McMicken Dam Rehabilitation Project

OUTLET CHANNEL ALTERNATIVES REPORT

Contract FCD 2011C030

Prepared for:

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

September 2014

Prepared by:

Gannett Fleming

Excellence Delivered As Promised

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Phoenix, Arizona 85016-4852

REGISTERED PROFESSIONAL ENGINEER (CIVIL)
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ARIZONA, U.S.A.
EXPIRES 3/31/2016

In Association with:

URS CORPORATION

GF Project No. 056312

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LIST OF ACRONYMS AND ABBREVIATIONS

ADWR	Arizona Department of Water Resources
BNSF	Burlington Northern Santa Fe
District	Flood Control District of Maricopa County
FEMA	Federal Emergency Management Agency
IDF	Inflow Design Flood
MCDOT	Maricopa County Department of Transportation
NAVD88	North America Vertical Datum of 1988
PMF	Probable Maximum Flood
Project	McMicken Dam Rehabilitation Project
RCBC	Reinforced Concrete Cox Culvert
SPF	Standard Project Flood
URS	URS Corporation
USACE	United States Army Corps of Engineers

1.0 INTRODUCTION

1.1 Purpose of Report

The purpose of the McMicken Dam Outlet Channel Alternatives Report is to evaluate alternative designs and provided recommendations for upgrading the existing Outlet Channel which was designed by the US Army Corps of Engineers 1953/54 and built in 1956 (Ref. 13: USACE, 1953, Ref. 14: USACE, 1954 and Ref. 15: USACE, 1956).

Work for this report was performed by Gannett Fleming, Inc. in association with URS Corporation (URS) for the District under Contract FCD 2011C030, Work Assignment No. 1-2.

A DVD, provided in Appendix F, includes an electronic copy of this report and electronic copies of the referenced design requirements and guidelines referenced in this report.

1.2 Proposed Outlet Channel Alternatives

The following alternatives are being investigated (refer to Figures 2-1 through 2-5 and 3-1 through 3-4):

1. **Construct New Levee with Central Filter North of Existing Levee.** The new levee will be designed to meet FEMA requirements for a minimum three (3) feet of freeboard. The existing levee will not be removed during the construction of the new levee in order to maintain the current level of flood protection during construction. The new levee would consist of a zoned earthfill structure with upstream and downstream structural fill and a central filter. The levee crest would have a 6-inch thick layer of aggregate base course.
2. **Modify Existing Levee with Upstream Filter.** The modification of the existing levee would maintain the flood protection characteristics of the existing levee and will be designed to meet FEMA requirements, included a minimum three (3) feet of freeboard. Excavation of the upstream face of the levee during construction will result in a decrease in the level of flood protection. A structural fill section would be used as cover over the filter section. The levee crest would have a 6-inch thick layer of aggregate base course.
3. **Reconstruct Excavated Outlet Channel along Existing Alignment.** The excavated Outlet Channel will eliminate the need for as much of the existing levee as feasible east of the US 60 and BNSF Railroad bridges and will be designed to meet the District's requirements for minimum one (1) foot freeboard. Both alternatives 3 and 4 are similar as they eliminate the need for much of the existing levee east of US 60.
4. **Realign Outlet Channel North.** The excavated Outlet Channel would be re-aligned to avoid the existing electrical transmission line towers. It will also eliminate the need for as much of the existing levee as feasible east of the US 60 and BNSF Railroad bridges. The new excavated channel will be designed to meet the District's requirements for minimum one (1) foot freeboard.

1.3 McMicken Dam Existing Conditions Physical Data

The physical data for McMicken Dam Rehabilitation Project are presented in Table 1 as presented in the *McMicken Dam Design Criteria Report* (Ref. 7: Gannett Fleming, April 2013). This data includes original design and as-built information collected by the District following construction. The design for the McMicken Dam Outlet Channel will need to account for the existing constraints as defined in Table 1 and follow the District design criteria and guidelines within the *Drainage Design Manual, Volume II, Hydraulics* (Ref. 6: District, 2013).

1.4 Past Modeling

The past/historic modeling provides information for the selection of the hydrologic/hydraulic parameters used in the alternatives analysis. The hydrologic and hydraulic reports/models relevant to the alternatives preparation are described below.

Hydrologic Reports/Models

A list of the drainage documents and their associated hydrologic models along with a brief description are provided below.

1. *Design Memorandum No. 1 – Hydrology and Hydraulic Design for Trilby Wash Detention Basin and Outlet Channel* (Ref. 13: USACE, 1953); The memorandum states: "The outlet channel would accommodate discharges ranging between 4,450 cubic feet per second and 14,000 cubic feet per second, including side inflows from adjacent drainage areas". The 4,450 cubic feet per second flow is used as design flow for the upstream segment of all Outlet Channel alternatives.
2. *Design Memorandum No. 2 – Design Analysis for Trilby Wash Detention Basin and Outlet Channel* (Ref. 14: USACE, 1954); A table within the memorandum provides the following breakdown in the design discharges along the Outlet Channel:

Station	Flow (cfs)
324+44 to 248+19	14,000
248+19 to 148+19	13,000
148+19 to 77+17	6,000
77+17 to 66+13	5,000
66+13 to 11+16	4,450

As stated earlier 4,450 cfs is used as design flow for the upstream segment of all Outlet Channel alternatives. The design flows for the downstream segments of all Outlet Channel alternatives are taken from the *McMicken Dam Draft Section 4 (Hydrology)* (Ref. 10: RBF, January 2013) as described below.

Please note that Figures 2 and 3 have the same stations as shown above.

3. *McMicken Dam Draft Section 4 (Hydrology)* (Ref. 10: RBF, January 2013); this partial report contains HEC-1 models for two scenarios: Scenario 1 hydrologic model considers

outflow from the dam while Scenario 2 hydrologic model considers no outflow from the dam; The downstream flows in the Outlet Channel are greater in the Scenario 2 hydrologic model and are consequently used for design of the Outlet Channel alternatives; Although the *McMicken Dam Draft Section 4 (Hydrology)* (Ref. 10: RBF, January 2013) is superseded by *McMicken Dam Outlet Wash Floodplain Delineation Study (FDS) Technical Support Data Notebook* (Ref. 11: RBF Consulting, June 2013), the design flows are taken from the hydrologic models within the Draft Section 4 (hydrology) report; The hydrologic HEC 1 model in the FDS has an overall larger watershed area and a greater subdivision of the watershed area compared to the HEC-1 model within the McMicken Dam Draft Section 4 (Hydrology) Report and was therefore used for delineating the Outlet Wash floodplain; the FDS HEC-1 models are now commonly called the "high resolution" hydrologic models and the Section 4 HEC-1 models are called the "low resolution" hydrologic models; the new "high resolution" hydrologic model may be used in the future to prepare the Conditional Letter of Map Revision (CLOMR) for the Outlet Channel so that it is compatible with Outlet Wash CLOMR that the District is currently pursuing with (Federal Emergency Management Agency Federal Emergency Management Agency) FEMA; For the McMicken Dam Outlet Channel the "low resolution" HEC-1 model with slightly higher flows has been as directed by the District.

4. *McMicken Dam Outlet Wash Floodplain Delineation Study (FDS) Technical Support Data Notebook* (Ref. 11: RBF Consulting, June 2013); the hydrology within this report succeeds the hydrology within the *McMicken Dam Draft Section 4 (Hydrology)* (Ref. 10: RBF Consulting, January 2013) report; however, it is not relevant to the McMicken Dam design as stated within item 3 above. It may be used in the future to prepare CLOMR for FEMA as stated above.

Hydraulic Models

A list of the drainage documents and their associated hydraulic models along with a brief description, as relevant to the alternatives evaluation, is provided below.

1. *Design Memorandum No. 1 – Hydrology and Hydraulic Design for Trilby Wash Detention Basin and Outlet Channel* (Ref. 13: USACE, 1953); the memorandum describes the original design of the McMicken Dam and Outlet Channel. The memorandum states that the Outlet Channel will: "consist of three principal parts joined by two transitions. The first part would be a trapezoidal channel with a 20-foot bottom width from station 17+50 (the downstream end of the stilling basin) to station 58+00. From this station, a trapezoidal transition channel ranging in bottom width between 20 and 60 feet would extend to station 64+00 (just upstream from the highway bridge). The second part, a 60-foot bottom width trapezoidal channel, would extend through the highway and railroad bridges to station 70+00. Then another trapezoidal transition channel would extend to station 76+00. The

third part of the channel, from this station downstream, would be developed by excavating a channel to a width of 100 feet and an average depth of 2.5 feet to provide sufficient material to construct a single levee on the right (down-hill) bank .... Depth of flow would range between 8.8 and 12.5 feet with velocities of 3.0 to 7.9 feet per second. The average height of the levee above existing ground level would be about 8.5 feet, which would provide about 2.5 feet for freeboard."

The alternatives evaluation is based on exceeding the original freeboard criteria due to FEMA requirements of a minimum 3 feet freeboard for the levee. Also, as directed by the District, the flow velocities in proposed channel alternatives will be at 5 feet/second or lower values.

2. *Design Memorandum No. 2 – Design Analysis for Trilby Wash Detention Basin and Outlet Channel* (Ref. 14: USACE, 1954); the hardcopy hydrologic calculations for the Dam, Outlet Channel and Outlet Wash contain a backwater analysis for the Outlet Channel.

   For purposes of the alternatives evaluation, uniform flow hydraulic analyses are used instead of backwater analyses. Final design will be based on the more detailed backwater hydraulic analyses using the Corps of Engineers' HEC-RAS computer program.

3. *McMicken Dam Outlet Channel Analysis* (Ref. 2: Baker, June 2003); this report describes the preparation of a HEC-RAS hydraulic model (McMickenfinal.prj) for the Outlet Channel upstream of BNSF railroad bridge.

   The hydraulic analyses for Alternatives 1 and 2 and upstream segments of Alternatives 3 and 4 are based on the channel and overbanks roughness within this report and model.

4. *McMicken Dam Outlet Channel Inundation Report Emergency Action Plan Update* (Ref. 9: Kimley Horn, June 2004); this report describes the preparation of a HEC-RAS hydraulic model (McMicken.prj) for the Outlet Channel downstream of BNSF railroad bridge.

   The hydraulic analyses for Alternatives 1 and 2 and upstream segments of Alternatives 3 and 4 are based on the channel and overbanks roughness within this report and model.

5. *Wittmann Area Drainage Master Study Update Volume MA Alternative Analysis for McMicken Dam* (Ref. 3: Entellus, June 2005); the updated HEC-RAS model (mdoc_levee.prj) for the Outlet Channel from principal outlet to a little downstream of Grand Avenue bridge originally prepared by Baker was updated as part of this report; also, the HEC-RAS Outlet Channel model (mdoc_eap.prj) from BNSF to the end of the levee upstream of Outlet Wash originally prepared by Kimley-Horn was updated.

The hydraulic analyses for Alternatives 1 and 2 and upstream segments of Alternatives 3 and 4 are based on the channel and overbanks roughness within this report and model.

6. *McMicken Dam Outlet Wash Floodplain Delineation Study (FDS) Technical Support Data Notebook* (Ref. 11: RBF Consulting, June 2013); the HEC-RAS hydraulic model for the Outlet Wash was prepared as part of this study.

   The hydraulic analyses for the downstream Outlet Channel improvements (for all alternatives) after confluence with Outlet Wash are based on the channel and overbanks roughness within this report and model.

Note: Hydraulic parameters for Figures 2-1 and 2-4 are described in sections 4.1, 4.2, 4.3 and 4.4. Please also refer to Section 3.0 in this regard.

2.0 DESIGN DISCHARGES

The following discharges were used in the Outlet Channel alternatives analyses after consultation with the District project team staff:

1. 4,450 cfs from Grand Avenue to 2.4 miles downstream (east); 4,450 cfs is the Principal Outlet discharge used in the original design of the dam according to the *Design Memorandum No. 1 – Hydrology and Hydraulic Design for Trilby Wash Detention Basin and Outlet Channel* (Ref. 13: USACE, 1953) and the McMicken Dam Outlet Channel Inundation Report EAP Update by Kimley Horn and Associates (Ref. 9: Kimley Horn, June 2004).
2. 7,045 cfs from 2.4 to 3.2 miles downstream (east) of Grand Avenue; 7,045 cfs is the 100-year discharge used in the Low Resolution Hydrology Model within the *McMicken Dam Draft Section 4 (Hydrology)* by RBF Engineering (Ref. 10: RBF, January 2013). The discussion on Low Resolution Hydrology Model is only contained in the Draft Section 4 (Hydrology) report and was not included in the final report.
3. 9,090 cfs from 3.2 to 5 miles downstream (east) of Grand Avenue i.e., to Outlet Wash; 9,090 cfs is the 100-year discharge used in the Low Resolution Hydrology Model within the *McMicken Dam Draft Section 4 (Hydrology)* by RBF Engineering (Ref. 10: RBF, January 2013).

Note: The 100-year discharge of 9,090 cfs is continued to be used downstream of confluence with Outlet Wash as it is just slightly higher than the 100-year peak discharge of 9,083 cfs for the combined Outlet Channel and Outlet Wash flow per the *McMicken Dam Draft Section 4 (Hydrology)* (Ref. 10: RBF, January 2013). Flow in Outlet Wash prior to confluence with Outlet Channel is 6,830 cfs.

Although the design for the alternatives is based on the discharges described above, the alternatives were also evaluated for the following 200-year discharges obtained from the same HEC-1 model used to generate the 100-year discharges:

1. 8,243 cfs from 2.4 to 3.2 miles downstream (east) of Grand Avenue.
2. 10,716 cfs from 3.2 to 5 miles downstream (east) of Grand Avenue i.e., to Outlet Wash.

Note: The Principal Outlet discharge of 4,450 cfs is still used for the upstream segment of the Outlet Channel (Grand Avenue to 2.4 miles downstream (east) of Grand Avenue).

3.0 HYDRAULIC DESIGN CRITERIA

Hydraulic design for the Outlet Channel Alternatives was based on:

1. *Drainage Design Manual, Volume II, Hydraulics* (Ref. 6: District, 2013).
2. Discussions with District project team staff.

The significant design criteria included:

1. Flow velocities in proposed channel alternatives will be at 5 feet/second or lower.
2. Manning's roughness will be taken as 0.035 for the channel and 0.07 in the overbanks as in the previous HEC-RAS models within the *Wittmann Area Drainage Master Study Update Volume MA Alternative Analysis for McMicken Dam* (Ref. 3: Entellus, June 2005).
3. Manning's roughness in Outlet Wash will be taken as 0.04 for the channel and 0.056 in the overbanks as in the HEC-RAS model within the *McMicken Dam Outlet Wash Floodplain Delineation Study (FDS) Technical Support Data Notebook* (Ref. 11: RBF Consulting, June 2013).
4. Freeboard of a minimum of one (1) foot or as per the guidelines within the District's *Drainage Design Manual, Volume II, Hydraulics* (Ref. 6: District, August 2013) will be used for the excavated channel alternatives.
5. Freeboard of a minimum of three (3) feet will be used for the levee alternatives. In addition, a minimum freeboard of four (4) feet will be used at the bridges/structures next to a levee.
6. Minimum radius of curvature for a bend in the Outlet Channel as three (3) times the water surface width.
7. Transition length for the successive downstream expansion/contraction of the Outlet Channel trapezoidal section was 4.5H:1V (12.5 degrees) based on guidance within the District's *Drainage Design Manual, Volume II, Hydraulics, Section 8.6.1* (Ref. 6: District, August 2013) which refers to *HEC-14: Hydraulic Design of Energy Dissipators for Culverts and Channels* by Federal Highway Administration (Ref. 5: FHWA, 2006). Please refer to Appendix B. However, at tie-in with the Outlet Wash the contraction length was based on a 6H:1V transition.
8. Minimum crest width of twenty (20) feet for the levee alternatives as shown on Figures 2-1 and 2-2.
9. Maintenance access paths (16-foot minimum width as shown on Figures 2-1 through 2-4) along both sides of the proposed Outlet Channel.
10. Ramps at a spacing of every half mile.

11. Western Area Power Administration's (WAPA) *Policy and Information Sheet* (Ref. 18: WAPA, 2005) states "No excavation/trenching shall be performed within 50 feet in each direction, or 100-foot-diamtere of any of our transmission line structures (towers/poles)."

4.0 ALTERNATIVES EVALUATION

The four proposed Outlet Channel alternatives designed for the 100-year storm event are described below. The first two alternatives are based on providing a levee while the third and fourth alternatives consist of excavated channels.

A DVD, provided in Appendix F, includes backup documentation for all the hydrologic/hydraulic analyses/designs as well as other items such report text, tables, figures, roll plots, appendices and references associated with this report.

4.1 Alternative 1: Construct New Levee with Central Filter North of Existing Levee

Removal and reconstruction of the existing levee was initially considered for this alternative. However discussions with the District resulted in the decision that the levee could not practically be removed and reconstructed along the same alignment because this would result in compromised flood protection during the period of construction. As a result, this alternative was modified to consist of construction of a new levee immediately upstream from the existing levee.

This alternative would consist of constructing a new levee immediately upstream (north) from the existing levee and would maintain the functionality of the existing levee during construction. The levee would be designed to meet FEMA requirements for freeboard and embankment protection. FEMA criteria requires a minimum of 3 feet of freeboard, Embankment design considerations include embankment and foundation stability, settlement, and interior drainage. These analyses would be performed in accordance with USACE Engineering Manuals *EM 1110-2-1913 Design and Construction of Levees* (Ref. 16: USACE, 2000) for stability and *EM 1110-2-1904 Settlement Analysis* (Ref. 17: USACE, 1990) for settlement. The new levee would consist of a homogeneous earthfill embankment with a central filter designed to provide appropriate internal drainage and as a defensive measure against internal erosion due to cracking. The levee would be constructed with a cutoff extending into competent foundation material with a 5-foot thick central filter to protect against failure through cracks in the embankment, seepage erosion and poor foundation materials. The filter would also extend into competent foundation material. The levee crest will be plated with aggregated base material. Rock mulch will be used on the upstream slope for erosion protection (see Figure 2-1 for the typical section, Figure 3-1A-E for the plan-profile view and Figure 5-1 for excess land available for sale).

A trapezoidal excavated channel with a curved alignment would be constructed at the downstream end of the Outlet Channel. The excavated channel will have grouted riprap lined drop structures (see Figure 4-1: Drop Structures Typical Sections) across its width in order to flatten the longitudinal slope and reduce flow velocities. These drop structures would span across the proposed excavated channel and will be two (2) feet high.

The downstream toe of the new levee would be approximately coincident with the upstream toe of the existing levee to allow full functioning of the existing levee during construction. Decommissioning of the existing levee could begin after a segment of new levee has been constructed. This would enable reuse of the existing levee as fill material for the new levee. After construction of the new levee, the existing levee would be removed and an access road would be constructed at the downstream toe of the new levee. A 16-foot wide maintenance access road with

an aggregate base course plating will be provided at the south toe of the new levee and a 16-foot wide earthen access road along the north side of existing channel.

Side inflows are directed into the existing Outlet Channel through grouted riprap spillways. The side inflows into the proposed excavated channel should also be routed through grouted riprap spillways. Where the Outlet Channel curves into the Outlet Wash, a grouted grade control/drop structure (for a two foot drop in grade) will be installed in the Outlet Wash prior to its confluence with the Outlet Channel. Dumped riprap will be provided at the downstream end of the proposed Outlet Channel prior to discharge into the existing Outlet Wash.

All disturbed areas will be hydroseeded after construction. Rock mulch will be used on the south side slope of the levee.

Construction can be phased with the excavation of the downstream channel providing borrow for the upstream levee construction.

The approximate uniform flow hydraulic analyses indicate that flow velocities within the existing and proposed Outlet Channel will be at five (5) ft/sec or less while the freeboard along the levee will be a minimum of three (3) feet. The freeboard of a minimum of one (1) foot or as per the guidelines within the District's *Drainage Design Manual, Volume II, Hydraulics* (Ref. 6: District, August 2013) shall be provided along the entire length of the excavated channel at the downstream end of this levee alternative. Please refer to Figure 2-1 for a description of the Alternative 1 Outlet Channel typical section and hydraulics and levee foundation tables. Refer to Appendix A for the uniform flow calculations along the Outlet Channel for this alternative.

4.2 Alternative 2: Modify Existing Levee with Upstream Filter

This alternative would consist of excavating into the upstream slope of the existing levee at a 1.5H:1V angle and constructing an upstream filter that extends into competent foundation material at the upstream toe. A structural fill section would be used as cover over the filter section. The levee would be designed to meet FEMA requirements for freeboard and embankment protection. FEMA criteria requires a minimum of 3 feet of freeboard, Embankment design considerations include embankment and foundation stability, settlement, and interior drainage. These analyses would be performed in accordance with USACE Engineering Manuals *EM 1110-2-1913 Design and Construction of Levees* (Ref. 16: USACE, 2000) for stability and *EM 1110-2-1904 Settlement Analysis* (Ref. 17: USACE, 1990) for settlement. The modified levee would consist of a zoned earthfill structure with structural fill and an upstream sloping filter designed to provide appropriate internal drainage and as a defensive measure against internal erosion due to cracking. The levee crest would be plated with untreated base material (see Figure 2-2 for the typical section, Figure 3-2A-E for the plan-profile view and Figure 5-2 for excess land available for sale). A 16-foot wide maintenance access road with an aggregate base course will be provided at the south toe of the modified levee and a 16-foot wide earthen access road along the north side of existing channel.

A trapezoidal excavated channel with a curved alignment would be constructed at the downstream end of the Outlet Channel. The excavated channel should have grouted riprap lined drop structures (see Figure 4-1: Drop Structures Typical Sections) across its width in order to flatten the

longitudinal slope and reduce flow velocities. These drop structures would span across the proposed excavated channel and would be two (2) feet high.

Side inflows are directed into the existing Outlet Channel through grouted riprap spillways (see Figure 4-1: Drop Structures Typical Sections). The side inflows into the proposed excavated channel should be routed through grouted riprap spillways. A grouted grade control/drop structure (for a two foot drop in grade) will be installed in the Outlet Wash prior to its confluence with the Outlet Channel. Dumped riprap would be provided at the downstream end of the proposed Outlet Channel prior to discharge into the existing Outlet Wash.

All disturbed areas will be hydroseeded after construction. Rock mulch will be used on the south side slope of the levee.

The approximate uniform flow hydraulic analyses indicate that flow velocities within the existing and proposed Outlet Channel would be at five (5) ft/sec or less while the freeboard along the levee will be a minimum of three (3) feet. The freeboard of a minimum of one (1) foot or as per the guidelines within the District's *Drainage Design Manual, Volume II, Hydraulics* (Ref. 6: District, August 2013) shall be provided along the entire length of the excavated channel at the downstream end of this levee alternative. Please refer to Figure 2-2 for a description of the Alternative 2 Outlet Channel typical section and hydraulics and levee foundation tables. Refer to Appendix A for the uniform flow calculations along the Outlet Channel for this alternative.

It may be noted that although a significant portion of Alternative 2 improvements includes the existing levee, Alternative 2 is still considered a viable alternative based on a review of the available limited information from AMEC's earlier investigations as reported within the *Wittman Area Drainage Master Plan McMicken Dam Project Alternatives Analysis Volume MA 1 of 2* (Ref 4: Entellus August 2008). A few relevant items of information from this report are provided below.

1. The outlet channel "levee suffers from many of the same problems as the dam and would need to be rehabilitated to mitigate structural deficiencies, subsidence, and in some locations, potential for fissure formation."
2. "Geophysical results indicate that much of the levee embankment may not be sufficiently dense to maintain its structural integrity. S-wave velocities in the embankment were typically less than 700 ft/s, with some as low as 430 ft/s." P-wave velocities generally ranged from 940 ft/s to 1,400 ft/s. Using Rucker's table estimating unit weight from seismic velocities these seismic wave velocities correspond to density values between about 108 pcf and 112 pcf. AMEC measured in-situ density using a nuclear gauge in the 8 shallow test holes. The results were reported to be between 78 pcf and 110 pcf. Data were not presented to evaluate the distribution of these values.
3. "In addition to AMEC's initial field investigation, review of the as-built plans indicates that the levee was constructed of homogeneous earthfill without any structural components that would resist failure through transverse cracks or seepage erosion. No

additional documentation was located of the construction practices utilized in completing the levee earthwork activities. Therefore, to mitigate similar embankment failure modes, AMEC recommends incorporation of design components in all levee embankment alternatives to protect against failure through embankment cracks, seepage erosion, and poor foundation conditions. Due to the relatively low average height (10 feet) of the levee, complete removal and replacement may be considered the most cost effective means to mitigate potential failures."

AMEC did not propose an upstream raise for the levee and the recommendation to remove and replace it appears to have been economic. The limited available data seems to indicate that the soil densities may be adequate.

4.3 Alternative 3: Reconstruct Excavated Outlet Channel along Existing Alignment

This excavated channel alternative comprises a trapezoidal channel designed to convey the peak flow from the 100-year storm event. The proposed earthen channel has 4H:1V side slopes while the depth and width vary along the entire length of the Outlet Channel (see Figure 2-3 for the typical section, Figure 3-3A-E for the plan-profile view and Figure 5-3) for excess land available for sale). The Outlet Channel widens significantly around nine (9) existing transmission line towers. A mounded island protected with grouted riprap along the sides is provided for each transmission line tower within the channel bottom. A 16-foot wide maintenance access road with an aggregate base course will be provided along the south side of the channel and a 16-foot wide earthen access road along the north side of existing channel. A trapezoidal excavated channel with a curved alignment will be constructed at the downstream end of the Outlet Channel. A low flow channel can be investigated during final design in order to efficiently convey sediment inflows.

Side inflows are directed into the proposed excavated Outlet Channel through grouted riprap spillways – similar to the existing grouted spillways at the Outlet Channel (see Figure 4-1: Drop Structures Typical Sections). Three grouted grade control/drop structures – each with a two foot drop (for a total six foot drop in grade) – will be constructed in the Outlet Wash prior to its confluence with the Outlet Channel. Dumped riprap will be provided at the downstream end of the proposed Outlet Channel prior to discharge into the existing Outlet Wash.

All disturbed areas will be hydroseeded after construction.

The approximate uniform flow hydraulic analyses indicate that flow velocities within the existing and proposed Outlet Channel will be at five (5) ft/sec or less. The Outlet Channel branches into two channels at the electricity transmission towers. At these locations flow velocities are likely to be less than five (5) ft/sec. The freeboard of a minimum of one (1) foot or as per the guidelines within the District's *Drainage Design Manual, Volume II, Hydraulics* (Ref. 6: District, August 2013) shall be provided along the entire length of the excavated channel. The freeboard along the Outlet Channel is for the most part greater than required. This is due to the channel cutting across the land almost perpendicular to the incoming natural washes. Consequently, the freeboard is the least where the excavated channel cuts across a natural wash and increases significantly at the natural ridges. Please refer to Figure 2-3 for a description of the Alternative 3 Outlet Channel

typical section and hydraulics and levee foundation tables. Refer to Appendix A for the uniform flow calculations along the Outlet Channel for this alternative.

4.4 Alternative 4: Realign Outlet Channel North

This second "excavated channel" alternative is similar to Alternative 3. However the proposed excavated channel is re-aligned towards the north in order to avoid having the existing transmission line towers within the channel. The proposed earthen channel has 4H:1V side slopes while the depth and width vary along the entire length of the Outlet Channel (see Figure 2-4 for the typical section, Figure 3-4A-E for the plan-profile view and Figure 5-4 for excess land available for sale). Generally, the realigned channel to the north is deeper than in Alternative 3 with respect to existing ground which is higher. A 16-foot wide maintenance access road with an aggregate base course will be provided along the south side of the channel and a 16-foot wide earthen access road along the north side of existing channel. A trapezoidal excavated channel with a curved alignment will be constructed at the downstream end of the Outlet Channel.

Side inflows are directed into the proposed excavated Outlet Channel through grouted riprap spillways – similar to the existing grouted spillways at the Outlet Channel (see Figure 4-1: Drop Structures Typical Sections). Three grouted grade control/drop structures – each with a two foot drop (for a total six foot drop in grade) – will be installed in the Outlet Wash prior to its confluence with the Outlet Channel. Dumped riprap will be provided at the downstream end of the proposed Outlet Channel prior to discharge into the existing Outlet Wash.

All disturbed areas will be hydroseeded after construction.

The approximate uniform flow hydraulic analyses indicate that flow velocities within the existing and proposed Outlet Channel will be at five (5) ft/sec or less. The freeboard of a minimum of one (1) foot or as per the guidelines within the District's *Drainage Design Manual, Volume II, Hydraulics* (Ref. 6: District, August 2013) shall be provided along the entire length of the excavated channel. The freeboard along the Outlet Channel is for the most part greater than required. This is due to the channel cutting across the land almost perpendicular to the incoming natural washes. Consequently, the freeboard is the least where the excavated channel cuts across a natural wash and increases significantly at the natural ridges. Please refer to Figure 2-4 for a description of the Alternative 4 Outlet Channel typical section and hydraulics and levee foundation tables. Refer to Appendix A for the uniform flow calculations along the Outlet Channel for this alternative.

4.5 Levee and Channel Lining Considerations

Both levee Alternatives 1 and 2 are proposed to have the following lining materials:

1. Rock mulch along the levee downstream side slopes; rock mulch is anticipated to prevent surficial erosion due to rain falling on the downstream side slopes.

2. Riprap along the levee upstream side slopes; riprap is sized to counter the erosive effect of flow velocities for stormwater flowing west-east along the upstream side of the levee; "launchable" riprap is provided along the toe of the levee based on potential scour depth;

geotextile fabric will be provided below the riprap; procedures within the District's *Drainage Design Manual, Volume II, Hydraulics* (Ref. 6: District, August 2013) have been used to estimate scour depth and riprap size, thickness and extent; Riprap sizing is dependent on flow velocities; a more accurate representation of flow velocities next to the levee can be estimated through the use of HEC-RAS in final design; uniform flow method is used for this conceptual design; D_{50} riprap size ranges from 4 to 9 inches for Alternative 1 levee and 3 to 6 inches for Alternative 2; the difference is due to the smaller channel area used for Alternative 1 which results in increased channel flow velocity compared to Alternative 2; however, for conceptual design the riprap size for both alternatives is considered in the 4 to 9 inches range; riprap layer thickness is 1.5 times the D_{50} size along the side slope and 3 times the D_{50} size along the launchable riprap apron; launchable riprap apron length varies from 14-27 feet for both Alternatives 1 and 2; however, for conceptual design the launchable riprap length is taken as 20 feet in the upper (5500 feet for levee alternatives and 4500 feet for channel alternatives) Outlet Channel segment and 30 feet for the remainder downstream Outlet Channel segment. Refer to Appendix A for the hydraulic and scour analyses and design of riprap.

The two excavated channel alternatives 3 and 4 were evaluated for channel lining. At this conceptual design stage, erosion protection was not considered necessary for Alternatives 3 and 4 because a) seismic refraction survey by AMEC (Ref. 1: AMEC, June 2014) – even though limited in extent – indicated that the erosion threshold stream power of the existing soils was adequate and b) significant erosion/scour has not been observed within the existing outlet channel which has a similar channel slope and channel velocity to the slope and velocity for the proposed alternative. More specifically, the unlined excavated channel was considered acceptable based on the following considerations:

1. Geotechnical investigations (Ref. 1: AMEC, June 2014) along the alternative 4 alignment indicate that the underlying soil in the channel flow areas has s-wave (640-3200 ft/sec) and p-wave (1800-6300 ft/sec) velocities and stream power erodibility index values (within the range of <0.2-30 KW/m^2); the hydraulic analyses for different segments of Outlet Channel indicates flow velocities of 5 ft/sec and consequent stream power values ranging from 0.015-0.037 KW/m^2. The combination of s-wave, p-wave and stream power erodibility index values implies that the underlying soil can accommodate these design flow velocities and resulting stream power values; refer to Appendix A for the relevant geotechnical investigation results and hydraulic evaluation.
2. Discussions with District engineering division staff indicated that Table 6.2 "Maximum Permissible Velocities for Roadside Drainage Channels" is provided for guidance and not design; the table does not indicate size of gravel or cobbles; other analyses and past performance of channels in the vicinity should be used to arrive at maximum permissible velocities for proposed channel; the design flow velocities of 4-5 ft/sec within the proposed channel design are similar to the flow velocities experienced from historic flow events in the existing channel along the upstream side of the existing levee; refer to Appendix A for Table 6.2 "Maximum Permissible Velocities for Roadside Drainage Channels" which was originally developed by Federal Highway Administration's publication "Hydraulic Design Series No. 4, Design of Roadside Channels" (1965).

Additional geotechnical investigations will be done for erosion assessment purposes during final design as necessary. Slurry/riprap may be used for the "soft" soils as necessary.

4.6 Outlet Wash Inflow

All alternatives receive inflow from the Outlet Wash. A short stretch of graded channel for the Outlet Wash and a shallow (two feet or less) drop structure are proposed for all alternatives upstream of the confluence with Outlet Channel.

4.7 Landscape Architecture Considerations

The following landscape architecture considerations are significant with regards to the alternatives:

1. There are more opportunities for aesthetic improvements in case of channel alternatives such as varying channel geometry.

2. The eroded side slopes and treatment of side inflows shall be addressed during final design.

3. Enhanced vegetation and other landscape features will be provided for aesthetics as well as any 404 permit mitigation measures. Vegetation along the levees will require offsets based on guidance in USACE documents.

4. Maricopa Trail will be relocated along the north side of the channel in case of the channel alternatives. The Maricopa Regional Trail (Trail) is currently located at the northern limits of the District property. The Trail would stay at this location for the levee alternative and be relocated adjacent to the channel for the channel alternatives. The 16-foot Operation and Maintenance (O&M) access road on north side of all alternatives could be used for the Maricopa Trail.

5. Rock mulch will be used on the downstream/south levee slope for erosion protection with regards to Alternatives 1 and 2 as well as at the levee segments of Alternatives 3 and 4. Riprap can similarly be used on the upstream/north levee slope for erosion protection for Alternatives 1 and 2 as well as at the levee segments of Alternatives 3 and 4.

6. The levee alternatives do not significantly change the landscape character of the existing Outlet Channel. The proximity of the transmission towers to the proposed levee improvements serve to diminish the appeal of the levee alternatives based on landscape considerations. Alternative 4 is the best alternative in this regard because the channel is moved away from the utility towers and lines.

7. The islands around the utility towers in Alternative 3 worsen the aesthetics from the landscape architecture perspective.

8. Alternatives 1, 2, and 3 will require excavation into the north bank of the channel and removal of a significant area of existing trees compared to Alternative 4.

9. Alternative 4 provides an opportunity for increasing aesthetics. A shallow swale can be provided within the intervening area/strip between the realigned channel and existing

levee. This shallow swale can sustain/nurture the existing trees and vegetation along the north side of the existing Outlet Channel.

4.8 Utilities Impacts

All alternatives avoid impacts to the following utilities:

1. Utilities under the access road to the City of Surprise Wastewater Treatment Plant.

2. Transwestern Gas line across the Outlet Wash at the downstream end of the proposed Outlet Channel improvements (see Figures 3-1 through 3-4 and Appendix C). The proposed excavated Outlet Channel is centered over the deeper segment of the Transwestern Gas line thereby providing adequate cover. The Outlet Channel over the Transwestern Gas line (invert elevation of approximately 1280 feet) is over 10 feet deep over the deeper excavated channels in Alternatives 3 and 4 (proposed Outlet Channel elevations of approximately 1294 feet). The Outlet Channel is less deep (proposed Outlet Channel elevations of approximately 1297 feet) in Alternatives 1 and 2. A reinforced concrete slab for the channel bottom and side slopes is proposed above the Transwestern Gas line.

As mentioned earlier, the electrical transmission line towers are impacted by excavated channel alternative 3. Alternatives 1, 2 and 4 do not impact the transmission line towers. However the impact to the transmission line towers for Alternative 3 is mitigated by providing erosion/scour protection around them.

4.9 Environmental Impacts and Mitigation

All alternatives impact the Outlet Wash at the downstream end of the Outlet Channel in order to improve channel hydraulics and thereby minimize erosion/scour and consequent water quality impairment. Alternatives 3 and 4 have the most significant impact on two jurisdictional washes ("Waters of the United States") by intercepting these washes further north than Alternatives 1 and 2. As stated earlier, mitigation for the impacts to the jurisdictional washes will be provided through enhanced vegetation and other appropriate measures. The existing trees and cacti along the north bank, especially near the incoming washes will need to be evaluated and salvaged if feasible during the construction of all alternatives.

4.10 Cost Estimate for the Alternatives

Comparative construction cost estimates were developed to allow comparison of the four Outlet Channel alternatives. The cost estimates are commensurate with the level of conceptual design of the alternatives. Unit costs for different items of construction were provided by the District or developed based on recent similar projects. Please refer to Table 2 for a summary of the costs for the alternatives and Appendix D for more detailed cost estimates for each alternative. The detailed cost estimates present the major line items and include 3 percent for Mobilization, 1 percent for Supplementary General Conditions, and 25 percent for Contingency for Alternatives 1 and 2. For Alternatives 3 and 4, values of 3 percent for Mobilization, 0 percent for Supplementary General Conditions, and 20 percent for Contingency are used.

A key component of the Outlet Channel alternatives evaluation is the potential to open up land for sale along the north side of the Outlet Channel. The estimated value for the sale of land is provided for each alternative in Table 3. For the levee alternatives (Alternatives 1 and 2), we assumed that only land outside of the area inundated to the top of levee would be available for sale. For the channel alternatives (Alternatives 3 and 4), we assumed that land beyond the channel corridor would be available for sale. The value of available land was estimated at $40,000 per acre based on recommendations of the District staff after the alternatives review meeting in January 2014. During a subsequent meeting in July 2014 a lower value of $20,000 was suggested by the District. It was recommended that cost estimate be provided for both the low and high range of excess land unit cost values.

As recommended during the alternatives review meeting at the District, the cost estimates for Alternative 4 channel and the "curved" downstream segments of the other alternatives have been updated based on recent geotechnical investigation (Ref. 8: Gannett Fleming, July 2014) for excavation of cemented (caliche) and non-cemented soil material. For alternatives 1, 2 and 3, the volume of cemented soil (caliche) excavation was estimated from soil boring logs taken during the design and construction of the existing levee and Outlet Channel in 1954-1956 (Ref. 15: USACE, 1956). The 2014 Alternative 4 geotechnical investigation results provided a more precise definition of the caliche distribution and expected excavation requirements than the information available in the historic boring logs. As such, there may not be a direct correlation between the estimates of easy and difficult excavation quantities between Alternative 4 and the other alternatives. The depths to the top and bottom of the cemented soil (caliche), as shown within the original soil boring logs and the information from the recent geotechnical investigation were used to create surfaces within Civil 3D. The caliche strata (between the top and bottom cemented soil (caliche) surfaces) were compared against the channel bottom (surface) for each alternative in order to quantify the excavation into the cemented soil (caliche). The recent geotechnical investigation shows that the amount of excavation into the cemented soil (caliche) material increased for Alternatives 1, 2 and 3 but decreased for Alternative 4. This change in excavation amounts is based on the recent soil borings that were taken in the downstream "curved" portion of the channel for all four alternatives.

After the alternatives review meeting at the District, 6-inch thick reinforced concrete slab protection is proposed over the existing gas line crossing the downstream end of the Outlet Channel for all four alternatives.

Since the alternatives review meeting at the District, the levee top width has been increased to 20 feet to meet the most recent levee recommendations in the *"Urban Levee Design Criteria"* by the State of California (May 2012). This results in increased earthwork volumes for the levee and backfill quantities and related cost items for both cemented and non-cemented excavations.

As a result of the recommendations during the alternatives review meeting at the District, the existing side inflow spillways have been replaced by new grouted riprap spillways and associated riprap at the top and toe of slope. Also, additional side inflow spillways were provided at all significant concentrated inflows into the Outlet Channel for all alternatives with consequent increase in construction costs. These costs are greater in Alternatives 3 and 4 due to the deeper channel excavation and consequently longer spillways.

Also, as a result of recommendations within the alternatives review meeting at the District, the cost of the levee Alternatives 1 and 2 increased due to the provision of riprap along the northern levee slopes and rock mulch along the southern slopes.

The cost estimates are presented in Tables 2, 3 and 4. The levee Alternative 2 has the least cost at $12.8 million followed by levee Alternative 1 at $14.7 million. Channel Alternative 4 is the next least cost alternative at $16.4 million. Channel Alternative 3 has the highest cost at $27.4 million. Excavated channel Alternative 3 is most expensive due to the wider excavated channel (along the transmission line towers), significant volume of cemented soil (caliche excavation and the erosion/scour protection for the transmission line towers within the excavated channel. Table 3 tabulates the excess land that will be available for sale as a result of each alternative. A review of Table 3 indicates that levee Alternative 2 has the least amount of excess land (86 acres) available for sale whereas the channel Alternative 3 has the most amount of excess land (443 acres) available for sale. Alternatives 1 and 4 have 91 acres and 369 acres of excess land respectively. Table 4 provides an overall cost evaluation of all four alternatives. If we consider excess land unit cost of $40,000 per acre, channel Alternative 4 is the least expensive alternative at $1.6 million whereas channel Alternative 3 is significantly more expensive than Alternative 4 at $9.6 million. Levee alternatives 1 and 2 are at $11.0 million and $9.4 million respectively.

The most significant cost line item for the channel alternatives (Alternatives 3 and 4) is the Excavation of Cemented Soils. The geotechnical investigation performed to evaluate the depth and excavatability of the cemented soils indicated that these soils could be ripped and/or excavated with a D-9 dozer or equivalent. In consultation with the District the unit cost for rock excavation is taken as $6.00 per cubic yard, for earth excavation as $1.50 per cubic yard and for stockpiling as $0.50 per cubic yard. We recommend that the District continue to evaluate the excavatability in the next phase of design through field trials in order to confirm the unit cost associated with the estimated equipment type and level of effort.

4.11 Advantages and Disadvantages of the Alternatives

The advantages and disadvantages of each alternative are described within Table 5: Advantages and Disadvantages of the Alternatives. Alternatives 1 and 2 are termed as "levee" alternatives while Alternatives 3 and 4 are referred to as "channel" alternatives.

Consideration of the channel alternatives was done to avoid the responsibilities associated with a levee that is Federal Emergency Management Agency (FEMA) certified. The levee alternatives pose greater risks compared to the channel alternatives and will require greater scrutiny from the FEMA. Levees are above ground earthen structures that have a risk of failure. The existing levee is not FEMA certified or under FEMA's jurisdiction.

Levee alternatives will result in inundation areas to the north of the levee. The channel alternatives will enable excess land to be freed up for sale and other uses by the District or potential buyers including possibly the municipalities. Future roadways crossing the Outlet Channel will be relatively easier to construct over an excavated channel compared to going over the levees. Access to the project will also be easier with the channel alternatives compared to the levee alternatives. An advantage of the channel alternatives is that they are more conducive to incorporating natural aesthetic features such as varying of channel slopes and planting of trees along the edge of the

channel. In addition, there will be significantly more borrow generated from the excavated channel alternatives for sale compared to the levee alternatives. A significant advantage of the channel Alternative 4 over Alternative 3 is that the realigned channel does not impact the electrical transmission line towers, thereby avoiding a wider channel and expensive erosion/scour protection around the transmission line towers associated with the channel Alternative 3.

An advantage of channel Alternative 4 is that the existing vegetation along the north bank is not disturbed/removed for the most part as compared to the other alternatives.

4.12 Alternatives Review Meeting

An alternatives review meeting was conducted on January 14 to discuss the Outlet Channel alternatives (see minutes in Appendix E). Significant issues from the meeting included:

1. Recommendation for geotechnical investigation along Alternative 4 channel alignment to characterize the nature of the soil with regards to cementitious (caliche) and non-cementitious soil; The *Geotechnical Investigation and Data Report for Outlet Channel Alternative 4 (Draft)* (Ref. 8: Gannett Fleming, July 2014) provides information on channel excavability due to the presence of cemented material, engineering properties of the excavated material for reuse on other construction projects and develop construction quantities; the excavation costs for cementitious soil in Channel Alternative 4 is less than for Channel Alternative 3. Channel 3 has wider excavation in cemented soils compared to Channel Alternative 4.

2. Recommendation for riprap along the northern levee slopes, rock mulch along the southern slopes and aggregate base course for the levee crest and the south access road.

3. Recommendation to replace existing side inflow spillways and add new side inflow spillways.

4. Recommendation to provide a 16-foot wide access road along south side of levee or channel and a 16-foot unpaved access road along the north side of the channel.

5. Alternative 4 was preferred from the landscape perspective as well as risk considerations.

6. Recommendation to use $20,000 to $40,000 per acre for value of excess land outside the 100-year floodplain and freeboard.

7. Recommendation to place a 6-inch thick reinforced concrete slab over the existing gas line crossing the downstream end of the Outlet Channel for all four alternatives.

8. Recommendation to use levee top width as 20 feet for all four alternatives. This results in increased earthwork volumes for the levee alternatives related cost items for both cemented and non-cemented excavations.

9. As a result of the recommendations during the alternatives review meeting at the District, the existing side inflow spillways have been replaced by new grouted riprap spillways and associated riprap at the top and toe of slope. Also, additional side inflow spillways were

provided at all significant concentrated inflows into the Outlet Channel for all alternatives. The cost of the levee Alternatives 1 and 2 increased due to the provision of riprap along the northern levee slopes and rock mulch along the southern slopes.

4.13 Concluding Remarks

The preferred levee alternative is "Alternative 1 Construct New Levee with Central Filter North of Existing Levee". Alternative 2 will have a higher "exposure to flooding" risk during construction than Alternative 1. Alternative 1 provides a new levee and is about 20 percent more expensive than "Alternative 2 Modify Existing Levee with Upstream Filter". More geotechnical investigation and possible remedial work will be required for the existing levee that will be retained as part of Alternative 2.

The preferred channel alternative is "Alternative 4 Realign Outlet Channel North". This alternative is significantly less expensive than "Alternative 3 Reconstruct Excavated Outlet Channel along Existing Alignment" and avoids impacts to the electrical transmission towers and existing vegetation along the north side of existing channel. It also has less excavation of cemented soils as compared to channel Alternative 3.

The preferred overall alternative is "Alternative 4 Realign Outlet Channel North". This alternative has the least overall cost and avoids the responsibilities associated with the levee alternatives that will need to be Federal Emergency Management Agency (FEMA) certified. The levee alternatives pose greater risks and require greater scrutiny from the FEMA. Channel Alternative 4 will enable construction of public roadway connections to the 303 relatively more easily and with less cost as it will be easier to obtain clearances under the power lines. Channel Alternative 4 will enable excess land to be freed up for sale and other uses by the District or potential buyers including possibly the municipalities. Channel earth materials can potentially be auctioned to others in need of the materials, which would decrease the construction costs. Channel earth materials excavation is approximately half of the total cost for Alternative 4. Another advantage of the Channel Alternative 4 is that it is more conducive to incorporating natural aesthetic features such as varying of channel slopes and preserving trees along the edge of the channel as compared to the levee alternatives.

It should be mentioned here that the existing outlet channel will be backfilled with material obtained from the removal of the existing levee if the channel alternatives are implemented. The excess material will be stockpiled and auctioned when the opportunity presents.

An Operation and Maintenance (O&M) plan will be prepared during the final design for sediment monitoring and removal.

5.0 REFERENCES

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TABLES

Table 1

McMicken Dam Physical Data

Item NATDAM ID AZ00109 ADWR ID 07.28	PHYSICAL DATA
Principal Outlet	
Inlet control elevation (A-Team, 2009)	1,333.6, ungated
Diameter of conduit	11' high x 20'wide RCBC
Length of conduit (Ninyo & Moore, 2005)	188.33 ft
Capacity at ES elevation (USACE, 1954)	4,450 cfs
Time to drain (Ninyo & Moore, 2005)	3 to 4.5 days from emergency spillway crest elevation
Emergency Spillway	
Crest elevation	
Design (USACE, 1956)	1,355.87 ft NAVD88
Survey (A-Team, 2008)	1,355.25 ft NAVD88
Bottom width	
Design (USACE, 1954)	2,000 ft, grouted riprap
Current	2,000 ft, grouted riprap
Design spillway capacity (USACE, 1954)	76,800 cfs
Estimated spillway capacity (Entellus, 2005)	51,300 cfs
Freeboard hydrograph	PMF 72-hour
72-hr storm rainfall (Rumann & Sutko, 1987)	15.7 inches
Top of Dam Elevation	
Design (USACE, 1954)	1,362.77 ft NAVD88
Survey (A-Team, 2009)	1,361.92 ft NAVD88 @ Sta. 210+00
Dam Parameters	
Dam height (DSFRM)	39.3 ft
Dam length (District, 2011)	46,200 ft
Crest length (District, 2011)	44,200 ft
Crest width (USACE, 1956)	12 ft
Slope of upstream face	2.5H:1V
Slope of downstream face	2 H:1V
Drainage Area	
Design (USACE, 1956)	247 sq mi
Estimate (Entellus, 2005)	245 sq mi
Storage Capacity	
Sediment	
Design (USACE, 1954)	2,500 ac-ft
Estimate (West, 2004)	4,340 ac-ft
Floodwater (up to emergency spillway)	
Design (USACE, 1954)	19,300 ac-ft @ 1355.87 NAVD88
Estimate (Entellus, 2005)	21,000 ac-ft @ 1355.87 NAVD88

Table 1

McMicken Dam Physical Data

Item NATDAM ID AZ00109 ADWR ID 07.28	PHYSICAL DATA
Freeboard (emergency spillway up to top of dam) Design (USACE, 1954) Estimate (Entellus, 2005)	 16,500 ac-ft @ 1362.87 NAVD88 13,000 ac-ft @ 1361.92 NAVD88
Surface Area Floodwater pool (up to emergency spillway) Design (USACE, 1954) Estimate (District, 2012)	 2,230 ac 2,117 ac
Classification Type of Dam Purpose of Dam Hazard classification (ADWR) Size of dam (ADWR)	 Earthen Flood Control High Intermediate
PMF Event [Inflow design flood (IDF)] (Entellus, 2005) PMF peak inflow discharge Spillway max flow depth during PMF Max discharge during PMF	 129,600 cfs 6.67 ft 51,300 cfs
Warning Systems at Dam	ALERT pressure transducer for water level monitoring, 5448
Communication Systems at Dam	ALERT transmitter; District observer
Outlet Channel Standard Project Flood (SPF) Discharges Outlet Channel - Principal Outlet to Outlet Wash (USACE, 1953) Outlet Channel at US 60 and BNSF Railroad Bridge (USACE 1954) Outlet Channel at confluence with Outlet Wash (USACE 1954) Note: The District has been using 14,000 cfs as the SPF for the Outlet Wash.	 4,450 – 14,000 cfs 4,450 cfs 14,000 cfs

Note: Above Table 1 is taken from the McMicken Dam Design Criteria Report (Ref. 4: Gannett Fleming, April 2013).

Table 2
Cost Estimates Summary for the Alternatives

Item Description	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Upstream Channel and Levee Improvements	$ 1,221,433	$ 1,261,017	$ 1,112,233	$ 1,092,549
Excavation - Channel (non-cemented soils)	$ 259,358	$ 260,317	$ 2,123,550	$ 3,229,707
Excavation - Channel (cemented soils)	$ 1,937,930	$ 1,943,889	$ 12,021,589	$ 4,553,762
Excavation - Levee Foundation (non-cemented soils)	$ 45,581	$ 16,790	$ 5,449	$ -
Excavation - Existing Levee	$ 247,407	$ 85,973	$ 249,341	$ 251,355
Remove and Stockpile Topsoil	$ 165,811	$ 108,493	$ 390,652	$ 445,570
Topsoil Plating and Grading	$ 26,181	$ 17,130	$ 61,682	$ 70,353
Levee Fill	$ 1,211,316	$ 336,924	$ 12,490	$ -
Levee Fill (Foundation)	$ 116,791	$ 35,216	$ 11,400	$ -
Filter	$ 1,007,590	$ 890,667	$ 61,071	$ -
Excess Borrow Material Placement	$ 217,464	$ 238,734	$ 1,833,325	$ 1,581,727
Rock Mulch	$ 155,478	$ 243,804	$ -	$ -
Hydroseed	$ 216,370	$ 141,574	$ 509,768	$ 581,431
O&M Road (North Channel Bank)	$ 18,176	$ 18,177	$ 19,596	$ 19,193
O&M Road AB (Levee Crest, Downstream Toe)	$ 189,837	$ 189,564	$ 90,534	$ 89,882
Levee Riprap Lining (d50 = 7")	$ 2,369,930	$ 2,211,304	$ 92,569	$ -
Geotextile for Riprap	$ 129,928	$ 98,578	$ 2,970	$ -
Side Channel Drop Structures (Riprap, d50 = 8", D=16")	$ 364,579	$ 364,577	$ 386,716	$ 313,063
Side Channel Drop Structures (Grouted Riprap, d50 = 8", D=16")	$ 662,136	$ 662,136	$ 1,229,360	$ 1,078,154
Longitudinal Channel Drop Structures (Riprap, d50 = 12", D=24")	$ 153,650	$ 153,650	$ -	$ -
Longitudinal Channel Drop Structures (Grouted Riprap, d50 = 12", D=24")	$ 81,000	$ 81,000	$ -	$ -
Outlet Wash Drop Structures (Riprap, d50 = 12", D=24")	$ 11,233	$ 11,233	$ 36,557	$ 38,729
Outlet Wash Drop Structures (Grouted Riprap, d50 = 12", D=24")	$ 6,067	$ 6,067	$ 20,156	$ 20,862
Channel Bottom Riprap at Outlet Wash (Riprap, d50 = 12", D=24")	$ 14,296	$ 14,296	$ 13,499	$ 14,948
Utility Footing Erosion Protection (Grouted Riprap, d50=12", D=24")	$ -	$ -	$ 1,432,396	$ -
Backfill Existing Outlet Channel (Common Fill)	$ 52,528	$ 59,326	$ -	$ -
Concrete Slab Protection for Existing Gas Line (Reinforced Concrete, D=6")	$ 53,880	$ 53,880	$ 70,889	$ 67,676
Mitigation for Waters of the US	$ 259,348	$ 259,279	$ 279,865	$ 279,409
Tall Pot Planting	$ 25,000	$ 25,000	$ 25,000	$ 25,000
Biological Assessment	$ 5,000	$ 5,000	$ 5,000	$ 5,000
Desert Tortoise and Burrowing Owl Surveys and Relocation	$ 8,000	$ 8,000	$ 8,000	$ 8,000
Cultural Resources Report	$ 14,000	$ 14,000	$ 14,000	$ 14,000
Cultural Resources Mitigation Measures	$ 116,684	$ 116,684	$ 116,684	$ 116,684
Subtotal	**$ 11,363,980**	**$ 9,932,277**	**$ 22,236,342**	**$ 13,897,054**
Mobilization	$ 340,919	$ 297,968	$ 667,090	$ 416,912
Supplemental General Conditions	$ 113,640	$ 99,323	$ -	$ -
Construction Contingency	$ 2,840,995	$ 2,483,069	$ 4,447,268	$ 2,084,558
Total	**$ 14,659,535**	**$ 12,812,638**	**$ 27,350,701**	**$ 16,398,524**

Table 3
Outlet Channel Alternatives
Cost Estimates for Potential Land for Sale

Alternative	Excess Land (acres)	Potential Saleable Land Value (at $20,000 per acre)	Potential Saleable Land Value (at $40,000 per acre)
Alternative 1 - Construct New Levee with Central Filter North of Existing Levee	91	$1,814,000	$3,628,000
Alternative 2 - Modify Existing Levee with Upstream Filter	86	$1,718,000	$3,436,000
Alternative 3 - Reconstruct Excavated Outlet along Existing Alignment	443	$8,862,000	$17,724,000
Alternative 4 - Realign Outlet Channel North	369	$7,384,000	$14,768,000

Notes:

1) A range of values for potential saleable excess land are used as directed by FCDMC with a lower estimate of $20,000/acre and an upper estimate of $40,000/acre.

2) Excess land for Alternatives 1 and 2 consists of land above the levee crest elevation.

3) Excess land for Alternatives 3 and 4 consists of land north of the channel corridor.

Table 4
Outlet Channel Alternatives
Net Cost Summary

Alternative	Estimated Constrution Cost	Potential Saleable Land Value		Range of Net Costs (Construction Cost less Land Value)	
		(at $20,000 per acre)	(at $40,000 per acre)	(at $20,000 per acre)	(at $40,000 per acre)
Alternative 1 - Construct New Levee with Central Filter North of Existing Levee	$14,659,535	$1,814,000	$3,628,000	$12,845,535	$11,031,535
Alternative 2 - Modify Existing Levee with Upstream Filter	$12,812,638	$1,718,000	$3,436,000	$11,094,638	$9,376,638
Alternative 3 - Reconstruct Excavated Outlet along Existing Alignment	$27,350,701	$8,862,000	$17,724,000	$18,488,701	$9,626,701
Alternative 4 - Realign Outlet Channel North	$16,398,524	$7,384,000	$14,768,000	$9,014,524	$1,630,524

Notes:
1) A range of values for potential saleable excess land are used as directed by FCDMC with a lower estimate of $20,000/acre and an upper estimate of $40,000/acre.
2) Excess land for Alternatives 1 and 2 consists of land above the levee crest elevation.
3) Excess land for Alternatives 3 and 4 consists of land north of the channel corridor.

Table 5: McMicken Outlet Channel Alternatives Evaluation

Alternative	Issue	Advantages	Disadvantages
1. Construct New Levee with Central Filter North of Existing Levee	Construction Cost Estimate	Second lowest cost	
	Design and Geotechnical Investigations Cost		More costly
	Operations & maintenance costs		The levee alternatives including Alternative 1 will require greater operating and maintenance costs than the channel alternatives.
	FEMA oversight and accompanying requirements		Construction of a levee alternative 1 will require certification by FEMA which requires significant inspections and monitoring, and development of an Emergency Action Plan and an evacuation plan and regular training exercises
	Inundation area and availability of excess land for sale		Significantly more land is inundated north of the levee for Alternative 1 compared to Alternatives 3 and 4; however Alternative 2 inundates slightly less land than Alternative 1 due to the location of the levee structures. Alternative 1 with a new levee is worst than all alternatives because it has the most inundation area. Consequently, less area (330 ac) is available for sale.
	Availability of excess borrow material for sale		Alternative 1 is unlikely to generate excess borrow material for sale as borrow will be needed to construct the new levee.
	Future road crossing		Construction of future planned road crossings may be very difficult and expensive with the levee alternatives, thereby limiting future development of the area.
	Risk of potential failure		Alternative 1 is a levee which is an above ground earthen structure that has inherently greater risk of potential failure and associated downstream flooding when compared to channels.
	Aesthetic features and vegetation		The construction of Alternative 1 which comprises a levee will limit the potential for aesthetic treatment to rock mulch on the levee slopes and hydroseed. The channel and levee are linear. Trees cannot be planted near the levee.
	Impacts to electrical transmission line towers	Alternative 1 Maintains the existing channel alignment and does not widen the channel thereby avoiding the electrical transmission line towers.	
	Preservation of existing vegetation and impact on biological resources	In Alternative 1 the vegetation along the north bank is not disturbed/removed. In Alternative 1 the biological resources are less impacted than for the channel alternatives 3 and 4 and relatively more impacted than the levee retrofit alternative 2. Alternative 1 does not require disturbance of vegetation along the north bank of the existing channel.	
	Impacts to "Waters of United States" (WUS)	Alternative 1 has the second lowest direct impact to WUS. However, construction activities within the existing channel will likely have impacts that may be equivalent to Alternative 2 and 3.	

Table 5: McMicken Outlet Channel Alternatives Evaluation

Alternative	Issue	Advantages	Disadvantages
2. Modify Existing Levee with Upstream Filter	Construction Cost Estimate	Lowest cost	
	Design and Geotechnical Investigations Cost		More costly
	Operations & maintenance costs		The levee alternatives including Alternative 2 will require greater operating and maintenance costs than the channel alternatives.
	FEMA oversight and accompanying requirements		Construction of a levee alternative 2 will require certification by FEMA which requires significant inspections and monitoring, and development of an Emergency Action Plan and an evacuation plan and regular training exercises
	Inundation area and availability of excess land for sale		Significantly more land is inundated north of the levee for Alternative 2 compared to Alternatives 3 and 4; however Alternative 2 inundates slightly less land than Alternative 1 due to the location of the levee structures. Consequently, less area is available for sale.
	Availability of excess borrow material for sale		Alternative 2 is unlikely to generate excess borrow material for sale as borrow will be needed to construct the retrofit levee.
	Future road crossing		Construction of future planned road crossings may be very difficult and expensive with the levee alternatives, thereby limiting future development of the area.
	Risk of potential failure		Alternative 2 is a levee which is an above ground earthen structure that has inherently greater risk of potential failure and associated downstream flooding when compared to channels. Also, it will continue to have existing foundation soils of uncertain quality along the downstream side of the levee foundation.
	Aesthetic features and vegetation		The construction of Alternative 2 which comprises a levee will limit the potential for aesthetic treatment to rock mulch on the levee slopes and hydroseed. The channel and levee are linear. Trees cannot be planted near the levee.
	Preservation of existing vegetation and impact on biological resources	In Alternative 2 the vegetation along the north bank is not disturbed/removed. In Alternative 2 the biological resources are less impacted than for the channel alternatives 3 and 4 and relatively less impacted than the levee retrofit alternative 1. Alternative 2 does not require disturbance of vegetation along the north bank of the existing channel.	
	Impacts to electrical transmission line towers	Alternative 2 Maintains the existing channel alignment and does not widen the channel thereby avoiding the electrical transmission line towers.	
	Impacts to "Waters of United States" (WUS)	Alternative 2 has the lowest direct impact to WUS. However, construction activities within the existing channel will likely have impacts that may be equivalent to Alternative 1 and 3.	

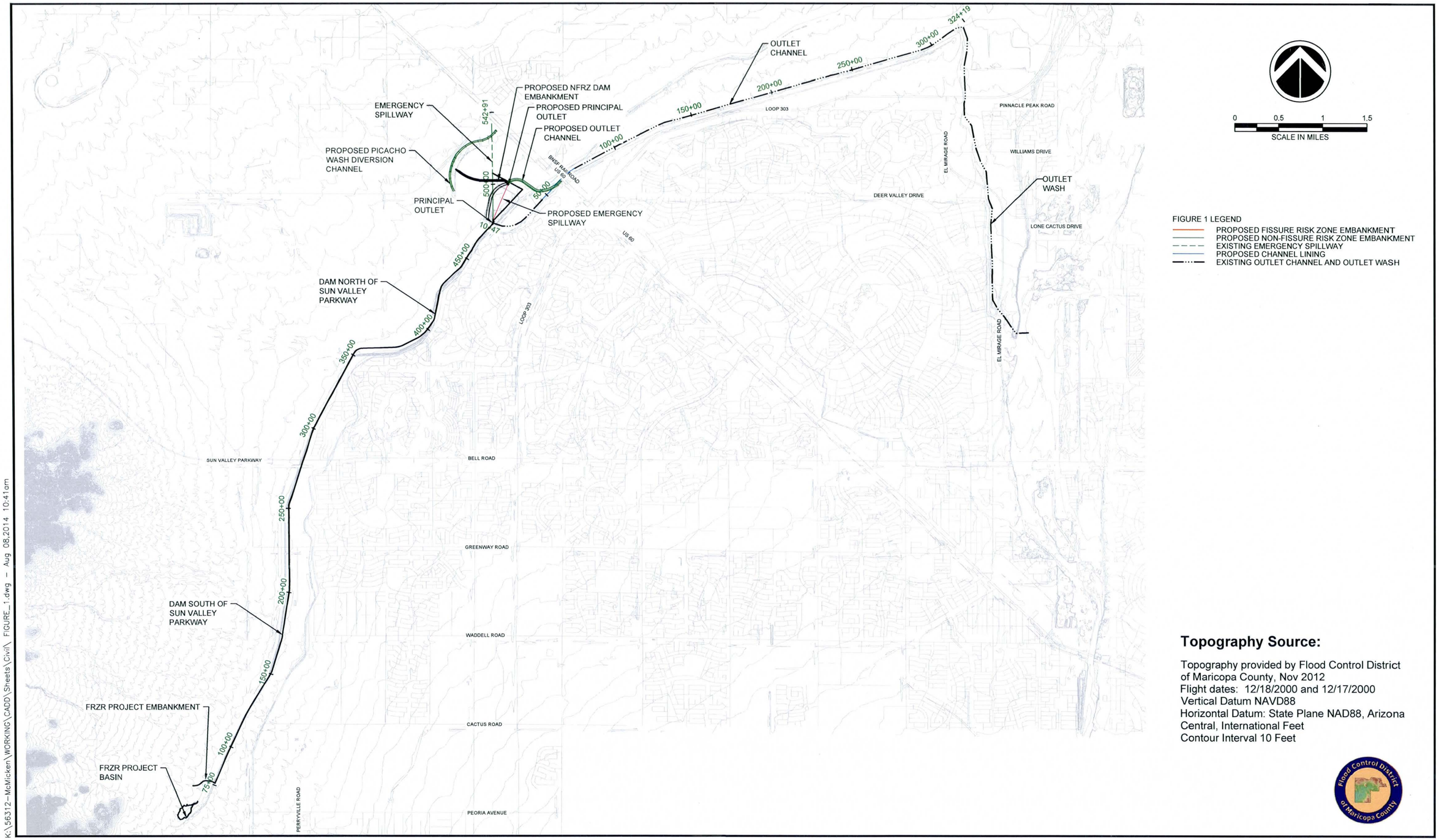
Table 5: McMicken Outlet Channel Alternatives Evaluation

Alternative	Issue	Advantages	Disadvantages
3. Reconstruct Excavated Outlet Channel along Existing Alignment	Construction Cost Estimate		Highest cost
	Design and Geotechnical Investigations Cost	Less costly	
	Operations & maintenance costs	The channel alternatives including Alternative 3 will require less operating and maintenance costs than the levee alternatives.	
	FEMA oversight and accompanying requirements	Construction of an excavated channel alternative 3 will not require levee certification by FEMA which also involves significant inspections and monitoring, and development of an Emergency	
	Inundation area and availability of excess land for sale	Alternative 3 results in less inundation than the levee alternatives but has a wider channel and consequent inundation area to accommodate the electrical transmission line towers compared to Alternative 4. Alternative 3 with an excavated channel can release more land for sale than the levee alternatives which result in a greater inundation area.	
	Availability of excess borrow material for sale	The District is evaluating the option to provide excavated material to ADOT for the Loop 303 project, which would reduce the potential construction cost to the District for channel excavation and consequent construction of Alternative 3.	
	Future road crossing	Construction of future road crossing will be simpler with the channel alternatives including Alternative 3.	
	Risk of potential failure	Alternative 3 is an excavated channel which does not have the risk of potential failure and associated downstream flooding when compared to levees.	
	Aesthetic features and vegetation	Alternative 3 channel design provides opportunities to incorporate natural aesthetic features such as varying of channel slopes and planting of trees along the edge of the channel.	
	Preservation of existing vegetation and impact on biological resources		In Alternative 3 the vegetation along the north bank is disturbed/removed due to the widening and deepening of the existing channel. In Alternative 3 the biological resources are more impacted than for the levee alternatives 1 and 2 due to the widening and deepening of the existing channel.
	Impacts to electrical transmission line towers		In Alternative 3, the existing electrical transmission line towers are located within the channel footprint and require erosion protection. These towers are not impacted by the other alternatives.
	Impacts to "Waters of United States" (WUS)		Alternative 3 has the 2nd highest direct impact to WUS.

Table 5: McMicken Outlet Channel Alternatives Evaluation

Alternative	Issue	Advantages	Disadvantages
4. Realign Outlet Channel North	Construction Cost Estimate		Second highest cost
	Design and Geotechnical Investigations Cost	Less costly	
	Operations & maintenance costs	The channel alternatives including Alternative 4 will require less operating and maintenance costs than the levee alternatives.	
	FEMA oversight and accompanying requirements	Construction of an excavated channel alternative 4 will not require levee certification by FEMA which also involves significant inspections and monitoring, and development of an Emergency Action Plan.	
	Inundation area and availability of excess land for sale	Alternative 4 results in less inundation than the levee alternatives as well as Alternative 3 which consists of a wider channel. Alternative 4 with an excavated channel can release more land for sale than the levee alternatives which result in a greater inundation area.	
	Availability of excess borrow material for sale	The District is evaluating the option to provide excavated material to ADOT for the Loop 303 project, which would reduce the potential construction cost to the District for channel excavation and consequent construction of Alternative 4.	
	Future road crossing	Construction of future road crossing will be simpler with the channel alternatives including Alternative 4.	
	Risk of potential failure	Alternative 4 is an excavated channel which does not have the risk of potential failure and associated downstream flooding when compared to levees.	
	Aesthetic features and vegetation	Alternative 4 channel design provides opportunities to incorporate natural aesthetic features such as varying of channel slopes and planting of trees along the edge of the channel.	
	Preservation of existing vegetation and impact on biological resources		In Alternative 4 the vegetation along the north bank is disturbed/removed due to the realignment and deepening of the existing channel. In Alternative 4 the biological resources are more impacted than for the levee alternatives 1 and 2 as well as Alternative 3 which follows the existing Outlet Channel alignment.
	Impacts to electrical transmission line towers	In Alternative 4, the realignment of the channel avoids the electrical transmission line towers.	
	Impacts to "Waters of United States" (WUS)		Alternative 4 has the greatest direct impact to WUS. The new channel is excavated across 3 washes and the existing channel will be backfilled to match existing adjacent ground grade.

FIGURES



Topography Source:

Topography provided by Flood Control District of Maricopa County, Nov 2012
Flight dates: 12/18/2000 and 12/17/2000
Vertical Datum NAVD88
Horizontal Datum: State Plane NAD88, Arizona Central, International Feet
Contour Interval 10 Feet

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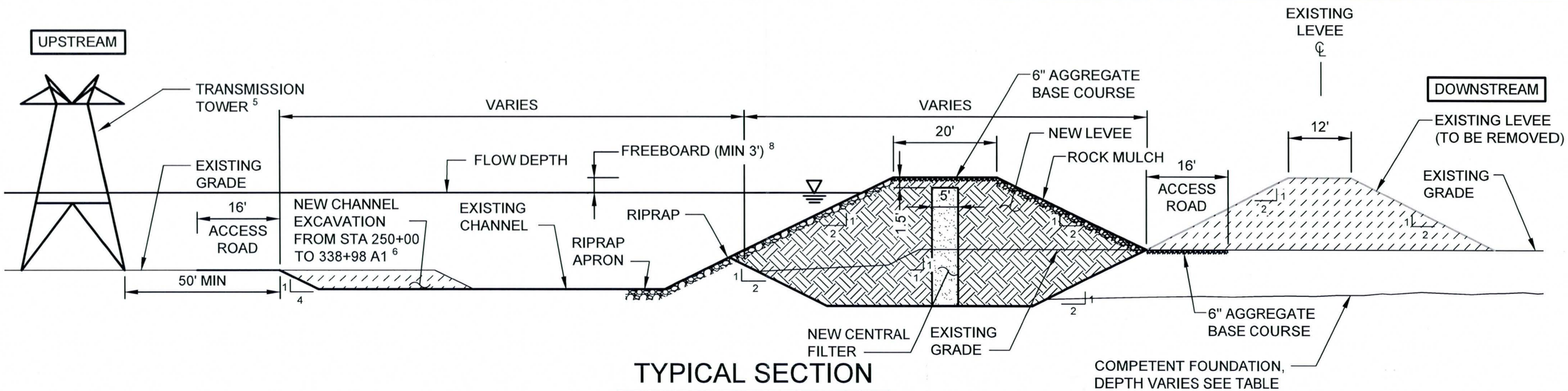
McMicken Dam Rehabilitation Project
Project Site
Figure 1



TYPICAL SECTION

NTS

HYDRAULICS TABLE

STATION	100-YEAR DISCHARGE (CFS)	200-YEAR DISCHARGE (CFS)	100-YEAR VELOCITY (FPS)	200-YEAR VELOCITY (FPS)	BOTTOM WIDTH (FT)	100-YEAR FLOW DEPTH (FT)	200-YEAR FLOW DEPTH (FT)	LONGITUDINAL SLOPE (FT/FT)	COMMENTS
121+50 TO 190+00	4,450 [1]	4,450	1.9	1.9	VARIES	9.8	9.8	0.0014	Data displayed are taken at section 160+00. Data could vary at other locations in this range.
190+00 TO 232+00	7,045 [2]	8,243	2.1	2.2	VARIES	10.0	10.4	0.0017	Data displayed are taken at section 190+00. Data could vary at other locations in this range.
232+00 TO 250+00	9,090 [3]	10,716	2.6	2.6	VARIES	10.8	11.5	0.0019	Data displayed are taken at section 235+00. Data could vary at other locations in this range.
250+00 TO 338+98 A1 [6]	9,090 [3]	10,716	1.6	1.7	VARIES	12.8	13.5	0.0006	Data displayed are taken at section 265+00. Data could vary at other locations in this range.

LEVEE FOUNDATION TABLE

OUTLET CHANNEL STATION (FROM-TO)	AVERAGE DEPTH (FT) TO GOOD FOUNDATION AT EXISTING DOWNSTREAM LEVEE TOE	AVERAGE DEPTH (FT) TO GOOD FOUNDATION AT LEVEE CENTERLINE FROM EXISTING LEVEE FOUNDATION
121+50 TO 200+00	9.0	7.0
200+00 TO 245+00	5.0	3.0
245+00 TO 317+20	8.0	6.0

NOTE: OVEREXCAVATION WILL BE DONE TO REMOVE POORLY CONSOLIDATED, OR COLLAPSIBLE SOILS OR UNSUITABLE FOUNDATION MATERIALS. LEVEE WILL BE FOUNDED ON COMPETENT FOUNDATION MATERIAL.

SOURCE: GEOTECHNICAL APPRAISAL REPORT McMICKEN DAM PROJECT BY:
AMEC ENVIRONMENTAL AND INFRASTRUCTURE, INC., FEBRUARY 22, 2013

NOTES:

1. 4,450 cfs is the Principal Outlet discharge from 66+50 to 190+00 used in the McMicken Dam Outlet Channel Inundation Report EAP Update (2004) by Kimley Horn and Associates (KHA).
2. 7,045 cfs is the 100-year discharge from 190+00 to 232+00 used in the Low Resolution Hydrology Model within the McMicken Dam Draft Hydrology Report (late 2012) by RBF Engineering.
3. 9,090 cfs is the 100-year discharge used in the Low Resolution Hydrology Model within the McMicken Dam Draft Hydrology Report (late 2012) by RBF Engineering.
4. Manning's Roughness Coefficients are based on the FCDMC Hydraulic Manual in conjunction with discussions with the District project team staff.
5. Refer to the plans for location of transmission towers.
6. A1 refers to Alternative 1 Alignment Stationing.
7. Figure 2-5 "Modify Existing Levee with Recessed Upstream Filter for Alternatives 1 - 4" will be common to all four alternatives.
8. Freeboard shown in this typical section is for the 100-year storm. Freeboard for the 200- year storm is 2.3 feet min.

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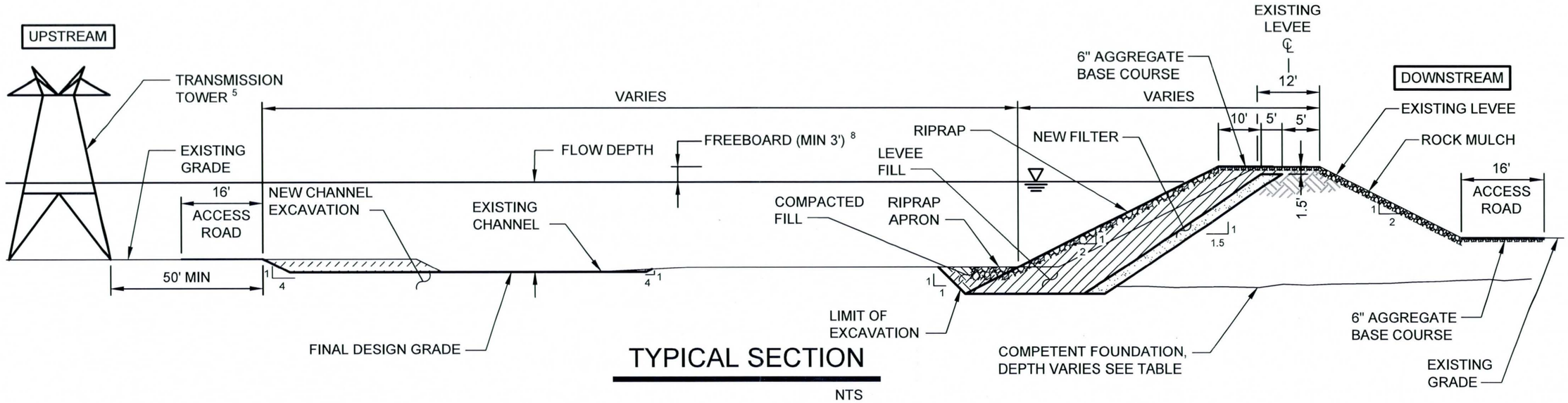
McMicken Dam Rehabilitation Project

Alternative 1: Construct New Levee with Central Filter North of Existing Levee Typical Section

Figure 2-1



TYPICAL SECTION

NTS

HYDRAULICS TABLE

STATION	100-YEAR DISCHARGE (CFS)	200-YEAR DISCHARGE (CFS)	100-YEAR VELOCITY (FPS)	200-YEAR VELOCITY (FPS)	BOTTOM WIDTH (FT)	100-YEAR FLOW DEPTH (FT)	200-YEAR FLOW DEPTH (FT)	LONGITUDINAL SLOPE (FT/FT)	COMMENTS
121+50 TO 190+00	4,450 [1]	4,450	1.9	1.9	VARIES	9.6	9.6	0.0014	Data displayed are taken at section 160+00. Data could vary at other locations in this range.
190+00 TO 232+00	7,045 [2]	8,243	2.1	2.2	VARIES	9.7	10.0	0.0017	Data displayed are taken at section 190+00. Data could vary at other locations in this range.
232+00 TO 250+00	9,090 [3]	10,716	2.6	2.7	VARIES	10.3	10.8	0.0019	Data displayed are taken at section 235+00. Data could vary at other locations in this range.
250+00 TO 338+98 A2 [6]	9,090 [3]	10,716	1.7	1.7	VARIES	12.5	13.1	0.0006	Data displayed are taken at section 265+00. Data could vary at other locations in this range.

LEVEE FOUNDATION TABLE

OUTLET CHANNEL STATION (FROM-TO)	AVERAGE DEPTH (FT) TO GOOD FOUNDATION AT EXISTING DOWNSTREAM LEVEE TOE	AVERAGE DEPTH (FT) TO GOOD FOUNDATION AT LEVEE CENTERLINE FROM EXISTING LEVEE FOUNDATION
121+50 TO 200+00	9.0	7.0
200+00 TO 245+00	5.0	3.0
245+00 TO 317+20	8.0	6.0

NOTE: OVEREXCAVATION WILL BE DONE TO REMOVE POORLY CONSOLIDATED, OR COLLAPSIBLE SOILS OR UNSUITABLE FOUNDATION MATERIALS. LEVEE WILL BE FOUNDED ON COMPETENT FOUNDATION MATERIAL.

SOURCE: GEOTECHNICAL APPRAISAL REPORT McMICKEN DAM PROJECT BY:
AMEC ENVIRONMENTAL AND INFRASTRUCTURE, INC., FEBRUARY 22, 2013

NOTES:

1. 4,450 cfs is the Principal Outlet discharge from 66+50 to 190+00 used in the McMicken Dam Outlet Channel Inundation Report EAP Update (2004) by Kimley Horn and Associates (KHA).
2. 7,045 cfs is the 100-year discharge from 190+00 to 232+00 used in the Low Resolution Hydrology Model within the McMicken Dam Draft Hydrology Report (late 2012) by RBF Engineering.
3. 9,090 cfs is the 100-year discharge used in the Low Resolution Hydrology Model within the McMicken Dam Draft Hydrology Report (late 2012) by RBF Engineering.
4. Manning's Roughness Coefficients are based on the FCDMC Hydraulic Manual in conjunction with discussions with the District project team staff.
5. Refer to the plans for location of transmission towers.
6. A2 refers to Alternative 2 Alignment Stationing.
7. Figure 2-5 "Modify Existing Levee with Recessed Upstream Filter for Alternatives 1 - 4" will be common to all four alternatives.
8. Freeboard shown in this typical section is for the 100-year storm. Freeboard for the 200-year storm is 2.4 feet min.

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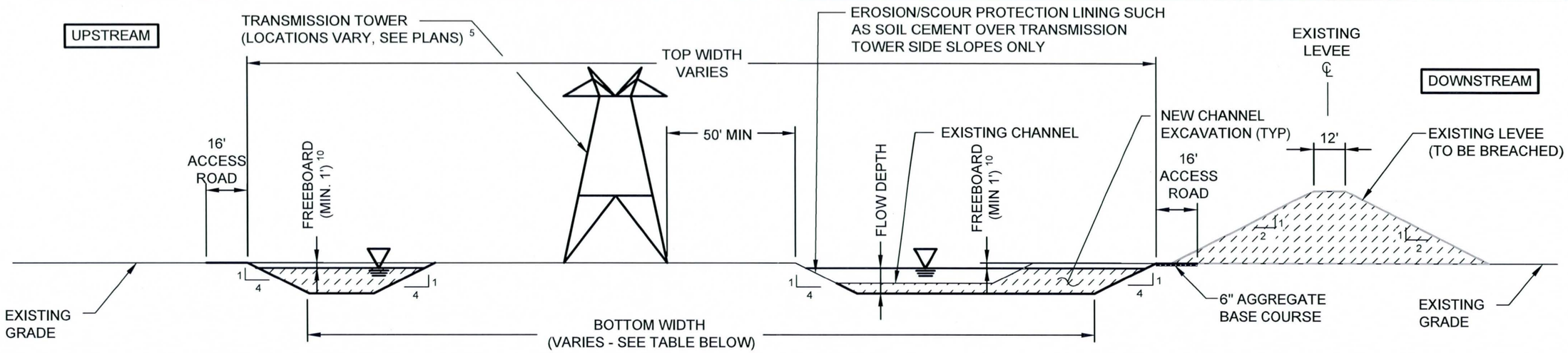
McMicken Dam Rehabilitation Project

Alternative 2: Modify Existing Levee with Upstream Filter Typical Section

Figure 2-2



HYDRAULICS TABLE

STATION	100-YEAR DISCHARGE (CFS)	200-YEAR DISCHARGE (CFS)	100-YEAR VELOCITY (FPS)	200-YEAR VELOCITY (FPS)	BOTTOM WIDTH (FT)	100-YEAR FLOW DEPTH (FT)	200-YEAR FLOW DEPTH (FT)	LONGITUDINAL SLOPE (FT/FT)
121+50 TO 126+50 [6]	4,450 [1]	4,450	5.2	5.2	50	9.7	9.7	0.0012
129+00 TO 158+90	4,450 [1]	4,450	4.6	4.6	120	6.6	6.6	0.0012
167+00 TO 180+00	4,450 [1]	4,450	3.6	3.6	300	4.0	4.0	0.0012
182+25 TO 190+00	4,450 [1]	4,450	3.8	3.8	250	4.4	4.4	0.0012
190+00 TO 232+00	7045 [2]	8,243	4.5	4.7	250	5.8	6.3	0.0012
232+00 TO 327+25 A3 [8]	9090 [3]	10,716	4.9	5.2	250	6.7	7.4	0.0012

NOTES:
1. 4,450 cfs is the Principal Outlet discharge used in the McMicken Dam Outlet Channel Inundation Report EAP Update (2004) by Kimley Horn and Associates (KHA).
2. 7,045 cfs is the 100-year discharge used in the Low Resolution Hydrology Model within the McMicken Dam Draft Hydrology Report (late 2012) by RBF Engineering.
3. 9,090 cfs is the 100-year discharge used in the Low Resolution Hydrology Model within the McMicken Dam Draft Hydrology Report (late 2012) by RBF Engineering.
4. Manning's Roughness Coefficients are based on the FCDMC Hydraulic Manual in conjunction with discussions with the District project team staff.
5. Refer to the plans for location of transmission towers.
6. Channel sections between stations 121+50 and 126+50 retains the existing channel side slopes.
7. Channel bottom widths vary linearly where there are gaps between stations in the table above.
8. A3 refers to Alternative 3 Alignment Stationing.
9. Figure 2-5 "Modify Existing Levee with Recessed Upstream Filter for Alternatives 1 - 4" will be common to all four alternatives.
10. Freeboard shown in this typical section is for the 100-year storm. Freeboard for the 200-year storm is 0.3 feet min.

TYPICAL SECTION

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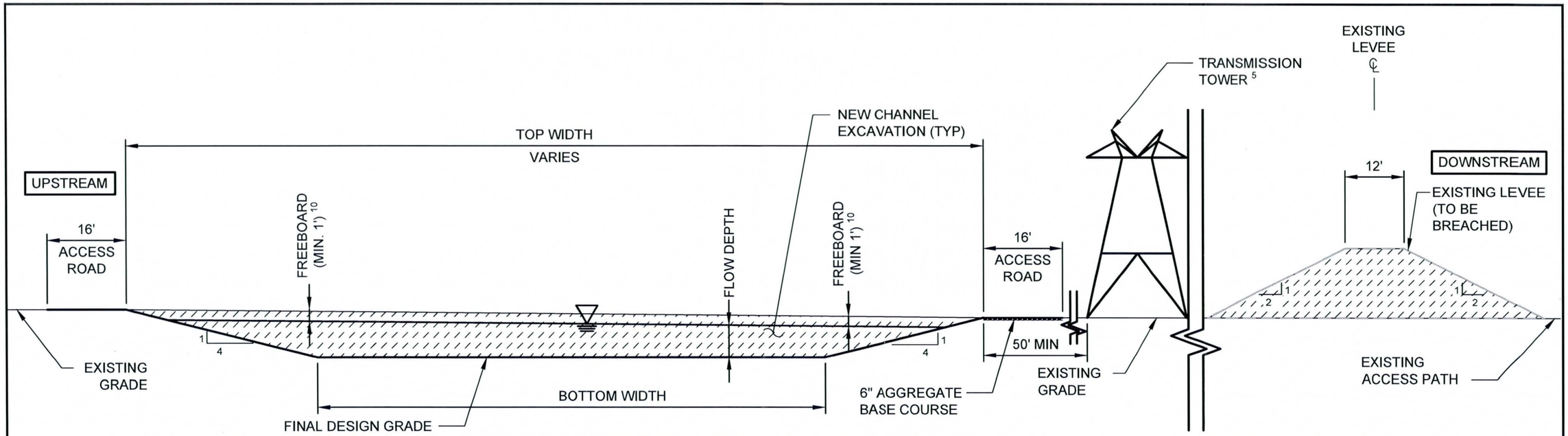
Alternative 3: Remove Existing Levee and Reconstruct Excavated Outlet Channel along Existing Alignment Typical Section

Figure 2-3



HYDRAULICS TABLE								
STATION	100-YEAR DISCHARGE (CFS)	200-YEAR DISCHARGE (CFS)	100-YEAR VELOCITY (FPS)	200-YEAR VELOCITY (FPS)	BOTTOM WIDTH (FT)	100-YEAR FLOW DEPTH (FT)	200-YEAR FLOW DEPTH (FT)	LONGITUDINAL SLOPE (FT/FT)
111+50 TO 129+20 A4 [6, 8]	4,450 [1]	4,450	5.2	5.2	50	9.7	9.7	0.0012
131+00 A4 TO 158+85 A4 [8]	4,450 [1]	4,450	4.7	4.7	100	7.3	7.3	0.0012
162+00 A4 TO 230+30 A4 [8]	7045 [2]	8,243	4.9	5.2	170	7.2	7.9	0.0012
233+00 A4 TO 328+00 A4 [8]	9090 [3]	10,716	5.0	5.3	230	7.1	7.7	0.0012

NOTES:
1. 4,450 cfs is the Principal Outlet discharge used in the McMicken Dam Outlet Channel Inundation Report EAP Update (2004) by Kimley Horn and Associates (KHA).
2. 7,045 cfs is the 100-year discharge used in the Low Resolution Hydrology Model within the McMicken Dam Draft Hydrology Report (late 2012) by RBF Engineering.
3. 9,090 cfs is the 100-year discharge used in the Low Resolution Hydrology Model within the McMicken Dam Draft Hydrology Report (late 2012) by RBF Engineering.
4. Manning's Roughness Coefficients are based on the FCDMC Hydraulic Manual in conjunction with discussions with the District project team staff.
5. Refer to the plans for location of transmission towers.
6. Channel sections between stations 111+50 and 129+20 retains the existing channel side slopes.
7. Channel bottom widths vary linearly where there are gaps between stations in the table above.
8. A4 refers to Alternative 4 Alignment Stationing.
9. Figure 2-5 "Modify Existing Levee with Recessed Upstream Filter for Alternatives 1 - 4" will be common to all four alternatives.
10. Freeboard shown in this typical section is for the 100-year storm. Freeboard for the 200-year storm is 0.3 feet min.

TYPICAL SECTION

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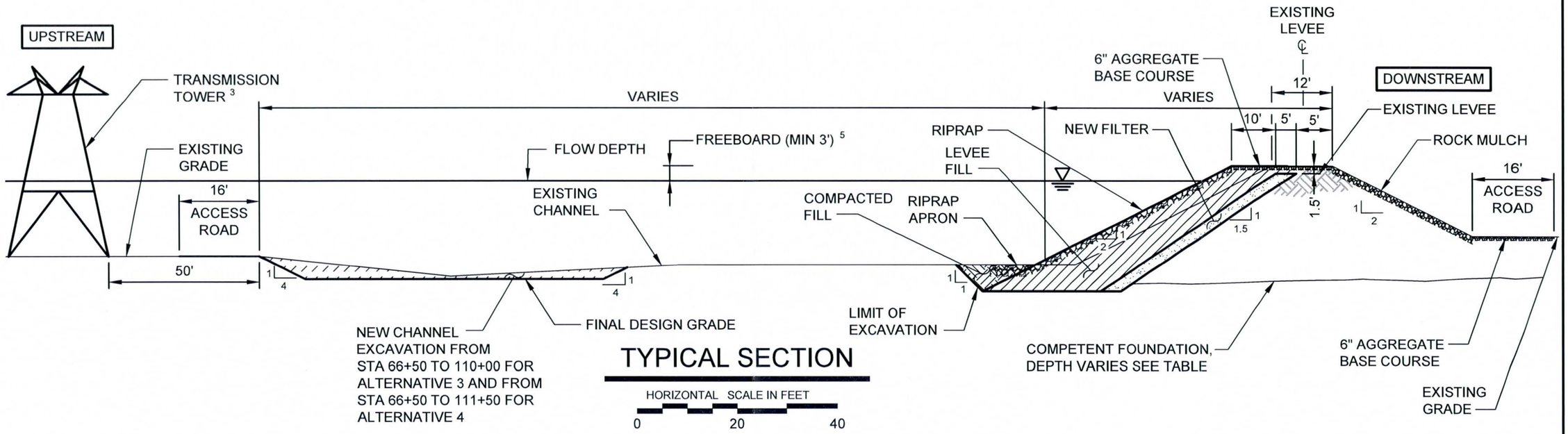
McMicken Dam Rehabilitation Project
Alternative 4: Realign Outlet Channel North and Remove Existing Levee Typical Section
Figure 2-4



TYPICAL SECTION

HORIZONTAL SCALE IN FEET

0 20 40

HYDRAULICS TABLE

STATION	MCMICKEN DAM PRINCIPLE OUTLET DISCHARGE (CFS)	VELOCITY (FPS)	BOTTOM WIDTH (FT)	FLOW DEPTH (FT)	LONGITUDINAL SLOPE (FT/FT)	COMMENTS
66+50 TO 121+50	4,450 [1]	2.1	EXISTING CHANNEL BOTTOM WIDTH VARIES	12.0	0.0016	Data displayed are taken at section 100+00 for Alternatives 1 and 2. Data could vary at other locations in this range.
66+50 TO 121+50	4,450 [1]	2.0	EXISTING CHANNEL BOTTOM WIDTH VARIES	14.0	0.0012	Data displayed are taken at section 100+00 for Alternatives 3 and 4. Data could vary at other locations in this range.

LEVEE FOUNDATION TABLE

OUTLET CHANNEL STATION (FROM-TO)	AVERAGE DEPTH (FT) TO GOOD FOUNDATION AT EXISTING DOWNSTREAM LEVEE TOE	AVERAGE DEPTH (FT) TO GOOD FOUNDATION AT LEVEE CENTERLINE FROM EXISTING LEVEE FOUNDATION
66+50 TO 110+00	13.0	11.0
110+00 TO 121+50	9.0	7.0

NOTE: OVEREXCAVATION WILL BE DONE TO REMOVE POORLY CONSOLIDATED, OR COLLAPSIBLE SOILS OR UNSUITABLE FOUNDATION MATERIALS. LEVEE WILL BE FOUNDED ON COMPETENT FOUNDATION MATERIAL.

SOURCE: GEOTECHNICAL APPRAISAL REPORT McMICKEN DAM PROJECT BY:
AMEC ENVIRONMENTAL AND INFASTRUCTURE, INC., FEBRUARY 22, 2013

NOTES:

1. 4,450 cfs is the Principal Outlet discharge from 66+50 to 190+00 used in the McMicken Dam Outlet Channel Inundation Report EAP Update (2004) by Kimley Horn and Associates (KHA).
2. Manning's Roughness Coefficients are based on the FCDMC Hydraulic Manual in conjunction with discussions with the District project team staff.
3. Refer to the plans for location of transmission towers.
4. For Alternatives 1-2 this typical section applies from station 66+50 to 121+50. For Alternative 3 this typical section applies from sta 66+50 to 110+00. For Alternative 4 this typical section applies from sta 66+50 to 111+50.
5. Freeboard shown in this typical section is for the 100-year storm.

K:\56312-McMicken\WORKING\CADD\Sheets\Civil\ 056312-E-Alternate Analysis-005.dwg - Sep 22,2014 10:22am

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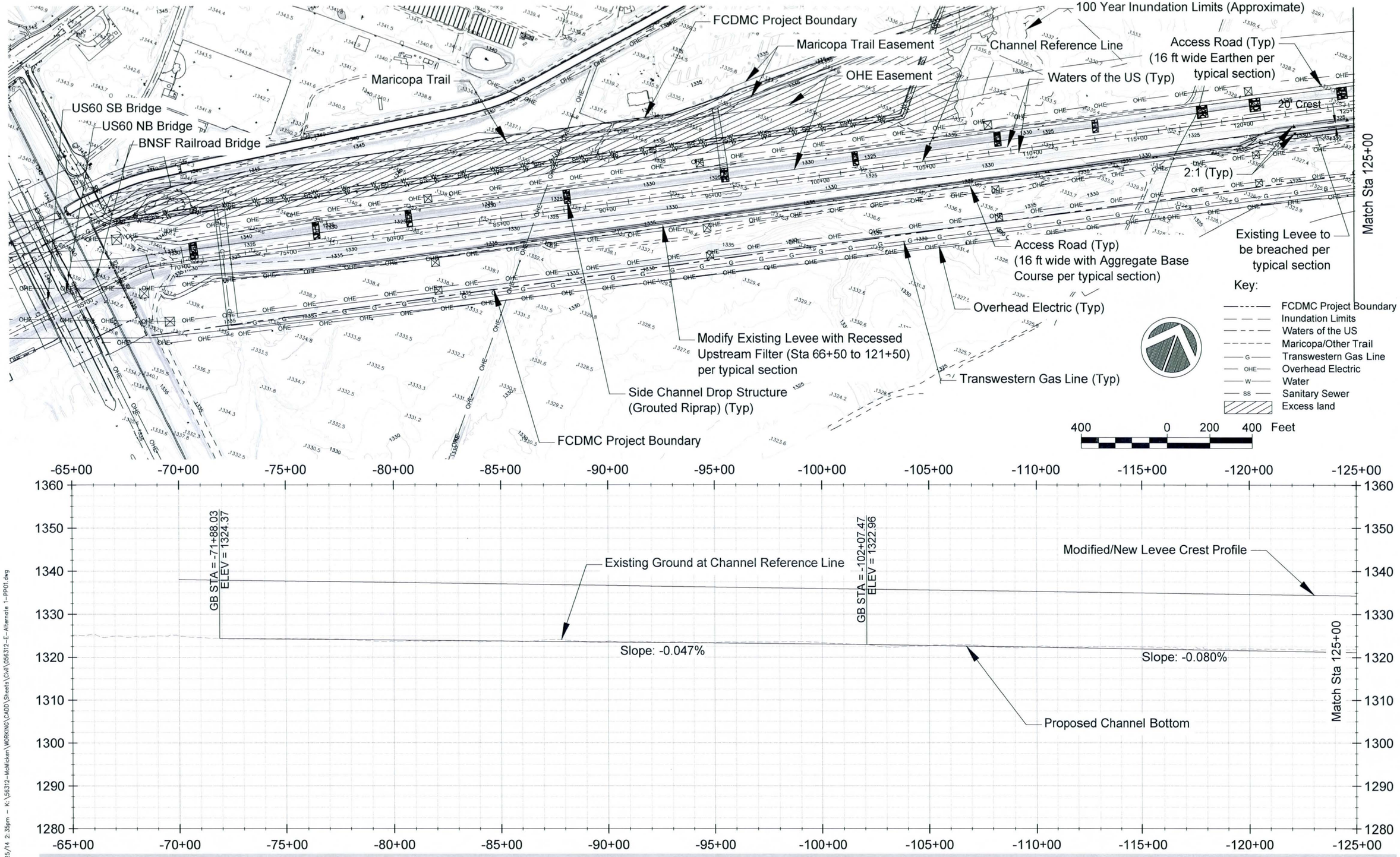
Modify Existing Levee with Recessed Upstream Filter for Alternatives 1-4 Typical Section

Figure 2-5

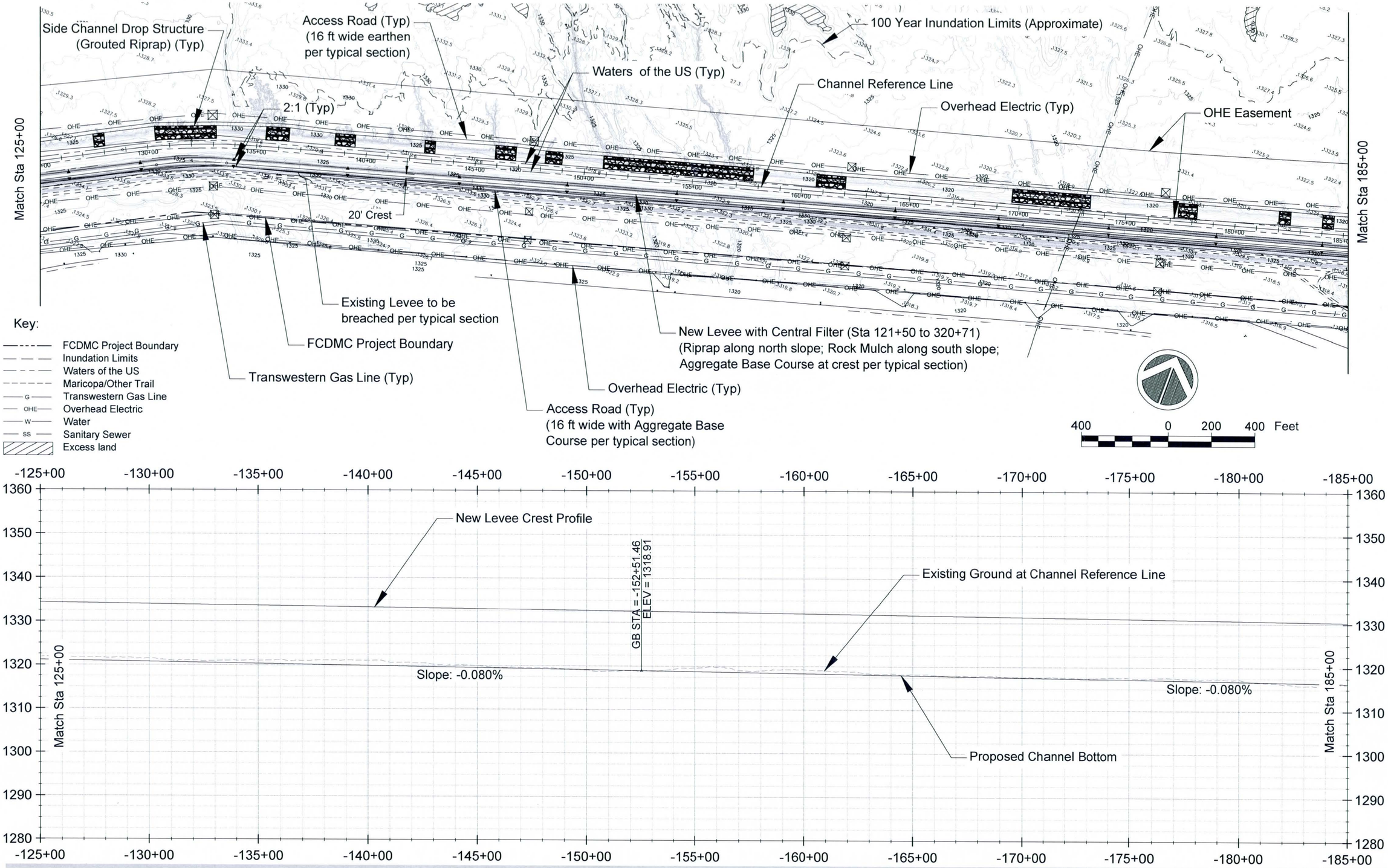


Gannett Fleming

Alternative 1: Construct New Levee with a Central Filter North of Existing Levee

July 2014 FIGURE 3-1A

ehynick 08/25/14 2:35pm – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 1-PP01.dwg

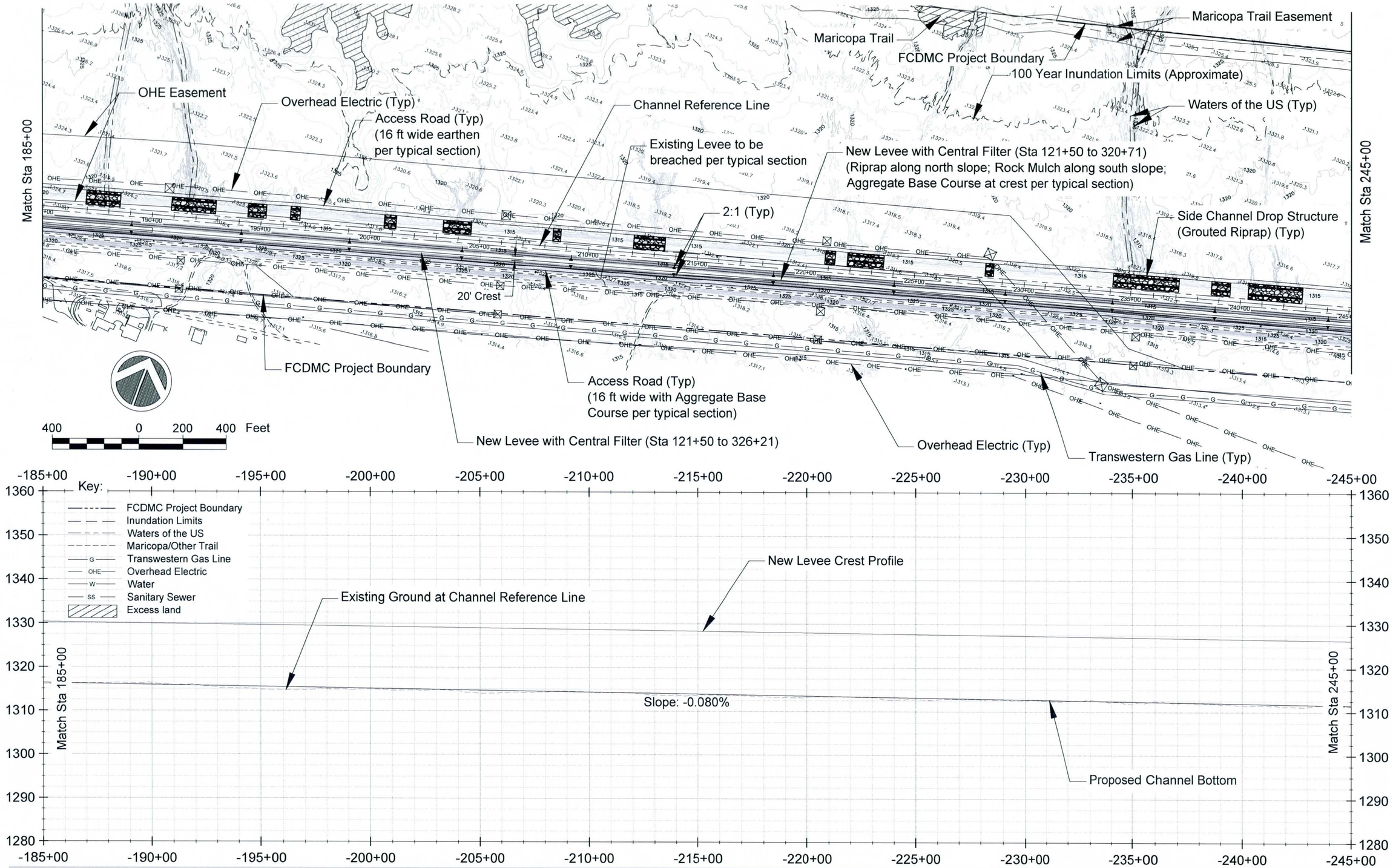


Gannett Fleming

Alternative 1: Construct New Levee with a Central Filter North of Existing Levee

July 2014 FIGURE 3-1B

ehynick 08/06/14 11:10am – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 1-PP02.dwg

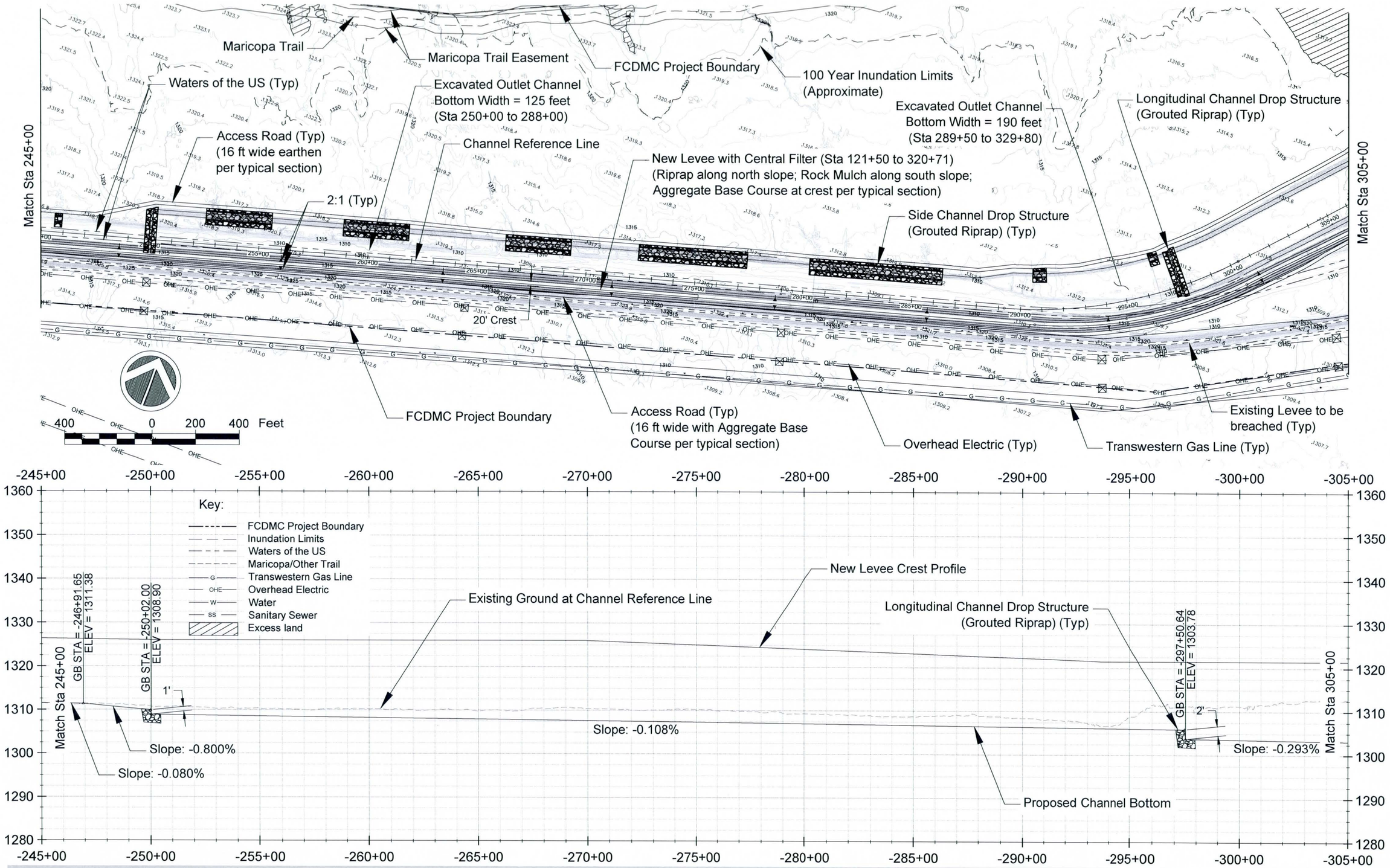


Gannett Fleming

Alternative 1: Construct New Levee with a Central Filter North of Existing Levee

July 2014 FIGURE 3-1C

ehynick 08/06/14 11:18am – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 1-PP03.dwg

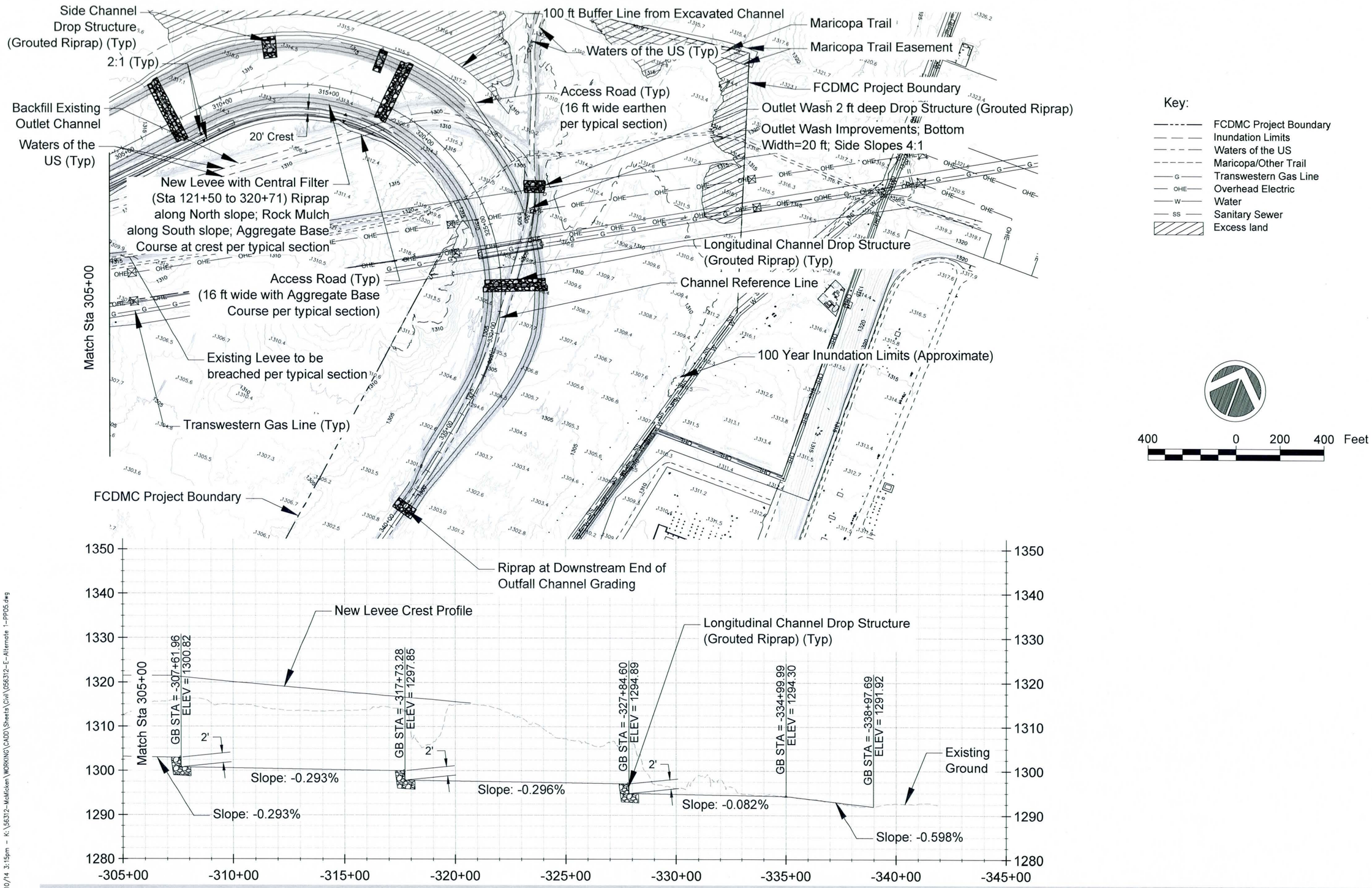


Gannett Fleming

Alternative 1: Construct New Levee with a Central Filter North of Existing Levee

July 2014 FIGURE 3-1D

ehynick 08/06/14 11:22am – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 1-PP04.dwg

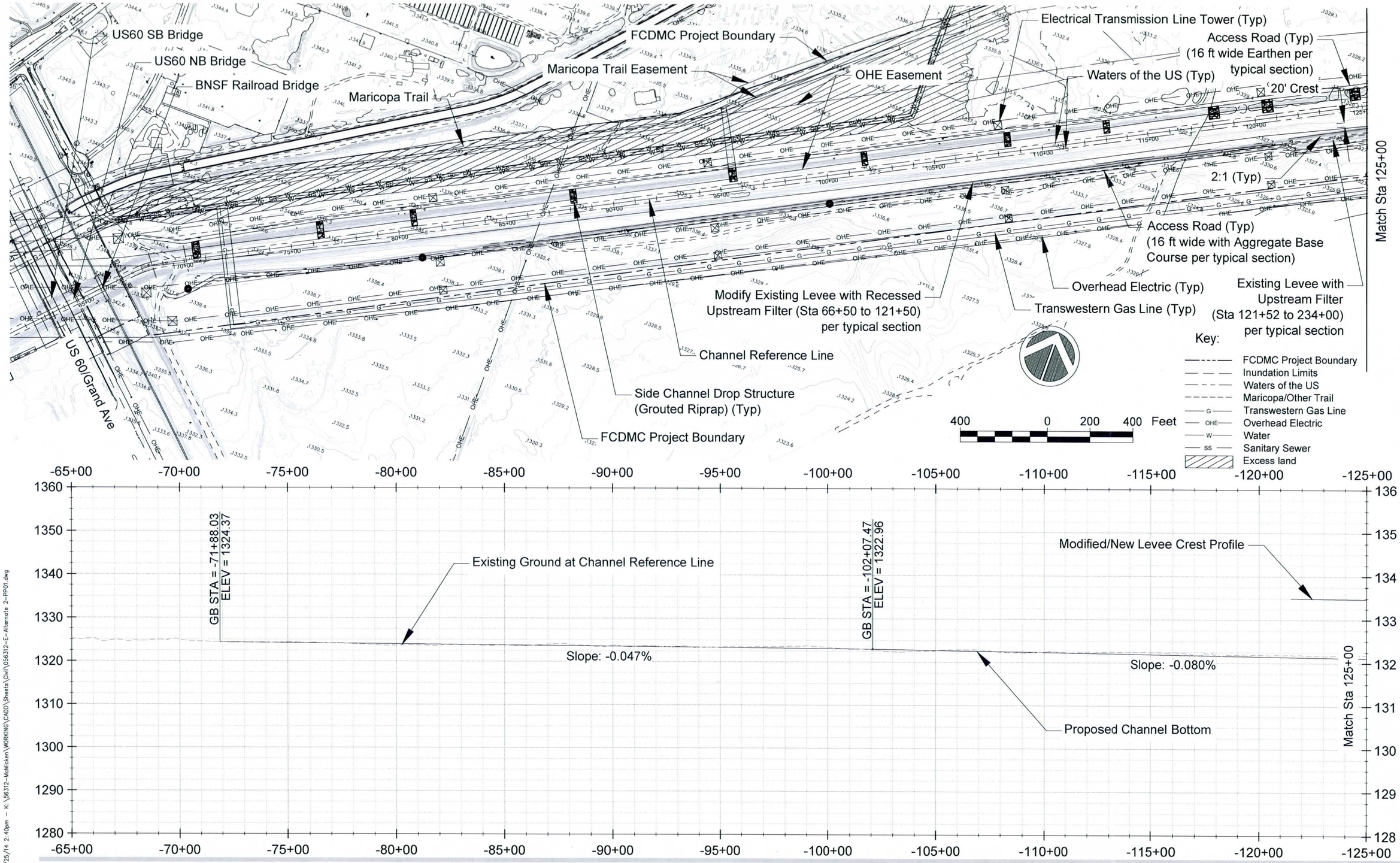


Gannett Fleming

Alternative 1: Construct New Levee with a Central Filter North of Existing Levee

July 2014 FIGURE 3-1E

ehynick 09/10/14 3:15pm - K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 1-PP05.dwg

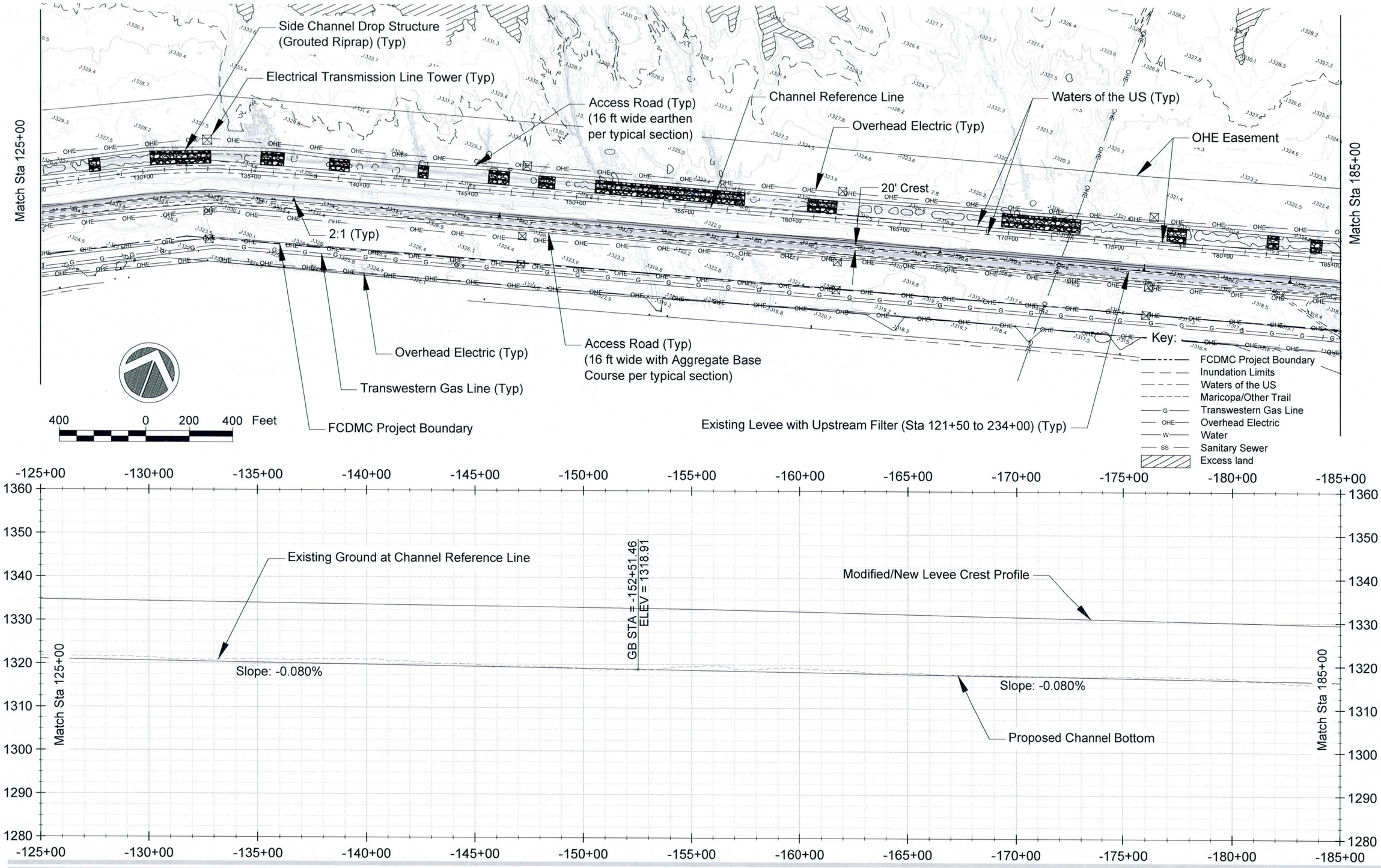


Gannett Fleming

Alternative 2: Modify Existing Levee with Upstream Filter

July 2014 FIGURE 3-2A

ehynick 08/25/14 2:40pm – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 2-PP01.dwg

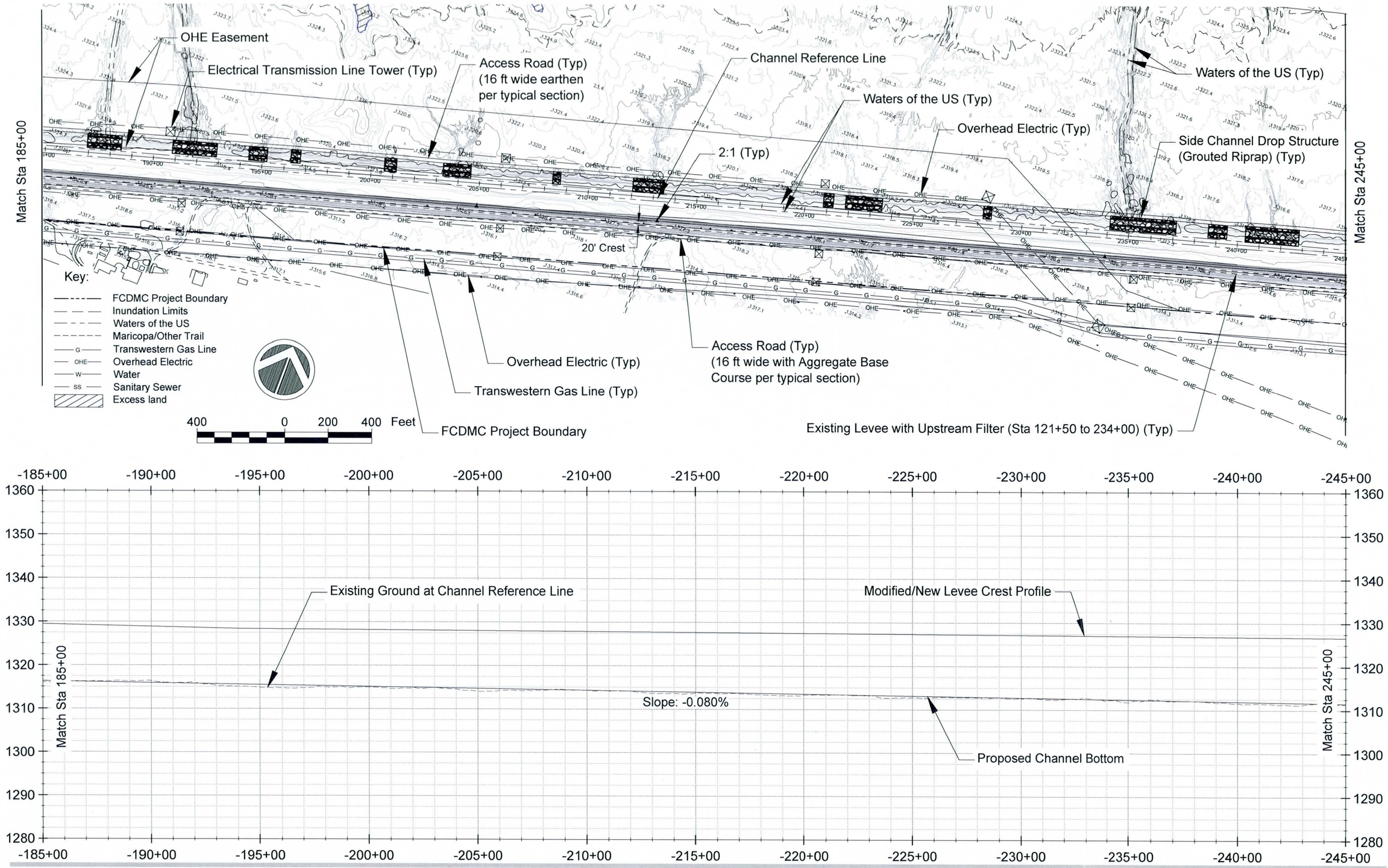


Gannett Fleming

Alternative 2: Modify Existing Levee with Upstream Filter

July 2014 FIGURE 3-2B

ehynick 08/07/14 4:37pm – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 2-PP02.dwg

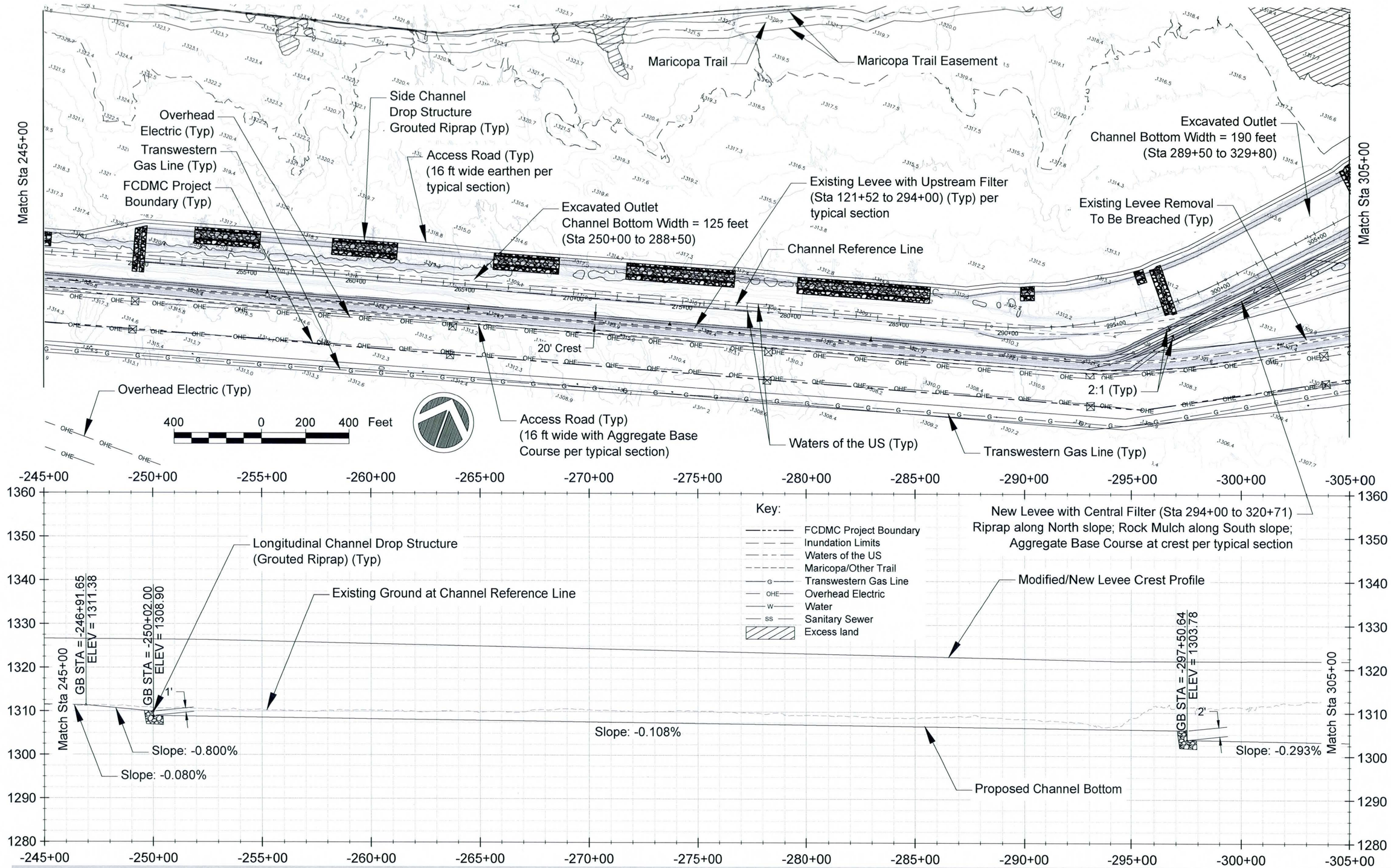


Gannett Fleming

Alternative 2: Modify Existing Levee with Upstream Filter

July 2014 FIGURE 3-2C

ehynick 08/07/14 4:38pm – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 2-PP03.dwg

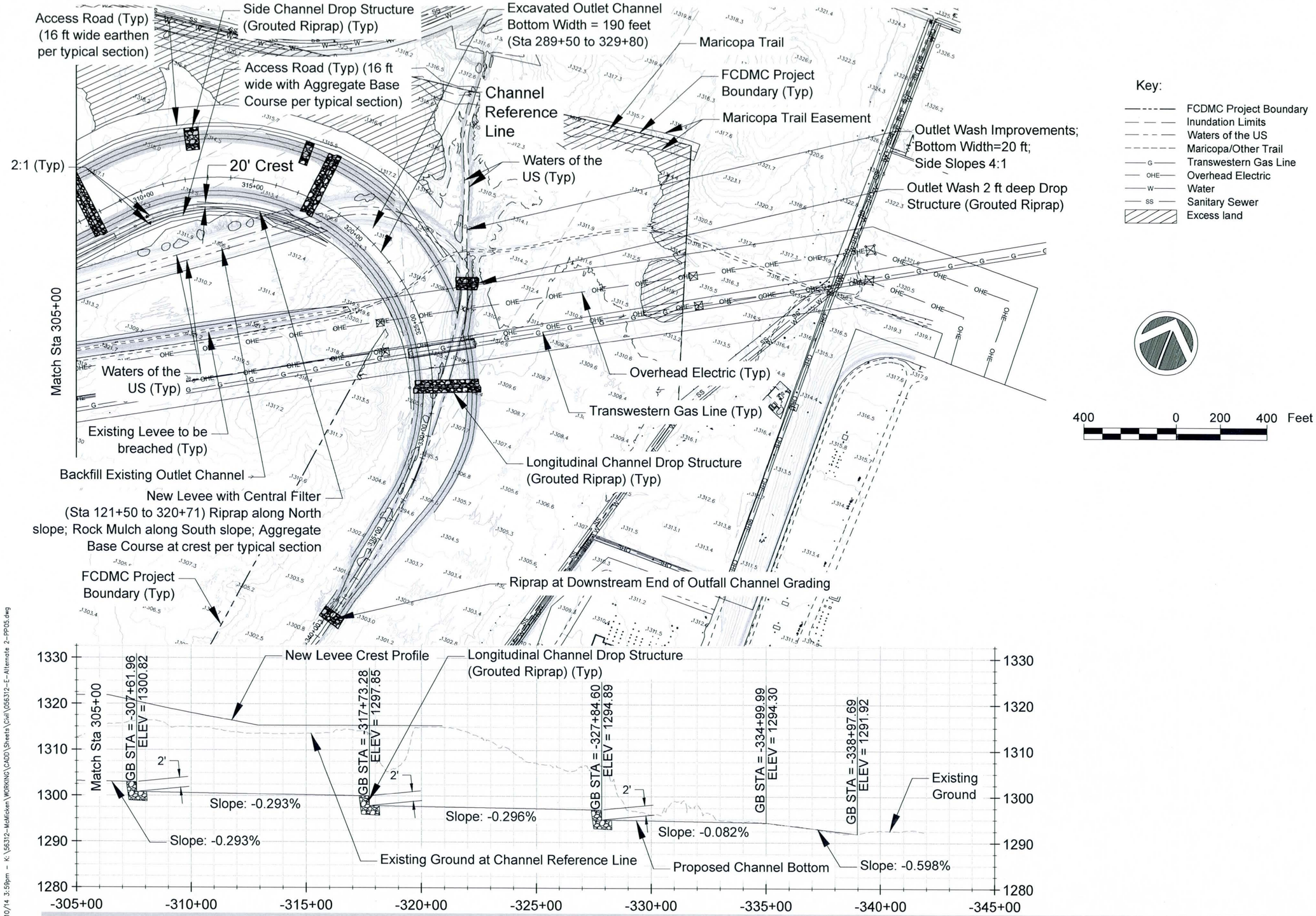


Gannett Fleming

Alternative 2: Modify Existing Levee with Upstream Filter

July 2014 FIGURE 3-2D

ehynick 08/08/14 9:40am – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 2-PP04.dwg



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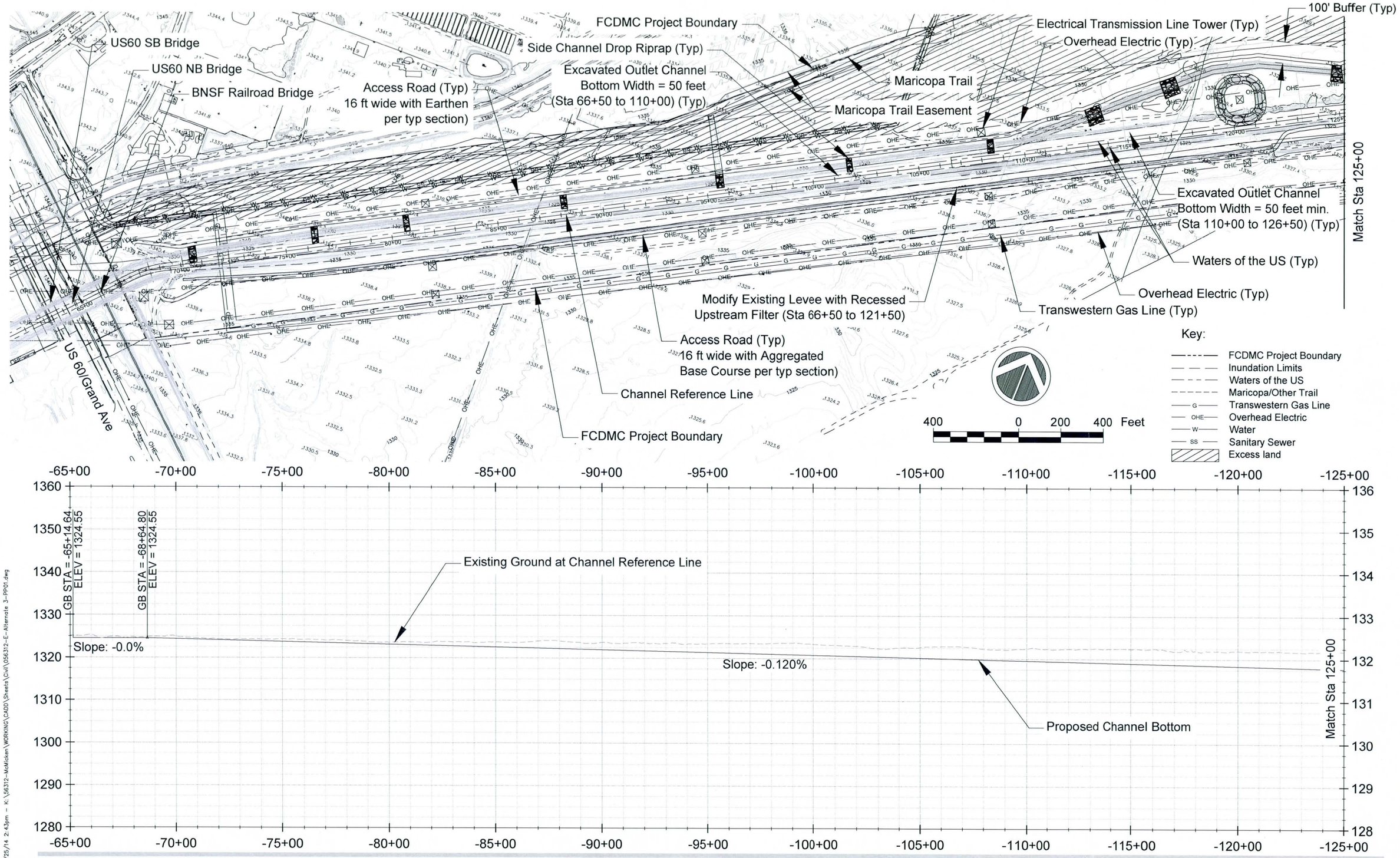
Alternative 2: Modify Ehrenick 09/10/14 3:59pm – K:\56312–McMicken\WORKING\CADD\Sheets\Civil\056312–E–Alternate 2–PP05.dwg

July 2014 FIGURE 3-2E



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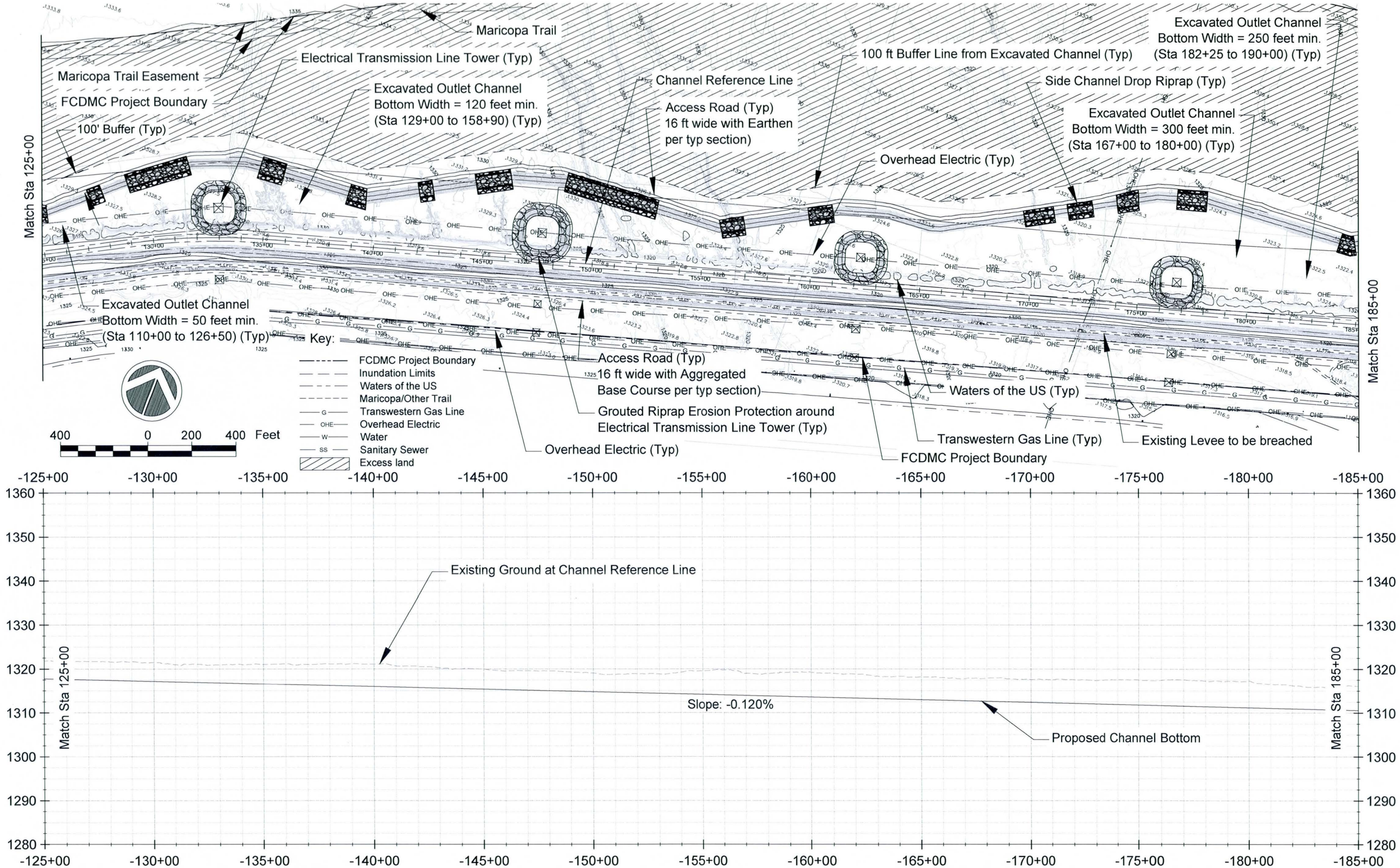
Alternative 3: Reconstruct Excavated Outlet Channel Along Existing Alignment

July 2014 FIGURE 3-3A

ehynick 08/25/14 2:43pm – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 3-PP01.dwg

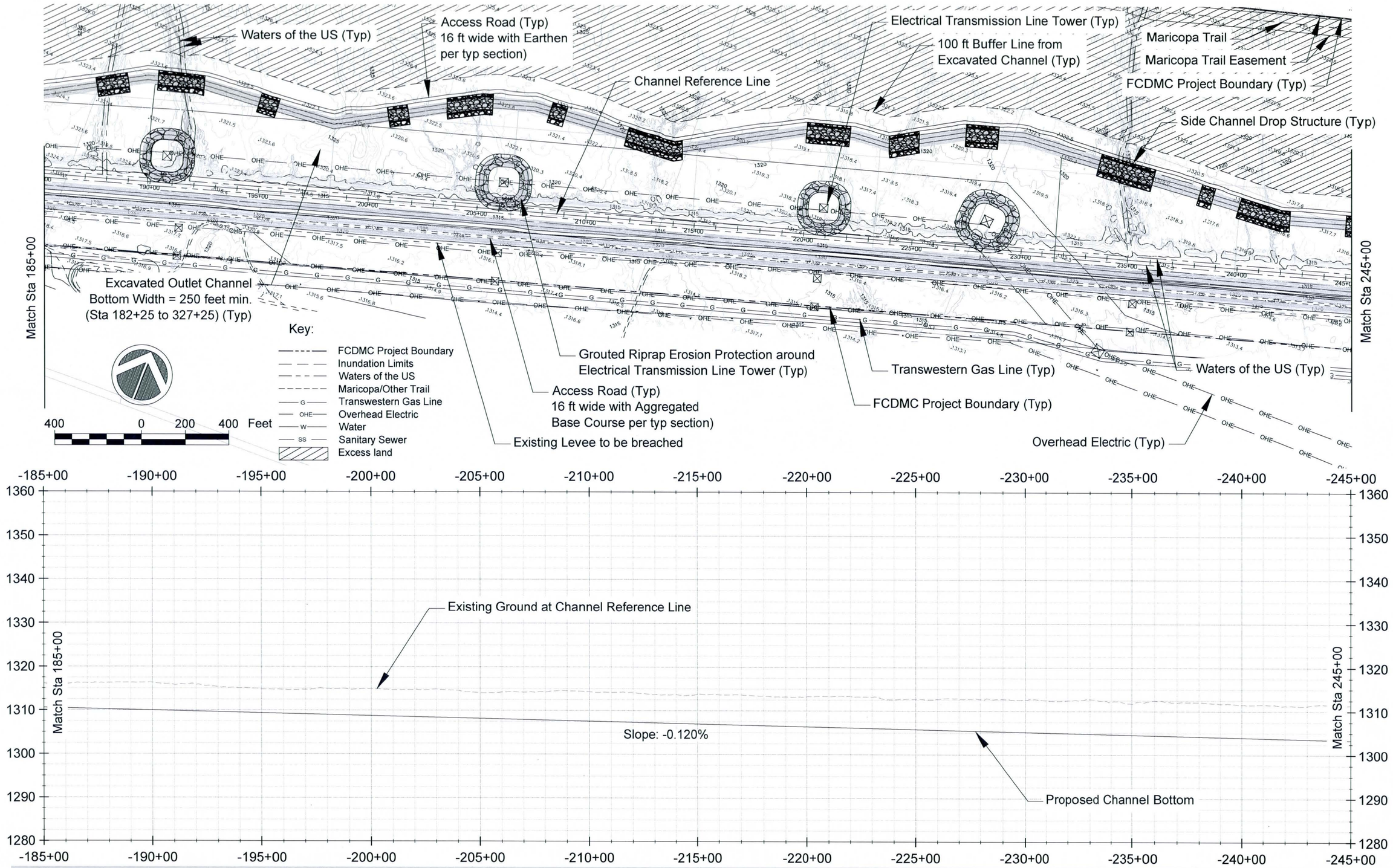


Gannett Fleming

Alternative 3: Reconstruct Excavated Outlet Channel Along Existing Alignment

July 2014 FIGURE 3-3B

ehynick 08/08/14 2:21pm – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 3-PP02.dwg

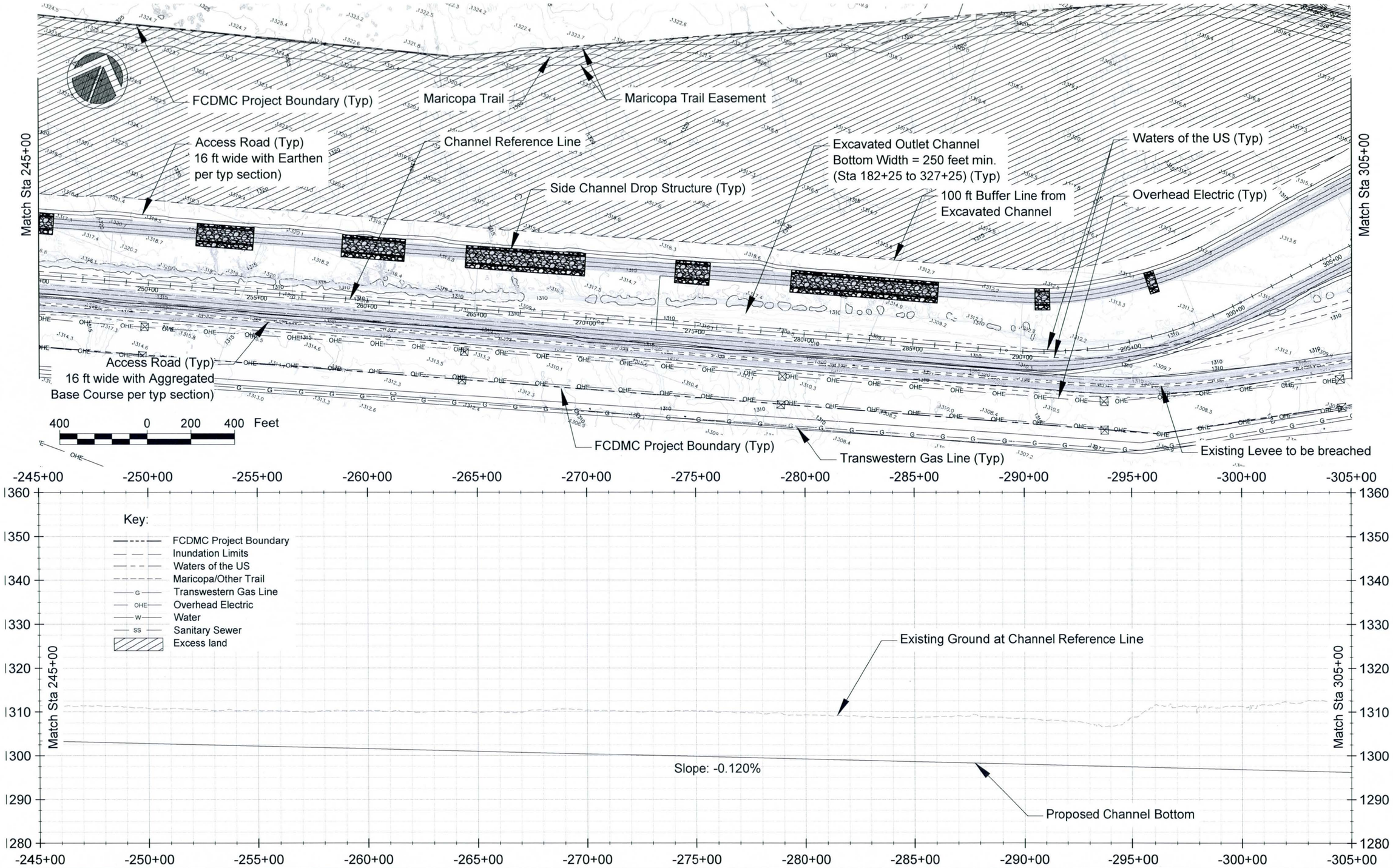


Gannett Fleming

Alternative 3: Reconstruct Excavated Outlet Channel Along Existing Alignment

July 2014 FIGURE 3-3C

ehynick 08/06/14 12:32pm – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 3-PP03.dwg

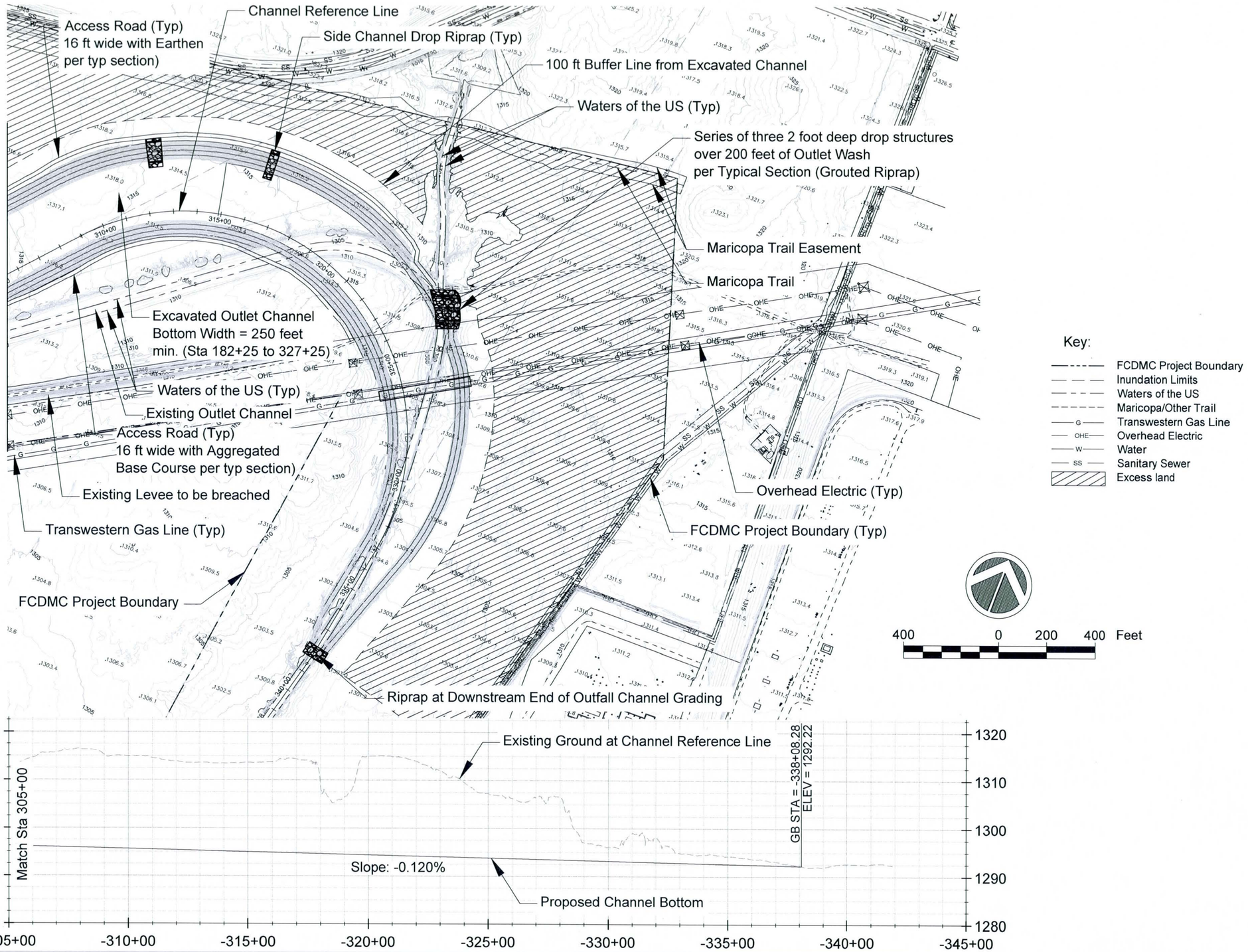


Gannett Fleming

Alternative 3: Reconstruct Excavated Outlet Channel Along Existing Alignment

July 2014 FIGURE 3-3D

ehynick 08/06/14 12:35pm – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 3-PP04.dwg

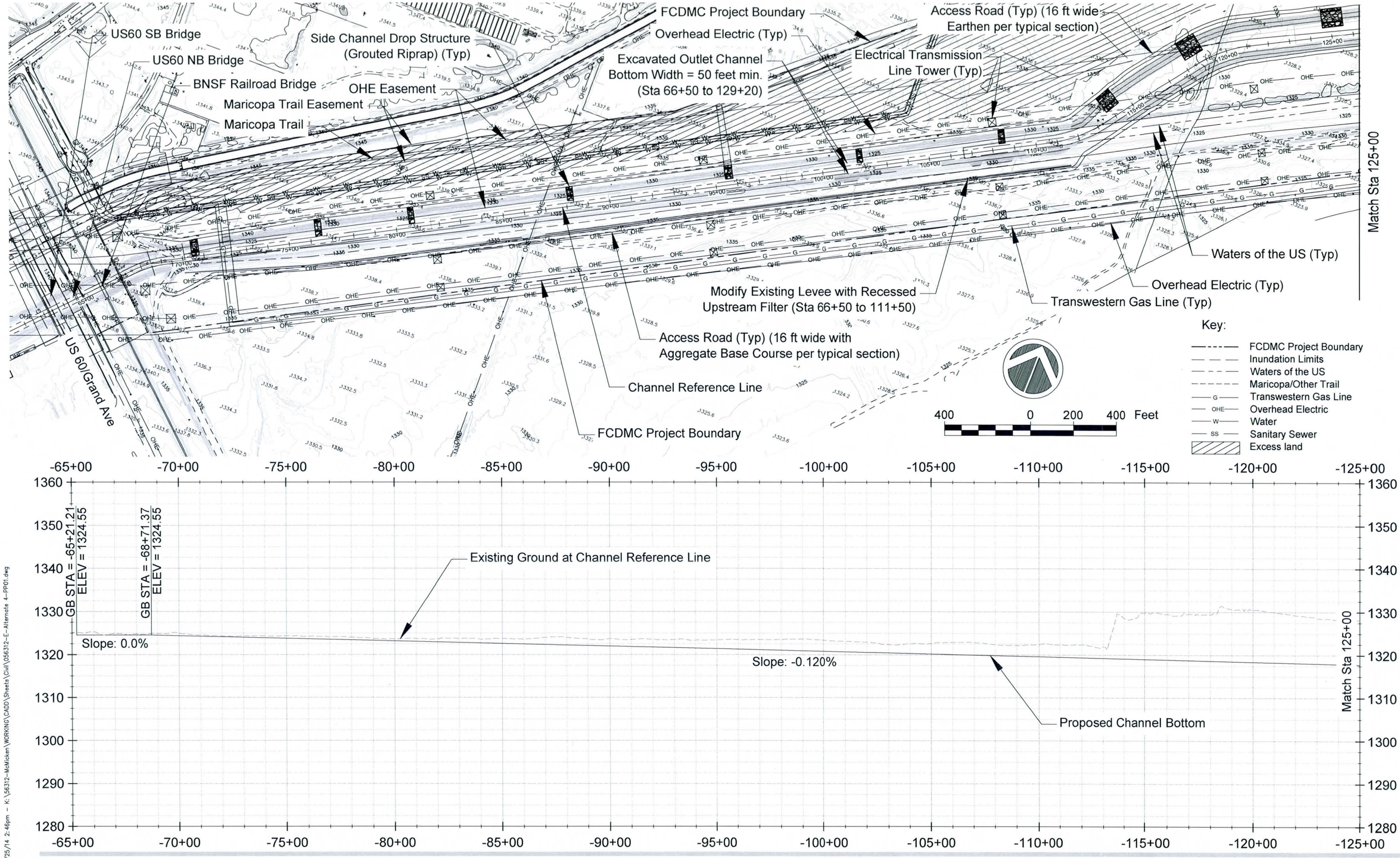


Gannett Fleming

Alternative 3: Reconstruct Excavated Outlet Channel Along Existing Alignment

July 2014 FIGURE 3-3E

ehynick 09/10/14 3:41pm – K:\58312–McMicken\WORKING\CADD\Sheets\Civil\058312–E–Alternate 3–PP05.dwg

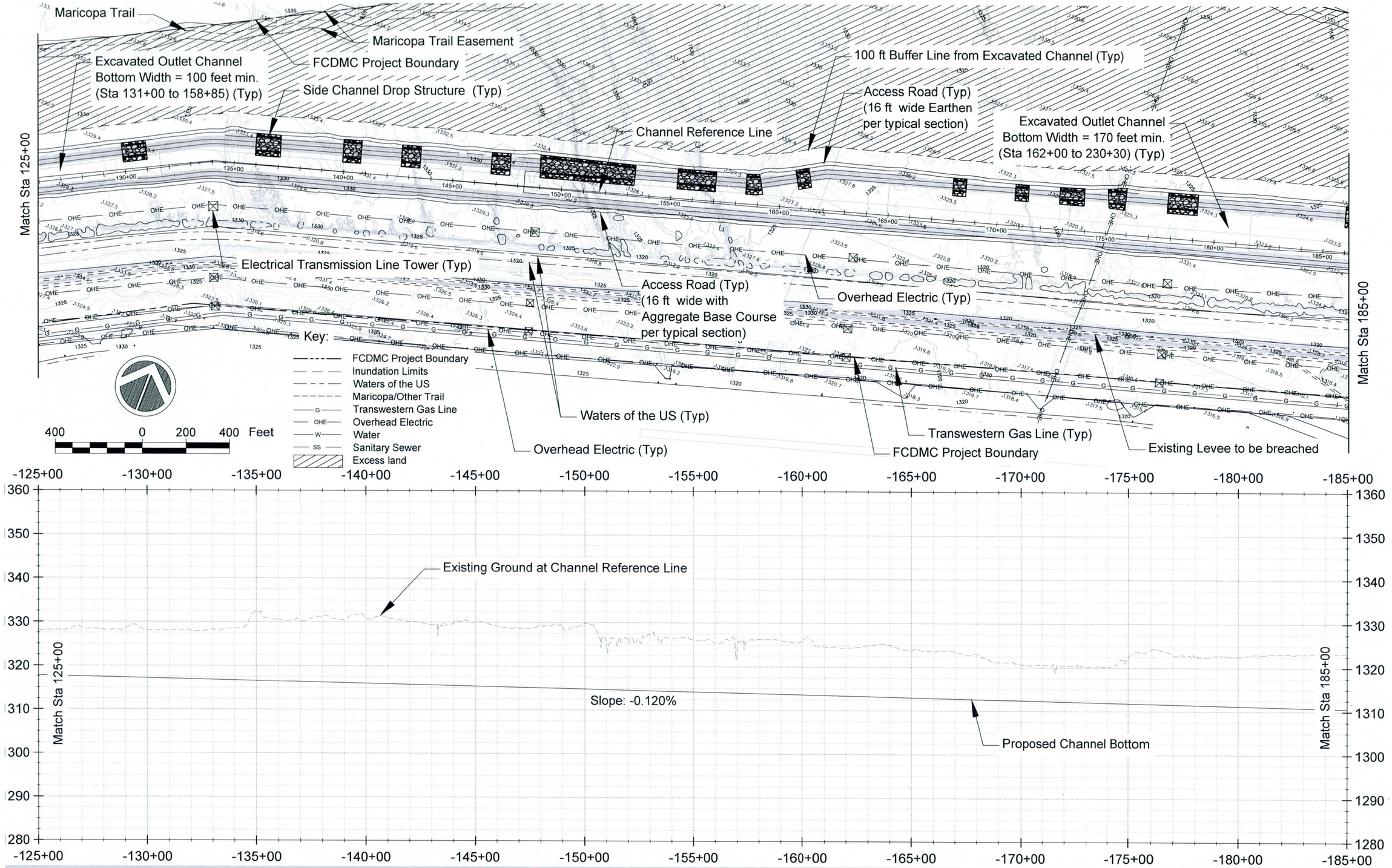


Gannett Fleming

Alternative 4: Realign Outlet Channel North

July 2014 FIGURE 3-4A

ehynick 08/25/14 2:46pm – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 4-PP01.dwg

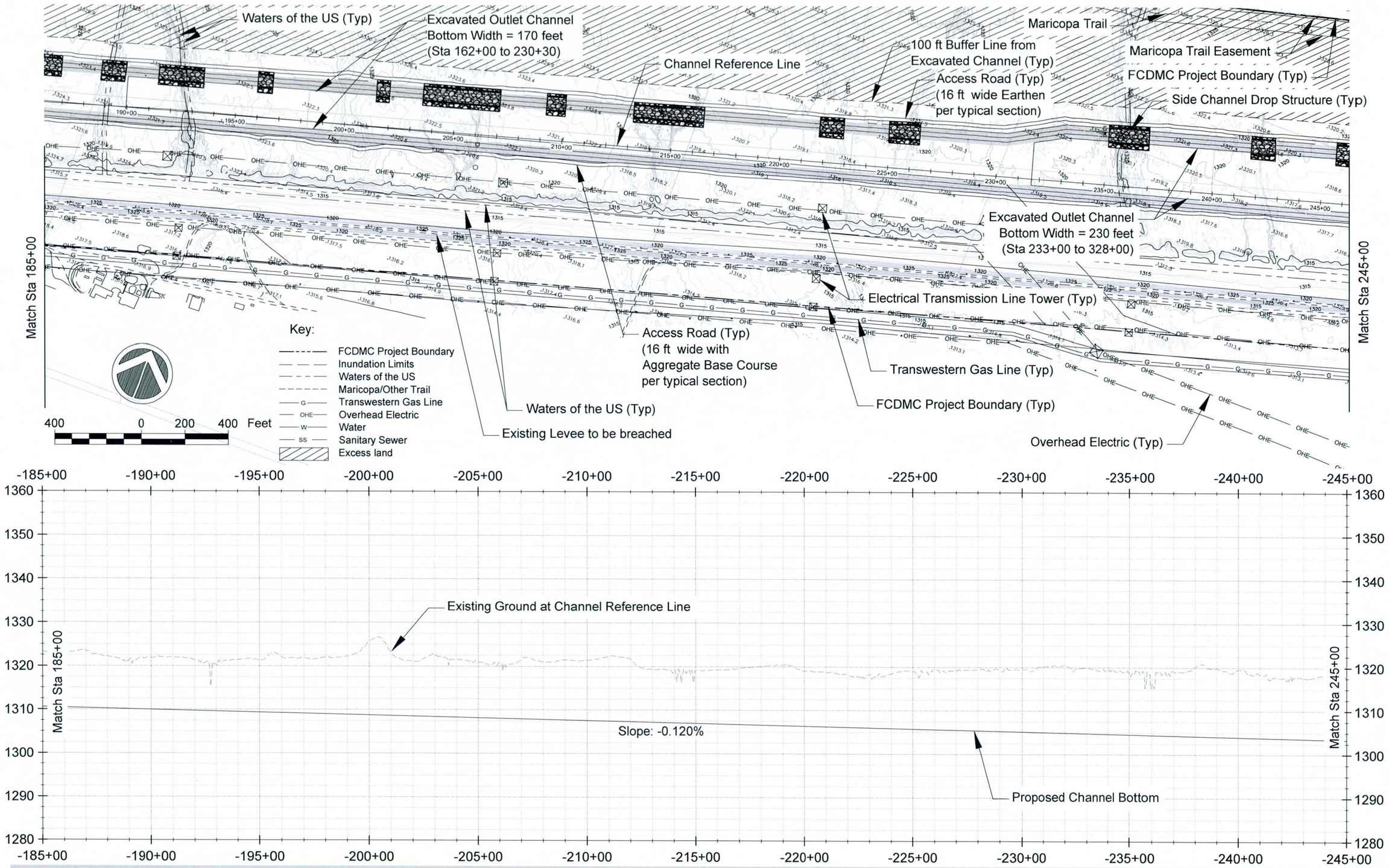


Gannett Fleming

Alternative 4: Realign Outlet Channel North

July 2014 FIGURE 3-4B

ehynick 08/06/14 12:47pm – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 4-PP02.dwg

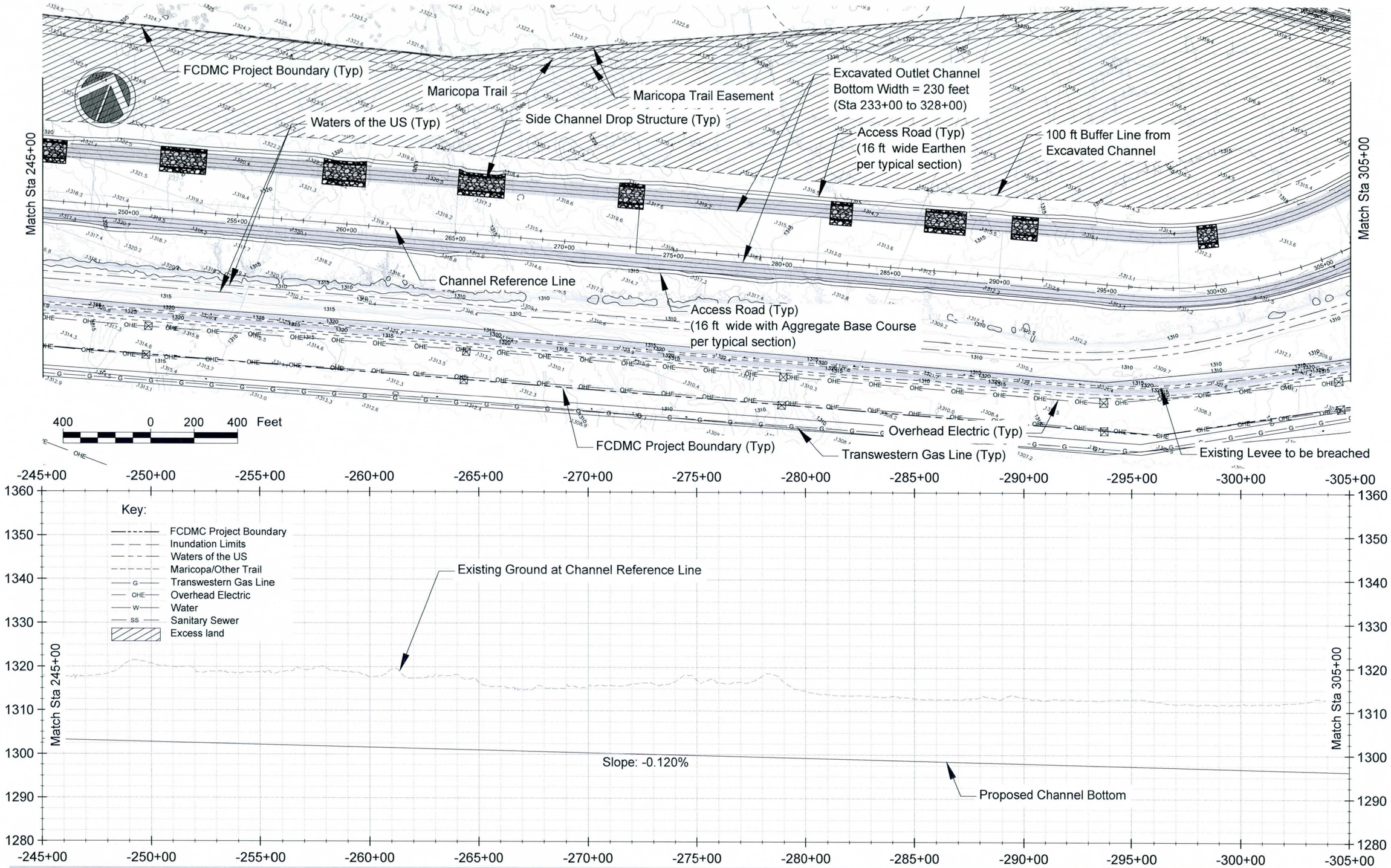


Gannett Fleming

Alternative 4: Realign Outlet Channel North

July 2014 FIGURE 3-4C

ehynick 08/06/14 12:52pm – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 4-PP03.dwg

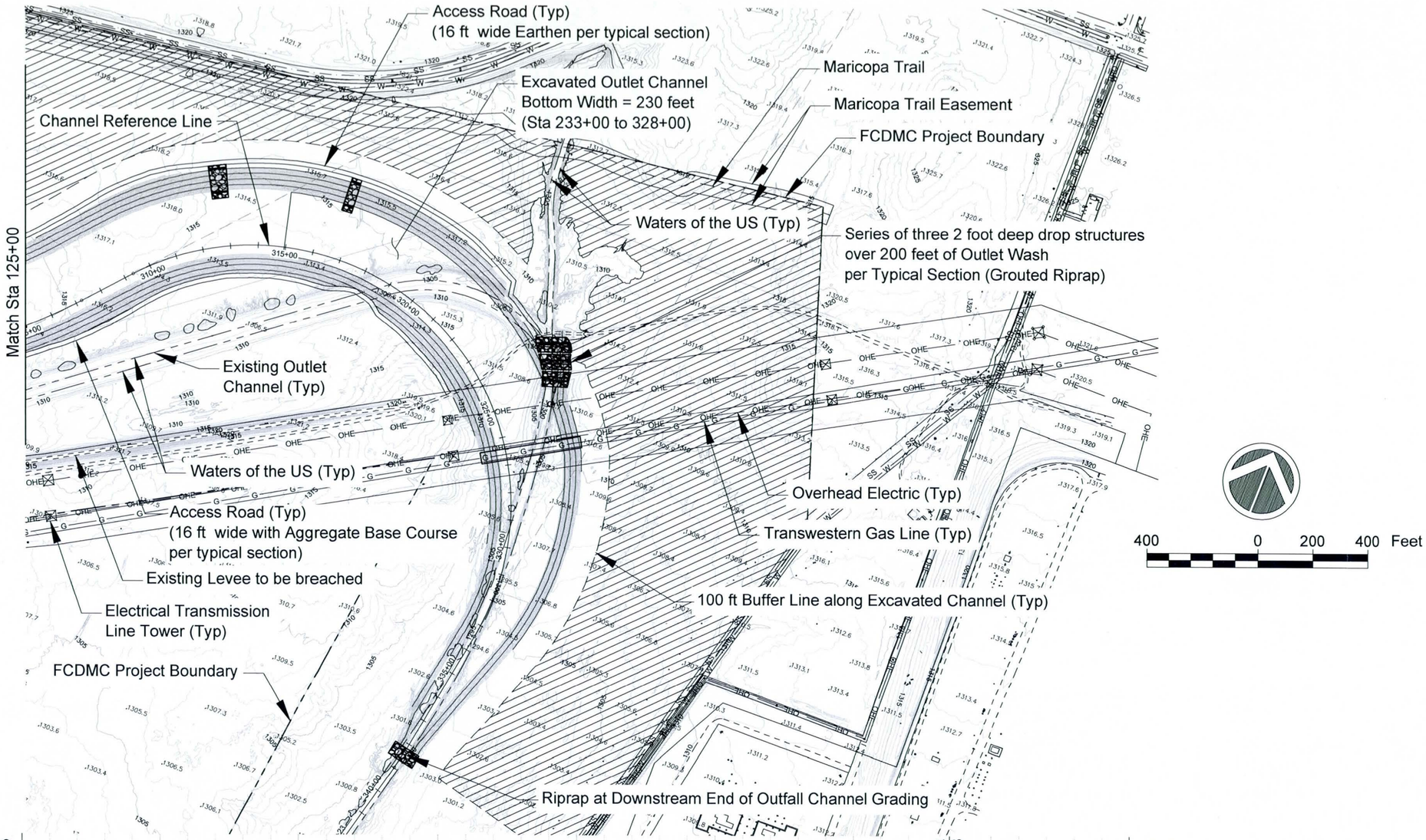


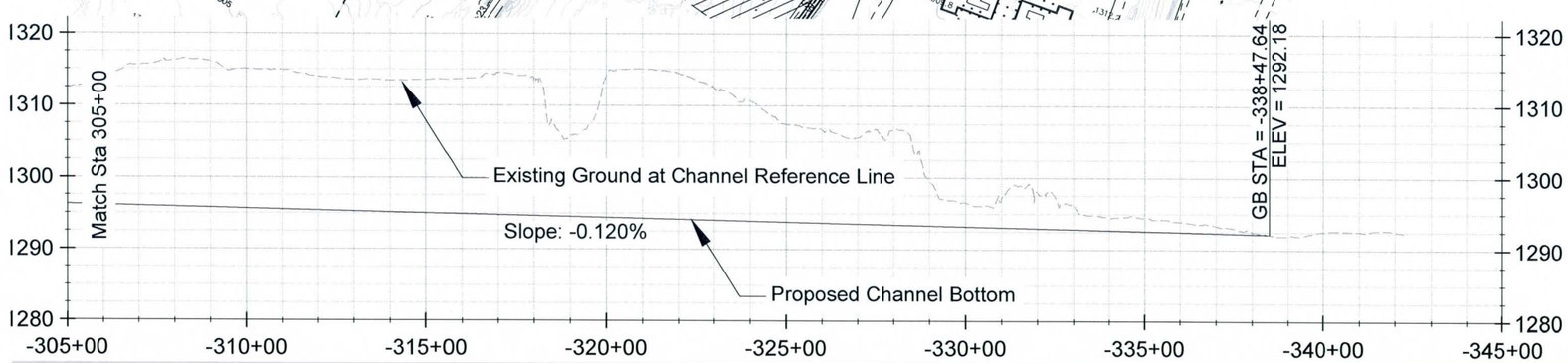
Gannett Fleming

Alternative 4: Realign Outlet Channel North

July 2014 FIGURE 3-4D

ehynick 08/06/14 12:54pm – K:\56312-McMicken\WORKING\CADD\Sheets\Civil\056312-E-Alternate 4-PP04.dwg





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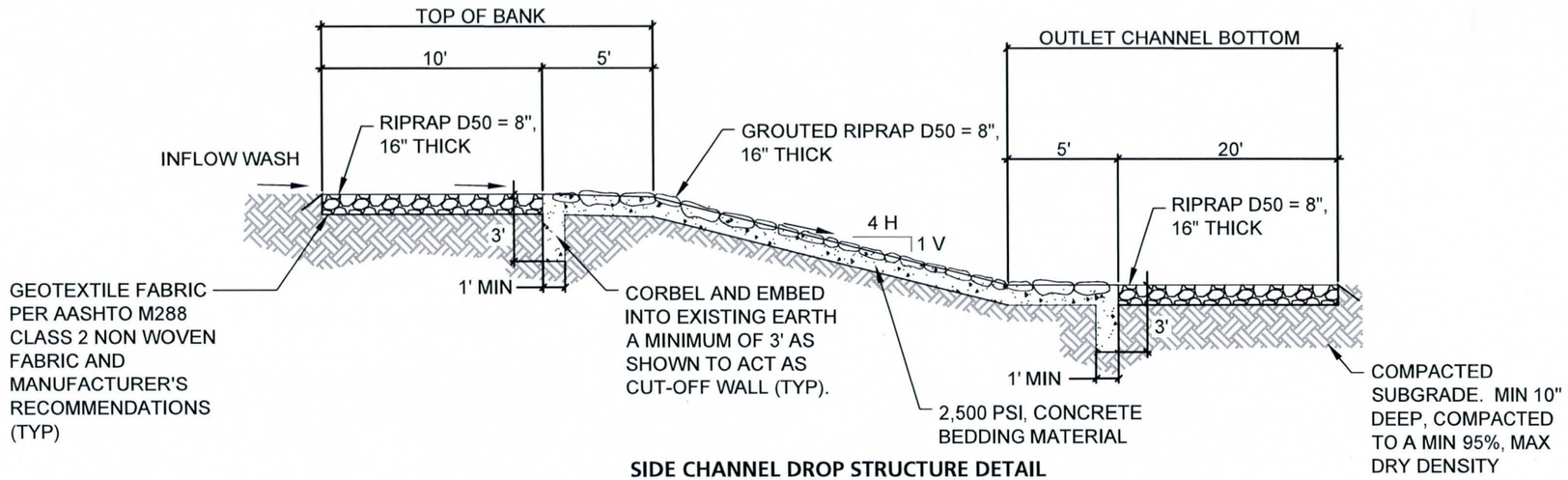
Alternative 4: Realign Outlet Channel North

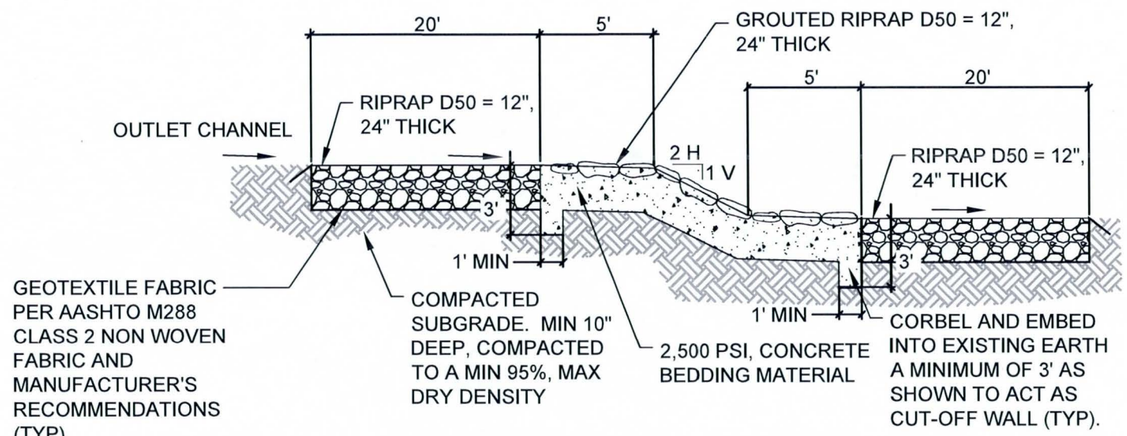
July 2014 FIGURE 3-4E

ehynick 09/10/14 3:41pm – K:\56312–McMicken\WORKING\CADD\Sheets\Civil\056312–E–Alternate 4–PP05.dwg



SIDE CHANNEL DROP STRUCTURE DETAIL

N.T.S.



LONGITUDINAL CHANNEL DROP STRUCTURE DETAIL

N.T.S.

K:\56312-McMicken Dam\WORKING\WA 1\CADD\ 056312-E-Drop Structures.dwg - Dec 20,2013 10:11am

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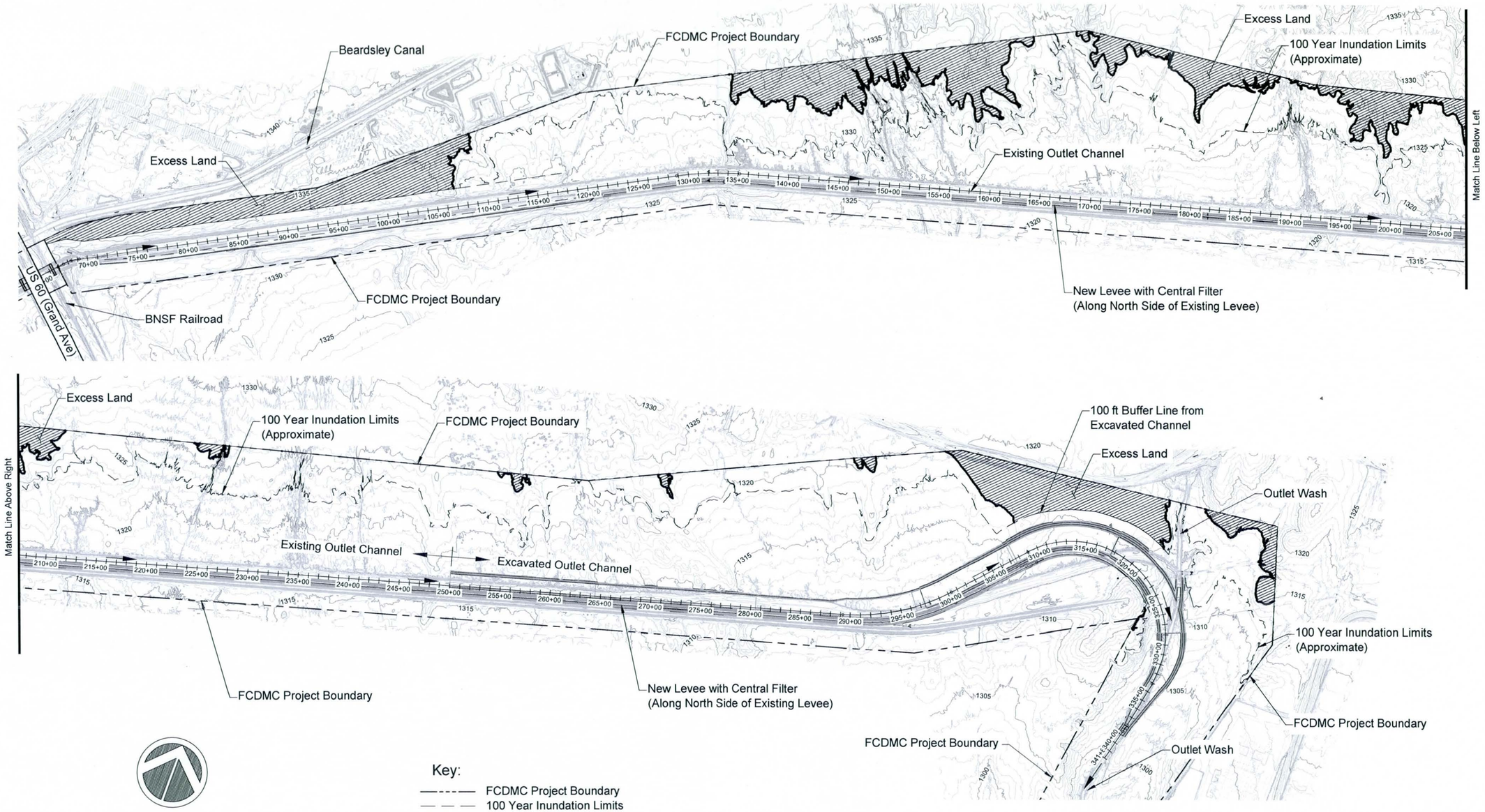
Drop Structures Typical Sections

Figure 4-1



K:\56312-McMicken\WORKING\CADD\Sheets\Civil\Excess Land Exhibits\ 056312-E-Alternate 1-Excess Land.dwg - Aug 04,2014 1:55pm

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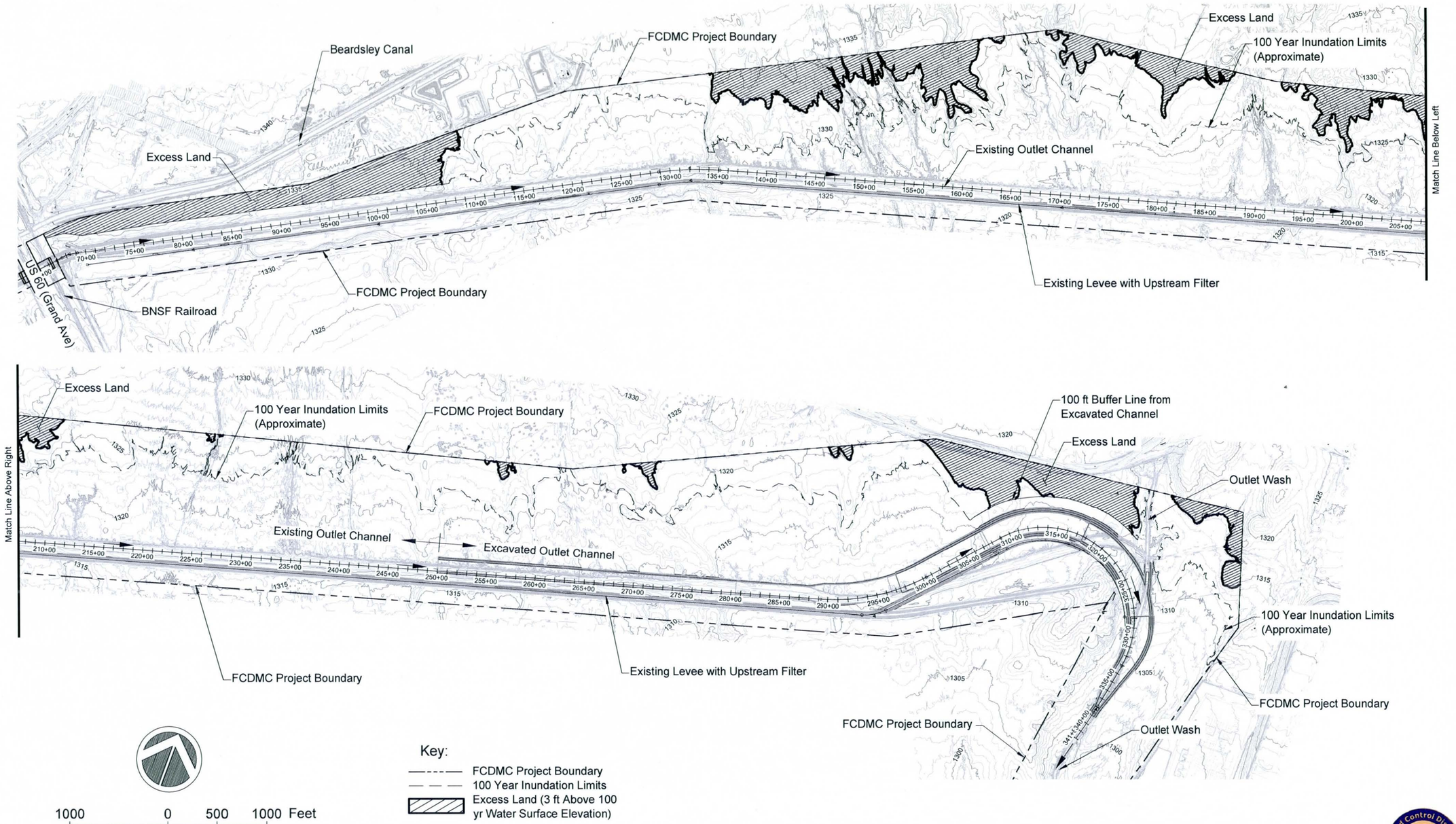
Alternative 1: Construct New Levee with Central Filter North of Existing Levee - Excess Land

Figure 5-1



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URS

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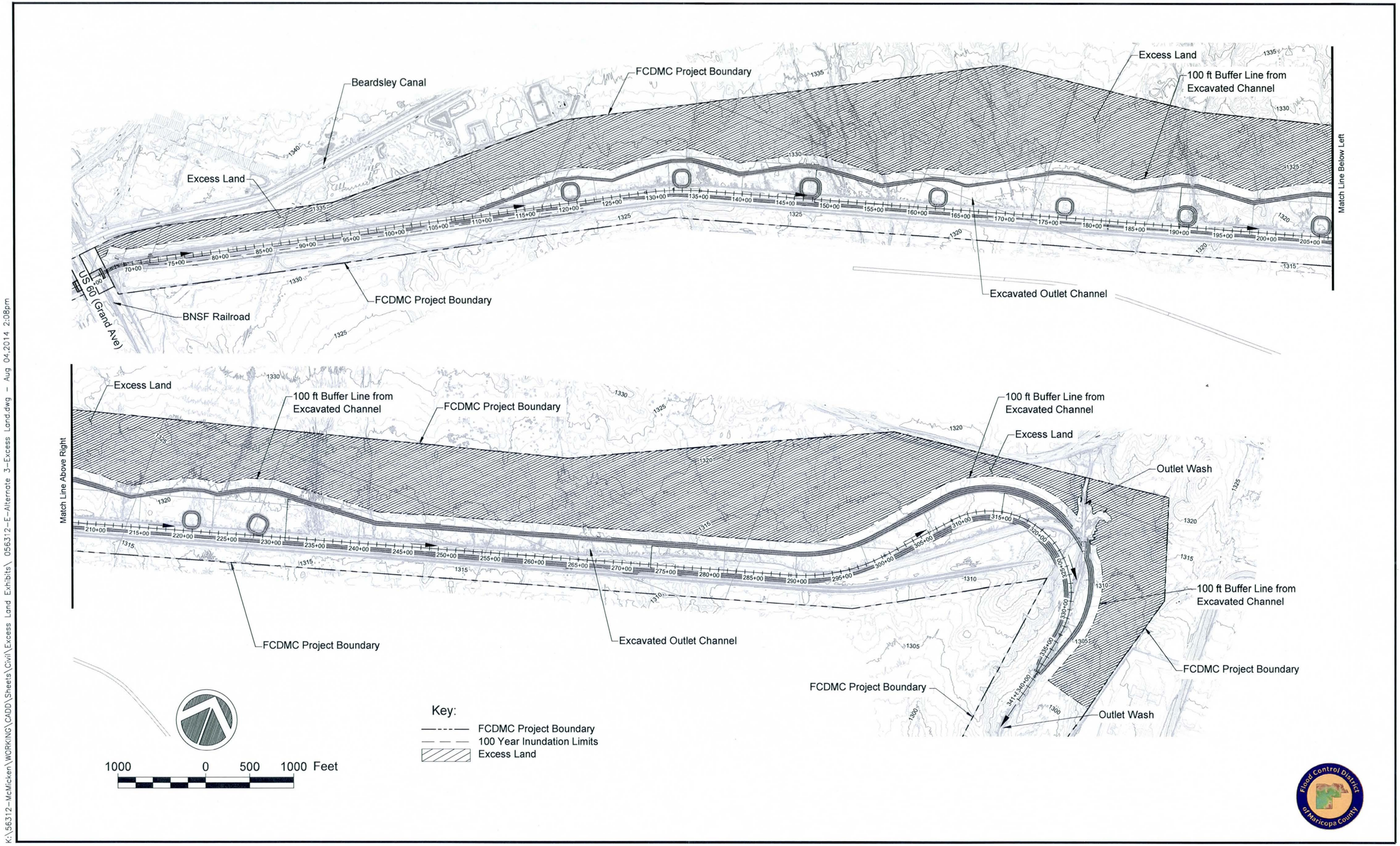
McMicken Dam Rehabilitation Project
Alternative 2: Modify Existing Levee with Upstream Filter - Excess Land
Figure 5-2



K:\56312-McMicken\WORKING\CADD\Sheets\Civil\Excess Land Exhibits\ 056312-E-Alternate 3-Excess Land.dwg - Aug 04,2014 2:08pm

URS

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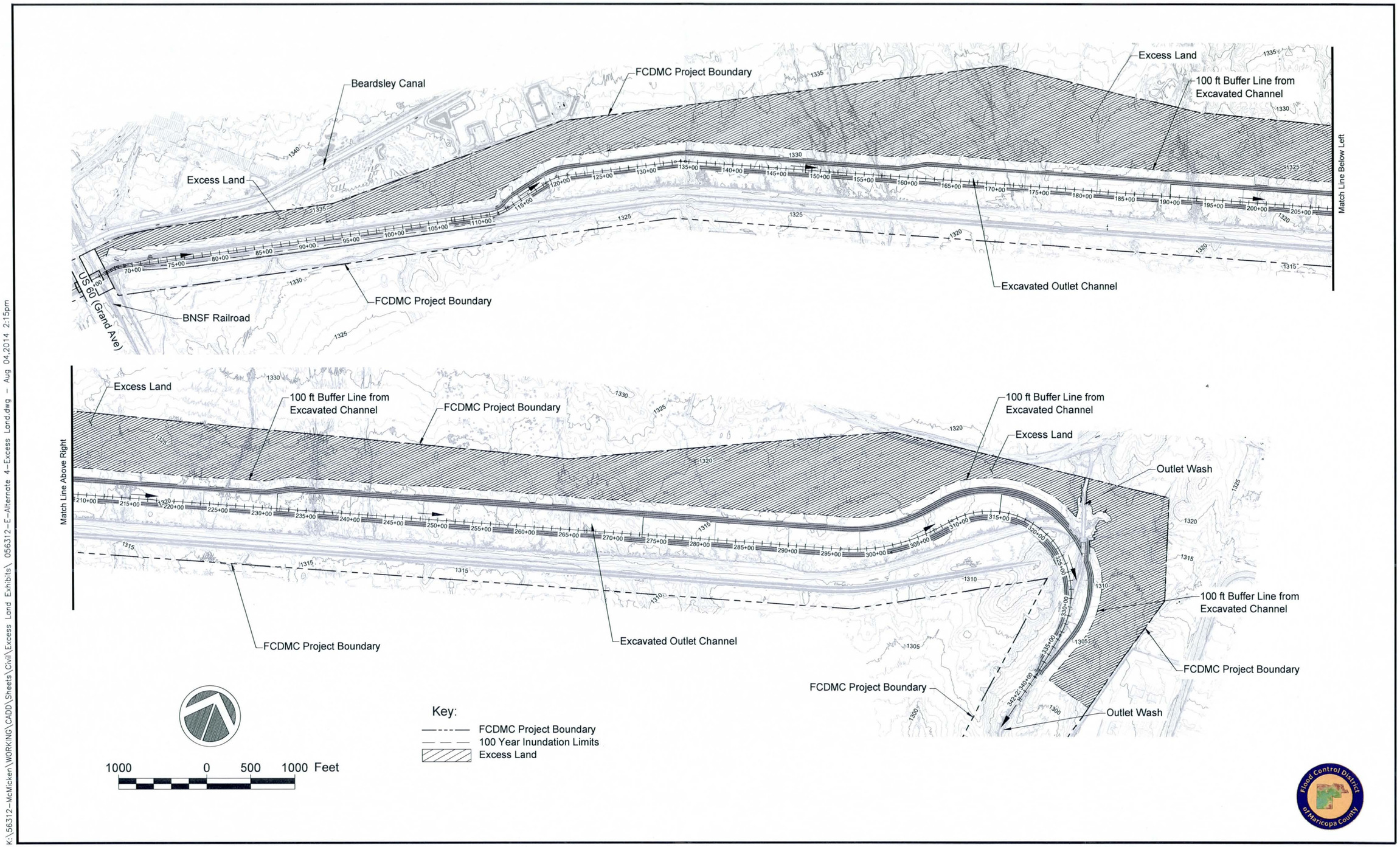
McMicken Dam Rehabilitation Project

Alternative 3: Reconstruct Excavated Outlet Channel Along Existing Alignment - Excess Land

Figure 5-3



K:\56312-McMicken\WORKING\CADD\Sheets\Civil\Excess Land Exhibits\ 056312-E-Alternate 4-Excess Land.dwg - Aug 04,2014 2:15pm

URS

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McMicken Dam Rehabilitation Project
Alternative 4: Re-align Outlet Channel North - Excess Land
Figure 5-4

Appendix A

Hydraulic Documentation for all Alternatives

Appendix A consists of:

Appendix A1. Alternatives 1 - 4 Hydraulics Calculations

Appendix A2. Scour and Riprap Calculations

Appendix A3. Alternatives 3 and 4 Stream Power Calculations

Appendix A4. Max Permissible Velocity Table from FCDMC Hydraulic Manual

Appendix A5. Soil Chart from FCDMC Hydrology Manual

APPENDIX A-1

Alternatives 1 – 4 Hydraulic Calculations

The hydraulics calculations consist of uniform flow analyses that are backup for the data in Figures 2-1 through 2-5 for all four alternatives using FlowMaster software by Bentley Systems.

Cross Section for Sta 160+00 - levee 20 - 100&200yr

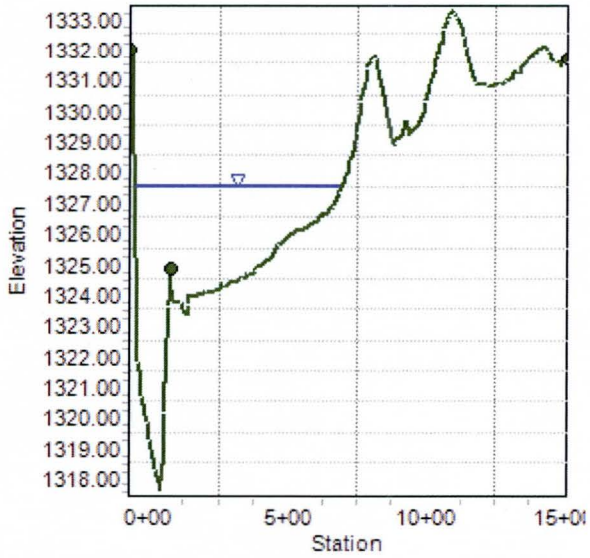
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00140	ft/ft
Normal Depth	9.83	ft
Discharge	4450.00	ft³/s

Cross Section Image



Worksheet for Sta 160+00 - levee 20 - 100&200yr

Input Data

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+79, 1332.00)	(0+73, 1324.81)	0.035
(0+73, 1324.81)	(15+08, 1331.69)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		9.83	ft
Elevation Range	1317.64 to 1333.21 ft		
Flow Area		2398.50	ft²
Wetted Perimeter		747.89	ft
Hydraulic Radius		3.21	ft
Top Width		745.32	ft
Normal Depth		9.83	ft
Critical Depth		6.54	ft
Critical Slope		0.05005	ft/ft
Velocity		1.86	ft/s
Velocity Head		0.05	ft
Specific Energy		9.89	ft
Froude Number		0.18	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft

Worksheet for Sta 160+00 - levee 20 - 100&200yr

GVF Output Data

Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	9.83	ft
Critical Depth	6.54	ft
Channel Slope	0.00140	ft/ft
Critical Slope	0.05005	ft/ft

Cross Section for Sta 190+00 - levee 20 - 100yr

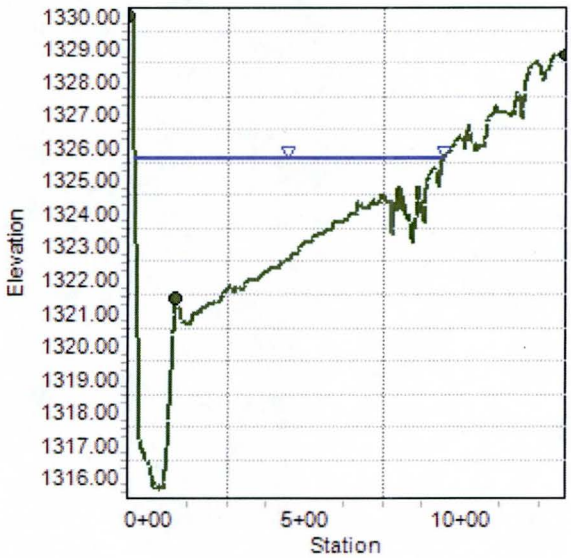
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00170	ft/ft
Normal Depth	10.03	ft
Discharge	7045.00	ft^3/s

Cross Section Image



Worksheet for Sta 190+00 - levee 20 - 100yr

Input Data

Station (ft)	Elevation (ft)
12+54	1328.14
12+55	1328.10
12+60	1327.97
12+61	1328.02
12+63	1328.06
12+68	1328.21
12+71	1328.22
12+76	1328.28
12+80	1328.39
12+85	1328.48
12+88	1328.65
12+95	1328.75
12+96	1328.83
13+03	1328.77
13+10	1328.79
13+12	1328.83
13+15	1328.80
13+17	1328.77
13+21	1328.76
13+28	1328.78
13+33	1328.74

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+74, 1330.00)	(0+84, 1321.41)	0.035
(0+84, 1321.41)	(13+33, 1328.74)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method

Worksheet for Sta 190+00 - levee 20 - 100yr

Options

Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		10.03	ft
Elevation Range	1315.57 to 1330.00 ft		
Flow Area		3370.97	ft²
Wetted Perimeter		992.22	ft
Hydraulic Radius		3.40	ft
Top Width		989.08	ft
Normal Depth		10.03	ft
Critical Depth		6.58	ft
Critical Slope		0.05013	ft/ft
Velocity		2.09	ft/s
Velocity Head		0.07	ft
Specific Energy		10.10	ft
Froude Number		0.20	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	10.03	ft
Critical Depth	6.58	ft
Channel Slope	0.00170	ft/ft
Critical Slope	0.05013	ft/ft

Cross Section for Sta 190+00 - levee 20 - 200yr

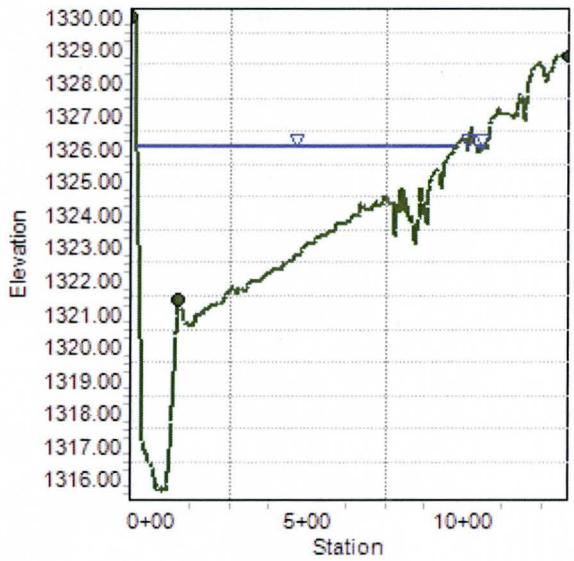
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00170	ft/ft
Normal Depth	10.47	ft
Discharge	8243.00	ft^3/s

Cross Section Image



Worksheet for Sta 190+00 - levee 20 - 200yr

Input Data

Station (ft)	Elevation (ft)
12+54	1328.14
12+55	1328.10
12+60	1327.97
12+61	1328.02
12+63	1328.06
12+68	1328.21
12+71	1328.22
12+76	1328.28
12+80	1328.39
12+85	1328.48
12+88	1328.65
12+95	1328.75
12+96	1328.83
13+03	1328.77
13+10	1328.79
13+12	1328.83
13+15	1328.80
13+17	1328.77
13+21	1328.76
13+28	1328.78
13+33	1328.74

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+74, 1330.00)	(0+84, 1321.41)	0.035
(0+84, 1321.41)	(13+33, 1328.74)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method

Worksheet for Sta 190+00 - levee 20 - 200yr

Options

Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		10.47	ft
Elevation Range	1315.57 to 1330.00 ft		
Flow Area		3815.58	ft²
Wetted Perimeter		1063.10	ft
Hydraulic Radius		3.59	ft
Top Width		1059.83	ft
Normal Depth		10.47	ft
Critical Depth		6.89	ft
Critical Slope		0.05017	ft/ft
Velocity		2.16	ft/s
Velocity Head		0.07	ft
Specific Energy		10.54	ft
Froude Number		0.20	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	10.47	ft
Critical Depth	6.89	ft
Channel Slope	0.00170	ft/ft
Critical Slope	0.05017	ft/ft

Cross Section for Sta 235+00 - levee 20 - 100 yr

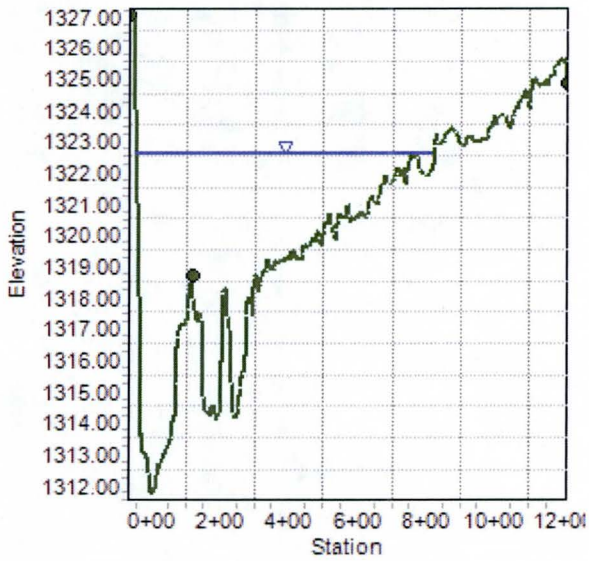
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00190	ft/ft
Normal Depth	10.81	ft
Discharge	9090.00	ft³/s

Cross Section Image



Worksheet for Sta 235+00 - levee 20 - 100 yr

Input Data

Station (ft)	Elevation (ft)
11+71	1325.24
11+73	1325.30
11+76	1325.33
11+77	1325.36
11+81	1325.49
11+84	1325.50
11+84	1325.52
11+87	1325.53
11+88	1325.55
11+91	1325.52
11+96	1325.63
11+98	1325.56
12+00	1325.53
12+01	1325.38
12+03	1325.43
12+05	1325.48
12+06	1325.12
12+07	1324.91
12+07	1325.08
12+09	1324.84
12+10	1324.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+70, 1327.01)	(1+16, 1318.68)	0.035
(1+16, 1318.68)	(12+10, 1324.80)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method

Worksheet for Sta 235+00 - levee 20 - 100 yr

Options

Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		10.81	ft
Elevation Range	1311.75 to 1327.01 ft		
Flow Area		3560.18	ft²
Wetted Perimeter		872.24	ft
Hydraulic Radius		4.08	ft
Top Width		866.36	ft
Normal Depth		10.81	ft
Critical Depth		6.17	ft
Critical Slope		0.04286	ft/ft
Velocity		2.55	ft/s
Velocity Head		0.10	ft
Specific Energy		10.91	ft
Froude Number		0.22	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	10.81	ft
Critical Depth	6.17	ft
Channel Slope	0.00190	ft/ft
Critical Slope	0.04286	ft/ft

Cross Section for Sta 235+00 - levee 20 - 200 yr

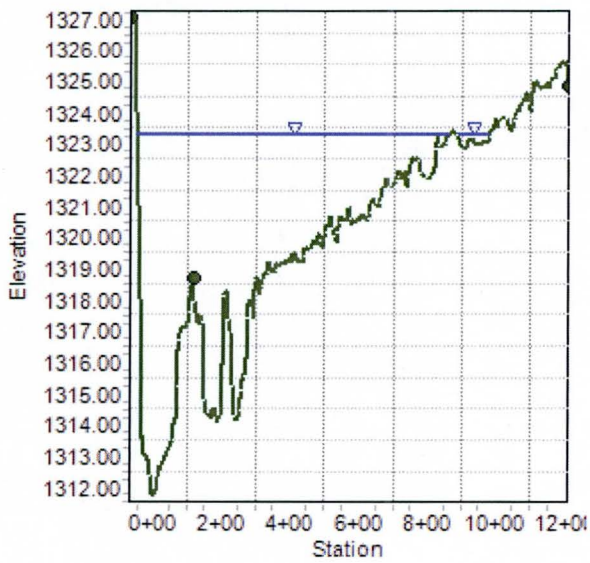
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00190	ft/ft
Normal Depth	11.51	ft
Discharge	10716.00	ft^3/s

Cross Section Image



Worksheet for Sta 235+00 - levee 20 - 200 yr

Input Data

Station (ft)	Elevation (ft)
11+71	1325.24
11+73	1325.30
11+76	1325.33
11+77	1325.36
11+81	1325.49
11+84	1325.50
11+84	1325.52
11+87	1325.53
11+88	1325.55
11+91	1325.52
11+96	1325.63
11+98	1325.56
12+00	1325.53
12+01	1325.38
12+03	1325.43
12+05	1325.48
12+06	1325.12
12+07	1324.91
12+07	1325.08
12+09	1324.84
12+10	1324.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+70, 1327.01)	(1+16, 1318.68)	0.035
(1+16, 1318.68)	(12+10, 1324.80)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method

Worksheet for Sta 235+00 - levee 20 - 200 yr

Options

Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		11.51	ft
Elevation Range	1311.75 to 1327.01 ft		
Flow Area		4202.63	ft^2
Wetted Perimeter		1014.88	ft
Hydraulic Radius		4.14	ft
Top Width		1008.76	ft
Normal Depth		11.51	ft
Critical Depth		6.62	ft
Critical Slope		0.04327	ft/ft
Velocity		2.55	ft/s
Velocity Head		0.10	ft
Specific Energy		11.61	ft
Froude Number		0.22	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	11.51	ft
Critical Depth	6.62	ft
Channel Slope	0.00190	ft/ft
Critical Slope	0.04327	ft/ft

Cross Section for Sta 265+00 - levee 20 - 100yr

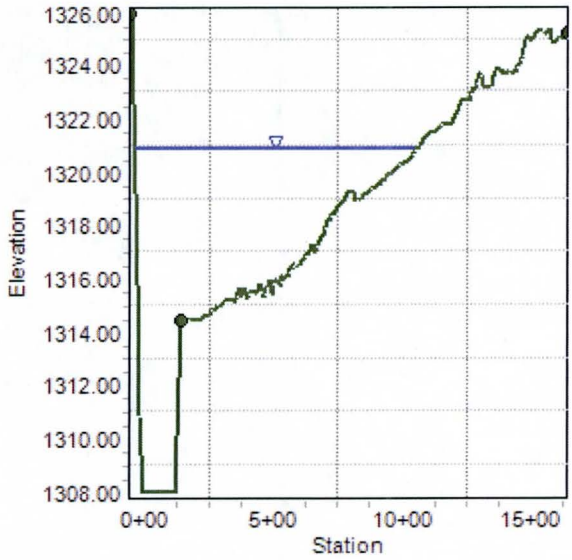
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00060	ft/ft
Normal Depth	12.92	ft
Discharge	9090.00	ft³/s

Cross Section Image



Worksheet for Sta 265+00 - levee 20 - 100yr

Input Data

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+67, 1326.00)	(1+41, 1314.47)	0.035
(1+41, 1314.47)	(16+43, 1325.27)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		12.92	ft
Elevation Range	1307.97 to 1326.00 ft		
Flow Area		5545.85	ft^2
Wetted Perimeter		1098.72	ft
Hydraulic Radius		5.05	ft
Top Width		1094.99	ft
Normal Depth		12.92	ft
Critical Depth		5.15	ft
Critical Slope		0.03795	ft/ft
Velocity		1.64	ft/s
Velocity Head		0.04	ft
Specific Energy		12.96	ft
Froude Number		0.13	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft

Worksheet for Sta 265+00 - levee 20 - 100yr

GVF Output Data

Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	12.92	ft
Critical Depth	5.15	ft
Channel Slope	0.00060	ft/ft
Critical Slope	0.03795	ft/ft

Worksheet for Sta 265+00 - levee 20 - 200yr

Input Data

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+67, 1326.00)	(1+41, 1314.47)	0.035
(1+41, 1314.47)	(16+43, 1325.27)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		13.59	ft
Elevation Range	1307.97 to 1326.00 ft		
Flow Area		6302.02	ft^2
Wetted Perimeter		1174.12	ft
Hydraulic Radius		5.37	ft
Top Width		1170.22	ft
Normal Depth		13.59	ft
Critical Depth		5.71	ft
Critical Slope		0.03711	ft/ft
Velocity		1.70	ft/s
Velocity Head		0.04	ft
Specific Energy		13.63	ft
Froude Number		0.13	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft

Cross Section for Sta 265+00 - levee 20 - 200yr

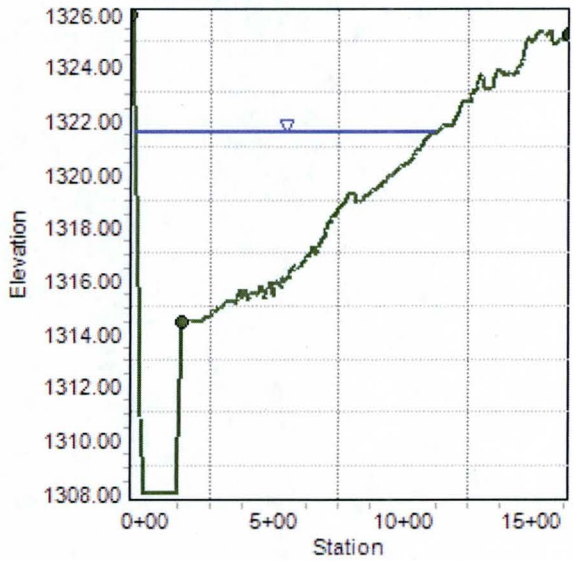
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00060	ft/ft
Normal Depth	13.59	ft
Discharge	10716.00	ft^3/s

Cross Section Image



Worksheet for Sta 265+00 - levee 20 - 200yr

GVF Output Data

Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	13.59	ft
Critical Depth	5.71	ft
Channel Slope	0.00060	ft/ft
Critical Slope	0.03711	ft/ft

Cross Section for Sta 160+00 - Levee 20 - 100&200yr

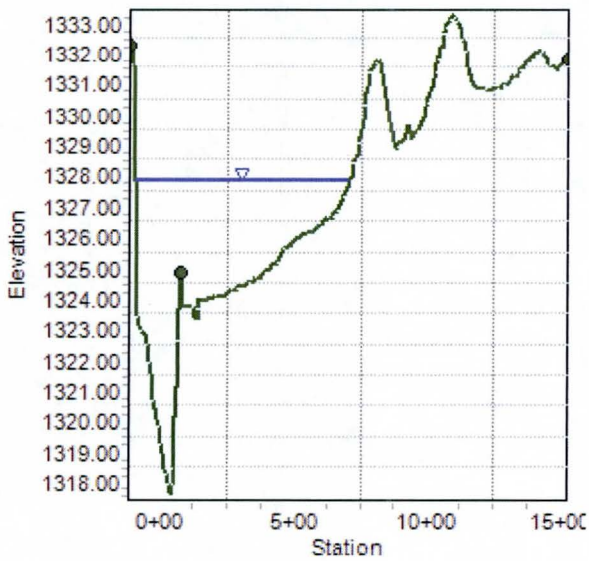
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00080	ft/ft
Normal Depth	10.19	ft
Discharge	4450.00	ft^3/s

Cross Section Image



Worksheet for Sta 160+00 - Levee 20 - 100&200yr

Input Data

Station (ft)	Elevation (ft)
14+30	1332.06
14+36	1331.94
14+39	1331.87
14+40	1331.87
14+49	1331.64
14+51	1331.63
14+59	1331.58
14+73	1331.51
14+84	1331.44
14+87	1331.45
14+88	1331.45
14+88	1331.51
14+97	1331.61
15+10	1331.71
15+16	1331.74
15+28	1331.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-1+26, 1332.24)	(0+74, 1324.87)	0.035
(0+74, 1324.87)	(15+28, 1331.80)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	10.19	ft

Worksheet for Sta 160+00 - Levee 20 - 100&200yr

Results

Elevation Range	1317.64 to 1333.21 ft		
Flow Area		2895.31	ft²
Wetted Perimeter		809.92	ft
Hydraulic Radius		3.57	ft
Top Width		807.68	ft
Normal Depth		10.19	ft
Critical Depth		5.93	ft
Critical Slope		0.04302	ft/ft
Velocity		1.54	ft/s
Velocity Head		0.04	ft
Specific Energy		10.23	ft
Froude Number		0.14	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	10.19	ft
Critical Depth	5.93	ft
Channel Slope	0.00080	ft/ft
Critical Slope	0.04302	ft/ft

Cross Section for Sta 190+00 - Levee 20 - 100yr

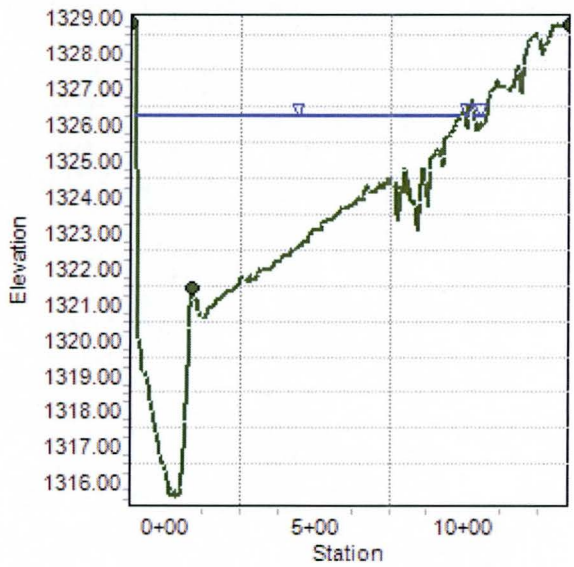
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00080	ft/ft
Normal Depth	10.68	ft
Discharge	7045.00	ft^3/s

Cross Section Image



Worksheet for Sta 190+00 - Levee 20 - 100yr

Input Data

Station (ft)	Elevation (ft)
13+28	1328.78
13+36	1328.73
13+38	1328.72
13+43	1328.68
13+49	1328.78
13+50	1328.79
13+52	1328.79
13+52	1328.79
13+53	1328.78

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-1+27, 1328.86)	(0+84, 1321.41)	0.035
(0+84, 1321.41)	(13+53, 1328.78)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	10.68	ft
Elevation Range	1315.57 to 1328.86 ft	
Flow Area	4449.78	ft^2
Wetted Perimeter	1149.76	ft
Hydraulic Radius	3.87	ft
Top Width	1146.94	ft
Normal Depth	10.68	ft
Critical Depth	5.99	ft

Worksheet for Sta 190+00 - Levee 20 - 100yr

Results

Critical Slope		0.04687	ft/ft
Velocity		1.58	ft/s
Velocity Head		0.04	ft
Specific Energy		10.72	ft
Froude Number		0.14	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	10.68	ft
Critical Depth	5.99	ft
Channel Slope	0.00080	ft/ft
Critical Slope	0.04687	ft/ft

Cross Section for Sta 190+00 - Levee 20 - 200yr

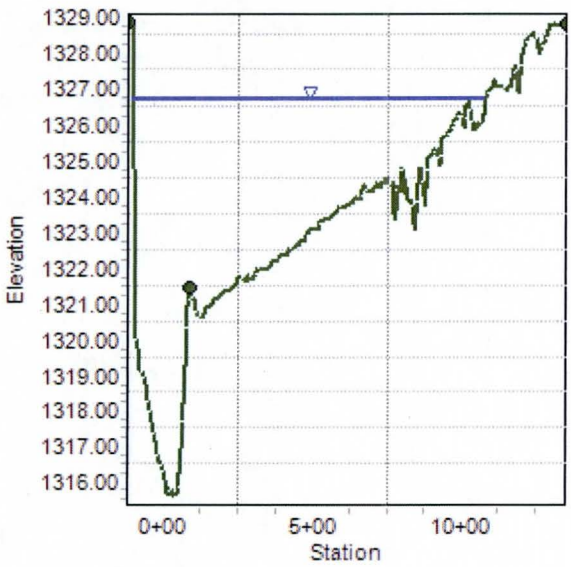
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00080	ft/ft
Normal Depth	11.12	ft
Discharge	8243.00	ft^3/s

Cross Section Image



Worksheet for Sta 190+00 - Levee 20 - 200yr

Input Data

Station (ft)	Elevation (ft)
13+28	1328.78
13+36	1328.73
13+38	1328.72
13+43	1328.68
13+49	1328.78
13+50	1328.79
13+52	1328.79
13+52	1328.79
13+53	1328.78

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-1+27, 1328.86)	(0+84, 1321.41)	0.035
(0+84, 1321.41)	(13+53, 1328.78)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	11.12	ft
Elevation Range	1315.57 to 1328.86 ft	
Flow Area	4967.38	ft²
Wetted Perimeter	1192.16	ft
Hydraulic Radius	4.17	ft
Top Width	1189.18	ft
Normal Depth	11.12	ft
Critical Depth	6.44	ft

Worksheet for Sta 190+00 - Levee 20 - 200yr

Results

Critical Slope		0.04839	ft/ft
Velocity		1.66	ft/s
Velocity Head		0.04	ft
Specific Energy		11.16	ft
Froude Number		0.14	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	11.12	ft
Critical Depth	6.44	ft
Channel Slope	0.00080	ft/ft
Critical Slope	0.04839	ft/ft

Cross Section for Sta 235+00 - Levee 20 - 100yr

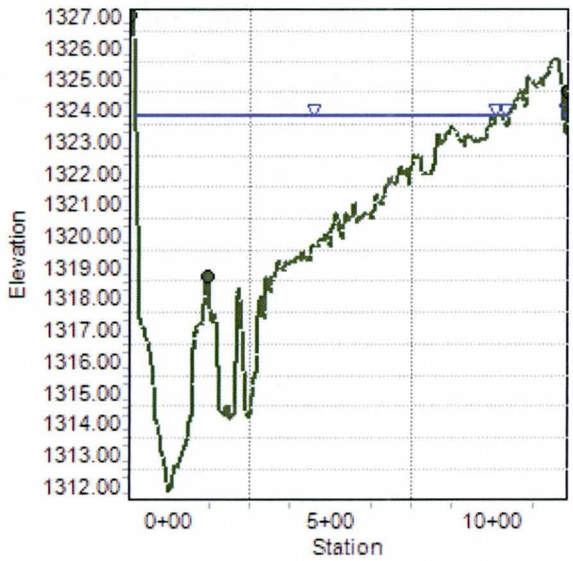
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00080	ft/ft
Normal Depth	11.99	ft
Discharge	9090.00	ft³/s

Cross Section Image



Worksheet for Sta 235+00 - Levee 20 - 100yr

Input Data

Station (ft)	Elevation (ft)
12+19	1323.20
12+20	1323.21
12+22	1323.18
12+24	1323.17
12+25	1323.50
12+26	1323.60
12+28	1323.96
12+31	1324.49
12+31	1324.51

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-1+27, 1326.98)	(1+16, 1318.68)	0.035
(1+16, 1318.68)	(12+31, 1324.51)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	11.99	ft
Elevation Range	1311.75 to 1326.98 ft	
Flow Area	5162.09	ft²
Wetted Perimeter	1156.87	ft
Hydraulic Radius	4.46	ft
Top Width	1151.20	ft
Normal Depth	11.99	ft
Critical Depth	5.94	ft

Worksheet for Sta 235+00 - Levee 20 - 100yr

Results

Critical Slope	0.04374	ft/ft
Velocity	1.76	ft/s
Velocity Head	0.05	ft
Specific Energy	12.04	ft
Froude Number	0.15	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	11.99	ft
Critical Depth	5.94	ft
Channel Slope	0.00080	ft/ft
Critical Slope	0.04374	ft/ft

Cross Section for Sta 235+00 - Levee 20 - 200yr

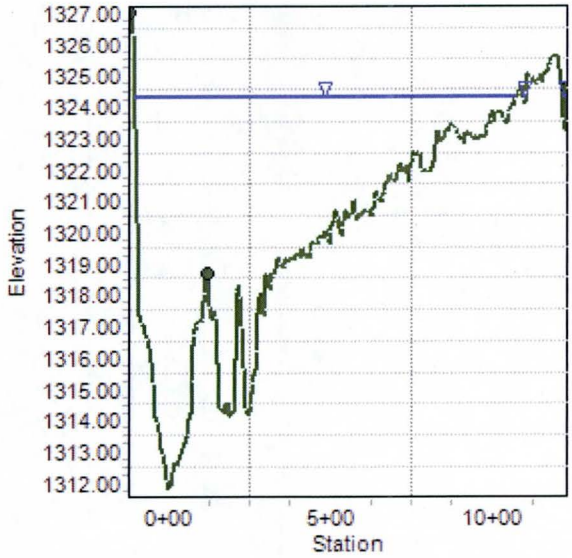
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00080	ft/ft
Normal Depth	12.54	ft
Discharge	10716.00	ft³/s

Cross Section Image



Worksheet for Sta 235+00 - Levee 20 - 200yr

Input Data

Station (ft)	Elevation (ft)
12+19	1323.20
12+20	1323.21
12+22	1323.18
12+24	1323.17
12+25	1323.50
12+26	1323.60
12+28	1323.96
12+31	1324.49
12+31	1324.51

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-1+27, 1326.98)	(1+16, 1318.68)	0.035
(1+16, 1318.68)	(12+31, 1324.51)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	12.54	ft
Elevation Range	1311.75 to 1326.98 ft	
Flow Area	5811.79	ft^2
Wetted Perimeter	1209.78	ft
Hydraulic Radius	4.80	ft
Top Width	1203.83	ft
Normal Depth	12.54	ft
Critical Depth	6.33	ft

Worksheet for Sta 235+00 - Levee 20 - 200yr

Results

Critical Slope		0.04318	ft/ft
Velocity		1.84	ft/s
Velocity Head		0.05	ft
Specific Energy		12.59	ft
Froude Number		0.15	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	12.54	ft
Critical Depth	6.33	ft
Channel Slope	0.00080	ft/ft
Critical Slope	0.04318	ft/ft

Cross Section for Sta 265+00 - Levee 20 - 100yr

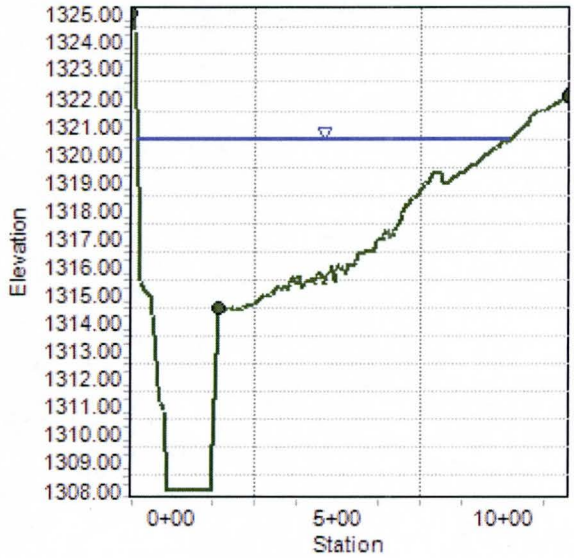
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00060	ft/ft
Normal Depth	12.52	ft
Discharge	9090.00	ft^3/s

Cross Section Image



Worksheet for Sta 265+00 - Levee 20 - 100yr

Input Data

Station (ft)	Elevation (ft)
11+77	1321.81
11+77	1321.81
11+77	1321.82
11+77	1321.82
11+85	1321.86
11+87	1321.87
11+94	1321.98
11+96	1322.01

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-1+28, 1325.02)	(1+41, 1314.47)	0.035
(1+41, 1314.47)	(11+96, 1322.01)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	12.52	ft
Elevation Range	1307.97 to 1325.02 ft	
Flow Area	5530.88	ft²
Wetted Perimeter	1126.89	ft
Hydraulic Radius	4.91	ft
Top Width	1124.17	ft
Normal Depth	12.52	ft
Critical Depth	5.14	ft
Critical Slope	0.03724	ft/ft

Worksheet for Sta 265+00 - Levee 20 - 100yr

Results

Velocity		1.64	ft/s
Velocity Head		0.04	ft
Specific Energy		12.56	ft
Froude Number		0.13	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	12.52	ft
Critical Depth	5.14	ft
Channel Slope	0.00060	ft/ft
Critical Slope	0.03724	ft/ft

Cross Section for Sta 265+00 - Levee 20 - 200yr

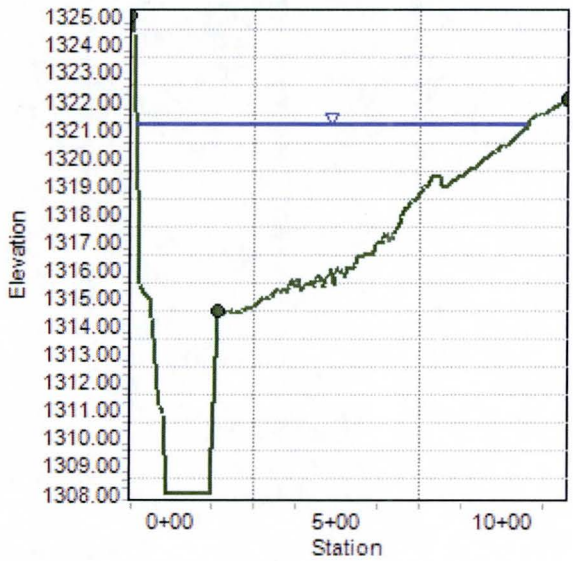
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00060	ft/ft
Normal Depth	13.14	ft
Discharge	10716.00	ft³/s

Cross Section Image



Worksheet for Sta 265+00 - Levee 20 - 200yr

Input Data

Station (ft)	Elevation (ft)
11+77	1321.81
11+77	1321.81
11+77	1321.82
11+77	1321.82
11+85	1321.86
11+87	1321.87
11+94	1321.98
11+96	1322.01

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-1+28, 1325.02)	(1+41, 1314.47)	0.035
(1+41, 1314.47)	(11+96, 1322.01)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	13.14	ft
Elevation Range	1307.97 to 1325.02 ft	
Flow Area	6239.53	ft²
Wetted Perimeter	1182.65	ft
Hydraulic Radius	5.28	ft
Top Width	1179.78	ft
Normal Depth	13.14	ft
Critical Depth	5.67	ft
Critical Slope	0.03646	ft/ft

Worksheet for Sta 265+00 - Levee 20 - 200yr

Results

Velocity		1.72	ft/s
Velocity Head		0.05	ft
Specific Energy		13.18	ft
Froude Number		0.13	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	13.14	ft
Critical Depth	5.67	ft
Channel Slope	0.00060	ft/ft
Critical Slope	0.03646	ft/ft

Alt 3 4450cfs - 120 FT BOT - 100 & 200 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	120.00	ft
Discharge	4450.00	ft^3/s

Results

Normal Depth	6.60	ft
Flow Area	966.40	ft^2
Wetted Perimeter	174.43	ft
Hydraulic Radius	5.54	ft
Top Width	172.81	ft
Critical Depth	3.36	ft
Critical Slope	0.01239	ft/ft
Velocity	4.60	ft/s
Velocity Head	0.33	ft
Specific Energy	6.93	ft
Froude Number	0.34	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	6.60	ft
Critical Depth	3.36	ft
Channel Slope	0.00120	ft/ft

Alt 3 Cross Section 4450cfs - 120 FT BOT - 100 & 200 yr

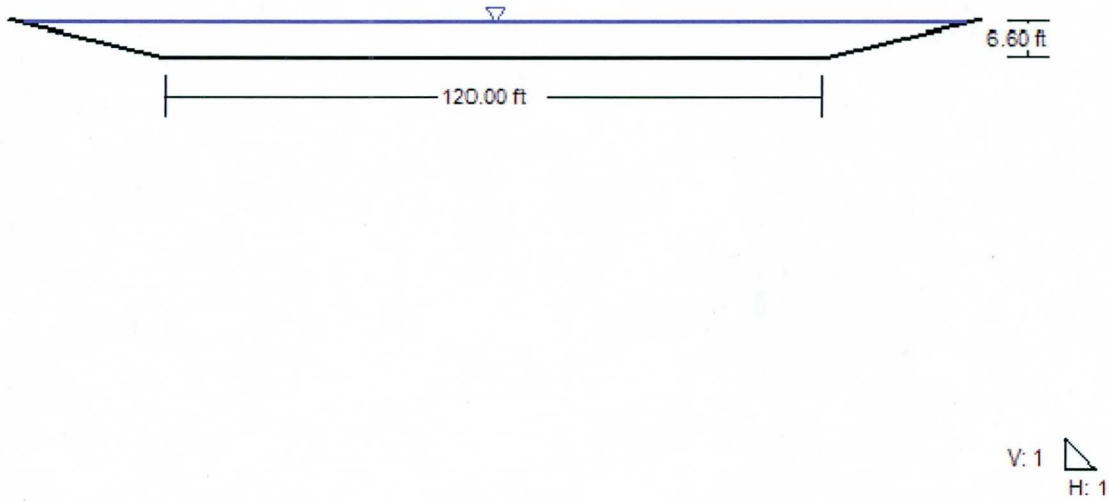
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Normal Depth	6.60	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	120.00	ft
Discharge	4450.00	ft^3/s

Cross Section Image



Alt 3 4450cfs - 250 FT BOT - 100 & 200 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	250.00	ft
Discharge	4450.00	ft^3/s

Results

Normal Depth	4.40	ft
Flow Area	1178.25	ft^2
Wetted Perimeter	286.31	ft
Hydraulic Radius	4.12	ft
Top Width	285.22	ft
Critical Depth	2.12	ft
Critical Slope	0.01408	ft/ft
Velocity	3.78	ft/s
Velocity Head	0.22	ft
Specific Energy	4.62	ft
Froude Number	0.33	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	4.40	ft
Critical Depth	2.12	ft
Channel Slope	0.00120	ft/ft

Alt 3 4450cfs - 250 FT BOT - 100 & 200 yr

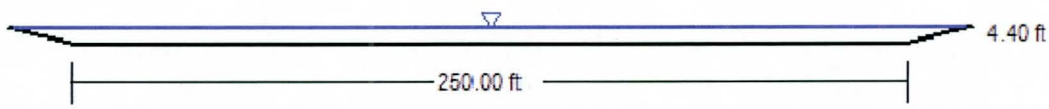
Project Description

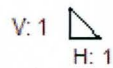
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Normal Depth	4.40	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	250.00	ft
Discharge	4450.00	ft^3/s

Cross Section Image





Alt 3 7045cfs - 250 FT BOT - 100 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	250.00	ft
Discharge	7045.00	ft^3/s

Results

Normal Depth	5.77	ft
Flow Area	1576.42	ft^2
Wetted Perimeter	297.60	ft
Hydraulic Radius	5.30	ft
Top Width	296.18	ft
Critical Depth	2.87	ft
Critical Slope	0.01279	ft/ft
Velocity	4.47	ft/s
Velocity Head	0.31	ft
Specific Energy	6.08	ft
Froude Number	0.34	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	5.77	ft
Critical Depth	2.87	ft
Channel Slope	0.00120	ft/ft

Alt 3 7045cfs - 250 FT BOT - 100 yr

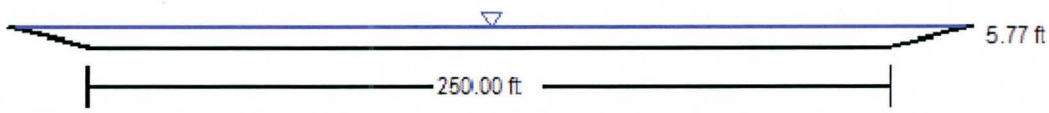
Project Description

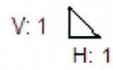
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Normal Depth	5.77	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	250.00	ft
Discharge	7045.00	ft^3/s

Cross Section Image





Alt 3 9090cfs - 250 FT BOT - 100 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	250.00	ft
Discharge	9090.00	ft^3/s

Results

Normal Depth	6.70	ft
Flow Area	1855.71	ft^2
Wetted Perimeter	305.28	ft
Hydraulic Radius	6.08	ft
Top Width	303.63	ft
Critical Depth	3.39	ft
Critical Slope	0.01213	ft/ft
Velocity	4.90	ft/s
Velocity Head	0.37	ft
Specific Energy	7.08	ft
Froude Number	0.35	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	6.70	ft
Critical Depth	3.39	ft
Channel Slope	0.00120	ft/ft

Alt 3 9090cfs - 250 FT BOT - 100 yr

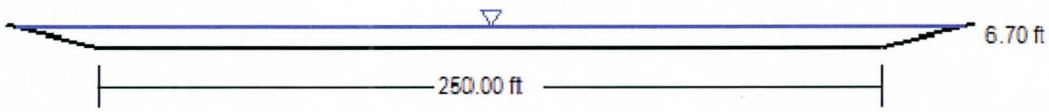
Project Description

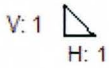
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Normal Depth	6.70	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	250.00	ft
Discharge	9090.00	ft^3/s

Cross Section Image





Alt 3 10716cfs - 250 FT BOT - 200 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	250.00	ft
Discharge	10716.00	ft^3/s

Results

Normal Depth	7.38	ft
Flow Area	2063.19	ft^2
Wetted Perimeter	310.87	ft
Hydraulic Radius	6.64	ft
Top Width	309.05	ft
Critical Depth	3.77	ft
Critical Slope	0.01173	ft/ft
Velocity	5.19	ft/s
Velocity Head	0.42	ft
Specific Energy	7.80	ft
Froude Number	0.35	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	7.38	ft
Critical Depth	3.77	ft
Channel Slope	0.00120	ft/ft

Alt 3 10716cfs - 250 FT BOT - 200 yr

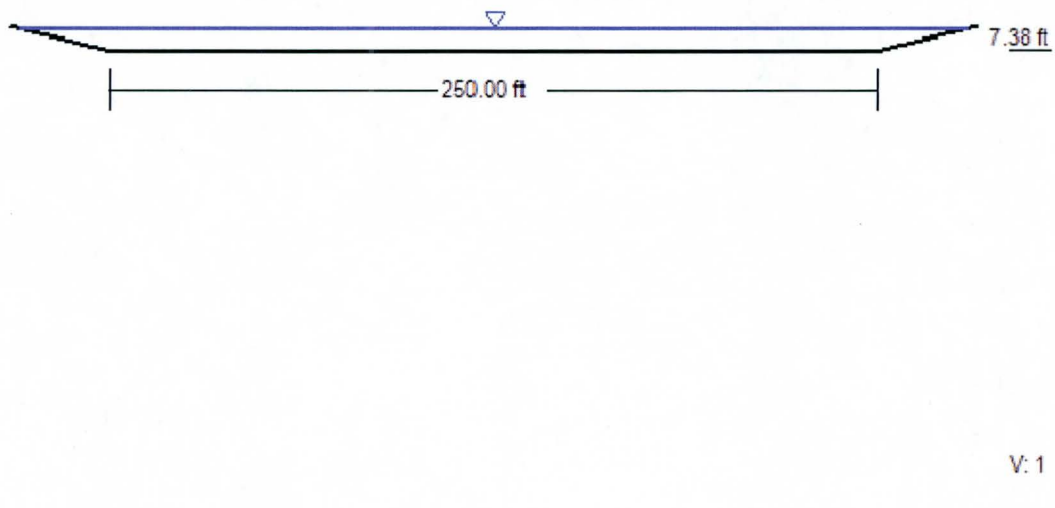
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Normal Depth	7.38	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	250.00	ft
Discharge	10716.00	ft^3/s

Cross Section Image



Alt 3 8243cfs - 250 FT BOT - 200 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	250.00	ft
Discharge	8243.00	ft^3/s

Results

Normal Depth	6.33	ft
Flow Area	1742.80	ft^2
Wetted Perimeter	302.20	ft
Hydraulic Radius	5.77	ft
Top Width	300.64	ft
Critical Depth	3.18	ft
Critical Slope	0.01238	ft/ft
Velocity	4.73	ft/s
Velocity Head	0.35	ft
Specific Energy	6.68	ft
Froude Number	0.35	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	6.33	ft
Critical Depth	3.18	ft
Channel Slope	0.00120	ft/ft

Alt 3 8243cfs - 250 FT BOT - 200 yr

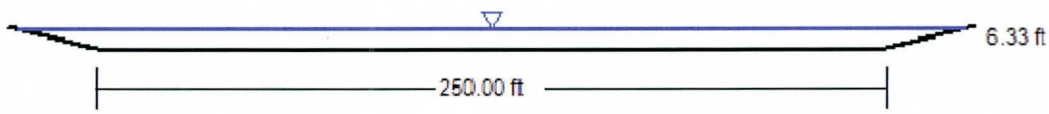
Project Description

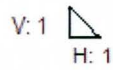
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Normal Depth	6.33	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	250.00	ft
Discharge	8243.00	ft^3/s

Cross Section Image





Alt 3 4450cfs - 300 FT BOT - 100 & 200 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	300.00	ft
Discharge	4450.00	ft^3/s

Results

Normal Depth	3.96	ft
Flow Area	1251.14	ft^2
Wetted Perimeter	332.67	ft
Hydraulic Radius	3.76	ft
Top Width	331.69	ft
Critical Depth	1.88	ft
Critical Slope	0.01460	ft/ft
Velocity	3.56	ft/s
Velocity Head	0.20	ft
Specific Energy	4.16	ft
Froude Number	0.32	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.96	ft
Critical Depth	1.88	ft
Channel Slope	0.00120	ft/ft

Alt 3 Cross Section 4450cfs - 300 FT BOT - 100 & 200 yr

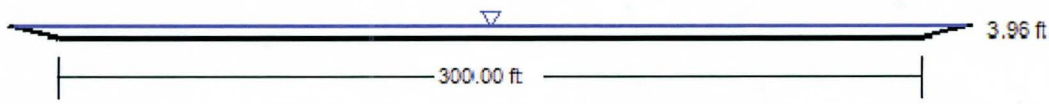
Project Description

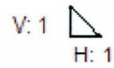
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Normal Depth	3.96	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	300.00	ft
Discharge	4450.00	ft^3/s

Cross Section Image





Alt 3 4450cfs - 50 FT BOT - 100 & 200 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	50.00	ft
Discharge	4450.00	ft^3/s

Results

Normal Depth	9.68	ft
Flow Area	858.69	ft^2
Wetted Perimeter	129.82	ft
Hydraulic Radius	6.61	ft
Top Width	127.43	ft
Critical Depth	5.39	ft
Critical Slope	0.01133	ft/ft
Velocity	5.18	ft/s
Velocity Head	0.42	ft
Specific Energy	10.10	ft
Froude Number	0.35	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	9.68	ft
Critical Depth	5.39	ft
Channel Slope	0.00120	ft/ft

Alt 3 4450cfs - 50 FT BOT - 100 & 200 yr

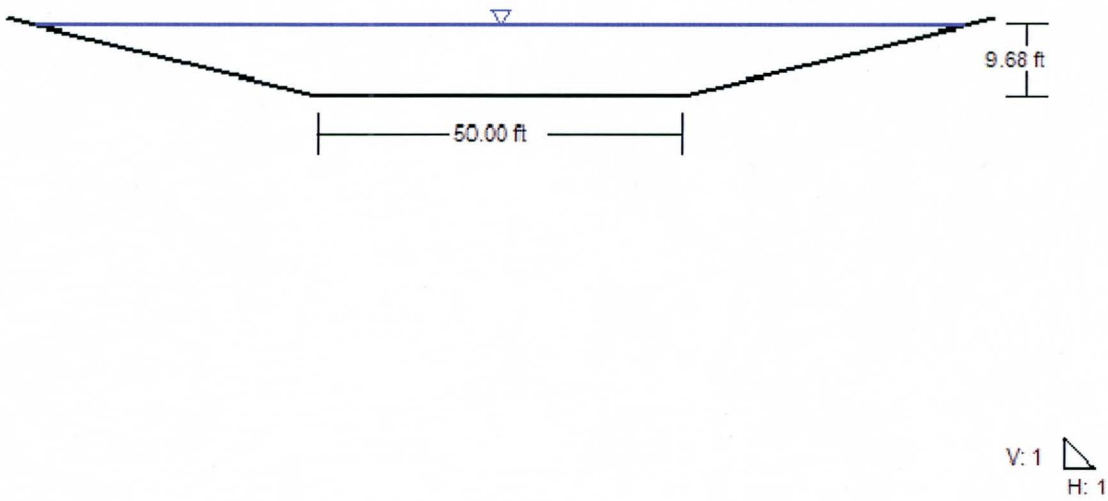
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00120	ft/ft
Normal Depth	9.68	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	50.00	ft
Discharge	4450.00	ft^3/s

Cross Section Image



Alt 4 4450cfs - 100 FT BOT - 100 & 200 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00118	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	100.00	ft
Discharge	4450.00	ft^3/s

Results

Normal Depth	7.27	ft
Flow Area	938.15	ft^2
Wetted Perimeter	159.94	ft
Hydraulic Radius	5.87	ft
Top Width	158.15	ft
Critical Depth	3.75	ft
Critical Slope	0.01209	ft/ft
Velocity	4.74	ft/s
Velocity Head	0.35	ft
Specific Energy	7.62	ft
Froude Number	0.34	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	7.27	ft
Critical Depth	3.75	ft
Channel Slope	0.00118	ft/ft

Alt 4 4450cfs - 100 FT BOT - 100 & 200 yr

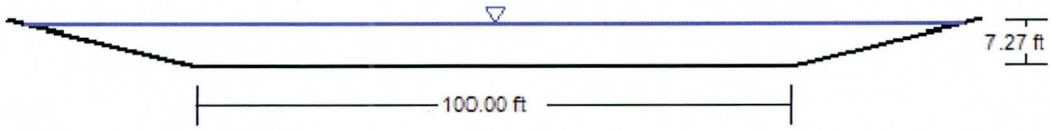
Project Description

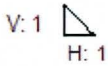
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00118	ft/ft
Normal Depth	7.27	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	100.00	ft
Discharge	4450.00	ft^3/s

Cross Section Image





Alt 4 7045cfs - 170 FT BOT -100 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00118	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	170.00	ft
Discharge	7045.00	ft^3/s

Results

Normal Depth	7.18	ft
Flow Area	1427.29	ft^2
Wetted Perimeter	229.23	ft
Hydraulic Radius	6.23	ft
Top Width	227.46	ft
Critical Depth	3.66	ft
Critical Slope	0.01196	ft/ft
Velocity	4.94	ft/s
Velocity Head	0.38	ft
Specific Energy	7.56	ft
Froude Number	0.35	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	7.18	ft
Critical Depth	3.66	ft
Channel Slope	0.00118	ft/ft

Alt 4 7045cfs - 170 FT BOT - 100 yr

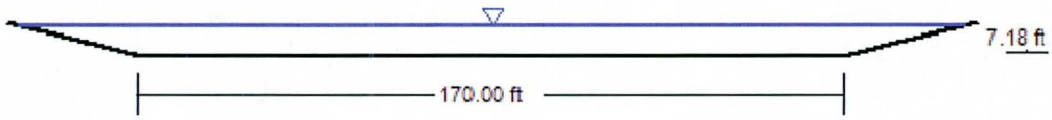
Project Description

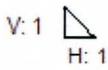
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00118	ft/ft
Normal Depth	7.18	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	170.00	ft
Discharge	7045.00	ft^3/s

Cross Section Image





Alt 4 8243cfs - 170 FT BOT - 200 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00118	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	170.00	ft
Discharge	8243.00	ft^3/s

Results

Normal Depth	7.86	ft
Flow Area	1583.53	ft^2
Wetted Perimeter	234.82	ft
Hydraulic Radius	6.74	ft
Top Width	232.89	ft
Critical Depth	4.05	ft
Critical Slope	0.01159	ft/ft
Velocity	5.21	ft/s
Velocity Head	0.42	ft
Specific Energy	8.28	ft
Froude Number	0.35	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	7.86	ft
Critical Depth	4.05	ft
Channel Slope	0.00118	ft/ft

Alt 4 8243cfs - 170 FT BOT - 200 yr

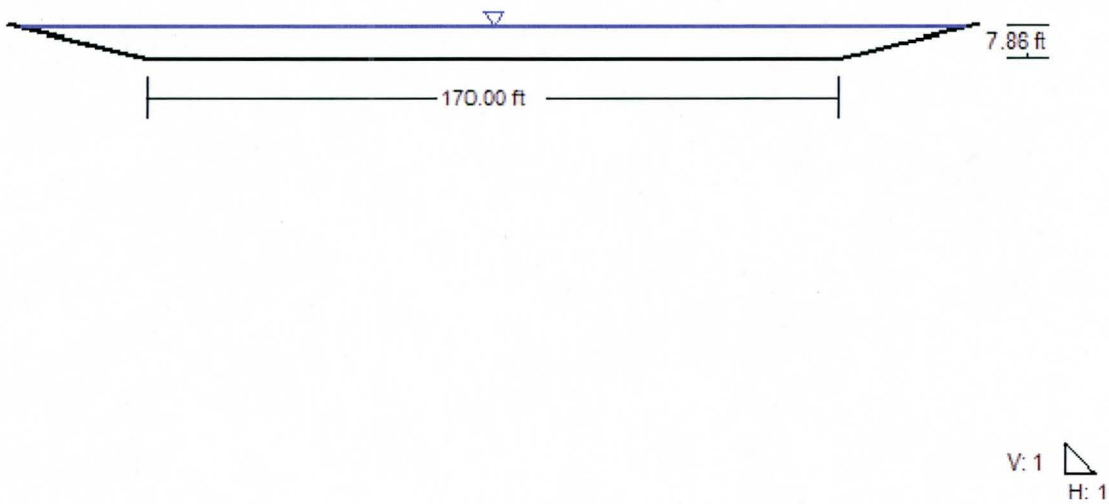
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00118	ft/ft
Normal Depth	7.86	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	170.00	ft
Discharge	8243.00	ft^3/s

Cross Section Image



Alt 4 9090cfs - 230 FT BOT - 100 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00118	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	230.00	ft
Discharge	9090.00	ft^3/s

Results

Normal Depth	7.06	ft
Flow Area	1822.61	ft^2
Wetted Perimeter	288.20	ft
Hydraulic Radius	6.32	ft
Top Width	286.46	ft
Critical Depth	3.57	ft
Critical Slope	0.01196	ft/ft
Velocity	4.99	ft/s
Velocity Head	0.39	ft
Specific Energy	7.44	ft
Froude Number	0.35	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	7.06	ft
Critical Depth	3.57	ft
Channel Slope	0.00118	ft/ft

Alt 4 9090cfs - 230 FT BOT - 100 yr

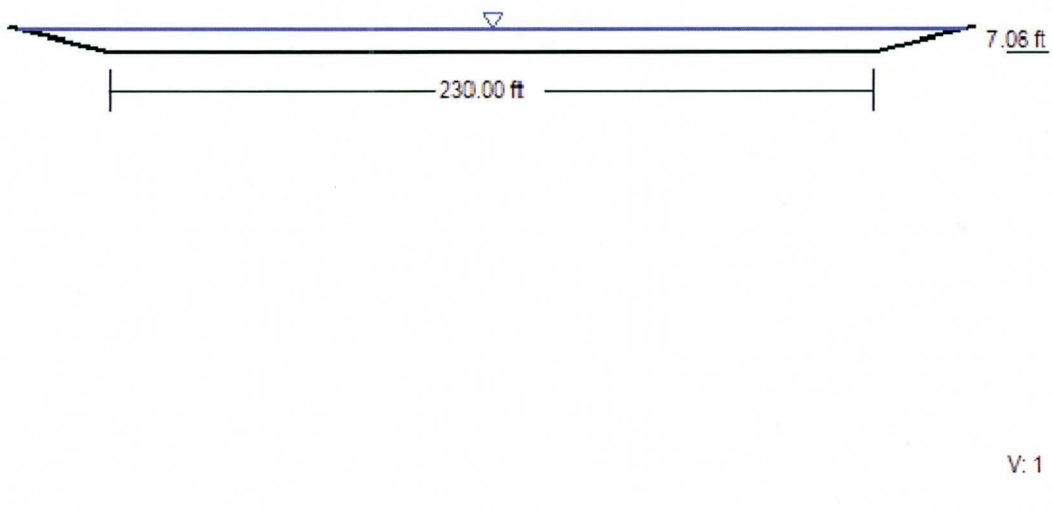
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00118	ft/ft
Normal Depth	7.06	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	230.00	ft
Discharge	9090.00	ft^3/s

Cross Section Image



Alt 4 10716cfs - 230 FT BOT - 200 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00118	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	230.00	ft
Discharge	10716.00	ft^3/s

Results

Normal Depth	7.77	ft
Flow Area	2028.01	ft^2
Wetted Perimeter	294.06	ft
Hydraulic Radius	6.90	ft
Top Width	292.14	ft
Critical Depth	3.98	ft
Critical Slope	0.01156	ft/ft
Velocity	5.28	ft/s
Velocity Head	0.43	ft
Specific Energy	8.20	ft
Froude Number	0.35	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	7.77	ft
Critical Depth	3.98	ft
Channel Slope	0.00118	ft/ft

Alt 4 10716cfs - 230 FT BOT - 200 yr

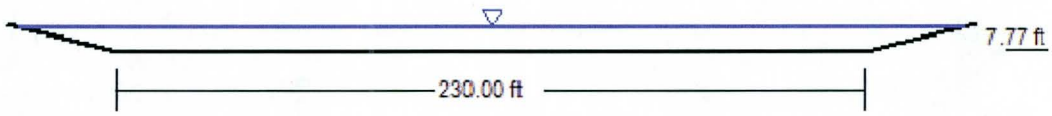
Project Description

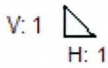
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00118	ft/ft
Normal Depth	7.77	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	230.00	ft
Discharge	10716.00	ft^3/s

Cross Section Image





Alt 4 4450cfs - 50 FT BOT - 100 & 200 yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00118	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	50.00	ft
Discharge	4450.00	ft^3/s

Results

Normal Depth	9.72	ft
Flow Area	863.93	ft^2
Wetted Perimeter	130.15	ft
Hydraulic Radius	6.64	ft
Top Width	127.76	ft
Critical Depth	5.39	ft
Critical Slope	0.01133	ft/ft
Velocity	5.15	ft/s
Velocity Head	0.41	ft
Specific Energy	10.13	ft
Froude Number	0.35	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	9.72	ft
Critical Depth	5.39	ft
Channel Slope	0.00118	ft/ft

Alt 4 4450cfs - 50 FT BOT - 100 & 200 yr

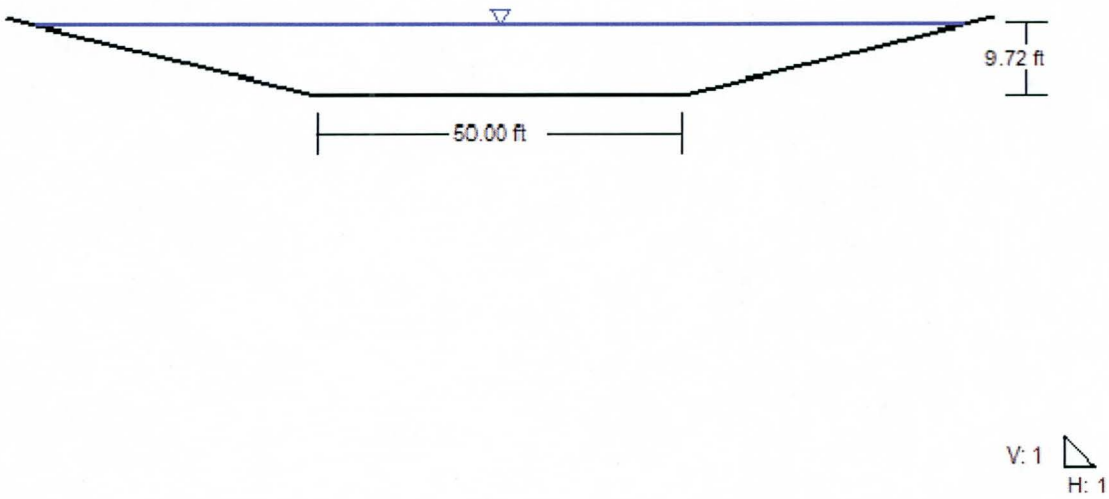
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00118	ft/ft
Normal Depth	9.72	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	50.00	ft
Discharge	4450.00	ft^3/s

Cross Section Image



Worksheet for Sta 100+00 - levee 20 - 100yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00160	ft/ft
Discharge	4450.00	ft^3/s

Section Definitions

Station (ft)	Elevation (ft)
-1+42	1336.71
-1+41	1336.76
-1+40	1336.88
-1+39	1336.94
-1+26	1337.55
-1+26	1337.58
-1+26	1337.59
-1+21	1337.59
-1+19	1337.59
-1+16	1336.29
-1+08	1331.87
-1+08	1331.86
-1+07	1331.84
-1+05	1331.50
-1+03	1331.25
-1+00	1331.01
-0+98	1330.97
-0+90	1330.91
-0+81	1330.77
-0+74	1330.61
-0+66	1330.14
-0+57	1329.44
-0+54	1329.10
-0+51	1328.64
-0+47	1327.52
-0+41	1325.89
-0+28	1324.79

Worksheet for Sta 100+00 - levee 20 - 100yr

Input Data

Station (ft)	Elevation (ft)
-0+25	1324.51
-0+21	1324.13
-0+14	1323.53
-0+13	1323.49
-0+06	1323.48
0+00	1323.37
0+04	1323.30
0+08	1323.22
0+11	1323.15
0+19	1323.06
0+21	1322.96
0+27	1322.75
0+35	1322.72
0+36	1322.74
0+40	1322.83
0+49	1323.09
0+52	1323.90
0+53	1324.15
0+55	1324.55
0+57	1325.51
0+60	1326.46
0+68	1329.88
0+75	1332.77
0+82	1332.25
0+87	1331.89
0+88	1331.82
0+94	1331.20
0+94	1331.19
1+02	1331.12
1+15	1331.25
1+17	1331.29
1+17	1331.42
1+17	1331.61
1+19	1332.01
1+21	1331.84
1+21	1331.81
1+25	1331.78

Worksheet for Sta 100+00 - levee 20 - 100yr

Input Data

Station (ft)	Elevation (ft)
1+29	1331.80
1+30	1331.81
1+32	1331.86
1+42	1331.96
1+43	1331.95
1+43	1331.95
1+47	1332.06
1+57	1332.36
1+59	1332.48
1+70	1332.68
1+76	1332.75
1+81	1332.79
1+88	1332.86
1+92	1332.88
2+00	1332.82
2+05	1332.75
2+05	1332.74
2+07	1332.50
2+10	1332.36
2+18	1332.82
2+22	1332.92
2+33	1332.81
2+35	1332.78
2+38	1333.15
2+42	1333.59
2+52	1333.83
2+55	1333.89
2+56	1333.89
2+67	1333.89
2+73	1333.95
2+80	1334.06
2+89	1334.13
2+92	1334.18
2+97	1334.13
3+04	1334.07
3+06	1334.05
3+15	1334.01

Worksheet for Sta 100+00 - levee 20 - 100yr

Input Data

Station (ft)	Elevation (ft)
3+26	1334.02
3+27	1334.02
3+29	1334.02
3+37	1334.01
3+40	1333.95
3+49	1333.86
3+56	1333.94
3+61	1333.89
3+71	1333.97
3+75	1333.98
3+79	1334.01
3+87	1334.12
3+94	1334.12
3+98	1334.08
4+02	1334.03
4+09	1334.16
4+13	1334.25
4+15	1334.16
4+16	1334.10
4+19	1334.14
4+21	1334.14
4+30	1334.57
4+40	1335.06
4+45	1335.06
4+50	1335.06
4+57	1334.39
4+62	1334.05
4+72	1334.15
4+73	1334.17
4+74	1334.18
4+88	1334.51
5+01	1334.74
5+03	1334.79
5+04	1334.80
5+07	1334.92
5+07	1335.06
5+10	1335.72

Worksheet for Sta 100+00 - levee 20 - 100yr

Input Data

Station (ft)	Elevation (ft)
5+16	1333.89
5+17	1333.61
5+18	1333.74
5+21	1334.17
5+23	1333.76
5+23	1333.76
5+23	1333.76
5+34	1334.00
5+44	1334.09
5+46	1334.12
5+48	1334.25
5+52	1334.52
5+55	1335.15
5+61	1336.53
5+61	1336.59
5+63	1336.61
5+67	1336.61
5+71	1336.70
5+79	1336.76
5+84	1336.77
5+85	1336.78

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-1+42, 1336.71)	(0+75, 1332.77)	0.035
(0+75, 1332.77)	(5+85, 1336.78)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method

Worksheet for Sta 100+00 - levee 20 - 100yr

Options

Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		11.98	ft
Elevation Range	1322.72 to 1337.59 ft		
Flow Area		2086.97	ft²
Wetted Perimeter		635.27	ft
Hydraulic Radius		3.29	ft
Top Width		631.49	ft
Normal Depth		11.98	ft
Critical Depth		4.94	ft
Critical Slope		0.03622	ft/ft
Velocity		2.13	ft/s
Velocity Head		0.07	ft
Specific Energy		12.06	ft
Froude Number		0.21	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	11.98	ft
Critical Depth	4.94	ft
Channel Slope	0.00160	ft/ft
Critical Slope	0.03622	ft/ft

Cross Section for Sta 100+00 - levee 20 - 100yr

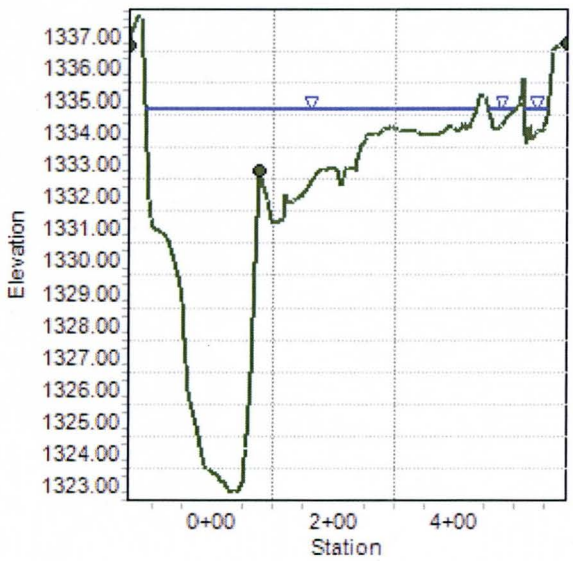
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00160	ft/ft
Normal Depth	11.98	ft
Discharge	4450.00	ft³/s

Cross Section Image



Worksheet for Alt 3&4 Sta 100+00

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00120	ft/ft
Discharge	4450.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
-1+29	1337.41
-1+26	1337.55
-1+26	1337.59
-1+26	1337.59
-1+21	1337.59
-1+19	1337.59
-1+16	1336.04
-1+07	1331.83
-1+07	1331.83
-1+07	1331.72
-1+03	1331.24
-1+00	1331.01
-0+98	1330.97
-0+90	1330.91
-0+81	1330.77
-0+74	1330.61
-0+66	1330.14
-0+57	1329.44
-0+54	1329.10
-0+51	1328.64
-0+47	1327.52
-0+41	1325.89
-0+40	1325.84
-0+20	1320.79
0+00	1320.79
0+30	1320.79
0+38	1322.78

Worksheet for Alt 3&4 Sta 100+00

Input Data

Station (ft)	Elevation (ft)
0+49	1323.09
0+52	1323.90
0+53	1324.15
0+55	1324.55
0+57	1325.51
0+60	1326.46
0+68	1329.88
0+75	1332.77
0+82	1332.25
0+87	1331.89
0+88	1331.82
0+94	1331.20
0+94	1331.19
1+02	1331.12
1+15	1331.25
1+17	1331.29
1+17	1331.42
1+17	1331.61
1+19	1332.01
1+21	1331.84
1+21	1331.81
1+25	1331.78
1+29	1331.80
1+30	1331.81
1+32	1331.86
1+42	1331.96
1+43	1331.95
1+43	1331.95
1+47	1332.06
1+57	1332.36
1+59	1332.48
1+70	1332.68
1+76	1332.75
1+81	1332.79
1+88	1332.86
1+92	1332.88
2+00	1332.82

Worksheet for Alt 3&4 Sta 100+00

Input Data

Station (ft)	Elevation (ft)
2+05	1332.75
2+05	1332.74
2+07	1332.50
2+10	1332.36
2+18	1332.82
2+22	1332.92
2+33	1332.81
2+35	1332.78
2+38	1333.15
2+42	1333.59
2+52	1333.83
2+55	1333.89
2+56	1333.89
2+67	1333.89
2+73	1333.95
2+80	1334.06
2+89	1334.13
2+92	1334.18
2+97	1334.13
3+04	1334.07
3+06	1334.05
3+15	1334.01
3+26	1334.02
3+27	1334.02
3+29	1334.02
3+37	1334.01
3+40	1333.95
3+49	1333.86
3+56	1333.94
3+61	1333.89
3+71	1333.97
3+75	1333.98
3+79	1334.01
3+87	1334.12
3+94	1334.12
3+98	1334.08
4+02	1334.03

Worksheet for Alt 3&4 Sta 100+00

Input Data

Station (ft)	Elevation (ft)
4+09	1334.16
4+13	1334.25
4+15	1334.16
4+16	1334.10
4+19	1334.14
4+21	1334.14
4+30	1334.57
4+40	1335.06
4+45	1335.06
4+50	1335.06
4+57	1334.39
4+62	1334.05
4+72	1334.15
4+73	1334.17
4+74	1334.18
4+88	1334.51
5+01	1334.74
5+03	1334.79
5+04	1334.80
5+07	1334.92
5+07	1335.06
5+10	1335.72
5+16	1333.89
5+17	1333.61
5+18	1333.74
5+21	1334.17
5+23	1333.76
5+23	1333.76
5+23	1333.76
5+34	1334.00
5+44	1334.09
5+46	1334.12
5+48	1334.25
5+52	1334.52
5+55	1335.15
5+61	1336.53
5+61	1336.59

Worksheet for Alt 3&4 Sta 100+00

Input Data

Station (ft)	Elevation (ft)
5+63	1336.61
5+67	1336.61
5+71	1336.70
5+79	1336.76
5+80	1336.76

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-1+29, 1337.41)	(0+75, 1332.77)	0.035
(0+75, 1332.77)	(5+80, 1336.76)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	13.97	ft
Elevation Range	1320.79 to 1337.59 ft	
Flow Area	2283.69	ft^2
Wetted Perimeter	640.65	ft
Hydraulic Radius	3.56	ft
Top Width	636.09	ft
Normal Depth	13.97	ft
Critical Depth	5.18	ft
Critical Slope	0.03562	ft/ft
Velocity	1.95	ft/s
Velocity Head	0.06	ft
Specific Energy	14.03	ft

Worksheet for Alt 3&4 Sta 100+00

Results

Froude Number	0.18	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	13.97	ft
Critical Depth	5.18	ft
Channel Slope	0.00120	ft/ft
Critical Slope	0.03562	ft/ft

Cross Section for Alt 3&4 Sta 100+00

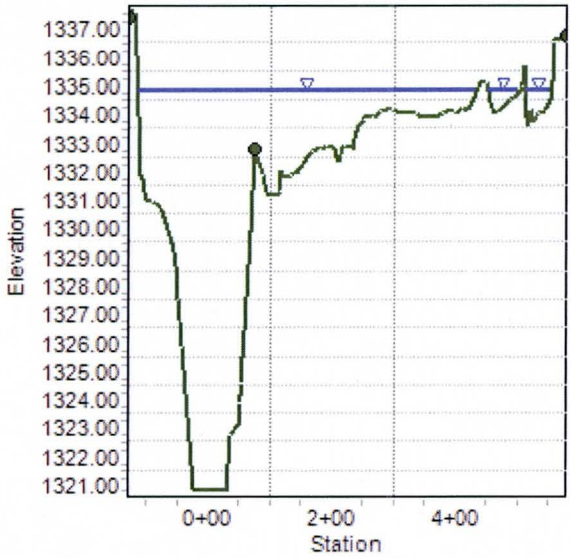
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00120	ft/ft
Normal Depth	13.97	ft
Discharge	4450.00	ft^3/s

Cross Section Image



APPENDIX A-2

Scour and Riprap Calculations

The scour and riprap calculations are done only for levee alternatives 1 and 2; the scour calculations are based on hydraulic data from Appendix A1; the riprap sizing calculations are based on uniform flow analyses for the following two conditions: i) flow in channel and overbank and ii) flow in channel only; conservatively the entire 100 yr discharge or upto the 100 yr flow depth is considered for flow in channel only; the channel only flow is provided in FlowMaster files within Appendix F and not in Appendix A1; Launchable riprap calculations are based on the scour calculations and riprap sizing as described above.

McMicken Dam Outlet Channel Alternative 1 100-Year Discharge Scour Analyses Using the Blench Equation

											General Scour					Bedform Scour						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]
Section Description (-) (-)	FlowMaster Section RS (ft)	100-yr Main Channel Discharge Q100 (cfs)	100-yr Average Channel Velocity V_{avg} (fps)	100-yr Channel Froude Number F_r (-)	100-yr Flow Area A (sq ft)	100-yr Flow Top Width TW (ft)	100-yr Channel Hydraulic Depth Y_h (ft)	100-yr Max Channel Depth Dmax100 (ft)	100-yr Average Width W (ft)	**Long Term Scour Z_{lts} (ft)**	Grain Size D_{50} (mm)	Design Flood Discharge per Unit Width q_f (cfs/ft)	Blench's Zero Bed Factor F_{b0} (-)	Gen. Scour Factor Z (-)	**Gen. Scour Depth Z_{gs} (ft)**	Max. Dune Height d_h (ft)	Anti-Dune Height Z_a (ft)	**Bedform Scour Depth $Z_{bedform}$ (ft)**	**Low-Flow Incisement Depth Z_{lft} (ft)**	**HEC-18 Contraction Scour Zc (ft)**	**Factor of Safety** FS (-)	**Total Scour Depth Z_t (ft)**
Alt 1 New Levee 121+50 - 190+00	125+00	4450	1.38	0.13	3216.73	945.69	3.40	11.75	273.76	3.09	0.08	16.25	0.32	0.60	5.65	1.02	0.05	0.51	1.0	0.00	1.3	13.32
Alt 1 New Levee 121+50 - 190+00	160+00	4450	1.86	0.18	2398.50	745.32	3.22	9.83	244.00	3.09	0.08	18.24	0.32	0.60	6.10	0.97	0.09	0.48	1.0	0.00	1.3	13.87
Alt 1 New Levee 121+50 - 190+00	175+00	4450	1.41	0.15	3158.31	1112.30	2.84	10.76	293.52	3.09	0.08	15.16	0.32	0.60	5.39	0.85	0.05	0.43	1.0	0.00	1.3	12.88
Alt 1 New Levee 190+00 - 232+00	190+00	7045	2.09	0.20	3370.97	989.08	3.41	10.03	336.09	4.07	0.08	20.96	0.32	0.60	6.69	1.02	0.12	0.51	1.0	0.00	1.3	15.96
Alt 1 New Levee 190+00 - 232+00	205+00	7045	1.92	0.17	3678.81	892.49	4.12	10.86	338.75	4.07	0.08	20.80	0.32	0.60	6.66	1.24	0.10	0.62	1.0	0.00	1.3	16.05
Alt 1 New Levee 190+00 - 232+00	220+00	7045	1.79	0.16	3938.99	1046.63	3.76	10.79	365.06	4.07	0.08	19.30	0.32	0.60	6.33	1.13	0.09	0.56	1.0	0.00	1.3	15.56
Alt 1 New Levee232+00 - 250+00	235+00	9090	2.55	0.22	3560.18	866.36	4.11	10.81	329.34	4.74	0.08	27.60	0.32	0.60	8.04	1.23	0.18	0.62	1.0	0.00	1.3	18.72
Alt 1 New Levee232+00 - 250+00	240+00	9090	2.38	0.20	3823.25	849.41	4.50	11.93	320.47	4.74	0.08	28.36	0.32	0.60	8.19	1.35	0.15	0.68	1.0	0.00	1.3	18.99
Alt 1 New Levee 250+00 - 338+98	265+00	9090	1.64	0.13	5545.85	1094.99	5.06	12.92	429.25	4.74	0.08	21.18	0.32	0.60	6.74	1.52	0.07	0.76	1.0	0.00	1.3	17.21
Alt 1 New Levee 250+00 - 338+98	290+00	9090	1.56	0.13	5844.37	1251.32	4.67	11.82	494.45	4.74	0.08	18.38	0.32	0.60	6.13	1.40	0.07	0.70	1.0	0.00	1.3	16.35
Alt 1 New Levee 250+00 - 338+98	297+30	9090	1.75	0.14	5209.14	1118.68	4.66	11.20	465.10	4.74	0.08	19.54	0.32	0.60	6.39	1.40	0.08	0.70	1.0	0.00	1.3	16.68
Alt 1 New Levee 250+00 - 338+98	306+00	9090	1.74	0.14	5220.89	1135.81	4.60	15.03	347.36	4.74	0.08	26.17	0.32	0.60	7.76	1.38	0.08	0.69	1.0	0.00	1.3	18.45
Alt 1 New Levee 250+00 - 338+98	307+50	9090	3.37	0.19	2701.05	281.64	9.59	11.45	235.90	4.74	0.08	38.53	0.32	0.60	10.04	2.88	0.31	1.44	1.0	0.00	1.3	22.39
Alt 1 New Levee 250+00 - 338+98	317+50	9090	3.31	0.19	2747.65	293.28	9.37	11.26	244.02	4.74	0.08	37.25	0.32	0.60	9.82	2.81	0.30	1.41	1.0	0.00	1.3	22.06

Notes:

[1] Channel Section Description
[2] From FlowMaster
[3] From FlowMaster
[4] From FlowMaster
[5] From FlowMaster
[6] From FlowMaster
[7] From FlowMaster
[8] From FlowMaster
[9] From FlowMaster
[10] Col 6/Col 9
[11] Long term degradation formula in ADWR State Standard 5-96, Guideline 2. See FCDMC Hydraulics Design Manual, Aug 15, 2013, Section 11.8.2.1.
[12] From Hoque & Associates, Inc. Particle Distribution Report dated Oct 10, 2013.
[13] Col 3/Col 9
[14] From Equation 11.57 in FCDMC Hydraulics Design Manual, Aug 15, 2013.
[15] From Equation 11.57 in FCDMC Hydraulics Design Manual, Aug 15, 2013.
[16] Blench's Equation for Scour - Equation 11.57 in FCDMC Hydraulics Design Manual, Aug 15, 2013.
[17] Equation 11.62 in FCDMC Hydraulics Design Manual, Aug 15, 2013.
[18] Equation 11.63 in FCDMC Hydraulics Design Manual, Aug 15, 2013.
[19] Equation 11.61 in FCDMC Hydraulics Design Manual, Aug 15, 2013.
[20] Estimated to be 1 foot according to FCDMC Hydraulics Design Manual, Aug 15, 2013, Section 11.8.2.5.
[21] From HEC-RAS. Total scour depth includes the greater of the General Scour component or the HEC-18 Contraction Scour component.
[22] FS = 1.3 per Section 11.8.2 of FCDMC Hydraulics Design Manual, Aug 15, 2013.
[23] Total Scour Depth, based on Eqn. 11.41 of the FCDMC Hydraulics Design Manual, Aug 15, 2013.

McMicken Dam Outlet Channel Alternative 2 100-Year Discharge Scour Analyses Using the Blench Equation

											General Scour					Bedform Scour						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]
Section Description (-) (-)	FlowMaster Section RS (ft)	100-yr Main Channel Discharge Q100 (cfs)	100-yr Average Channel Velocity V_{avg} (fps)	100-yr Channel Froude Number F_r (-)	100-yr Flow Area A (sq ft)	100-yr Flow Top Width TW (ft)	100-yr Channel Hydraulic Depth Y_h (ft)	100-yr Max Channel Depth Dmax100 (ft)	100-yr Average Width W (ft)	**Long Term Scour Z_{lts} (ft)**	Grain Size D_{50} (mm)	Design Flood Discharge per Unit Width q_f (cfs/ft)	Blench's Zero Bed Factor F_{b0} (-)	Gen. Scour Factor Z (-)	**Gen. Scour Depth Z_{gs} (ft)**	Max. Dune Height d_h (ft)	Anti-Dune Height Z_a (ft)	**Bedform Scour Depth $Z_{bedform}$ (ft)**	**Low-Flow Incisement Depth Z_{lft} (ft)**	**HEC-18 Contraction Scour Zc (ft)**	**Factor of Safety** FS (-)	**Total Scour Depth Z_t (ft)**
Alt 1 New Levee 121+50 - 190+00	125+00	4450	1.40	0.13	3182.04	944.88	3.37	11.46	277.66	3.09	0.08	16.03	0.32	0.60	5.60	1.01	0.05	0.51	1.0	0.00	1.3	13.25
Alt 1 New Levee 121+50 - 190+00	160+00	4450	1.54	0.14	2895.31	807.68	3.58	10.19	284.13	3.09	0.08	15.66	0.32	0.60	5.51	1.08	0.06	0.54	1.0	0.00	1.3	13.18
Alt 1 New Levee 121+50 - 190+00	175+00	4450	1.31	0.13	3395.11	1152.93	2.94	10.61	319.99	3.09	0.08	13.91	0.32	0.60	5.09	0.88	0.05	0.44	1.0	0.00	1.3	12.51
Alt 1 New Levee 190+00 - 232+00	190+00	7045	1.58	0.14	4449.78	1146.94	3.88	10.68	416.65	4.07	0.08	16.91	0.32	0.60	5.80	1.16	0.07	0.58	1.0	0.00	1.3	14.89
Alt 1 New Levee 190+00 - 232+00	205+00	7045	1.72	0.15	4087.36	944.36	4.33	10.83	377.41	4.07	0.08	18.67	0.32	0.60	6.19	1.30	0.08	0.65	1.0	0.00	1.3	15.49
Alt 1 New Levee 190+00 - 232+00	220+00	7045	1.61	0.14	4382.91	1107.20	3.96	10.86	403.58	4.07	0.08	17.46	0.32	0.60	5.92	1.19	0.07	0.59	1.0	0.00	1.3	15.07
Alt 1 New Levee232+00 - 250+00	235+00	9090	1.76	0.15	5162.09	1151.20	4.48	11.99	430.53	4.74	0.08	21.11	0.32	0.60	6.72	1.35	0.08	0.67	1.0	0.00	1.3	17.08
Alt 1 New Levee232+00 - 250+00	240+00	9090	1.78	0.15	5101.95	1105.95	4.61	12.75	400.15	4.74	0.08	22.72	0.32	0.60	7.06	1.38	0.09	0.69	1.0	0.00	1.3	17.55
Alt 1 New Levee 250+00 - 338+98	265+00	9090	1.64	0.13	5530.88	1124.17	4.92	12.52	441.76	4.74	0.08	20.58	0.32	0.60	6.61	1.48	0.07	0.74	1.0	0.00	1.3	17.02
Alt 2 New Levee 250+00 - 338+98	290+00	9090	1.61	0.13	5651.32	1196.60	4.72	11.19	505.03	4.74	0.08	18.00	0.32	0.60	6.05	1.42	0.07	0.71	1.0	0.00	1.3	16.25
Alt 2 New Levee 250+00 - 338+98	297+30	9090	1.61	0.13	5658.58	1203.12	4.70	11.34	498.99	4.74	0.08	18.22	0.32	0.60	6.09	1.41	0.07	0.71	1.0	0.00	1.3	16.31
Alt 2 New Levee 250+00 - 338+98	306+00	9090	1.74	0.14	5220.42	1135.52	4.60	15.08	346.18	4.74	0.08	26.26	0.32	0.60	7.78	1.38	0.08	0.69	1.0	0.00	1.3	18.47
Alt 2 New Levee 250+00 - 338+98	307+50	9090	3.37	0.19	2701.04	281.64	9.59	11.45	235.90	4.74	0.08	38.53	0.32	0.60	10.04	2.88	0.31	1.44	1.0	0.00	1.3	22.39
Alt 2 New Levee 250+00 - 338+98	317+50	9090	3.37	0.19	2701.04	281.64	9.59	11.45	235.90	4.74	0.08	38.53	0.32	0.60	10.04	2.88	0.31	1.44	1.0	0.00	1.3	22.39

Notes:

[1] Channel Section Description
[2] From FlowMaster
[3] From FlowMaster
[4] From FlowMaster
[5] From FlowMaster
[6] From FlowMaster
[7] From FlowMaster
[8] From FlowMaster
[9] From FlowMaster
[10] Col 6/Col 9
[11] Long term degradation formula in ADWR State Standard 5-96, Guideline 2. See FCDMC Hydraulics Design Manual, Aug 15, 2013, Section 11.8.2.1.
[12] From Hoque & Associates, Inc. Particle Distribution Report dated Oct 10, 2013.
[13] Col 3/Col 9
[14] From Equation 11.57 in FCDMC Hydraulics Design Manual, Aug 15, 2013.
[15] From Equation 11.57 in FCDMC Hydraulics Design Manual, Aug 15, 2013.
[16] Blench's Equation for Scour - Equation 11.57 in FCDMC Hydraulics Design Manual, Aug 15, 2013.
[17] Equation 11.62 in FCDMC Hydraulics Design Manual, Aug 15, 2013.
[18] Equation 11.63 in FCDMC Hydraulics Design Manual, Aug 15, 2013.
[19] Equation 11.61 in FCDMC Hydraulics Design Manual, Aug 15, 2013.
[20] Estimated to be 1 foot according to FCDMC Hydraulics Design Manual, Aug 15, 2013, Section 11.8.2.5.
[21] From HEC-RAS. Total scour depth includes the greater of the General Scour component or the HEC-18 Contraction Scour component.
[22] FS = 1.3 per Section 11.8.2 of FCDMC Hydraulics Design Manual, Aug 15, 2013.
[23] Total Scour Depth, based on Eqn. 11.41 of the FCDMC Hydraulics Design Manual, Aug 15, 2013.

McMicken Dam Outlet Channel Alternative 2 - Launchable Riprap

Location of Outlet Channel Alternative/Section	Median Rock D_{50} ft	Riprap Layer Thickness T ft	Toe Protection Top Elevation El_{TOP} ft	Thalweg Elevation EL_{TG} ft	Total Scour Depth Z_T ft	Riprap Volume Increase Coefficient C_{VI}	Toe Thickness H ft	Vertical Launch Distance H_V ft	Toe Length L ft
Alt 2 Modified Levee Segment 121+50 - 190+00									
Alt 1/Sta. 125+00	0.58	0.875	1325.3	1320.1	13.2	50	2.6	15.8	21.6
Alt 1/Sta. 160+00	0.17	0.25	1321.8	1317.9	13.2	50	0.8	16.4	19.4
Alt 1/Sta. 175+00	0.17	0.25	1318.7	1316.5	12.5	25	0.8	14.0	14.2
Alt 2 Modified Levee Segment 190+00 - 232+00									
Alt 1/Sta. 190+00	0.17	0.25	1317.4	1315.6	14.9	50	0.8	16.0	19.0
Alt 1/Sta. 205+00	0.17	0.25	1315.0	1314.0	15.5	50	0.8	15.7	18.7
Alt 1/Sta. 220+00	0.58	0.875	1314.2	1312.3	15.1	50	2.6	14.4	20.0
Alt 2 Modified Levee Segment 232+00 - 250+00									
Alt 1/Sta. 235+00	0.08	0.13	1313.6	1311.8	17.1	50	0.4	18.5	21.3
Alt 1/Sta. 240+00	0.58	0.875	1312.3	1310.8	17.5	50	2.6	16.4	22.3
Alt 2 Modified Levee Segment 250+00 - 338+98									
Alt 1/Sta. 265+00	0.17	0.25	1308.0	1308.0	17.0	50	0.8	16.3	19.3
Alt 1/Sta. 290+00	0.25	0.38	1306.4	1306.4	16.2	50	1.1	15.1	18.6
Alt 1/Sta. 297+30	0.25	0.38	1307.0	1306.0	16.3	50	1.1	16.2	19.8
Alt 1/Sta. 306+00	0.33	0.5	1303.1	1303.1	18.5	50	1.5	17.0	21.2
Alt 1/Sta. 307+50	0.33	0.5	1303.0	1303.0	22.4	50	1.5	20.9	25.6
Alt 1/Sta. 317+50	0.58	0.875	1305.3	1300.0	22.4	50	2.6	25.1	32.0

Note: Launchable riprap is estimated based on procedures within the FCDMC's Hydraulic Design Manual.
Riprap size is based on "Riprap Sizing" table.

McMicken Dam Outlet Channel Alternative 1 - Launchable Riprap

Location of Outlet Channel Alternative/Section	Median Rock D_{50} ft	Riprap Layer Thickness T ft	Toe Protection Top Elevation El_{TOP} ft	Thalweg Elevation EL_{TG} ft	Total Scour Depth Z_T ft	Riprap Volume Increase Coefficient C_{VI}	Toe Thickness H ft	Vertical Launch Distance H_V ft	Toe Length L ft
Alt 1 New Levee Segment 121+50 - 190+00									
Alt 1/Sta. 125+00	0.58	0.88	1325.0	1320.1	13.3	50	2.6	15.6	21.4
Alt 1/Sta. 160+00	0.25	0.38	1321.5	1317.6	13.9	50	1.1	16.6	20.3
Alt 1/Sta. 175+00	0.17	0.25	1318.5	1316.5	12.9	25	0.8	14.2	14.3
Alt 1 New Levee Segment 190+00 - 232+00									
Alt 1/Sta. 190+00	0.58	0.88	1317.4	1315.6	16.0	50	2.6	15.2	20.9
Alt 1/Sta. 205+00	0.17	0.25	1315.0	1314.0	16.1	50	0.8	16.3	19.4
Alt 1/Sta. 220+00	0.17	0.25	1314.2	1312.3	15.6	50	0.8	16.8	19.9
Alt 1 New Levee Segment 232+00 - 250+00									
Alt 1/Sta. 235+00	0.17	0.25	1313.6	1311.8	18.7	50	0.8	19.8	23.2
Alt 1/Sta. 240+00	0.58	0.88	1312.3	1310.8	19.0	50	2.6	17.8	23.9
Alt 1 New Levee Segment 250+00 - 338+98									
Alt 1/Sta. 265+00	0.17	0.25	1308.0	1308.0	17.2	50	0.8	16.5	19.5
Alt 1/Sta. 290+00	0.25	0.38	1306.4	1306.4	16.3	50	1.1	15.2	18.7
Alt 1/Sta. 297+30	0.17	0.25	1307.0	1306.0	16.7	50	0.8	16.9	20.1
Alt 1/Sta. 306+00	0.33	0.50	1303.1	1303.1	18.5	50	1.5	17.0	21.2
Alt 1/Sta. 307+50	0.33	0.50	1303.0	1303.0	22.4	50	1.5	20.9	25.6
Alt 1/Sta. 317+50	0.58	0.88	1305.3	1300.0	22.1	50	2.6	24.7	31.6

Note: Launchable riprap is estimated based on procedures within the FCDMC's Hydraulic Design Manual.
Riprap size is based on "Riprap Sizing" table.

McMicken Dam Outlet Channel Alternative 2 - Riprap Sizing

Location of Outlet Channel Alternative/Section	Channel & Overbanks Average Velocity	Channel Only Average Velocity	Velocity Factor	Maximum Velocity	Gravity	Coefficient	Side Slope	Bank Angle	Water Specific Weight	Stone Specific Weight	Median Rock		Riprap Layer Thickness	Comments
	V_{aoc}	V_{ac}	V.F	V	g	C	H:V	θ	γ_w	γ_s	D_{50}		T	
	ft/sec	ft/sec		ft/sec	ft/sec^2			degrees	lb/ft^3	lb/ft^3	ft	in.	in	
Alt 2 Modified Levee Segment 121+50 - 190+00														
Alt 2/Sta. 125+00	1.4	3.9	1.33	5.2	32.2	1.2	0	0	62.4	150	0.21	3	4.5	Riprap on bed of straight channel
Alt 2/Sta. 125+00	1.4	3.9	1.33	5.2	32.2	1.2	2	26.6	62.4	150	0.23	3	4.5	Riprap on bank of straight channel
Alt 2/Sta. 160+00	1.5	4.0	1.33	5.3	32.2	1.2	0	0	62.4	150	0.22	3	4.5	Riprap on bed of straight channel
Alt 2/Sta. 160+00	1.5	4.0	1.33	5.3	32.2	1.2	2	26.6	62.4	150	0.24	3	4.5	Riprap on bank of straight channel
Alt 2/Sta. 175+00	1.3	4.0	1.33	5.3	32.2	1.2	0	0	62.4	150	0.22	3	4.5	Riprap on bed of straight channel
Alt 2/Sta. 175+00	1.3	4.0	1.33	5.3	32.2	1.2	2	26.6	62.4	150	0.24	3	4.5	Riprap on bank of straight channel
Alt 2 Modified Levee Segment 190+00 - 232+00														
Alt 2/Sta. 190+00	1.6	4.8	1.33	6.4	32.2	1.2	0	0	62.4	150	0.31	4	6	Riprap on bed of straight channel
Alt 2/Sta. 190+00	1.6	4.8	1.33	6.4	32.2	1.2	2	26.6	62.4	150	0.35	5	7.5	Riprap on bank of straight channel
Alt 2/Sta. 205+00	1.7	4.7	1.33	6.3	32.2	1.2	0	0	62.4	150	0.30	4	6	Riprap on bed of straight channel
Alt 2/Sta. 205+00	1.7	4.7	1.33	6.3	32.2	1.2	2	26.6	62.4	150	0.34	5	7.5	Riprap on bank of straight channel
Alt 2/Sta. 220+00	1.6	4.6	1.33	6.1	32.2	1.2	0	0	62.4	150	0.29	4	6	Riprap on bed of straight channel
Alt 2/Sta. 220+00	1.6	4.6	1.33	6.1	32.2	1.2	2	26.6	62.4	150	0.32	4	6	Riprap on bank of straight channel
Alt 2 Modified Levee Segment 232+00 - 250+00														
Alt 2/Sta. 235+00	1.8	4.9	1.33	6.5	32.2	1.2	0	0	62.4	150	0.33	4	6	Riprap on bed of straight channel
Alt 2/Sta. 235+00	1.8	4.9	1.33	6.5	32.2	1.2	2	26.6	62.4	150	0.36	5	7.5	Riprap on bank of straight channel
Alt 2/Sta. 240+00	1.8	5.2	1.33	6.9	32.2	1.2	0	0	62.4	150	0.37	5	7.5	Riprap on bed of straight channel
Alt 2/Sta. 240+00	1.8	5.2	1.33	6.9	32.2	1.2	2	26.6	62.4	150	0.41	5	7.5	Riprap on bank of straight channel
Alt 2 Modified Levee Segment 250+00 - 338+98														
Alt 2/Sta. 265+00	1.6	4.3	1.33	5.7	32.2	1.2	0	0	62.4	150	0.25	4	6	Riprap on bed of straight channel
Alt 2/Sta. 265+00	1.6	4.3	1.33	5.7	32.2	1.2	2	26.6	62.4	150	0.28	4	6	Riprap on bank of straight channel
Alt 2/Sta. 290+00	1.6	4.1	1.33	5.5	32.2	0.86	0	0	62.4	150	0.44	6	9	Riprap on bed of curved channel
Alt 2/Sta. 290+00	1.6	4.1	1.33	5.5	32.2	0.86	2	26.6	62.4	150	0.50	6	9	Riprap on bank of curved channel
Alt 2/Sta. 297+30	1.6	4.1	1.33	5.5	32.2	0.86	0	0	62.4	150	0.44	6	9	Riprap on bed of curved channel
Alt 2/Sta. 297+30	1.6	4.1	1.33	5.5	32.2	0.86	2	26.6	62.4	150	0.50	6	9	Riprap on bank of curved channel
Alt 2/Sta. 306+00	1.7	3.3	1.33	4.3	32.2	0.86	0	0	62.4	150	0.28	4	6	Riprap on bed of curved channel
Alt 2/Sta. 306+00	1.7	3.3	1.33	4.3	32.2	0.86	2	26.6	62.4	150	0.31	4	6	Riprap on bank of curved channel
Alt 2/Sta. 307+50	3.4	3.4	1.33	4.5	32.2	0.86	0	0	62.4	150	0.30	4	6	Riprap on bed of curved channel
Alt 2/Sta. 307+50	3.4	3.4	1.33	4.5	32.2	0.86	2	26.6	62.4	150	0.34	4	6	Riprap on bank of curved channel
Alt 2/Sta. 317+50	3.3	3.3	1.33	4.4	32.2	0.86	0	0	62.4	150	0.29	4	6	Riprap on bed of curved channel
Alt 2/Sta. 317+50	3.3	3.3	1.33	4.4	32.2	0.86	2	26.6	62.4	150	0.32	4	6	Riprap on bank of curved channel

McMicken Dam Outlet Channel Alternative 1 - Riprap Sizing

Location of Outlet Channel Alternative/Section	Channel & Overbanks Average Velocity	Channel Only Average Velocity	Velocity Factor	Maximum Velocity	Gravity	Coefficient	Side Slope	Bank Angle	Water Specific Weight	Stone Specific Weight	Median Rock		Riprap Layer Thickness	Comments
	V_{aoc}	V_{ac}	V.F	V	g	C	H:V	θ	γ_w	γ_s	D_{50}		T	
	ft/sec	ft/sec		ft/sec	ft/sec^2			degrees	lb/ft^3	lb/ft^3	ft	in.	in	
Alt 1 New Levee Segment 121+50 - 190+00														
Alt 1/Sta. 125+00	1.4	4.3	1.33	5.7	32.2	1.2	0	0	62.4	150	0.25	4	6	Riprap on bed of straight channel
Alt 1/Sta. 125+00	1.4	4.3	1.33	5.7	32.2	1.2	2	26.6	62.4	150	0.28	4	6	Riprap on bank of straight channel
Alt 1/Sta. 160+00	1.9	5.4	1.33	7.2	32.2	1.2	0	0	62.4	150	0.40	5	7.5	Riprap on bed of straight channel
Alt 1/Sta. 160+00	1.9	5.4	1.33	7.2	32.2	1.2	2	26.6	62.4	150	0.44	6	9	Riprap on bank of straight channel
Alt 1/Sta. 175+00	1.4	4.8	1.33	6.4	32.2	1.2	0	0	62.4	150	0.31	4	6	Riprap on bed of straight channel
Alt 1/Sta. 175+00	1.4	4.8	1.33	6.4	32.2	1.2	2	26.6	62.4	150	0.35	5	7.5	Riprap on bank of straight channel
Alt 1 New Levee Segment 190+00 - 232+00														
Alt 1/Sta. 190+00	2.1	6.7	1.33	8.9	32.2	1.2	0	0	62.4	150	0.61	8	12	Riprap on bed of straight channel
Alt 1/Sta. 190+00	2.1	6.7	1.33	8.9	32.2	1.2	2	26.6	62.4	150	0.68	8	4.5	Riprap on bank of straight channel
Alt 1/Sta. 205+00	1.9	5.8	1.33	7.7	32.2	1.2	0	0	62.4	150	0.46	6	9	Riprap on bed of straight channel
Alt 1/Sta. 205+00	1.9	5.8	1.33	7.7	32.2	1.2	2	26.6	62.4	150	0.51	7	10.5	Riprap on bank of straight channel
Alt 1/Sta. 220+00	1.8	5.5	1.33	7.3	32.2	1.2	0	0	62.4	150	0.41	5	7.5	Riprap on bed of straight channel
Alt 1/Sta. 220+00	1.8	5.5	1.33	7.3	32.2	1.2	2	26.6	62.4	150	0.46	6	9	Riprap on bank of straight channel
Alt 1 New Levee Segment 232+00 - 250+00														
Alt 1/Sta. 235+00	2.6	7.1	1.33	9.4	32.2	1.2	0	0	62.4	150	0.68	9	13.5	Riprap on bed of straight channel
Alt 1/Sta. 235+00	2.6	7.1	1.33	9.4	32.2	1.2	2	26.6	62.4	150	0.77	9	13.5	Riprap on bank of straight channel
Alt 1/Sta. 240+00	2.4	7.0	1.33	9.3	32.2	1.2	0	0	62.4	150	0.67	8	12	Riprap on bed of straight channel
Alt 1/Sta. 240+00	2.4	7.0	1.33	9.3	32.2	1.2	2	26.6	62.4	150	0.74	9	13.5	Riprap on bank of straight channel
Alt 1 New Levee Segment 250+00 - 338+98														
Alt 1/Sta. 265+00	1.6	4.8	1.33	6.4	32.2	1.2	0	0	62.4	150	0.31	4	6	Riprap on bed of straight channel
Alt 1/Sta. 265+00	1.6	4.8	1.33	6.4	32.2	1.2	2	26.6	62.4	150	0.35	5	7.5	Riprap on bank of straight channel
Alt 1/Sta. 290+00	1.6	4.5	1.33	6.0	32.2	0.86	0	0	62.4	150	0.54	7	10.5	Riprap on bed of curved channel
Alt 1/Sta. 290+00	1.6	4.5	1.33	6.0	32.2	0.86	2	26.6	62.4	150	0.60	7	10.5	Riprap on bank of curved channel
Alt 1/Sta. 297+30	1.8	3.5	1.33	4.7	32.2	0.86	0	0	62.4	150	0.32	4	6	Riprap on bed of curved channel
Alt 1/Sta. 297+30	1.8	3.5	1.33	4.7	32.2	0.86	2	26.6	62.4	150	0.36	5	7.5	Riprap on bank of curved channel
Alt 1/Sta. 306+00	1.7	3.4	1.33	4.5	32.2	0.86	0	0	62.4	150	0.31	4	6	Riprap on bed of curved channel
Alt 1/Sta. 306+00	1.7	3.4	1.33	4.5	32.2	0.86	2	26.6	62.4	150	0.34	5	7.5	Riprap on bank of curved channel
Alt 1/Sta. 307+50	3.4	3.4	1.33	4.5	32.2	0.86	0	0	62.4	150	0.30	4	6	Riprap on bed of curved channel
Alt 1/Sta. 307+50	3.4	3.4	1.33	4.5	32.2	0.86	2	26.6	62.4	150	0.34	4	6	Riprap on bank of curved channel
Alt 1/Sta. 317+50	3.3	4.0	1.33	5.3	32.2	0.86	0	0	62.4	150	0.42	6	9	Riprap on bed of curved channel
Alt 1/Sta. 317+50	3.3	4.0	1.33	5.3	32.2	0.86	2	26.6	62.4	150	0.47	6	9	Riprap on bank of curved channel

APPENDIX A-3

Alternatives 3 and 4 Stream Power Calculations

The stream power calculations are done only for channel alternatives 3 and 4; the Stream Power Table 2 is taken from AMEC's report Seismic Refraction and ReMi Evaluation McMicken Dam Outlet Channel dated June 2014; the erosion potential for the soil i.e., "Erosion Threshold Stream Power" is related to the "Seismic Velocity" for "s-waves" and "p-waves"; the subsequent "Interpretation of Refraction Seismic Data" charts at various stations along the Outlet Channel are based on actual s-wave and p-wave velocities encountered for the soils at various depths below the ground; the handwritten "Hydraulic Data" is then compared with the "Geotech Data" to indicate if the soil can withstand the hydraulic stream power calculations; the hydraulic data is based on the hydraulic stream power calculations within the table "McMicken Dam Outlet Channel Alternatives 3 and 4 – Stream Power Evaluation" at the end of Appendix A-3.

McMicken Dam Outlet Channel Alternatives 3 and 4 - Hydraulic Stream Power Evaluation

Alternative ID, Flow, Channel Bottom Width	(ft/ft) "S"	Hydraulic Radius (ft) "R"	(ft/s) "V"	s)) "SP"	Stream Power (lbm/s^3) "SP"	Stream Power (kW/m^2) "SP"	Comments
Alternative 3 9090cfs - 250 FT BOT	0.0012	6.08	4.9	2.231	71.775	0.0326	100 yr Flow Evaluation
Alternative 3 4450cfs - 120 FT BOT	0.0012	5.54	4.6	1.908	61.396	0.0278	100 yr Flow Evaluation
Alternative 3 4450cfs - 50 FT BOT	0.0012	6.61	5.18	2.564	82.490	0.0374	100 yr Flow Evaluation
Alternative 4 9090cfs - 230 FT BOT	0.00118	6.32	4.99	2.322	74.712	0.0339	100 yr Flow Evaluation
Alternative 4 7045cfs - 170 FT BOT	0.00118	6.23	4.94	2.266	72.910	0.0331	100 yr Flow Evaluation
Alternative 4 4450cfs - 100 FT BOT	0.00118	5.87	4.74	2.049	65.916	0.0299	100 yr Flow Evaluation
Alternative 4 4450cfs - 50 FT BOT	0.00118	6.64	5.15	2.518	81.012	0.0367	100 yr Flow Evaluation
Alternative 3 7045cfs - 250 FT BOT	0.0012	5.3	4.47	1.774	57.076	0.0259	100 yr Flow Evaluation
Alternative 3 4450cfs - 300 FT BOT	0.0012	3.76	3.56	1.002	32.248	0.0146	100 yr Flow Evaluation
Alternative 3 4450cfs - 250 FT BOT	0.0012	4.12	3.78	1.166	37.520	0.0170	100 yr Flow Evaluation
Alternative 3 8243cfs - 250 FT BOT	0.0012	5.77	4.73	2.044	65.752	0.0298	200 yr Flow Evaluation
Alternative 3 10716cfs - 250 FT BOT	0.0012	6.64	5.19	2.580	83.025	0.0377	200 yr Flow Evaluation
Alternative 4 8243cfs - 170 FT BOT	0.00118	6.74	5.21	2.586	83.190	0.0377	200 yr Flow Evaluation
Alternative 4 10716cfs - 230 FT BOT	0.00118	6.9	5.28	2.683	86.309	0.0391	200 yr Flow Evaluation

Note: Stream Power P (lbm/s^3) = 62.4 x g x R x S x V

McMicken Dam Outlet Channel Alternatives 3 and 4 - Erosion Threshold Stream Power vs Hydraulic Stream Power Evaluation

Outlet Channel Station Range	Geotechnical Data					Hydraulic Data						Comments
	Seismic Refraction Line No.	100-yr Flow Zone (Range of Depths below Ground in ft) "FZ"	S-Wave Velocity (ft/s) "V_s"	P-Wave Velocity (ft/s) "V_p"	Erosion Threshold Stream Power (kW/m^2) "ETSP"	Alternative No.	Channel Slope (ft/ft) "S"	Bottom Width (ft) "W"	Flow Depth (ft) "D"	Hydraulic Radius (ft) "R"	Hydraulic Stream Power (kW/m^2) "HSP"	
120+00 - 175+00	6	9-17	1300	2500-3600	0-1	3	0.0012	50	9.7	6.61	0.04	HSP vs ETSP - Say Ok
						3	0.0012	120	6.6	5.54	0.03	HSP vs ETSP - Say Ok
						3	0.0012	300	4	3.76	0.01	HSP vs ETSP - Say Ok
						4	0.00118	50	9.7	6.64	0.04	HSP vs ETSP - Say Ok
						4	0.00118	100	7.3	6.23	0.03	HSP vs ETSP - Say Ok
						4	0.00118	170	7.2	6.64	0.04	HSP vs ETSP - Say Ok
175+00 - 230+00	5	6-13	1200	2100-2800	0-0.2	3	0.0012	300	4	3.76	0.01	HSP vs ETSP - Say Ok
						3	0.0012	250	4.4	4.12	0.02	HSP vs ETSP - Say Ok
						3	0.0012	250	5.8	5.3	0.03	HSP vs ETSP - Say Ok
						4	0.00118	170	7.2	6.23	0.03	HSP vs ETSP - Say Ok
						4						
230+00 - 270+00	4	10-20	850-880	1800-2100	0-0.2	3	0.0012	250	5.8	5.3	0.03	HSP vs ETSP - Say Ok
						3	0.0012	250	6.7	6.08	0.03	HSP vs ETSP - Say Ok
						4	0.00118	170	7.2	6.23	0.03	HSP vs ETSP - Say Ok
						4	0.00118	230	7.1	6.32	0.03	HSP vs ETSP - Say Ok
270+00 - 305+00	3	10-18	750-3200	3000-6300	0-30	3	0.0012	250	6.7	6.08	0.03	HSP vs ETSP - Say Ok
						4	0.00118	230	7.1	6.32	0.03	HSP vs ETSP - Say Ok
305+00 - 315+00	2	12-20	2400	4500-6200	5-30	3	0.0012	250	6.7	6.08	0.03	HSP vs ETSP - Say Ok
						4	0.00118	230	7.1	6.32	0.03	HSP vs ETSP - Say Ok
315+00 -330+00	1	13-20	860-2000	3900-6200	0-0.2	3	0.0012	250	6.7	6.08	0.03	HSP vs ETSP - Say Ok
						4	0.00118	230	7.1	6.32	0.03	HSP vs ETSP - Say Ok

TABLE 2

Approximate Erodability & Excavatability of Materials
Limestone & Cemented Soils (caliche)

Seismic Velocity f/s (m/s) (Rucker and Fergason, 2006)	Trackhoe / Dozer Type & Power (Cat, 1984, 1993)	Erodability / Excavatability Index (Kirsten 1982, 1986; NRCS, 2001)	Erosion Threshold Stream Power, KW/m^2 (Annandale, 1995)
s-wave < 750 f/s (230 m/s) p-wave < 1,500 f/s (460 m/s)	Hand spade	< 0.01	Very erodable
s-wave 750 – 1,500 (230 – 460) p-wave 1,500 – 3,000 (460 – 910)	Hand pick & spade	0.01 – 0.099	Very erodable – 0.2
s-wave 1,500 - ~1,800 (460 – 550) p-wave 3,000 - ~3,500 (910 – 1,070)	Cat 325BL 168 hp 125 KW Cat D6D 136 hp 101 KW	0.1 – 0.99	0.2 – 1.0
s-wave ~1,800 – 2,000 (550 – 610) p-wave ~3,500 – 4,000 (1,070 – 1,220)	Cat 330BL 222 hp 165 KW Cat D7G 200 hp 149 KW	1.0 – 9.99	1.0 – 5.0
s-wave ~2,100 – 3,000 (640 – 910) p-wave ~4,200 – 5,900 (1,280 – 1,800)	Cat 345BL 321 hp 239 KW Cat D8L 335 hp 249 KW	10 – 99	5.0 – 30
s-wave 3,000 – 3,600 (910 – 1,100) p-wave 5,900 – 7,200 (1,800 – 2,200)	Cat 375 428 hp 319 KW Cat D9L 460 hp 342 KW	100 – 999	30 – 200

***Table Notes**: Bulldozer and backhoe power ranges are presented by Kirsten (1982, 1988) as a measure of equivalent performance for excavation. All velocities are approximate and represent a typical range. S-wave velocities are assumed to be about half of p-wave velocities consistent with a Poisson's ratio of 0.33. Seismic velocity ranges for backhoes and trackhoes in cemented soils with typical p-wave velocity less than 6,000 f/s (1,830 m/s) are from Rucker and Fergason (2006). See the Caterpillar Performance Handbook (Caterpillar, 1984, 1993 or current edition) for details on use of seismic information for rippability. Different model configurations include variations in weight and horsepower.*

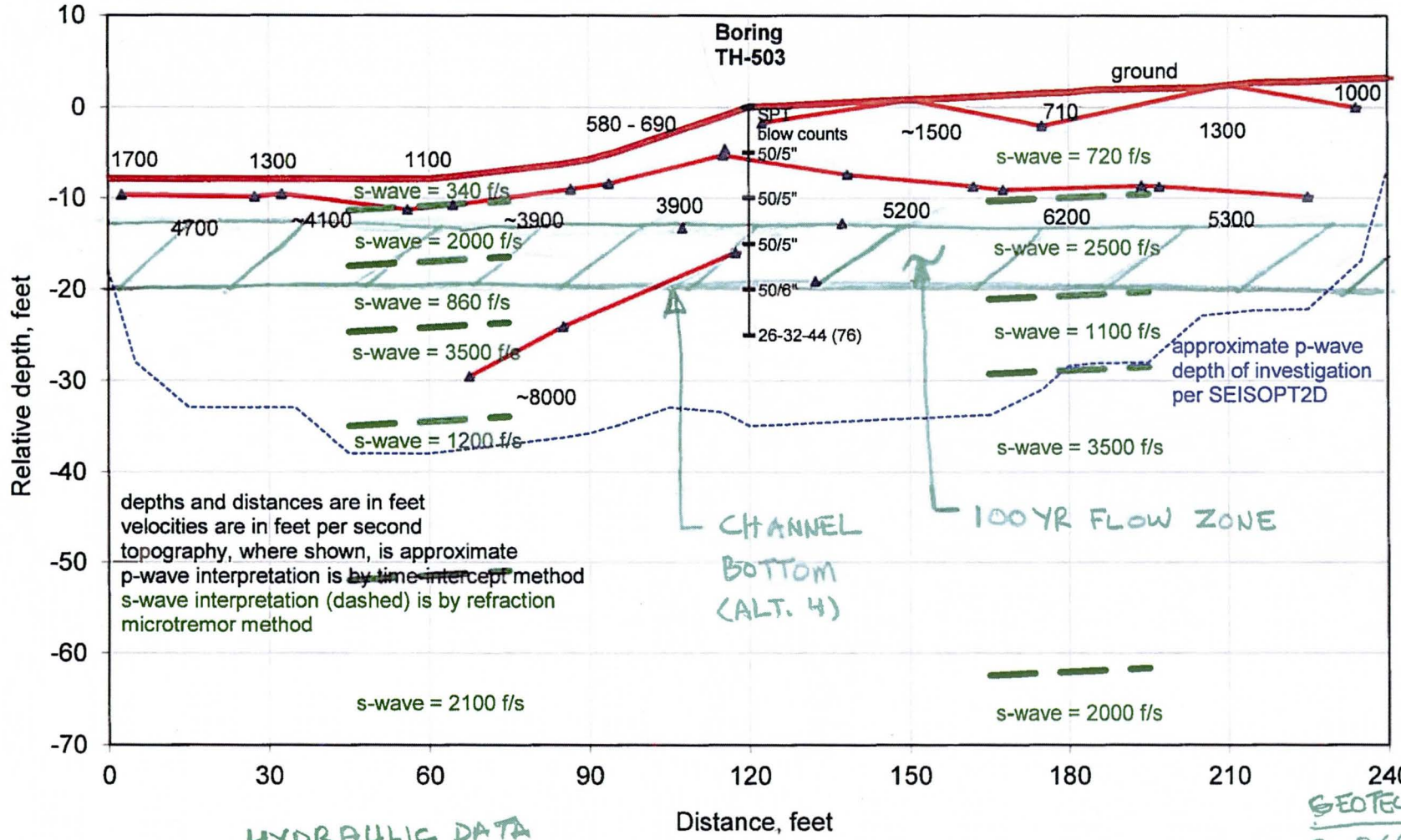
Seismic Refraction and Refraction Microtremor Interpretation

Line 1

Sta. 315+00 to 330+00

AMEC Job No. 17-2013-4059

Interpretation of Refraction Seismic Data



HYDRAULIC DATA

CHANNEL BOTTOM ≈ ~20' DEEP

FLOW VEL = 5 FT/SEC, FLOW DEPTH = 7ft

STREAM POWER = 0.1334 kg/m² SAY OK

GEOTECH DATA

S = 860 - 2000 f/s

P = 3900 - 8000 f/s

SP = 0 - 0.279 kW/m²

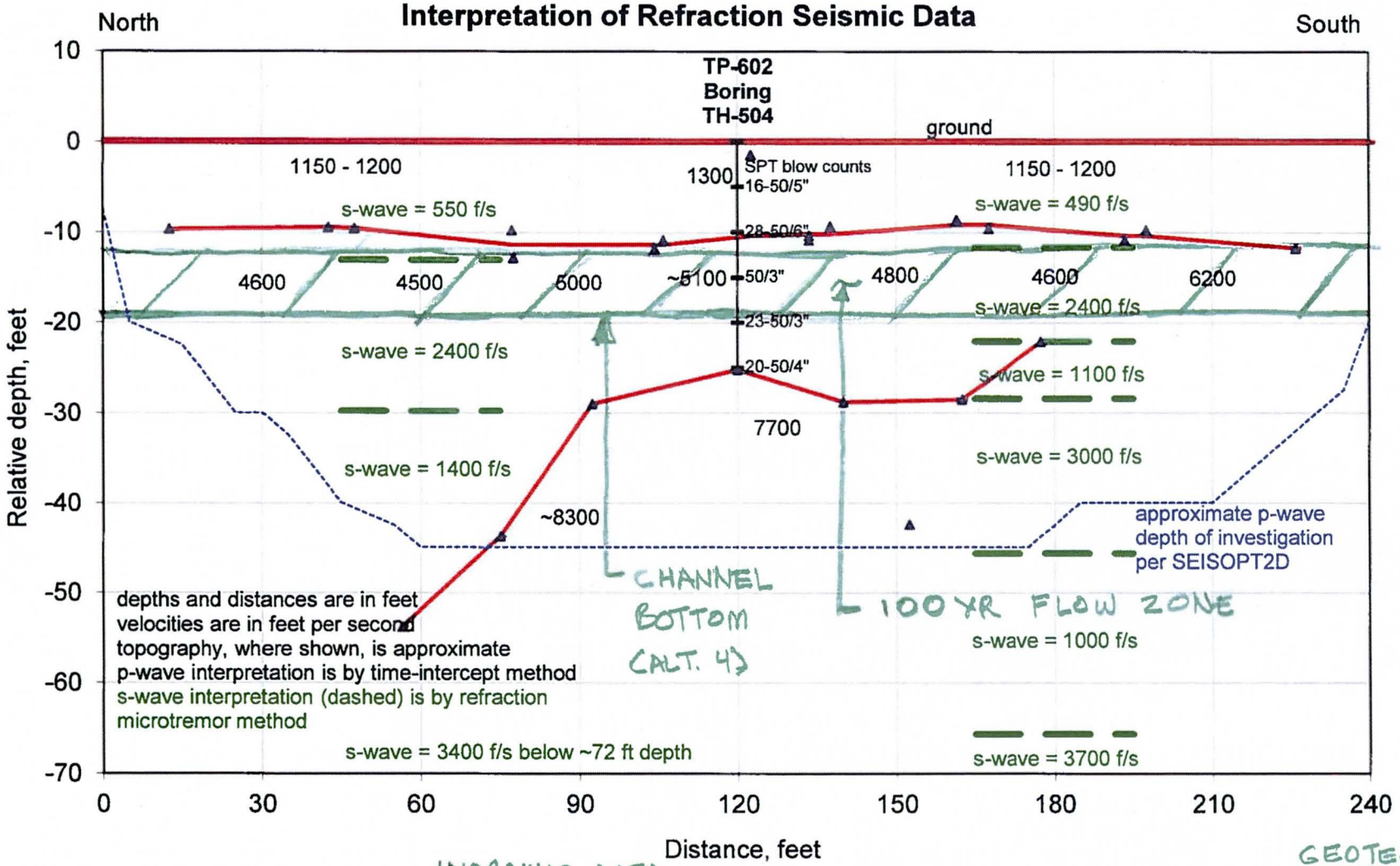
Seismic Refraction and Refraction
Microtremor Interpretation

Line 2

Sta 305+00 to 315+00

AMEC Job No. 17-2013-4059

Interpretation of Refraction Seismic Data



HYDRAULIC DATA

CHANNEL BOTTOM: 18'-20' (MOSTLY 20')

VEL: 5 FT/SEC, FLOW DEPTH = 7 ft

STREAM POWER = 0.033 kg < 5.0 OK

GEOTECH DATA

S ≃ 2400 f/s

P = 4500-6200 f/s

SP = 5.0 - 30 kg/2

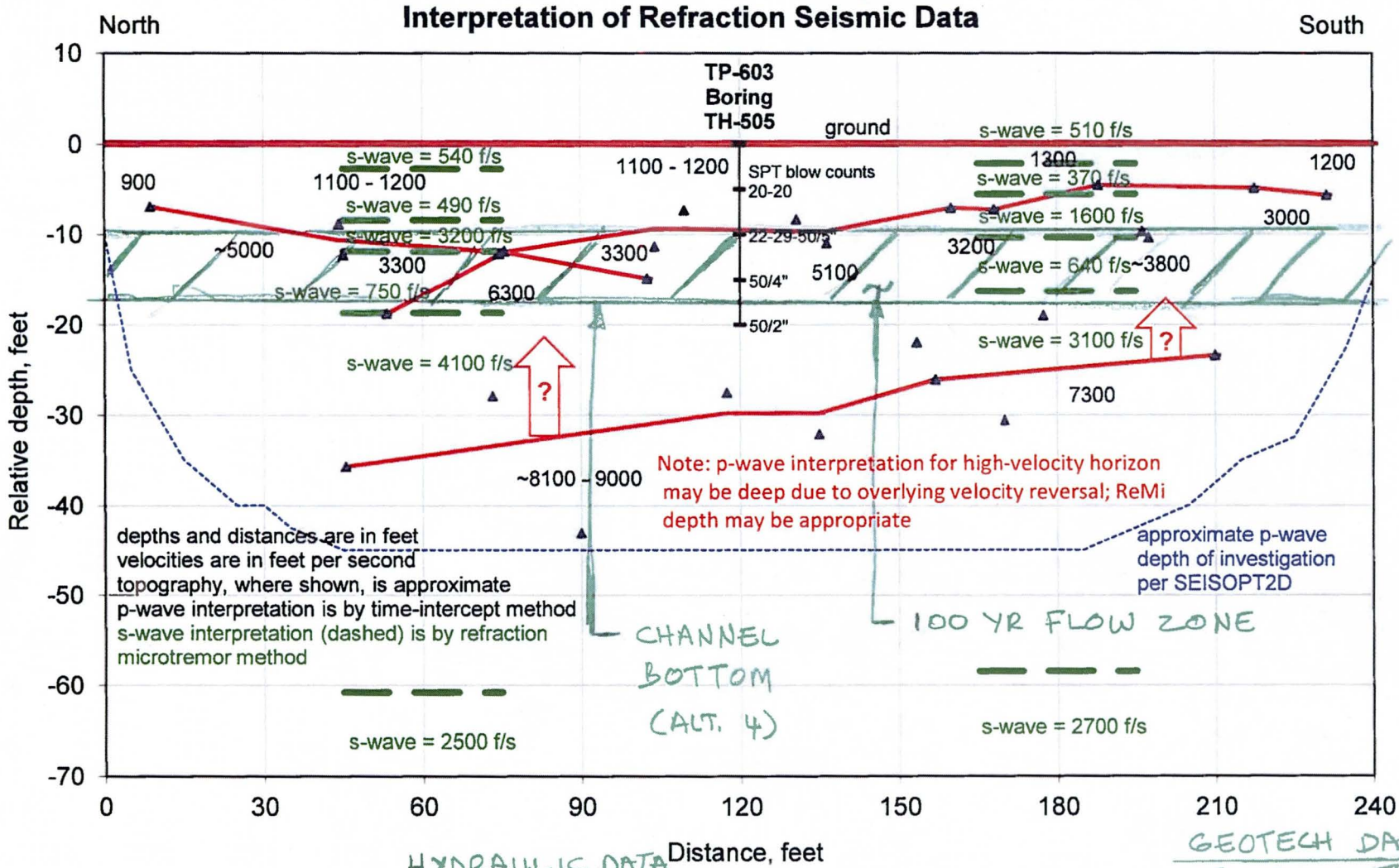
Seismic Refraction and Refraction
Microtremor Interpretation

Line 3

AMEC Job No. 17-2013-4059

STA. 270+00 to 305+00

Interpretation of Refraction Seismic Data



HYDRAULIC DATA
CHANNEL BOTTOM: 15' - 18'
VELOCITY: < 5 FT/SEC
DEPTH = < 7'
STREAM POWER = 0.033 kg/m² SAY OK

GEOTECH DATA
S = 3200 - 750 f/s
P = 3200 - 6300+ f/s
SP = 0 - 30 kg/m²

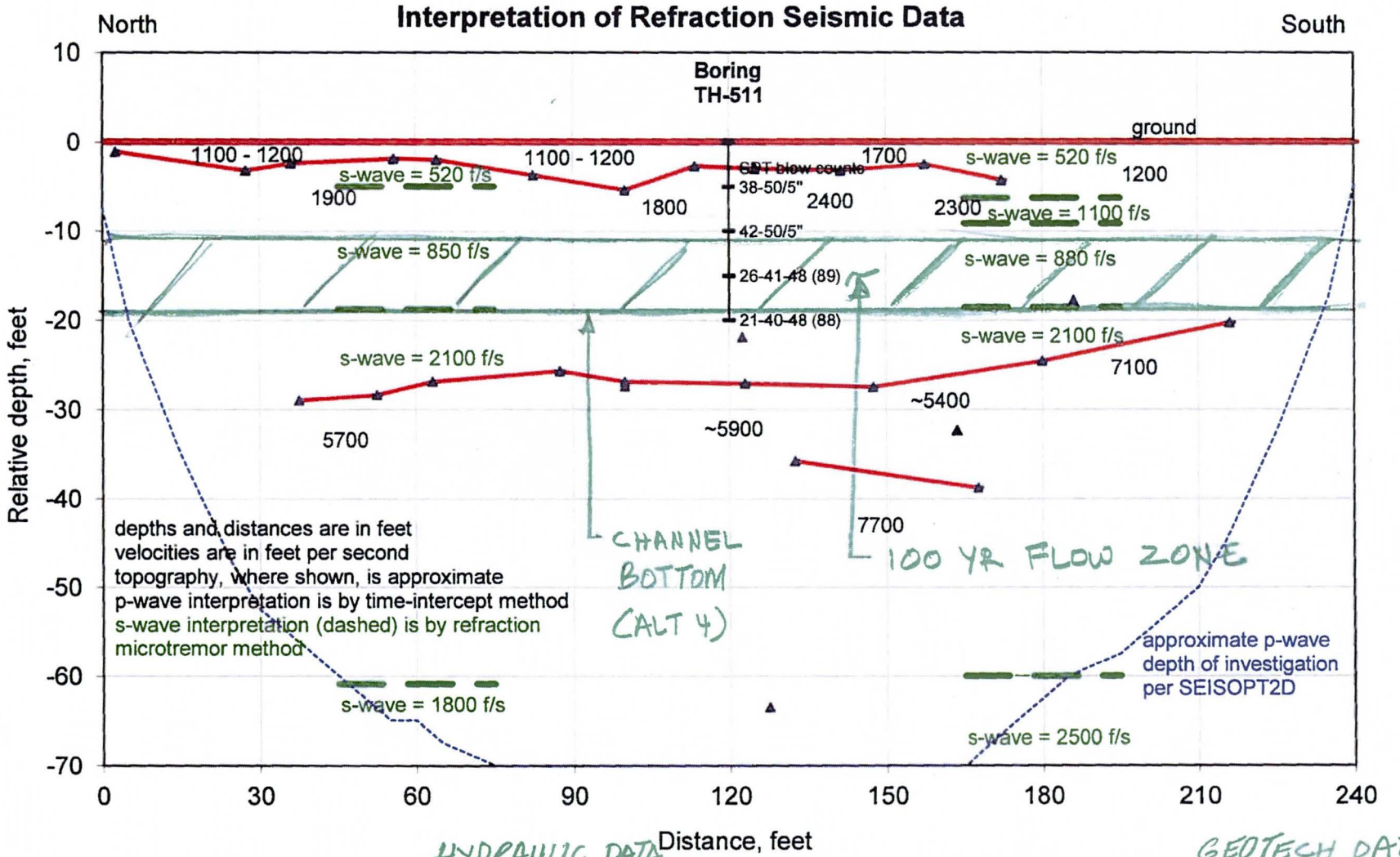
Seismic Refraction and Refraction
Microtremor Interpretation

Line 4

Sta 230+00 to 270+00

AMEC Job No. 17-2013-4059

Interpretation of Refraction Seismic Data



HYDRAULIC DATA
CHANNEL BOTTOM = 15'-18' DEEP
VEL = 5 FT/SE
FLOW DEPTH = 7 FT
STREAM POWER = 0.03 kg SAY OK

GEOTECH DATA
S = 850-880 f/s
P = 1800-2100 f/s
SP = 0 - 0.2 Kg/m²

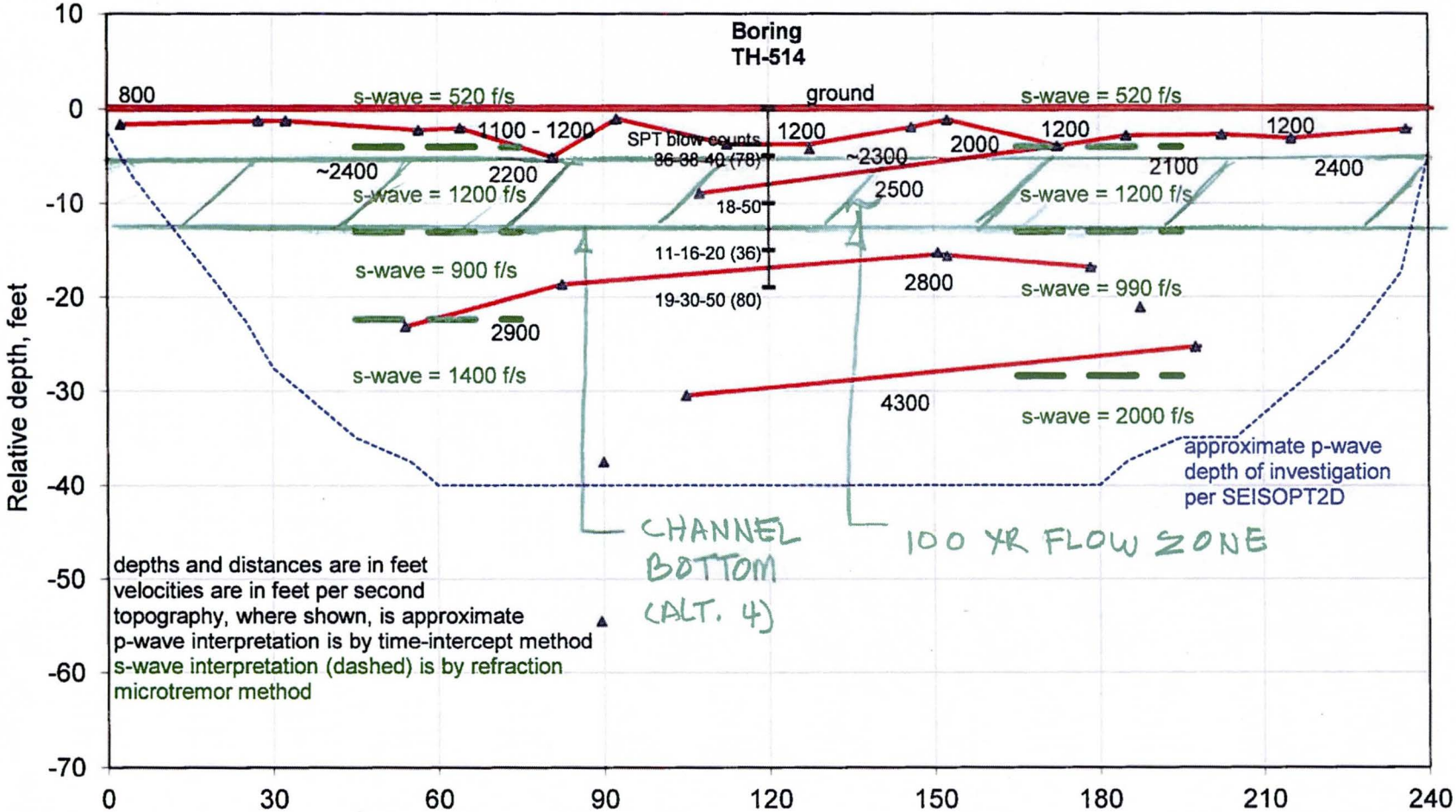
Seismic Refraction and Refraction
Microtremor Interpretation

Line 5

AMEC Job No. 17-2013-4059

Sta 175+00 + 230+00

Interpretation of Refraction Seismic Data



HYDRAULIC DATA
CHANNEL BOTTOM: 12' - 16'
FLOW VEL = 5 FT/SEC
" DEPTH = 7 FT
[illegible] = 0.03 kg SAY OF

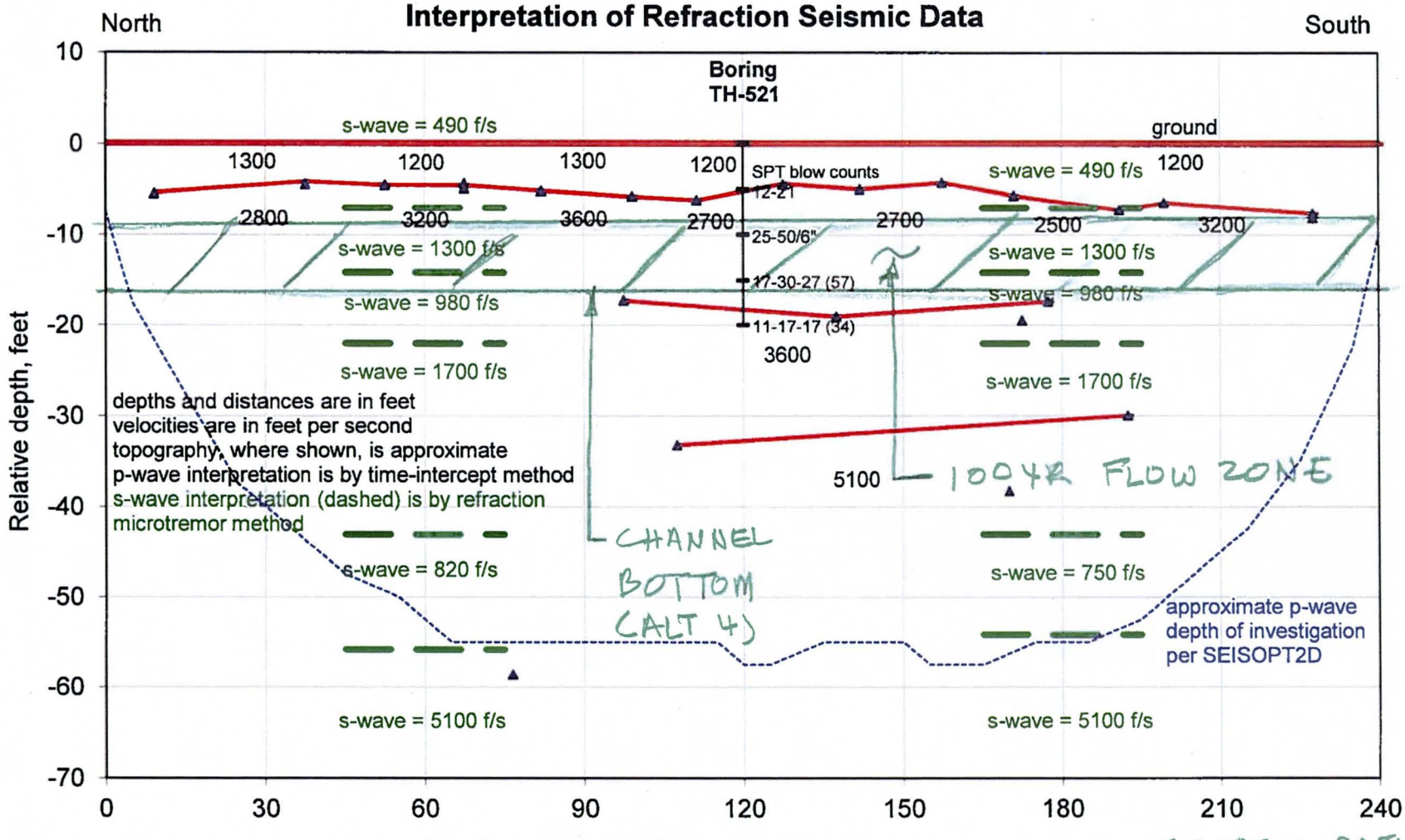
GEOTECH DATA
S = 1200 f/s
P = 2100 - 2800 f/s
SP = 0 - 0.2 kg/m²

Seismic Refraction and Refraction
Microtremor Interpretation

Line 6
Sta 120+00 to 175+00

AMEC Job No. 17-2013-4059

Interpretation of Refraction Seismic Data



HYDRAULIC DATA
CHANNEL BOTTOM: 12' - 16'
FLOW VELOCITY = 5 FT/SEC
" DEPTH = 5 FT
STORM POWER - [illegible] SAY OK

GEOTECH DATA
S = 1300 f/s
P = 2500 - 3600 f/s
SP = 0 - 0.0 kg/m²

APPENDIX A-4

Max Permissible Velocity Table from FCDMC Hydraulic Manual

TABLE 6.2
MAXIMUM PERMISSIBLE VELOCITIES FOR ROADSIDE DRAINAGE CHANNELS
WITH ERODIBLE LININGS
(USDOT, FHWA, 1961 AND 1988)

Soils Type of Lining (Earth, No Vegetation)	Permissible Velocity (1)(2) (ft/sec)
Fine Sand (noncolloidal)	2.5
Sandy Loam (noncolloidal)	2.5
Silt Loam (noncolloidal)	3.0
Ordinary Firm Loam	3.5
Fine Gravel	5.0
Stiff Clay (very colloidal)	5.0
Graded, Loam to Cobbles (noncolloidal)	5.0
Graded, Silt to Cobbles (noncolloidal)	5.5
Alluvial Silts (noncolloidal)	3.5
Alluvial Silts (colloidal)	5.0
Coarse Gravel (noncolloidal)	6.0
Cobbles and Shingles	5.5
Shales and Hard Pans	6.0

(1) For sinuous channels multiply permissible velocity by:

0.95 for slightly sinuous;

0.90 for moderately sinuous; and

0.80 for highly sinuous

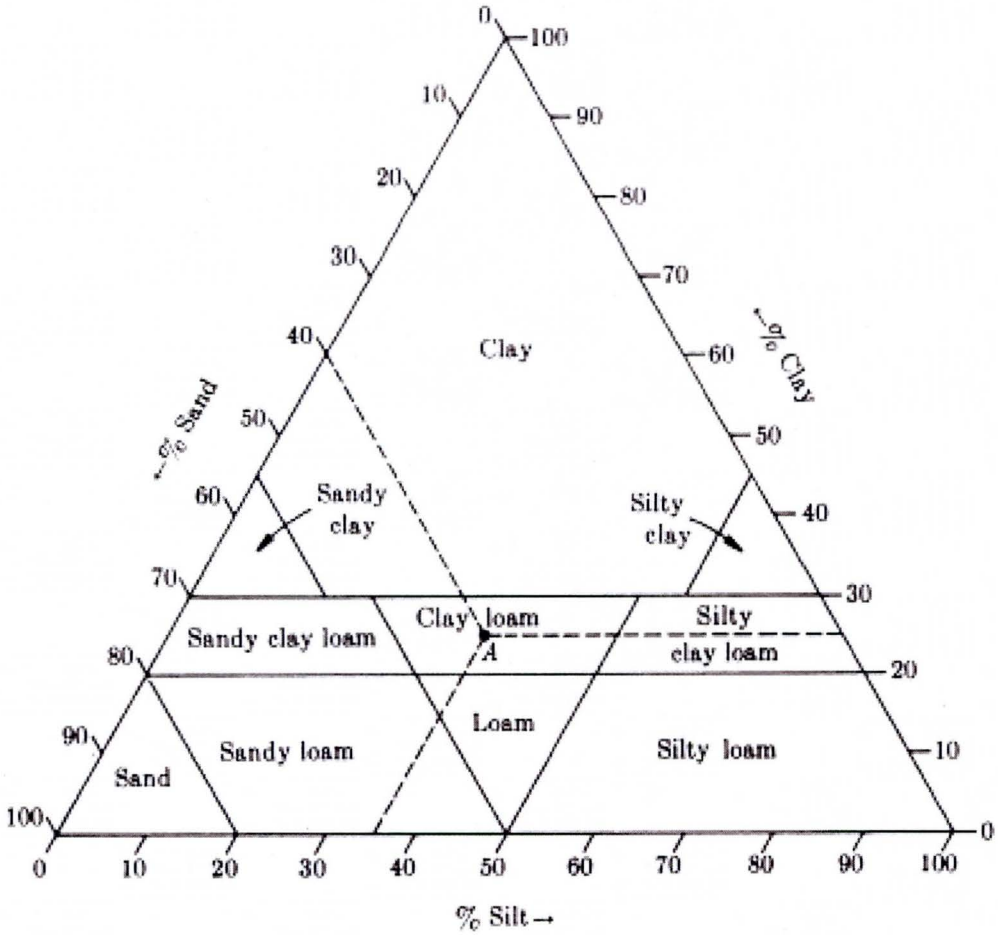
(2) Higher velocities may be allowed for design of unlined channels, for the 100-year design event in particular, based on sediment balance considerations defined using the guidelines in Chapter 11. However, sufficient setback allowance should be provided for expected bank erosion during the 100-year event, or a series of annualized events over a 60-year period. Higher velocities may also be acceptable for 100-year peak flow design with approved engineering justification based on a tractive force analysis (USDOT, FHWA HEC-11, 1989).

APPENDIX A-5

Soil Chart from FCDMC Hydrology Manual

SOIL TEXTURE CLASSIFICATION

TRIANGLE



Definitions: Clay - mineral soil particles less than 0.002 mm in diameter.
Silt - mineral soil particles that range in diameter from 0.002 mm to 0.05 mm.
Sand - mineral soil particles that range in diameter from 0.05 mm to 2.0 mm.

Example: Point A is a soil composed of 40% sand, 35% silt, and 25% clay. It is classified as a clay loam.

APPENDIX B

Section 4.2: Subcritical Flow Transition from HEC-14: Hydraulic Design of Energy Dissipators for Culverts and Channels by Federal Highway Administration (2006)

Alternative 2. Assume W_2 is based on θ where $\tan\theta = 1/3$ Fr.

$W_2 = W_o + 2L \tan 12.41° = 5 + 20(0.22) = 9.4$ ft

$A_2 = 9.4\ y_2$ and $V_2 = 270/(9.4y_2) = 28.7/y_2$

$7.32 = y_2 + 12.8/y_2^2$

$y_2 = 1.48$ ft, which is 68% higher than the original solution

$V_2 = 28.7/1.48 = 19.4$ ft/s, which is 2% higher than the original solution.

4.2 SUBCRITICAL FLOW TRANSITION

Subcritical flow can be transitioned into and out of highway structures without causing adverse effect if subcritical flow is maintained throughout the structure. The flow cannot approach or pass through critical depth, y_c. The range of depths to avoid is $0.9y_c$ to $1.1y_c$. In this range, slight changes in specific energy are reflected in large changes in depth, i.e., wave problems develop. The straight line or wedge transition should be used if conservation of flow energy is required, for example, for an irrigation canal structure that traverses a highway. Warped and cylindrical transitions are more efficient, but the additional construction cost can only be justified for structures where backwater is critical.

Figure 4.5 illustrates the design problem. Starting upstream of section 1 where some backwater exists due to the culvert, the flow is transitioned from a canal into and then out of the highway culvert. The flare angle, θ_w, should be 12.5°, (1:4.5 (lateral:longitudinal) or smaller) according to Hinds (1928). This criterion provides a gradually varied transition that can be analyzed using the energy equation.

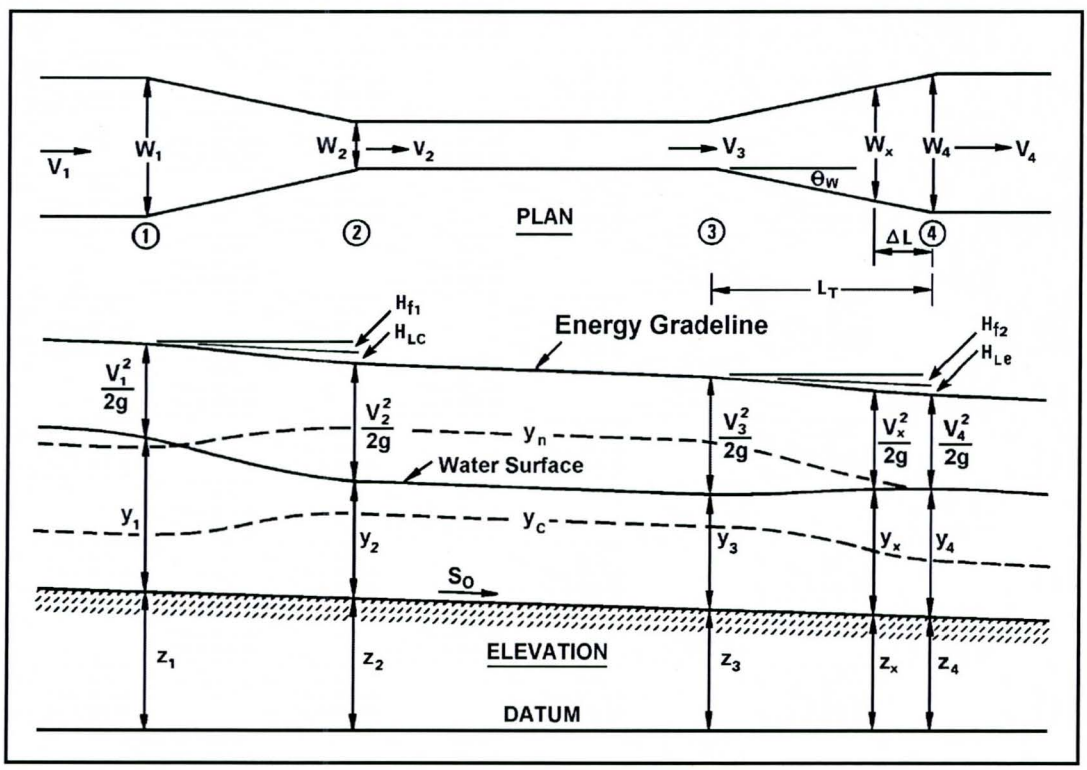
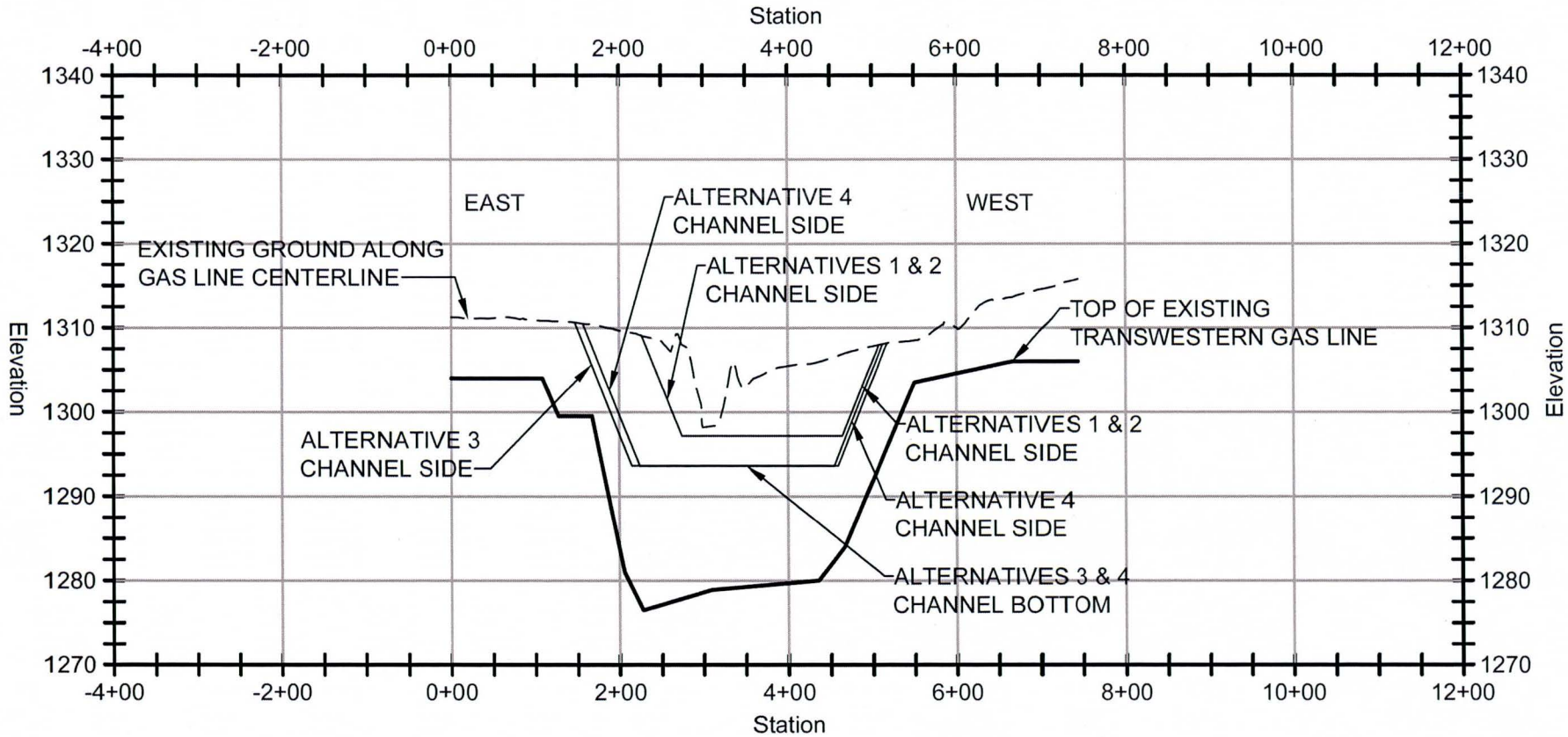


Figure 4.5. Subcritical Flow Transition

APPENDIX C

Gas Line across Outlet Channel

McMicken Dam Outlet Channel
Profile View of Transwestern Gas Line
Across the Proposed Excavated Channel for All Outlet Channel Alternatives



NOTES:

1. Top of existing gas line elevations are from Drawing Number PX-46-B of the "Transwestern Pipeline Company 36" Phoenix Lateral (AZBM121A1) F.C.D.M.C. C/L Wash Area 1" Plan Set (March 13, 2013).

2. 6 inch thick reinforced concrete slab, 20 ft on both sides of Transwestern Gas Line, provide 6 ft deep concrete cutoff wall at each end.

APPENDIX D

Cost Estimates of all Alternatives

APPENDIX D-1

Alternatives 1 – 4 Construction Cost Estimates

Table 2
Cost Estimates Summary for the Alternatives

Item Description	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Upstream Channel and Levee Improvements	$ 1,221,433	$ 1,261,017	$ 1,112,233	$ 1,092,549
Excavation - Channel (non-cemented soils)	$ 259,358	$ 260,317	$ 2,123,550	$ 3,229,707
Excavation - Channel (cemented soils)	$ 1,937,930	$ 1,943,889	$ 12,021,589	$ 4,553,762
Excavation - Levee Foundation (non-cemented soils)	$ 45,581	$ 16,790	$ 5,449	$ -
Excavation - Existing Levee	$ 247,407	$ 85,973	$ 249,341	$ 251,355
Remove and Stockpile Topsoil	$ 165,811	$ 108,493	$ 390,652	$ 445,570
Topsoil Plating and Grading	$ 26,181	$ 17,130	$ 61,682	$ 70,353
Levee Fill	$ 1,211,316	$ 336,924	$ 12,490	$ -
Levee Fill (Foundation)	$ 116,791	$ 35,216	$ 11,400	$ -
Filter	$ 1,007,590	$ 890,667	$ 61,071	$ -
Excess Borrow Material Placement	$ 217,464	$ 238,734	$ 1,833,325	$ 1,581,727
Rock Mulch	$ 155,478	$ 243,804	$ -	$ -
Hydroseed	$ 216,370	$ 141,574	$ 509,768	$ 581,431
O&M Road (North Channel Bank)	$ 18,176	$ 18,177	$ 19,596	$ 19,193
O&M Road AB (Levee Crest, Downstream Toe)	$ 189,837	$ 189,564	$ 90,534	$ 89,882
Levee Riprap Lining (d50 = 7")	$ 2,369,930	$ 2,211,304	$ 92,569	$ -
Geotextile for Riprap	$ 129,928	$ 98,578	$ 2,970	$ -
Side Channel Drop Structures (Riprap, d50 = 8", D=16")	$ 364,579	$ 364,577	$ 386,716	$ 313,063
Side Channel Drop Structures (Grouted Riprap, d50 = 8", D=16")	$ 662,136	$ 662,136	$ 1,229,360	$ 1,078,154
Longitudinal Channel Drop Structures (Riprap, d50 = 12", D=24")	$ 153,650	$ 153,650	$ -	$ -
Longitudinal Channel Drop Structures (Grouted Riprap, d50 = 12", D=24")	$ 81,000	$ 81,000	$ -	$ -
Outlet Wash Drop Structures (Riprap, d50 = 12", D=24")	$ 11,233	$ 11,233	$ 36,557	$ 38,729
Outlet Wash Drop Structures (Grouted Riprap, d50 = 12", D=24")	$ 6,067	$ 6,067	$ 20,156	$ 20,862
Channel Bottom Riprap at Outlet Wash (Riprap, d50 = 12", D=24")	$ 14,296	$ 14,296	$ 13,499	$ 14,948
Utility Footing Erosion Protection (Grouted Riprap, d50=12", D=24")	$ -	$ -	$ 1,432,396	$ -
Backfill Existing Outlet Channel (Common Fill)	$ 52,528	$ 59,326	$ -	$ -
Concrete Slab Protection for Existing Gas Line (Reinforced Concrete, D=6")	$ 53,880	$ 53,880	$ 70,889	$ 67,676
Mitigation for Waters of the US	$ 259,348	$ 259,279	$ 279,865	$ 279,409
Tall Pot Planting	$ 25,000	$ 25,000	$ 25,000	$ 25,000
Biological Assessment	$ 5,000	$ 5,000	$ 5,000	$ 5,000
Desert Tortoise and Burrowing Owl Surveys and Relocation	$ 8,000	$ 8,000	$ 8,000	$ 8,000
Cultural Resources Report	$ 14,000	$ 14,000	$ 14,000	$ 14,000
Cultural Resources Mitigation Measures	$ 116,684	$ 116,684	$ 116,684	$ 116,684
Subtotal	**$ 11,363,980**	**$ 9,932,277**	**$ 22,236,342**	**$ 13,897,054**
Mobilization	$ 340,919	$ 297,968	$ 667,090	$ 416,912
Supplemental General Conditions	$ 113,640	$ 99,323	$ -	$ -
Construction Contingency	$ 2,840,995	$ 2,483,069	$ 4,447,268	$ 2,084,558
Total	**$ 14,659,535**	**$ 12,812,638**	**$ 27,350,701**	**$ 16,398,524**

McMicken Dam Rehabilitation Project
Flood Control District of Maricopa County

Outlet Channel Alternatives
Comparative Construction Cost Estimate
Alternative 1 - Construct New Levee with Central Filter North of Existing Levee

DESCRIPTION	UNIT	PROJECT QUANTITY	UNIT COST NUMBERS	EXTENDED AMOUNT
Outlet Channel				
Upstream Channel and Levee Improvements	EA	1	$ 1,221,432.52	$ 1,221,432.52
Excavation - Channel (non-cemented soils)	CY	172,905	$ 1.50	$ 259,358.22
Excavation - Channel (cemented soils)	CY	322,988	$ 6.00	$ 1,937,929.56
Excavation - Levee Foundation (non-cemented soils)	CY	30,388	$ 1.50	$ 45,581.31
Excavation - Existing Levee	CY	247,407	$ 1.00	$ 247,407.00
Remove and Stockpile Topsoil	CY	87,269	$ 1.90	$ 165,811.21
Topsoil Plating and Grading	CY	87,269	$ 0.30	$ 26,180.72
Levee Fill	CY	285,015	$ 4.25	$ 1,211,315.80
Levee Fill (Foundation)	CY	27,480	$ 4.25	$ 116,790.56
Filter	CY	31,487	$ 32.00	$ 1,007,589.92
Excess Borrow Material Placement	CY	434,929	$ 0.50	$ 217,464.33
Rock Mulch	SY	38,869	$ 4.00	$ 155,477.78
Hydroseed	AC	108	$ 2,000.00	$ 216,369.56
O&M Road (North Channel Bank)	SY	36,352	$ 0.50	$ 18,176.00
O&M Road AB (Levee Crest, Downstream Toe)	SY	79,099	$ 2.40	$ 189,836.80
Levee Riprap Lining (d_{50} = 7")	CY	59,248	$ 40.00	$ 2,369,930.37
Geotextile for Riprap	SY	51,971	$ 2.50	$ 129,928.06
Side Channel Drop Structures (Riprap, d_{50} = 8", D=16")	CY	9,114	$ 40.00	$ 364,578.77
Side Channel Drop Structures (Grouted Riprap, d_{50} = 8", D=16")	CY	11,036	$ 60.00	$ 662,136.30
Longitudinal Channel Drop Structures (Riprap, d_{50} = 12", D=24")	CY	3,841	$ 40.00	$ 153,650.37
Longitudinal Channel Drop Structures (Grouted Riprap, d_{50} = 12", D=24")	CY	1,350	$ 60.00	$ 81,000.00
Outlet Wash Drop Structures (Riprap, d_{50} = 12", D=24")	CY	281	$ 40.00	$ 11,232.59
Outlet Wash Drop Structures (Grouted Riprap, d_{50} = 12", D=24")	CY	101	$ 60.00	$ 6,066.67
Channel Bottom Riprap at Outlet Wash (Riprap, d_{50} = 12", D=24")	CY	357	$ 40.00	$ 14,296.30
Utility Footing Erosion Protection (Grouted Riprap, d_{50}=12", D=24")	CY	0	$ 60.00	$ -
Backfill Existing Outlet Channel (Common Fill)	CY	26,264	$ 2.00	$ 52,528.00
Concrete Slab Protection for Existing Gas Line (Reinforced Concrete, D=6")	CY	216	$ 250.00	$ 53,879.63
Mitigation for Waters of the US	AC	17	$ 15,000.00	$ 259,348.14
Tall Pot Planting	AC	5	$ 5,000.00	$ 25,000.00
Biological Assessment	EA	1	$ 5,000.00	$ 5,000.00
Desert Tortoise and Burrowing Owl Surveys and Relocation	EA	1	$ 8,000.00	$ 8,000.00
Cultural Resources Report	EA	1	$ 14,000.00	$ 14,000.00
Cultural Resources Mitigation Measures	EA	1	$ 116,684.00	$ 116,684.00
			SUBTOTAL	$ 11,363,980.45
Mobilization	%		3%	$ 340,919.41
Supplemental General Conditions	%		1%	$ 113,639.80
Construction Contingency	%		25%	$ 2,840,995.11
			OUTLET CHANNEL TOTAL	**$14,659,534.78**

McMicken Dam Rehabilitation Project
Flood Control District of Maricopa County

Outlet Channel Alternatives
Comparative Construction Cost Estimate
Alternative 2 - Modify Existing Levee with Upstream Filter

DESCRIPTION	UNIT	PROJECT QUANTITY	UNIT COST NUMBERS	EXTENDED AMOUNT
Outlet Channel				
Upstream Channel and Levee Improvements	EA	1	$ 1,261,016.96	$ 1,261,016.96
Excavation - Channel (non-cemented soils)	CY	173,545	$ 1.50	$ 260,316.80
Excavation - Channel (cemented soils)	CY	323,981	$ 6.00	$ 1,943,888.94
Excavation - Levee Foundation (non-cemented soils)	CY	11,194	$ 1.50	$ 16,790.28
Excavation - Existing Levee	CY	85,973	$ 1.00	$ 85,973.35
Remove and Stockpile Topsoil	CY	57,102	$ 1.90	$ 108,492.85
Topsoil Plating and Grading	CY	57,102	$ 0.30	$ 17,130.45
Levee Fill	CY	79,276	$ 4.25	$ 336,923.55
Levee Fill (Foundation)	CY	8,286	$ 4.25	$ 35,215.97
Filter	CY	27,833	$ 32.00	$ 890,666.67
Excess Borrow Material Placement	CY	477,468	$ 0.50	$ 238,733.82
Rock Mulch	SY	60,951	$ 4.00	$ 243,804.00
Hydroseed	AC	71	$ 2,000.00	$ 141,573.97
O&M Road (North Channel Bank)	SY	36,354	$ 0.50	$ 18,176.89
O&M Road AB (Levee Crest, Downstream Toe)	SY	78,985	$ 2.40	$ 189,563.73
Levee Riprap Lining (d_{50} = 7")	CY	55,283	$ 40.00	$ 2,211,303.89
Geotextile for Riprap	SY	39,431	$ 2.50	$ 98,577.50
Side Channel Drop Structures (Riprap, d_{50} = 8", D=16")	CY	9,114	$ 40.00	$ 364,576.79
Side Channel Drop Structures (Grouted Riprap, d_{50} = 8", D=16")	CY	11,036	$ 60.00	$ 662,136.30
Longitudinal Channel Drop Structures (Riprap, d_{50} = 12", D=24")	CY	3,841	$ 40.00	$ 153,650.37
Longitudinal Channel Drop Structures (Grouted Riprap, d_{50} = 12", D=24")	CY	1,350	$ 60.00	$ 81,000.00
Outlet Wash Drop Structures (Riprap, d_{50} = 12", D=24")	CY	281	$ 40.00	$ 11,232.59
Outlet Wash Drop Structures (Grouted Riprap, d_{50} = 12", D=24")	CY	101	$ 60.00	$ 6,066.67
Channel Bottom Riprap at Outlet Wash (Riprap, d_{50} = 12", D=24")	CY	357	$ 40.00	$ 14,296.30
Utility Footing Erosion Protection (Grouted Riprap, d_{50}=12", D=24")	CY	0	$ 60.00	$ -
Backfill Existing Outlet Channel (Common Fill)	CY	29,663	$ 2.00	$ 59,326.00
Concrete Slab Protection for Existing Gas Line (Reinforced Concrete, D=6")	CY	216	$ 250.00	$ 53,879.63
Mitigation for Waters of the US	AC	17	$ 15,000.00	$ 259,278.93
Tall Pot Planting	AC	5	$ 5,000.00	$ 25,000.00
Biological Assessment	EA	1	$ 5,000.00	$ 5,000.00
Desert Tortoise and Burrowing Owl Surveys and Relocation	EA	1	$ 8,000.00	$ 8,000.00
Cultural Resources Report	EA	1	$ 14,000.00	$ 14,000.00
Cultural Resources Mitigation Measures	EA	1	$ 116,684.00	$ 116,684.00
			SUBTOTAL	$ 9,932,277.17
Mobilization	%		3%	$ 297,968.32
Supplemental General Conditions	%		1%	$ 99,322.77
Construction Contingency	%		25%	$ 2,483,069.29
			OUTLET CHANNEL TOTAL	**$12,812,637.55**

McMicken Dam Rehabilitation Project
Flood Control District of Maricopa County

Outlet Channel Alternatives
Comparative Construction Cost Estimate
Alternative 3 - Reconstruct Excavated Outlet along Existing Alignment

DESCRIPTION	UNIT	PROJECT QUANTITY	UNIT COST NUMBERS	EXTENDED AMOUNT
Outlet Channel				
Upstream Channel and Levee Improvements	EA	1	$ 1,112,233.41	$ 1,112,233.41
Excavation - Channel (non-cemented soils)	CY	1,415,700	$ 1.50	$ 2,123,550.50
Excavation - Channel (cemented soils)	CY	2,003,598	$ 6.00	$ 12,021,588.54
Excavation - Levee Foundation (non-cemented soils)	CY	3,632	$ 1.50	$ 5,448.70
Excavation - Existing Levee	CY	249,341	$ 1.00	$ 249,341.22
Remove and Stockpile Topsoil	CY	205,607	$ 1.90	$ 390,652.39
Topsoil Plating and Grading	CY	205,607	$ 0.30	$ 61,681.96
Levee Fill	CY	2,939	$ 4.25	$ 12,490.28
Levee Fill (Foundation)	CY	2,682	$ 4.25	$ 11,399.88
Filter	CY	1,908	$ 32.00	$ 61,071.23
Excess Borrow Material Placement	CY	3,666,651	$ 0.50	$ 1,833,325.45
Rock Mulch	SY	0	$ 4.00	$ -
Hydroseed	AC	255	$ 2,000.00	$ 509,768.23
O&M Road (North Channel Bank)	SY	39,193	$ 0.50	$ 19,596.44
O&M Road AB (Upstream Toe, Levee Crest)	SY	37,723	$ 2.40	$ 90,534.40
Levee Riprap Lining (d_{50} = 7")	CY	2,314	$ 40.00	$ 92,568.52
Geotextile for Riprap	SY	1,188	$ 2.50	$ 2,970.28
Side Channel Drop Structures (Riprap, d_{50} = 8", D=16")	CY	9,668	$ 40.00	$ 386,716.05
Side Channel Drop Structures (Grouted Riprap, d_{50} = 8", D=16")	CY	20,489	$ 60.00	$ 1,229,360.00
Longitudinal Channel Drop Structures (Riprap, d_{50} = 12", D=24")	CY	0	$ 40.00	$ -
Longitudinal Channel Drop Structures (Grouted Riprap, d_{50} = 12", D=24")	CY	0	$ 60.00	$ -
Outlet Wash Drop Structures (Riprap, d_{50} = 12", D=24")	CY	914	$ 40.00	$ 36,557.04
Outlet Wash Drop Structures (Grouted Riprap, d_{50} = 12", D=24")	CY	336	$ 60.00	$ 20,155.56
Channel Bottom Riprap at Outlet Wash (Riprap, d_{50} = 12", D=24")	CY	337	$ 40.00	$ 13,499.26
Utility Footing Erosion Protection (Grouted Riprap, d_{50}=12", D=24")	CY	23,873	$ 60.00	$ 1,432,395.56
Backfill Existing Outlet Channel (Common Fill)	CY	0	$ 2.00	$ -
Concrete Slab Protection for Existing Gas Line (Reinforced Concrete, D=6")	CY	284	$ 250.00	$ 70,888.89
Mitigation for Waters of the US	AC	19	$ 15,000.00	$ 279,864.67
Tall Pot Planting	AC	5	$ 5,000.00	$ 25,000.00
Biological Assessment	EA	1	$ 5,000.00	$ 5,000.00
Desert Tortoise and Burrowing Owl Surveys and Relocation	EA	1	$ 8,000.00	$ 8,000.00
Cultural Resources Report	EA	1	$ 14,000.00	$ 14,000.00
Cultural Resources Mitigation Measures	EA	1	$ 116,684.00	$ 116,684.00
			SUBTOTAL	$ 22,236,342.43
Mobilization	%		3%	$ 667,090.27
Supplemental General Conditions	%		0%	$ -
Construction Contingency	%		20%	$ 4,447,268.49
			OUTLET CHANNEL TOTAL	**$27,350,701.19**

McMicken Dam Rehabilitation Project
Flood Control District of Maricopa County

Outlet Channel Alternatives
Comparative Construction Cost Estimate
Alternative 4 - Realign Outlet Channel North

DESCRIPTION	UNIT	PROJECT QUANTITY	UNIT COST NUMBERS	EXTENDED AMOUNT
Outlet Channel				
Upstream Channel and Levee Improvements	EA	1	$ 1,092,549.04	$ 1,092,549.04
Excavation - Channel (non-cemented soils)	CY	2,153,138	$ 1.50	$ 3,229,706.87
Excavation - Channel (cemented soils)	CY	758,960	$ 6.00	$ 4,553,762.34
Excavation - Levee Foundation (non-cemented soils)	CY	0	$ 1.50	$ -
Excavation - Existing Levee	CY	251,355	$ 1.00	$ 251,355.00
Remove and Stockpile Topsoil	CY	234,511	$ 1.90	$ 445,569.99
Topsoil Plating and Grading	CY	234,511	$ 0.30	$ 70,353.16
Levee Fill	CY	0	$ 4.25	$ -
Levee Fill (Foundation)	CY	0	$ 4.25	$ -
Filter	CY	0	$ 32.00	$ -
Excess Borrow Material Placement	CY	3,163,453	$ 0.50	$ 1,581,726.65
Rock Mulch	SY	0	$ 4.00	$ -
Hydroseed	AC	291	$ 2,000.00	$ 581,431.04
O&M Road (North Channel Bank)	SY	38,386	$ 0.50	$ 19,192.89
O&M Road AB (Upstream Toe, Levee Crest)	SY	37,451	$ 2.40	$ 89,881.60
Levee Riprap Lining (d_{50} = 7")	CY	0	$ 40.00	$ -
Geotextile for Riprap	SY	0	$ 2.50	$ -
Side Channel Drop Structures (Riprap, d_{50} = 8", D=16")	CY	7,827	$ 40.00	$ 313,062.72
Side Channel Drop Structures (Grouted Riprap, d_{50} = 8", D=16")	CY	17,969	$ 60.00	$ 1,078,154.07
Longitudinal Channel Drop Structures (Riprap, d_{50} = 12", D=24")	CY	0	$ 40.00	$ -
Longitudinal Channel Drop Structures (Grouted Riprap, d_{50} = 12", D=24")	CY	0	$ 60.00	$ -
Outlet Wash Drop Structures (Riprap, d_{50} = 12", D=24")	CY	968	$ 40.00	$ 38,728.89
Outlet Wash Drop Structures (Grouted Riprap, d_{50} = 12", D=24")	CY	348	$ 60.00	$ 20,862.22
Channel Bottom Riprap at Outlet Wash (Riprap, d_{50} = 12", D=24")	CY	374	$ 40.00	$ 14,948.15
Utility Footing Erosion Protection (Grouted Riprap, d_{50}=12", D=24")	CY	0	$ 60.00	$ -
Backfill Existing Outlet Channel (Common Fill)	CY	0	$ 2.00	$ -
Concrete Slab Protection for Existing Gas Line (Reinforced Concrete, D=6")	CY	271	$ 250.00	$ 67,675.93
Mitigation for Waters of the US	AC	19	$ 15,000.00	$ 279,409.44
Tall Pot Planting	AC	5	$ 5,000.00	$ 25,000.00
Biological Assessment	EA	1	$ 5,000.00	$ 5,000.00
Desert Tortoise and Burrowing Owl Surveys and Relocation	EA	1	$ 8,000.00	$ 8,000.00
Cultural Resources Report	EA	1	$ 14,000.00	$ 14,000.00
Cultural Resources Mitigation Measures	EA	1	$ 116,684.00	$ 116,684.00
			SUBTOTAL	$ 13,897,053.97
Mobilization	%		3%	$ 416,911.62
Supplemental General Conditions	%		0%	$ -
Construction Contingency	%		15%	$ 2,084,558.10
			OUTLET CHANNEL TOTAL	**$16,398,523.69**

McMicken Dam Rehabilitation Project
Flood Control District of Maricopa County

Outlet Channel Alternatives
Comparative Construction Cost Estimate

Alternative 1 - Construct New Levee with Central Filter North of Existing Levee - Upstream Improvements Only (66+50 to 121+50)

DESCRIPTION	UNIT	PROJECT QUANTITY	UNIT COST NUMBERS	EXTENDED AMOUNT
Outlet Channel				
Excavation - Channel (non-cemented soils)	CY	57	$ 1.50	$ 86.04
Excavation - Channel (cemented soils)	CY	0	$ 6.00	$ -
Excavation - Levee Foundation (non-cemented soils)	CY	34,646	$ 1.50	$ 51,969.53
Excavation - Existing Levee	CY	6,613	$ 1.00	$ 6,612.85
Remove and Stockpile Topsoil	CY	1,747	$ 1.90	$ 3,319.16
Topsoil Plating and Grading	CY	1,747	$ 0.30	$ 524.08
Levee Fill	CY	784	$ 4.25	$ 3,332.79
Levee Fill (Foundation)	CY	25,641	$ 4.25	$ 108,972.80
Filter	CY	11,575	$ 32.00	$ 370,404.56
Rock Mulch	SY	77	$ 4.00	$ 306.22
Hydroseed	AC	2	$ 2,000.00	$ 4,331.22
O&M Road (North Channel Bank)	SY	9,575	$ 0.50	$ 4,787.56
O&M Road AB (Levee Crest, Downstream Toe)	SY	21,637	$ 2.40	$ 51,929.60
Levee Riprap Lining (d_{50} = 7")	CY	11,997	$ 40.00	$ 479,881.11
Geotextile for Riprap	SY	4,963	$ 2.50	$ 12,407.50
Side Channel Drop Structures (Riprap, d_{50} = 8", D=16")	CY	489	$ 40.00	$ 19,569.38
Side Channel Drop Structures (Grouted Riprap, d_{50} = 8", D=16")	CY	573	$ 60.00	$ 34,355.56
Mitigation for Waters of the US	AC	5	$ 15,000.00	$ 68,642.56
			SUBTOTAL	$ 1,221,432.52

McMicken Dam Rehabilitation Project
Flood Control District of Maricopa County

Outlet Channel Alternatives
Comparative Construction Cost Estimate

Alternative 2 - Modify Existing Levee with Upstream Filter - Upstream Improvements Only (66+50 to 121+50)

DESCRIPTION	UNIT	PROJECT QUANTITY	UNIT COST NUMBERS	EXTENDED AMOUNT
Outlet Channel				
Excavation - Channel (non-cemented soils)	CY	11	$ 1.50	$ 15.81
Excavation - Channel (cemented soils)	CY	0	$ 6.00	$ -
Excavation - Levee Foundation (non-cemented soils)	CY	34,646	$ 1.50	$ 51,969.53
Excavation - Existing Levee	CY	6,613	$ 1.00	$ 6,612.85
Remove and Stockpile Topsoil	CY	1,500	$ 1.90	$ 2,850.32
Topsoil Plating and Grading	CY	1,500	$ 0.30	$ 450.05
Levee Fill	CY	10,599	$ 4.25	$ 45,045.57
Levee Fill (Foundation)	CY	25,641	$ 4.25	$ 108,972.80
Filter	CY	11,575	$ 32.00	$ 370,404.56
Rock Mulch	SY	0	$ 4.00	$ -
Hydroseed	AC	2	$ 2,000.00	$ 3,719.42
O&M Road (North Channel Bank)	SY	9,575	$ 0.50	$ 4,787.56
O&M Road AB (Levee Crest, Downstream Toe)	SY	21,637	$ 2.40	$ 51,929.60
Levee Riprap Lining (d_{50} = 7")	CY	11,981	$ 40.00	$ 479,247.22
Geotextile for Riprap	SY	4,978	$ 2.50	$ 12,444.17
Side Channel Drop Structures (Riprap, d_{50} = 8", D=16")	CY	489	$ 40.00	$ 19,569.38
Side Channel Drop Structures (Grouted Riprap, d_{50} = 8", D=16")	CY	573	$ 60.00	$ 34,355.56
Mitigation for Waters of the US	AC	5	$ 15,000.00	$ 68,642.56
			SUBTOTAL	$ 1,261,016.96

McMicken Dam Rehabilitation Project
Flood Control District of Maricopa County

Outlet Channel Alternatives
Comparative Construction Cost Estimate

Alternative 3 - Reconstruct Excavated Outlet along Existing Alignment - Upstream Improvements Only (66+50 to 110+00)

DESCRIPTION	UNIT	PROJECT QUANTITY	UNIT COST NUMBERS	EXTENDED AMOUNT
Outlet Channel				
Excavation - Channel (non-cemented soils)	CY	2,698	$ 1.50	$ 4,046.94
Excavation - Channel (cemented soils)	CY	13,475	$ 6.00	$ 80,848.68
Excavation - Levee Foundation (non-cemented soils)	CY	31,014	$ 1.50	$ 46,520.83
Excavation - Existing Levee	CY	4,441	$ 1.00	$ 4,440.63
Remove and Stockpile Topsoil	CY	6,748	$ 1.90	$ 12,820.43
Topsoil Plating and Grading	CY	6,748	$ 0.30	$ 2,024.28
Levee Fill	CY	6,132	$ 4.25	$ 26,062.24
Levee Fill (Foundation)	CY	22,958	$ 4.25	$ 97,572.92
Filter	CY	9,667	$ 32.00	$ 309,333.33
Rock Mulch	SY	0	$ 4.00	$ -
Hydroseed	AC	8	$ 2,000.00	$ 16,729.57
O&M Road (North Channel Bank)	SY	7,516	$ 0.50	$ 3,758.22
O&M Road AB (Upstream Toe, Levee Crest)	SY	17,030	$ 2.40	$ 40,872.53
Levee Riprap Lining (d_{50} = 7")	CY	9,188	$ 40.00	$ 367,523.33
Geotextile for Riprap	SY	3,468	$ 2.50	$ 8,670.00
Side Channel Drop Structures (Riprap, d_{50} = 8", D=16")	CY	303	$ 40.00	$ 12,124.44
Side Channel Drop Structures (Grouted Riprap, d_{50} = 8", D=16")	CY	395	$ 60.00	$ 23,706.67
Mitigation for Waters of the US	AC	4	$ 15,000.00	$ 55,178.37
			SUBTOTAL	$ 1,112,233.41

McMicken Dam Rehabilitation Project
Flood Control District of Maricopa County

Outlet Channel Alternatives
Comparative Construction Cost Estimate
Alternative 4 - Realign Outlet Channel North - Upstream Improvements Only (66+50 to 111+50)

DESCRIPTION	UNIT	PROJECT QUANTITY	UNIT COST NUMBERS	EXTENDED AMOUNT
Outlet Channel				
Excavation - Channel (non-cemented soils)	CY	17,471	$ 1.50	$ 26,207.18
Excavation - Channel (cemented soils)	CY	1	$ 6.00	$ 3.00
Excavation - Levee Foundation (non-cemented soils)	CY	31,488	$ 1.50	$ 47,231.53
Excavation - Existing Levee	CY	4,724	$ 1.00	$ 4,723.96
Remove and Stockpile Topsoil	CY	7,180	$ 1.90	$ 13,641.61
Topsoil Plating and Grading	CY	7,180	$ 0.30	$ 2,153.94
Levee Fill	CY	6,516	$ 4.25	$ 27,691.41
Levee Fill (Foundation)	CY	23,308	$ 4.25	$ 99,059.86
Filter	CY	9,916	$ 32.00	$ 317,299.15
Rock Mulch	SY	0	$ 4.00	$ -
Hydroseed	AC	9	$ 2,000.00	$ 17,801.15
O&M Road (North Channel Bank)	SY	7,828	$ 0.50	$ 3,913.78
O&M Road AB (Upstream Toe, Levee Crest)	SY	17,787	$ 2.40	$ 42,688.00
Levee Riprap Lining (d_{50} = 7")	CY	9,688	$ 40.00	$ 387,516.11
Geotextile for Riprap	SY	3,697	$ 2.50	$ 9,242.50
Side Channel Drop Structures (Riprap, d_{50} = 8", D=16")	CY	303	$ 40.00	$ 12,124.44
Side Channel Drop Structures (Grouted Riprap, d_{50} = 8", D=16")	CY	395	$ 60.00	$ 23,706.67
Mitigation for Waters of the US	AC	4	$ 15,000.00	$ 57,544.77
			SUBTOTAL	$ 1,092,549.04

APPENDIX D-2

Cost Estimates for Potential Land for Sale

Table 3
Outlet Channel Alternatives
Cost Estimates for Potential Land for Sale

Alternative	Excess Land (acres)	Potential Saleable Land Value (at $20,000 per acre)	Potential Saleable Land Value (at $40,000 per acre)
Alternative 1 - Construct New Levee with Central Filter North of Existing Levee	91	$1,814,000	$3,628,000
Alternative 2 - Modify Existing Levee with Upstream Filter	86	$1,718,000	$3,436,000
Alternative 3 - Reconstruct Excavated Outlet along Existing Alignment	443	$8,862,000	$17,724,000
Alternative 4 - Realign Outlet Channel North	369	$7,384,000	$14,768,000

Notes:

1) A range of values for potential saleable excess land are used as directed by FCDMC with a lower estimate of $20,000/acre and an upper estimate of $40,000/acre.

2) Excess land for Alternatives 1 and 2 consists of land above the levee crest elevation.

3) Excess land for Alternatives 3 and 4 consists of land north of the channel corridor.

APPENDIX D-3

Net Cost Summary

Table 4
Outlet Channel Alternatives
Net Cost Summary

Alternative	Estimated Construction Cost	Potential Saleable Land Value		Range of Net Costs (Construction Cost less Land Value)	
		(at $20,000 per acre)	(at $40,000 per acre)	(at $20,000 per acre)	(at $40,000 per acre)
Alternative 1 - Construct New Levee with Central Filter North of Existing Levee	$14,659,535	$1,814,000	$3,628,000	$12,845,535	$11,031,535
Alternative 2 - Modify Existing Levee with Upstream Filter	$12,812,638	$1,718,000	$3,436,000	$11,094,638	$9,376,638
Alternative 3 - Reconstruct Excavated Outlet along Existing Alignment	$27,350,701	$8,862,000	$17,724,000	$18,488,701	$9,626,701
Alternative 4 - Realign Outlet Channel North	$16,398,524	$7,384,000	$14,768,000	$9,014,524	$1,630,524

Notes:
1) A range of values for potential saleable excess land are used as directed by FCDMC with a lower estimate of $20,000/acre and an upper estimate of $40,000/acre.
2) Excess land for Alternatives 1 and 2 consists of land above the levee crest elevation.
3) Excess land for Alternatives 3 and 4 consists of land north of the channel corridor.

APPENDIX E

Correspondence

MEETING MINUTES
Alternatives Evaluation Meeting – January 14, 2014
8:30 am FCDMC Adobe Conference Room
McMicken Dam Rehabilitation Project

Attendees

- District – Mike Greenslade, Bobbie Ohler, Tom Renckly, Ken Rakestraw, Bob Stevens, Dennis Holcomb, Harry Cooper, Don Rerick, Bill Leal, Gary Shapiro, Charles Klenner, Frank Brown, Scott Vogel
- URS –Todd Ringsmuth, Patrick Gorman, Sue Ellen Barnes
- Gannett Fleming, Inc. (GF) – Syed (Nasir) Raza, Frances Ackerman

1. Introductions

Attendance list is attached.

2. Summary of Overall Project and Meeting Goals

- The goals for the McMicken Dam Rehabilitation Project (Project) are to eliminate or mitigate current dam safety deficiencies and failure modes through rehabilitation. Rehabilitation designs will be developed for the Dam, Emergency Spillway, and Principal Outlet. In addition, design modifications will be prepared for the Outlet Channel and Outlet Wash to address safety deficiencies and improve the level of protection.
- The goals of the meeting are to select preferred alternatives for the Emergency Spillway, Principal Outlet, and Outlet Channel. In addition, a preferred alternative will be selected for the alignment of the Dam in the Moderate Fissure Risk Zone.
- The preferred alternatives will be presented and reviewed at the upcoming District Internal Project Review (IPR) meeting. Upon acceptance of the selected alternatives, they will be incorporated into the 30 Percent Design.

3. Outlet Channel Alternatives Evaluation

- The Outlet Channel Alternatives Evaluation consisted of evaluating alternatives for the existing channel between the US 60 bridges and the Outlet Wash.
- Two channel alternatives and two levee alternatives were considered in the evaluation. The channel alternatives include only a small length of levee at the west section near the US 60 bridges.
- Alternatives Design Basis
    - Design discharges are: Principal Outlet flow of 4,450 cfs (USACE design) for the western segment; 100-year peak discharges of 7,045 cfs and 9,090 cfs for the eastern segment (RBF Consulting). The 200-year peak discharges were evaluated for comparison purposes and consist of 8,243 cfs and 10,716 cfs for the eastern segment. The 4,450 cfs discharge in the upstream segment is not likely to increase due to flow constraints at the US 60 bridges.
    - A limiting (maximum) flow velocity of 5 feet per second was used for the preliminary design of the channel and levees. Based on direction provided by the District, riprap would not be required for these flow velocities. Historic flows in the channel have not resulted in significant erosion. Historic erosion is evident at locations where side washes enter the Outlet Channel on the north bank. However, Scott Vogel (District) recommends that Gannett Fleming conduct a simple evaluation to assess the erodibilty of the soil in the channel in order to support the

preliminary design approach. Also, verify that minimum velocity requirements have been met or provide a discussion for a variance. Minimum flow velocities are typically required for removal of sediment. Historical observations suggest that sediment deposition has not been a significant issue in the Outlet Channel. However, upstream development could introduce sediment in the future. Thus sediment deposition, as well as erodibility, should be addressed during final design.

- Freeboard for channels is a minimum of 1.0 ft per District criteria and 3 ft (4 ft at bridges) for levees per FEMA criteria.
- No excavation will be performed closer than 50 feet around the transmission towers per Western Area Power Administration (WAPA) criteria.
- Hydraulic design of levees and channels is based on uniform flow analysis. During final design, backwater analyses will be performed based on the steady state flow modeling using the USACE HEC-RAS software. The backwater analyses will be used to establish the maximum water surface and top elevations for the selected channel or levee alternative.
- The levee and channel alternatives include O&M access ramps into the channel spaced every half-mile.
- The Outlet Channel levee east of US 60 is not under the jurisdiction of ADWR or FEMA at this time. ADWR has informally indicated this reach of the Outlet Channel and Levee will not fall under their jurisdiction.

- Levee Alternatives
  - The two levee alternatives consisted of the following: Alternative 1 – Construction of a new levee with central filter north and adjacent to the existing levee; and Alternative 2 – Construction of an upstream section with filter on the upstream slope of the existing levee. Both the new levee and upstream section would include excavation to remove poor foundation material. Alternative 2 should be modified to include a greater width of fill material upstream of the filter, similar to what is required for the NFRZ Embankment design, to provide sufficient protection against seepage. Also, the filter material should stop 1 ft below levee crest. If Alternative 2 is selected as the preferred alternative, assess during 30 Percent Design if geotextile is needed beneath the filter material to prevent loss of filter material into cracks in the existing levee.
  - There is a significant long term O&M benefit to placing rock mulch on levee slopes. Update the figures and construction costs to include rock mulch on all levee side slopes.
  - Side inflow spillways will be constructed with grouted riprap. District maintenance staff has observed and repaired erosion due to runoff flowing along/below existing spillway structures. The alternatives evaluation should assume that existing side inflow spillways will be replaced for Alternatives 1 and 2. Alternatives 3 and 4 already include removal and construction of new side inflow spillways.

- The levee designs should incorporate sufficient crest width to allow addition of fill in the future to maintain the design crest elevation. With levee side slopes of 2:1 (H:V), the levee design crest widths should consist of the following:

Stations	Estimated future subsidence for 100 ft of groundwater withdrawal (ft)	Design crest width required to maintain minimum crest width of 14 ft after fill placement (ft)
0+00 to 60+00	2.0	22.0
60+00 to 250+00	1.5	20.0
250+00 to Outlet Wash	1.0	18.0

  The figures and cost estimates will be updated to reflect this modification to Alternatives 1 and 2. The estimated future subsidence presented in this table is based on the recommendations presented in the Subsidence and Earth Fissure Risk Zoning Report (AMEC 2013). However, a figure in the same report indicates lower subsidence estimates. URS will coordinate with AMEC to verify the estimated subsidence for final design.

- Differential subsidence along the length of the channel could result in flattening of the channel slope. This slope flattening should be considered in final design to ensure that sufficient freeboard is maintained if subsidence occurs.

- The curvature of the channel at the east end of the channel is based on District criteria. The alignment of the channel is constrained by District property limits and the Transwestern Pipeline crossing.

- Current FEMA floodplains extend north beyond the District property line. The current floodplain is likely based on the as-built levee crest elevation, Beardsley Canal, and other features. Gannett Fleming estimated the limits of flooding associated with the top of levee and 100-year flood and presented the limits on the plan view figures for Alternatives 1 and 2. The limits of flooding associated with the top of levee extend beyond the District property in some locations.

- The levee will be designed to contain the 100-year flood plus a minimum of 3 ft of freeboard (4 ft of freeboard at bridges). The 200-year flood will be contained within the levee freeboard.

- The filter within the levee will consist of a sand material. A geotextile is not included in the design. However, if Alternative 2 is selected, the final design should evaluate if a geotextile beneath the filter is needed to prevent loss of filter material into embankment cracks.

- Construction of future roadways and installation of underground utilities across the levee will be more difficult than for the incised channel. Roadways would require additional over-build at the levee. Future roadways should be evaluated to verify that their construction does not impact the design inundation area.

- The existing levee has a very flat channel, which may need to be steepened to attain minimum flow requirements (to be considered in final design).

- FEMA considers all levees including certified and accredited levees to pose risks to downstream properties and inhabitants. FEMA code of regulations (44CFR 65.10) governs

design of new levees. FEMA guidance on levees continues to change with regards to design and flood insurance for downstream properties. The District has certified and accredited seven levees. The McMicken Outlet Channel levee is not FEMA certified or accredited. If a levee alternative is selected, it will be designed per FEMA criteria and USACE design guidance and criteria. The District will evaluate if there are any internal requirements that obligate the District to own all land within the inundation pool measured from the top of levee. Similarly, the District will evaluate if FEMA or USACE have any land ownership requirements related to flood containment. O&M costs are potentially higher for levees than channels. Design and geotechnical investigation costs are likely higher for the levee than channel. The estimated costs only include construction costs and do not include costs associated with O&M, , project design, or geotechnical investigations.

- Incised Channel Alternatives
  - The two incised channel alternatives consisted of the following: Alternative 3 – Construction of an excavated, widened channel along the existing alignment; and Alternative 4 – Construction of a new channel located north of the existing alignment. The channels will be designed to convey the 100-year peak flow with a minimum freeboard of 1 ft. The 200-year flow will be contained with no freeboard.
  - Side inflow spillways will be constructed with grouted riprap. District maintenance staff has observed and repaired erosion due to runoff flowing along/below existing spillway structures. The alternatives evaluation should assume that existing side inflow spillways will be replaced for Alternatives 1 and 2. Alternatives 3 and 4 already include removal and construction of new side inflow spillways.
  - Differential subsidence along the length of the channel could result in flattening of the channel slope. This slope flattening should be considered in final design to ensure that sufficient freeboard is maintained if subsidence occurs.
  - The channel alternatives incorporate excavation and deepening of the channel bottom. Therefore, a drop structure will be required at the confluence of the Outlet Wash and Outlet Channel.
  - One of the major differences in construction costs between the channel and levee alternatives is the excavation of cemented soils (caliche) quantity. The channel alternatives require significant excavation. The excavation quantity was estimated using geotechnical data from along the existing channel alignment. Additional geotechnical investigations of the foundation conditions are warranted if an incised channel alternative is further considered.
  - The channel excavation presented in Alternatives 3 and 4 extends into the WAPA utility easement. The power line operators will need to maintain access to the towers and lines. This may require design of ramps with 10:1 slopes beneath the power lines and into the channel. Tower and line access will need to meet WAPA and operator requirements. These items should be discussed with WAPA and the operators.

- For Alternative 3, the District suggested replacing the riprap around the tower footings with soil cement. If this alternative is selected, the final design will consider this modification and potential modification of the protected footing design to improve channel hydraulics.
- The channel alternatives provide significantly greater excess land for potential sale. This is a result of containing the 100-year flood within the channel and not having to hold land to the top of a levee. The potential value of the excess land could offset the cost difference between the channel and levee alternatives.
- The District suggested that the excavation depths for Alternative 4 could be reduced by assuming the freeboard can be accounted for by small berms at wash crossings or by building up the O&M access roads. Utilizing the berms or road will allow for raising the channel bottom by at least 1 ft. The details of the alternative and associated costs should be modified to reflect this modification.
- Construction of a channel has the benefit of removing all outside agency involvement with construction and O&M.
- All of the levee and channel alternatives have potential impacts to Waters of the United States (WUS). The levee alternatives include construction within the existing channel; the channel alternatives impact washes form the north; and all alternatives require construction in the Outlet Wash. Therefore, mitigation will be required for each alternative.

- Landscape Architecture and Multi-Use Discussion
  - Dennis Holcomb presented the District's ideas, goals, and comments regarding landscape architecture and multi-use opportunities for the Outlet Channel alternatives
    - The levee alternatives do not significantly change the landscape character of the existing Outlet Channel. The proximity of the transmission towers and the levee serve to diminish the appeal of the levee alternatives based on landscape considerations. Alternative 4 is the best alternative because the channel is moved away from the utility towers and lines.
    - The Maricopa Regional Trail (Trail) is currently located at the northern limits of the District property. The District indicated that the Trail would stay at this location for the levee alternative and be relocated adjacent to the channel for the channel alternatives.
    - The islands around the utility towers in Alternative 3 worsen the view.
    - Alternative 4 provides an opportunity for increasing natural resource. A shallow swale can be provided within the intervening area/strip between the realigned channel and existing levee. This shallow swale can sustain/nurture the existing trees and vegetation along the north side of the existing Outlet Channel.
    - Channel alternatives could be aesthetically improved by varying side slopes (4H:1V to 6H:1V) without impeding into the 100-foot buffer zone, varying the bottom width of the channel, or adding rock mulch to the slopes.
    - Alternatives 1, 2, and 3 will require excavation into the north bank of the channel and removal of a significant area of existing trees. For the levee alternatives (1 and 2), the trees

could potentially remain in place, but the levee crest elevation would need to be raised to provide sufficient flow capacity and would result in increased inundation area.

- Vegetation along the levees will require offsets similar to that required for dams and will be based on guidance in USACE documents.

- Conclusions and Recommendations
  - The realigned channel presented in Alternative 4 is considered better than Alternatives 1 through 3 for providing the minimum required level of flood protection at the overall lowest downstream risk.
  - Alternative 4 was considered to be better than Alternatives 1 through 3 for landscape and multi-use considerations.
  - Constraints associated with existing utility towers are more easily addressed by Alternative 4 compared to Alternatives 1 through 3.
  - The channel alternatives provide significantly greater excess land for potential sale than the levee alternatives.
  - There is a potential for much of the channel to be excavated by others needing the soil or for the excavated soils to be sold, neither of which are considered in the estimate.
  - Alternative 4 is viewed as the preferred channel alternative.
  - The channel alternatives were found to be more expensive than the levee alternatives in terms of initial capital cost. However, it was decided in the meeting that the cost estimates require further study. During the meeting, several suggestions were made that have the potential to change the estimates to a degree that could significantly impact the comparative costs. One of the major differences in construction cost between the channel and levee alternatives is the quantity of cemented soil (caliche) excavation. Before the preferred alternative is presented to management for concurrence, additional geotechnical investigation along the proposed Alternative 4 alignment should be performed to characterize the on-site soils and verify the quantity and costs of cemented soils that must be excavated for the Alternative 4 channel. It appears that Alternative 2 is the preferred levee alternative based on the construction cost.
  - For purpose of this study, the value of all identified excess property was estimated at $40,000 per acre. It needs to be determined if the excess property resulting from these alternatives would be removed from the floodplain by the Project and if not the estimated land value should be adjusted accordingly.
  - Life cycle costs (long term maintenance, sustainability of structures) should be evaluated to more accurately illustrate the true costs of each alternative.

4. Emergency Spillway and Principal Outlet Alternatives Evaluation

- The Emergency Spillway and Principal Outlet Alternatives Evaluation consisted of evaluating alternatives for the Emergency Spillway (ES) location and weir structure, and Principal Outlet (PO) location and structure. The evaluation included development of alternative alignments of the Outlet Channel west of US 60 to protect the channel from Emergency Spillway discharge.

- ES and PO Location Alternatives
  - Protection of the existing utility towers from spillway discharges was a key element for locating the ES. Each of the alternatives will require some level of erosion protection from spillway discharges, including berms with riprap or the spillway dike. In addition to the utility towers, the clearance between the dam and ES structures and overhead power lines is a critical design issue.
  - Each of the alternatives includes some curvature to the ES downstream channel. Significant channel curvature is not ideal for hydraulic design and it is recommended to minimize the curvature.
  - Each of the location alternatives provides excess land for potential sale between US 60, Deer Valley Road, the ES, and the dam.
  - Alternative 1 places the ES as far north as possible and maintains the PO at its current location. The alternative requires placement of concrete lining and erosion protection in the Outlet Channel to protect against erosion during and maintain flow after an ES discharge. This alternative provides the least excess land for potential sale.
  - Alternatives 2 through 6 consider locations south of the existing location. Each alternative incorporates dikes and berms to protect the utility towers. The PO is relocated to the north side of the ES weir structure. The levee along the south bank of the Outlet Channel is removed to prevent flow from backing up against the dam and ES, and prevent levee failure and concentration of flow during an ES discharge.
  - Alternative 2 – The ES weir structure is relocated to the south and upstream of the existing dam. The ES downstream channel has significant curvature. The weir structure is located beneath the power lines. The utility towers immediately east of the ES weir structure in the ES downstream channel will require berms and erosion protection. This alternative provides significant excess land for potential sale (about 250 acres).
  - Alternative 3 – The ES weir structure is relocated south and downstream of the existing dam. The ES downstream channel has minimum curvature. The weir structure is located beneath the power lines. The previously downstream utility towers will be located within the reservoir pool, where flow velocity and erosion are not a concern. This alternative may provide the advantage of allowing phased construction of the weir structure with its location downstream of the existing dam. The weir structure is turned to the east and might be more visible to downstream residents. This alternative provides significant excess land for potential sale (about 250 acres).
  - Alternative 4 – The ES weir structure is relocated south but remains north of the utility towers. The ES downstream channel has significant curvature. Only the existing embankment is beneath the power lines. The downstream utility towers are protected by a dike. This alternative provides only a small amount of excess land for potential sale (about 100 acres).
  - Alternative 5 – The ES weir structure is relocated south and is split on both sides of the utility towers. The ES downstream channel has significant curvature. Only the existing embankment

is beneath the power lines. The downstream utility towers are protected by a dike. This alternative provides only a small amount of excess land for potential sale (about 150 acres).

- Alternative 6 – The ES weir structure is relocated south, downstream of the existing dam, and tilted to be parallel to the Beardsley Canal. The ES downstream channel has no curvature. The weir structure and the new NFRZ Embankment are located beneath the power lines. The previously downstream utility towers will be located within the reservoir pool, where flow velocity and erosion are not a concern. This alternative may provide the advantage of allowing phased construction of the weir structure with its location downstream of the existing dam. The weir structure is turned to the east and might be more visible to downstream residents. There is some concern that the Beardsley Canal is too near the weir structure and could experience increased adverse impacts due to the proximity. This alternative provides significant excess land for potential sale (about 260 acres).
- Alternative 3 is considered the preferred alternative due to ideal downstream channel hydraulics, minimal utility impacts, minimal upstream excavation, and the significant area of available excess land for potential sale.

- ES Structure Alternatives
  - Three types of weir structures were evaluated – concrete, roller-compacted concrete (RCC), and concrete labyrinth weir. The spillway crest length was assumed to be 2,250 ft.
  - Concrete Weir – The concrete weir spillway consists of a vertical concrete wall with an apron energy dissipation structure similar to the spillway constructed at White Tanks FRS No. 3. Riprap is placed downstream to provide erosion protection at the transition from the apron to the downstream channel. O&M access across the riprap and onto the apron will be addressed in the final design. Railing will be provided on top of walls to prevent public access on top of the structure. The approximate cost of the concrete weir is $11.2 million for the Alternative 3 ES location.
  - RCC Weir – The RCC weir spillway consists of a trapezoidal structure constructed of RCC. The RCC spillway structure is similar the spillway presented in the Area Drainage Master Plan (ADMP). A concrete apron will function as the energy dissipation structure. Riprap is placed downstream to provide erosion protection at the transition from the apron to the downstream channel. O&M access across the riprap and onto the apron will be addressed in the final design. The RCC weir structure costs approximately $2.6 million more than the concrete weir structure. Dennis (District) suggested that the exposed RCC steps could be meandered to provide aesthetic treatment.
  - Labyrinth Weir – The labyrinth weir spillway consists of a vertical concrete weir in a labyrinth shape to provide more-efficient weir hydraulics. Labyrinth weirs with channel widths of 1,000 ft and 2,250 ft were evaluated. A concrete apron will function as the energy dissipation structure. Riprap is placed downstream to provide erosion protection at the transition from the apron to the downstream channel. O&M access across the riprap and onto the apron will be addressed in the final design. The 2,250-ft labyrinth weir lowers the reservoir water level 2 ft compared to the concrete weir (3 ft lower than the RCC weir), and reduces dam costs by approximately $6 million. The 2,250-ft labyrinth weir structure costs approximately $5.4

million more than the concrete weir. The 1,000-ft labyrinth weir provides the same reservoir water level as the concrete weir, and has similar costs to the concrete weir. One of the concerns with the 1,000-ft labyrinth weir is the increase in flow depths and velocities downstream of the spillway and the potential for greater impacts to property. The 1,000-ft labyrinth weir provides greater area of excess land for potential sale (about 100 acres additional land).

- PO Structure Alternatives
  - Two PO structure types were evaluated: a PO structure identical to the existing PO structure and a PO with a lowered invert elevation.
  - The PO will be designed to maintain a peak flow of 4,450 cfs with the reservoir at the ES crest elevation.
  - PO Option 1, Open Channel (Existing) – This option consists of constructing the same type of structure as the existing PO, including the energy dissipation basin. The invert elevation would match the existing elevation at 1,337 ft.
  - Option 2, Box Culvert – This option consists of a 36-ft-wide by 6-ft-tall box culvert. The box culvert would provide greater discharge at lower elevations and lowers the maximum reservoir pool elevation during the 100-year event by 0.6 ft. The invert elevation would match the existing elevation at 1,337 ft.
  - PO with Lowered Invert Elevation – An additional PO option was considered for a lowered invert elevation. In order to maintain the design flow, the box culvert dimensions are 30-ft-wide by 5-ft tall. The inlet invert elevation would be 1,327 ft. A PO with a lowered invert elevation will lower the maximum reservoir pool elevation during the 100-year event by about 1 to 2 ft. Due to the lowered elevation, a CSU Energy Dissipation structure is utilized. The lowered invert PO costs about $1.4 million.
  - Bill Leal (District) recommends a culvert with internal height of 7 ft (instead of the proposed hydraulic optimal design of 5 ft in height) to provide for O&M access. This option would result in a less efficient hydraulic system. The option will be evaluated for a future decision.
  - The PO invert elevation accounts for future differential subsidence.
  - Scott Vogel (District) suggested a reconfiguration of the outlet to allow maintenance access to the trash rack over the culvert inlet. The configuration would consist of a vertical concrete wall above the outlet, with the inlet set near the crest alignment.
  - Trash racks should be installed at the upstream end of the PO. The report will be revised to include discussion of the trash rack and estimated costs.
- Landscape Architecture and Multi-Use Discussion
  - Dennis Holcomb (District) presented the District's ideas, goals, and comments regarding landscape architecture and multi-use opportunities for the ES and PO alternatives.
  - Dennis rated each ES location and structure using the following criteria: 1) Impacts to the wash receiving flow from Picacho Wash; 2) Impacts to natural landforms; 3) Effect on property owners; and 4) Potential for context sensitive solution. Dennis expressed concern regarding the ES Alternatives 1, 2, 3, and 6 potentially impacting the wash receiving flow from Picacho Wash. Todd (URS) explained that the new NFRZ Embankment will be aligned to provide

minimal impact to the wash. In addition, the new embankment alignment can be modified to soften the right angles, including the potential for possible excess soil disposal as overbuilding.

  - ES Alternatives 1 and 4 have the greatest impact to undisturbed land; Alternatives 2, 3, and 6 have the least impact to undisturbed land.
  - ES Alternatives 1, 4, and 6 have least potential for multi-use opportunities. ES Alternatives 2, 3, and 5 have the most opportunity to design structural components and to provide multi-use opportunities.

- Conclusions and Recommendations
  - The ES location Alternative 3 was considered to be the best alternative due to ideal downstream channel hydraulics, minimal utility impacts, minimal upstream excavation, the significant area of available excess land for potential sale, and potential for multi-use opportunities. Coordination with utilities will be required to identify any potential issues.
  - The concrete weir structure was considered the best alternative due to lowest construction cost and resulting maximum reservoir pool elevation (and corresponding dam crest elevation).
  - The PO with lowered invert elevation was considered the best alternative. This PO consists of a lowered box culvert. This PO will provide lowered pool elevations for the 100-year through 500-year events, which will provide improved level of flood protection.

5. Dam Realignment Alternative Evaluation

- The FRZ Embankment Realignment Alternatives Evaluation consisted of evaluating a dam realignment within the Moderate Fissure Risk Zone (FRZ). The realignment provides the potential to reduce the overall dam length and, more importantly, the FRZ Embankment. The FRZ Embankment is 14 percent of the dam length but over 25 percent of the dam construction cost.
- The FRZ Embankment consists of a soil cement dam covered by structural fill. A soil cement apron will be constructed at the upstream toe of the soil cement core or parallel cutoff walls will be constructed beneath the soil cement core. The apron and cutoff walls are designed to prevent dam failure due to erosion through ground fissures.
- The dam realignment reduces the FRZ Embankment length by 1,000 feet, to 4,000 ft.
- The dam height along the realignment is shorter than along the existing alignment.
- The dam crest elevation must increase by 1.6 ft with the dam realignment to account for the lost reservoir volume and the restricted flow area through realigned reservoir section.
- Drop structures should be constructed where the low flow channel intersects natural washes. The report will be updated to include costs for the drop structures.
- The realigned dam results in increased reservoir pool elevations, which results in flooding beyond District property lines for the PMF and reduced levels of flood protection for smaller storm events.
- The design of the fissure erosion protection component (apron or cutoff walls) is still being evaluated. The final design could include either component or a combination of both. The recent

geotechnical investigations did not find significant cemented soils along the realigned dam alignment.

- Landscape Architecture and Multi-Use Discussion
  - Dennis Holcomb (District) presented the District's ideas, goals, and comments regarding landscape architecture and multi-use opportunities for the dam realignment alternative.
  - The existing alignment is preferred because there is less impact to the natural landforms. The existing dam appears to allow flow in Trilby Wash to flow more naturally, where the realigned dam cuts through existing topography forcing water where it naturally would not flow. The realigned dam has greater impacts to the biological resources and vegetation formed by the historic Trilby Wash flows.
  - The realigned low flow channel requires deep excavations and will require construction of drop structures to prevent head-cutting where natural washes enter the channel.
  - Dennis (District) estimated 230 acres of impact to high value land associated with the dam realignment. This entire area would have a higher cost in construction mitigation, land restoration and erosion control efforts.
- Conclusions and Recommendations
  - The existing dam alignment was considered to be the best alternative. The realigned dam increases the maximum reservoir pool elevation (dam crest elevation) and increases construction cost. The increase in dam crest elevation offsets any savings found in realigning the dam. In addition, the realigned dam reduces the level of flood protection.
  - The existing dam alignment has fewer impacts to the natural landforms and vegetation and minimizes disturbances to stabilized landscapes.

6. Next Steps

- Mike and Bobbie will present the preferred dam alternatives to management at the IPR Meeting scheduled for January 28, 2014 at the District. The Outlet Channel alternatives will be presented as a status update only, until further information is developed and a preferred channel alternative is identified.
- The alternatives evaluation reports will include a discussion of this meeting and details of the alternative selection.
- Geotechnical investigations will be performed for Outlet Channel Alternative 4 in order to verify and refine the excavation costs.
- URS will incorporate the selected alternatives into the 30 Percent Design.

7. Attachments:

- Figures, tables, and cost estimates.

Alternatives Evaluation Meeting – January 14, 2014
McMicken Dam Rehabilitation Project
Flood Control District of Maricopa County

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APPENDIX F

Reference DVD