

Preliminary Design Report

March 13, 2015

Preliminary (30%) Design Report

*RS-G341 Conveyance Improvements
Phase 1: Bolles East (L-16) Canal Conveyance
Improvement Project*



Prepared for:

South Florida Water Management District





South Florida Water Management District RS-G341 Conveyance Improvements Phase 1: Bolles East (L16) Canal Conveyance Improvement Project

Design Report (DR) for Preliminary (30%) Design

March 13, 2015

Prepared by J-Tech for the South Florida Water Management District
Work Order No. 4600003015-WO2, Deliverable 2.1.1.2





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EXECUTIVE SUMMARY

The Bolles East (L16) Canal links the Hillsboro (L15) Canal and the North New River (NNR) (L19/20) Canal. The canal currently serves adjacent agricultural landowners by supplying them with irrigation water and drainage. The canal has limited hydraulic capacity due to its shallowness as well as constrictions at existing bridges and the Duda Road culvert crossing near the midpoint of the canal. It discharges water during storm events by splitting the flow of water east to the Hillsboro (L15) Canal or west to the NNR (L19/L20) Canal. During dry periods when irrigation demand is high, landowners have reported that the canal runs dry due to its shallow profile.

The objective of the RS-G341 Conveyance Improvements Phase 1: Bolles East (L16) Canal Conveyance Improvement Project (Project) is to improve the capacity of the Bolles East (L16) Canal from the Hillsboro (L15) Canal to the NNR (L19/L20) Canal, and portions of the NNR (L19/L20) Canal from the Bolles (L16/L21) Canal south to Storm Water Treatment Area (STA) 3/4. The scope of the Project is to excavate the largest canal cross section possible, while maximizing all material storage within the existing canal right-of-way. For the Bolles East (L16) Canal, the District specified the use of a canal section equivalent to a design section with 60 foot bottom width at El. 0. Additionally, the Project proposes to improve the flow capacity in the NNR (L19/L20) Canal by removing high areas or “humps” in the bottom profile of the canal. These “humps” are generally located immediately south of the confluence of the NNR (L19/L20) and the Bolles (L16/L17) canals and approximately 2.5 miles south.

The improvements in the capacity of the Bolles East (L16) Canal and the NNR (L19/L20) Canal will reduce flooding and improve water supply to the STAs (e.g. STAs 1W, 2 and 3/4) and farmlands in the region. These improvements will also allow the District to move water east and west within the EAA for treatment by Stormwater Treatment Areas (STA) within different areas of the basin.



1.0 INTRODUCTION

1.1 Project Description

The Project is located within the Everglades Agricultural Area (EAA) in southwestern Palm Beach County and involves increasing the conveyance capacity of the Bolles East (L16) Canal and the North New River (NNR) (L19/L20) Canal.

The Bolles East (L16) Canal is owned by the South Florida Water Management District (SFWMD/District) and connects the NNR (L19/L20) Canal to the Hillsboro (L15) Canal as shown in **Figure 1**. The Bolles East (L16) Canal is not part of the Central and Southern Florida Flood Control (C&SF) System but is important to the S-2 and S-6 Basins it is located in. The Bolles East (L16) Canal, which can flow bi-directionally, has a total length of approximately 8.9 miles and provides irrigation water, as well as, drainage to the properties along its north and south banks. The Bolles East (L16) Canal has four bridge crossings and two culvert crossings, which form six sub-reaches within the canal. The Project involves the deepening and widening the canal in order to increase the conveyance capacity of the canal. Although the six crossings significantly restrict flow within the canal, the Project does not include the removal or replacement of any of these crossings. See Figure 2-4 and Table 2-3 in the EAA Bolles Canal Improvements Project Draft BODR by EarthTech included in **Appendix 1-1** for a map with corresponding tables showing existing structures and facilities along the Bolles East (L16) Canal.

The NNR Canal, which is owned by the District, is part of the C&SF System and is located within Basins S-2 and S-7. The NNR (L19) Canal extends 9.25 miles south of the Bolles East (L16) Canal to the northern limits of the A-1 Flow Equalization Basin (FEB). From this location, the NNR (L18) Canal resumes its southern reach another 4.8 miles to the inflow canal for STA 2 and Pump Station G-434. Continuing south another 3.1 miles brings the NNR (L18) Canal to the inflow canal for STA 3/4 and Pump Station G-370 as shown in **Figure 1.1**.

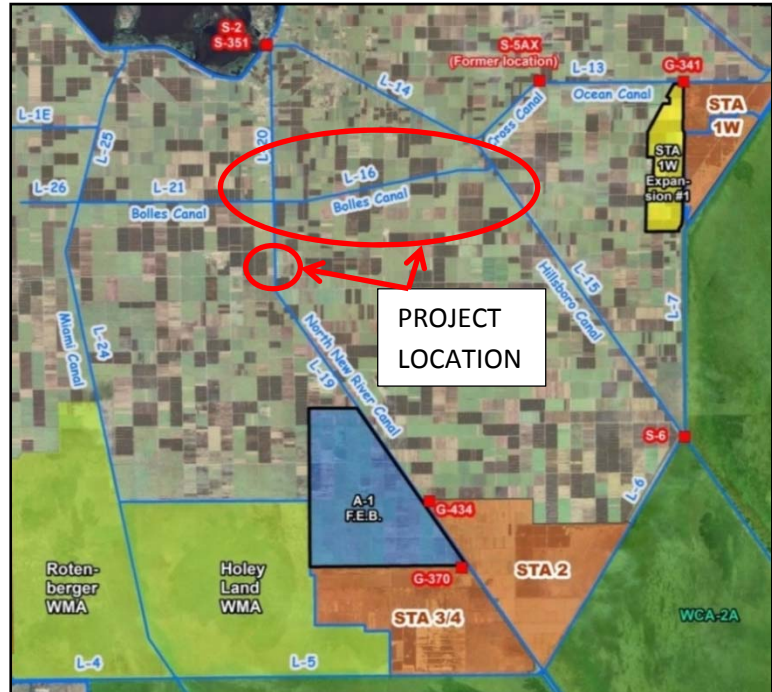


Figure 1.1 – Project Location Map

The Project (Phase 1) is the first phase of the larger RS-G341 Conveyance Improvement Project. The Bolles East (L16) Canal was slated to be improved as part of the EAA A1 Storage Reservoir CERP project. The Preliminary Hydraulics Evaluation Report for the Bolles and Cross Canals by the Jacobs MWH Joint Venture (JMJV), was prepared in 2004 to determine the conveyance capacity improvements necessary to provide deliveries to the EAA A1 Reservoir. Although improvements to multiple canals were explored in this report, the Bolles East (L16) and NNR (L19/L20) Canals were of particular interest. In addition to sizing the canals to provide deliveries to the reservoir, the study also examined the concept of improved flexibility in the primary C&SF System. The study confirmed that the canal improvements would allow better distribution of water between the STAs and found the expanded canals would provide improved water supply and flood

protection for the areas served by the canals. The specific plan details of the EAA A1 Storage Reservoir Project have changed since this report was finalized and the project currently being constructed in that specific location is called the A-1 FEB.



Figure 1.2 - Pump Station at STA 505+75 on south side of canal

The preferred option to improve the conveyance of the Bolles East (L16) Canal involves the development of optimized canal sections that balances canal section excavation quantities and embankment (disposal) requirements while maximizing the canal conveyance capacity within the current right-of-way.

1.2 Project Goals and Objectives

The primary goal of the project is to increase the conveyance capacity of the Bolles East (L16) Canal and the L19/L20 reach of the NNR Canal which will enhance the District's operational flexibility within the EAA region allowing for the following benefits:

- Optimized performance of STAs (e.g. STAs 1W, 2 and 3/4) through improved water supply to the STAs.
- Increased production of farmlands along the Bolles East (L16) Canal through improved water supply (especially during drought periods) and flood protection for the farmlands.

1.3 Other Studies, Reports and Technical Documents

The following is a list of other studies, reports and technical documents which are related to the Project, that were reviewed by J-Tech during the preliminary design phase. These documents are provided in **Appendix 1-1**.



- EAA Bolles Canal Improvements Project Draft Basis of Design Report, by EarthTech, dated October 2006.
- Preliminary Hydraulic Design of L16 Channel Improvements, by M. M. Wilsnack, P.E., dated September 2014.
- Technical Memorandum: An Atlas of the Everglades Agricultural Area Surface Water Management Basins, by the SFWMD Water Resources Division, dated 1989.
- Preliminary Hydraulic Evaluation (Permitted Pump Flows & ¾" Runoff) Report for Bolles and Cross Canals, by Jacobs MWH Joint Venture (JMJV), dated 2004.

1.4 Preliminary Design Report (DR)

1.4.1 Authorization for the DR

This DR is prepared in accordance with the requirements of Subtask 2.1.1 of Work Order No. 2 issued under General Engineering Services Contract No. 4600003015, dated July 14, 2014 between the District and J-Tech (an alliance of Jacobs Engineering Group and Tetra Tech, Inc.). The Statement of Work (SOW) for this work order is included in **Appendix 1-2**. This Work Order specifies that J-Tech provides a separate construction package for the initial construction of the Phase I Project, up to a budget of \$8,000,000.

1.4.2 Purpose of the DR

In general, the purpose of this DR is to document the design assumptions, criteria, considerations and engineering design methodologies involved with the development of the preliminary design of the project by J-Tech in coordination with the District (see Project meeting minutes provided in **Appendix 1-3**). This DR also provides the design details required for the technical review and permitting of the Project. A preliminary list of the technical specifications that will be required for the Project design is included in **Appendix 1-4**.

The number and sequencing of the construction packages for the project will be provided in the Corrected Final/RTA Design Report that will be submitted as part of Deliverable 2.4.1.1 of the Work Order.

For detailed information concerning the existing conditions of the Project site, please refer to the EAA Bolles Canal Improvements Project Draft Basis of Design Report, by EarthTech dated October 2006, included in **Appendix 1-1**.

2.0 GENERAL DESIGN REQUIREMENTS

2.1 Project Limits and Site Datum

The Bolles East (L16) Canal, for the purposes of the Project, extends approximately 8.9 miles from the NNR (L19/L20) Canal to the Hillsboro Canal (L15). The Canal is located in the S2 and S6 Basins of the EAA. In previous studies and reports the Bolles East (L16) Canal has sometimes been referred to as the Cross Canal, although it is believed this is not correct.

The Project limits for the Bolles East (L16) Canal generally consists of a 260 foot wide right-of-way. However, at the eastern end of the Project the right-of-way narrows to approximately 230 feet wide. Additionally, several areas in the SFWMD real estate certification (included in **Appendix 2-1**) were identified as having prescriptive rights. District staff stated that prescriptive rights may indicate a canal right-of-way that extends only to the edge of water of the canal, not the 260 foot wide right of way. These areas are generally located at the western end of the project. J-Tech staff has been directed to include in the design of the project a proposed



Figure 2.1 - Bolles East (L16) Canal looking east at Station 487+50 (Star Farms Bridge)

temporary construction easement (TCE) for the purpose of constructing replacement farm ditches and roads. For the preliminary submittal, the width of the proposed TCE is 80 feet. It is likely that the width of the TCE will be refined to reduce the width prior to the delivery of the Final submittal.

The Datum for the survey data are NAD 83 (horizontal) and NAVD 88 (vertical). The approximate conversion between vertical elevations in the NAVD 88 Datum and the NGVD 29 Datum within the Bolles East (L16) Canal project limits is $NGVD = NAVD + 1.38$ feet.

2.2 Units and System of Measurements

The preliminary design uses the English units and system of measurements.



2.3 Codes and Standards

The design and specification of all work for the Project will be in accordance with latest laws and regulations of the federal government, with applicable local codes and ordinances, and with codes and industry standards referenced below. The following is a summary of organizations with codes and standards that may apply to work of the Project:

2.3.1 General

- CERP Guidance Memoranda
- SFWMD Design Criteria Memoranda, and
- SFWMD Engineering Design Standards for Water Resource Facilities

2.3.2 Site Work Design Criteria

- American Association of State Highway and Transportation Officials (AASHTO)
- American National Standards Institute, Inc. (ANSI)
- American Society for Testing and Materials (ASTM)
- Asphalt Institute (AI)
- Federal Highway Administration (FHWA)
- Florida Department of Transportation (FDOT)
- Manual on Uniform Traffic Control Devices (MUTCD)
- South Florida Water Management District (SFWMD)
- Uniform Federal Accessibility Standards (UFAS)
- United States Army Corps of Engineers (USACE)

2.3.3 Geotechnical Design Criteria

- American Society for Testing and Materials (ASTM)
- EM 1110-2-1902 - Slope Stability
- Florida Building Code, 2004 Edition
- Florida Department of Transportation (FDOT)
- South Florida Water Management District (SFWMD)
- United States Army Corps of Engineers (USACE)
- CERP Standard Design Manual, USACE and SFWMD, June 06, 2003
- Recommended and recognized standards from other organizations shall be used where required and approved to serve as guidelines for the design, fabrication, and construction when not in conflict with the standards referenced above.



2.3.4 Design Criteria Not Applicable to the Project

Structural, architectural, mechanical, electrical, instrumentation & control and telemetry design criteria are not applicable for the design of this Project.



3.0 REGULATORY CONSIDERATIONS

3.1 Introduction

The proposed deepening and widening of the Bolles East (L16) Canal and the excavation of the “humps” in the NNR (L19/L20) Canal as part of the Project will be subject to certain regulatory authorizations which are required to be obtained prior to construction. The District or the construction contractor will be required to submit permit applications to state, federal or local agencies for review and approval. The following permits are expected to be required or will need to be reviewed by regulatory agencies.

3.2 Federal Requirements

The Project will require a Federal Dredge and Fill authorization under Section 404 of the Clean Water Act through the U.S. Army Corps of Engineers (Corps). It is expected that the Corps may be able to authorize the Project through one of the Nationwide permits to minimize permitting efforts and shorten timeframes. If a Nationwide permit is not appropriate, the Corps will issue an Individual permit for the project. Through the permitting process, the Corps will coordinate with Federal commenting agencies including the U.S. Fish and Wildlife Service. Because of the nature of the Project and the construction occurring within the EAA, it is not expected that there will be wildlife concerns or that species protected under the Endangered Species Act or Migratory Bird Act will be affected. Similarly, the area has been previously reviewed for cultural and historic properties and is not expected to require consultation under the National Historic Preservation Act.

3.3 State of Florida Requirements

It will be necessary for the District to submit an application for an Environmental Resource Permit (ERP) to the Florida Department of Environmental Protection (DEP). The ERP application, in this case, will be reviewed by the DEP Tallahassee Office through the Everglades Forever Act. The application will be coordinated with the Florida Fish and Wildlife Commission (FWC) and the State Historic Preservation Office (SHPO) along with any other interested parties. The District will hold a pre-application meeting with DEP to identify any additional regulatory concerns.

It is not expected at this time that any of the proposed roads or infrastructure will require a permit from the Florida Department of Transportation.

It will be necessary for the contractor to obtain a National Pollutant Discharge Elimination System (NPDES) Permit prior to construction. The contractor will need to supply a Stormwater Pollution Prevention Plan (SWPPP) which will include all soil and sediment control measures to be implemented on the project site during construction.



3.4 South Florida Water Management District

If the construction of the project requires dewatering of the canal, in sections, it will be necessary for the contractor to obtain a Consumptive Water Use Permit from SFWMD. The permit will be coordinated through DEP for review and comment. The DEP may determine that this project should be included in the SFWMD Master Dewatering Permit; however, this determination will not change the process or cause delay in issuance.

3.5 Local Permits

No local building permit approvals are expected to be necessary for the project. If blasting is expected to be necessary for excavating the rock from the canal, a blasting permit will be required by the County, which should be coordinated with FWC to ensure that any necessary wildlife safety concerns are evaluated by the agency.



4.0 HYDRAULICS

4.1 Hydraulic Design Criteria for Canal Improvements

4.1.1 Existing Conveyance Capacity and Facilities

Historically, the Bolles East (L16) Canal has been used as a source of irrigation water for adjacent farmlands and for stormwater management (to remove runoff from the farmlands). The flow in either case was divided somewhat evenly to/from the primary canals on either end of the Bolles East (L16) Canal, namely, the NNR (L19/L20) Canal at the west end and the Hillsboro (L15) Canal on the east end. Passively, the Bolles East (L16) Canal has provided some small degree of water level equalization between the two primary canals, but it has not historically been used for that purpose. See Figure 2-4 and Table 2-3 in the EAA Bolles Canal Improvements Project Draft BODR by EarthTech included in **Appendix 1-1** for a map with corresponding tables showing existing structures and facilities along the Bolles East (L16) Canal.

Over the years, flooding has been reported on the farmlands along the canal caused by the canal overtopping its banks. The reason cited has been canal conveyance limitations and the height of the existing berm. Previous investigations and studies have indicated that the limitations in the capacity of the canal are primarily the road crossings of the canal (bridges and culverts) and the shallow cross section of the existing canal.

The existing canal bottom width varies from approximately 50 feet to 100 feet and side slopes are typically 1(H):1(V) or steeper. In general, the bottom of the channel is on a rock layer, at about elevation 6.5 feet, NAVD. This provides a relatively shallow canal section, compared to the typical adjacent canal bank elevations that are commonly as between El. 12 and 13.5 feet, NAVD. Where slope degradation and sediment deposition have occurred, the flow area has been additionally compromised.

There are portions of the canal bank, primarily located on the north side of the canal at the east end, that have a relatively low top elevation of 12ft NAVD, compared with other areas where the top of bank is around 15 ft NAVD, and this has resulted in overtopping when stages in the canal are high enough.

This current evaluation was undertaken to further investigate potential channel improvements that would benefit the stakeholders. The Bolles East (L16) Canal, between the Hillsboro (L15) and NNR (L19/L20) Canals, was last surveyed in 2007, with cross sections obtained approximately every 500 feet. For this evaluation, cross sections were obtained every 2,500 feet, to confirm the previously obtained information, and at the approach and departure from each of the canal crossings. Preliminary review of the two data sets indicates that little has changed in the canal over the past seven years.

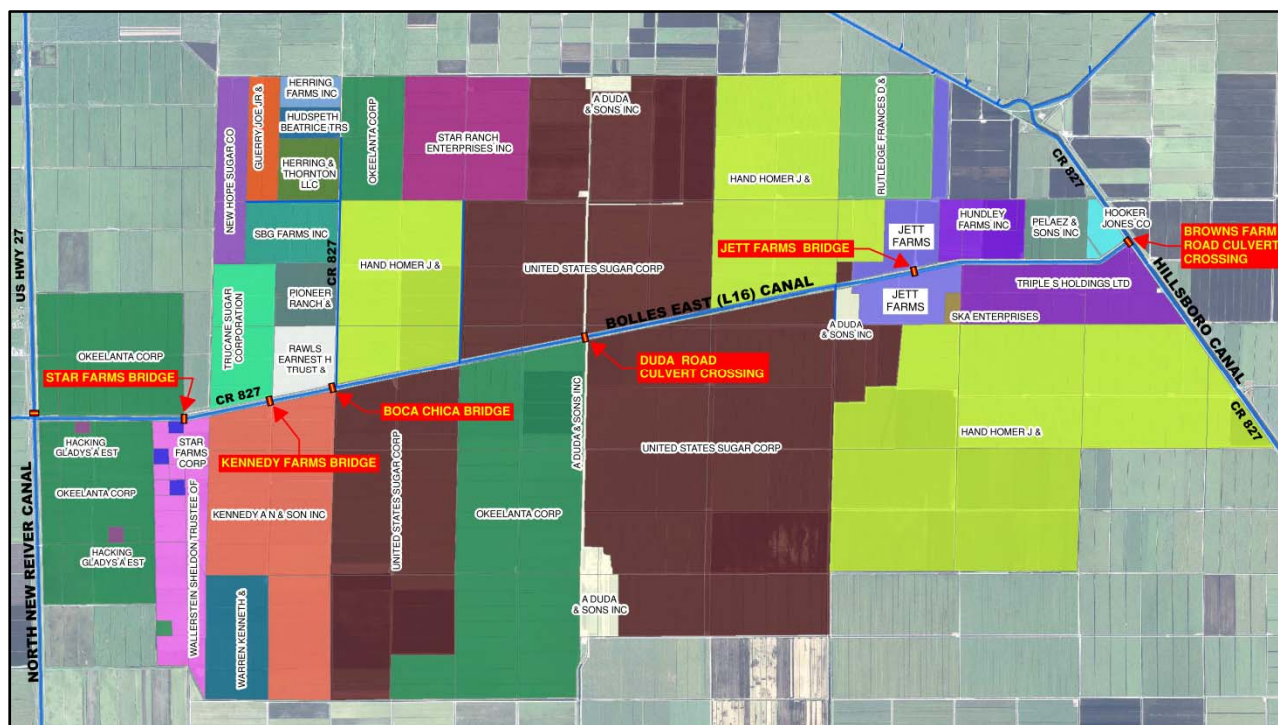


Figure 4.1 – Bolles East (L16) Canal Road Crossings and Land Ownership Map

There are six canal crossings of the Bolles East (L16) Canal between the Hillsboro and NNR Canals. Brown's Farm Road, the eastern-most crossing, was inspected by Infrastructure Engineers in 2014. The five remaining crossings were resurveyed as part of this evaluation. **Table 4.1** provides a summary of the crossings.

Table 4.1 – Bolles East (L16) Canal Crossings

NAME	DESCRIPTION	MODEL RIVER MILE
Star Farms Bridge	Free span, +/- 31' flow width; low member @ 12.43' NAVD	6296
Kennedy Farms Bridge	Free span, +/- 35' flow width; low member @ 14.15' NAVD	10068
Boca Chica Bridge	Free span, +/- 26' flow width; low member @ 13.52' NAVD	12800
Duda Road Culvert Crossing	Three 42-inch CMPs; avg. invert @ +/- 6.3' NAVD	23587
Jett Farms Bridge	Free span, +/- 30' flow width; low member @ 14.14' NAVD	37816
Browns Farm Road Culvert Crossing	Five 72-inch CMPs; avg. invert @ +/- 1.0' NAVD	47161



4.1.2 Computer Models

The Bolles East (L16) Canal has been previously modeled, by the JMJV Team in 2004 and, most recently, by the District in 2014. In both cases, the computer modeling software used was HEC RAS, by the U.S. Army Corps of Engineers. The District updated the model from version 3.1.1 to version 4.1.0 for its use in 2014. For the current evaluation, the District's model was provided for use by J-Tech. Elevations in the model are in the NAVD 88 datum. For detailed discussion of the model elements and assumptions, refer to the document Preliminary Hydraulic Design of L16 Channel Improvements by M. M. Wilsnack, P.E., dated September 2014 (included in **Appendix 1-1**). The information and assumptions input to the model to represent the existing conditions were reviewed and no significant discrepancies were noted. The recently surveyed cross sections and information about the canal crossings were incorporated to update the model to the best available information at this time.



Figure 4.1 - Farm ditch on south side of the Bolles East (L16) Canal Station 554+00 (west of Boca Chica Bridge)

The boundary conditions for this model consist of the primary canals on either end of the Bolles East (L16) Canal. In the previous modeling effort by the District in 2014, the levels were set at 12.5 feet, NGVD, which is approximately 11.1 feet, NAVD. This stage was cited as "the upper limit of the optimal control range." According to information reviewed in the District's DBHydro database, the water level elevations in these canals have averaged approximately 9.0 feet, NAVD over the past 10 years. The 2004 modeling effort by JMJV used a boundary condition of 11.8 feet, NGVD, or 10.4 feet, NAVD. For this modeling effort, the boundary stages were set to 11 feet, NAVD for the runoff removal scenarios. For the conveyance scenarios (no pumping condition), a water surface level differential was used to drive the flow; a headwater elevation of 12.0 feet, NAVD on the east end and a tailwater elevation of 10.0 feet, NAVD on the west end were assigned.



4.1.3 Range of Operating Conditions

The District specified that several flow condition scenarios be evaluated for the proposed improvements to the canal. These included the removal of the volume of runoff generated by the adjacent farm lands for several rainfall amounts (0.75, 1.0, 1.25, 1.5-inch). (Note that the model as provided was set up to discharge the specified volume of runoff at the rate of the existing pump capacities. Thus, the pumps operate at their stated capacity for however many hours it takes to discharge the volume of water produced by the specified rainfall amount over the land area controlled by that pump. This is not the same as an allowable discharge rate, which typically assumes discharging the volume of runoff over a 24-hour period.) In addition to the runoff removal scenarios, the conveyance through the full length of the canal, (including the road crossings) generated by a differential stage condition in the bounding primary canals was also simulated (no pumping condition).

4.2 Existing Condition Model Results

4.2.1 Water Surface Profiles

The various runoff removal and the conveyance scenarios were simulated using the existing condition model, as a basis for comparison with the proposed alternative improvements. As revealed by the profiles for the existing condition simulations, **Figures 4.2 to 4.6**, there are significant restrictions along the canal, most notably at the crossings. The crossing at Duda Road is the most restrictive and, in fact, the crossing acts as a basin divide during the runoff removal simulations. The restriction posed by the three 42-inch culverts is significant. These results are consistent with previous evaluations of the Canal.

In the runoff removal scenarios, headlosses from the approximate center of the canal to either end are moderate. In the conveyance scenario, the total headloss from the east end to the west end is significant.



EXISTING MAXIMUM WATER SURFACE LEVEL PROFILES

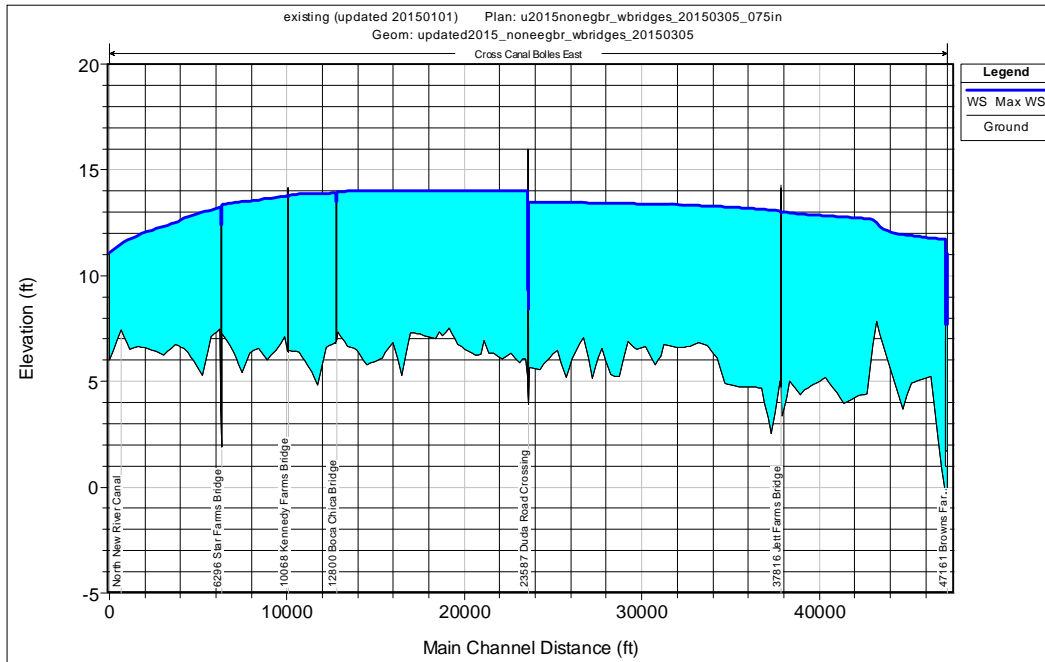


Figure 4.2 - Removal of 0.75-inch Over Contributing Area

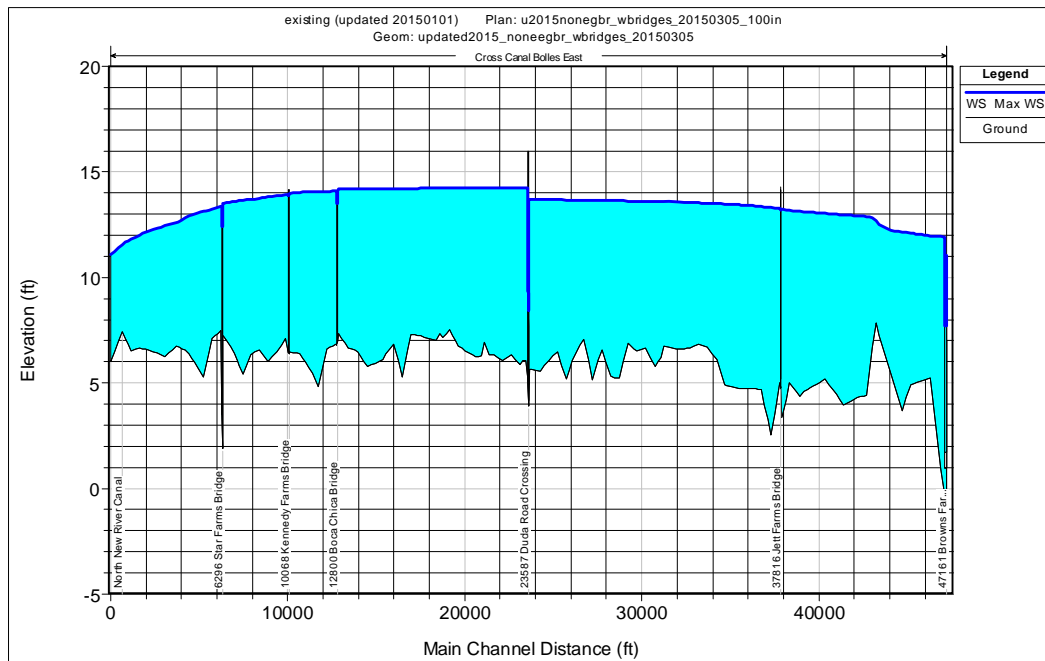


Figure 4.3 - Removal of 1.0-inch Over Contributing Area

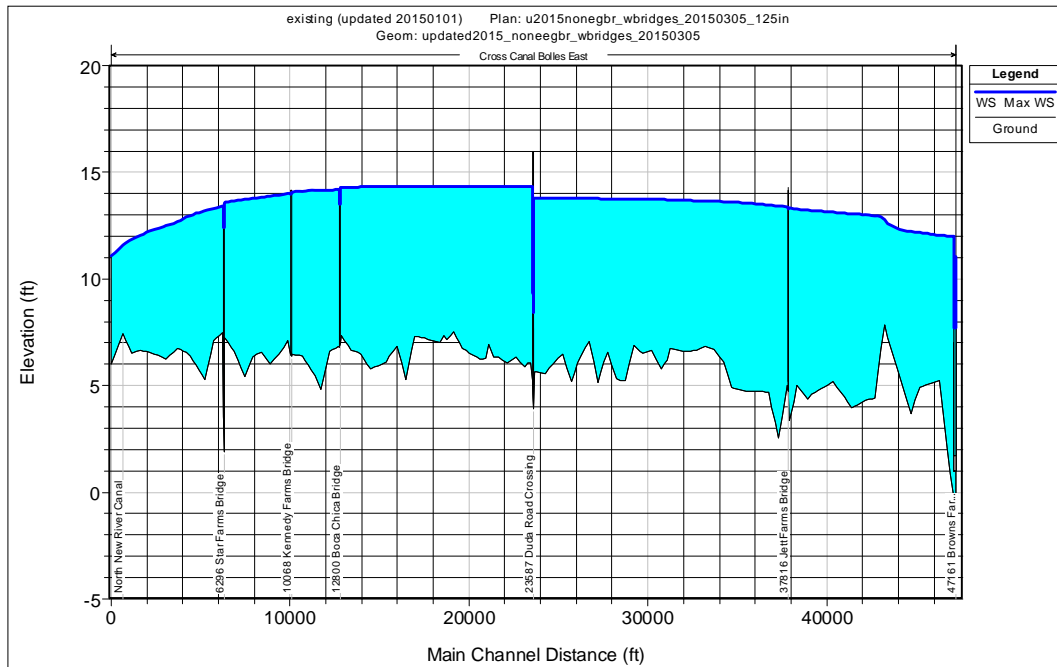


Figure 4.4 - Removal of 1.25-inch Over Contributing Area

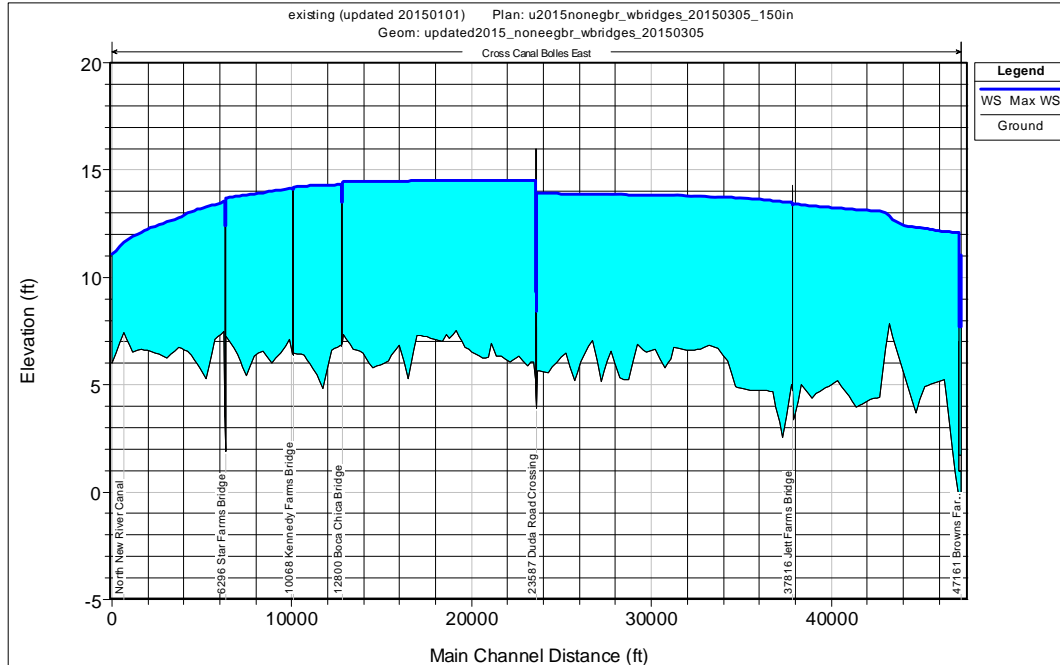


Figure 4.5 - Removal of 1.5-inch Over Contributing Area

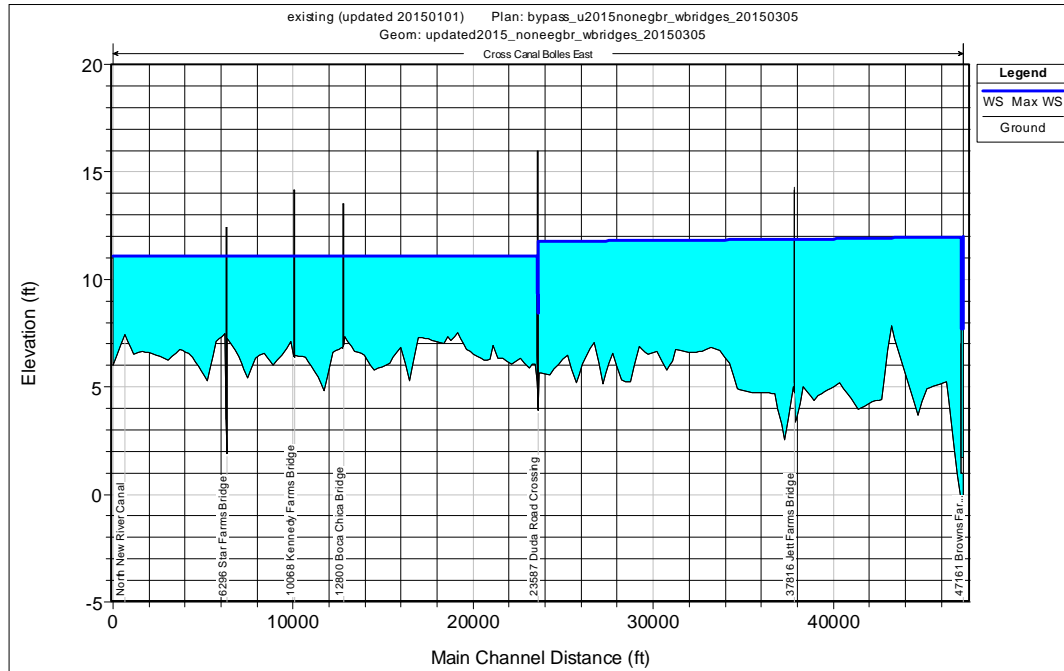


Figure 4.6 - Conveyance (East to West) from Hillsboro Canal to NNR Canal



4.2.2 Water Levels

The cross section in **Figure 4.7** below, from the simulation of the 1.5-inch runoff removal scenario under existing Canal conditions, depicts the problem with berm overtopping that occurs. The cross section is looking west, and is in the area previously mentioned, generally from 830+00 895+00 where the canal bank is low.

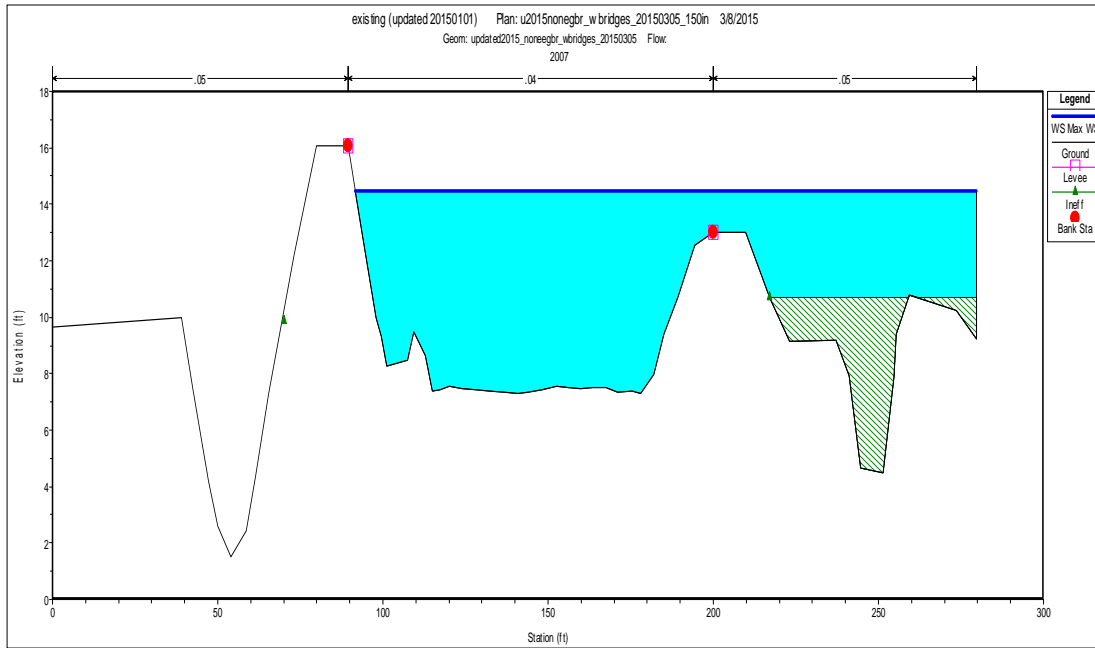


Figure 4.7 – Bolles East (L16) Canal Cross Section from Model

4.2.3 Canal Flows

As previously mentioned, flow in the Canal during the runoff removal scenarios is generally split at the Duda Farms crossing, and discharges in either direction. As shown in the **Table 4.2**, it appears that more flow moves to the east than to the west. This can be a function of contributing area, pumping capacities and channel capacity. In the conveyance scenario, the flow is a function of channel capacity, including canal crossings, driven solely by the stage differential in the primary canals at either end.

Table 4.2 - Maximum Canal Flows (cfs)

MODEL RIVER MILE	FEATURE	REMOVAL VOLUMES				CONVEYANCE
		¾"	1"	1¼"	1½"	
6281	Star Farms Br, W	526	561	580	610	111
47107	Browns Farm culverts, W	545	617	643	672	111



4.2.4 Canal Velocities

Maximum flow velocities through the Canal, in the range of 2.5 ft/s, are unremarkable for the existing condition, and of little concern in their erosive capabilities. Maximum velocities in the Canal for the various flow conditions simulated are provided in the **Table 4.3** below.

Table 4.3 - Maximum Canal Velocities (ft/s)

MODEL RIVER MILE	FEATURE	REMOVAL VOLUMES				CONVEYANCE
		¾"	1"	1¼	1½	
6281	Star Farms Br, W	2.12	2.23	2.28	2.38	0.64
6311	Star Farms Br, E	1.8	1.89	1.94	2.02	0.52
10046	Kennedy Farms Br, W	2.13	2.23	2.29	2.38	0.91
10090	Kennedy Farms Br, E	2.13	2.23	2.29	2.38	0.93
12771	Boca Chica Rd Br, W	2.02	2.16	2.26	2.39	1.21
12829	Boca Chica Rd Br, E	2.02	2.19	1.19	1.22	1.21
23552	Duda Road culverts, W	0.28	0.21	0.21	0.22	0.39
23622	Duda Road culverts, E	0.19	0.19	0.19	0.20	0.28
37788	Jett Farms Br, W	2.32	2.43	2.50	2.57	0.66
37844	Jett Farms Br, E	2.32	2.44	2.52	2.59	0.66
47107	Browns Farm culverts, W	1.22	1.36	1.40	1.46	0.24
47208	Browns Farm culverts, E	0.05	0.06	0.06	0.06	0.24



4.3 Evaluated Alternatives Model Results

After preliminary analyses and discussion with the District, the two agreed-upon improvement scenarios were:

- **Alternative 1:** 40-ft wide canal bottom at el. -2.0, with 1:1.5 side slopes to top of rock and 3:1 side slopes to existing grade; existing bridges and culverts to remain.
- **Alternative 2:** 40-ft wide canal bottom at el. -2.0, with 1:1.5 side slopes to top of rock and 3:1 side slopes to existing grade; Consolidated two bridges at the west end of the project, modified all remaining bridges to three span bridges that match the canal section, Duda Road Culvert crossing converted to a bridge, no change to the 5 – 72" Diameter Culverts under Brown's Farm Road at the junction with the Hillsboro (L15) Canal.

The modified bridges configuration for the model consisted of three-span bridges (i.e., two piers in the canal) with a low bridge member at elevation 14.0 feet, NAVD, which is two feet above anticipated high water in the canal. The modified bridge alternative also included the consolidation of the two bridges on the west end.

4.3.1 Water Surface Profiles

As depicted in the **Figures 4.8 to 4.17** below, the two canal alternatives both provide improvements with regard to flow restriction and headloss. The difference in the degree of improvement is visible in these figures.



PROPOSED MAX. WATER SURFACE LEVEL PROFILES FOR REMOVAL OF 0.75" OVER CONTRIBUTING AREA

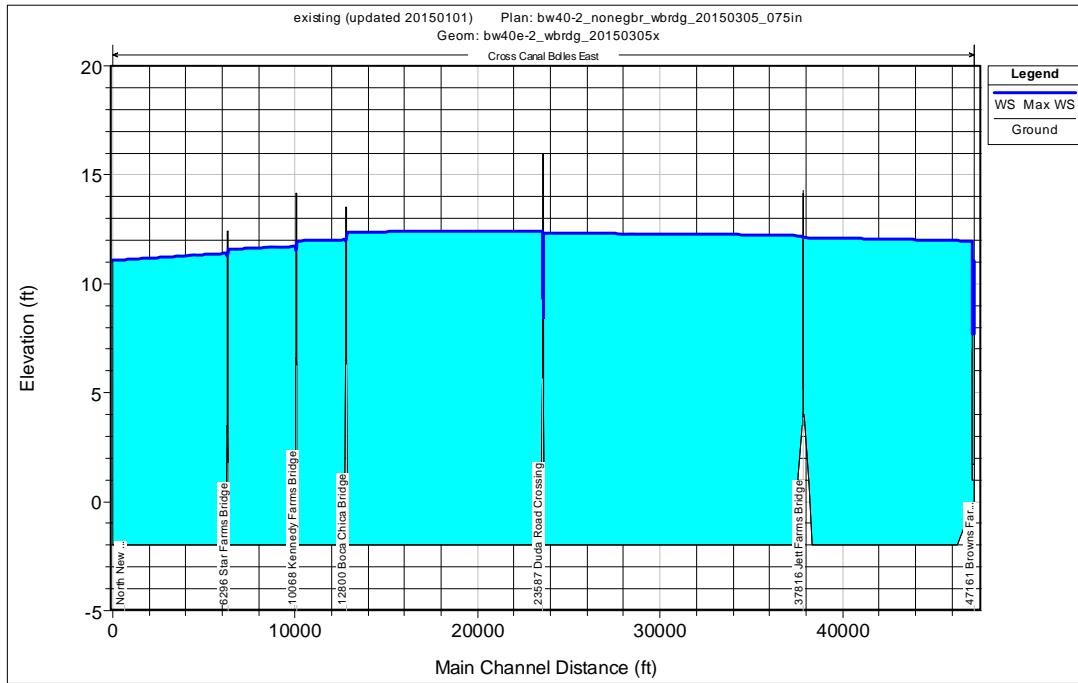


Figure 4.8 - Alt 1 - Canal Improvements

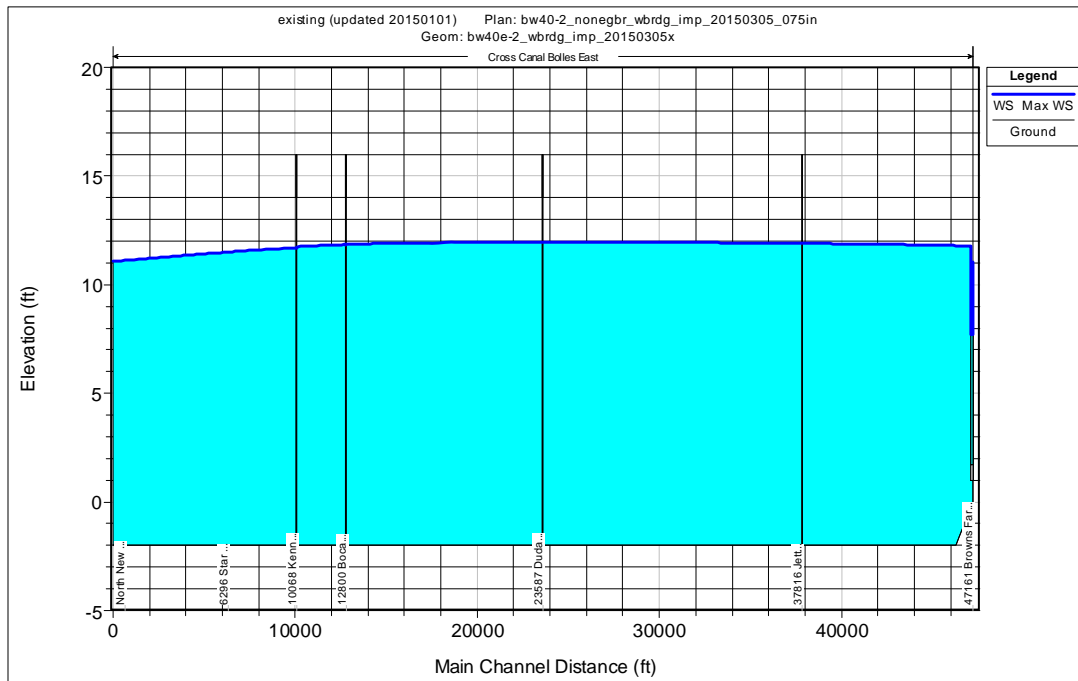


Figure 4.9 - Alt 2 - Canal and Bridge Improvements



PROPOSED MAX. WATER SURFACE LEVEL PROFILE FOR REMOVAL OF 1.0" OVER CONTRIBUTING AREA

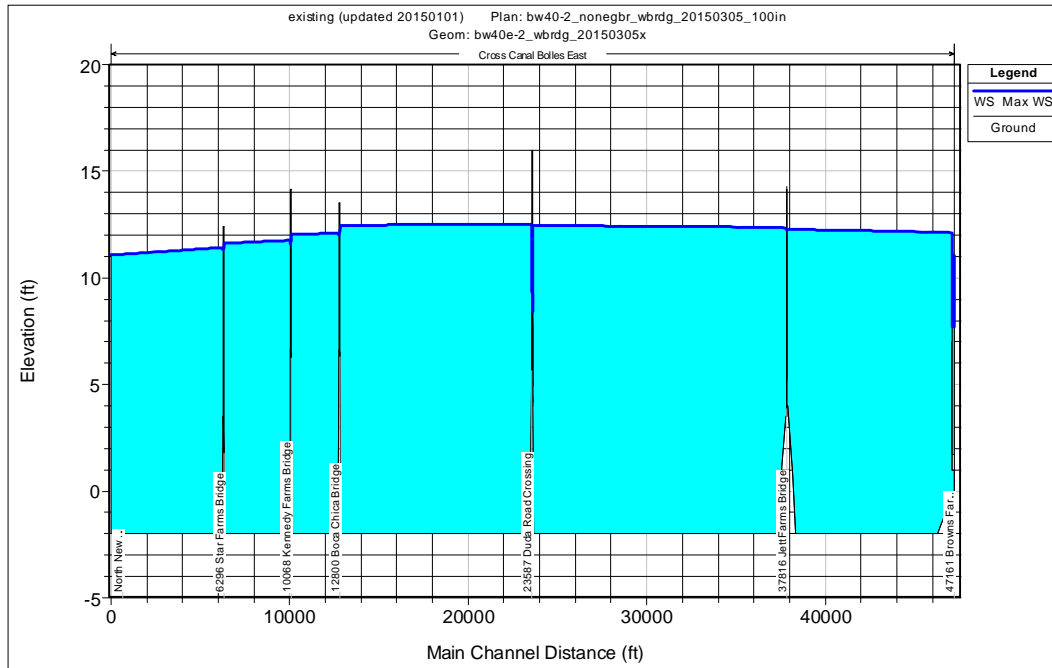


Figure 4.10 - Alt 1 - Canal Improvements

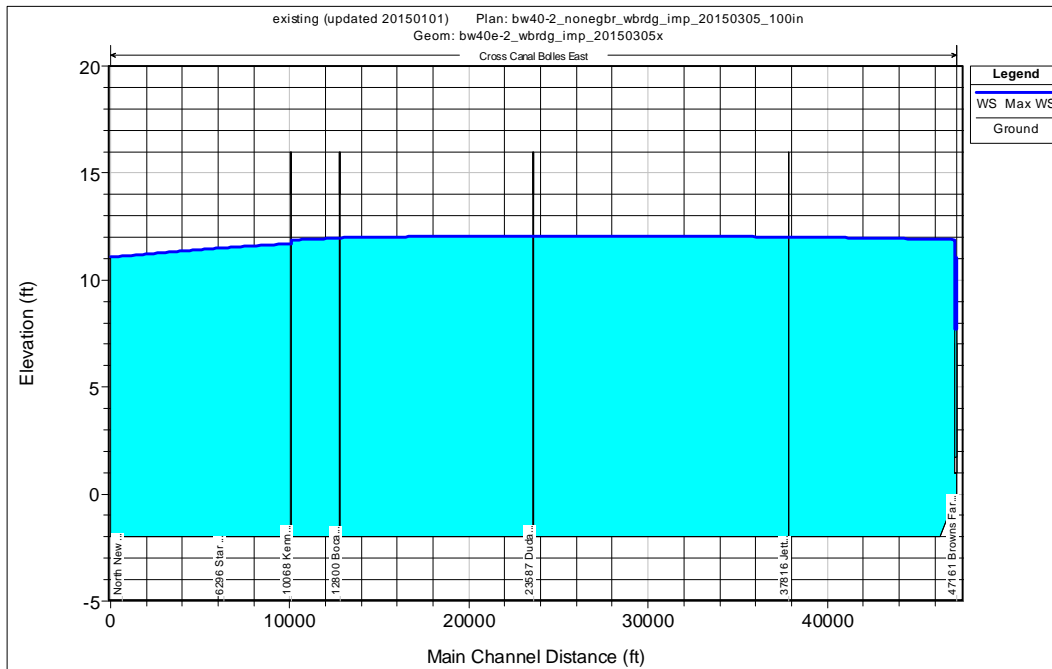


Figure 4.11 - Alt 2 - Canal and Bridge Improvements



PROPOSED MAX. WATER SURFACE LEVEL PROFILE FOR REMOVAL OF 1.25" OVER CONTRIBUTING AREA

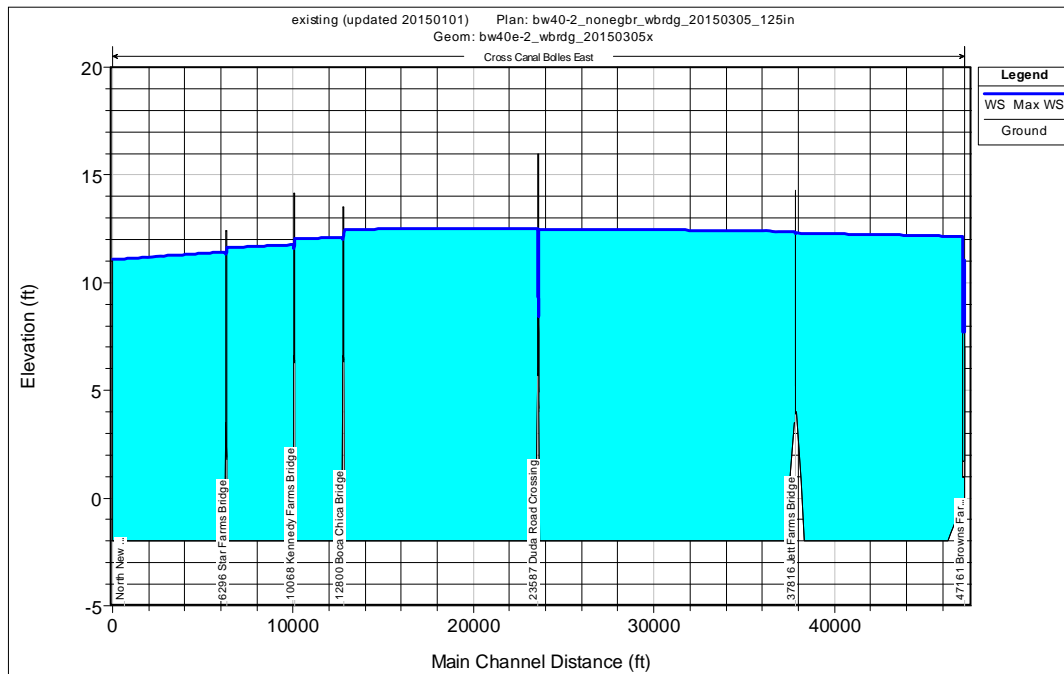


Figure 4.12 - Alt 1 - Canal Improvements

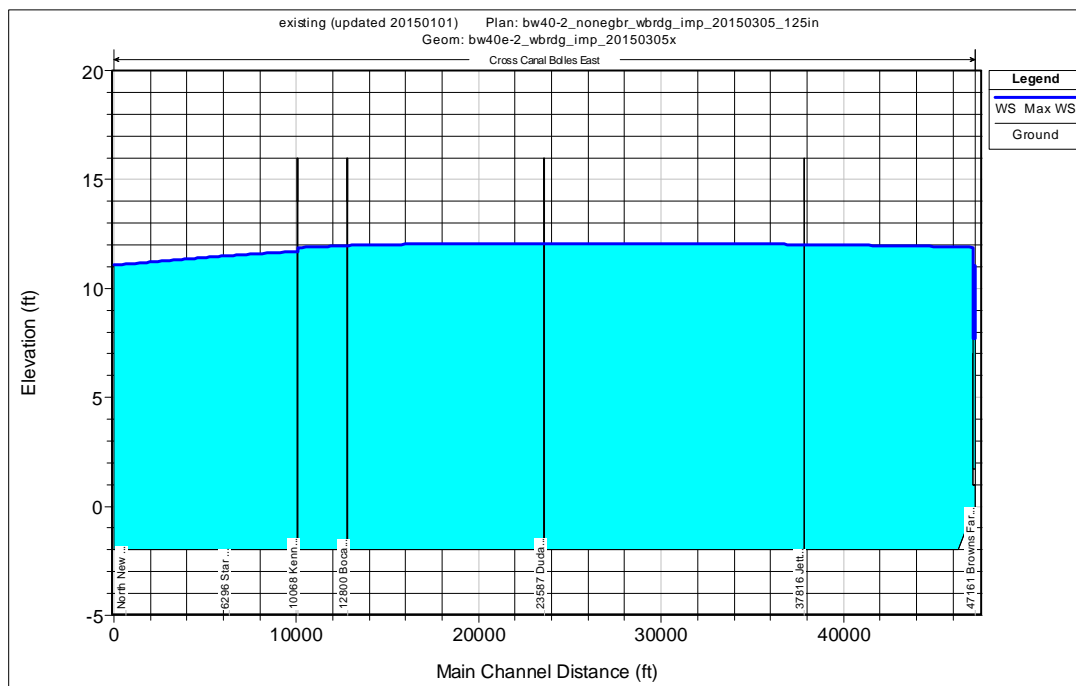


Figure 4.13 - Alt 2 - Canal and Bridge Improvements



PROPOSED MAX. WATER SURFACE LEVEL PROFILE FOR REMOVAL OF 1.5" OVER CONTRIBUTING AREA

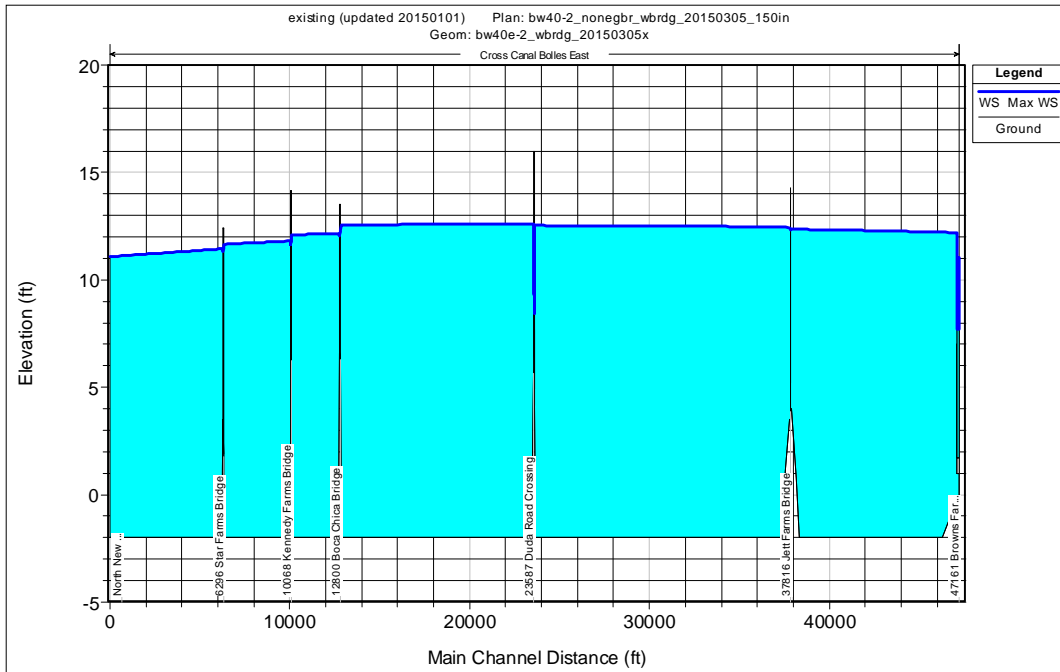


Figure 4.14 - Alt 1 - Canal Improvements

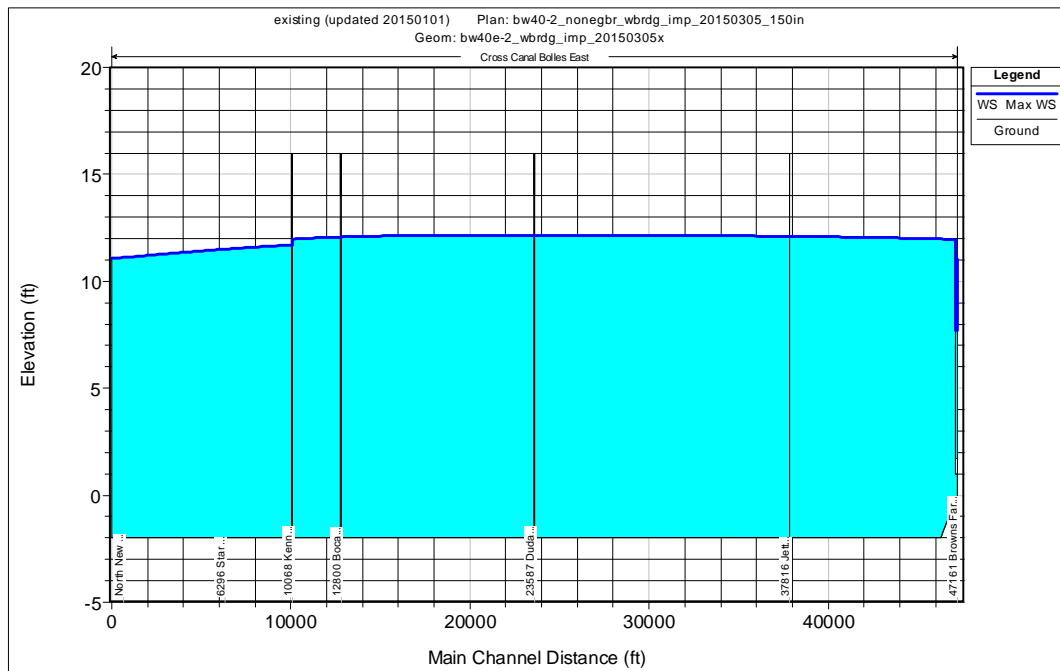


Figure 4.15 - Alt 2 - Canal and Bridge Improvements



PROPOSED MAX. WATER SURFACE LEVEL PROFILE FOR CONVEYANCE FROM HILLSBORO TO NNR CANAL

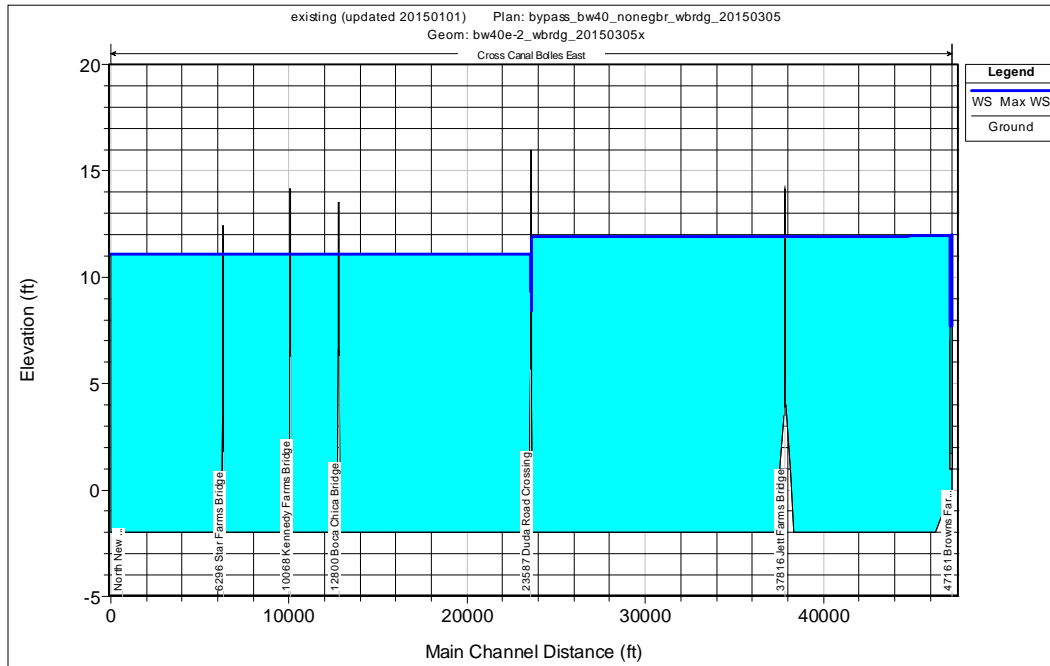


Figure 4.16 - Alt 1 - Canal Improvements

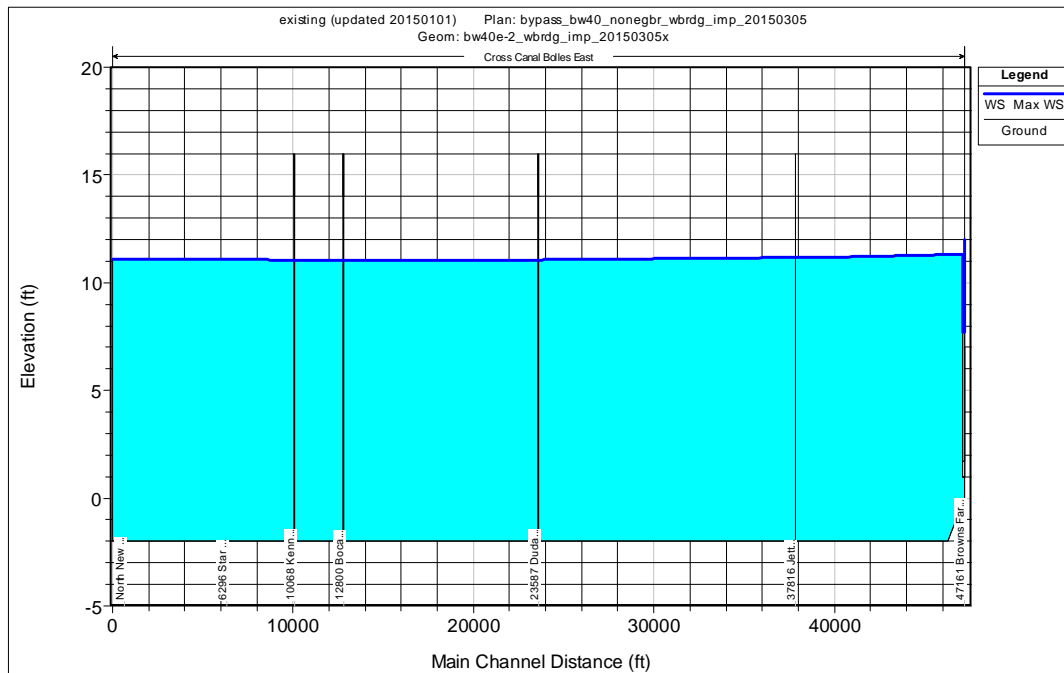


Figure 4.17 - Alt 2 - Canal and Bridge Improvements



4.3.2 Water Levels

The improvements also address the berm over-topping that was evident in the existing condition simulations as shown in **Figures 4.18 to 4.19** below.

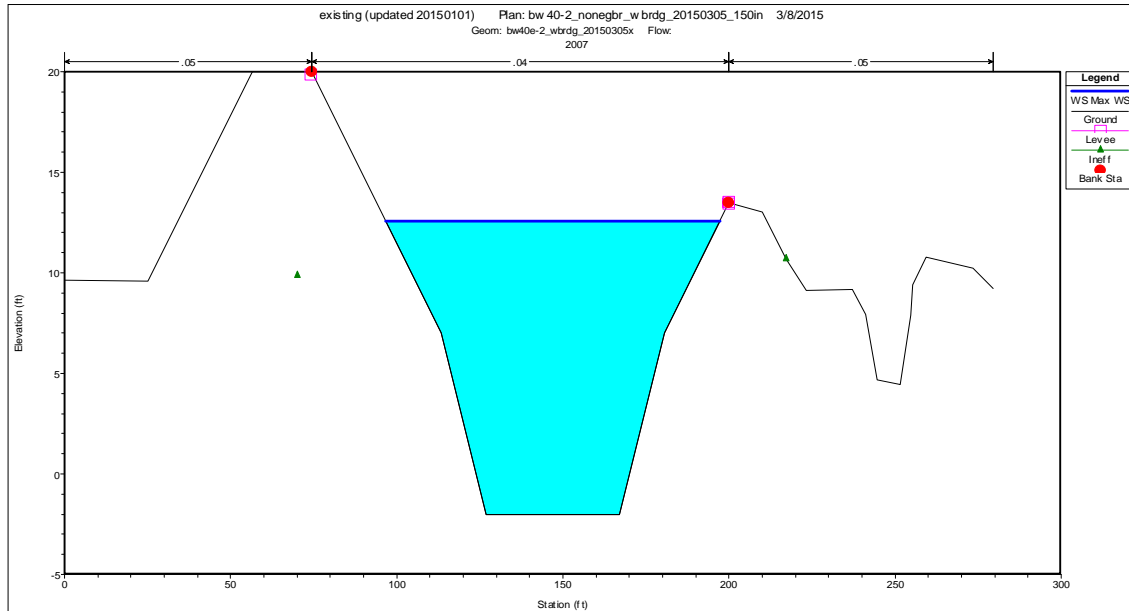


Figure 4.18 - Alt 1 - Canal Improvements

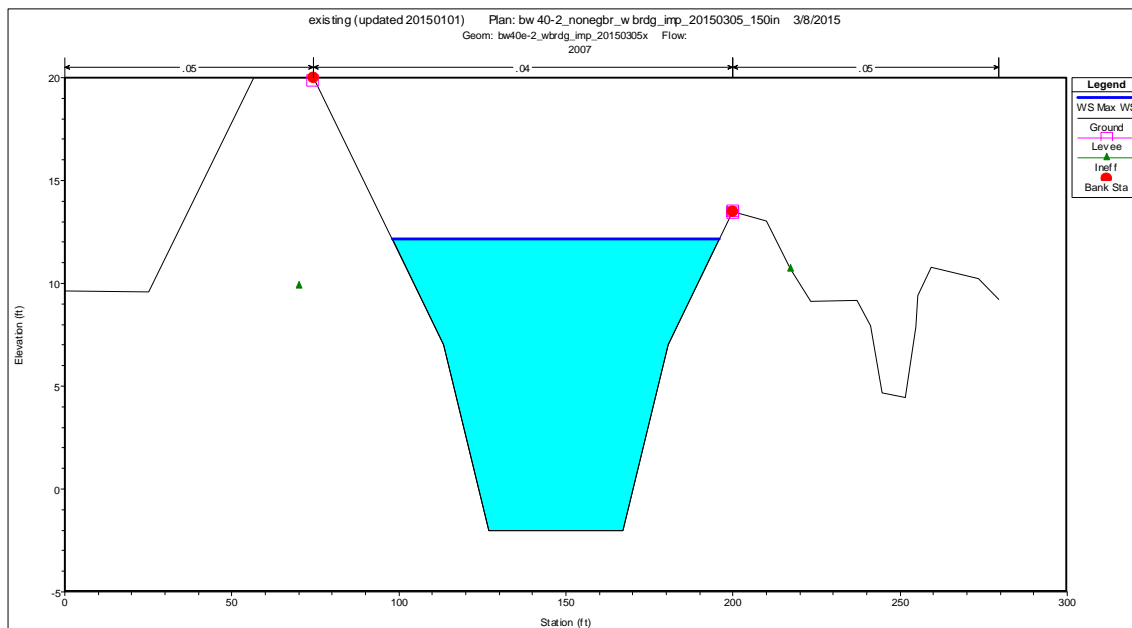


Figure 4.19 - Alt 2 - Canal and Bridge Improvements



4.3.3 Canal Flows

The Flow values for the alternative scenarios are provided in **Tables 4.4 to 4.8** below, along with the existing condition (repeated here for reference). The numbers readily show the improvement of flow values making their way to the either end of the Bolles East (L16) Canal.

Table 4.4 - Flow Values (cfs) for Removal of 0.75-inch Over Contributing Area

	Exist	Alt 1	Alt 2
NNR Canal	526	819	952
Hillsboro Canal	545	625	558

Table 4.5 - Flow Values (cfs) for Removal of 1.0-inch Over Contributing Area

	Exist	Alt 1	Alt 2
NNR Canal	561	850	952
Hillsboro Canal	617	677	598

Table 4.6 -Flow Values (cfs) for Removal of 1.25-inch Over Contributing Area

	Exist	Alt 1	Alt 2
NNR Canal	580	852	952
Hillsboro Canal	643	681	600

Table 4.7 - Flow Values (cfs) for Removal of 1.5-inch Over Contributing Area

	Exist	Alt 1	Alt 2
NNR Canal	611	880	952
Hillsboro Canal	672	700	626

Table 4.8 - Flow Values (cfs) for Conveyance from Hillsboro Canal to NNR Canal

	Exist	Alt 1	Alt 2
NNR Canal	111	166	575
Hillsboro Canal	111	166	575

4.3.4 Canal Velocities

The maximum velocity values along the Bolles East (L16) Canal for the Alternative scenarios are provided in **Tables 4.9 to 4.13** below, along with the existing condition (repeated here for reference). Values highlighted in yellow indicate velocity values that exceed 2.5 feet per second. These elevated values raise concern regarding erosive conditions that could pose a risk to the stability of both the canal bank and the crossing structures. The problem appears in Alt 1, the alternative of canal improvements without the corresponding bridge improvements because the canal improvements alone allow greater volumes of runoff to be conveyed to the crossings where the restrictions still remain. The head differential drives the



velocities up through the crossings. This situation must be more closely evaluated if the decision is made to move forward with only canal improvements.

Table 4.9 - Maximum Velocities (ft/s) for Removal of 0.75-inch Over Contributing Area

MODEL RIVER MILE		EXIST	ALT 1	ALT 2
6281	Star Farms Br, W	2.12	3.84	1.13
6311	Star Farms Br, E	1.8	3.19	1.13
10046	Kennedy Farms Br, W	2.13	5.08	1.05
10090	Kennedy Farms Br, E	2.13	4.97	1.04
12771	Boca Chica Rd Br, W	2.02	4.69	0.89
12829	Boca Chica Rd Br, E	2.02	4.46	0.89
23552	Duda Road culverts, W	0.28	0.16	0.09
23622	Duda Road culverts, E	0.19	0.04	0.08
37788	Jett Farms Br, W	2.32	2.08	0.40
37844	Jett Farms Br, E	2.32	2.20	0.40
47107	Browns Farm culverts, W	1.22	1.37	1.24
47208	Browns Farm culverts, E	0.05	0.06	0.01

Table 4.10 - Maximum Velocities (ft/s) for Removal of 1.0-inch Over Contributing Area

MODEL RIVER MILE		EXIST	ALT 1	ALT 2
6281	Star Farms Br, W	2.23	3.98	1.13
6311	Star Farms Br, E	1.89	3.31	1.13
10046	Kennedy Farms Br, W	2.23	5.25	1.05
10090	Kennedy Farms Br, E	2.23	5.12	1.03
12771	Boca Chica Rd Br, W	2.16	4.87	0.87
12829	Boca Chica Rd Br, E	2.19	4.6	0.88
23552	Duda Road culverts, W	0.21	0.11	0.08
23622	Duda Road culverts, E	0.19	0.01	0.08
37788	Jett Farms Br, W	2.43	2.03	0.40
37844	Jett Farms Br, E	2.44	2.14	0.40
47107	Browns Farm culverts, W	1.36	1.46	1.32
47208	Browns Farm culverts, E	0.06	0.07	0.01



Table 4.11 - Maximum Velocities (ft/s) for Removal of 1.25-inch Over Contributing Area

MODEL RIVER MILE		EXIST	ALT 1	ALT 2
6281	Star Farms Br, W	2.28	3.99	1.13
6311	Star Farms Br, E	1.94	3.31	1.13
10046	Kennedy Farms Br, W	2.29	5.26	1.05
10090	Kennedy Farms Br, E	2.29	5.13	1.03
12771	Boca Chica Rd Br, W	2.26	4.88	0.87
12829	Boca Chica Rd Br, E	1.19	4.61	0.88
23552	Duda Road culverts, W	0.21	0.10	0.08
23622	Duda Road culverts, E	0.19	0.02	0.08
37788	Jett Farms Br, W	2.50	2.03	0.40
37844	Jett Farms Br, E	2.52	2.14	0.40
47107	Browns Farm culverts, W	1.40	1.47	1.32
47208	Browns Farm culverts, E	0.06	0.07	0

Table 4.12 - Maximum Velocities (ft/s) for Removal of 1.5-inch Over Contributing Area

MODEL RIVER MILE		EXIST	ALT 1	ALT 2
6281	Star Farms Br, W	2.38	4.11	1.13
6311	Star Farms Br, E	2.02	3.41	1.13
10046	Kennedy Farms Br, W	2.38	5.42	1.05
10090	Kennedy Farms Br, E	2.38	5.25	1.02
12771	Boca Chica Rd Br, W	2.39	5.05	0.86
12829	Boca Chica Rd Br, E	1.22	4.72	0.86
23552	Duda Road culverts, W	0.22	0.07	0.06
23622	Duda Road culverts, E	0.20	0	0.06
37788	Jett Farms Br, W	2.57	2.07	0.42
37844	Jett Farms Br, E	2.59	2.18	0.42
47107	Browns Farm culverts, W	1.46	1.51	1.37
47208	Browns Farm culverts, E	0.06	0.07	0.03



Table 4.13 - Maximum Velocities (ft/s) for Conveyance from Hillsboro Canal to NNR Canal

MODEL RIVER MILE		EXIST	ALT 1	ALT 2
6281	Star Farms Br, W	0.64	0.96	0.79
6311	Star Farms Br, E	0.52	0.79	0.79
10046	Kennedy Farms Br, W	0.91	1.67	0.78
10090	Kennedy Farms Br, E	0.93	1.73	0.78
12771	Boca Chica Rd Br, W	1.21	1.9	0.78
12829	Boca Chica Rd Br, E	1.21	1.81	0.77
23552	Duda Road culverts, W	0.39	0.8	0.75
23622	Duda Road culverts, E	0.28	0.42	0.75
37788	Jett Farms Br, W	0.66	0.81	0.72
37844	Jett Farms Br, E	0.66	0.85	0.72
47107	Browns Farm culverts, W	0.24	0.36	1.34
47208	Browns Farm culverts, E	0.24	0.36	1.25

4.4 Conclusions and Recommendations

Preliminary modeling indicates that channel improvements are needed, both to improve the removal efficiency for the adjacent landowners and the conveyance capacity for the District. While channel improvements alone improve some of the restrictions, bridge improvements are also needed to take advantage of canal improvements constructed at a significant cost.

Should channel improvements alone be pursued, it is recommended that erosion controls at each bridge crossing be increased to withstand the increased velocities anticipated as a result of the channel improvements.

4.5 References

<http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html> - for vertical datum conversion in the vicinity of the project site.

Preliminary Hydraulic Evaluation Report for Bolles and Cross Canals. JMJV, 2004.

Preliminary Hydraulic Design of L16 Channel Improvements. Wilsnack, M.M., 2014.

HEC-RAS User Manual, Version 4.1.0, January 2010. U.S. Army Corps of Engineers, CPD 68.



5.0 SUBSURFACE CONDITIONS

5.1 Site Specific Soils and Geology

To explore the subsurface conditions at the Project site, seven Standard Penetration Test (SPT) borings were performed by Independent Drilling, Inc. under the supervision of Ardaman and Associates, Inc. personnel. The location of these borings is shown in **Figure 5.1**. The field work was conducted between January 22 and 28, 2015. Six borings were generally distributed along length of the SFWMD Bolles East (L16) Canal and one boring was performed in the NNR (L19) Canal. The boring in the NNR Canal was located approximately 2.5 miles south of the confluence of the NNR (L19/L20) Canal, the Bolles West (L21) Canal and the Bolles East (L16) Canal. The boreholes were advanced using rotary-wash drilling methods, with sampling performed in accordance with the procedures described in ASTM D-1586. All borings except boring B-4 were performed using an amphibious drill rig within in the Bolles East (L16) Canal and the NNR (L19/L20) Canal to a depth of 40 feet below the mudline. The water in the Bolles (L16) Canal was approximately 6 to 8 feet in depth and the water in the NNR (L19) Canal was approximately 17 feet in depth. Boring B-4 was performed using a truck mounted drilling rig to a depth of approximately 60 feet below grade. Detailed boring logs and a subsurface profile are located in the geotechnical report included in **Appendix 5-2**.

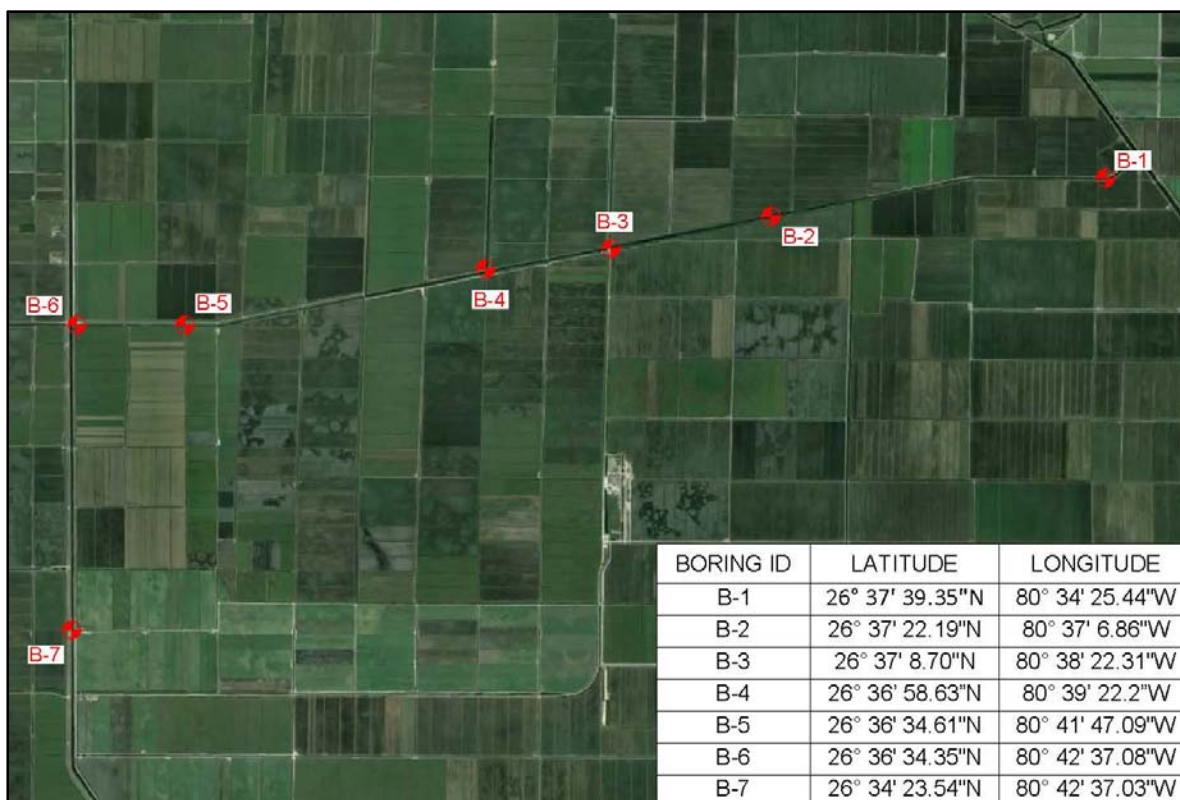


Figure 5.1 - Boring Locations



The subsurface conditions within the canal at the explored locations consist generally of a thin surficial layer of soft silts and organics ranging in thickness from a few inches to 4 feet followed by alternating layers of moderately hard to hard, slightly silty to silty, poorly cemented sand and shell and loose to medium dense, slightly silty to silty fine sand with varying amounts of shell and cemented fragments to the termination depth of our boring at about 40 feet below the mudline. At the location of boring B-4, which was performed on north embankment of the canal, approximately 3 feet of limerock fill material was encountered followed by soft silty organics to a depth of about 7 feet, in turn followed by alternating layers of moderately hard to hard, slightly silty to silty, poorly cemented sand and shell and loose to medium dense, slightly silty to silty fine sand with varying amounts of shell and cemented fragments to the termination depth of our boring at about 60 feet below the ground surface. The poorly cemented sand and shell stratum may also be considered a limestone and includes erratic hard lenses. In general, the weathered limestone/cemented sand and shell stratum immediately underlying the soft canal deposits are relatively hard and well cemented.

The drillers observed groundwater in borehole B-4 at a depth of approximately 8.0 feet below the ground surface. In general, the groundwater levels along the canal banks are controlled by the surface water levels of the canal, with the groundwater in the banks typically within a foot or so of the canal surface water elevation.

5.2 Discussions and Recommendations

It is evident that hard limestone will have to be removed to increase the depth of the channel. Cofferdams (earthen plugs) are anticipated to be installed in the canal to allow dewatering which would allow the placement of excavating equipment directly at the bottom of the canal. Blasting may or not be needed to allow the removal of the upper limestone layer. Indiscriminate blasting may not be prudent in the vicinity of bridges and culverts.

Cuts into the area limestone typically withstand slopes steeper than one horizontal to one vertical, and even some minor overhangs of harder surface layers. A slope of 1.5 Horizontal to 1.0 Vertical should be satisfactory. Considering the width of the channel, it does not appear that the slope of the channel side will influence the flow capacity to any significant degree. The sides of the canal appear to have an organic soil layer which may have been given a cover of limerock produced during the excavation of

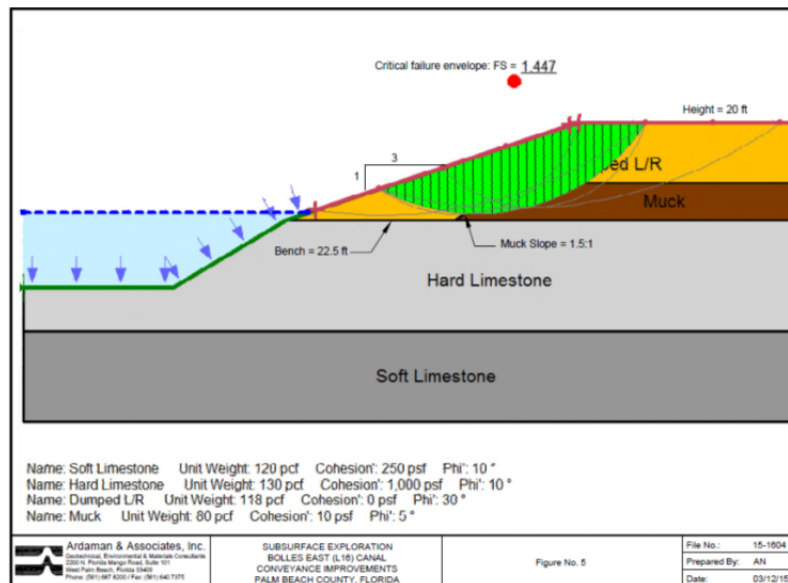


Figure 5.2 - Bolles East (L16) Canal looking west at Station 487+50 (Star Farms Bridge)



the canal (at least along some canal segments). It would appear that it would be best if the organic soils could be removed when the given canal segment is dewatered, with the material to be replaced with limerock obtained from the bottom of the canal. The limerock fill would be shaped with a bulldozer and its upper surface compacted with a heavy vibratory roller. For a demucked strip 12 feet wide and a fill height of 12 feet it is anticipated that the slope of the fill wedge can be given a slope of 3 Horizontal to 1.0 Vertical. If the sides of the canal are not demucked then the fill material will tend to compress the organics and displace them laterally. We tentatively recommend a slope of 5 Horizontal to 1.0 Vertical in the organics with a slope of 5 Horizontal to 1.0 vertical in the limerock fill. The slope would be shaped not earlier than a week after the placement of the fill. We recommend that auger borings be performed along the banks of the canal to determine the thickness of the organics in case it is desired to remove them, so that an estimate of the quantity to be removed can be made.

Four alternative sections were evaluated for slope stability. It appears that a reasonable safety factor for an embankment constructed on a strip section of rock on the canal side toe and muck on the opposite side given a maximum embankment height would be suitable for this construction.



Future projects that include replacement of existing bridges with new bridges may be supported on prestressed concrete, driven piles installed with their tips bearing on the limestone underlying the area. It is evident that pre-augering the pile locations to a depth of at least 5 feet into the underlying limestone will be required. We preliminarily estimate that 18 inch square piles should easily carry up to 80 tons each when sufficiently embedded into the limestone; however, further analyses is needed once a plan has been developed. Furthermore, the Pile Driving Analyzer (PDA) method is to be used to determine the actual pile embedment and pile driving criteria required to attain the design capacity of the piles. The lateral capacity



of the piles will depend on the embedment depth and unsupported lengths, with the possible use of batter piles to provide transverse stiffness. In any case, piles should be spaced a minimum of 4 feet (center-to-center) to provide a reasonable measure of lateral pile capacity and to promote the independent behavior of the individual piles in axial capacity.

Table 5.1 below provides a conservative estimate of the engineering properties of the soils/limestone present within the explored depths.

Table 5-1: Recommended Engineering Properties for Geotechnical Design

MATERIAL DESCRIPTION	MOIST UNIT WEIGHT (pcf)	SATURATED UNIT WEIGHT (pcf)	INTERNAL FRICTION ANGLE (degrees)	COHESION (psf)
Slightly silty to silty fragmented limestone. Hard, relatively well cemented	140	140	40	500*
Slightly silty to silty fragmented limestone. Moderately hard, poorly cemented with erratic hard/well cemented lenses.	120	120	35	50*
Loose to medium dense, slightly silty to silty fine sand with varying amounts of shell fragments and limestone fragments	110	120	35	0
Soft silt and organics	80	100	0	0.5

The effective unit weight can be obtained using the following equations:

Above groundwater level: $\gamma_{\text{EFFECTIVE}} = \gamma_{\text{MOIST}}$

Below groundwater level: $\gamma_{\text{EFFECTIVE}} = \gamma_{\text{SATURATED}} - \gamma_{\text{WATER}}$

*The cemented sand and shell limestone formation is relatively hard/well cemented beneath the soft canal deposits and will require the use of heavy duty excavation equipment and/or blasting. Note that the strength properties listed in the table above are conservative estimates recommended for use in the engineering design, taking into consideration the presence of fractures and weak layers in the heterogeneous rock mass. The limestone, particularly the more weathered near-surface stratum, is likely to have a significantly higher strength, with compressive strengths in excess of 2500 psi.

5.3 Sediment Analysis

J-Tech performed limited sediment analysis to determine potential contamination that would affect the excavation process for the Bolles East (L16) Canal Project and to ensure proper handling of excavated material. The process of excavating these materials will cause some mixing of sediment and rock material. To allow the District to assess the contaminate reduction during the excavation process J-Tech conducted a limited canal sediment sampling for organochlorine pesticides, chlorinated herbicides, and metals. Eighteen (18) locations within the Bolles East (L16) canal were selected along the 9-miles with one sediment sample collected from each estimated 0.5 mile section.



The limited sediment analysis completed by J-Tech at the Bolles East (L16) Canal revealed the presence of DDT metabolites DDE and DDD in concentrations above the PEC criteria stipulated in FDEP's SQAGs for Florida Inland Waters. The PECs are intended to identify chemicals of potential concern (COPC) concentrations above which harmful effects on sediment-dwelling organisms are likely to be frequently, or always, observed. Detailed sampling results are provided in **Appendix 5-3**.

Alternatives for handling of the fine sediments are outlined in **Appendix 5-3**. It is recommended, however to incorporate the muck into the excavated material used to build the levee within the District ROW and thereby sequester the material onsite.



6.0 BOLLES EAST (L16) CANAL ALTERNATIVES

The existing Bolles East (L16) Canal connects the Hillsboro (L15) Canal with the NNR (L19/L20) Canal. The connection with the NNR (L19/L20) Canal is an open connection and the connection with the Hillsboro Canal (L15) is via five 72" CMP culverts under the Brown's Farm Road crossing. Flow in the canal is typically split with the western portion of the canal (west of Duda Road) flowing to the NNR (L19/L20) Canal and the eastern portion of the canal flowing east to the Hillsboro (L15) Canal. The Duda Road crossing that is located near the midpoint of the canal and has three 42" CMP culverts. The Bolles East (L16) Canal provides both irrigation water supply and drainage to adjacent landowners and is not frequently used for inter-basin transfers of water due to the limited capacity of the canal. The Bolles East (L16) Canal capacity is limited based on the following:

- The connection to the Hillsboro Canal consisting of five 72" CMP Culverts.
- Generally the canal section is irregular and is shallow.
- The Duda Road crossing consisting of three 40" CMP culverts which significantly restrict the ability to cross flow water in the canal.
- There are four existing bridges that cross the canal to provide access across the canal to the landowners. These bridges vary in size; however all of the bridges encroach on the canal cross section.

The largest inflows to the canal are flows generated by the discharge of stormwater runoff pumped from the adjacent farmlands. The Hillsboro (L15) and the NNR (L19/L20) canal are designed for a removal rate of 3/4" of an inch of runoff in 24 hours from the basin. However, the adjacent landowners' pumps have much greater capacity. This can result in periods when the landowners' pumped volume exceeds the capacity of the canal and waters overtop existing canal banks.



Figure 6.1 - Jett Farms Bridge at Station 803+00



Based on input from District staff, the landowners' representative and a preliminary evaluation of the available survey data, two design cross sections were initially proposed. Both cross sections proposed side slopes of 1(H):1(V) in the rock (generally below elevation 6 NAVD) and 3(H):1(V) in the organic (muck) above the rock. These two initial alternatives are described as follows:

- Initial Alternative 1 - 30 foot wide section with an invert of El. 0 NAVD
- Initial Alternative 2 - 60 foot wide section with an invert of El. 0 NAVD

Based on preliminary modeling and the development of canal cross sections, the District directed J-Tech to move forward with a design section with a 60 foot wide bottom and an invert of elevation 0 NAVD. This was done to maximize the ability to flow water east or west through the Bolles East (L16) Canal to allow better distribution of water between the STAs.



Figure 6.2 - Farm ditch and water control structure on south side of the Bolles East (L16) Canal Station 554+00 (west of Boca Chica Bridge)

After the receipt of the geotechnical report, the design of the canal side slopes in the rock was revised to 1.5(H):1(V). Additionally, during progress meetings with the representative for the adjacent landowners, J-Tech was directed by District Staff to revise the SOW to include the reconstruction of farm ditches and farm roads located within the canal ROW that will be filled with spoil from the excavation of the canal. It was requested by District staff that, to the extent possible, that only farm ditches on one side of the canal should be filled with spoil from the canal excavation. Based on these changes the preliminary design section

was altered to lower the invert of the section from elevation 0 NAVD to elevation -2 NAVD and to narrow the bottom width of the section to 40 feet. This change narrowed the top width of the canal to provide more room for the spoil pile within the Bolles East (L16) Canal right-of-way. This cross section has the same cross sectional area of rock to be excavated.

The following are the two alternatives modeled for the preliminary design submittal:

- Proposed section with 40-foot wide bottom width with an invert of El. -2 NAVD with the existing five farm bridges and culvert crossings
- Proposed section with 40-foot wide bottom width with an invert of El. -2 NAVD with new farm bridges that match the proposed cross section of the canal



There are four typical sections discussed in Section 8 – SITE CIVIL DESIGN. All of the sections share the same cross section excavated from the rock, the cross sections vary based on the placement of the spoil and the construction of replacement farm roads and ditches, to replace ones filled during construction. Refer to Section 8 and the construction plans for a more detailed discussion of the typical sections to be constructed.



7.0 NNR (L19/L20) CANAL HUMP REMOVAL

The study by the Jacobs MWH Joint Venture (JMJV) identified two “humps” in the NNR (L19) Canal that, if removed, could improve the capacity of the NNR (L19) Canal. Survey information provided by the District indicated the “humps” were located in the NNR (L19) Canal immediately south of the confluence of the Bolles West (L21) Canal, the Bolles East (L16) Canal and the NNR (L19/L20) Canals and a second location approximately 2.5 miles south of this first “hump” location. Betsy Lindsay, Inc., a J-Tech subconsultant land surveyor, surveyed the canal by first surveying a profile of the canal and then surveying canal cross sections at 200 foot intervals. Also included were probes of the bottom of the canal to determine the thickness of any accumulated organic (muck) material on the bottom of the canal.

The design section of the NNR (L19), per the USACOE record drawings, was designed with a width of 22 feet with side slopes of 1(H):1(V). The invert of the north design section was elevation of -16.1 FT NAVD (-14.8 feet MSL) and the invert of the south design section was elevation -14.1 FT NAVD (-12.7 feet MSL). The as-built cross sections show the canal was constructed wider and slightly lower than designed.

The survey data collected for this Project shows that the NNR (L19) canal has elevations significantly higher than the design or as-built elevations. The profile of the bottom of the canal generally varies between elevations -3 and -9 FT NAVD. At the confluence of the Bolles (L16/L20) Canal and the NNR (L19/L20) Canals there is an area that appears to be a scour hole that is as deep as elevation -15 FT. Because the SOW limits the Project to the removal of the “humps” at the two specific locations, the construction plans are based on removing the portions of the canal higher than adjacent grades, not restoring the canal to the deeper design section. The high areas were defined by reviewing the elevations within the Project limits. Based upon probes performed by the surveyor and a geotechnical boring (boring B-7) this material appears to be organic (muck) material. Based on the boring the proposed side slope will be 1.5(H):1(V).

The north “hump” begins at the confluence of the Bolles (L16/L20) Canal the NNR (L19/L20) Canals (Station 334+00) and extends south approximately 1,400 feet (Sta. 348+20). Based on the available information, the profile of the existing canal bottom is proposed to be lowered from El. -5+/- to El. -8+/- with a bottom width of 38 feet. The preliminary estimate of the volume of material to be excavated is 6,700 CY.

The south “hump” generally begins at Station 462+18 and extends approximately 800 feet to the south to Station 470+37. Based on the available information, the existing profile of the canal bottom for this portion of the canal varies from El. -3+/- to El. -7+/- . The profile of the bottom of the canal is proposed to be lowered to El. -9 with a bottom width of 28 feet to match up and downstream conditions. The preliminary estimate of the volume of material to be excavated is 6,200 CY.



The survey and geotechnical information gathered to date indicate that the excavated material will consist of accumulated organic (muck) material. The SOW did not include sediment samples from the NNR (L19) Canal. We recommend that samples of this material be obtained and analyzed to confirm the nature of the material that is proposed to be excavated. It is anticipated that the nature of the material will be similar to the Bolles East (L16) Canal and will have levels of DDT and its metabolites DDE and DDD in excess of the limits of the FDEP Sediment Quality Assessment Guidelines. If true, this will result in the material being required to be sequestered onsite or hauled offsite to a suitable disposal site.

Based on the need to sequester the material onsite, and the depth of the canal, the right of way constraints and the need for the canal to be in operation, the use of a hydraulic dredge will likely be the most cost effective way to excavate this material. The material will be placed in geotextile tubes on the maintenance bench on east side of the canal. The geotextile tubes will allow the dredged material to be dewatered within the right of way. The geotextile tubes are very effective at reducing the turbidity that is typically generated while dredging. The contractor will also likely include a flocculent to promote the settling of the dredged material.



8.0 SITE CIVIL DESIGN

8.1 Topographic Survey

The preliminary design of the project is based on the following boundary and topographic surveys that were provided to J-Tech by the District, which are included in **Appendix 8-1**.

- SFWMD Boundary Survey North New River Canal (L-18, L-19) – F.R.S. & Associates, Inc.
- SFWMD Topographic Survey North New River Canal (L-18, L-19) – F.R.S. & Associates, Inc.
- SFWMD Topographic Survey Bolles / Cross Canal (L-16) – F.R.S. & Associates, Inc.
- SFWMD Boundary Survey Bolles / Cross Canal (L-16) – F.R.S. & Associates, Inc.
- SFWMD Bolles Canal – GCY Incorporated

To support the development of the preliminary design, additional topographic data was collected by Betsy Lindsay, Inc. for the Bolles East (L16) Canal and the NNR (L19) Canal. Survey drawings of this additional topographic data were prepared by Betsy Lindsay, Inc. and are included in **Appendix 8-2**. The following is a summary of the additional survey work performed for the Project.

Horizontal control was established from the Lengemann network. The NGS bench marks were shot with GPS/RTK from the Lengemann network to establish horizontal control on each bench mark that would be used as a base station. Vertical control was established from onsite published control. The horizontal control references state plane coordinates, reference the North American Datum of 1983/1990 adjusted (NAD 83/90), Florida East zone, US survey feet. Elevations reference the North American Vertical datum of 1988.

A base station was set up on a published control point and the job was calibrated to that point. Several check shots were taken on other published control points to verify that the data collected was accurate. The cross sections of the Bolles canal were acquired by setting up a tag line across the canal at each station. The tag line is marked in 5 foot increments. The field crew used the tag line to keep the canoe on line and to keep the shots spaced at equal increments. GPS with RTK was used to collect the cross sections. The GPS receiver was mounted on the top of 25 foot telescoping rod and the soundings in the river and the ground shots were taken with this equipment configuration. The rock probes were acquired with a range pole driven to rock. Each rock shot in the Bolles East (L16) Canal resulted in a definite audible “ping” sound as the rod connected with the rock.

The land and shallow water shots on the NNR (L19) Canal were acquired using the GPS receiver mounted on the 25 foot telescoping rod. The soundings in the NNR (L19) Canal were acquired using a Sonarmite eco-sounding portable blue tooth hydrographic survey system. The system is an integration of the Trimble ‘GeoExplorer XT’ sub-meter handheld GPS with the Ohmex ‘SonarMite’ portable DSP echo sounder with a single beam running at a frequency of 200 KHz with a beam width of 4 degrees and a ping rate of 6Hz, producing a depth accuracy of 0.1%. The rock probes were acquired using 40 feet of copper rod. The rod



was pushed through the muck and hammered to refusal. The crew did not get a definite rock “ping” from the rock probes in the NNR (L19) Canal.

8.2 Proposed Canal Excavation

8.2.1 Proposed Construction Sequence

Based on previous and similar projects it is anticipated that the contractor will excavate/dredge the canal “in the dry”, in segments 400 to 600 feet in length. The actual length will be determined based on site specific field conditions (e.g. pump stations, bridges, and other property constraints). The contractor will construct temporary earthen cofferdams at each end of the excavation segment and install dewatering pumps. The dewatering effluent will be discharged into a settling basin formed from the previous (adjacent) excavation. The settling basin will have a water control structure to discharge the water downstream. Turbidity curtains will be installed to control the discharge of turbid water.

Prior to initiating excavation of each segment, the contractor will clear and grub the area adjacent to the canal that the spoil will be placed. It is anticipated that the contractor will blast the rock as the most efficient way to prepare the rock for excavation. The contractor will first drill for blasting and will then “shoot” the rock with the intent of minimizing any additional processing of the rock. The side slopes adjacent to the canal will consist of rock to ensure that the spoil pile is stable. The contractor will then excavate the rock material from the canal and spread, shape and compact it to form the embankment. A layer of organic material approximately 6” in thickness will be spread on the outside of the embankment to promote the growth of grass to stabilize the slopes.

Upon completion of the canal embankment the contractor will begin construction of the replacement farm ditch and road within the TCE. It is anticipated that the landowners will be willing to accept the non-contaminated organic material (muck) from these areas for future use. Based on this assumption, the contractor will scrape this area to the top of the underlying rock layer and push the organic material to the edge of the TCE for utilization by the landowner. Excavation of the replacement farm ditch is anticipated to be completed with tracked excavators equipped with a rock bucket, it is uncertain if blasting will be required. The material excavated from the replacement ditch will be utilized to construct the replacement road. It may be necessary to crush the material to obtain material acceptable for road construction. Material from the Bolles East (L16) Canal excavation may also be used to construct the road. It may be possible to provide additional organic material from the existing (historic) levees, within the Bolles East (L16) Canal ROW to the landowners, however the material has not been tested for contaminants. J-Tech will discuss this issue with District Staff and the landowners’ representatives to determine if this option should be pursued. The replacement road and ditches will be connected to the existing road and ditches. Any material excavated within the Project’s limits of construction, that is disposed of off-site (i.e. outside the Project’s limits of construction) will require the review and approval under the appropriate regulatory programs.



At existing pump stations, water control structures, bridges and open canal connections the spoil pile will be interrupted so that these facilities can remain. This will result in sections of the canal bank that have a lower level of flood protection. It may be necessary to replace certain connecting culverts or portions of these pipes where the canal is being excavated, if the pipes are in poor condition.

8.2.2 Typical Canal Sections

The Bolles East (L16) Canal was divided into reaches to develop typical sections. All of the typical sections are based on side slopes excavated in the rock (typically below El. 6.5 NAVD) to be 1.5(H):1(V). The slopes excavated in the organic (muck) material are cut at a 3(H):1(V). The side slopes of the spoil pile are 3(H):1(V). The top of the spoil pile is sloped at 2% toward the outside of the right of way.

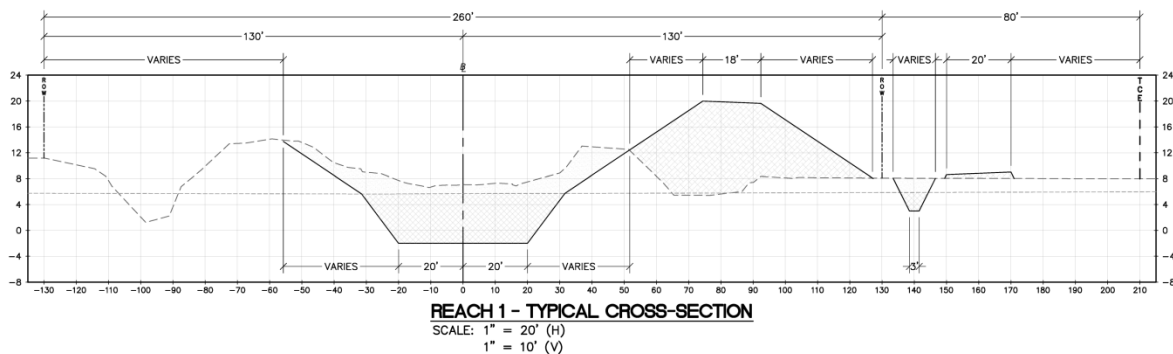
It should be noted that in order to minimize the offsite disposal of excess cut materials (and associated costs), that it is proposed and the District agreed to variances in the District Standard Guidelines provided in the District Engineering Standards. The variances result in a smaller canal and embankment footprints and reductions in the overall earthwork.

The replacement farm ditch has an invert of El. 3 NAVD and has a three foot wide bottom. The side slopes are consistently 1(H):1(V) in both rock and muck. This is consistent with the existing ditches. It is anticipated that the design will be refined after meetings with landowners. The proposed replacement farm road is 20 feet wide and will be constructed approximately 6" above existing grade. Preliminary estimates were based on placing the rock on top of the existing organic (muck) material; however, landowners may want the organic material to replenish adjacent fields. This will be explored in meetings with landowners. The road may also provide opportunities to place surplus material that is proposed to be exported offsite.



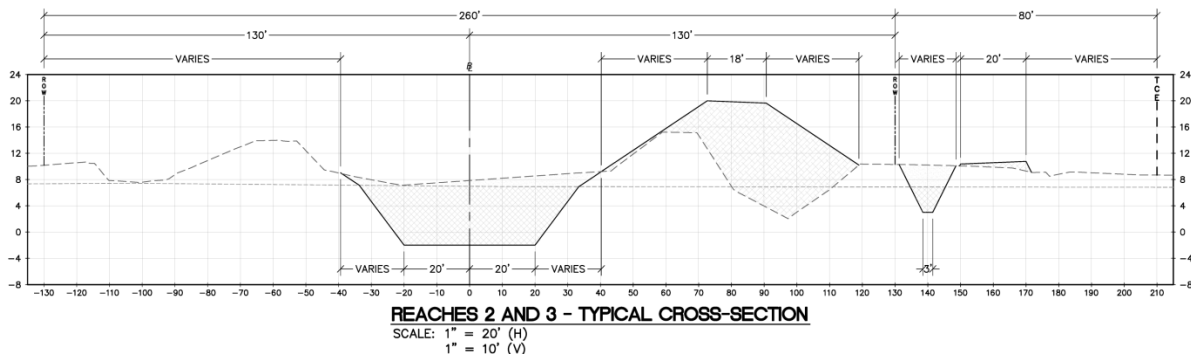
8.2.2.1 Reach 1A, 1B and 1C (Station 424+80 to Station 552+06)

Reach 1A begins at the confluence of the NNR (L19/L20) Canal, the Bolles West (L21) Canal and the Bolles East (L16) Canal and ends at the west side of the Boca Chica Bridge. The existing canal section is narrow, County Road 827 is located on the north side of the canal (outside of the right of way) and there are existing overhead utilities on the north side of the canal right of way. The proposed typical section places all of the spoil on the south side of the Canal to avoid delays and cost to relocate the overhead utilities in the right of way on the north side of the canal. The decision to place the spoil only on the south side of the canal results in a surplus of material. This requires that approximately 75,000 CY of material be exported offsite. This section includes a replacement ditch and farm road on the south side of the canal within an 80 foot wide TCE.



8.2.2.2 Reach 2-3 (Station 553+66 to Station 659+66)

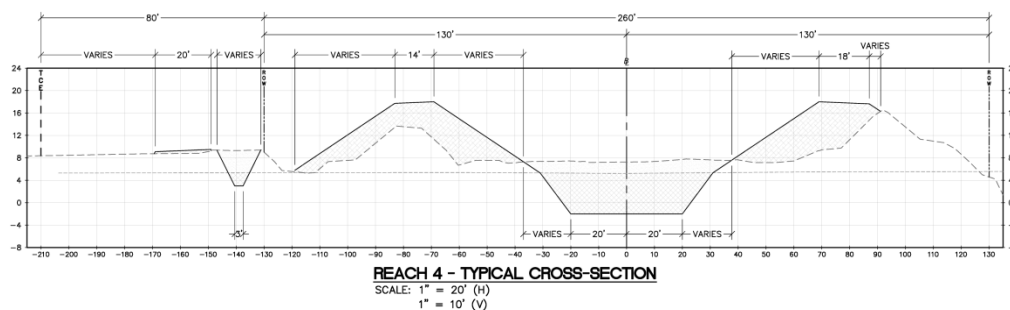
Reach 2-3 begins on the east side of the Boca Chica bridge and continues to west side of the Duda Road culvert crossing. County Road 827 turns to the north at the Boca Chica bridge, however the overhead utilities continue on the north side of the canal until Duda Road. The existing canal cross section widens significantly compared to Reach 1A, 1B and 1C. The proposed typical section places all of the spoil on the south side of the Canal to avoid delays and cost to relocate the overhead utilities in the right of way on the north side of the canal. The section is close to balancing the cut and fill volumes and will be further refined before the Final Design submittal. This section includes a replacement ditch and farm road on the south side of the canal within an 80 foot wide TCE.





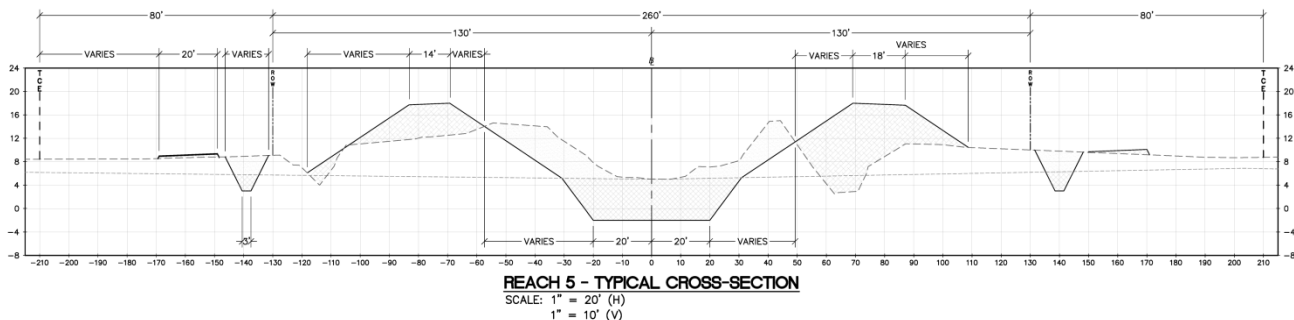
8.2.2.3 Reach 4 (Station 661+90 to Station 802+25)

Reach 4 begins on the east side of the Duda Road Culvert Crossing and ends to the Jett Farms bridge. This reach of the canal is the widest existing section and includes areas with shallow islands. Due to the width of the existing section some portions of the existing shallow canal are filled due to constraints in placing spoil and the proposed typical section places spoil material on both sides of the canal. The canal requires the spoil be placed on both sides of the canal because the existing canal section is wide and because the proposed section cuts significantly into the existing weak non-engineered berm on the north side of the canal. This section includes a replacement ditch and farm road on the north sides of the canal within an 80 foot wide TCE. The section is close to balancing the cut and fill volumes and will be further refined before the Final Design submittal.



8.2.2.4 Reach 5A, 5B and 5C (Station 803+79 to Station 895+83)

Reach 5A begins on the east side of the Jett Farms bridge and continues to end of the project at the Brown's Farm Road culvert crossing. The existing canal cross section narrows compared to the majority of Reach 4 and a very large existing farm ditch is located immediately adjacent to the south side of the canal for most of Reach 5. Additionally, the existing berm located on the south side of Reach 5 is very narrow. The majority of Reach 5 has a wide road on the north side of the canal. The right of way narrows at the east end of Reach 5 approximately Station 876+00. The typical section for the western portions of Reach 5 includes spoil piles on both sides of the canal due to the proposed section cutting into the berm on the north side of the canal. However, for the eastern most portion of the reach the spoil pile is only proposed on the south side. The typical canal section was shifted to the south side of the construction baseline due the narrowness of the right of way. The cut and fill balances for this section of the canal. This section includes a replacement ditch and farm road on the both sides of the canal within an 80 foot wide TCE.





8.2.3 Need for Additional Data

The existing SOW excluded work outside of the Bolles East (L16) Canal right-of-way. Additionally, the SOW was heavily reliant on topographic survey information previously obtained by the District. Because of the addition of the replacement farm ditches and roads, J-Tech recommends that additional topographic survey information be obtained. This information will be used to determine the depth of the organic material and to provide information to more accurately design the Project.



9.0 SPECIAL CONSIDERATIONS

9.1 Existing Utilities

The project is located in the EAA which is generally rural and without significant development. Based on the review of previous reports and the project site visit, it appears that overhead utility lines for electric distribution and telephone service are the only utilities within the project limits. Overhead utilities are located on both the east and west side of US Highway 27 and along the south side of CR 827 starting at the



Figure 9.1 - Bolles East (L16) Canal looking east at Station 525+70 (Kennedy Farms Bridge)

into a north-south transmission line.

intersection with US Highway 27. The overhead utilities are located on the north side of CR 827 for approximately 580 feet east of US Highway 27 and then the lines move to the south side of CR 827. The overhead utilities are located within the Bolles East (L16) Canal right-of-way. The overhead lines cross the Bolles East (L16) canals at numerous locations, primarily to serve agricultural buildings and pump stations on both the north and south sides of the road. CR 827 turns north at the Boca Chica Bridge, approximately 2.5 miles east of US Highway 27. The overhead utilities continue east

along the north side of the Bolles East (L16) Canal right-of-way to Duda Road where they then tie

It does not appear that there are buried utilities within the project limits, although it should be noted that buried fiber optic and gas lines run north/south along US Highway 27 on the west side of the NNR (L19/L20).

9.2 Existing Infrastructure

Landowners have numerous water management facilities located within the Bolles East (L16) Canal right of way. These facilities include pump stations, water control structures and culverts. Additionally, there are numerous open connections from ditches. Generally, these facilities will not be disturbed with the proposed canal expansion. The proposed spoil pile will be interrupted at these locations to avoid disturbing them. This will result in portions of the proposed spoil pile at much lower grades, potentially decreasing the level of flood protection at these locations. Preliminary modeling has shown a decrease in the profile of the hydraulic grade line of the canal; however it will need to be compared to the profile of the proposed berm. The level of flood protection will not be any lower than the existing condition.



This phase of the project will not include the replacement of existing bridges or culvert crossings. However, preliminary modeling indicates that the velocity of the water under the bridges will increase and armoring of the bridges may be required to prevent scour. This is problematic in that several of the bridges are in poor condition and work around the bridges could cause them to be damaged, resulting in claims from the landowner. This issue will be fully addressed in the final design submittal. See Figure 2-4 and Table 2-3 in the EAA Bolles Canal Improvements Project Draft BODR by EarthTech included in **Appendix 1-1** for a map with corresponding tables showing existing structures and facilities along the Bolles East (L16) Canal, that were originally developed during the JMJV 2004 report.

9.3 Manatee Protection

The Florida Fish and Wildlife Conservation Commission's Central and Southern Florida Project Manatee Accessibility Map, dated 2006 (included in **Appendix 9-1**) indicates that the Bolles East (L16) Canal and the NNR (L19/20) Canal are not accessible to manatees. Therefore, manatee protection measures should not be required for the construction of this project.

9.4 Issues Requiring Resolution

The following are issues that been raised during the preliminary design and require resolution prior to the submittal of the Final Design:

- Preliminary modeling shows a significant construction at the Duda Road Crossing. Additional evaluations are required to develop an acceptable dewatering plan.
- Coordination with Landowners for sequence of construction
- Location of contractor "laydown" areas
- Width of the Temporary Construction Easement
- Testing of the organic material in the existing canal embankment for contaminants
- Determination if the landowners want non-contaminated organic material
- Testing of the NNR sediment for contaminants
- The need for supplemental survey information
 - Farm fields where ditches and roads will be constructed
 - Locations where proposed ditches and roads will connect with existing
 - Locations where additional detail is needed



10.0 OPINION OF PROBABLE CONSTRUCTION COST

The Opinion of Probable Cost report is included as an attachment and is intended to provide support for the development of project Opinion of Probable Construction Costs (OPCC). It has been prepared in accordance with the Design Criteria Memorandum (DCM-7).

This OPCC is presented as an attachment to the Basis of Design Report and will be revised as a Class 3 (Preliminary), Class 2 (Intermediate) and Class 1 (Final Design) cost estimates as the project itself develops. It includes tables for volume estimates by reach for the Bolles Canal, volume estimates for the proposed Farm (Seepage) Ditch and Road, volumes estimates for the humps in the North New River Canal, and the demolition and reconstruction of the bridges.

A summary of the scope of construction included in the OPCC includes:

1. The expected level of effort to improve the conveyance characteristics of the Bolles (East) Canal,
2. Construct a new seepage (farm) ditch and new farm road south of the Bolles Canal
3. Hydraulically dredge the humps identified in the North New River Canal
4. Provide Estimates for demolishing and re-constructing four new farm service bridges over the Bolles.
5. In addition, a rough order estimate was provided for discussion for the removal and reconstruction of the Duda Road culvert crossing.

Originally no impacts to the existing farm ditches and farm roads adjacent to the Bolles were planned. All work was to remain inside the right-of-way and all impacts to the adjacent land owners would be mitigated by those land owners. The project was updated to include the relocation and reconstruction of the impacted ditches and roadways outside the Bolles right-of-way. The plans were updated accordingly and the cost estimate revised.

Previous rough order of magnitude estimates did not include the following:

- Bridge removal and replacement
- Dredging the NNR
- Construction of replacement farm ditches and roads.

These additions increased the cost by approximately \$10,000,000.



The items of work listed above were used to develop the project's **Direct Costs**. These direct costs were then marked up in accordance with the DCM-7 to include field office overhead, home office overhead, mobilization, profit and bond/insurance and develop the project's **Contractor Costs**. These contractor costs are then marked up with the SFWMD Allowance and the Class 3 contingency to develop the total **Project Cost**.

Summary Cost Estimate for Bolles Canal (East)			
Description		Amount	Net Amount
Direct Cost			
Bolles Canal			26,731,550
North New River Canal			371,914
Farm Ditch and Road			1,200,049
Bridges			6,402,540
Sub-Total: Direct Project Cost			34,706,084
Contractor Cost			
FOOH (Field Office Overhead)	15%	5,205,913	39,911,997
HOOH (Home Office Overhead)	5%	1,995,600	41,907,596
Mobilization	10%	4,190,760	46,098,356
Contractor Profit	10%	4,609,836	50,708,192
Bonds & Insurance	2%	1,014,164	51,722,356
Sub-Total: Construction Costs			51,722,356
Project Cost			
SFWMD Allowance Account (SIOH)	4%	2,068,894	53,791,250
Contingency	25%	13,447,812	67,239,062
Total: Project Cost			67,239,062

Class 3 Estimate	L: -25%	50,429,297
	H: +30%	87,410,781
Class 2 Estimate	L: -15%	57,153,203
	H: +20%	80,686,875
Class 1 Estimate	L: -5%	63,877,109
	H: +10%	73,962,968

11.0 CONSTRUCTION COORDINATION

11.1 General Coordination with Adjacent Landowners During Construction

During construction, the contractor will be required to coordinate construction activities with the adjacent landowners to minimize the impact of construction on their operations. The contractor will be required to provide a schedule and work plan prior the start of the construction. The contractor and District staff will coordinate with landowners and make adjustments to the schedule based on landowner input.

The contractor will coordinate with the landowners during construction of the new ditches and roads proposed to be constructed to replace the existing ditches and roads. The existing ditches are used by the farms for irrigation and drainage of land and to manage the water table to limit the oxidation of the soil. The existing ditches located within the Bolles East (L16) Canal right-of-way will be filled to construct the spoil pile for the material excavated from the canal. However, it is anticipated that the contractor will need



Figure 11.1 - Typical farm ditch

to utilize the proposed TCE and will be unable to construct the new farm ditch prior to the filling of the existing ditch. Prior to the Final Design submittal, J-Tech will meet with landowners and excavation contractors to determine the final location of the proposed ditches and the sequence of construction.

11.2 Dewatering Coordination

The proposed construction sequence requires that the contractor dewater the canal in sections to excavate the material from the canal. This will result in periods of time that landowners' pump stations will not be able to discharge drainage water or withdraw water from the canal for irrigation. During this time, the contractor will be required to provide temporary pumps equal in capacity to the exiting pumps at locations along the canal right of way approved by the owner.

Previous modeling has found that the Bolles East (L16) Canal generally flows in two directions, and is generally split at the Duda Road Culvert Crossing. The Duda Road Crossing is located near the midpoint of the canal between the NNR (L19/L20) Canal and the Hillsboro (L15) Canal. The proposed dewatering operation will require that the canal be temporarily blocked with temporary cofferdams so that the canal can be dewatered. When the Bolles East (L16) Canal is blocked stormwater discharge or irrigation water is passed through the Duda Road Culvert crossing.



Based on preliminary modeling the limited capacity of the Duda Road Culvert crossing will significantly restrict flow in the canal. During heavy storms this could result in landowners not being able to pump or if pumping occurs, the canal could overtop its banks. As a result, it may be necessary to temporarily or permanently upgrade the Duda Road crossing prior to the construction of the first phase of the project to alleviate this issue. Other solutions could be the requirement that the contractor suspend operations during periods of heavy rain or when demand for irrigation water is high and remove the dewatering cofferdams. This is problematic because the contractor will be in the process of degrading the existing canal berm to construct the new berm. This could result in water from the canal overflowing and flooding an adjacent property. This issue will be studied further prior to the submission on the Final Design submittal.

11.3 Contractor Access

The contractor will be required to coordinate with the landowners to obtain access to the sites via existing landowner bridges and culvert crossings. The contractor will access the site via the existing farms roads location in the Bolles East (L16) Canal right-of-way or via the TCE. The existing bridges will need to be evaluated to determine if they are of adequate strength to support the contractor's equipment. It is very likely that some of the bridges are not of adequate capacity. If they are not adequate, it may be necessary for the contractor to incorporate canal crossings into the temporary dewatering levees.

The issue of contractor access also depends on the sequence of construction for the various phases of the project. This issue will be studied further prior to the submission on the Final Design submittal.



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