RESOLUTION NO. 2022- 124

A RESOLUTION OF THE BOARD OF COUNTY COMMISSIONERS OF NASSAU COUNTY, FLORIDA, ADOPTING PLANNING ASSISTANCE TO STATES PROGRAM FINAL REPORT FOR THOMAS CREEK PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS; PROVIDING FOR A PURPOSE AND INTENT, AND PROVIDING AN EFFECTIVE DATE.

WHEREAS, pursuant to Section 22 of the Water Resources Development Act of 1974, Nassau County, in a letter dated February 12, 2018, requested technical assistance from the U. S. Army Corps of Engineers to address flooding issues associated with Thomas Creek; and,

WHEREAS, the U. S. Army Corps of Engineers and Nassau County Engineering staff partnered to conduct a Planning Assistance to the States Study for the purpose of gathering flood impact data to evaluate structural and non-structural solutions to Thomas Creek in an effort to reduce risk associated with flooding and to reduce impacts to natural resources within the Thomas Creek area; and,

WHEREAS, the Planning Assistance to the States Study has identified problems and opportunities within the Thomas Creek project area to mitigate the risk of flooding in the study area that can be implemented once funding is available and permits are acquired; and,

WHEREAS, the Board of County Commissioners is committed to protecting the public health, safety, and general welfare of all Nassau County residents; and,

WHEREAS, the Board of County Commissioners and county staff will work to create an implementation plan to address flooding concerns in the Thomas Creek area using the findings of the Planning Assistance to the States Study as a tool to execute feasible alternatives to mitigate the risk of flooding within the study area of Thomas Creek; and,

WHEREAS, the Board of County Commissioners now finds it in the best interest of Nassau County and its citizens to adopt the Planning Assistance to the States Study conducted by the U. S. Army Corps of Engineers.

NOW, THEREFORE, BE IT RESOLVED by the Board of County Commissioners of Nassau County, Florida, as follows:

SECTION 1. FINDINGS. The above findings are true and correct and are hereby incorporated herein by reference.

SECTION 2. ADOPTION OF THE U. S. ARMY CORPS OF ENGINEERINGS PLANNING ASSISTANCE TO STATES REPORT. The U. S. Army Corps of Engineering Planning Assistance to States Report dated April 2022, is hereby adopted, and will serve as a tool to assist in the formulation of an implementation plan until a fully adopted plan can be approved by the Board of County Commissioners.

SECTION 3. EFFECTIVE DATE. This Resolution shall take effect immediately upon its passage.

DULY ADOPTED this 13th day of June, 2022.

BOARD OF COUNTY
COMMISSIONERS NASSAU
COUNTY, FLORIDA

~~AARON C. BELL~~ Jeff Gray, Vice Chairman
~~Its: Chairman~~

ATTEST as to Chairman's Signature:

JOHN A. CRAWFORD
Its: Ex-Officio Clerk

MP
6.14.22

Approved as to form and legality by the Nassau County Attorney:

DENISE C. MAY

Resolution No. 2022-124

PLANNING ASSISTANCE TO STATES PROGRAM

FINAL REPORT for THOMAS CREEK PAS

Nassau County, Florida

April 2022

Prepared By:

U.S. Army Corps of Engineers, Jacksonville District

US Army Corps of Engineers ®
Jacksonville District

TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

1.1 STUDY PURPOSE

Pursuant to Section 22 of the Water Resources Development Act of 1974, this Planning Assistance to States (PAS) study was conducted at the request of Nassau County. In a letter dated 12 February 2018, Nassau County requested technical assistance from the U.S. Army Corps of Engineers (USACE) to address flooding issues associated with Thomas Creek.

This study is not associated with a Federal action to implement the findings of this analysis. Any participation from USACE with implementation would require a Department of the Army Decision Document under a study authority as well as the associated National Environmental Policy Act (NEPA) documentation. The non-federal sponsor (NFS), Nassau County, will be responsible for implementing and obtaining all required permits to construct the project, as well as design and construction.

The conceptual-level analysis performed supports the development of alternatives to mitigate flood risk to residences and businesses, as well as reduce impacts to the natural resources within the project area.

1.2 STUDY SPONSOR

The Non-federal sponsor for the study is Nassau County. They requested assistance in a letter to the U.S. Army Corps of Engineers dated 12 February 2018.

1.3 STUDY GOAL

The purpose of the Thomas Creek PAS is to determine source(s) of flooding and gather flood impact data to evaluate structural and non-structural solutions to:

- Reduce risk associated with floods
- Reduce impacts to natural resources within project area

2 PLAN FORMULATION

2.1 PLAN FORMULATION RATIONALE

Structural and non-structural management measures were first developed to lay out a basis for formulation of alternatives. Once alternative plans were developed, the evaluation and comparison process began. After evaluation and comparison, one alternative was selected as the best performing alternative and further refined to support the development of cost estimates, real estate requirements and permitting requirements.

2.2 PROBLEMS AND OPPORTUNITIES

The team identified problems and opportunities for Thomas Creek. Problems are existing undesirable conditions and opportunities are future desirable conditions. The identification of problems and opportunities for the study aids the team with generating feasible alternatives to mitigate the risk of flooding in the study area that can be implemented by Nassau County once funding is available and permits have been acquired.

2.2.1 PROBLEMS

The problem within Thomas Creek is the damage to the surrounding residences, businesses, and natural resources as well as drainage issues due to heavy flooding. A site visit conducted 28 January 2020 identified flooding concerns in various areas along Thomas Creek. Areas of concern noted during the site visit are shown in Figure 2-1. See Appendix A (Engineering) for more details of the areas of concern.

Figure 2-1 Project Area Features

2.2.2 OPPORTUNITIES

There is an opportunity to reduce flooding in the Thomas Creek project area.

2.3 CONSTRAINTS AND OBJECTIVES

2.3.1 CONSTRAINTS

The project must not negatively impact environmental and cultural resources in the study area and must minimize adverse impacts to surrounding landowners.

2.3.2 OBJECTIVES

Reduce flooding of residences, businesses, and natural resources within the Thomas Creek project area by a foot for a 10-year storm event.

2.3.3 SUMMARY OF MANAGEMENT MEASURES

Management measures are individual structural (S) or non-structural (NS) actions that would take place at geographical locations within the project area to alleviate the problem and take advantage of opportunities in ways that contribute to the objective. A management measure is a feature (a structural element that requires construction or assembly on-site) or an activity (a non-structural action) that can stand alone or be combined with other management measures to form alternative plans.

Non-structural measures:

- buyouts
- flood-proof
- relocations
- raise first-floor elevations
- update FEMA floodplain maps

Structural management measures:

- storage areas
- floodwall
- earthen berm
- pumps
- channel clearing
- channel widening
- snagging
- clearing
- construct culverts beneath the CSX Railroad

After modeling the management measures and analyzing the results against the objectives and constraints, the earthen berm and channel clearing structural measures were not carried forward. The earthen berm was eliminated due to the large amount of land it would require and channel clearing was eliminated due to limited available space.

2.4 SUMMARY OF ALTERNATIVES

Alternatives were formulated and evaluated based on the study objective and constraints.

Initial Array of Alternatives

- No Action
- Alternative 1 – Floodwall with pumps, and snagging and clearing from two drainage ditches
- Alternative 2 – Construct one detention pond as storage area and snagging and clearing of two drainage ditches
- Alternative 3 – Culverts beneath CSX with channel widening
- Alternative 4 – Channel widening
- Alternative 5 – Storage areas
- Alternative 6 – Floodwall
- Alternative 7 – Floodwall with pumps
- Alternative 8 – Buy Outs
- Alternative 9 -- Flood-proof
- Alternative 10 -- Relocations
- Alternative 11 -- Raise first-floor elevations
- Alternative 12 -- Update FEMA floodplain maps

Modeling analysis was conducted on the initial array of alternatives to determine flood reduction of Thomas Creek. Alternatives 3, 4, 5, 6, and 7 were screened out. Alternative 3 did not result in flood reduction. Alternative 4 resulted in reduction of flood stages of 3-6 inches within the homes however, the flood depths of these homes is 2-3 feet. Alternatives 5, 6 and 7 as standalone alternatives did not provide flood reduction but were combined and optimized for the final array.

Final Array of Alternatives

- No Action
- Alternative 1 – Floodwall with pumps, and snagging and clearing from two drainage ditches
- Alternative 2 –Construct one detention pond and snagging and clearing from two drainage ditches.
- Alternative 8 – Buyouts
- Alternative 9 – Flood-proof
- Alternative 10 – Relocations
- Alternative 11 – Raise first-floor elevations
- Alternative 12 – Update FEMA floodplain maps

After further engineering analysis, Alternative 2 was screened out because the detention pond did not have the storage volume available to provide flood protection. Analysis performed on Alternative 1, the floodwall and pump system, resulted in flood risk reduction for the 10% Annual Event Probability (AEP) and higher (more frequent), and only for the properties located between US-1 and SR-115. Alternative 1 analyses showed little to no benefits in a 25-year or 100-year storm event. Alternative 1 was selected as the best performing structural alternative. The non-structural alternatives (Alts 8-12) were carried into the final array and while they are not listed as a component of the best performing alternative, they are still a viable option that Nassau County can implement to reduce impacts to structures from flooding.

The best performing structural alternative, Alternative 1, consists of the following components:

- Floodwall with pumps
- Snagging and clearing of two drainage ditches

However, during a Nassau County Board Meeting, 27 September 2021, a detailed presentation was given of the modeling results, the best-performing alternative, and preliminary costs. Due to the cost and associated limited benefits of the best-performing alternative, the Nassau County Board of County Commissioners decided to move forward with the non-structural alternative of real estate buyouts.

3 ENGINEERING ANALYSIS

The engineering analysis entailed multiple disciplines and was an iterative process that evolved as part of the alternative development. Discussion of the engineering analysis is difficult to separate from the alternative development process, and the entire integrated analysis process is covered in the Engineering Appendix. A majority of the technical analysis was performed using the Hydrologic Engineering Center River Analysis System (HEC-RAS) model provided by FEMA. HEC-RAS is a hydraulic model and was used to analyze the impacts of each management measure and alternative on flood stages within the project area. The detailed components, such as the floodwall, pump stations, earthwork, and costs, were analyzed and designed by Civil, Geotechnical, Structural, Mechanical, Electrical, and Cost Engineers. The costs of the best-performing alternative are shown in Table 3-1.

Table 3-1 – Best-Performing Alternative Costs

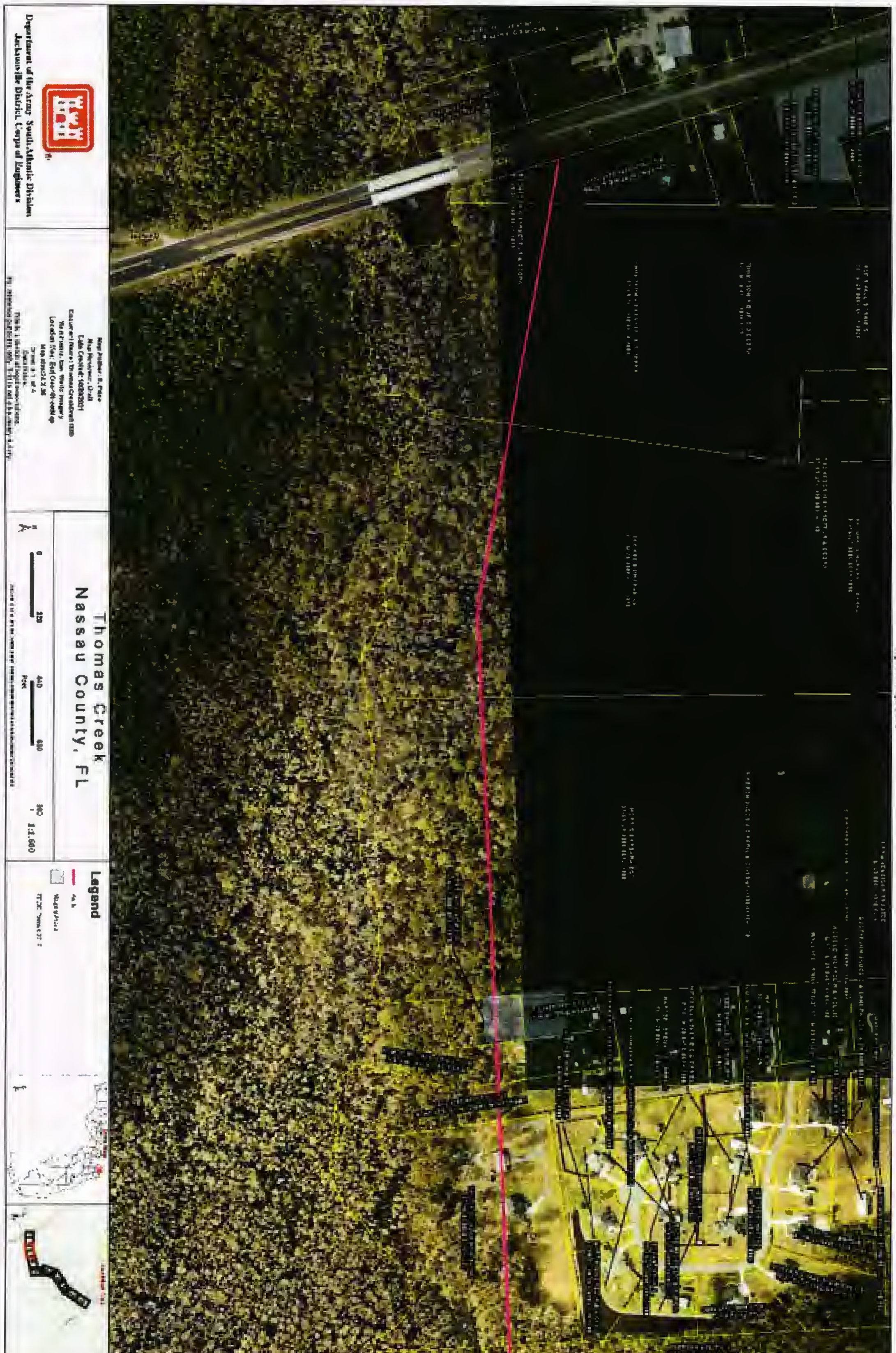
Alternative	Component	Component Cost
	Sheet Pile Floodwall	$22,562,000
	Connecting Channel to Pump Houses	$7,594,000
	Pump House Structures & Equipment	$32,038,300
	Pump House Channels	$3,341,100
	Pump House Access Roads	$3,398,100
	Pump Power Connection	$2,000,000
	Ditch Clearing at Ratliff Road, 519 feet	$4,500
	Ditch Clearing at Larsen Road, 130 feet	$3,500
Total:		**$70,941,500**

4 REAL ESTATE REQUIREMENTS

This project's recommended best alternatives include non-structural risk management measure of complete buyout of identified properties and acquiring lands needed for the construction of a permanent sheet pile wall with pumps and the snagging and clearing from two drainage ditches. Project parcels for the buyout alternative have been identified by the NFS and are not included in this report. The projected parcels needed for the sheet pile wall construction are shown in Figure 4-1 through Figure 4-9. Fee estate will be required to support both options. The staging and access areas will be identified prior to construction and the appropriate interest will be required. This project is located within Nassau County and access to the construction sites, staging areas, etc. will be via existing public city streets.


Thomas Creek
Nassau County, FL
Legend
Department of the Army South Atlantic Division
Jacksonville District, Corps of Engineers

Figure 4-1


Thomas Creek
Nassau County, FL
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Department of the Army South Atlantic Division
Jacksonville District Corps of Engineers

Figure 4-2

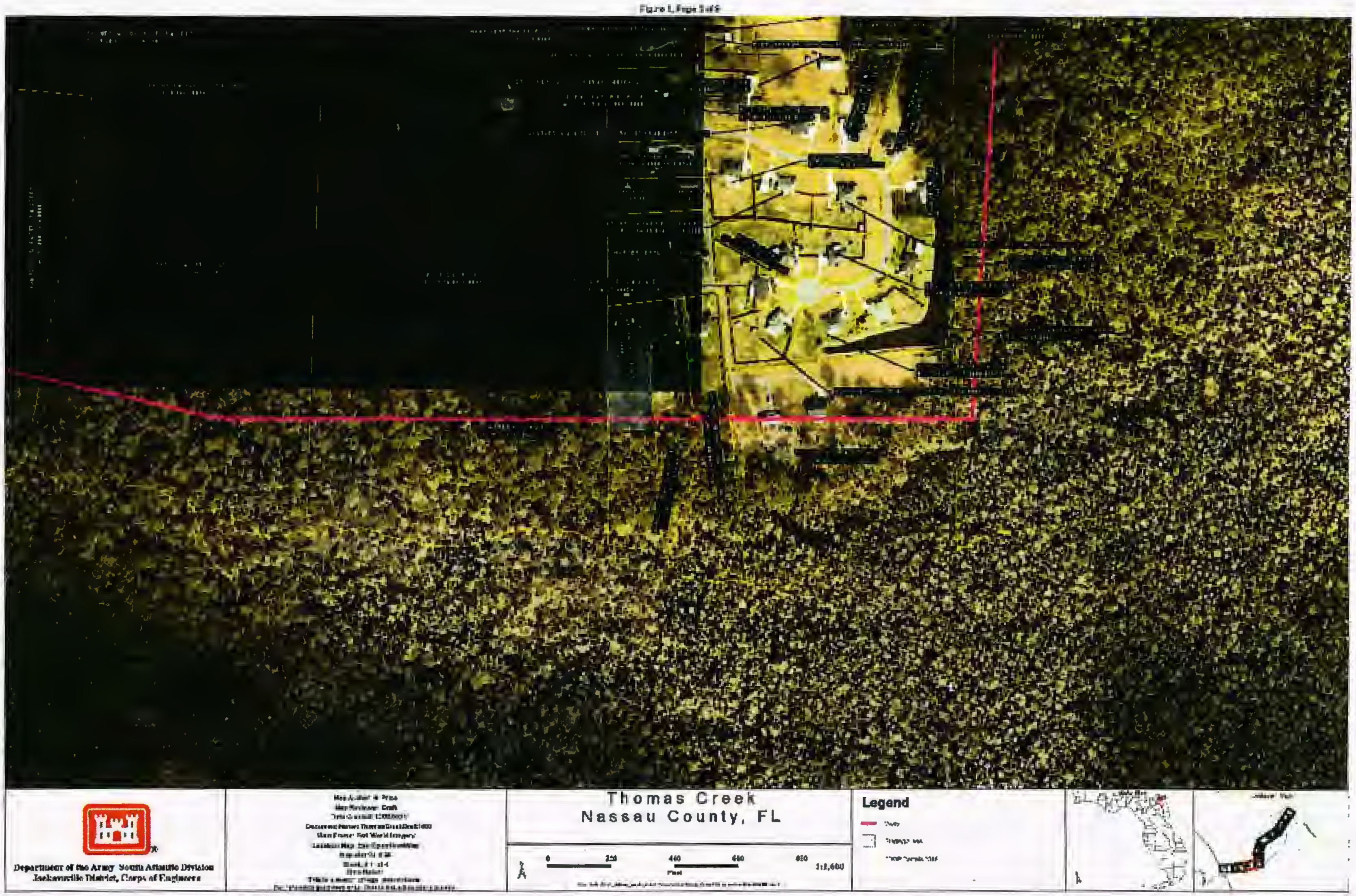
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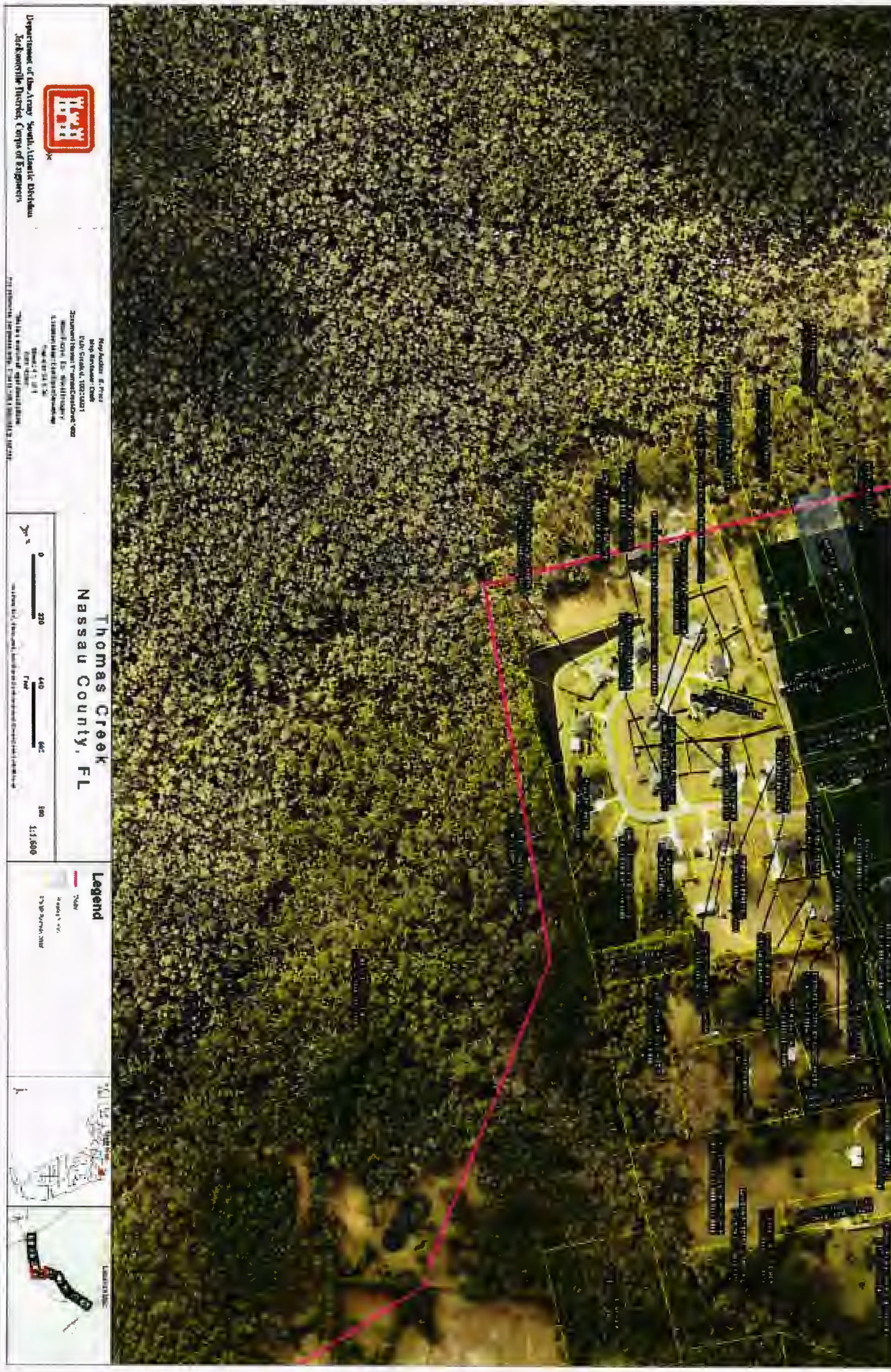
Figure 4-3


Thomas Creek
Nassau County, FL
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Department of the Army South Atlantic Division
Jacksonville District, Corps of Engineers

Figure 4-4

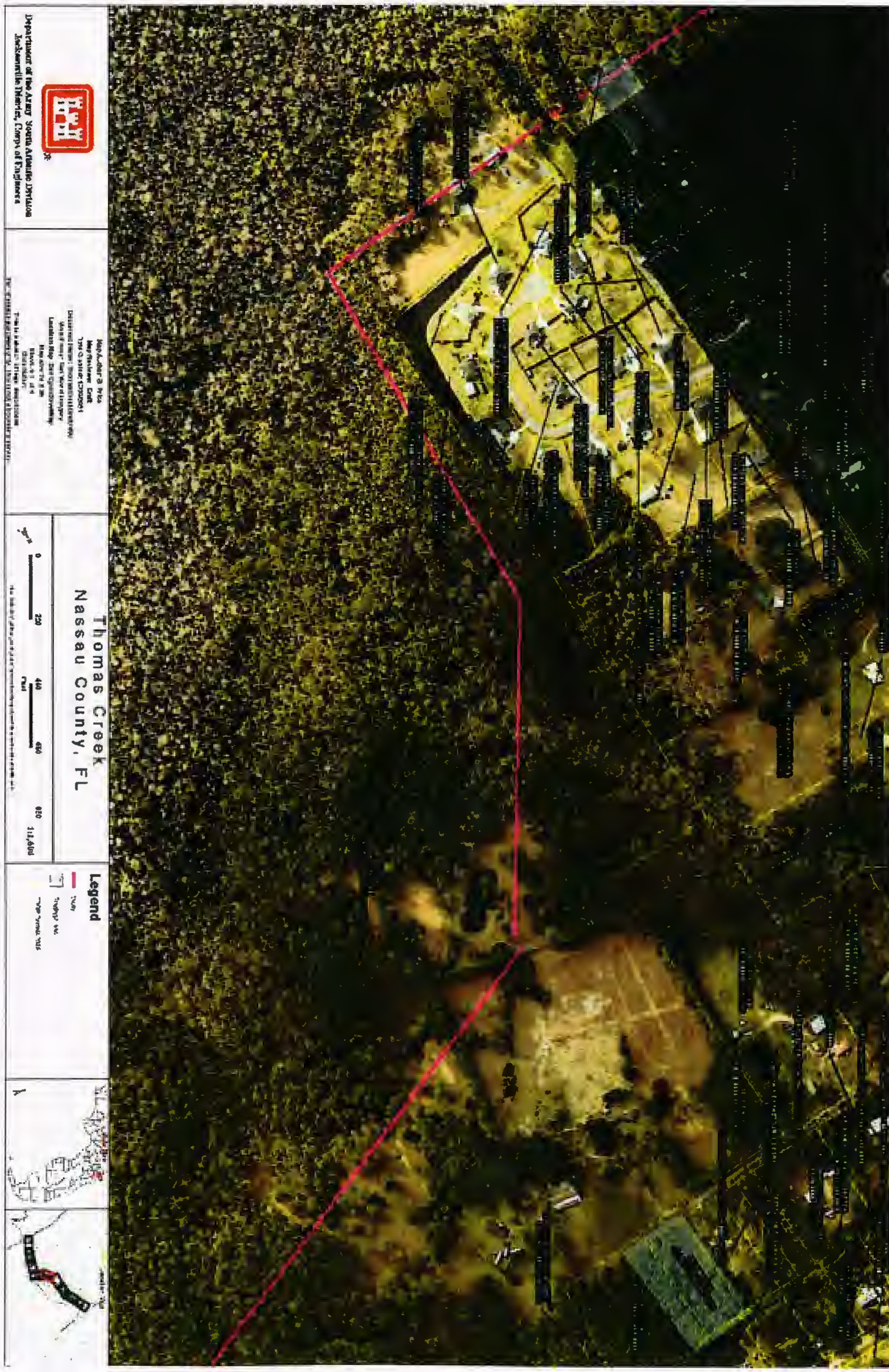
Department of the Army South Atlantic Division
Jacksonville District, Corps of Engineers
Thomas Creek
Nassau County, FL
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Figure 1, Page 5 of 6

Figure 4-5


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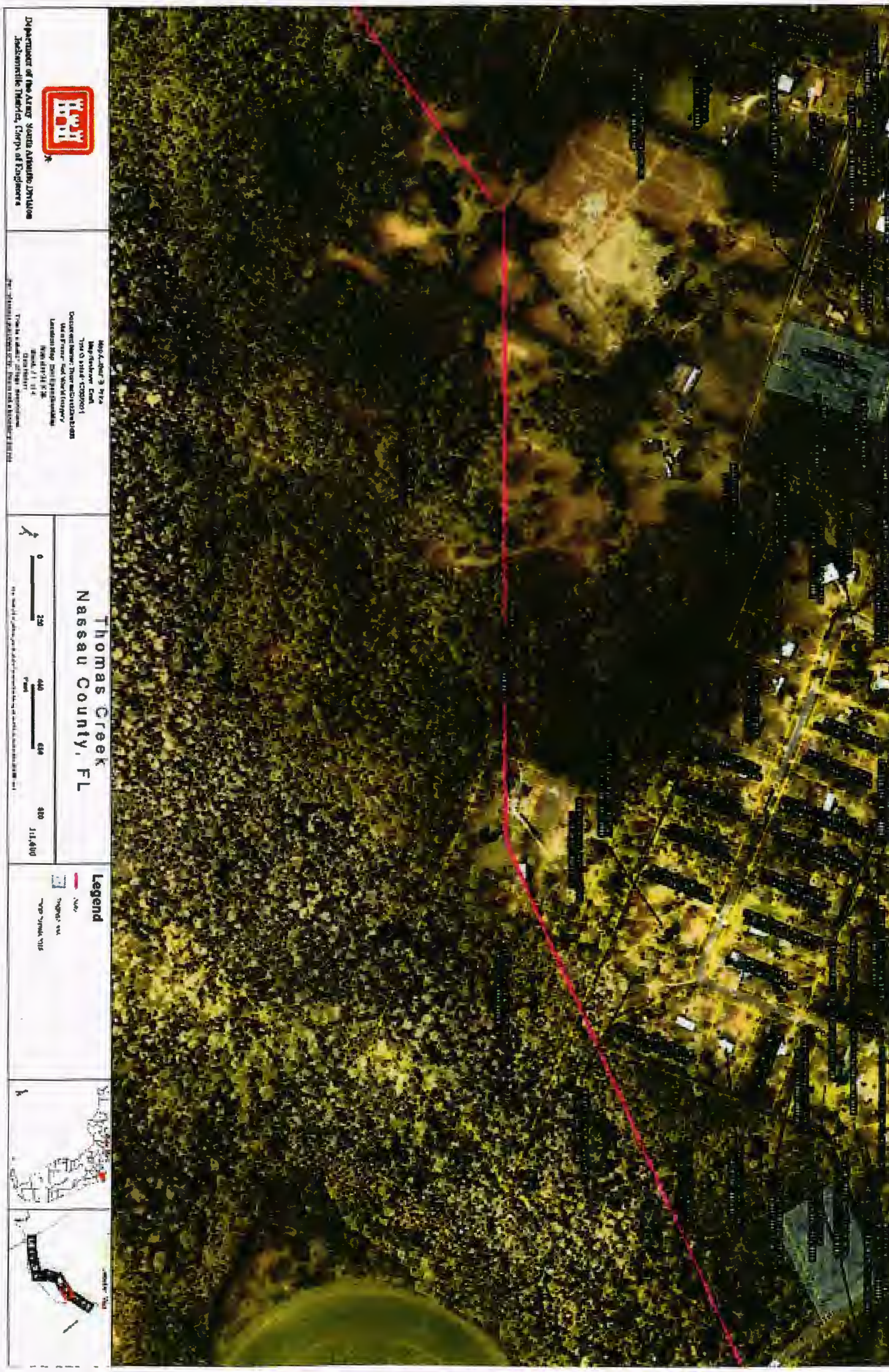
Figure 4-6


Thomas Creek
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Department of the Army South Atlantic Division
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Figure 4-7

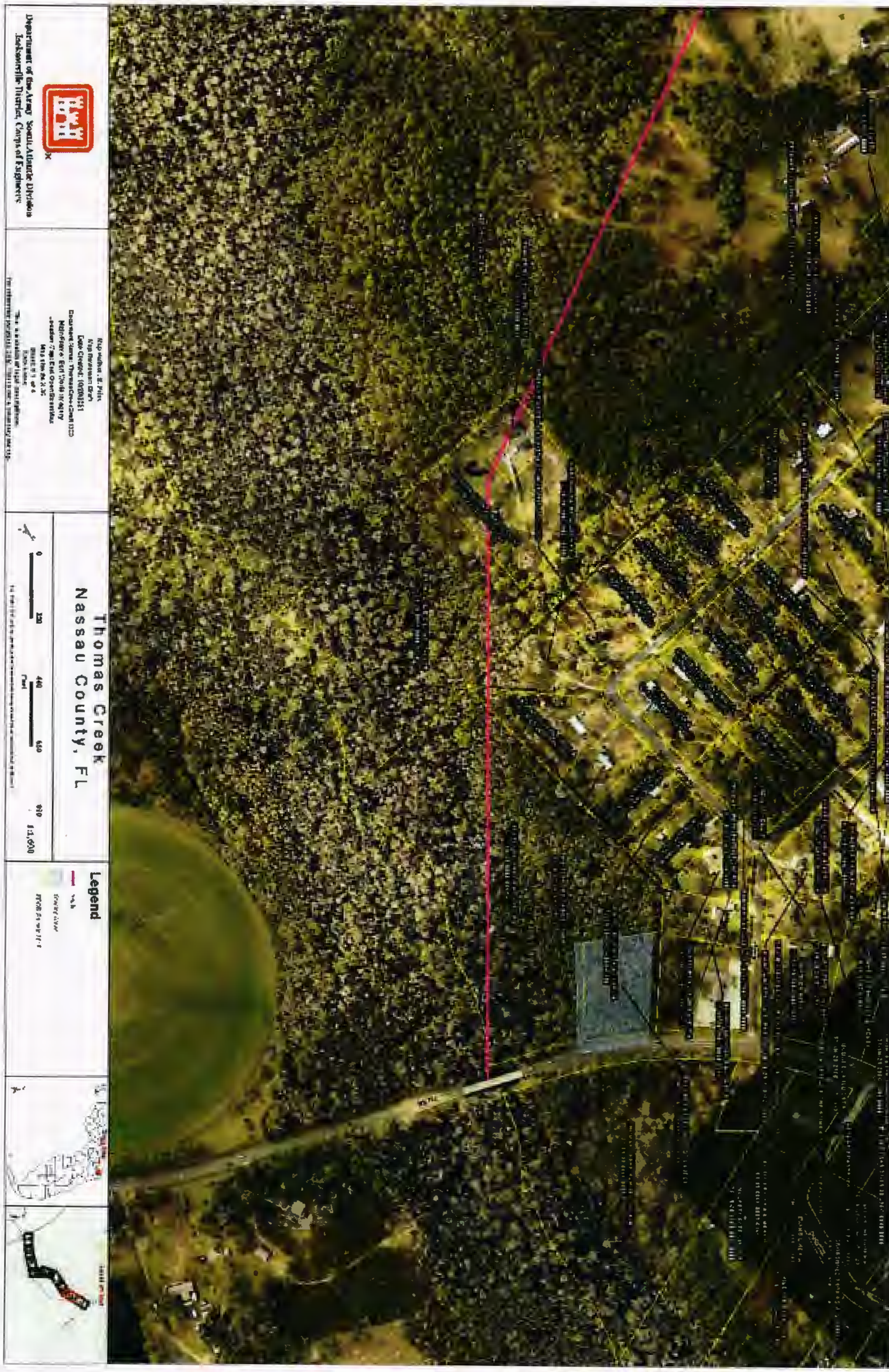
Thomas Creek
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Figure 4-8

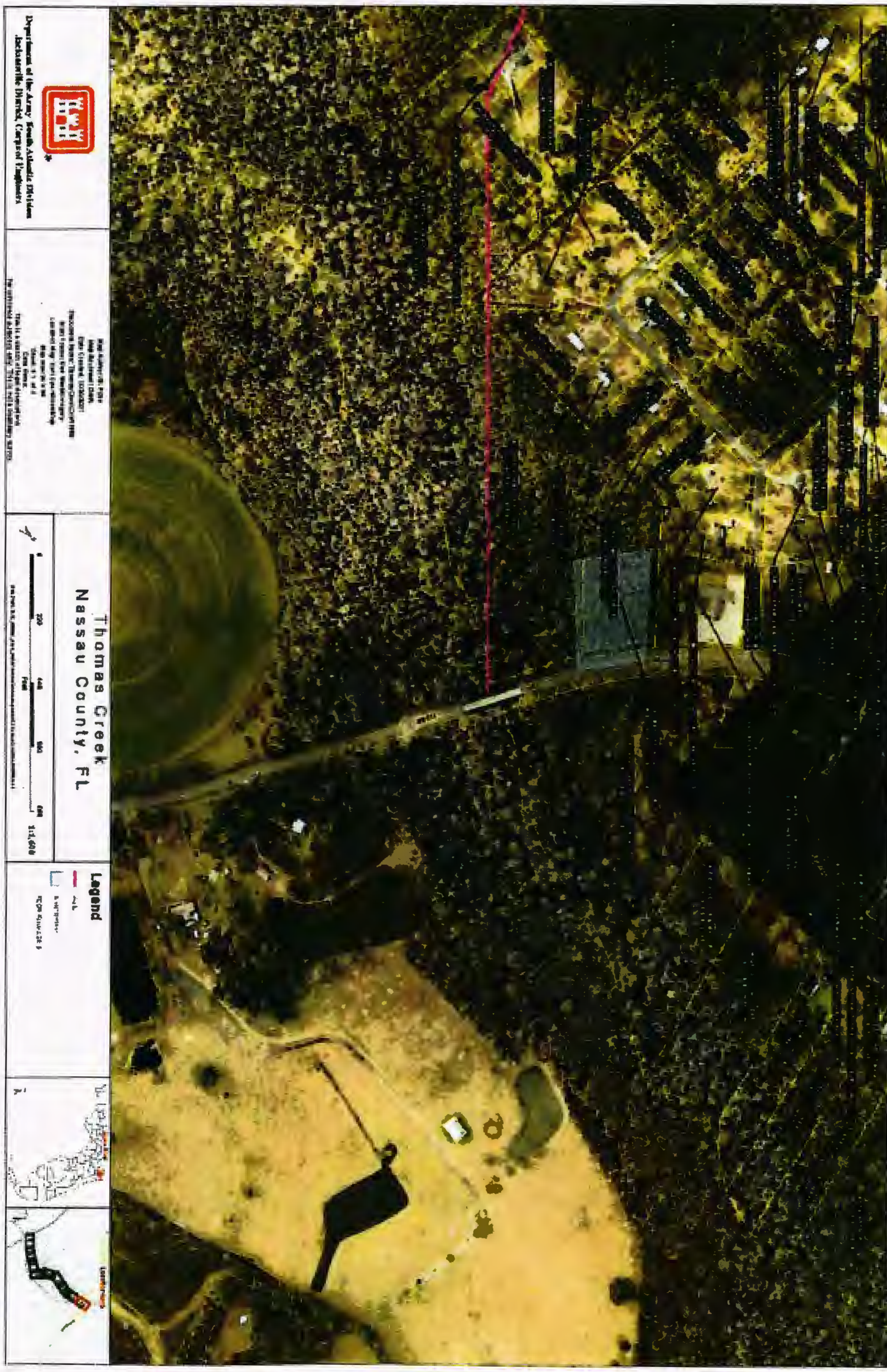

Figure 4-9

5 ENVIRONMENTAL PERMITTING

Nassau County will be required to comply with all environmental laws and regulations in the planning, development, construction, and post-construction phases of the Thomas Creek project if the Best Performing Alternative is selected. Considerations include 404(b)(1) of the Clean Water Act, and the Endangered Species Act (ESA). As of 22 December 2020, the State of Florida assumed the Environmental Protection Agency's (EPA) 404(b)(1) permitting program from the USACE Jacksonville District Regulatory Division (RD). This would require Nassau County to apply for a 404 permit through the State of Florida for any activities occurring in waters of the United States.

5.1 CLEAN WATER ACT COMPLIANCE

A desk review of the proposed action area shows the project site and proposed alternatives involve activities within potential waters of the United States. A wetland delineation will need to be performed to determine the limits of the wetlands and impacts to the defined areas. The delineation will provide a baseline for the permitting process. A mitigation plan will be necessary for loss of wetland functions due to construction activities. The plan should be developed through a review of the proposed impacts and a functional assessment (i.e., Uniform Mitigation Assessment Methodology). The project site is located within the Service Area for the Greens Creek Mitigation Bank, which has palustrine forested credits available for potential mitigation.

5.2 ENDANGERED SPECIES COMPLIANCE

A review of the project site notes there are multiple federally endangered and threatened species that could be present in the vicinity of the construction. These species include: Piping Plover (*Charadrius melodus*), Eastern Black Rail (*Laterallus jamaicensis* ssp. *jamaicensis*), Red Knot (*Calidris canutus rufa*), Red-cockaded Woodpecker (*Picoides borealis*), Wood Stork (*Mycteria americana*), and Eastern Indigo Snake (*Drymarchon corais couperi*). One candidate species could also be present in the project area and should be considered: Gopher Tortoise (*Gopherus polyphemus*). The potential presence of these species and impacts to specific habitat types requires the State to coordinate with the Florida Fish and Wildlife Conservation Commission and the U.S. Fish and Wildlife Service to ensure compliance with the Environmental Protection Agency's Programmatic Biological Opinion. The project location is not within an identified critical habitat for any listed species.

5.3 STATE OF FLORIDA PERMIT

In order to comply with the Clean Water Act, Nassau County will apply for an environmental resource permit. The process of application and receipt of the permit will provide all the necessary regulatory compliance requirements to proceed with the project. The permit will give authorization for the discharge of fill into assumed waters of the U.S. and conclude any resource consultations or determinations of compliance with programmatic biological opinions required to comply with any applicable laws and regulations It is recommended to initiate the permit application process at the earliest possible time to allow for extended consultation periods with resource agencies.

5.4 NON-FEDERAL SPONSOR DECISION (BUY-OUTS)

The Nassau County Board of County Commissioners has decided to pursue buy-outs due to the cost and limited benefits of the best performing alternative. Environmental considerations in regard to the option of buy-outs is similar to the construction activities noted above. The demolition of properties and/or foundations could potentially impact waters of the United States and any construction or staging activities should be examined to determine any potential impacts to wetlands. Additionally, the potential effects to endangered species should be coordinated with the appropriate agencies. Overall, the environmental considerations for the buy-out decision are smaller than direct construction activities, however, Nassau County should be aware of the potential for impacts and permitting requirements with any activity carried forward.

6 CULTURAL RESOURCES COMPLIANCE

Compliance with the National Historic Preservation Act of 1966 (NHPA) and its implementing regulations (36 C.F.R. Part 800) would be required as part of the State of Florida's Coastal Management Program. In addition, if State of Florida funds are used, Chapter 267 of the Florida Statutes may apply and require coordination with the Florida Bureau of Archaeological Research to consider effects to Florida's cultural resources.

Though no surveys have been conducted for this study, previous cultural resource surveys have been conducted in this area. One of these previous surveys, *An Intensive Cultural Resource Survey of the Evergreen Estates, Nassau County, Florida* (Bland, 2004), has documented prehistoric archaeological sites within a mile of the proposed management measures, and none have documented historic archaeological sites within a mile of the proposed management measures. According to the Florida Master Site File (FMSF), the prehistoric site is located within 1000 ft of both a proposed pump house and a staging area and is characterized as a "specialized site for the procurement of raw materials" with a low-density artifact scatter. This site was determined by the Florida SHPO to be ineligible for listing in the NRHP.

6.1 BEST PERFORMING ALTERNATIVE

Of the multiple alternatives considered for the project, the identified BPA is a floodwall between US Highway 1 and State Route 115 with pump houses and drainage ditches at four locations and clearing snags from two drainage ditches. The ditch clearings are located just north of Ratliff Road between Winding Lane and Thomas Creek Road and the south side of Larsen Road at its northeastern terminus. Six different soil units are mapped for the new floodwall, associated pump houses and drainage ditches, cleared extant ditches, and staging areas. Each unit is characterized as poorly or very poorly drained and exhibits qualities inconsistent with high potential for archaeological deposits. Based on a review of historic aerial mapping, the general area within which the identified measures are located has seen fairly significant development since at least the early 1950s.

The proposed new access roads and staging areas are located in areas generally considered to have moderate to high potential to contain archaeological deposits, based on the soils, topography, and access to resources, while the proposed locations of the floodwall, pump houses, and drainage channels are located in areas generally considered to have low potential to contain archaeological deposits. The proposed ditch clearings are unlikely to produce significant subsurface impacts and occur within the previously-disturbed, man-made ditches. The identified plan would not result in effects that would reasonably adversely impact other (above ground) cultural resources, such as historic structures or districts. Due to the proposed location of staging areas and new access roads within moderate to high potential archaeological areas, it is reasonable to assume the FDEP will require a cultural resource assessment survey as part of the Section 404 permit application. However, should the staging areas and new access roads be limited to areas of existing fill and/or previous disturbance, the potential to directly impact cultural resources would be minimized.

6.2 NFS DECISION (BUY-OUTS)

As a result of the cost of the BPA and its limited benefits, the NFS decided to move forward with buy-outs instead. From a cultural resource standpoint, implications from buy-outs could come in the form of impacts to historic structures that are listed in, or are potentially eligible for listing in the NRHP, as well as potential impacts to archaeological deposits due to demolition of properties, removal of foundations, etc.

According to the FMSF, while the majority of the study area has not been subject to cultural resource evaluations and no NRHP listed structures are noted, two previously conducted surveys have addressed above ground cultural resources in the vicinity of the project. One of these surveys, "Cultural Resource Survey of the Proposed Reconstruction of Ratliff Road in Nassau County, Florida (2003)" identified three structures over 50 years in age. All three structures were determined ineligible for listing in the NRHP by the Florida SHPO. Due to possible impacts to structures potentially eligible for listing in the NRHP, as well as possible impacts to previously unrecorded archaeological deposits from actions associated with the demolition of properties, the option to pursue buy-outs in the previously unsurveyed remainder of the study area may be subject to both above ground architectural surveys and below ground archaeological investigations as a permitting requirement.

7 ACRONYMS

EPA – Environmental Protection Agency

ESA – Endangered Species Act

FDEP – Florida Department of Environmental Protection

FMSF – Florida Master Site File

HEC – Hydrologic Engineering Center

HEC-RAS – Hydrologic Engineering Center River Analysis System

LiDAR – Light Detection and Ranging

NEPA – National Environmental Policy Act

NFS – Non-Federal Sponsor

NHPA – National Historic Preservation Act of 1966

NRHP – National Register of Historic Places

PAS – Planning Assistance to States

SHPO – State Historic Preservation Office

RD – Regulatory Division

USACE – U.S. Army Corps of Engineers

USFWS – U.S. Fish and Wildlife Service

8 REFERENCES

An Intensive Cultural Resource Survey of the Evergreen Estates, Nassau County, Florida (Bland, 2004)

APPENDIX A

ENGINEERING ANALYSIS

Table of Contents

Controlled Unclassified Information (CUI)

List of Tables

List of Figures

Acronyms/Abbreviations

AEP	Annual Exceedance Probability
AHJ	Authority Having Jurisdiction
ASTM	American Society for Testing and Materials
ATS	automatic transfer switch
CFD	computational fluid dynamics
cfs	cubic feet per second
CN	curve number
CoP	Community of Practice
CPR	Climate Preparedness and Resilience
cy	cubic yards
ECB	Engineering and Construction Bulletin
EL.	elevation
EP	Engineering Pamphlet
ER	Engineering Regulation
ESA	Environmental Site Assessment
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
FPL	Florida Power and Light
FPMS	Floodplain Management Services
GIS	geographic information system
gph	gallons per hour
gpm	gallons per minute
HEC-HMS	Hydrologic Engineering Center Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center's River Analysis System
hp	horsepower
Hwy	Highway
Hz	Hertz
Ia	initial abstraction
IEEE	Institute of Electrical and Electronics Engineers
kW	kilowatt
LED	light emitting diode
LiDAR	Light Detection and Ranging
MCC	motor control center
NFPA	National Fire Protection Association
NFS	non-Federal sponsor
NOAA	National Oceanographic and Atmospheric Association
NRCS	Natural Resources Conservation Service
	limited
PAS	Planning Assistance to States
PRF	peak rate factor

PVC	polyvinyl chloride
rpm	revolutions per minute
SCS	Soil Conservation Services
SJRWMD	St. Johns River Water Management District
SLC	sea-level change
TDH	total dynamic head
USACE	U.S. Army Corps of Engineers
USCS	U.S. Soil Classification System
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VA	Vulnerability Assessment

1. INTRODUCTION

The Jacksonville District of the U.S. Army Corps of Engineers (USACE) was tasked to assist Nassau County, Florida, the non-Federal sponsor (NFS), in the identification of long-term structural and nonstructural flood risk Management Measures to alleviate flooding along Thomas Creek associated with rainfall events. This Planning Assistance to States (PAS) study focuses on the Thomas Creek watershed within Nassau County and identifies potential solutions to address flooding concerns.

1.1 LOCATION

The project is in Nassau County, on the northeast coast of Florida, as shown in Figure 1-1. Thomas Creek flows along the border of Nassau County and Duval County, through pristine wetlands, and discharges into the Atlantic Ocean. The NFS for this study is Nassau County; therefore, the design footprints of the proposed solutions, as well as all impacts, must be contained within Nassau County.

Figure 1-1. Thomas Creek Project Location

1.2 BACKGROUND

The Thomas Creek Drainage Basin includes numerous properties that have experienced repetitive loss and routinely suffered property damage during named and unnamed storm events. From January 2010 to April 2019, approximately $3,340,000 was spent using County and grant funding to clear debris, or "de-snag", roughly 6 miles of Thomas Creek. An additional phase was added during 2018-2019 to address Hurricanes Matthew and Irma storm-related debris deposited into the phases completed before those storms occurred.

The project study area is defined by the repetitive loss areas (Figure 1-2), the HUC-8 watershed boundaries (Figure 1-3), and work order volumes from the Road Department (Figure 1-4). Figure 1-5 through Figure 1-7 show close-up views of the properties with repetitive losses.

Figure 1-2. Thomas Creek Flood Management Study Project Location

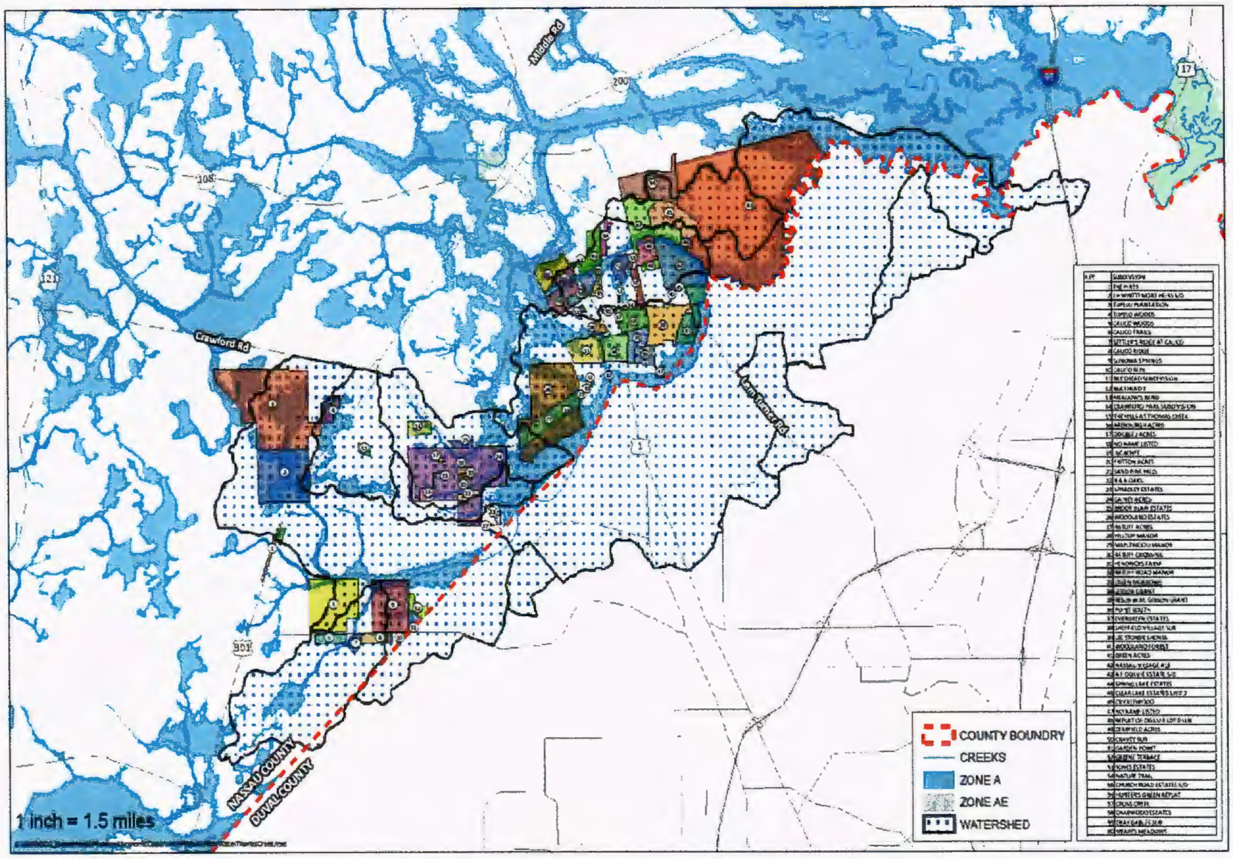

Figure 1-3. Nassau County Flood Zone Map

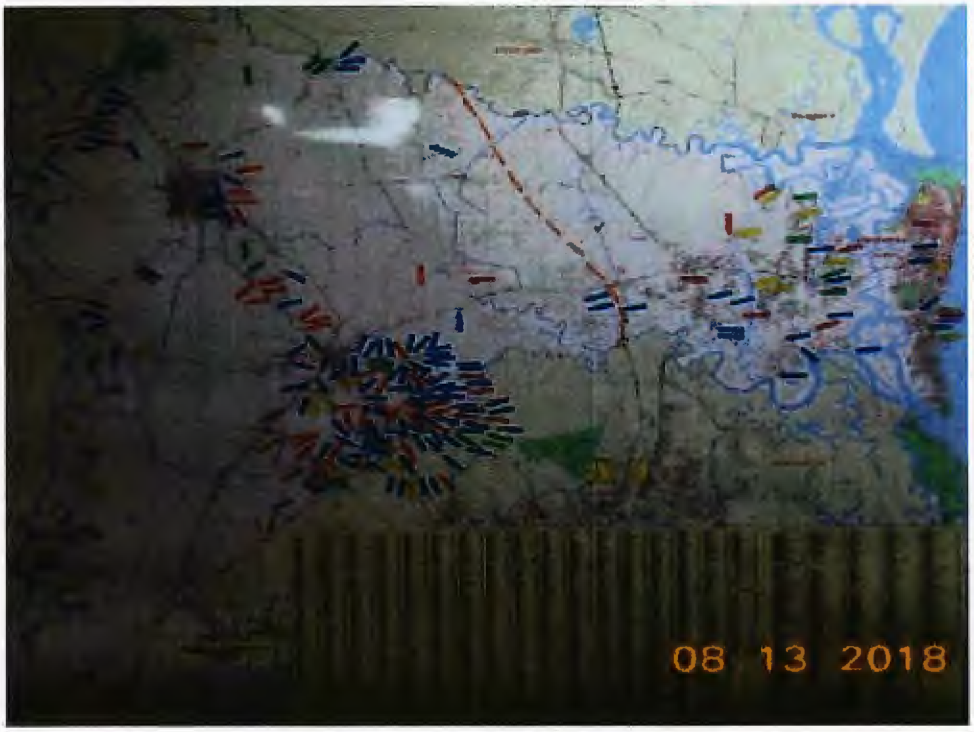

Figure 1-4. Work Orders from 2018 Pinned Locations

Redacted - Protected Information

Figure 1-5. Repetitive Loss Location 1a

Redacted - Protected Information

Figure 1-6. Repetitive Loss Location 3a

Redacted - Protected Information

Figure 1-7. Repetitive Loss Location 3b

USACE did not evaluate the following flooding areas (shown in Figure 1-2) for the following reasons:

- Area #4 was omitted because it is on a different creek, not Thomas Creek.
- Area #5 was omitted because it is in Duval County.

This appendix documents the development of the solution, development of the Thomas Creek HEC-RAS hydraulic model, calibration of the model, and application of this hydraulic model to evaluate management Alternatives to alleviate flooding risks. The event frequencies analyzed included 100-year, 25-year, and 10-year frequency rainfalls (all 24-hour-long storms). The applied technical term in the Hydrologic community for the rainfall event frequency is Annual Exceedance Probability, or AEP. Hereafter within this report, the storm frequencies are labeled as follows:

- The 100-year storm is the 1% AEP
- The 25-year storm is the 4% AEP
- The 10-year storm is the 10% AEP
- The 5-year storm is the 20% AEP

2. AVAILABLE DATA

2.1 SITE VISIT

A site visit of Thomas Creek was conducted on January 28, 2020 by the entire team. Nassau County staff showed USACE the main areas of concern. This included, Freedom Drive, Marlee, Vontz Circle, and Thomas Creek Baptist Church. Staff had access to the creek along Marlee to review the creek's banks. The group also reviewed the creek along Lem Turner Bridge.

The creek was at normal water level as it had not rained in the past seven days, according to the Jacksonville International Airport Station, the closest station. Staff did have photos of structures along the review route to reflect where the creek rose during Hurricane Irma.

The stream appeared to be the same width of the bridge, if not wider, as staff discussed dredging options. The vegetation near the bridge was also noted, but the engineers on site stated it should not obstruct flow.
Staff was also able to discuss narrowing down the project's scope to areas of repetitive loss as opposed to the entire watershed.

2.2 EXISTING DATA

Nassau County used the following existing information and tools in its hydrologic and flooding analysis:

- Federal Emergency Management Agency (FEMA) HEC-RAS model (1-D)
- Nassau County permitted stormwater calculations and designs
- Nassau County repetitive loss data
- Road Department work orders as seen in Figure 1-4 above
- FDOT bridge designs
- Sub-basins for the Thomas Creek project area from the Florida Department of Environmental Protection's (FDEP) 1997 Florida Drainage Basins
- Light Detection and Ranging (LiDAR) elevation data provided by the Nassau County Property Appraiser Department
- USGS contour information
- NOAA Atlas 14 rainfall data

3. POTENTIALLY BEST PERFORMING ALTERNATIVES

The team met to define a comprehensive list of all potential solutions to reduce the flood risk. Each individual solution is called a Management Measure. Once all Management Measures had been analyzed individually to determine the effectiveness of each, they were combined in different permutations designated Alternatives.

3.1 MANAGEMENT MEASURES

The individual Management Measures developed by the team included:

- building a floodwall or earthen berm
- using pumps
- channel clearing and widening
- snagging and clearing from drainage ditch systems (three defined by the NFS)
  - Ratliff Road
  - Larsen Road East
  - Larsen Road West
- using storage areas (three County-owned areas identified by the NFS)
- adding culverts beneath the CSX Railroad
- snagging and clearing of Thomas Creek
- raising first-floor elevations
- flood-proofing
- using buyouts
- relocating
- updating FEMA floodplain maps

The following sections summarize the engineering analysis results of the structural measures, and whether or not they were carried forward. Section 5.6 provides the detailed results of each individual engineering analysis.

3.1.1 FLOODWALL OR EARTHEN BERM

The earthen berm Management Measure was eliminated, as it would have required a large footprint, which would entail a large amount of land. The floodwall Management Measure was carried forward.

3.1.2 PUMPS

Pumps would be required as part of the floodwall system, but would not be effective by themselves. The pumps were carried forward as part of the floodwall design.

3.1.3 CHANNEL CLEARING AND CHANNEL WIDENING

Channel clearing and widening of the channel was determined likely to only be marginally effective. As only the Nassau County side could be excavated, and homes had to be avoided, the channel clearing Management Measure would have been inadequate due to limited space.

On the other hand, channel widening resulted in a reduction of flood stages within the homes by 3 to 6 inches for the 1% AEP. However, the flood depths in these homes had been 2 to 3 feet, so a reduction of 3 to 6 inches would provide no significant benefit resulting in no reduction to repetitive losses. The flood stage reduction for the 10% AEP was even less at 0.15 feet, as shown in Figure 3-1. In addition, mitigation credits may be needed and approved, per the St. Johns River Water Management District (SJRWMD).

HEC-RAS River: Thomas Creek Reach:

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	127146	10-year	Existing Steady State	19984.90	7.09	14.14	12.87	14.18	0.000447	3.63	13613.98	6594.35	0.24
Reach-1	127146	10-year	Alternative Steady State	19984.90	7.09	14.17	12.87	14.21	0.000426	3.55	13834.05	6634.77	0.24
Reach-1	127146	10-year	WIDENING	19984.90	7.09	14.06		14.11	0.000503	3.82	13099.94	6392.52	0.26
Reach-1	124837	10-year	Existing Steady State	5502.20	6.31	13.73	11.24	13.74	0.000035	1.06	11003.74	4173.23	0.07
Reach-1	124837	10-year	Alternative Steady State	5502.20	6.31	13.79	11.24	13.79	0.000033	1.03	11231.91	4228.74	0.07
Reach-1	124837	10-year	WIDENING	5502.20	6.31	13.60		13.60	0.000041	1.13	10436.35	4041.43	0.07
Reach-1	123555	10-year	Existing Steady State	5502.20	6.55	13.68	11.31	13.69	0.000046	1.17	10076.72	4069.40	0.08
Reach-1	123555	10-year	Alternative Steady State	5502.20	6.55	13.74	11.31	13.75	0.000043	1.14	10311.44	4094.09	0.08
Reach-1	123555	10-year	WIDENING	5502.20	6.55	13.53		13.54	0.000055	1.26	9478.15	4005.20	0.08
Reach-1	122925	10-year	Existing Steady State	5502.20	6.34	13.66	11.06	13.66	0.000030	0.96	12753.67	5358.94	0.06
Reach-1	122925	10-year	Alternative Steady State	5502.20	6.34	13.72	11.06	13.72	0.000028	0.93	13071.04	5406.73	0.06
Reach-1	122925	10-year	WIDENING	5502.20	6.34	13.51		13.51	0.000035	1.04	11951.42	5147.49	0.07
Reach-1	121204	10-year	Existing Steady State	5502.20	5.29	13.65	9.84	13.65	0.000004	0.40	27050.28	7778.46	0.02
Reach-1	121204	10-year	Alternative Steady State	5502.20	5.29	13.71	9.86	13.71	0.000004	0.40	25895.42	6446.00	0.02
Reach-1	121204	10-year	WIDENING	5502.20	5.29	13.49		13.49	0.000005	0.42	25857.30	7640.60	0.03
Reach-1	119565	10-year	Existing Steady State	5502.20	4.97	13.64	9.40	13.64	0.000005	0.43	23450.45	5513.38	0.03
Reach-1	119565	10-year	Alternative Steady State	5502.20	4.97	13.70	9.40	13.70	0.000004	0.42	23744.96	5426.17	0.03
Reach-1	119565	10-year	WIDENING	5502.20	4.97	13.48		13.49	0.000005	0.45	22601.92	5415.11	0.03
Reach-1	118600	10-year	Existing Steady State	4445.80	4.58	13.64	8.97	13.64	0.000003	0.34	24540.75	5502.92	0.02
Reach-1	118600	10-year	Alternative Steady State	4445.80	4.58	13.70	9.00	13.70	0.000003	0.35	22675.61	4679.85	0.02
Reach-1	118600	10-year	WIDENING	4445.80	4.58	13.48		13.48	0.000003	0.35	23686.18	5455.31	0.02
Reach-1	117764	10-year	Existing Steady State	4445.80	4.36	13.63	8.69	13.63	0.000003	0.34	26213.85	6357.84	0.02
Reach-1	117764	10-year	Alternative Steady State	4445.80	4.36	13.69	8.74	13.69	0.000003	0.36	22157.24	4558.82	0.02
Reach-1	117764	10-year	WIDENING	4445.80	4.36	13.48		13.48	0.000003	0.35	25221.80	6336.33	0.02
Reach-1	116897	10-year	Existing Steady State	4445.80	2.90	13.63	8.23	13.63	0.000004	0.48	17544.18	3468.00	0.03
Reach-1	116897	10-year	Alternative Steady State	4445.80	2.90	13.69	8.54	13.69	0.000005	0.53	15556.79	2915.85	0.03
Reach-1	116897	10-year	WIDENING	4445.80	2.90	13.47		13.48	0.000005	0.50	17002.81	3443.15	0.03
Reach-1	116246	10-year	Existing Steady State	4445.80	4.17	13.63	8.69	13.63	0.000010	0.67	13022.34	3757.90	0.04
Reach-1	116246	10-year	Alternative Steady State	4445.80	4.17	13.68	8.69	13.69	0.000011	0.69	10997.29	2102.84	0.04
Reach-1	116246	10-year	WIDENING	4445.80	4.17	13.47		13.47	0.000011	0.69	12439.51	3659.73	0.04
Reach-1	115233	10-year	Existing Steady State	4445.80	4.03	13.59	9.15	13.60	0.000134	1.64	9200.37	2575.04	0.09
Reach-1	115233	10-year	Alternative Steady State	4445.80	4.03	13.65	9.15	13.66	0.000128	1.61	9314.27	2454.87	0.09
Reach-1	115233	10-year	WIDENING	4445.80	4.03	13.43	9.15	13.44	0.000152	1.72	8792.35	2510.30	0.10
Reach-1	115000			Bridge									
Reach-1	114090	10-year	Existing Steady State	4445.80	2.02	12.66	7.80	12.70	0.000279	2.54	5425.37	1428.99	0.14
Reach-1	114090	10-year	Alternative Steady State	4445.80	2.02	12.77	7.80	12.80	0.000255	2.45	5540.02	1339.05	0.13
Reach-1	114090	10-year	WIDENING	4445.80	2.02	12.40		12.45	0.000320	2.68	5064.93	1356.00	0.15
Reach-1	112663	10-year	Existing Steady State	4445.80	1.46	12.19	7.75	12.24	0.000360	2.90	5026.74	1653.18	0.16
Reach-1	112663	10-year	Alternative Steady State	4445.80	1.46	12.23	7.79	12.31	0.000457	3.28	3867.96	1089.87	0.18
Reach-1	112663	10-year	WIDENING	4445.80	1.46	11.83		11.90	0.000453	3.19	4457.44	1510.62	0.18

Figure 3-1. 10% AEP Results

3.1.4 DITCH SNAGGING AND DITCH CLEARING

The NFS determined that the SJRWMD would not permit the clearing of one of the ditch systems on Larsen Road, so the other two were carried forward. Figure 3-2 shows the ditch-clearing locations.

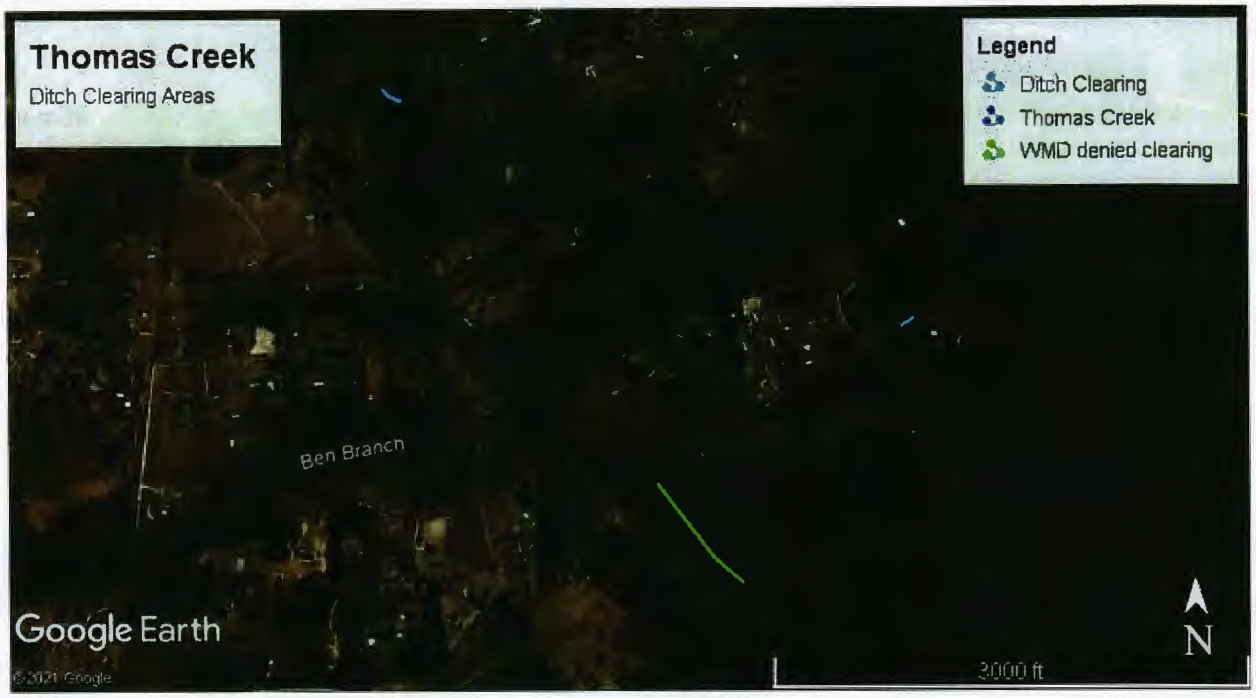

Figure 3-2. Ditch-Clearing Locations

3.1.5 STORAGE AREAS

Figure 3-3 shows the locations of the detention ponds. During the analysis, it was determined that Thomas Creek flood stages do not impact two of the three storage areas considered (shown in purple). As such, detention of overland flow would only work in one of the detention pond areas (shown in red). The detention pond denoted in red was carried forward.

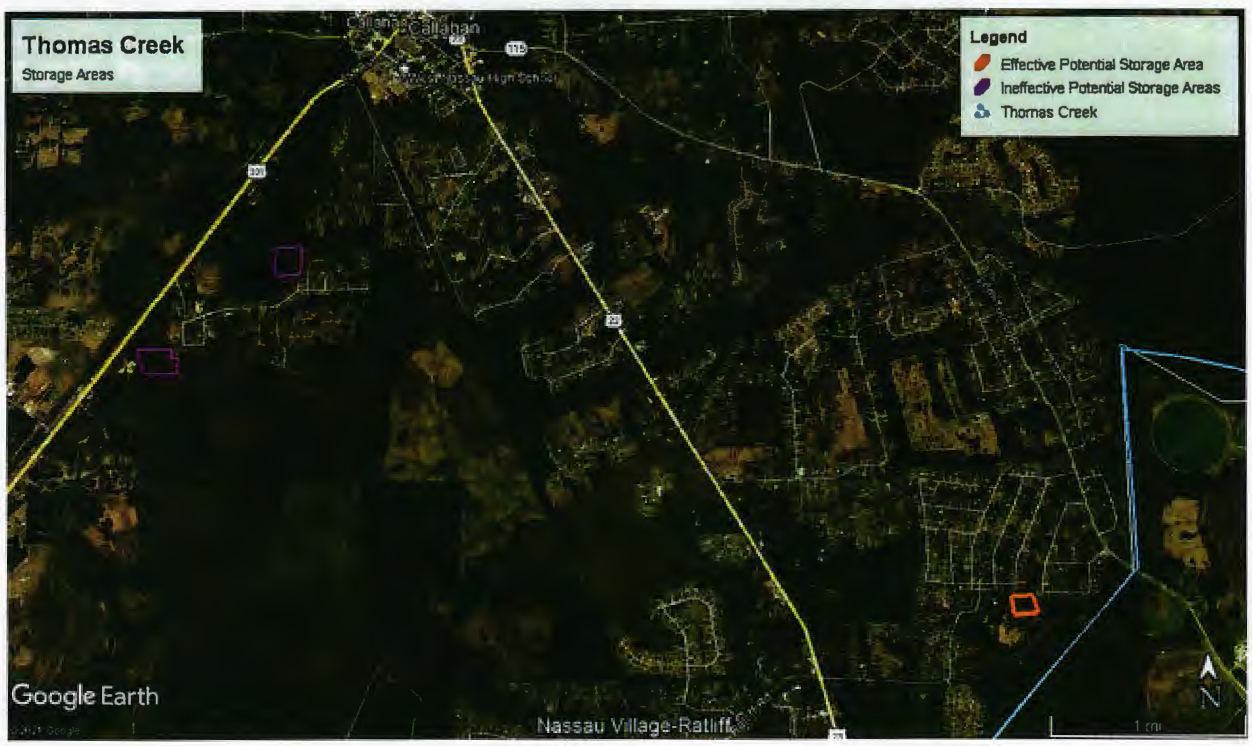

Figure 3-3. Storage Area Locations

3.1.6 ADDITIONAL CULVERTS BENEATH CSX

The additional culverts beneath the CSX railroad bridge could possibly provide flood risk reduction, and was carried forward for modeling. Results are discussed in Section 5.5.1.

3.1.7 SNAGGING AND CLEARING THOMAS CREEK

In 2016, the NFS spent millions with grant funds to snag and clear multiple sections of Thomas Creek, as shown in Figure 3-4. All cleared areas returned to the same debris-filled channel. This Management Measure was determined to be unsustainable in Thomas Creek. However, the NFS determined that they planned to perform snagging and clearing of the drainage ditches regardless of the outcome of this analysis and was carried forward for application in smaller drainage ditches.

Figure 3-4. 2016 Snagging and Clearing Locations

3.2 THE BEST-PERFORMING STRUCTURAL ALTERNATIVES

As discussed in Section 3.1, the best-performing Management Measures were combined into Alternatives and analyzed. Section 5.5 presents the detailed analysis for each Alternative. Since the NFS determined that they planned to perform snagging and clearing of the drainage ditches regardless of the outcome of this analysis, so this Management Measure was included in all Alternatives. The floodwall would not provide a flood risk reduction without pumps, and the pumps would not provide flood risk reduction as a stand-alone feature. Thus, the floodwall and the pumps were combined. The initial array of alternatives and their analysis results are discussed in Section 5.5. The resulting Best-Performing Alternatives were as follows:

1 Alternative 1 – Construction of floodwall with pumps and snagging and clearing from two drainage ditches.

2 Alternative 2 – Creation of one detention pond and snagging and clearing from two drainage ditches.

3.2.1 FLOODWALL WITH PUMPS

The floodwall design included the sheet pile floodwall, flap-gated culverts to discharge runoff, four pump houses to discharge water when the stages in Thomas Creek were above the flap-gated culverts, and a channel to hydraulically connect the pump houses. Based upon the road elevations at each end of the floodwall, the floodwall crest elevation was set to provide protection from the 10% AEP stages in Thomas Creek. The pumps were sized to drain the 10% AEP runoff volume within 24 hours. Each pump house included a power connection to the local utility, a backup generator and secondary containment, and an access road. The flap-gated culverts were sized to pass the 20% AEP to match the FDOT roadway storm sewer system capacity.

3.2.2 CREATION OF DETENTION POND

The pond had been designed to route water from the Sheffield Village Subdivision. This subdivision consists of 100 1-acre parcels. The water table in the area is high relative to the road elevations in the area. Storage for the pond could not reach a current 4% AEP, 24-hour storm event rain capture.

4. THOMAS CREEK HYDROLOGIC MODELING

4.1 MODELING PLATFORM

The hydrologic analysis was performed with the USACE Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) model, version 4.4.1, to simulate runoff volumes and flow hydrographs. This information was an input for the hydraulic analyses conducted using the Hydrology Engineering Center River Analysis System (HEC-RAS) model. Figure 4-1 shows the Thomas Creek hydrologic modeling domain.

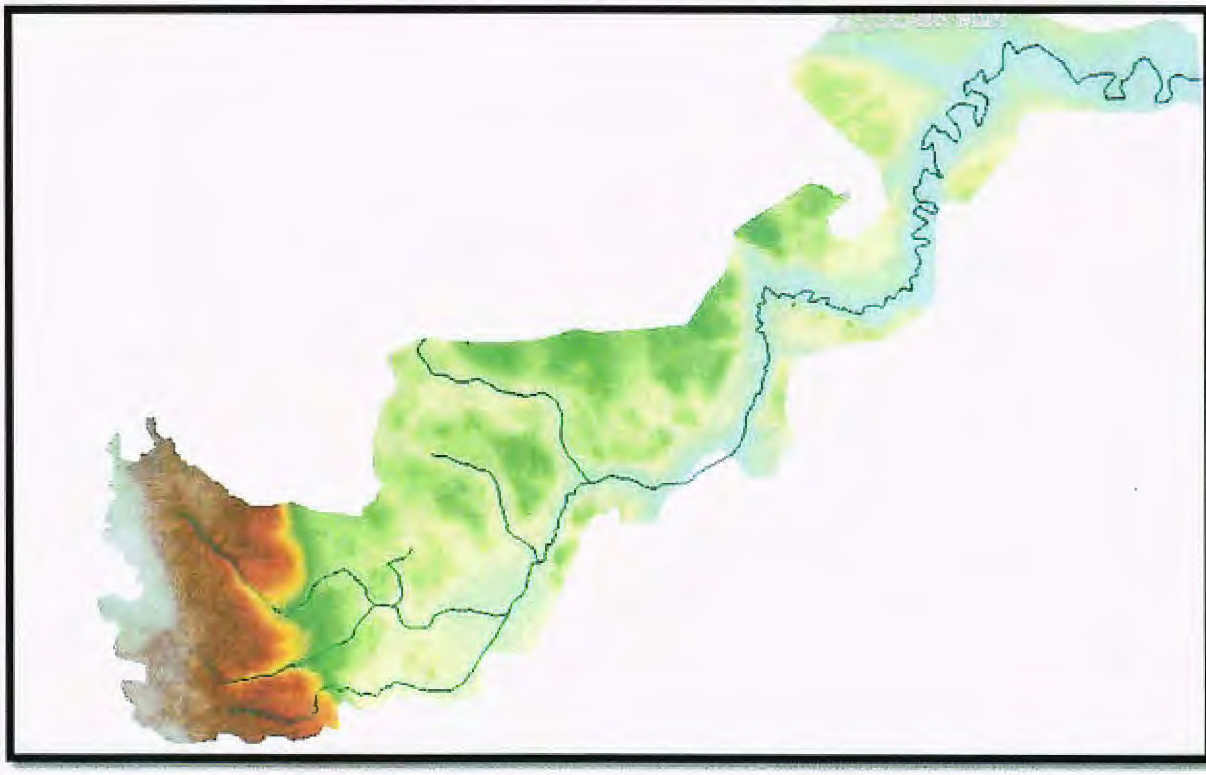

Figure 4-1. Digital Terrain Model for Thomas Creek HEC-HMS

4.2 SUB-BASIN ELEMENTS

Sub-basins for the Thomas Creek project area were delineated using the most refined pre-published basins available from the Florida Department of Environmental Protection's (FDEP) 1997 Florida Drainage Basins shapefile (below). Thomas Creek basins drain into the Nassau basin. However, given the size of the flooded areas being studied, the sub-basins were further refined by Light Detention and Ranging (LiDAR) elevation data provided by Nassau County Property Appraiser's Department. One-foot contours captured in 2007 created the digital elevation model. USGS contours were utilized to fill in portions of Duval County's side of the watershed.

The Thomas Creek watersheds were conceptualized to capture the timing, magnitude, and duration of the inflow hydrographs. HEC-HMS computes sub-basin outflow from precipitation data by subtracting the losses, transforming excess precipitation, routing open channel flow, and computing baseflow for each sub-basin. This model did not include baseflow calculations. Figure 4-2 presents the sub-basin connectivity map used in the HEC-HMS model. The following sections explain how the various input parameters for the sub-basin element were computed. Total drainage area is approximately 28 square miles.

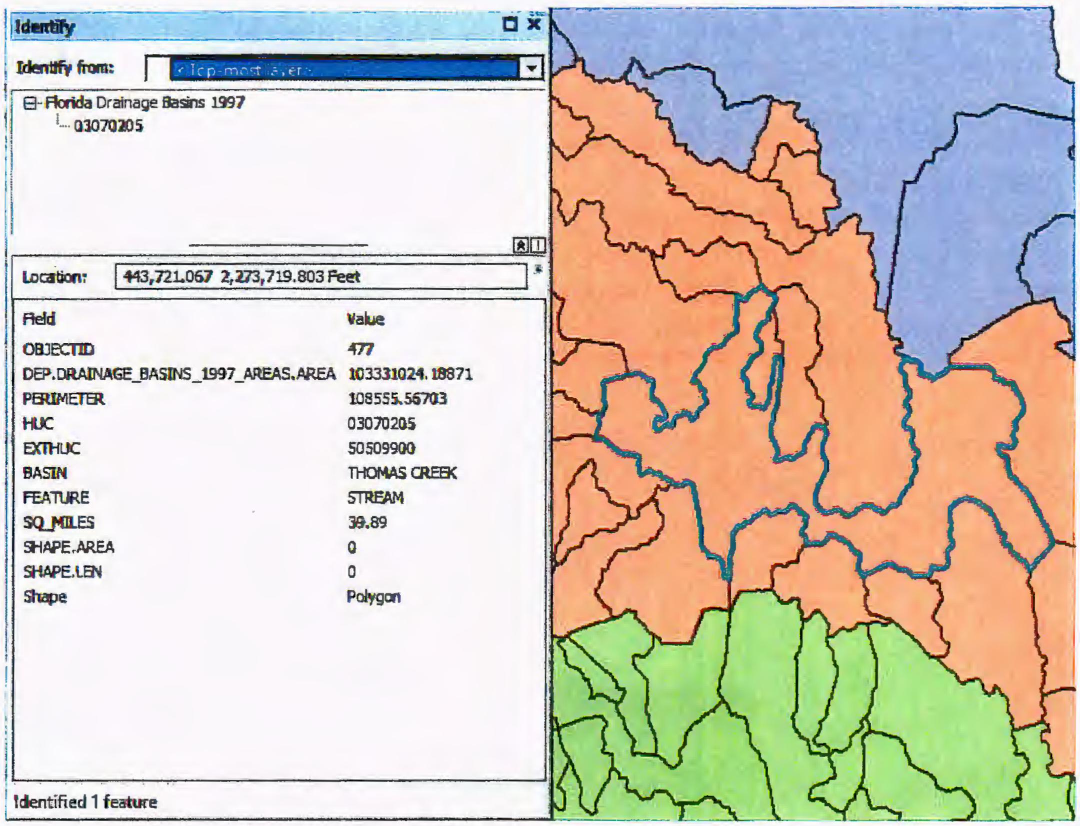

Figure 4-2. Thomas Creek 1997 Florida Drainage Basins

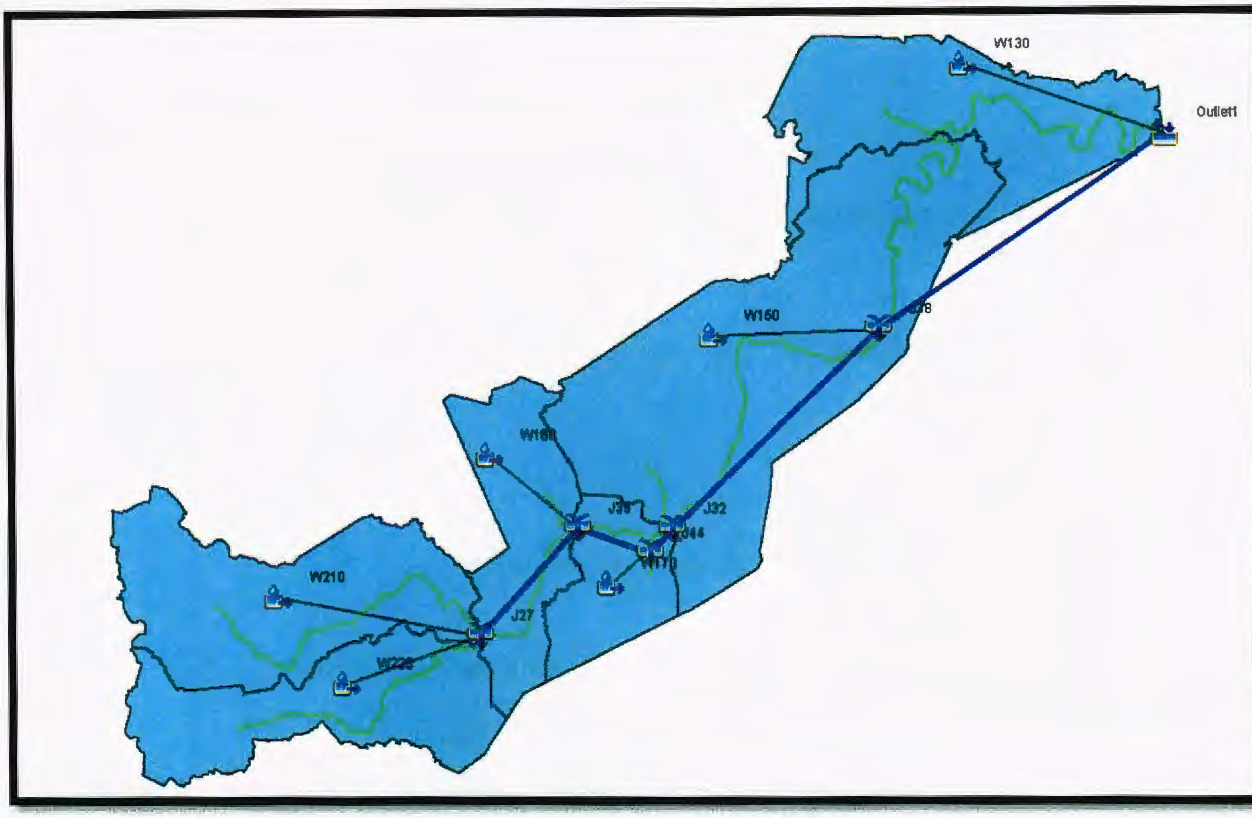

Figure 4-3. Subbasin Connectivity

4.3 LOSS METHOD

The Soil Conservation Services (SCS) curve number loss method was used to estimate an amount of runoff potential from a rainfall event based on the relationship between soil type, land use, and hydrologic soil conditions. This method is applicable for single-storm event modeling. HEC-HMS input parameters for the SCS curve number loss method are initial abstraction (Ia), curve number (CN), and percent impervious.

CNs were derived from the relationship between soil type (coverage), land use, and the antecedent moisture condition in the basin. The land use data was expressed using the Florida Land Use and Cover Classification System. The Soil Survey Geographic dataset soil coverage was used to determine soil types, hydrologic soil group, and total area for each soil classification using geographic information system (GIS). Composite CNs were developed for each of the subbasins based on these data parameters. The percent impervious was assumed to be included in the CN calculation, so the HEC-HMS input was set to zero.

Additionally, the antecedent moisture condition (AMC), which is how wet or dry the soil is when it starts to rain, was considered to be an AMC II, the average moisture condition, in the construction of the Thomas Creek HEC-HMS model.

Additional losses can occur in the form of infiltration into the soil, interception due to foliage, and depression storage due to ponding or surface undulations. The initial abstraction calculation is based on land-use pattern, hence the CN for initial modeling runs.

1. The SCS CN is related to the potential maximum retention by Equation 1 below.
2. The empirical equation used to determine the Initial Abstraction can be seen in Equation 2.
3. Both equations were obtained from TR-55 Urban Hydrology for Small Watersheds (USDA, 1986).

$$S = \left(\frac{1000}{CN}\right) - 10$$

Equation 1

where S = Potential Maximum Retention after Runoff Begins (in),
CN = Curve Number.

$$I_a = 0.2 * S$$

Equation 2

where I_a = Initial Abstraction (in).

Table 4-1 below lists the final calculated CNs and subbasin areas.

Table 4-1. Calculated CNs and Subbasin Areas

Subbasin	Area (sq. miles)	Curve Number
W130	4.7	83
W150	10.0	83
W160	2.9	87
W170	1.8	85
W210	5.0	73
W220	3.9	82

4.4 TRANSFORM METHOD

The transform method for sub-basins converts the rainfall (after subtracting losses) to streamflow hydrograph (runoff). To accurately represent the response of each sub-basin to a rainfall event, a hydrograph, based on the time of concentration and lag time, is calculated for each sub-basin. The transform method chosen for this model was the SCS Unit Hydrograph. The peak rate factor (PRF) alters the hydrograph's shape while maintaining the total volume of runoff. Natural Resources Conservation Service (NRCS) has published the Delmarva Unit Hydrograph particularly suited for flat coastal areas. Due to the relatively flat topography in the project area, the team chose the Delmarva PRF (284).

The time of concentration is defined as the time it takes water to travel from the hydraulically furthermost point in the watershed to the outlet. The lag time is defined as the delay between the time runoff from a rainfall event begins until runoff reaches its maximum peak. Within the hydrologic modeling platform, the lag time is used to create the resulting hydrographs. For average natural watershed conditions and an approximately uniform distribution of runoff, the lag time is 60% of the time of concentration.

Several formulas are available to estimate the time of concentration and lag time. A common formula is the SCS watershed lag time equation. This equation uses parameters such as the flow length, average sub-basin slope, and retention based on the CN to determine the adequate lag. The lag time (Table 4-2 below) was evaluated to ensure the lag time was sufficient to describe the hydrologic conditions present in both the existing condition and with project models.

Table 4-2. Lag Time (in minutes)

Subbasin	Lag Time (minutes)
W130	51.6
W150	109.4
W160	98.1
W170	43.7
W210	57.6
W220	40.0

4.5 ROUTING METHOD

A reach element has one or more sources of inflow from another element and computes one combined outflow. It represents a segment of the river or flow way and simulates the movement of water by employing a user-selected routing method.

The hydrologic routing method chosen for the model was the kinematic-wave method because kinematic waves govern the flow when inertial and pressure forces are not important. Thus, in a kinematic wave the gravity and frictional terms are balanced, so the flow does not accelerate appreciably. For these kinds of waves, the energy grade line is parallel to the channel bottom.

The kinematic-wave method is based on physical parameters such as the reach length, Manning's roughness coefficient, channel geometry, and slope. The routing parameters were estimated using GIS software to determine the reach length and channel bed slope. The shape of the channel was assumed to be trapezoidal, with 2H:1V side slopes and an average channel width of 50 feet estimated from aerial photography and estimates made during the initial field visit. Accuracy of GIS methods depends on the resolution of the LiDAR data used to determine these parameters. Aerial photography, literature values, and engineering judgment were used to determine appropriate Manning's coefficients.

4.6 METEOROLOGICAL MODEL

The specified hyetograph methodology was selected for meteorological model input for the design storm events for both existing conditions and project models. The user-specified hyetograph option allows for input of a gauge in each subbasin for the use of time series data. NOAA Atlas 14 precipitation depth (in.) were used for the following storm events: the 100-year 50-year, 25-year, 10-year, 5-year, and 2-year storms, or the 1%, 2%, 4%, 10%, and 50% Annual Exceedance Probability (AEP) events in the Thomas Creek watershed.

4.7 CONTROL SPECIFICATION

Control specifications were used to input the start date and time as well as the end date and time. The time interval for the model was also entered here. The synthetic design storms were run from 01 January 2000 to 02 January 2000 at a time interval of 15 minutes. The simulation time was longer than 24 hours to ensure the receding limb of the hydrograph was captured.

4.8 TIME-SERIES DATA

The Time-Series Data Manager allows observed time-series data or hypothetical time-series data to be incorporated into the model either as an initial condition, a boundary condition, or a parameter used for calibration. Precipitation gauges were developed for the 1% (100-year), 4% (25-year), and 10% (10-year) NOAA Atlas 14 rainfall AEP entered as cumulative rainfall. The data was entered manually for each precipitation gauge in 15-minute time increments. The same precipitation values were used in both the existing condition and with project models.

4.9 MODEL ASSUMPTIONS

Thomas Creek watershed natural flow pattern has changed with development. Runoff may vary in comparison to the natural watershed as subdivisions' water was rerouted into ditches. Each sub-basin element and its associated loss and transform methods were reviewed and modified to produce a runoff hydrograph that was reasonable for the physical conditions.

4.10 MODEL VERIFICATION

The resulting HEC-HMS hydrographs were input into the HEC-RAS model at appropriate river or subbasin cross sections. No gauges were available in the project basin for calibration. However, to determine if the HEC-HMS-calculated hydrographs were within a reasonable threshold, the HEC-RAS-calculated flows at structures in Thomas Creek were compared to observed flows during Hurricane Irma. Section 5.4 provides further discussion on the indirect verification.

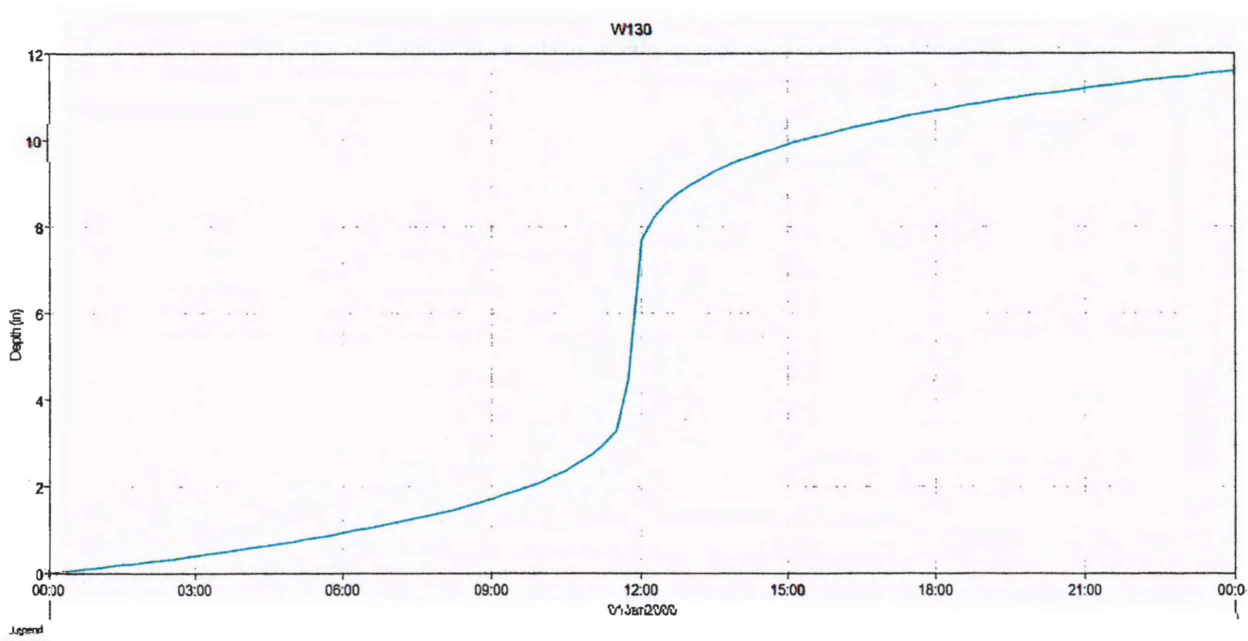

Figure 4-4. HEC-HMS Hydrograph

Electronic model files and .pdf results are maintained in the Nassau County database on the Engineering Drive under Thomas Creek PAS.

5. THOMAS CREEK HYDRAULIC MODELING

5.1 HYDRAULIC MODEL PLATFORM

The Hydrologic Engineering Center's River Analysis System (HEC-RAS), Version 5.0.7 (March 2019) modeling software was used for developing the Thomas Creek hydraulic model. HEC-RAS Version 5.0.7 modeling advantages and capabilities include:

1 The ability to perform 1D only, 2D only, or to combine 1D and 2D modeling.
2 The 2D equation solver using an implicit finite volume algorithm.
3 Solving either 2D diffusion wave or 2D full Saint-Venant equations.
4 Tightly coupling the 1D and 2D solution algorithms on a time-step by time-step basis (or even iteration by iteration).
5 The software having been designed to use unstructured and structured computational meshes. The outer boundary is defined with a multi-point polygon.
6 The underlying terrain and the computational mesh are pre-processed to develop detailed hydraulic property table of the cells and the cell faces.
7 Performing mapping of the 1D/2D inundation area and animations of the flooding right inside of RAS using RAS-Mapper.
8 Creating multiple 2D flow areas in the same geometry.
9 Directly connecting multiple 2D flow areas with hydraulic structures.
10 Mixing flow regimes where flow transitions from subcritical to supercritical and from supercritical to subcritical.
11 The 2D flow computations taking advantage of multi-processors.
12 Using both 64-bit and 32-bit computation engines.

5.2 TERRAIN AND SURVEY DATA

HEC-RAS is currently capable of performing 1D water surface profile calculations for steady, gradually varied flow in natural or constructed channels. The modeler can calculate subcritical, supercritical, and mixed flow regime water surface profiles (reference manual). For Thomas Creek, 1D steady-state, subcritical flow ultimately was chosen as the evaluation model as steady state most resembled the FEMA model on the Duval side of Thomas Creek.

5.3 DEVELOPMENT OF THE THOMAS CREEK HYDRAULIC MODEL

The Thomas Creek hydraulic model was based on a preliminary HEC-RAS model developed by FEMA as part of the Flood Insurance Study (FIS) for Thomas Creek. The HEC-RAS model was a 1D HEC-RAS model that covered the Thomas Creek reach and its affluents.

FEMA mass edited the model to cover the study area. Additional data was entered into the HEC-RAS model based on information gathered from field visits, available documentation, and from using standard engineering equations to estimate model parameters. Information collected from field measurement, Google Earth, and terrain data were combined to estimate culvert invert, size, bridge span, etc.

5.3.1 BRIDGES

FEMA's HEC-RAS model did not include the existing bridges located in the Thomas Creek reach. Bridges were added to the HEC-RAS model using the Bridge Culvert condition in the geometric data. FDOT provided data such as as-built drawings and CSX data collections.

5.3.1.1 CSX RAILROAD BRIDGE

The bridge is just to the south of crossing A628.73 of CSX Railroad. Staff received this information from CSX because the site is inaccessible except by the railroad itself.

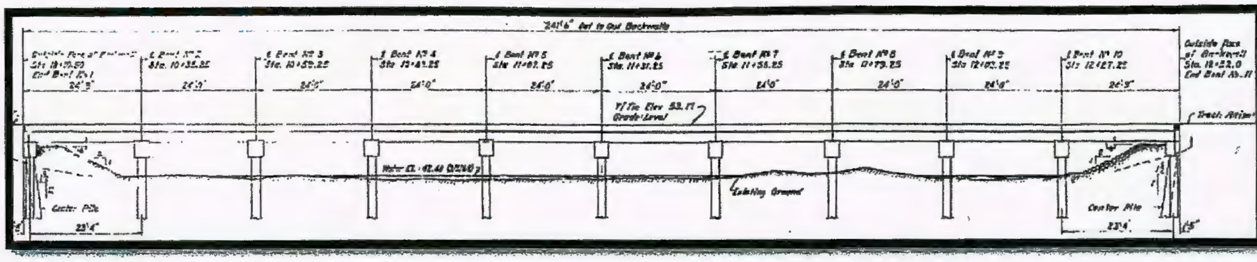

Figure 5-1. The Existing CSX Railroad Bridge

5.3.1.2 US-1 BRIDGE OR FDOT 720662

FDOT provided the as-builts for Bridge 720662. It was confirmed to be in the 1988 datum. Staff needed to convert some data from meters to feet to keep uniformity of the system.

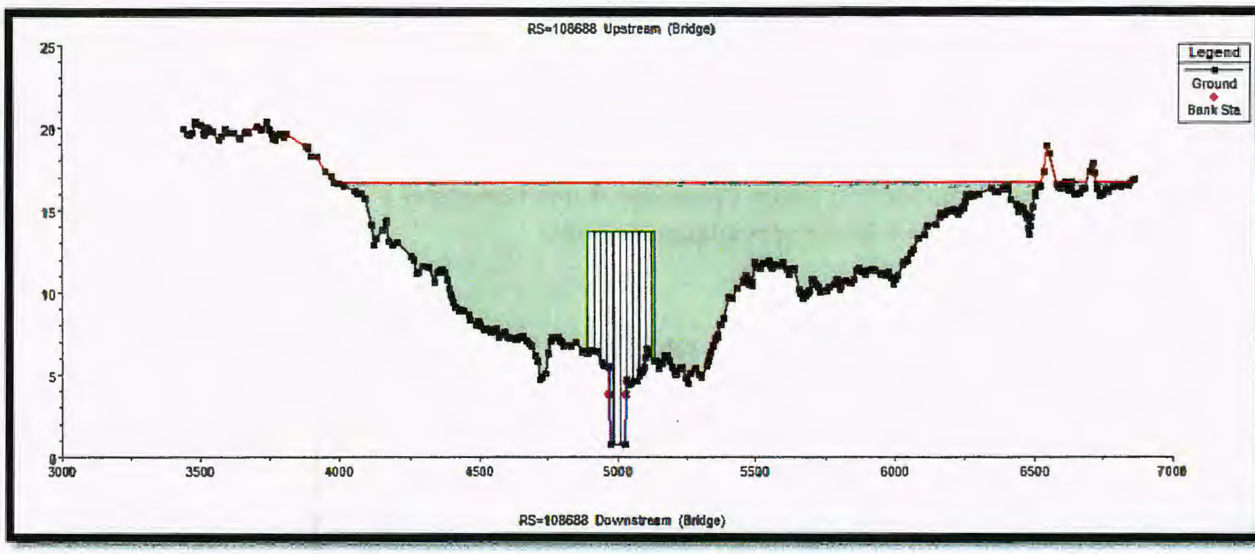

Figure 5-2. US-1 Bridge Simulation in HEC-RAS

5.3.1.3 STATE ROAD-115 BRIDGE OR FDOT 740054

FDOT provided the as-builts for Bridge 740054. During the site visit, staff noticed vegetation on top of the water that could preclude navigability, but the vegetation was not considered a factor since it was surface level only.

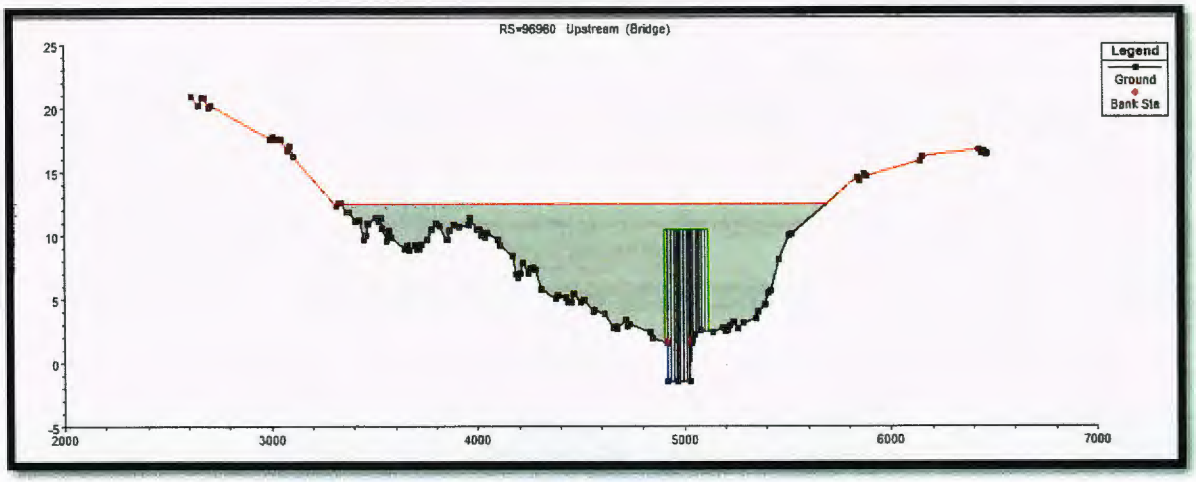

Figure 5-3. US 115 Box Culvert and Simulation

5.3.2 MANNING'S "N" VALUES

Base Manning's n values were based on the FEMA's HEC-RAS model. After initial Manning's n values and ranges were calculated during the model calibration process, Manning's n values were adjusted for a good model fit. This included adjustments around bridges and heavier vegetative areas. The model was compared to Duval's FEMA-published model for comparsion.

Table 5-1. Manning's "n" Starting Values Used for Land Classifications

	Acceptable Manning's "n" Range	Base Manning's "n"	Final Calibrated Manning's "n"
No Data	--	--	0.06
Barren Land Rock/Sand/Clay	0.023-0.03	0.025	0.03
Cultivated Crops	0.02-0.05	0.035	0.05
Deciduous Forest	0.1-0.2	0.16	0.2
Developed, High Intensity	0.12-0.2	0.15	0.2
Developed, Low Intensity	0.06-0.12	0.1	0.12
Developed, Medium Intensity	0.08-0.16	0.08	0.16
Developed, Open Space	0.03-0.05	0.04	0.05
Emergent Herbaceous Wetlands	0.05-0.085	0.07	0.081
Evergreen Forest	0.08-0.16	0.16	0.16
Grassland/Herbaceous	0.025-0.05	0.035	0.05
Mixed Forest	0.08-0.2	0.16	0.2
Open Water	0.025-0.05	0.04	0.05
Pasture/Hay	0.025-0.05	0.03	0.05
Shrub/Scrub	0.07-0.16	0.1	0.15
Woody Wetlands	0.045-0.15	0.12	0.15

5.3.3 BOUNDARY CONDITIONS

Since the steady-state conditions were selected for the overall evaluation, the boundary conditions reflect the HEC-HMS peak flows. The six boundary conditions selected were the inflow of the subbasins' runoff to the reaches. HEC-HMS 4.4.1 externally simulated these subbasins' runoffs; the results were stored in an Excel spreadsheet.

Enter/Edit Number of Profiles (32000 max): 5 Reach Boundary Conditions ...

Locations of Flow Data Changes

River: Thomas Creek Add Multiple...

Reach: Reach-1 River Sta.: 176221 Add A Flow Change Location

	Flow Change Location			Profile Names and Flow Rates					
	River	Reach	RS	100-year	2-year	5-year	10-year	25-year	50-year
1	Thomas Creek	Reach-1	176221	42826.3	10400.1	28018.7	19984.9	35201.8	28018.7
2	Thomas Creek	Reach-1	124837	10659.5	3144.7	4346.4	5502.2	7322.5	8906.9
3	Thomas Creek	Reach-1	118600	9590.8	2270.1	3361.9	4445.8	6216.7	7807.6
4	Thomas Creek	Reach-1	111031	4626.9	1510.8	2018.1	2500.2	3253.5	3906.2
5	Thomas Creek	Reach-1	108389	4781.2	1487.3	2020	2528.7	3325.8	4017.3
6	Thomas Creek	Reach-1	93980	14228.5	4286.3	5878.2	7407.2	9814.2	11909.5
7	Thomas Creek	Reach-1	49440	11126.1	3356.1	4604.1	5801	7682.4	9317.9

Figure 5-4. Storm Flows in Thomas Creek

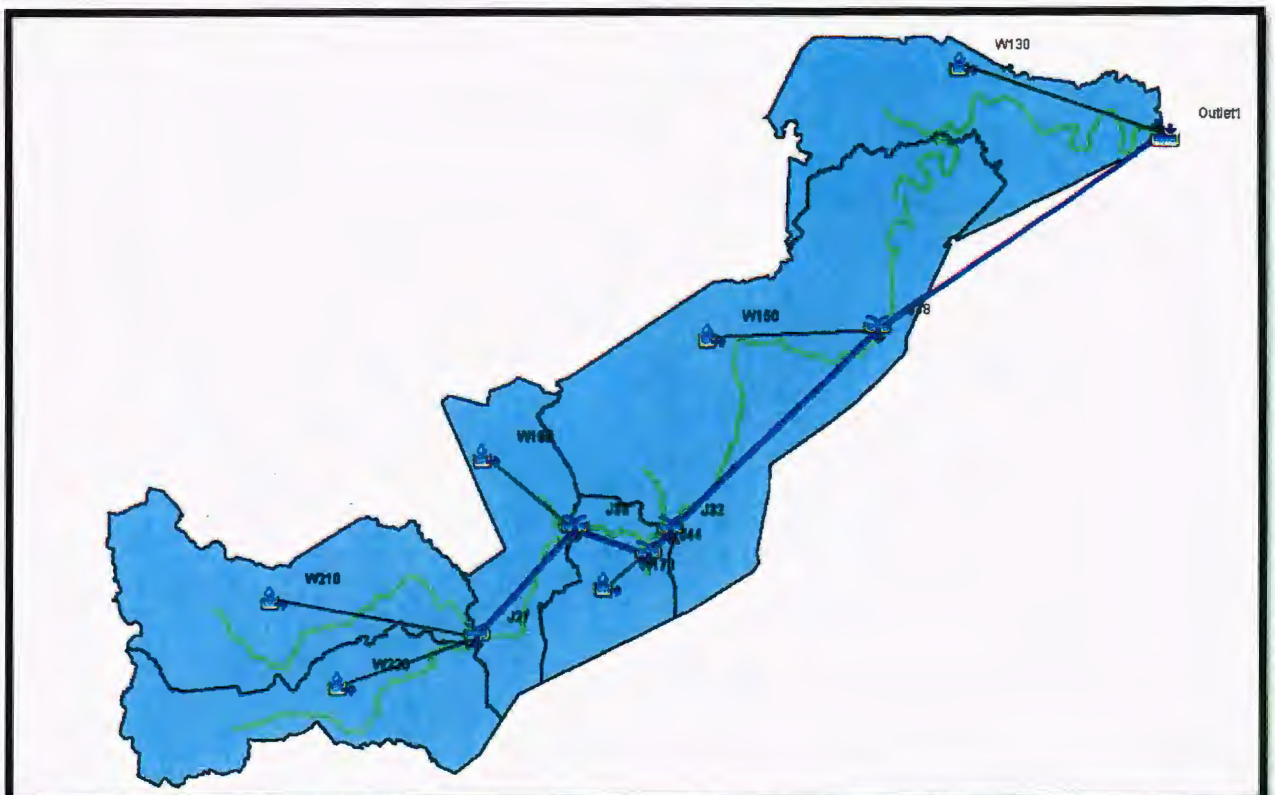

Figure 5-5. HEC-HMS Sub-Basin Boundary and Boundary Condition Lines

Controlled Unclassified Information (CUI)

5.4 THOMAS CREEK HEC-RAS MODEL CALIBRATION AND DUPLICATION

No recorded stage or flow data was near the study area to calibrate a HEC-RAS model for Thomas Creek. Instead, a Thomas Creek HEC-RAS 1D model was calibrated against high-water elevations reported by residents.

During the field visit on January 6, 2020, staff compiled flood complaints from September 2017's Hurricane Irma. Figure 5-6 shows these photos. The houses on Freedom Drive were flooded with 3 to 4 feet of water during Hurricane Irma. The houses in Greenwood subdivision's roadways were underwater. A duplication of FEMA's FIS for Thomas Creeks was performed by duplicating the water surface elevations reported in the Duval County published FEMA Federal Information Processing System Maps with the HEC-RAS results. Thomas Creek HEC-RAS model was run from Sept 10, 00:00 to Sept 11, 24:00, 2017 to 1% AEP event. Manning's roughness coefficients were modified to duplicate water surface elevations to match the values FEMA reported. Manning's roughness coefficients modifications were based on the acceptable ranges of values recommended for the land use (Table 5-1) and flood plains conditions in the study area.

The model results (Table 5-2) demonstrated that Freedom houses were flooded with about 3 to 4 feet of water (by comparing the W.S. Elevations to the average ground elevation of approximately 7-ft NAVD88 in the frequently flooded areas) during Hurricane Irma as shown in Figure 5-6. The model results also correctly showed Greenwood subdivision's roads underwater.

The model did not account for flooding seen in Sheffield Village. This led staff to believe concerns in this subdivision were localized and not due to the elevations in Thomas Creek. This was proven during the 06 July 2021 rainfall from Tropical Storm Elsa (results not shown). Homes at elevation (EL.) 20 feet NAVD88 were underwater, while the Thomas Creek riverbank water never reached EL. 16-ft NAVD88.

In another verification, the Thomas Creek model of the 1% AEP simulation was compared with FEMA's 2017 study (Figure 5-7), and the model's 1% AEP 24-hour maximum water surface approximately matched with FEMA's Zone A boundary. FEMA's more robust data collection and modeling to achieve closer calibration, along with a statistical analysis of the calibration, was not in the scope of FPMS projects though the model would still be able to show the general effectiveness of Alternatives.

Overall, comparing with the high-water stage and FEMA's 2017 study indicated that Thomas Creek model calibration was acceptable. Considering no recorded stage or flow data existed for calibration, this represented the best effort.

Figure 5-6. Flooded House during Hurricane Irma in September 2017

Table 5-2. Model Results Showing Houses Were Flooded with 3.5 Feet of Water during Hurricane Irma

HEC RAS Plan: Existing Steady State River: Thomas Creek Reach: Reach 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	105297	50-year	4017.30	-0.94	12.91	3.95	12.91	0.000023	0.79	42027.25	6824.00	0.04
Reach-1	103935	100-year	4781.20	-1.29	13.65	3.82	13.65	0.000010	0.56	74381.41	10730.60	0.03
Reach-1	103935	2-year	1487.30	-1.29	8.90	1.48	8.90	0.000010	0.42	29186.88	7384.26	0.02
Reach-1	103935	5-year	2020.00	-1.29	9.98	3.03	9.98	0.000009	0.44	38057.80	8926.18	0.02
Reach-1	103935	10-year	2528.70	-1.29	10.88	3.23	10.88	0.000011	0.50	46309.21	9461.39	0.03
Reach-1	103935	25-year	3325.80	-1.29	12.02	3.51	12.02	0.000011	0.52	57461.98	10047.40	0.03
Reach-1	103935	50-year	4017.30	-1.29	12.89	3.66	12.89	0.000010	0.53	66321.70	10412.19	0.03

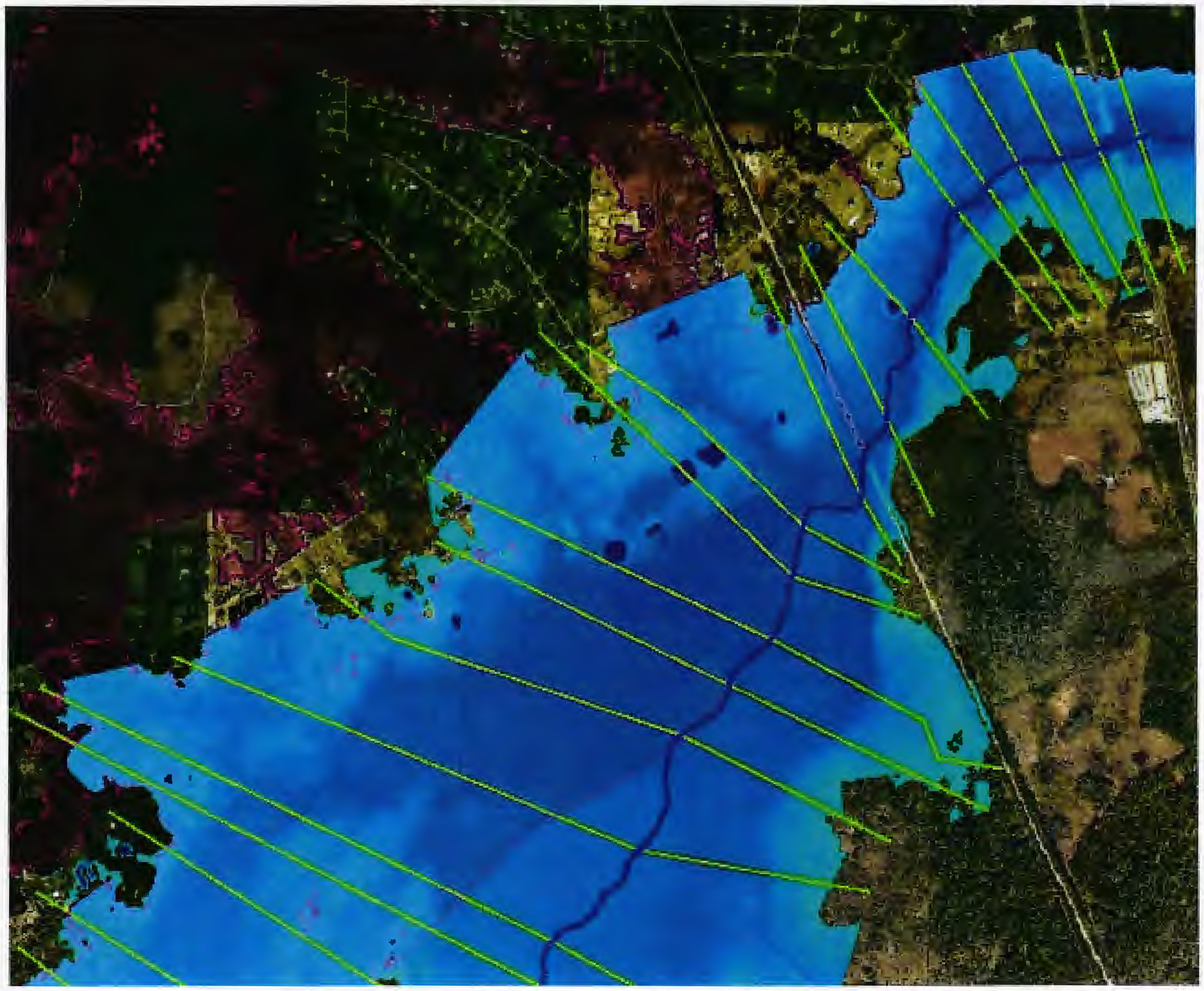

Figure 5-7. Thomas Creek 1D model 1% AEP Storm Maximum Water Surface (blue) Approximately Matched with FEMA Zone A (purple lines)

5.5 ALTERNATIVE ANALYSIS RESULTS

To find the best solution to reduce flooding at the Thomas Creek Watershed, the structural Management Measures were analyzed individually, as presented in Section 3.1. The best-performing Management Measures were then combined into Alternatives. This section presents the results of the Alternatives that were analyzed using Hydraulic modeling and numerical calculations. It is important to note that not all Management measures were analyzed using modeling and other numerical calculations, such as snagging and clearing of drainage ditches. The following Alternatives were evaluated using modeling or other numerical calculations:

- Culverts beneath CSX (with Channel widening)
- Channel widening alone
- Storage areas
- Floodwall
- Pumps (with Floodwall)

The Alternatives were evaluated comparing the existing condition with the proposed condition for each one of the Alternatives evaluated under 2-, 5-, 10-, 25-, and 100-year 24-hour storms. The hydraulic modeling results were evaluated to determine impacts to water surface elevations at Thomas Creek and CSX Railroad West and flooding reduction efforts at Thomas Creek.

After evaluating each of the Alternatives, the final best-performing structural Alternatives are as follows:

1. Construction of Floodwall with pump system and snagging and clearing from two drainage ditches.
2. Create one detention pond and snagging and clearing from two drainage ditches.

5.5.1 CULVERTS BENEATH CSX/WIDENING THOMAS CREEK

One of the major components of all the proposed Alternatives was to add additional conveyance capacity under the CSX Railroad near the existing bridge to drain water quickly from Thomas Creek during storm events (Table 5-3). The existing bridge constrains flow. The thought behind this analysis was to see if widening in the smallest place would alleviate flooding for major storm events. For this analysis, a widening of 50 feet, the maximum allowed with the bridge constraint, was also modeled.

The following three scenarios of additional pipes under CSX were run: four 24-inch barrels, Two 60-inch barrels, and four 60-inch barrels. These analyses was run as a multiple openings HEC-RAS and then compared to the multiple openings HEC-RAS model without any additional openings.

The model result showed that proposed alternative will not reduce flooding at Thomas Creek, as evident from no reduction in the W.S. Elevations in Table 5-3. No structures were mapped out of the water inundation area under the 1% AEP storm event.

Table 5-3. Proposed Alternative Did Not Reduce the Water Surface Elevation at Thomas Creek

HEC-RAS River: Thomas Creek

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	108917.*	100-year	4 Pipes CSX	4626.90	0.75	14.91	7.09	14.95	0.000213	2.43	12304.75	2143.03	0.11
Reach-1	108688			Bridge									
Reach-1	108389	100-year	CSX_PIPES	4781.20	0.66	13.84	7.08	13.90	0.000300	2.75	10941.81	2078.05	0.13
Reach-1	108389	100-year	One PIPE	4781.20	0.66	13.84	7.08	13.90	0.000300	2.75	10941.81	2078.05	0.13
Reach-1	108389	100-year	TEST NO PIPE	4781.20	0.66	13.84	7.08	13.90	0.000300	2.75	10941.81	2078.05	0.13
Reach-1	108389	100-year	4 Pipes CSX	4781.20	0.66	13.84	7.08	13.90	0.000300	2.75	10941.81	2078.05	0.13
Reach-1	106091	100-year	CSX_PIPES	4781.20	-0.42	13.69	5.09	13.69	0.000031	0.93	37537.51	4805.21	0.04
Reach-1	106091	100-year	One PIPE	4781.20	-0.42	13.69	5.09	13.69	0.000031	0.93	37537.51	4805.21	0.04
Reach-1	106091	100-year	TEST NO PIPE	4781.20	-0.42	13.69	5.09	13.69	0.000031	0.93	37537.51	4805.21	0.04
Reach-1	106091	100-year	4 Pipes CSX	4781.20	-0.42	13.69	5.09	13.69	0.000031	0.93	37537.51	4805.21	0.04
Reach-1	105297	100-year	CSX_PIPES	4781.20	-0.94	13.67	4.15	13.67	0.000024	0.83	47351.59	7186.16	0.04
Reach-1	105297	100-year	One PIPE	4781.20	-0.94	13.67	4.15	13.67	0.000024	0.83	47351.59	7186.16	0.04
Reach-1	105297	100-year	TEST NO PIPE	4781.20	-0.94	13.67	4.15	13.67	0.000024	0.83	47351.59	7186.16	0.04
Reach-1	105297	100-year	4 Pipes CSX	4781.20	-0.94	13.67	4.15	13.67	0.000024	0.83	47351.59	7186.16	0.04
Reach-1	103935	100-year	CSX_PIPES	4781.20	-1.29	13.65	3.82	13.65	0.000010	0.56	74381.41	10730.60	0.03
Reach-1	103935	100-year	One PIPE	4781.20	-1.29	13.65	3.82	13.65	0.000010	0.56	74381.41	10730.60	0.03
Reach-1	103935	100-year	TEST NO PIPE	4781.20	-1.29	13.65	3.82	13.65	0.000010	0.56	74381.41	10730.60	0.03
Reach-1	103935	100-year	4 Pipes CSX	4781.20	-1.29	13.65	3.82	13.65	0.000010	0.56	74381.41	10730.60	0.03
Reach-1	102342	100-year	CSX_PIPES	4781.20	-1.53	13.63	3.58	13.63	0.000015	0.67	66130.55	11128.05	0.03
Reach-1	102342	100-year	One PIPE	4781.20	-1.53	13.63	3.58	13.63	0.000015	0.67	66130.55	11128.05	0.03
Reach-1	102342	100-year	TEST NO PIPE	4781.20	-1.53	13.63	3.58	13.63	0.000015	0.67	66130.55	11128.05	0.03
Reach-1	102342	100-year	4 Pipes CSX	4781.20	-1.53	13.63	3.58	13.63	0.000015	0.67	66130.55	11128.05	0.03
Reach-1	101179	100-year	CSX_PIPES	4781.20	-1.22	13.62	3.79	13.62	0.000010	0.55	71540.39	9577.54	0.03
Reach-1	101179	100-year	One PIPE	4781.20	-1.22	13.62	3.79	13.62	0.000010	0.55	71540.39	9577.54	0.03
Reach-1	101179	100-year	TEST NO PIPE	4781.20	-1.22	13.62	3.79	13.62	0.000010	0.55	71540.39	9577.54	0.03
Reach-1	101179	100-year	4 Pipes CSX	4781.20	-1.22	13.62	3.79	13.62	0.000010	0.55	71540.39	9577.54	0.03
Reach-1	100249	100-year	CSX_PIPES	4781.20	-1.62	13.59	3.78	13.60	0.000044	1.17	33186.45	5758.50	0.05
Reach-1	100249	100-year	One PIPE	4781.20	-1.62	13.59	3.78	13.60	0.000044	1.17	33186.45	5758.50	0.05
Reach-1	100249	100-year	TEST NO PIPE	4781.20	-1.62	13.59	3.78	13.60	0.000044	1.17	33186.45	5758.50	0.05
Reach-1	100249	100-year	4 Pipes CSX	4781.20	-1.62	13.59	3.78	13.60	0.000044	1.17	33186.45	5758.50	0.05
Reach-1	99137	100-year	CSX_PIPES	4781.20	-1.64	13.50	4.02	13.52	0.000111	1.84	19869.83	3641.34	0.08
Reach-1	99137	100-year	One PIPE	4781.20	-1.64	13.50	4.02	13.52	0.000111	1.84	19869.83	3641.34	0.08
Reach-1	99137	100-year	TEST NO PIPE	4781.20	-1.64	13.50	4.02	13.52	0.000111	1.84	19869.83	3641.34	0.08
Reach-1	99137	100-year	4 Pipes CSX	4781.20	-1.64	13.50	4.02	13.52	0.000111	1.84	19869.83	3641.34	0.08
Reach-1	98107	100-year	CSX_PIPES	4781.20	-1.42	13.47	3.97	13.47	0.000026	0.97	16090.75	2508.92	0.04
Reach-1	98107	100-year	One PIPE	4781.20	-1.42	13.47	3.97	13.47	0.000026	0.97	16090.75	2508.92	0.04
Reach-1	98107	100-year	TEST NO PIPE	4781.20	-1.42	13.47	3.97	13.47	0.000026	0.97	16090.75	2508.92	0.04
Reach-1	98107	100-year	4 Pipes CSX	4781.20	-1.42	13.47	3.97	13.47	0.000026	0.97	16090.75	2508.92	0.04
Reach-1	96960			Bridge									

5.5.2 CHANNEL WIDENING

This analysis reviewed widening the smallest place to alleviate flooding for major storm events. The channel was modeled 50 feet wider, the maximum allowed with the bridge constraint.

A pre-construction feasibility meeting had been held between County Staff and the Saint John's River Water Management District (SJRWMD). SJRWMD could not say whether the proposal would be permittable. Concerns stemmed from wetland mitigation credits for the basin. The maximum flood stage reduction was minimal for all scenarios, as evident by comparing reduction in the W.S. Elevations in Table 5-4 and Table 5-5, which show the results for the 1% and 10% AEPs, respectively.

Table 5-4. Proposed Alternative Did Not Improve Flooding at Thomas Creek Compared to Existing Conditions Under a 1% AEP Storm Event

HEC-RAS River: Thomas Creek Reach: I

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	127146	100-year	Existing Steady State	42826.30	7.09	17.18	13.40	17.20	0.000113	2.32	38439.63	9255.10	0.13
Reach-1	127146	100-year	Alternative Steady State	42826.30	7.09	17.33	13.40	17.35	0.000102	2.22	39818.69	9334.28	0.12
Reach-1	127146	100-year	WIDENING	42826.30	7.09	16.96		16.98	0.000134	2.49	36364.84	9143.89	0.14
Reach-1	124837	100-year	Existing Steady State	10659.50	6.31	17.07	11.63	17.08	0.000010	0.73	31300.45	7584.11	0.04
Reach-1	124837	100-year	Alternative Steady State	10659.50	6.31	17.23	11.63	17.23	0.000009	0.70	32520.06	7683.81	0.04
Reach-1	124837	100-year	WIDENING	10659.50	6.31	16.83		16.83	0.000012	0.78	29452.39	7462.31	0.04
Reach-1	123555	100-year	Existing Steady State	10659.50	6.55	17.06	11.67	17.06	0.000012	0.79	31246.34	8823.17	0.04
Reach-1	123555	100-year	Alternative Steady State	10659.50	6.55	17.22	11.67	17.22	0.000011	0.77	32676.77	8940.81	0.04
Reach-1	123555	100-year	WIDENING	10659.50	6.55	16.81		16.81	0.000015	0.84	29080.10	8623.63	0.05
Reach-1	122925	100-year	Existing Steady State	10659.50	6.34	17.05	11.40	17.05	0.000008	0.64	36254.41	8897.49	0.03
Reach-1	122925	100-year	Alternative Steady State	10659.50	6.34	17.21	11.40	17.22	0.000007	0.61	37704.59	9052.00	0.03
Reach-1	122925	100-year	WIDENING	10659.50	6.34	16.80		16.81	0.000009	0.68	34066.79	8653.26	0.04
Reach-1	121204	100-year	Existing Steady State	10659.50	5.29	17.05	10.15	17.05	0.000002	0.34	55721.41	8884.05	0.02
Reach-1	121204	100-year	Alternative Steady State	10659.50	5.29	17.21	10.17	17.21	0.000002	0.35	49064.97	6820.07	0.02
Reach-1	121204	100-year	WIDENING	10659.50	5.29	16.80		16.80	0.000002	0.36	53507.30	8833.24	0.02
Reach-1	119565	100-year	Existing Steady State	10659.50	4.97	17.04	9.65	17.04	0.000003	0.42	44924.09	6843.45	0.02
Reach-1	119565	100-year	Alternative Steady State	10659.50	4.97	17.21	9.65	17.21	0.000003	0.40	43943.87	6050.90	0.02
Reach-1	119565	100-year	WIDENING	10659.50	4.97	16.79		16.79	0.000003	0.43	43211.65	6819.94	0.02
Reach-1	118600	100-year	Existing Steady State	9590.80	4.58	17.04	9.33	17.04	0.000002	0.37	45520.36	7361.13	0.02
Reach-1	118600	100-year	Alternative Steady State	9590.80	4.58	17.20	9.34	17.20	0.000002	0.39	40653.02	5936.25	0.02
Reach-1	118600	100-year	WIDENING	9590.80	4.58	16.79		16.79	0.000002	0.38	43711.38	6976.38	0.02
Reach-1	117764	100-year	Existing Steady State	9590.80	4.36	17.04	9.04	17.04	0.000002	0.34	50884.87	8294.89	0.02
Reach-1	117764	100-year	Alternative Steady State	9590.80	4.36	17.20	9.06	17.20	0.000002	0.40	40113.48	5547.41	0.02
Reach-1	117764	100-year	WIDENING	9590.80	4.36	16.79		16.79	0.000002	0.36	48814.66	8196.00	0.02
Reach-1	116897	100-year	Existing Steady State	9590.80	2.90	17.04	8.68	17.04	0.000004	0.56	30505.32	4499.46	0.03
Reach-1	116897	100-year	Alternative Steady State	9590.80	2.90	17.20	8.97	17.20	0.000005	0.61	26055.49	3227.10	0.03
Reach-1	116897	100-year	WIDENING	9590.80	2.90	16.79		16.79	0.000005	0.58	29391.78	4352.59	0.03
Reach-1	116246	100-year	Existing Steady State	9590.80	4.17	17.03	9.16	17.03	0.000006	0.65	27034.82	4298.87	0.03
Reach-1	116246	100-year	Alternative Steady State	9590.80	4.17	17.19	9.22	17.19	0.000010	0.81	18579.96	2237.54	0.04
Reach-1	116246	100-year	WIDENING	9590.80	4.17	16.78		16.78	0.000007	0.68	25954.94	4280.69	0.03
Reach-1	115233	100-year	Existing Steady State	9590.80	4.03	17.01	10.02	17.02	0.000086	1.61	19353.31	3217.37	0.08
Reach-1	115233	100-year	Alternative Steady State	9590.80	4.03	17.16	10.05	17.17	0.000080	1.57	18543.71	2703.45	0.08
Reach-1	115233	100-year	WIDENING	9590.80	4.03	16.76	10.02	16.76	0.000097	1.69	18538.44	3187.57	0.08
Reach-1	115000			Bridge									
Reach-1	114090	100-year	Existing Steady State	9590.80	2.02	15.69	10.04	15.72	0.000250	2.85	11386.55	2216.24	0.14
Reach-1	114090	100-year	Alternative Steady State	9590.80	2.02	15.90	10.25	15.94	0.000239	2.81	9837.75	1405.86	0.13
Reach-1	114090	100-year	WIDENING	9590.80	2.02	15.25		15.29	0.000316	3.13	10421.76	2171.96	0.15
Reach-1	112663	100-year	Existing Steady State	9590.80	1.46	15.33	9.99	15.36	0.000250	2.88	11881.95	2424.54	0.14
Reach-1	112663	100-year	Alternative Steady State	9590.80	1.46	15.43	10.00	15.50	0.000388	3.60	8659.14	1629.35	0.17
Reach-1	112663	100-year	WIDENING	9590.80	1.46	14.76		14.81	0.000349	3.31	10532.80	2365.86	0.16

Reach-1	115233	100-year	Existing Steady State	9590.80	4.03	17.01	10.02	17.02	0.000086	1.61	19353.31	3217.37	0.08
Reach-1	115233	100-year	Alternative Steady State	9590.80	4.03	17.16	10.05	17.17	0.000080	1.57	18543.71	2703.45	0.08
Reach-1	115233	100-year	WIDENING	9590.80	4.03	16.76	10.02	16.76	0.000097	1.69	18538.44	3187.57	0.08
Reach-1	115000			Bridge									
Reach-1	114090	100-year	Existing Steady State	9590.80	2.02	15.69	10.04	15.72	0.000250	2.85	11386.55	2216.24	0.14
Reach-1	114090	100-year	Alternative Steady State	9590.80	2.02	15.90	10.25	15.94	0.000239	2.81	9837.75	1405.86	0.13
Reach-1	114090	100-year	WIDENING	9590.80	2.02	15.25		15.29	0.000316	3.13	10421.76	2171.96	0.15
Reach-1	112663	100-year	Existing Steady State	9590.80	1.46	15.33	9.99	15.36	0.000250	2.88	11881.95	2424.54	0.14
Reach-1	112663	100-year	Alternative Steady State	9590.80	1.46	15.43	10.00	15.50	0.000388	3.60	8659.14	1629.35	0.17
Reach-1	112663	100-year	WIDENING	9590.80	1.46	14.76		14.81	0.000349	3.31	10532.80	2365.86	0.16
Reach-1	111031	100-year	Existing Steady State	4626.90	1.10	15.09	7.23	15.11	0.000074	1.57	9500.33	1800.47	0.07
Reach-1	111031	100-year	Alternative Steady State	4626.90	1.10	15.16	7.26	15.17	0.000073	1.57	9158.92	1518.76	0.07
Reach-1	111031	100-year	WIDENING	4626.90	1.10	14.44		14.46	0.000100	1.77	8361.13	1720.28	0.09
Reach-1	110502.*	100-year	Existing Steady State	4626.90	1.01	15.05	7.12	15.07	0.000072	1.56	10061.56	2015.27	0.07
Reach-1	110502.*	100-year	Alternative Steady State	4626.90	1.01	15.12	7.12	15.13	0.000070	1.54	10198.99	2074.47	0.07
Reach-1	110502.*	100-year	WIDENING	4626.90	1.01	14.39		14.41	0.000090	1.69	8811.45	1775.86	0.08
Reach-1	109974.*	100-year	Existing Steady State	4626.90	0.92	15.02	7.28	15.03	0.000064	1.48	10856.63	2120.27	0.07
Reach-1	109974.*	100-year	Alternative Steady State	4626.90	0.92	15.09	7.28	15.10	0.000062	1.45	11001.93	2124.96	0.07
Reach-1	109974.*	100-year	WIDENING	4626.90	0.92	14.35		14.36	0.000091	1.70	9455.48	2020.97	0.08
Reach-1	109445.*	100-year	Existing Steady State	4626.90	0.84	14.99	7.22	15.00	0.000052	1.34	11643.69	2104.38	0.06
Reach-1	109445.*	100-year	Alternative Steady State	4626.90	0.84	15.06	7.22	15.07	0.000054	1.37	10438.03	1687.33	0.06
Reach-1	109445.*	100-year	WIDENING	4626.90	0.84	14.30		14.32	0.000073	1.53	10220.42	2042.20	0.07
Reach-1	108917.*	100-year	Existing Steady State	4626.90	0.75	14.91	7.09	14.95	0.000213	2.43	12304.75	2143.03	0.11
Reach-1	108917.*	100-year	Alternative Steady State	4626.90	0.75	14.97	7.12	15.01	0.000209	2.41	11606.61	1867.66	0.11
Reach-1	108917.*	100-year	WIDENING	4626.90	0.75	14.19	7.09	14.24	0.000284	2.71	10814.60	2050.50	0.13
Reach-1	108688			Bridge									
Reach-1	108389	100-year	Existing Steady State	4781.20	0.66	13.84	7.08	13.90	0.000300	2.75	10941.81	2078.05	0.13
Reach-1	108389	100-year	Alternative Steady State	4781.20	0.66	13.92	7.14	13.97	0.000295	2.73	11091.55	2093.22	0.13
Reach-1	108389	100-year	WIDENING	4781.20	0.66	13.46		13.51	0.000189	2.17	10421.54	1982.50	0.11
Reach-1	106091	100-year	Existing Steady State	4781.20	-0.42	13.69	5.09	13.69	0.000031	0.93	37537.51	4805.21	0.04
Reach-1	106091	100-year	Alternative Steady State	4781.20	-0.42	13.76	5.00	13.76	0.000031	0.93	36034.38	4342.41	0.04
Reach-1	106091	100-year	WIDENING	4781.20	-0.42	13.34		13.34	0.000028	0.87	36111.06	4724.90	0.04
Reach-1	105297	100-year	Existing Steady State	4781.20	-0.94	13.67	4.15	13.67	0.000024	0.83	47351.59	7186.16	0.04
Reach-1	105297	100-year	Alternative Steady State	4781.20	-0.94	13.74	4.15	13.74	0.000024	0.84	44934.60	6307.35	0.04
Reach-1	105297	100-year	WIDENING	4781.20	-0.94	13.32		13.32	0.000022	0.79	45090.61	6979.01	0.04
Reach-1	103935	100-year	Existing Steady State	4781.20	-1.29	13.65	3.82	13.65	0.000010	0.56	74381.41	10730.60	0.03
Reach-1	103935	100-year	Alternative Steady State	4781.20	-1.29	13.72	3.86	13.72	0.000011	0.57	70489.63	9818.70	0.03

Table 5-5. Proposed Alternative Did Not Improve Flooding at Thomas Creek Compared to Existing Conditions Under a 10% AEP Storm Event

HEC-RAS River: Thomas Creek Reach:

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	127146	10-year	Existing Steady State	19984.90	7.09	14.14	12.87	14.18	0.000447	3.63	13613.98	6594.35	0.24
Reach-1	127146	10-year	Alternative Steady State	19984.90	7.09	14.17	12.87	14.21	0.000426	3.55	13834.05	6634.77	0.24
Reach-1	127146	10-year	WIDENING	19984.90	7.09	14.06		14.11	0.000503	3.82	13099.94	6392.52	0.26
Reach-1	124837	10-year	Existing Steady State	5502.20	6.31	13.73	11.24	13.74	0.000035	1.06	11003.74	4173.23	0.07
Reach-1	124837	10-year	Alternative Steady State	5502.20	6.31	13.79	11.24	13.79	0.000033	1.03	11231.91	4228.74	0.07
Reach-1	124837	10-year	WIDENING	5502.20	6.31	13.60		13.60	0.000041	1.13	10436.35	4041.43	0.07
Reach-1	123555	10-year	Existing Steady State	5502.20	6.55	13.68	11.31	13.69	0.000046	1.17	10076.72	4069.40	0.08
Reach-1	123555	10-year	Alternative Steady State	5502.20	6.55	13.74	11.31	13.75	0.000043	1.14	10311.44	4094.09	0.08
Reach-1	123555	10-year	WIDENING	5502.20	6.55	13.53		13.54	0.000055	1.26	9478.15	4005.20	0.08
Reach-1	122925	10-year	Existing Steady State	5502.20	6.34	13.66	11.06	13.66	0.000030	0.96	12753.67	5358.94	0.06
Reach-1	122925	10-year	Alternative Steady State	5502.20	6.34	13.72	11.06	13.72	0.000028	0.93	13071.04	5406.73	0.06
Reach-1	122925	10-year	WIDENING	5502.20	6.34	13.51		13.51	0.000035	1.04	11951.42	5147.49	0.07
Reach-1	121204	10-year	Existing Steady State	5502.20	5.29	13.65	9.84	13.65	0.000004	0.40	27050.28	7778.46	0.02
Reach-1	121204	10-year	Alternative Steady State	5502.20	5.29	13.71	9.86	13.71	0.000004	0.40	25895.42	6446.00	0.02
Reach-1	121204	10-year	WIDENING	5502.20	5.29	13.49		13.49	0.000005	0.42	25857.30	7640.60	0.03
Reach-1	119565	10-year	Existing Steady State	5502.20	4.97	13.64	9.40	13.64	0.000005	0.43	23450.45	5513.38	0.03
Reach-1	119565	10-year	Alternative Steady State	5502.20	4.97	13.70	9.40	13.70	0.000004	0.42	23744.96	5426.17	0.03
Reach-1	119565	10-year	WIDENING	5502.20	4.97	13.48		13.49	0.000005	0.45	22601.92	5415.11	0.03
Reach-1	118600	10-year	Existing Steady State	4445.80	4.58	13.64	8.97	13.64	0.000003	0.34	24540.75	5502.92	0.02
Reach-1	118600	10-year	Alternative Steady State	4445.80	4.58	13.70	9.00	13.70	0.000003	0.35	22675.61	4679.85	0.02
Reach-1	118600	10-year	WIDENING	4445.80	4.58	13.48		13.48	0.000003	0.35	23686.18	5455.31	0.02
Reach-1	117764	10-year	Existing Steady State	4445.80	4.36	13.63	8.69	13.63	0.000003	0.34	26213.85	6357.84	0.02
Reach-1	117764	10-year	Alternative Steady State	4445.80	4.36	13.69	8.74	13.69	0.000003	0.36	22157.24	4558.82	0.02
Reach-1	117764	10-year	WIDENING	4445.80	4.36	13.48		13.48	0.000003	0.35	25221.80	6336.33	0.02
Reach-1	116897	10-year	Existing Steady State	4445.80	2.90	13.63	8.23	13.63	0.000004	0.48	17544.18	3468.00	0.03
Reach-1	116897	10-year	Alternative Steady State	4445.80	2.90	13.69	8.54	13.69	0.000005	0.53	15556.79	2915.85	0.03
Reach-1	116897	10-year	WIDENING	4445.80	2.90	13.47		13.48	0.000005	0.50	17002.81	3443.15	0.03
Reach-1	116246	10-year	Existing Steady State	4445.80	4.17	13.63	8.69	13.63	0.000010	0.67	13022.34	3757.90	0.04
Reach-1	116246	10-year	Alternative Steady State	4445.80	4.17	13.68	8.69	13.69	0.000011	0.69	10997.29	2102.84	0.04
Reach-1	116246	10-year	WIDENING	4445.80	4.17	13.47		13.47	0.000011	0.69	12439.51	3659.73	0.04
Reach-1	115233	10-year	Existing Steady State	4445.80	4.03	13.59	9.15	13.60	0.000134	1.64	9200.37	2575.04	0.09
Reach-1	115233	10-year	Alternative Steady State	4445.80	4.03	13.65	9.15	13.66	0.000128	1.61	9314.27	2454.87	0.09
Reach-1	115233	10-year	WIDENING	4445.80	4.03	13.43	9.15	13.44	0.000152	1.72	8792.35	2510.30	0.10
Reach-1	115000			Bridge									
Reach-1	114090	10-year	Existing Steady State	4445.80	2.02	12.66	7.80	12.70	0.000279	2.54	5425.37	1428.99	0.14
Reach-1	114090	10-year	Alternative Steady State	4445.80	2.02	12.77	7.80	12.80	0.000255	2.45	5540.02	1339.05	0.13
Reach-1	114090	10-year	WIDENING	4445.80	2.02	12.40		12.45	0.000320	2.68	5064.93	1356.00	0.15
Reach-1	112663	10-year	Existing Steady State	4445.80	1.46	12.19	7.75	12.24	0.000360	2.90	5026.74	1653.18	0.16
Reach-1	112663	10-year	Alternative Steady State	4445.80	1.46	12.23	7.79	12.31	0.000457	3.28	3867.96	1089.87	0.18
Reach-1	112663	10-year	WIDENING	4445.80	1.46	11.83		11.90	0.000453	3.19	4457.44	1510.62	0.18

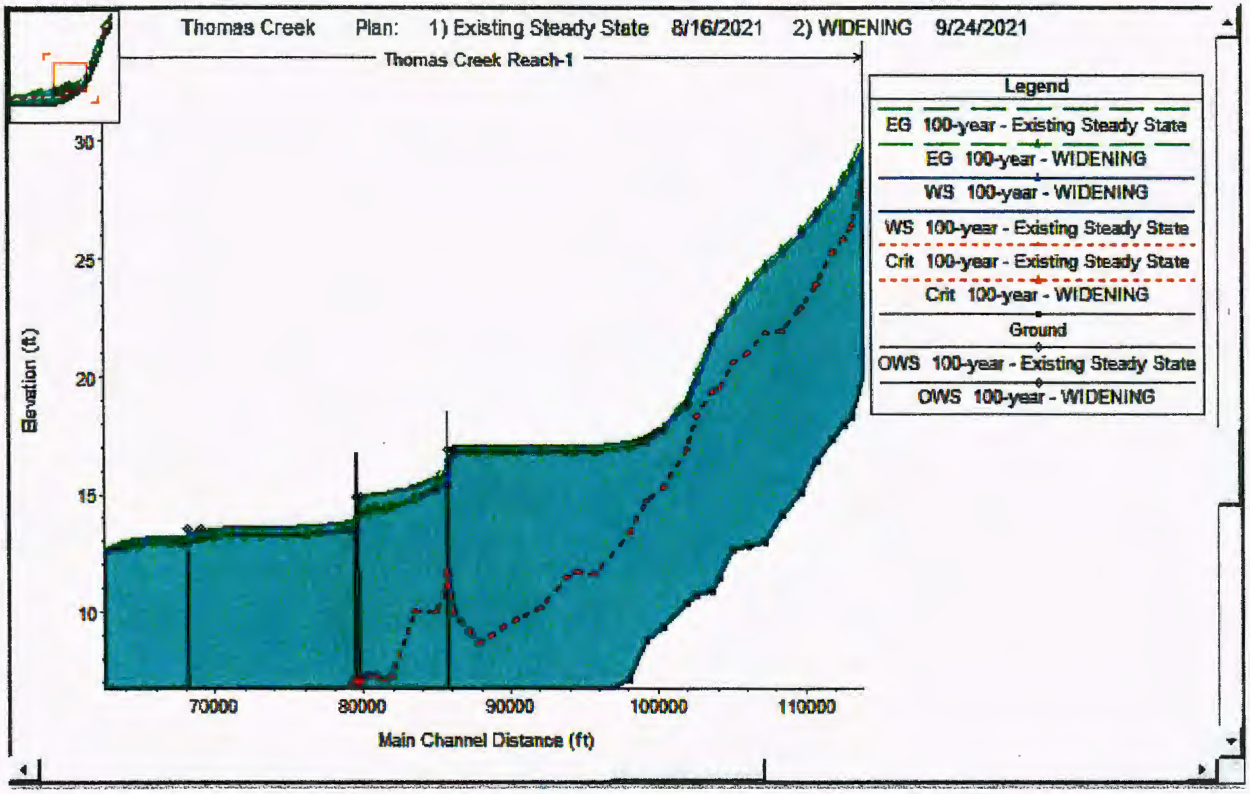

Figure 5-8. Proposed Alternative Did Not Improve Flooding at Thomas Creek Compared to Existing Conditions Under a 1% AEP Storm Event

5.5.3 STORAGE AREAS

Multiple locations for water storage were considered during the hydraulic analysis. After a review of the steady-state model, overland flow was determined to be less of a concern. Therefore, detention further from the floodplain was ruled out.

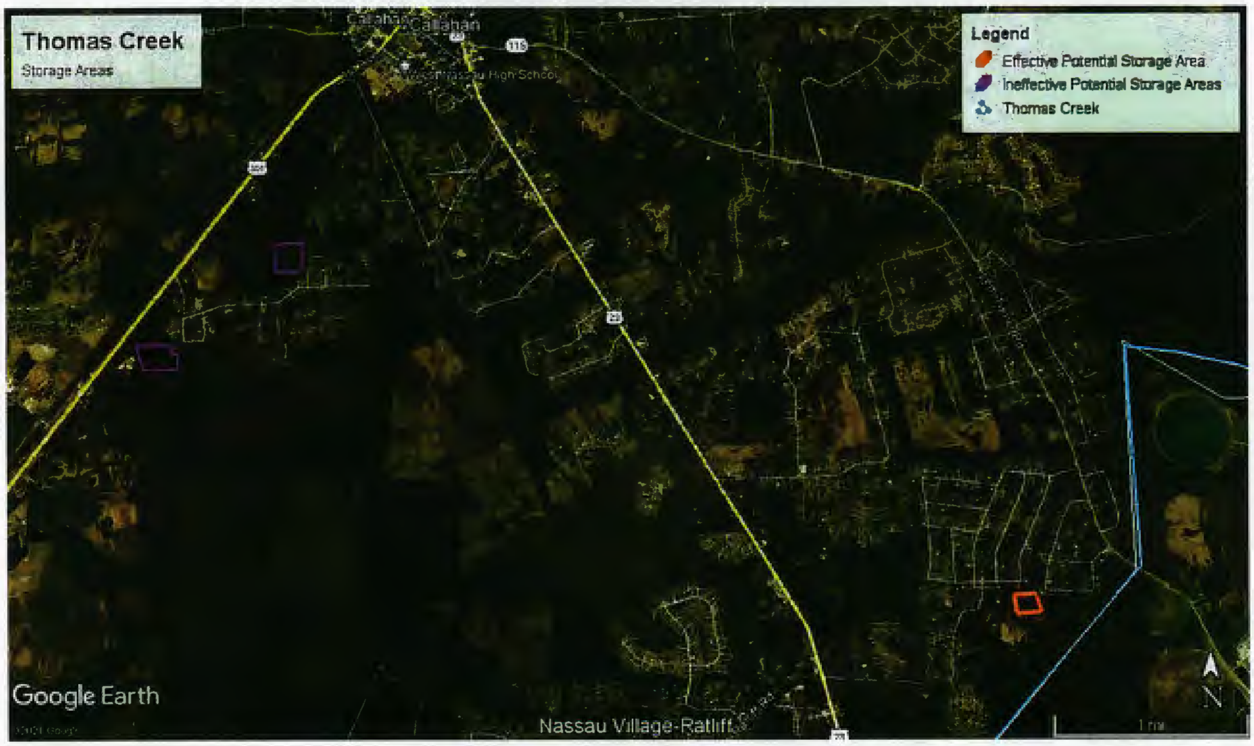

Figure 5-9. Storage Area Locations Analyzed

However, currently owned county property situated outside of FEMA's special flood hazard area A was modeled for storage. The pond had been designed to route water from the Sheffield Village Subdivision. This subdivision consists of 100 1-acre parcels. The water table in the area is high relative to the road elevations in the area. Storage for the pond could not reach a current 4% AEP, 24-hour storm event rain capture.

The storage area was then routed back through the base HEC-HMS model to see if the flow rates were reduced. No noticeable difference was noted.

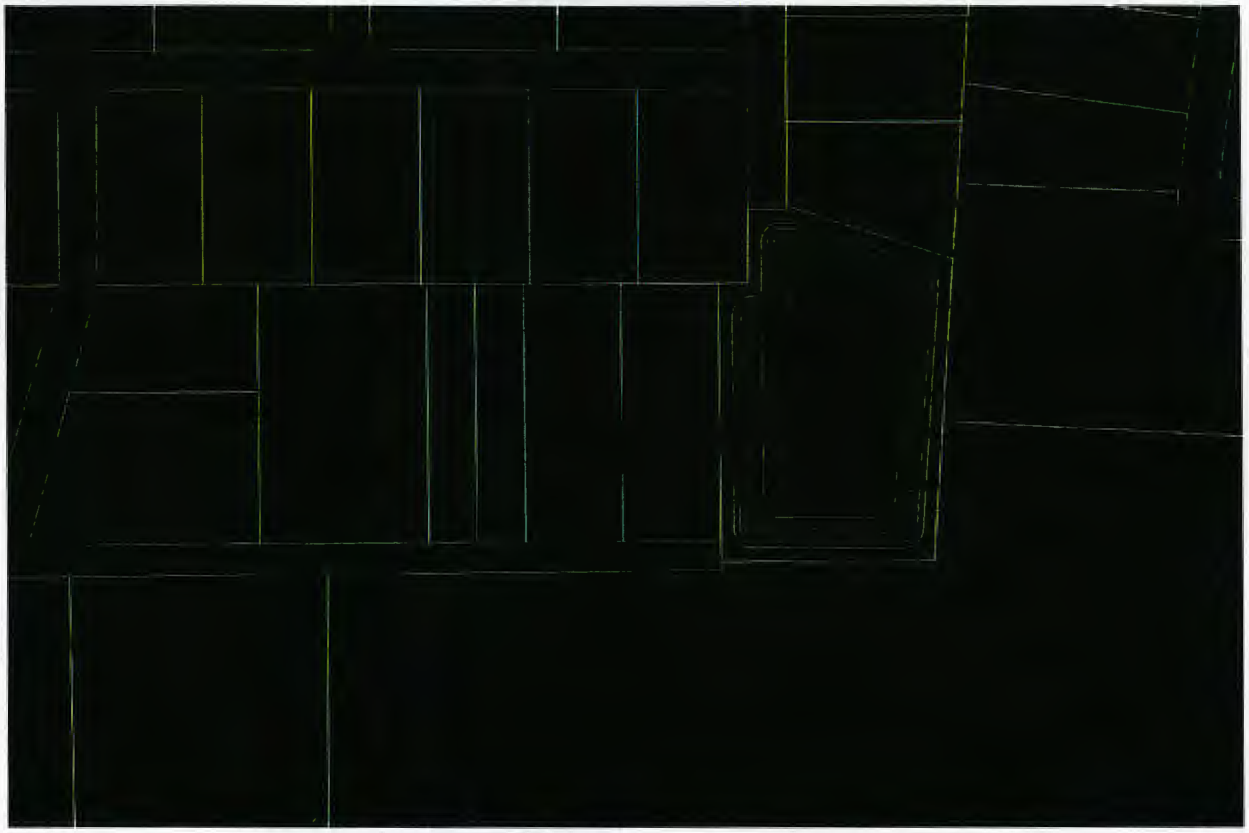

Figure 5-10. Proposed Alternative Did Not Improve Flooding at Thomas Creek

NWL	12.00	69018	1.58	3.07	
Weir	14.00	84485	1.94	7.33	
	15.00	85218	1.96	13.04	
	16.00	92622	2.13	20.61	
	17.00	100167	2.30	30.21	
Top of Bank	18.00	101690	2.33	41.53	
	Supplied Treatment Volume:			4.26	ac-ft
	Required Treatment Volume:			8.25	ac-ft
	Permanent Pool Volume:			3.07	ac-ft
	Required Permanent Pool Volume:			10.64	ac-ft
	Excess Treatment Volume Pond 1 =			-3.99	ac-ft
	Excess Permanent Pool Pond 1 =			-7.57	ac-ft

Figure 5-11. Worksheet Showing the Pond Did Not Meet a 4% AEP Storm Event

5.5.4 FLOODWALL

Staff discussed several Alternatives regarding a wall. Once dredging had been ruled out, the idea of a berm became less desirable due to the additional soil that would be needed. Then the elevation itself would have made the berm's footprint and wetland mitigation infeasible.

The wall should be 1 foot above the target water surface elevation for Thomas Creek. In this study, would be the 100-year (1% AEP) floodplain elevation to protect homes in the area. This would require the wall to be over 8 feet high in certain areas. This led the team to choose sheet wall for the material. The results shown in Table 5-6 show that the wall does not increase flood stages (see W.S. Elev column).

Table 5-6. Floodwall Results For 1% AEP

HEC-RAS River: Thomas Creek Reach: Reach-1 Profile: 100-year

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	122925	100-year	10YR WALL	10659.50	6.34	17.05	11.40	17.05	0.000008	0.64	36253.78	8897.43	0.03
Reach-1	121204	100-year	Existing Steady State	10659.50	5.29	17.05	10.15	17.05	0.000002	0.34	55721.41	8884.05	0.02
Reach-1	121204	100-year	10YR WALL	10659.50	5.29	17.05	10.15	17.05	0.000002	0.34	55720.84	8884.03	0.02
Reach-1	119565	100-year	Existing Steady State	10659.50	4.97	17.04	9.65	17.04	0.000003	0.42	44924.09	6843.45	0.02
Reach-1	119565	100-year	10YR WALL	10659.50	4.97	17.04	9.65	17.04	0.000003	0.42	44923.63	6843.44	0.02
Reach-1	118600	100-year	Existing Steady State	9590.80	4.58	17.04	9.33	17.04	0.000002	0.37	45520.36	7361.13	0.02
Reach-1	118600	100-year	10YR WALL	9590.80	4.58	17.04	9.33	17.04	0.000002	0.37	45519.86	7361.06	0.02
Reach-1	117764	100-year	Existing Steady State	9590.80	4.36	17.04	9.04	17.04	0.000002	0.34	50884.87	8294.89	0.02
Reach-1	117764	100-year	10YR WALL	9590.80	4.36	17.04	9.04	17.04	0.000002	0.34	50884.36	8294.87	0.02
Reach-1	116897	100-year	Existing Steady State	9590.80	2.90	17.04	8.68	17.04	0.000004	0.56	30505.32	4499.46	0.03
Reach-1	116897	100-year	10YR WALL	9590.80	2.90	17.04	8.68	17.04	0.000004	0.56	30505.03	4499.42	0.03
Reach-1	116246	100-year	Existing Steady State	9590.80	4.17	17.03	9.16	17.03	0.000006	0.65	27034.82	4298.87	0.03
Reach-1	116246	100-year	10YR WALL	9590.80	4.17	17.03	9.16	17.03	0.000006	0.65	27034.53	4298.86	0.03
Reach-1	115233	100-year	Existing Steady State	9590.80	4.03	17.01	10.02	17.02	0.000086	1.61	19353.31	3217.37	0.08
Reach-1	115233	100-year	10YR WALL	9590.80	4.03	17.01	10.02	17.02	0.000086	1.61	19353.09	3217.37	0.08
Reach-1	115000			Bridge									
Reach-1	114090	100-year	Existing Steady State	9590.80	2.02	15.69	10.04	15.72	0.000250	2.85	11386.55	2216.24	0.14
Reach-1	114090	100-year	10YR WALL	9590.80	2.02	15.69	10.04	15.72	0.000250	2.85	11386.29	2216.23	0.14
Reach-1	112663	100-year	Existing Steady State	9590.80	1.46	15.33	9.99	15.36	0.000250	2.88	11881.95	2424.54	0.14
Reach-1	112663	100-year	10YR WALL	9590.80	1.46	15.33	9.99	15.36	0.000250	2.88	11881.60	2424.51	0.14
Reach-1	111031	100-year	Existing Steady State	4626.90	1.10	15.09	7.23	15.11	0.000074	1.57	9500.33	1800.47	0.07
Reach-1	111031	100-year	10YR WALL	4626.90	1.10	15.09	7.23	15.11	0.000074	1.57	9500.04	1800.43	0.07
Reach-1	110502.*	100-year	Existing Steady State	4626.90	1.01	15.05	7.12	15.07	0.000072	1.56	10061.56	2015.27	0.07
Reach-1	110502.*	100-year	10YR WALL	4626.90	1.01	15.05	7.12	15.07	0.000072	1.56	10061.23	2015.17	0.07
Reach-1	109974.*	100-year	Existing Steady State	4626.90	0.92	15.02	7.28	15.03	0.000064	1.48	10856.63	2120.27	0.07
Reach-1	109974.*	100-year	10YR WALL	4626.90	0.92	15.02	7.28	15.03	0.000064	1.48	10856.27	2120.25	0.07
Reach-1	109445.*	100-year	Existing Steady State	4626.90	0.84	14.99	7.22	15.00	0.000052	1.34	11643.69	2104.38	0.06
Reach-1	109445.*	100-year	10YR WALL	4626.90	0.84	14.99	7.22	15.00	0.000052	1.34	11643.32	2104.35	0.06
Reach-1	108917.*	100-year	Existing Steady State	4626.90	0.75	14.91	7.09	14.95	0.000213	2.43	12304.75	2143.03	0.11
Reach-1	108917.*	100-year	10YR WALL	4626.90	0.75	14.91	7.09	14.95	0.000213	2.43	12304.37	2142.96	0.11
Reach-1	108688			Bridge									
Reach-1	108389	100-year	Existing Steady State	4781.20	0.66	13.84	7.08	13.90	0.000300	2.75	10941.81	2078.05	0.13
Reach-1	108389	100-year	10YR WALL	4781.20	0.66	13.84	7.14	13.90	0.000300	2.75	10941.41	2077.96	0.13
Reach-1	106091	100-year	Existing Steady State	4781.20	-0.42	13.69	5.09	13.69	0.000031	0.93	37537.51	4805.21	0.04
Reach-1	106091	100-year	10YR WALL	4781.20	-0.42	13.69	5.11	13.69	0.000032	0.93	37360.53	4804.63	0.04

The HEC-RAS model results of the wall extents between Freedom Drive to Marlee Road demonstrated that the wall would protect the homes from the 1% AEP storm event. This is indicated by the thin green line in Figure 5-12. However, during the constructability process, the road elevations of Ratliff Road limited the wall along Freedom to the point that no flood relief could be accomplished. The team therefore reduced the wall footprint to be located between US-1 and SR-115, as indicated by the thick green line in Figure 5-12. Lem Turner's (SR-115) elevation was also a limiting factor. The wall could only be built to a 10% AEP storm event instead of the original 100-year (1% AEP) floodplain protection, thereby reducing benefits. The results are shown in Table 5-7.

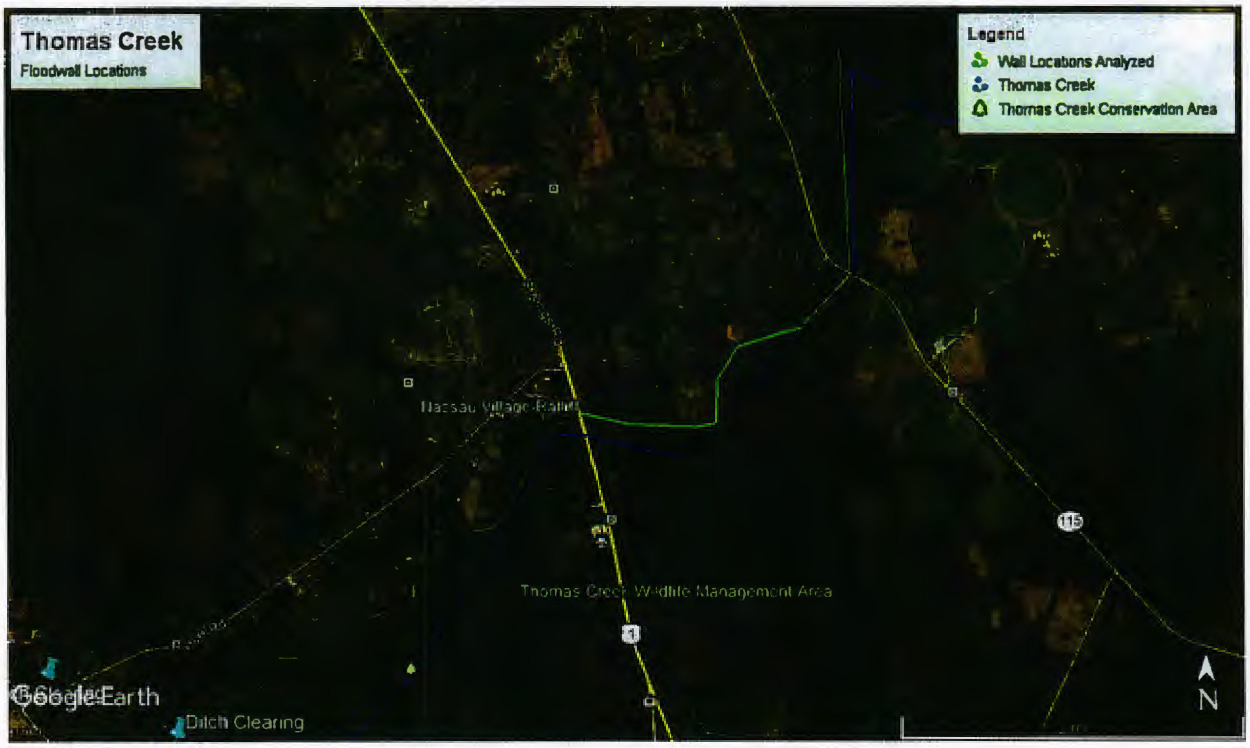

Figure 5-12. Location of Original Wall versus Final Wall Design

Table 5-7. Floodwall Results for 10% AEP

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)
Reach-1	121204	10-year	Existing Steady State	5502.20	5.29	13.65	9.84	13.65	0.000004
Reach-1	121204	10-year	10YR WALL	5502.20	5.29	13.65	9.84	13.65	0.000004
Reach-1	119565	10-year	Existing Steady State	5502.20	4.97	13.64	9.40	13.64	0.000005
Reach-1	119565	10-year	10YR WALL	5502.20	4.97	13.64	9.40	13.64	0.000005
Reach-1	118600	10-year	Existing Steady State	4445.80	4.58	13.64	8.97	13.64	0.000003
Reach-1	118600	10-year	10YR WALL	4445.80	4.58	13.64	8.97	13.64	0.000003
Reach-1	117764	10-year	Existing Steady State	4445.80	4.36	13.63	8.69	13.63	0.000003
Reach-1	117764	10-year	10YR WALL	4445.80	4.36	13.63	8.69	13.64	0.000003
Reach-1	116897	10-year	Existing Steady State	4445.80	2.90	13.63	8.23	13.63	0.000004
Reach-1	116897	10-year	10YR WALL	4445.80	2.90	13.63	8.23	13.63	0.000004
Reach-1	116246	10-year	Existing Steady State	4445.80	4.17	13.63	8.69	13.63	0.000010
Reach-1	116246	10-year	10YR WALL	4445.80	4.17	13.63	8.69	13.63	0.000010
Reach-1	115233	10-year	Existing Steady State	4445.80	4.03	13.59	9.15	13.60	0.000134
Reach-1	115233	10-year	10YR WALL	4445.80	4.03	13.59	9.15	13.60	0.000133
Reach-1	115000			Bridge					
Reach-1	114090	10-year	Existing Steady State	4445.80	2.02	12.66	7.80	12.70	0.000279
Reach-1	114090	10-year	10YR WALL	4445.80	2.02	12.66	7.80	12.70	0.000278
Reach-1	112663	10-year	Existing Steady State	4445.80	1.46	12.19	7.75	12.24	0.000360
Reach-1	112663	10-year	10YR WALL	4445.80	1.46	12.19	7.75	12.25	0.000360
Reach-1	111031	10-year	Existing Steady State	2500.20	1.10	11.84	5.40	11.86	0.000126
Reach-1	111031	10-year	10YR WALL	2500.20	1.10	11.84	5.40	11.86	0.000126
Reach-1	110502.*	10-year	Existing Steady State	2500.20	1.01	11.78	5.32	11.79	0.000114
Reach-1	110502.*	10-year	10YR WALL	2500.20	1.01	11.78	5.32	11.80	0.000114
Reach-1	109974.*	10-year	Existing Steady State	2500.20	0.92	11.72	5.19	11.74	0.000097
Reach-1	109974.*	10-year	10YR WALL	2500.20	0.92	11.72	5.19	11.74	0.000097

5.5.5 PUMPS

The team estimated pump sizes using the 10% AEP storm event. Hydrograph was calculated in the hydrologic analysis for the areas draining north of the proposed flood wall (interior area). The interior area would likely act as a storage area where the runoff accumulated, and the proposed flood wall and higher stages in Thomas Creek might prevent runoff from draining during a storm event. LiDAR data was used to determine the elevation storages area. Table 5-6 presents the storage data extracted from LiDAR.

Table 5-8. Elevation Storage Data

Elevation ft-NAVD88	Storage ac-ft
-1.00	0.00
0.02	4.99
2.26	16.91
3.35	23.24
4.84	32.25
6.00	39.62
7.00	47.40
7.50	55.75
8.00	65.59
9.00	104.07
10.00	167.41
11.00	252.33
12.00	382.84
13.00	581.47
14.00	865.94
15.00	1,209.65
16.00	1,604.03
17.00	2,037.39
20.00	3,449.11
24.43	5,674.69
25.43	6,180.25

HEC-RAS modeling was used to determine the pump sizes required for the project area. Data in Table 5-6 was used to create a storage area in HEC-RAS. The 10% AEP storm event was routed through the storage area. Four pump houses were tested to control stages in the interior area, and several pump size combinations were tested to determine the optimal combination to reduce the flood impact in the areas located in the interior area. Pumps simulated pulling water out of the storage area and discharging it into Thomas Creek at a tailwater EL. 15.0 feet NAVD88, which was the stage elevation at Thomas Creek determined for the 1% AEP.

Two options were evaluated at each pump house: total pump capacity of 100 cubic feet per second (cfs) and total pump capacity of 250 cfs. Figure 5-13 and Figure 5-14 include the data used to evaluate the pump house options, including mix criteria and target water surface elevations. HEC-RAS was used to determine the time that the pump would be required to operate to reduce the flood stages (time to dry). Staff calculated that the 100-cfs pump houses would operate for around 23 hours, and the 250-cfs pump houses would operate for nine hours. The 100-cfs pump house was selected to minimize construction and power costs, as well as to limit required fuel storage.

Thomas Creek - Pumps
Pump Option 1

Date Compiled (or revised) - 13-September-2021

Design Condition		
Design Condition	100	cfs
Number of Pumps		
Pump Mix type and Size		
Electric 2 @ 50 cfs		
Mix Criteria		
Pump station will have 2 - 50 cfs electric pumps to provide a 100 cfs . Pump allows intermediate flow of 50 cfs.		
Design Operating Heads		
Normal	9.50	ft
Maximum	10.50	ft
Intake Water Surface Elevations		
Maximum Non-Pumping	13.50	ft, NAVD88
Maximum Pumping	13.00	ft, NAVD88
Start Pumping	6.00	ft, NAVD88
Normal Drawdown	5.50	ft, NAVD88
Minimum Drawdown	5.00	ft, NAVD88
Minimum Non-Pump	4.50	ft, NAVD89
Invert Intake Canal	3.00	ft, NAVD88
Discharge Water Surface Elevations		
Maximum Non-Pumping	15.50	ft, NAVD88
Maximum Pumping	15.00	ft, NAVD88
Normal Pumping -10.8 -15	10.8 -15.0	ft, NAVD88
Minimum Pumping	6.00	ft, NAVD88
Minimum Non-Pump	6.00	ft, NAVD89
Invert Discharge Canal	5.00	ft, NAVD88

Figure 5-13. Hydraulic Design Data Sheet for Pump House Option 1

Thomas Creek - Pumps
Pump Option 2

Date Compiled (or revised) - 13-September-2021		
Design Condition		
Design Condition	250	cfs
Number of Pumps		
Pump Mix type and Size		
Electric 2 @ 100 cfs, 1 @ 50 cfs		
Mix Criteria		
Pump station will have 2 - 100 cfs and 1 - 50 cfs electric pumps to provide a 250 cfs capacity. Pump allows intermediate flows of 50 , 100, 150 and 200 cfs.		
Design Operating Heads		
Normal	9.50	ft
Maximum	10.50	ft
Intake Water Surface Elevations		
Maximum Non-Pumping	13.50	ft, NAVD88
Maximum Pumping	13.00	ft, NAVD88
Start Pumping	6.00	ft, NAVD88
Normal Drawdown	5.50	ft, NAVD88
Minimum Drawdown	5.00	ft, NAVD88
Minimum Non-Pump	4.50	ft, NAVD89
Invert Intake Canal	3.00	ft, NAVD88
Discharge Water Surface Elevations		
Maximum Non-Pumping	15.50	ft, NAVD88
Maximum Pumping	15.00	ft, NAVD88
Normal Pumping -10.8 -15	10.8 --15.0	ft, NAVD88
Minimum Pumping	6.00	ft, NAVD88
Minimum Non-Pump	6.00	ft, NAVD89
Invert Discharge Canal	5.00	ft, NAVD88

Figure 5-14. Hydraulic Design Data Sheet for Pump House Option 2

5.6 CLIMATE CHANGE ASSESSMENT

In 2011, USACE established an overarching USACE Climate Change Adaptation Policy Statement to support climate preparedness and resilience. In 2014, the policy was updated, and a Climate Preparedness and Resilience (CPR) Community of Practice (CoP) was established. CPR policy states that climate change assessments are to be considered for all phases of the project life cycle, for both existing and proposed projects. To determine the risk and resiliency of the project to climate change, this project was evaluated in compliance with USACE climate guidance.

5.6.1 SEA-LEVEL CHANGE (SLC) DUE TO CLIMATE CHANGE

The climate assessment for SLC follows USACE guidance of Engineer Regulation (ER) 1100-2-8162, Incorporating Sea-Level Change in Civil Works Programs and Engineering Pamphlet (EP) 1100-2-1, Procedures to Evaluate Sea-Level Change: Impacts, Responses, and Adaptation. ER 1100-2-8162 and EP 1100-2-1 provide guidance for incorporating the direct and indirect physical effects of projected future SLC across the project life cycle in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects.

The Thomas Creek project study area is located at the southern border of Nassau County that empties into Nassau River. The Nassau River ends and drains into the Atlantic Ocean within Nassau County and Duval County borders. Sea levels in the Atlantic Ocean are projected to rise in future years. The discharge point of the Nassau River will be affected by sea-level rise. However, since this Thomas Creek project is located 30 miles inland, the project is not expected to be significantly impacted by SLC. The elevations in the Thomas Creek watershed are lower than EL. 50 feet NAVD88; therefore, USACE's SLC analysis was performed on HUC 03080103 Palm Cove, St. Johns River using the Mayport, FL gauge at Bar Pilot's Dock. Using the assessment, sea level will rise 0.32 feet to 4.64 feet by 2100. The structural component is preliminarily designed to have a freeboard to account for 1 foot of change. Research shows increased alluvial deposits could shift the flow of water as the sea level rises.

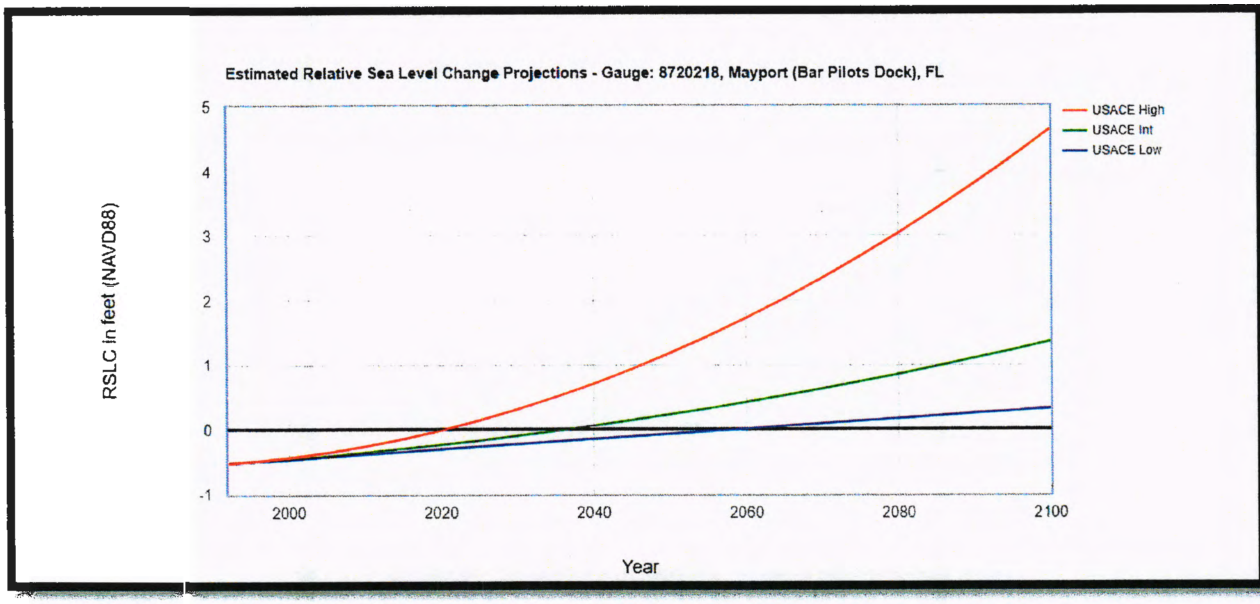

Figure 5-15. Estimated Relative Sea-Level Change Projections for Mayport Gauge

Thomas Creek
Gauge Status: Active and compliant tide gauge
Epoch: 1983 to 2001
8720218, Mayport (Bar Pilots Dock), FL
NOAA's 2006 Published Rate: 0.00787 feet/yr
All values are expressed in feet relative to NAVD88

Year	USACE Low	USACE Int	USACE High
1992	-0.53	-0.53	-0.53
1995	-0.51	-0.51	-0.50
2000	-0.47	-0.46	-0.44
2005	-0.43	-0.41	-0.37
2010	-0.39	-0.36	-0.27
2015	-0.35	-0.30	-0.15
2020	-0.31	-0.24	-0.02
2025	-0.27	-0.17	0.13
2030	-0.23	-0.10	0.31
2035	-0.19	-0.03	0.49
2040	-0.15	0.05	0.70
2045	-0.11	0.14	0.93
2050	-0.07	0.23	1.17
2055	-0.03	0.32	1.44
2060	0.01	0.42	1.72
2065	0.05	0.52	2.02
2070	0.08	0.63	2.34
2075	0.12	0.74	2.68
2080	0.16	0.85	3.03
2085	0.20	0.97	3.41
2090	0.24	1.10	3.80
2095	0.28	1.22	4.21
2100	0.32	1.36	4.64

Figure 5-16. Sea-Level Change Relative to Thomas Creek

5.6.2 INLAND HYDROLOGY DUE TO CLIMATE CHANGE

The climate assessment for inland hydrology follows the USACE guidance of Engineering and Construction Bulletin (ECB) 2018-14, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects. ECB 2018-14 provides guidance for incorporating climate change information in the hydrologic analyses in accordance with the USACE climate preparedness and resilience policy and ER 1105-2-101, Risk Assessment for Flood Risk Management Studies.

The vulnerability and risk to this project associated with inland hydrology climate change was assessed qualitatively as outlined in ECB 2018-14. In general, projects addressing climate change during the Floodplain Management Services (FPMS) phase of the project are less comprehensive than projects evaluated at the feasibility phase and Preconstruction Engineering and Design phase.

The vulnerability assessment includes a literature review and the application of climate tools to evaluate observed and projected climate trends.

The literature review includes the following sources specific to Florida and the surrounding region:

1 Recent U.S. Climate Change and Hydrology Literature Applicable to USACE Missions – South Atlantic-Gulf Region 03 (USACE, 2015a)
2 Climate Change Indicators in the United States (EPA, 2016)
3 Climate Science Special Report: Fourth National Climate Assessment, Volume I (USGCRP, 2017) and II (USGCRP, 2018)
4 NOAA State Climate Summaries (Runkle et. al., 2017)
5 USACE Jacksonville District Report on Climate Change, Comprehensive Everglades Restoration Plan Central Everglades Planning Project Final Integrated Project Implementation Report and Environmental Impact Statement (USACE, 2014)

In addition to a literature review, the vulnerability assessment includes the application of climate tools used to provide information on observed and projected climate trends relevant to the project area. The following USACE CPR web-based tools were referenced in the analysis:

1. Climate Hydrology Assessment Tool – evaluate historic and projected climate trends.
2. Nonstationarity Detection Tool – evaluate historic climate trends.
3. Vulnerability Assessment Tool (VA) – provide qualitative information on projected climate conditions.

However, the three above sites were not operational at the time of this analysis.

5.6.3 CLIMATE HYDROLOGY ASSESSMENT TOOL

The Climate Hydrology Assessment Tool (CHAT), accessed at https://climate.sec.usace.army.mil/chat/, uses simulated historical hydrology (annual maximum of average monthly streamflow) to project future climate-changed hydrology for individual stream reaches within each stream Hydrologic Unit Code (HUC-8) watershed. Streamflow represents the cumulative flow from all upstream inflows, including local runoff contributions.

The gage site located closest to the project is located in HUC 03070205 – Nassau, in the Altamaha-St. Marys HUC-4, as shown in Figure 5-17. Figure 5-18 shows the climate-changed hydrology for the stream segment aligned to the selected HUC-8 watershed. The range of the 64 projections of annual of average maximum monthly flow is shown in yellow, and the mean of the 64 projections of annual maximum of average monthly streamflow is shown in blue. The graphic indicates a projected increase in hydrologic inflow. Figure 5-19 shows the simulated historical trends in conjunction with projected future trends projected for the stream segment aligned to the for the selected HUC-8 watershed. Trend line analysis for simulated and projected data is shown in Figure 5-20. The results show a projected increase of streamflow in this stream segment.

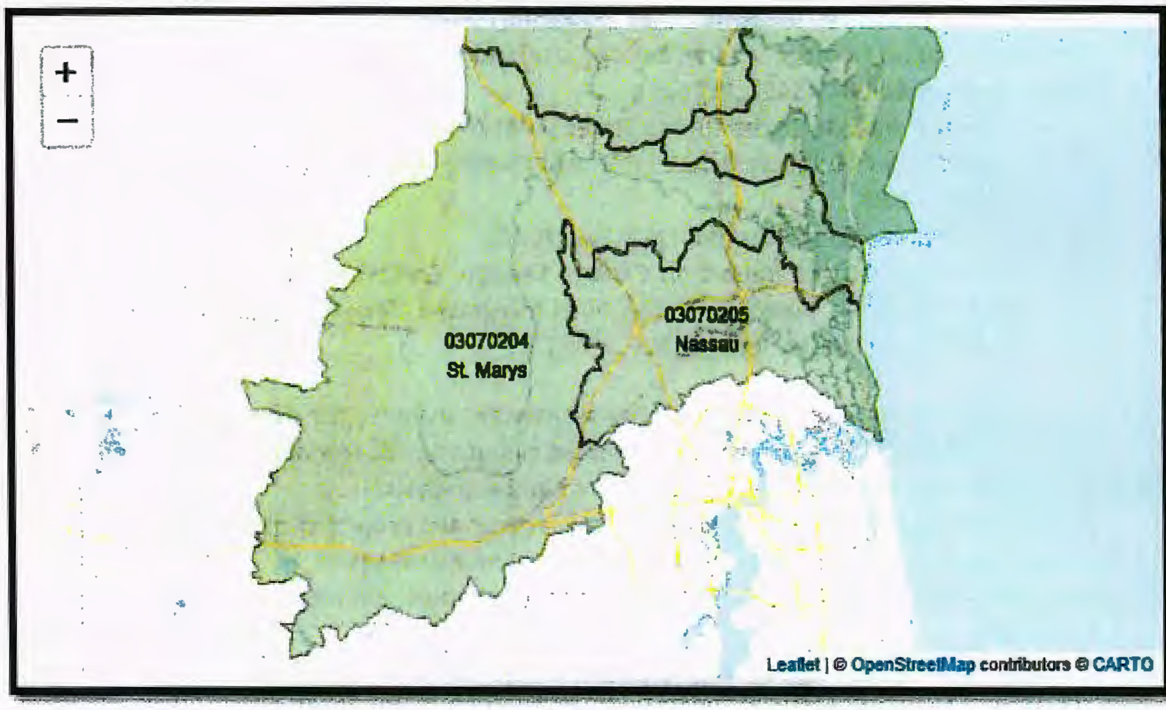

Figure 5-17. HUC Location Map

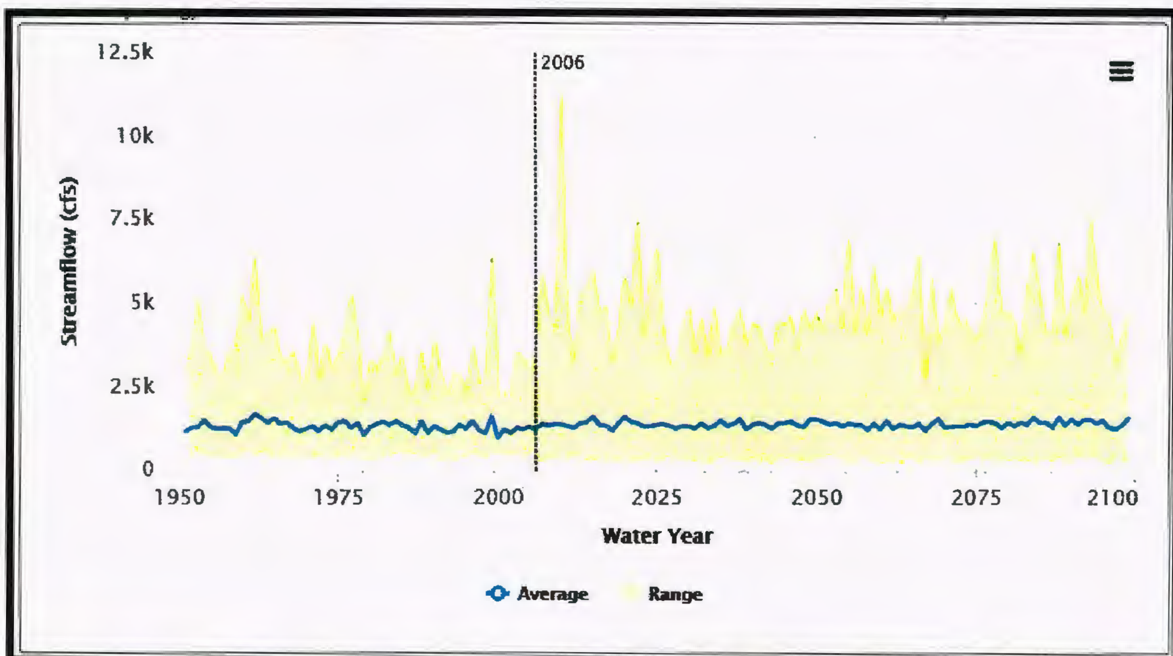

Figure 5-18. Measured and Projected Annual Max Monthly Streamflow

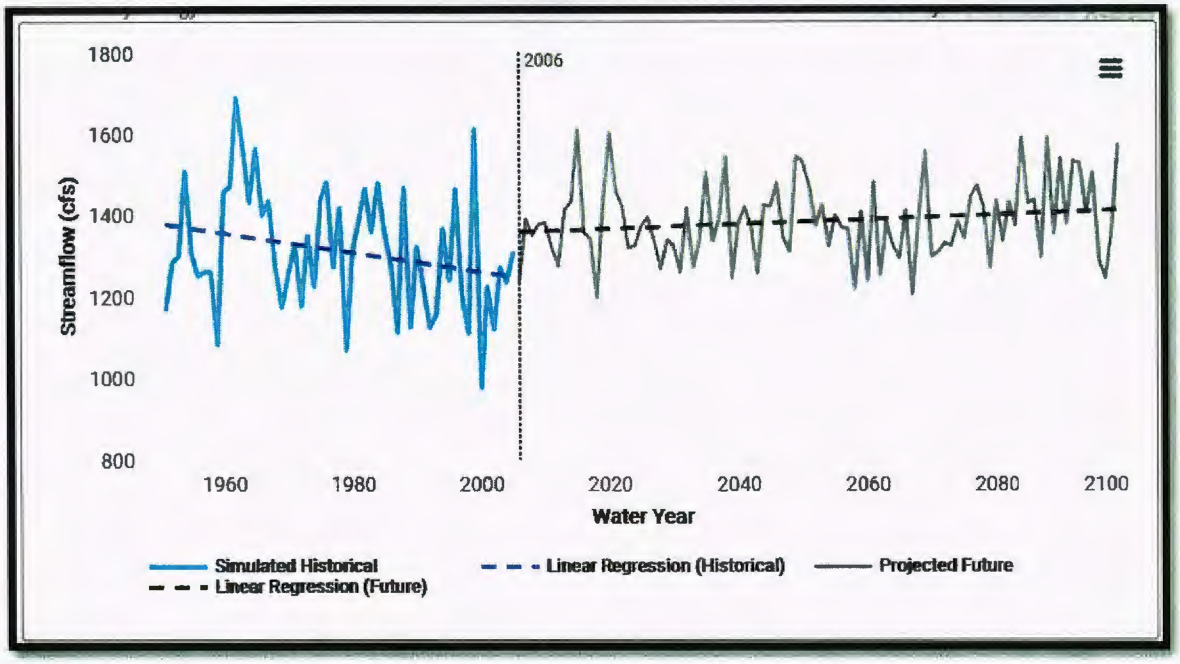

Figure 5-19. Trends in Mean Annual Max of Average Monthly Streamflow

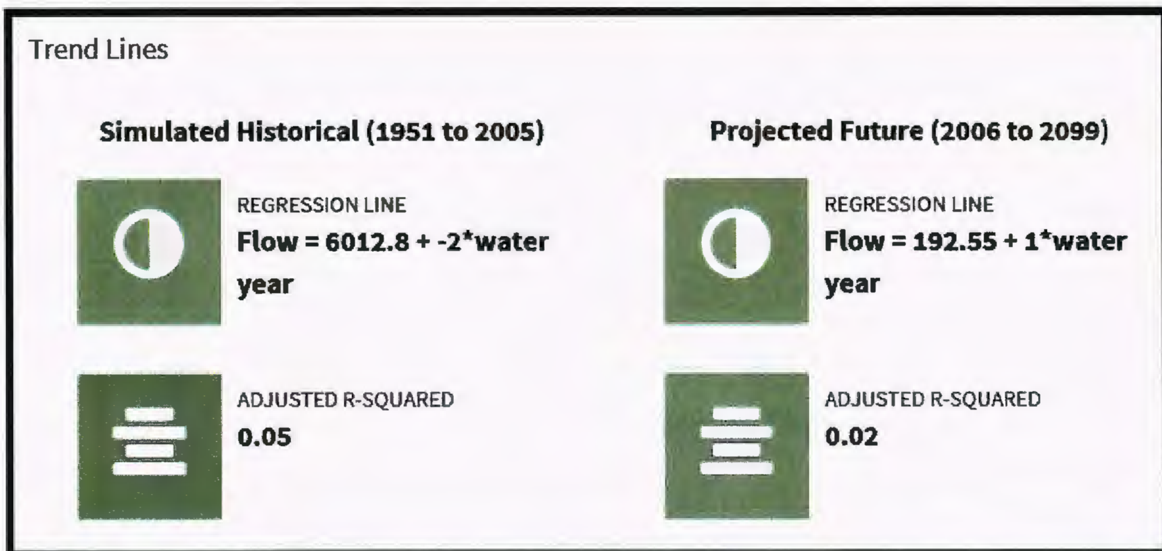

Figure 5-20. Trend Line Analysis

5.6.4 NONSTATIONARITY DETECTION TOOL

This tool, located at https://maps.crrel.usace.army.mil/projects/rcc/portal.html, accesses streamflow data collected by USGS gages. The nonstationarity gage closest to the project on Thomas Creek is Site Number 02231280-THOMAS CREEK NEAR CRAWFORD, FL, as shown in Figure 5-20. This gage is located in HUC-8 03070205-Nassau, and contained data recorded for over 30 years.

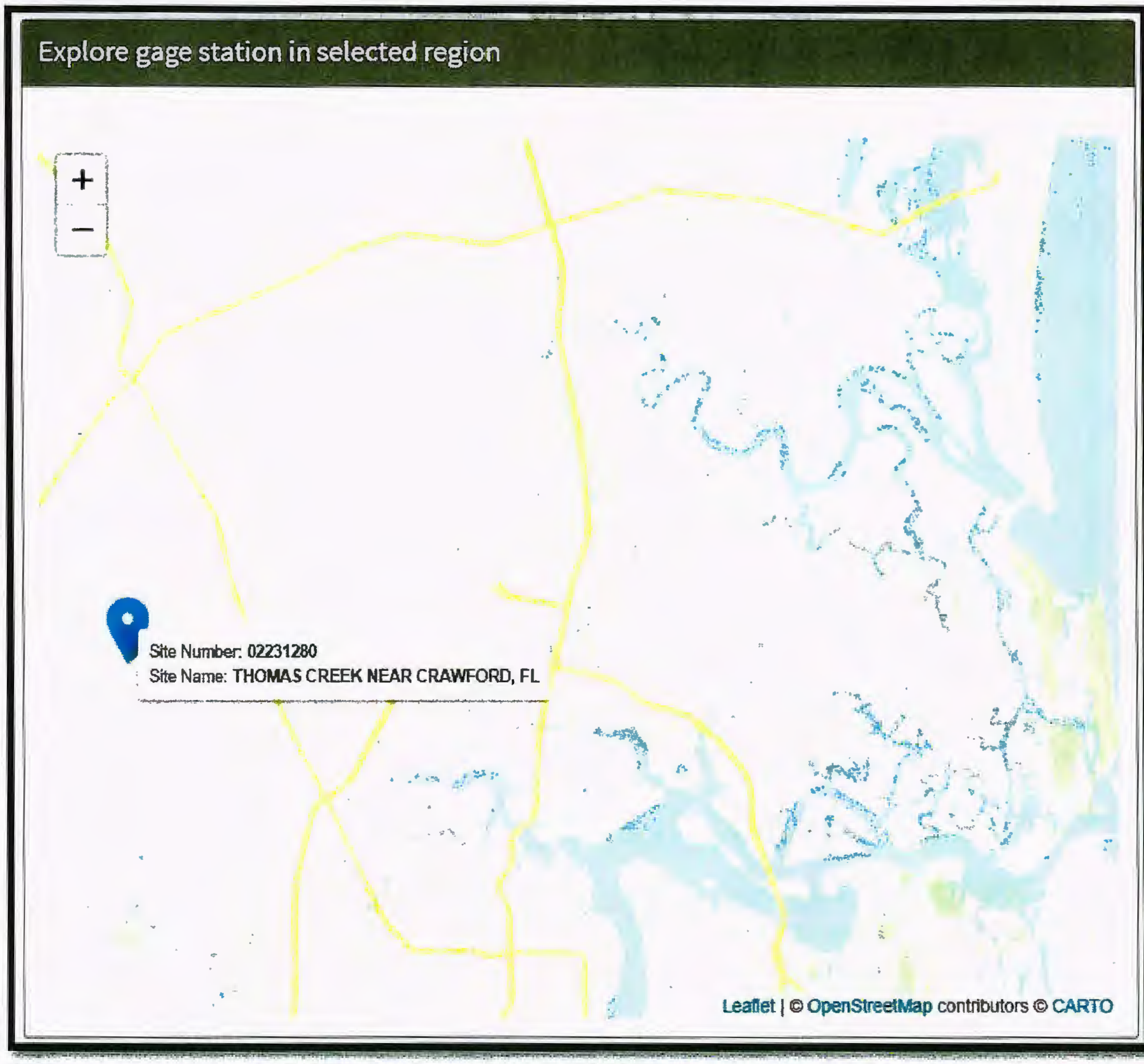

Figure 5-21. Nonstationarity Gage Site Location

Maximum annual flows are used to detect nonstationarities, as shown in Figure 5-21. No nonstationarities are detected at this site.

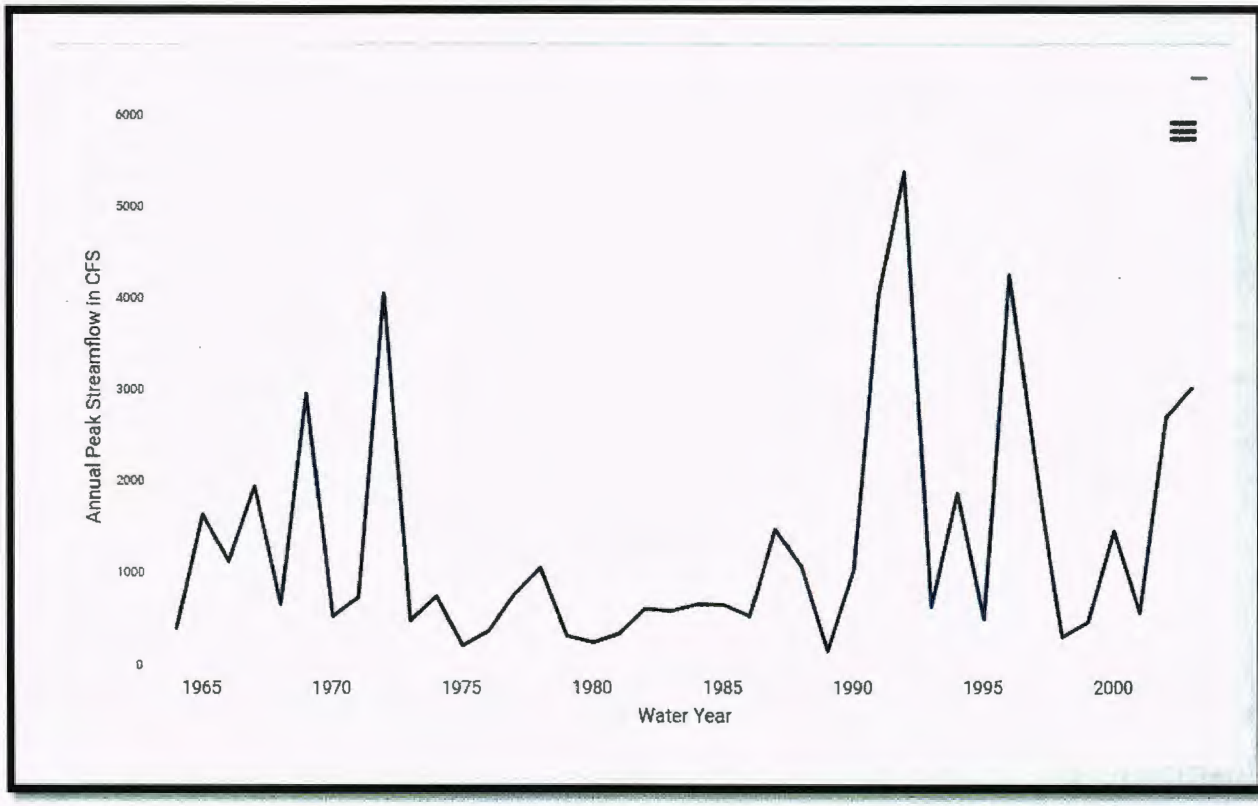

Figure 5-22. Nonstationarities Graph

5.6.5 VULNERABILITY ASSESSMENT TOOL

The Vulnerability Assessment Tool was under construction at the time of this analysis. However, it can be determined through inspection of the model results that as the sea level rises and climate change progresses, the vulnerable components will be the same as what currently experience repetitive losses. Residential landowners, and possibly public roads and utilities.

5.7 RISK ASSESSMENT

The literature review indicates there are potential increases in extreme precipitation and air temperature. Hence, it would be beneficial to account for risk due to climate change by developing a strategy for adaptive management of the project. Per guidance in ECB 2018-14, Table 5-7 identifies risks resulting from changed climate conditions in the future. The table shows the major project feature, the trigger event (climate variable that causes the risk), the hazard (resulting dangerous environmental condition), the harm (potential damage to the project or changed project output), and a qualitative assessment of the likelihood and uncertainty of this harm. Note that not all impacts of climate change will result in increased risk as there may be project benefits.

Adaptive management could be used as a means of ensuring that the project is resilient to the impact of climate change for the duration of the project life cycle. This includes that both the floodwall and the surrounding roadways can be adapted (raised) to handle extreme wet conditions. This will ensure that the plan selected is robust enough to accommodate changing climatic conditions.

Table 5-9. Climate Risk Assessment

Feature or Measure	Trigger	Hazard	Harm	Qualitative Likelihood
Floodwall	Increased extreme precipitation and sea-level rise	Increased flow and increased tailwater	The wall will no longer provide protection against the 10% AEP. It will overtop more often.	Very Likely
Pump Houses	Increased extreme precipitation and sea-level rise	Increased runoff	The pump houses will no longer provide protection against the 10% AEP. The wall will overtop more frequently, and the pumps will run longer to drain the floodwaters.	Very Likely

6. GEOTECHNICAL ANALYSIS

As no borings were available for the project proposed sheet pile wall/creek channel, USDA soil maps information was reviewed as the sole source of generalized geotechnical information. USDA soil maps provide information of the soil types present to a depth of around 80 inches. USDA soil maps do not provide engineering properties, but knowing the type of soil present does assist in the prediction of appropriate soil properties for engineering purposes"
The shallow, near-surface soil type and USCS classifications from this review are listed below:

Figure 6-1. Goldhead Fine Sands, Poorly Drained

The Goldhead series consisted of poorly drained and very poorly drained soils on broad areas of the flatwoods and in depressions. They formed in thick beds of stratified, unconsolidated, loamy, and sandy marine sediments. Generally speaking, sandy cohesionless soils (SP, SP-SM) are better suited for earthwork and foundation support than silty sands (SM) or clayey sands (SC). Soils classified as SC, SM, ML, CL, CH, and MH tend to retain moisture and are difficult to place and compact properly, and dewatering these types of soils is very difficult.

USACE strongly recommends that site-specific geotechnical explorations be performed for each section of the proposed project floodwall along the top of the creek bed. The geotechnical explorations should consist of borings (preferably standard penetration test borings (ASTM D1586) and associated laboratory testing of soils as needed for classification purposes and estimation of soil strength and density characteristics, as well as the determination of local groundwater depths. The length of the proposed wall is 11,060 linear feet. USACE recommends that borings be performed at a spacing of one boring for each 500 feet length for a total of 22 borings. Laboratory soil tests would likely include organic contents, Atterberg limits, and fines content or sieve tests. The results of the borings and lab tests would allow for a determination on the type of wall needed (gravity wall or sheet pile wall) and required wall foundation depths and sizes. The geotechnical exploration scope should be sufficient to allow for proper design and provide the contractor the most information possible with which to make an informed bid.

7. CIVIL DESIGN

Attachment 1 to this appendix provides the calculations discussed in this section.

7.1 PROJECT FEATURES

Figure 7-1. Pump House Locations

7.1.1 FLOODWALL

To reduce flooding risk to the communities north and west of Thomas Creek, a floodwall will need to be constructed on the north side of the creek from U.S. Highway 1, New Kings Road, east to State Road 115, Lem Turner Road. The purpose of the floodwall is to hold back water from Thomas Creek during high-water flood conditions. The floodwall will have four 48-inch culverts with flap gates. This will allow water to flow into the creek during normal conditions while holding back Thomas Creek during flood conditions. During Thomas Creek high-water events, drainage west of the proposed flood wall will back up due to the closed flap gates. To have continuous flood risk reduction during Thomas Creek high-water events, pump houses will be required to convey water to Thomas Creek through the floodwall.

7.1.2 PUMP HOUSE

It was determined that four pump houses would be needed for this project. Figure 7-1 above shows the locations for each pump house. To ensure that the pump houses are operational and unaffected during a flood event, the sites need to be at EL. 14.5 feet NAVD88, which is higher than the 1% AEP elevation. This elevation will allow fuel trucks to be able to reach the pump houses during flood conditions. The sites for the pump houses are 100 feet by 100 feet, with a side slope of 1V:3H. This will accommodate the pump house, generator, and a turning circle for fuel trucks with a turning radius of 41 feet.

7.1.3 ROADWAY

Four new roads will be needed to allow for access to each proposed pump house. Figure 7-1 shows the paths for the four proposed roads to each pump house. To ensure that refueling of the pump houses can occur during a flood event, the road embankments need to be at EL. 14.5 feet NAVD88, which is higher than the 1% AEP elevation. The road embankments will be 10 feet wide with side slopes of 1V:3H and an 8-foot wide 4-inch-thick asphalt road.

7.1.4 FLOODWALL CHANNEL

The landside of the floodwall will have a channel adjacent it. This will hydraulicly connect all four pump houses to each other for redundancy and will allow water to flow to one of the four culverts. The bottom channel width would be 15 feet with side slopes of 1V:3H. The channel bottom will be at EL. 3 feet NAVD88 with no gradient. The channel bottom elevation was chosen based off the lowest elevation along the path of the floodwall.

7.1.5 CHANNELS

Four channels will be cleared to direct flood waters towards the culverts and pump houses. Figure 7-1 above shows the paths for the four proposed channels. The channels will have a side slope of 1V:3H and a channel bottom width of 15 feet. The channels will begin just below the starting location elevations and slope towards the culverts at a final EL. 3 feet NAVD88.

7.2 SITE ACCESS AND STAGING AREAS

Four storage areas were chosen for construction laydown sites. Figure 7-2 shows these storage areas below. Figure 7-1 shows access road locations for each of the four pump houses above. Storage Area 1 will be adjacent to Pump House 1. The main access road for Storage Area 1 and the pump house will be south of Lem Turner Road before the bridge. This area will also be a starting point for the eastern edge of the floodwall. Storage Area 2 will be at the east end of Roy Booth Road and will also be used as an access point for Pump House 2. Storage Area 3 will be located at the end of Gray Rock Lane. This area will also serve as an access point for Pump House 4 and roughly a midway point for floodwall construction. Storage Area 4 will be located at the western side of the project off New Kings Road, right before the intersection with Roy Booth Road. Lastly Rock Trail will be used as an access road for Pump House 3.

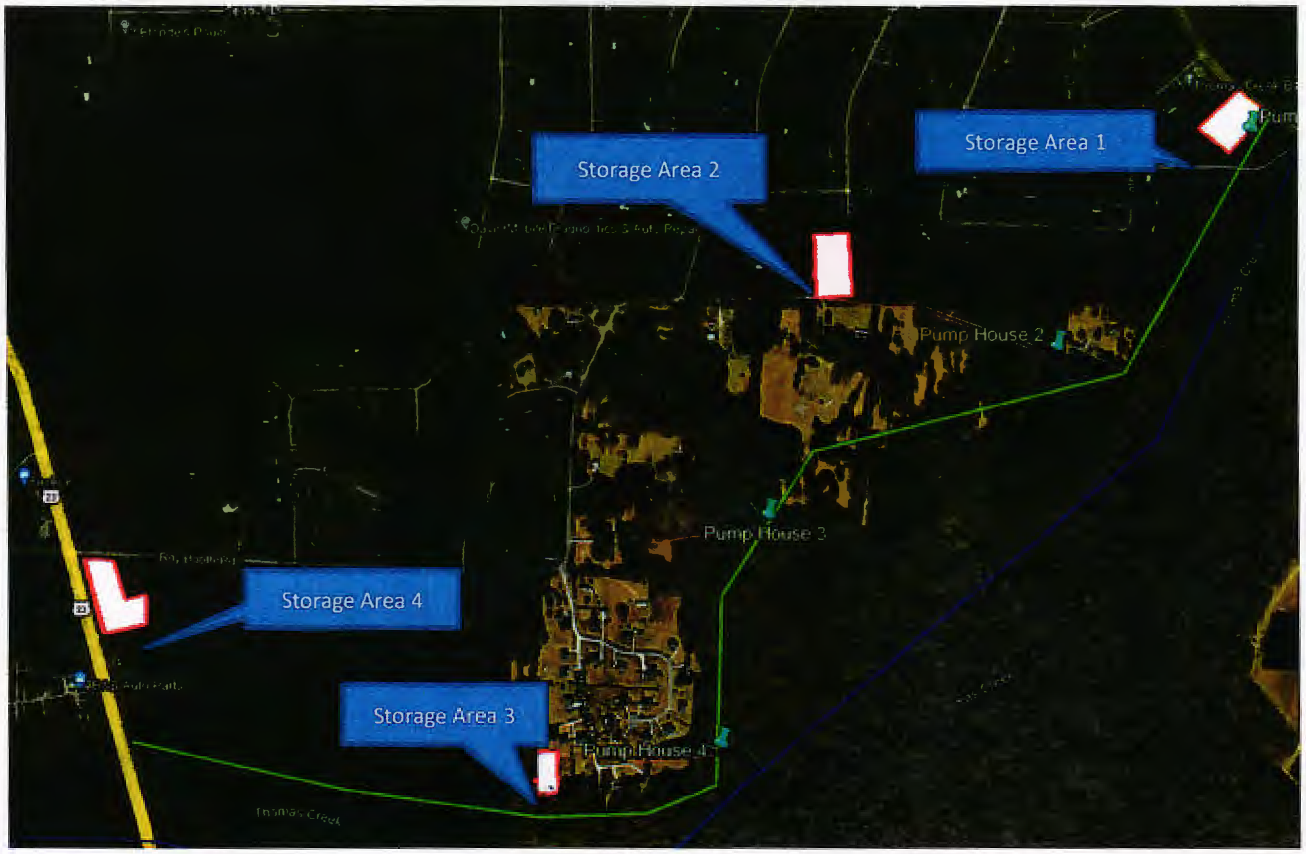

Figure 7-2. Staging Area Locations

7.3 CHANNEL EARTHWORK QUANTITIES

Calculating the earthwork quantities for the construction of the Thomas Creek floodwall and pump-house system required accurate elevation data. To obtain this, LiDAR data was used along with the program ArcMap to obtain the elevations of the proposed channels, roads, and pump house locations. This data was then used to obtain the necessary earthwork quantities. The excavation equations for the channels are dependent on the channel bottom width, channel side slopes, distance of the channels, and elevation differences to determine the amount of cut volumes that would be generated while constructing each channel. The pump houses and access roads will be constructed in heavily wooded areas. The assumption was that 2 feet of muck needed to be excavated and disposed of prior to placing embankment fills. The muck volume equation for the pump houses and roads used the width, length of the roads/pump houses, and the assumed 2-foot depth of muck. The fill equation for the road and pump house embankments used width, length, side slope, and elevation difference between existing elevation, minus 2 feet for muck removal and the final grade of EL. 14.5 feet NAVD88.

$$Channel\ Excavation\ Volume = [(b \times y) + (m \times y \times y)] \times x$$

Where b = channel bottom width

m = channel side slope

x = Distance of channel x_1 to x_2

y = elevation differential between existing grade to channel bottom elevation

$$Muck\ Removed = x \times b \times r$$

Where x = Distance of road/pump house x_1 to x_2

b = width of road/pump house

r = 2 feet of muck to remove

$$Road/Pump\ House\ Fill\ Volume = [(b \times y) + (m \times y \times\ y)] \times x$$

Where b = width of road/pump house

m = road/pump house side slope

x = Distance of road/pump house $x_1$to x_2

y = elevation differential between existing grade -2 (for muck) to new elevation of 14.5 feet

7.3.1 PUMP HOUSE EMBANKMENT

All four of the pump houses will need a total of 12,148 cubic yards (cy) of muck removed before building the embankment.

Pump House 1 will need 6,366 cy of soil to build the embankment, 2,980 cy for Pump House 2, 2,373 cy for Pump House 3, and 5,729 cy for Pump House 4. In total, 17,448 cy of soil will be needed to build the embankments for all the pump houses.

7.3.2 CHANNELS

To construct the channel along the floodwall, 51,653 cy of soil will need to be removed. Next, channel 1 will generate 1,215 cy of soil, channel 2 will generate 4,421 cy of soil, channel 3 will generate 5,856 cy of soil, and channel 4 will generate 147 cy of soil. In total 63,292 cy of soil will need to be removed to construct all the channels. The onsite materials from the cut were assumed to be not usable for the fill process, so this material will need to be disposed of off-site

7.3.3 ROADS

Road 1 will need 1,323 cy of muck removed; 5,166 cy of muck removed for road 2; 2,385 cy of muck removed for road 3; and 3,361 cy of muck removed for road 4. A total of 12,235 cy of muck will need to be removed for the roads.

Road 1 will need 3,724 cy of soil to construct the embankment, road 2 will need 7,994 cy of soil to construct the embankment, road 3 will need 3,806 cy of soil to construct the embankment, and road 4 will need 8,553 cy of soil to construct the embankment. The total volume of soil for all four road is 24,077 cy of soil to construct the embankments. All roads will also have a 4-inch-thick, 8-foot-wide asphalt surface along the entire length, with the total length of all the roads being 3,408 feet.

7.4 CHANNEL CLEARING

The NFS identified three locations for which snagging and clearing of garbage and excess vegetation would improve local drainage. Figure 7-3 shows the three locations, represented by the blue and green lines. Location #1 is at 43027 Ratliff Road (as denoted by the blue line) and will include cleaning dirt and debris out of 519 feet of the ditch. Location #2 is at 49580 Larsen Road (as denoted by the blue line) and will include cleaning dirt and debris out of 130 feet of the ditch. Location #3 is at the head of Larsen Road (as denoted by the green line) and will include cleaning dirt and debris out of the ditch. The NFS had determined that the SJRWMD would not permit the clearing of location #3 (green line); therefore, the NFS obtained cost quotes for snagging and clearing of the channels in only the blue areas. The Cost section of this appendix includes the costs.

Figure 7-3. Ditch-Clearing Locations

8. STRUCTURAL REQUIREMENTS

During this feasibility study, USACE was asked to provide flood protection for the 10-year storm event along the targeted 11,000-foot floodwall alignment. Based on the Nassau County topographic survey information and a flood water surface of 7.0 feet NAVD88, USACE determined that the most economic wall style would be an I-Wall (see Figure 8-1 below).

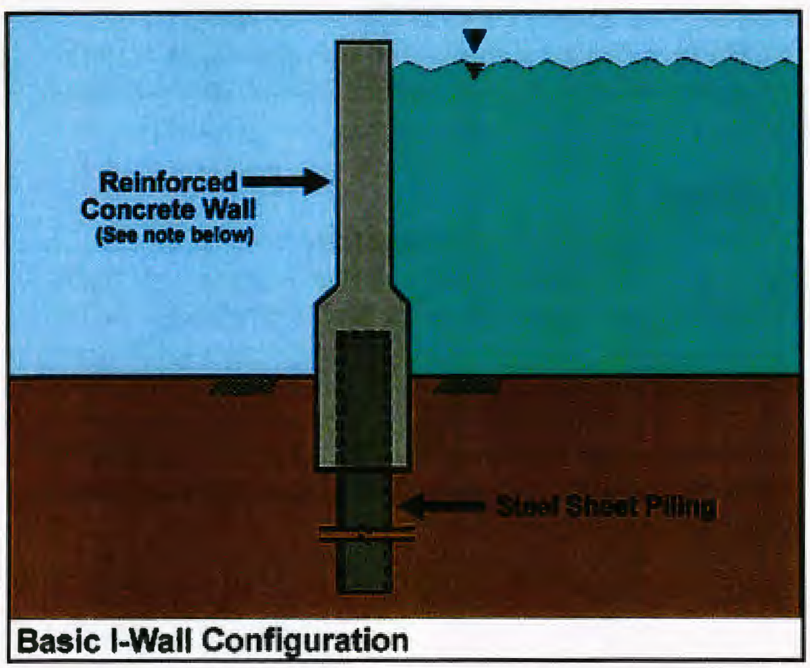

Figure 8-1. Structural Graphic (Basic I-Wall Configuration)

General graphic notes:

1. I-Walls are used when the exposed height of wall is low (usually < 10 feet)
2. I-Walls are used because they are notably cheaper than T-walls

In short, the 11,000-foot floodwall alignment would use three different I-Wall heights and use a one-foot earthen berm (or similar construction) spanning roughly 1,800 of the 11,000-foot floodwall alignment (this will reduce the amount of I-Wall construction necessary).
This would require the following amounts of I-Wall by length and height:

Table 8-1. Structural Table (I-Wall Element Sizes)

Length	Concrete Wall (*height)	Steel Sheet (*height)
3,000 feet	4.0 feet	9.33 feet
3,000 feet	6.5 feet	15.45 feet
3,100 feet	9.0 feet	21.56 feet

* = the concrete wall (height) extends 1.0 foot below ground level (GL) and the steel sheet is 2.0 feet above GL

Note, the actual element sizes will be determined more accurately during the design phase.

9. MECHANICAL AND ELECTRICAL REQUIREMENTS

9.1 MECHANICAL REQUIREMENTS

9.1.1 PUMP HOUSE

The pump houses will have a capacity of 100-cfs with a pump mix of two 50-cfs pumps. The pump houses will consist of separate inlet bays with independent trash racks, submersible axial-flow pumps, discharge piping, discharge flap gate, and accessories.

9.1.2 PUMP HOUSE FEATURES

9.1.2.1 INLET BAYS

The inlet bays will serve as the approach for the pump intake and a location for the trash rack. The depths of the supply canals will be determined by considering water surface elevation in the supply canal, minimum required submergence over the pump intakes, and minimum vertical clearance between the pump intakes and the floor of the sump. Minimum submergence for the pumps will be determined by using Hydraulic Institute Standard 9.8 and 2.3 and EM 1110-2-3105, Mechanical and Electrical Design of Pump Stations for a suction bell.

9.1.2.2 DISCHARGE ARRANGEMENT

The discharge for the pump houses will be located within the embankment with discharge pipes, air vent valves, and a flap gate.

To prevent backflow (two means are necessary) from the tailwater area back to the headwater area, the invert of the discharge pipes for the inflow pumps will be set at an elevation 1 foot higher than the pumping high-water level in the discharge basin. For the second means of backflow prevention, the pump houses will also incorporate flap gates.

Each of the pump discharge pipes will have a vent pipe for air to escape during filling.

9.1.3 PUMPING HOUSE EQUIPMENT

9.1.3.1 INFLOW PUMPS

The pump houses will all be equipped with electric motor-driven, submersible, axial-flow pumps. This pump type is a completely submerged, self-contained unit with a bell entrance, propeller, planetary reduction gear, motor, and diffuser. The unit will be supported and housed by a steel discharge column, and on-site staff will be able to remove the unit without unbolting the discharge piping. Use of this submerged unit will provide for quiet operation and will permit the pump house's superstructure size to be greatly reduced.

9.1.3.2 ELECTRIC MOTORS

The inflow pumps are intended to be driven by electric motors. The required motor horsepower rating will be derived by examining the horsepower (hp) requirements when operating in the required range from the minimum static head (and corresponding minimum total dynamic head (TDH)), through the design point (design point static head and TDH), to the maximum static head and TDH in the priming state.

9.1.3.3 GENERATOR

The 450-kW generator will be used to provide power to the two 50-cfs submersible units as well as the required telecommunications equipment. The generator will be rated for 277/480 volts and 3 phase with engine speeds not to exceed a maximum of 1,800 rpm. The engine will be 4 cycle and air cooled by a radiator. The generator will sit in the pump house control building with the proper ventilation system provided for the generator's exhaust.

9.1.3.4 DIESEL FUEL SYSTEM

Based on the data sheet in Attachment 2, the generator's fuel consumption rate at full load is 30.1 U.S. gph. The fuel supply system will need to provide the generator with enough fuel to pump dry the 1% AEP at the full load. Staff determined that the estimated duration would be 23 hours.
Staff calculated the required fuel storage would be 692.3 gallons. According to NFPA 37 Paragraph 6.3.2.2, fuel tanks not in a room by themselves must not exceed a 660-gallon capacity. Fuel tanks larger than a 660-gallon capacity must be enclosed in a room in accordance with 6.3.5 and 6.3.6. Not more than one 660-gallon capacity tank, or two or more tanks with an aggregate capacity of not more than 660 gallons, must be connected to one engine. Because of this requirement, the amount of fuel needed to operate the pumps at full load for 23 hours would not be permitted within the same room as the generator. A fuel tank will need to be installed outside of the structure or within a separate structure in accordance with NFPA 37 paragraph 6.3.5. Attachment 2 shows an 800-gallon Convault fuel storage tank. The 800-gallon tank will provide an additional 15% of fuel on top of the minimum requirements.

9.1.4 MODELING

9.1.4.1 PHYSICAL MODELING

A physical model study is a reliable method to identify unacceptable flow patterns at the pump suction for a given pump house design and to derive acceptable intake sump or piping designs. A physical hydraulic model study will be conducted for pump intakes with one or more of the following features.

- A suction intake arrangement with an elevation relative to water level that does not provide the minimum submergence requirement of this standard is irrespective of the pump manufacture's stated submergence values.
- The intake design is not a standard intake design, as the geometry deviates from this standard.
- No prior physical model study for the intake design is considered in terms of physical features and flow rates.

- Non-uniform or non-symmetric approach flow to the pump sump exists.
- Proper pump operation of a critical service or application is defined by the customer.
- Pump repair, remediation of a poor design, and the impacts of inadequate performance or pump failure all together would cost more than 10 times the cost of a physical model study.
- The pumps have flows greater than 40,000 gpm per pump, or the total station flow with all pumps running would be greater than 100,000 gpm.

A hydraulic laboratory will conduct the physical model using personnel that have experience in modeling pump intakes.
A properly conducted physical model study can be used to derive remedial measures, if necessary, to alleviate these undesirable flow conditions due to the approach upstream from the pump impeller. The objective of a model study is to ensure that the final sump or piping design generates favorable flow conditions at the inlet to the pump.

9.1.4.2 COMPUTATIONAL FLUID DYNAMICS (CFD) MODELING

CFD may be useful in determining the general approach flow to a sump and pump suction piping. CFD simulations may be used to determine the extent of the physical model and the velocity distribution needed at the physical model boundary. Useful applications of CFD would include determining if physically modelling a single pump bay or single suction pipe would be adequate. CFD simulations may also be used to compare designs, to aid in the initial selection of a design for testing using a physical model, or to better define the range of variables to be tested.

9.2 ELECTRICAL REQUIREMENTS

9.2.1 GENERAL

The electrical design focused on the portions of the Thomas Creek PAS that would require electrical power to properly operate. At a minimum, each pump house will require systems and/or components related to electrical power service, a backup generator, a transfer switch, grounding, lightning protection, exterior electrical distribution, interior electrical distribution for two electric motor-driven pumps, general use receptacles, lighting, controls, monitoring, water levels sensors, stilling wells, fire detection, intrusion detection, and security camera surveillance. Additional information on the project's electrical requirements is explained in the system- or component-specific paragraph within this section. Electrical design must be in accordance with Federal, state, and local jurisdiction ordinances. The most stringent rule will govern when two or more address the requirement. Where there is contradiction between two or more guidance, the electrical design must seek a reasonable resolution from the Authority Having Jurisdiction.

9.2.2 ELECTRICAL UTILITY RELOCATIONS

The Thomas Creek PAS Project is adjacent developed and residential property. As would be expected, both high-voltage transmission and distribution electrical lines are close to the Thomas Creek PAS Project. Currently no electrical utilities require relocation for construction or operation of the pump houses. The utility company for electrical service to the pump houses is Florida Power and Light (FPL). Maintaining regular periodic coordination with FPL will minimize utility relocations in the future.

9.2.3 ELECTRICAL POWER SERVICE

Preliminary coordination has been initiated with Hayes Lucas and Robert Haddock, FPL representatives in the Nassau Service Office. FPL has power suitable to the project needs along Lem Turner Road and alternately along US Hwy 1/US Hwy 23. FPL will require a 20-foot utility easement clear from sky to ground along the access road for power-pole and power-line installation. The project will acquire the capital cost of the new aerial overhead service provided by FPL via payment of terms and conditions on an FPL presented invoice. The estimated rough order of magnitude to have FPL bring power to the four pump houses is $2M. FPL will install a feeder branch in the utility easement from Lem Turner Road and U.S. Hwy 1/U.S. Hwy 23 for pump houses. FPL will provide each pump house with pole-mounted transformers, a meter, and service to the meter base. The electrical service required for each pump house is 277/480-volts, 3-phase, 60-Hz stable and reliable. Transient Voltage Surge Suppression will be provided at the service entrance.

9.2.4 BACKUP GENERATOR AND AUTOMATIC TRANSFER SWITCH

A backup generator is required to assure pumping operations are conducted as necessary during commercial power outages. The generator will be rated 450 kW for prime power for the duration of pumping needed to lower water in the collection canal to acceptable levels. Each pump house will have a backup generator appropriately sized to power the installed pumps and all other station electrical loads. The generator will be installed in a generator room adjacent the control room and fueled with diesel or liquid petroleum gas. A fuel storage tank with sufficient capacity to assure operation of the pump house for at least seven days will be required. A generator sizing software suite will be used to facilitate generator selection. An emergency stop button for the generator will be located outside the generator room or near the generator room exit door. An automatic transfer switch (ATS) will be installed in the generator room. Generator and ATS must be products from the same manufacturer. The ATS will signal the generator to start upon a loss of stable commercial power and transfer electrical load to the generator when ready to accept. Upon return of stable commercial power, the ATS will transfer the electrical load to the commercial power source and initiate a cooldown cycle for the generator. The ATS will include a function to test the generator monthly. The backup generator and ATS must be in accordance with NFPA 110, Standard for Emergency and Standby Power Systems.

9.2.5 GROUNDING AND LIGHTNING PROTECTION SYSTEM

The grounding system will include a grounding conductor buried around the pump house building and connected to three ground rods spaced approximately 10 feet apart, connected via grounding conductors in an equilateral triangle arrangement. Door embedded metal masses, sheet pile, structure steel, door frame equipment, and electrical enclosures must be bonded to the grounding system. Each pump house grounding system must be in accordance with NFPA 70. A lightning protection system in accordance with NFPA 780, Standard for the Installation of Lightning Protection Systems will be installed on the pump house roof. The lightning protection system will consist of interconnected air terminals with a roof ground ring and at least two down conductors to connect to the station-grounding ring. A test well will be connected to the grounding system for resistance testing of the grounding system.

9.2.6 EXTERIOR ELECTRICAL DISTRIBUTION

Any underground electrical lines must be placed in PVC conduit for protection. Any buried electrical conduit subject to vehicle traffic loading must be encased in a concrete duct. Light fixtures will be installed on poles rated to pre-determined hurricane strength, wind-loading requirement. Exterior lighting will use LED fixtures with a photocell switch that turns the fixture off during daylight hours. The photocell switch will be incorporated into a lighting contact control when several lights are present at the pump house site. The lighting contact will include an on-off auto-control switch. Exterior electrical distribution will be in accordance with IEEE C2, National Electrical Safety Code, and FPL standards and requirements.

9.2.7 INTERIOR ELECTRICAL DISTRIBUTION

A motor control center (MCC) rated for 600 volts, three phases with a main breaker, will be connected to the incoming service 277/480-volt, 3-phase and will feed electric motors via soft starters. The MCC will be placed on a rebar-reenforced, 4-inch-high housekeeping pad above the finished floor. The electric motors for the pumps in the pump house are rated 200 hp with a full load of up to 246-amps. The electrical motors will have power factor correction in their control schematic. The MCC will feed dry type transformer for 120/208-volt, 3-phase power panels. All electrical loads, excluding the pump motors, will have a breaker protected branch circuit from the 120/208-volt power panel. The power panel will have a minimum of 36 slots for breakers and spares. General use duplex power receptacles will be provided in the control and generator room. Exterior general-use receptacles will be weather protected. Interior light fixtures will be equipped with motion sensor to keep lights on while the space is occupied. Surge suppression will be provided for each electrical/electronic system within the pump house. An electrical design software suite will be used to develop the electrical design and to conduct an Arc Flash Hazard analysis. Interior electrical distribution will be in accordance with NFPA 70, National Electrical Code and NFPA 101, Life Safety Code.

9.2.8 CONTROLS AND MONITORING

Each pump house will have a centralized control and monitoring room. The control systems will include manual, automatic, and telemetry capabilities for the pumps and auxiliary systems. Telemetry capabilities may be obtained via commercial cellular network, an existing internet network, or a dedicated sponsor-designed and constructed microwave network. Electric motor-driven pumps will be controlled from the MCC and pump control station. Equipment, water-level devices, fuel-level devices, bearing water flow, motor temperatures, pump temperatures, and well head pressures will be electrically monitored for safe operation or as required by the equipment manufacturers.

9.2.9 WATER-LEVEL SENSORS AND STILLING WELLS

Water-level sensors in stilling wells will be installed at or near each pump house. One water-level sensor with readout shall provide a continuous water-level status. Each pump will have two water-level sensors to provide normal cutoff and ultimate cutoff for the pump.

9.2.10 FIRE DETECTION AND ALARM

Each pump house will be equipped with a fire detection and alarm panel. An audible and visual alarm will be activated at the station when smoke or fire is detected. The alarm status will be transmitted via the telemetry system to the central control station or as required by the Authority Having Jurisdiction. Fire detection and the alarm will be in accordance with NFPA 72, National Fire Alarm and Signaling Code.

9.2.11 INTRUSION DETECTION AND ALARM

Each pump house will be equipped with an intrusion detection and alarm system. An audible and visual alarm will be activated at the pump house when an intrusion is detected. The alarm status will be transmitted via the telemetry system to the central control station.

9.2.12 SECURITY CAMERA SURVEILLANCE

Each pump house will be equipped with a security camera surveillance system. The output from the system will be viewable in the station and at the central control station.

10. HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

Phase I and Phase II Environmental Site Assessments (ESAs) are not part of the scope of this study. It is recommended that a Phase I ESA be completed prior to design.

11. CONSTRUCTION COSTS

Table 11-1 shows the estimated construction costs. USACE estimated the floodwall and pump component costs. These estimates include mobilization and de-mobilization but do not include design or permitting. Attachment 3, Cost Estimate, of this appendix provides the approved cost estimate.

Hayward Construction Group, LLC prepared the ditch-clearing estimates for Nassau County, Nassau County provided them. Attachment 3 of this appendix provides these independent estimates.

Table 11-1. Alternative Costs

Alternative	Component	Component Cost
	Sheet Pile Floodwall	$22,562,000
	Connecting Channel to Pump Houses	$7,594,000
	Pump House Structures & Equipment	$32,038,300
	Pump House Channels	$3,341,100
	Pump House Access Roads	$3,398,100
	Pump Power Connection	$2,000,000
	Ditch Clearing at Ratliff Road, 519 feet	$4,500
	Ditch Clearing at Larsen Road, 130 feet	$3,500
Total:		**$70,941,500**

To estimate the costs of the buy-out Alternative, the NFS estimated the total value of 78 properties along the creek. The available data did not include all the repetitive loss homes; nonetheless, the 78 property values available totaled $8,341,049. Attachment 3 provides this calculation.

12. RISK REGISTER AND RECOMMENDATIONS

12.1 RISK REGISTER

Due to the nature and intent of the PAS program, this study was limited in scope and budget. The best performing Alternative is a conceptual-level design on which the construction cost is based. The engineering analyses were performed using available data as collection of detailed survey and soil data was not in the scope of this study. Any differences in the terrain, soil properties, or design may result in a risk of cost increases. The presence of any contamination or endangered species in the project area will also risk cost increases. The limited scope feasibility study results in the following risks to cost and design changes:

- Modeleding based on LiDAR only, without recent topographic survey data, increases uncertainty in modeled stages, resulting in uncertainty of the magnitude of flood management impacts by the design.
- A lack of detailed data on culverts within the project area increases uncertainty in modeled stages, resulting in uncertainty of the magnitude of flood management impacts by the design.
- Detailed hydraulic modeling with current topography and more detailed channel and culvert features risk revealing hydraulic conditions that will require a design change or the increased cost of erosion protection.
- The presence of contaminants at project feature locations may result in design changes to avoid contamination or a cost increase to remove it.
- Soil properties differing from local data used may result in design changes, including different channel side slopes or select fill requirements.

- A change in land use may result in increased peak runoff rates and may require a design change.
- Real estate easements, both permanent and temporary, for access and construction may not be easily acquired.
- Permitting of construction within a wetland may be difficult, and the permitting agencies will need to approve construction of a project that would result in peak stage increases in other areas.
-

12.2 DESIGN PROCESS RECOMMENDATIONS

This feasibility-level study was limited in analysis scope. Completion of the following data and detailed analyses are highly recommended during the design process:

- Design-level survey collection, including existing culvert sizes and inverts, utility locations, and adjacent parcel owners
- Collection of flood stage records for model calibration
- Phase I ESAs
- Updated topographical/LiDAR survey
- Updated modeling to verify benefits
- Soil sampling and analyses in project areas
- Slope stability analyses in project areas
- Construction sequence

13. CONCLUSION

As discussed in Section 3.2, the two structural Alternatives analyzed included:

1. Alternative 1 – Floodwall with pumps and snagging clearing from two drainage ditches.
2. Alternative 2 – Detention pond and snagging and clearing from two drainage ditches.

As discussed in Section 5.5.4, the storage area Alternative did not have the storage volume available to detain the 10% AEP runoff volume. Therefore, this Alternative was not carried forward. As presented in Section 5.5.5, the floodwall and pump system Alternative will be able to provide flood risk reduction benefits for the 10% AEP storm. Therefore, the best-performing structural Alternative is Alternative 1, which includes a floodwall, pumps, and snagging and clearing from two drainage ditches.

However, it is very important to state that during a Nassau County Board Meeting on 27 September 2021, the Nassau County Board of County Commissioners (Board) made the final decision. At the meeting, the modeling results of each Management Measure were presented, along with the best-performing Alternative results and preliminary costs. As a result of the cost of the best-performing Alternative and its limited benefits, the Board decided to move forward with buyouts instead.

This study was instrumental in showing that the structural solution would be expensive and limited in effectiveness, which verified that pursuing buyouts would be the best option.

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SIMULATION TOOLS

HEC-HMS Version 4.4.1

HEC-RAS Version 6.0

ATTACHMENT 1

Width of Road (ft)	Side Slope of road	Asphalt Thickness (ft)
10	3	0.333

Road to Pump Station 4

Distanance (Ft)	Elevation (Ft)	Muck (Ft)	Volume of Removed Muck (Ft^3)	Total Volume of Removed Muck (Ft^3)
0	10	2	1915.400384	90770.5996
17.60907192	9.8525	2	1982.819533	
35.21814383	9.4199	2	2081.896977	
52.82721575	9	2	2130.697701	
70.43628766	9	2	2130.697703	
88.04535959	9	2	2130.697701	
105.6544315	9	2	2130.697702	
123.2635034	9	2	2171.165462	
140.8725753	8.6518	2	2287.385337	
158.4816472	8	2	2363.137452	
176.0907192	8	2	2363.137451	
193.6997911	8	2	2381.058555	
211.308863	7.8458	2	2451.83646	
228.9179349	7.391	2	2550.135229	
246.5270068	7	2	2595.577201	
264.1360787	7	2	2595.577201	
281.7451507	7	2	2599.900579	
299.3542226	6.9628	2	2632.558365	
316.9632945	6.719	2	2744.45486	
334.5723664	6	2	2828.016948	
352.1814383	6	2	2844.101781	
369.7905102	5.8616	2	2938.437452	
387.3995822	5.1883	2	3001.219429	
405.0086541	5.3214	2	2941.191864	
422.617726	5.7048	2	2862.325057	
440.2267979	6	2	2828.01695	
457.8358698	6	2	2831.596521	
475.4449417	5.9692	2	2762.594293	
492.5777897	5.933	2	2853.372344	
509.7106376	5.1664	2	2958.872996	
526.8434856	5	2	2974.477594	
543.9763336	5.0284	2	2974.477593	
561.1091815	5	2	2977.688974	
578.2420295	5	2	2977.688975	
595.3748774	5	2	2977.688974	
612.5077254	5	2		

Elevation Without Muck (Ft)	Road Elevation (Ft)	Difference Between Without Muck and Road Elevation (Ft)	Fill Volume (Ft^3)	Total Fill Volume (Ft^3)
8	14.5	6.5	3440.461655	230942.3681
7.8525	14.5	6.6475	3697.434083	
7.4199	14.5	7.0801	4091.203495	
7	14.5	7.5	4292.211278	
7	14.5	7.5	4292.211281	
7	14.5	7.5	4292.211278	
7	14.5	7.5	4292.21128	
7	14.5	7.5	4462.428183	
6.6518	14.5	7.8482	4969.081684	
6	14.5	8.5	5313.537452	
6	14.5	8.5	5313.53745	
6	14.5	8.5	5396.668702	
5.8458	14.5	8.6542	5731.127007	
5.391	14.5	9.109	6211.884694	
5	14.5	9.5	6440.518054	
5	14.5	9.5	6440.518054	
5	14.5	9.5	6462.480754	
4.9628	14.5	9.5372	6629.562683	
4.719	14.5	9.781	7217.856812	
4	14.5	10.5	7673.153083	
4	14.5	10.5	7762.360047	
3.8616	14.5	10.6384	8295.733579	
3.1883	14.5	11.3117	8660.347517	
3.3214	14.5	11.1786	8311.568491	
3.7048	14.5	10.7952	7864.038196	
4	14.5	10.5	7673.153089	
4	14.5	10.5	7692.961732	
3.9692	14.5	10.5308	7526.920531	
3.933	14.5	10.567	8039.249846	
3.1664	14.5	11.3336	8655.479953	
3	14.5	11.5	8748.525677	
3.0284	14.5	11.4716	8748.525674	
3	14.5	11.5	8767.734938	
3	14.5	11.5	8767.734943	
3	14.5	11.5	8767.734938	
3	14.5	11.5		

Total Fill Volume (Yd^3)	**Total Width Needed for the Road (Ft)**	**Average Total Width Needed (Ft)**	**Woods needed to be Cleared (ft^2)**	**Woods Needed to be Cleared (yd^2)**	**Volume of Asphalt Needed (Ft^3)**
8553.421726	49.4425	67.42584571	8259.770278	916.8345009	2039.650725
	51.1828				
	53.7403				
	55				
	55				
	55				
	55				
	56.0446				
	59.0446				
	61				
	61				
	61.4626				
	63.2896				
	65.827				
	67				
	67				
	67.1116				
	67.9546				
	70.843				
	73				
	73.4152				
	75.8503				
	77.4709				
	75.9214				
	73.8856				
	73				
	73.0924				
	73.2934				
	75.7018				
	78.5008				
	78.9148				
	78.9148				
	79				
	79				
	79				

Road to Pump Station 2

Distanance (ft)	Elevation (ft)	Much (ft)	Volume of Removed Muck (Ft^3)	Total Volume of Removed Muck (Ft^3)
0	18	2	391.0969372	139501.5067
17.77713351	18	2	391.0969372	
35.55426702	18	2	391.096937	
53.33140052	18	2	391.0969372	
71.10853403	17.6175	2	391.0969372	
88.88566753	17.0161	2	391.096937	
106.662801	17	2	391.0969372	
124.4399345	17	2	391.0969372	
142.2170681	17	2	391.096937	
159.9942016	17	2	391.0969372	
177.7713351	17	2	391.0969372	
195.5484686	16.6131	2	431.2704144	
213.3256021	16.1576	2	465.9294251	
231.1027356	16.2046	2	484.4204884	
248.8798691	16	2	508.4260181	
266.6570026	16	2	508.4260184	
284.4341361	16	2	508.4260184	
302.2112696	16	2	508.4260181	
319.9884031	16	2	508.4260184	
337.7655366	16	2	546.9216899	
355.5426701	15.6719	2	664.2507707	
373.3198036	15	2	743.0841806	
391.0969371	15	2	743.0841807	
408.8740706	15	2	743.0841807	
426.6512042	15	2	743.0841804	
444.4283377	15	2	776.9805522	
462.2054712	14.7111	2	894.3096334	
479.9826047	14	2	977.7423426	
497.7597382	14	2	977.7423429	
515.5368717	14	2	977.7423429	
533.3140052	14	2	1007.813786	
551.0911387	13.7437	2	1125.142868	
568.8682722	13	2	1212.400505	
586.6454057	13	2	1184.628711	
604.4225392	13.2367	2	1078.058707	
622.1996727	13.9083	2	1043.035977	
639.9768062	13.5352	2	1149.605981	
657.7539397	13	2	1212.400505	
675.5310732	13	2	1212.400505	
693.3082067	13	2	1217.093668	

711.0853403	12.96	2	1251.623617	
728.8624738	12.7057	2	1364.259535	
746.6396073	12	2	1447.058668	
764.4167408	12	2	1447.058668	
782.1938743	12	2	1447.058667	
799.9710078	12	2	1436.976125	
817.5625167	11.9567	2	1547.843794	
835.1540255	11.0451	2	1658.920452	
852.7455344	11	2	1664.15674	
870.3370433	11	2	1664.156739	
887.9285522	11	2	1664.15674	
905.5200611	11	2	1680.898931	
923.1115699	10.8558	2	1680.898932	
940.7030788	11	2	1676.254773	
958.2945877	10.8958	2	1790.779717	
975.8860966	10.0136	2	1894.785643	
993.4776055	10	2	1896.364658	
1011.069114	10	2	1896.364658	
1028.660623	10			
		2	1896.364657	
1046.252132	10	2	1896.364657	
1063.843641	10	2	1896.364658	
1081.43515	10	2	1896.45754	
1099.026659	9.9992	2	1896.457539	
1116.618168	10	2	1896.364658	
1134.209677	10	2	1896.364657	
1151.801185	10	2	1896.364657	
1169.392694	10	2	1896.364658	
1186.984203	10	2	1896.364656	
1204.575712	10	2	1896.364658	
1222.167221	10	2	1908.021496	
1239.75873	9.8996	2	1909.751443	
1257.350239	9.9851	2	1898.094606	
1274.941748	10	2	1909.577289	
1292.533256	9.8862	2	1909.577288	
1310.124765	10	2	1951.421154	
1327.716274	9.5258	2	2044.768737	
1345.307783	9.196	2	2060.872357	
1362.899292	9.3871	2	2076.82504	
1380.490801	9.0586	2	2113.026254	
1398.08231	9.0753	2	2111.528513	
1415.673819	9.0715	2	2013.188462	
1433.265328	9.9223	2	1905.385935	

1450.856836	10	2	1896.364657	
1468.448345	10	2	1962.404589	
1486.039854	9.4312	2	2078.508548	
1503.631363	9	2	2113.920256	
1521.222872	9.1262	2	2112.329631	
1538.814381	9.0137	2	2073.957272	
1556.40589	9.4567	2	2073.29548	
1573.997399	9.0194	2	2120.038935	
1591.588907	9.0541	2	2122.29135	
1609.180416	9	2	2128.572574	
1626.771925	9	2	2128.572574	
1644.363434	9	2	2128.572574	
1661.954943	9	2	2109.485085	
1679.546452	9.1644	2	2015.847241	
1697.137961	9.8065	2	2034.934732	
1714.72947	9	2	2128.572576	
1732.320979	9	2	2035.561692	
1749.912487	9.8011	2		

Elevation Without Muck (Ft)	Road Elevation (Ft)	Difference Between Without Muck and Road Elevation (Ft)	Fill Volume (Ft^3)	Total Fill Volume (Ft^3)
16	14.5	0	0	215840.4657
16	14.5	0	0	
16	14.5	0	0	
16	14.5	0	0	
15.6175	14.5	0	0	
15.0161	14.5	0	0	
15	14.5	0	0	
15	14.5	0	0	
15	14.5	0	0	
15	14.5	0	0	
15	14.5	0	0	
14.6131	14.5	0	31.99756604	
14.1576	14.5	0.3424	62.1149334	
14.2046	14.5	0.2954	79.1348364	
14	14.5	0.5	102.2185176	
14	14.5	0.5	102.2185177	
14	14.5	0.5	102.2185177	
14	14.5	0.5	102.2185176	
14	14.5	0.5	102.2185177	
14	14.5	0.5	141.5661976	
13.6719	14.5	0.8281	279.1994316	
13	14.5	1.5	386.6526538	
13	14.5	1.5	386.6526538	
13	14.5	1.5	386.6526538	
13	14.5	1.5	386.6526537	
13	14.5	1.5	436.555688	
12.7111	14.5	1.7889	626.4750273	
12	14.5	2.5	777.7495907	
12	14.5	2.5	777.749591	
12	14.5	2.5	777.749591	
12	14.5	2.5	835.578913	
11.7437	14.5	2.7563	1077.960351	
11	14.5	3.5	1275.509329	
11	14.5	3.5	1211.034691	
11.2367	14.5	3.2633	977.4893519	
11.9083	14.5	2.5917	905.5408563	
11.5352	14.5	2.9648	1131.856389	
11	14.5	3.5	1275.509329	
11	14.5	3.5	1275.509329	
11	14.5	3.5	1286.552485	

10.96	14.5	3.54	1369.114246
10.7057	14.5	3.7943	1654.483316
10	14.5	4.5	1879.931868
10	14.5	4.5	1879.931869
10	14.5	4.5	1879.931868
10	14.5	4.5	1874.418479
9.9567	14.5	4.5433	2198.305358
9.0451	14.5	5.4549	2546.93165
9	14.5	5.5	2563.96242
9	14.5	5.5	2563.962418
9	14.5	5.5	2563.962419
9	14.5	5.5	2618.775718
8.8558	14.5	5.6442	2618.77572
9	14.5	5.5	2603.515929
8.8958	14.5	5.6042	2992.138975
8.0136	14.5	6.4864	3367.312777
8	14.5	6.5	3373.171828
8	14.5	6.5	3373.17183
8	14.5	6.5	3373.171828
8	14.5	6.5	3373.171828
8	14.5	6.5	3373.17183
8	14.5	6.5	3373.51663
7.9992	14.5	6.5008	3373.516628
8	14.5	6.5	3373.17183
8	14.5	6.5	3373.171828
8	14.5	6.5	3373.171828
8	14.5	6.5	3373.17183
8	14.5	6.5	3373.171826
8	14.5	6.5	3373.17183
8	14.5	6.5	3416.576417
7.8996	14.5	6.6004	3423.040597
7.9851	14.5	6.5149	3379.596537
8	14.5	6.5	3422.389579
7.8862	14.5	6.6138	3422.389577
8	14.5	6.5	3580.515013
7.5258	14.5	6.9742	3945.621453
7.196	14.5	7.304	4010.331958
7.3871	14.5	7.1129	4074.936458
7.0586	14.5	7.4414	4223.390507
7.0753	14.5	7.4247	4217.197694
7.0715	14.5	7.4285	3820.193688
7.9223	14.5	6.5777	3406.739557

8	14.5	6.5	3373.171828
8	14.5	6.5	3622.58864
7.4312	14.5	7.0688	4081.783315
7	14.5	7.5	4227.089088
7.1262	14.5	7.3738	4220.509583
7.0137	14.5	7.4863	4063.285967
7.4567	14.5	7.0433	4060.599678
7.0194	14.5	7.4806	4252.44473
7.0541	14.5	7.4459	4261.797137
7	14.5	7.5	4287.93029
7	14.5	7.5	4287.93029
7	14.5	7.5	4287.93029
7	14.5	7.5	4208.755669
7.1644	14.5	7.3356	3830.678335
7.8065	14.5	6.6935	3906.354307
7	14.5	7.5	4287.930292
7	14.5	7.5	3908.85211
7.8011	14.5	6.6989	

Total Fill Volume (Yd^3)	Total Width Needed for the Road (Ft)	Average Total Width Needed (Ft)	Woods needed to be Cleared (ft^2)	Woods Needed to be Cleared (yd^2)	Volume of Asphalt Needed (Ft^3)
7994.09196	10	36.31325758	31772.51145	3526.74877	5827.208583
	10				
	10				
	10				
	10				
	10				
	10				
	10				
	10				
	10				
	10				
	11.0272				
	11.9134				
	12.3862				
	13				
	13				
	13				
	13				
	13				
	13.9843				
	16.9843				
	19				
	19				
	19				
	19				
	19.8667				
	22.8667				
	25				
	25				
	25				
	25.7689				
	28.7689				
	31				
	30.2899				
	27.565				
	26.6695				
	29.3944				
	31				
	31				
	31.12				

32.0029
34.8829
37
37
37
37.1299
39.9946
42.8647
43
43
43
43.4326
43.4326
43.3126
46.2718
48.9592
49
49
49
49
49
49.0024
49.0024
49
49
49
49
49
49
49.3012
49.3459
49.0447
49.3414
49.3414
50.4226
52.8346
53.2507
53.6629
54.5983
54.5596
52.0186
49.2331

49
50.7064
53.7064
54.6214
54.5803
53.5888
53.5717
54.7795
54.8377
55
55
55
54.5068
52.0873
52.5805
55
52.5967

Road to Pump Station 3

Distanance Ft)	Elevation (Ft)	Muck (Ft)	Volume of Removed Muck (Ft^3)	Total Volume of Removed Muck (Ft^3)	Elevation Without Muck (Ft)
0	18.3955	2	385.8502541	64395.34375	16.3955
17.53864791	18	2	385.8502542		16
35.07729583	18	2	385.8502541		16
52.61594374	17.6492	2	385.850254		15.6492
70.15459165	17.2221	2	385.8502541		15.2221
87.69323956	17	2	385.8502542		15
105.2318875	17	2	385.8502541		15
122.7705354	16.5937	2	447.142567		14.5937
140.3091833	15.9705	2	505.0201051		13.9705
157.8478312	16	2	540.3254032		14
175.3864791	15.6655	2	681.3845392		13.6655
192.925127	14.7814	2	825.5227602		12.7814
210.463775	14.4203	2	852.9335621		12.4203
228.0024229	14.5446	2	842.6313602		12.5446
245.5410708	14.5093	2	905.6715748		12.5093
263.0797187	14	2	964.6256354		12
280.6183666	14	2	964.6256351		12
298.1570145	14	2	978.4236405		12
315.6956624	13.8808	2	1064.533841		11.8808
333.2343103	13.2561	2	1171.063238		11.2561
350.7729583	12.9605	2	1275.173354		10.9605
368.3116062	12.3567	2	1502.111181		10.3567
385.8502541	11	2	1654.329106		9
403.388902	11.0417	2	1433.109579		9.0417
420.9275499	12.9111	2	1319.333916		10.9111
438.4661978	12.0246	2	1424.798365		10.0246
456.0048457	12	2	1427.64594		10
473.5434936	12	2	1427.64594		10
491.0821415	12	2	1475.093946		10
508.6207895	11.5901	2	1579.85229		9.5901
526.1594374	11.095	2	1648.159361		9.095
543.6980853	11	2	1752.674619		9
561.2367332	10.1921	2	1871.277269		8.1921
578.7753811	9.9754	2	2073.790776		7.9754
596.314029	8.4426	2	2387.64909		6.4426
613.8526769	7.264	2	2472.208172		5.264
631.3913249	7.7121	2	2466.675079		5.7121
648.9299728	7.3118	2	2498.889718		5.3118
666.4686207	7.4338	2	2444.994154		5.4338
684.0072686	7.7774	2	2455.157449		5.7774

701.5459165	7.346	2	2545.145445		5.346
719.0845644	7	2	2453.583182		5
736.6232123	8.137	2	2204.756068		6.137
754.1618602	9.1496	2	1998.399494		7.1496
771.7005082	9.9197	2	1811.964369		7.9197
789.2391561	10.7602	2	1686.91416		8.7602
806.777804	11	2	1659.156092		9
824.3164519	11	2			9

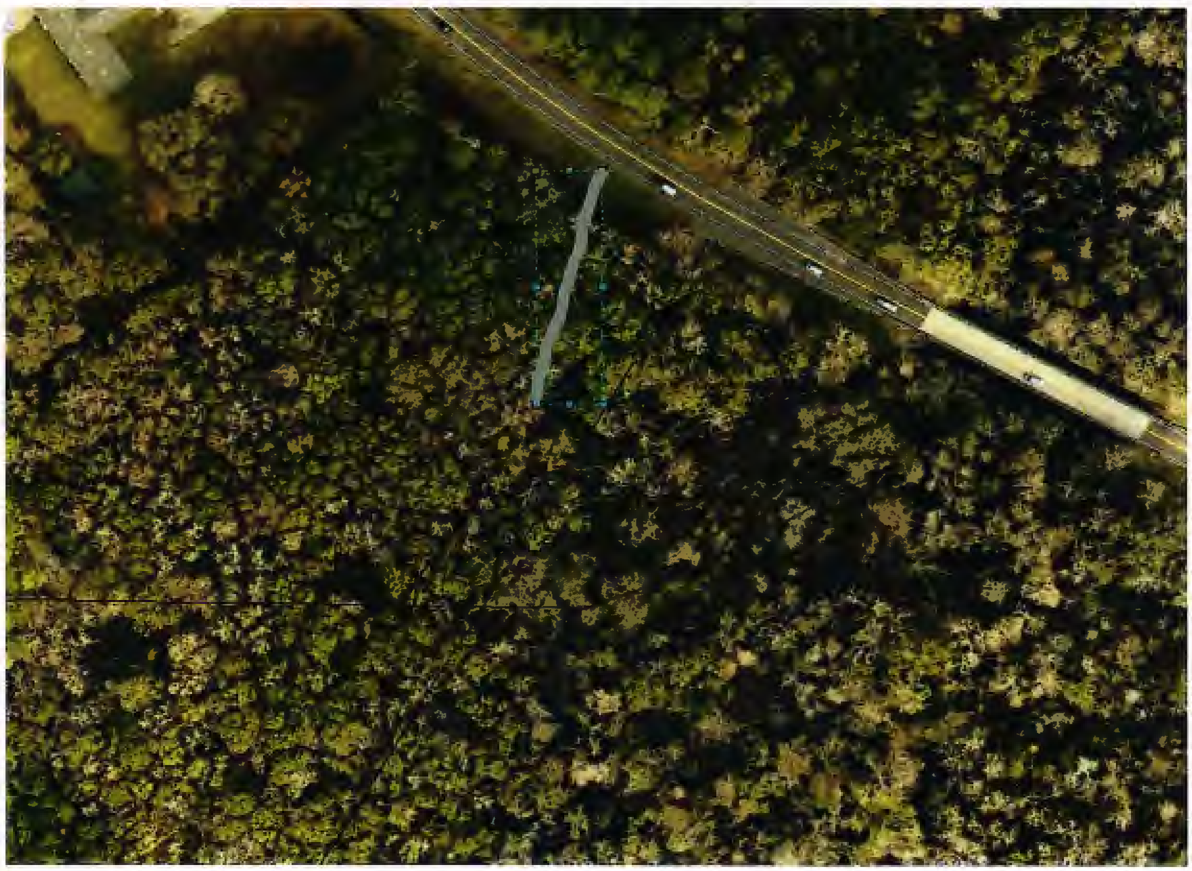
Road Elevation (Ft)	Difference Between Without Muck and Road Elevation (Ft)	Fill Volume (Ft^3)	Total Fill Volume (Ft^3)	Total Fill Volume (Yd^3)	Total Width Needed for the Road (Ft)
14.5	0	0	102766.1	3806.152681	10
14.5	0	0			10
14.5	0	0			10
14.5	0	0			10
14.5	0	0			10
14.5	0	0			10
14.5	0	0			10
14.5	0	50.121557			11.5885
14.5	0.5295	104.22171			13.0885
14.5	0.5	140.45243			14.0035
14.5	0.8345	309.63149			17.6593
14.5	1.7186	522.85888			21.3949
14.5	2.0797	568.02461			22.1053
14.5	1.9554	550.87628			21.8383
14.5	1.9907	659.0724			23.4721
14.5	2.5	767.31585			25
14.5	2.5	767.31585			25
14.5	2.5	793.63533			25.3576
14.5	2.6192	966.33489			27.5893
14.5	3.2439	1200.1326			30.3502
14.5	3.5395	1450.1491			33.0484
14.5	4.1433	2068.8839			38.9299
14.5	5.5	2540.5565			42.8749
14.5	5.4583	1870.0561			37.1416
14.5	3.5889	1562.6269			34.1929
14.5	4.4754	1846.7381			36.9262
14.5	4.5	1854.712			37
14.5	4.5	1854.712			37
14.5	4.5	1989.9203			38.2297
14.5	4.9099	2304.0938			40.9447
14.5	5.405	2520.554			42.715
14.5	5.5	2869.4873			45.4237
14.5	6.3079	3291.4306			48.4975
14.5	6.5246	4075.737			53.746
14.5	8.0574	5450.3674			61.8802
14.5	9.236	5853.7908			64.0717
14.5	8.7879	5826.9637			63.9283
14.5	9.1882	5983.9997			64.7632
14.5	9.0662	5722.4233			63.3664
14.5	8.7226	5771.3134			63.6298

14.5	9.154	6213.0447	65.962
14.5	9.5	5763.7272	63.589
14.5	8.363	4625.822	57.1402
14.5	7.3504	3774.3486	51.7921
14.5	6.5803	3076.9654	46.9603
14.5	5.7398	2647.4383	43.7194
14.5	5.5	2556.2579	43
14.5	5.5		

Average Total Width Needed (Ft)	Woods needed to be Cleared (ft^2)	Woods Needed to be Cleared (yd^2)	Volume of Asphalt Needed (Ft^3)
35.50894894	29270.6108	3249.037799	2744.973785

Road to Pump Station 1

Distanance (ft)	Elevation (ft)	Muck (ft)	Volume of Removed Muck (Ft^3)	Total Volume of Removed Muck (Ft^3)	Elevation Without Muck (Ft)	Road Eleva	Difference Between Without
0	11.0588	2	1655.351311	35730.4793	9.0588	14.5	5.4412
17.00615924	10.5263	2	1934.269329		8.5263	14.5	5.9737
34.01231849	8.5738	2	2342.398783		6.5738	14.5	7.9262
51.01847773	6.8901	2	2631.283769		4.8901	14.5	9.6099
68.02463696	6	2	2731.189176		4	14.5	10.5
85.03079621	6	2	2829.657896		4	14.5	10.5
102.0369554	5.1227	2	2941.898549		3.1227	14.5	11.3773
119.0431147	5	2	2955.670477		3	14.5	11.5
136.0492739	5	2	3028.032024		3	14.5	11.5
153.0554332	4.3553	2	3140.272673		2.3553	14.5	12.1447
170.0615924	4	2	3180.15178		2	14.5	12.5
187.0677517	4	2	3180.151776		2	14.5	12.5
204.0739109	4	2	3180.151778		2	14.5	12.5
221.0800701	4	2			2	14.5	12.5



Fill Volume (Ft^3)	**Total Fill Volume (Ft^3)**	**Total Fill Volume (Yd^3)**	Total Width Needed for the	Average Total Width Needed	**Woods needed to be Cleared**	**Woods Needed to be Cleared**	**Volume of Asphalt Needed**
2632.544	**100534.7**	**3723.506**	44.2447	73.46265	**14991.81**	**1664.091**	**736.1966**
3646.204			51.6997				
5413.343			62.6083				
6868.032			70.3297				
7410.434			73				
7964.812			75.6319				
8620.671			78.6319				
8702.902			79				
9141.276			80.9341				
9842.22			83.9341				
10097.41			85				
10097.41			85				
10097.41			85				

Turning Radius for Truck (Ft)	Asphalt Thickness (ft)	Width of the Pump Station (ft)	Side Slope of the Pump Station
41	0.333	100	3

Pump Station 4

Distance (ft)	Elevation (ft)	Muck (ft)	Total Volume of Muck Removed (Ft^3)	Elevation Without Muck (Ft)	Pump Station Elevation (ft)
0	5	2	109285	3	14.5
100	5	2		3	14.5

Pump Station 2

Distance (ft)	Elevation (ft)	Muck (ft)	Total Volume of Muck Removed (Ft^3)	Elevation Without Muck (Ft)	Pump Station Elevation (ft)
0	9.8011	2	51617.6724	7.8011	14.5
100	9.8011	2		7.8011	14.5

Difference Between Without Muck and Pump Station Elevation (ft)	Total Fill Volume (Ft^3)	Total Fill Volume (Yd^3)	Volume of Asphalt Needed (Ft^3)	Total Width Needed for the Pumpdtstion (Ft)
11.5	154675	5728.704	1355.810858	496.75
11.5				

Difference Between Without Muck and Pump Station Elevation (ft)	Total Fill Volume (Ft^3)	Total Fill Volume (Yd^3)	Volume of Asphalt Needed (Ft^3)	Total Width Needed for the Pumpdtstion (Ft)
6.6989	80451.58	2979.688	1355.810858	234.6257836
6.6989				

Pump Station 3

Distance (ft)	Elevation (ft)	Muck (ft)	Total Volume of Muck Removed (Ft^3)	Elevation Without Muck (Ft)	Pump Station Elevation (ft)	Difference Between Without Muck and Pump Station Elevation (ft)
0	11	2	41965	9	14.5	5.5
100	11	2		9	14.5	5.5

Pump Station 1

Distance (ft)	Elevation (ft)	Muck (ft)	Total Volume of Muck Removed (Ft^3)	Elevation Without Muck (Ft)	Pump Station Elevation (ft)	Difference Between Without Muck and Pump Station Elevation (ft)
0	4	2	125125	2	14.5	12.5
100	4	2		2	14.5	12.5

Total Fill Volume (Ft^3)	Total Fill Volume (Yd^3)	Volume of Asphalt Needed (Ft^3)	Total Width Needed for the Pumpdtstion (Ft)
64075	2373.148	1355.810858	190.75

Total Fill Volume (Ft^3)	Total Fill Volume (Yd^3)	Volume of Asphalt Needed (Ft^3)	Total Width Needed for the Pumpdtstion (Ft)
171875	6365.741	1355.810858	568.75

Bottom Channel Width (Ft)	Channel Side Slope
15	3

Channel 4

Distance (ft)	Current Elevation (ft)	Bottom Elevation of Channel (ft)	Difference Between Bottom of Channel and Current Elevation (Ft)
0	5.581	4.4	1.181
16.58895864	5.8424	4.2	1.6424
33.17791728	6	4	2
49.76687591	5.5315	3.8	1.7315
66.35583455	5	3.6	1.4
82.94479319	5	3.4	1.6
99.53375182	5	3.2	1.8
116.1227105	5	3	2
117.2077799	5	3	2

Excavation Volume (Ft^3)	Total Excavation Volume Ft^3	Total Excavation Volume (Yd^3)
450.459746	3967.912536	146.9597353
618.242425		
637.5023864		
511.6195623		
485.2270401		
566.8447166		
652.443743		
45.57291665		

Channel 3

Distance (ft)	Current Elevation (ft)	Bottom Elevation of Channel (ft)	Between Bottom of Channel and	Excavation Volume (Ft^3)	Total Excavation Volume (Ft^3)	Excavation Volume (Yd^3)
0	13.5272	12.6	0.9272	190.0017945	158115.3004	5856.12271
17.68277	12.8439	12.5	0.3439	47.1767664		
35.36555	12	12.4	0	0		
53.04832	12	12.3	0	0.397981793		
70.7311	12.203	12.2	0.003	54.082472		
88.41387	12.4894	12.1	0.3894	53.65350465		
106.0966	12	12	0	13.39470196		
123.7794	12	11.9	0.1	40.97983077		
141.4622	12	11.8	0.2	69.62592601		
159.145	12	11.7	0.3	99.33298778		
176.8277	12	11.6	0.4	130.1010161		
194.5105	12	11.5	0.5	160.8142402		
212.1933	11.9931	11.4	0.5931	193.6675981		
229.8761	12	11.3	0.7	200.1136454		
247.5588	11.8316	11.2	0.6316	234.2322057		
265.2416	12	11.1	0.9	299.8556547		
282.9244	12	11	1	306.0199889		
300.6072	11.8336	10.9	0.9336	294.4135339		
318.2899	11.7366	10.8	0.9366	323.2940439		
335.9727	11.7903	10.7	1.0903	412.5116508		
353.6555	12	10.6	1.4	496.134456		
371.3383	12	10.5	1.5	497.8745586		
389.021	11.8083	10.4	1.4083	377.4127329		
406.7038	11.2032	10.3	0.9032	195.0372275		
424.3866	10.5981	10.2	0.3981	54.89816754		
442.0694	9.999	10.1	0	0		
459.7521	9.4279	10	0	0		
477.4349	9.217	9.9	0	27.24776743		
495.1177	10.0014	9.8	0.2014	113.0165914		
512.8005	10.2884	9.7	0.5884	329.2905918		
530.4832	11.0706	9.6	1.4706	578.0264619		
548.166	11.311	9.5	1.811	755.3658227		
565.8488	11.642	9.4	2.242	885.7465011		
583.5316	11.6386	9.3	2.3386	804.1909417		
601.2143	11.1155	9.2	1.9155	699.0144713		
618.8971	10.9997	9.1	1.8997	718.8666007		
636.5799	11	9	2	766.6809117		
654.2627	11	8.9	2.1	826.463871		
671.9454	11.0444	8.8	2.2444	894.2998177		
689.6282	11.0698	8.7	2.3698	932.5387388		

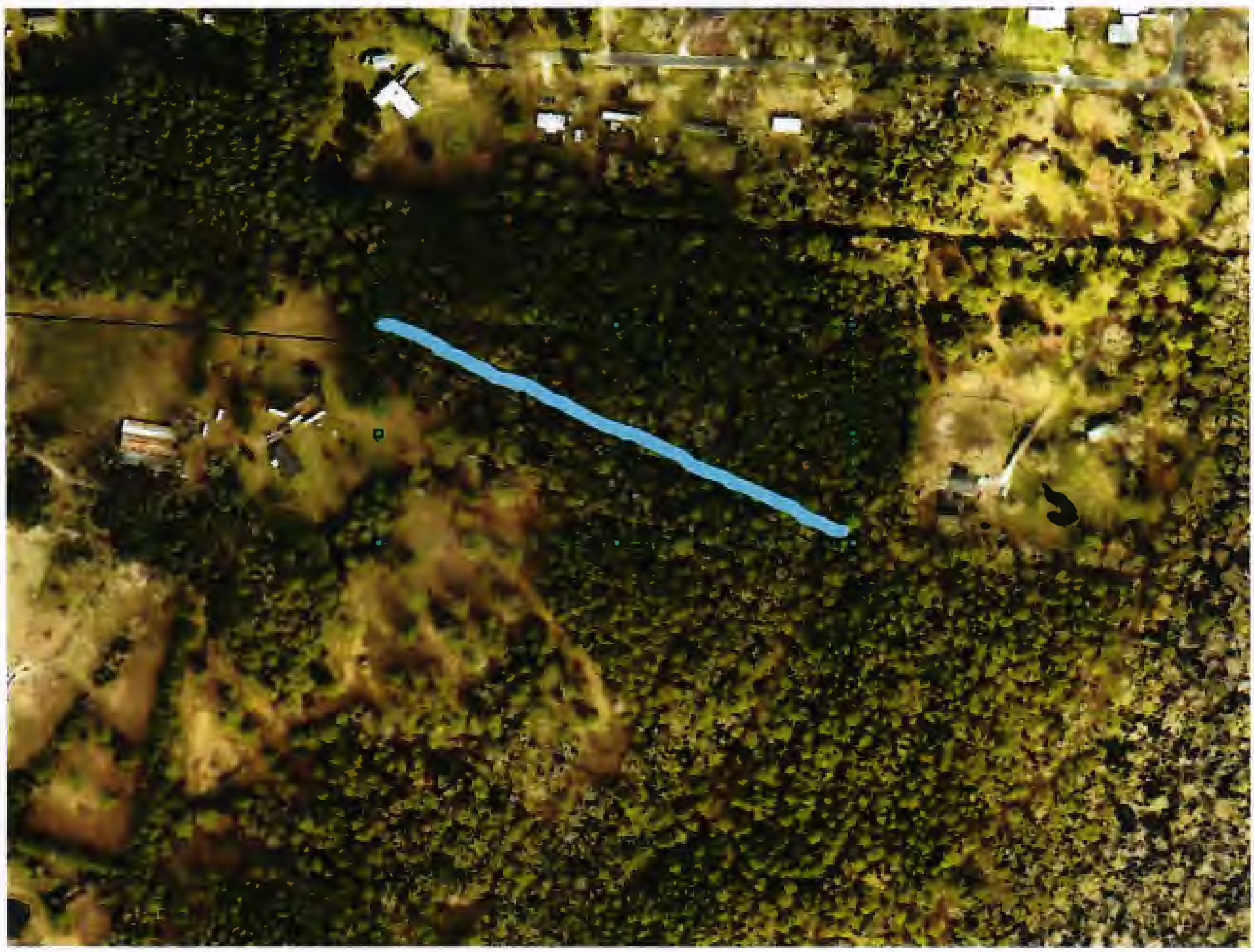
707.311	10.9932	8.6	2.3932	966.479551
724.9938	11	8.5	2.5	1018.876133
742.6765	10.9909	8.4	2.5909	1072.937149
760.3593	11	8.3	2.7	1130.592418
778.0421	11	8.2	2.8	1186.823642
795.7249	11	8.1	2.9	1227.621939
813.4076	10.9428	8	2.9428	1198.111743
831.0904	10.6969	7.9	2.7969	1272.255443
848.7732	11	7.8	3.2	1256.601255
866.456	10.4431	7.7	2.7431	1077.089167
884.1387	10.163	7.6	2.563	1011.418945
901.8215	10	7.5	2.5	1112.711782
919.5043	10.3356	7.4	2.9356	1424.188848
937.1871	10.8704	7.3	3.5704	1561.862591
954.8698	10.5782	7.2	3.3782	1648.269948
972.5526	10.94	7.1	3.84	1730.713525
990.2354	10.63	7	3.63	1431.368066
1007.918	9.7995	6.9	2.8995	1022.53709
1025.624	9	6.8	2.2	866.5017083
1043.331	9	6.7	2.3	917.4958323
1061.037	9	6.6	2.4	892.9115751
1078.743	8.7041	6.5	2.2041	977.4524382
1096.45	9.1259	6.4	2.7259	1161.298971
1114.156	9.1783	6.3	2.8783	1182.24153
1131.862	9	6.2	2.8	1188.402114
1149.569	9	6.1	2.9	1245.770501
1167.275	9	6	3	1356.79864
1184.981	9.177	5.9	3.277	1417.231988
1202.687	9	5.8	3.2	1534.730277
1220.394	9.3562	5.7	3.6562	1599.393182
1238.1	9.0036	5.6	3.4036	1849.335209
1255.806	9.9128	5.5	4.4128	2055.219053
1273.513	9.3948	5.4	3.9948	2106.556632
1291.219	9.8562	5.3	4.5562	2431.259378
1308.925	10.0688	5.2	4.8688	2601.692482
1326.631	10.0944	5.1	4.9944	3057.848396
1344.338	10.9826	5	5.9826	3435.778273
1362.044	10.7615	4.9	5.8615	3316.48476
1379.75	10.5138	4.8	5.7138	3411.034741
1397.457	10.7749	4.7	6.0749	3723.263287
1415.163	11	4.6	6.4	3922.961987
1432.869	11	4.5	6.5	4018.575971
1450.575	11	4.4	6.6	4115.252328
1468.282	11	4.3	6.7	4212.991065
1485.988	11	4.2	6.8	4311.792179
1503.694	11	4.1	6.9	4411.655673

1521.401	11	4	7	4512.58154
1539.107	11	3.9	7.1	4614.56979
1556.813	11	3.8	7.2	4717.620412
1574.52	11	3.7	7.3	4821.733414
1592.226	11	3.6	7.4	4926.908797
1609.932	11	3.5	7.5	5033.146551
1627.638	11	3.4	7.6	5140.446686
1645.345	11	3.3	7.7	5248.809199
1663.051	11	3.2	7.8	5358.234092
1680.757	11	3.1	7.9	5468.721356
1698.464	11	3	8	5524.363385
1716.17	11	3	8	

Channel 2

Distance (ft)	Current Elevation (ft)	Bottom Elevation of Channel (ft)	Difference Between Bottom of Channel and Current Elevation (Ft)	Excavation Volume (Ft^3)
0	12	8.5	3.5	1596.222801
17.52983	12	8.4	3.6	1660.381991
35.05967	12	8.3	3.7	1725.592972
52.5895	12	8.2	3.8	1735.992526
70.11933	11.8316	8.1	3.7316	1517.378258
87.64917	11.118	8	3.118	1325.827628
105.179	11	7.9	3.1	1350.103941
122.7088	11	7.8	3.2	1410.055971
140.2387	11	7.7	3.3	1471.05979
157.7685	11	7.6	3.4	1533.115401
175.2983	11	7.5	3.5	1513.772932
193.1149	10.6595	7.4	3.2595	1282.086823
210.9315	10.0381	7.3	2.7381	1149.85694
228.748	10	7.2	2.8	1195.80293
246.5646	10	7.1	2.9	1253.528582
264.3811	10	7	3	1312.323229
282.1977	10	6.9	3.1	1324.240209
300.0142	9.8401	6.8	3.0401	1104.722374
317.8308	9.0365	6.7	2.3365	1181.396241
335.6474	9.913	6.6	3.313	1641.456741
353.4639	10.346	6.5	3.846	1835.715197
371.2805	10.2968	6.4	3.8968	1786.279838
389.097	10	6.3	3.7	1753.817572
406.9136	10	6.2	3.8	1821.164168
424.7302	10	6.1	3.9	1889.579755
442.5467	10	6	4	1959.064338
460.3633	10	5.9	4.1	2029.617913
478.1798	10	5.8	4.2	2097.886334
495.9964	9.9907	5.7	4.2907	2170.528189
513.813	10	5.6	4.4	2247.692601
531.6295	10	5.5	4.5	2142.361756
549.4461	9.5135	5.4	4.1135	2177.924452
567.2626	9.8974	5.3	4.5974	2435.770351
585.0792	10	5.2	4.8	2535.107568
602.8958	9.9533	5.1	4.8533	2248.509912
620.7123	9.0489	5	4.0489	2167.931102
638.5289	9.5347	4.9	4.6347	2338.750128
656.3454	9.3083	4.8	4.5083	2213.740682
674.162	9	4.7	4.3	2175.836284
691.9786	9.0052	4.6	4.4052	2304.91623

709.7951	9.148	4.5	4.648	2736.763041
727.6117	9.9115	4.4	5.5115	3177.753515
745.4282	10	4.3	5.7	3303.858246
763.2448	10	4.2	5.8	3032.290223
781.0614	9.1722	4.1	5.0722	2782.632313
798.8779	9.2001	4	5.2001	2793.989203
816.6945	9	3.9	5.1	2793.948314
834.511	9	3.8	5.2	2876.26082
852.3276	9	3.7	5.3	2959.642318
870.1442	9	3.6	5.4	3044.092809
887.9607	9	3.5	5.5	3129.612294
905.7773	9	3.4	5.6	3262.569937
923.5938	9.1061	3.3	5.8061	3350.79451
941.4104	9	3.2	5.8	3392.584712
959.227	9	3.1	5.9	3648.320474
977.0435	9.3635	3	6.3635	2457.786367
988.1091	9.5571	3	6.5571	



Total Excavation Volume (Ft^3)	Total Excavation Volume (Yd^3)
119360.0117	4420.741529

Channel 1

Distance (ft)	Current Elevation (ft)	Bottom Elevation of Channel (ft)	Difference Between Bottom of Channel and Current Elevation (Ft)	Excavation Volume (Ft^3)
0	10	6.2	3.8	1772.053604
17.49885	10	6.15	3.85	1805.388908
34.9977	10	6.1	3.9	1838.986696
52.49654	10	6.05	3.95	1872.846966
69.99539	10	6	4	1906.969718
87.49424	10	5.95	4.05	1941.354953
104.9931	10	5.9	4.1	1976.002672
122.4919	10	5.85	4.15	2010.912872
139.9908	10	5.8	4.2	2046.085556
157.4896	10	5.75	4.25	2003.629931
174.9885	9.7792	5.7	4.0792	1699.378869
192.4873	9	5.65	3.35	1483.847585
209.9862	9	5.6	3.4	1514.820545
227.485	9	5.55	3.45	1500.168601
244.9839	8.8528	5.5	3.3528	1231.976364
262.4827	8	5.45	2.55	994.7250688
279.9816	7.8896	5.4	2.4896	768.1856889
297.4804	7	5.35	1.65	586.944156
314.9793	7	5.3	1.7	596.7894497
332.4781	6.9448	5.25	1.6948	406.4721452
349.977	5.9866	5.2	0.7866	184.0497232
367.4758	5.6103	5.15	0.4603	63.19108688
384.9746	5	5.1	0	0
402.4735	5	5.05	0	0
419.9723	5	5	0	6.594878157
437.4712	5	4.95	0.05	19.9814965
454.97	5	4.9	0.1	33.63059757
472.4689	5	4.85	0.15	47.54218134
489.9677	5	4.8	0.2	61.71624783
507.4666	5	4.75	0.25	76.15279703
524.9654	5	4.7	0.3	90.85182894
542.4643	5	4.65	0.35	105.8133436
559.9631	5	4.6	0.4	121.0373408
577.462	5	4.55	0.45	136.5238209
594.9608	5	4.5	0.5	152.2727837
612.4597	5	4.45	0.55	168.2842292
629.9585	5	4.4	0.6	184.5581574
647.4574	5	4.35	0.65	201.0945683
664.9562	5	4.3	0.7	217.8934619
682.4551	5	4.25	0.75	160.8222782

699.9539	4.5536	4.2	0.3536	48.04789313
717.4527	4.1109	4.15	0	0
734.9516	4	4.1	0	0
752.4504	4	4.05	0	0
769.9493	4	4	0	6.594878157
787.4481	4	3.95	0.05	19.98149651
804.947	4	3.9	0.1	33.63059755
822.4458	4	3.85	0.15	47.54218134
839.9447	4	3.8	0.2	61.59827763
857.4101	4	3.75	0.25	76.00723144
874.8755	4	3.7	0.3	90.67816624
892.3409	4	3.65	0.35	105.6110821
909.8063	4	3.6	0.4	120.8059788
927.2717	4	3.55	0.45	131.7524373
944.159	4	3.5	0.5	66.49365976
961.0462	3.2337	3.45	0	0
977.9335	3	3.4	0	0
994.8208	3	3.35	0	0
1011.708	3	3.3	0	0
1028.595	3	3.25	0	0
1045.483	3	3.2	0	0
1062.37	3	3.15	0	0
1079.257	3	3.1	0	0
1096.144	3	3.05	0	0
1113.032	3	3	0	0
1129.919	3	3	0	

Total Excavation Volume (Ft^3)	Total Excavation Volume (Yd^3)
32798.29505	1214.751766

Bottom Channel Width (Ft)	Channel Side Slope
15	3

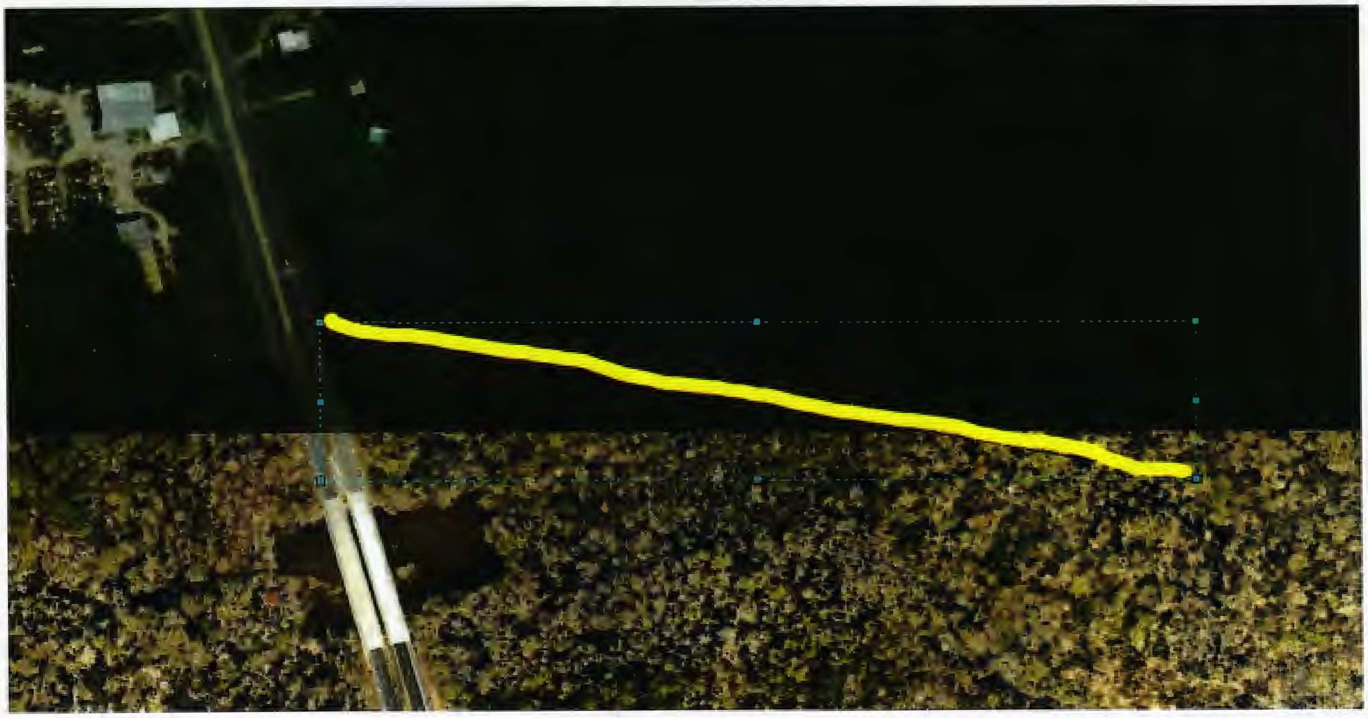
	Excavation Volume (Ft^3)	Total Excavation Volume (Ft^3)	Total Excavation Volume (Yd^3)
Part 1	117207.084		
Part 2	119169.9985		
Part 3	88519.81836		
Part 4	335333.5201		
Part 5	734401.8638		
		1394632.285	51653.05172

Part 1

Distance (ft)	Elevation (ft)	Bottom Elevation of Channel (ft)	Difference Between Bottom of Channel and Current Elevation (Ft)	Excavation Volume (Ft^3)	Total Excavation Volume (Ft^3)
0	9.3771	3	6.3771	3600.5855	117207.084
17.8030048	8.7886	3	5.7886	3026.1696	
35.6060096	8.0746	3	5.0746	2414.1522	
53.4090144	7.2713	3	4.2713	2017.8914	
71.2120192	7	3	4	1922.7245	
89.01502399	7	3	4	1922.7245	
106.8180288	7	3	4	1922.7245	
124.6210336	7	3	4	1922.7245	
142.4240384	7	3	4	1922.7245	
160.2270432	7	3	4	1922.7245	
178.030048	7	3	4	1922.7245	
195.8330528	7	3	4	1922.7245	
213.6360576	7	3	4	1945.2067	
231.4390624	7.0646	3	4.0646	1966.7486	
249.2420672	7.0616	3	4.0616	1944.1602	
267.045072	7	3	4	1922.7245	
284.8480768	7	3	4	1922.7245	
302.6510816	7	3	4	1889.2102	
320.4540864	6.9031	3	3.9031	1628.0505	
338.2570912	6.2184	3	3.2184	1626.1087	
356.060096	6.8971	3	3.8971	1556.0848	
373.8631008	6	3	3	1281.8163	
391.6661056	6	3	3	1281.8163	
409.4691104	6	3	3	1281.8163	
427.2721152	6	3	3	1277.3251	
445.07512	5.9847	3	2.9847	1217.5498	
462.8781248	5.7943	3	2.7943	1109.8735	
480.6811296	5.6039	3	2.6039	1006.0696	
498.4841344	5.4135	3	2.4135	853.49111	
516.2871392	5.0163	3	2.0163	751.6473	
534.090144	5	3	2	747.7262	
551.8931488	5	3	2	747.7262	
569.6961536	5	3	2	747.7262	
587.4991584	5	3	2	802.45415	
605.3021632	5.2249	3	2.2249	1014.8315	
623.105168	5.8252	3	2.8252	1199.3253	
640.9081728	5.8903	3	2.8903	1229.8075	
658.7111776	5.9312	3	2.9312	1261.6696	

676.5141824	6	3	3	1281.8163
694.3171872	6	3	3	1281.8163
712.120192	6	3	3	1281.8163
729.9231968	6	3	3	1232.3805
747.7262016	5.8304	3	2.8304	1188.3568
765.5292064	5.8467	3	2.8467	1237.0983
783.3322112	6	3	3	1281.8163
801.135216	6	3	3	1281.8163
818.9382208	6	3	3	1281.8163
836.7412256	6	3	3	1281.8163
854.5442304	6	3	3	1281.8163
872.3472352	6	3	3	1281.8163
890.15024	6	3	3	1281.8163
907.9532448	6	3	3	1425.2181
925.7562496	6.4778	3	3.4778	1745.0794
943.5592544	7	3	4	1772.9958
961.3622592	6.5613	3	3.5613	1450.9047
979.165264	6	3	3	1281.8163
996.9682688	6	3	3	1281.8163
1014.771274	6	3	3	1281.8163
1032.574278	6	3	3	1281.8163
1050.377283	6	3	3	1281.8163
1068.180288	6	3	3	1281.8163
1085.983293	6	3	3	1281.8163
1103.786298	6	3	3	1281.8163
1121.589302	6	3	3	1281.8163
1139.392307	6	3	3	1281.8163
1157.195312	6	3	3	1281.8163
1174.998317	6	3	3	1227.9874
1192.801322	5.8152	3	2.8152	952.52508
1210.604326	5	3	2	747.7262
1228.407331	5	3	2	747.7262
1246.210336	5	3	2	747.7262
1264.013341	5	3	2	747.7262
1281.816346	5	3	2	747.7262
1299.61935	5	3	2	747.7262
1317.422355	5	3	2	747.7262
1335.22536	5	3	2	747.7262
1353.028365	5	3	2	747.7262
1370.83137	5	3	2	747.7262
1388.634374	5	3	2	681.03527
1406.437379	4.7181	3	1.7181	468.90862
1424.240384	4.0355	3	1.0355	327.10698
1442.043389	4	3	1	320.45409
1459.846394	4	3	1	321.83811
1477.649398	4.0074	3	1.0074	447.21282

1495.452403	4.6407	3	1.6407	646.27653
1513.255408	4.9268	3	1.9268	730.20482
1531.058413	5	3	2	747.7262
1548.861418	5	3	2	747.7262
1566.664422	5	3	2	747.7262
1584.467427	5	3	2	747.7262
1602.270432	5	3	2	747.7262
1620.073437	5	3	2	747.7262
1637.876442	5	3	2	747.7262
1655.679446	5	3	2	747.7262
1673.482451	5	3	2	



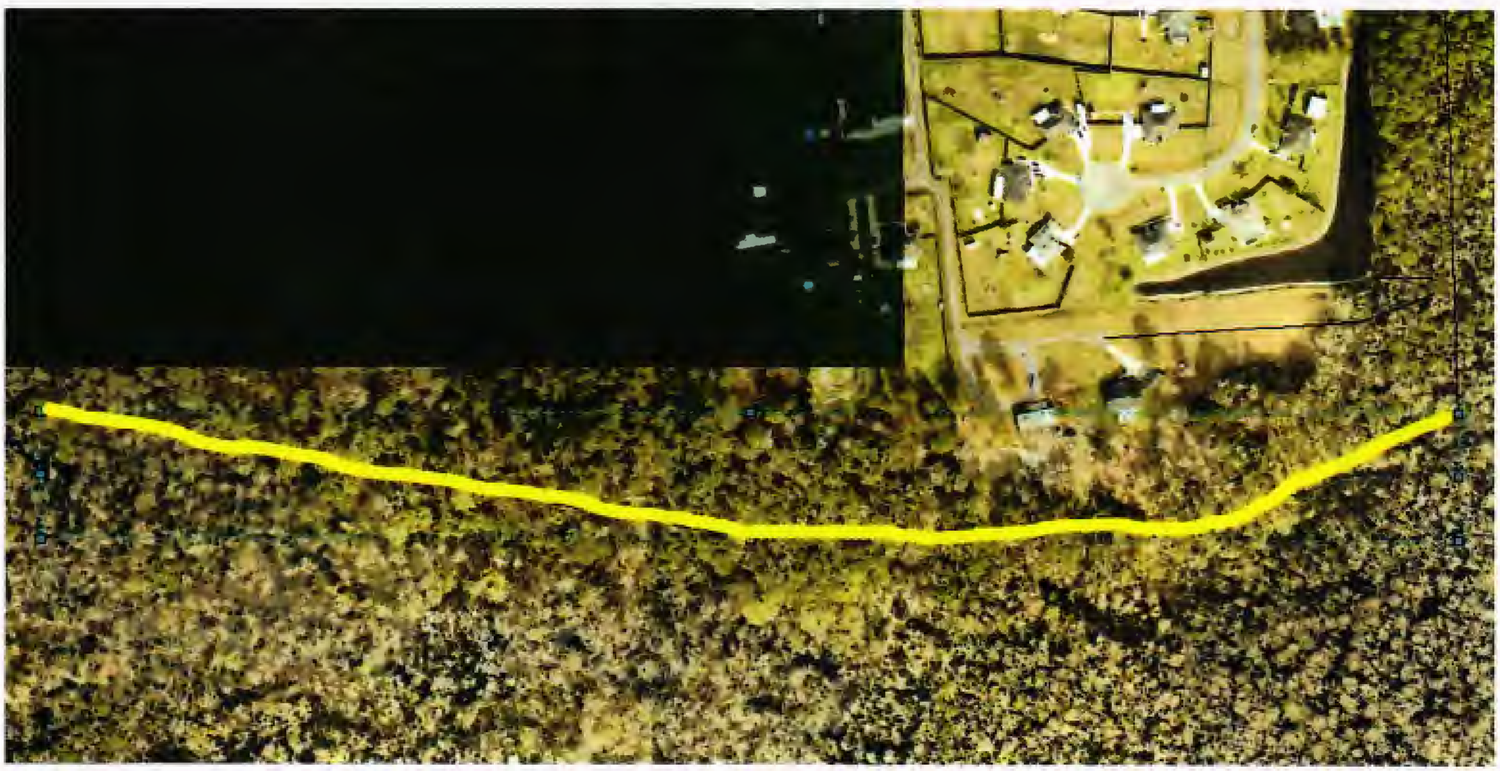
Part 2

Distance (ft)	Elevation (ft)	Bottom Elevation of Channel (ft)	Difference Between Bottom of Channel and Current Elevation (Ft)	Excavation Volume (Ft^3)	Total Excavation Volume (Ft^3)
0	5	3	2	745.3495872	119169.9985
17.74641874	5	3	2	765.1810736	
35.49283748	5.0824	3	2.0824	819.188038	
53.23925622	5.2207	3	2.2207	798.8724553	
70.98567496	5	3	2	723.3737642	
88.7320937	4.9078	3	1.9078	708.5585192	
106.4785124	4.9373	3	1.9373	663.7500093	
124.2249312	4.7154	3	1.7154	504.7476759	
141.9713499	4.217	3	1.217	360.4974983	
159.7177687	4	3	1	319.4355373	
177.4641874	4	3	1	319.4355373	
195.2106061	4	3	1	319.4355373	
212.9570249	4	3	1	319.4355373	
230.7034436	4	3	1	319.4355373	
248.4498624	4	3	1	319.4355372	
266.1962811	4	3	1	319.4355374	
283.9426998	4	3	1	319.4355373	
301.6891186	4	3	1	331.9610789	
319.4355373	4.0669	3	1.0669	456.086097	
337.1819561	4.6316	3	1.6316	531.8008112	
354.9283748	4.4279	3	1.4279	401.6063152	
372.6747935	4	3	1	319.4355372	
390.4212123	4	3	1	512.9606256	
408.167631	4.9712	3	1.9712	738.4608192	
425.9140498	5	3	2	745.349587	
443.6604685	5	3	2	745.349587	
461.4068872	5	3	2	745.3495871	
479.153306	5	3	2	745.3495872	
496.8997247	5	3	2	745.349587	
514.6461435	5	3	2	745.3495872	
532.3925622	5	3	2	944.0426503	
550.1389809	5.7943	3	2.7943	1218.073088	
567.8853997	6	3	3	1277.742149	
585.6318184	6	3	3	1277.742149	
603.3782371	6	3	3	1277.742149	
621.1246559	6	3	3	1277.742149	
638.8710746	6	3	3	1089.841043	
656.6174934	5.3384	3	2.3384	827.9464939	

674.3639121	5	3	2	745.3495871
692.1103309	5	3	2	892.6863283
709.8567496	5.5953	3	2.5953	1084.452151
727.6031683	5.7235	3	2.7235	1063.107883
745.3495871	5.5173	3	2.5173	977.2367962
763.0960058	5.4035	3	2.4035	844.1857672
780.8424245	5	3	2	772.2763644
798.5888433	5.1117	3	2.1117	895.2930311
816.335262	5.4938	3	2.4938	1039.95141
834.0816808	5.6617	3	2.6617	1180.205794
851.8280995	6	3	3	1166.218037
869.5745183	5.6123	3	2.6123	978.2141039
887.320937	5.3122	3	2.3122	987.5034481
905.0673557	5.6474	3	2.6474	1075.402119
922.8137745	5.6384	3	2.6384	1173.600235
940.5601932	6	3	3	1277.742149
958.3066119	6	3	3	1277.742149
976.0530307	6	3	3	1277.74215
993.7994494	6	3	3	1277.742149
1011.545868	6	3	3	1277.742149
1029.292287	6	3	3	1277.742149
1047.038706	6	3	3	1267.334772
1064.785124	5.9644	3	2.9644	1174.053373
1082.531543	5.6756	3	2.6756	929.87291
1100.277962	5.0642	3	2.0642	860.2858177
1118.024381	5.4034	3	2.4034	895.3697406
1135.770799	5.2024	3	2.2024	794.6791253
1153.517218	5.0012	3	2.0012	749.7382967
1171.263637	5.0171	3	2.0171	912.1753785
1189.010056	5.6542	3	2.6542	1031.044828
1206.756474	5.4683	3	2.4683	863.7410445
1224.502893	5.013	3	2.013	748.4663329
1242.249312	5	3	2	745.3495871
1259.995731	5	3	2	745.3495871
1277.742149	5	3	2	745.3495871
1295.488568	5	3	2	745.3495871
1313.234987	5	3	2	745.3495871
1330.981405	5	3	2	742.1564081
1348.651796	5	3	2	742.1564077
1366.322187	5	3	2	742.1564077
1383.992577	5	3	2	742.1564081
1401.662968	5	3	2	742.1564077
1419.333359	5	3	2	742.1564081
1437.003749	5	3	2	808.096306
1454.67414	5.2723	3	2.2723	832.1846455
1472.344531	5.0975	3	2.0975	765.5410442

1490.014921	5	3	2	742.1564077
1507.685312	5	3	2	742.1564081
1525.355703	5	3	2	742.1564081
1543.026093	5	3	2	742.1564077
1560.696484	5	3	2	742.1564077
1578.366875	5	3	2	742.1564081
1596.037265	5	3	2	681.2145612
1613.707656	4.7408	3	1.7408	654.0379946
1631.378047	4.8819	3	1.8819	714.1684652
1649.048437	5	3	2	742.1564081
1666.718828	5	3	2	701.4944326
1684.389219	4.8279	3	1.8279	680.8207431
1702.059609	4.9112	3	1.9112	721.0776475
1719.73	5	3	2	742.1564081
1737.400391	5	3	2	742.1564077
1755.070781	5	3	2	742.1564081
1772.741172	5	3	2	742.1564077
1790.411563	5	3	2	873.9784881
1808.081953	5.5366	3	2.5366	981.2409501
1825.752344	5.4153	3	2.4153	843.5121004
1843.422735	5	3	2	743.9701553
1861.093125	5.0076	3	2.0076	749.8275273
1878.763516	5.0245	3	2.0245	765.782192
1896.433907	5.074	3	2.074	784.6977084
1914.104297	5.1026	3	2.1026	798.6538922
1931.774688	5.1312	3	2.1312	919.3147679
1949.445079	5.5831	3	2.5831	1153.019571
1967.115469	6	3	3	1303.116496
1984.78586	6.1053	3	3.1053	1376.178781
2002.456251	6.2455	3	3.2455	1427.341499
2020.126641	6.2741	3	3.2741	1402.51451
2037.797032	6.1639	3	3.1639	1320.411062
2055.467423	6	3	3	1272.268128
2073.137813	6	3	3	1272.268128
2090.808204	6	3	3	1151.56127
2108.478595	5.5779	3	2.5779	884.4406257
2126.148985	5	3	2	742.1564081
2143.819376	5	3	2	727.2043905
2161.133766	5	3	2	727.2043909
2178.448157	5	3	2	727.2043909
2195.762547	5	3	2	771.7027366
2213.076937	5.1884	3	2.1884	806.9418066
2230.391327	5.1465	3	2.1465	761.7266306
2247.705718	5	3	2	727.2043913
2265.020108	5	3	2	727.2043905
2282.334498	5	3	2	727.2043909

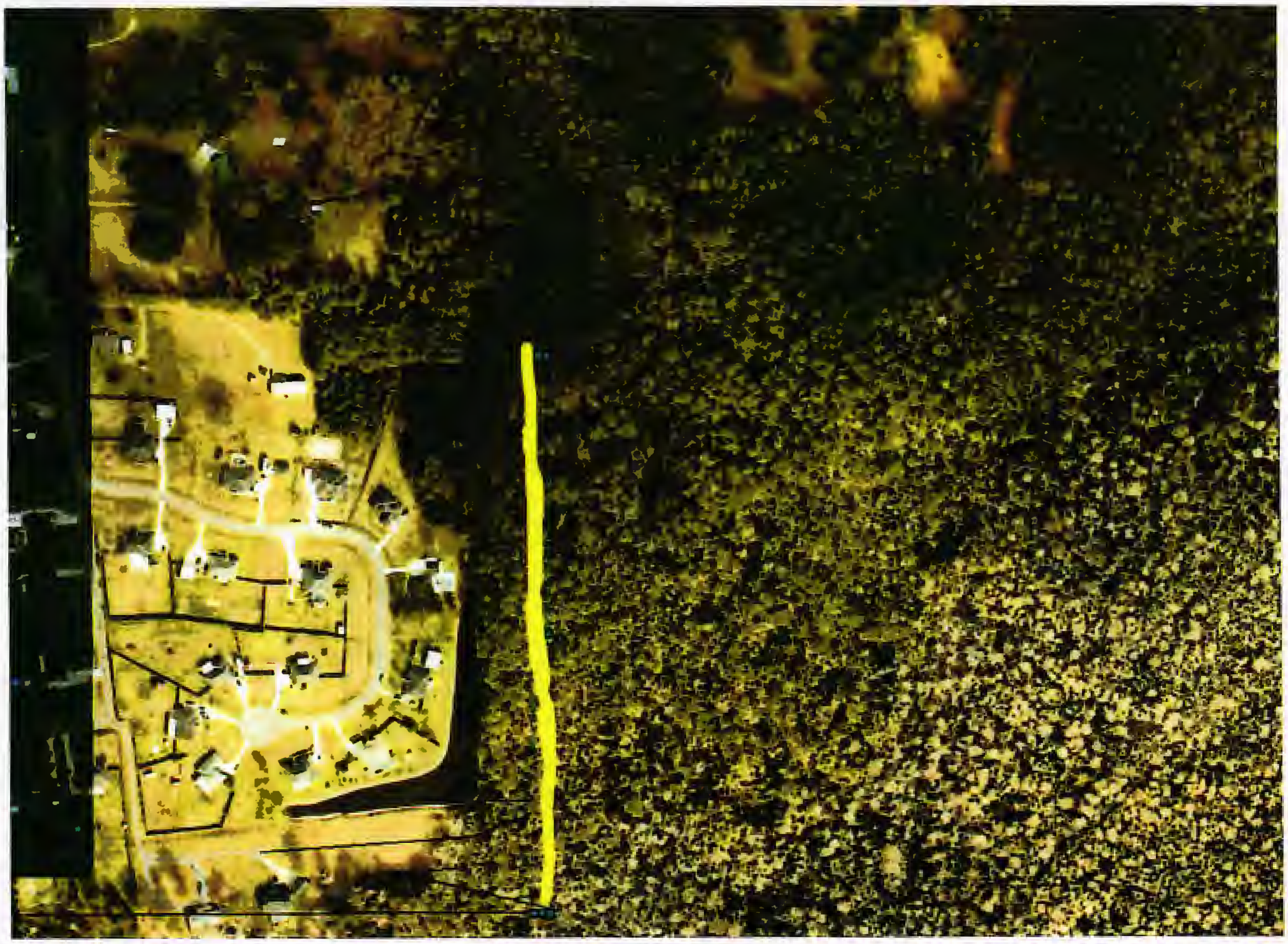
2299.648888	5	3	2	727.2043909
2316.963279	5	3	2	727.2043905
2334.277669	5	3	2	727.2043909
2351.592059	5	3	2	727.2043913
2368.906449	5	3	2	727.2043909
2386.22084	5	3	2	716.2936007
2403.53523	4.9532	3	1.9532	716.2936016
2420.84962	5	3	2	727.2043905
2438.16401	5	3	2	705.1158822
2455.478401	4.905	3	1.905	493.675776
2472.792791	4.0333	3	1.0333	317.7274012
2490.107181	4	3	1	311.6590245
2507.421572	4	3	1	311.6590247
2524.735962	4	3	1	311.6590247
2542.050352	4	3	1	311.6590245
2559.364742	4	3	1	311.6590249
2576.679133	4	3	1	311.6590247
2593.993523	4	3	1	311.6590247
2611.307913	4	3	1	311.6590247
2628.622303	4	3	1	311.6590247
2645.936694	4	3	1	311.6590247
2663.251084	4	3	1	



Part 3

Distance (ft)	Elevation (ft)	Bottom Elevation of Channel (ft)	Difference Between Bottom of Channel and Current Elevation (Ft)	Excavation Volume (Ft^3)	Total Excavation Volume (Ft^3)
0	4	3	1	318.2453113	88519.81836
17.68029507	4	3	1	318.2453113	
35.36059014	4	3	1	318.2453114	
53.04088522	4	3	1	318.2453113	
70.72118029	4	3	1	318.2453113	
88.40147536	4	3	1	318.245311	
106.0817704	4	3	1	318.2453114	
123.7620655	4	3	1	318.2453113	
141.4423606	4	3	1	318.2453112	
159.1226556	4	3	1	318.2453111	
176.8029507	4	3	1	318.2453112	
194.4832458	4	3	1	348.0218537	
212.1635408	4.1586	3	1.1586	494.326847	
229.8438359	4.7331	3	1.7331	493.1761458	
247.524131	4.1531	3	1.1531	537.810313	
265.204426	4.9437	3	1.9437	688.1207152	
282.8847211	4.8252	3	1.8252	510.0771613	
300.5650162	4.1414	3	1.1414	547.4136798	
318.2453112	5	3	2	713.0146978	
335.9256063	4.8753	3	1.8753	515.3461988	
353.6059014	4.1162	3	1.1162	541.9810793	
371.2861964	5	3	2	742.5723929	
388.9664915	5	3	2	739.0666038	
406.6467866	4.9853	3	1.9853	678.9554785	
424.3270817	4.7441	3	1.7441	463.7243238	
442.0073767	4	3	1	330.4243483	
459.6876718	4.0653	3	1.0653	531.0594523	
477.3679669	5	3	2	734.496245	
495.0482619	4.9661	3	1.9661	580.1430434	
512.728557	4.3255	3	1.3255	450.2679318	
530.4088521	4.3528	3	1.3528	464.3405742	
548.0891472	4.3943	3	1.3943	602.8663141	
565.7694422	5	3	2	742.5723929	
583.4497373	5	3	2	742.5723929	
601.1300323	5	3	2	742.5723932	
618.8103274	5	3	2	742.5723929	
636.4906225	5	3	2	742.5723929	
654.1709176	5	3	2	843.5105169	

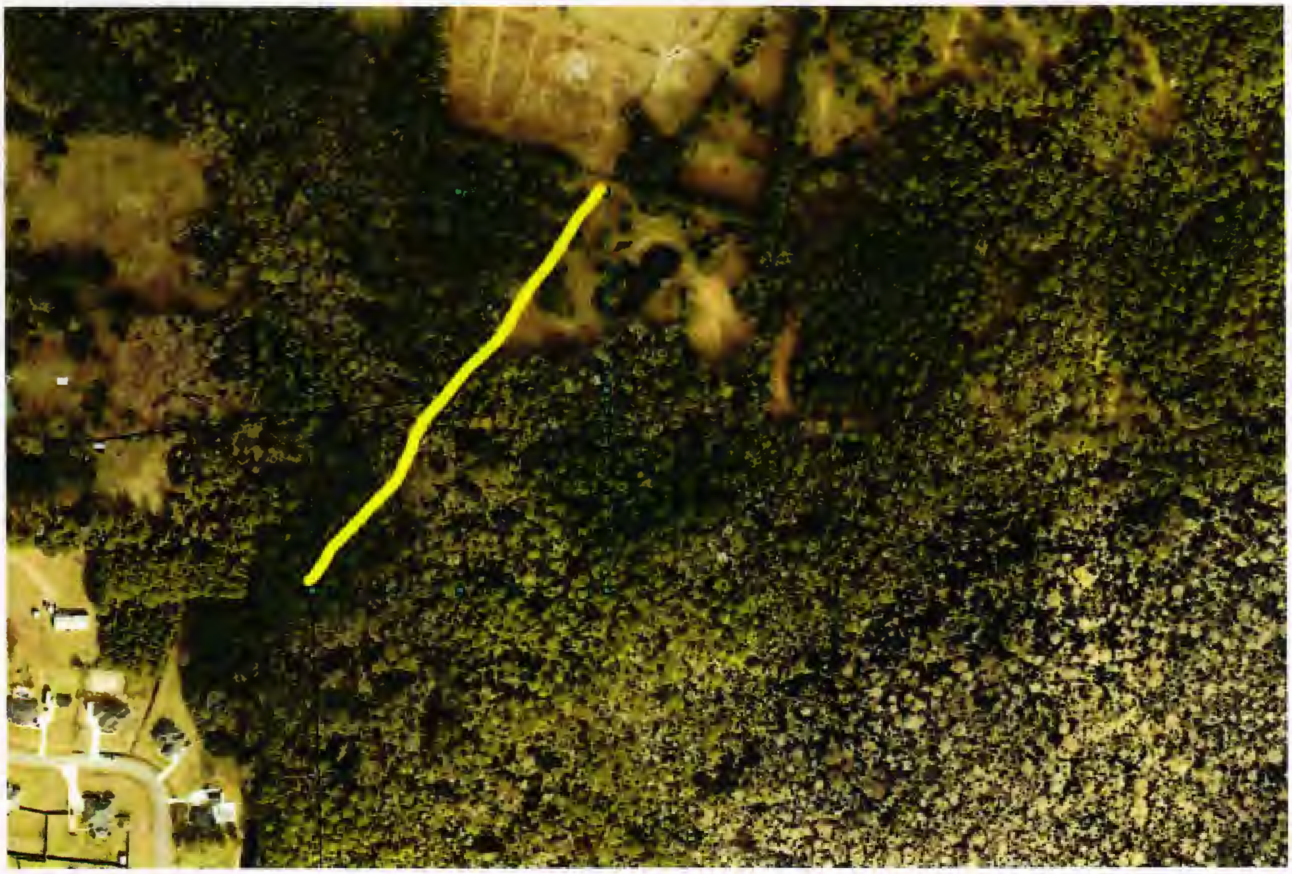
671.8512126	5.4134	3	2.4134	1098.99895
689.5315077	5.9731	3	2.9731	1265.143441
707.2118028	6	3	3	1272.981245
724.8920978	6	3	3	1272.981244
742.5723929	6	3	3	1272.981245
760.252688	6	3	3	1272.981245
777.932983	6	3	3	1272.981245
795.6132781	6	3	3	1272.981246
813.2935732	6	3	3	1272.981245
830.9738682	6	3	3	1272.981245
848.6541633	6	3	3	1272.981244
866.3344584	6	3	3	1534.269551
884.0147535	6.8619	3	3.8619	1862.112611
901.6950485	7	3	4	1640.528391
919.3753436	6.195	3	3.195	1589.025413
937.0556387	6.8397	3	3.8397	1854.546653
954.7359337	7	3	4	1909.471867
972.4162288	7	3	4	1909.471868
990.0965239	7	3	4	1909.471868
1007.776819	7	3	4	1909.471868
1025.457114	7	3	4	1909.471868
1043.137409	7	3	4	1909.471866
1060.817704	7	3	4	1909.471868
1078.497999	7	3	4	1711.103833
1096.178294	6.4113	3	3.4113	1650.469784
1113.858589	6.8144	3	3.8144	1845.940122
1131.538884	7	3	4	1909.471868
1149.219179	7	3	4	1994.032949
1166.899475	7.243	3	4.243	2122.872641
1184.57977	7.3619	3	4.3619	2175.869727
1202.260065	7.3891	3	4.3891	2090.077244
1219.94036	7.1246	3	4.1246	2199.959895
1237.620655	7.6923	3	4.6923	2530.894627
1255.30095	8	3	5	2787.407679
1272.981245	8.3365	3	5.3365	3139.233099
1290.66154	8.8419	3	5.8419	3429.750876
1308.341835	9	3	6	3500.698424
1326.02213	9	3	6	



Part 4

Distance (ft)	Elevation (ft)	Bottom Elevation of Channel (ft)	Difference Between Bottom of Channel and Current Elevation (Ft)	Excavation Volume (Ft^3)	Total Excavation Volume (Ft^3)
0	9	3	6	3508.238769	335333.5201
17.71837762	9	3	6	3508.238768	
35.43675524	9	3	6	3508.238769	
53.15513286	9	3	6	3508.238769	
70.87351048	9	3	6	3583.834964	
88.59188809	9.1665	3	6.1665	4008.628125	
106.3102657	9.9071	3	6.9071	4418.233787	
124.0286433	10	3	7	4465.03116	
141.747021	10	3	7	4465.031161	
159.4653986	10	3	7	4465.031159	
177.1837762	10	3	7	4465.031158	
194.9021538	10	3	7	4465.031162	
212.6205314	10	3	7	4465.031161	
230.3389091	10	3	7	4334.337471	
248.0572867	9.7394	3	6.7394	3934.588028	
265.7756643	9.1794	3	6.1794	3202.593969	
283.4940419	8.1301	3	5.1301	2724.421891	
301.2124195	8.0362	3	5.0362	2475.406009	
318.9307972	7.4992	3	4.4992	2089.374131	
336.6491748	7	3	4	1913.584783	
354.3675524	7	3	4	1920.085037	
372.08593	7.0188	3	4.0188	1920.085036	
389.8043076	7	3	4	1785.384599	
407.5226852	6.6235	3	3.6235	1755.63019	
425.2410629	6.911	3	3.911	2094.399599	
442.9594405	7.6022	3	4.6022	2895.812497	
460.6778181	8.9835	3	5.9835	3881.605363	
478.3961957	9.8237	3	6.8237	4409.142801	
496.1145733	10.0653	3	7.0653	4922.076805	
513.832951	10.8192	3	7.8192	5427.658505	
531.5513286	11	3	8	5528.133818	
549.2697062	11	3	8	5528.133816	
566.9880838	11	3	8	5528.13382	
584.7064615	11	3	8	5528.133814	
602.4248391	11	3	8	5528.133818	
620.1432167	11	3	8	5528.133816	
637.8615943	11	3	8	5545.50448	
655.5799719	11.0311	3	8.0311	5689.35482	

673.2983495	11.2558	3	8.2558	5248.578333
691.0167272	10.2372	3	7.2372	4585.558614
708.7351048	10	3	7	4628.599729
726.4534824	10.3212	3	7.3212	5159.882636
744.17186	11.0083	3	8.0083	5532.767203
761.8902376	11	3	8	5528.133817
779.6086153	11	3	8	5528.133815
797.3269929	11	3	8	5528.133818
815.0453705	11	3	8	5528.133818
832.7637481	11	3	8	5528.133816
850.4821257	11	3	8	5528.133818
868.2005034	11	3	8	5766.144597
885.918881	11.4222	3	8.4222	6338.18003
903.6372586	11.9822	3	8.9822	6686.670096
921.3556362	12	3	9	6697.546738
939.0740138	12	3	9	6697.546741
956.7923915	12	3	9	6697.546737
974.5107691	12	3	9	6697.546743
992.2291467	12	3	9	6982.297527
1009.947524	12.4612	3	9.4612	7619.12792
1027.665902	13	3	10	8010.320419
1045.38428	13.0557	3	10.0557	8010.320423
1063.102657	13	3	10	8264.68033
1080.821035	13.4348	3	10.4348	8910.666055
1098.539412	13.9383	3	10.9383	9311.078404
1116.25779	14	3	11	9057.953439
1133.976168	13.5824	3	10.5824	8364.746711
1151.694545	13	3	10	7973.269933
1169.412923	13	3	10	



Part 5

Distance (ft)	Elevation (ft)	Bottom Elevation of Channel (ft)	Difference Between Bottom of Channel and Current Elevation (Ft)	Excavation Volume (Ft^3)	Total Excavation Volume (Ft^3)
0	13	3	10	7995.746476	734401.8638
17.7683255	13	3	10	7995.746473	
35.536651	13	3	10	7995.746476	
53.3049765	13	3	10	7995.746476	
71.073302	13	3	10	7995.746476	
88.8416275	13	3	10	7995.746473	
106.609953	13	3	10	7995.746471	
124.3782785	13	3	10	8039.714325	
142.146604	13.0659	3	10.0659	8638.141998	
159.9149295	13.8803	3	10.8803	8711.732862	
177.683255	13.1721	3	10.1721	8646.92659	
195.4515805	13.7868	3	10.7868	9401.40338	
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4310.527318	5.3406	3	2.3406	1697.216135
4328.230997	8.0216	3	5.0216	3397.257137
4345.934676	9.7373	3	6.7373	5117.769344
4363.638355	11.522	3	8.522	

ATTACHMENT 2

US Measurements					Metric Measurements				
ConVault Size Gallons	Weight Pounds	A (Length) ft. & in.	B (Width) ft. & in.	C (Height) ft. & in.	ConVault Size Liters	Weight kg	A (Length) mm	B (Width) mm	C (Height) mm
125	6,200	4' 0.5"	4' 0.5"	3' 11"	1 000	4 000	2 350	1 150	1 100
250	8,000	7' 8"	3' 9.5"	3' 3"	2 000	6 000	3 300	1 450	1 100
500	12,000	11' 0"	4' 6"	3' 4"	4 000	9 000	3 300	1 750	1 450
1,000	18,000	11' 0"	5' 8"	4' 4"	6 000	12 000	3 400	2 400	1 500
2,000	30,000	11' 3"	8' 0"	5' 6"	8 000	13 500	3 400	2 400	1 800
3,000 LP	36,000	11' 3"	8' 0"	7' 3.5"	12 000	18 000	4 900	2 400	1 800
3,000 HP	37,500	9' 9"	8' 0"	8' 9"	16 000 LP	22 000	5 800	2 400	1 950
4,000 LP	44,000	17' 7"	8' 0"	6' 5.25"	16 000 HP	20 000	4 050	2 400	2 650
4,000 HP	40,000	12' 6"	8' 0"	8' 9"	20 000 LP	21 000	7 150	2 400	1 950
4,000 DW	44,000	12' 2"	8' 0"	8' 9"	20 000 HP	24 000	4 950	2 400	2 650
5,200	47,000	15' 6"	8' 0"	8' 9"	22 000	25 000	5 400	2 400	2 650
6,000	60,000	17' 7"	8' 0"	8' 9.25"	25 000	28 000	6 100	2 400	2 650
8,000	72,000	23' 1"	8' 0"	8' 9.25"	30 000	34 000	7 250	2 400	2 650
10,000	87,000	28' 7"	8' 0"	8' 9.25"	35 000	41 000	9 100	2 400	2 650
12,000	101,000	34' 1"	8' 0"	8' 9.25"	45 000	46 000	10 700	2 400	2 650

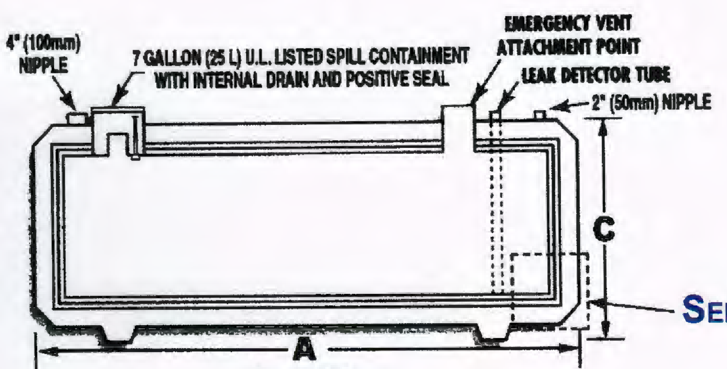
Cylindrical			
Size Gallons	Weight Pounds	Diameter ft. & in.	Length ft. & in.
4,000 Cyl	46,000	9' 4.5"	11' 11"
5,200 Cyl	52,000	9' 4.5"	15' 1.5"
6,000 Cyl	60,000	9' 4.5"	17' 3"
8,000 Cyl	72,000	9' 4.5"	22' 7"
10,000 Cyl	80,000*	9' 4.5"	27' 11"
12,000 Cyl	90,000*	9' 4.5"	33' 3"

* If "lightweight Concrete is used."

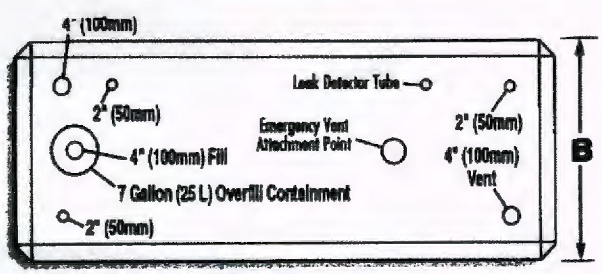
Most units are also available as a split unit in several configurations.

Caution! All sizes are not available from all manufacturing plants. Shape, dimensions, and weights may vary between manufacturing plants. Other sizes not listed may be available.

Check with your local representative.



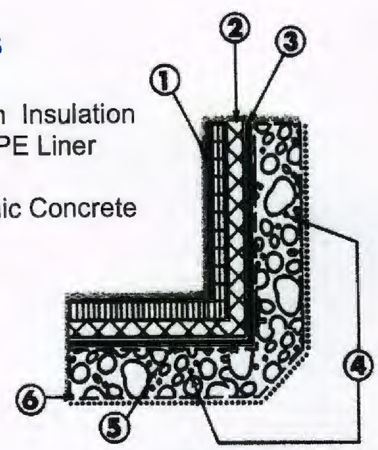
SIDE VIEW



TOP VIEW

Six Step Process

1. Steel Tank
2. ¼ " (6mm) Styrofoam Insulation
3. 30 Mil. (0.76mm)HDPE Liner
4. ½" (12mm) Rebar
5. 6" (105mm) Monolithic Concrete
6. Finish



DETAIL

U.S. PATENT #4,826,644; #4,931,235; #4,934,122; #4,963,082; #4,986,436; #5,064,155; #5,157,888; #5,174,079; #5,234,191; #5,126,095

(OTHER U.S. & FOREIGN PATENTS PENDING)

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ATTACHMENT 3

BUDGET ESTIMATE
FOR PLANNING PURPOSES

PLANNING ASSISTANCE TO STATES (PAS)
THOMAS CREEK FPMS, FL
FINAL ALTERNATIVES FOR RECOMMENDED PLAN

Project Number: 485362

Date of Estimate: 20 OCTOBER 2021

PREPARED UNDER THE DIRECTION

OF

JAMES L. BOOTH

COLONEL, U.S. ARMY

DISTRICT COMMANDER

U. S. ARMY ENGINEER DISTRICT, JACKSONVILLE

BUDGET ESTIMATE
FOR PLANNING PURPOSES

PLANNING ASSISTANCE TO STATES (PAS)
THOMAS CREEK FPMS, FL
FINAL ALTERNATIVES FOR RECOMMENDED PLAN

Date of Estimate: 20 OCTOBER 2021

Engineer Technical Letter 1110-2-573, elaborating on FAR 36.203(c) provides this information on safeguarding cost estimates: Project cost estimates should be safeguarded and handled in a discretionary manner. The estimates may contain proprietary information. Access to each estimate and its contents will be limited to those persons whose duties require knowledge of the estimate. Estimates prepared by contract will also be similarly handled. Any request by the public for information and pricing in the estimate will not be provided until coordination, verification of data, and approvals have been given by the commander or the responsible cost engineer. In addition, CESAJR 1110-2-7 adds documentation in the form of "...a list of individual's names who have had access to the total amount of the estimate." By listing my name below I am documenting that I have had access to the Government's estimate.

1. ____
Name Signature Discipline

2. ____
Name Signature Discipline

3. ____
Name Signature Discipline

4. ____
Name Signature Discipline

5. ____
Name Signature Discipline

6. ____
Name Signature Discipline

7. ____
Name Signature Discipline

8. ____
Name Signature Discipline

9. ____
Name Signature Discipline

10. ____
Name Signature Discipline

Project Manager to
Acknowledge Budget
Requirements

BUDGET ESTIMATE
FOR PLANNING PURPOSES

PLANNING ASSISTANCE TO STATES (PAS)
THOMAS CREEK FPMS, FL
FINAL ALTERNATIVES FOR RECOMMENDED PLAN

This estimate has undergone a Discipline Quality Check and Review in accordance with 02611-SAJ, 02612-SAJ, 02613-SAJ, 02614-SAJ

THIS ESTIMATE INCLUDES PROFIT AND CONTINGENCY

ALT 1 - Sheetpile Floodwall	**$22,562,000.00**
ALT 2 - Connecting Channel	**$7,594,000.00**
ALT 3 - Pump Stations - Structure & Equipment	**$32,038,300.00**
ALT 4 - Pump Stations - Channels	**$3,341,100.00**
ALT 5 - Pump Stations - Access Roads	**$3,398,100.00**
TOTAL COST	**$68,933,500.00**

Date of Estimate 20 OCTOBER 2021

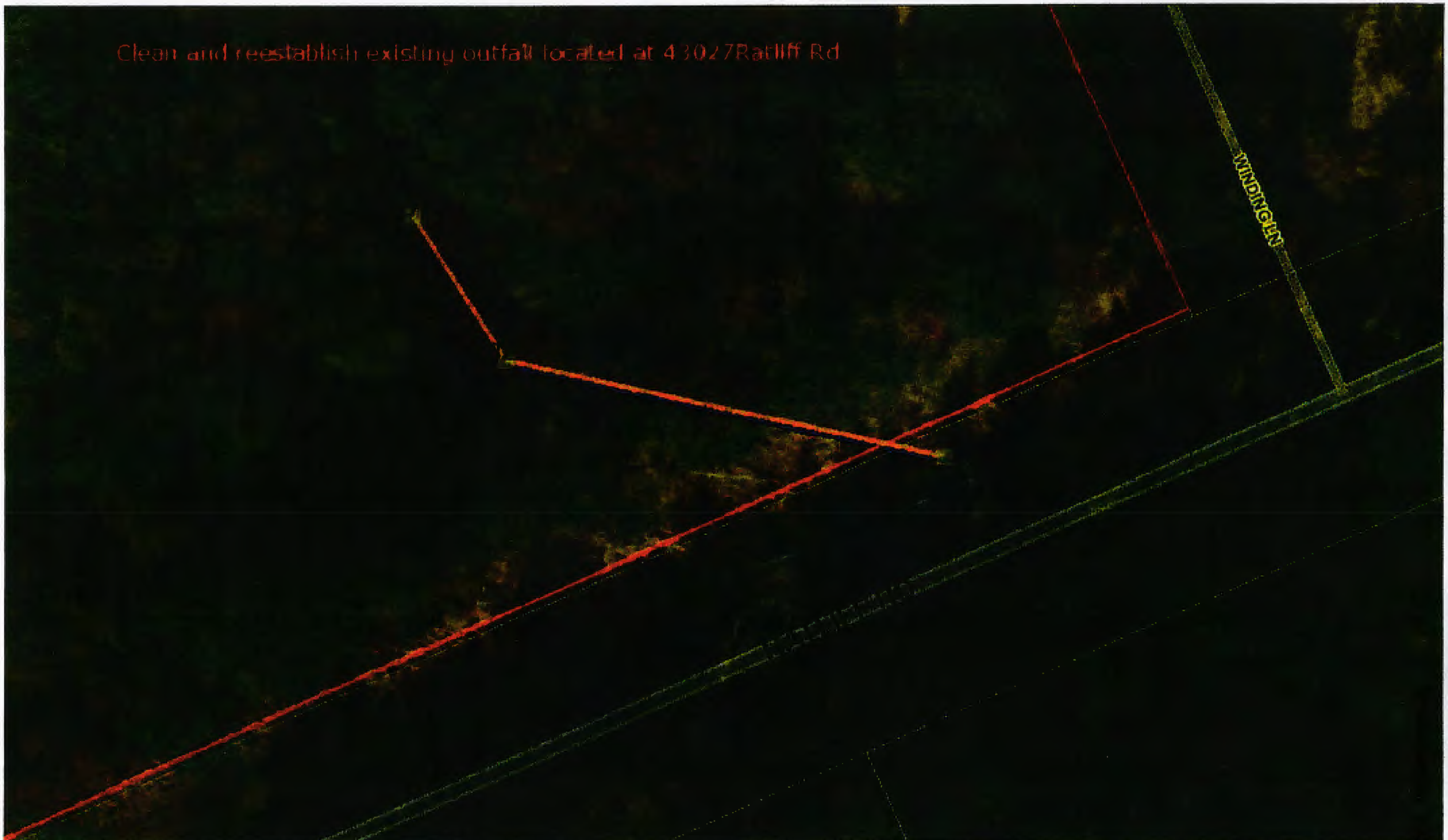
Prepared By: ______________________ Date ________
LAURA C. GAUDIER, C.C.C.
Cost Engineering Section

Reviewed By: ______________________ Date ________
CARLOS RIVERA, P.E.
Cost Engineering Team Leader

Submitted By: ______________________ Date ________
MATTHEW W. CUNNINGHAM, P.E.
Chief, Cost Engineering Section (CESAJ-EN-TC)

Approved By: ______________________ Date ________
KIMBERLY BROOKS-HALL, P.E., PMP
Chief, Technical Services Branch (CESAJ-EN-T)

GoMaps



e 7, 2021

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0 0.0075 0.015 0.03 km

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USI USGS, AeroGRID, IGN, and the GIS User Community
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS u community

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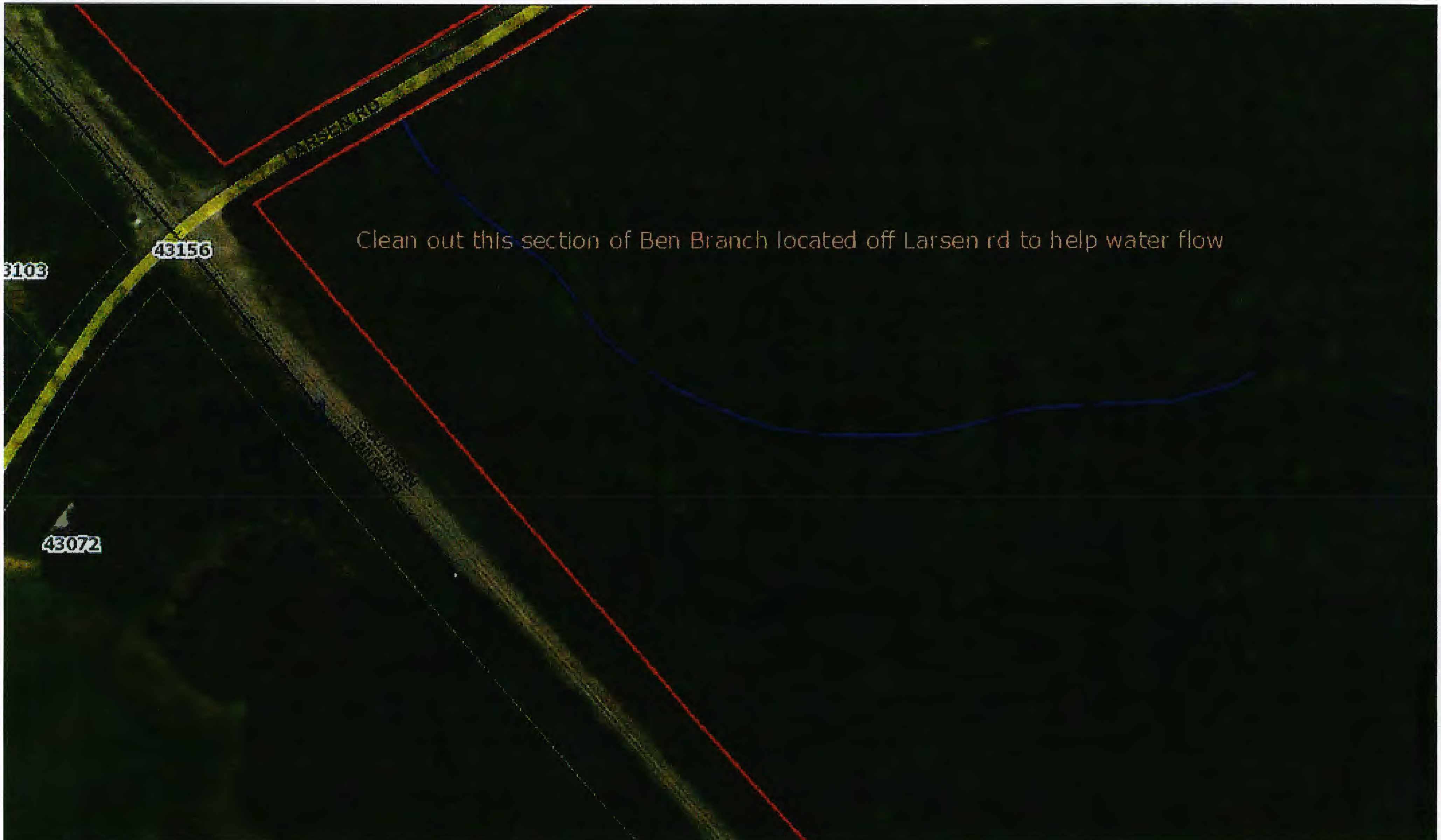
GoMaps



ıe 7, 2021

1:2,257

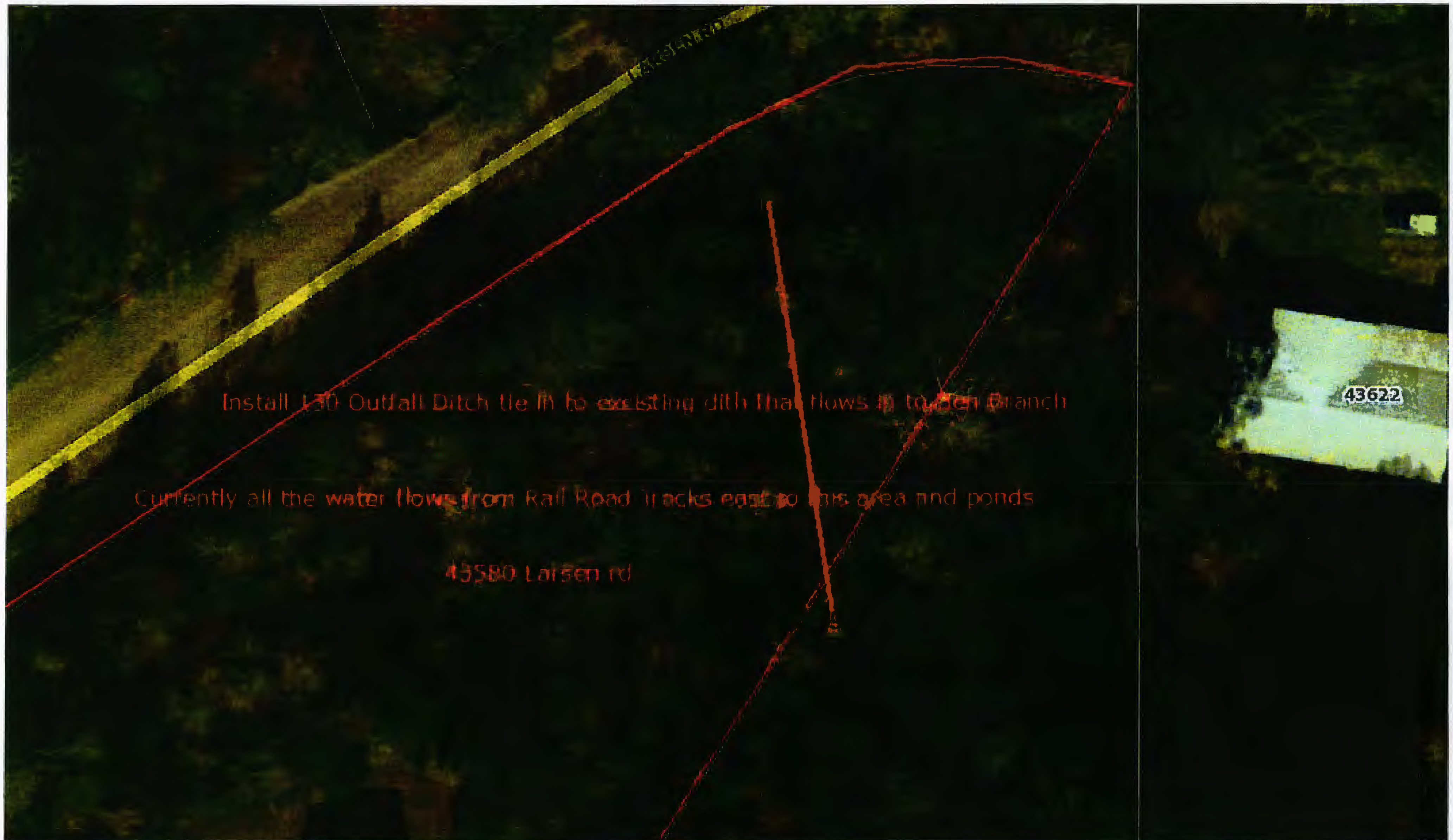
0 0.0175 0.035 0.07 mi

0 0.03 0.06 0.12 km

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USI
USGS, AeroGRID, IGN, and the GIS User Community
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS u
community

124

GoMaps



ıe 7, 2021

24

1:564

0 0.00475 0.0095 0.019 mi

0 0.0075 0.015 0.03 km

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USI USGS, AeroGRID, IGN, and the GIS User Community
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS u community

HAYWARD CONSTRUCTION GROUP, LLC
12058 San Jose Boulevard #803
Jacksonville FL 32223
CGC 1524614
Office (904) 886-7122 **Fax** (904) 886-7992 **E-mail:** haywardconstruct@bellsouth.net

PROPOSAL

August 6, 2021

Proposal Submitted to: **Nassau County - Katie Peay**
Phone #'s: 904-530-6239 - or cell 904-5562086 E-mail: kpeay@nassaucountyfl.com

Work to be performed at following address: **43027 RATLIFF RD - DITCH**
We hereby propose to furnish all the materials and perform the labor necessary for the completion of:

- **Clean dirt, and debris out of ditch ,approx. 519 'long located at 43027 Ratliff Rd.**
- **Grades will be shot per survey and instruction to be provided by Nassau county**
- **Any good sand or dirt excavated will be put into driveway per owner & county. If homeowner does not want the dirt, we will haul it away.**

Total Price $4,500

Payment Intervals: Due upon Completion

****Excludes any sod, surveys, as builts, electrical, plumbing, permitting and/or engineering fees****
****Prices subject to change due to engineering requirements and/or unforeseen site conditions****
****Although every effort will be taken to prevent any damages when accessing the worksite; HCG is not responsible for any damage to landscape/sod, irrigation, utilities and/or existing concrete/asphalt or pavers****

Prices are based upon sand bottom, in the event there are adverse conditions, such as limerock, coquina, concrete, etc., an additional charge will be required. Materials and workmanship installed or performed by Hayward Construction shall be guaranteed under normal conditions for a period of one year from the date of installation; excluding accidents and/or Acts of God. The above work will be performed in accordance with the drawings and/or specifications submitted by the owner for the above project and completed in a timely and professional manner. Should any of the work not be performed or supervised by Hayward Construction Group, we cannot be held responsible for any damage and/or malfunction.

HAYWARD CONSTRUCTION GROUP, LLC

Nassau County – Katie Peay
August 6, 2021

Any alteration or deviation from the above specifications involving additional costs, will be executed only upon written agreement from both parties, and will become an extra charge over and above the estimate. All agreements are contingent upon strikes, accidents and/or delays beyond our control. Owner will carry fire, tornado/storm damage and other insurance necessary for the job listed above. Worker's Compensation and General Liability Insurance for the above estimate will be carried by Hayward Construction Group.

* *

ACCEPTANCE OF PROPOSAL

The above estimate, specifications and conditions are satisfactory and are hereby accepted. The signing of this proposal authorizes Hayward Construction Group to commence work as specified above.

Signature: ______________________________ **Date:** ________________

HAYWARD CONSTRUCTION GROUP, LLC
12058 San Jose Boulevard #803
Jacksonville FL 32223
CGC 1524614
Office (904) 886-7122 **Fax** (904) 886-7992 **E-mail:** haywardconstruct@bellsouth.net

PROPOSAL

August 6, 2021

Proposal Submitted to: **Nassau County - Katie Peay**
Phone #'s: 904-530-6239 - or cell 904-5562086 E-mail: kpeay@nassaucountyfl.com

Work to be performed at following address: **49580 Larsen Rd. – Ditch Clean out**

We hereby propose to furnish all the materials and perform the labor necessary for the completion of:

- **Clean dirt, and debris out of ditch , to create outfall ditch, approx. 130 'long located at 49580 Larsen Rd.**
- **Grades will be shot per survey and instruction to be provided by Nassau county**
- **Any good sand or dirt excavated will be put into driveway per owner & county. If homeowner does not want the dirt, we will haul it away.**

Total Price $3,500

Payment Intervals: Due upon Completion

****Excludes any sod, surveys, as builts, electrical, plumbing, permitting and/or engineering fees****
****Prices subject to change due to engineering requirements and/or unforeseen site conditions****
****Although every effort will be taken to prevent any damages when accessing the worksite; HCG is not responsible for any damage to landscape/sod, irrigation, utilities and/or existing concrete/asphalt or pavers****

Prices are based upon sand bottom, in the event there are adverse conditions, such as limerock, coquina, concrete, etc., an additional charge will be required. Materials and workmanship installed or performed by Hayward Construction shall be guaranteed under normal conditions for a period of one year from the date of installation; excluding accidents and/or Acts of God. The above work will be performed in accordance with the drawings and/or specifications submitted by the owner for the above project and completed in a timely and professional manner. Should any of the work not be performed or supervised by Hayward Construction Group, we cannot be held responsible for any damage and/or malfunction.

HAYWARD CONSTRUCTION GROUP, LLC

Nassau County – Katie Peay
August 6, 2021
Larsen Rd. Ditch Proposal – Page 2 of 2

Any alteration or deviation from the above specifications involving additional costs, will be executed only upon written agreement from both parties, and will become an extra charge over and above the estimate. All agreements are contingent upon strikes, accidents and/or delays beyond our control. Owner will carry fire, tornado/storm damage and other insurance necessary for the job listed above. Worker's Compensation and General Liability Insurance for the above estimate will be carried by Hayward Construction Group.

* *

ACCEPTANCE OF PROPOSAL

The above estimate, specifications and conditions are satisfactory and are hereby accepted. The signing of this proposal authorizes Hayward Construction Group to commence work as specified above.

Signature: ______________________________ **Date:** ________________