loading, but includes a complete replacement of the entire dam that would meet current USACE standards for embankment dams.

2.3.2.1 Dam Removal Alternative

This alternative includes removal of some portion(s) of the dike, or water control structures, such that the dike no longer retains a permanently impounded pool. Because the dike and its associated water control structures are integral components of the C&SF Project, this plan would require deauthorization of major portions of the C&SF Project. Without the dike, major portions of the C&SF Project cannot function as intended. According to the FY14 Corps Annual Civil Works Budget, the C&SF project produces over $225M in annual flood risk management benefits. The majority of that benefit is derived from lake stages above the 100-year storm event stage. As little as 20% of these benefits would still accrue, primarily from C&SF project components north of the lake, in the absence of the dike.

Based on analysis performed to route inflow volume that would result in a lake stage of 24.5 feet (the maximum inflow volume that would need to be passed to reduce both annual probability of failure and societal risk estimates to tolerable levels), the dam removal alternative includes the degradation of a 1.0 mile portion of the dam in Segment 2 to a crest elevation of 9.50 ft. NAVD88. The resulting peak lake stage during this inflow event was 12.29 ft. NAVD88, which would meet risk reduction objectives. The downstream area required to: 1) sufficiently capture discharges from this inflow volume, and 2) meet the desired downstream pool depth (depth of 6ft or less to allow emergent vegetation to dampen wind effects) resulted in use of lands between the North New River Canal and Miami Canal, as well as land east of the North New River Canal. This plan includes levee modifications to the Miami Canal, North New River Canal, L-5 Canal, L-6 Canal, L-15 Canal, and the L-16 Canal. Additionally, reconstruction of a portion of US Hwy 27, including a 1.0 mile bridge along HHD to allow water through the roadway corridor; relocation of a railroad that traverses the retention area; demolition of an existing industrial complex; and remediation of soil contaminated with agriculture industry chemicals will be required. Acquisition of real estate, relocation of public infrastructure, construction of additional levees, installation of pump stations, and water quality treatment would all be required for this alternative. The estimated real estate cost would be similar to the real estate costs for the controlled breach and the spillway/retention area alternatives, $1.6 to $1.9 billion. Construction costs would be additional.

The Dam Removal Alternative (**Figure 2-4**) is not pursued further because of the high cost, time to implement, and the significant adverse impacts to the benefits provided by Lake Okeechobee and the entire C&SF Project.

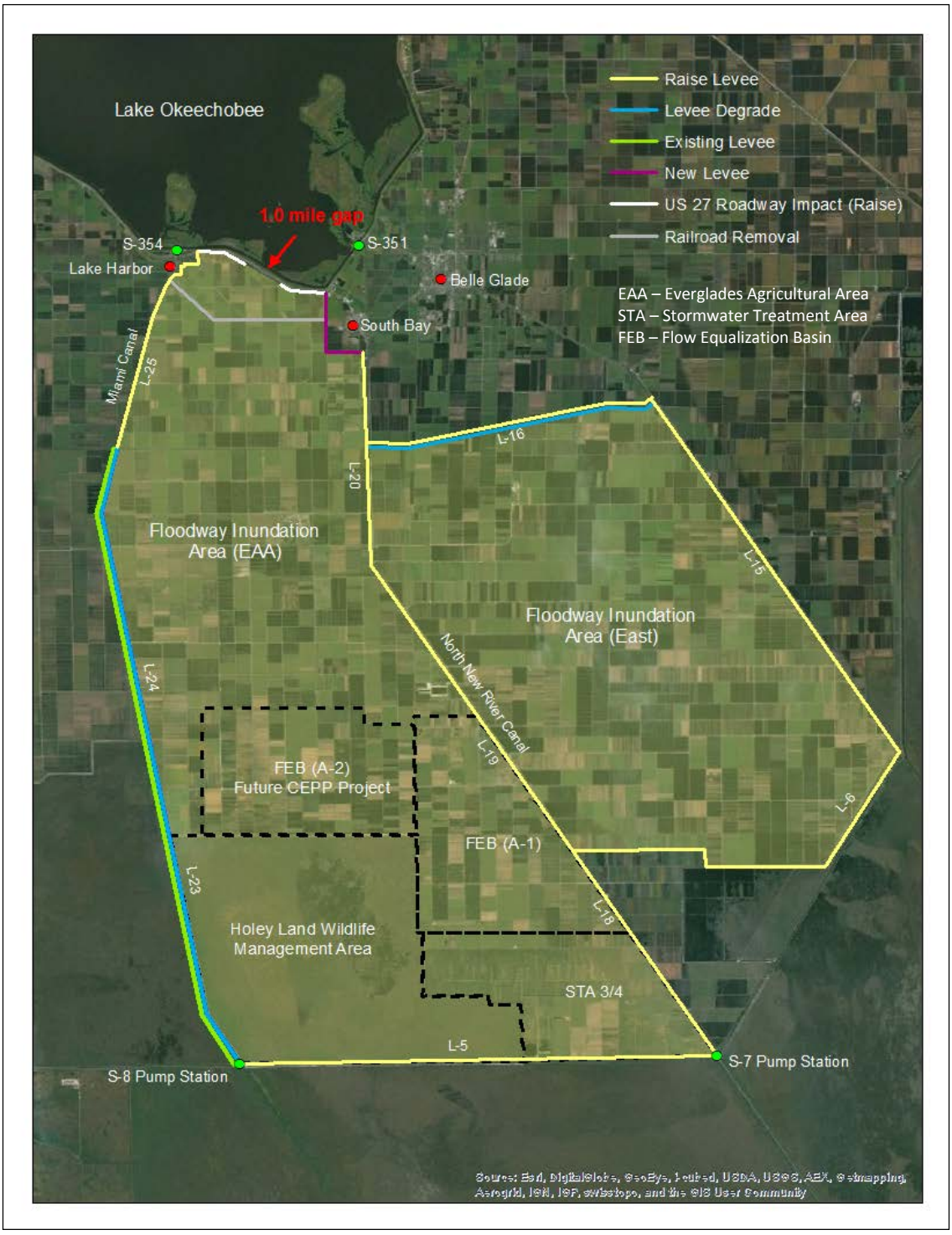

Figure 2-4. Conceptual Dam Removal Alternative

2.3.2.2 Gated Spillway and Retention Area Alternative

This plan includes the construction of a multi-bay bottom-hinge gated spillway (crest elevation 14.0 ft. with gate closed (in "up" position) and 10.5 ft. with gate open (in "down" position)) and an 89,000 acre downstream water retention area (**Figure 2-5**). The Lake Okeechobee pool stage requirement is the same for the spillway option as described in the Dam Removal - the maximum stage was established as 15.50 ft. NAVD88. Such a pool restriction is expected to reduce risk to tolerable levels, while preserving C&SF water supply and navigation benefits, and having only minimal adverse effects on the existing lake ecology. This plan would require reauthorization of major portions of the C&SF Project. The spillway configuration reduced the Lake Okeechobee stage to 15.94 ft. NAVD88 during the modeled inflow event.

The retention area would be formed by levee modifications adjacent to the Miami Canal, the North New River Canal, and Holey Land, and new levee construction near the town of South Bay, and partial levee degrading along the Miami Canal north of Holey Land. This plan also includes reconstruction of a portion of US Hwy 27, including a new 1,000 ft. bridge to allow water through the roadway corridor; relocation of a railroad that traverses the retention area; demolition of an existing industrial complex; and remediation of soil contaminated with agriculture industry chemicals. This plan is intended to preserve the function of the State's existing Stormwater Treatment Area 3/4 and future A-1 Flow Equalization Basin, although the infrastructure modifications required to do so have not been investigated. The estimated real estate cost would be similar to the real estate costs for the dam removal and controlled breach alternatives, $1.6 to $1.9 billion. Construction costs would be additional.

The gated spillway alternative is not pursued further in this DSMS because of the high cost and time to implement, and the significant adverse impacts to portions of the C&SF Project south of the retention area.

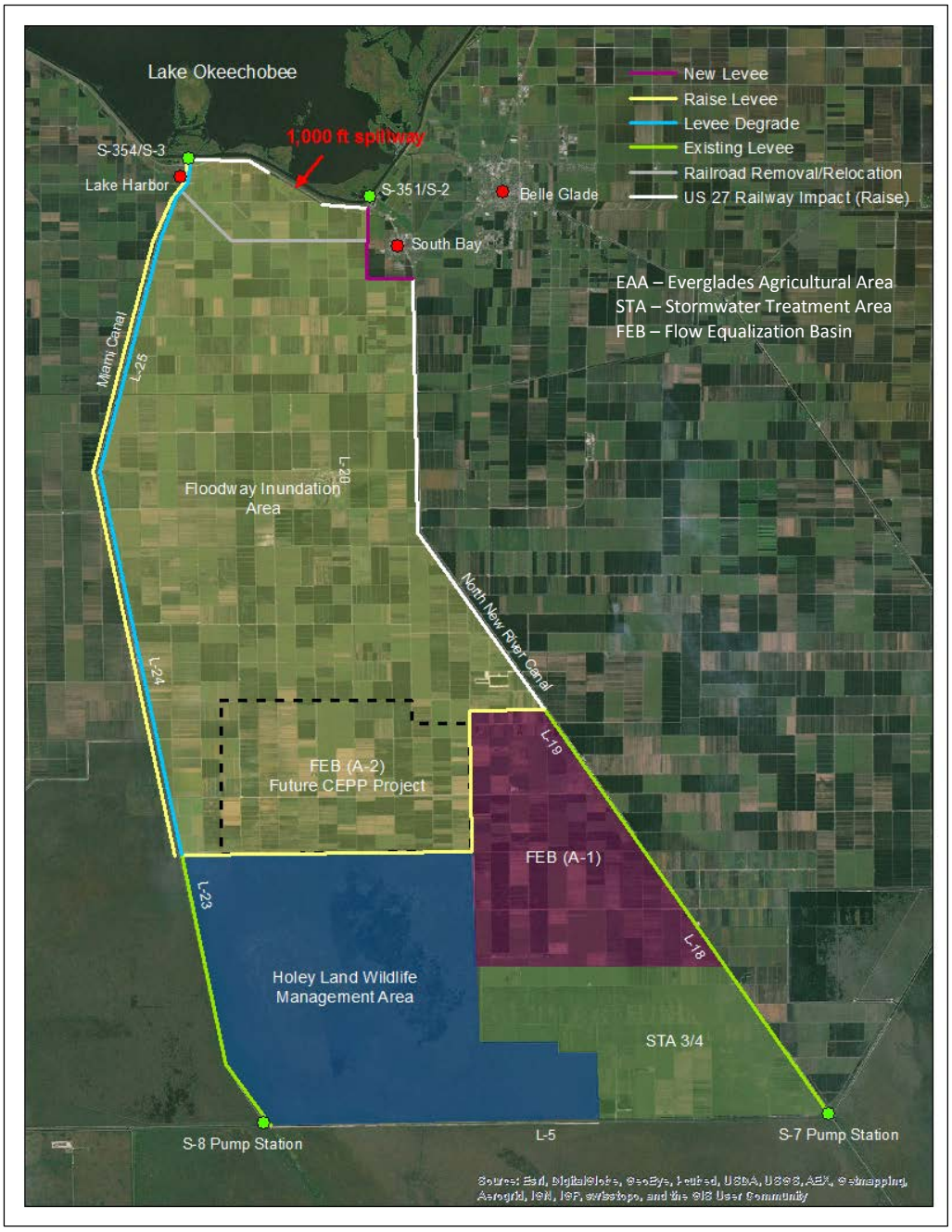

Figure 2-5. Conceptual Spillway and Retention Area Alternative

2.3.2.3 Controlled Breach and Retention Area Alternative

This plan includes deliberately breaching the dam at a predetermined location that would result in no/low potential for life loss and low economic damages to preclude a breach in a location that would result in a much higher consequences. This plan differs from the Dam Removal Alternative in that the this plan is based on a scenario in which an internal erosion failure has progressed, intervention has failed, and a breach would occur within 24 to 36 hours absent a rapid drop in lake stage. This plan requires that within a short notice period (2-3 hours), local law enforcement clear the Population At Risk (PAR) from the predetermined impacted/inundation area and re-

route all traffic accordingly. The proposed controlled breach location is the same as the new service spillway, to take advantage of a low-lying downstream agricultural area that would serve as a breach flood getaway and temporary retention area, assuming required flowage easements are secured. The breach width necessary to lower the reservoir from 25 ft to 18 ft NAVD 88 within 24 hours is estimated to be 3.75 miles.

Although this plan offers an opportunity to reduce risks, it does not reduce risk associated with a wind-driven wave overwash failure. For internal erosion failure modes, this plan may not reduce individual risk to within tolerable guidelines, meaning that, despite the efforts of local law enforcement, transient PAR would likely remain in the inundation area. This alternative also assumes that the control breach would undoubtedly prevent an additional uncontrolled breach at the progressing failure mode location. It is likely that by the time the breach was determined to be imminent at a progressing failure mode location, a controlled breach of the dam at a different location would not progress and reduce reservoir loading quickly enough to stop the progressing failure.

Downstream property damages are not well defined and would likely include damages to US Hwy 27 (emergency and interior hurricane evacuation route for south Florida region), a railroad, an existing industrial complex, and others. In addition to infrastructure damage, indirect damages include economics of the region with loss of crops and flooded quarries for an extended period of time (e.g. months to a year), as well as catastrophic environmental damages to a sensitive and unique ecosystem currently holding hundreds of millions of dollars in sunken Federal and state capital investments. Potentially, flood damages may occur elsewhere within the C&SF system as the main floodwater storage components of the system (Lake, Water Conservation Areas, future reservoirs) would be strained with dewatering of the flooded EAA area for up to a year (e.g. lack of pumped water storage, excess seepage from the conservation areas over long duration, canal storage, etc.).

Based on a screening level evaluation, this plan was eliminated from further consideration. Although major consequences have been noted here, there are various other consequences that would further justify the final decision to eliminate breaching the dike in a deliberate manner.

2.3.2.4 Dam Replacement Alternative

This alternative includes replacing the existing dam with a new dam, built in increments, along the same alignment. Existing embankment material would be reused to the extent practical. This plan would require reauthorization of major portions of the C&SF Project. Dam replacement may require multiple decades to complete, with an estimated construction cost of $15B.

The Dam Replacement Alternative is not pursued further because of the high cost and time to implement.

2.3.3 System-Wide Non-Structural Risk Management Plans

System-wide alternatives were formulated to determine if solutions other than rehabilitation of the dike existed to satisfy the risk reduction objectives.

2.3.3.1 New Lake Okeechobee Regulation Schedule Alternative

Several Lake Okeechobee regulation schedules were considered to determine if a change in the lake regulation schedule could significantly reduce the loading on the dam, and therefore the necessary rehabilitation. **Figure 2-6** depicts Lake Okeechobee Regulation Schedule 2008, developed to satisfy flood control, water supply, environmental requirements, and dam safety concerns.

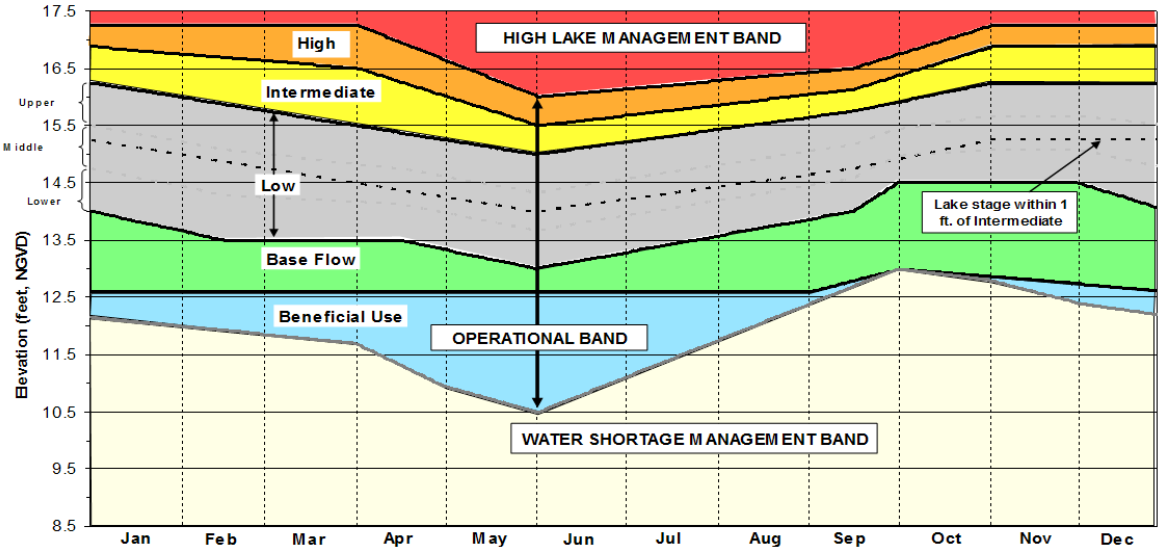

Figure 2-6. Lake Okeechobee Regulation Schedule 2008

As part of the HHD Major Rehabilitation Report 2000, a stage-frequency analysis was conducted that demonstrates that, even with an initial lake stage of 9.1 ft. (NAVD88), the Standard Project Flood (SPF) event results in a peak lake stage of 23.7 ft. (NAVD88). This situation is caused by a large volume of water that flows into the lake during an SPF event combined with a limited lake discharge capacity. Therefore, implementing a modified operational schedule would not significantly reduce lake stages during large storm events, and this alternative was screened from further consideration from the DSMS.

More recent hydrologic modeling using the MCRAM methodology also demonstrates that the LORS has limited ability to reduce the peak SPF on the lake versus prior regulation schedules. **Figure 2-7** and **Figure 2-8** show a peak SPF stage of el. 22.8 ft., NGVD29 (el. 21.5 ft., NAVD88) and el. 23.7 ft., NGVD29 (el. 22.4 ft., NAVD88) for the current LORS (2008-present) and RUN25 (1994-2000) lake regulation schedules, respectively.

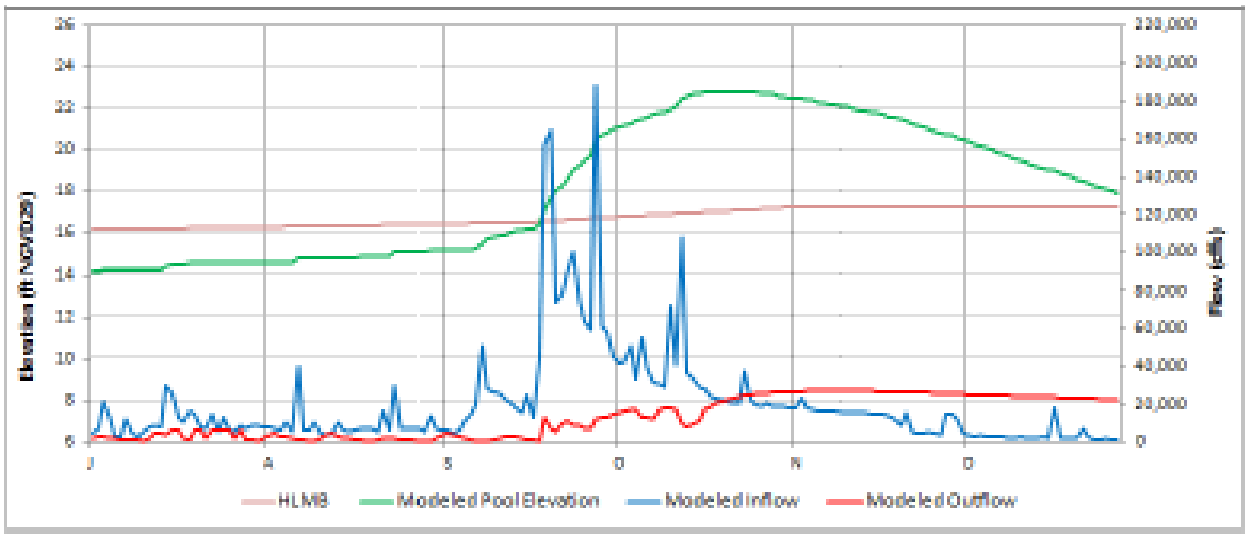

Figure 2-7 . Lake Okeechobee SPF Stage Hydrograph Using the MCRAM Methodology and LORS Schedule

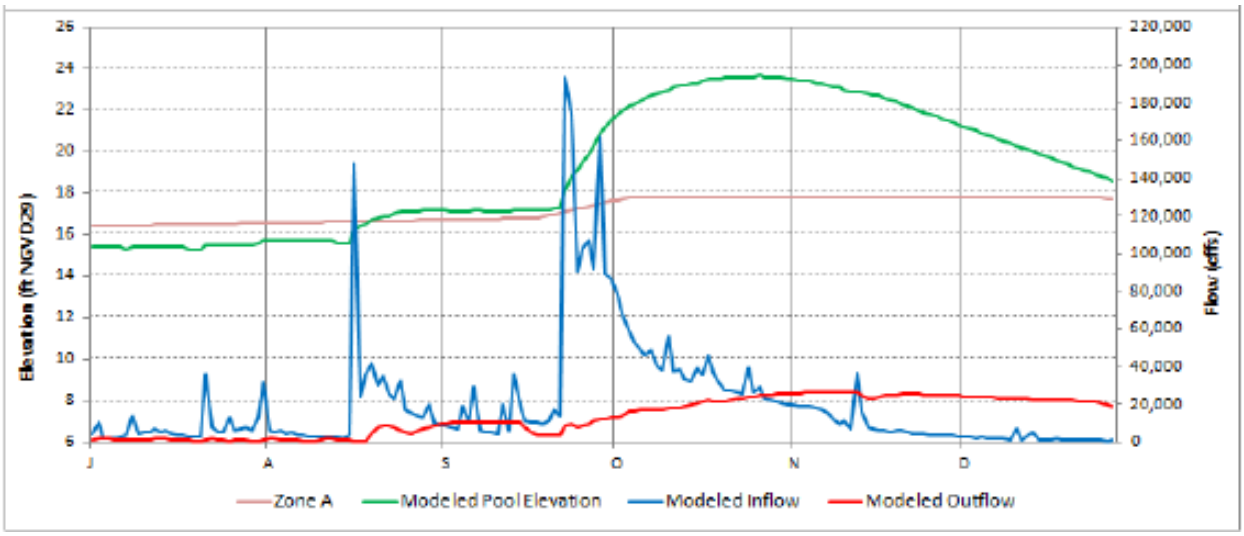

Figure 2-8. Lake Okeechobee SPF Stage Hydrograph Using the MCRAM Methodology and RUN25 Schedule

2.3.3.2 Relocate Population at Risk Alternative

Non-Structural Measures (relocation)

While structural measures only reduce the probability of failure, non-structural measures are designed to reduce the consequences of failure by relocating people. Though the NED impacts of relocation are expected to be minimal, many RED impacts must be considered, including:

- Potential Loss of Employment
- Potential Loss of Business Revenue
- Loss of Tax Revenue
- Loss of Regional Competiveness and Diversity
- Indirect Economic Impacts
- Induced Economic Impacts

In addition to these RED impacts, Other Social Effects (OSE) should be considered as well:

- Health and Safety: Defined as the perception of personal and group safety. If some people are relocated while others are not, the remaining population at risk may feel unsafe and vulnerable.
- Economic Vitality: Defined as quality of life. Buyout or flood proofing could decrease the quality of life or the perception of quality.
- Social Connectedness: Defined as community's social networks that provide meaning and structure. Relocations could result in a negative impact on social connectedness.
- Identity: Defined as community's member's sense of self. Relocations could result in a negative impact on a community's sense of identity.
- Social Vulnerability and Resiliency: Probability of a community being damaged or negatively affected by hazards and its ability to recover from a traumatic event. The non-structural measures should decrease social vulnerability and increase resiliency.
- Participation: Defined as community member's ability to interact and influence social outcomes. Community participation in the planning process (through the NEPA process) should prevent negative impacts on social participation.
- Leisure and Recreation: Defined as the amount of personal leisure time available and whether community members are able to depend it in preferred recreational pursuits. Permanent easements over some areas could have an impact on the availability of recreational opportunities.

The relocation of the structure inventory in the area of inundation from potential breaches, when the lake stage is the PMF stage, is estimated to cost approximately $18.4 billion. This cost is considered prohibitive. From a system perspective, the relocation of populations from around the entire dam is considered too costly, and would be unacceptable to the public. A relocation alternative was screened from further analysis for this reason.

2.3.4 Segmental Risk Management Plans

While system-wide solutions are geared towards universally remediating the failure modes in the dike, segmental solutions are based on the understanding that different failure modes exist in discrete areas of the dike, therefore, different solutions may be more appropriate for one area than another. As previously described, the dike was divided into thirty-two segments (**Figure 2-1**) for which performance of adjacent lengths are considered statistically independent. Alternative plans were formulated and evaluated for each segment based on their measured success at meeting the Federal objective of identifying a risk management plan that supports the expeditious and cost effective reduction of risk within the overall Corps portfolio of dams and satisfying or partially satisfying specific study objectives of:

1. Reduce societal life safety risks to tolerable levels for the entire system with the least cost/technically acceptable solution
2. Reduce societal and individual life safety risks and the probability of failure to tolerable levels for the entire dam (holistic solutions) with the least cost/technically acceptable solutions
3. Comply with essential USACE guidelines with cost effective solutions to the extent practicable

Formulation of alternatives by segments followed a series of steps to identify solutions that satisfy tolerable risk guidelines for both the segment and CIZ.

Step 1: The risk assessment of each segment for both existing and future without federal action conditions (FWAC)/No Action was examined to identify where formulation of risk reduction measures is needed.

The first criterion in identifying minimally acceptable alternatives pertains to remediating areas of the dike where the risks of public safety and loss of life is intolerable. Since societal life loss is paramount to the Dam Safety program, a conservative approach was taken to account for uncertainty and formulate any segment without considering the potential for human intervention to detect and stop progression of a failure mode prior to breach. At a minimum, all alternatives in the final array would reduce risks to greater than an order of magnitude below societal life safety Tolerable Risk Guidelines (TRGs).

Segments 5-2, 8, 12, and 13 all present societal life safety risks that were determined to be intolerable.

The second criterion examined the probability of a dike breach occurring in any given Segment on an annual basis. Contrary to the formulation of segments for societal life loss and public safety, a less conservative approach was taken when formulating solutions based on the annual probability of a dike failure and consideration for possible intervention was included. Intervention would occur if a failure mode were detected and active flood fighting took place to prevent breach (as has occurred historically at HHD and at similar facilities).

Segments 4 through 9, 12, and 13 are all considered to have an annual probability of failure from internal erosion failure modes that causes concern and are included in the formulation of alternatives.

Structures S-71, S-72, and the SR 78 Harney Pond Canal Bridge crossing also cause concern for an overtopping driven failure due to low dike elevations at these points. The remediation of these structures (articulated concrete block armor and/or floodwall) is included in all of the alternatives as the cost of remediation is low when compared to the economic, social, and environmental damages that would occur from a breach at these locations.

Step 2: In addition to formulating solutions at the segment level, alternative formulation then focused on identifying combinations of segmental measures within CIZs in order to reduce the probability of a breach, and the resulting economic, social, and environmental risks to tolerable levels for the entire zone. As previously described, common economic, social, and environmental impacts would occur due to overlapping inundation patterns that occur for a breach in any segment within a CIZ. The annual probability of a breach and the breach-related economic and environmental risks for a given zone are not tolerable unless each segment in that zone is tolerable. Leaving a "weak link" or intolerable segment in any of the zones would render the entire zone intolerable.

Step 3: After solutions were formulated per segment, they were categorized into alternative concepts. The resulting measures identified at the segment were simply combined to form four alternatives at the CIZ. Respective alternatives per CIZ were then combined to provide four complete alternatives based on segmental solutions. The four alternatives are as follows:

Alternative 1: Alternative 1 reduces societal life safety risk to tolerable levels for every segment using the most cost-effective approach. As societal life safety is of paramount concern to the nation, the segments included in this minimal alternative are also included in Alternatives 2-4.

Alternative 2: Alternative 2 includes the risk management plans identified in Alternative 1 to reduce societal life safety risk and includes segments where the risk to individuals and the probability of a dike breach are intolerable. This alternative includes remediation of segments or CIZs having an intolerable probability of failure, regardless of the economic, environmental or social consequences.

Alternative 3: Alternative 3 reduces risks for all segments in which either societal or individual life safety risks were determined to be intolerable. However, this alternative only includes risk reduction for segments where the probability of a dike breach is intolerable and there are significant economic, social or environmental risks.

Alternative 4: Alternative 4, similar to Alternative 2, also reduces individual and societal risk for every segment, and brings the probability of failure to tolerable levels for every segment regardless of the economic, environmental or social consequences. However, this alternative is formulated to achieve a complete remediation of the individual failure modes being addressed to support the ultimate goal of having an adequately safe dam that meets essential USACE guidelines and the total residual risk for the dam is considered tolerable (DSAC V).

Each of the alternatives was analyzed to determine if there was a faster means of satisfying the primary objectives and considerations were applied to each alternative to identify if there was a refinement that could further reduce risk in a cost effective manner.

2.3.4.1 Segmental Risk Management Measures Considered

This section discusses the structural risk reduction measures that were carried forward for further evaluation. The measures for segmental designs are probabilistic, meaning no minimum service reservoir level and factors of safety were selected for design as would be done for a typical deterministic engineering solution. Rather, the robustness of the designs was tailored to annual probability of reservoir loadings and resulting downstream consequences. These plans will reduce risk and probability of failure.

2.3.4.1.1 Internal Erosion

Structural risk reduction measures for internal erosion can be generalized into two categories; cutoff walls and internal drainage systems. Three general variations of cutoff wall and three general variations of internal drainage systems were evaluated. For cutoff walls, these variations include different depth governing criteria based on the location specific geology and the cross sectional details of the embankment in each segment. Two different alignments of the cutoff wall were also considered (i.e. in the upstream face of embankment or along the centerline). Variations in the internal drainage system included depth or presence of a foundation trench to intercept through foundation seepage, presence of a chimney drain in the embankment to intercept through embankment seepage, and the materials and stages within the drain.

2.3.4.1.2 Cutoff Walls

Cutoff walls were evaluated as a risk reduction measure around the dam. Cutoff wall depth varied by segment based on local geologic conditions (permeability of the strata penetrated by the wall, erodeability of the foundation strata, reduction in estimated seepage exit gradients, etc.). The proposed wall depths were also influenced by the cross sectional characteristics of the embankment that could influence the depth of an internal erosion failure path; such as ground surface elevations at the toe and ditch or canal invert elevations. The proposed cutoff wall would be constructed of a Soil-Cement-Bentonite mixture, constructed by mixing a cement bentonite clay slurry with in-situ HHD soils. This would result in a low permeability barrier with strength characteristics similar to weak concrete.

Generally, the proposed cutoff walls can be separated into three categories; 1) traditional cutoff walls that tie into a confining layer, 2) partly penetrating (hanging) cutoff walls or walls that do not tie into any specific confining unit, and 3) cutoff walls that tie into a less erodible limestone layer. The magnitude of risk reduction is significantly different for the various wall types and therefore the depth requirements of the wall are variable around the dam.

Traditional fully penetrating cutoff walls that tie into a confining layer provide the largest magnitude of risk reduction. These walls cut off most seepage, reduce downstream pore water and exit gradients, cut off horizontal failure paths and force a failure path to advance through less erodible soils. This type of cutoff wall could be implemented in Segments 12/13 and in Segments 5 and 6 and throughout portions of other segments where clay or clayey soils are present in the foundation. **Figure 2-9** presents a generalized section of this variation of cutoff wall.

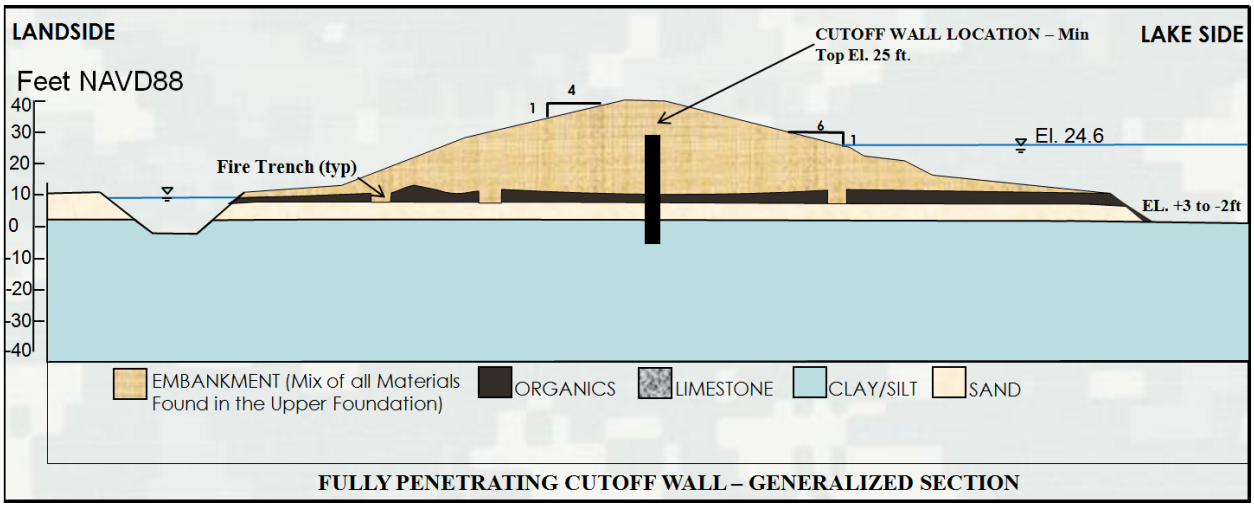

Figure 2-9. Generalized Section of Fully Penetrating Cutoff Wall

Partly penetrating cutoff walls achieve risk reduction by increasing the seepage path length, interrupting the horizontal failure path through the embankment and shallow foundation, add a vertical component to the failure mode progression, and significantly increase the reservoir levels that could initiate and progress an internal erosion failure mode to failure. For this variation of cutoff wall, the minimum wall depth that was established extends the cutoff wall to at least 20 feet below the adjacent canal/ditch invert elevation. This cutoff wall is proposed for a few isolated

areas in the south of HHD. **Figure 2-10** presents a generalized section of this variation of cutoff wall.

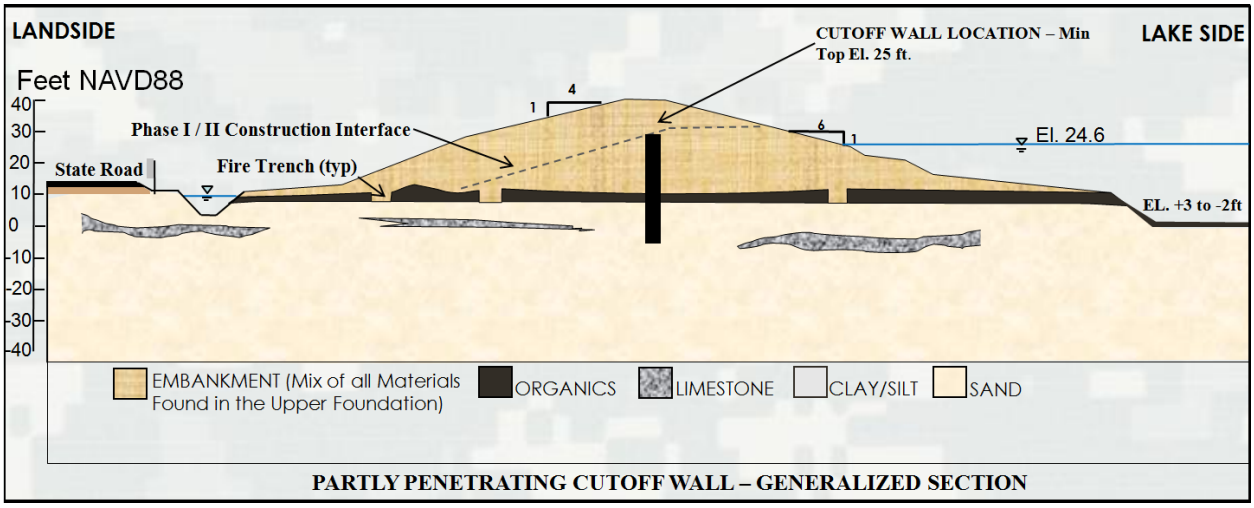

Figure 2-10. Generalized Section of Partly Penetrating Cutoff Wall

Partly penetrating cutoff walls that penetrate limestone are similar to that discussed above but with the additional benefit of forcing seepage flows and the failure path through un-erodible limestone or through a more tortuous path that must progress through defects in the limestone. This type of cutoff wall could be implemented throughout most of the southern segments of HHD.

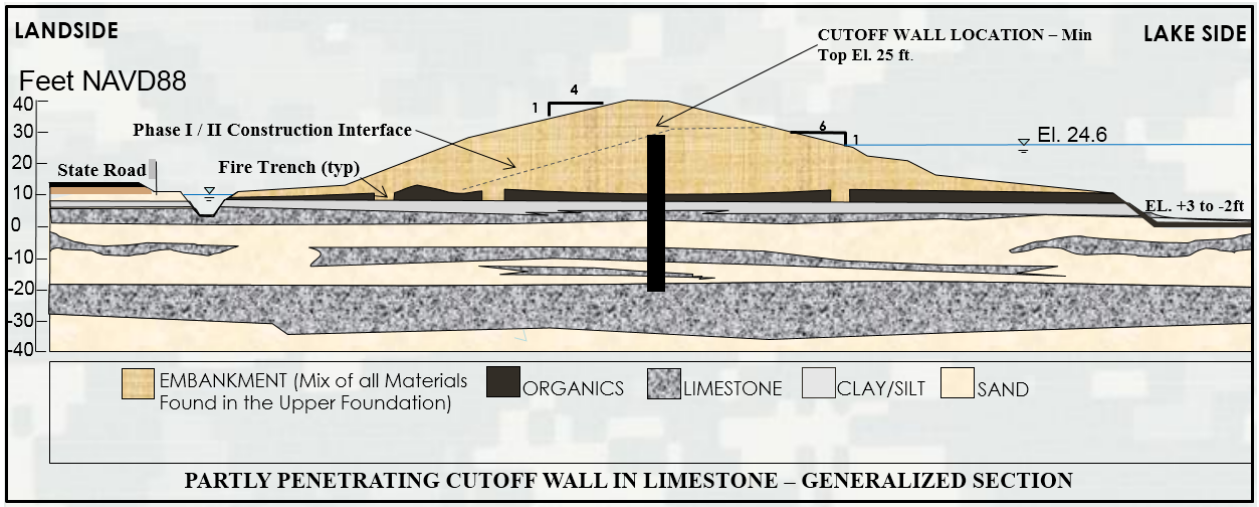

Figure 2-11. Generalized Section of Partly Penetrating Cutoff Wall Tipped In Limestone

The partly penetrating cutoff walls meet the risk reduction objectives; however, it should be understood that unfiltered seepage would likely still discharge in the toe ditch during high reservoirs.

2.3.4.1.3 Internal Drainage Systems

Internal drainage systems of varying designs and configurations were evaluated around the full length of the dam. The design and effectiveness of an internal drainage system varied around the dam considering local geologic conditions, actionable failure modes, and adjacent features such

as ground surface elevations and ditch or canal invert elevations. The proposed internal drainage systems are composed of different variations of chimney, blanket, and trench drains. The functionality of the various drainage systems is the same; however, some have trenches to intercept through foundation seepage while other variations simply line the seepage exit point with filter materials. All of the drains are passive systems with the exception of the trapezoidal drain that contains a sump and pump and is not reliant on the upstream to downstream gradient.

The primary internal drainage system designs considered are described below:

Chimney, blanket, and trench drains – this system includes a chimney to intercept through embankment seepage, a trench to intercept and drain through foundation seepage, and a continuous blanket that discharges to a downstream ditch or canal (**Figure 2-12**).

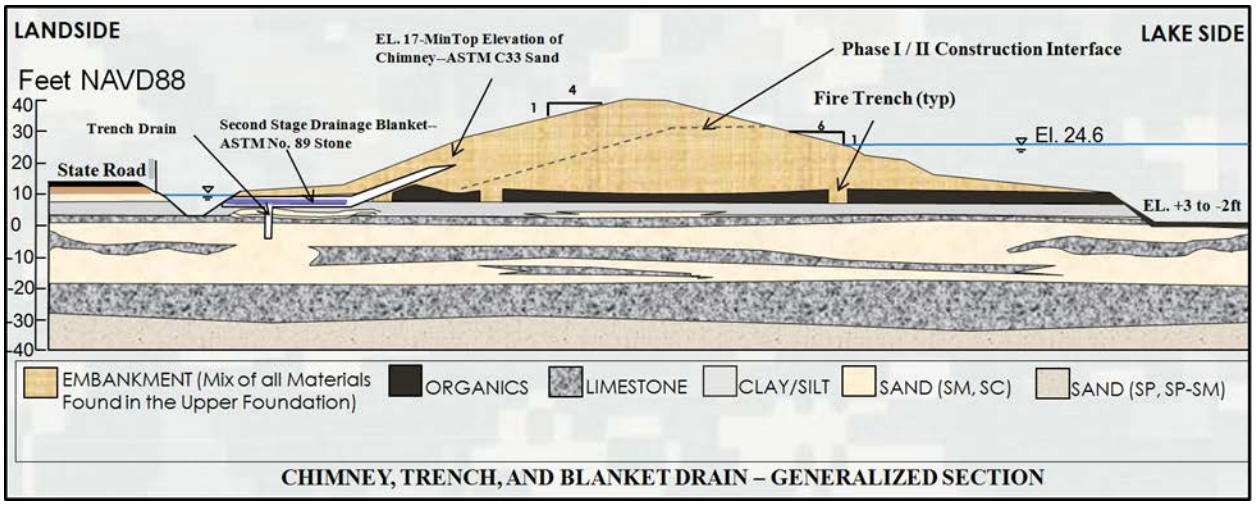

Figure 2-12. Generalized section of chimney, blanket, and trench drain

Trapezoidal Drains – similar to that described above, except that seepage is collected into a trapezoidal drain with imbedded perforated pipe. Seepage is collected in sumps and point discharged by pumping to downstream ditch or canal (**Figure 2-13**).

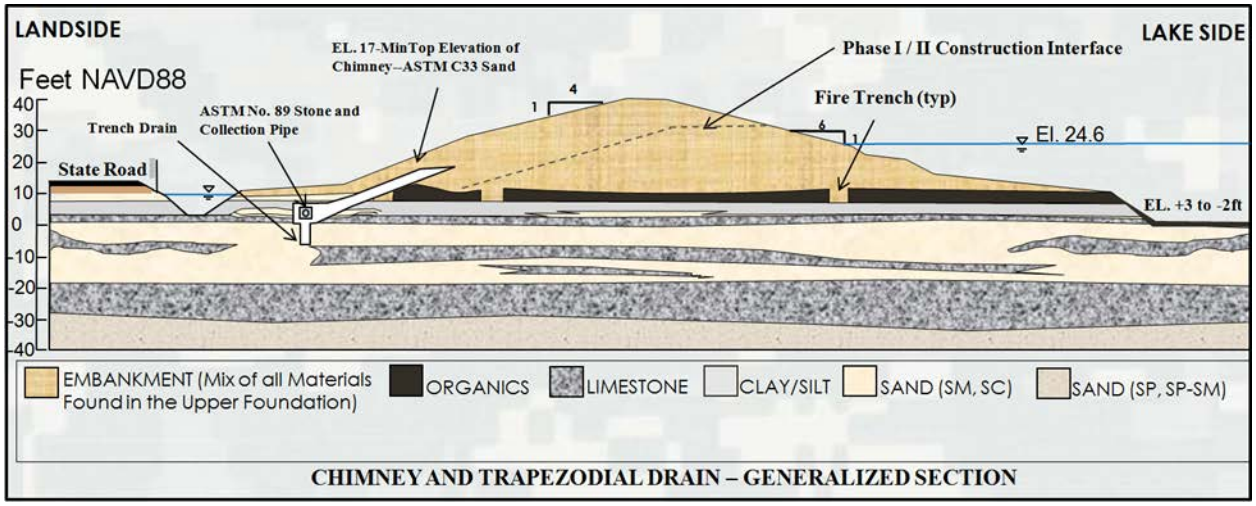

Figure 2-13. Generalized section trapezoidal drain

Chimney, blanket, and ditch lining – also includes a chimney and blanket with continuous discharge through a blanket drain into the downstream toe ditch; however, this measure eliminates the trench feature in the foundation and utilized an inverted filter at the seepage exit location. This measure is only applicable at location where the downstream side of the dam is paralleled by shallow toe ditch (rather than deep canal) (**Figure 2-14**).

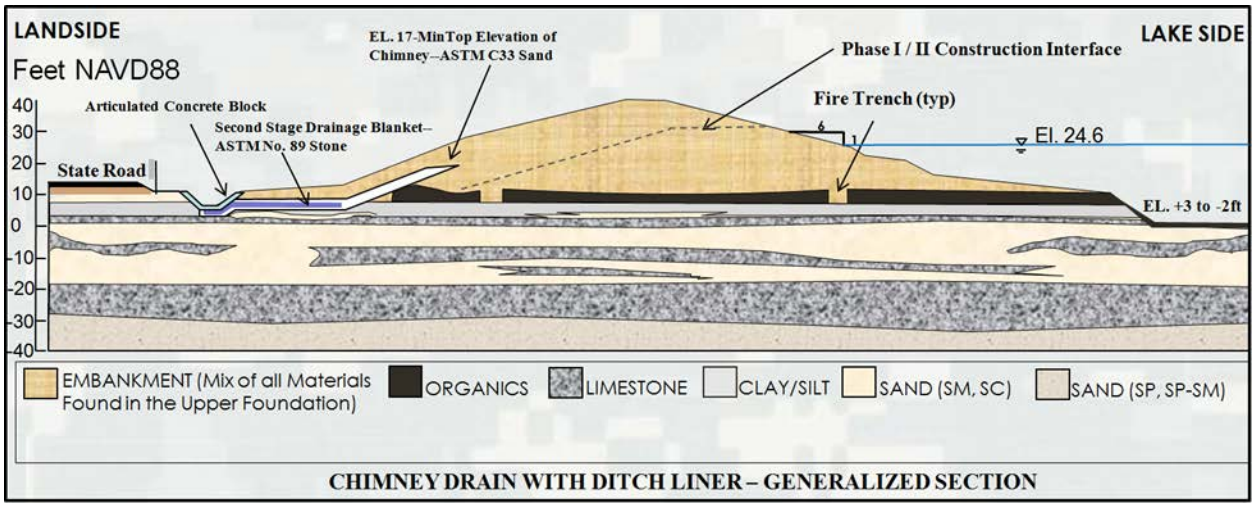

Figure 2-14. Generalized section chimney, blanket, and ditch lining

The design of each internal drainage system has been optimized to provide the most benefit for the embankment/foundation while minimizing construction costs by optimizing cut and fill and import material quantities.

2.3.4.2 Wind Driven Wave Overwash and Overtopping

Several locations on the tieback segments are excessively low, such that overtopping risk from reservoir/tropical cyclone wind loading events was above tolerable levels. Note: all areas of HHD could overtop or overwash under extreme hurricane loading if impacts were to occur on an already excessively high lake level. The probability of these events occurring is low and the coincident probability of these events occurring at the same time is even lower; therefore most areas of HHD are considered adequately designed.

The areas identified for remediation due to overwash/overtop are the embankment adjacent to S71 at the northern terminus of Harney Pond Canal, the State Road 78 Bridge crossing at Harney Pond Canal, and the embankment adjacent to S72 at the northern terminus of Indian Prairie Canal. Risk reduction adjacent to Structure S71 and S72 includes localized floodwalls that range in height from one to 7 feet above existing crest elevations. These flood walls would be located a few hundred feet from the structures in each direction until the floodwalls match typical crest elevations of the tieback levees.

Raising the embankment elevation at the SR78 Bridge would require replacement of the bridge; therefore, recommendations would be made to the State of Florida Department of Transportation to reconstruct the bridge to match HHD design grades at the end of the bridge's service life. In the interim, the low area surrounding the bridge would be armored with articulated concrete block such that the embankment would not fail under short duration, shallow depth overtopping.

Short duration, shallow overtopping could occur under certain elevated lake levels in combination with tropical cyclone storm surge on the lake.

2.3.4.2.1 Articulated Concrete Block (ACB)

Articulated Concrete Block (ACB) is a crest and landside slope protection measure that was evaluated as a risk reduction measure for the overwash/overtopping failure mode. ACB consists of inter-connected concrete blocks that form a hard armor to protect against surface erosion. These blocks can be open cell and infilled with topsoil and vegetated, or can be closed cell concrete surface treatments (depending on the severity of the erosive forces being resisted). ACB is proposed to armor the crest and landside of the embankment for several hundred feet surrounding the Harney Pond Bridge. Construction of an ACB erosion protection system around the SR78 Harney Pond Bridge meets risk reduction objectives in this area. This structural measure would reinforce the embankment such that short duration overtopping during a storm would not fail the embankment; however, some flooding could still occur in the areas surrounding the bridge as a result of the overtopping. The combinations of loading events that would result in overtopping this area have a low probability of occurrence; therefore, this interim risk reduction measure is considered practical. The recommendation will be made to Florida Department of Transportation to raise the bridge to match surrounding embankment crest elevations upon normal service life replacement.

2.3.5 Formulation of Segmental Risk Management Plans

Plans were developed to remediate both the internal erosion and overwash and overtopping failure modes. The primary consideration is ensuring risks are reduced to tolerable levels with cost-effective considerations, and every alternative considered would, at a minimum, reduce risks to tolerable levels for life safety. Additionally, as a secondary metric, an assessment of the economic, environmental, and societal benefits and impacts determined if there was justification to take action in areas exhibiting intolerable probabilities of failure, but the risk to life safety was above guidelines. Plans were also examined based on implementation speed, robustness, resiliency, and redundancy.

Upon identification of the required depth of cutoff wall to reduce risks to tolerable levels, and the internal drainage system that most practicably meets Essential USACE guidelines, formulation of alternatives focused on which segments these solutions would be applied. Alternative 1, focused specifically on the most economical means to reduce life safety risks. Alternative 2 focused on the most economical means to reduce probability of failure for all segments that were identified as intolerable. Alternative 3 focused on the most economical means to reduce risks below TRGs, but also relied upon the significance of the economic, environmental, and social impacts that would result in the aftermath of a breach. Alternative 4 is similar to Alternative 2, but includes the most practicable means to meet essential USACE guidelines while reducing risks.

Table 2-2 presents the results for all four of the segmental alternatives arranged by common environmental and economic zone. Each of these alternatives were determined to be cost effective solutions to providing at a minimum life safety, and to varying degrees reduce risks in order to lower the likelihood of expected annual economic and environmental damages. **Table 2-3** presents the results of the overwash and overtopping alternatives arranged by common environmental and economic zone.

Table 2-2. Segmental Alternatives Description for Internal Erosion Failure Modes

Segment	Intolerable Probability of a Breach (Yes/No?)	Intolerable Societal Life Loss (Yes/No?)	Alternative 1	Alternative 2	Alternative 3	Alternative 4
ZONE A						
22, 23, 24	NO	NO	No action included in the DSMS: Cutoff-wall constructed as part of the 2000 MRR			
1	YES	YES	No action included in the DSMS: To be completed as part of the 2015 MRR Supplement			
2 and 3	YES	NO				
ZONE B						
4, 5, 6 and 7	YES	NO	No Action Recommended	Cutoff Wall	Cutoff Wall	Internal Drainage System
5-2 and 8	YES	YES	Filter at the Raw Water Intake	Cutoff Wall and Filter at Raw Water Intake	Cutoff Wall and Filter at Raw Water Intake	Internal Drainage System and Filter at Raw Water Intake
8	YES	YES	Cutoff Wall	Cutoff Wall	Cutoff Wall	Internal Drainage System
9	YES	NO	No Action Recommended	Cutoff Wall (Full Segment)	Cutoff Wall to C-5A	Internal Drainage System (Complete Segment)
Segment 10: No action is recommended. Risk is considerable tolerable.						
ZONE C						
Segments 11 and 14A: No action is recommended. Risk is considered tolerable.						
12	YES	YES	Cutoff wall from the interceptor levee east to segment end	Cutoff wall (Full Segment)	Cutoff wall from the interceptor levee east to segment end	Internal Drainage System (Complete Segment)
13	NO	YES (Adjacent to Segment 12)	Cutoff Wall- segment start to Sta. 4665	Cutoff Wall- segment start to Sta. 4665	Cutoff Wall - segment start to Sta. 4665	Internal Drainage System - segment start to Sta. 4665
Zone E						
Segments 17, 18A, 18A-2 and 18B: No action is recommended. Risk is considered tolerable.						
Zone F						
Segments 19A, 19A-2, 19A-3, 19B and 19C: No action is recommended. Risk is considered tolerable.						
Zone G						
Segments 20 and 21: No action is recommended. Risk is considered tolerable.						

Table 2-3. Overwash and Overtopping Alternatives Organized by Segment

Segment	Intolerable Probability of a Breach (Yes/No?)	Intolerable Societal Life Loss (Yes/No?)	Alternative 1	Alternative 2	Alternative 3	Alternative 4
ZONE A, B, F and G– No Overwash and Overtopping Failure Modes						
ZONE C						
13	YES	NO	No Action Recommended	Armoring West Harney Pond Bridge – Have State Raises Bridge	Armoring West Harney Pond Bridge – Have State Raises Bridge	Armoring West Harney Pond Bridge – Have State Raises Bridge
14A	YES	NO	No Action Recommended	Floodwall at S-71 (West)	Floodwall at S-71 (West)	Floodwall at S-71 (West)
ZONE D						
14B	YES	NO	No Action Recommended	Floodwall at S-71 (East)	Floodwall at S-71 (East)	Floodwall at S-71 (East)
15	YES	NO	No Action Recommended	Armoring at East side of Harney Pond Bridge – Have State Raises Bridge	Armoring at East side of Harney Pond Bridge – Have State Raises Bridge	Armoring at East side of Harney Pond Bridge – Have State Raises Bridge
16	YES	NO	No Action Recommended	Floodwall at S-72 (East)	Floodwall at S-72 (East)	Floodwall at S-72 (East)
ZONE E						
17	YES	NO	No Action Recommended	Floodwall at S-72 (West)	Floodwall at S-72 (West)	Floodwall at S-72 (West)

2.4 ALTERNATIVES RETAINED FOR DETAILED ANALYSIS

The four segmental risk management plans were retained for evaluation and comparison as a final array of alternatives, based on their effectiveness at meeting project objectives, cost, cost effectiveness, constructability, time to implement and economic, social and environmental impacts avoided. Descriptions of the final array of alternatives are provided in the following section and details are included in **Table 2-5**. Each alternative in the final array was evaluated and compared on their contribution to National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED) and Other Social Effects (OSE). The alternatives were also evaluated on completeness, acceptability, efficiency, and effectiveness. The results of the evaluations were used to compare alternatives and resulted in the identification of the recommended Recommended Plan.

The benefits of remediation were based on the ability of a plan to reduce risks of life loss and dike failure in areas that exhibit intolerable risk levels. Cost estimates were generated for each alternative plan, and an efficiency (Cost Effectiveness) evaluation was conducted to identify the alternatives that maximize risk reduction benefits compared to costs.

2.4.1 Alternative 1

Alternative 1 contains the minimal solutions to ensure that any segment presenting intolerable societal life loss is remediated. This alternative includes the areas of HHD protecting the cities of Clewiston (Segments 5-2), Moore Haven (Segment 8), Lake Port (Segment 12 from theInterceptor Levee L-61 to the end of the segment and the eastern half of Segment 13).

Risk reduction proposed for Segment 5-2 under this alternative includes construction of a filter and drainage blanket around the downstream end of the US Sugar Raw Water Intake pipes. These pipes penetrate the HHD embankment and were constructed with no seepage protection as would be required by modern design standards. The proposed risk reduction for these pipes requires that they be retrofitted with a drain at the downstream toe of HHD. The drainage system would wrap around the pipes and intercept seepage (lake water seepage that could be concentrating and flowing around the exterior of these pipes) though the embankment and collect, filter, and discharge the seepage through designed sand and gravel filter.

Risk reduction proposed for Segment 8, 12, and 13 under this alternative includes construction of an approximate 24 inch wide, Soil Cement Bentonite (SCB) cutoff wall that would extend through the embankment from a minimum top elevation of 25 ft. and into the foundation to a bottom elevation between approximately -10 to -30 ft. The proposed cutoff wall location would be along the approximate centerline of the embankment, with construction platforms needed to temporarily widen the crest for the duration of construction (**Figure 2-15**).

An alternative alignment was considered along the upstream face of the embankment. This location was screened out because the upstream location provided no additional risk reduction, required fill for the temporary construction platform to be placed over the existing interior riprap and in some locations into the littoral zone of the lake, and excavation into the embankment required for work platforms would leave it more vulnerable to construction related failure modes during hurricane season.

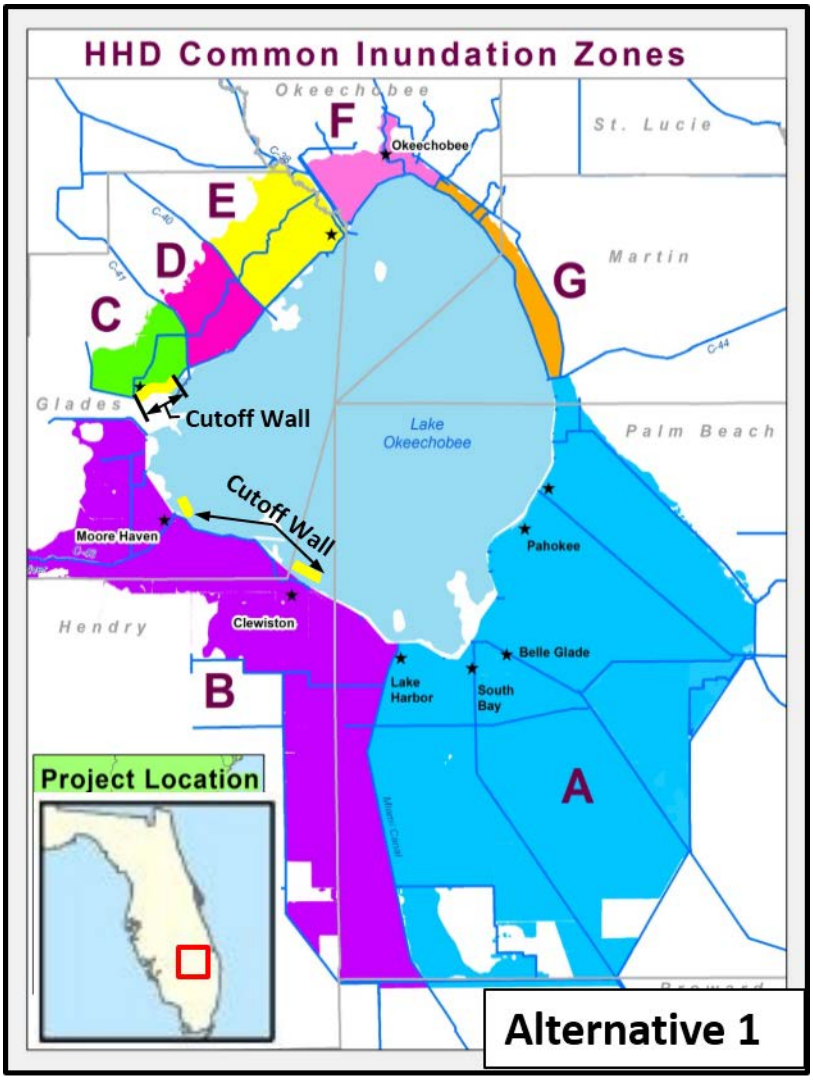

Figure 2-15. Alternative 1

2.4.2 Alternative 2

Alternative 2 is tailored to reduce societal risk for life safety concerns, similar to Alternative 1, but also includes measures to reduce risk in all segments determined to pose intolerable annual probability of failure (APF). This alternative would reduce APF for the entire southern perimeter of the embankment, from just west of Lake Harbor (areas east of Lake Harbor already approved for remediation) to Fisheating Creek (north of Moore Haven); Segments 4 through 9, and all of Segment 12. In addition to the cutoff walls proposed for reducing the APF, cutoff wall would also be proposed to provide societal life safety risk reduction in Lakeport (eastern half of Segment 13). **Figure 2-16** depicts the location of the cutoff wall for Alternative 2. Risk reduction proposed for these areas includes construction of a SCB cutoff wall that would extend through the embankment and into the foundation. The cutoff wall would have a minimum top elevation of 25 ft. with varying bottom elevation between approximately -10ft to -30ft NAVD 88 based on variations in local geologic and topographic characteristics of the Segment.

The proposed cutoff wall location would be along the approximate centerline of the embankment, with temporary construction platforms needed to widen the crest for the duration of construction. An alternative alignment was also considered along the upstream face of the embankment but was screened out for the same reasons noted in Alternative 1 above.

The cutoff walls described above would be connected to the side of the concrete structures that penetrate HHD throughout these segments. Additionally, the drain around the lakeside of the US Sugar Raw Water Intake in Segment 5-2, as described in Alternative 1, is also included in Alternative 2.

Lastly, this alternative includes remediation of several low spots in the crest of HHD that exceed life safety and/or APF guidelines. It is predicted that these locations could overtop from hurricane storm surge under the right wind and reservoir elevation combinations. These low crest elevations occur on both sides of S71 and S72 at the terminus of the Harney Pond and Indian Prairie tie back embankments, respectively (Segments 14A, 14B, 16 and 17). Remediation in these areas would include construction of several hundred feet of flood wall (raising elevations to match adjacent embankment crest elevations – an approximate 6 ft. maximum wall height) adjacent to Structures S71 and S72. This would also require some regrading of the embankment crest and slopes around the floodwall. The embankment crest is also low where State Road 78 Bridge crosses the Harney Pond Canal embankments (Segments 13 and 15). At these locations, the embankment crest is lower to allow vehicle access to the structures or to match abutment grades of the bridge. Remediation would include placement of Articulated Concrete Block and riprap armoring to protect the embankment from failure during a temporary overtopping event at the SR78 Crossing of Harney Pond Canal. The armoring would cover the crest and landsides of the embankment in these areas. Additionally, a recommendation would be provided to FDOT to raise the abutments of the bridge when it reaches the end of its service life and requires replacement.

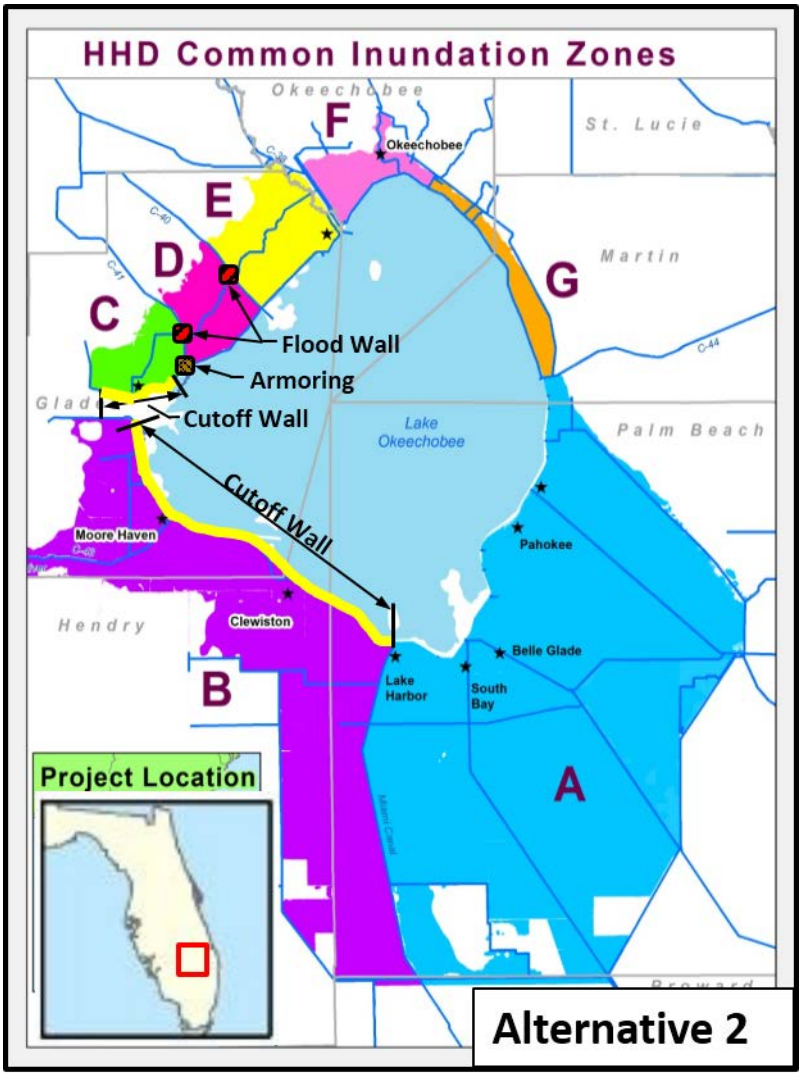

Figure 2-16. Alternative 2

2.4.3 Alternative 3

Alternative 3 is tailored to reduce societal risk for life safety concerns, similar to Alternative 1, but also includes measures to reduce risk in segments determined to pose intolerable annual probability of failure (APF) where economically, environmentally, and or socially justified. This alternative evaluates risk reduction for all areas that exceed risk guidelines for annual probability of failure; however, only recommends risk reduction for those areas where the benefits can justify the monetary investment to construct the risk reduction measures. This alternative would reduce the probability of dam failure for the entire southern perimeter of the embankment, from just west of Lake Harbor (areas east of Lake Harbor already approved for remediation) to just east of Moore Haven; Segments 4 through a portion of Segment 9. A cutoff wall through a portion of Segments 12 and13 would also be proposed under this alternative to reduce the probability of life loss in Lakeport. Unlike Alternative 2, no remediation is recommended in the section of Segment 12 east of the interceptor levee L-61, and in Segment 9 north of the vicinity of the L-41/Culvert 5A due to the low environmental and economic consequences realized from a breach in these area. **Figure 2-17** depicts the location of the cutoff wall, floodwall, and armoring for Alternative 3. Risk reduction proposed for these areas also includes construction of a SCB cutoff

wall that would extend through the embankment and into the foundation. The cutoff wall would have a minimum top elevation of 25 ft. with varying bottom elevations (based on local geologic and topographic characteristics of the Segment). The range of depths proposed for the cutoff wall are presented in **Table 2-4.**

Table 2-4. Alternative 3 Cutoff Wall Termination Elevations

Segment	Proposed Cutoff Wall Termination Elevation (ft. NAVD 88)(1)
Segment 4	-10 to -30
Segment 5-2	-25 to -30
Segment 5	-20 to -30
Segment 6	-15 to -30
Segment 7	-20 to -30
Segment 8	-15 to -30
Segment 9	-10 to -20
Segment 12/13	-15 to -30

(1) Cutoff wall depths are approximate. Additional subsurface investigation would be completed to support final design of the walls. Minor adjustments to the cutoff wall termination depths may be required to correct for variations in geology (minor variations would include adjustments of the cutoff wall depths by several feet to adjust for elevation variations of the subsurface unit being targeted by the design).

The proposed cutoff wall location would be along the approximate centerline of the embankment, with temporary construction platforms needed to widen the crest for the duration of construction. An alternative alignment was also considered along the upstream face of the embankment but was screened out for the same reasons noted in Alternative 1 above.

The cutoff walls described above would be connected to the side of the concrete structures that penetrate HHD throughout these segments. Additionally, the drain around the lakeside portion of the US Sugar Raw Water Intake in Segment 5-2, as described in Alternative 1, is also included in Alternative 3.

Lastly, this alternative also includes the same overwash/overtopping risk reduction features described in alternative 2 above.

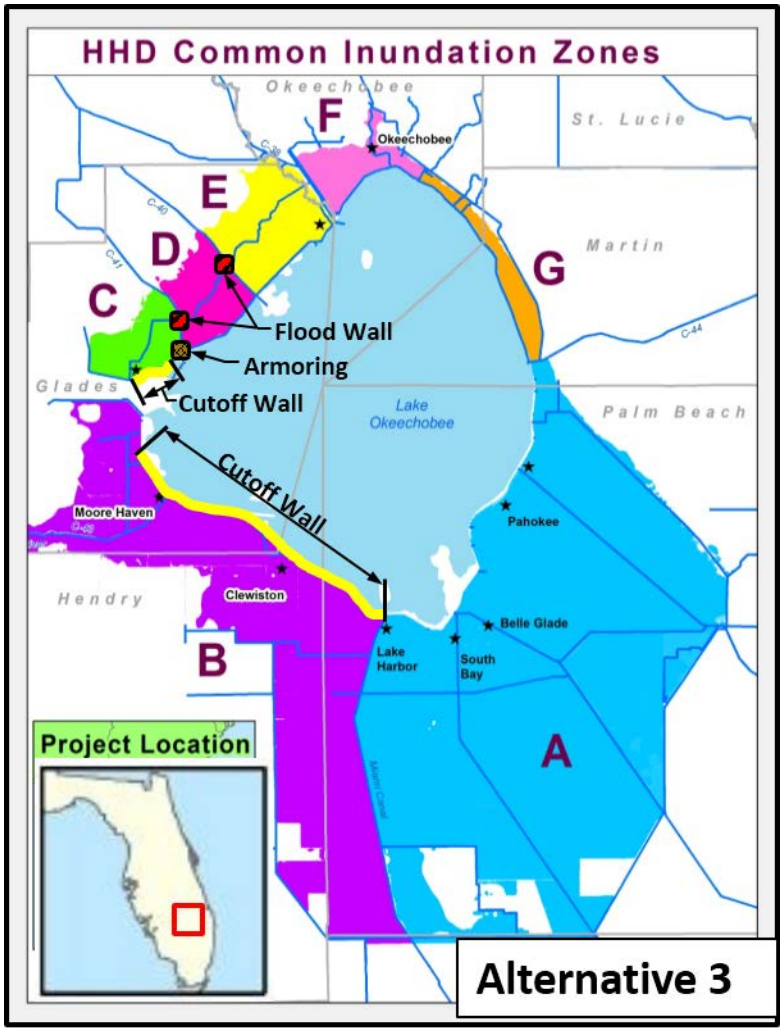

Figure 2-17. Alternative 3

2.4.4 Alternative 4

Alternative 4 is tailored to reduce societal risk for life safety concerns and includes measures to reduce risk in all segments determined to pose intolerable annual probability of failure (APF) (similar to Alternative 2) and also meets USACE essential guidelines to the extent practical. This alternative would reduce APF for the entire southern perimeter of the embankment, from just west of Lake Harbor (areas east of Lake Harbor already approved for remediation) to Fisheating Creek (north of Moore Haven); Segments 4 through 9. The areas of embankment protecting Lakeport (Segment 12 and a portion of 13) would also be included to reduce the risk of life loss. Risk reduction proposed under this alternative includes an internal drainage system constructed within the embankment and foundation. **Figure 2-18** depicts the location of the internal/filter drainage system for Alternative 4.

The internal drainage system would intercept seepage waters (water that historically seeps uncontrolled into the downstream ditches and canals) and collect, filter, and discharge this seepage through a designed sand and gravel filter. This alternative includes a chimney drain in the embankment that extends to a minimum top elevation of 17 ft. The chimney connects to a drainage blanket and foundation trench drain at the toe of the embankment. The foundation

trench drain extends vertically into the foundation to the tip elevations noted below. Seepage collected in this system is piped to sumps located on approximate 1,000 foot spacing along the toe. Electric pumps then pump the collected seepage from the sump to the adjacent canal or ditch. The trench feature would extend to elevations listed in **Table 2-5**.

Table 2-5. Alternative 4 Internal Drain Termination Elevations.

Segment	Proposed Foundation Drain Termination Elevation (ft. NAVD 88)
Segment 4	-7
Segment 5-2	-7
Segment 5	-7
Segment 6	-7
Segment 7	-7
Segment 8	-11
Segment 9	-7
Segment 12/13	-20
Segment 13	-20

The drain described above would be connected to the side of the concrete structures that penetrate HHD throughout these segments. Additionally, the drain around the lakeside portion of the US Sugar Raw Water Intake in Segment 5-2, as described in Alternative 1, is also included in Alternative 4.

Lastly, this alternative also includes the same overwash/overtopping risk reduction descried in alternative 2 above.

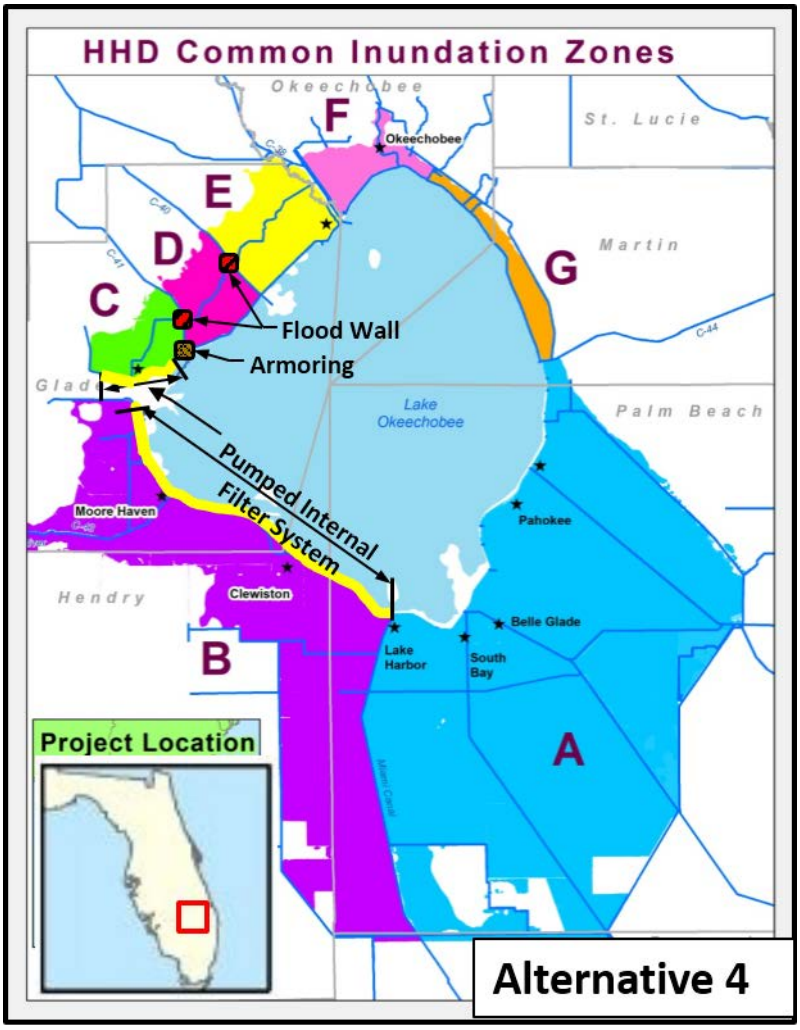

Figure 2-18. Alternative 4

2.5 ENVIRONMENTALLY PREFERRED ALTERNATIVE

The environmentally preferred alternative is also the economically preferred alternative, Alternative 3. Constructing a cutoff wall would increase stability of the embankment as well as adequately accommodate for economic and environmental damages if a breach were to occur. The No Action Alternative does not address the imminent need for public safety according to current dam safety standards.

2.6 IDENTIFICATION OF THE RECOMMENDED PLAN

Reducing risk where intolerable societal life safety concerns exist is the paramount factor in selecting a plan for implementation. All alternatives in the final array are effective at reducing life safety risks to the populations of Clewiston, Moore Haven, and Lakeport. Additionally, in accordance with ER-1105-100, the socioeconomic impacts of the alternatives must be considered in plan formulation and evaluation. Typically, economic impacts are measured by National Economic Development (NED). In the case of the HHD DSMS, NED impacts are measured as reduced economic risk. However, Regional Economic Development (RED) and Other Social Effects

(OSE) were also considered. RED has to do with regional economics, such as benefits of employment during construction, or if recreational features are gained or lost, rather than on a national level. OSE include environmental justice, prime and unique farmlands, protection of children, health and safety, and recreation. The comparison of the final array has resulted in the identification of the economically, environmentally, and socially efficient alternative as the plan being recommended to reduce the overall risks attributed to a breach associated with the Herbert Hoover Dike. Alternative 3 has been identified as the Recommended Plan (Recommended Plan). The Recommended Plan is a cost-effective plan and consists of structural measures that work in unison to reduce risk, achieving the primary objective of reducing life loss. The Recommended Plan includes remediating the southern half of the dam, greatly reducing the potential for breach-related damages to the nationally significant agricultural industry in the Everglades Agricultural Area, and the nationally and internationally significant Everglades ecosystem.

2.6.1 Description of the Recommended Plan

The proposed cutoff wall was determined to be the least cost, technically acceptable risk reduction solution to remediate areas of HHD that were identified as having intolerable internal erosion risk. The proposed cutoff wall location would be constructed along the approximate centerline of the embankment, with temporary construction platforms needed to widen the crest for the duration of construction. A total of 33.3 miles of cutoff wall would be constructed.

The construction would span from just west of Lake Harbor (areas east of Lake Harbor already approved for remediation) to just east of Moore Haven; Segments 4 through a portion of Segment 9. A cutoff wall through a portion of Segments 12 and 13 would also be proposed under this alternative to reduce the probability of life loss in Lakeport. No remediation is recommended in the section of Segment 12 west of the interceptor levee and in Segment 9 north of the vicinity of the L-41 canal/Culvert 5A due to the low environmental and economic consequences realized from a breach in these area. The cutoff wall would likely be constructed of a mix of soil, cement, and bentonite clay and would have a minimum top elevation of 25-ft NAVD (but would likely be constructed to within a foot or two of the crest) with varying bottom elevations (based on local geologic and topographic characteristics of the Segment) and an approximate width of 2 feet. The range of bottom elevations for the proposed for the cutoff wall are -10-ft to -30-ft NAVD **Table 2-4**.

Risk reduction proposed for Segment 5-2 would include construction of a filter and drainage blanket around the downstream end of the US Sugar Raw Water Intake pipes. These pipes penetrate the HHD embankment and were constructed with no seepage protection as would be required by modern design standards. The proposed risk reduction for these pipes requires that they be retrofitted with a drain at the downstream toe of HHD. The drainage system would wrap around the pipes and intercept seepage (lake water seepage that could be concentrating and flowing around the exterior of these pipes) though the embankment and collect, filter, and discharge the seepage through designed sand and gravel filter.

In addition to the cutoff wall, Alternative 3 includes three locations where the embankment is low and intolerably susceptible to overwash or overtopping. These locations include the embankment adjacent to S-71 (Segments 14A & 14B) located on the Harney Pond Canal, the embankment adjacent to S-72 (Segments 16 & 17) located on Indian Prairie, and the embankment at the intersection of SR-78 bridge and Harney Pond Canal (Segments 13 and 15). S-71 and S-72 are structures on the Harney Pond and Indian Prairie canal. They are nearly identical in design and

construction and are the terminus of HHD to the north. At these locations, the HHD earthen embankment drops down in elevation to meet the service platform of each structure. A similar situation occurs at the intersection of SR 78 Bridge and Harney Pond canal. The embankment drops down in elevation to meet the bridge abutment. These low areas in the embankment would be armored.

Armoring the embankment at the intersection of the bridge at the SR-78 and Harney Pond Canal is proposed (a few hundred feet of floodwall may also be included in the design for this area) (**Figure 2-19**). While this configuration would not provide a greater level of service for flood protection, armoring would greatly reduce risks of breach during a short duration overtopping event from storm surge. Additional coordination is needed with the non-Federal sponsor identifying the need to raise the bridges (Harney Pond Canal and Indian Prairie Canal) in the future. The Non-Federal sponsor through coordination with the State of Florida's Department of Transportation should ensure that bridges, bridge abutments, and corresponding roads be raised as part of the State's regularly schedule bridge replacement.

S-71 and S-72 are structures located on the Harney Pond Canal and Indian Prairie Canal. They are nearly identical in design and construction and are the terminus of HHD to the north. At these locations, the HHD earthen embankment drops down in elevation to meet the service platform of each structure. A similar situation occurs at the intersection of SR-78 Bridge and Harney Pond canal. The embankment drops down in elevation to meet the bridge abutment. A floodwall ranging in height from 1 to 6 feet or embankment armoring would be constructed adjacent to these structures.

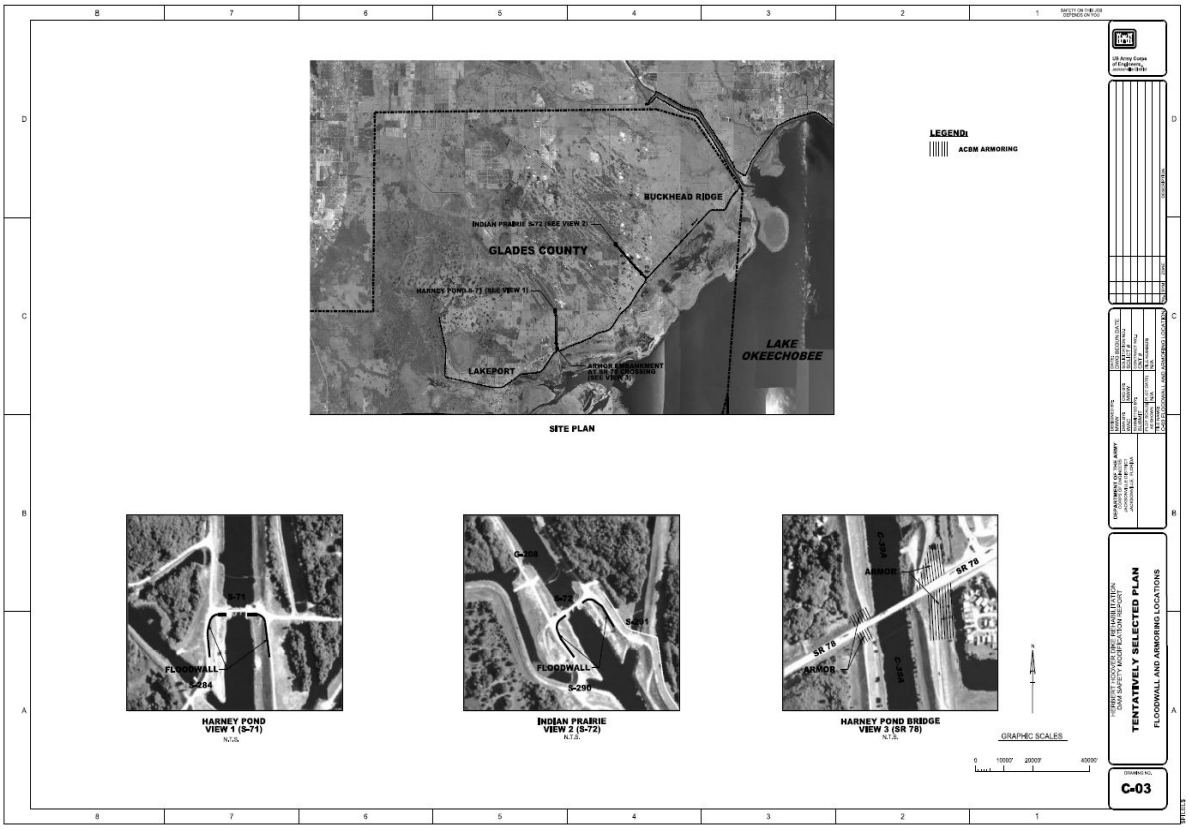

Figure 2-19. Limits of ACB armoring

3.0 AFFECTED ENVIRONMENT (EXISTING CONDITIONS)

The affected environment section succinctly describes the existing environmental resources of the areas that would be affected on the Herbert Hoover Dike (HHD) if any of the alternatives were implemented. This section describes only those environmental resources that are relevant to the decision to be made. Because the purpose of the project is to reduce risk within the embankment itself, the estuaries and water conservation areas are not described. The existing conditions within the estuaries and water conservation areas would be expected to remain as they are now due to the assumption that the LORS 2008 is the water management operations. It does not describe the entire existing environment, but only those environmental resources that would affect or be affected by the alternatives if they were implemented. This section, in conjunction with the description of the No Action Alternative, forms the baseline conditions for determining potential environmental impacts of the proposed action and reasonable alternatives. Further, the existing condition captures the risk associated with the HHD project as it stands today. The risk also takes into account that if a failure was to occur as it stands today that local and Federal government would intervene and begin flood fighting.

3.1 GEOLOGY

The HHD embankment was constructed using dredged material from Lake Okeechobee and is a heterogeneous mixture of lightly compacted to dense, fine to medium carbonate, quartz clayey, and silty sands, shells, organic soils, and peat (**Figure 3-1**) Other materials encountered are limestone and sandstone gravels, cobbles, and occasional small boulders. Pockets with high concentrations of limestone cobbles and boulders can be found within the embankment. These coarse pockets vary in length and thickness, and can have voids between the cobbles or be filled with a matrix of sand and gravel. These pockets are highly permeable. Geology of each Reach is discussed below depicts a general representation of HHD geologic foundation conditions and to be used along with the descriptions of geologic conditions by Reach below.

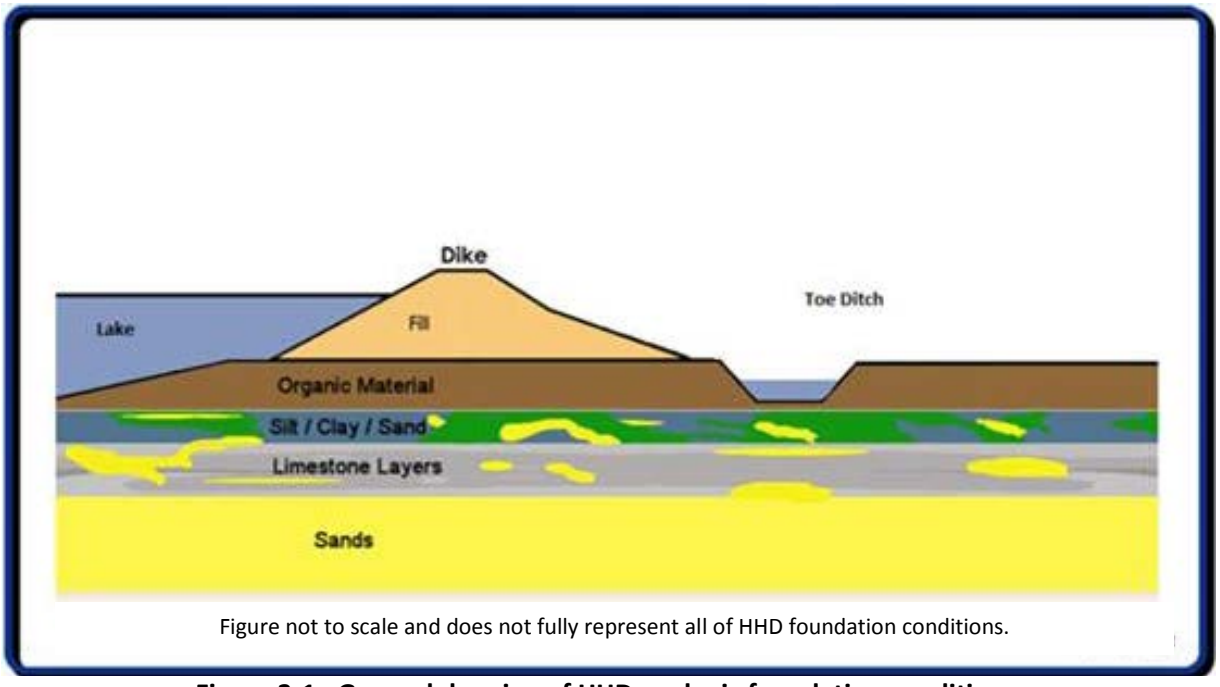

Figure 3-1. General drawing of HHD geologic foundation conditions

Reach 1 (CIZ A)

Embankment:

The HHD embankment was constructed using dredged material from Lake Okeechobee and is a heterogeneous mixture of lightly compacted to dense, fine to medium carbonate, quartz clayey, and silty sands, shells, organic soils, and peat. Other materials encountered are limestone and sandstone gravels, cobbles, and occasional small boulders. Pockets with high concentrations of limestone cobbles and boulders can be found within the embankment. These coarse pockets vary in length and thickness, and can have voids between the cobbles or be filled with a matrix of sand and gravel. These pockets are highly permeable.

Foundation:

Organic Horizon: The organic horizon is 1 to 12 feet thick and has low permeability. The color of this horizon is typically black or brown, and it may vary from fibrous to intensely decomposed. The organic horizon is primarily composed of peat, silt, and silty sands. These organic materials vary in thickness and are found to be almost continuous throughout the length of the reach. The organic material thins and all but disappears in the northern 1/3 section of sub-reach 1A near Port Mayaca where it grades into organic stained sands. This horizon sometimes appears to be thicker, thinner, or out of sequence compared to the natural geologic sequence. This is usually the result of local excavations, fill placement, or spoil disposals. Any material overlying the organics is usually fill from adjacent borrow used to construct the dike.

Sand and Fines Horizon: Directly below the organic horizon a 0.0 to 1.0 foot thick hard cap rock may be encountered. The cap rock appears throughout Reach 1 being most dominant in sub-reaches 1D and 1C. Found below the cap rock is a 2 to 15 foot thick layer of gray, fine quartz sand, lean silts, clays, and sandy silt/clay with shells. This layer begins in sub-reach 1A as fine quartz sand and transitions throughout sub-reach 1B into lean silts and clay, with carbonate sand and shell layer below. It is common to find thin discontinuous layers of limestone from 1 inch to 3 feet thick within this horizon.

Rock Horizon: The rock horizon is typically 5 to 30 feet thick. The rock horizon is continuous throughout Reach 1, its thickness is variable, and is found to have undulating top and base. This horizon is composed of interbedded limestone or sandstone and sand layers. The limestone within the rock horizon varies from dense crystalline limestone to sandy and shelly limestone. Some of the limestone is essentially impermeable, while the remainder varies to highly permeable, containing fractures, voids and solutioning features. In some areas, the rock horizon is essentially all limestone. In other areas, the limestone grades into sand deposits. The sands are usually clayey and silty, calcareous sands. Fine deposits such as silt and clay are interbedded within the rock horizon, formed from decomposing limestone.

Sand Horizon: The sand horizon is typically over 70 feet thick and follows the undulating base of the rock horizon. The sand horizon is typically fine to medium grained quartz sand and quartz silty sand. It sometimes has a significant shell component, and occasionally shell layers are present. Limestone beds are common.

Reaches 2 and 3 (CIZ A and B)

Embankment

The HHD embankment was constructed using dredged material from Lake Okeechobee and is a heterogeneous mixture of lightly compacted to dense, fine to medium carbonate, quartz clayey, and silty sands, shells, organic soils, and peat. Other materials encountered are limestone and sandstone gravels, cobbles, and occasional small boulders. Pockets with high concentrations of limestone cobbles and

boulders can be found within the embankment. These coarse pockets vary in length and thickness, and can have voids between the cobbles or be filled with a matrix of sand and gravel. These pockets are highly permeable.

Foundation

Organic Horizon: The organic horizon is 0 to 10 feet thick and has low permeability. The color of this horizon is typically black or brown, and it may vary from fibrous to intensely decomposed. The organic horizon is also composed of organic silt. The organic horizon is about eight feet thick at Belle Glade and gradually thins out both to the northeast and west. It is continuous in Reach 3 but thins and grades to organic stained sands in Reach 2. This horizon sometimes appears to be thicker, thinner, or out of sequence compared to the natural geologic sequence. This is usually the result of local excavations, fill placement, or spoil disposals. Any material overlying the organics is usually fill used to construct the dike.

Fines Horizon: The fines horizon has low permeability and alternating marine and freshwater limestone and/or marls. This horizon is typically tan, calcareous silts and clays formed from decomposed limestone. The fines horizon is not continuous, and pinches out in the eastern half of Reach 2 and ranges from one to five feet thick. Where the fines horizon is absent, the rock or sand horizons underlie the organic horizon.

Rock Horizon: The rock horizon is usually 0 to 30 feet thick. The rock horizon occurs throughout Reach 3 but thins in Reach 2 and is no longer continuous. This horizon is composed of interbedded limestone or sandstone and sand layers. The limestone within the rock horizon varies from dense crystalline limestone to sandy and shelly limestone. Some of the limestone is essentially impermeable, while the remainder varies to highly permeable, containing fractures, voids and solutioning features. In some areas, the rock horizon is essentially all limestone. In other areas, the limestone grades into sand deposits. The sands are usually clayey and silty, calcareous sands. Fine deposits such as silt and clay are interbedded within the rock horizon, formed from decomposing limestone.

Sand Horizon: The sand horizon is usually 30 to 110 feet thick. The sand horizon is typically fine to medium grained quartz sand and quartz silty sand. It sometimes has a significant shell component, and occasionally shell layers are present. Limestone beds are common.

Reach 4 (CIZ B)

Embankment

The HHD embankment was constructed using dredged material from Lake Okeechobee and is a heterogeneous mixture of loose to medium density, fine grained, silty, clayey, quartz sand with high percentages of silt and clay (average 30%), and varying amounts of shell. Other materials encountered in the fill at minor percentages are organic soils and peat, limestone and sandstone gravel, and cobbles, with occasional layers of sandy clay and silt. Along the Fisheating Creek tieback, the amount of fines decreases significantly. The fill is approximately 22 feet thick along the main stem of the crest and pinches out at the west end of the Fisheating Creek tieback.

Foundation

Organic Horizon: The organic horizon is 0 to 2 feet thick and has moderate permeability. The color of this horizon is typically black or brown and consists primarily of fine, organic stained, silty quartz sand and occasional layers of sandy organic silt and peat. These organic materials may become thicker in lower lying areas.

Sand Horizon: Below the organic horizon, over 100 foot thick sand is encountered. The sand horizon is composed of two distinct sand units. A bowl of high fines content sand and clays are found in the middle of the reach and are surrounded and underlain by cleaner sands with occasional rock layers. The sand within the bowl is found to be up to 70 feet thick and is composed of greenish gray, silty, clayey, and fine to very fine quartz sand with shell. The sands have a high fines content that averages over 30 percent, and is found to transition into layers of sandy silts and clays. The clay layers can run for several thousand feet, interbedded with silty/clayey sand and can be over 5 feet thick. The sand that surrounds and underlies the dirty sand is a homogeneous fine, partially cemented, light greenish gray, slightly silty to clean quartz sand with trace shell. These sands are dense, partial cemented, with occasional layers of sandstone and sandstone nodules.

Reach 5 (CIZ F)

Embankment

The HHD embankment was constructed using dredged material from Lake Okeechobee and is a semi-homogeneous mixture of loose to dense, fine to medium grained, clean to slightly silty quartz sand with shell. Other materials encountered in the fill at minor percentages are organic soils, and limestone and sandstone gravel, cobbles, with possible boulders. The thickness of the fill averages 25 feet.

Foundation

Organic Horizon: The organic horizon is 0 to 1 foot thick, semi-continuous, and has moderate permeability. The color of this horizon is typically black and consists of primarily of loose fine to medium grained clean to silty organic stained quartz sand with varying amounts of silt and occasional pockets of organic sandy silt, and peat. These organic materials may become thicker in lower lying areas.

Sand Horizon: This sand horizon is found to be over 100 feet thick and consists of semi-homogeneous light greenish gray, clean to slightly silty fine quartz sand with shell. Also found widely scattered throughout this unit are layers of silty to clayey fine quartz sand and layers of clay and silt. At various locations within this sand unit, the sand is composed of wholly fine to coarse sand sized broken shell with lesser amounts of quartz sand and fines; which account for less than 5% of the whole unit. This sand unit is generally of loose to medium consistency with dense areas generally caused by higher degrees of cementation, consolidation or thin layers of sandstone. Multiple thin layers of discontinuous soft to moderately hard sandstone can be found widely scattered throughout this sand unit.

Reach 6 (Includes Harney Pond Canal and Indian Prairie Canal; CIZ C, D)

Embankment

The HHD embankment was constructed using dredged material from Lake Okeechobee and is a heterogeneous mixture of loose to medium consistency, fine to medium grained, clean to silty quartz sand with shell. Minor percentages of organic materials and organic stained sands would also be present. At several locations within the main stem, the sand becomes considerably finer consisting of mostly, loose, very silty and clayey, fine quartz sand with significant interbedded layers of soft, sandy clay and silt up to 5 feet thick. In addition, from the middle of the reach towards the east, the shell content increases as does the appearance of limestone gravel, cobbles, and an occasional boulder. The fill is approximately 25 feet thick along the main stem of the crest and pinches out at the west end of the Fisheating Creek tieback.

Foundation

Organic Horizon: The organic horizon is 0 to 1 foot thick, semi-continuous, and has moderate permeability. The color of this horizon is typically black and consists primarily of loose fine to medium

grained clean to silty organic stained quartz sand with varying amounts of silt and occasional pockets of organic sandy silt, and peat. These organic materials may become thicker in lower lying areas.

Rock Horizon: Near surface rock is found to begin in the middle of Reach 6 and continue towards the east. The rock is typically less than 2 feet thick and is found from 2 to 10 feet below ground. The rock is discontinuous, soft, highly weathered, and often found surrounded by clayey material. At the Harney Pond Canal area, the rock becomes thicker and more competent. Outcropping of isolated near surface rock can be found along the rim canal in this reach.

Sand Horizon: This sand horizon is found to be over 75 feet thick and beginning at the west end of Fisheating Creek tieback is a semi-homogenous light greenish gray, clean, to silty, fine quartz sand with minor shell. Near the eastern edge of the tieback the fines content begins to increase, transitioning into a heterogeneous unit of silty, clayey fine quartz sand with shell and occasional thin layers of silt and clay. The shell content varies horizontally and vertically, from 5 to 45 percent. Just west of Harney Pond Canal towards the east, the fines content of the sand decreases into a slightly silty to silty quartz sand with shell. At various locations within this sand unit significant silt and clay layers are encountered. These layers can be found 20 feet below ground surface, run for several thousand feet and can be up to 30 feet thick. These layers alternates from clay and silt both vertically and horizontally and are found to be interbedded with layers of sand. The clay and silts are greenish gray, soft to medium stiff consistency, with variable sand and shell content.

Reach 7 (CIZ G)

Embankment

The HHD embankment was constructed using dredged material from Lake Okeechobee and is a heterogeneous mixture of dense, fine to medium grained clean to silty quartz sands with shell, and limestone/sandstone gravel, cobbles, and occasional boulders. The rock content increases significantly in the southern half and has varying percentages and distribution within the embankment. Unique to this reach, the fill attains a much higher density which may be caused by the presence of rock, compaction during construction, and minor cementation. The thickness of the fill averages 25 feet.

Foundation

Organic Horizon: The organic horizon is 0 to 1 foot thick, semi-continuous, and has moderate permeability. The color of this horizon is typically black and consists of primarily of loose fine to medium grained clean to silty organic stained quartz sand with varying amounts of silt and occasional pockets of organic sandy silt, and peat. At natural lower lying areas, pockets of organic silt and peat may be present.

Sand Horizon: This sand horizon is found to be from 20 to over 75 feet thick. The sand is a heterogeneous, fine, light gray, clean, to silty quartz sand with shell. Within this sand layer, numerous thin limestone layers are encountered. The limestone is fossiliferous, sandy, heavily weathered, and moderately hard, with interbedded poorly cemented sand and shell. No rock is found in the northern ¼ of the reach. To the south, the rock layers become thicker, more numerous, and deeper. The rock layers are fairly shallow and average 2.0 foot thick.

Rock Horizon: Halfway in Reach 7 towards the south, the limestone layers begin to consolidate into one rock unit where it ranges in thickness of 5 to 20 feet thick and averages over 15 feet thick. The rock unit is not homogeneous, occasional thick layers of discontinuous poorly cemented sand and shell are observed within the rock. The quality of the rock increases with depth. The upper portions of the rock is found to be heavily weathered, soft to moderately hard, and often interbedded with discontinuous thin

layers of poorly cemented sand and shell. The lower rock is more competent and solid; it is less weathered, harder, and has fewer partings. Some of the limestone is essentially impermeable, while the remainder varies to highly permeable, containing fractures, voids and solutioning features.

Lower Sand Horizon: The lower sand horizon is from 20 to 60 feet thick. Below the limestone unit a sand layer is encountered between elevations -5.0 to -25.0 feet NAVD88. The sand layer transitions from limestone in the upper 5 feet of the unit in the form of thin interbedded layers and nodules of limestone. The material is light greenish gray, partially cemented, clean to silty, fine quartz sand with shell.

Reach 8 (Including the Kissimmee River; CIZ E)

Embankment

The HHD embankment was constructed using dredged material from Lake Okeechobee and is a heterogeneous mixture of loose to medium, fine to medium grained clean to silty and clayey quartz sand with shell and limestone gravel, cobbles, and occasional boulders. Other materials encountered throughout the embankment in minor amounts are thin, scattered layers of organics, and clay/silt layers. The limestone materials would also have minor percentages, but with widely varying distribution within the embankment. The thickness of the fill averages 25 feet at the crest and thins on the flanks. The percentages of fines and rock would decrease, and organics would increase within the embankment going up stream in the Kissimmee Valley.

Foundation

Organic Horizon: The organic horizon is 0 to 1 foot thick, semi-continuous, and has moderate permeability. The color of this horizon is typically black and consists primarily of loose fine to medium grained clean to silty organic stained quartz sand with varying amounts of silt and occasional pockets of organic sandy silt, and peat. These organic materials may become thicker in lower lying areas. Running up the Kissimmee Valley, the organics become more continuous, thicker, and consist of primarily sandy organic silt.

Rock Horizon: Near surface rock is typically less than 2 feet thick and is found from 2 to 10 feet below ground. The rock is discontinuous, soft, highly weathered, and often found surrounded by clayey material. This rock layer is found to pinch out shortly up the Kissimmee Valley. Outcropping of isolated near surface rock can be is found along the rim canal in this reach.

Sand Horizon: This sand horizon is found to be over 65 feet thick and consist of a heterogeneous, light greenish gray, fine, clean to silty/clayey, fine quartz sand with shell, and occasional layers of silt, clay, and limestone. The fines content of the sand is variable both horizontally and vertically and shows only a minor decrease to the northeast. This sand unit is generally of loose to medium consistency, and has a tendency to become denser to the northeast and with depth. The denser materials are generally caused by zones with a higher degree of cementation, consolidation, or thin layers of limestone.

3.2 SOILS

Soils in the Lake Okeechobee region are grouped based on distinctive patterns of composition, relief, drainage, and natural landscape. There are three predominant soil groups in areas nearest to the HHD, each representing a distinct group of soil classes. These groups are referred to as (1) Soils of the Flatwoods, (2) Soils of Sloughs and Freshwater Marshes, and (3) Soils of the Everglades. All are primarily moderately permeable soils with a water table within three feet of ground surface.

The Soils of the Flatwoods group are level to gently sloping flat areas and poorly drained. These soils are acid to loamy sands and are low in fertility. Flatwood soils occur in areas where the water table rises to within five to 20 inches of the soil surface at least once during a growing season. The Soils of Sloughs and Freshwater Marshes are nearly level and poorly drained. These soils are found in areas with longer hydroperiods (typically nine to twelve months) and greater maximum depths of flooding. The soils of the Everglades group are nearly level and very poorly drained. This group of soils has a surface layer of muck underlain by limestone. These are primarily moderately permeable soils with a water table within three feet of the ground surface.

3.3 LAND USE

The primary land use in the Lake Okeechobee region is agriculture. Major agricultural activities in the area include sugarcane plantations, ornamental plant nurseries, and citrus groves. The primary land use in the Lake Okeechobee region is agriculture. Major agricultural activities in the southern area include sugarcane and row crops, along with ornamental and tree nurseries. Along the east side of the Lake, there are citrus groves, sugar cane and increasingly row crops. To the west and north, agricultural activities include rangeland, citrus, and cow calf operations.

The Farmland Protection Policy Act of 1981 was enacted to minimize the extent that Federal programs contribute to the unnecessary and irreversible conversion of farmland to non-agricultural uses. The U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) is responsible for designating prime or unique farmland protected by the Act. In early 2010, the NRCS designated certain high-value crops in Florida, such as sugarcane, ornamental plant nurseries, and citrus groves, as "unique," thereby protecting these farmlands under the Act. Unique farmland protected by the Act exists in close proximity to the HHD in Reaches 2 and 3.

3.4 HYDROLOGY & HYDRAULICS

Surface Water

The majority of inflow enters Lake Okeechobee through several major canals (C-38, C-40, C-41) along the northwestern shore of the lake, through Fisheating Creek from the west, and through control structures and pumping stations along the northeastern shore of the lake that receive flows from Taylor Creek-Nubbin Slough, Mosquito Creek, Henry Creek, and Lettuce Creek. Additional inflow to Lake Okeechobee for agricultural, municipal, and local drainage purposes and outflow for water supply purposes are made through a series of 28 Federal, state, and local drainage district culverts that penetrate the HHD. Water supply releases through these culverts are made to the Lake Okeechobee Service Area (LOSA), municipal areas, the Seminole Tribe of Florida, Water Conservation Areas (WCA), fish and wildlife, Stormwater Treatment Areas (STA) and other mandated water quality treatment facilities, groundwater recharge in the Lower East Coast and Everglades Agricultural Area (EAA), and Everglades National Park. The remaining inflow to the lake occurs in the form of pumped inflows from large pumping stations (S-2, S-3, and S-4) located along the southern perimeter of the lake (Moorehaven to Belle Glade).

Inflow enters from the north, east, and west of Lake Okeechobee through the following watersheds: Kissimmee River (Upper Kissimmee and Lower Kissimmee), Taylor Creek-Nubbin Slough, Fisheating Creek (Nicodemus Slough), Indian Prairie, Lake Istokpoga, East Lake Okeechobee, and West Lake Okeechobee. Of the 28 culvert structures that penetrate the HHD, 13 of the structures are located in the reach between S-77 (Moorehaven) and S-308 (Canal Point). Drainage in this reach is managed by local water control districts, also referred to as special "298 Districts," mostly contained within the EAA, and on property owned by U.S. Sugar, Trucane, Lake Point, Five Smooth Stones, and numerous other landowners. The EAA

is divided into seven drainage basins and is comprised of a network of canals, structures, and levees that divide the area to provide for the removal of excess water to Lake Okeechobee and the WCAs to the south. The '298 Districts' have governmental pump stations that discharge to Lake Okeechobee or the EAA Canals. **Figure 3-3** provides a map of the 298 Districts. Inflow enters from the south of Lake Okeechobee through mostly state and local water control districts in the watershed designated as the 'South Shore'. These basin discharges are generally pumped back into Lake Okeechobee through the HHD culverts, with the exception of Pumping Stations S-2, S-3, and S-4 which pump directly into Lake Okeechobee. In general, the HHD culverts along the south shore have surface water management permits for drainage to Lake Okeechobee and water supply from Lake Okeechobee for agricultural irritation purposes.

The largest outlets of Lake Okeechobee include the St. Lucie (C-44) and the Caloosahatchee Rivers (C-43). Four major agricultural canals (West Palm Beach, Hillsboro, North New River, and Miami) drain to the south into Stormwater Treatment Areas (STAs), and then sequentially through the three Water Conservation Areas (WCAs). **Figure 3-2** shows the major Lake Okeechobee hydrologic features including the contributing watersheds to the north, east, and west, and the local water control districts along the south shore of Lake Okeechobee. Please see **Figure 3-4** for a map of structure locations.

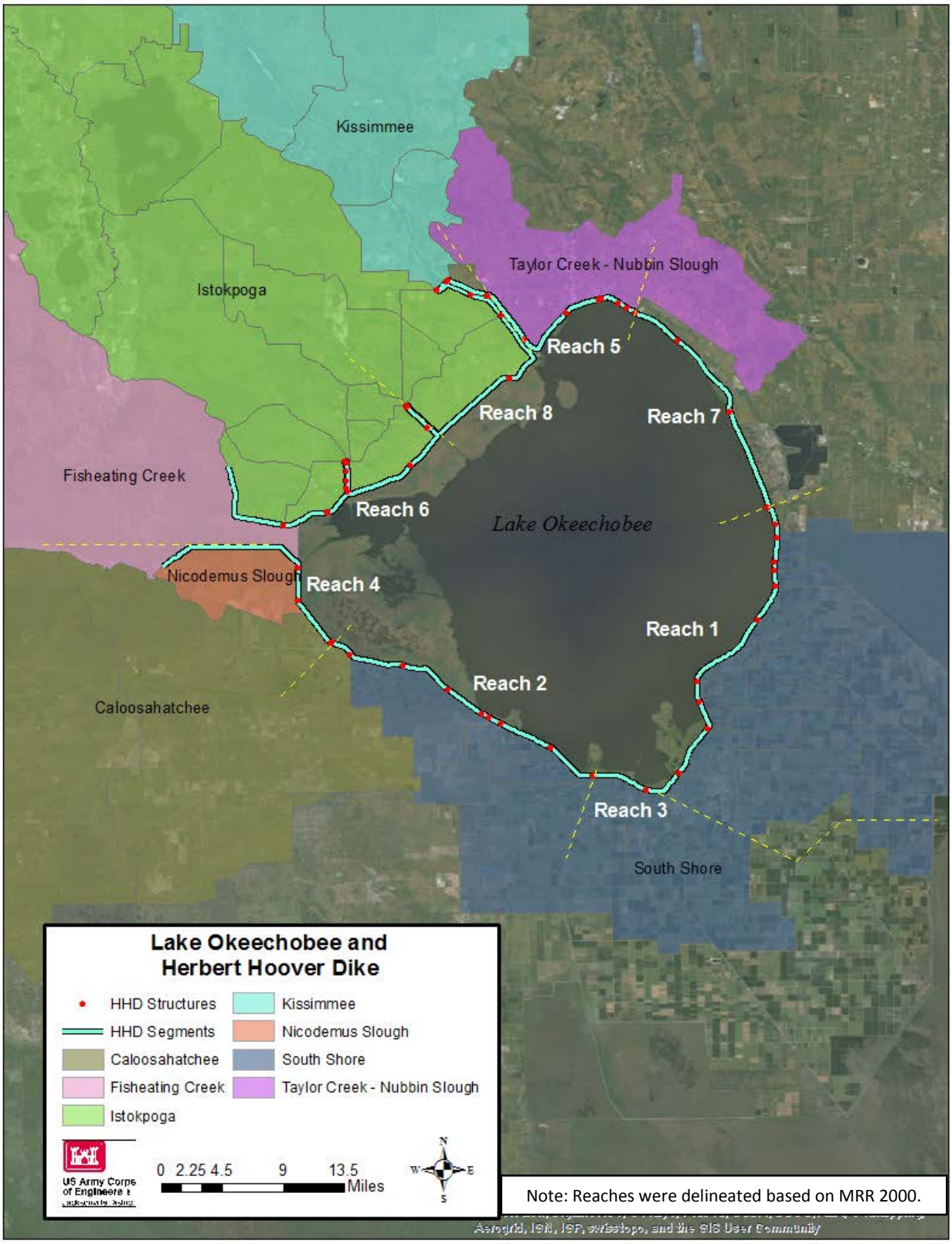

Figure 3-2. Basin Location Map

Kissimmee River

The Kissimmee River drainage basin encompasses about 2,260 square miles and extends from Orlando southward to Lake Okeechobee at the mouth of the Kissimmee River (C-38). The basin is the largest source of surface water flow to Lake Okeechobee with the inflow from C-38 controlled at SFWMD structure S-65E. There are two culverts that discharge into C-38 south of S-65E: KI-1 and KI-2.

Taylor Creek – Nubbin Slough

The Taylor Creek – Nubbin Slough drainage area bordering the north and northeast shores of Lake Okeechobee encompasses about 309 square miles and extends from the Kissimmee River (C-38) to the St. Lucie River (C-44). All inflow from this watershed is controlled. There are five HHD culverts in the basin: C-6, C-7 (abandoned), C-8, C-9 (abandoned), and Taylor Creek Culvert (TCC; abandoned). The C-7, C-9 and TCC culverts are not in use and considered abandoned in place.

Fisheating Creek

Fisheating Creek is located principally in the western portions of Highlands and Glades counties, with the western boundary extending into the easterly edges of Hardee, DeSoto, and Charlotte counties. The drainage area is adjacent to the Peace Creek Basin on the west and northwest, the Lake Istokpoga-Indian Prairie and Harney Pond Canal areas on the north and northeast, and Nicodemus Slough on the south. Fisheating Creek drains an L-shaped area of about 550 square miles. From the headwaters near Lake Josephine, the creek discharges uncontrolled and flows south for 32 miles, then east for 23 miles to discharge into Lake Okeechobee.

Nicodemus Slough

The Nicodemus Slough drainage basin borders the southwest shore of Lake Okeechobee extending from Fisheating Creek to Culvert 5A just north of the Caloosahatchee River watershed. The area encompasses about 39 square miles and normally drains to Lake Okeechobee. When lake levels are abnormally high, it is necessary to drain some of Nicodemus Slough south to the Caloosahatchee River through structures C-5 and C-5A. There are two HHD culverts in the basin: C-5 and C-5A.

Istokpoga

The Istokpoga drainage basin borders the northwest shore of Lake Okeechobee from Kissimmee River (C-38) to Fisheating Creek and encompasses about 1,070 square miles. Levees isolate the two main canals, Indian Prairie Canal (C-40) and Harney Pond Canal (C-41) from the watershed. There are three culverts that discharge into Indian Prairie Canal: IP-1, IP-2, and IP-3, as well as the S-72 gated spillway; and six culverts discharge into Harney Pond Canal: HP-1, HP-2, HP-3, HP-5, HP-6, and HP-7, as well as the S-71 gated spillway. The FC-1 culvert discharges into the L-50 borrow (Refer to **Figure 3-4** for a structure location map).

South Shore

The South Shore of Lake Okeechobee extends from Moore Haven at the Caloosahatchee River to Port Mayaca at the St. Lucie River. There are 13 HHD culverts in the basin: 1, 1A, 2, 3, 4A, 10, 10A, 11, 12, 12A, 13, 14 (to be removed), and 16. The drainage areas associated with these 13 culverts are local water control districts mostly contained within the Everglades Agricultural Area (EAA), but also include U.S. Sugar, Trucane, Lake Point and Five Smooth Stones. The EAA is divided into seven drainage basins and is comprised of a network of canals, structures, and levees that divide the area to provide for the removal of excess water to Lake Okeechobee and the WCAs to the south. The local drainage districts, also referred to as '298 Districts', have private pump stations that discharge to Lake Okeechobee or the EAA canals. **Figure 3-3** provides a map of the 298 Districts.

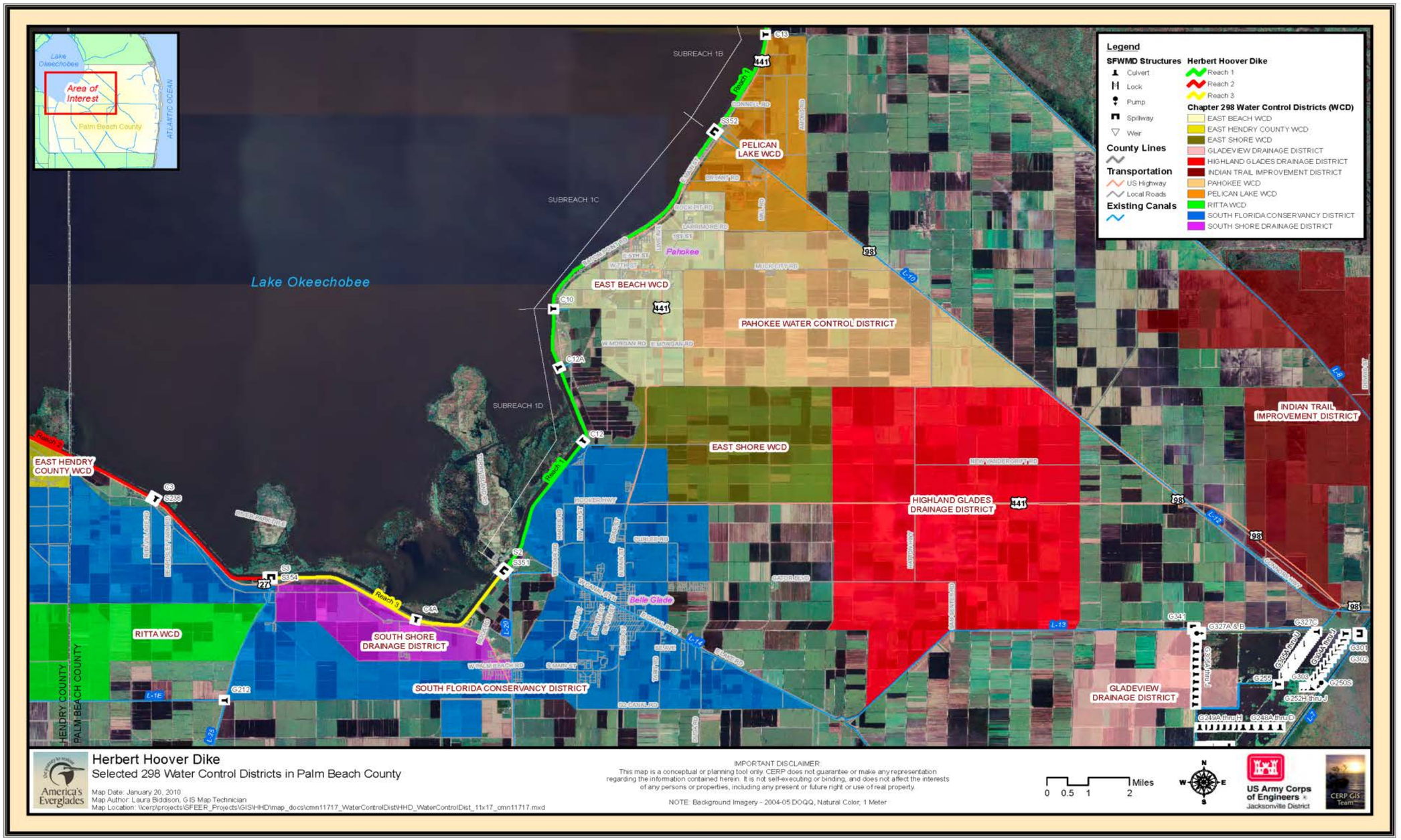

Figure 3-3. 298 Water Control Districts

Surface Water Use

Surface water releases from Lake Okeechobee meet several different C&SF project purposes, including flood control, water supply, navigation, recreation and environmental enhancement. The SFWMD manages the water use permitting process within its boundaries under authority of Chapter 373, Florida Statutes, and several Florida Administration Code (F.A.C.) rule chapters. A water use permit provides the user with a right to divert and use the allocated quantity from a designated source (both groundwater and surface water sources). Permit use classes include agricultural, recreation, public water supply, industrial and "diversion and impoundment" (including the 298 Water Control Districts).

There are 298 Water Control Districts (originated under the authority of Chapter 298, Florida Statutes), which maintain and operate secondary canal systems in the EAA (Pickett et al., 2013; **Figure 3-3**). These districts are only a portion of the agricultural lands served by Lake Okeechobee. For users within these water control districts, the water supply in the EAA is assured by maintaining water levels in these canals. Water levels in the 298 Districts with the EAA are maintained approximately 1 to 2 feet below the ground surface; however, during most of the year and further lowered during the planting and harvesting seasons to facilitate operations, the depth of the control elevations below ground surface at the pump stations can vary as much as three to four feet. The depth to groundwater along a particular pumped canal can also vary due to changes in ground elevation and the 5-10 mile length of the canal over which groundwater levels are being influenced. The amount of rainfall in the area also influences the water surface profile in the canals that are being pumped. For users outside of the water control districts and within the EAA, water tables are maintained by inflow from the SFWMD primary canals. For water users outside of the EAA, including the rest of the Lake Okeechobee Service Area and the Seminole Tribe, water users depend upon the level of Lake Okeechobee to provide irrigation to maintain seepage systems or for overhead irrigation. During dry periods, increased water use and high evapotranspiration can result in undesirably low water levels in Lake Okeechobee. To reduce adverse ecological effects from low lake levels, the SFWMD has developed a water supply management plan that requires various actions to be taken according to the severity of the dry conditions. The basis of this plan is an allocation scheme that parcels out lake water based on estimated water use for the remainder of the dry season.

Groundwater

The groundwater resources in the Lake Okeechobee area include the surficial unconfined aquifer system (SAS) and the Floridan Aquifer System (FAS) separated by the Intermediate Confining Units (Radin et al. 2005). Artesian freshwater conditions exist in the Upper Floridan Aquifer in the areas along HHD Reaches 4, 5, 6, and 8. Groundwater recharge in the area occurs primarily from precipitation. Pumping of the surficial aquifer for agricultural and potable water needs occurs around the entire perimeter of the lake though it is most predominant in the northern reaches of the lake. In the northern reaches (Reaches 4, 5, 6, 7, and 8) of the HHD, surficial aquifer groundwater tends to move from the landside to the lakeside since adjacent land elevations and groundwater levels are generally higher than the lake levels. Through the southern reaches (Reaches 1, 2 and 3) of the HHD, surficial aquifer groundwater tends to move from the lakeside to the landside (England et al. 2013) since adjacent land elevations and groundwater levels are generally lower than the lake levels.

The typical depth to the surficial groundwater table in the Lake Okeechobee area is about three feet below ground surface. In Palm Beach, Glades, and Hendry counties, the SAS may extend to

200 feet below ground surface in HHD Reaches 2 and 3. The surficial groundwater aquifer in the vicinity of the eastern and southern portions of the HHD extends from the land surface (8.7 feet NAVD88) to a depth of -180 feet. The upper portion of this aquifer is potable to a depth of approximately -50 feet below land elevation. Residents and agricultural operations adjacent to the eastern and southern portions of Lake Okeechobee use shallow wells as a source of drinking and irrigation water. The groundwater below elevation -50 feet is not considered potable due to the high salinity of the underlying trapped connate water (i.e., ancient saline water).

Lithologies that include the SAS consist of undifferentiated fill, peat/silt, inter-bedded zones, highly permeable limestone layers, sand, and semi-confining units (Pickett et al. 2013). Pumping tests and other aquifer performance tests have been conducted along the HHD alignment to estimate values of key hydrologicparameters that characterize the transmissivity and storativity of groundwater within the SAS. These tests show that the transmissivity of groundwater in the SAS generally increases moving from north to south, with the overall hydraulic conductivity estimated at 14 ft/day for the HHD Reaches 4, 5, 6, 7 and 8 and from 1 to 2 orders of magnitude higher along the HHD Reaches 1, 2, and 3.

Groundwater levels surrounding the HHD are rarely static and often fluctuate with changes in lake levels, recent rain events, agricultural pumping and operation of water control structures and canals. Typically, toe ditch water levels adjacent to the HHD are reflective of the local groundwater levels. In contrast, the water levels in the C&SF Project canals are managed by the SFWMD and water levels in those canals do not necessarily represent local groundwater levels. Within the EAA, due to land subsidence and the presence of levees bounding the C&SF Project canals, water levels in these canals can often be several feet higher than the groundwater levels being managed in the adjoining EAA farms.

Compared to the pre-historic condition, the groundwater hydrologic system in the area (particularly along the southern portions of Reaches 1 and 2 and all of Reach 3) has been changed due to the construction of the HHD, the construction/operation of public and private drainage systems and agricultural practices. The completion of the HHD and the primary drainage canal system of the C&SF Project allowed agricultural operations to flourish in the peat-deposited lands downstream of Reaches 1, 2, and 3, to the point that this region became known as the EAA. Water levels in the 298 Water Control Districts with the EAA are maintained approximately 1 to 2 feet below the ground surface. However, during the majority of the year and especially for harvest, planting, and cultivation the depth of the control elevations below ground surface at the pump stations can vary as much as three to four feet because of changes in topography and the 5-10 mile length of the canal over which groundwater levels are being controlled by pumping. The amount of rainfall in the area also influences the water surface profile in the canals that are being pumped. Other entities (lessees) of the EAA have similar practices. These systems operate under surface water and groundwater use permits issued by the SFWMD. Ultimately, the altered distribution of flows, peat loss, land subsidence, and decline of groundwater tables has caused an increase in the groundwater gradients across the HHD (England et al. 2013).

Groundwater Use

Lake Okeechobee provides potable water and recharges the surficial aquifer. The unconfined SAS is the principal source of groundwater for the basin's potable, agricultural, and industrial uses. The confined FAS aquifer has higher levels of dissolved solids such as sodium, thus it is not suitable for potable water except in some areas of Okeechobee and Glades Counties with the higher

quality FAS water. Only eight water supply wells are known to tap into the Upper Floridan aquifer in the basin.

There are approximately 300 surficial aquifer system groundwater pumping wells permitted within the general vicinity of the south, southwest, and southeastern portions of Lake Okeechobee. These wells, in addition to unpermitted wells in the area, are used for household, agricultural, industrial consumption, and de-watering activities. Some of these wells are located within 2,500 ft. of the HHD. The majority of the wells have pump capacities below 1 million gallons per day. In the area south of the HHD, groundwater is used primarily for irrigation, livestock, and landscaping. In addition, there are several groundwater wells that are used for industrial and public water supply. For instance, the city of Moorehaven uses a surficial aquifer wellfield located within one mile of the HHD for its potable water supply.

Water control Structures

Culverts

The HHD has numerous culvert structures that provide flood protection to residents of Palm Beach, Okeechobee, Highlands, Broward, Hendry, Glades, and Martin counties. Lake Okeechobee and the HHD are integral components of both the C&SF Project and the CERP which aim to provide flood protection, navigation, agricultural and municipal water supply, prevention of saltwater intrusion, recreation, enhancement of environmental resources, and ecosystem restoration.

The current HHD system is composed of 28 operational culvert structures, designated as either 'primary' or 'secondary' culverts (**Figure 3-4**). Primary culverts were mainly constructed along the southern and eastern portions of Lake Okeechobee with a few located near the City of Okeechobee on the northern end of Lake Okeechobee. Secondary culverts, located along the northern side of Lake Okeechobee, were constructed as feeder canals and rivers flowing into Lake Okeechobee. **Table 3-1** summarizes details of each culvert structure.

- 15 primary culverts (adjacent to Lake Okeechobee): Culverts 1, 1A, 2, 3, 4A, 5, 5A, 8, 10, 10A, 11, 12, 12A, 13, and 16
- 13 secondary culverts: Culverts 6, FC-1, HP-1, HP-2, HP-3, HP-5, HP-6, HP-7, IP-1, IP-2, IP-3, KI-1, and KI-2

Four additional primary culverts (C-7, C-9, C-15 and TCC) have been buried and/or scheduled to be removed from service. Additionally, the SFWMD and other private entities operate separate additional culverts into and out of Lake Okeechobee. **Table 3-2** summarizes details of these additional culverts.

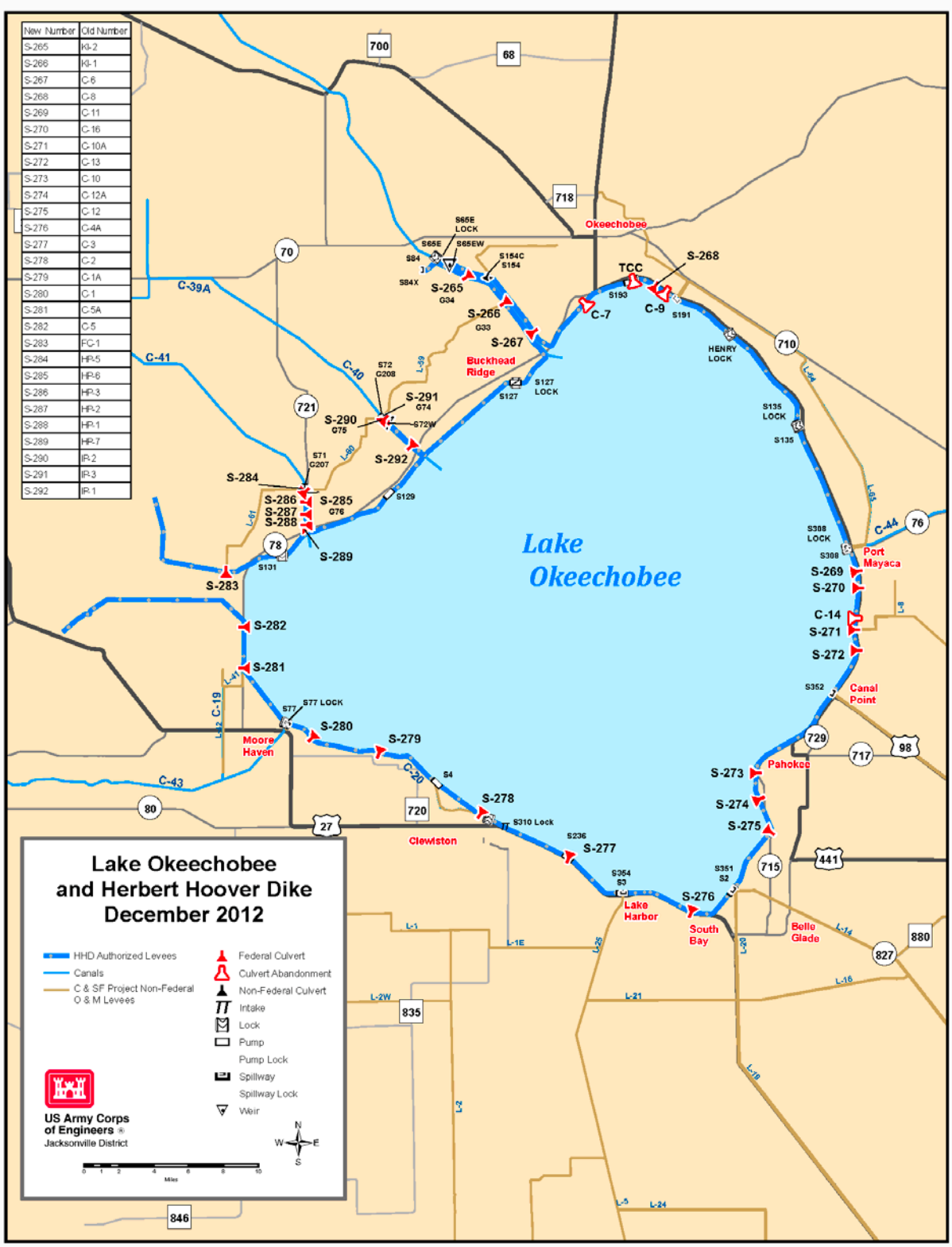

Figure 3-4. Structure Location Map

Table 3-1. HHD Culvert Summary

Culvert Name	New Structure Name	Barrels	Size (ft.)	Pipe Length (ft.)	Barrel Type	Reach	Basin
C-11	S-269	1	10	95	Concrete	1	South Shore
C-16	S-270	1	10	96	Concrete		
C-10A	S-271	5	10	76	Concrete		
C-13	S-272	1	10	95	Concrete		
C-10	S-273	2	10	111	Concrete		
C-12A	S-275	1	7	86	Concrete		
C-12	S-274	3	10	91	Concrete		
C-4A	S-276	1	10	177	Concrete	3	
C-3	S-277	2	10	105	Concrete	2	
C-2	S-278	6	10	105	Concrete		
C-1A	S-279	3	7	172	Concrete		
C-1	S-280	2	10	115	Concrete		
C-5A	S-281	3	10	160	Concrete	4	Nicodemus Slough
C-5	S-282	3	10	160	Concrete		
FC-1	S-283	2	9	118	Concrete	6	Istokpoga
HP-1	S-288	1	2.5	94	Concrete		
HP-2	S-287	1	7	94	Concrete		
HP-3	S-286	1	9	94	Concrete		
HP-5	S-284	2	9	96	Concrete		
HP-6	S-285	2	7	94	Concrete		
HP-7	S-289	1	5	94	Concrete		
IP-1	S-292	1	5	94	Concrete		
IP-2	S-290	2	7	80	Concrete		
IP-3	S-291	2	6	80	Concrete	8	
KI-1	S-266	3	6	145	Concrete		Kissimmee
KI-2	S-265	1	6	145	Concrete		
C-6	S-267	1	10	151	Concrete	5	Taylor Creek/ Nubbin Slough
C-8	S-268	3	10	151	Concrete		

Table 3-2. Additional HHD Culverts Summary

Culvert Name	Entity	Barrels	Size (ft.)	Pipe Length (ft.)	Barrel Type	Reach	Basin
S-169	SFWMD	3	7	60	CMP	2	South Shore
S-235	SFWMD	2	6	70	RCP	4	Caloosahatchee
S-47B	SFWMD	2	8	38	CMP	4	Nicodemus Slough
S-129	SFWMD	1	8	119	CMP	6	Istokpoga
S-131	SFWMD	1	8	217	CMP	6	
S-127	SFWMD	1	8	131	CMP	8	
S-154	SFWMD	2	8x10	117	CBC	5	Taylor Creek-Nubbin Slough
S-154C	SFWMD	1	6	136	RCP	5	
S-192	SFWMD	1	4	112	RCP	5	
S-135	SFWMD	2	8	161	CMP	7	S-135 Basin*
IPPC-1	Private	1	3	N/A	CMP	N/A	N/A
IPPC-2	Private	1	3	N/A	CMP	N/A	N/A

* Basin description not included because inflow provides negligible impact on Lake Okeechobee stages

Lock Structures

The Corps, the SFWMD, and other private entities operate and maintain several other water control structures around Lake Okeechobee for navigation, such as locks. **Table 3-3** summarizes lock structures around Lake Okeechobee. See **Figure 3-4** for a structure location map.

Table 3-3. Lock Summary

Lock	Owner	Name	Reach	Basin
S-308B	Corps	Port Mayaca	1/7	South Shore
S-310	Corps	Clewiston	2	
S-77	Corps	Moore Haven	4	Caloosahatchee
S-131	SFWMD	Lakeport	6	Istokpoga
S-127	SFWMD	Buckhead Ridge	8	
S-65E	SFWMD	Kissimmee River		Kissimmee
S-193	SFWMD	Taylor Creek	5	Taylor Creek-Nubbin Slough
S-135	SFWMD	N/A	7	S-135 Basin*
G-36	Private	Henry Creek		S-135 Basin*

* Basin description not included because inflow provides negligible impact on Lake Okeechobee stages.

Pump Stations and Spillways

Several pump stations and spillways are operated along Lake Okeechobee to provide flood relief, irrigation water, and water supply to downstream property owners and municipalities. Many pump stations are adjacent to and operated in conjunction with spillways, locks, and culverts. All pump stations are operated by the SFWMD and have the ability to pump nearly 12,000 cfs at maximum operating capacity.

Additionally, there are several spillways on the tributary systems which assist in flood control, water supply, and irrigation needs. These spillways are owned and operated by the Corps and/or the SFWMD in accordance with the LORS 2008. All of the spillways operate with vertical lift gates that allow flow to spill over the crest. Locations of all pump stations and spillways can be found on **Figure 3-4**. **Table 3-4** summarizes pump station information; **Table 3-5** summarizes spillway information.

Table 3-4. Pump Station Summary

Pump Station Number	No. of units	Max cfs	Reach	Basin
S-2	4	3600	1/3	South Shore
S-3	3	2670	2/3	
S-4	3	2805	2	
S-236	3	255		
S-131	2	250	6	Istokpoga
S-129	3	375		
G-207	1	135		
S-208	1	135	8	
S-127	5	625		
S-133	5	625	5	Taylor Creek - Nubbin Slough
S-135	4	500	7	S-135 Basin*

* Basin description not included because inflow provides negligible impact on Lake Okeechobee stages.

Table 3-5. Spillway Summary

Spillway No.	No. of gates	Max cfs	Reach	Basin
S-47D	1	1195	4	Caloosahatchee
S-77	4	9300	2/4	
S-71	3	6800	6	Istokpoga
S-72	2	3800	6/8	
S-84	2	9000	8	
S-65E	6	26000	8	Kissimmee
S-135	2	500	7	S-135 Basin*
S-191	3	7440	5/7	
S-153	2	4400	1/7	S-308C Basin*
S-308	4	17000	1/7	L-8 Basin*
S-351	3	2400	1	South Shore
S-352	2	1250	1	
S-354	2	2000	2/3	

* Basin description not included because inflow provides negligible impact on Lake Okeechobee stages.

Existing Canals

Major outflow canals from Lake Okeechobee include the Caloosahatchee River (C-43), St. Lucie River (C-44), Miami Canal, North New River Canal, Hillsboro Canal, and the West Palm Beach Canal. The Caloosahatchee River and the St. Lucie River are the primary outlets for release of floodwater when the lake is above regulation stages. Releases are controlled by a regulatory schedule and zones (USACE 2008).

The Caloosahatchee River (C-43), extending 52.8 miles from Lake Okeechobee, provides drainage for an area of about 1,230 square miles. The canal provides water control for the area adjacent to C-43 to prevent excessive depletion of groundwater during normal or dry periods. It also provides regulatory discharge capacity for Lake Okeechobee; serves as a navigation channel as part of the Okeechobee Water Way (OWW); and prevents saltwater intrusion and maintains freshwater supplies in the lower reaches of the Caloosahatchee River. Structure S-77, S-78, and S-79 in the Caloosahatchee River maintain normal pool elevations in the canal to prevent excessive velocities.

The St. Lucie River begins at Port Mayaca (S-308) and extends 23.9 miles east. The canal provides drainage for a 245-square mile area and for regulatory discharges for Lake Okeechobee. The canal also serves as a navigation channel as part of the OWW and prevents saltwater intrusion. Structure S-80 maintains normal regulated pool elevations in the canal.

Smaller outlet sources include the Miami, North New River, Hillsboro, and West Palm Beach Canals. The Miami Canal extends from Lake Okeechobee at pump station S-3 southeast to Miami-Dade County, by way of the S-8 pump station and through Water Conservation Area 3A. The Miami Canal is the primary drainage component of the S-3 and S-8 basins, the South 298 Drainage Districts and C-139 basin. The North New River Canal extends from Lake Okeechobee at pump station S-2 to pump station S-7, bordering Water Conservation Areas 2A and 3A, and on eastward to Ft. Lauderdale. The North New River Canal is the primary drainage feature of the S-2 and S-7 basins in the EAA. The Hillsboro Canal extends from Lake Okeechobee at the S-351 structure eastward to tide near Boca Raton. The West Palm Beach Canal extends from Lake Okeechobee at S-352 eastward to tide south of West Palm Beach.

Embankments

The existing HHD totals about 143 miles in length with crest elevations ranging from 30 to 45 feet NAVD88. Adjacent land elevations typically range from 8 to 19 feet NAVD88. Lakeside levee slopes vary from one foot vertical to three feet horizontal (1V:3H) to 1V:10H and landside slopes range from 1V:2H to 1V:5H. In addition to the main levees, there are several tie back levees on the Kissimmee River, Indian Prairie Canal, Harney Pond Canal, and Fisheating Creek. These tieback levees are considered part of the HHD system. The HHD is used for water storage and water control structures follow an operational schedule, whereas a dike does not have such characteristics (USACE 2008).

3.5 WATER QUALITY

Surface Water

Lake Okeechobee is a multipurpose reservoir providing drinking water for urban areas, irrigation water for agricultural lands, recharge for aquifers, freshwater for the Everglades, habitat for fish and waterfowl, flood control, navigation, and many recreational opportunities. Lake Okeechobee

has been designated by the FDEP as a Class I water body (drinking water supply). The surface water in the HHD toe ditch and nearby canals meets most Class III water quality standards (recreation and maintenance of healthy fish and wildlife populations). However, the water in Lake Okeechobee and canals has elevated concentrations of nutrients (primarily phosphorus and nitrogen). The Clean Water Act requires states to classify their surface waters according to designated uses and to develop water quality standards. If water bodies are not meeting the standards, states are required to develop Total Maximum Daily loads (TMDLs). The TMDLs establish the maximum amount of a pollutant that a water body can assimilate without causing an exceedance of water quality standards. Nutrient loads within the Lake Okeechobee Basin are regulated under the Northern Everglades and Estuaries Protection Act (NEEPA). The NEEPA specifies the implementation of Basin Management Action Plans (BMAPs). The Lake Okeechobee BMAP was adopted in December 2014 and allocated the TMDL to the entire Lake Okeechobee Watershed which includes all nine-sub watersheds to the north, south, east and west. The plans contain a schedule for subsequent phases of phosphorus load reduction consistent with the TMDLs and milestones must be set. The FDEP has a five-year cycle for setting and updating TMDLs and BMAPs. Revisions to the NEEPA were enacted in January 2016 and scheduled to become effective July 1, 2016.. Over the past 30 or more years, state and federal agencies have been working to reduce nutrient loading associated with agricultural operations in the Lake Okeechobee basin and downstream. Agricultural best management practices (BMPs) have been implemented by farm operators and nutrient loading has been reduced significantly in many of the hydrologic basins contributing to these basins. Backpumping agricultural storm runoff into the lake has been significantly curtailed and that has also improved lake water quality. A reduction in Lake Okeechobee phosphorus is desired, in part, to reduce the occurrence of blue-green algal blooms in the lake, and to reduce the adverse effects of phosphorus on downstream systems, including the Caloosahatchee River Basin and the St. Lucie River Basin. During high lake stages conditions, large volumes of water are released from Lake Okeechobee and sent to the Caloosahatchee and St. Lucie Estuaries. These large flow events are undesirable because they contribute to harm in the downstream estuaries (USACE 2007d).

Groundwater

Groundwater quality varies throughout the five counties surrounding Lake Okeechobee, depending on geographic location and the subsurface aquifer characteristics. Two aquifer systems are present within Okeechobee County. These are the SAS and the FAS, which are separated from one another by a thick and impermeable Hawthorn Group sediments. Water quality within the SAS in most areas of Okeechobee County is considered suitable for drinking water supply.

Similarly, in Glades County, two aquifer systems are present beneath the entire county, the SAS and the FAS. The Intermediate Aquifer System is present in the western third of the county. The SAS yields low to moderate quantities of potable water in most areas of Glades County, except for the area near Lake Okeechobee, and in the western area of the county near the border with Charlotte County. The Intermediate Aquifer System is present in the western portion of Glades County but yields only small to moderate quantities of relatively good quality water. The FAS is utilized primarily for irrigation. Throughout most of the county it is highly mineralized and would require expensive treatment to meet public drinking water standards. However, in the northwestern corner of the county the FAS water quality generally meets drinking water standards.

In Hendry County, the SAS is the primary source of groundwater throughout the county and is composed of two aquifers, the Water Table Aquifer and the Lower Tamiami Aquifer. Water quality within the SAS is considered poor in the Everglades area in the northeastern corner of the county where incomplete flushing of connate seawater, or FAS irrigation water, has left high chloride and total dissolved solids concentrations (SFWMD 1989). The FAS in this area is highly mineralized and for this reason it is not used as a source of potable water.

Two aquifer systems are present in Martin County that provide drinking water and irrigation water. These are the SAS and the FAS, which are separated from one another by the thick and impermeable Hawthorn Group sediments. The SAS is the primary source of drinking water throughout the county. The FAS is an alternate source of agriculture and potable water supplies.

The surficial groundwater aquifer surrounding Palm Beach County, the vicinity of the eastern and southern portions of the HHD extends from the land surface (8.7 feet NAVD88) to a depth of -180 feet. In the vicinity of HHD, the upper portion of this aquifer is potable to a depth of approximately -50 feet elevation. Rural houses and agricultural operations adjacent to the eastern and southern portions of Lake Okeechobee use shallow wells as a source of drinking and irrigation water. The groundwater below elevation -50 feet is not considered potable due to its high salt content.

The quality of the groundwater in the lower portion of the SAS is compromised by the presence of remnant seawater (Reese and Wacker, 2009), which has a high salt content and renders much of this water unsuitable for most potable and agricultural uses. The cities of Belle Glade, Pahokee, and South Bay historically drew their potable water supply from Lake Okeechobee because of the poor quality of the SAS and the underlying FAS in this part of Florida. Agricultural water demand in this area is generally met by water delivered through an extensive surface water canal network. Despite the poor water quality of the surficial aquifer, there are water supply wells that are primarily use the water for irrigation, though some of the shallower wells may be used as a source of potable water.

The USACE and the U.S. Geological Survey have been monitoring groundwater quality in the vicinity of the HHD Levee in Reaches 1, 2, and 3 since 2011 (Prinos and Valderrama, 2015). Groundwater quality is characterized using geophysical induction logging methods, in which the relative tendency of saturated sediments to conduct an induced electric charge is measured. Saline water has a greater tendency to conduct an electric charge, so saline water shows higher values of bulk conductivity. Most of the logging was conducted in Palm Beach County (CIZ A), where the saltwater interface is clearly defined in the SAS. Some of this monitoring occurred prior to the cutoff wall installation in Reach 1 which was completed in 2013. **Figure 3-5** shows a monitoring well at Segment 22 (PB-1815). The cutoff wall at this location is placed to a depth that is 30 or more feet above the elevation of the interface between fresh groundwater and saline groundwater. Induction logs at this monitoring well show that the cutoff wall has not had a significant effect on groundwater quality, as shown by a repeated pattern with depth over a four-year period. This is likely because the cutoff wall does not restrict all of the fresh groundwater that flows from the lake side of the levee landward. In contrast, **Figure 3-6** shows induction logs from a monitor well (PB-1819) in which the observed change in the saltwater interface became shallower subsequent to the installation of the cutoff wall in Segment 24. Based on the data available to date, it appears that the cutoff wall has caused the saltwater interface depth to decrease by about 10 feet. Given that each successive measurement shows a smaller change in the zone of interest in comparison to the prior measurement event, it is likely that the elevation

of the saltwater interface is equilibrating. As long as the saltwater interface is substantially below the bottom of drainage and water supply ditches, the impact of the reduced depth of saline water is likely to be limited to those water supply wells located within the zone of influence of the cutoff wall and are screened at the depth of the cutoff wall tip. There are no monitoring wells placed in the 500 to 1,000 foot downstream range from the levee so at present the USACE cannot determine the maximum distance from the levee that changes to groundwater saline interface depth occur; however, density dependent groundwater modeling simulation results indicate that this distance is likely less than 1,500 ft. In the vicinity ofSegment 23, there is some recent evidence of increased chloride concentrations in surface water drainage/supply canals that are located within 500 or so feet of the HHD levee. This area in the vicinity of Sand Cut has at least two active rock mines that may be possible sources of the elevated concentrations in the surface water. It is possible, though not proven, that installation of the cutoff wall in this location may contribute to the observed increase in surface water chloride concentrations. The Corps and USGS continue to conduct groundwater monitoring in Reaches 1, 2, and 3 to further understand the impact of the cutoff wall on groundwater and surface water quality.

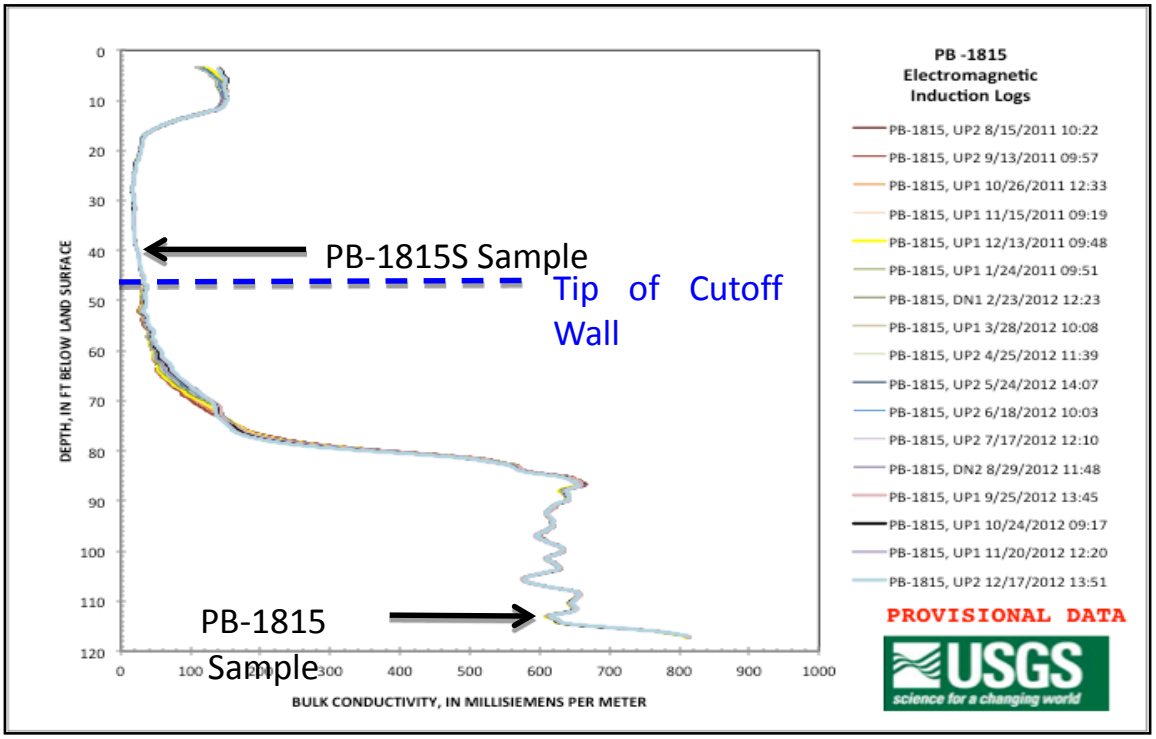

Figure 3-5. Bulk Conductivity at PB-1815 Well (Segment 22)

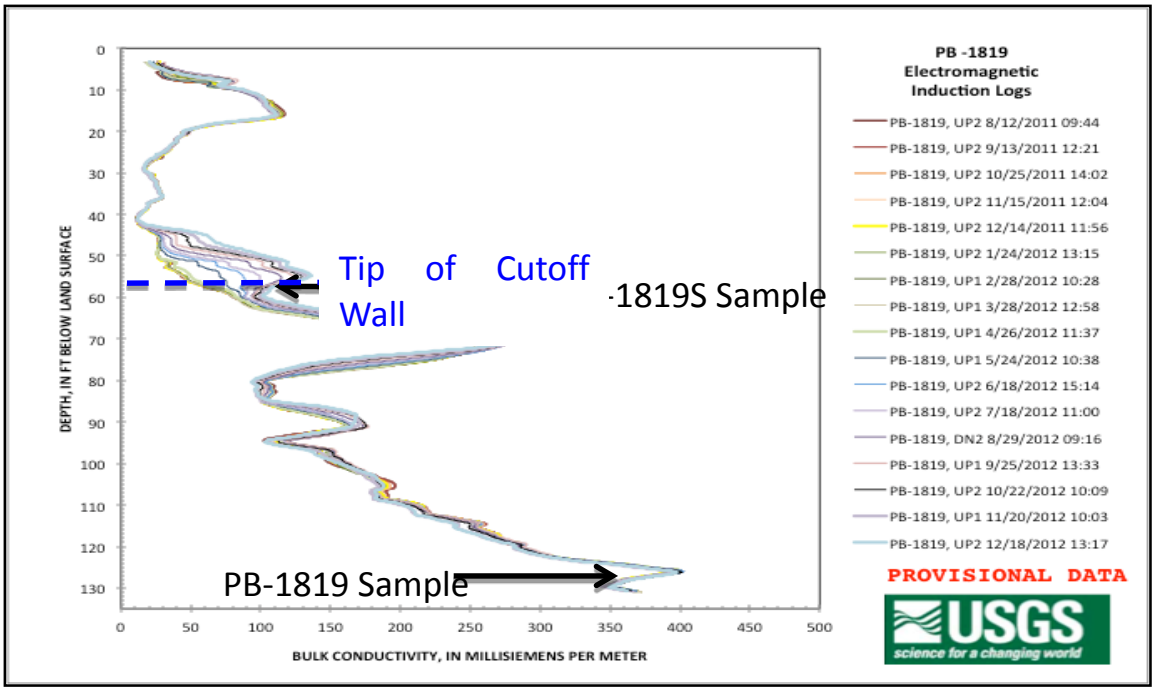

Figure 3-6. Bulk Conductivity at PB-1819 Well (Segment 24)

Saltwater Interface Characteristics in CIZ B (area of the Recommended Plan)

Additional monitor well clusters were constructed in the area during 2015 to supplement two existing monitor wells locations. Groundwater quality sampling and induction logs were obtained from all new well clusters. The depth and salinity of the saltwater interface in CIZ B wells differ from those in CIZ A. The saltwater interface occurs at greater depth, and the contrast in chloride concentration between overlying fresh groundwater and saltwater is not as great in CIZ B wells. **Figure 3-7** shows the induction log, chloride concentrations, and the proposed range of cutoff water termination depths for Segment 6 near Moore Haven.

Bulk conductivity values are significantly lower, indicating lower salinity in well G-333 at depth along CIZ B (100 to 200 mS/m at -60 to -80 ft NAVD88; **Figure 3-7**). For comparison, bulk conductivity values range between 100 and 600 mS/m at depths of -40 to -100 ft NAVD88) ft in Palm Beach County wells (CIZ A, **Figures 3-5** and **3-6**).

Chloride concentrations are considered elevated when they exceed the drinking water standard of 250 mg/L. Along CIZ B, chloride concentrations that exceed 250 mg/L (along with bulk conductivity values that exceed 100 mS/m) are found at elevations greater than approximately -50 ft NAVD88. The maximum cutoff wall elevation proposed for CIZ B is -30 ft NAVD88. The proposed cutoff wall will not intrude directly on the deeper, less saline saltwater interface in that area. Changing hydrologic flowpaths could cause some displacement of the saltwater interface at depth in CIZ B. However, groundwater quality changes are unlikely in this area due to the deeper occurrence and more dilute nature of the saltwater interface.

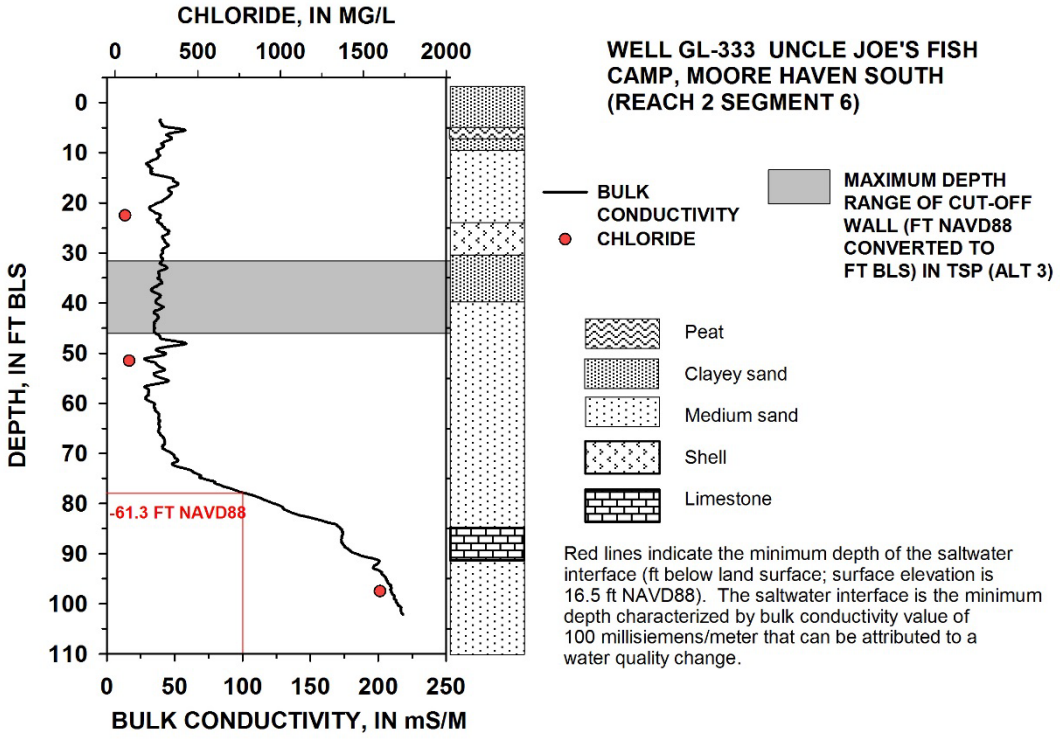

Figure 3-7. Bulk conductivity, chloride concentration, and lithology at well GL-333 (Segment 6)

3.6 VEGETATION

The vegetation within the Lake Okeechobee region has been greatly altered during the last century. Historically, the natural vegetation was a mix of freshwater marshes, hardwood swamps, cypress swamps, and pine flatwoods. Although some of these natural areas still exist, the introduction of controlled drainage for agriculture and land development has resulted in a significantly different set of cover types.

Landward of the HHD, sugarcane plantations, improved pasture, row crops, and urban lands now prevail. The HHD itself is covered with mixed grasses and some shrubs and trees that are mowed on a regular basis. The exotic invasive plants melaleuca (*Melaleuca quinquenervia*), Australian pine (*Casuarina* sp.), and Brazilian pepper (*Schinus terebinthifolius)* are found throughout the area. Wetland vegetation can be found in the toe ditch of the HHD though this vegetation is mowed during regular maintenance activities to allow inspection of the toe of the HHD embankment. In the toe ditch and the network of canals, exotic and nuisance vegetation exists, including species such as water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*), hydrilla (*Hydrilla verticillata*), cattails (*Typha* sp.), and bamboo (*Arundinaria* sp.).

The major cover types lakeward of the HHD include openwater and freshwater marshes. A 98,000-acre (154-square-mile) littoral zone is found along Lake Okeechobee's western edge and on the islands in its southern shore (Kraemer Island, Torry Island, and Ritta Island, which together encompass 4,000 acres). The littoral zone supports more than 50 species of emergent, submerged, and floating-leaf plants. Emergent vegetation within the littoral zone is dominated by cattail, spike rush (*Eleocharis* sp.), and the nuisance exotic torpedo grass (*Panicum repens*).

Submerged vegetation, such as tape grass (*Vallisneria americana*), is abundant within the photic zone of Lake Okeechobee.

3.7 WETLANDS

Wetlands in the Lake Okeechobee area, though greatly reduced in area and quality through human impact, still exist as valuable ecosystems both landward and lakeward of the HHD. Lake Okeechobee hydraulically feeds wetlands beyond the dike, providing freshwater for the Florida Everglades to the south and for the Water Conservation Areas in Palm Beach and Broward Counties. Low quality wetlands also occur in the toe ditches around the HHD. Typical vegetation in the toe ditch wetlands includes baby bluestem (*Andropogon* spp.), rush fuirena (*Fuirena scirpoidea*), bald cypress (*Taxodium distichum*), begger's tick (*Torilis arvensis*), matchhead (*Phyla* sp.), alligator weed (*Alternanthera philoxeroides*), Brazilian pepper, common reed (*Phragmities austalis*), common hackberry (*Celtis occidentalis*), elderberry (*Sambucus nigra* subsp. *canadensis*), smartweed (*Polygonum* sp.), southern willow (*Salix caroliniana*), cabbage palm (*Sabal palmetto*), sweetscent (*Pluchea odorata*), day flower (*Commelina* sp.), pennywort (*Hydrocotyle* sp.), Australian pine, water hyacinth, cattails, and water lettuce. Although wetlands present on the landward side of the HHD (toe ditch) may not be considered high quality ecosystems, they host small fishes and invertebrates and provide usable foraging habitat for wading birds, alligators, and turtles. High quality wetland habitat can be found in the extensive littoral zone covering the western side of Lake Okeechobee. This habitat (littoral zone) is outside of the proposed project footprint.

3.8 THREATENED AND ENDANGERED SPECIES

The U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and State of Florida have designated certain species of reptiles, birds, mammals, gastropods, and plants and lichens in Glades, Hendry, and Palm Beach counties as threatened or endangered (**Table 3-6**). Several of these listed species have been observed within the vicinity of the HHD. Additional detail can also be found in the USFWS draft Interim Fish and Wildlife Coordination Act Report (2014)(CAR) included in Appendix E.

Table 3-6. Federal and State Listed Plant and Animal Species Occurring in Glades, Hendry, Martin, Okeechobee, and Palm Beach Counties, Florida

Scientific Name	Common Name	Federal Status	State Status
Amphibians			
Rana capito	Gopher frog	Not listed	S*
Reptiles			
Caretta caretta	Loggerhead sea turtle	Threatened	Threatened
Chelonia mydas	Green sea turtle	Endangered	Endangered
Crocodylus acutus	American crocodile	Threatened	Endangered
Drymarchon couperi	Eastern indigo snake	Threatened	Threatened
Eumeces egregius lividus	Bluetail mole skink	Threatened	Threatened
Gopherus polyphemus	Gopher tortoise	Candidate	Threatened
Pituophis melanoleucus mugitus	Florida pine snake	Not listed	S
Birds			

Scientific Name	Common Name	Federal Status	State Status
Ammodramus savannarum floridanus	Florida grasshopper sparrow	Endangered	Endangered
Aphelocoma coerulescens	Florida scrub jay	Threatened	Threatened
Aramus guarauna	Limpkin	Not listed	S
Athene cunicularia	Burrowing owl	Not listed	S
Calidris canutus rufus	Red knot-migrant	Candidate	Candidate
Campephilus principalis	Ivory-billed woodpecker	Endangered (Historic)	Endangered
Charadrius melodus	Piping plover	Threatened	Threatened
Egretta caerulea	Little blue heron	Not listed	S
Egretta thula	Snowy egret	Not listed	S
Egretta tricolor	Tricolored heron	Not listed	S
Eudocimus albus	White ibis	Not listed	S
Falco sparverius paulus	Southeastern American kestrel	Not listed	Threatened
Grus Americana	Whooping crane	Endangered	S
Grus canadensis pratensis	Florida sandhill crane	Not listed	Threatened
Haematopus palliates	American oystercatcher	Not listed	S
Mycteria americana	Wood stork	Endangered	Endangered
Pandion haliaetus	Osprey	Not listed	S
Pelecanus occidentalis	Brown pelican	Not listed	S
Picoides borealis	Red-cockaded woodpecker	Endangered	S
Platalea ajaja	Roseate spoonbill	Not listed	S
Polyborus plancus audubonii	Audubon's crested caracara	Threatened	Not listed
Rostrhamus sociabilis plumbeus	Snail kite	Endangered	Endangered
Rychops niger	Black skimmer	Not listed	S
Sterna antillarum	Least tern	Threatened	Threatened
Invertebrates			
Anaea troglodyte floridalis	Florida's leafwing butterfly	Candidate (historical)	Not listed
Strymon acis bartrami	Bartram's hairstreak butterfly	Candidate (1974)	Not listed
Mammals			
Eumops floridanus	Florida bonneted bat	Endangered	Endangered
Podomys floridanus	Florida mouse	Not listed	S
Puma concolor coryi	Florida panther	Endangered	Endangered
Sciurus niger shermani	Sherman's fox squirrel	Not Listed	S
Trichechus manatus	Manatee	Endangered	Endangered
Ursus americanus floridanus	Florida black bear	Not Listed	Threatened
Gastropods (Snails and Allies)			
Orthalicus reses reses	Stock Island tree snail	Threatened	Endangered
Plants and Lichens			
Acrostichum aureum	Golden leather fern	Not Listed	Threatened
Argusia gnaphalodes	Sea lavender	Not Listed	Endangered

Scientific Name	Common Name	Federal Status	State Status
Asimina tetramera	Four-petal pawpaw	Endangered	Endangered
Calopogon multiflorus	Many-flowered grasspink	Not Listed	Endangered
Chamaesyce cumulicola	Sand-dune spurge	Not Listed	Endangered
Cladonia perforata	Perforate reindeer lichen	Endangered	Endangered
Coccothrinax argentata	Silver palm	Not Listed	Threatened
Cucurbita okeechobeensis	Okeechobee gourd	Endangered	Endangered
Dalea carthagenensis floridana	Florida prairie cover	Candidtate (1918)	Endangered
Dicerandra immaculate	Lakela's mint	Endangered	Endangered
Glandularia maritima	Coastal vervain	Not Listed	Endangered
Halophila johnsonii	Johnson's seagrass	Threatened	Threatened
Hypericum edisonianum	Edison's ascyrum	Not Listed	Endangered
Jacquemontia reclinata	Beach jacquemontia	Endangered	Endangered
Lantana depressa var. *floridana*	Atlantic Coast Florida lantana	Not Listed	Endangered
Lantana depressa var.*sanibelensis*	Gulf Coast Florida lantana	Not Listed	Endangered
Lechea cernua	Nodding pinweed	Not Listed	Threatened
Lechea divaricata	Pine pinweed	Not Listed	Endangered
Liatrus ohlingerae	Scrub blazing star	Endangered	Endangered
Linum carteri var. *smallii*	Carter's large-flowered flax	Not Listed	Endangered
Nemastylis floridana	Celestial lily	Not Listed	Endangered
Okenia hypogaea	Burrowing four-o'clock	Not Listed	Endangered
Ophioglossum palmatum	Hand fern	Not Listed	Endangered
Panicum abscissum	Cutthroat grass	Not Listed	Endangered
Paronchia chartacea	Papery whitlow-wort	Threatened	Endangered
Polygala lewtonii	Lewton's polygala	Endangered	Endangered
Polygala smallii	Tiny polygala	Endangered	Endangered
Pteris bahamensis	Bahama brake	Not Listed	Threatened
Pteroglassaspis ecristata	Giant orchid	Not Listed	Threatened
Sacoila lanceolata var. *paludicola*	Fahkahatchee ladies' tresses	Not Listed	Threatened
Schizaea pennula	Ray fern	Not Listed	Endangered
Tephrosia angustissima var. *cutissii*	Coastal hoary-pea	Not Listed	Endangered
Thelypteris serrata	Toothed maiden fern	Not Listed	Endangered
Tillandsia flexuosa	Banded wild-pine	Not Listed	Threatened
Tolumnia bahamensis	Dancing-lady orchid	Not Listed	Endangered
Warea carteri	Carter's mustard	Endangered	Endangered
Critical Habitat			
Rostrahamus sociabilis plumbeus	Everglade snail kite	Endangered	Endangered
Trichechus manatus	West Indian manatee	Endangered	Endangered
Chelonia mydas	Green sea turtle	Endangered	Endangered
Halophila johnsonii	Johnson's seagrass	Threatened	Threatened

*S=species of special concern

3.8.1 Federally Listed Species Expected to Occur Within the Study Area

3.8.1.1 Audubon's Crested Caracara

The threatened caracara is a unique raptor scavenger in the family Falconidae that reaches the northern limit of its geographic range in the southern U.S. In Florida, this raptor occurs as an isolated population in the south-central region of the state. Changes in land use patterns throughout central Florida have resulted in this population becoming a subject of concern. This raptor has been documented to occur almost exclusively on privately owned cattle ranches in the south-central part of the state.

Currently, much of the caracara population is found on improved or semi-improved pastures on private cattle ranches. Available evidence suggests that the most serious threat to Florida's caracara population is loss or degradation of nesting and feeding habitat. Such loss is most commonly due to conversion of pasture and other grassland habitats and wetlands to citrus, sugar cane, other agriculture, and urban development.

Adult caracaras exhibit high site- and mate-fidelity; therefore, extensive loss of habitat within the home range, particularly of the nesting site itself, may cause the pair to abandon that home range, or at least the nesting site (Morrison 2001). Egg laying has been documented as early as September and as late as June; peak activity occurs from late December through February (Morrison 2001). Clutch size is 2-3 eggs, with an incubation period of 32-33 days. Double brooding can occur if a nest is lost early in the season. Fledging occurs at 8 weeks. Young are dependent on parents for at least 2 months post-fledging, and may remain in the natal territory for up to 10 months. Most young in Florida leave natal territory after 4-6 months and form groups of up to 30 individuals.

The caracara is an opportunistic feeder, taking prey items such as insects, small reptiles and amphibians, and small mammals. Eggs and carrion are also included in the diet of caracaras. Foraging for food takes place in early morning and late afternoon. Caracaras often walk through pastures searching for prey items, particularly after disturbance such as mowing or plowing. Caracaras have also been observed feeding in recently burned areas. Hunting takes place from conspicuous perches or while in flight. Once prey is sighted, the caracara flies to the ground and walks up to prey item (Morrison 1996, Morrison 2001). The caracara is known to occur in the vicinity of the HHD and Fisheating Creek (USFWS produced map 2014). Audubon's crested caracara have been documented to nest near the project area, specifically nests have been reported south of Port Mayaca outside of the Federal right-of-way. Additionally, it is possible that nests could be found in other areas within the project area. Caracara nests around Lake Okeechobee are shown in **Figure 3-8**.

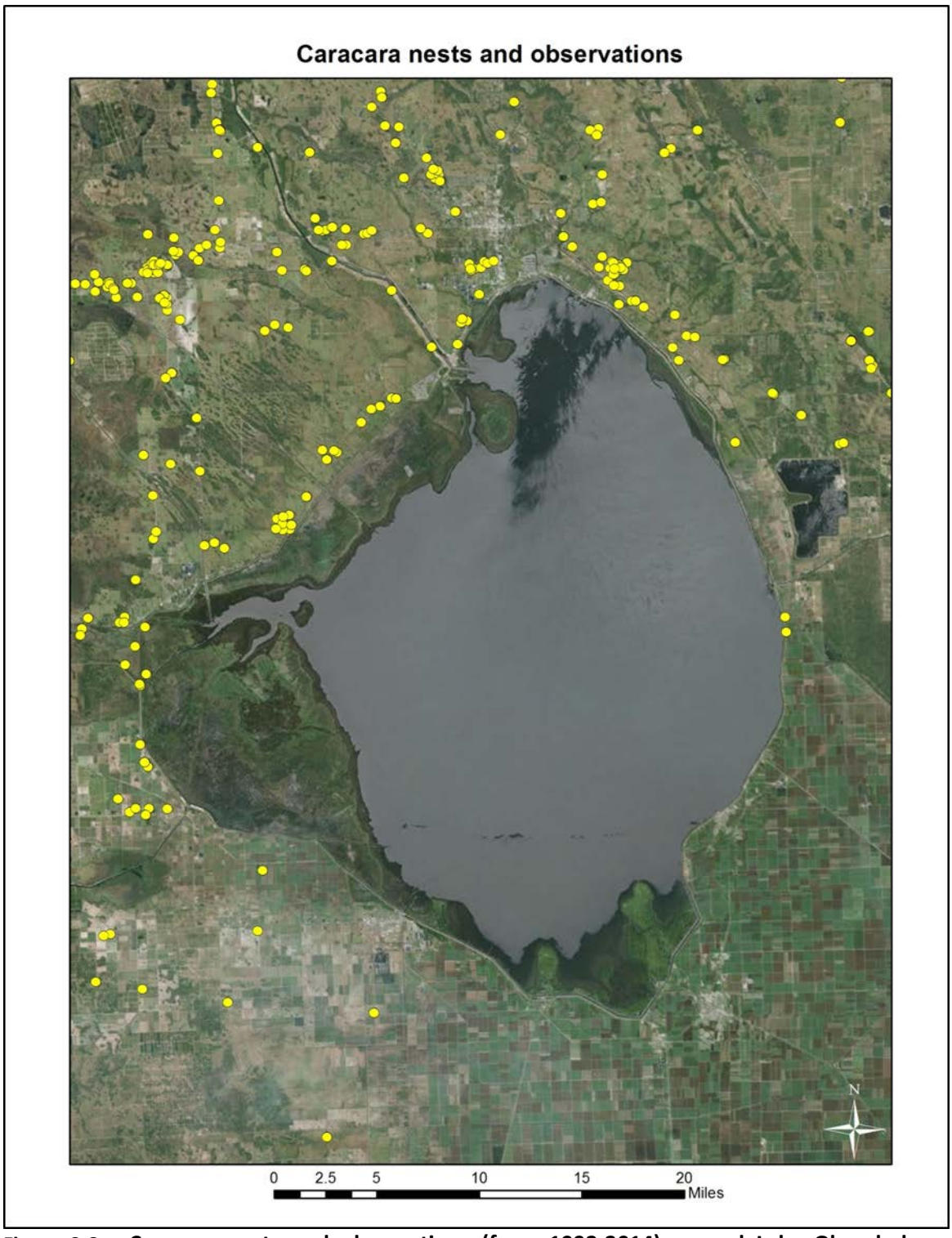

Figure 3-8. Caracara nests and observations (from 1992-2014) around Lake Okeechobee. Obtained source from USFWS 2015

3.8.1.2 Eastern Indigo Snake

The threatened Eastern indigo snake is the largest native non-venomous snake in North America. It is an isolated subspecies occurring in southeastern Georgia and throughout peninsular Florida.

The Eastern indigo snake prefers drier habitats, but may be found in a variety of habitats from xeric sandhills, to cabbage palm hammocks, to hydric hardwood hammocks (Schaefer and Junkin 1990). Eastern indigo snakes need relatively large areas of undeveloped land to maintain their population. In warm months, indigo snakes use a variety of natural areas and have large home ranges (Moler 1992; USFWS 1999). Indigo snakes occupy larger home ranges in the summer than the winter. Information on snakes in Florida indicates adult males have home ranges as high as 224 ha in the summer (Moler 1992). Because it is such a wide-ranging species, the eastern indigo snake is especially vulnerable to habitat fragmentation that makes travel between suitable habitats difficult. The main reason for its decline is habitat loss due to development. Further, as habitats become fragmented by roads, Eastern indigo snakes become increasingly vulnerable to highway mortality as they travel through their large territories (Schaefer and Junkin 1990).

In south Florida, the Eastern indigo snake is thought to be widely distributed. Given their preference for upland habitats, Eastern indigo snakes are not commonly found in great numbers in wetland complexes, though they have been found in pinelands, tropical hardwood hammocks, and mangrove forests in extreme south Florida (Duellman and Schwartz 1958; Steiner *et al*. 1983). Within the range of the gopher tortoise, tortoise burrows are favorite refugia for indigo snakes. They are known to use burrows made by cotton rats and land crabs, hollows at bases of trees and stumps, ground litter, trash piles and rock piles lining banks of canals and pipes or culverts.

Sexual maturity appears to occur around 3-4 years of age. In North Florida, breeding occurs November to April with females laying 4-12 eggs in May-June (Moler 1992). Most hatching of eggs occurs August-September, with yearling activity peaking in April-May (USFWS 1999). Limited data on reproduction in south Florida indicate the breeding season is extended; breeding occurs from June-January, egg deposition is April to July, and hatchlings are born through early fall (USFWS 1999). The Eastern indigo snake is known to occur in the vicinity of the HHD, but has not been observed on the embankment during construction activities in Reach 1 and culvert replacements.

3.8.1.3 Everglade Snail Kite

The snail kite is listed as an endangered species by both the USFWS and the State of Florida. Although previously located in freshwater marshes over a considerable area of peninsular Florida, the range of the snail kite is now limited to several impoundments on the headwaters of the St. John's River, the southwest side of Lake Okeechobee, the eastern and southern portions of Water Conservation Areas (WCAs) 1, 2A and 3, the southern portion of WCA 2B, the western edge of WCA 3B, and the northern portion of Everglades National Park.

The kite inhabits relatively open freshwater marshes that support adequate populations of apple snail (*Pomacea* sp.), upon which this bird feeds almost exclusively. Favorable areas consist of extensive shallow, open water such as sloughs and flats, vegetated by sawgrass (*Cladium jamaicense*) and spike rush. The areas are often interspersed with tree islands or small groups of scattered shrubs and trees that serve as perching and nesting sites. The water level must be sufficiently stable to prevent loss of the food supply through drying out of the surface.

The snail kite is threatened primarily by habitat loss and destruction. Widespread drainage has permanently lowered the water table in some areas. This drainage permitted development in

areas that were once kite habitat. In addition to loss of habitat through drainage, large areas of marsh are heavily infested with water hyacinth that inhibits the kite's ability to see its prey.

Based on the description in the Federal Register (1977), snail kite critical habitat in Lake Okeechobee is located in the western parts of Glades and Hendry Counties, extending along the western shore to the east of the dike system and the undiked high ground at Fisheating Creek, and from the Hurricane Gate at Clewiston northward to the mouth of the Kissimmee River, including all the spike rush (*Eleocharis* sp.*)* flats of Moonshine Bay, Monkey Box, and Observation Shoal, but excluding the open water north and west of the northern tip of Observation Shoal north of Monkey Box and east of Fisheating Bay. Critical habitat for the snail kite includes the southwest and western shore of Lake Okeechobee from Clewiston to the Kissimmee River (excluding deep open water). In the project area, this critical habitat includes the area along the HHD in CIZ B and CIn the project area (**Figure 3-9**). Snail kite nests around Lake Okeechobee are shown in **Figure 3-10.**

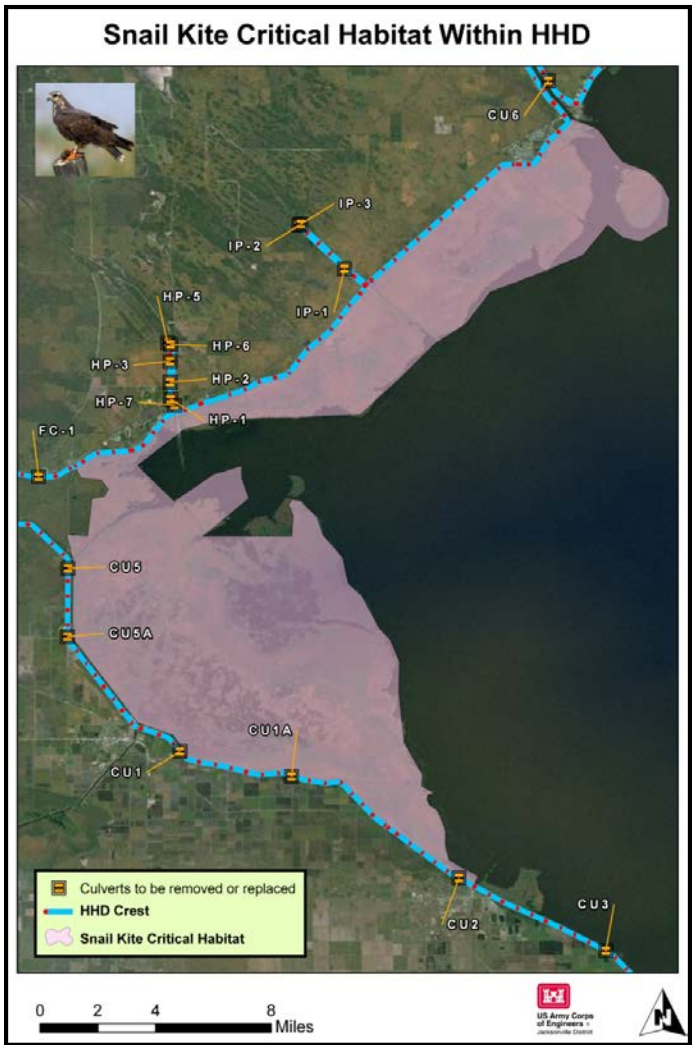

Figure 3-9. Snail Kite Critical Habitat. Source: USFWS 2015

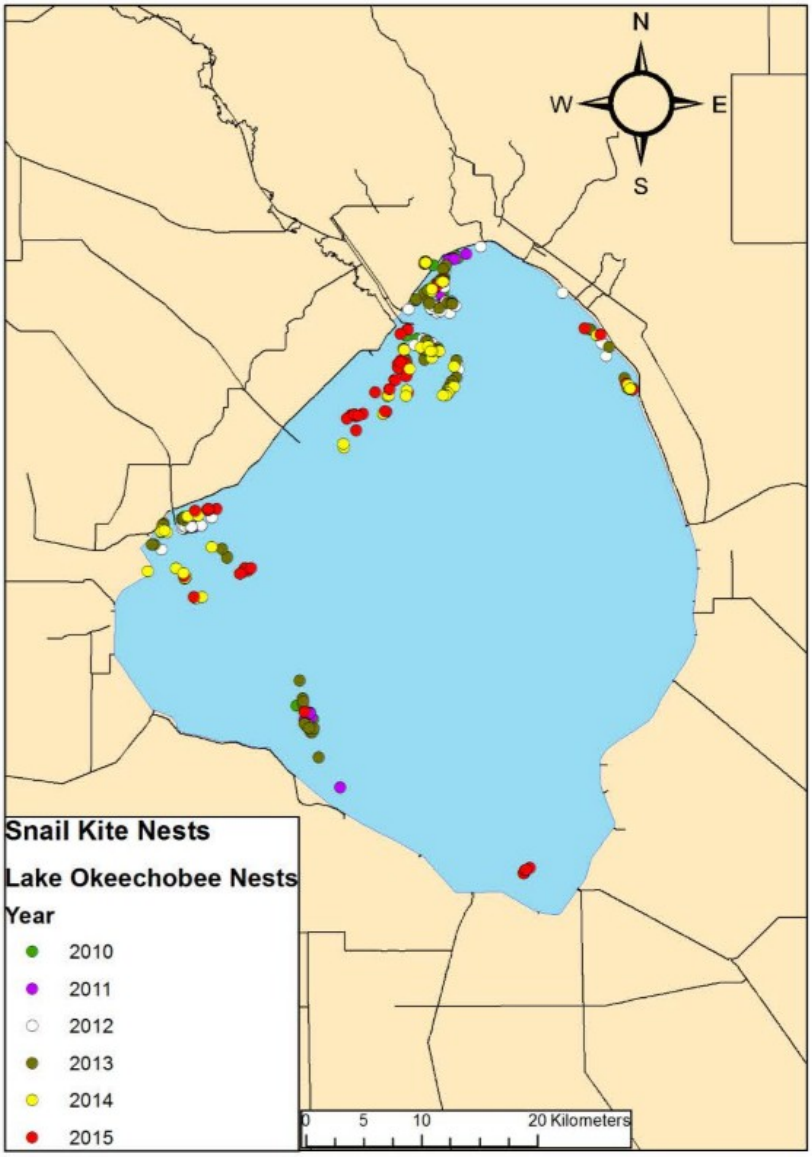

Figure 3-10. Snail kite nest locations from 2010-2015 (*active nests only). Source obtained from USFWS 2015.

3.8.1.4 Okeechobee Gourd

The endangered Okeechobee gourd is a climbing annual or perennial vine possessing heart to kidney-shaped leaf blades. The cream-colored flowers are bell-shaped and the light green gourd is globular or slightly oblong.

The Okeechobee gourd was locally common in the extensive pond apple forest that once grew south of Lake Okeechobee. Historically, the Okeechobee gourd was found on the southern shore of Lake Okeechobee in Palm Beach County and in the Everglades. Currently this species is limited to two disjunct populations, one along the St. Johns River in Volusia, Seminole and Lake Counties in northern Florida and a second around the shoreline of Lake Okeechobee in south Florida (USFWS 1999). The conversion of the pond apple forested swamps and marshes for agricultural purposes as well as water-level regulation within Lake Okeechobee have been the principal causes

of the reduction in both range and number of the Okeechobee gourd. The Okeechobee gourd is known to occur in the vicinity of the HHD.

3.8.1.5 West Indian Manatee

The Florida manatee is a large, plant-eating aquatic mammal that can be found in the shallow coastal waters, rivers, and springs of Florida. The Florida manatee, Trichechus manatus, was listed as endangered throughout its range for both the Florida and Antillean subspecies (T. manatus latirostris and T. manatus manatus) in 1967 (32 FR 4061) and received Federal protection with the passage of the ESA in 1973. Because the Florida manatee was designated as an endangered species prior to enactment of ESA, there was no formal listing package identifying threats to the species, as required by section 4(a)(1) of the Act.

Florida manatees can be found throughout the southeastern United States; however, within this region, they are at the northern limit of their range (Lefebvre et al. 2000). Because they are a subtropical species with little tolerance for cold, they remain near warm water sites in peninsular Florida during the winter. During periods of intense cold, Florida manatees will remain at these sites and will tend to congregate in warm springs and outfall canals associated with electric generation facilities (Florida Power and Light 1989). During warm interludes, Florida manatees move throughout the coastal waters, estuaries, bays, and rivers of both coasts of Florida and are usually found in small groups. During warmer months, Florida manatees may disperse great distances. Florida manatees have been sighted as far north as Massachusetts and as far west as Texas and in all states in between (Rathbun et al. 1983; Fertl et al. 2005). Warm weather sightings are most common in Florida and coastal Georgia. They will once again return to warmer waters when the water temperature is too cold (Hartman 1979; Stith et al. 2006). Florida manatees live in freshwater, brackish, and marine habitats, and can move freely between salinity extremes. It can be found in both clear and muddy water. Water depths of at least three to seven feet (one to two meters) are preferred and flats and shallows are avoided unless adjacent to deeper water.

Over the past centuries, the principal sources of Florida manatee mortality have been opportunistic hunting by man and deaths associated with unusually cold winters. As of March 2010, the FWC reported 431 Florida manatee deaths, more than the total number of deaths in reported 2009, related to the prolonged cold water conditions in the winter of 2009-2010. Today, poaching is rare, but high mortality rates from human-related sources threaten the future of the species. The largest single mortality factor is collision with boats and barges. Florida manatees also are killed in flood gates and canal locks, by entanglement or ingestion of fishing gear, and through loss of habitat and pollution. The manatee is known to inhabit Lake Okeechobee.

3.8.1.6 Wood Stork

The wood stork is a large, white, long-legged wading bird that relies upon shallow, freshwater wetlands for foraging. Black primary and secondary feathers, a black tail and a blackish, featherless neck distinguish the wood stork from other wading birds species. This species was federally listed as endangered under the ESA on February 28, 1984. No critical habitat has been designated for the wood stork.

In the United States, wood storks were historically known to nest in all coastal states from Texas to South Carolina (Wayne 1910; Bent 1926; Howell 1932; Oberholser 1938). Dahl (1990) estimates these states lost about 38 million acres, or 45.6 percent, of their historic wetlands

between the 1780s and the 1980s. However, it is important to note wetlands and wetland losses are not evenly distributed in the landscape. Hefner et al. (1994) estimated 55 percent of the 2.3 million acres of the wetlands lost in the southeastern United States between the mid-1970s and mid-1980s were located in the Gulf-Atlantic coastal flats. These wetlands were strongly preferred by wood storks as nesting habitat. Currently, wood stork nesting is known to occur in Florida, Georgia, South Carolina, and North Carolina from March to late May. However, in south Florida, wood storks lay eggs as early as October and fledge in February or March. Breeding colonies of wood storks are currently documented in all southern Florida counties except for Okeechobee County. Known nesting colonies are shown in **Figure 3-11**.

The wood stork population in the southeastern United States appears to be increasing. Preliminary population totals indicate that the wood stork population has reached its highest level since it was listed as endangered in 1984. In all, approximately 11,200 wood stork pairs nested within their breeding range in the southeastern United States. Wood stork nesting was first documented in North Carolina in 2005 and wood storks have continued to nest in this state through 2009. This suggests that the northward expansion of wood stork nesting may be continuing.

The primary cause of the wood stork population decline in the United States is loss of wetland habitats or loss of wetland function resulting in reduced prey availability. Almost any shallow wetland depression where fish become concentrated, either through local reproduction or receding water levels, may be used as feeding habitat by the wood stork during some portion of the year; but only a small portion of the available wetlands support foraging conditions (high prey density and favorable vegetation structure) that wood storks need to maintain growing nestlings. Browder et al. (1976) and Browder (1978) documented the distribution and the total acreage of wetland types occurring south of Lake Okeechobee, Florida, for the period 1900 through 1973. They combined their data for habitat types known to be important foraging habitat for wood storks (cypress domes and strands, wet prairies, scrub cypress, freshwater marshes and sloughs, and saw grass marshes) and found these habitat types have been reduced by 35 percent since 1900.

Wood storks forage primarily within freshwater marsh and wet prairie vegetation types, but can be found in a wide variety of wetland types, as long as prey are available and the water is shallow and open enough to hunt successfully (Ogden et al. 1978; Browder 1984; Coulter 1987; Gawlik et al. 2004; Herring and Gawlik 2007). Calm water, about 5 to 25 centimeters in depth, and free of dense aquatic vegetation is ideal, however, wood storks have been observed foraging in ponds up to 40 centimeters in depth (Coulter and Bryan 1993; Gawlik 2002). Typical foraging sites include freshwater marshes, ponds, hardwood and cypress swamps, narrow tidal creeks or shallow tidal pools, and artificial wetlands such as stock ponds, shallow, seasonally flooded roadside or agricultural ditches, and managed impoundments (Coulter et al. 1999; Coulter and Bryan 1993; Herring and Gawlik 2007). During nesting, these areas must also be sufficiently close to the colony to allow wood storks to efficiently deliver prey to nestlings.

The wood stork is known to occasionally feed in the toe ditch wetlands of the HHD. However, the principal habitat in the area for the wood stork is within the littoral zone of Lake Okeechobee.

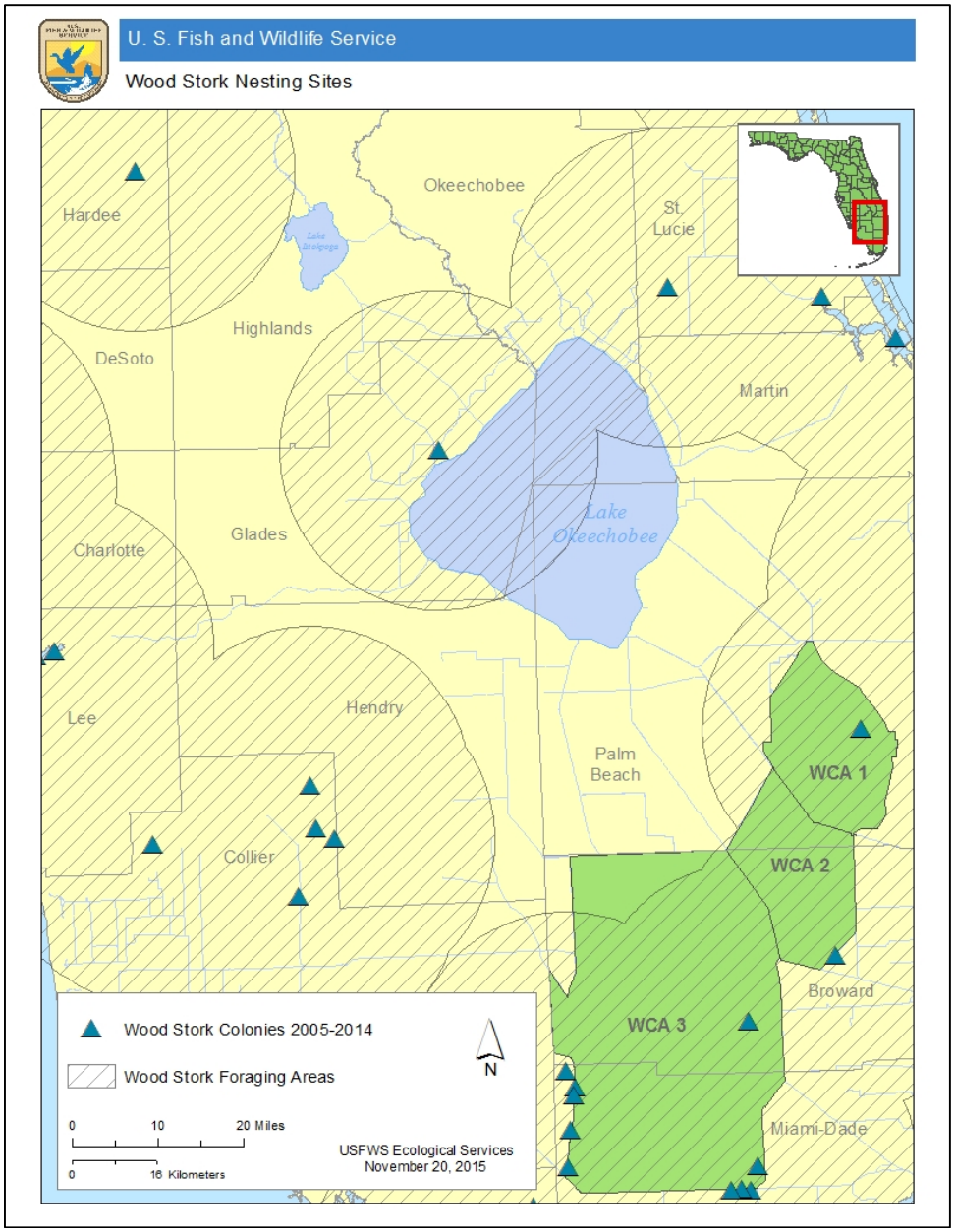

Figure 3-11. Wood stork colonies (2005-2015) near HHD and Lake Okeechobee. Source obtained from USFWS 2015

3.8.1.7 Florida Panther

The endangered Florida panther, also known as cougar, mountain lion, puma and catamount, was once the most widely distributed mammal (other than humans) in North and South America, but it is now virtually exterminated in the eastern United States. Habitat loss has driven the subspecies known as the Florida panther into a small area, where the few remaining animals are highly inbred, causing such genetic flaws as heart defects and sterility. Recently, closely-related panthers from Texas were released in Florida and are successfully breeding with the Florida panthers. Increased genetic variation and protection of habitat may save the subspecies.

One of 30 cougar subspecies, the Florida panther is tawny brown on the back and pale gray underneath, with white flecks on the head, neck and shoulder. Male panthers weigh up to 130 pounds and females reach 70 pounds. Preferred habitat consists of cypress swamps, pine and hardwood hammock forests. The main diet of the Florida panther consists of white-tailed deer, sometimes wild hog, rabbit, raccoon, armadillo and birds. Present population estimations range from 80 to 100 individuals. Florida panthers are solitary, territorial, and often travel at night. Males have a home range of up to 400 square miles and females about 50 to 100 square miles. Florida panther primary, secondary, and dispersal zones are shown in **Figure 3-12**. Female panthers reach sexual maturity at about three years of age. Mating season is December through February. Gestation lasts about 90 days and females bear two to six kittens. Juvenile panthers stay with their mother for about two years. Females do not mate again until their young have dispersed. The main survival threats to the Florida panther include habitat loss due to human development and population growth, collision with vehicles, parasites, feline distemper, feline alicivirus (an upper respiratory infection), and other diseases (USFWS 1999).

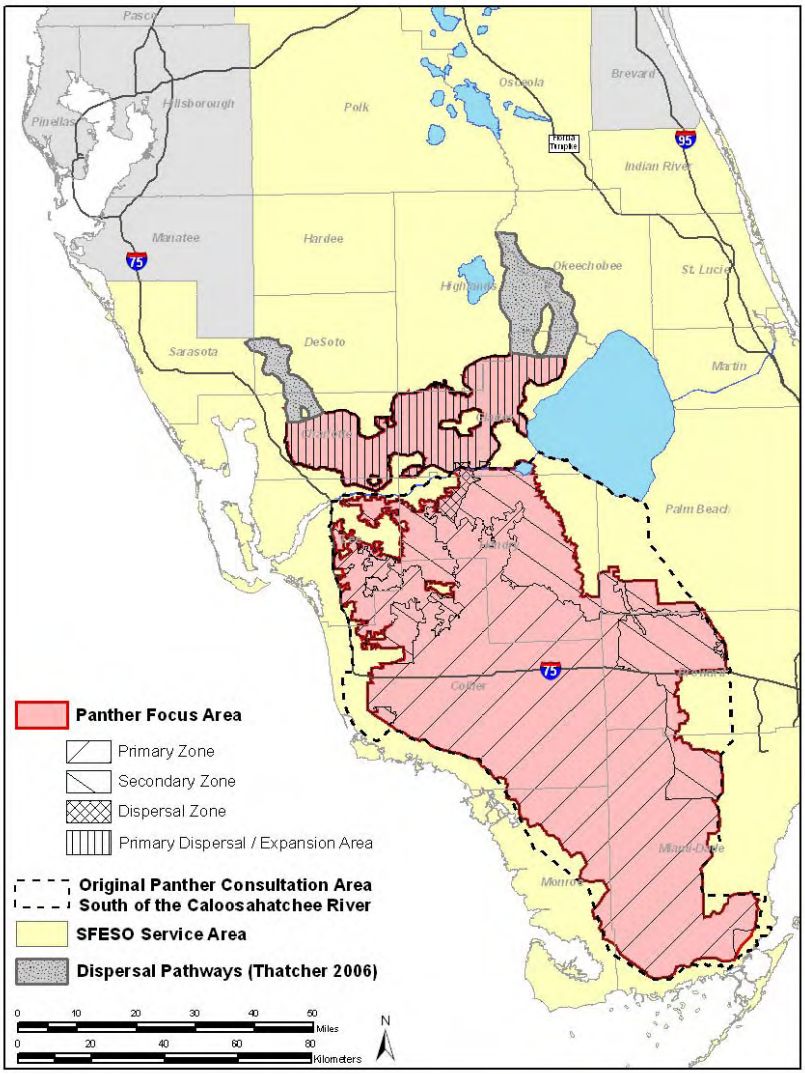

Figure 3-12. Florida panther zones in South Florida. Source obtained from USFWS 2015.

3.8.1.8 Florida Bonneted Bat

The Florida bonneted bat is Florida's largest bat, weighing approximately 1.1 to 2.0 ounces, with a 19 to 21 inch wingspan, and a body length of 5.1 to 6.5 inches. The species has dark brown fur and large broad ears that join together and slant forward over the eyes. Relatively little is known regarding the ecology and habitat requirements of this species. In general, bats will forage over ponds, streams and wetlands and require roosting habitat for daytime roosting, protection from predators and rearing of young (FFWCC 2011). Florida bonneted bats roost in tree cavities, rocky outcrops and dead palm fronds. In residential communities, the bats roost in Spanish tile roofs, but have also been found in attics, rock or brick chimneys and fireplaces of old buildings (FFWCC 2011). Colonies are small, with the largest reported as just a few dozen individuals. The bat is a nocturnal insectivore and relies upon echolocation to navigate and detect prey. Females give birth to a single pup from June through September (FFWCC 2011); however limited data suggests that a female may undergo a second birthing season possibly in January or February.

The Florida bonneted bat is Florida's only endemic bat and is listed by FWC as a state listed endangered species and is a candidate species for Federal listing under the ESA. The range of this species is limited to southern Florida, although this species was encountered in 2008 in two locations within the Kissimmee River Wildlife Management Area north of Lake Okeechobee. Records indicate that it was once common in the 1950s and early 1960s near Coral Gables and Miami (Belwood 1992). The Florida bonneted bat has only been documented in 12 locations within Florida, including areas within Coral Gables, Homestead, Naples, Everglades City and North Fort Myers. Seven of the locations are under public ownership with the Florida bonneted bat found in discrete and specific areas within BCNP, Fakahatchee Strand Preserve State Park, Kissimmee River Wildlife Management Area, Babcock Ranch and Fred C. Babcock and Cecil M. Webb Wildlife Management Area. Loss of suitable habitat is believed to be the primary cause of population declines. Other perceived threats include pesticide and herbicide use, which decrease populations of insects, the bats primary prey.

3.8.2 State Listed Species Expected to Occur Within the Study Area

State listed species likely to use the HHD for foraging and nesting include the gopher tortoise and burrowing owl. In addition, other state listed species known to occur in and around Lake Okeechobee include many wading bird species (see **Table 3-6**). Similar to the wood stork, state listed wading bird species are known to occasionally feed in the toe ditch wetlands of the HHD. However, the principal habitat in the area for wading birds is within the littoral zone of Lake Okeechobee.

3.8.2.1 Gopher tortoise

The gopher tortoise, an upland dwelling reptile, is currently listed as a candidate species in the Eastern U.S. by the USFWS (USFWS 2013). The gopher tortoise shell can be from 5.9 to 14.6 inches long, is dark-brown to grayish-black terrestrial turtle, has large hind feet, and shovel-like forefeet (Ernest & Barbour, 1972). In Florida, individuals from coastal areas are generally darker than more central populations. Gopher tortoises excavate deep burrows that provide shelter from weather extremes and refuge from predation (Diemer, 1989). The gopher tortoise commonly occupies habitats with a well-drained sandy substrate, ample herbaceous vegetation for food, and sunlit areas for nesting (Landers, 1980; Landers, Garner, & McRae, 1980; Diemer, 1989). Diemer (1992) found that gopher tortoise activity increased in April, peaked in July, and remained high through October. Many vertebrate and invertebrates species are known to seek refuge in gopher tortoise

burrows, including protected species like the Eastern indigo snake (Franz, 1986; Jackson & Milstrey, 1989; Lips, 1991; Witz, Wilson, & Palmer, 1991).

3.8.2.2 Burrowing Owl

The Florida burrowing owl occurs throughout the state although its distribution is considered local and spotty. The presence of burrowing owls is primarily dependent upon habitat. Humans have created new habitat for burrowing owls by clearing forests and draining wetlands. Burrowing owls inhabit open native prairies and cleared areas that offer short groundcover including pastures, agricultural fields, golf courses, airports, and vacant lots in residential areas. Historically, the burrowing owl occupied the prairies of central Florida. Recently, these populations have decreased because of disappearing habitat while populations in south Florida coastal areas have increased due to modification of habitat by humans.

Burrowing owls live as single breeding pairs or in loose colonies consisting of two or more families. Burrowing owls use burrows year-round; for roosting during the winter and for raising young during the breeding season (Feb - July). Florida's owls typically dig their own burrows but will use gopher tortoise or armadillo burrows. Burrows extend 4 to 8 feet underground and are lined with materials such as grass clippings, feathers, paper, and manure (www.myfwc.com 2014).

3.9 FISH AND WILDLIFE RESOURCES

A great diversity of fish and wildlife species occur throughout Lake Okeechobee and south Florida including freshwater and saltwater species. Fish and wildlife resources include aquatic macroinvertebrates, small freshwater marsh fishes, larger predatory sport fishes, amphibians and reptiles, colonial wading birds and mammals. Wading birds frequent the littoral zone in the Lake, and migratory birds heavily use Lake Okeechobee throughout the year, as well as during the migratory season as a resting and foraging stop. Eagles are know to use large trees on the HHD embankment.

3.10 NOISE

Along the HHD there are a number of existing sources currently contributing to the overall ambient noise level. The more predominant of these sources include: vehicular traffic on U.S. 27 and other local roadways, boat traffic along the rim canal, small industry (i.e., produce processing and distribution), urban activities in Moore Haven, Clewiston, Pahokee, Okeechobee, and Belle Glade, agricultural equipment (tractors, trucks, etc.), and pumping stations.

Rural areas typically have noise levels of 35-55 decibels. Sound levels along transportation arteries are typically in the range of 70 decibels. According to the FDOT State Environmental Management's Office, no known ambient noise monitoring has been conducted in the project area; consequently, no quantitative data on noise levels within the project area are available for analysis.

3.11 AIR QUALITY

The U.S. Environmental Protection Agency's (EPA) AirData database contains measurements of air pollutant concentrations for the entire United States. The measurements include both criteria air pollutants and hazardous air pollutants and are compared against the National Ambient Air Quality Standards (NAAQS) specified by the EPA. The AirData database was queried for air quality data between 2002 and 2006 (newest comparison information available) within the project area.

The data show that Glades, Hendry, Martin, Okeechobee, and Palm Beach counties are currently in attainment for all six criteria air pollutants. The AirData database also provides annual summaries of Air Quality Index (AQI) values for counties or metropolitan areas. The AQI is an approximate indicator of overall air quality, because it takes into account all of the criteria air pollutants measured within a geographic area. The AQI summary values include both qualitative measures (i.e., days of the year having "good" air quality) and descriptive statistics (i.e., median AQI value). The AQI for Palm Beach County, the most developed portion of the study area indicates that air quality is generally good, with no periods when air quality is classified as unhealthy for sensitive groups. Of the six criteria air pollutants, ozone and particulate matter of 2.5 millimeters or less are most likely to occur within this county. However, the air quality is within NAAQS limits for these parameters.

3.12 TRANSPORTATION AND UTILITIES

3.12.1 Transportation

U.S. Highway 27, 78, and 98 are major Federal roadways within the project area. There are numerous state highways and local roadways as well, many of which are at the toe of the HHD landside embankment. The South Central Railway travels along the southern end of Lake Okeechobee, where it comes within one mile of the HHD in Reach 2.

In 2000, the Governor's Hurricane Evacuation Task Force identified six limited access routes with a potential "need to reverse" to enhance regional evacuations (www.fhwa.dot.gov). Though not a designated evacuation route, U.S. 27 would undoubtedly be used for hurricane evacuation if necessary, though traffic would likely be maintained in both directions. U.S. 27 would likely be used for evacuations because of its location as the only east-west corridor in the area. The use of U.S. 27 for hurricane evacuation requires that the highway's traffic flow not be impeded during the hurricane season.

In addition, the OWW provides economically important commerce between the eastern and western coasts of Florida. The waterway connects the Atlantic Intracoastal Waterway to the Gulf Intracoastal Waterway and is a congressionally authorized project, with depths and operations required for efficient navigation on the system. The authorized C&SF Project depths for Lake Okeechobee navigation are based on the lake being at water levels of elevation 12.56, ft., NGVD29 (el. 11.26 ft., NAVD88) or higher.

3.12.2 Utilities

As part of field surveys completed by the Corps staff since 2006, records were made of overhead utility and transmission lines in a portion of the project area. These surveys were completed in Reach 1 due to cutoff wall construction as well as in the areas immediately adjacent to the culvert replacement projects as part of Planning, Engineering, and Design (PED). Additional surveys will be undertaken during PED for the DSMS in preparation for construction efforts.

3.13 SOCIOECONOMICS

3.13.1 Economic Activities In and Around Lake Okeechobee

The primary economic activity throughout the study area is agriculture. The EAA, located directly south of Lake Okeechobee, consists of approximately 500,000 acres of highly productive

agricultural land, the vast majority of which is under active sugarcane cultivation. In addition to sugarcane, crops grown in the EAA include an array of winter vegetables including sweet corn, green beans, all varieties of lettuce, radishes, celery, rice and sod. This region of Palm Beach County is the nation's top producer of sugar, sweet corn, radishes and number two in winter vegetables. The economic value of these crops exceed $3 billion annually (FDACS 2016) and provide employment for more than 12,000 people in the sugar sector alone (LMC Internation-2011). The agricultural operations are vertically integrated and there are four raw sugar mills, two sugar refineries, a rice mill, eight vegetable packing houses and distribution centers, and a renewable energy power plant. Other agricultural activities in the Lake Okeechobee watershed include citrus, pasture, livestock and dairy operations.

A second major economic activity is recreation. Lake Okeechobee and its associated waterways, shoreline, and the Lake Okeechobee Scenic Trail (LOST) on top of the dike provide a wide variety of water-based recreation activities for local residents and tourists, including fishing, boating, picnicking, sightseeing, camping, swimming, birding, hunting, biking, horse-back-riding, roller blading, air boating and hiking. Recreation facilities associated with Lake Okeechobee include: 37 picnic sites, 309 individual camp sites, 4 playgrounds, 1 public swimming area, 1 marina with 41 boat slips, 29 boat ramps, 12 general recreation areas, and hundreds of acres open to hunting. Annual visitation based on a five-year average (2006-2010), amounts to 5,616,000 recreation visits per year. Data for specific recreation activities in these years were obtained from the Institute for Water Resources (IWR) "Lakes Gateway" website. According to the IWR 2010 *Lake Level Report*, it is estimated that visitors to Lake Okeechobee spend approximately $172 million per year, directly supporting more than 1,800 local jobs.

Additionally, Lake Okeechobee supports an active commercial and recreational fishing industry. This includes several different types of commercial fishing operations and landside support activities, such as marinas and wholesale and retail distribution facilities. There are commercial fisheries on Lake Okeechobee that harvest the American alligator. Alligators are harvested from the lake population to supplement the stock in alligator farming operations. Recreational fishing tournaments are held on the lake multiple times a year.

The depth of Lake Okeechobee also makes commercial navigation on the lake possible. There are two navigation routes in Lake Okeechobee, including Route 1 through the center of the lake and Route 2 along the south shore of the lake. Only Route 1 is fully maintained at its authorized depth for commercial navigation. Petroleum products, including distillate fuel oil, residual fuel oil, and liquid natural gas, comprise the majority of tonnage shipped. Other commercial navigation includes fleets of day/dinner cruise vessels that operate from Pahokee during the tourist season. As stated in Section 3.11 above, the OWW allows passage of boats between the Atlantic Ocean and the Gulf of Mexico through Lake Okeechobee.

Other than agriculture, recreation, tourism, commercial fishing, and navigation, secondary economic activities include: services (banking, insurance, etc.) healthcare, education, and government activities. Examples of the above include:the Lakeside Medical Center, and the University of Florida- Everglades Research and Education Center, Palm Beach State College, Belle Glade Campus and the Dolly Hand Cultural Arts Center; Glades Day School serving students Pre-K-12; seven public elementary schools, two middle schools and two high schools as well as the West Technical Training and Education Center. The City of Clewiston is a major center of the agricultural community around the Lake. Known as the "Gateway to Lake Okeechobee" it has

many of the above activities. Also, the Town of Moore Haven is the seat of government for Glades County, so there are several public buildings in the town..

3.13.2 Demographics

The majority of the study area is rural and agricultural. However, there are a number of towns and cities located in close proximity to the HHD (see **Figure 3-13** and **Table 3-7**). In most of these communities, homes, business and public buildings can be found within 100 feet of the dike. The largest of the communities is Belle Glade, located near the Hillsboro Canal with a population of more than 17,000 people. The study area also includes the Brighton Seminole Indian Reservation in Glades County, which is home to approximately 600 people.

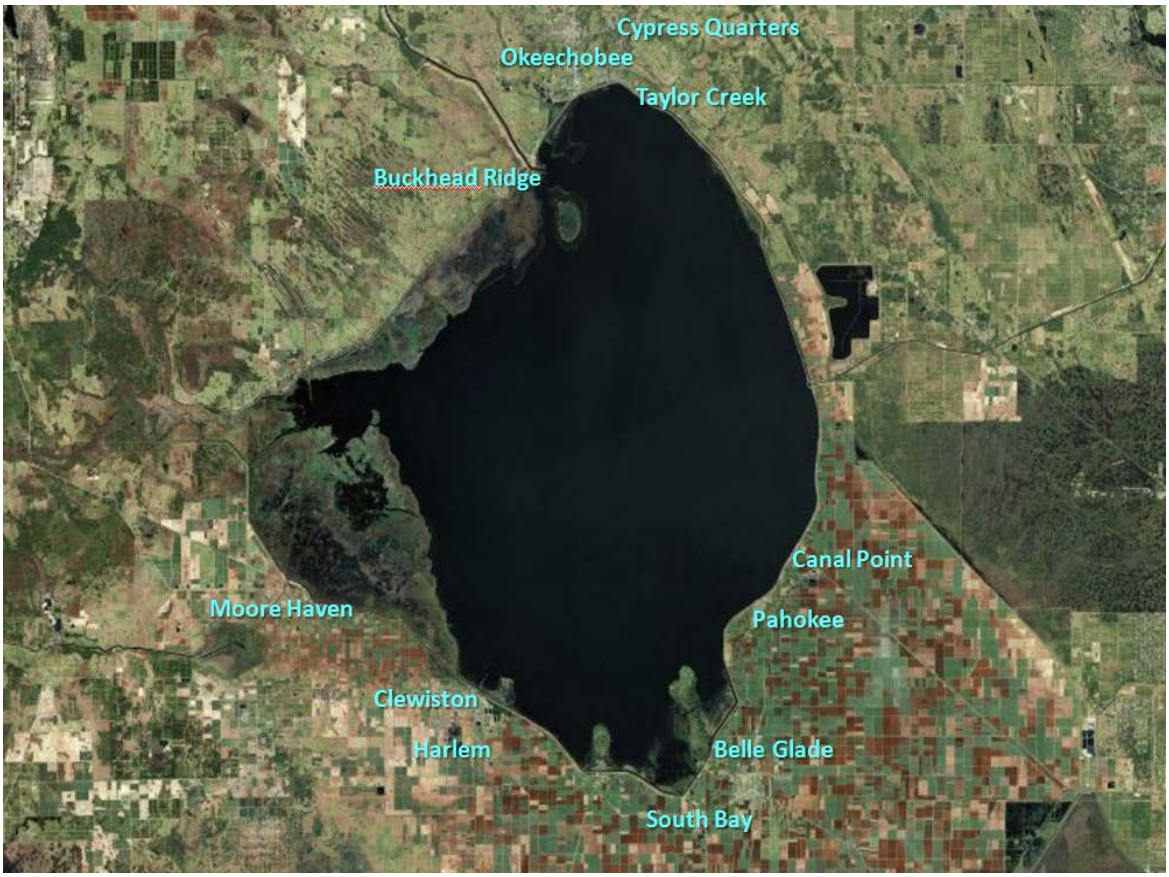

Figure 3-13. Major cities in study area considered in demographics study.

Table 3-7. Major Population Centers Subject to Flooding*

City / Town	County	2010 Population
Pahokee	Palm Beach	5,649
Belle Glade	Palm Beach	17,467
South Bay	Palm Beach	4,876
Clewiston	Hendry	7,155
Harlem	Hendry	2,658
Moore Haven	Glades	1,680
Buckhead Ridge	Glades	1,450

City / Town	County	2010 Population
Okeechobee	Okeechobee	5,621
Taylor Creek	Okeechobee	4,348
Cypress Quarters	Okeechobee	1,215

*Please note: Population estimates in this table do not include very small towns (Canal Point, Lake Harbor, Bryant, Lakeport, etc.) in the inundation zones or population at risk in unincorporated areas of Palm Beach, Martin, Hendry, Glades, and Okeechobee counties. The table also does not include population associated with the Brighton Indian Reservation in Glades County.

In general, these are diverse, relatively low income communities. Hendry, Glades, and Okeechobee counties all have median household incomes that are less than the state average. They also have a relatively high proportion of households below the poverty line (**Table 3-8**). Palm Beach County has an above average median income, but the communities in the county near the HHD (Pahokee, Belle Glade, and South Bay) have socioeconomic characteristics much more similar to Hendry and Glades counties.

Table 3-8. Economic characteristics of counties adjacent to Lake Okeechobee

	Median Household Income	Persons below poverty line
State of Florida	$47,827,000	14.70%
Hendry County	$37,989,000	26.00%
Glades County	$39,611,000	19.50%
Okeechobee County	$36,929,000	23.70%
Palm Beach County	$52,951,000	13.30%

The primary economic activity throughout the study area is agriculture. The Everglades Agricultural Area (EAA), located directly south of Lake Okeechobee consists of approximately 500,000 acres of highly productive agricultural land, the vast majority of which is under active sugarcane cultivation. Palm Beach County is the nation's leader in production of sugarcane, sweet corn, winter leaf crops and radishes and number two in winter vegetable production. In addition, citrus and pasture lands for livestock and dairy operations are located in the watershed.

3.14 PUBLIC SAFETY

The HHD system is paramount to public safety. With six times more inflow capacity to the lake versus outflow capacity, the dike provides flood risk management not only to towns immediately adjacent to the dike, but to a vast area south of the lake. Due to signs of dike instability during high water stages in the lake after 2004 and 2005 hurricanes in South Florida, the SFWMD contracted for an expert review panel of the stability and safety of the HHD. Particular emphasis was placed on the structural stability of the dike with regard to seepage and water pressures within the embankment and erosion and potential overtopping concerns during large storm events. The technical review concluded that the current condition of the HHD poses imminent risk to the people and the environment of South Florida (BCI 2006). Throughout the life of HHD and the recent Dam Safety Modification Study, the Corps has also conducted many modeling studies to determine the risk to the public if a breach were to occur.

The term "dike failure" implies a catastrophic breaching of some portion of the HHD system. This situation would result in widespread flooding, as waters from Lake Okeechobee pass through the breach and onto adjacent lands.

3.15 REAL ESTATE

The geographic area for the project is located in southern Florida encircling Lake Okeechobee. The lands encircling Lake Okeechobee known as the HHD are approximately 143 miles of real estate that cross several counties in the State of Florida. The Federal Government has approximately 7,802 acres of interests in real estate to support construction and the operation and maintenance (including staging areas, borrow, or disposal sites) for the HHD. These lands are on the north side near Okeechobee in CIZ E, Segments 18A and 18B, and CIZ F, Segments 19A, 19A-2, 19A-3, 19B, and 19C and on the south side near CIZ A, Segments 22, 23, 24, 1, 2, and 3 and CIZ B, Segments 4, 5-2, 5, 6, 7, 8, 9, and 10. The SFWMD has approximately 2,413 acres of interests in real estate that have been certified to the Federal Government to support construction, operation and maintenance (including staging areas, borrow, or disposal sites) for the HHD. These lands are in CIZ C, Segments 11, 12, 13 and 14A, CIZ D, Segments 14B, 15, and 16, and CIZ E, Segments 17 and 18A-2. Currently, there are a number of public roads providing access to the HHD.

3.16 HAZARDOUS, TOXIC AND RADIOACTIVE WASTES

Hazardous, toxic, and radioactive waste (HTRW) surveys have been conducted as part of EAs and EISs prepared as part of the prior HHD rehabilitation efforts. In December 2007, a HTRW survey of the HHD was conducted using aerial imagery and a contaminated site and petroleum storage site database compiled by the FDEP. A visual survey was conducted to verify the findings of the desktop survey. The survey was updated in August 2009 for the Reach 1A Supplemental EIS (USACE 2010) and in February 2010 for L-D1 and L-D2 and January 2014 for additional levees and remaining Federal right-of-way. The purpose of the additional surveys was to preliminarily identify potential contamination sites within 500 feet of the HHD in remaining reach areas. The results of these surveys show that agricultural and rural residential development has resulted in the HTRW contamination in areas adjacent to the HHD. A subsequent survey conducted as part of this EIS found 27 locations where petroleum has been stored or released within 100 ft of the levee right-of-way. **Table 3-9** is a list of these sites by location, ownership, and status. Five of these sites have been closed and the storage tank or release has been removed. Twelve of the petroleum storage sites are operational and require ongoing monitoring for releases. Seven sites have been closed and required no clean up action. Two sites require clean up actions. The S-12A and S-127 structures have contamination present such that cleanup is required. As of August 2014, there is no plan to remediate the S-127 site. At the S-12A structure in Reach 1, the FDEP spill database shows that a release of approximately 4,000 gallons of diesel occurred in 1991. The Corps and FDEP are coordinating remediation actions to minimize disruption of construction during the replacement of the S-12A structure which will began in early 2015.

Table 3-9. List of Petroleum Storage Facilities within 100 ft. of HHD Right-of-Way (Listed in clockwise order from Port Mayaca)

Site Name	Reach	Operator	Status
S-308 (Port Mayaca Lock)	1	Corps	Ongoing Monitoring
Pahokee Camp Ground	1	City of Pahokee	Ongoing Monitoring
S-12	1	East Shore W. Control District	Cleanup Completed
S-12A	1	New Hope Sugar Company	Cleanup Underway
Torry Island	1	SFWMD	Cleanup not required
S-2 Pump Station	1	SFWMD	Cleanup Completed

Site Name	Reach	Operator	Status
Maintenance Shop	3	South Bay	Cleanup not required
South Shore Pump Station	3	South Shore Drainage District	Ongoing Monitoring
Spill Site	2	Hialeah Transport Inc.	Cleanup Completed
S-3 Pump Station	2	SFWMD	Ongoing Monitoring
S-236 Pump Station	2	SFWMD	Ongoing Monitoring
S-310 Pump Station	2	SFWMD	Cleanup not required
S-169 Structure	2	SFWMD	Cleanup not required
S-4 Pump Station	2	SFWMD	Cleanup not required
Diston Island Pump #1	2	Diston Island	Ongoing Monitoring
Diston Island Pump #2	2	Diston Island	Ongoing Monitoring
S-78 (Moorehaven Lock)	4	Corps	Ongoing Monitoring
Road Dept. Maintenance Facility	4	Glades County	Ongoing Monitoring
Pierce Property Pump	4	SFWMD	Ongoing Monitoring
S-131 Structure	6	SFWMD	Cleanup completed
S-129 Structure	6	SFWMD	Ongoing Monitoring
S-127 Structure	8	SFWMD	Cleanup Required
S-133 Structure	5	SFWMD	Ongoing Monitoring
S-193 Structure	5	SFWMD	Cleanup completed
S-191 Structure	5	SFWMD	Cleanup not required
G-36 Structure	5	SFWMD	Cleanup not required

3.17 RECREATIONAL RESOURCES

A general discussion of recreational resources is described in Section 3.12.1.

Lake Okeechobee Scenic Trail (LOST)

The LOST circles the entire lake on top of the dike. The LOST is located on lands held in fee simple title by the State of Florida. This is a mostly double-track trail that offers recreation opportunities for hiking, biking, horseback riding, roller-blading and fishing around the lake. Many portions of the trail are paved. Pedestrians and mountain bikers are able to access the trail from many locations in towns adjacent to the HHD. Informational signs along the roadways direct recreational users to the LOST access points as well as wildlife viewing locations. Equestrians are able to access the trail from various locations in the project area as well.

Fishing and Boating

Lake Okeechobee offers a wide-range of fishing opportunities. There are more than 60 species of fish in the lake, the most sought-after game fish being largemouth bass, catfish, and black crappie. Fishing tournaments are regularly held throughout the year. Boats can access the lake through navigation locks and boat ramps. Public boat ramps are available for use at the Moore Haven Lock and Dam, Alvin Ward Park, Lake Observation Point (Bare Beach), the Clewiston Recreation Area, and the South Bay Boat Ramp. Belle Glade has a marina and camp ground with access to the Lake off of Torey Island. Another fishing and boating resource in the area includes Uncle Joe's Fish Camp at Liberty Point, which dates back to the 1940s.

3.18 AESTHETIC RESOURCES

There are many public access points to view Lake Okeechobee from the elevated vantage point of the length of the HHD crest. In addition, the LOST runs atop the HHD around the entire lake, totaling approximately 110 miles.

The HHD crest affords panoramic views of the flat agricultural (mostly sugarcane) fields and rim canal to the south, southwest, and southeast. The extensive littoral zone on the west side of the lake's perimeter can be viewed from the dike in Reach 2. The littoral zone plant community is composed of a mosaic of emergent and submerged plant species. Emergent vegetation within the littoral zone is dominated by cattail, spike rush, and torpedo grass.

Rita Island dominates the landscape when looking northward from the dike in Lake Harbor. Also in this area is John Stretch Park, which is located adjacent to the south side of the dike near the Miami Canal. This park includes a pond, picnic areas, restrooms, a large grassy field, an outdoor basketball court and a boat ramp. There are several parks adjacent to the HHD, and along the northern area. These parks include resources such as ponds, bird viewing areas, picnic areas, restrooms, grassy fields, boat ramps, and other amenities.

3.19 CULTURAL RESOURCES

The earliest widely accepted date of occupation by aboriginal inhabitants of Florida dates from around 12,000 years ago. This earliest cultural period, called the Paleo-Indian period, lasted until about 7500 B.C. Few Paleo-Indian archeological sites are recorded in Florida, and none are identified by the Florida Master Site Files (FMSF) near the HHD. During the Archaic period (ca. 7500 B.C. - ca. 500 B.C.), a wider range of resources was exploited and may have led to a more sedentary existence. Few Archaic period archeological sites are recorded in south Florida. Known sites are clustered along the Atlantic and Gulf coasts and inland waterways. No Archaic period sites are located near the dike, as recorded in the FMSF. In the Okeechobee Basin, the Belle Glades culture sequence (ca. 500 B.C. - A.D. 1500) follows the Archaic. Black earth middens, low sand mounds and circular and linear earthworks are Belle Glade site types located near the HHD, as recorded in the FMSF.

During the early historic period, beginning with the first Spanish colonial period (1513 - 1763), the Calusa, a native tribe, inhabited southern Florida. Their population was decimated by European-introduced diseases, warfare, enslavement, and migration out of Florida. The Miccosukee and the Seminole migrated into Florida in the 18th and 19th centuries from Georgia and Alabama. Throughout the mid-1800s, the U.S. relentlessly pursued a policy of Indian removal in Florida, and the Seminole, resisting removal, eventually established themselves in the Everglades, Big Cypress Swamp, and the Ten Thousand Islands. Several important battles of the Seminole Wars occurred around Lake Okeechobee including the largest and bloodiest battle of the Second Seminole War, the Battle of Okeechobee on Christmas Day in 1837. The Okeechobee Battlefield site is located at the north end of Lake Okeechobee and is a National Historic Landmark site. Other Seminole battle and habitation sites, predominantly on tree islands, are located near the HHD.

American settlement around Lake Okeechobee began in earnest in the late 19th century when efforts to drain and reclaim the Everglades began. Agriculture began in the Everglades, south of Lake Okeechobee after drainage projects of the 1906-1927 era. By 1921, there were 16 settlements on or near Lake Okeechobee, with a total estimated population of 2,000. By the

1940s, a number of homes had been built in this area forming historic districts that are potentially eligible for listing in the National Register of Historic Places (NRHP).

The HHD and surrounding area has been subjected to numerous cultural resources surveys, including a 2010 assessment and documentation of the dike and a 2011 Phase I survey of reaches 1B, 1C, 1D, 2 and 3. A review of the FMSF lists both prehistoric and historic archeological sites located in the near vicinity of the HHD. Prehistoric Native American sites consist of middens, mounds and earthworks. Historic sites include buildings, shipwrecks, canoes, cemeteries, and Fort McRae, an early nineteenth century Seminole War fort. An historic dugout canoe and artifacts associated with early military exploration of the Everglades was discovered in the lake near the entrance of the St. Lucie River. Early 20th century homes and historic districts have been recorded along the shoreline of Lake Okeechobee. The HHD, including various locks, dams, buildings and hurricane gates associated with it, is eligible for listing in the NRHP and is recorded by the FMSF in each county surrounding Lake Okeechobee (HN179, GL421, PB2028, OB244). A discussion of the recorded sites by Zone is discussed below:

Zone A
A review of the FMSF lists over 25 recorded archeological sites, hundreds of historic structures and NRHP Resource Groups such as the HHD, FEC Railroad, West Palm Beach Canal, and North New River Canal. National Register Historic Districts include the Main Street Historic District in Pahokee and the Lake Harbor Historic District.

Zone B
A review of the FMSF lists over 50 recorded archeological sites, including earthworks and burial mounds, hundreds of historic structures (five of which are NRHP eligible) and NRHP Resource Groups such as the HHD, the Caloosahatchee River and the Moore Haven Lock and Dam. The Moore Haven Historic District is a NRHP Historic District.

Zone C
A review of the FMSF lists over 30 recorded archeological sites, including earthworks and burial mounds, the majority of which are recorded on Brighton Indian Reservation.

Zone D
A review of the FMSF lists over 50 recorded archeological sites, including earthworks and burial mounds, many of which are located on Brighton Indian Reservation and six historic structures.

Zone E
A review of the FMSF lists over 30 recorded archeological sites, including earthworks and burial mounds, many of which are located on Brighton Indian Reservation.

Zone F
A review of the FMSF lists over 15 recorded archeological sites, including the Okeechobee Battlefield which is also a NRHP Resource Group and eligible for listing in the NRHP.

Zone G
A review of the FMSF lists over 10 recorded archeological sites, including prehistoric earthworks, prehistoric middens and a historic canoe from the nineteenth century Fort McRae. Over 15

historic structures are recorded (three NRHP eligible) and include houses and locks and culverts associated with the dike.

Consultation with the State Historic Preservation Office and other interested parties was initiated July 2013. Consultation with the State Historic Preservation Office and other interested parties will continue through completion of the project.

3.20 TRIBAL RESOURCES

There are two Federally recognized tribes (Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida) that are located within the region of the project area. Both tribes have historically utilized the project area and maintain a strong connection to the region through continued use and regard the indigenous populations of Florida as their ancestors.

The Miccosukee Tribe of Indians of Florida and Seminole Tribe of Florida have a long history of living within the project area. Both tribes moved into the region during the 18th and 19th centuries from Georgia and Alabama. Fleeing the U.S. Army and the forced relocation policies of the Indian Removal Act (1830), the Miccosukee and Seminoles were part of Native American groups commonly referred to as Seminoles; however, there are references to some of the groups involved in the conflict as Mikasuki which supports the later reasons for separations of the two groups (Weisman 1999). Many of these groups fled into the swamp areas of south Florida and made their homes within the Everglades and other remote areas of region. The coming of the Civil War led to the abandonment of the removal efforts and the various Native American groups were largely left alone until the late nineteenth century. In 1928 the Tamiami Trail opened, cutting through the Everglades and bringing along with it tourists and explorers into the region, and, for the first time, bringing complete access for the various tribes to participate in the larger economy that was growing in south Florida.

In the 1930s, the Federal Government started to bring services to the various Seminole groups. Some of the groups relocated and started to receive Federal aid, while some groups resisted government intrusion into their lives and remained in various traditional areas that now included sites along Tamiami Trail (Weisman 1999). By 1938, the U.S. Congress and the Department of the Interior had set aside land for the remaining Seminoles to use, including the Brighton Seminole Indian Reservation which is located within and adjacent to HHD in northwestern Glades County. The Seminole Tribe continues to rely on the water from Lake Okeechobee as water supply and a secondary irrigation supply for water shortages on the reservation. The Tribe also has access and uses the HHD and Lake Okeechobee for hunting, fishing, and recreational activities.

4.0 ENVIRONMENTAL EFFECTS: NO ACTION ALTERNATIVE

The U.S. Water Resources Council's Principles and Guidelines provide the instructions and rules for Federal water resources planning. One Principles and Guidelines requirement is to evaluate the effects of alternative plans based on a comparison of the most likely future conditions with and without those plans in place. In order to make this type of comparison, descriptions (often called forecasts) must be developed for two different future conditions: the future without (FWO) project condition and the future with project condition. Note that the project referred to in this context is any one of the alternative plans that have been considered in the study. The FWO project condition describes what is assumed to be in place if none of the study's alternative plans are implemented. The FWO project condition is the same as the alternative of "no action" that is required to be considered by the Federal regulations implementing the National Environmental Policy Act (NEPA) of 1969, and the future without action condition (FWAC) described in Corps ER 1110-2-1156, Safety of Dams – Policies and Procedures. The future with project condition describes what is expected to occur as a result of implementing each alternative plan that is being considered in the study. The differences between the future without project condition and the future with project condition are the effects of the project.

The FWAC for HHD is the condition mostly likely to exist during the period of analysis if Corps takes no action, and considers what others would do absent of Corps action. The FWAC risk provides the basis from which risk management alternative plans are formulated and their impacts are assessed. All proposed risk management plans are compared to FWAC rather than the existing condition. The assumptions in the following sections were used to estimate the FWAC consequences and to estimate the consequences avoided due to the implementation of risk reduction measures. Without improvements to the HHD embankment, the safety of the surrounding human and natural environment may be severely impacted with additional effects upon the local and regional economies.

The FWAC is synonymous with the No Action Alternative and for the HHD DSMS is generally assumed to be the same as the existing risk condition with the exception of minor population increases and improved evacuation. The No Action Alternative does not provide a long-term solution to the potential for internal erosion throughout the system. This alternative adopts the interim risk reduction measure (IRRM) of an interim regulation schedule (Lake Okeechobee Regulation Schedule, LORS 2008). LORS 2008 is the current water control plan in which the Corps manages lake levels through a series of water management structures to the Caloosahatchee estuary to the west, the St. Lucie estuary to the east, and to major canals to the south of the lake.

The planning horizon encompasses the Planning Study period, construction period, consequence analysis period, and the effective life of the project. The time frame used when forecasting future with and without project conditions while considering impacts of alternative plans is called the period of economic analysis. The period of analysis for water resources projects usually falls between 50 and 100 years. Even if project structures last more than 100 years, there is too much inherent uncertainty to reliably forecast conditions and impacts beyond 100 years. The base year for the period of analysis for the HHD DSMS is 2017. The base year assumes an unconstrained implementation timeline in which CEPP will be authorized, designed, and construction begun. By incorporating a 100-year period of analysis to reflect beneficial and adverse effects of the project through time, the period of analysis for the proposed project will end in the year 2117. The 100-

year planning horizon will be used in the discussion of effects of the No Action and Action Alternatives. The No Action Alternative is also known as the future without project condition.

Environmental conditions in and around Lake Okeechobee would not be expected to change significantly. Operations and maintenance costs would increase to maintain the current integrity of the HHD and offset future deterioration. Additional expectations in the future without project condition include: limited changes in land use and structure inventories, enhanced warning systems as a local responsibility, greater public awareness and education, and more effective evacuation planning. In addition, hydrologic and hydraulic assumptions include the limited effect of external projects on lake inflows (CERP, Kissimmee River Restoration, State of Florida Restoration Strategies) and either LORS 2008 or a LORS-like regulation schedule going forward.

The assumption used in the DSMS is if a breach were to occur at 25 ft, lands to the south would remain temporarily inundated with water for up to two years. This would discontinue operation of farmland and displace residents throughout that period of time, and potentially longer. A breach would have negative impacts to species (including Federal and state listed) foraging and nesting habitat within the lake and in to south Florida and Everglades National Park. A breach would have major, long term negative impacts on the environment.

4.1 GEOLOGY

The geology of the HHD would not change from the discussion provided in the Existing Conditions (**Section 3**).

4.2 SOILS

The soils in the Lake Okeechobee region and comprising the HHD would not change from the discussion provided in **Section 3** (Existing Conditions). Subsidence of adjacent agricultural lands is expected to continue as a result of oxidation of soils, therefore there is a negligible, but long term effect to this resource due to the No Action Alternative.

4.3 LAND USE

For the past 100 years, the primary economic activity in this area has been agriculture. As discussed previously, ecosystem restoration projects are projected to be completed in areas south of the HHD project area designed to restore the hydrology and water quality in the Everglades Protection Area. According to the South Florida Water Management District's Lower East Coast Water Supply Plan, agricultural production south of Lake Okeechobee is projected to remain steady. As urban development continues to move west, there is an opportunity for the Glades community to grow in the light manufacturing, industrial development and distribution center areas. The tri cities (Pahokee, Belle Glade, and South Bay) participate in the Lake Okeechobee Region Economic (LORE) alliance that has partnered with the Business Development Board of Palm Beach County in attracting new businesses to the Glades region. The former Glades Correctional Institute site is being actively marketed and several agricultural businesses have expanded in this region. Also, through the LORE/BDB partnership two additional employment centers are being built and several other leads are underway. Improvement to the local infrastructure has received both state and local funding to improve the area. Land use (Figure 4-1) (**Figure 4-1**) for the northern part of the watershed (i.e., Kissimmee Upper Basin) will become increasingly developed as the Orlando-Kissimmee urban epicenter continues to sprawl. Existing

population centers in the southern part of the watershed and along the perimeter of Lake Okeechobee are predicted to expand outward such that development along the entire rim of the lake would be nearly continuous.

Figure 4-1. Florida Land Use (2005 and Projected 2060)

One major constraint to future development in the future with the No Action Alternative is the Federal Emergency Management Agency (FEMA) flood insurance program. Currently, this Federal program offers flood insurance in the communities near Lake Okeechobee. However, without rehabilitation of the HHD, flood insurance rates are expected to increase significantly in the future. Development and population growth pressures in South Florida would be offset by the increased cost of developing and maintaining property in the areas near the HHD.

For all of the above reasons, major changes in land use are not expected in the future without project condition. The area is primarily rural and agricultural. It is expected to remain rural and agricultural in the foreseeable future.

It should be noted though that there is tremendous uncertainty with regard to population changes and land use changes over such a long planning horizon, it is impossible to predict all potential changes over a 100-year period. The assumptions presented here represent conservative assumptions based on best available information, therefore, there would be a minor, long term effect on land use due to the No Action Alternative.

4.4 HYDROLOGY & HYDRAULICS

Surface Water

General

The hydrology and hydraulics of the Lake Okeechobee watershed as described in Section 3 of the report would remain essentially unchanged. However, there are a few notable exceptions regarding population growth that are described above in Section 4.3 Land Use.

Increased development can often lead to increased surface water runoff due to natural pervious areas being converted to impervious areas (i.e., parking lots, roadways, roofs). However,

increased regulation of stormwater by permitting agencies has tempered the potential for increased surface water runoff by requiring new developments and infrastructure projects to both detain a certain volume of runoff on their property and to ensure that post-project peak discharge rates do not exceed pre-project discharge rates.

In the future, Lake Okeechobee would remain the hydrologic hub of the Greater Everglades System. Presently, there are large competing demands for the water stored in Lake Okeechobee: urban water supply for the Florida Lower East Coast, agricultural water supply, environmental releases to the estuaries and water for the downstream natural systems. The competition for this water is intense since it represents the most available and economical source of freshwater. Even though there would be environmental consequences for lake ecology if Lake Okeechobee were to store more water, without rehabilitation of the HHD and under continuance of the Future Without condition, the lack of the internal storage option for Lake Okeechobee would by necessity drive water managers to seek and develop alternate freshwater sources for the Greater Everglades System. The most practical of these storage options is to divert Lake Okeechobee watershed runoff into storage reservoirs that would be developed. Also, the freshwater needs of the Florida Lower East Coast, particularly in the face of sea level rise and expanding saltwater intrusion, would need to consider desalinization of brackish waters pumped from deeper aquifers and perhaps some reliance on desalinization of seawater.

Key assumptions for the Future Without Condition that can affect hydrology within Lake Okeechobee, within the Lake Okeechobee watershed, and on related projects and downstream areas are presented below:

LORS 2008 in-place

Prior to the LORS 2008, Lake Okeechobee operated under the Water Suuply and Environmental Regulation Schedule (WSE). The 2006-2008 LORS study was initiated because of adverse environmental impacts that the WSE had on the lake and estuary ecology. Dam safety was later added as a performance criterion since lowering of the lake, as the LORS study was pursuing, is one of the basic Interim Risk Reduction Measures implemented for deficient dams until appropriate remediation is effectuated. The WSE held Lake Okeechobee stages approximately 1.0 – 1.5 ft. higher than the 2008 LORS under wet conditions. Studies for the remediation of the HHD are based on the 2008 LORS.

When it was approved in April 2008, the LORS was identified as an interim schedule. The Corps expects to operate under the LORS 2008 until there is a need for revisions due to the earlier of either of the following actions: (1) system-wide operating plan updates to accommodate CERP Band 1 Projects, or (2) completion of sufficient HHD remediation for all reaches and associated culvert improvements as determined necessary to lower the DSAC rating from Level 1.

CERP Band 1 Projects In-Place

The 1999 CERP, which was approved as a framework for restoring the south Florida ecosystem while providing for other water-related needs of the region in the 2000 WRDA, also recognized the need to modify the Lake Okeechobee Regulation Schedule. Modifications are necessary to reduce the extreme high and extreme low lake levels that adversely impact lake ecology, while improving the management of intermediate water levels and maintaining the capability to manage the lake to balance the requirements of the C&SF Project purposes, including water supply storage. The CERP proposed modifications to the Lake Okeechobee Regulation Schedule

(Run 25 at the time of the CERP, prior to WSE implementation in 2000) were dependent on additional regional water storage capability north of Lake Okeechobee and new Lake Okeechobee regional aquifer storage and recovery (ASR). CERP also included water storage components within the C-43 Basin (west of Lake Okeechobee) and the C-44 Basin (east of Lake Okeechobee) to improve the timing, quantity, and quality of freshwater flows to the Caloosahatchee River and Estuary and the Saint Lucie Estuary. South of Lake Okeechobee, CERP proposed an additional water storage component to capture a portion of the high volume freshwater discharges sent from Lake Okeechobee to the Caloosahatchee and St. Lucie Estuaries, to increase the quantity and improve the timing of freshwater flows sent south to the Everglades system, and to provide increased water supply storage within the EAA Basin.

Construction has begun on the first generation of CERP projects already authorized by Congress. These include the Indian River Lagoon Project, the Picayune Strand Restoration Project, and the Site 1 Impoundment Project. The second generation of CERP projects, authorized in WRRDA 2014, include the Biscayne Bay Coastal Wetlands Project, Broward County Water Preserve Areas Project, the Caloosahatchee River West Basin Storage Reservoir, and the C-111 Spreader Canal Western Project. The first generation and second generation of authorized CERP projects listed here were previously referenced as the CERP "Band 1" Projects in the 2005 CERP Master Implementation Sequencing Plan, with the "Band 1" list also originally included the Acme Basin B, Loxahatchee River Watershed, and the EAA Storage Reservoir (Part 1) CERP projects.

CERP Central Everglades Planning Project (CEPP) – In Place

The Corps and the SFWMD initiated the Central Everglades Planning Project (CEPP) as the next proposed increment of the CERP Program in November 2011. The purpose of the CEPP is to improve the quantity, quality, timing and distribution of water flows to the Northern Estuaries, central Everglades (Water Conservation Area 3 (WCA 3) and Everglades National Park (ENP), and Florida Bay while increasing water supply for municipal, industrial and agricultural users. The CEPP draft Project Implementation Report (PIR) was released for public and agency review in August 2013, and the Record of Decision (ROD) was signed August 31, 2015. The recommended plan would achieve these benefits by reducing the large pulses of regulatory flood control releases sent from Lake Okeechobee by redirecting approximately 210,000 acre-feet of water on an annual basis to the historical southerly flow path.

CEPP benefits gained from sending new water south from Lake Okeechobee are derived in part from operational refinements that can take place within the existing, inherent flexibility of the LORS 2008, and in part with refinements that are beyond the schedule's current flexibility. Modifications to LORS 2008 would be required to optimally utilize the added storage capacity of the A-2 Flow Equalization Basin (FEB) to send the full 210,000 acre-feet per year of new water available in CEPP south to the Everglades, while maintaining compliance with requirements for water supply and flood control performance levels. The CEPP "new" water accounts for the additional volume of regulatory releases able to be made from Lake Okeechobee to the southerly WCAs, releases that are not currently assumed to be delivered under the pre-CEPP conditions with the 2008 LORS and the State of Florida's Restoration Strategies Project due to water quality constraints.

Most of the LORS 2008 refinements applied in the CEPP modeling lie within the bounds of the operational limits and flexibility available in the current LORS 2008, with the exception of the adjustments made to the class limits for the Lake Okeechobee inflow and climate forecasts. Under

some hydrologic conditions, the class limit adjustments made to the Lake Okeechobee inflow and climate forecasts reduced the magnitude of allowable discharges from the Lake, thereby resulting in storage of additional water in the Lake in order to optimize system-wide performance and ensure compliance with Savings Clause requirements. However, these class limit changes represent a change in the flow chart guidance that extends beyond the inherent flexibility in the current LORS 2008.

Independent of CEPP implementation, the CEPP PIR assumes that revisions to the LORS 2008 would be needed following the implementation of other CERP projects and the HHD infrastructure remediation. When the HHD remediation is completed and the HHD DSAC Level 1 rating is lowered, higher maximum lake stages and increased frequency and duration of high lake stages may be possible to provide the additional storage capacity assumed with the recommended plan. The future LORS which may be developed in response to actions (1) and/or (2) is unknown at this time. It is anticipated that the need for modifications to the 2008 LORS would be initially triggered by non-CEPP actions and that these actions would occur earlier than implementation of CEPP.

Kissimmee River Restoration (KRR) Project Complete

Completion of the KRR Project construction features is scheduled for 2019. Currently, outstanding construction features include Reaches 2 and 3 backfill, the S-69 U-Shaped Weir at the downstream terminus of Reach 3 backfill, removal of the S-65C spillway and tieback levees and completion of the additional spillway capacity at S-65E. However, completion of the KRR project also includes implementation of operational changes in the Upper (i.e., Headwaters Revitalization) and Lower Basins that would provide for restoration as well as maintain existing levels of flood protection. In order to maintain existing levels of flood protection within the Kissimmee River Upper Basin, the KRR Project included canal improvements within the Chain of Lakes and additional spillway capacity at S-65 (the outlet from Lake Kissimmee), increasing the design discharge from 11,000 cfs up to 18,000 cfs. Spillway additions as part of the KRR Project also increased the design discharge of S-65D from 21,300 cfs up to 31,000 cfs and the design discharge of S-65E from 24,000 cfs up to 34,000 cfs. Additional discharge capacity beyond existing levels at some of these spillways is expected for events larger than the 50-yr and the full additional discharge would likely only be required for a basin-wide SPF event. Ongoing studies as part of the Kissimmee Basin Modified Water Control Plan continue to develop flood operations for the anticipated future state of the KRR Project.

With LORS 2008 in-place as an interim risk reduction measure for the HHD Future Without Project condition, there would not be the option to store additional water within Lake Okeechobee (for purposes such as water supply or in order to buffer large releases to the coastal estuaries) because of continued concerns with the structural integrity of the HHD. Since the Kissimmee River basin comprises between 40 to 60 percent of the inflows to Lake Okeechobee, there is instead impetus to intercept and store these excess flows (i.e., during floods) before they reach Lake Okeechobee.

SFWMD Northern Everglades and Estuaries Protection Program

The SFWMD, the Corps cost-share sponsor for the C&SF Project, continues to study storage options as part of the Northern Everglades and Estuaries Protection Program, established in 2007 to strengthen protection for the Northern Everglades by expanding the Lake Okeechobee Protection Area (LOPA). One particularly relevant plan component is "The Lake Okeechobee Watershed Construction Project, Phase II Technical Plan". The Plan identifies projects and urban and agricultural best management practices needed to achieve water quality targets for Lake

Okeechobee. In addition, it includes projects for increasing water storage north of Lake Okeechobee to achieve healthier lake levels and reduce harmful discharges to the Caloosahatchee and St. Lucie Rivers and Estuaries.

SFWMD Dispersed Water Management Program

Since 2005, the SFWMD has been working with a coalition of agencies, environmental organizations, ranchers and researchers to enhance opportunities for storing excess surface water on public and private lands. Over the years, these partnerships have made thousands of acre-feet of water retention and storage available throughout the greater Everglades system, including the Northern Everglades. In addition to utilizing regional public projects, the SFWMD's Dispersed Water Management Program encourages private property owners to retain water on their land rather than drain it and/or accept and detain regional runoff for storage. Landowners typically become involved in the program through cost-share cooperative projects, easements or payment for environmental services.

Managing water on these lands is one means of reducing the amount of water delivered into Lake Okeechobee during the wet season. With Lake Okeechobee's water levels high from months of above-average rainfall during the 2013 rainy season, the SFWMD utilized this storage while taking further actions to capture and store water throughout the regional water management system. Holding water on these lands helped reduce the amount of water flowing into Lake Okeechobee and/or discharged to the Caloosahatchee and St. Lucie Estuaries during the high water conditions throughout south Florida.

Water control Structures, Culverts, Lock Structures, Pump Stations & Spillways, Canals, Embankments

The structures, as described in Section 3 (Existing Conditions), are not expected to change from what is currently in place. Further, it is expected the structures, canals, and embankments would be operated in much the same manner, except as noted for related projects discussed above. As mentioned previously, the 28 Federal culverts are currently being replaced as discussed in the 2010 HHD Culvert Removal and Replacement EA. The culverts are being replaced in kind, and therefore would not be expected to change the future function of water flows. Construction of the replacement culverts is expected to be completed in 2020.

4.5 WATER QUALITY

Surface Water

Regardless of the condition of the dike, the highly eutrophic condition of Lake Okeechobee is expected to persist for the foreseeable future due to past and future nutrient loading. Increased population may result in some change to surface water quality; however, the most significant source of surface water pollution in the lake will continue to be from the northern Lake Okeechobee basin and from agricultural operations in the EAA when they infrequently backpump stormwater into the lake. The FDEP and SFWMD implementation of the NEEPA programs will likely result in a reduction of nutrient loading into the lake which should improve lake water quality and eventually downstream estuary water quality.

If a breach in the dike were to occur, mud sediments from Lake Okeechobee would be transported to nearby waterways, resulting in localized elevated total suspended solids and phosphorus concentrations that might be higher than typical depending upon the affected water body. It is

possible that a breach might result in the entrainment of HTRW contaminants into flood waters; however, dispersion and dilution would likely result in few limited areas where water quality standards would be exceeded. No significant effects outside the immediate area of the breach would be expected. Without dike rehabilitation, the lake would be operated at lower stages, which may improve water quality conditions somewhat in the littoral zone of the lake. However, because of the dike's current lack of structural integrity, high-volume freshwater releases are required during flood events to avoid the possibility of a breach in the dike. These releases affect the lake's two primary outlets: the St. Lucie and Caloosahatchee Rivers. Water released from the lake contains elevated nutrient concentrations that contribute to degradation of water quality in the St. Lucie and Caloosahatchee Rivers and Estuaries. None of the projects or assumptions discussed in the Section 4.4 Hydrology & Hydraulics will result in significant changes to water quality in the project area. Since Florida Water Quality Standards were recently revised, it is not likely that the State will develop stronger more effective regulations in the foreseeable future. A Total Maximum Daily Limit for Phosphorus, the limiting nutrient in Lake Okeechobee, was established for the Lake in 2002. Efforts to attain the TMDL limit through the implementation of Basin Management Plans are likely to continue.

Groundwater

Increased population in the vicinity of the HHD is likely to result in greater use of the Floridan Aquifer as a source of potable water where its quality supports such use. The FAS groundwater quality conditions are not expected to change in the vicinity of the HHD in the foreseeable future with or without rehabilitation. Along the perimeter of the lake from Port Mayaca southwest to Moorehaven, the original draining of the EAA lands has likely resulted in a shallowing of the freshwater/saline water interface depth in the surficial aquifer as would be indicated by the Ghyben-Herzberg principle. It is likely a new equilibrium depth of the freshwater/saline water was reached shortly after the EAA drainage was established since the drainage has been in place for 80 or more years and this aquifer continues to be used to supply freshwater from shallow groundwater wells.

Preliminary measurements in Reach 1 (Port Mayaca to Belle Glades) indicate the possibility that a new equilibrium depth for the freshwater/saline water interface is being established in some locations directly adjacent to the cutoff wall installed between Port Mayaca and Belle Glade (USGS Open File Report 2014-1256). The upward movement of connate groundwater in Reaches 2 and 3 are not expected to impact surface water quality.

From Port Mayaca northwest towards Okeechobee City and Lake Port, the groundwater is not likely to change significantly in the absence of a rehabilitated HHD. This area is expected to experience increased population over the next 50 years which is likely to be the largest driver of changes to surficial groundwater quality conditions as this aquifer is likely to be used as a source for landscape irrigation.

4.6 VEGETATION

The No Action Alternative is expected to continue to provide conditions for which the same vegetation, as described in **Section 3** (Existing Conditions), would occur. The HHD itself would continue to be covered with mixed grasses and mowed on a regular basis. Wetland vegetation would likely continue to be found in the toe ditch between operation and maintenance mowing activities.

Open water and freshwater marsh habitats are expected to continue lakeward of the HHD within Lake Okeechobee. It is expected the littoral zone, as described in **Section 3**, would continue on the lake's western edge and on the islands in its southern shore (Kraemer Island, Torry Island, and Ritta Island). The littoral zone would support emergent, submerged, and floating-leaf plants. Depending on the effects of climate change (temperature and rainfall especially), plant community structure within the littoral zone of Lake Okeechobee may change. Further, changes in special extent and distribution of the Lake Okeechobee littoral zone are anticipated as the regulation schedule for Lake Okeechobee may need to be revised as a result of implementation of the CEPP (USACE 2013). In addition, it is anticipated that species composition and abundance within submerged, emergent and floating-leaf communities would likely be altered as a result of changes in lake stage or regulation.

4.7 WETLANDS

The No Action Alternative is expected to continue to provide conditions for which the same wetlands, as described in **Section 3** (Existing Conditions), would occur. Low quality wetlands would continue to occur in the toe ditches around HHD, providing foraging opportunities for wildlife. High quality wetland habitat would be expected to continue in the littoral zone currently on the western side of Lake Okeechobee with the same lake stages as are provided for by the LORS 2008. Lake Okeechobee would continue to hydraulically feed wetlands beyond the HHD, providing freshwater for the Florida Everglades to the south and for the WCAs in Palm Beach and Broward Counties.

If a breach of the HHD were to occur in the southern reaches, it is expected the EAA, the STAs, the WCAs, and ENP could be negatively impacted as a result of the flow of water from Lake Okeechobee. In addition to flooding and destroying the crops within the agricultural areas, water would more than likely overwhelm the STAs and WCAs and continue to move south towards ENP.

4.8 THREATENED AND ENDANGERED SPECIES

The habitat surrounding the HHD is expected to remain similar to that described in **Section 3** (Existing Conditions) and the same species are expected to remain in the area. The No Action Alternative, with continued current conditions, would not have adverse effects on protected species. However, if the dike were to fail, species and habitats directly on the dike and within the path of the water would be negatively impacted, and snail kite critical habitat could be negatively impacted due to lower lake levels.

Further, if a breach were to occur along the southern portions of the HHD, flooding would occur within the EAA and further south, through the WCAs, and eventually to Everglades National Park. There are many state and federally protected species within south Florida that would be negatively impacted due to a loss of habitat from flooding resulting from a breach of the HHD.

4.8.1 Federally Listed Species Expected to Occur Within the Study Area

4.8.1.1 Audubon's Crested Caracara

The No Action Alternative is not expected to affect the caracara. Caracara typically nest in open fields and ranch lands. If the dike were to breach, ranch lands could be flooded and negative

impacts to nesting trees could occur. Changes in land use are expected to have a greater impact to the caracara than a potential breach in the HHD.

4.8.1.2 Eastern Indigo Snake

The Eastern indigo snake is expected to continue to have the potential to be found on the HHD embankment with the No Action Alternative. If the dike were to breach, snakes within the breach zone could be swept away due to the loss of water from Lake Okeechobee.

4.8.1.3 Everglade Snail Kite

The snail kite is expected to continue to be present within the littoral zone of Lake Okeechobee with the No Action Alternative. If the dike were to breach, negative effects to the littoral zone could occur due to loss of water within Lake Okeechobee. The littoral zone in Lake Okeechobee is designated as critical habitat for the Everglade snail kite and loss of this habitat would have a negative effect on the snail kite. Further, it is safe to assume the LORS would be updated during the planning horizon. Changes to the LORS could have the potential to affect the snail kite, however, these effects would be analyzed in a separate NEPA document for an updated regulation schedule for Lake Okeechobee.

4.8.1.4 Okeechobee Gourd

The Okeechobee gourd is expected to be found along or adjacent to the HHD with the No Action Alternative. If the dike were to breach, plants along and within the breach zone would be swept away due with the flow of water from Lake Okeechobee.

4.8.1.5 West Indian Manatee

The manatee is expected to continue to inhabit Lake Okeechobee and the canals adjacent to the HHD with the No Action Alternative. If the dike were to breach and a manatee was in the water near the breach zone, it could be caught up in the water flow and potentially be stranded on dry land.

4.8.1.6 Wood Stork

The wood stork is expected to continue to nest adjacent to the HHD and forage within Lake Okeechobee with the No Action Alternative. If the dike were to beach, temporary impacts to foraging due to loss of water within the littoral zone are expected.

4.8.1.7 Florida Panther

The Florida panther is expected to inhabit the lands surrounding the HHD with the No Action Alternative. The Florida panther continues to extend its territory northward from the southwest Florida region as its population grows. A breach of the HHD could negatively impact the panther if it is caught in the flood waters resulting from a breach.

4.8.1.8 Florida Bonneted Bat

The bonneted bat is expected to continue to inhabit lands north and west of Lake Okeechobee with the No Action Alternative. A breach of the dike could negatively impact foraging habitat of the bat within Lake Okeechobee or adjacent wetlands depending on the location of the breach and flow path of the water.

4.8.2 State Listed Species Expected to Occur Within the Study Area

With the No Action Alternative, the gopher tortoise, burrowing owl, and many wading birds are likely to continue to use the HHD for foraging and nesting. The wading bird species that could potentially occur in the project area are listed in Table 3-6 and would have similar effects as listed for the wood stork.

4.8.2.1 Gopher Tortoise

The gopher tortoise is expected to continue to be found on the HHD embankment with the No Action Alternative. If the dike were to breach, tortoises within the breach zone could be swept away due to the loss of water from Lake Okeechobee.

4.8.2.2 Burrowing Owl

The burrowing owl is expected to continue to be found on the HHD embankment with the No Action Alternative. If the dike were to breach, owls within the breach zone could be swept away due to the loss of water from Lake Okeechobee.

4.9 FISH AND WILDLIFE RESOURCES

Declining environmental trends from existing C&SF drainage structures would continue to cause stress on the ecosystem. Disruption of the natural hydrology has resulted in changes in aquatic vegetation communities, and disruption of aquatic productivity and function. These changes have had repercussions throughout the food web, including wading birds, raptors, larger predatory fishes, reptiles, and mammals. These effects are likely to continue with No Action. The littoral zone would be continued to be managed as is, providing habitat for wading birds and the entire lake as migratory bird habitat.

4.10 NOISE

Noise sources and levels are not expected to change significantly from that described in Section 3 (Existing Conditions) with the No Action Alternative. Vehicular traffic on local roadways is expected to increase along with increased population; however, noise conditions are not expected to significantly change. The project area is expected to remain predominantly rural with pockets of low-density residential.

4.11 AIR QUALITY

The No Action Alternative would not affect air quality. Relative to the existing condition, it is expected that traffic and other practices affecting air quality would increase marginally in most areas of the study area due to moderate population growth.

4.12 TRANSPORTATION AND UTILITIES

Transportation and utilities are not expected to be impacted due to the No Action Alternative. If a breach were to occur, impacts to highways and the railroad would be extensive. Structures nearest the breach could be destroyed. Further, travelers or freight on the roads or railroad could be endangered. Even moderate flooding from a low velocity breach would likely cause road closures and traffic delays. The utility infrastructure located on lands adjacent to HHD could be destroyed, resulting in communication and power outages.

4.13 SOCIOECONOMICS

4.13.1 Socioeconomic Characteristics of the Study Area

As described in **Section 3.0** (Existing Conditions, Socioeconomics), the areas surrounding Lake Okeechobee are largely rural with some small towns and cities dispersed throughout agricultural areas. The primary economic activity is agriculture; secondary activities include: recreation, commercial fishing, commercial navigation, services (banking, insurance, etc.) healthcare, education, and government activities.

The general economic characteristics of the study area are not expected to change significantly in the foreseeable future. The economic engine of the region is agriculture and to a lesser extent tourism associated with Lake Okeechobee. This is unlikely to change much over time. The basic economic drivers associated with high value integrated agricultural operations are expected to remain in place over time. Value added by agricultural businesses and industries will likely occur over the long term. If a breach were to occur, thousands of acres of productive farmland (almost entirely sugarcane) would be inundated and likely out of production for several growing seasons. In addition, Zone A (Reaches 2 and 3, see **Figure 2-2**) has the greatest potential for economic damage, which could be significant with a breach. Relative to the other zones, urban damages are highest in Zone A. Agricultural damages are also the largest for Zones A and B due to the close proximity to the EAA.

4.13.2 Demographic Changes Over Time

In most of the communities surrounding Lake Okeechobee, population growth has been slow in recent decades (less than 1% per year). It is reasonable to assume that slow population growth would continue into the foreseeable future. The State of Florida's Office of Population and Demographic Research provides projections for all Florida Counties through 2040. The projections are summarized in **Table 4-1**. The table also shows percent increase in the total population from 2010 to 2040.

Table 4-1. Projected population growth by county from 2010 to 2040

	2010	2015	2020	2025	2030	2035	2040	% Increase
Palm Beach	1,320,134	1,377,239	1,465,309	1,545,998	1,616,867	1,678,101	1,733,331	**31.30%**
Hendry	39,140	38,463	39,750	40,847	41,700	42,468	42,861	**9.51%**
Glades	12,884	13,035	13,744	14,389	14,950	15,519	15,860	**23.10%**
Okeechobee	39,996	40,530	42,105	43,461	44,574	45,464	46,186	**15.48%**
Martin	146,318	151,983	160,964	169,130	176,238	182,322	187,765	**28.33%**

Source: State of Florida Office of Population and Demographic Research. *Florida Population by County: 1977 through 2040*

It should be noted that Palm Beach County and Martin County are projected to grow much more quickly than the other counties. This is primarily due to expected growth in the coastal areas in each county. The communities near the HHD in Palm Beach County (South Bay, Belle Glade, and Pahokee) are not likely to grow as quickly as coastal cities such as West Palm Beach, Jupiter, and Boca Raton. Therefore, the growth rate for Palm Beach County (31.3% over 30 years) is probably overly aggressive for the communities near the HHD. Instead, the growth rate for Hendry County (9.5% over 30 years) is more realistic projection. Hendry County is adjacent to Palm Beach County,

and its demographic characteristics are much more similar to Belle Glade and Pahokee than those cities are to West Palm Beach. For Martin County, the growth rate for Okeechobee County (15.5% years) is more realistic for unincorporated areas near the HHD. In this case, Okeechobee is also an adjacent county with similar demographic and socioeconomic characteristics.

4.14 PUBLIC SAFETY

It is expected the inflow capacity versus outflow capacity of Lake Okeechobee would be as described in the existing conditions. The HHD would continue to provide flood risk management not only to towns immediately adjacent to the dike, but to a vast area south of the lake in the future.

Though major demographic and land-use changes are not expected, the No Action Alternative assumes that reasonable risk management measures would be taken by state and local authorities regardless of Federal action. This is an important assumption, because it ensures that the Federal government would not be making large investments based on poor local planning and preparedness. In other words, risk reduction should be shared responsibility, not an exclusively Federal objective.

In the case of the HHD, several specific local planning changes are assumed in the future condition.

- Improved public warning systems (Reverse 911 and warning sirens)
- Improved Public Awareness and education (more effective pre-breach evacuation warnings)
- Improved evacuation planning (more efficient evacuation plans during breach scenarios)

All of the above changes result in more effective public evacuation in the case of a dike breach. If all of the above actions are taken, life loss associated with a breach is expected to decrease over time (i.e. No Action Alternative), however, it would not decrease below tolerable risk guidelines. The earliest year in which these measures could realistically be implemented by local authorities is 2020, which is a key assumption of the consequences analysis.

4.15 REAL ESTATE

A breach in the HHD would result in widespread flooding of lands and the structures located on them as waters from Lake Okeechobee pass through the breach and onto adjacent lands. The risk to lands and structures located within the vicinity of the HHD is substantial. Inundation mapping and flood stage hydrographs indicate that flooding would be severe. Agricultural lands would also suffer damage, possibly for several growing seasons.

4.16 HAZARDOUS, TOXIC AND RADIOACTIVE WASTES

The No Action Alternative is not expected to result in any HTRW concerns. However, if there is a breach in the dike, some lands adjacent to the dike breach may potentially be subject to HTRW contamination as a result of the dispersion of otherwise contained pollutants on private lands.

4.17 RECREATIONAL RESOURCES

It is expected that Lake Okeechobee and the HHD would continue to host a variety of recreational activities year-round as described in **Section 3** (Existing Conditions). The OWW should continue to allow transit between the Gulf of Mexico and the Atlantic Ocean using the Caloosahatchee

River (west coast) through Lake Okeechobee and reaching the Atlantic Ocean through the St. Lucie River. Recreational resources in the project area include the LOST, fishing and boating opportunities, campgrounds, hunting, and park areas. Additional opportunities for recreation could be developed by local entities as population numbers increase in the future.

However, though recreational opportunities will continue to exist (and possibly expand) in the future, they will remain at risk from a potential dike breach in the No Action alternative. A dike breach would be expected to cause a major disruption to recreation facilities associated with Lake Okeechobee, including the LOST and the navigation channel. This disruption could last for weeks, months, or even years depending on the lake stage when the breach occurred. And depending on the location and timing of the breach, some adverse effects could be permanent (parks, boat ramps, and portions of the LOST could be destroyed).

As part of the HHD risk assessment, an evaluation was conducted of potential lost recreation benefits. This evaluation concluded that annual visitation to Lake Okeechobee amounts to approximately 5.6 million visits per year, and that more than $8.6 million in recreational benefits would be lost per year in the aftermath of a major breach. As noted in Section 3 of this document, agriculture is the primary economic activity in the communities near Lake Okeechobee. But recreation is a critical secondary activity. In addition the direct damage to property, a dike breach could devastate the local economy by disrupting or destroying recreational facilities near the dike. This risk will continue to exist in the No Action alternative.

4.18 AESTHETIC RESOURCES

With the No Action Alternative, the HHD crest would continue to provide panoramic views of the flat agricultural (mostly sugarcane) fields and rim canal to the south, southwest, and southeast of Reaches 2 and 3. The extensive littoral zone on the west side of the lake's perimeter can be viewed from the dike in Reach 2, as well as Reaches 4, 6, and 8. The littoral zone plant community is composed of a mosaic of emergent and submerged plant species. Emergent vegetation within the littoral zone is dominated by cattail, spike rush, and torpedo grass. Along Reach 3, submerged vegetation is abundant along the lakeshore. There are several parks adjacent to the HHD. These parks include resources such as ponds, picnic areas, restrooms, grassy fields, boat ramps, and other amenities.

As stated above in the Socioeconomics Section, the general economic characteristics of the study area are not expected to change significantly in the foreseeable future. Therefore, land use is expected to remain the same with a large amount of agricultural practices continuing in the future and excessive development is not expected. Depending on the effects of climate change (temperature and rainfall especially), plant community structure within the littoral zone of Lake Okeechobee may change.

4.19 CULTURAL RESOURCES

Compared to the existing conditions in **Section 3.18**, the No Action Alternative would not have any expected impacts to cultural resources. In the event of a breach failure in the HHD, there would be a potential for adverse effects to both recorded and unrecorded historic properties, including the HHD itself which is eligible for listing in the NRHP. Depending on the location and severity of the breach, impacts from flooding, erosion, and standing water could cause varying adverse effects to historic properties within the vicinity of the HHD.

4.20 TRIBAL RESOURCES

The Seminole Brighton Reservation on the northwest side of Lake Okeechobee would still exist under the No Action Alternative. It is expected the Seminole Tribe would continue to use the HHD for hunting and fishing as discussed in Section 3 (Existing Conditions). If a breach were to occur, lands within the Seminole Brighton Reservation would be inundated, potentially causing adverse effects to hundreds of recorded and as yet, unrecorded historic properties depending upon the severity of the breach.

5.0 ENVIRONMENTAL EFFECTS: FINAL ARRAY OF ALTERNATIVES

This assessment of environmental effects evaluates the anticipated environmental effects within each common inundation zone (CIZ) of the alternative actions described in **Section 2.0**. The following includes anticipated changes to the existing environment including direct, indirect, and cumulative effects. The effects described in this section are based on the assumption that all real estate required to implement these alternatives have been acquired or use is permitted via formal land agreements and that LORS 2008 is in place. The common inundation zones and their relationship to the HHD reaches and segments are summarized in **Table 5-1** below and can be viewed in **Figure 2-2**. The alternative descriptions are summarized in **Table 2-2 and Table 2-3**.

Table 5-1. Common Inundation Zones (Zone) and Segments with HHD Reaches

Zone	Segment	Reach
A	22, 23, 24, 1, 2, 3	1 3
B	4, 5, 6, 7, 8, 9, 10	2 4
C	11, 12, 13, 14A	6
D	14B, 15, 16	6
E	17, 18A, 18A-2, 18B	8
F	19A, 19A-2, 19A-3, 19B, 19C	5
G	20, 21	7

Since the final array of alternatives contains a no action alternative, the other four action alternatives were compared to and evaluated against the No Action Alternative to describe changes to existing conditions with implementation of each action alternative. These potential effects are summarized within this section. In all alternatives, Zones A, G, and F did not propose any actions and are therefore determined to have no effect on any resource discussed, and existing conditions are assumed to remain the same. Because the purpose of the project is to reduce risk within the embankment itself, effects to the estuaries and water conservation areas would not be expected due to any of the alternatives. The existing conditions within the estuaries and water conservations areas would be expected to remain as they are now due to the assumption that the LORS 2008 is the water management operations.

For analysis on environmental effects, intensity was rated as follows:

Negligible - effect to the resource or discipline is barely perceptible and not measurable and confined to a small area
Minor - effect to the resource or discipline is perceptible and measurable and is localized
Moderate - effect is clearly detectable and could have appreciable effect on the resource or discipline; or the effect is perceptible and measurable throughout the project area
Major - effect would have a substantial, highly noticeable influence on the resource or discipline on a regional scale

Duration: The duration of the effects in this analysis is defined as follows:
Short term - when effects last less than one year
Long term - effects that last longer than one year

No duration - no effect

5.1 GEOLOGY

5.1.1 Alternative 1

No impacts to the geologic features described in **Section 3.1** are expected as a result of Alternative 1. The cutoff wall would penetrate only the top layers of limestone in the foundation and would not tie into a confining layer and therefore would have no impacts to the geologic features.

5.1.2 Alternative 2 & 3

No impacts to the geologic features described in **Section 3.1** are expected as a result of Alternative 2 or 3. The cutoff wall would penetrate only the top layers of limestone in the foundation and would not tie into a confining layer, therefore, no impacts to the geologic features would occur. Segments proposed to have armoring and floodwall would not impact the geology of the area.

5.1.3 Alternative 4

No impacts to the geologic features described in **Section 3.1** are expected as a result of Alternative 4. The internal drainage system, floodwall, and armoring would have no impacts to the geologic features.

5.2 SOILS

5.2.1 Alternatives 1, 2, 3, and 4

The cutoff wall, internal drainage system, floodwall, and armoring would temporarily disturb soils within the construction footprint, but would not have a long term effect on soils in the area.

5.3 LAND USE

5.3.1 Alternative 1

Land use within the footprint of the proposed alternative is not expected to change with the exception of Segments 8 (Zone B), 12, and 13 (Zone C). The proposed cutoff wall could have an indirect effect on land use in the area because current seepage of groundwater availability may be reduced. In general, the agricultural operators in the vicinity of the HHD levee are artificially draining the soils to remove excess seepage water that can flood the root zone and reduce productivity. When seepage is not sufficient for the needs of the crops, supplemental water is provided via the drainage/water supply canals and ditches. The installation of a cutoff wall may reduce excess seepage during some periods, which may improve cultivation conditions by reducing excessive root zone moisture. During periods when insufficient seepage is available, agricultural operators can use surface water supplies to supplement. Thus, a cutoff wall may permanently (long term) alter seepage flows for agricultural use with potential to moderately impact current land use. However, since other water sources are available, the determination is that land use would have minor impacts due to Alternative 1. No prime or unique farmland would be negatively effected due to this alternative.

5.3.2 Alternative 2

Land use within the footprint of the proposed alternative is not expected to change with the exception of segments 4-9 (Zone B), 12, and13 (Zone C). The cutoff wall in these segments could

have an indirect effect on land use in the area because current seepage of groundwater availability may be reduced. In general, the agricultural operators in the vicinity of the HHD levee are artificially draining the soils to remove excess seepage water that can flood the root zone and reduce productivity. When seepage is not sufficient for the needs of the crops, supplemental water is provided via the drainage/water supply canals and ditches. The installation of a cutoff wall may reduce excess seepage during some periods which may improve cultivation conditions by reducing excessive root zone moisture. During periods when insufficient seepage is available, agricultural operators can use surface water supplies to supplement. Thus, a cutoff wall may permanently (long term) alter seepage flows for agricultural use with potential to moderately impact current land use. However, since other water sources are available, the determination is that land use would have minor impacts due to Alternative 2. The floodwall and armoring would have no effect on land use within the project area. No prime or unique farmland would be negatively effected due to this alternative.

5.3.3 Alternative 3: Recommended Plan

Effects due to this Alternative are the same as discussed in Alternative 2.

5.3.4 Alternative 4

This alternative would not affect existing land use in the area because the internal drainage system would occur adjacent to the embankment within the toe ditch, thus not affecting land use in the surrounding areas. The cutoff wall would have the same effects as described for the other alternatives. The floodwall and armoring would have no effect on land use within the project area. No prime or unique farmland would be negatively effected due to this alternative.

5.4 HYDROLOGY & HYDRAULICS

No modification to the LORS 2008 lake regulation schedule or decision tree would be required upon implementing any or all of the features in the final array of alternatives. However, it can be anticipated that the Corps would be formally requested to modify the current LORS schedule to a new lake water management schedule at some point in the future if the proposed modifications in the final risk reduction that address dam safety concerns are implemented. Additionally, no new surface water regulating structures or modifications to existing structures are proposed at this time. The effects described in this section are based on the assumption that all real estate required to implement these alternatives have been acquired or use is permitted via formal land agreements and that LORS 2008 is in place.

5.4.1 Alternative 1

Zones A, D, E, F, and G do not have any proposed features in this Alternative and are therefore the same as existing conditions.

Zones B & C: There would be minor, short term impacts to surface and ground water quantity within this zone with this alternative (additional surface water and groundwater discussion in Section 5.5). Although sections of cutoff wall would be implemented between various water control structures, there would be no impacts to the actual structures or their operations. Existing canals would not be modified nor would their operations be changed.

5.4.1.1 Surface Water Flow

Zones B & C: The proposed action in Zones B and C to construct a cutoff wall in any of the segments would not result in additional surface water runoff.

5.4.1.2 Surface Water Use

Zones B & C: The construction of a filter and drainage blanket around the downstream end of the U.S. Sugar Raw Water Intake in Segment 5-2 would not change the permitted intake of the U.S. Sugar or the utility, therefore, no negative impact is anticipated. Implementation of a cutoff wall in these Zones is not anticipated to have impacts on surface water use.

5.4.1.3 Groundwater Flow

Zones B & C: Cutoff walls would be constructed in Segments 8, 12, and 13. The cutoff walls would prevent seepage through the levee forcing groundwater movement to occur below the toe of the levee. The analyses conducted to date on the impacts of cutoff wall to groundwater flow and ground water quality is available upon request. Also, see Section 5.4.2.3 for effects to groundwater.

5.4.2 Alternative 2

Zones B-E: There would be minor impacts to surface and ground water quantity and use within these zones. Although sections of cutoff wall, floodwall, and armoring would be implemented between various water control structures, there would be no impacts to the actual structures or their operations. Existing canals would not be modified nor would their operations be changed.

5.4.2.1 Surface Water Flow

Zones B-E: The proposed action to construct cutoff wall in any of the segments should not result in additional surface water runoff. In Zones C, D, and E, floodwall around S-71 and S-72, and armoring around the Harney Pond bridge would not result in increased regional surface water flow, but may increase localized runoff on the landside of the structures, resulting in negligible effects.

5.4.2.2 Surface Water Use

Zone B: The construction of a filter and drainage blanket around the downstream end of the U.S. Sugar Raw Water Intake in Segment 5 would not change the permitted intake of the U.S. Sugar or the utility, therefore, no negative impact is anticipated.

Zones C - E: Implementation of a cutoff wall, armoring (at Harney Pond bridge embankments), or floodwalls (at S-71 and S-72) in these zones is not anticipated to have impacts on surface water use. The SR 78 Bridge over the Harney Pond Canal (C-40) in Segment 13 would be replaced by the state of Florida as part of their regular lifecycle replacement program. The bridge would be replaced in-kind and would not impact the ability to pass storm discharges in the C-40 Canal.

5.4.2.3 Groundwater Flow

Zones B - E: A cutoff wall would be constructed in Segments 4, 5-2, 5, 6, 7, 8, 9, 12, and 13. The cutoff wall would prevent seepage through the levee forcing groundwater movement to occur below the toe of the levee. In the northern Zones (Zone C, D, and E) of the HHD, groundwater

tends to move from the landside to the lakeside since adjacent land elevations and groundwater levels are generally higher than the lake levels. Thus, the installation of cutoff walls is not expected to have an adverse impact to groundwater users in this area since these users are not relying on seepage from Lake Okeechobee. No impacts are expected to groundwater recharge to the shallow surficial and deeper Floridan aquifers. The armoring and floodwall would not have any anticipated effects on groundwater flow.

5.4.3 Alternative 3: Recommended Plan

Zone B- E: The effects of Alternative 3 (Recommended Plan) are the same as those discussed above for Alternative 2.

5.4.4 Alternative 4

Zones B-E: There would be minor impacts to surface and ground water flow or use within this zone. Installation of an internal drainage system is proposed for various segments which would collect seepage and pump to adjacent canals and ditches. Additionally, floodwall around S-71 and S-72 and armoring at the Harney Pond bridge would be implemented; however, there would be no impacts to the actual structures or their operations. Existing canals would not be modified nor would their operations be changed.

5.4.4.1 Surface Water Flow

Zones B-C: Implementation of an internal drainage system would produce negligible increases to surface water flows within the adjacent canals and ditches. Internal drainage is proposed in Segments 4, 5-2, 5, 6, 7, 8, and 9. The proposed action to construct cutoff wall in Segments 12 and 13 should not result in additional surface water runoff.

Zones C-E: Floodwall at S-71 and S-72 would not result in increased regional surface water flow. The armoring at the SR 78 Bridge over the Harney Pond Canal (C-40) in Segment 13 would not result in impacts to surface water flow, and would be replaced by the state of Florida as part of their regular lifecycle replacement program. The bridge would be replaced in-kind and would not impact the ability to pass storm discharges in the C-40 Canal.

5.4.4.2 Surface Water Use

Zones B - E: Since the increase of additional seepage to adjacent canals and ditches is minor, no impacts to surface water use are expected.

5.4.4.3 Groundwater Flow

Zones B-E: The internal drainage system that is proposed in Zone B would be collecting any additional seepage and would not have an impact on groundwater flow. Floodwall, cutoff wall, and armoring would have the same negligible effects as described for the other alternatives.

5.5 WATER QUALITY

Proposed actions that potentially could affect surface and ground water quality are limited to the installation of cutoff walls and internal drainage features. Installation of the filter at the raw water intake at Segment 5-2, floodwall, or armoring adjacent to structures would not significantly affect surface water quality or groundwater quality, therefore, discussion of effects to Zones C, D, and E related to armoring or floodwall are not continued throughout this resources alternatives analysis. The cutoff wall could potentially alter shallow groundwater quality if the depth of the

wall is placed at or below the depth to the saline groundwater. In Reach 1, the cutoff wall was placed at depths ranging from -20 ft to -40 ft NAVD88. As discussed in **Section 3.5**, the Corps and USGS have conducted groundwater monitoring which has shown impacts to shallow groundwater quality at locations where the tip of the cutoff wall is less than approximately 15 ft. above the underlying saline groundwater. The observed impacts include a reduction in the depth at which the groundwater quality transitions from freshwater to saline water. There is the potential that groundwater wells in the vicinity of the cutoff wall in Reach 1 may be affected by the changed groundwater quality conditions.

For the alternatives considered in this EIS, the effect on groundwater quality is expected to be minimal because of a shallower cutoff wall installation depth and lower salinity concentrations in shallow groundwater in reaches other than Reach 1. To address the public's concern regarding impact to groundwater quality, the Corps has continued groundwater monitoring and installed six new monitoring wells in Reaches 1, 2 and 3 in 2015 and 2016. The Corps currently plans to continue to monitor these wells through 2018 and follow up with additional groundwater modeling efforts to predict long-term impacts. Monitoring efforts will be reviewed in 2018 to evaluate the need for and scope of subsequent long-term groundwater quality monitoring.

Short-term impacts to surface water quality are likely to occur for all of the alternatives during construction activities. These will be addressed as part of the Clean Water Act, Section 401 water quality certification process Section 402 NPDES construction activities permitting which specifies the use of best management practices to control stormwater pollution.

5.5.1 Alternative 1

Zones B-D: For this alternative, cutoff wall is proposed for Zone B Segment 8, and Zone C Segments 12 and 13. There would be minor long-term impacts to surface and ground water quality within these zones with this alternative as a result of installing a cutoff wall. No significant impact to surface and groundwater from the proposed armoring.

5.5.1.1 Groundwater Quality

Zones B-D: Installation of cutoff wall in Zone B, Segment 8 is not expected to affect ground water quality or impact surface water quality in adjacent surface water ditches through upwelling of low quality groundwater, given that at this location, the tip of the cutoff wall is expected to be at least 10 ft. above the estimated highest elevation of the connate groundwater in Segment 8. Adjacent to Segment 8, the closest permitted groundwater wells are those associated with the Moore Haven public well field which is approximately 1,800 ft west of the levee. Wells at this facility are screened to a depth of -55 ft below land surface which is approximately -40 ft NAVD88. Given the lateral distance from the levee and depth of these wells, no impact to the quality of the water provided from these wells is expected. For Segments 12 and 13 the cutoff wall would be installed to a depth of -30 ft. NAVD88. Given the predominant direction of groundwater flow, which is towards the HHD from the north, the installation of a cutoff wall in Segments 12 and 13 would be unlikely to adversely impact groundwater quality for users in the vicinity of this portion of the HHD. After installation of the cutoff wall, short-term reversals of the groundwater flow direction are not likely to significantly alter groundwater quality given the depth to potable or agricultural water is at least -40 feet NAVD88 which is more than 15 feet below the maximum depth of the cutoff wall proposed for this area.

5.5.1.2 Surface Water Quality

Zones B & C: Installation of cutoff wall in Zone B, Segment 8 and a filter in 5-2 is not expected to affect surface water quality in the lake or nearby surface water canals. Installation of cutoff wall in Zone C, Segments 12 and 13 is not expected to affect surface water quality in the lake or nearby surface water canals.

5.5.2 Alternative 2

Zone B & C: For this alternative, cutoff wall is proposed in Segments 4 through 9. The elevated bulk conductivity measurements in GL-332 (Segment 6) are associated with a clay later, rather than the saltwater interface. The top of the saltwater interface appears to be at approximately -50 ft NAVD88. Bulk conductivity and chloride indicating the top of the saltwater interface in GL-334 (Segment 7) also are below a clay layer, so conservatively are at about -46 ft NAVD88. Since the maximum tip elevation for the cutoff wall is -30 ft NAVD88, no impacts are expected to occur (discussed in 5.5.2.1).

5.5.2.1 Groundwater Quality

Zone B & C: In Segments 4, 5, 7, and 9, the maximum tip elevation of the cutoff wall is -30 ft NAVD88, or approximately 15 to 20 ft above the saltwater interface. As mentioned earlier (Section 3.5), the saltwater interface is deeper and less saline in Zone B compared to locations in Zone A. Clay layers are observed in borings in Segments 5-2, 6, and 7, and these would separate the base of the cut-off wall from the saltwater interface at many locations. As such, degradation of shallow groundwater quality from cutoff wall construction is unlikely. Along Segments 12 and 13, the predominant groundwater flow direction is from the north towards the lake which means the cutoff wall would have little to no effect on groundwater quality north of the lake.

In Segment 6, the cutoff wall may be installed as deep as -30 ft NAVD88 in locations above the depth of moderately elevated chloride (500 mg/L) groundwater is as shallow as -50 ft NAVD88. A thick (15 ft) clay layer extends from approximately -15 ft to -30 ft NAVD88. The high chloride water is believed to be confined below this clay layer. After cutoff wall installation to the depth of -15 to -30 ft NAVD88, upper layers of fresher groundwater would no longer pass under the cutoff wall. Along Segment 6, no permitted wells were found within 2,500 ft. of the levee, therefore, no groundwater users are expected to be affected. Agriculture operations primarily rely upon surface water supplies in this area. A moderate change in the depth of saltwater interface in Segment 6 is not likely to affect agricultural users.

The proposed bottom elevation of the cutoff wall is -30 ft NAVD88 in Segment 8 and -20 ft NAVD88 for Segment 9. The closest public water supply well in this area appears to be the Moorehaven Water Utility well field that is 1,800 feet from the levee. The water supply wells at this location are screened to approximately -40 ft NAVD88 indicating that groundwater quality is likely to be potable to at least that depth. Given that the wells at this utility are screened at a depth more than 10 ft below the bottom of the proposed cutoff wall, it is unlikely that the cutoff wall would adversely impact water quality for these wells or other wells in the area, therefore, this Alternative would be expected to have minor, long term effects.

5.5.2.2 Surface Water Quality

Zone B & C: No significant impact is expected to occur to surface water quality for Alternative 2 in Segments 4, 5, 7, 8, 9, 12, and 13 because the bottom tip of the cutoff wall proposed in this zone would be sufficiently above the saltwater interface elevation, making significant change to groundwater quality and surface water quality unlikely. It is unlikely that placement of a cutoff wall to -30 ft NAVD88 in Segment 6 will result in significant degradation of surface water quality due a thick confining clay layer between the base of the cutoff wall and the saltwater interface.

5.5.3 Alternative 3: Recommended Plan

Zone B & C: For this alternative, cutoff wall is proposed Segments 4 through 9, 12 and 13. All information discussed in Alternative 2 is the same for the Recommended Plan; therefore, minor, long term impacts would be expected to occur to groundwater and surface water due to this Alternative.

5.5.4 Alternative 4

Zone B & C: Segments 4 through 9, 12, and 13 would have an internal drainage system installed to collect seepage water. The internal drainage system is not likely to impact surface or groundwater quality.

5.5.4.1 Groundwater Quality

Zone B & C: No significant impact to groundwater quality is expected to occur from the installation of internal drainage features in any of the Segments in Zones B and C. The proposed depths of the internal drainage features in all of the Segments is at least 8 ft above the known elevation of saline groundwater so the higher chloride groundwater layers would not be intercepted by the drainage feature. The internal drainage feature includes the ability to pump collected seepage out of the levee embankment. The seepage collection overflow pipes that discharge into collection sumps would be set to an elevation equivalent to the normal toe ditch water surface elevation. For this reason, the pumped system would not draw down the landside groundwater surface profile below the normal toe ditch elevation and thus it would not cause upwelling of groundwater that might have higher levels of dissolved solids.

5.5.4.2 Surface Water Quality

Zone B & C: At present, the adjacent toe ditch water quality is composed of seepage water from the levee and surface water. The internal drainage features are not expected to discharge water with high concentrations of dissolved solids because they are not pumped in a manner that would cause an upwelling of deeper – higher chloride groundwater. It is reasonable to expect that in terms of dissolved solids (chloride, sulfate, etc.) the concentrations in the toe ditch would remain similar to present conditions.

5.6 VEGETATION

Vegetation would not be expected to change with any alternative. Temporary disruption in upland grasses would result from construction of each alternative, however, upon completion of the project, grasses for dam safety standards would be reseeded. Invasive species prevention is included in all construction specifications to deter the spread of exotic or invasive plant species. Work within the toe ditches is discussed below in 5.7, Wetlands.

5.7 WETLANDS

5.7.1 Alternative 1

Zones B - E: Impacts to wetlands would not be expected as a result of this Alternative. Proposed structural features would be constructed on or within the HHD embankment and construction/staging areas would be located in upland or previously disturbed areas. It is possible that incidental temporary impacts may occur in association with staging or site access, however, these would total less than half an acre, and would therefore would result in minor, short term impacts.

5.7.2 Alternative 2 & 3

Zones B - E: Impacts to wetlands would not be expected as a result of this alternative. Proposed structural features would be constructed on or within the HHD embankment and construction/staging areas would be located in upland or previously disturbed areas. It is possible that incidental temporary impacts may occur in association with staging or site access, however, these would total less than half an acre, and would therefore would result in minor, short term impacts.

5.7.3 Alternative 4

Zones B - E: Impacts to wetlands would be minor, short term, and temporary due to construction within the toe ditches. An ACBM is proposed to line the toe ditch, which could prohibit growth of the same wetland vegetation that is currently within the toe ditch, however, the current quality of wetlands within the toe ditches is typically low and is periodically mowed for maintenance. Assessment of the toe ditch wetlands would be performed prior to construction of the internal drainage system, however, mitigation would not be expected due to the low quality of wetlands within the toe ditches.

5.8 THREATENED AND ENDANGERED SPECIES

Threatened and endangered species that the Corps anticipates could occur in the project area were compared to the No Action Alternative. Species would not be directly affected by the long term effects of a cut off wall, internal drainage system, floodwall, or armoring; however, there is moderate, short term potential for disturbance to species during construction activities. The action may produce noise above ambient levels, however, mufflers and sound dampening equipment would be required during construction, along with preconstruction surveys.

5.8.1 Alternatives 1, 2, 3, & 4 – Federally listed species

5.8.1.1 Audubon's Crested Caracara

Audubon's crested caracara have been documented to nest near the project area; specifically, nests have been reported south of Port Mayaca outside of the Federal right-of-way. Additionally, it is possible that nests could be found in other areas within the project area. Surveys would be conducted prior to the initiation of construction and during construction at each site to determine if caracara is present in the project area. Monitoring for caracara during the nesting season (January through April) within 985-4920 ft. of the nests would ensure the action would not increase noise above ambient levels within nest protection areas of active caracara nests. If the project area is within a 4920 ft. buffer of the consultation area, this would also be surveyed for

nests because of the established buffer zone. The action may produce noise above ambient levels, however, mufflers and sound dampening equipment would be required during construction.

Conclusion: All alternatives, including the Recommended Plan may affect, but are not likely to adversely affect, the Audubon's crested caracara.

5.8.1.2 Eastern Indigo Snake

Eastern indigo snakes may be found along the embankment of the HHD, however, throughout recent HHD construction phases (i.e. culverts, cutoff wall) none have been encountered. Preconstruction surveys would be completed in the project area, monitors would be on site during all phases of construction, and construction crews would be educated on identifying the indigo snake and the precautions to take to prevent impacts to the indigo snake. Eastern indigo snake Standard Protection Measures would be included in the environmental protection plan to provide guidance. Onsite gopher tortoise burrows would be protected to the extent possible to provide snake habitat during construction. The habitat that would be temporarily impacted would be seeded or replaced by sod and is expected to recover within a few months of project completion.

Conclusion: All alternatives, including the Recommended Plan may affect, but are not likely to adversely affect, the eastern indigo snake.

5.8.1.3 Everglade Snail Kite

Impacts to snail kite resulting from implementation of a cutoff wall, internal drainage system, floodwall, or armoring would be minimal, and restricted to the immediate area of construction. Construction activities would be limited to the levee itself and the landward side of the levee where this species does not forage extensively. Snail kites are known to nest near the project area but not directly near Segments 6-18. These segments are noted because they are adjacent to the critical habitat. In addition, snail kites forage within the southwestern Lake Okeechobee littoral zone. The action may produce noise above ambient levels, however, mufflers and sound dampening equipment would be required during construction. Preconstruction surveys would be completed prior to the initiation of construction activities. Monitoring kites during the nesting season (January through June) within 1640 ft. of active snail kite nests would ensure the action would not increase noise above ambient levels within nest protection areas of active snail kite nests.

Conclusion: All alternatives, including the Recommended Plan may affect, but are not likely to adversely affect Everglade snail kite or its critical habitat.

5.8.1.4 Okeechobee Gourd

The Okeechobee gourd is known to occur on the HHD. Preconstruction surveys would be completed to locate any plants within the construction footprint. If plants are found, the USFWS would be contacted to determine an appropriate course of action for removal and relocation of plants. Flagging would be placed around the gourd for additional protection from pedestrian traffic if plants are sighted outside of, but adjacent to, the construction area.

Conclusion: All alternatives, including the Recommended Plan may affect, but are not likely to adversely affect the Okeechobee Gourd.

5.8.1.5 West Indian Manatee

Manatees are known to occur in Lake Okeechobee. West Indian manatee would not be directly affected by the long term effects of a cut off wall, internal drainage system, floodwall, or armoring; however, there is potential for minor, short term disturbance to the species during construction activities. All alternatives would produce noise above ambient levels. Preconstruction surveys would be completed to ensure that no manatees are harmed or harassed before or during construction. No manatee critical habitat is adjacent or near the dike.

Conclusion: All alternatives, including the Recommended Plan may affect, but are not likely to adversely affect, the West Indian manatee.

5.8.1.6 Wood stork

Wood storks are known to forage within the toe ditch and nest near the proposed project area. The last noted colony near culvert HP-3 was about 3,400 feet away from the culvert. Wood storks would not be directly affected by construction of a cut off wall or internal drainage system; however, there is potential for disturbance to the species during construction activities. The action may produce noise above ambient levels, however, mufflers and sound dampening equipment would be required during construction. Project activities near foraging wood storks could temporarily displace individuals to other foraging areas available within the littoral zone of Lake Okeechobee during construction. Construction activity should take place no closer than 500-1500 feet to active colonies. Temporary displacement is not expected to adversely affect wood stork foraging opportunities or efficiency.

Conclusion: All alternatives, including the Recommended Plan may affect, but are not likely to adversely affect wood stork.

5.8.1.7 Florida Panther

Florida panthers are thought to use HHD for traversing from one habitat to the next. Construction of the cutoff wall could temporarily impact panthers to traverse the embankment because the embankment would not be passable during construction. Since this would be temporary in nature, it is not expected to harm or harass the species, resulting in minor, short term effects. Construction of the internal drainage system would not occur on the crest of the embankment and would therefore not likely impede Florida panther from traversing along the embankment.

Conclusion: All alternatives, including the Recommended Plan may affect, but are not likely to adversely affect Florida panther.

5.8.1.8 Florida Bonneted Bat

The Florida bonneted bat consultation area includes Okeechobee County, which is within the project area. The project area does not include the 2013 bonneted bat focal area as described by FWS (2013). The HHD contains man-made culverts, which could be suitable for roosting, however, roosts are more likely to occur if trees are surrounding the man-made structures in order to avoid predators (DOI 2013). HHD also contains open water, which is amenable to bonneted bat foraging. None of the alternatives would disrupt any of the culverts more than the culvert replacement project where the Florida bonneted bat was concluded as may affect, not likely to

adversely affect the species. If bats are encountered, the Corps will coordinate measures with FWS to minimize or avoid potentially adverse effects.

Conclusion: Since HHD is within the Florida bonneted bat consultation area and contains man-made structures in which bats could potentially roost, the Corps has determined that all alternatives including the Recommended Plan may affect, but are not likely to adversely affect, Florida bonneted bat.

5.8.2 Alternatives 1, 2, 3, & 4 - State Listed Species Expected to Occur Within the Study Area

While small foraging or nesting areas utilized by the gopher tortoise and burrowing owl may be temporarily affected by this project, each alternative is not likely to adversely affect protected State species and have a less than significant effect on protected State species. Preconstruction surveys for gopher tortoise and burrowing owls would occur, with appropriate relocation permits obtained by the contractor if necessary. Overall, negligible adverse impacts are anticipated to State listed species as a result of this project.

5.9 FISH AND WILDLIFE RESOURCES

Alternatives 1, 2, 3, & 4

All alternatives would temporarily disrupt wildlife through indirect construction noise. However, species would expect to use the embankment as they did prior to construction upon completion of the project. Contractors would be required to perform preconstruction surveys to ensure no nesting birds or other species were present prior to construction. Wading birds would be expected to have the same effects as the wood stork, therefore, no adverse effects are expected.

5.10 NOISE

Alternative 1, 2, & 3 (Recommended Plan)

Zones B – E: Heavy machinery associated with construction of these alternatives could result in nuisance noise. Although sound levels could exceed 70 decibels in proximity to construction activities, attenuation with distance from the construction site would reduce the noise. Contractors would be required to meet local noise ordinances and place noise dampening equipment on trucks and machinery. The effect of noise during construction would be localized and insignificant.

Alternative 4

Zones B - E: Heavy machinery associated with construction of this alternative could result in nuisance noise. Although sound levels could exceed 70 decibels in proximity to construction activities, attenuation with distance from the construction site would reduce the noise. The effect of noise during construction would be localized and insignificant. Contractors would be required to meet local noise ordinances and place noise dampening equipment on trucks and machinery. In addition, many segments have a seepage filter and pump identified to collect seepage of water through the embankment. Pump operations during the life of the project, mainly during high water events, would be a new source of noise in the area. Noise associated with pump operations is common within the south Florida environment due to the numerous pumps and canals within the C&SF Project. The effect of noise during construction would be localized and insignificant. Further, the effect of noise from operations of the pumps associated with the seepage filters would be occasional and insignificant.

5.11 AIR QUALITY

The U.S. Environmental Protection Agency (EPA) published *Determining Conformity of General Federal Actions to State or Federal Implementation Plans; Final Rule* in the 30 November 1993, Federal Register (40 Code of Federal Regulations [CFR] Parts 6, 51, and 93). This publication provides implementing guidance to document the Clean Air Act (CAA) Conformity Determination requirements. Subsequent to the 1993 rule, EPA collected information from other Federal agencies on how to maintain the same environmental protections while streamlining the general conformity implementation process. This information was used to develop and propose regions associated with the general conformity rule. After soliciting comments on these revisions from the public, EPA issued a final rule revision on April 5, 2010.

The Proposed Action Alternatives would occur within the following counties; Palm Beach, Hendry, Martin, Okeechobee, and Glades. Each county currently attains the National Ambient Air Quality Standards (NAAQS) for all six criteria air quality criteria pollutants as designated under Section 110(a)(1) of the CAA; sulfur oxides (SOx), volatile organic compounds (VOCs), nitrogen oxides (NOx), carbon dioxide (CO), particulate matter 10 (PM10), and PM2.5.

Short term impacts from mobile sources and other construction equipment associated with Alternatives 1, 2, 3, or 4 would not significantly impact air quality. No air quality permits are expected to be required regardless of the selected alternative. The project is located within an attainment area and therefore the EPA's general conformity rule to implement Section 176(c) of the CAA does not apply and a conformity statement should not be required. The criteria pollutants, including ozone, are estimated herein for planning purposes only.

Direct emissions from the construction of the all alternatives would be confined to exhaust emissions of construction equipment (excavators, dump trucks, etc.). Pollutants considered in this air quality assessment are sulfur oxides (SOx), volatile organic compounds (VOCs), nitrogen oxides (NOx), carbon dioxide (CO), PM10, and PM2.5. Volatile organic compounds, sulfur oxides, and nitrogen oxides are precursors to ozone generation. These criteria pollutants are generated by the activities (e.g., construction and mobile source operations) associated with all alternatives.

Emission rates for each applicable criteria pollutant CO, NOx, PM2.5, PM10, SOx, and VOCs were estimated based on probable fuel use by year and calculated in tons per year. Fuel use was estimated as a percentage of total construction costs. Emission estimates can be made using a percentage of the total construction cost as a means of estimating fuel use during construction activities. The Federal Highway administration estimates that fuel costs 8 to 10 percent of the construction cost (FHWA 1980). For this air pollution analysis, a factor of 8 percent of the alternative cost is used since there are design and contract administration costs included in the estimated costs. A fuel price of $4.00/gallon is used to estimate gallons used. Excavators and dump trucks were assumed to be the primary sources of air pollutants with each burning 50 percent of the estimated annual fuel requirement. The construction activities were assumed to be conducted over a period of 5 to 15 years depending upon the alternative with the work load spread evenly over the period and distributed by county. Each sources' (engine) emission rate was derived from the following formula:

Emission Rate (tons/hr) = Engine Horsepower × Engine Load Factor × Emission Factor

The construction equipment's engine load factors were estimated from the USEPA technical report *Compilation of Air Emission Factors, AP-42, 5th Edition, USEPA 1995,* incorporating each source's suggested operating mode. Potential criteria air pollutant quantities emitted were calculated based on the following formula:

Emission Amount (tons/year) = Emission Rate (tons/hour) × Working Hours (hours/year)

Since air quality criteria are evaluated on a county by county or air-shed basis, pollutant emissions were estimated for each affected county separately based on the estimated work effort in each county.

Conformity Assessment: A general conformity applicability determination is made by estimating the total of direct and indirect VOC and NOX emissions caused by the construction of each of the project alternatives. Prescribed *de minimis* levels of 100 tons per year per pollutant were compared for planning purposes only. Project alternatives that would result in discharges below the *de minimis* level are exempt from further consultation and development of mitigation plans for reducing emissions.

Carbon Dioxide Emissions: Carbon dioxide (CO_2) is emitted in a number of ways. It is emitted naturally through the carbon cycle and through human activities like the burning of fossil fuels. Natural sources of CO_2 occur within the carbon cycle where billions of tons of atmospheric CO_2 are removed from the atmosphere by oceans and growing plants, also known as 'sinks,' and are emitted back into the atmosphere annually through natural processes also known as 'sources.' When in balance, the total carbon dioxide emissions and removals from the entire carbon cycle are roughly equal. Since the Industrial Revolution in the 1700s, human activities, such as the burning of oil, coal, and gas, and deforestation have increased CO_2 concentrations in the atmosphere. In 2005, global atmospheric concentrations of CO_2 were 35% higher than they were before the Industrial Revolution. As an important greenhouse gas (GHG), CO_2 emissions were also calculated for planning purposes and reported in the air emissions tables below.

Greenhouse gas emissions will result from any of the proposed alternatives as a result of operating earth moving equipment, manufacturing of supplies, mining of earth materials, and other activities. The generation of greenhouse gases can be minimized by utilizing high efficiency construction equipment and locally sourcing the construction material supplies. The Corps value engineering process may also reduce GHG emissions since optimizing design and costs inherently will result in lower GHG emissions.

5.11.1 Alternatives 1

For purposes of the air quality estimation, it is assumed that the construction duration for this alternative is five years. Based on an 8 percent fuel cost factor, the annual fuel use is estimated to be 200,000 gallons/year. As shown in **Table 5-2**, none of the regulated pollutants exceeds 100 tons per year. The CO_2 emission rate is approximately 2,200 tons/year.

Table 5-2. Estimate of emissions resulting from the construction of Alternative 1 by county

County	Pollutant Emissions (tons/year)						
	CO	VOC	Nox	Sox	PM10	PM2.5	CO_2
Palm Beach	0	0	0.0	0	0	0	0

County	Pollutant Emissions (tons/year)						
	CO	VOC	Nox	Sox	PM10	PM2.5	CO_2
Hendry	0	0	0.0	0	0	0	0
Glades	10.5	1.8	23.3	3.3	1.7	1.7	2,200
Okeechobee	0	0	0.0	0	0	0	0
Martin	0	0	0.0	0	0	0	0
Total	10.5	1.8	23.3	3.3	1.7	1.7	2,200

5.11.2 Alternative 2

For purposes of the air quality estimation, it is assumed that the construction duration for this alternative is 10 years. Based on an 8 percent fuel cost factor, the annual fuel use is estimated to be 1,700,000 gallons/year. As shown in **Table 5-3**, none of the regulated pollutants exceeds 100 tons per year for any county. The CO_2 emission rate is approximately 9,435 tons/year.

Table 5-3. Estimate of emissions resulting from the construction of Alternative 2 by county

County	Pollutant Emissions (tons/year)						
	CO	VOC	Nox	Sox	PM10	PM2.5	CO_2
Palm Beach	**7.2**	1.3	15.9	2.2	1.2	1.1	1,513
Hendry	**5.0**	0.9	11.0	1.5	0.8	0.8	1,046
Glades	**17.3**	3.0	38.4	5.4	2.8	2.8	3,649
Okeechobee	**0.0**	0.0	0.0	0.0	0.0	0.0	0
Martin	**15.3**	2.7	33.9	4.7	2.5	2.4	3,227
Total	44.7	7.8	99.2	13.9	7.3	7.1	9,435

5.11.3 Alternatives 3

For purposes of the air quality estimation, it is assumed that the construction duration for this alternative is five years. Based on an 8 percent fuel cost factor, the annual fuel use is estimated to be 1,120,000 gallons/year. As shown in **Table 5-4**, none of the regulated pollutants exceeds 100 tons per year for any county. The CO_2 emission rate is approximately 12,435 tons/year. Based on the analysis, effects to air quality would result in minor, short-terms effects.

Table 5-4. Estimate of emissions resulting from the construction of Alternative 3 by county

County	Pollutant Emissions (tons/year)						
	CO	VOC	Nox	Sox	PM10	PM2.5	CO_2
Palm Beach	14.3	2.5	31.8	4.4	2.3	2.3	3,019
Hendry	9.9	1.7	21.9	3.1	1.6	1.6	2,087
Glades	34.5	6.0	76.6	10.7	5.6	5.5	7,282
Okeechobee	0.0	0.0	0.0	0.0	0.0	0.0	0
Martin	0.0	0.0	0.0	0.0	0.0	0.0	0
Total	58.7	10.3	130.3	18.2	9.6	9.4	12,388

Notes: [1] The Proposed Action Alternative is located within a designated attainment area and a formal conformity determination is not required, emissions for the proposed alternative were compared to the de minimis values of criteria pollutants for reference only.

5.11.4 Alternatives 4

For purposes of the air quality estimation, it is assumed that the construction duration for this alternative is 15 years. Based on an 8 percent fuel cost factor, the annual fuel use is estimated to be 4,300,000 gallons/year. As shown in **Table 5-5**, none of the regulated pollutants exceeds 100 tons per year for any county. The CO_2 emission rate is approximately 9,435 tons/year.

Table 5-5. Estimate of emissions resulting from the construction of Alternative 4 by county

County	Pollutant Emissions (tons/year)						
	CO	VOC	Nox	Sox	PM10	PM2.5	CO_2
Palm Beach	8.6	1.5	19.1	2.7	1.4	1.4	1,820
Hendry	7.0	1.2	15.6	2.2	1.1	1.1	1,480
Glades	33.6	5.9	74.6	10.4	5.5	5.4	7,089
Okeechobee	0.0	0.0	0.0	0.0	0.0	0.0	0
Martin	24.6	4.3	54.5	7.6	4.0	3.9	5,180
Total	73.8	12.9	163.7	22.9	12.1	11.8	15,570

The temporary increases in the project-related emissions are relatively minor compared to the existing point, nonpoint, and mobile source emissions in each of the counties. Effects from project emissions and other construction equipment associated with any of the alternatives including the Recommended Plan would not significantly affect air quality within the local air-sheds, resulting in minor short-term effects. Short-term loadings of internal-combustion engine exhaust gasses are expected to be negligible, not posing a threat to workers, local populations, or the area's attainment status. As mobile and temporary sources, no air quality permit would be required for this project. Because the project is located within a designated attainment area, USEPA's general conformity rule Section 176 (c) of the CAA does not apply and a Conformity Determination Analysis would not be required.

5.12 TRANSPORTATION AND UTILITIES

Alternatives 1, 2, 3 (Recommended Plan), & 4

All alternatives would require use of the crest of the dike for several months. None of the transportation or utilities described in **Section 3** would be negatively affected as a result of implementation of any alternative.

5.13 SOCIOECONOMICS

All alternatives are not expected to change the socioeconomics discussed in the No Action Alternative. The reduction in the probability of failure results in reduced economic risk, therefore potentially benefitting socioeconomics. Minor RED impacts of implementing structural measures (including a cutoff wall, floodwall, internal drainage features, and armoring) could include:

- Temporary business interruption costs
- Minor, potentially long term disruptions to recreational activities (including tourism) with temporary closure of the LOST trail

Though these impacts have not been quantified, they are expected to be minor in the life of the HHD. Temporary recreational closures would most likely result in a maximum duration of one year as each portion of cutoff wall or internal drainage features are implemented. During construction, some positive RED benefits are expected to accrue, such as temporary employment increases due to construction jobs.

Also, these potential temporary impacts should be compared to the lingering socioeconomic risks of dike failure in the No Action alternative. A major dike breach could inflict hundreds of millions or even billions of dollars in economic damage. This potential impact includes direct property damage (to structures, contents, and agricultural land) as well as lost benefits from a major disruption to recreation facilities, roads, the navigation channel, and other existing infrastructure.

5.14 PUBLIC SAFETY

Alternatives 1, 2, 3 (Recommended Plan), and 4

The cutoff wall, internal drainage features, floodwall, and/or armoring would be built in an effort to improve public safety adjacent to HHD and provide the least cost solutions supporting the overall risk reduction strategy for HHD. Life loss estimates are largely based on societal risk, which considers the loss of life to the overall number of people that are present in the flood zone, known as the downstream population at risk (PAR). The PAR is comprised of residents, local work force, and transient or recreational populations. Societal risk is used to represent society's general perception that probability of high life loss consequences must be remediated. All alternatives at a minimum would reduce the risk to life safety to greater than an order of magnitude below the societal life safety TRG.

None of the alternatives would result in environmental health risks or safety risks. Alternatives 1, 2, 3, and 4 would decrease existing risk to human life and safety to all communities and property in Zones B and C. In Zones C, D, and E where armoring or floodwall is proposed, risk would also be reduced. In Zones D, E, F, and G, existing risk from HHD failure are currently within the tolerable risk guidelines, and do not require Federal action.

5.15 REAL ESTATE

The real estate impacted for the alternatives is land where the Federal Government, South Florida Water Management District (SFWMD), the State of Florida, and private land owners have real estate interests, including the construction and staging areas. The real estate impacts for all alternatives are as follows.

5.15.1 Alternative 1

Zone B – E: The real estate impact for installation of cutoff wall would be in Zone B Segments 5-2, 8, and Zone C Segments 12 and 13. The lands required are lands in which the Federal government has an interest or on lands the State of Florida and/or the SFWMD has an interest and would provide to the Federal Government for the project. These lands are sufficient to support the construction, operation, staging, and maintenance for the project.

5.15.2 Alternative 2

Zone B – E: The real estate impact for installation of cutoff wall would be in Zone B Segments 4, 5-2, 5, 6, 7, 8, and 9, and Zone C Segments 12 and 13. Impacts for installation of a floodwall are in Zones C, D, and E Segments 14A, 14B, 16, and 17; and impacts for armoring around Harney Pond Bridge are in Zone C Segment 13 and Zone D Segment 15. The lands required are lands in which the Federal government has an interest or on lands the State of Florida and/or the SFWMD has an interest and would provide to the Federal Government for the project. These lands are sufficient to support the construction, operation, and maintenance for the project.

5.15.3 Alternative 3: Recommended Plan

Zone B - E – The real estate impact for installation of cutoff wall would be in Zone B Segments 4, 5-2, 5, 6, 7, 8, and 9, and Zone C Segments 12 and 13. Impacts for installation of a Floodwall are in Zones C, D, and E Segments 14A, 14B, 16, and 17; and impacts for armoring around Harney Pond Bridge are in Zone C Segment 13 and Zone D Segment 15. The lands required are lands in which the Federal government has an interest or on lands the State of Florida and/or the SFWMD has an interest and would provide to the Federal Government for the project. These lands are sufficient to support the construction, operation, and maintenance for the project.

5.15.4 Alternative 4

Zone B - The real estate impact for installation of an internal drainage system would be in Zone B Segments 4, 5-2, 5, 6, 7, 8, 9. The lands required are lands owned by private landowners, the State of Florida, and the SFWMD in which would be provided to the Federal Government for the project. These lands are sufficient to support the construction, operation, and maintenance for the project.

Zone C, D, & E - The real estate impact for installation of an internal drainage system would be in Zone C Segments 12, and 13. Impacts for installation of a proposed floodwall in Zones C, D, and E Segments 14A, 14B, 16, and 17, and impacts for armoring around Harney Pond Bridge would be in Zone C Segment 13 and Zone D Segment 15. The lands required are lands in which the Federal government has an interest or on lands the State of Florida and/or the SFWMD has an interest and would provide to the Federal Government for the project. These lands are sufficient to support the construction, operation, and maintenance for the project.

5.16 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES

5.16.1 Alternatives 1, 2, 3, and 4

Over the last 50 plus years, the Federal right-of-way has not been utilized in a way that would result in widespread HTRW contamination. HTRW surveys conducted along the HHD as part of prior HHD EIS reports have identified several potentially contaminated areas associated with existing or abandoned pump stations or culverts. It is probable that smaller localized contaminated spots also exist. These smaller HTRW sites are nearly impossible to identify prior to construction activities that disturb these locations.

All of the alternatives include cutoff walls, internal drainage features, embankment modification, bridge replacement, or structure construction. Within the existing Federal HHD right-of-way, the likelihood of encountering HTRW materials during implementation of any of these alternatives is low. The most likely locations in which HTRW contamination may be found within the HHD right-of-way are the 26 petroleum storage locations identified in **Table 3-9**. Contamination at the S-127 site appears at this time to require remediation prior to the rebuilding of this structure; however, the rebuilding of this structure is not included in any of the alternatives. Prior to earthwork in the vicinity of the non-leaking petroleum storage locations identified in **Table 3-9**, this HTRW assessment should be updated to verify that no recent HTRW release has occurred. Overall, the relative risk of encountering HTRW materials during the construction of a given alternative is proportional to the amount of area disturbed during construction. Since Alternative 1 has the smallest construction footprint, the risk of encountering HTRW materials is lowest with

this alternative. Alternatives 2 presents the next highest risk of encountering HTRW. Alternatives 3, and 4 have very similar risks since generally disturb nearly identical footprints.

5.17 RECREATIONAL RESOURCES

5.17.1 Alternatives 1, 2, 3 (Recommended Plan), & 4

Temporary impacts to recreational resources within the project area would result from all of the proposed alternatives within Zones B-E where construction would occur as described below. Camping facilities, parks, and recreational areas adjacent to the HHD may be closed temporarily during construction. However, construction would be implemented in phases so not all RV parks and campgrounds would be closed at the same time. Also, these potential temporary impacts should be compared to the lingering socioeconomic risks of dike failure in the No Action alternative. A dike breach could disrupt, damage, or destroy (through flooding) existing recreational resources. And, in the aftermath of a breach, many other recreational areas would likely be inaccessible for months or even years.

5.17.1.1 Lake Okeechobee Scenic Trail

Portions of the Lake Okeechobee Scenic Trail (LOST) would be temporarily closed during construction activities. However, there are multiple access points to enter and exit the LOST and closings would be coordinated with the FDEP and the Office of Greenways and Trails. Portions of the LOST are paved. The LOST and pavement would be removed during construction and installation of the cutoff wall or internal drainage features. The HHD rehabilitation authorization does not allow funds to be used to replace the asphalt paving on the LOST after construction is completed. The Corps is pursuing Section 111 Chief of Engineer's discretionary funds to replace the asphalt paving due to the limited authority to replace paved areas. If not approved, the pavement would not be replaced, and the LOST would be graded and graveled for continued use.

5.17.1.2 Fishing and Boating

There are numerous boat ramps along the HHD. Boat ramps would be temporarily closed during construction activities at locations impacted by construction. However, construction would be implemented in phases, so not all boat ramps would be closed at the same time. Public coordination through FDEP and appropriate agencies would occur for notification of when boat ramps would be closed. Boat ramps not in the immediate area of construction would be open for use. Boat access to Lake Okeechobee via structures would be temporarily closed during construction activities at those locations.

5.18 AESTHETIC RESOURCES

5.18.1 Alternative 1

Moderate short term impacts to aesthetic resources within the project area would result from construction activities and the movement of construction equipment through lands designated for staging and construction. The LOST, used for viewing Lake Okeechobee from the top of the HHD, would be temporarily closed during construction. Grassy side slopes of the HHD would be affected during construction, but would be reseeded or sod would be used to replace grassy

vegetation upon completion of construction activities. The cutoff wall and filter are contained within the existing footprint with limited to no visibility once construction is complete.

5.18.2 Alternatives 2, 3, & 4

Zones B, C, D, & E: Short term impacts to aesthetic resources within the project area would result from construction activities and the movement of construction equipment through lands designated for staging and construction for the cutoff wall, internal drainage features, and/or the armoring. The LOST, used for viewing Lake Okeechobee from the top of the HHD, would be temporarily closed during construction. Grassy side slopes of the HHD would be affected during construction, but would be reseeded or sod would be used to replace grassy vegetation upon completion of construction activities.

Moderate long term effects to aesthetics include the floodwall proposed in Zones C, D, and E Segments 14A, 14B, 16, and 17. The floodwall would be up to six feet above the current crest of HHD in order to reduce the risk of wind and wave overtop/overwash.

5.19 CULTURAL RESOURCES

Resources that are eligible for listing and completed surveys are discussed in Section 4.17. The impacts of each element of the alternative on cultural resources is discussed by Alternative. Because impacts to zones around HHD are very similar, if a Zone has different effects within each element of the alternative, it will be called out individually and discussed.

5.19.1 Alternative 1

Zones B - E: As long as the area of potential effect (APE) is within the previously disturbed Federal right-of-way, the Corps does not expect Alternative 1 to adversely affect historic properties listed or eligible for listing in the NRHP. In 2005, the Corps determined the cutoff wall for Reach 1 (within Zone A and covered in the HHD MRR), constructed within the Federal right-of-way, would not affect the NRHP eligibility of the dike and the Florida State Historic Preservation Officer (SHPO) concurred (DHR No. 2007-2429B, April, 2005, and DHR No. 2007-9225, July, 2007; see Appendix C for letters). Within the Federal right-of-way, the remaining reaches would be expected to attain this determination and subsequent SHPO concurrence. However, as Alternative 1 has not been subject to preliminary engineering and design, a determination of effects based on a precise APE cannot be stated at this time. Additionally, any actions outside of the Federal right-of-way may have the potential to affect historic properties within the APE. Once the design has been finalized and prior to construction, the APE will be subject to separate consultation and consideration of effects with the Florida SHPO and appropriate federally-recognized tribes. Initial consultation with these parties has been undertaken and is ongoing.

5.19.2 Alternatives 2, 3 (Recommended Plan), & 4

Zones B - E: As long as the APE is within the previously disturbed Federal right-of-way, the Corps does not expect Alternatives 2, 3, and 4 to adversely affect historic properties listed or eligible for listing in the NRHP. In 2005, the Corps determined the cutoff wall for Reach 1 (within Zone A and covered in the HHD MRR), constructed within the Federal right-of-way, would not affect the NRHP eligibility of the dike and the Florida SHPO concurred (DHR No. 2007-2429B, April, 2005, and DHR No. 2007-9225, July, 2007; see letters in Appendix C). Within the Federal right-of-way, the remaining reaches would be expected to attain this determination and subsequent SHPO concurrence. However, preliminary engineering and design has not been completed for

Alternatives 2, 3, and 4, therefore, a determination of effects based on a precise APE cannot be stated at this time. Additionally, any actions outside of the Federal right-of-way may have the potential to affect historic properties within the APE. Once the design has been finalized and prior to construction, the APE will be subject to separate consultation and consideration of effects with the Florida SHPO and appropriate federally-recognized tribes. Initial consultation with these parties has been undertaken and is ongoing.

5.20 TRIBAL RESOURCES

5.20.1 Alternative 1

Native American properties or resources would not be affected due to cutoff wall or a filter.

5.20.2 Alternatives 2, 3 (Recommended Plan), & 4

Cutoff wall, internal drainage features, and/or armoring would not affect Native American properties or resources. However, there would be a moderate, long term aesthetic effects in Zones C, D, and E due to the floodwall at structures S-71 and S-72. The Seminole Tribe of Florida use this area for recreation purposes, as well as fishing. Access would still be available for fishing and recreation, however, the floodwall would reduce aesthetics and would potentially change where access to fishing would occur around the structures. Because access to fishing and recreation would still be accessible, the effect is reduced to minor, long term impacts.

5.21 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The Recommended Plan (Alternative 3) would require irreversible and irretrievable commitments of resources including the expenditure of funding, energy, labor, and materials. The project would not cause the permanent removal or consumption of any renewable resources. However, implementation would commit lands and resources for reconstruction of the cutoff wall, fill material, and other project features.

5.22 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Both the Recommended Plan and the No Action Alternative have unavoidable adverse direct and indirect environmental effects that are discussed in this document. The No Action Alternative would have significant adverse effects on public health and safety. Due to signs of HHD instability during high water stages in Lake Okeechobee after the 2004 and 2005 hurricanes in South Florida, the SFWMD contracted for an expert review panel of the stability and safety of the HHD. Particular emphasis was placed on the structural stability of the HHD with regard to seepage and water pressures within the embankment and erosion and potential overtopping concerns during large storm events. The technical review concluded that the current condition of the HHD poses imminent risk to the people and the environment of south Florida.

Inundation maps and flood stage hydrographs generated by the Corps indicate that flooding in the communities near the HHD would be severe and warning times would be limited if a breach in the HHD was to occur. The location of the breach and the size of the storm event would determine the geographic extent of the flooding. Based on Corps analysis, the most significant flooding would occur if the dike were to breach along segments 1 through 9, 12, and 13 due to the topography and communities located in close proximity to the dike. A breach in the dike could cause significant adverse effects on not only public safety, but also on agriculture, recreational

resources, transportation and communication infrastructure, real estate, and environmental and cultural resources.

As discussed under each resource subsection above, adverse effects associated with implementing the Recommended Plan are expected to be minimal to moderate. Many effects, such as recreation and noise levels would be temporary during construction activities. Potential moderate effects are only expected to occur to aesthetics as discussed previously.

5.23 COMPATIBILITY WITH FEDERAL, STATE, AND LOCAL OBJECTIVES

The objective of this project is rehabilitation of the HHD. State and local agencies concur with the Federal objective and current operations would be maintained throughout the duration of the HHD construction work as justified on a temporary basis to prevent significant hardships.

5.24 CONFLICTS AND CONTROVERSY

There are no known conflicts or controversy over the HHD rehabilitation itself. Indirectly related to the rehabilitation efforts is the potential for revisions to LORS 2008 for operations of Lake Okeechobee. The LORS Final EIS (USACE 2007) stated the following with respect to rehabilitation of the HHD:

> *A new regulation schedule is required to respond to high lake levels that have resulted in integrity issues and concerns with the Herbert Hoover Dike (HHD), high volume releases to the estuaries, and impacts to Lake Okeechobee littoral zones. Hence, a new Lake Okeechobee Regulation Schedule was developed. LORS is intended to be an interim schedule. Because this schedule was formulated to address specific conditions existing in 2007, as circumstances change, the Corps will adapt its Lake Okeechobee operations accordingly. The Corps expects to operate under LORS until the earlier of (1) implementation of a new Lake Okeechobee schedule as a component of the system-wide operating plan to accommodate the Comprehensive Everglades Restoration Plan (CERP Band 1 projects) and the State of Florida's fast track Acceler8 projects, or (2) completion of HHD seepage berm construction or equivalent dike repairs for reaches 1, 2 and 3. The occurrence of the above referenced events are expected to allow for greater operational flexibility, potentially including higher lake levels for increased water storage. In balancing the multiple project purposes, the Corps, will timely shift from the interim LORS to a new schedule with the intent to complete any necessary schedule modifications or deviations concurrent with completion of (1) or (2).*

This Final EIS, in support of the HHD DSMS, does not propose to change LORS 2008 as part of the rehabilitation efforts.

5.25 CUMULATIVE EFFECTS

Cumulative environmental effects for the proposed project were assessed in accordance with guidance provided by the President's Council on Environmental Quality (CEQ). Cumulative effects are defined in 40 CFR 1508.7 as those effects that result from:

> *...the incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or nonfederal) or person*

undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

South Florida has many project authorities to provide restoration opportunities to the Everglades, as well as provide flood protection. These projects are all inter-related and eventually cumulative in their effects and shared goals. This HHD rehabilitation provides flood damage reduction to the surrounding communities and Everglades restoration. It would also be one step in providing a means to allow for a concurrent study on revising the LORS 2008, which could cumulatively and positively effect Everglades restoration, as well as potentially benefit the health of the estuaries. Figure 5-1 shows many of the restoration projects in Florida that are currently authorized or expected to occur in the future.

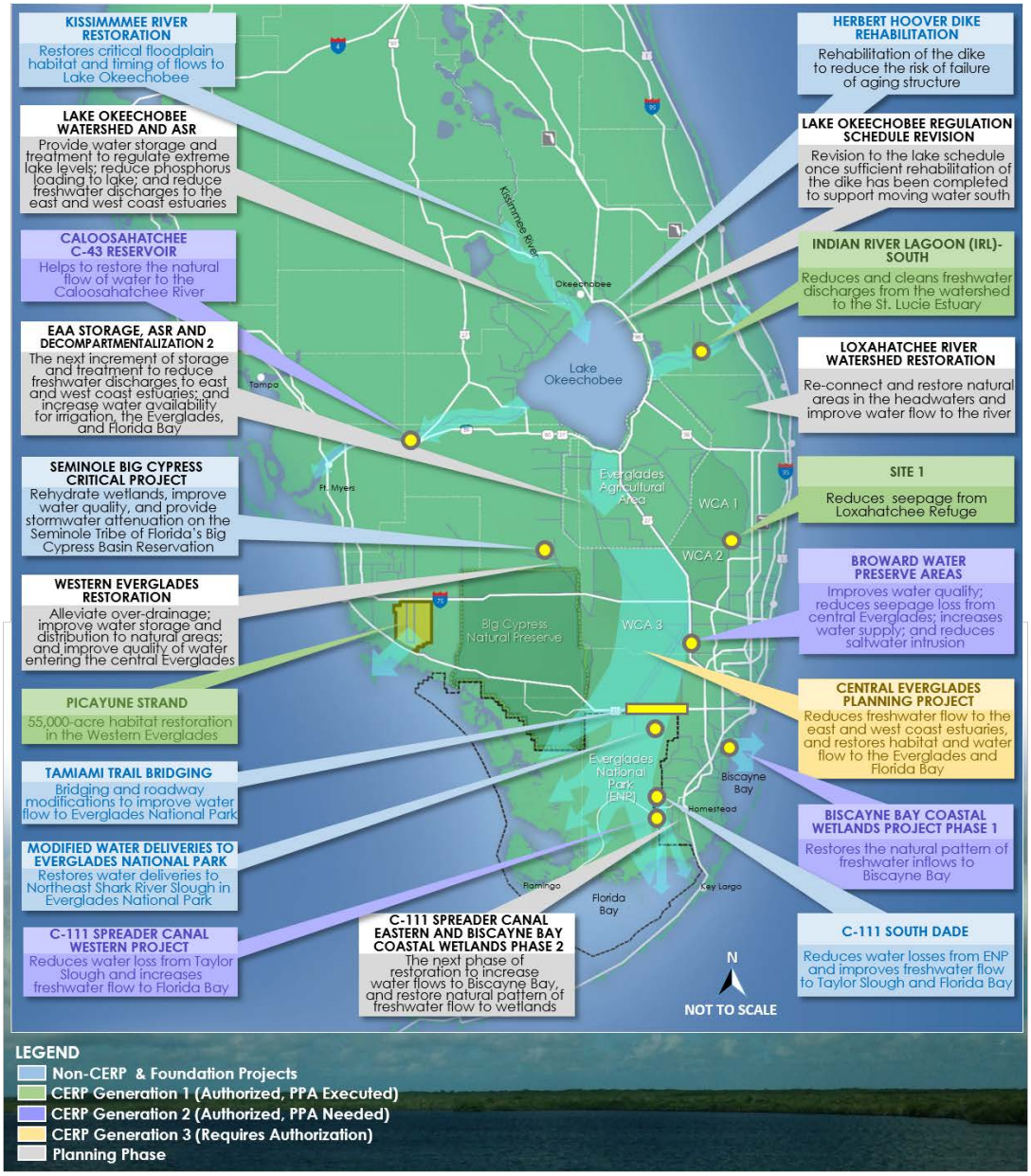

Figure 5-1. Restoration Projects throughout Florida

Table 5-6 summarizes the impact of such cumulative actions by identifying the past, present, and reasonably foreseeable future condition of the various resources which are directly or indirectly impacted by the proposed action and its alternatives. Also illustrated is the future condition with any reasonable alternatives (or range of alternatives).

Table 5-6. Summary of Cumulative Effects

Resources/Issues	Past Actions & Their Effects	Recommended Plan Effects	Other Present and Reasonably Foreseeable Future Actions & Their Effects	Cumulative Effects of All Actions
Groundwater and Water Quality	The C&SF Project has greatly altered the natural hydrology of the project area. Construction methods implemented in the 1930s and 1940s created a dike unable to withstand lake stages higher than 18 feet (NGVD). As a result, rapid, high-volume releases of lake water are required during storm events that stress downstream estuaries.	The Recommended Plan would not be expected to improve or degrade water quality.	To avoid stressing the structural integrity of the HHD, the current operating schedule for the lake (LORS) operates a lower lake regulation schedule. The LORS operating plan could be re-evaluated once the HHD has been rehabilitated. CERP projects and other initiatives would improve the water quality in Lake Okeechobee, reduce undesirable freshwater releases from the lake, and reduce watershed runoff to the estuaries.	Rehabilitation of the HHD is not expected to improve water quality in Lake Okeechobee. Other CERP projects around HHD may improve water quality in south Florida.
Aesthetics	Aesthetics have not greatly changed from past actions of construction of HHD.	The Recommended Plan may impede views due to construction of a floodwall at S-71 and S-72. However, access to the lake from these areas would remain.	Because this study analyzes the system as a whole, no other aesthetics would be expected to be affected for future plans.	Rehabilitation of HHD would reduce aesthetics at S-71 and S-72 depending on the height of the floodwall proposed to be built for public safety purposes.

Resources/Issues	Past Actions & Their Effects	Recommended Plan Effects	Other Present and Reasonably Foreseeable Future Actions & Their Effects	Cumulative Effects of All Actions
Protected Species	Fish and wildlife habitat has been greatly altered as a result of the C&SF Project. Most land has been converted to agricultural, commercial, or residential use.	Minor temporary impacts to foraging and loafing habitat are expected from the intermittent maintenance operations and for construction of the Recommended Plan.	An abundance of alternative foraging and loafing habitats are available around the lake and on Kreamer and Torry islands.	HHD rehabilitation as a whole is not expected to significantly affect protected species. Coordination with USFWS is ongoing.
Wetlands	The C&SF Project has greatly altered the natural hydrology of the project area. Most land has been converted to agricultural, commercial, or residential use. The Corps removed 57 acres of the invasive species melaleuca, which was compensatory mitigation for rehabilitation features in Reach 1.	The Recommended Plan would potentially have temporary impacts to wetlands during construction. The wetlands that would potentially be impacted are adjacent to the landside of the HHD, which are currently low quality toe ditch wetlands.	If rehabilitation features in the future include filling in the HHD toe ditch, there would be a loss of low quality wetlands.	Overall, there would probably be a slight decrease in low quality toe ditch wetlands, however, the toe ditches would likely regain wetland plant species after any disturbance.

Resources/Issues	Past Actions & Their Effects	Recommended Plan Effects	Other Present and Reasonably Foreseeable Future Actions & Their Effects	Cumulative Effects of All Actions
Public Safety	Construction methods implemented in the 1930s and 1940s created a dike unable to withstand lake stages higher than 18 feet (NGVD). As a result, communities near the HHD are at risk during storm events. Past actions including construction of the Reach 1 cutoff wall have improved portions of the HHD stability.	The Recommended would aid in improving public safety for the communities that exist near the dike. The plan is designed to prevent seepage and piping around the culverts within in the HHD. Public safety would be increased due to the rehabilitation of the HHD to the current dam safety regulations.	To avoid stressing the structural integrity of the HHD, the current operating schedule for the lake (LORS) operates a lower lake regulation schedule than the previous operating schedule (WSE). CERP projects designed to store excess water would help managers to operate the lake at lower stages during flood events. Glades, Hendry, and Palm Beach counties are finalizing Emergency Operations Plans for an HHD failure scenario. These plans would help avoid significant adverse effects on residents near the dike if a breach occurs.	Rehabilitation of the HHD, along with other current and reasonably foreseeable actions, would significantly improve the safety of the communities adjacent to the dike.

6.0 ENVIRONMENTAL COMPLIANCE

The Recommended Plan was considered in relation to compliance with Federal environmental review and consultation requirements. The following paragraphs document compliance with all applicable Federal statutes, Executive Orders, and policies.

BALD AND GOLDEN EAGLE PROTECTION ACT

The Bald and Golden Eagle Protection Act (16 U.S.C. 668-668c), enacted in 1940, and amended several times since then, prohibits anyone, without a permit issued by the Secretary of the Interior, from "taking" bald eagles, including their parts, nests, or eggs. The Act provides criminal penalties for persons who "take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or any manner, any bald eagle ... [or any golden eagle], alive or dead, or any part, nest, or egg thereof." The Act defines "take" as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb." The Corps and its contractors are commited to preventing any take of eagles, and provide language in the construction specs to assure no take. The project is in compliance with the Act.

CLEAN AIR ACT OF 1972, AS AMENDED

This project will be coordinated with the FDEP, Air Quality Division, and the U. S. Environmental Protection Agency. No air quality permits are required, and no permanent sources of air emissions are part of the Recommended Plan . The Corps will be in compliance with Sections 176 and 309 of the Clean Air Act.

CLEAN WATER ACT OF 1972, AS AMENDED

To comply with the Clean Water Act, the Corps will apply to the FDEP for Water Quality Certification prior to advertising a contract for construction. The FDEP has been delegated regulatory responsibility for the CWA by the USEPA. The FDEP typically issues an Enviornmental Resource Permit (ERP) that serves as Water Quality Certification. The ERP permit also typically requires that the Corps apply for a consumptive use permit in the case where the construction will require dewatering activities. For the selected alternative, no dredge and fill is expected to occurRecommended Plan, however, it is possible that incidental temporary impacts may occur in association with staging or site access, but these would total less than half an acre, therefore a Section 404(b)(1) Evaluation short version was prepared and is located in Appendix F. Section 402(b) (2) requires that a NPDES construction activities permit be acquired for construction activities that disturb more than one acre of land. The Corps or its contractor will obtain the 402(b)(2) permit just before construction commences. The project will be in compliance with this Act.

COASTAL BARRIER RESOURCES ACT

This Act is not applicable. The study area is not in a designated Coastal Barrier Resources Act unit.

COASTAL ZONE MANAGEMENT ACT OF 1972, AS AMENDED

A Federal Consistency Determination has been prepared in accordance with the provisions of 15 CFR 930 and is located in Appendix D. Upon review of the Draft EIS and Federal Consistency Determination, the project is currently in compliance, however, the state's final concurrence of the project's consistency with the Florida Coastal Management Program will be determined during the state's environmental permitting process. All water quality certificates will be completed prior to any construction activities.

ENDANGERED SPECIES ACT OF 1973, AS AMENDED

A Complete Initiation Package was prepared and submitted to the USFWS (Appendix E). The Corps sent a letter to the USFWS on December 24, 2015 that provided a determination that the project"may affect, but is not likely to adversely affect" threatened and endangered species. A letter was received from the USFWS on February 22, 2016 that concurred with the Corps' determinations, provided that conservation measures outlined in the 2014 Draft Interim CAR are implemented and adhered to during preconstruction, construction, and after construction phases of the project.

ESTUARY PROTECTION ACT OF 1968

No estuaries under the Act are in the project area. However, failure of the dike, a possibility under the No Action Alternative, could severely adversely impact the Caloosahatchee River and St. Lucie Estuaries downstream of Lake Okeechobee as large deliveries of freshwater dramatically change the estuarine water chemistry and associated environmental resources. The project is in compliance.

FARMLAND PROTECTION POLICY ACT OF 1981

Prime or unique farmland may exist within the project footprint. Coordination with NRCS was completed April 23, 2014 and is included in Appendix C. The NRCS noted there are delineations of Important Farmland soils (Farmland of Unique Importance) within the scope of the HHD DSMS project. The project is in compliance.

FEDERAL WATER PROJECT RECREATION ACT OF 1965, AS AMENDED

The effects of the Recommended Plan on outdoor recreation have been considered and are presented in the Final EIS. Impacts to the LOST located on top of the dike will require close coordination with FDOT and FDEP. The LOST would be closed during construction. Closing of the LOST would be coordinated with the FDEP and the Office of Greenways and Trails. Boat ramps and access to lake side recreational resources would also be closed temporarily during construction.

FISH AND WILDLIFE COORDINATION ACT OF 1958, AS AMENDED

This project has been coordinated with the USFWS. A Fish and Wildlife Coordination Act Report (FWCAR) for Reach 1 was submitted by the FWS in 2001 for the 2000 HHD MRR. Supplemental FWCARs for HHD rehabilitation in Reach 1 were provided by USFWS in 2003 (Reach 1), 2004 (Reach 1A), and 2006 (Reach 1A). The USFWS provided a Draft FWCAR for the HHD DSMS July 14, 2014. In response to the requirements of this Act, the Corps has and will continue to maintain coordination with the USFWS and the Florida Fish and Wildlife Conservation Commission during all stages of planning and implementation of this project. Coordination is ongoing and the HHD DSMS is compliance with this Act.

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

The National Oceanic and Atmospheric Administration, National Marine Fisheries Service works with the regional fishery management councils to identify the essential habitat for every life stage of each federally managed species using the best available scientific information. Essential fish habitat has been described for approximately 1,000 managed species to date. There is no essential fish habitat, as designated by National Marine Fisheries Service, within the project area. This Act is not applicable.

MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT OF 1972, AS AMENDED
This Act is not applicable. Ocean disposal of dredged material is not proposed as a part of the HHD DSMS.

MIGRATORY BIRD TREATY ACT AND MIGRATORY BIRD CONSERVATION ACT
Under the Migratory Bird Treaty Act, project construction shall not destroy migratory birds, their active nests, their eggs, or their hatchlings. Monitoring for such would be required by the construction contractor. A buffer zone around active nests or nestling activity would be required during the nesting season. No migratory birds would be affected by project activities; however, the bald eagle has been identified in the project area. The toe ditch wetlands provide low quality foraging habitat for migratory birds. Alternative and higher quality habitats are available along the Lake Okeechobee shoreline and in adjacent canals. This project is in compliance with these Acts.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) OF 1969, AS AMENDED
A Notice of Intent to prepare the draft EIS was published in the Federal Register February 15, 2013 (78 FR 11164-11165). A scoping meeting was held February 26, 2013 in Clewiston, Florida and a second meeting February 28, 2013 in Okeechobee, Florida. A Notice of Availability of the Draft EIS was published in the Federal Register on December 24 for a 60-day public comment period. During this time, public meetings were held in Clewiston, Lake Harbor, and Okeechobee to inform the public and receive comments on the Draft EIS. The Final EIS is in compliance with this Act.

NATIONAL HISTORIC PRESERVATION ACT OF 1966 (NHPA)
Consultation with the Florida State Historic Preservation Officer (SHPO) was initiated in April 2005 and is ongoing in accordance with the National Historic Preservation Act of 1966, as amended, and as part of the requirements and consultation processes contained within the NHPA implementing regulations of 36 CFR 800. This project is also in compliance, through ongoing consultation, with the Archeological Resources Protection Act (96-95), the Abandoned Shipwreck Act of 1987 (PL 100-298; 43 U.S.C. 2101-2106); American Indian Religious Freedom Act (PL 95-341), Executive Orders (E.O) 11593, 13007, & 13175 and the Presidential Memo of 1994 on Government to Government Relations. Consultation is ongoing with the SHPO and appropriate federally recognized tribes.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA), AS AMENDED BY THE HAZARDOUS AND SOLID WASTE AMENDMENTS (HSWA) OF 1984, COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION AND LIABILITY ACT (CERCLA) AS AMENDED BY THE 5.26.21 SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) OF 1996, TOXIC SUBSTANCES CONTROL ACT OF 1976
A preliminary Phase I HTRW assessment conducted in November of 2009 revealed minor potential contamination issues. Parcel specific Phase I/II audits will be conducted for lands to be acquired and will be remediated as necessary. The project is in compliance with these Acts.

RIVER AND HARBOR APPROPRIATION ACT OF 1899
The project is in compliance. The proposed work would not obstruct navigable waters of the United States.

SAFE DRINKING WATER ACT (SDWA) OF 1974, AS AMENDED

Lake Okeechobee, as well as local ground and surface waters, supply drinking water for several communities around Lake Okeechobee. Implementation of the project would not impact water quality of Lake Okeechobee, ground waters, or surface water used to supply drinking water. This project complies with the Act.

UNIFORM RELOCATION ASSISTANCE AND REAL PROPERTY ACQUISITION POLICIES ACT OF 1970 (PUBLIC LAW 91-646)

All real estate interests acquired for construction of the Recommended Plan will be in accordance with the provisions of this law. The Uniform Act sets forth procedures for the acquisition of private property for public use and specifically requires that the acquiring agency appraise the real property interests it wishes to acquire and provide the owner a written summary of the basis for the amount established as just compensation.

WILD AND SCENIC RIVER ACT OF 1968, AS AMENDED

No rivers designated under the Act are in the project area. This Act is not applicable.

WATER RESOURCES DEVELOPMENT ACT (WRDA) OF 1986, SECTION 904

Section 904 of the 1986 Water Resources Development Act requires that the plan formulation and evaluation process consider both quantifiable and unquantifiable benefits and costs of the quality of the total environment, and preservation of cultural and historical values. The engineering study and Final EIS are in compliance.

EXECUTIVE ORDER 11990, PROTECTION OF WETLANDS

The Recommended Plan would not result in impacts to wetlands. The engineering study and Final EIS are in compliance with the goals of this Executive Order (EO).

EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT The Recommended Plan would directly support a reduction in hazards and risks associated with floods and would minimize the impact of floods on human safety, health, and welfare. The Recommended Plan would have no impact on the restoration and preservation of the natural and beneficial values of the base floodplain. The HHD DSMS applied the eight step process outlined by EO 11988 during development of the Recommended Plan. The study is in compliance.

EXECUTIVE ORDER 12898, ENVIRONMENTAL JUSTICE

Executive Order 12898 requires agencies of the Federal Government to review the effects of their programs and actions on minorities and low-income communities. The HHD rehabilitation program is to ensure safety of all communities surrounding the dike. The Recommended Plan would help to ensure the safety of those communities within the study area as well as residents living within the area anticipated to be impacted in the event of a project failure. In addition to ensuring the safety and well-being of residents and their property, implementation of the Recommended Plan may have a significant beneficial effect on local communities through job creation, increased sale of construction material and other goods necessary to sustain a large construction force for the duration of the project. The study area is known to contain a significant percentage of low income and minority individuals. Planning and construction activities have been coordinated with the public through the NEPA process, and ongoing rehabilitation discussions over the past several years. This project is not expected to have disproportionately high and

adverse human health or environmental impacts on minority or low-income populations. The study is in compliance.

EXECUTIVE ORDER 13112, INVASIVE SPECIES

Exotic and invasive plant species are within drainage swales, connecting canals, wetlands, and some uplands within the project area. However, the project would not contribute to nutrient loading that could favor invasive species. Further, some removal of invasive species will be necessary within the project footprint. Ballast water organisms or terrestrial exotic wildlife species would not be affected. This study is in compliance.

EXECUTIVE ORDER 13045, PROTECTION OF CHILDREN

Executive Order 13045, requires each Federal agency to "identify and assess environmental risks and safety risks [that] may disproportionately affect children" and ensure that its "policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks." This project has no environmental or safety risks that may disproportionately affect children. The study is in compliance.

EXECUTIVE ORDER 13653, CLIMATE CHANGE CONSIDERATIONS

EO 13653 requires Federal agencies to review the effect of climate change on their programs. For this project, climate change is likely to affect water management operations of Lake Okeechobee which is contained within Herbert Hoover Dike. Under present hydrologic and climatologic conditions, Lake Okeechobee water levels are managed such that the lake level remains within an envelope between approximately 9 ft. NAVD88 and 15 ft. NAVD88. In the future, the ability of water managers to keep the lake level within the target envelope is likely to be adversely impacted because climate change could increase or decrease the frequency and magnitude of large storm events, alter the frequency and characteristics of "wet" and "dry" year rainfall patterns, and likely increase evapotranspiration from the lake and upstream basins which will decrease the quantity of water available for storage in the lake. The effectiveness of the dike renovation alternatives proposed in this Final EIS will not be compromised by climate change impacts associated with increased evapotranspiration since lake stages are likely to be lower as a result. However, the effectiveness of the dike renovation efforts may be adversely impacted by potential climate change impacts associated with increased frequency and magnitude of large storm events which could result in more extreme high lake stage events which would put more stress on the dike. At present, there is no published or widely accepted projection of climate change related variance in storm event magnitude and frequency in South Florida so per Corps Engineering and Construction Bulletin No. 2014-10, the design of dike renovation alternatives has been based on historic extreme event climatic conditions. Herbert Hoover Dike has man controlled lake levels, therefore each alternative for rehabilitation of the embankment would not be directly affected by sea level rise. However, if storms become stronger, rehabilitation of the embankment would provide more stability for life safety and resource protection with implementation of the project. The project is in compliance.

7.0 PUBLIC COORDINATION

7.1 PUBLIC INVOLVEMENT

In compliance with the NEPA and Corps policies, input on projects is solicited from the public and other governmental agencies. The public was invited to comment during the scoping process and during public meetings, and comments were solicited during review of the Draft EIS. Appendix C contains all pertinent correspondence. Numerous public meetings and information sessions have been held concerning the rehabilitation of the HHD, the most recent during the public comments period on January 26 in Lake Harbor, January 27 in Clewiston, and January 28, 2016 in Okeechobee, Florida. The Jacksonville District of the Corps maintains a public outreach program meant to keep the public informed of rehabilitation activities. Copies of presentations previously given to the communities surrounding the HHD and information fact sheets can be found on the Jacksonville District website:
http://www.saj.usace.army.mil/Missions/CivilWorks/LakeOkeechobee/HerbertHooverDike.aspx

7.2 SCOPING

A Notice of Intent to prepare an EIS for the HHD DSMS was published in the Federal Register February 15, 2013 (78 FR 11164-11165). A scoping letter, dated February 15, 2013, was sent to Federal, state, and local agencies, Federally recognized tribes, and interested stakeholders requesting their comments and questions regarding alternatives for rehabilitating the HHD. A public NEPA scoping meeting was held February 26, 2013 in Clewiston, Florida and a second meeting February 28, 2013 in Okeechobee, Florida. This meeting was held during the Notice of Intent scoping comment period. Transcripts from the public scoping meetings are included in Appendix C.

A Notice of Availability (NOA) was published in the Federal Register on December 24, 2015 to formally initiate review of the Draft EIS. The NOA letters were mailed to the same stakeholders as was the scoping letter. Public meetings were held during the public review period (See above Section 7.1 for dates) of the Draft EIS to present the Tentatively Selected PLan and solicit comments.

7.3 PUBLIC MEETINGS

The Corps held the following meetings during formulation for the HHD DSMS.

Table 7-1. Public Meetings

Date	Meeting Name	Agency/Attendees
February 26, 2013	Scoping Meeting	Public Meeting Clewiston, FL
February 28, 2013	Scoping Meeting	Public Meeting Okeechobee, FL
March 26, 2013	HHD DSMS Coordination Meeting	Florida Department of Transportation (FDOT), District 1
March 27, 2013	HHD DSMS Coordination Meeting	FDOT, District 4
August 12, 2013	HHD DSMS Coordination Meeting	Florida Department of Environmental Protection & South

Date	Meeting Name	Agency/Attendees
May 5, 2014		Florida Water Management District Florida Department of Transportation, District 1
January 14, 2014	Fish and Wildlife Coordination Act Meeting	USFWS – Vero Beach, FFWCC
August 18, 2014	HHD DSMS Coordination Meeting, Government to Government Consultation	Seminole Tribe of Florida staff level brief
September 4, 2014	HHD DSMS Coordination Meeting, Government to Government Consultation	Seminole Tribe of Florida, government to government consultation
November 23, 2015	HHD DSMS Coordination Meeting, Government to Government Consultation	Seminole Tribe of Florida staff level brief
December 21, 2015	Webinars	Webinar for emergency managers, Congressional staff/local officials, and media
January 13, 2016	HHD DSMS Coordination Meeting, Government to Government Consultation	Okeechobee, FL Seminole Tribe of Florida staff level brief
January 26, 2016	NEPA Public Meetings	Public Meeting in Lake Harbor
January 27, 2016	NEPA Public Meetings	Public Meeting in Clewiston
January 28, 2016	NEPA Public Meetings	Public Meeting in Okeechobee
February 24, 2016	HHD DSMS Coordination Meeting, Government to Government Consultation	Seminole Tribe of Florida staff level brief to address comments on Draft EIS
April 4, 2016	HHD DSMS Coordination Meeting, Government to Government Consultation	Seminole Tribe of Florida staff level brief

7.4 LIST OF RECIPIENTS

The scoping letter was mailed to the Federal and state agencies, tribal representatives, and interested stakeholders as listed below in **Table 7-2**. A complete mailing list is available upon request. The Final EIS will be posted on the internet at the following address under Hendry, Palm Beach, Okeechobee, Martin, and Glades Counties:

http://www.saj.usace.army.mil/About/DivisionsOffices/Planning/EnvironmentalBranch/EnvironmentalDocuments.aspx

Table 7-2. List of recipients.

Agency	Recipients
Federal	Advisory Council on Historic Preservation
	Council on Environmental Quality
	Department of Energy
	Federal Emergency Management Agency
	Federal Maritime Commission
	U. S. Department of Commerce (National Oceanic and Atmospheric Administration, Florida Keys National Marine Sanctuary, and National Marine Fisheries Service)
	U.S. Department of Homeland Security (U.S. Coast Guard 7th District)
	U.S. Department of Housing and Urban Development
	U.S. Department of Transportation (Federal Highway Administration)
	U.S. Department of Agriculture (Natural Resources Conservation Service, Aquatic Plant Lab and U.S. Forest Service)
	U.S. Department of Justice
	U.S. Department of the Interior (Bureau of Indian Affairs, National Park Service [Big Cypress National Preserve, Biscayne National Park, Everglades National Park], U.S. Fish and Wildlife Service, U.S. Geological Survey, Office of Environmental Policy and Compliance)
	U.S. Environmental Protection Agency
	U.S. House of Representatives
	U.S. Senate
State	Florida Department of Agriculture and Consumer Services
	Florida Department of Environmental Protection
	Florida Department of Transportation
	Florida Fish and Wildlife Conservation Commission
	Florida Governor's Office
	Florida House Representatives
	Florida State Clearinghouse
	Florida State Senators
	Government Responsibility Council
	South Florida Water Management District
	State Historic Preservation Office
Tribe	Miccosukee Tribe of Indians of Florida
	Seminole Tribe of Florida
County Agencies	Economic Council of Okeechobee County
	Economic Council of Palm Beach County
	Glades County Administration
	Hendry County Administration
	Lee County Administration
	Martin County Administration
	Miami-Dade County Manager
	Okeechobee Chamber of Commerce
	Okeechobee County Administration
	Osceola County Administration
	Palm Beach County Administration

Agency	Recipients
	Polk County Administration
	St. Lucie County Administration
County Government	Glades City Board of County Commissioners
	Hendry County Board of County Commissioners
	Martin County Board of County Commissioners
	Okeechobee County Board of County Commissioners
	Palm Beach Board of County Commissioners
	Polk County Board of County Commissioners
Municipalities	City of Belle Glade
	City of Pahokee
	Highlands Glades Drainage District
	Pahokee Water Control District
	Town of Palm Beach
	Palm Beach County Water Utilities Department
Libraries	Glades County Library
	Hendry County Barron Library
	Martin County Elisabeth Lahti Library
	Martin County Blake Library
	Okeechobee County Public Library
	Palm Beach County Library, Belle Glade Branch
	Palm Beach County Library, Main Branch
	Palm Beach County Library, Loula V. York Branch
	Palm Beach County Library, Clarence E. Anthony Branch
Groups and Organizations	Audubon Society of the Everglades
	Caloosahatchee River Citizens Association
	Camp Dreser & McKee, Inc.
	Central Florida Regional Planning Council
	Conservation Alliance of St. Lucie County
	Everglades Coordinating Council
	Florida Wildlife Federation
	Friends of Lake Okeechobee
	Friends of the Everglades
	Gulf Citrus Growers Association
	Ladies of the Lake, U.S.A.
	Lake Region Audubon Society
	Landers & Parsons
	League of Women Voters, Broward
	Macvicar, Frederico & Lamb, Inc.
	National Audubon Society
	National Resources Defense Council
	Okeechobee Waterway Association
	South FL Regional Planning Council
	South FL Watershed Council Inc.
	South Florida Agricultural Council

Agency	Recipients
	St. Lucie River Initiative
	SW Florida Watershed Council
	The Florida Biodiversity Project
	The Nature Conservancy
	Treasure Coast Environmental Defense Fund
	Treasure Coast Regional Planning Council
	Tropical Audubon Society
	Trust for Public Lands
	University of Florida IFAS Research Center
Business	Angler's Guide Service
	Atlanta Sugar Association, Inc.
	Berry Grove Corporation
	Camp Dreser & McKee, Inc.
	Dairy Farmers Inc.
	Fast Break
	Five Smooth Stone Incorporated
	Florida Citrus Mutual
	Florida Power and Light
	Florida Sugar Cane League, Inc.
	Frierson Farm
	Garrard's Bait & Tackle
	Gutwein Groves, Inc.
	J & S Fish Camp
	Larson Dairy, Inc.
	Little Big Man's
	Lykes Bros. Inc.
	Martin's Marina & Resort
	McArthur Farms Inc.
	Okee Tantie Bait & Tackle
	Okeelanta Corporation
	Sugar Cane Growers Cooperative
	Taylor Creek Lodge
	Trucane Sugar Corporation
	Twin Palm Resort
	University of Florida Institute of Food & Agr. Sciences / Center for Aquatic Plants

8.0 LIST OF PREPARERS

The people responsible for contributing to this Final EIS are listed below.

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9.0 REFERENCES

Belwood, J.J. *Florida mastiff bat Eumops glaucinus floridanus.* Vol. Volume 1. Mammals, in *Rare and endangered biota of Florida*, by S.R. Humphrey, 216-223. Gainesville, Florida: University Press of Florida, 1992.

Bent, A.C. 1926. Life histories of North American marsh birds. U.S. Natl. Mus. Bull. 135

Browder, J.S., C. Littlejohn, and D. Young. 1976. The Florida Study. Center for Wetlands, University of Florida, Gainesville, and Bureau of Comprehensive Planning, Florida Department of Administration, Tallahassee.

Browder, J. A., V. R. Restrepo, J. Rice, M. B. Robblee, Z. Zein-Eldin. 1999. Environmental influences on potential recruitment of pink shrimp, Farfantepenaeus duorarum, from Florida Bay nursery grounds. Estuaries 22(2B):484-499.

Browder, J.S., P.J. Gleason, and D.R. Swift. 1994. Periphyton in the Everglades: spatial variation, environmental correlates, and ecological implications. Pages 379-418, in Everglades: The Ecosystem and Its Restoration, S.M. Davis and J.S. Ogden (Eds.). St. Lucie Press, Delray Beach, Florida, USA.

Coulter, M.C. 1987. Foraging and breeding ecology of wood storks in East-Central Georgia. Pages 21-27, *in* Proceedings of the Third Southeastern Nongame and Endangered Wildlife Symposium, R.R. Odom, K.A. Riddleberger, and J.C. Ozier (Eds.). Georgia Department of Natural Resources, Game and Fish Division.

Coulter, M.C. and A.L. Bryan, Jr. 1993. Foraging ecology of wood storks (*Mycteria americana*) in east central Georgia: Characteristics of foraging sites. Colonial Waterbirds 16:59-70.

Coulter, M.C., J.A. Rodgers, J.C. Ogden, and F.C. Depkin. 1999. Wood stork (Mycteria americana). In The Birds of North America, No. 306, A. Poole and F. Gill (Eds.). Academy of Natural Sciences, Philadelphia, Pennsylvania and American Ornithologists' Union, Washington, D.C., USA.

Department of the Interior. 50 CFR Part 17, Endangered and Threatened Wildlife and Plants; Endangered Species Status for the Florida Bonneted Bat; Final Rule. Federal Register. Volume 78, No. 191. Wednesday, October 2, 2013. Rules and Regulations. pp. 61004 – 61043.

Diemer, J. (1989). Gopherus Polyphemus. In I. Swingland, & M. Klemens, *The Conservation Biology of Tortoises.* Occasional Papers IUCN Species Survival Commission 5.

Diemer, J. (1992). Home Range and Movements of the Tortoise Gopherus Polyphemus in Northern Florida. *Journal of Herpetology , 26*, 158-165.

Duellman, W.E. and A. Schwartz. 1958. Amphibians and reptiles of southern Florida. Bulletin Florida State Museum, Biological Science 3:181-324.

Duellman, W.E. and A. Schwartz. 1958. Amphibians and reptiles of southern Florida. Bulletin Florida State Museum, Biological Science 3:181-324.

England, S., North, T., & Cheng, H. (2013). Draft Herbert Hoover Dike (HHD) Transport Model. USACE Engineer Research and Development Center, Vicksburg, MS.

ERDC. (2008). *Herbert Hoover Dike Phase 1A Groundwater Model, FInal Report.* Philadelphia: Engineering Research and Development Center and USACE Philadelphia District.

Ernest, C., & Barbour, R. (1972). *Turtles of the United States.* Lexington: University Press of Kentucky.

Fertl, D., A.J. Schiro, G.T. Regan, C.A. Beck, N.M. Adimey, L. Price-May, A. Amos, G.A.J Worthy, and R. Crossland. 2005. Manatee occurrence in the Northern Guld of Mexico, west of Florida. Gulf and Caribbean Research 17:69-74.

Florida Fish and Wildlife Conservation Commission. 2011. http://myfwc.com/media/2273295/Florida-Bonneted-Bat-BSR.pdf

Florida Bat Conservency. *Florida bonneted bat (Eumops floridanus).* 2005. http://www.floridabats.org/Species_EUFL.htm.

Franz, R. (1986). Gopherus Polyphemus (Gopher Tortoise). Burrow Commensals. *Herpetological Review , 17*, 64.

Gawlik, D.E., 2002. The effects of prey availability on the numerical response of wading birds. Ecological Monographs 72(3): 329-346.

Gawlik, D. E., G. Crozier, K. H. Tarboton. 2004. Wading bird habitat suitability index. Pages 111-127, *In* K. C. Tarboton, M. M. Irizarry-Ortiz, D. P. Loucks, S. M. Davis, and J. T. Obeysekera. Habitat suitability indices for evaluation water management alternatives. Technical Report, South Florida Water Management District, West Palm Beach, FL.

Hartman, D.S. 1979. Ecology and behavior of the manatee in Florida. American Society of Mammalogists Special Publication No. 5. 153 pp.

Hefner, J.M., B.O. Wilen, T.E. Dahl, W.E. Frayer. 1994. Southeast wetlands: Status and trends, mid-1970s to mid-1980s. U>s. Department of the Interior, Fish and Wildlife Service; Atlanta, Georgia.

Herring, G. and D. E. Gawlik. 2007. Multiple nest-tending behavior in an adult female white ibis. Waterbirds 30:150-151.

Howell, A.H. 1932. Florida bird life. Coward-McCann; New York, New York.

Jackson, D., & Milstrey, E. (1989). The Fauna of Gopher Tortoise Burrows. In J. Diemer, & E. al., *Gopher Tortoise Relocation Symposium Proceedings* (pp. 86-98). Tallahassee: Florida Game and Fresh Water Fish Commission, Program Technical Report 5.

Landers, J. (1980). Recent Research on the Gopher Tortoise and its implications. In R. Franz, & R. Bryant (Ed.), *The Dilemma of Gopher Tortoise--is there a solution? Proceedings of the 1st Annual Meeting* (pp. 8-14). Gopher Tortoise Council.

Landers, J., Garner, A., & McRae, W. (1980). Reproduction of Gopher Tortoises (Gopherus polyphemus) in Southwestern Georgia. *Herpetologica , 36*, 353-361.

Lips, K. (1991). Vertebrates Associated with Tortoise (Gopherus polyphemus) Burrows in Four Habitats in South-Central Florida. *Journal of Herpetology , 25*, 477-481.

Marks, G.E., and C.S. Marks. *Status of the Florida bonneted bat (Eumops floridanus).* Final Report, Submitted by Florida Bat Conservancy for the U.S. Fish and Wildlife Service under grant agreement number 401815G192, Bay Pines, Florida: Florida Bat Conservancy, 2008.

Moler, P. 1992. American Crocodile population dynamics. Final Report. Study Number: 7532. Bureau of Wildlife Research Florida Game and Fresh Water Fish Commission

Moler, P.E. 1992. Eastern indigo snake. Pages 181-186. In P.E. Moler, ed. Rare and endangered biota of Florida, volume III, Amphibians and Reptiles. University Press of Florida; Gainesville, Florida.

Morrison, J.L. 1996. Crested Caracara. In The Birds of North America, No. 249 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington D.C.

Morrison, J.L. and S.R. Humphrey. 2001. Conservation value of private lands for Crested Caracaras in Florida. Conservation Biology 15:675-684.http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A0JB (accessed November 4, 2013).

NatureServe. November 1, 2013.

Oberholser, H.C. 1938. The bird life of Louisiana. Louisiana Department of Conservation, Bulletin 28.

Ogden, J.C. and S.A. Nesbitt. 1979. Recent wood stork population trends in the United States. Wilson Bulletin 91(4):512-523.

Ogden. John C. 1994. A comparison of wading bird nesting colony dynamics (1931-1946 and 1974-1989) as an indication of ecosystem conditions in the southern Everglades in, "Everglades the Ecosystem and its Restoration", eds,. Davis, S.M. and J.C. Ogden. pps. 533- 570.

Ogden, J.C., J.A. Kushlan, and J.T. Tilmant. 1976. Prey selectivity by the wood stork. Condor 78(3):324 330.

Ogden, J.C., J.A. Kushlan, and J.T. Tilmant. 1978. The food habits and nesting success of wood storks in Everglades National Park in 1974. U.S. Department of the Interior, National Park Service, Natural Resources Report No. 16.

Ogden, J.C., 1991. Nesting by wood storks in natural, altered, and artificial wetlands in central and northern Florida. Colonial Waterbirds 14:39 45.

Pickett, R., Winters, K., Cheng, H., & England, S. (2013). Draft Herbert Hoover Dike (HHD) Flow Model. USACE Engineer Research and Development Center, Vicksburg, MS.

Prinos, S.T. and Valderrama, R. (2015). Changes in the saltwater interface corresponding to the installation of a seepage barrier near Lake Okeechobee, Florida. U.S. Geological Surve

Rathbun, G.B., R.K. Bonde, and D. Clay. 1982. The status of the West Indian manatee on the Atlantic Coast north of Florida. Proceedings: Symposium on Non-game and Endangered Wildlife. Technical Bulletin WL5. Georgia Department of Natural Resources, Game and Fish Division, Social Circle, GA.

Reese, R.S. and Wacker, M.A. (2009). Hydrogeologic and hydraulic characterization of the Surficial Aquifer System, and origin of high salinity groundwater, Palm Beach County, Florida. U.S. Geological Survey Scientific Investigations Report 2009-5113, 83 p.

Schaefer, J. and J. Junkin. 1990. The Eastern Indigo Snake: A Threatened Species. University of Florida, Florida Cooperative Extension Service. Publication SS-WIS-24, Gainesville, Florida, USA.

Steiner, T.M., O.L. Bass, Jr., and J.A. Kushlan. 1983. Status of the eastern indigo snake in southern Florida national parks and vicinity. South Florida Research Center Report SFRC-83/01. Everglades National Park, Homestead, Florida, USA.

Stith, B.M., D.H. Slone, and J.P. Reid. 2006. Review and synthesis of manatee data in Everglades National Park. Final Report for USGS/ENP Agreement #IA F5297-04-0119, November 2006. 110 pp. Sustainable Ecosystems Institute, 2007. Everglades Multi-Species Avian Ecology and Restoration Review. Sustainable Ecosystems Institute, Portland Oregon.

USACE. (2007). *Final Supplemental Environmental Impact Statement Lake Okeechobee Regulation Schedule.* Jacksonville: U.S. Army Corps of Engineers, Jacksonville District.

USACE. (2014). Central Everglades Planning Project. Final Integrated Project Implementation Report and Environmental Impact Statement. Jacksonville District, Jacksonville, FL, USA.

USFWS. (2014). U.S. Fish and Wildlife Service Draft Interim Coordination Act Report. South Florida Ecological Services Office, Vero Beach, Florida.

USFWS. (2013, November 25). Retrieved from Species Profile: http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=C044#candidate

U.S. Fish and Wildlife Service. 1999. South Florida Multi-Species Recovery Plan. Southeast Region, Atlanta, Georgia, USA.

USGS (2014) Changes in Saltwater Interface Corresponding to the Installation of a Seepage Barrier Near Lake Okeechobee, Florida, Open File Report 2014-1256.

Wayne, A.T. 1910. Birds of South Carolina. Contributions to the Charleston Museum No. 1

Witz, B., Wilson, D., & Palmer, M. (1991). Distribution of Gopherus Polyphemus and its Vertebrate Symbionts in Three Burrow Categories. *American Midland Naturalist , 126*, 152-158.

10.0 INDEX

11.0 LIST OF ACRONYMNS

A	
ac	Acres
ACBM	Articulated Concrete Block
APE	Area of Potential Effect
APF	Annual Probability of Failure
AQI	Air Quality Index
ASR	Aquifer Storage Recovery
B	
BCNP	Big Cypress National Preserve
BMAP	Best Management Agricultural Practices
C	
CEPP	Central Everglades Planning Project
CERP	Comprehensive Everglades Restoration Plan
C&SF	Central and Southern Florida
Cfs	Cubic feet per second
CIZ	Common Inundation Zone
Corps	United States Army Corps of Engineers
D	
DSAC	Dam Safety Action Classification
DOI	Department of Interior
DSMS	Dam Safety Modification Study
E	
EA	Environmental Assessment
EAA	Everglades Agricultural Area
EIS	Environmental Impact Statement
ENP	Everglades National Park
EO	Executive Order
EPA	Everglades Protection Area
EQ	Environmental Quality
ERP	Environmental Resource Permit
ERTP	Everglades Restoration Transition Plan
ESA	Endangered Species Act
F	
F.A.C.	Florida Administrative Code
FEB	Flow Equalization Basin
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FONSI	Finding of No Significant Impact
FMSF	Florida Master Site Files
F.S.	Florida Statute
ft	feet
FWC	Florida Fish and Wildlife Conservation Commission
FWAC	Future Without Action Condition
G	

GDM	General Design Memorandum
GRR	General Reevaluation Report
H	
HHD	Herbert Hoover Dike
HTRW	Hazardous, Toxic and Radioactive Waste
I	
IOP	Interim Operations Plan
J	
K	
KRR	Kissimmee River Restoration
L	
LORS	Lake Okeechobee Regulation Schedule
LOSA	Lake Okeechobee Service Area
LOST	Lake Okeechobee Scenic Train
LTGM	Long Term Geometric Mean
M	
MRR	Major Rehabilitation Report
N	
NAAQS	National Ambient Air Quality Standards
NAVD	North American Vertical Datum
NED	National Economic Development
NEEPA	Northern Everglades and Estuary Protection Act
NEPA	National Environmental Policy Act
NESRS	Northeast Shark River Slough
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NRHP	National Register of Historic Places
O	
OMRR&R	Operations, Maintenance, Repair, Rehabilitation, and Replacement
P	
PAR	Population At Risk
PED	Preconstruction, Engineering, and Design
ppb	Parts Per Billion
ppt	Parts Per Thousand
Q	
R	
RED	Regional Economic Development
ROD	Record of Decision
RMP	Risk Management Plan
S	
SAS	Surficial Aquifer System
SFWMD	South Florida Water Management District
SHPO	State Historic Preservation Office(er)
SPF	Standard Project Flood
STA	Stormwater Treatment Area
T	

TCC	Taylor Creek Culvert
THPO	Tribal Historic Preservation Office(er)
TMDL	Total Maximum Daily Limits
TP	Total Phosphorous
TRG	Tolerable Risk Guidelines
U	
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USDA	United States Department of Agriculture
USGS	United States Geological Survey
V	
W	
WQBELs	Water Quality Based Effluent Limits
WCA	Water Conservation Area
WQC	Water Quality Certificate
WRDA	Water Resources Development Act
WSE	Water Supply and Environmental Regulation Schedule
X	
Y	
Z	