Everglades National Park
Monroe County, FL

Engineering Analysis and Feasibility
of
Repairing or Replacing Failed Dams
and
Limiting Salt Water Intrusion in Cape Sable Everglades National Park

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April 2012

Contract No.: P 11 PD51977

Table of Contents

List of Figures

List of Photos

List of Tables

List of Appendices

1.0 Introduction

The National Park Service (NPS) has retained URS Corporation to identify and develop alternatives for the mitigation of eroding dam plugs on the House and Slagle ditches, restoration of the failed dam on the Raulerson Canal and the potential construction of a new dam on East Side Creek. This Engineering Analysis and Feasibility Report presents the results of the field assessments; preliminary engineering analysis, cost estimates and the concept design alternatives for mitigating the current ditch plug erosion, restoring the failed dam and construction of a new dam. **Figure 1** shows the location of the House and Slagle ditches, the Raulerson Canal and the East Side Creek which are the subject of this study and report.

The assessment results, mitigation, restoration and new dam construction alternatives and anticipated environmental impacts associated with each, alternative are presented for each dam in subsequent sections of this report in sufficient detail to begin the NEPA process. It is to be noted that this Feasibility Study is based primarily on field inspections of the existing or proposed dam areas combined with prior knowledge of the Cape Sable Region gained from the design and permitting of other recently completely dam replacements on the East Cape Canal Extension and the Homestead Canal. No additional site specific investigations such as topographic surveying, soil borings or other environmental related or archeological surveys have been authorized or performed as part of this Feasibility study. These additional studies will be scoped and performed as part of subsequent

permitting and design activities for the various components of this project and as may be needed to complete the NEPA process.

The House and Slagle ditches and dam plugs will be presented first in Section 2, followed by the Raulerson Canal Dam replacement in Section 3 and finally the East Side Creek dam construction alternatives in Section 4. Preliminary order of magnitude cost estimates are also presented in this report in Section 5.0 with more detailed Cost Estimate Backup included in Appendix B.

1.1 Cape Sable Region Brief Overview

The interior wetlands of Cape Sable region were historically isolated from both Florida Bay and the Gulf of Mexico by a marl ridge known as the Flamingo Embankment. Early in the last century, five canals were dug through the marl ridge in attempts to drain and reclaim the interior marsh areas for development, agricultural, and cattle grazing. These canals opened up the interior wetlands to tidal influence and the inflow of salt water from the Gulf of Mexico and Florida Bay. The canals were plugged with earthen dams at the marl ridge during the 1950's but all of the earthen dams have either been breached or severely compromised by the forces of weathering and erosion over the intervening years.

The Middle Cape Canal between the north end of Lake Ingraham and Florida Bay did not widen appreciably until after the 1935 Labor Day Hurricane but today the opening is greater than 300 hundred feet wide and still enlarging rapidly. The East Cape Canal connection to the southern end of Lake Ingraham was completed in the 1920's and the lower portion of the canal between Florida Bay and Ingraham Canal is now more than 200 hundred feet wide. At present, five other major ditch/canal plugs or dams are known to exist in the Cape Sable region including the House and Slagle's ditch plugs, the Raulerson Canal dam and the Homestead and East Cape Extension Canal dams. The House, Slagle ditches and Raulerson Canal are subjects of this report and the Homestead and East Cape Canal Extension Dams have recently been replaced as will be subsequently briefly discussed.

1.2 Replaced Homestead and East Cape Canal Extension Dams

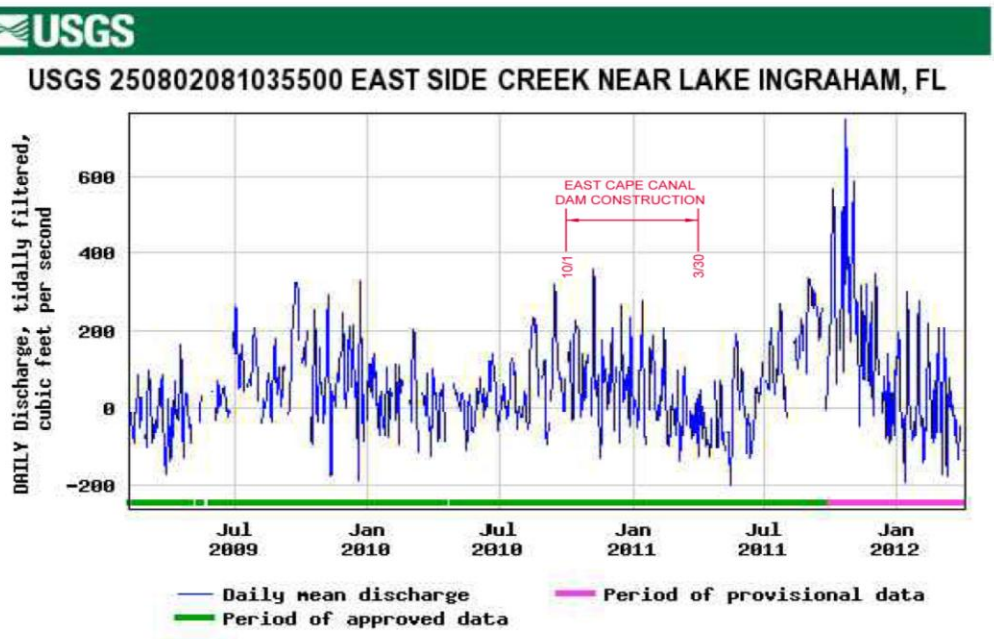
The East Cape Canal extension and Homestead Canals on Cape Sable were constructed in the 1920's to allow draining of interior Everglades fresh water marshes and provide improved access to the inland marshes. The construction of the canals allowed tidal saltwater to intrude into the brackish water marshes of Cape Sable. To control the intrusion of saltwater, dams were initially constructed on the East Cape Canal Extension and Homestead Canals in the 1950's.

Both of the previous East Cape Canal Extension and Homestead Dams were initially constructed as earthen dams buttressed with timber. The initial earthen dams partially failed in 1992 from the cumulative effects of erosion, excavation of embankment material, vegetation growth in the dam and seepage through the dam section. The failed earthen dams on the Homestead Canal and East Cape Canal Extension were replaced in 1997 with sheet pile dams but these dams also failed after a few years by erosional breaching around the ends of the installed sheet piling, possibly due to vandalism and/or lack of sufficient armouring of canal banks adjacent to the sheet piling. The perimeter failure of these two sheet pile dams again subjected the interior wetlands to unnatural tidal flows. The unnatural flows resulted in multiple hydrological changes to the interior area, including rapid drainage of brackish water during the wet season, reduction in hydro period of the wetlands, and increased salinity during the dry season. These physical changes are believed to have dramatically altered and reduced the biological productivity of the interior wetlands negatively impacting fish and wading birds. The failed dams and widening of the canals also allowed fisherman to unlawfully take their motorized skiffs into the interior wetlands and constituted a safety hazard for boaters.

The failed dams on the Homestead and East Cape Canals have been recently replaced in October 2010 through March 2011, with 100 foot long earthen structures bounded at each end by two sheet pile bulkheads and rip rap armouring with sheet piling along the banks on all four corners. **Photo 1** shows the re-constructed East Cape Canal extension dam. These structures were designed to last 50 years under normal overtopping events and have substantially reduced saltwater intrusion and freshwater loss from the interior marshes while also addressing safety and illegal access issues. With the completion of these dam replacements, it is envisioned that drainage flows out of the Cape Sable interior areas will occur via other drainage features such as the currently open Raulerson Canal, East Side Creek and other more northern natural discharge routes.

Photo 1 – Reconstructed East Cape Dam

The following **Figure 2** appears to indicate that some increased flows out to the East Side Creek may potentially be occurring subsequent to the East Cape Canal Extension dam construction in October, 2010 through March, 2011. However, the period of record is short and needs to be compared to rainfall records from interior marsh areas before a definitive assessment can be made in this regard. Review of the **Figure 2** data also indicates that negative flows, or flows back into the interior marshes are occurring at a flow rate potentially similar to available data for the prior 2009 and 2010 years.



CAPE SABLE
EAST SIDE CREEK FLOW VOLUMES (CF/Sec)

URS

FIGURE 2

Review of similar but more limited available data for the Raulerson Canal as obtained from data collection records for USGS Monitoring Station #251115081075800, indicates that Raulerson stream data collection did not begin until September of 2011 subsequent to the Homestead Dam completion in March of 2011. Correspondingly, data for comparison of the Raulerson Canal flows with pre-Homestead Dam construction periods are not available.

1.3 National Environmental Policy Act Compliance and Environmental Permitting

Presented below is an overview of the National Environmental Policy Act (NEPA) compliance and environmental permitting requirements for all of the proposed alternatives for restoration/repair of the dams/plugs along House's Ditch and Slagle Ditch's and construction of new dams along the Raulerson Canal and East Side Creek.

1.3.1 National Environmental Policy Act Requirements

In order to implement any of the build alternatives at any of the four dam restoration/construction sites, the potential for environmental impacts associated with the activities would need to be assessed for these proposed Federal actions. Since each build alternative for restoration/construction activities involves potential impacts to Park resources, these impacts will need to be accounted for and assessed under an appropriate Class of Action, as defined by the NEPA and associated Council on Environmental Quality (CEQ) implementing regulations and outlined by the NPS in Director's Order 12: "*Conservation Planning, Environmental Impact Analysis, and Decision Making"*.

House and Slagle Dams - For the proposed build alternatives associated with restoration/repair of House Ditch dam and Slagle Ditch dam, the Class of Action is likely to be a Categorical Exclusion (CE) or Environmental Assessment (EA), depending upon the anticipated environmental impacts for each site. Director's Order 12 states that "CEs are applicable to actions that, under normal circumstances, are not considered major federal actions and that have no measurable impacts on the human environment." If these projects do not qualify for a CE, an EA will be required. If the EA analysis determines that no significant impact to the environment is anticipated, a Finding of No Significant Impact (FONSI) can be issued. If the EA analysis determines that a significant impact to the environment is anticipated from the selected alternative for either site, a Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) must be issued and an EIS must be prepared; however, this outcome is highly unlikely for these two sites.

Raulerson Replacement Dam - For the proposed build alternatives associated with the construction of a new replacement dam at the Raulerson Canal site, the Class of Action is likely to be an EA. If the EA analysis determines that no significant impact to the environment is anticipated from the selected alternative, a FONSI can be issued. If the EA analysis determines that a significant impact to the environment is anticipated from the selected alternative, a NOI to prepare an EIS must be issued and an EIS must be prepared; however, this outcome is unlikely for the Raulerson Canal site.

East Side Creek - For the proposed build alternatives associated with the construction of a new dam on East Side Creek, the Class of Action is likely to be an EA at a minimum, with the possibility of the project being elevated to an EIS due to the fact that the site is a "natural" waterway and construction of a new dam on the Creek could potentially alter the natural system in the interior area. However, it is important to note that the "natural" waterway has been significantly altered by the effects of the East Cape Canal, a man-made structure. Therefore, the purpose of this dam would be to mitigate saltwater flows back into the interior marsh areas with the intent of re-establishing to the extent possible, those natural conditions which existed prior to construction of the drainage ditches and canals in the area. Due to these mitigating factors, the project may potentially qualify as an EA.

It must be noted that a final determination of the Class of Action for each of the proposed dam restoration/construction sites is solely up to the discretion of the NPS. In determining the Class of Action for a project, the NPS *Director's Order 12: Conservation Planning, Environmental Impact Analysis and Decision Making* states the following:

> *The decision to categorically exclude an action from further NEPA analysis is documented using the CEF. This form is signed by the park superintendent or his or her designee.* [Section 3.8 (Administrative Process)].
>
> *A FONSI or notice of intent to prepare an EIS following the completion of an EA must be signed and dated. The signatory for either rests with the Regional Director. In addition, the Regional Director is responsible for deciding when an EA is adequate for public review.* [Section 5.6 (Administrative Process of Review of EAs)].

In order to finalize the NEPA documentation for any of the sites, concurrence letters will need to be received from the State Historic Presentation Officer (SHPO) for archeological and historic resources; from the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS) regarding threatened and endangered species; from the NMFS concerning the Essential Fish Habitat Assessment (EFHA); and from the State of Florida regarding consistency with the Coastal Zone Management Act (CZMA). The proposed project will also need to be reviewed for potential effects to social, economic, and community aspects of the human environment as required by the NEPA. In addition, the indirect effects of each alternative, which may be considered either adverse or beneficial, will need to be assessed.

1.3.2 Environmental Permitting Requirements

In order to implement any of the build alternatives at any of the four dam restoration/construction sites, the NPS would be required to obtain all appropriate Federal and State environmental permits (or exemptions) for the proposed activities. The following discussion applies to all of the four dam restoration/construction sites.

1.3.2.1 Federal Permits

A U.S. Army Corps of Engineers (USACE) Dredge and Fill Permit would be required for any of the build alternatives that involve activities within the Waters of the U.S. As a component of the USACE permitting process, the NOAA's NMFS serves as one of the Federal commenting agencies on permit issuance. Under the Magnuson-Stevens Fishery Conservation and Management Act, the NMFS will require that an EFHA be conducted for the proposed restoration activities within Waters of the U.S. which are designated as Habitat Areas of Particular Concern (HAPC) for managed fisheries. Mangrove wetlands and the coastal waters within Everglades National Park are designated as HAPC for a number of commercially managed invertebrate and fish species.

Under the Endangered Species Act, the NMFS and the USFWS act as commenting agencies on the USACE permitting process regarding listed species. Therefore, an Endangered Species Biological Assessment (ESBA) will need to be prepared which documents the potential effects of the proposed action.

In addition, if any of the proposed alternatives disturb land surface area greater than one (1) acre during construction, a U.S. Environmental Protection Agency (USEPA) National Pollutant Discharge Elimination System (NPDES) Permit for Construction Activities will need to be obtained by the

Contractor at least 48 hours prior to initiation of construction. In the state of Florida, the USEPA has delegated authority for the issuance of this NPDES Permit to the Florida Department of Environmental Protection (FDEP). In order to obtain coverage under this NPDES Permit, an appropriate Storm Water Pollution Prevention Plan (SWPPP) will need to be developed for the project. This plan will include the Best Management Practices (BMPs) for sedimentation and erosion control, all appropriate measures that are required for pollution abatement and control for heavy equipment operations and solid waste management during construction activities. In order to receive coverage under this NPDES Permit, the Contractor will be required to file a NOI with FDEP. This letter will state that an appropriate SWPPP has been developed for the project.

1.3.2.2 State Permit

An Environmental Resource Permit (ERP) issued by the FDEP will also be required for any of the build alternatives. The NPS should seek to include FDEP as a cooperating agency in the proposed restoration activities. This cooperative effort may potentially allow the proposed restoration activities for the House Ditch dam and Slagle Ditch dam sites to be covered under an existing ERP exemption for FDEP habitat restoration projects. The proposed dam sites along the Raulerson Canal and East Side Creek will most likely not qualify for an exemption and will require an ERP.

In order for the USACE to issue the Federal permit required for these sites, an exemption letter or ERP will need to be issued by FDEP. Both documents will provide the USACE with the Water Quality Certification requirements of the Clean Water Act, which are a condition of the USACE's Section 404 Dredge and Fill Permit issuance.

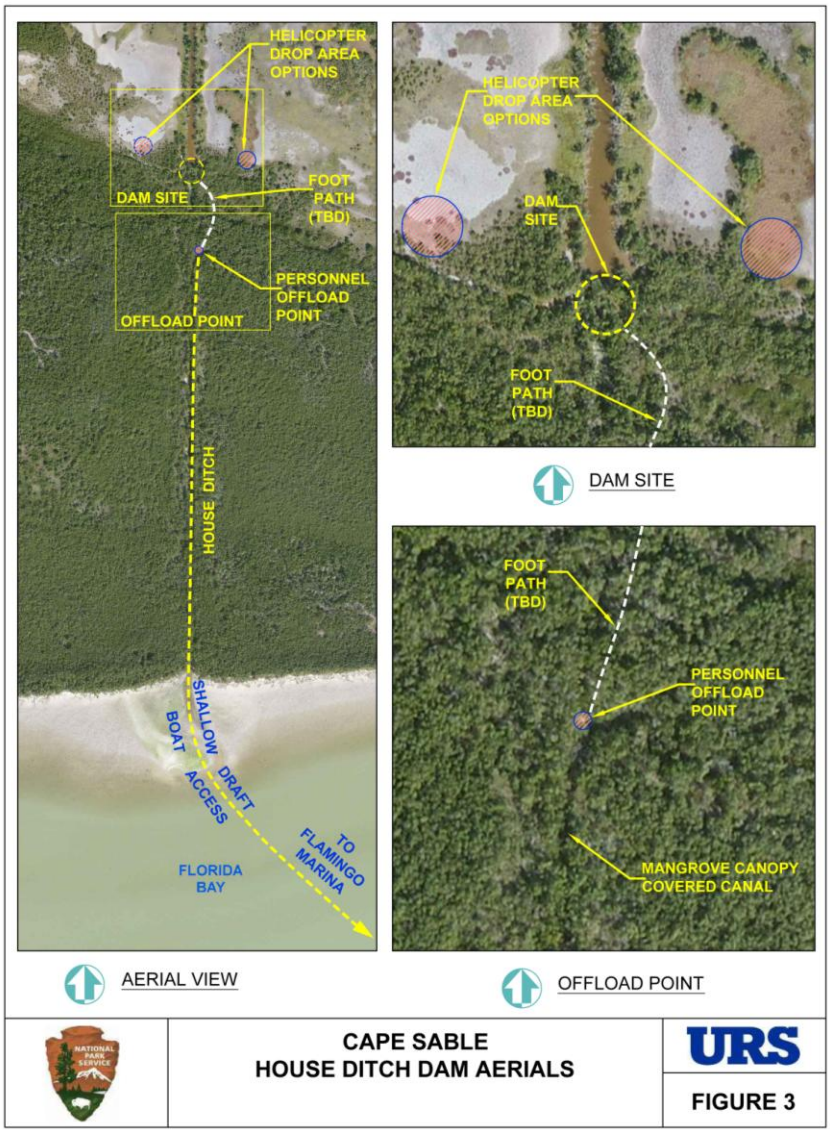
2.0 Assessment of House and Slagle Ditch Dams

Discussion of the House and Slagle Ditch dams are being combined under a common section as the nature of these two ditch dam plugs and repairs thereof are very similar. Essentially, the dam plugs were formed in the mid-1900s by placing a fill plug across the canal. It appears as if the width of the ditch plug was initially on the order of 18 feet (+/-) and it was adequate to initially function as a narrow inland roadway for the movement of vehicles and equipment deep into the backcountry along what is now termed as the Coastal Prairie Trail. Based on observations made in the field, it appears that a coarser well graded sand and gravel mixture was used to initially construct the plug. The surface of the plug is dense and hard and likely well compacted as a result of its early use as a roadway into the inland marshes. The fill mixture also appears to contain some silty to slightly clayey fines which impart a slight cementation to the fill helping to keep the fill mixture intact in the field.

2.1 House Ditch Dam Assessment

House Ditch is located approximately 0.8 miles east of the East Cape Canal entrance off of Florida Bay as shown on previous **Figure 1**. This dam site is also located approximately 6-2/3rds miles west of the Flamingo Campgrounds along the Coastal Prairie Trail. As can be seen in **Figure 3**, the Florida Bay side access along the southern alignment of the ditch is heavily overgrown with Mangroves but is accessible by small shallow draft boats capable of moving beneath the overhanging canopy and transporting personnel to an inland off-load point.

The dam/canal plug along the House Ditch is the most structurally intact of the 3 known remaining earthen dams on Cape Sable. Although this small dam and ditch plug has continued to slowly erode over the years, it appears to be structurally sound and there is no visible evidence of leaking or piping through the dam based on an inspection made in December, 2011. The earthen fill portion of the dam was recently estimated to be about 10 to 15 feet wide across the Coastal Prairie Trail.



It is somewhat apparent that the dam plug is being frequently used by crocodiles moving along the ditch and over the ditch/dam plug. As shown on **Photos 2N and 2S**, a worn path with eroded side slope slides are clearly evident on the top of the plug and the north and south sides of the plug fill respectively. It is postulated and it appears that some of the experienced erosion is potentially associated with the claws of crocodiles digging into the fill sides slopes of the plug as they crawl over the plug area. The loosened fill is then eroded away by a combination of factors including rainfall, higher water level rises on the sides of the dam plug and the long term downslope movement of loose material as the crocodiles move up and down the dam slopes. However, additional reported observations by others who have periodically visited the dam site over the last several years have indicated that there was some accelerated erosion of the dam slopes as the result of storm surge events since 2005 primarily believed associated with Hurricanes Katrina and Wilma.

2N - North Side Dam Erosion **2S - South Side Dam Erosion**

Photo 2 – North & South Views of House Ditch Dam Erosion

The southern side of the dam plug is heavily forested by Mangroves and as can be seen by **Photo 2S** above, root systems from the adjacent Mangrove Trees are helping to stabilize the dam fill and reduce erosion propagation into the ditch dam. The eroded areas appear to be about 5 to 6 feet in width, several feet in length and on the order of 2 feet deep south of the dam.

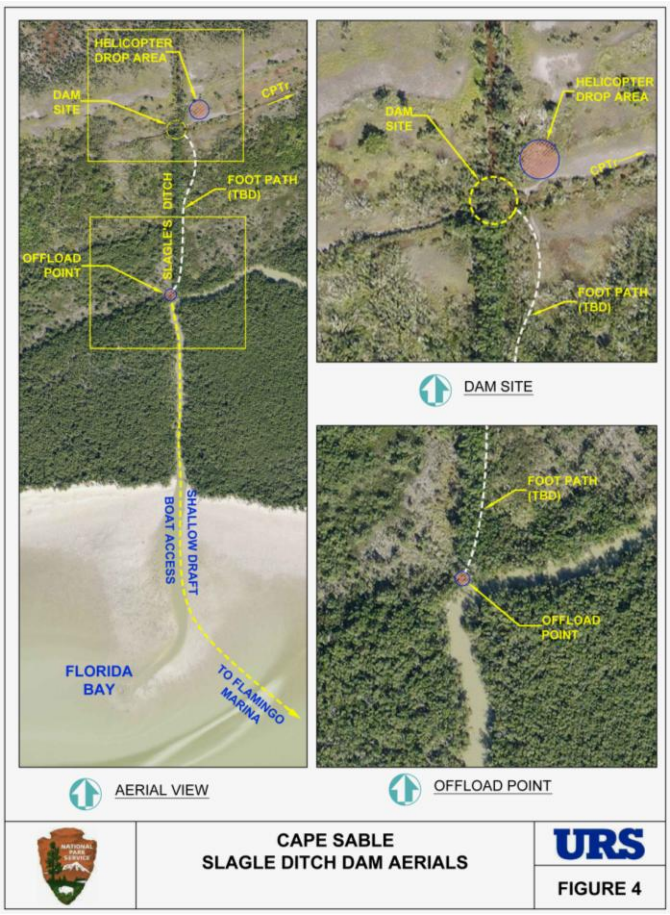
The north side of the plug is less vegetated as shown in **Photo 2N** above and in general, the observed erosion has propagated to a more significant degree into the dam section compared to the south side of the plug. The House Ditch width is also much more sizeable north of the dam plug and it is possible that some small wind driven wave action may also be contributing to the dam plug erosion on the north face of the dam during higher water level conditions in the interior marsh. The north side erosion are appears to be about 8 to 9 feet in width, in excess of 10 feet in length and on the order of 3 feet deep north of the dam.

As indicated earlier, it is important to note that this ditch plug has likely experienced several storm surge and overtopping events since the mid - 1900s and more recently since the early to mid-2000's. That being said, the observed existing erosion conditions are considered manageable at the present time and for the foreseeable near future. However, over the longer term with anticipated sea level rise over the next several decades, such overtopping events may become more frequent and problematic and the potential for accelerated erosion at this dam site as well as other low lying areas in the region will increase in future decades. Without remediation, the erosion will eventually propagate through

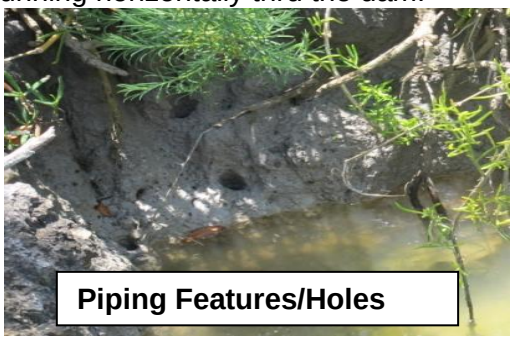
the dam plug therein providing direct communication of the enlarged ditch north of the dam with the smaller southern, tidally influenced ditch. Left unchecked, this ditch will eventually become re-opened to tidal flushing and become an unrestricted flow way for tidal saltwater propagation to the Cape Sable interior will occur.

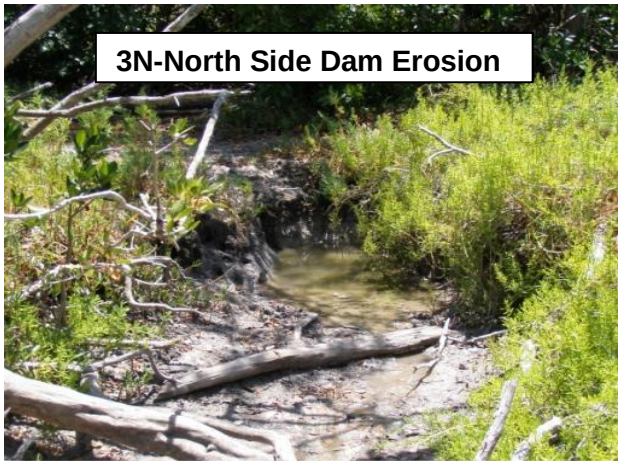
2.2 Slagle Ditch Dam Assessment

The Slagle Ditch dam is located about 5.1 miles west of the Flamingo campgrounds and about 2.3 miles east of the East Cape canal and is shown on **Figure 4.** The Slagle ditch dam plug is very similar to the House Ditch dam plug with the exception that the extent of erosion has been more extensive particularly on the north side of the dam.



The earthen dam on Slagle's Ditch as shown in the **Photo 3** picture set below has been eroding at an apparent more significant rate compared to the House Ditch dam and in August 2009, the first sign of lateral seepage was noticed thru the dam in small side erosion piping features/holes. During an inspection performed in December 2011, water was observed to be seeping/flowing through a number of golf ball to fist sized holes running horizontally thru the dam.





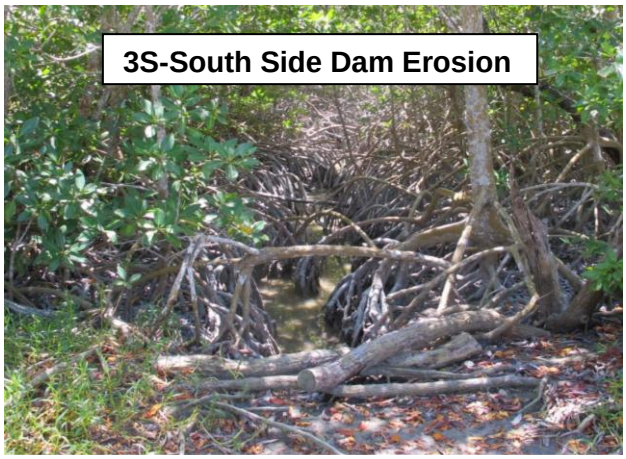


Photo 3 – North & South Views of Slagle's Ditch Dam Erosion

These holes appear to have been initially excavated by small to medium sized crabs on the north side of the dam fill. Such crabs are typically found in the region and they are known to borrow into the softer limemud ground beneath the upper compacted dam fill. It is also possible that macro-pores and flow conduits associated with decayed root systems may be contributing to the observed seepage. The December 2011 field inspection indicates that the dam cross-section is currently only partially intact but the remaining cross-width has been reduced to roughly 10 feet.

Similar to the House dam plug, the south side of the Slagle Ditch dam shown in **Photo 3S** above is heavily vegetated with Mangroves and extensive Mangrove root systems are helping to stabilize the south side slope. Erosion on the south side of the dam is only about 3 to 4 feet wide and similarly 4 to 5 feet in length and about 2 feet deep.

The north side dam face, as evidenced in **Photo 3N** above, is much less heavily vegetated by Mangroves and is mostly covered by low ground vegetation and a few trees. On the north side of the dam, the erosion has been much more extensive. The eroded area is estimated to be about 8 feet wide and up to about 20 feet in length before it reaches the main ditch north of the plug. Active on-going erosion into the dam is pronounced by a small 1 to 2 foot high vertical erosion scarp that is exposed at the leading erosional face into the dam.

There is also a smaller secondary erosional finger which propagates to the west off of the main north erosional channel which also leads up to and just into the toe of the dam plug. The side finger channel is much smaller in size but it retains similar erosional features to the main erosional channel. There is no companion erosion feature on the south side of the dam plug in the side opposite vicinity of this smaller side finger.

Now that seepage water is observed to be potentially propagating through the Slagle earthen dam plug, concern is expressed that the remaining portion of the dam plug could become quickly eroded and the ditch dam structure could potentially fail in a few years, if not sooner. Of the two, House and Slagle Ditch dams, the Slagle dam plug is in the worst erosional condition, is of imminent pending breach failure and in need of the most immediate attention and remediation of the eroded conditions.

2.3 House and Slagle Ditch Logistics Issues

Remediation and restoration of both of the House and Slagle Ditch dams involve the need to address several logistical issues in order to affect any dam repair work. In short, the remote location of the dams interior to the Park and restrictions in accessing the dams sites, will present very challenging obstacles to moving personnel, materials and any equipment to perform the dam site remediation work. A summary listing of several logistical considerations is presented as follows:

A. Remote Small Interior Isolated Dam/ Sites
    1. Slagle's dam site is located about 3/8ths of a mile inland from the Florida Bay coastline.
    2. Slagle's dam site is located approximately 5 -1/10th miles from westernmost Flamingo campgrounds.
    3. House's dam site is located about 3/8ths of a mile inland from the Florida Bay coastline.
    4. House Dam is located approximately 6-2/3rds miles from westernmost Flamingo campgrounds.
    5. Wilderness access restrictions will likely prohibit or greatly restrict the use of mechanical equipment and/or mechanical/wheeled access to sites.

6. Material delivery to site to likely be limited to Helicopter drop or overland transport by Horses or mules.

B. Personnel Access:

1. Personnel mobilized daily from Flamingo Marina.
2. Small boat travel in Florida Bay and then inland from Bay along marginally to navigable canals to an inland drop off point.
   a. Very shallow near offshore water depths at entrances from Florida Bay requires access at higher tides.
   b. Dense Mangrove canopy overhang along approximate 0.27 miles of Canal leading to House Ditch interior off load point. Some localized trimming of Mangroves may be required to facilitate boat access and to prevent injury to workers siting in boats moving along the canal especially at high tides.

Photo 4
House Mangrove Canopy

   c. Minor overhanging Mangroves in 0.18 Miles of Canal leading to Slagle's Ditch off load point. Some minimal clearing of fallen or overhanging Mangroves may be required along the canal to facilitate boat movement and facilitate safety to workers.
3. Restricted foot access from off-load points through medium dense vegetation.
   a. Approximate 15 – 20 minute walk in-land from off-load points to dam sites.
   b. Approximate 1/10 mile walk in-land from House ditch off-load point.
   c. Approximate 2/10 mile walk inland from Slagle ditch off-load point.

C. Material/Equipment Supply:

1. Materials to be delivered and staged in Flamingo Park area.
   a. Staging at Heliport area for Airlift delivery to dam sites.
   b. Staging at west end of west campground for overland horse or mule delivery to dam sites.
   c. Temporary staging on west side of Marina for any small material/equipment delivery by boat.
2. Repairs requires an estimated 10 to 18 CY of fill at the House Dam and 10 to 21 CY of fill at the Slagle's Dam sites depending on the selected repair option.
3. Need small vibratory compactor to densify and compact backfill in eroded areas.
4. Mechanized wheeled equipment probably precluded from travel/use in the Wilderness area.
5. Possible material deliveries via air drop by helicopter from Flamingo Heliport.
   a. Estimated 8000 lbs. lift capacity = approximately 2.0 to 2.5(+/-) CY of fill delivery per Helicopter lift.
   b. House dam would require 6 to 10 Helicopter lifts and Slagle dam would require 6 to 12 lifts depending on the remediation Alternative selected.
   c. Requires approximate 1/8th acre clear drop zone area near dam sites.
   d. Some limited clearing and ground planking required from inland drop areas near dam to Coastal Prairie Trail.
6. Possible pack horse or mule access available along Coastal Prairie Trail from west end of Flamingo Campgrounds.

a. Requires 2500 SF retention pen and feed storage area at west Flamingo Campground.
b. Probable 12 to 15 horse/mule train carrying 200 lbs. average per mule.
c. One (1) CY (i.e. 3,000 lbs.) requires approximately 15 pack horse/mule trips.
d. Delivery rate of 1.5 average trips/day to the closer Slagle dam site and 1 trip/day to the further House dam site.
e. An intermittent fresh water tank/bladder required for re-hydration water supply for horses or mules to be located at Slagle Dam Site.

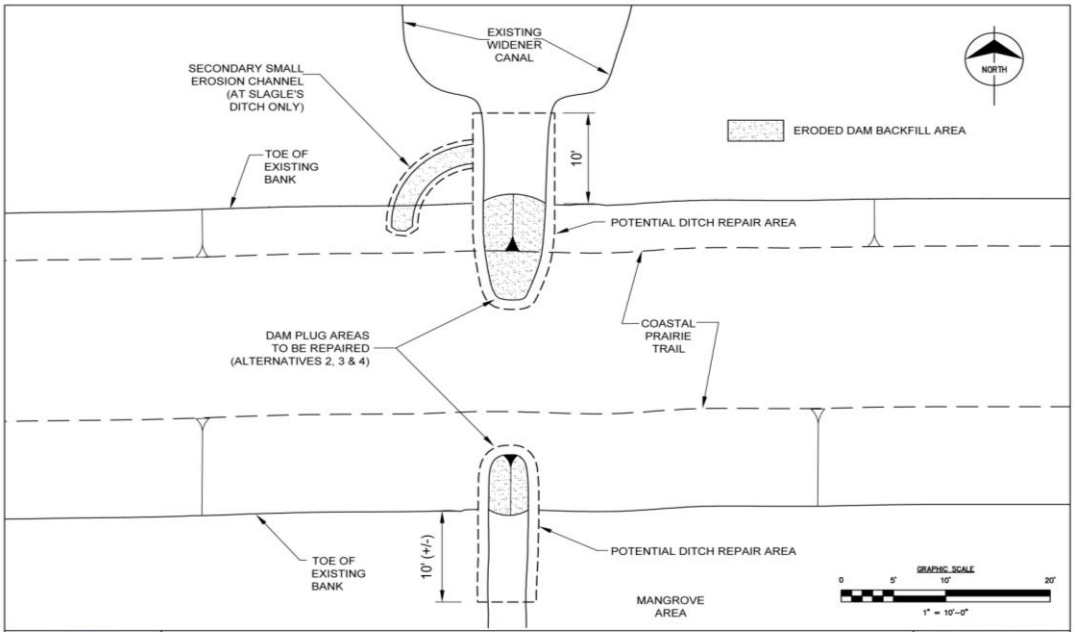
7. Equipment/Materials access from inland offload points would require significant path clearing and ground planking from off-load points.
   a. Approximate 15 – 20 minute walk in- from off-load points to dam sites.
   b. Approximate 1/10 mile walk in-land from House ditch off-load point.
   c. Approximate 2/10 mile walk inland from Slagle ditch off-load point.

Previous experience by the Park in re-constructing the Raulerson Dam in 2009 utilized a heavy lift helicopter as the approved Minimum Tool Assessment to deliver materials to the remote interior Raulerson dam site and an approximate 1/8th acre drop area. Open drop areas are readily available adjacent to the House and Slagle dam sites for the delivery of the small volumes of materials needed to effect the dam repairs. However, Helicopter leasing costs are expensive. In addition to an upfront mobilization charge of $25,000, hourly operations charges of $2,500 can be expected. These costs can be shared between dam sites if the material deliveries and repairs are affected at the same time.

2.4 House and Slagle Ditch Dam Restoration Alternatives

Figure 5 presents a conceptual plan view of the erosion occurring at the House and Slagle Ditch Dams which is in need of repair.

While the dams are of a similar nature, there are some important distinctions between them that are important to re-highlight. The House dam is more intact however, the erosion area and ditch



continuation south of the dam are more pronounced and are frequently used by crocodiles moving along the ditch and up and down the dam slopes. As shown in previous **Photo 2**, the north House ditch and erosion area are relatively open and readily accessible. At the Slagle dam, as shown in **Photo 3**, the south ditch and erosion area is much smaller in size and is heavily overgrown with Mangroves and their root systems. The previous Slagle ditch alignment is minimally evident south of the dam and it is likely that only smaller crocodiles would be able to make their way through the Mangrove root system if at all. The north Slagle's dam erosion is more extensive compared to the House dam, has propagated further into the dam section and is exhibiting signs of seepage and piping through the dam fill. In addition to the main ditch path leading up to the dam, a secondary erosion channel has developed on the north and west side of the dam. Smaller seepage features were also noted in the eroded dam face at the end of this secondary feature. Both of these erosion features would need to be mitigated.

URS was tasked with evaluating three (3) or more alternatives including a Take No - Action alternative as well as additional alternatives for restoring the House and Slagle Ditch dams to an original or better condition. In considering available alternatives to fix the dams, the remoteness and nature of the dam construction, wilderness access issues and limitations, costs and prior dam service history have all provided important considerations and limitations to the alternatives identified. It is to be noted that the dams were likely originally installed as simple ditch/canal infill plugs constructed by simply dumping and pushing gravelly fill into the ditch areas as was and is the common practice by farmers even to this day. The ditch plugs were placed not only to cutoff tidal flows inland along the ditches but also to provide access into more interior areas. These in-filled dam areas were constructed of sufficient width to allow for trucks and other maintenance equipment to access over the ditch while traveling further inland. Correspondingly, the fill within the upper few feet of the dams and generally on top of the Coastal Prairie Trail alignment can be expected to have been compacted to denser condition by the passage of such equipment. However, the fill lower in the dam section is likely to be of relatively poorer compacted condition.

These dam fills as well as the original Coastal Prairie Trail path were likely placed over extremely poor and weak lime mud soils which have minimal resistance to erosion unless stabilized by vegetation and tree root systems as has been the case over much of the Cape Sable region. These ditch dam fills were not constructed as engineering fills and consequently are vulnerable to natural destructive erosional forces with time. These dams also exist at linear ditch features which have the capability of passing more concentrated flows of water back into or out of the interior marshes particularly along un-vegetated ditch and/or canal sections. That being said, these dams have been subjected to numerous high/high tide conditions as well as several storm surge overtopping events during their history but appear to have generally retained their integrity under such conditions. This longer term integrity is attributed to some degree to the protection afforded by the dense Mangrove vegetation south of the dam sites which have diminished the development and movement of concentrated flows of water from and to Florida Bay along the ditch alignments. As the more severe erosion is on the north side of the dams, it is postulated that inland flows are the more pre-dominant direction of any overtopping flows at the dam sites. This being said, the long term ongoing erosion degradation at the Slagle dam has now reached a critical pre-failure condition and needs to be addressed in the near term.

In considering options available for the repair of the dams, one of the primary restrictions to their effective long term repair is the access limitations imposed as these dam sites are located in a designated Wilderness Area. The Wilderness Area designation effectively precludes and/or limits the re-establishment of the original Coastal Prairie Trail road bed area leading to the dam sites. This designation will also effectively preclude the access needed for heavier mechanical equipment to cost effectively mobilize to and work at the dam sites as necessary to make significant repairs and

engineered modifications and upgrades (e.g. such as sheet piling installation) to the dam plugs. The current Coastal Prairie Trail alignment has reportedly not been frequently or adequately maintained has become overgrown with vegetation in many areas and is currently reported to only have a few feet of passage in many areas sufficient only for walking or horseback riding access. Without the ability to mobilize significant mechanical equipment and materials to the dam sites along the Coastal Prairie Trail, the repairs capable of being effected at the dams are inherently limited to Wilderness Committee approved light weight hand operated equipment, small quantities of fill and surficial type applications of erosion repairs and protection systems. Placement of deep engineered sheet piling and large rip rap erosion protection systems etc. are not possible due to these restrictions. It may be potentially possible to hand drive thinner light weight flat sections of short plastic sheet piling however, embedded root systems within the fill may prevent their installation unless such roots can be excavated, exposed and removed along the alignment of the sheets. Final assessments in this regard have to be deferred until a subsequent phase of the design and permitting and would likely require that a soil boring or hand shovel excavated test pits be performed in the middle of the dam.

The ditch dam plugs have been in existence for several decades and due to their remote inland location have been relatively well protected from concentrated flows from high/high tide events and storm surges and have reportedly only required occasional maintenance in the past. Within the Parks historical records, it has apparently been reported that an occasional truck load of fill may have been dumped at the plugs probably to provide additional fill and/or to mitigate against some minor experienced erosion; however, no reported maintenance work has been performed on the dams over the last couple of decade or more. This apparent low maintenance history of the House and Slagle ditch dams provides for some positive re-enforcement that even minor affected surficial repairs will have some reasonable life expectancy for the next decade or so however, not to a 50 year level. It must be also be noted that if the sea level rise occurs over the next several decades to predicted levels of +19 to over +30 inches, much of the Cape Sable Region will become inundated and the low level marl ridge and Coastal Prairie Trail fill, will no longer provide an effective low level barrier to the movement of saltwater into the interior marshes. Thus, given the imposed access restrictions and associated limitations on materials and equipment capable of being mobilized to the site and given the predominant limits on available funding to accomplish the work, the dam repairs to be potentially implemented as part of this Feasibility study, are going to only be locally and regionally effective for a comparatively short period of time of a couple of decades.

For this study, the Take No – Action and three alternatives selected for consideration and further discussion are generally described as follows and are presented in concept section view on **Figure 6.**

- **Alternative 1** – Take No-Action and allow the dam plugs to continue to function in its current state.
- **Alternative 2** – Re-backfill the eroded areas back to the anticipated original dam plug widths with a coarse grained well graded limestone rock fill.
- **Alternative 3** – Re-backfill the eroded areas back to the anticipated original widths with a coarse grained limestone rock fill, place a sand drain for seepage control and place erosion protection along the downslope areas and up to 10 feet outward along the ditch.
- **Alternative 4** – Re-backfill the eroded areas back to the anticipated original widths with a coarse grained limestone rock fill, place a sand drain for seepage control and backfill the ditch up to 10 feet outward from the dam. Place erosion protection along the downslope areas of the dam and end sloping ditch backfill.

Further more detailed discussions of the alternatives are as follows:

2.4.1 Alternative 1: Take No – Action

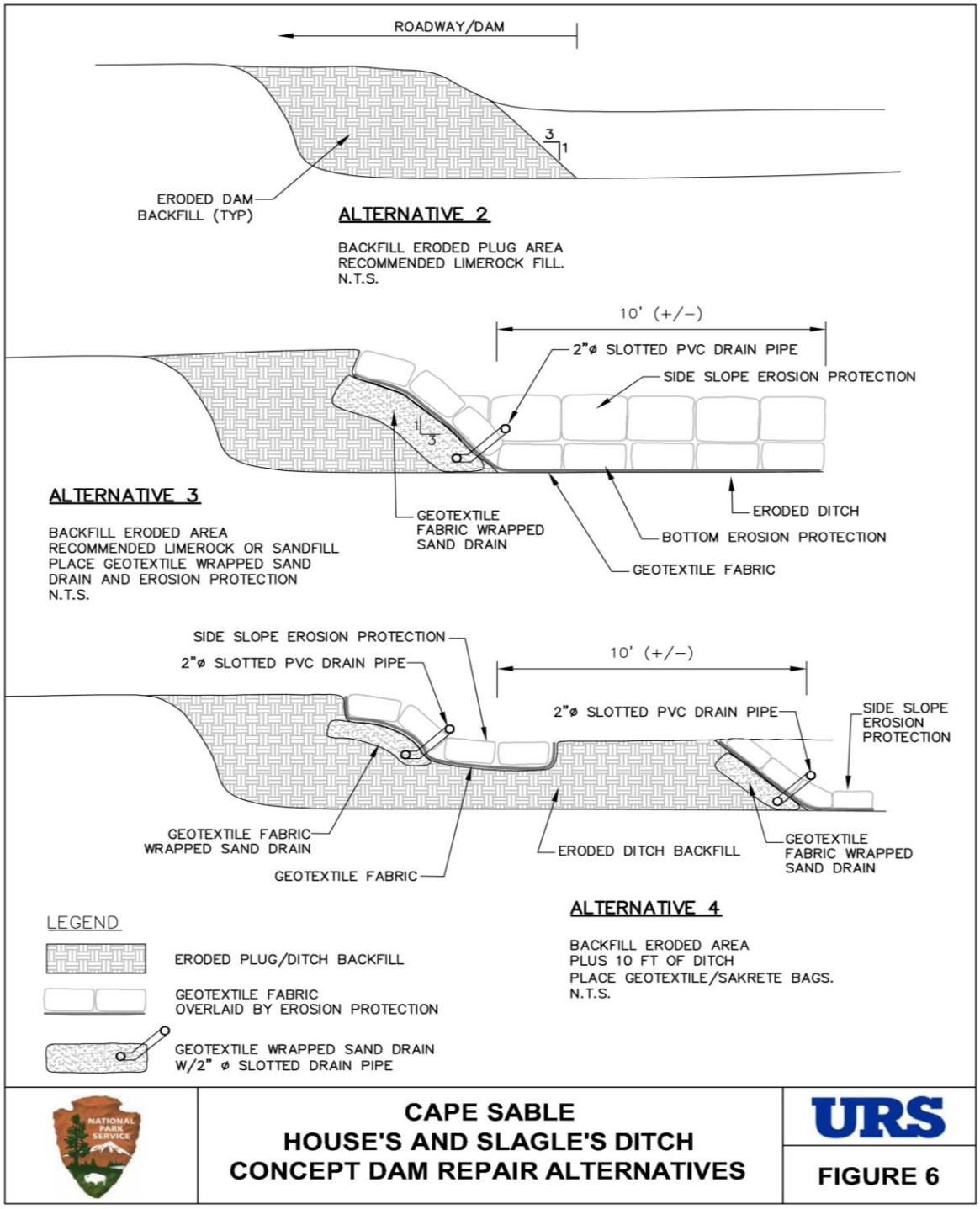
The No-Action alternative involves leaving the House and Slagle Ditch dam plugs in their current condition and allowing the dams to continue to be exposed to the current and futures erosion processes impacting the dam plugs. Eventually at some future time uncertain date, the dam plugs will become breached and tidal flows will be capable of propagating past the marl ridge and inland to the Park inland marshes. Once the dam breach occurs, future erosion will accelerate along the current ditch alignment down into the very soft lime mud soils and the ditch will erode significantly by widening and deepening therein creating a significant path for tidal inflow back into the Park. A similar process is currently on-going as will be discussed in the Raulerson Canal section of this report.

This alternative fails to accomplish the goals of the National Park Service which is to limit the flow of saltwater into the interior fresh water marshes; thereby enhancing the natural hydrology of the Cape Sable region north of the marl ridge. Maintaining and/or restoring the natural hydrology of the marshes of the Cape Sable region would enhance and improve the habitat for wading birds, juvenile crocodiles and other wildlife. The No-Action alternative is not a feasible solution because it does not achieve the goal of habitat protection required by the National Park Service. In addition, sediment from future ditch erosion as well as from any adjacent interior areas will become suspended in the outgoing flowing waters and ultimately will disperse and become deposited throughout Florida Bay and into the Gulf of Mexico.

The next three alternatives were determined to be feasible as a result of the site inspection performed in December of 2011 and subsequent preliminary engineering analysis. For each alternative, an overview of the planned construction methodology is provided in light of the logistic issues previously discussed in Section 2.3 and the advantages and disadvantages of each alternative are presented. The environmental impacts associated with the dam restorations are discussed in Section 2.5 of this report.

2.4.2 Alternative 2: Re-backfill Eroded Plug Areas

Alternative 2 through 4 are presented in the following Figure 6. Alternative 2 simply involves re-backfilling of the eroded dam ditch plugs with a gravelly limerock fill containing silty binder type fines. This alternative essentially re-establishes the dam section and is being further considered as it minimizes the amount of backfill material needed to affect the restoration work and therefore also minimizes the cost.



It is envisioned that locally available limerock fill, typical of that used for roadway base material in South Florida, will be used as backfill in the eroded area of the dam plug only. The backfill will be placed in sufficient quantities to only re-construct the original dam plug cross-section consistent with matching the adjacent dam slopes and elevation/grades. No other modifications would be provided to the dam plug area to provide any additional erosion protection other than that afforded by compacting the fill in-place and providing a fill material containing silty limestone fines. These silty fines will have a propensity to dry out and become dedicated and weakly cemented with time, therein providing a

slight cementation in the fill similar to that which exists in the present Dam plug fill. Additionally, it has been reportedly observed that the surface of the dam plugs may also have been further stabilized with a thin upper layer of cement mixed into or spread on the fill surface.

A. Advantages

1. Re-constitutes original Dam section with similar fill
2. Minimizes material volumes needed to affect restoration
3. Minimizes Labor and Material costs to affect restoration
4. Minimizes environmental impacts at work area
5. Minimizes Logistic Issues of Section 2.3
6. Complies with the Parks intent to limit saltwater intrusion and to mitigate against discharge of sediment into Florida Bay.

B. Disadvantages

1. Does not mitigate against continued long term plug erosion of a present similar nature
2. Does not mitigate against any future internal seepage piping which has developed at the Slagle Ditch site
3. Any native planting on dam side slopes would likely become destroyed by mammal ingress/egress

2.4.3 Alternative 3: Backfill Eroded Dam Area including Slope and Ditch Erosion Protection

Alternative 3 is an expanded variation of Alternative 2. In addition to backfilling of the eroded dam areas, the slopes of the dam plug in the repaired area and a few feet each side thereof will be covered with a geotextile wrapped sand drain. The geotextile and drain would then be covered with erosion protection amouring such as Sakcrete bags or gravel filled Geoweb up to a 4 inch size to mitigate against future erosion at the eroding dam location. A gravel filled Geoweb system may allow for some future vegetation re-growth into the Goewebs. A slotted PVC drain pipe would be inserted into the sand drain material to collect and discharge any seepage water passing through the Dam fill and entering the drain. The ditch alignment to a distance of 10 feet from the toe of the backfilled dam slope would also be covered with geotextile fabric and a layer of erosion protection to provide an amoured ditch surface leading up to the dam.

Such an application could potentially be expanded to a larger slope area along each dam face in the immediate ditch and adjacent areas. However, given the apparent long term stable condition of the adjacent slope areas and the fact that such an enlargement would require more material be delivered to the remote site, it appears that the cost benefit of expanding this alternative may not be warranted at this time.

A. Advantages

1. Re-constitutes original dam section with similar fill.
2. Collects and discharges seepage permeating through the re-constituted dam section.
3. Provides improved erosion protection on the currently impacted dam slopes and ditch areas leading up to the dam.
4. Provides a contained and hardened surface for crocodiles to crawl over when traversing the dam plug area.
5. No need for replanting of Dam side slope areas.

6. Complies with the Parks intent to limit saltwater intrusion and to mitigate against discharge of sediment into Florida Bay.

B. Disadvantages

1. Requires delivery of more dam modification materials to the remote dam sites.
2. Requires more labor and possibly small equipment to affect the restorations.
3. More costly remediation to implement.

2.4.4 Alternative 4: Backfill Eroded Dam Area and Canal Approaching Dam Including Slope Erosion Protection.

Alternative 4 is a modified variation of Alternative 3. In addition to backfilling of the eroded dam areas, the ditches approaching the dam plug would be backfilled to the prevailing adjacent ground level to a distance of 10 feet from the toe of the dam slope with limerock fill. The slopes of the dam plug and the sloped end of the refilled ditch areas including a few feet each side thereof will be covered with a geotextile wrapped sand drain. The geotextile and sand drain would then be covered with erosion protection such as Sakcrete bags or gravel filled Geoweb to mitigate against future erosion on the exposed slope faces. A slotted PVC drain pipe would be inserted into the sand drain material to collect and discharge any seepage water entering the drain behind the erosion protection. Such an application could potentially be expanded to a larger slope area along each dam face in the ditch area. However, given the apparent long term stable condition of the adjacent slope areas and the fact that such an enlargement would require more material to be delivered to a remote site, it appears that the cost benefit of expanding the this alternative may not be warranted at this time.

A. Advantages

1. Re-constitutes original dam section with similar fill.
2. Collects and discharges seepage permeating through the re-constituted dam and ditch backfill slopes.
3. Provides improved erosion protection on the currently impacted Dam slopes and ditch areas leading up to the dam.
4. Provides a contained and hardened slope surface for crocodiles to crawl over when traversing the dam plug area.
5. No need for replanting of dam side slope areas.
6. Complies with the Parks intent to limit saltwater intrusion and to mitigate against discharge of sediment into Florida Bay.

B. Disadvantages

1. Requires delivery of more dam modification materials to the remote dam sites.
2. Requires more labor and possibly small equipment to affect the restorations.
3. More costly remediation to implement.

2.5 Generalized Construction Approach and Sequencing

The following information presents a generalized presentation of the anticipated construction methods and approaches anticipated to be followed in order to complete the anticipated repairs.

Construction Approach and Sequencing

1. Work will be limited to the period of October 1 – March 31.
2. Small labor work force mobilized from Flamingo marina to offload points via shallow draft boats.
   a. Requires overland foot traffic to inland dam sites.
   b. Requires clearing of vegetation along foot path to dam sites. More extensive clearing will be required in the southern House Ditch area north of offload point due to denser Mangrove and other vegetation.
3. Mobilize materials and miscellaneous small equipment to work sites.

   a. Helicopter delivery.
      i. Material purchase and delivery to Flamingo Heliport area from local suppliers.
      ii. Material and small equipment staging and helicopter pickup at Flamingo Heliport.
      iii. Delivery to designated drop zone area adjacent to Dam areas.
      iv. 8000 lbs delivery per trip = 2.0+ CY/Trip. 10 CY will require 5 - 6 Trips per site including incidentals and equipment. 18 CY will require 9 -10 trips per site including incidentals and equipment. Helicopter should be able to supply material in 1.5 days for Alternatives 2 and 3 and 2 days for Alternative 4 assuming up to 5 trips per day.
      v. Short overland movement of material from drop site to Dam site.

   b. Pack mule or horse delivery.
      i. Material purchase and delivery to west end of westernmost Flamingo campground site from local suppliers.
      ii. Perform vegetation clearing of Coastal Prairie Trail as required in overgrown trail areas. Significant clearing will be required between the Clubhouse Beach Trail and the House Dam plug.
      iii. Delivery to dam sites by pack mule or horses. Place water tank for mules/horses at Slagle dam plug.
      iv. 200 lbs./mule or horse with 1 (House Dam) to 1.5 (Slagle Dam) average trips per day = 200 to 300 lbs./day/mule or horse
      v. 10 CY material = approximately 30,000 lbs. = 150 mule or horse days per dam site (i.e. a 15 mule or horses train would require 5.5 days to deliver materials).
      vi. 18 CY material = approximately 55,900 lbs. = 140 horse or mule days per dam site (i.e. a 15 mule or horses train would require 9.5 days to deliver materials).

4. Locally hand trim and clear vegetation/roots from dam repair areas.
5. Hand place and grade fill material in 6 inch lifts as applicable to alternative selected.
6. Compact fill using small vibratory walk behind compactor.
7. Grade and hand place Geotextile Fabric and drain material including slotted PVC pipe as applicable to alternative selected.
8. Hand place Geotextile Fabric and erosion protection as applicable to alternative selected.
9. Inspect and approve completed construction.
10. Cleanup work site and demobilize misc. bags, trash and any equipment from jobsites.
11. Demobilize personnel from job sites.

2.6 Potential Environmental Effects

In general, the Environmental/Permitting concerns consist of the following:

1. Wetland Impacts (Temporary and Permanent)
2. T & E Species (Crocodiles and Eastern Indigo Snakes and others)

3. Mitigation Requirements
4. Wilderness Program Coordination With the Park
5. May require SFWMD ERP (or exemption)
6. USACE Section 404 Consultation
7. NMFS/USFWLS Concurrence

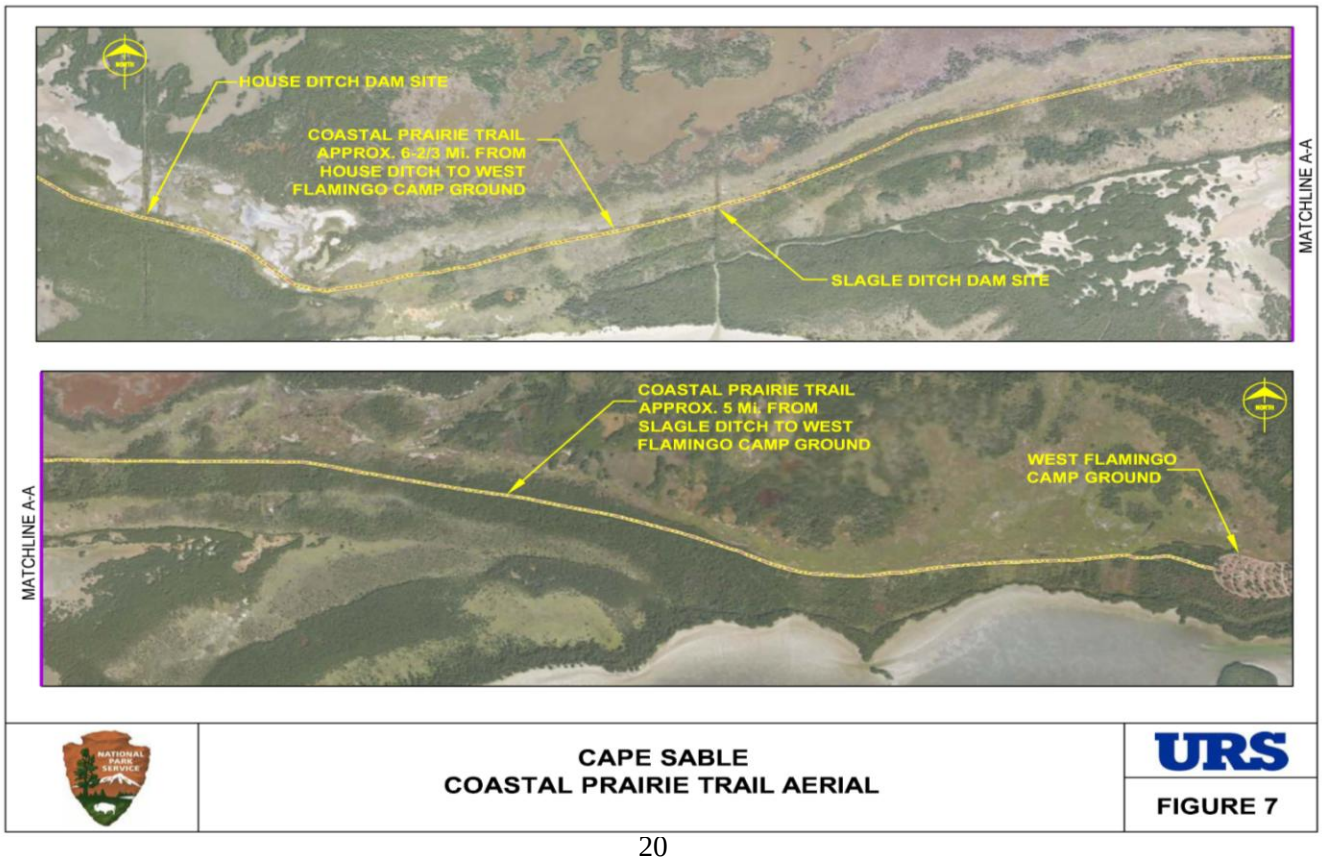
The direct and indirect environmental effects of the proposed alternatives for restoration/repair of House's Ditch dam and Slagle's Ditch dam are discussed in the following sections.

2.6.1 Direct Effects

The direct adverse effects of the proposed build alternatives include vegetation trimming or removal, wetland impacts, potential effects to threatened and endangered species, cultural resource considerations, and potential disturbance to designated Wilderness areas. With the Take No-Action alternative, no construction would take place and current conditions/processes would continue. With the Take No-Action alternative, there would be no direct adverse effect from construction; however, adverse impacts would continue to result from current conditions/processes. The direct adverse impacts from the proposed build alternatives are discussed in the following sections.

2.6.1.1 Vegetation and Wetland Impacts

Unavoidable direct Mangrove and other wetland impacts are likely to result from all of the build alternatives because the existing mangrove trees would need to be trimmed along overland access routes and in the proposed fill areas. **Figure 7** shows the alignment of the Coastal Prairie Trail thru the Park just inland from Florida Bay from its entrance at the west end of the westerly most Flamingo campground site to the Slagle and House ditches.



Unavoidable direct wetland and upland impacts would result from the placement of fill material for the dams. For preliminary planning purposes the following **Table 2.6-1** presents a Preliminary Estimate of Potentially Impacted Areas anticipated for the House and Slagle Dam repairs. The full extent of unavoidable impacts will be more exactly surveyed and quantified in the next phase of the project's development.

Table 2.6-1: Preliminary Estimate of Potential Impacted Areas House and Slagle Ditch Dams

Dam Site	Upland/Top of Dam (1)	North Slope (2)	South Slope (3)	North Canal Ditch (4)	South Canal Ditch (5)	Off load Walking Path (6)	Coastal Prairie Trail (7)	Material Drop Area (8)	Path from Material Drop Area (9)	Canal Mangrove Trimming (10)	Mule Coral and Bedding Area
	SF	SF	SF	SF	SF	SF	LF/SF	SF	SF	LF	SF
House Ditch	200	75	50	100	80	2100	8,300LF* 49,800 SF	5500	1000	150	3500
Slagle Ditch	200	75	40	200	60	3800	27,000LF 162,000SF	5500	1000	50	3500

*Additional distance from Slagle to House Ditch

Notes:

1. Assume 20 ft. X 10 ft. work area on upland top of dam plug.
2. Assumes 15 ft. X 5 ft. north side slope work area for both Dams.
3. Assumes 10 ft. X 5 ft. southern side slope work area for House dam and 8 ft. X 5 ft. southern side slope area for Slagle Dam.
4. Assume 10 ft. wide X 10 ft. long maximum ditch fill for House Ditch and 2 - 10 ft. wide X 10 ft. long maximum ditch fills for Slagle Ditch and secondary channel.
5. Assumes 8 ft. wide X 10 ft. long ditch fill for House Ditch and 6ft. X 10 ft. long ditch fill for Slagle Ditch.
6. Assumes 530 LF and 950 LF X 4 ft. wide walking path area canal from off load points to dam sites for House Ditch and Slagle Ditch dams respectively.
7. Assumes 5.1 mile distance from west campground to Slagle Ditch dam and 6.65 mile distance to House Ditch dam X 6' Wide Trail path. Assumes Coastal Prairie Trail generally passable to horse or mule traffic in a 6 ft. width. Vegetation trimming distances along trail have not been determine at this time, however, it is estimated that some 3000 LF of trail east of the House Ditch has not been more recently clearly and maintained.
8. Assumes $1/8^{th}$ (+) acre area for material/equipment drops by Helicopter.
9. Assumes 150 LF and 200 LF X 6 ft. wide paths from drop areas to dam sites for the House and Slagle Dams respectively. Some of these impacts may be on upland areas of the Coastal Prairie Trail leading up to the dam site plugs.
10. Only limited Mangrove trimming should be required along these canals lengths to partially remove overhanging Mangrove branches or isolated fallen in-canal Mangrove trees which interfere with the safe passage of personal sitting in watercraft transporting workers along the canals to the inland off load points.

It is noted that the area quantities estimated above are preliminary in nature and are based on rough visual estimates of anticipated impacted work and backfill areas at the dam sites and linear footage takeoffs from publically available aerial photographs of the ditch and Coastal Prairie Trail alignments. No detailed surveys including land and topographic, vegetation, archeological or other surveys have been proposed or performed as part of this initial feasibility study and assessment reported herein.

2.6.1.2 Threatened and Endangered Species

Table 2.6-2 details the Federal and State listed species that may potentially occur within the project.

Table 2.6-2: Summary of Threatened and Endangered Species Potentially Occurring within the House and Slagle's Project Area

Scientific Name	Vernacular Name	Federal Status	State Status
Fish			
Rivulus marmoratus	Mangrove rivulus	**C**	**SSC**
Pristis pectinata	Smalltooth sawfish	**E**	**FE**
Reptiles			
Alligator mississippiensis	American alligator	**T(S/A)**	**FT(S/A)**
Crocodylus acutus	American crocodile	**T**	**FT**
Caretta caretta	Loggerhead sea turtle	**T**	**FT**
Chelonias mydas	Green sea turtle	**E**	**FE**
Drymarchon couperi	Eastern Indigo snake	**T**	**FT**
Eretmochelys imbricata	Hawksbill sea turtle	**E**	**FE**
Lepidochelys kempii	Kemp's Ridley sea turtle	**E**	**FE**
Birds			
Mycteria americana	Wood stork	**E**	**FE**
Egretta caerulea	Little blue heron		**SSC**
Egretta thula	Snowy egret		**SSC**
Egretta rufescens	Reddish egret		**SSC**
Egretta tricolor	Tricolored heron		**SSC**
Eudocimus albus	White ibis		**SSC**
Charadrius melodus	Piping plover	**T**	**FT**
Patagioenas leucocephala	White-crowned pigeon		**ST**
Haliaeetus leucocephalus	Bald eagle	**NL**	**NL**
Pandion haliaetus	Osprey		**SSC**
Pelecanus occidentalis	Brown pelican		**SSC**
Platalea ajaja	Roseate spoonbill		**SSC**
Sterna antillarum	Least tern		**ST**
Ammodramus maritimus mirabilis	Cape Sable seaside sparrow	**E**	**FE**
Mammals			
Trichechus manatus latirostris	West Indian manatee (FL manatee)	**E**	**FE**
Eumops floridanus	Florida bonneted (mastiff) bat		**ST**
Plants			
Chamaesyce garberi	Garber's spurge	**T**	**E**
Acrostichum aureum	Golden leather fern		**T**
Catopsis berteroniana	Powdery catopsis		**E**
Chamaesyce porteriana	Porter's sandmat	**C**	**E**
Thrinax radiata	Florida thatch palm		**E**
Vanilla barbellata	Worm-vine orchid		**E**

***E** = Endangered; **T** = Threatened; **C** = Candidate; **T(S/A)** = Threatened due to Similarity of Appearance; **FE** = Federally Endangered; **FT** = Federally Threatened**; FT(S/A)** = Federally Threatened due to Similarity of Appearance; **SSC** = Species of Special Concern; **NL** = Not Listed but protected by the Bald and Golden Eagle Protection Act.*

The extent of potential impacts to threatened and endangered species will be quantified in the next phase of the project's development. Threatened and endangered species protection provisions will need to be incorporated into the project plans and specifications, which address the particular concerns related to each species. However, due to observed usage at the two sites by the American crocodile, it is anticipated that no work could take place during crocodile nesting season from April to September; construction activities for the proposed project would be limited to the months of October through March, during which no American crocodile nesting occurs.

2.6.1.3 Cultural Resources

House's Ditch, Slagle's Ditch, the existing plugs and the Coastal Prairie Trail (proposed overland access route) are all greater than 50-years-old and thus are eligible for consideration as historic cultural resources. An archeological and cultural resources survey will be required for all of these resources. Additionally, Section 106 (of the National Historic Preservation Act) coordination with the SPHO will be required for any potential impacts to these resources.

2.6.1.4 Wilderness

Both of the dam sites, potential access routes, and potential on-site staging areas are located in a designated Wilderness area. A Minimum Tool Assessment form must be prepared and submitted to the park Wilderness Committee. This document must describe any proposed mechanized vehicles and equipment, as well as alternative tools and methods (e.g. pack animals), proposed for construction and transport within wilderness.

2.6.2 Indirect Effects

The indirect effects of the proposed alternatives include adverse and beneficial effects to the environment.

2.6.2.1 Adverse Effects

Fill placement activities associated with all of the proposed build alternatives have the potential to increase turbidity levels during project construction. Therefore, a Water Quality Monitoring Plan will likely be required by the environmental regulatory agencies in order to ensure that State Water Quality Standards are adhered to during construction activities.

With the Take No-Action alternative, indirect adverse impacts would continue to result from current conditions/processes. It is likely that the current erosional processes will eventually cause the dams/plugs along House's Ditch and Slagle's Ditch to fail/breach completely, allowing continued salt water intrusion into the former brackish emergent marshes of interior Cape Sable as well as resulting in the transport of sediment into Florida Bay and the Gulf of Mexico.

Additionally, material deliveries to the dam sites by horse and/or pack mules will result in the trampling of vegetation along the path and deposition of bodily excrement along the Coastal Prairie Trail path leading from the Flamingo west Campground to the dam sites. Visual field observations of hoof marks near the dam sites indicates some animal traffic of this nature presently occurs along the trail however, the concentrated and more frequent passages required for material deliveries to the dam sites will inherently increase the short term excrement nutrient deposition along the trail alignment.

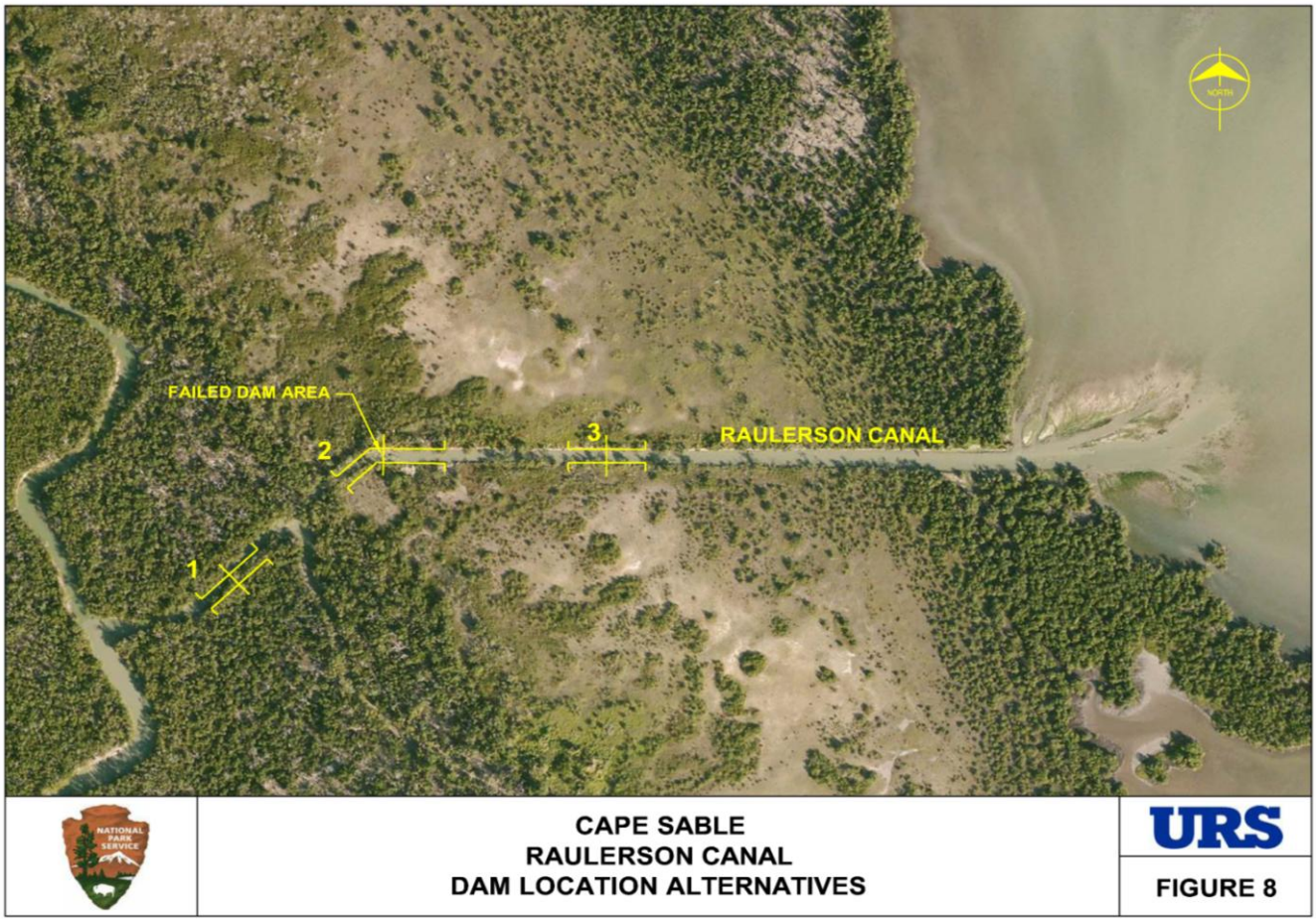
2.6.2.2 Beneficial Effects

All proposed build alternatives are anticipated to provide a positive regional benefit by preventing the complete failure of the existing plugs at the two ditch sites and continuing to restrict tidal intrusion of salt water into the former brackish emergent marshes of interior Cape Sable. Additionally, the dams will limit the discharge of sediment from the inland marshes out into Florida Bay, Historically, Cape Sable was protected from continuous salt water inflows by the marl ridge and elevated trail in the vicinity of House's and Slagle's ditch dams. Tidal waters would only flow into the emergent marshes during seasonal high tide periods or land overtopping events caused by tropical storm or hurricane storm surges. Prior to alteration by humans who created ditch/canal cuts through the marl ridge, the region's brackish emergent marshes experienced much longer hydro-periods of freshwater saturation during the rainy season.

The existing plugs/dams were intended to restrict this unnatural level of saltwater intrusion; however, they are in danger of imminent failure. The proposed build alternatives would stabilize the dams and continue to limit and restrict the salt water inflows thus providing a beneficial effect. Additionally, repair of the dams will reduce the chance of plug failure leading to further ditch erosion and sediment transport into Florida Bay and the Gulf of Mexico as an additional benefit. With the Take No - Action alternative, there would be no beneficial indirect effects.

3.0 Raulerson Canal Assessments

The Raulerson Canal shown on **Figure 8** is the most northern of the manmade canals that cross the marl ridge leading into the approximately 20 square mile brackish interior wetland complex of the Cape Sable region. This canal crosses the ridge near the northwestern end of Lake Ingraham near Middle Cape Canal so it is exposed to tidal influence from Florida Bay and the Gulf of Mexico. The Raulerson Canal connects into the Little Sable Creek which connects directly into Lake Ingraham just east of the Middle Cape entrance into Lake Ingraham from the Gulf of Mexico.



The Middle Cape Canal connecting North Lake Ingraham to the Gulf of Mexico is wider than East Cape Canal and as such, flow into the northern end of Lake Ingraham is believed to exceed flow into the southern end of the lake from the East Cape and Ingraham Canals. Tidal range in Lake Ingraham near the Raulerson Canal is on average about 3.5 feet but is seasonally higher during summer and early fall.

The Canal itself as shown in **Figure 8** initially consisted of a linear ditch formed by shallow mechanical excavation just into the naturally occurring lime mud surficial soil deposit. Based on the review of early aerial photographs and other literature, the canal was believed to have been excavated to the Little Sable Creek prior to the original canal dam construction. The westerly most portion of the canal appears to be constructed in lower ground areas dominated by Mangrove vegetation. This western section has become interconnected with other branching creeks west of the

marl ridge and appears to have become widened by tidal related erosion to its present day width and depths.

The surficial lime mud soils which exist along the canal alignment likely overlays a lower limestone base rock that is anticipated to exist over much of the southern Cape Sable region, particularly in the areas of the dams being addressed by this report. In the area of the Homestead and East Cape Extension Canal Dams, the surficial lime mud soil was found to be typically 8 -10 feet deep, is cohesive but very, very soft in consistency and strength and is highly erodible under the flowing action of water. For initial reference purposes, soil profiles obtained from soil borings obtained at the Homestead and East Cape Extension Canal dams are included as Appendix B.

An earthen plug, probably about 18 feet long and 20 feet wide, was initially installed on the Raulerson Canal about 1956 but by early 2005 it was only about 12 feet long. Hurricanes Katrina and Wilma caused significant storm surges in the Cape Sable region that helped to uproot a number of Black Mangrove trees growing on this earthen plug. The subsequent loosening and loss of soil from this uprooting coupled with the storm surge from Hurricane Wilma reduced the length of the plug to about 6 feet. In May of 2007 the first signs of piping or seepage through the earthen material of the plug were detected and by November 2007, the plug had been breached completely and water began to flow in and out of the interior wetlands through the canal.

Photo 5
Repaired Raulerson Canal Plug

Two separate repair efforts have been undertaken on the Raulerson Canal since the initial breach occurred. The first repair was in December 2007 and the second repair was in March 2008. During the second repair effort as shown in **Photo 5**, Everglades National Park maintenance staff used approximately 100,000 pounds of material (760 sand bags, 1240 bags of Sakcrete, wire baskets, and geo-fabric) to restore the canal dam/plug to its former dimensions.

Photo 6
Failed Raulerson Dam Repair

The plug reportedly settled somewhat over the next several months and inspectors noted some signs of erosion on the marine face of the plug and some evidence of seepage piping through the plug in the summer of 2008.

By the fall of 2009 as shown on **Photo 6** the repair had failed catastrophically and salt water was observed flowing freely through the canal. As of November, 2010, the breach was roughly 20 feet wide and nearly the same width as the canal. Inspection of the breach and canal in December, 2011 indicated the canal and breach had widened further to approximately a 25 foot width.

As shown in **Photo 7**, the Raulerson Canal continues to erode rapidly and the volume of salt water entering the interior marshes, and volume of fresher water flushed from the marshes, is expected to also increase. This is the same scenario that existed with the failed Homestead and East Cape Canal Extension dams before the recently completed dam projects blocked flow through these canals. The increased salinity resulting from the failed Raulerson Dam will most likely lead to degraded habitat for juvenile crocodiles and wading birds in the northern portion of the Cape Sable interior marshes. This area is vital habitat for the population of small fish that serve as the food base for roseate spoonbills, wood storks, and other wading birds and game fish. Furthermore, the breach is now large enough for motorized and other vessels to pass through, opening the door to illegal access to the Cape Sable wilderness. The failed dam debris remaining in the canal represents a safety hazard to anyone trying to boatover the failed dam plug and adjacent areas.

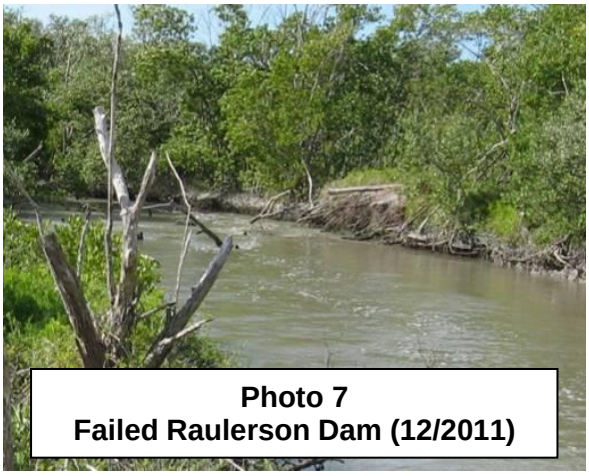


Photo 7
Failed Raulerson Dam (12/2011)

3.1 Raulerson Canal Logistics Issues

Restoration of the Raulerson Canal Dam involves the need to address several major logistical issues in order to affect any dam replacement work. In short, the remote location of the dam's interior to the Park and access restrictions in getting to the dams sites, will present very challenging obstacles for moving personnel, materials and any equipment to perform the dam remediation work.

A summary listing of logistical considerations is presented as follows:

1. Failed dam materials remaining in canal bottom may inhibit access to dam locations and will require localized mechanical excavation along with channel shoal material to facilitate access.
2. Smaller canal cross section at present time – enlarging monthly due to tidal driven higher flows along the canal into interior marsh areas.
3. Canal west of the failed dam area is smaller (Est. 20' – 25'), winding with a partial overhanging Mangrove canopy.
4. Narrow canal widths and tight/sharp turns will limit barge sizes capable of navigating back into the canal.
5. The overhanging Mangrove canopy will be required to be significantly cut back to facilitate barge and equipment access along the canal.
6. Canal Entrance from Lake Ingraham is near the Gulf of Mexico side hence stronger tidal flows, wind and wave issues will be a concern especially to barge movements in and out of Lake Ingraham.
7. Small shoal area exists at Little Sable Creek entrance from Lake Ingraham and at 90 degree entrance/turn into the Raulerson canal which may require localized mechanical excavation of shoal material to facilitate access.
8. Material/equipment mobilization by barge from off-site areas will be required.
9. Potential need to stage barge(s) in Lake Ingraham just outside of Little Sable Creek entrance.

3.2 Raulerson Canal Dam Replacement Alternatives

URS was tasked with evaluating three (3) or more alternatives including a Take No-Action alternative and additional alternatives for re-construction of the Raulerson dam to an original or better condition. Alternatives selected are generally described as follows:

3.2.1 Alternative 1 – Take No-Action

The Take No-Action alternative involves leaving the failed dam in its present condition and allowing the canal to continue to erode, widen and transport suspended sediment to the inland marshes as well as to Florida Bay and the Gulf of Mexico. However this alternative fails to accomplish the primary goals of the National Park Services which is to limit the flow of salt water into the interior fresh water marshes; thereby enhancing the natural hydrology and salinity of the inland Cape Sable Region north of the marl ridge. Restoring the hydrology and salinity of the marshes upstream of marl ridge should enhance the wetland habitat for wading birds, juvenile crocodiles and other wildlife. The Take No-Action alternative is not a feasible solution because it does not achieve the goal of limiting saltwater intrusion, reducing erosion and sediment transport and providing the habitat protection required by the National Park Service.

The next three alternatives were determined to be feasible as a result of the preliminary engineering analysis. An overview of the planned construction method is provided, in addition to discussing the advantages and disadvantages of each alternative, and material and equipment access issues. The preliminary environmental impacts associated with each alternative are discussed in a later section of the report.

3.2.2 Alternative 2 - Sheet Pile Only Dam with Rip Rap Erosion Protection

This alternative as shown on **Figure 9**, involves constructing a canal dam cut off comprised of cross canal steel sheet piling with sheet pile protected canal side banks extending up to 200 feet up and down stream of the dam cutoff for both sides of the cross canal sheet pile section. This design would provide a cross canal cutoff which would not be subject to internal erosion and end around seepage failure. This design would be an expanded version of the cross canal sheet piling design used earlier for the Homestead and East Cape Canal cutoffs constructed in the later 1990's.

Three (3) suggested locations were initially considered as being potentially viable for the Raulerson replacement dam construction as shown in earlier **Figure 8**.

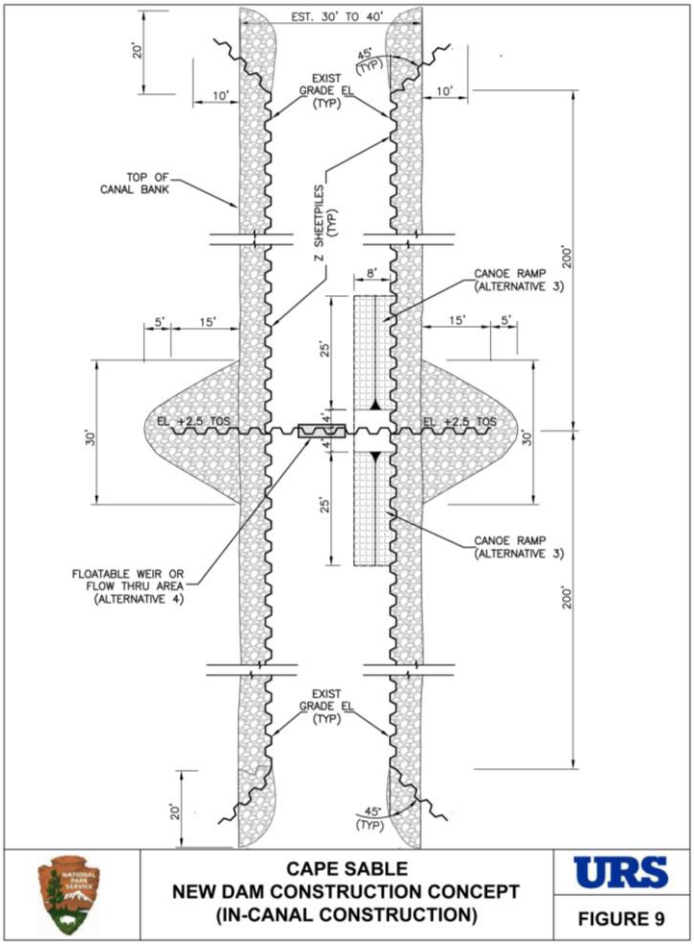
Location 1 - was situated west of the original failed dam location in the heavily vegetated and topographically lower Mangrove dominated area west of the Marl ridge. This area was not deemed suitable due to the anticipated lower ground topography and the dam construction in the dense Mangroves. A side creek also exists north and east of this conceptual location which could potentially facilitate flows around the dam location and into the Raulerson Canal from southern areas. This location would not meet the Parks objective of limiting saltwater intrusion into the inland marsh areas and was rejected from further consideration.

Location 2 - was situated at the failed dam site. This location had an initial advantage that the northern side of the canal is at a much higher elevation and would provide a topographic barrier to end around flows of the dam to the north. The higher land topography north of this dam location is believed due to elevations associated with the Flamingo Embankment (i.e. Marl Ridge) and/or possible filling for Coastal Prairie Trail alignment in the mid to later 1900s. This location has two other problematic considerations in that some of the present failed dam material remains in-place or

downstream in the bottom of the canal and would potentially have to be removed by mechanical dredging to allow for barge access and sheet pile installation. Additionally, the southern side of this dam location appears visually to be a topographically lower area and overland high/high tide flows would be more concentrated around and south of the dam location.

Location 3 was at the center of the apparent Flamingo Embankment/marl ridge east of the present failed dam section. This location is topographically more level on each side of the canal in the natural adjacent land surface elevations. This site also has the problematic consideration of the need to remove failed dam debris in the canal at the filed dam site in order to provide access past the original failed dam location.

The design of the dam as shown on **Figure 9** would include a cross canal sheet pile section constructed at a top elevation of +2.5 ft.-NAVD to essentially prevent any over-topping down the canal during normal tidal fluctuations and high/high tide events during the normal course of the year. The initial elevation was selected based on tide ranges at the off-shore Naples Monitoring Station which indicates that maximum normal tidal fluctuations in the 1.75 – 2.0 ft. NAVD elevation range are to be expected.



A slight modification to this design will be considered during subsequent modeling phases for the dam. This modification may include dropping the central 10 to 15 feet of the cross dam sheet piling section down to the elevation of the adjacent prevailing ground surface. This modification will allow overland flows to pass thru the at grade dam opening as well as overland around the dam. Flows allowed over the middle dam section will reduce flows around the perimeter areas therein facilitating more flows through the sheet pile protected areas of the dams and adjacent canals. Additionally, dropping of the top elevation of the cross canal sheet piling below the initially proposed +2.5 ft. NAVD elevation will also be evaluated during subsequent modeling efforts.

The area around the inland extension and around the ends of the inland sheet piling would be armoured with geotextile covered by 12 inch average to 18 inch sized rip rap needed to mitigate erosion action immediately adjacent to and at the end of the sheets. The cross canal sheet piling section would be extended some 15 feet inland from the canal to seat the cross canal dam well into the adjacent land surface. The area around the inland extension and around the inland end of the inland sheet piling would be armoured with geotextile and rip rap to mitigate flow related erosion action adjacent to the sheets. Rip rap would be of a 12 inch average to 18 inch maximum size stone.

In addition to the cross canal sheets, as shown on **Figure 9**, sheet piling would be installed along both canal banks of the canal both upstream (i.e. inland side) and downstream (i.e. Lake Ingraham side) of the canal cutoff. This side bank sheet piling would be installed within a few feet of the edge of the pre-existing canal and would be driven to an elevation of 0.0 to -0.5 feet below the prevailing ground surface. The intent of the side bank sheet piling is to allow for overland high tide events to flow around the cross canal cutoff sheet piling and then to re-enter the canal by flowing back over the top of the side bank sheet piling. The gap area between the side bank sheets and the eroded canal side bank would be backfilled with sand fill to within 2 feet of the top of the sheets, a geotextile filter fabric will then be placed and the remainder of the gap would be filled with rip rap stone up to an 18" max, 12" average size rock. The side bank canal sheet piling and rip rap would provide an amoured and protected overflow region both upstream and downstream of the main dam cutoff that would not become eroded by such over topping events. For preliminary estimating purposes, a 200 foot long sheet piled section either side of the dam is being estimated. Once field topographic surveying is completed for the selected dam site area, hydraulic modeling will be performed to evaluate the wrap around flows from overtopping events and adjustments to the length of side bank sheet piling may be required as part of the EA permit application and subsequent detailed design for the dam replacement.

A. Advantages

1. Re-constructs the dam and canal flow cutoff provided by the original canal plug.
2. Provides longer term erosion protection for overland flows around the dam.
3. Complies with the Parks intent to limit saltwater intrusion and to mitigate against discharge of sediment into Florida Bay and the Gulf of Mexico.

B. Disadvantages

1. Requires mobilization of barge mounted equipment capable of lifting and driving 20 foot long sheet piling.
2. See other logistics issues listed in earlier Section 3.1.

3.2.3 Alternative 3 - Sheet Pile Dam with Canoe Ramp and Rip Rap Erosion Protection

Alternative 3 is essentially the same as Alternative 2 except that the concept design will include as shown on **Figure 9**, a canoe access ramp area for the portage of canoes and kayaks over the dam sheet piling. Due to the relatively narrow width of the canal, a ramp width of 8 feet is initially proposed however, a 10' wide ramp could be provided. The ramp area will be horizontally contained and protected by sheet piling and in-filled with #57 coarse stone gravel. A concrete in-filled geotextile/geoblock system will be used to cover the 4H:1V sloping surface of the ramp between the sheet piling and a wooden lattice cover will be installed to provide a foot hold for the porting recreationist as well as to provide a protective layer to prevent damage to watercraft entering the ramp area.

A. Advantages

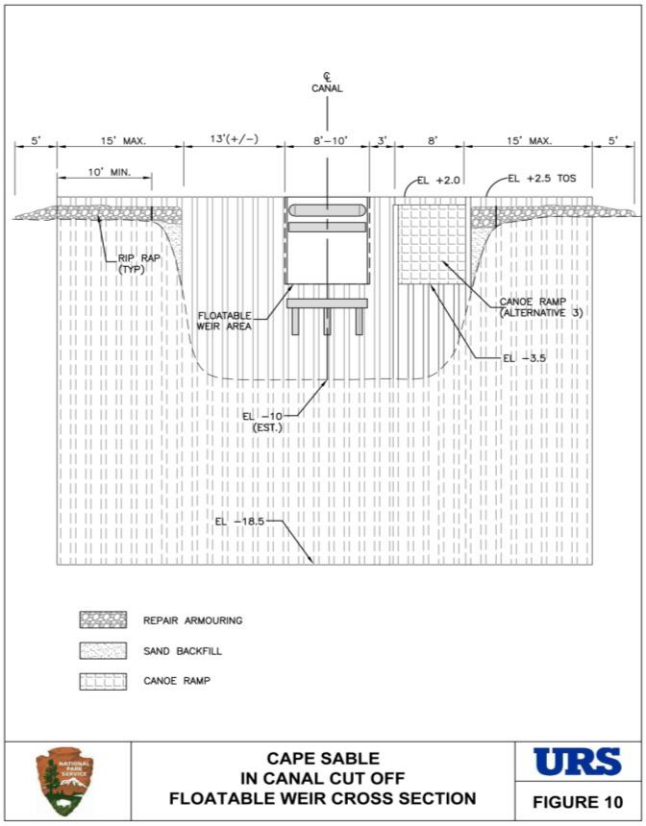
1. Re-constructs the dam and canal flow cutoff provided by the original canal plug.
2. Provides longer term erosion protection for overland flows around the dam.
3. Provides recreational access for canoeist and kayakers into the inland marshes.
4. Complies with the Parks intent to limit saltwater intrusion and to mitigate against discharge of sediment into Lake Ingraham, Florida Bay and the Gulf of Mexico.

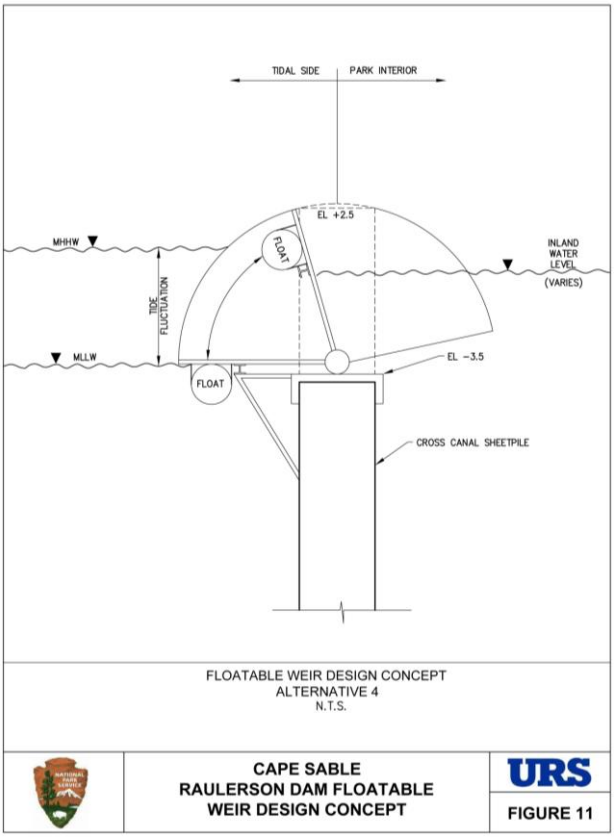
B. Disadvantages

1. Requires mobilization of barge equipment capable of lifting/ driving 20 foot long sheet piling.
2. Requires delivery a small volume of gravel plus fabric/geoblock/sakcrete and fabricated wood latticework.
3. More costly and difficult to construct compared to Alternative 2.
4. See other logistics issues listed in earlier Section 3.1

3.2.4 Alternative 4 - Sheet Pile Dam with Flow Discharge and Rip Rap Erosion Protection

Alternative 4 is a modification of Alternative 2 in that an overflow discharge mechanism as conceptionally shown on **Figures 10 and 11** could potentially be incorporated into the dam which will allow for the outbound flow of brackish water from the Park during the periods of low tide levels on the tidally influenced downstream side of the cutoff dam. It is desirable from a water quality perspective to allow some of the brackish water that is being contained and mounded inland of the dam in the Cape Sable region to be discharged back to tide in a controlled manner over the floatable weir and through the cross canal sheet pile section during those times when inland and upstream water levels become elevated relative to lower tide levels downstream of the dam.





Such an included option would potentially help improve water quality in the inland marsh if it is assumed that overland inflow volumes of salt water do not exceed freshwater and rainfall volumes entering the Cape Sable region. Such outbound discharges of brackish water would also potentially help to provide flushing of canal and Mangrove areas downstream of the dam. Alternative 3 however, would potentially present a hazard concern to recreationalist attempting to portage up to and around

the dam during low tide periods when the dam overflow weir structure is releasing flows. Additionally, recreationalist may attempt to travel out of the backcountry by canoeing/kayaking over the dam during those periodic short term flows and releases through/over the dam structure.

A. Advantages

1. Re-constructs the dam and canal flow cutoff provided by the original canal plug
2. Provides longer term erosion protection for overland flows around the dam
3. Provides discharge of inland brackish water buildup during low tide conditions downstream of the dam.
4. Complies with the Parks intent to limit saltwater intrusion and to mitigate against discharge of sediment into Lake Ingraham, Florida Bay and the Gulf of Mexico.

B. Disadvantages

1. Requires mobilization of barge equipment capable of lifting and driving 20 foot long sheet piling.
2. Requires fabrication offsite and delivery of a flow control mechanism to allow flow over the structure during low downstream tide conditions; Such a structure may require periodic scheduled inspections, maintenance and debris clearing during operation.
3. More costly and difficult to construct compared to Alternative 2
4. Increased long term maintenance requirements and costs
5. See other logistics issues listed in earlier Section 3.1

3.2.5 Alternative 5 - Sheet Pile Dam with Canoe Ramp, Flow Discharge and Rip Rap Erosion Protection

Alternative 5 is an expanded modification of Alternative 4 in that both the Alternative 3 canoe ramp and Alternative 4 flow discharge mechanism could potentially be incorporated into the dam. This alternative would allow direct portage over the dam for recreationalists as well as the outbound flow of brackish water from the Park during low tide levels on the downstream side of the dam.

Due to the relatively narrow width of the canal, a ramp width of 8 feet is initially proposed however, a 10’ wide ramp could potentially be provided if future surveys indicate there is adequate canal width to include both. The ramp area will be horizontally contained and protected by sheet piling and infilled with #57 coarse stone gravel. A concrete infilled geotextile/geoblock system will be used to cover the 4H:1V surface of the ramp between the sheet piling and a wooden lattice cover will be installed to provide a foot hold for the porting recreationist as well as to provide a protective layer to prevent damage to their watercraft.

With this option, it is potentially desirable to allow brackish water that is being contained and mounded inland of the dam in the interior Cape Sable region, to be discharged in a controlled manner through the cutoff sheet pile section during those times when upstream water levels become elevated relative to low tide levels downstream of the dam.

Such an included option would potentially help improve water quality in the inland marsh if it is assumed that overland inflow volumes of salt water do not exceed freshwater rainfall volumes entering the Cape Sable region. Such discharges and would also potentially help to provide brackish water flushing of canal and Mangrove areas downstream of the dam. Alternative 5 however, would potentially be a hazard concern to recreationalist attempting to portage up to and around the dam or

out of the inland marsh and over the dam due periodic short term flows through/over the dam structure.

A. Advantages

1. Re-constructs the dam and canal flow cutoff provided by the original canal plug
2. Provides longer term erosion protection for overland flows around the dam
3. Provides portage access for recreationalists via canoes and kayaks
4. Provides discharge of inland brackish water buildup during low tide conditions downstream of the dam.
5. Complies with the Parks intent to limit saltwater intrusion and to mitigate against discharge of sediment into Lake Ingraham, Florida Bay and the Gulf of Mexico.

B. Disadvantages

1. Requires mobilization of barge equipment capable of lifting and driving 20 foot long sheet piling
2. Requires delivery a small volume of gravel plus geotextile fabric/Geoblock/Sakcrete and fabricated wood latticework
3. Requires fabrication offsite and delivery of a flow control mechanism to allow flow over the structure during low downstream tide conditions. Such a structure may require periodic scheduled inspections, maintenance and debris clearing during operation
4. More costly and difficult to construct compared to Alternative 2 and 3.
5. Increased long term maintenance requirements and costs
6. See other logistics issues listed in earlier Section 3.1

3.3 Generalized Construction Approach and Sequencing

The following information provides a generalized presentation of the anticipated construction approach and sequencing anticipated to be followed in order to complete the anticipated dam replacement at the selected Raulerson Canal Dam site.

Construction Approach and Sequencing

1. Work will be limited to the period of October 1 – March 31.
2. Prepare and submit required upfront submittals for the work in sufficient time to begin work on October 1. Prefabricate overflow structure components at offsite fabrication shop.
3. Mobilize Barges/Equipment from offsite staging areas in the Florida Keys or elsewhere.
   a. Approval of offsite staging area anticipated to be required by permitting documents.
   b. Comply with all on-site environmental monitoring requirements during the duration of construction.
4. Mobilize daily work force from Flamingo marina.
5. Dredge Little Sable Creek entrance area shoal, shoals along creek and at entrance to the Raulerson Canal and old failed dam material in canal alignment sufficient to provide barge access.
   a. Comply with all environmental monitoring requirements specific to dredging activities as well as other general on-site site monitoring required during construction.
   b. Dispose of dredge spoil offsite or at an approved and permitted spoil disposal area in the Park.

6. Complete significant Mangrove clearing and trimming along west access canals and at the approved dam site area including isolated clearing for inland sheet pile sections.
7. Acquire and deliver sheet piling and other materials to jobsite.
   a. Deliver materials from offsite staging areas or,
   b. Temporarily deliver and store materials in Flamingo maintenance yard area and subsequently load and deliver from Flamingo Marina (West Bulkhead) with Park approval and coordination.
8. Drive easternmost sheet pile from barges and install backfill and rip rap erosion protection for eastern half of dam.
9. Drive canal cutoff sheets, canoe ramps sheets and westernmost sheet piling.
10. Install canoe ramp and overflow structure(s) depending on the approved and permitted Alternative(s).
11. Install sheet pile backfill and rip rap erosion protection around cutoff dam area and along westernmost canal sheet piling.
12. Perform necessary startup and overflow weir adjustments.
13. Secure final inspection and Substantial Completion Notice.
14. Cleanup and demobilize remnant materials and equipment including barges from dam site.
15. All work and demobilization to be completed by March 31.

3.4 Potential Environmental Effects

For the purpose of this Feasibility Report, the Potential Environmental Effects are anticipated to be very similar for both the Raulerson canal and East Side Creek dam sites. In general, the Environmental and Permitting concerns for both dam sites consist of the following:

- Wetland Impacts (Temporary and Permanent)
- Significant Mangrove Trimming and Removal
- Minor Dredging of small shoals at entry points from Lake Ingraham and at East Side Creek and dredge removal of failed dam materials in the Raulerson Canal.
- Minor Dredging of shoal areas in the access channels leading up to the selected dam site.
- Threatened and Endangered Species
- Mitigation Requirements
- Wilderness Program Coordination With the Park
- Requires SFWMD ERP
- USACE Section 404 Consultation
- NMSF/USFWLS Concurrence
- NMFS/USFWLS Concurrence

The direct and indirect environmental effects of the proposed alternatives for construction of dams along the Raulerson Canal as well as the East Side Creek are discussed in the following sections.

3.4.1 Direct Effects

The direct adverse effects of the proposed build alternatives include potential dredging and spoil disposal, vegetation trimming or removal, wetland impacts, potential effects to threatened and endangered species, and potential disturbance to designated Wilderness areas. With the Take No-Action alternative, no construction would take place and current conditions/processes would continue. With the Take No-Action alternative, there would be no direct adverse effect from construction; however, adverse impacts would continue to expand due to the result from current erosional conditions/processes. The direct adverse impacts from the proposed build alternatives are discussed in the following sections.

3.4.1.1 Dredging and Spoil Disposal

All of the build alternatives for construction of dams along the Raulerson Canal and East Side Creek may require mechanical dredging to some limited degree in order to transport heavy equipment and materials by barge to the proposed dam construction sites. For access to both dam sites, some localized dredging/excavation may be required in high energy areas such as at a small shoal area adjacent to the access entrances from Lake Ingraham into the Little Sable Creek and from the East Cape Canal into East Side Creek. Additionally, for the Raulerson Canal site, dredging may be required to remove small shoals at the entrance from Little Sable Creek into the Raulerson Canal as well as for removal of previous dam debris remaining in the vicinity of the former failed dam. Best Management Practices (BMPs) for sedimentation and erosion control will need to be incorporated into a Storm Water Pollution Prevention Plan (SWPPP) to be developed for any proposed dredging activities as well as for the dam site construction.

Deposition of dredged spoils may also be directed to offsite or out of park areas or may potentially be proposed within the benthic habitat of Lake Ingraham in order to limit disposal costs and the number of barge loads needed to deposit dredged spoils. Correspondingly, a benthic survey will also be required within any proposed spoil containment and surrounding area within Lake Ingraham for review, approval and permitting by the agencies. BMPs for sedimentation and erosion control in any such areas will also need to be incorporated into the SWPPP for the proposed spoil deposition activities.

3.4.1.2 Vegetation and Wetland Impacts

Unavoidable direct mangrove impacts are likely to result from all of the build alternatives proposed because the existing Mangrove trees would need to be trimmed along water access routes and in the proposed dam and fill areas. The placement of steel sheet pile associated with any of the proposed build alternatives may also result in unavoidable Mangrove impacts. Unavoidable direct wetland and upland impacts would result from the placement of fill material for the dams and creation of a canoe/kayak portage. For preliminary planning purposes, **Table 3.4-1** presents a Preliminary Estimate of Potentially Impacted Areas anticipated for the Raulerson Canal and East Side Creek dam construction projects. The full extent of unavoidable impacts will be more exactly surveyed and quantified in the next phase of the project's development.

Table 3.4 – 1: Preliminary Estimate of Potential Fill Volumes and Impacted Areas Raulerson Canal and East side Creek

Dam Site	Sheet Pile Wall Installation	Mangrove Trimming Along Access Route	Inland Sheet Piling Wetland Clearing	Volume of Rip Rap for Inland Cutoff Wall	Canal Sand Fill Behind Sheet Piling	Canal Rip Rap Behind Sheet Piling	Canal Rip Rap at End of Sheet Pile Wall	Canoe Ramp Sheet Piling	Canoe Ramp Fill Volume	Dredging Volume	Barge Staging Area
	LF	LF	SF	CY	CY	CY	CY	LF	SF	CY	SF
Raulerson Canal	910	2600	1000	90	300	160	340	74	170	350	10,000
East Side Creek	910	5800	1000	90	300	160	340	74	170	700	10,000

It is re-stated that the area quantities and volumes estimated above are preliminary in nature and are based on rough visual estimates of anticipated impacted work and backfill areas at the dam sites and linear footage takeoffs from publically available aerial photographs of the ditch and East Side Creek alignments. No detailed surveys including land and bathymetric, vegetation, archeological or other surveys have been proposed or performed as part of this initial feasibility study and assessment reported herein.

3.4.1.3 Threatened and Endangered Species

Table 3.4-2 details the Federal and State listed species that have the potential to occur within the project area or which may be affected by the barge movement within the access routes.

Table 3.4-2: Summary of Threatened and Endangered Species Potentially Occurring within the Raulerson and East Side Creek Project Area

Scientific Name	Vernacular Name	Federal Status	State Status
Fish			
Rivulus marmoratus	Mangrove rivulus	**C**	**SSC**
Pristis pectinata	Smalltooth sawfish	**E**	**FE**
Reptiles			
Alligator mississippiensis	American alligator	**T(S/A)**	**FT(S/A)**
Crocodylus acutus	American crocodile	**T**	**FT**
Caretta caretta	Loggerhead sea turtle	**T**	**FT**
Chelonias mydas	Green sea turtle	**E**	**FE**
Drymarchon couperi	Eastern Indigo snake	**T**	**FT**
Eretmochelys imbricata	Hawksbill sea turtle	**E**	**FE**
Lepidochelys kempii	Kemp's Ridley sea turtle	**E**	**FE**
Birds			
Mycteria americana	Wood stork	**E**	**FE**
Egretta caerulea	Little blue heron		**SSC**
Egretta thula	Snowy egret		**SSC**
Egretta rufescens	Reddish egret		**SSC**
Egretta tricolor	Tricolored heron		**SSC**
Eudocimus albus	White ibis		**SSC**
Charadrius melodus	Piping plover	**T**	**FT**
Patagioenas leucocephala	White-crowned pigeon		**ST**
Haliaeetus leucocephalus	Bald eagle	**NL**	**NL**
Pandion haliaetus	Osprey		**SSC**
Pelecanus occidentalis	Brown pelican		**SSC**
Platalea ajaja	Roseate spoonbill		**SSC**
Sterna antillarum	Least tern		**ST**
Ammodramus maritimus mirabilis	Cape Sable seaside sparrow	**E**	**FE**
Mammals			
Trichechus manatus latirostris	West Indian manatee (Florida manatee)	**E**	**FE**
Eumops floridanus	Florida bonneted (mastiff) bat		**ST**
Balaenoptera physalus	Finback whale	**E**	**FE**
Megaptera novaeangliae	Humpback whale	**E**	**FE**
Eubalaena glacialis	North Atlantic right whale	**E**	**FE**
Balaenoptera borealis	Sei whale	**E**	**FE**

Scientific Name	Vernacular Name	Federal Status	State Status
Physeter macrocephalus	Sperm whale	**E**	**FE**
Plants			
Chamaesyce garberi	Garber's spurge	**T**	**E**
Acrostichum aureum	Golden leather fern		**T**
Catopsis berteroniana	Powdery catopsis		**E**
Chamaesyce porteriana	Porter's sandmat	**C**	**E**
Thrinax radiata	Florida thatch palm		**E**
Vanilla barbellata	Worm-vine orchid		**E**

***E** = Endangered; **T** = Threatened; **C** = Candidate; **T(S/A)** = Threatened due to Similarity of Appearance; **FE** = Federally Endangered; **FT** = Federally Threatened; **FT(S/A)** = Federally Threatened due to Similarity of Appearance; **SSC** = Species of Special Concern; **NL** = Not Listed but protected by the Bald and Golden Eagle Protection Act.*

The extent of potential impacts to threatened and endangered species will be quantified in the next phase of the project's development. It is anticipated and known from field observations that Crocodiles inhabit the proposed dam areas consequently, construction activities will be precluded from occurring during their nesting season from April 1 to September 31 of any calendar year. Threatened and endangered species protection provisions will need to be incorporated into the project plans and specifications, which address the particular concerns related to each species.

3.4.1.4 Cultural Resources

The Raulerson Canal is greater than 50-years-old and thus is eligible for consideration as an historic cultural resource. Therefore, performance of an archeological and cultural resources survey will be required. Additionally, Section 106 (of the National Historic Preservation Act) coordination with the SPHO will be required for any potential impacts to this resource.

3.4.1.5 Wilderness

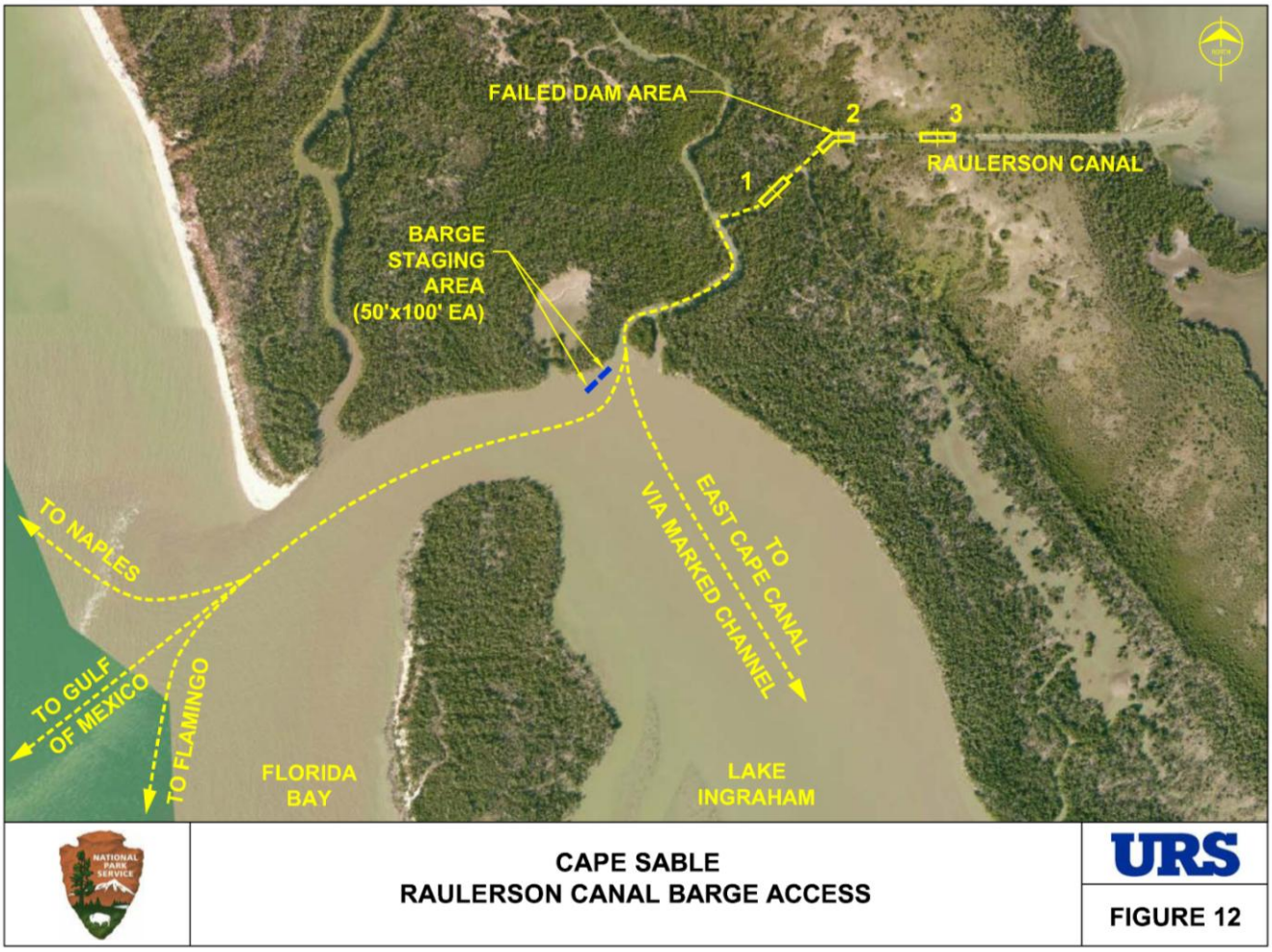
Both of the proposed dam sites, potential access routes, and potential on-site staging areas are located in a designated Wilderness area. A Minimum Tool Assessment form must be prepared and submitted to the park Wilderness Committee. This document must describe any proposed mechanized vehicles and equipment, as well as alternative tools and methods proposed for construction and transport within wilderness.

3.4.2 Indirect Effects

The indirect effects of the proposed alternatives include adverse and beneficial effects to the environment.

3.4.2.1 Adverse Effects

Barge movement and/or staging within the shallow coastal marine environments of the Gulf of Mexico, Florida Bay, and Everglades National Park has the potential of creating adverse impacts to benthic resources such as sea grass beds, hard bottom communities, and shallow oyster beds. Therefore, a barge routing plan as shown on **Figure 12** will need to be established for the project permitting and design which limits the potential for adverse effects from grounding, prop dredging, and/or prop wash associated with barge and crew boat navigation to and from the project site.



Offshore staging and barging routes into the East Cape Canal have been previously defined during the design of the Homestead and East Cape Canal extension dams. Such information may be useful in supporting the construction of the East Side Creek dam site and to a lesser extent, the Raulerson Dam site. It will be necessary during subsequent phases of the project to perform bathymetric studies in the north Lake Ingraham and Middle Cape Canal areas for the purpose of delineating channelized routes for the movement of barges into the existing access creeks leading to the Raulerson Canal. Some concern has been expressed by the Park regarding the potential existence of a shoal area exterior to the Middle Cape Canal similar to that at the entrance to the East Cape Canal. Such a shoal would potentially limit barge access to high tide events. The natural channel alignment thru Lake Ingraham is well delineated with channel markers. It should also be noted that during recent (March 2012) minor repairs performed at the East Cape Canal extension and Homestead dam sites. a

local marine contractor from the Florida Keys was capable of accessing the Flamingo Marina through Florida Bay.

Temporarily increased nutrient loading in the near shore environment has the potential of occurring as a result of the proposed dredging. Dredging of anaerobic calcareous marine clay and silt sized sediments has the potential of releasing nutrients such as phosphorous, ammonia, nitrite and nitrate into the water column. In addition, hydrogen sulfide and iron sulfide may be released from these anaerobic sediments. These nutrients and minerals, when released into the shallow coastal marine environment of Lake Ingraham, Florida Bay and the Gulf of Mexico have the potential of facilitating the growth of algal blooms that may become harmful to benthic resources and other marine organisms. Dredging, barge movements, and fill placement activities associated with all of the proposed build alternatives also have the potential of increasing turbidity levels during project construction. Therefore, a Water Quality Monitoring Plan will likely be required by the environmental regulatory agencies in order to ensure that State Water Quality Standards are adhered to during all aspects of the proposed dredging and construction activities.

With the Take No-Action alternative, indirect adverse impacts would continue to result from current conditions/processes. It is likely that the current erosional processes will continue to cause the Raulerson Canal and East Side Creek to widen, allowing continued salt water intrusion into the former brackish emergent marshes of interior Cape Sable as well as resulting in the transport of sediment into Florida Bay and the Gulf of Mexico.

3.4.2.2 Beneficial Effects

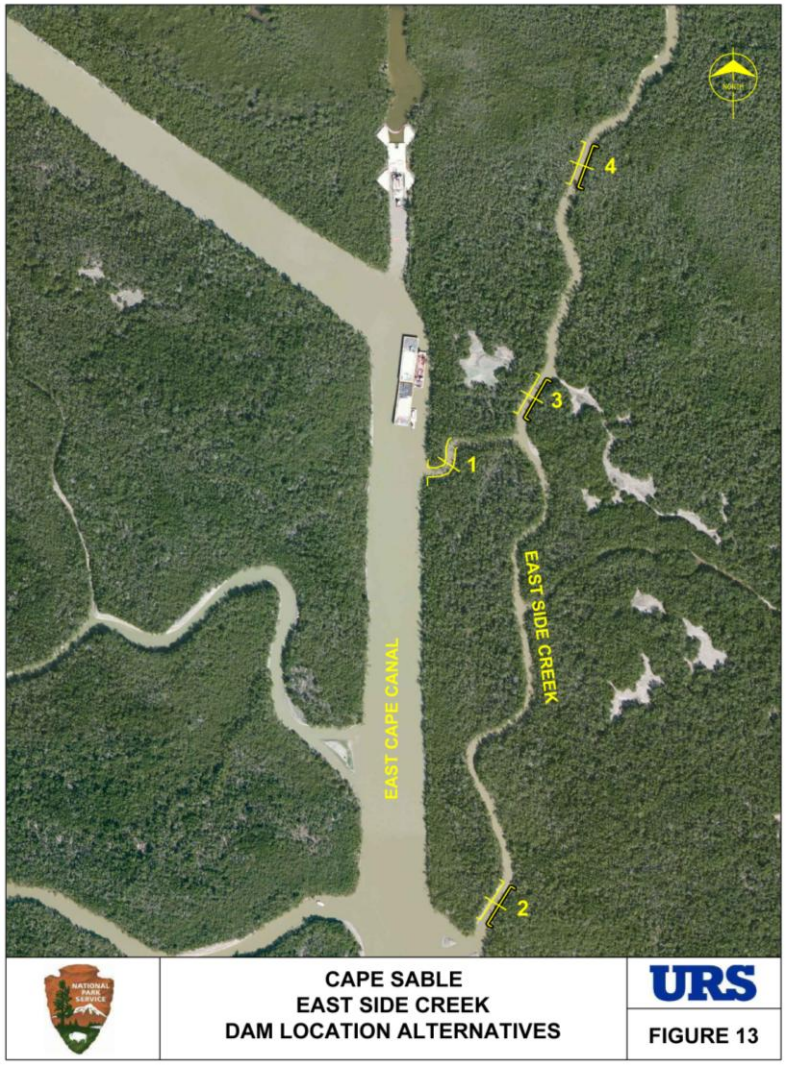
All proposed build alternatives would provide a significant positive regional benefit by reducing tidal intrusion of salt water into the former brackish emergent marshes of interior Cape Sable, which have been heavily degraded by extensive salt water inflows via the ditches. Historically, the Raulerson and East ide Creek areas were initially protected from tidal salt water inflows by the marl ridge and an outer beach ridge. Tidal waters would only flow over the ridges into the emergent marshes during seasonal high tide periods.

Prior to alteration by humans who created ditch/canal cuts through the marl ridge, the region’s brackish emergent marshes experienced much longer hydro-periods of freshwater saturation during the rainy season. This system was altered by the construction of man-made canals/ditches in the area. The proposed build alternatives would help to greatly decrease the salt water inflows that are currently degrading the Cape Sable brackish emergent marsh habitat and will reduce sediment transport into Lake Ingraham and ultimately into Florida Bay and the Gulf of Mexico. With the No-Action alternative, there would be no beneficial indirect effects.

4.0 East Side Creek Assessment

East Side Creek as shown on **Figure 13**, is a creek bed which somewhat parallels and is located east of the East Cape Canal and extension thereof. The creek alignment was not visible in a 1928 aerial photograph and is barely visible in a 1954 aerial photograph. However, because East Side Creek intersects the lower East Cape Canal near Florida Bay, it is being subjected to significant inward and outward tidally driven flow conditions similar to that of the East Cape Canal Extension and Lake Ingraham. The creek continues to transports a significant volume of salt water across the marl ridge and back into interior marshes on each tidal cycle. This is becoming evident based on the review of more recent aerial photographs of the area.

Presently, East Side Creek is connected to the East Cape Canal at two (2) locations as shown in **Figure 13**. The main Creek entrance is located about midway along the north-south section of the East Cape Canal and a smaller tributary feeder canal has opened up further to the north as shown on the adjacent photo. Due to a shorter flow path and corresponding less resistance to channelized flow, the northern feeder canal is believed to be experiencing increasing flows to and from the main East Side Creek channel and is believed to potentially be eroding and enlarging at an accelerated rate compared to the main East Side Creek channel. Also visible on **Figure 13 aerial (Feb/11)** is the nearly completed East Cape Canal extension dam near the top center area of the photograph. This dam was completed in late March of 2011.



The Creek itself consists of a winding creek bed formed by flow related erosion deep into the naturally occurring lime mud surficial soil deposit. In the Cape Sable region, this lime mud soil overlays a lower limestone base rock that is anticipated to exist over much of the southern Cape Sable region, particularly in the areas of the dams being addressed by this report. In the area of the Homestead and East Cape Extension Canal Dams, the lime mud was found to be typically 8 to 10 feet deep. Representative soil profile lithology's from the Homestead and East Cape Canal extension dam sites are shown the in boring logs contained in **Appendix A**. The lime mud is cohesive but very, very soft in consistency and strength and is highly erodible under the flowing action of water. The upper mantel of this layer is commonly impregnated and reinforced with extensive root systems from Mangrove trees and other vegetation.

The remoteness of both dam sites and the logistics and difficulty in accessing the dam area on the previously completed Homestead and East Cape Canals had significant impact on the repair alternatives that were developed herein as well as on the associated costs.

4.1 East Side Creek Logistics Issues

Construction of a Dam(s) on the East Side Creek will involve the need to address several major logistical issues in order to affect any dam construction work. In short, the remote location of the dam's interior to the Park and potential access restrictions in getting to the dam sites, will present very challenging obstacles to moving personnel, materials and any equipment inland to perform the dam site construction work. A summary listing of logistical considerations is presented as follows:

1. Canal cross section est. @ 30' – 40' at present time – some in-progress erosion on-going.
   a. Likely slow annual widening due to tidal driven high flows along creek.
2. Feeder canal width is smaller (est. 20' – 25'), winding with partial overhanging mangrove canopy.
3. Offshore shoal area exists at East Cape canal entrance from Florida Bay.
   a. Canal access during high tides conditions only.
4. Material and equipment mobilization by barge from off-site areas.
5. Barge staging areas available in East Cape canal adjacent to creek entrance.
6. Smaller sized barges likely needed for inland creek access.
7. Personnel mobilized daily from flamingo marina.

4.2 East Side Creek Dam Alternatives

4.2.1 Alternative 1 – No Action

The No-Action alternative involves leaving the creek in its present condition and allowing the creek to continue to erode, widen and transport suspended sediment to the inland marshes as well as to Florida Bay and the Gulf of Mexico. However this alternative fails to accomplish the primary goal of the National Park Services which is to limit the flow of salt water into the interior fresh water marshes; thereby enhancing the natural hydrology and salinity of the inland Cape Sable Region north of the marl ridge. Restoring the hydrology and salinity of the marshes upstream of marl ridge should enhance the wetland habitat for wading birds, juvenile crocodiles and other wildlife. The Take No-Action alternative is not a feasible solution because it does not achieve the goal of limiting saltwater intrusion, reducing erosion and sediment transport and providing the habitat protection required by the National Park Service.

The next three alternatives were determined to be feasible as a result of the preliminary engineering analysis. An overview of the planned construction method is provided, in addition to discussing the advantages and disadvantages of each alternative, and material and equipment access issues. The environmental impacts associated with each alternative are discussed in a later section of the report.

4.2.2 Alternative 2 - Sheet Pile Only Dam with Rip Rap Erosion Protection

This option involves constructing a canal dam/plug comprised of cross canal steel sheet piling with sheet pile protected canal side banks extending up to 200 feet along the canal banks from the cross canal sheet section. This design would provide a canal cutoff which would not be subject to internal erosion and end around seepage failure and would be an expanded version of the cross canal sheet piling design used earlier for the Homestead and East Cape Canal cutoffs in the later 1990s.

Four (4) suggested locations were initially considered as being potentially viable for the East Side Creek dam construction as shown on **Figure 13.**

Location 1 and 2 are located at the entrances to the main creek and at the feeder creek just off and east of the main East Cape Canal. Locations 1 and 2 were established to provide a design and construction option which locates the dams as close as possible to the main East Cape Canal to provide for ease of a construction access and to mitigate logistics issues. These locations are the closest to the wider and more navigable main East Cape Canal such that construction barging and staging areas etc. can be readily positioned in the main canal immediately adjacent to the dam sites. These locations would facilitate minimizing environmental impacts in that only limited clearing and trimming of Mangroves and other vegetation would be required in the immediate vicinities of the dam site areas. Such locations would significantly reduce the need to trim Mangrove overhangs from the Creek alignment in the vicinity of the dams and in-canal sheet piling.

This location option has two major drawbacks in that two (2) dams would need to be constructed therein significantly increasing the cost of the dam construction work. The second issue is that the creek in its southern section is located only about 150+/- feet east of the main East Cape Canal. Correspondingly, the potential exists for additional westerly breaches to develop across the narrow land segment between the creek and main East Cape Canal. Such a breach would negate the positive impacts gained by construction of the dams and along with cost factors, was not considered to be a viable location for the new dam. Finally, these locations are south of the marl ridge and they do not take advantage of the small topographic rise in elevation associated with this feature that helps to limit saltwater intrusion into interior marsh areas. Correspondingly, for these reasons, a site located more inland is considered necessary.

Location 3 is located further inland along the creek alignment just north of the intersection of the feeder creek with the main creek channel. This location was initially considered as it was the closest location which only requires one dam to be constructed. This location minimizes the distance of travel required to get to the first available single dam location and therein minimizes the Mangrove trimming of side banks required to facilitate access to the dam site. However, review of this location indicated a concern with the presence of open un-vegetated mudflat areas east and west of the proposed dam site. These open mud flat areas are lower in topographic elevations and would present avenues for more focused flow around the dam particularly to the west and back into the main East Cape Canal. Additionally, flows to the southeast would appear to make their way to a smaller feeder creek alignment to the south which would inherently allow flows to circumvent the Location 3 dam. For this primary reason, the site was not considered as meeting the Parks objective of limiting saltwater intrusion back into interior Cape Sable Marshes. Additionally, this location is south of the marl ridge and does not take advantage of the small topographic rise in elevation associated with this feature that helps to limit saltwater intrusion into interior marsh areas. Correspondingly, for these reasons, a site located more inland is considered necessary.

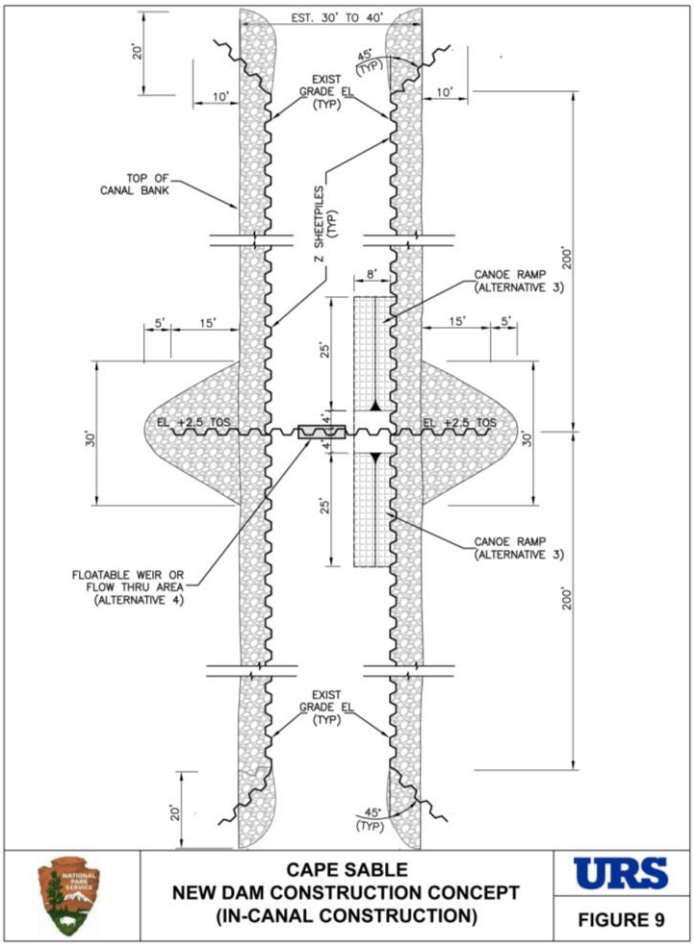
Location 4 as shown on **Figure 13** is located more interior to the Cape Sable region and is at a location approximately directly east of the newly constructed East Cape Canal Extension dam site. This site also provides more separation between the creek and the East Cape Canal Extension and the location appears to be surrounded by dense well established Mangrove stands and their surficial reinforcing root systems. The primary issues with this more inland site is the longer and more difficult travel distance and time needed for access that deep into the region. The windy creek bed will make barge access initially difficult until such time as flows coming out of the creek are initially cut off by installed cross canal sheet piling. This location will require much more significant trimming of Mangroves overhanging into the creek channel in order to allow access for barges and tows moving in and out of the creek. Additionally, the possible presences of shoals along the alignment of the creek

bed are as of yet uninvestigated and unknown and should they exist, it is possible that localized mechanical dredging will be required to facilitate creek passage particularly at corner /bend areas.

The design of the dam as previously shown in plan view on **Figure 9** below would include a cross canal section constructed at a top elevation of +2.5 ft. NAVD to essentially prevent any over-topping during normal tidal fluctuations and high/high tide events during the normal course of the year. This elevation was selected based on tide ranges at the off-shore Naples Monitoring Station which indicates that normal tidal fluctuations in the 1.75 – 2.0 ft. NAVD elevation range are to be expected. This cross-canal section would be extended some 15 feet inland from the canal to seat the dam well into the adjacent land surface.

A slight modification to this design will be considered during subsequent modeling phases for the dam. This modification may include dropping the central 10 to 15 feet of the cross dam sheet piling section down to the elevation of the adjacent prevailing ground surface. This modification will allow overland flows to pass thru the at grade dam opening as well as overland around the dam. Flows allowed over the middle dam section will reduce flows around the perimeter areas therein facilitating more flows through the sheet pile protected areas of the dams and adjacent canals.

The area around the inland extension and around the end of the inland sheet piling would be armoured with geotextile covered by 12 inch average to 18 inch sized rip rap needed to mitigate erosion action immediately adjacent to and at the end of the sheets. Additionally, dropping of the top elevation of the cross canal sheet piling below the initially proposed +2.5 ft. NAVD elevation will also be evaluated during subsequent modeling efforts.



In addition to the cross canal sheets, sheet piling would be installed along both canal banks both upstream (i.e. inland side) and downstream (i.e. East Cape Canal side) of the canal cutoff. The side bank sheet piling would be installed within a few feet of the edge of the canal bank and would be driven to an elevation of 0.0 to -0.5 feet below the prevailing ground surface. The intent of the side bank sheet piling is to allow for overland high tide events to flow around the cross canal cutoff sheet piling and then to re-enter the canal by flowing over the top of the side bank canal sheets. The small gap area between the side bank sheets and the pre-existing eroded canal side bank would be backfilled with sand fill to within 2 feet of the top of the sheets, a geotextile filter fabric placed and then the remainder of the gap would be filled with rip rap stone up to 18 inches in maximum size with a 12 inch average size. The side bank canal sheet piling and rip rap would provide a protected overflow area upstream and downstream of the main dam cutoff that would not become eroded by such over topping events.

For preliminary concept design and estimating purposes, a 200 foot long section for either side of the dam is being estimated. Once field topographic and bathymetric surveying is completed for the selected dam site area, hydraulic modeling will be performed to evaluate the overland flow regimes and adjustments to the length of side bank canal sheet piling required will be made as part of a detailed design for the work.

A. Advantages

1. Constructs the dam at a single location inland up the creek in the vicinity of the recently constructed East Cape Canal Extension Dam.
2. Provides longer term erosion protection for overland flows around the dam.
3. Complies with the Parks intent to limit saltwater intrusion and to mitigate against discharge of sediment into Lake Ingraham and Florida Bay.

B. Disadvantages

1. Longer more difficult access inland to dam site
2. Requires significant trimming of Mangroves along creek alignment
3. May require mechanical dredging of shoals at select locations along creek and at main entry to creek
4. Requires mobilization of barges and equipment up the narrow creek which are capable of lifting and installing 20 foot long sheet piling.
5. See other logistics issues listed in earlier Section 4.1
6. Does not allow for ingress or egress by Manatees or Smalltooth Sawfish

4.2.3 Alternative 3 - Sheet Pile Dam with Canoe Ramp and Rip Rap Erosion Protection

This Alternative is essentially the same as Alternative 1 except that the concept design will include a canoe access ramp area for the portage of canoes and kayaks over the dam sheet piling. Due to the relatively narrow width of the canal, a ramp width of 8 feet is initially proposed however, a 10 foot wide ramp could potentially be provided depending on the final selected alternative. The ramp area will be horizontally contained and protected by sheet piling and in-filled with #57 coarse stone gravel. A concrete in-filled geotextile/geoblock system will be used to cover the surface of the ramp between the sheet piling and a wooden lattice cover will be installed to provide a foot hold for the porting recreationist as well as to provide a protective layer to prevent damage to their watercraft.

A. Advantages

1. Constructs the dam at a single location inland up the creek in the vicinity of the recently constructed East Cape Canal Extension Dam
2. Provides longer term erosion protection for overland flows around the dam
3. Provides recreation access for canoeist and kayakers into the inland marshes.
4. Complies with the Parks intent to limit saltwater intrusion and to mitigate against discharge of sediment into Lake Ingraham and Florida Bay.

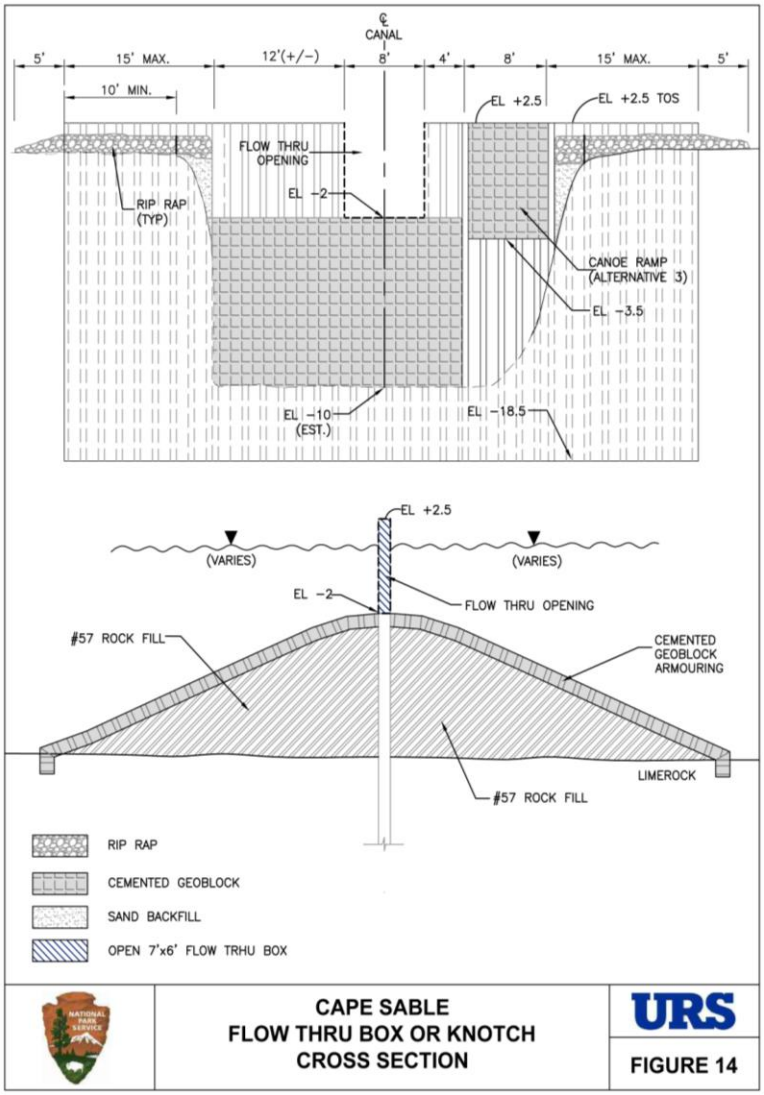
B. Disadvantages

1. Requires mobilization of barges and equipment which are capable of lifting and installing 20 foot long sheet piling.
2. Requires delivery a small volume of gravel plus geotextile fabric/Geoblock/Sakcrete and fabricated wood latticework.

3. More costly and difficult to construct compared to Alternative 2
4. See other logistics issues listed in earlier Section 4.1

4.2.4 Alternative 4 - Sheet Pile Dam with Flow-thru Capacity and Rip Rap Erosion Protection

This Alternative 4 is a modification of Alternative 1 in that a flow-thru capability as shown on **Figure 14** would be incorporated into the dam which would allow for some unrestricted but partial flows of salt water into and out of the Park interior marshes. The opening would be significantly smaller than the creek cross section which would comply in concept with the stated intent of the Park to limit saltwater intrusion into the interior Cape Sable Region but, this concept would only restrict and limit such intrusions, not prevent them.



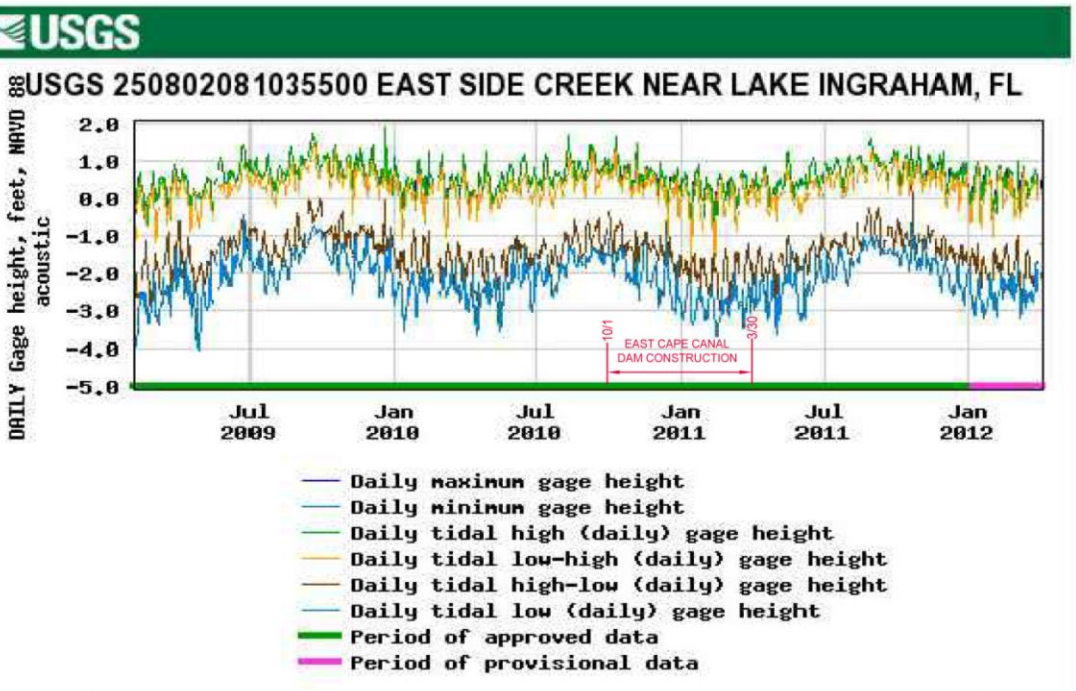
For the East Side Creek dam site, a permitting restriction was imposed for the approved construction of the East Cape Canal extension dam site that may impact potential dam designs for the creek. The permitting issue resolves around ingress/egress capabilities for Manatees and Smalltooth Sawfish to and from the inland marshes. Such mammals and fish cannot be prohibited from accessing or become trapped in the inland marsh area by such a dam structure unless it can be proven that there is an alternative ingress/egress point(s) for the Manatees and Smalltooth Sawfish to escape into the ocean. The East Cape Canal extension dam was permitted with the understanding that Manatees and Smalltooth Sawfish would be able to enter and escape from the inland marsh areas via the East Side Creek. At present, the determination of alternate ingress and egress routes elsewhere in the Park is beyond the scope of this work hence, a plausible dam design alternative is presented herein to potentially facilitate such ingress and egress.

Egress as well as ingress can only be provided by an opening constructed in the dam cutoff which will not potentially trap, endanger or injure mammals and fish passing through the opening. To accomplish this, the opening must be sufficiently sized to allow for a large Manatee or Smalltooth Sawfish to pass through the openings unabated with sufficient room to facilitate their passing. Utilization of typical bottom opening Tainter type gate is not considered a viable alternative to provide such an opening as there is an inherent risk that the Tainter gates would cause harm in a partially open or actively closing condition. Additionally, such gates can potentially become clogged with debris.

One viable solution however, is to provide a predetermined sized opening in the sheet pile dam cutoff wall as a fully notched opening in the sheet pile wall as shown on **Figure 14**. Such openings would allow for both inland and outward flow along the creek alignment however, due to the reduced size of the dam opening compared to the current canal cross section, the reduced size opening would inherently reduce and limit the flow volume thru the structure. Flow would be discharged in either direction into the sheet pile protected sections of the canal such that localized turbulent flow in the vicinity of the cutoff dam opening and just upstream or downstream thereof, would not cause any erosion of the adjacent canal slopes.

Preliminary discussions with knowledgeable Smalltooth Sawfish personnel from the Mote Marine Laboratory group in Sarasota FL, indicates that large Smalltooth Sawfish can reach up to 25 feet in length with fin spans up to a couple of meters in width. Installation of a floatable type weir structure similar to the Raulerson Canal would likely not be suitable and capable of being permitted as the Sawfish would not be able to access upstream inland marsh areas of the Cape Sable Region over such structures. Additionally, the Sawfish are bottom dwellers and will typically swim along the bottom of the creek and mud flats where they actually prefer water depths of around 2 feet or less. As such, it will be necessary to provide a simulated canal bottom via a ramp from the existing canal bottom up to the notch opening for Sawfish to swim along up to, through and then back down into the canal from the opening. It is envisioned that this ramp area will be filled with #57 stone and covered with a concrete filled, cabled Geoblock system securely welded and otherwise attached to the sheet piling to assure the Geoblock mat remains in place. In considering the notch design of a flow-thru structure able to facilitate necessary ingress and egress, the available period of record for Gage Height data for the USGS East Side Creek monitoring station was examined as shown on **Figure 15.**

Review of the data trends indicates there is about a 2 foot average difference between the daily low-



CAPE SABLE
EAST SIDE CREEK GAUGE HEIGHTS (FT/NAVD)

URS

FIGURE 15

high and daily high-low tides and about a 2.5 foot difference between daily low-high and daily high tide gauge levels. Although seasonal in nature (i.e. with generally higher levels in the 3rd and 4th quarters of the year), the data indicates that setting a Flow-thru weir elevation of -2.0 ft. NAVD would allow for at least 2 feet and up to 3 feet of water to be flowing over the structure during daily high and high-low tide events. This elevation should support the safe passage of Smalltooth Sawfish and Manatees while at the same time limiting the intrusion of saltwater into the interior marshes.

A. Advantages

1. Constructs the dam at a single location inland up the East Side Creek in the vicinity of the recently constructed East Cape Canal Extension Dam.
2. Provides longer term erosion protection for overland flows around the dam.
3. Reduces the volume of saltwater intrusion into the inland marsh areas.
4. Reduces sediment discharges to Florida Bay and the Gulf of Mexico.
5. Allows for both the ingress and egress of Manatees and Smalltooth Sawfish and other aquatic life.
6. Complies with the Parks intent to further limit saltwater intrusion and to mitigate to a certain degree against discharge of sediment into Lake Ingraham and Florida Bay.

B. Disadvantages

1. Requires mobilization of barge equipment capable of lifting and driving 20 foot long sheet piling.
2. Some increased long term maintenance requirements and costs as openings have the potential to trap larger tree debris moving down the canal. Maintenance and removal of such debris would be more problematic with the submerged box opening compared to the open notch design.
3. Flows through the opening could become a safety concern to recreationalist canoeing and kayaking at the dam especially at high or low tide conditions.
4. See other logistics issues listed in earlier Section 4.1.

4.2.5 Alternative 5 - Sheet Pile Dam with Canoe Ramp, Flow-thru Capability, Canoe Ramp and Rip Rap Erosion Protection

Alternative 5 is an expanded modification of Alternative 3 in that both a canoe ramp and the Alternative 4 flow-thru capability could potentially be incorporated into the dam. This alternative would allow safe portage over the dam as well as the flow of more limited and restricted volumes of water into and out of the inland marshes during variable tide elevations.

A. Advantages

1. Constructs the dam at a single location inland up the creek in the vicinity of the recently constructed East Cape Canal Extension Dam.
2. Provides longer term erosion protection for overland flows around the dam.
3. Provides portage access for recreationalists via canoes and kayaks.
4. Reduces the volume of saltwater intrusion into the inland marsh areas.
5. Reduces sediment discharges to Florida Bay and the Gulf of Mexico.
6. Allows for both the ingress and egress of Manatees and Smalltooth Sawfish and other aquatic life.

B. Disadvantages

1. Requires mobilization of barge equipment capable of lifting and driving 20 foot long sheet piling.
2. Requires delivery a small volume of gravel plus geotextile fabric/Geoblock/Sakcrete and fabricated wood latticework.
3. More costly and difficult to construct compared to Alternatives 2 and 3.
4. Some increased long term maintenance requirements and costs as openings have the potential to trap larger tree debris moving down the canal. Maintenance and removal of such debris would be more problematic with the submerged box opening compared to the open notch design.
5. Flows through the opening could become a safety concern to recreationalist canoeing and kayaking at the dam especially at high or low tide conditions.
6. See other logistics issues listed in earlier Section 4.1.

4.3 Generalized Construction Approach and Sequencing

The following information provides a generalized presentation of the anticipated construction approach and sequencing anticipated to be followed in order to complete the anticipated new dam at the selected East Side Creek Dam site.

A. Anticipated Approach and Sequencing

1. Work will be limited to the period of October 1 – March 31.
2. Prepare and submit required upfront submittals for the work in sufficient time to supply sheet piling and begin work on October 1.
3. Mobilize Barges/Equipment from Offsite Staging Areas in the Florida Keys or elsewhere.
   a. Approval of offsite staging area anticipated to be required by permitting documents.
   b. Comply with all on-site environmental monitoring requirements during the duration of construction.
4. Mobilize daily work force from Flamingo marina.
5. Dredge East Side Creek entrance area shoal and shoals along Creek as needed for access.
   a. Comply with all environmental monitoring requirements specific to dredging activities as well as other general on-site site monitoring required during construction.
   b. Dispose of dredge spoil offsite or at an approved and permitted spoil disposal area in the Park.
6. Complete significant Mangrove clearing and trimming along East Side Creek and at the approved dam site area including limited clearing for inland sheet pile sections.
7. Acquire and deliver sheet piling and other materials to East Cape Canal Staging area and then to jobsite.
   a. Deliver materials from offsite staging areas or,
   b. Temporarily deliver and store materials in Flamingo maintenance yard area and subsequently load and deliver from Flamingo Marina (West Bulkhead) with Park approval and coordination.
   c. Temporarily stage materials on barges as needed near entry to East Side Creek.

8. Deliver and install northernmost sheet pile from in-canal barges and install backfill and rip rap erosion protection for northern half of dam.
9. Drive canal cutoff sheets, southernmost sheet piling, canoe ramp sheets (i.e. if this alternative is selected) and temporary bulkhead sheets to facilitate dewatering and construction of the north ramped canal bottom section north of the cross canal cutoff sheets.

10. Construct north canoe ramp and flow-thru structure(s) depending on the approved and permitted alternative(s) and remove temporary sheet pile bulkhead.
11. Install sheet pile backfill and rip rap erosion protection around inland cutoff dam area and along southernmost canal sheet piling.
12. Secure final inspection and Substantial Completion Notice.
13. Cleanup and demobilize remnant materials and equipment including barges from dam site.
14. All work and demobilization to be completed by March 31.

4.4 Environmental and Permitting Considerations

Section 3.4 previously presented an analysis of the environmental impact assessment needs and regulatory agencies' permitting requirements for the viable restoration alternatives proposed within both the Raulerson Dam Restoration Site and East Side Creek Dam sites. The requirements under this category are essentially the same for the Raulerson Dam Construction Alternatives with the exception that this dam site has potential needs to address ingress and egress for Smalltooth Sawfish and Manatees whereas such ingress and egress is not an issue for the Raulerson Dam replacement. Additionally, barge access will primarily be from the Florida Bay into the East Cape Canal and then up the East Side Creek as shown on **Figure 16**.

From the previous Homestead and East Cape Canal dam construction, it is known that barge access out of the East Cape Canal could be a significant access concern due to an offshore shoal area. Previous bathymetric surveys of the shoal area may need to be updated during any subsequent design phases for this project to reconfirm the previously defined access route for ocean capable barges over the near shore shoal, thru Florida Bay and out to deeper water in the Gulf of Mexico. Recent (March 2012) minor repairs performed at the East Cape Canal extension and Homestead dam sites indicate that a local marine contractor from the Florida Keys has shallow draft barges that are even capable of being mobilized across Florida Bay and into the Flamingo Marina.

5.0 Cost Estimates

The URS Project Team developed preliminary 2012 cost estimates for the dam restoration and new construction for each canal. The useful life of the sheet pile used in the proposed dam repairs is estimated to be approximately 50 years with appropriate maintenance.

5.1 Cost Estimate

Cost estimates for each of the feasible alternatives are presented in Tables 5.1 and 5.2 for the House and Slagle Dams and the Raulerson Dam Reconstruction/New East Side Creek dam construction respectively. The costs for mobilization and demobilization, dredging, vegetation removal or trimming, spoils management, sheet piling, rip rap, fill material, permitting, and mitigation were evaluated as appropriate for each alternative as required. The cost estimate tables present restoration costs for the various dams and alternatives based on unit prices obtained from the most recent Homestead and East Cape Canal Extension dam re-construction and R.S. Means or other Vendor information where additional information is needed. Information is not presented for Alternative 1 – Take No-Action because there is no direct cost associated with the alternative.

Due to the uniqueness and remoteness of the various projects, it is possible that actual bids obtained from future bidders may be higher than the estimated cost determined below depending on market conditions at the time of bid and construction. For estimating purposes, a 28% markup was used for Standard Government General Conditions and a value of 25% was used for Overhead and Profit Markups. Considering the preliminary design nature of this feasibility study and the fact that limited field survey and other information such as canal depths and widths are not accurately known, these cost estimates will include an appropriate contingency as listed in the cost tables. For the House and Slagle dam estimates a 20% contingency was used owing to the relatively small quantities of fill. For the Raulerson and East Side Creek dams, a 30% contingency was used due to the more difficult and heavy equipment nature of this work.

5.1.1 House and Slagle Dam Restorations

Table 5.1–1: Summary of Cost Estimates for House and Slagle Dam Repairs*

Alternative	House Dam Plug ($)		Slagle Dam Plug ($)	
	Helicopter Delivery	Pack Mule Delivery	Helicopter Delivery	Pack Mule Delivery
Alternative 2 (Erosion Fill Only)	91,450	84,600	92,400	64,850
Alternative 3 (Erosion Fill w/Channel Erosion Protection)	99,300	106,300	101,150	91,150
Alternative 4 (Erosion & Canal Fill w/ Slope Erosion Protection)	119,700	148,600	120,550	122,950

The proposed alternative cost for restoring the House and Slagle Dams range from a low of $84,600 for the Alternative 2 Pack Mule delivery of fill to the closest Slagle dam site to up to $148,600 for the Pack Mule delivery of fill and erosion protection materials to the farthest House dam site under Alternative 4. These costs assume that the dams are constructed concurrently so that mobilization costs were split equally between the dam sites in the detailed cost estimate. The cost estimate breakouts are presented in **Appendix B** including a detailed breakdown of Pack Mule material transportation costs.

5.1.2 Raulerson Canal Dam Replacement and new East Side Creek Dam

Table 5.1–2: Summary of Cost Estimates for Raulerson Dam Replacement and New East Side Creek Dam

Alternative	Raulerson Dam Replacement ($)*	New East Side Creek Dam ($)**
Alternative 2 (Sheet Pile Dam w/Protection)	2,835,400	3,356,600
Alternative 3 (Sheet Pile Dam w/Protection & Canoe Ramp)	2,978,700	3,475,950
Alternative 4 (Sheet Pile Dam w/Protection & Overflow Structure or Flow-thru Structure)	3,008,530	3,435,050
Alternative 5 Sheet Pile Dam w/Protection, Canoe Ramp & Overflow or Flow -thru Structure)	3,127,850	3,554,350

*Assumes Dam Location 2 or 3
** Assumes Dam Location 4

The proposed alternative cost for restoring the Raulerson Dam ranges from a low of $2,835,400 up to $3,127,850 each depending on the Alternative selected. These costs assume that the Raulerson dam replacement is constructed at either location #2 or #3 and that some dredging will be required to facilitate access by locally removing shoal areas as well as dam debris at the previous failed dam location.

The proposed alternative cost for constructing the new East Side Creek dam ranges from a low of $3,356,600 up to $3,554,350 for a single interior dam location depending on the Alternative selected. These costs assume that the East Side Creek dam is constructed at location #4 and that some dredging may be required to facilitate access by locally removing creek or canal entry area shoal areas as well as any shoals restricting access along canal or creek alignments.

The backup cost estimate breakouts for both the Raulerson Canal Replacement dam and new East Side Creek dam are presented in **Appendix B**.

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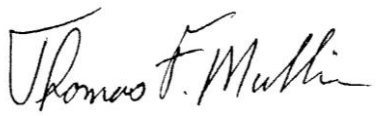
URS is pleased to have been of service on this contract.

Very Respectfully Submitted,



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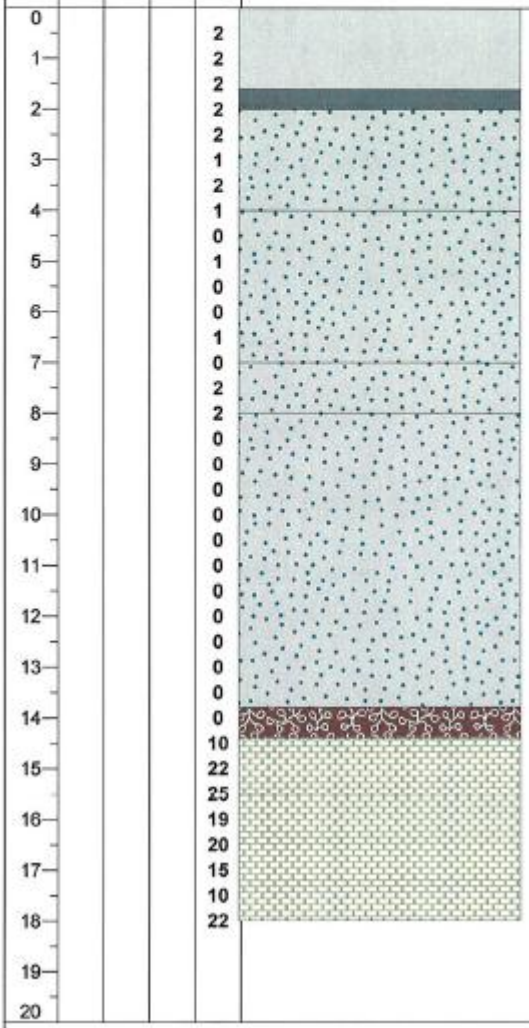
Appendix A

CAPE SABLE SOIL LITHOLOGY'S

CORE SAMPLE LOGS

WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS	Cape Sable	Log of Well No: CS- 01			
BORING LOCATION: East Cape Canal		GROUND SURFACE ELEVATION AND DATUM: 1.5			
DRILLING CONTRACTOR: Bureau Veritas		DATE STARTED: 03/19/07			DATE FINISHED: 03/19/07
DRILLING METHOD: Split Spoon		TOTAL DEPTH (ft.): 18.0			SCREEN INTERVAL (ft.): NA
DRILLING EQUIPMENT: Tripod & Gas Powered Winch		DEPTH TO WATER:	FIRST: NA	COMPL.: NA	CASING: NA
SAMPLING METHOD: Hammer		LOGGED BY: Ed Marks / URS			
HAMMER WEIGHT: 140 Lbs.	DROP: 3.0'	RESPONSIBLE PROFESSIONAL: Dan Levy / URS			REG. NO. NA



DESCRIPTION
NAME (USCS): color, composition, grain size, roundness, cementation, induration, plasticity.

Marl: Gray (7/2) to dark gray (6/1) colored carbonate marl having clay like properties-highly plastic in nature, live roots, few small clam shells.

Marl: Dark gray (4/1) colored carbonate marl having clay like properties-highly plastic in nature, live roots, few small clam shells.

Marl: Lite gray (7/2) to gray (6/1) colored carbonate marl having green-blue silt blebs throughout, clay like properties- highly plastic nature,5%-10% decayed plant material.

Hydrated Marl: Lite gray (7/2) to gray (6/1) colored carbonate marl having green-blue silt blebs throughout, clay like properties, highly plastic nature, 5%-10% decayed plant material,poorly indurated due to sediment saturation.

Marl: Lite gray (7/2) to gray (6/1) colored carbonate marl having clay like properties-highly plastic nature, 5%-10% decayed plant material.

Hydrated Marl: Lite gray (7/2) to gray (6/1) colored carbonate marl having green-blue silt blebs throughout, clay like properties, highly plastic nature, 5%-10% decayed plant material,poorly indurated due to sediment saturation.

Peat: Dark reddish brown (3/3) to brown black (2/1) plant material composed of stems, leaves and bark material with lenses of gray marl.

Limestone:Pale yellow (10 YR 8/3) to lite gray to dark gray (N4) limestone (Key Largo), moderately recrystallized with hexagonal coral and bryozoan skeletons as well as having gastropods and pelloids, highly vuggular, well indurated.

WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS: Cape Sable				**Log of Well No: CS- 02**	
BORING LOCATION: Homestead Canal				GROUND SURFACE ELEVATION AND DATUM: 1.0	
DRILLING CONTRACTOR: Bureau Veritas				DATE STARTED: 03/30/07	DATE FINISHED: 03/30/07
DRILLING METHOD: Split Spoon				TOTAL DEPTH (ft.): 16.0	SCREEN INTERVAL (ft.): NA
DRILLING EQUIPMENT: Tripod & Gas Powered Winch				DEPTH TO WATER: FIRST: NA / COMPL.: NA	CASING: NA
SAMPLING METHOD: Hammer				LOGGED BY: Ed Marks / URS	
HAMMER WEIGHT: 140 Lbs.	DROP: 3.0'			RESPONSIBLE PROFESSIONAL: Dan Levy / URS	REG. NO. NA

DEPTH (feet)	SAMPLES	BLOW COUNTS	DESCRIPTION NAME (USCS): color, composition, grain size, roundness, cementation, induration, plasticity.
0–1		2 1 1	Marl: Gray (6/1) to dark gray (4/1) colored carbonate marl having clay like properties-highly plastic nature, live roots, few small clam shells.
1–3		1 2 2	Marl: Lite gray (7/2) to gray (6/1) colored carbonate marl having clay like properties-highly plastic nature, 5%-10% decayed plant material.
3–5		2 2 1	Marl: Gray (6/1) to dark gray (4/1) colored carbonate marl having clay like properties-highly plastic nature,5%-10%decayed plant material, few small clam shells.
5–6		2 2	Marl: Lite gray (7/2) to gray (6/1) colored carbonate marl having clay like properties-highly plastic nature, 5%-10% decayed plant material.
6–12		2 0 0 0 0 0 0 0 0 0 0	Marl: Lite gray (7/2) to gray (6/1) colored carbonate marl having clay like properties-highly plastic nature, 5%-10% decayed plant material.
12–13		0 1 1	Marl: Gray (6/1) to dark gray (4/1) colored carbonate marl having clay like properties-highly plastic nature.
13–14		59 35	Peat: Dark reddish brown (3/3) to brown black (2/1) plant material composed of stems, leaves and bark material with lenses of gray marl.
14–16		20 18 28 37	Limestone:Pale yellow (10 YR 8/3) to lite gray to dark gray (N4) limestone (Key Largo), moderately recrystallized with hexagonal coral and bryozoan skeletons as well as having gastropods and pelloids, highly vuggular, well indurated.

Appendix B

BACKUP
DETAILED COST ESTIMATE BREAKDOWN
SPREADSHEETS

Table B-1A
House & Slagle Dam Repair Cost Estimate

Helicopter Air Lift of Materials to Dam Sites

Item	Alternative 2		Alternative 3		Alternative 4		
	House's Dam	Slagles's Dam	House's Dam	Slagles's Dam	House's Dam	Slagles's Dam	Notes
Mobilization/Demobilization	12,500	12,500	12,500	12,500	12,500	12,500	1.
Daily Helicopter Use ($20,000 Day)	30,000	30,000	30,000	30,000	40,000	40,000	
Site Preparation (5 Man Crew @ $500/Man-Day)	2,500	2,500	2,500	2,500	2,500	2,500	
Backfill Materials	500	1,000	750	1250	1250	1750	2.
Erosion Protection Materials (Sakcrete)	0	0	2500	3000	1000	1500	3.
Backfilling (5 Man Crew @ $500/Man-Day)	2,500	2,500	3750	3750	5000	5000	
Crew Boat ($600/Day)	1800	1800	2100	2100	2400	2400	
Subtotal	**49,800**	**50,300**	**54,100**	**55,100**	**64,650**	**65,650**	
Standard/Government GC's (28%)	13,950	14,100	15,150	15,400	18,100	18,400	
Overhead & Profit (25%)	12,450	12,600	13,500	13,800	16,150	16,400	
Base Estimate	**76,200**	**77,000**	**82,750**	**84,300**	**98,900**	**100,450**	
Contingency (20%)	15,250	15,400	16,550	16,850	19,800	20,100	
Total Preliminary Feasibility Estimate	**91,450**	**92,400**	**99,300**	**101,150**	**119,700**	**120,550**	

Table B-1B
House & Slagle Dam Repair Cost Estimate

Pack Mule Transportation of Materials Along Coastal Prairie Trail

Item	Alternative 2		Alternative 3		Alternative 4		
	House's Dam	Slagles's Dam	House's Dam	Slagles's Dam	House's Dam	Slagles's Dam	Notes
Mobilization/Demobilization	1300	1300	1300	1300	1300	1300	1.
Pack Mule Transport of Materials	37,500	26,250	45,000	35,750	67,500	52,500	
Site Preparation (5 Man Crew @ $500/Man-Day)	2,500	2,500	2,500	2,500	2,500	2,500	
Backfill Materials	500	1,000	750	1250	1250	1750	2.
Erosion Protection Materials (Sakcrete)	0	0	2500	3000	1000	1500	3.
Backfilling (5 Man Crew @ $500/Man-Day)	2,500	2,500	3750	3750	5000	5000	
Crew Boat ($600/Day)	1800	1800	2100	2100	2400	2400	
Subtotal	**46,100**	**35,350**	**57,900**	**49,650**	**80,950**	**66,950**	
Standard/Government GC's (28%)	12,900	9,900	16,200	13,900	22,650	18,750	12.
.Overhead & Profit (25%)	11,500	8,800	14,500	12,400	20,250	16,750	13.
Base Estimate	**70,500**	**54,050**	**88,600**	**75,950**	**123,850**	**102,450**	
Contingency (20%)	14,100	10,800	17,700	15,200	24,750	20,500	
Total Preliminary Feasibility Estimate	**84,600**	**64,850**	**106,300**	**91,150**	**148,600**	**122,950**	

Table B-1Ba
House & Slagle Dam Repair Cost Estimate

Sub- Breakout of Pack Mule Transportation of Materials Costs

Item	Alternative 2		Alternative 3		Alternative 4		
	House's Dam	Slagles's Dam	House's Dam	Slagles's Dam	House's Dam	Slagles's Dam	Notes
Quantity of Fill Material Delivery (CY)	10	10	12	13	18	21	
Weight of Fill Material Delivery (@ 3000 lbs/CY)	30,000	30,000	36,000	39,000	54,000	63,000	
Number of Mule Loads (@ 200 lbs/mule)	150	150	180	195	270	315	
Number of 15 Mule Trains Required	10	10	12	13	18	21	
Number of Days Required	10	7	12	9	18	14	
Mule Costs (@ $3000/day for 15 Mules)	30,000	21,000	36,000	27,000	54,000	42,000	
Mule Tenders (2 @ $250/Day each)	5,000	3,500	6,000	6,500	9,000	7,000	
Feed (@ $100/day)	1,000	700	1,200	900	1,800	1,400	
Boarding and Meals (@ $150/Day)	1,500	1,050	1,800	1,350	2,700	2,100	
Total	37,500	26,250	45,000	35,750	67,500	52,500	

Table B–2
Raulerson Dam Replacement Cost Estimate

Item	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Notes
Mobilization/Demobilization	250,000	250,000	250,000	250,000	
Canal Clearing and Trimming	250,000	250,000	250,000	250,000	4.
Perimeter Sheet Piling (910 LF@ $750/LF)	682,500	682,500	682,500	682,500	5.
Sheet Piling Sand Backfill (800 CY @ $72/CY)	57600	57600	57600	57600	6.
Erosion Protection Rip Rap/Fabric (500CY @ $120/CY)	60,000	60,000	60,000	60,000	7.
Dredging @ Entry & Failed Dam (250 CY @ $150/CY)	37,500	37,500	37,500	37,500	8.
Canoe Ramp	0	60,000	0	60,000	9.
Over Flow Gate	0	0	75,000	75,000	10.
Environmental Monitoring	100,000	100,000	100,000	100,000	
Subtotal	**1,437,600**	**1,497,600**	**1,512,600**	**1,572,600**	
Standard/Government GC's (28%)	402,500	419,300	423,500	440,300	12.
Overhead & Profit (25%)	359,400	374,400	378,150	393,150	13.
Base Estimate	**2,199,500**	**2,291,300**	**2,314,250**	**2,406,050**	
Contingency (30%)	635,900	687,400	694,280	721,800	
Total Preliminary Feasibility Estimate	**2,835,400**	**2,978,700**	**3,008,530**	**3,127,850**	

Table B–3
East Side Creek Dam Construction Cost Estimate

Item	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Notes
Mobilization/Demobilization	250,000	250,000	250,000	250,000	
Canal Clearing and Trimming	500,000	500,000	500,000	500,000	5. & 11
Perimeter Sheet Piling (710 LF@ $650/LF)	682,500	682,500	682,500	682,500	5.
Sheet Piling Sand Backfill (800 CY @ $72/CY)	57600	57600	57600	57600	6.
Erosion Protection Rip Rap/Fabric (500CY @ $120/CY)	60,000	60,000	60,000	60,000	7.
Dredging @ Entry & Failed Dam (250 CY @ $150/CY)	37,500	37,500	37,500	37,500	8.
Canoe Ramp	0	60,000	0	60,000	9.
Flow-thru Channel	0	0	40,000	40,000	10.
Environmental Monitoring	100,000	100,000	100,000	100,000	
Subtotal	**1,687,600**	**1,747,600**	**1,727,000**	**1,787,000**	
Standard/Government GC's (28%)	472,500	489,300	483,600	500,350	12.
Overhead & Profit (25%)	421,900	436,900	431,750	446,750	13.
Base Estimate	**2,582,000**	**2,673,800**	**2,642,350**	**2,734,100**	
Contingency (30%)	774,600	802,150	792,700	820,250	
Total Preliminary Feasibility Estimate	**3,356,600**	**3,475,950**	**3,435,050**	**3,554,350**	

Notes for Cost Estimate Sheets

1. Assumes dam repairs constructed at same time. Therefore only 1/2 Mob/Demob charge applied to each dam site.
2. Assumes 1 CY backfill costs $50/CY FOB @ Flamingo Heliport delivered in 1 CY bags.
3. Assumes 1 CY Sakcrete costs $1000 FOB @ Flamingo Heliport delivered on a plastic wrapped pallet.
4. Assumes Mangrove trimming of canals side banks from north Lake Ingraham entry point to failed dam location.
5. Assumes 800 LF along canal, 40 LF at the four corners, 30 LF cross canal and 40 LF inland for total of 910 LF.
6. Assumes 200 CY of backfill behind each of 4 sides of dam along the canal banks.
7. Assumes 60 CY of rip rap behind each of 4 sides of dam along the canal banks and 40 CY each for inland walls at main cutoff sheet piling and 180 CY of rip rap at the ends of the canal sheet pile walls
8. Assumes 150 CY mechanical dredging at canal/creek entry shoal and 100 CY dredging elsewhere in canal or creek to facilitate barge access.
9. Assumes 2 ramps at each dam @ $30,000 each.
10. Estimated cost of overflow gate at Raulerson and underflow gate at East Side Creek at $75,000 and $100,000 respectively.
11. Assumes 2X cost of Mangrove trimming on East Side Creek compared to Raulerson Canal costs.
12. Standard General Conditions generate costs to the government (from the contractor) which are basically the cost items defined in the Division 1 Project Specifications. Sometimes, some Division 1 items (Profit, Overhead) are included in the cost of individual bid items when preparing an estimate. These costs (that the Contractor passes on to the government through bid items) are indirect costs of the construction project. Standard General Conditions costs depend on the size, location and complexity and other variables of the project and estimate. This value is set at 28% for this estimate due to the difficult, complex and remote locations of these jobsites.
13. Overhead as the cost that a contractor has for staying in business not directly related to the construction of a project, but vital to the contractor's business operations. These include fixed overhead (Federal and State Unemployment costs, Social Security Tax, Builder's Risk Insurance and Public Liability Costs) and variable overhead (Worker's Compensation Insurance, Main Office Overhead, etc.). Profit is the just reward for the effort and risk a contractor undertakes to produce a project. The amount varies depending on the size of the job and yearly in a contractor's annual billing. This value is set at 28% for this estimate.