# VADO/DEL CERRO
# DRAINAGE MASTER PLAN

FINAL SUBMITTAL

DOÑA ANA COUNTY FLOOD COMMISSION

**Smith Engineering Company**
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Las Cruces, New Mexico 88001
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August 2019

Smith Project No.: 817103-03

# VADO / DEL CERRO DRAINAGE MASTER PLAN

FINAL SUBMITTAL

DOÑA ANA COUNTY FLOOD COMMISSION

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal as a professional engineer licensed to practice in the state of New Mexico, is affixed below.

EDWARD CHRISTIAN NAIDU
NEW MEXICO
22997
PROFESSIONAL ENGINEER

E. Christian Naidu

August 21, 2019

Michael Garza, EIT, CFM
Doña Ana County Flood Commission
845 N. Motel Blvd.
Las Cruces, New Mexico 88007

Re: Vado/Del Cerro Drainage Master Plan

Smith #: 817103-03

Dear Mr. Garza:

I am pleased to submit the final Vado/Del Cerro Drainage Master Plan Report for the Doña Ana County Flood Commission. This report includes findings based on analyses of the existing watershed conditions. It identifies areas of elevated risk and includes options for proposed improvements. We have incorporated the final review comments into the report and have provide final cost estimates and suggested phasing schedule for the recommended projects.

Please feel free to contact us at any time with questions.

Finally, thank you for giving Smith the opportunity to work with the Flood Commission on producing a product that will hopefully help with future drainage improvements made in the Vado/Del Cerro area.

Sincerely,
Smith Engineering Company

E. Christian Naidu, PE
Project Manager

Enclosure: Vado/Del Cerro Drainage Master Plan Final Submittal

CC:

John Gwynne, PE, CFM Engineering Director (DACFC)
Andrew Guerra, PE, CFM, Engineering Supervisor

## ACKNOWLEDGMENTS

DACFC for providing necessary digital files to perform the drainage study and local insight into the watershed.

The Community of Vado for invaluable historical accounts of flooding and input regarding areas of concern.

## EXECUTIVE SUMMARY

The Vado/Del Cerro Drainage Master Plan (DMP) was prepared by Smith Engineering Company (Smith) for the Doña Ana County Flood Commission (DACFC) to study the Vado Arroyo watershed. **Exhibit 1** shows the subbasin boundaries for the Vado/Del Cerro watershed. The Vado watershed is comprised of several ephemeral arroyos that drain from the Bishop Cap and Pyramid Peak area down to Interstate I-10 (I-10). The flows are then conveyed under I-10 through a series of culverts at various locations along the interstate, shown on **Exhibit 2**. The culverts along I-10 are the control points of the upper watershed, restricting the amount of water that flows from the upper watershed (east of I-10) to the Lower watershed (west of I-10). The entire watersheds western boundary is formed by the Mesquite Drain which is an Elephant Butte Irrigation District (EBID) facility. The Vado Arroyo, in particular, is conveyed through a series of box culverts (noted as C1 and C2 on **Exhibit 2**) into a channel that has been lined with grouted riprap in places with non-engineered earthen embankments. The arroyo, which runs parallel to Swannack Rd, has two significant drops in elevation which demonstrate significant scouring. The channel naturally dissipates into a large retention area on the upstream side of the Mesquite Drain leaving the water to pond and flood the surrounding area.

The purpose of this study is to quantify runoff rates from the Vado watershed, analyze the hydraulic characteristic of the Vado Arroyo, identify points of restriction and propose options that will convey the design flows safely through the project limits. Proposed alternatives were considered based on the following factors:

- Hydraulic design options for the Vado Channel for channel stability and safe conveyance
- Ponding and detention at the outfall of Vado Channel to mitigate flows into the Mesquite Drain
- Various drainage improvements that would address complaints by residents raised at the public meeting

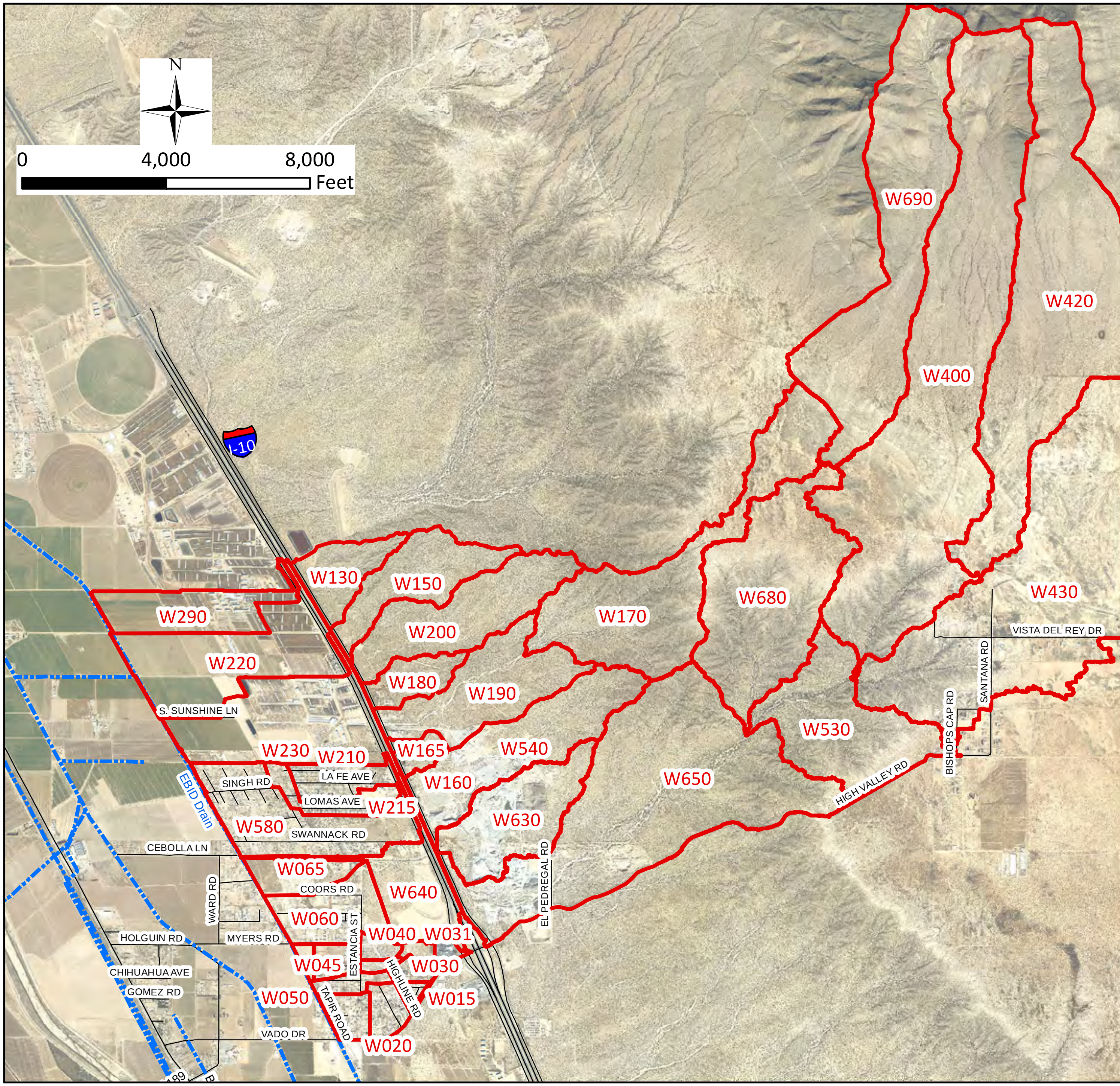
Several alternatives were considered to mitigate flooding for the 100-year storm**.** However, many were deemed unfeasible due to the excessive cost that the facilities would incur. All proposed ponds are designed to be non-jurisdictional ponds.

The greatest challenge in the design of the conceptual ponding facility improvements was the high runoff volume, approximately 247 AF, that arrived from culvert C1-C2 during the 10-year storm. The amount of real estate required to size a pond that would handle this volume is substantial. Secondly, there is very little elevation drop at the western boundary of the watershed both in the Vado and Del Cerro areas. The lack of slope severely hampers the design of gravity facilities such as storm drains and roadside ditches. In a large event, the entire western boundary will most likely become flooded and enter the Mesquite Drain. This is demonstrated in the 2D model, which is discussed in detail in Section 3 of the report.

Considering these factors, ponds were sized to control the 10-year storm. Storm drains were sized for the 10-year storm while the 100-year storm was used as a check to ensure that the Hydraulic Grade Line (HGL) remains at grade elevation.

The channel itself was designed to convey 1175 cfs as this is the maximum flow that the culverts C1-C2 can discharge into the channel.

For some facilities to work a drainage easement will be required and/or property will have to be acquired.




## Legend

Subbasin Boundary

EBID Drain

Roads

W200 Subbasin Name

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**Exhibit 1**
**Drainage Subbasin Map**

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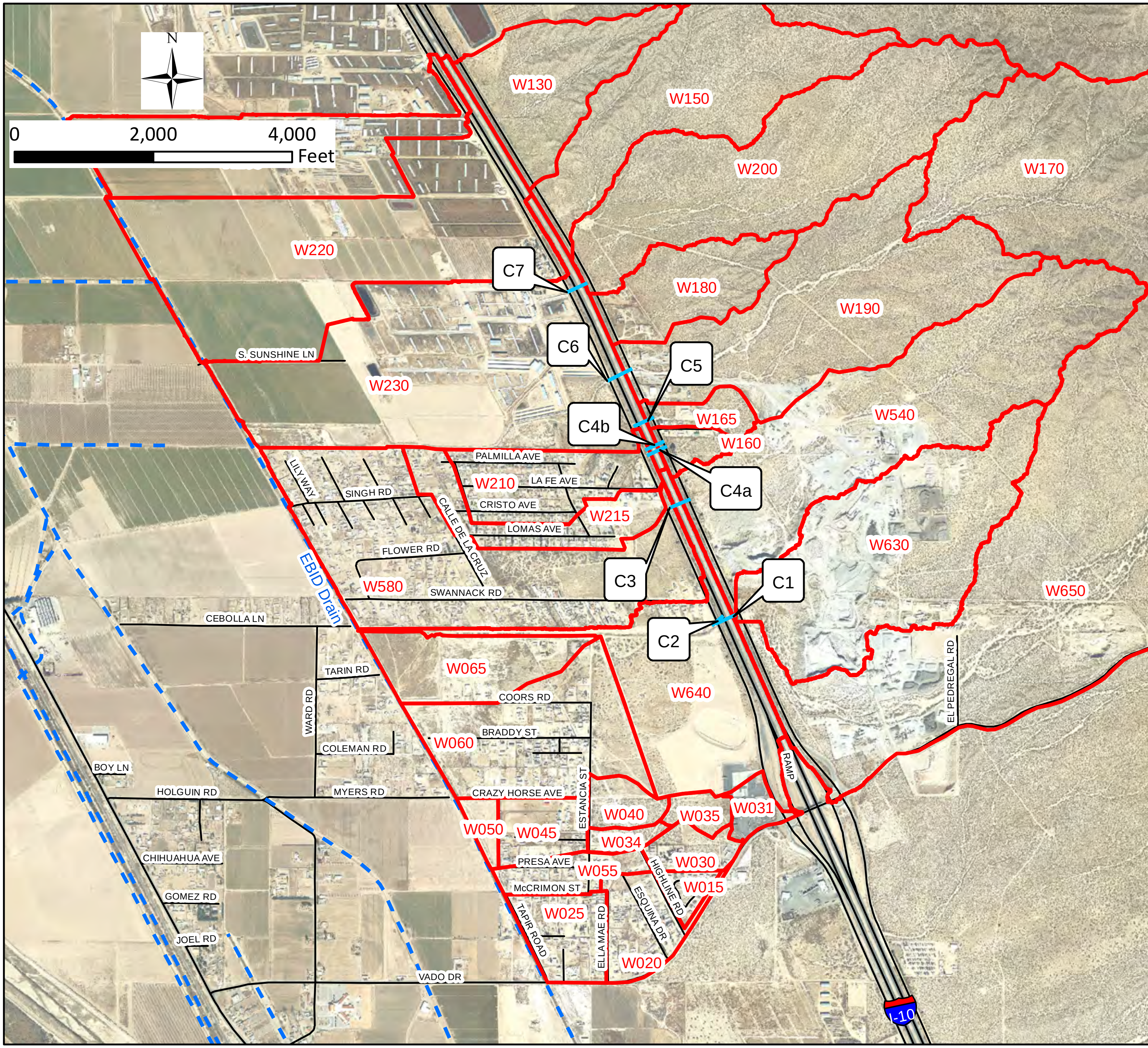


## Legend

- Subbasin Boundary
- Culverts*
- EBID Drain
- Roads

W200 Subbasin Name
C1 Culvert Name

* Culverts are not drawn to scale. Only for visualization and general location.

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**Exhibit 2**
**Culvert Locations**

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The four proposed alternatives are as follows:

Alternative 1: Detention Pond and Off Channel Storage using a Lateral Weir (not recommended due to high cost)

Alternative 2: Detention Tapir Pond and Vado Channel

Alternative 3: Lily Pond with Storm Drain

Alternative 4 Option 1: Two Detention Ponds with Storm Drain (not recommended)

Alternative 4 Option 2: Crazy Horse Detention Pond

Alternatives 1 and 4 option 1 were not recommended. Neither of these alternatives provided adequate protection and both were high in cost. A detail description and breakdown of these alternatives are included in the report. However, only the recommended alternatives are discussed in the executive summary. A schematic overview of all recommended alternatives is shown in **Exhibit 3** (below).

Alternative 2

Alternative 2 is proposed to convey runoff coming from I-10 through Vado Channel to Tapir Pond. This facility consists of one detention pond, one channel, and associated structures. **Exhibit 3** (below) shows the conceptual layout for this alternative.

Alternative 3

Alternative 3 is proposed to help reduce flooding in the residential communities located in subbasins W210 and W215. This alternative will help alleviate the stagnant water that residents have complained about at the terminus of subbasin 230. This alternative consists of one detention pond (Lily Pond), a storm drain system and associated structures. **Exhibit 3** (below) provides an overview of the alternative.

Alternative 4 Option 2

This area, shown on **Exhibit 3** (below), has a history of flooding complaints. The west side of Tapir Rd abuts the EBID Mesquite Drain and there are no outlets in the area that allow storm water to drain into the EBID drain. In the past, residents have made cuts in the embankment of the EBID drain to allow ponded storm water to drain. This alternative is comprised of a detention pond (Crazy Horse Pond) and roadside swales.

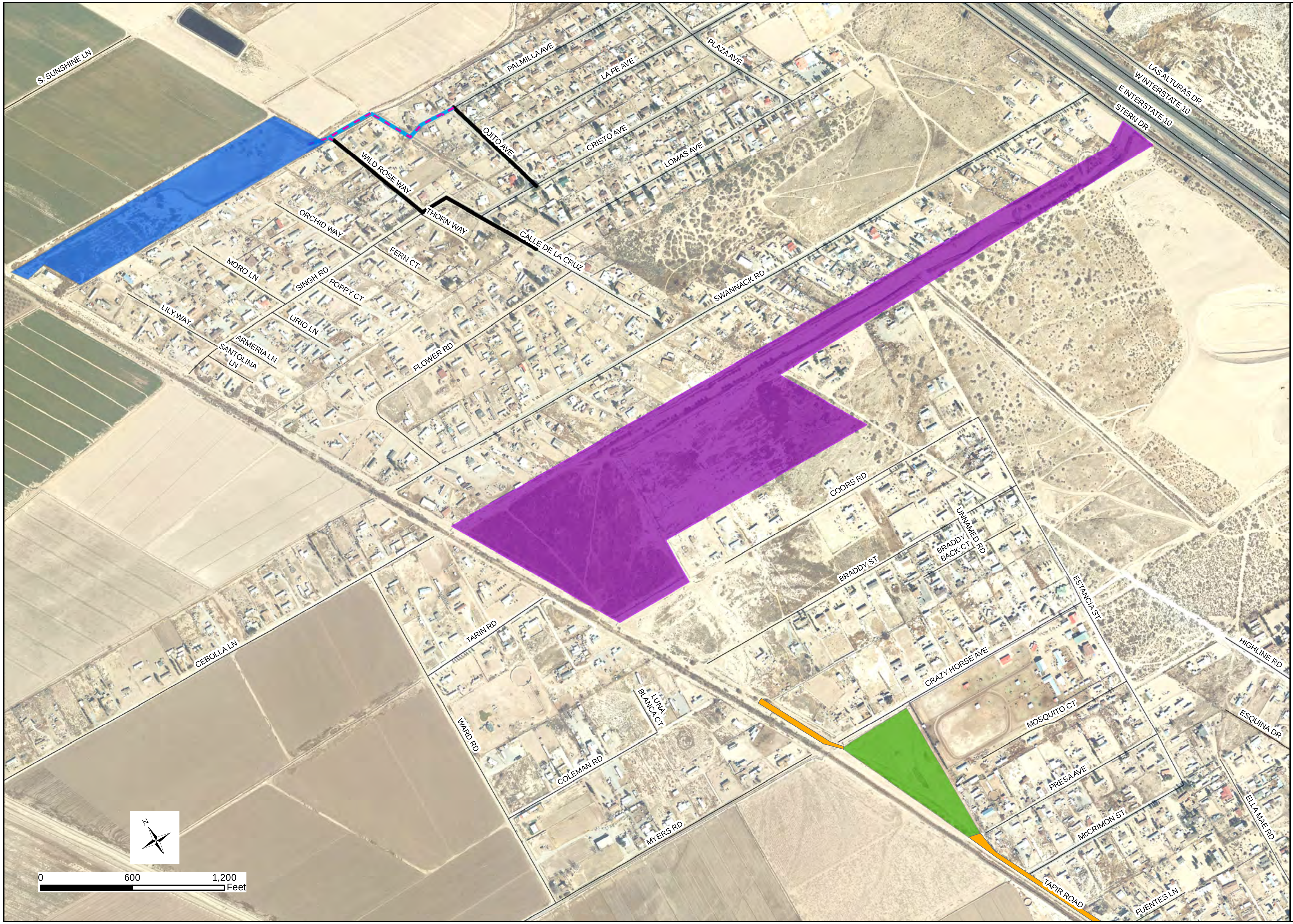
Project Phasing

Based on severity and frequency of complaints, cost and impact on the community the following priority of projects is suggested.

**Phase 1:** Consists of implementing Alternative 4 and a portion of Alternatives 2 and 3. The total cost for this phase is estimated at $2,581,000.

**Phase 2:** The Phase consists of implementing the remaining portions of Alternatives 2 and 3. The cost for Phase 2 is estimated at $4,136,000

The total cost for the recommended alternatives is estimated at $6,717,000.




## Legend

- Alt 4 Opt 2 - Roadside Swales
- Alt 4 Opt 2 - Pond
- Alt 2 - Pond and Channel
- Alt 3 - Pond
- Alt 3 - Storm Drain
- Alt 3 - Inverted Crown Road
- Roads

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**Exhibit 3**
**Overview of All Recommended Options**

August 2019

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## SECTION 1. GENERAL PROJECT INFORMATION

### 1.1 DESCRIPTION AND PURPOSE OF PROJECT

The Vado/Del Cerro Drainage Master Plan (DMP) was prepared by Smith Engineering Company (Smith) for the Doña Ana County Flood Commission (DACFC) to study the Vado Arroyo watershed. **Figure 1** shows the project vicinity map. The Vado watershed is comprised of several ephemeral arroyos that drain from the Bishop Cap and Pyramid Peak area down to Interstate I-10 (I-10). The flows are then conveyed under I-10 through a series of culverts at various locations along the interstate. The entire watersheds western boundary is formed by the Mesquite Drain which is an Elephant Butte Irrigation District (EBID) facility. The Vado Arroyo in particular is conveyed through a series of box culverts into a channel that has been lined with grouted riprap in places with non-engineered earthen embankments. The arroyo, which runs parallel to Swannack Rd, has two significant drops in elevation which demonstrate significant scouring. The channel naturally dissipates into a large retention area on the upstream side of the Mesquite Drain leaving the water to pond and flood the surrounding area. The purpose of this study is to quantify runoff rates from the Vado watershed, analyze the hydraulic characteristic of the Vado Arroyo, identify points of restriction and propose options that will convey the design flows safely through the project limits.

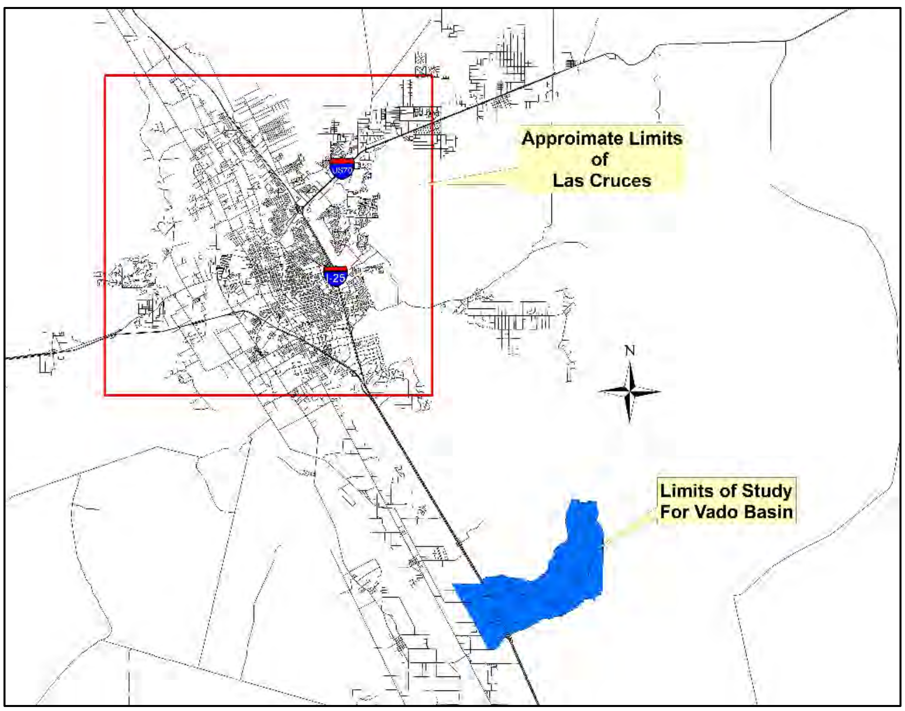


**Figure 1: Project Vicinity Map**

### 1.2 FIELD OBSERVATION

**Smith** conducted several field observations between November 2018 and March of 2019. The purpose of the field work was to observe the physical characteristics of the Vado watershed, the channel characteristics of the Vado Arroyo, the location of the main channel, location of other miscellaneous channels and take measurements of the various culvert crossings. **Appendix A** contains annotated photographs of the various locations in the watershed, existing drainage infrastructure, and culvert crossings.

# SECTION 2. EXISTING HYDROLOGIC AND HYDRAULIC ANALYSES

## 2.1 PREVIOUS STUDIES

The EBID's Mesquite Drain acts as a natural outlet for the stormwater runoff in the area. Smith received profiles and structures book of the Mesquite Drain and the East Drain from EBID. The information provided to Smith are included in **Appendix B**. Using this information Smith calculated the approximate capacity of the EBID drain along the project limits using Bentley Flow Master V8i. **Figure 2** below shows the alignment that was analyzed and **Figure 3** shows the cross sections of the EBID canal and the flow capacity at each section. Due to the varied slope and geometry, the capacity of the canal ranges from 350 to 450 cfs. Two points that should be noted are at stations 39+00 and 43+00. At these points the canal has been altered (this was field verified). The altered canal has low points, that reduce capacity down to 70 to 80 cfs. As part of the drainage improvements it is recommended that DACFC work with EBID to restore the canal back to its original trapezoidal geometry. This will ensure the proposed drainage improvements function as they are designed to.

The Flow Master output tables are summarized in **Table G2**. **Table G2** and the Flow Master output can be found in **Appendix G**.

Another point of restriction occurs where the Mesquite Drain intersects with Vado Dr. At this point, the EBID as-builts (in **Appendix B)** indicate that a 60-in CMP culvert conveys water underneath Vado Dr. However, a field visit verified that the culvert is actually an 84" CMP. From that information and the contour data that was provided by DACFC this culvert has an approximate capacity of 450 cfs. The Culvert Master Output is in **Appendix G.** In summary both the culvert and the canal, if the repairs are made to the canal, convey the same amount of flow.

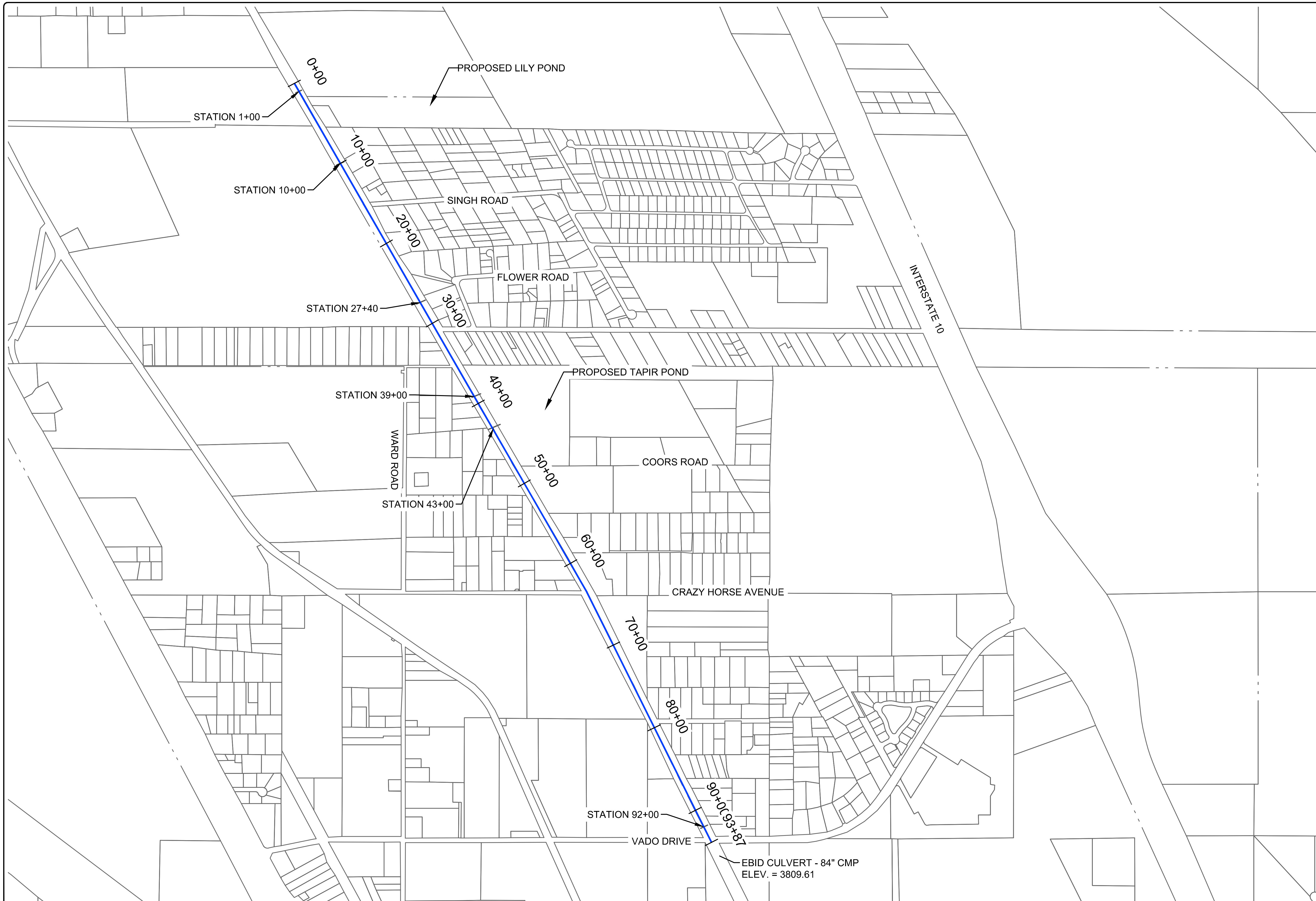


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FIGURE 2

EBID CANAL ANALYSIS - PLAN VIEW

PROJECT NO:
817103-03

DATE:
August 2019

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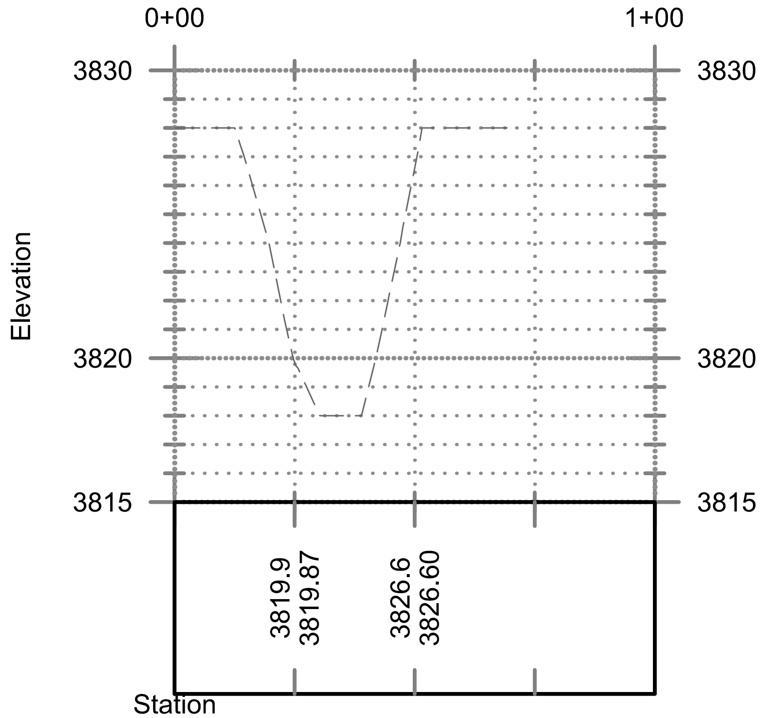
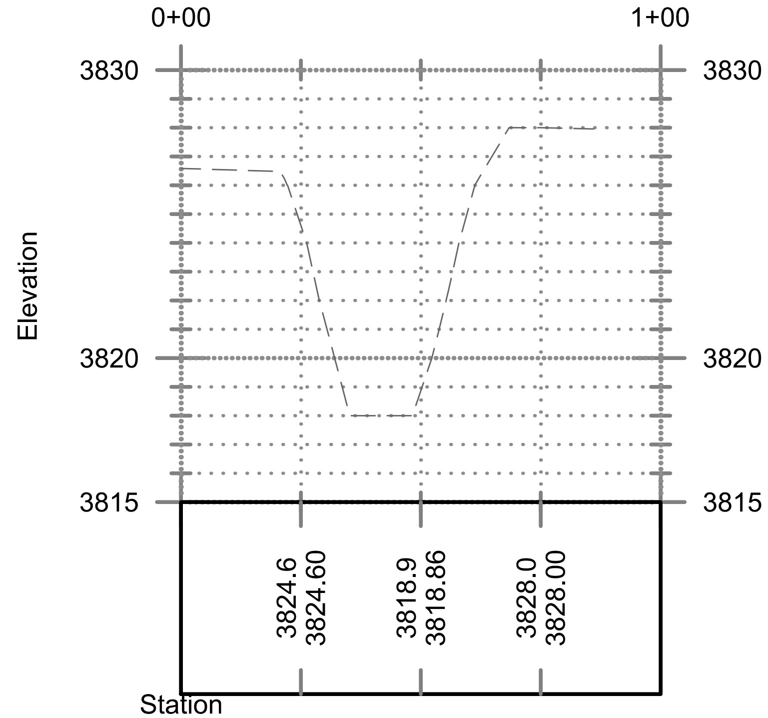
## STATION 1+00



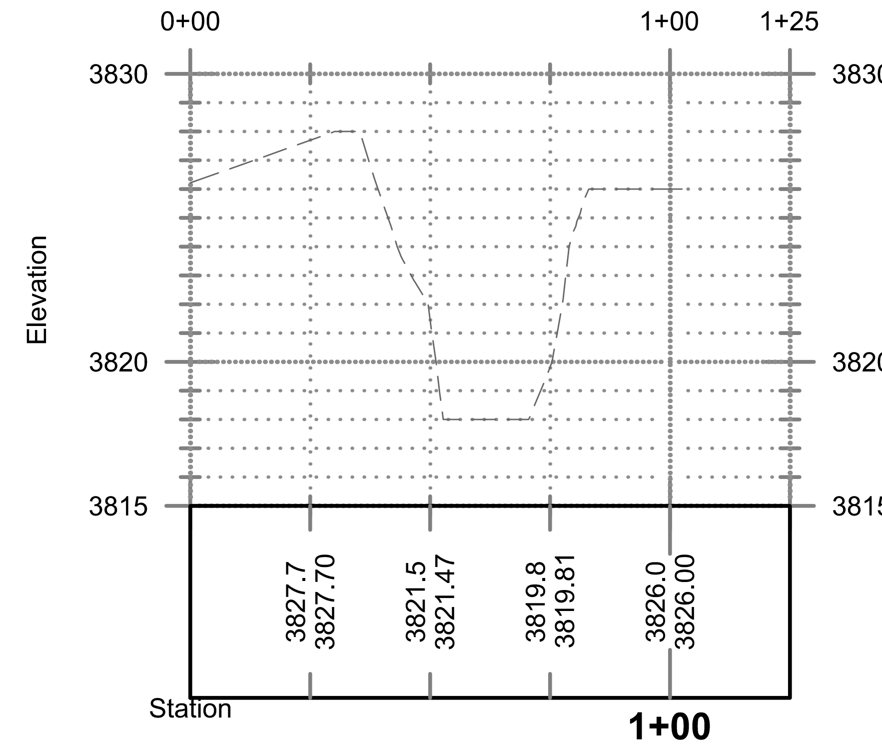

**$Q_{MAX}$ = 447 CFS**

## STATION 10+00



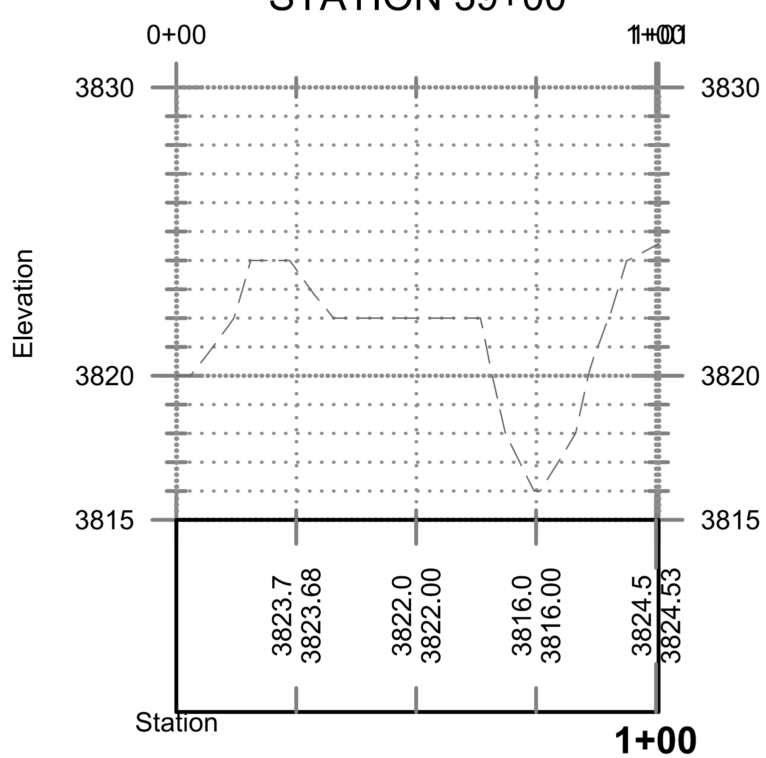

**$Q_{MAX}$ = 373 CFS**

## STATION 27+40



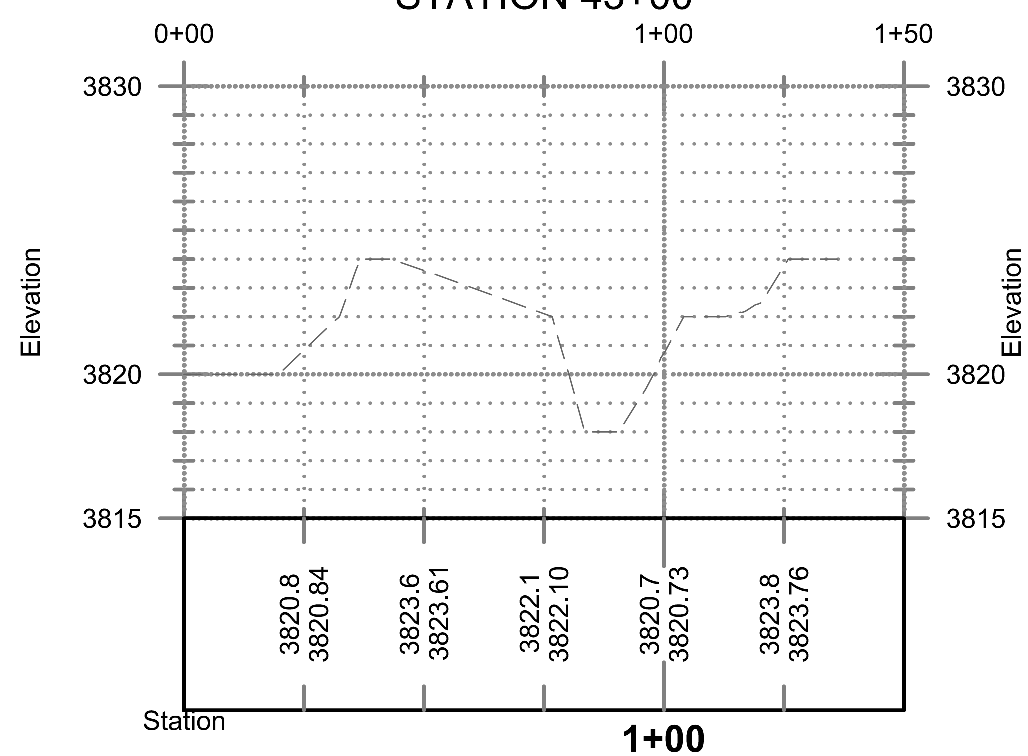

**$Q_{MAX}$ = 355 CFS**

## STATION 39+00



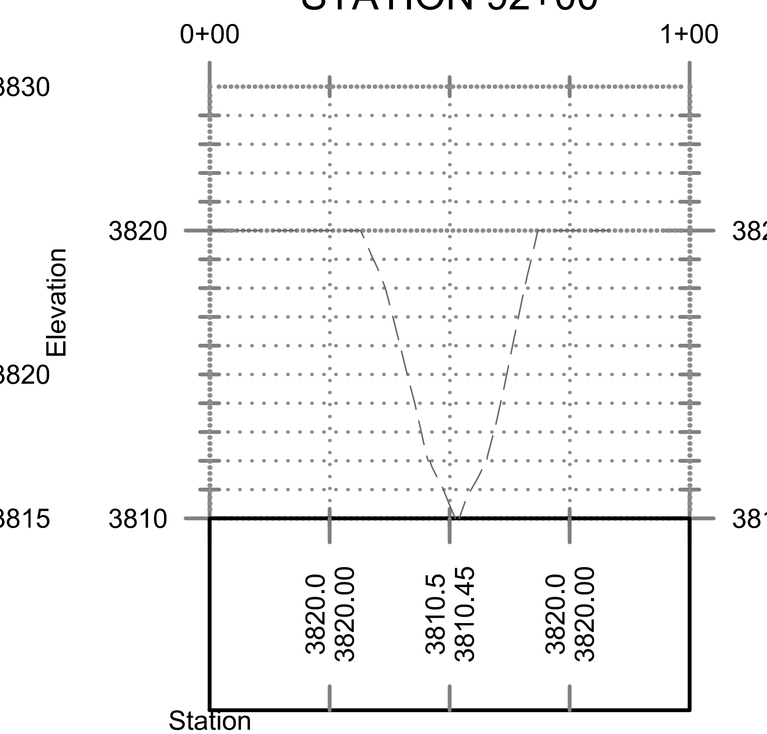

**$Q_{MAX}$ = 73 CFS**

## STATION 43+00




**$Q_{MAX}$ = 85 CFS**

## STATION 92+00




**$Q_{MAX}$ = 367 CFS**

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FIGURE 3

EBID CANAL ANALYSIS - CROSS SECTIONS

PROJECT NO: 817103-03

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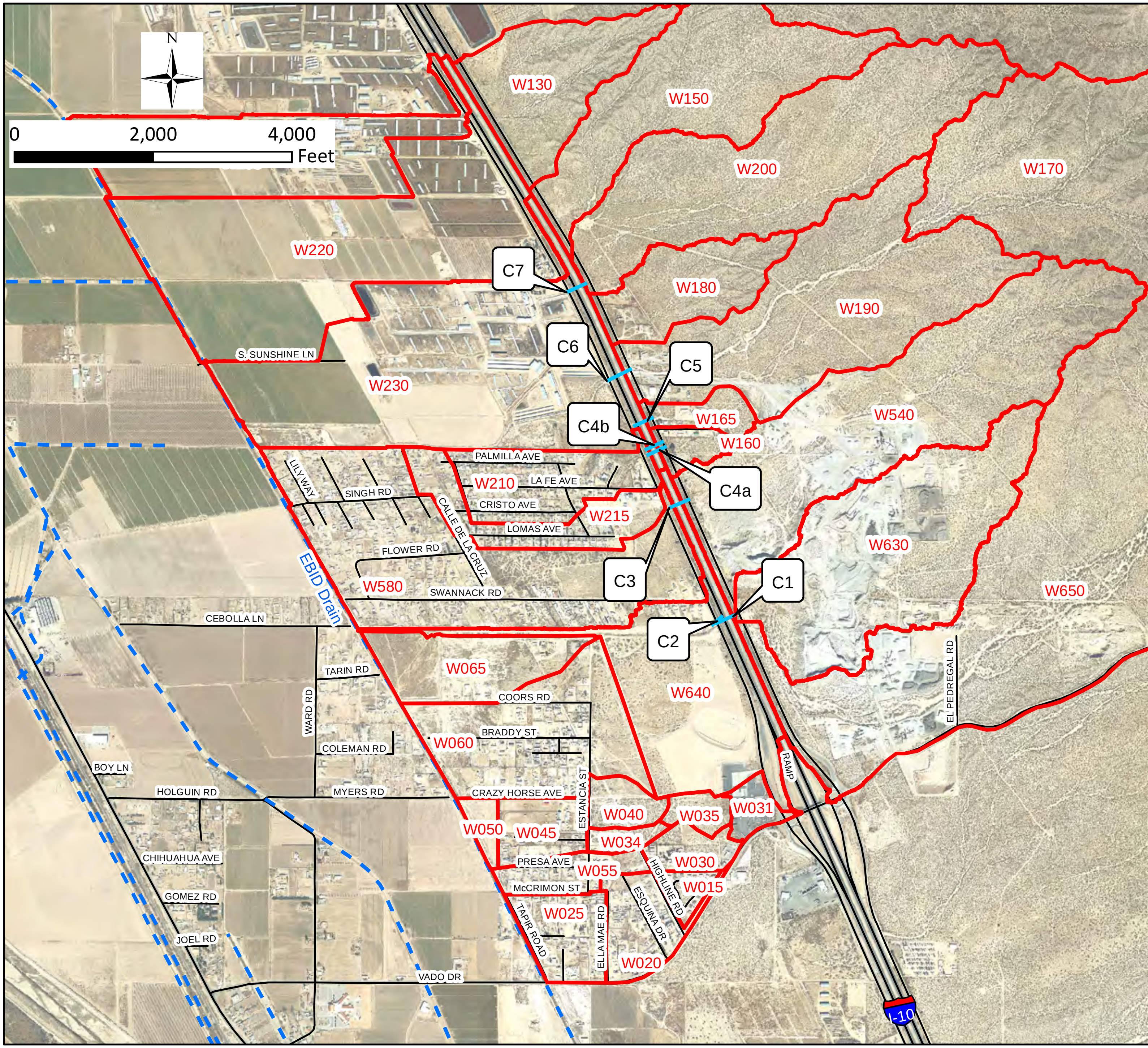
## 2.2 EXISTING FLOOD CONTROL STRUCTURES

There are no flood control structures present to detain flows in the upper watershed. There are eight culvert crossings, which are shown on **Figure 4**. The main culvert crossing is noted in **Figure 4** as C1 and C2. Culvert C1 is comprised of two 7 X 10 concrete box culverts that convey flow underneath I-10. C1 outfalls into a large ponding area in between the south bound I-10 lane and the frontage road (Stern Dr). At this point the water is conveyed under Stern Drive into the Vado Channel through culverts C2. C2 is comprised of an array of 4 X 48-inch and 3 X 60-inch RCP pipes. Together, culverts C1 AND C2 convey approximately 70% of the upper watershed under Interstate I-10 to the west into a channel (Vado Channel) that has no direct outlet. The Vado Channel has some energy dissipation, through a grouted riprap lining, just downstream of the culverts. There are also two major elevation drops located approximately 200-ft and 900-ft downstream of the culvert C2. The riprap that was designed initially to control the elevation drops have required consistent replacement and maintenance by the County maintenance crews. The non-engineered embankments are currently experiencing scouring and are in disrepair, showing early signs of lateral migration. The channel ends at a natural retention pond area and floods the area due to minimal slope and an undefined outlet.

Smith believes the original function of Culvert C3 was to convey water from subbasin W540 underneath I-10 into subbasin W215. The aerial imagery and contours do not show a well-defined downstream channel for this culvert. After a field verification, it was decided that the amount of flow coming from C3 is minimal. Field work seemed to indicate that the flows from subbasin W540 would drain south towards Culvert C1. To verify this further a HEC-RAS 2D model was constructed to determine the direction of the surface flows. A discussion of the outcome of this model is presented in Section 3 of this report. The 2D analysis shows that minimal flows to culvert C3. Culverts C4a and C4b are a series of culverts that are relatively close to one another and drain to subbasin W210. They are of varying sizes, hence the names C4a and C4b. **Table 1** summarizes the results of the culvert analyses. The culvert master output is found in **Appendix G.** The flow from these culverts appear to flow down La Fe Ave where the flow then ponds and eventually splits at Ojito Ave. The flow (from field visits and aerials) appears to flow north flowing through residential property.

Culverts C5-C7 convey water underneath I-10 onto private property. It does appear from aerial photos and site visits (restricted due to not being able to get onto the property) that the runoff is captured and conveyed through constructed channels. The flows from these channels appear to be conveyed into a natural retention pond that is on land owned by the Board of County Commissioners of Doña Ana County.




## Legend

- Subbasin Boundary
- Culverts*
- EBID Drain
- Roads

W200 Subbasin Name
C1 Culvert Name

* Culverts are not drawn to scale. Only for visualization and general location.

Vado/Del Cerro Drainage Master Plan Final Report

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**Figure 4**
**Culvert Locations**

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**Table 1: Summary of Existing Culvert Capacity**

| EXISTING CULVERT DATA AND RESULTS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CULVERT DATA FOR CULVERT MASTER | | | | | | | Culvert Capacity | | |
| Culvert Name / Location Description | Existing or Proposed | **No. of Culverts** | **Material** | **Culvert Rise** | **Culvert Rise** | **Culvert Span** | **Length** | Maximum Culvert Capacity from Culvert Master | Maximum Culvert Capacity 15% Clogging Factor | Discharge Per Culvert |
| | | | | **inches** | **feet** | **feet** | **ft** | cfs | cfs | cfs |
| | | | | | | | | | c | d |
| C1: NMDOT Crossing | Existing | **2** | **CBC** | **84** | **7** | **10** | **195** | 1323 | 1125 | 562 |
| C2: Fr. Rd. | Existing | **4** | **RCP** | **48** | **0** | **0** | **65** | 568 | 482 | 121 |
| C2: Fr. Rd. | Existing | **3** | **RCP** | **60** | **0** | **0** | **65** | 607 | 516 | 172 |
| C2: Fr. Rd. | **Total** | | | | | | | **1175** | **998** | **-** |
| C3 | Existing | **3** | **RCP** | **48** | **0** | **0** | **220** | 497 | 422 | 141 |
| C3: Fr. Rd. | Existing | **3** | **CMP** | **48** | **0** | **0** | **35** | 167 | 142 | 47 |
| C4a | Existing | **1** | **RCP** | **36** | **0** | **0** | **220** | 80 | 68 | 68 |
| C4a: Fr. Rd. | Existing | **1** | **CMP** | **30** | **0** | **0** | **35** | 38 | 32 | 32 |
| C4b | Existing | **3** | **RCP** | **36** | **0** | **0** | **220** | 236 | 201 | 67 |
| C4b: Fr. Rd. | Existing | **3** | **CMP** | **30** | **0** | **0** | **35** | 107 | 91 | 30 |
| C5 | Existing | **3** | **RCP** | **36** | **0** | **0** | **220** | 182 | 155 | 52 |
| C5: Fr. Rd. | Existing | **2** | **CMP** | **30** | **0** | **0** | **50** | 30 | 26 | 13 |
| C6 | Existing | **2** | **RCP** | **48** | **0** | **0** | **220** | 235 | 200 | 100 |
| C6: Fr. Rd. | Existing | **2** | **CMP** | **36** | **0** | **0** | **35** | 75 | 64 | 32 |
| C7 | Existing | **3** | **RCP** | **30** | **0** | **0** | **220** | 220 | 187 | 62 |

## 2.3 DRAINAGE BASIN DESCRIPTION, DELINEATION, AND MODELING CRITERIA

### A. Drainage Basin Description Based on Historical and Existing Conditions

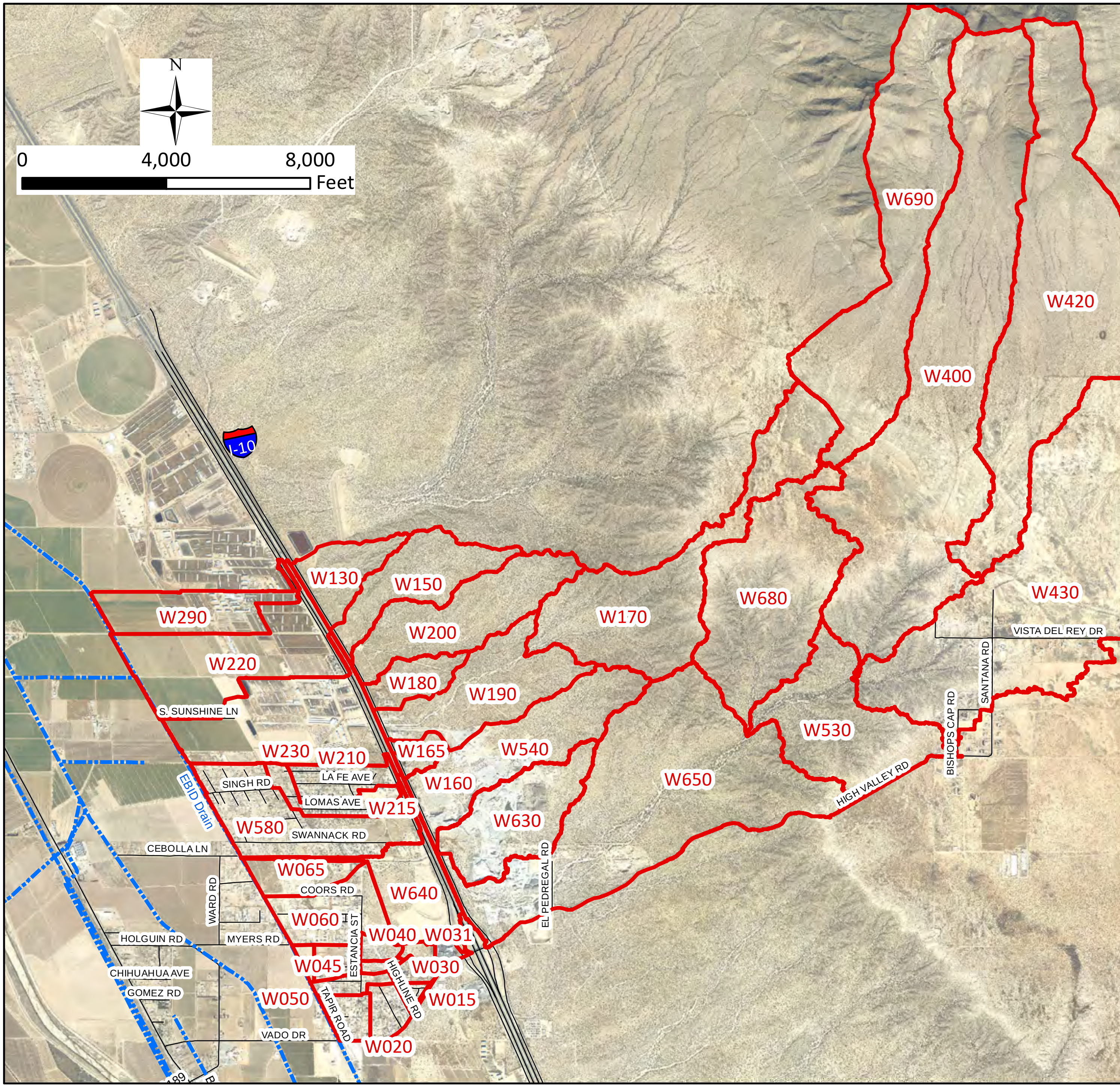
The Vado/Del Cerro Arroyo watershed has a total drainage area of 12.3 square miles. **Figure 5** shows the drainage area and the subbasin delineations. The watershed can be broken up into two sections the upper watershed, which includes the upper subbasins to the east of I-10, and the lower watershed, which includes the subbasins to the west of I-10. The upper watershed's average slope was computed to be approximately 13% reaching to upwards of 74% on the uppermost parts of the watershed. The lower watershed's computed average slope was between 0.5 -5% These values are on based spatial analysis of DACFC supplied digital elevation models (DEMs) from 2018.

The upper watershed is mainly undisturbed natural landscape. There is a residential area in a portion of subbasin W430. The residential area is large 1+ acre lots. A portion of subbasins W630 and W650 has a mining operation. Due to the nature of mining, this means these subbasins will constantly be changing, which means the flow paths of the subbasins are not permanent. For the purpose of this drainage report these subbasins were analyzed through DEMS, aerials, and site visits. As noted, Culverts C1 and C3 are the outlets for these subbasins.

The lower watershed is mainly developed with a mixture of residential lots, agriculture fields and farmstead buildings (dairy farms). The main residential communities are in subbasins W015-W065, W580 and W640. Subbasin W580, W215 and W210 are the most developed with paved streets and curb and gutter. Subbasin W230 is an agriculture facility with onsite private channels that convey storm water to a low point in the southwest corner of the subbasin.

### B. FEMA Floodplains

Portions of the Vado arroyo is classified under FEMA Flood Zone A and AE. FEMA floodplains (FEMA Maps No. 35013C1325G, 35013C1350G and 35013C1525G dated July 6, 2016) were downloaded from the FEMA website. The panels are included in **Appendix B**. Floodplains are shown on **Figure 6**.




**Legend**

Subbasin Boundary

EBID Drain

Roads

W200 Subbasin Name

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**Figure 5**
**Drainage Subbasin Map**

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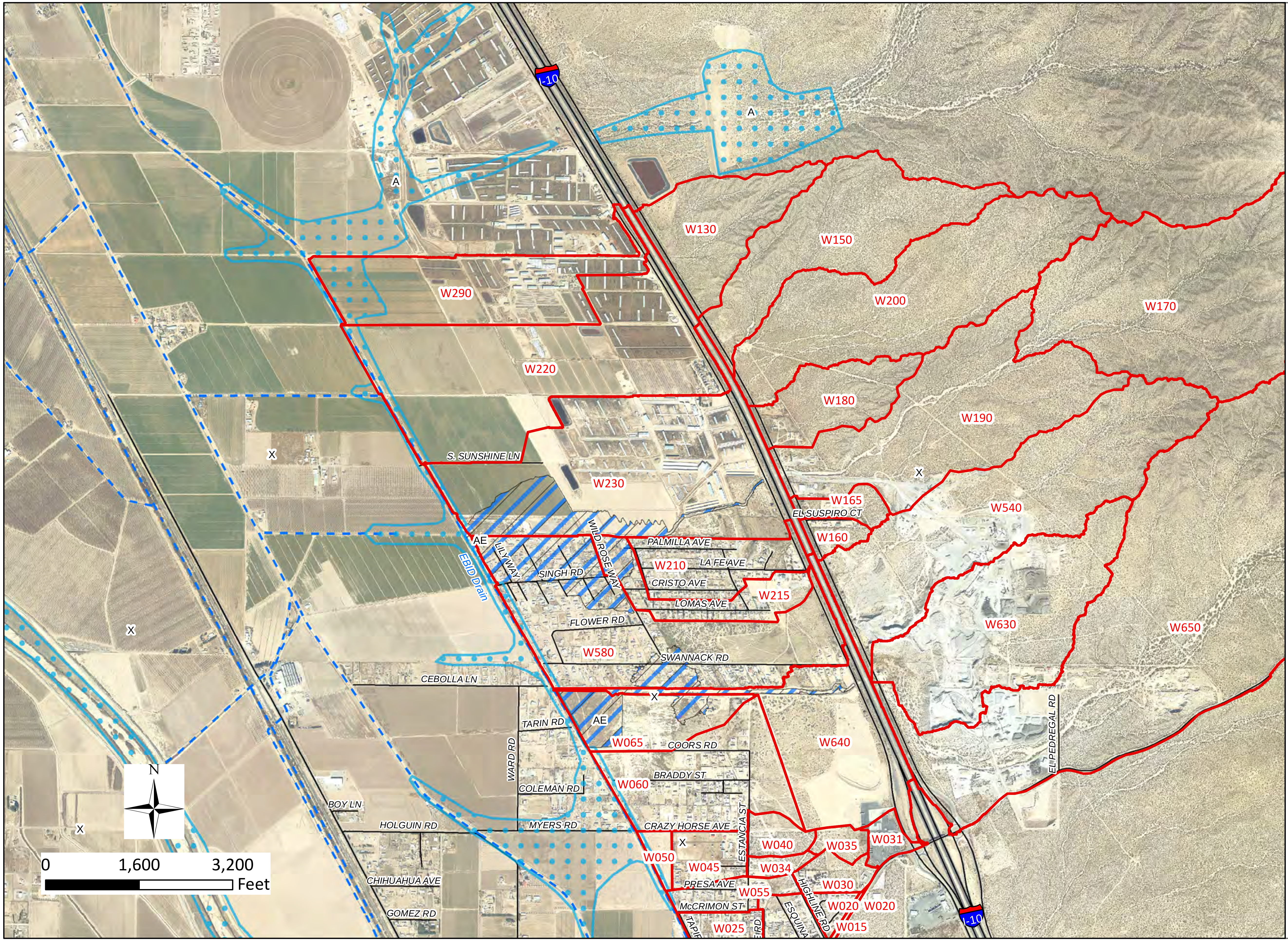


**Legend**

- Subbasin Boundary

**FEMA Flood Zone**

- A
- AE
- AH
- AO
- X
- EBID Drain
- Roads

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**Figure 6**
**Floodplain Overview**

August 2019

### C. Drainage Basin Delineation

The Vado/Del Cerro Arroyo watershed generally drains from northeast to southwest. The overall watershed area of 12.3 square miles was subdivided into 37 subbasins as shown on **Figure 5.** Subbasin delineation was automated using Arc Hydro version 10.2 and HEC-Geo-HMS version 10.2 in conjunction with ESRI ArcGIS Version 10.2.2. Arc Hydro tools were used to perform spatial analysis on the 2018 Digital Elevation Model (DEM) to derive several data sets that collectively describe the drainage patterns of the watershed. The Arc Hydro tools process the terrain model, delineates the outer watershed boundary, and generates the stream network required to compute longest flow paths, flow path lengths and average subbasin slopes. The subbasin boundaries delineated by the geospatial processing were field verified during the site visits. **Figure A,** located at the end of this report in a map pocket, presents the subbasins in greater detail along with topographic data

### D. Storms Evaluated

The DACFC requested that the 10, 25, 50 and 100-year - 24-hour duration storms be simulated.

### E. Hydrologic Computer Program

The U.S. Army Corps of Engineers Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) Version 4.2.1 was selected for hydrologic modeling.

## 2.4 RAINFALL DATA

**Rainfall Distribution**

The Vado Arroyo Watershed is located within the Natural Resources Conservation Service (NRCS), previously the Soil Conservation Service (SCS), Type II rainfall distribution area as defined by the NRCS.

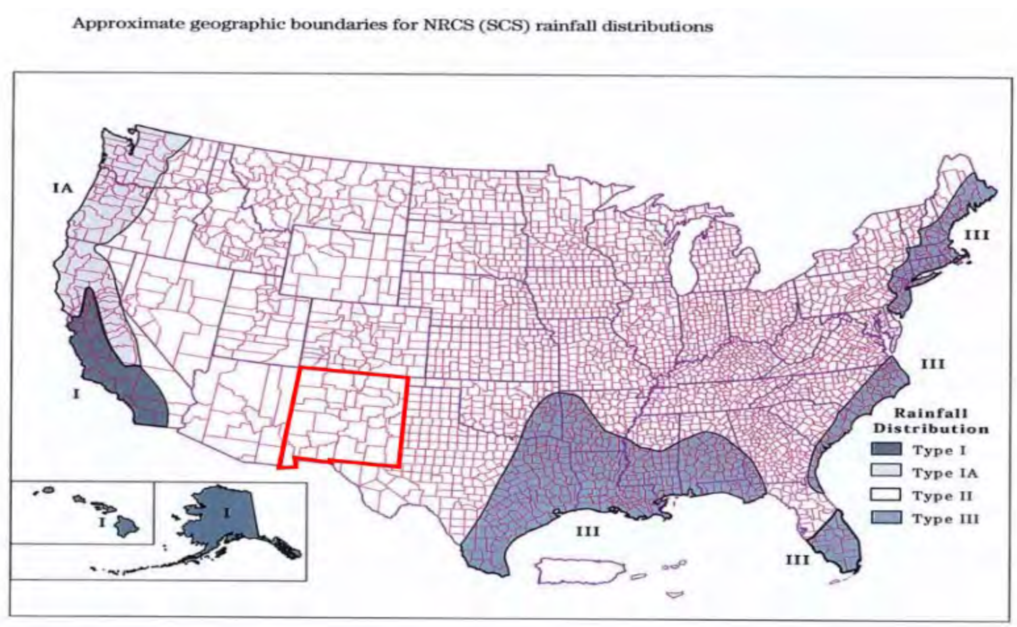



**Figure 7: Approximate Geographic Boundaries for NRCS Rainfall Distribution**

**Figure 7** illustrates the Type II boundaries. The DACFC directed Smith to use the 25% Frequency Storm Distribution storm to simulate the Type II-75 rainfall distribution which is supported by Figure R1 and R2 in **Appendix C**. This distribution is available in the HEC-HMS program and it places peak intensity of the rainfall at 25% of the storm duration, or at 6 hours for a 24-hour storm. The 25% Frequency Distribution Storm also distributes approximately 80% of the cumulative rainfall depth at 6 hours in the 24-hr storm. The SCS Type II on the other hand only distributes 40% of the cumulative rainfall depth over the same time. As a result, the peak discharges resulting from a 25% Frequency Storm will be higher.

**Figure 8** was adopted from a recent document by the Albuquerque Metropolitan Arroyo and the Flood Control Authority (AMAFCA), called the *State of Practice for Hydrology, Migrating from AHYMO'97 to HEC-HMS (and USEPA SWMM)* by Mr. Charles Easterling P.E., dated June 2018. This figure provides a graphical comparison between the different 24-hour rainfall distributions.

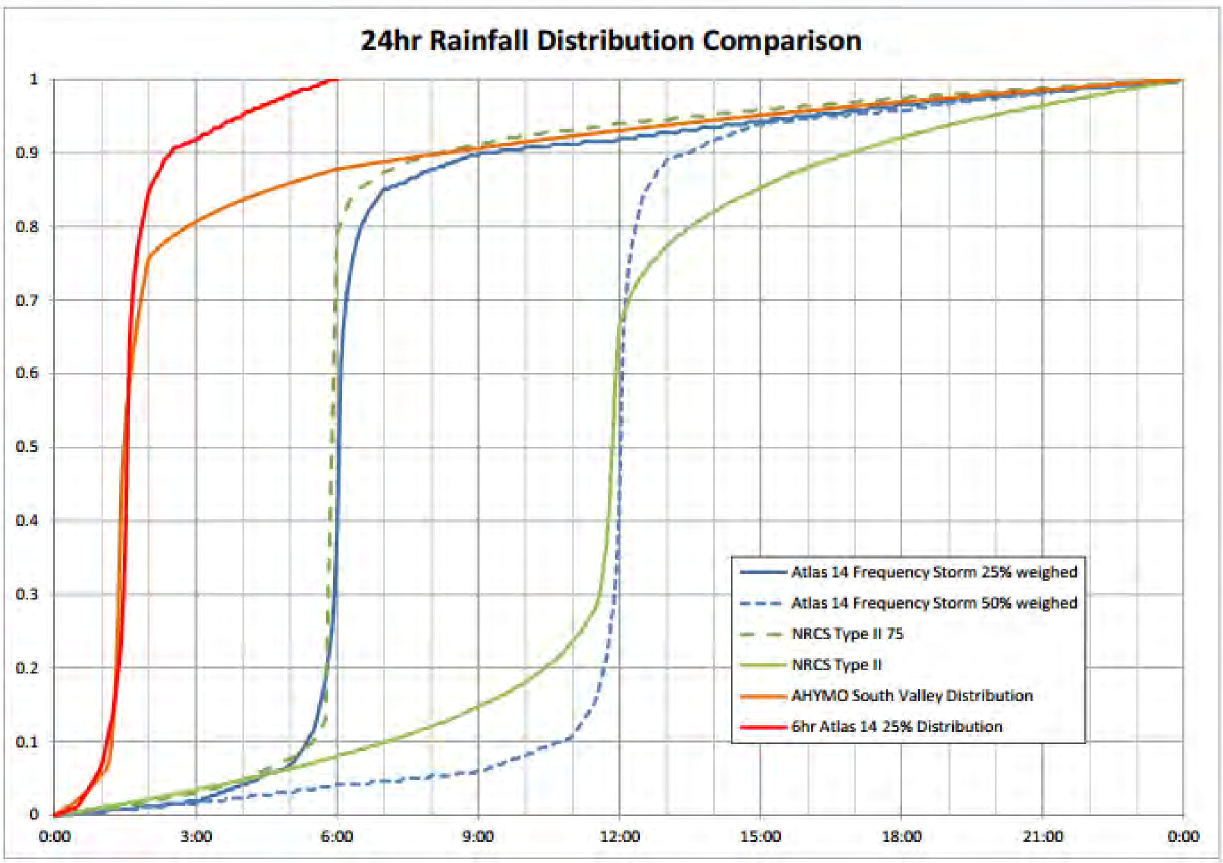



**Figure 8: 24 Hour Rainfall Distribution Comparison**

**Point Rainfall Data**

Point rainfall data were obtained from the NOAA Atlas 14 website for the watershed centroid. The estimated 100-year and 10-year - 24-hour precipitation depths are 3.52 inches and 2.19 inches, respectively. **Table C1** (**Appendix C**) documents the point precipitation depths used as input for the HEC-HMS model. **Appendix C** also contains the printouts from the NOAA Atlas 14-point rainfall data.

## 2.5 SOILS DATA AND RUNOFF CURVE NUMBERS (CNS)

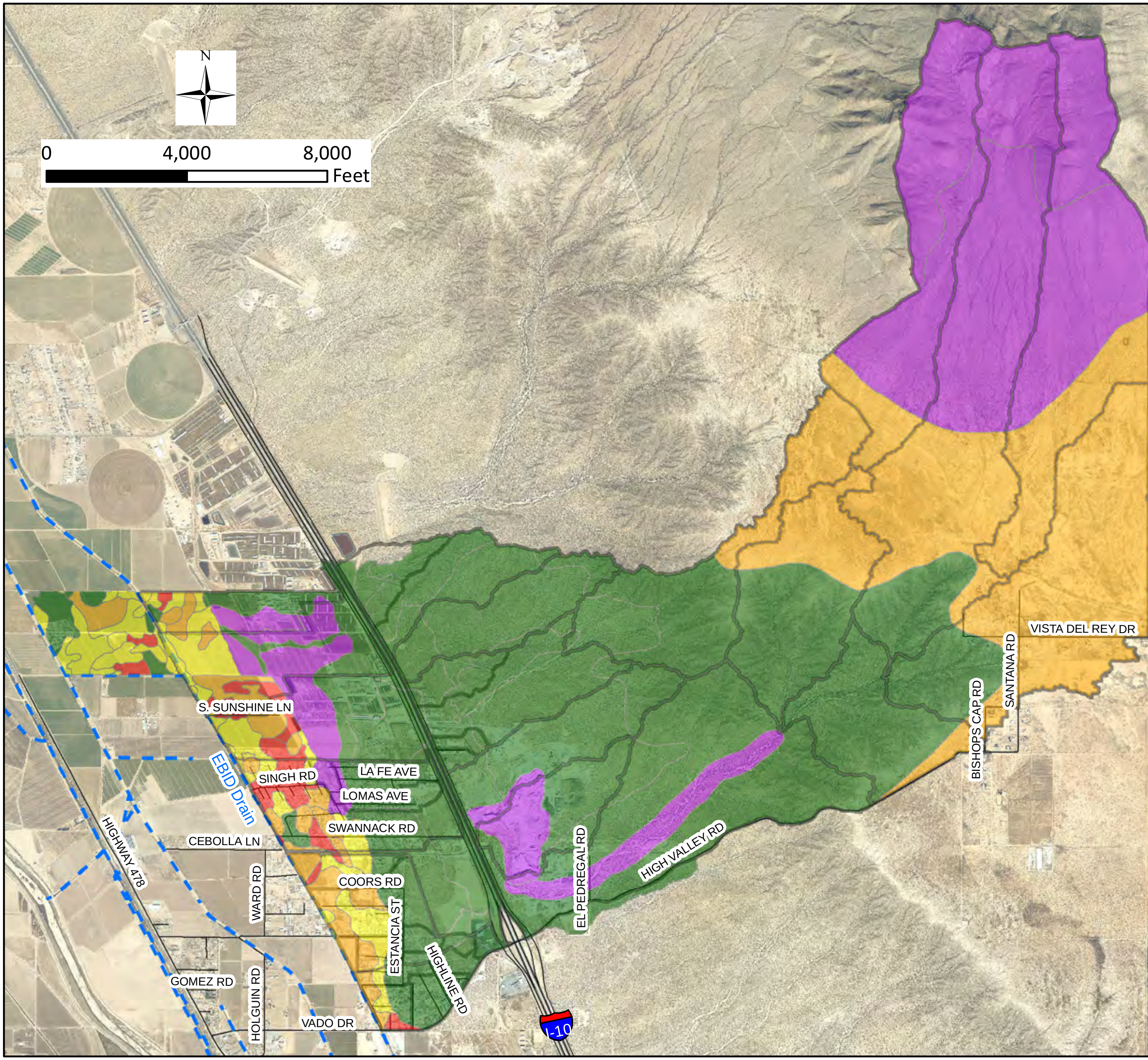
### A. Hydrologic Soil Information

The NRCS Runoff Curve Number (CN) Method was used to simulate the excess precipitation (storm runoff) as a function of the rainfall initial abstraction loss and rainfall infiltration loss. The CN value is selected based on the following items:

1. Antecedent Runoff Condition (ARC). This term represents an assumption as to the watershed moisture condition at the time of the storm event. CN values have been developed by the NRCS for three moisture conditions defined as either dry (ARC I), average (ARC II) or wet (ARC III). The average runoff condition (ARC II) was assumed for selection of CN values.
2. Soil characteristics based on the soil type and associated Hydrologic Soil Group (HSG) A, B, C or D.
3. Land use and cover type (imperviousness, vegetation type, agriculture, etc.)
4. Hydrologic Condition that is an estimate of ground cover density (poor, fair, good)

For the Vado Arroyo Watershed, CNs were selected for residential, commercial, and semi-arid rangelands (desert shrub assuming poor conditions) as defined in tables obtained from "Urban Hydrology for Small Watersheds, Natural Resources Conservation Service, TR-55 (Cronshey, 1986*).* A summary of the CNs used for the DMP are included in **Appendix C** along with the reference TR-55 tables.

The typical vegetative cover density as observed in the basin was generally poor, or less than 20% cover. **Appendix C** contains a detailed soils report obtained from the NRCS Web Soil Survey. The information obtained includes the soil map unit locations, distribution of hydrologic soil groups (HSG) and cover types for the various soil map units. **Figure 9** also shows the distribution of HSG (A, B, C, and D as defined by the NRCS Web Soil Survey) map for the watershed area. The soil information was used to determine the Curve Number (CN) for the watershed subbasins.




## Legend

**Hydrologic Soils Group**

- A
- B
- C
- D
- NA
- Subbasin Boundary
- EBID Drain
- Roads

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**Figure 9**
**Hydrologic Soils Groups**

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## 2.6 TRAVEL TIME ($T_t$), TIME OF CONCENTRATION ($T_C$), AND UNIT HYDROGRAPH LAG TIME ($T_L$) COMPUTATIONS

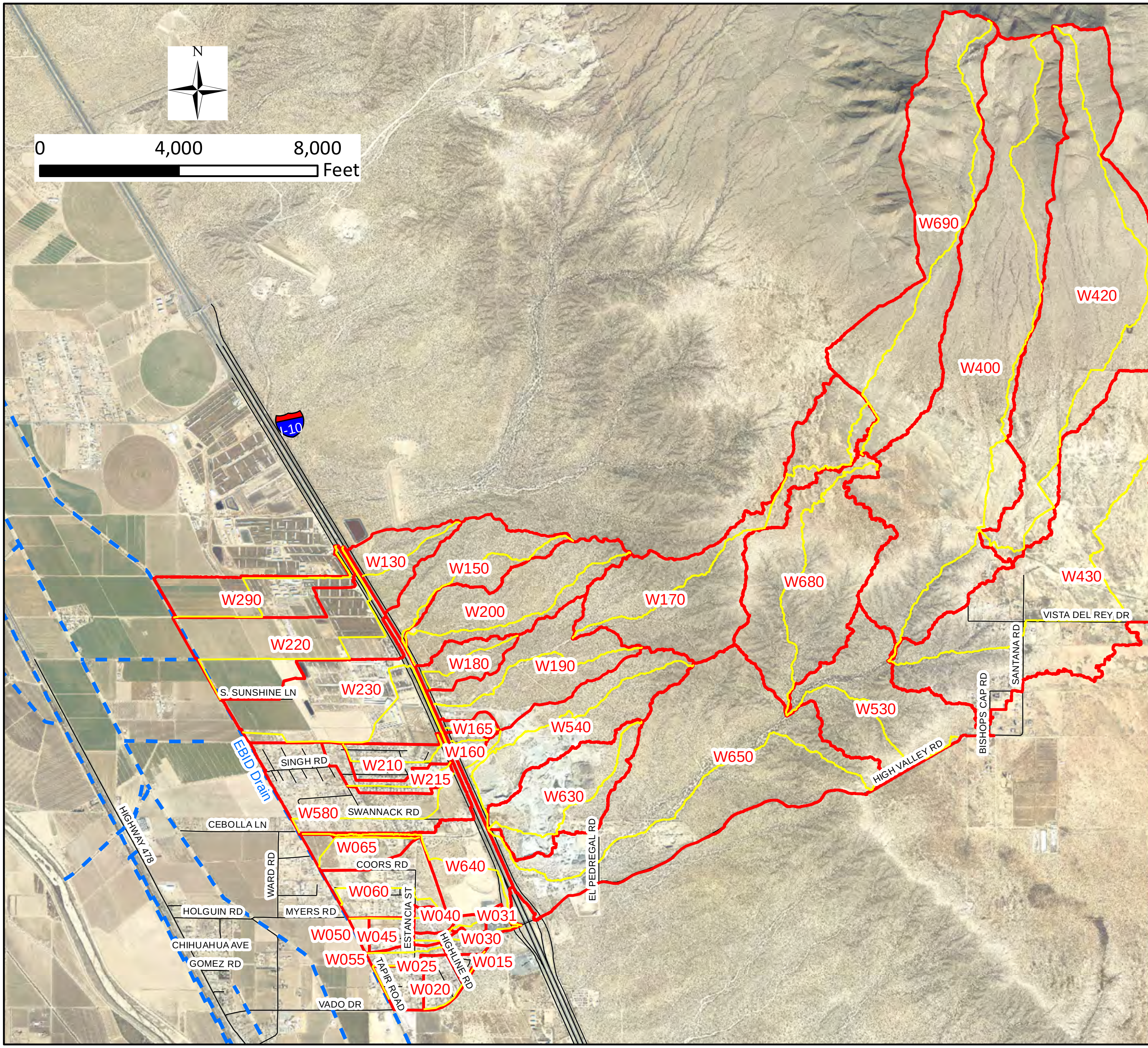
The TR-55 method (Cronshey, 1986, pp. 3-1 – 3-4) was used to compute the time of concentration for the subbasins in the Vado Watershed. A water course may have up to three sub-reaches that comprise the longest flow path as defined by the TR-55 method, including:

- **Sub-Reach 1** defined as an upper overland sheet flow reach not to exceed 300 ft in length. The method allows the engineer to exercise judgement on the appropriate reach length based on watershed characteristics. For the subbasins in the Vado Watershed, a typical length of 100 ft was selected.
- **Sub-Reach 2** defined as a shallow concentrated flow reach not to exceed 2000 ft. The maximum length of 2000 ft was selected for computations.
- **Sub-Reach 3** defined as a channel flow reach that comprises of the remainder of the flow path.

The time of concentration ($T_c$) for the watercourse equals the summation of travel times for each sub-reach. $T_c$ is defined as the time required for water to travel from the most hydraulically remote point in a subbasin to the point of interest or the outlet of the subbasin. The NRCS Unit Hydrograph Lag Time Method ($T_L$) was applied to the $T_c$ to compute the unit hydrograph Time to Peak ($T_p$). Note that Lag Time = 0.6 $T_c$. **Appendix C** contains the reference pages from National Engineering Handbook (NRCS, 2010, Chapter 15) describing the TR-55 method procedures used for each water course sub-reach previously described.

Using spatial analysis, elevations, lengths and slopes were extracted from the DEM. Typical channel widths were measured from the ortho-imagery provided by the DACFC. Manning's Roughness Coefficients "n" were chosen based on guidance provided in "Open Channel Hydraulics" (Chow, 1959). Copies of "n" value tables are included in **Appendix C**.

**Table 2** located in Section 2.12 provides the computed times of concentration and lag times for each subbasin. For more detail output see **Table C3** (**Appendix C**) which summarizes the travel time, time of concentration, and lag time data. See **Figure 10** for a simplified graphical representation of the delineated Tc flow paths for the Vado Arroyo Watershed. **Figure A** (in the Map Pocket) presents greater detail and illustrates the longest flow paths delineated for all the subbasins.




## Legend

- Subbasin Boundary
- Tc Flowpaths
- EBID Drain
- W200 Subbasin Name

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DONA ANA COUNTY NEW MEXICO

Prepared By:

SMITH ENGINEERING

**Figure 10 Time of Concentration Map**

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## 2.7 CHANNEL ROUTING

The "Muskingum-Cunge" channel routing method was applied to route hydrographs. Manning's Roughness Coefficients were chosen based on guidance provided in the Open Channel Hydraulics textbook (Chow, 1959), included in **Appendix C**. Channel routing lengths, slopes and typical bottom width were assumed based on the DEM and orthophotography. **Table C4 (Appendix C)** presents the Muskingum-Cunge channel routing input data summary. Arroyo bed runoff losses from infiltration and percolation were assumed to be small and were not considered or simulated. Routing reaches are shown on **Figure 11**, below.

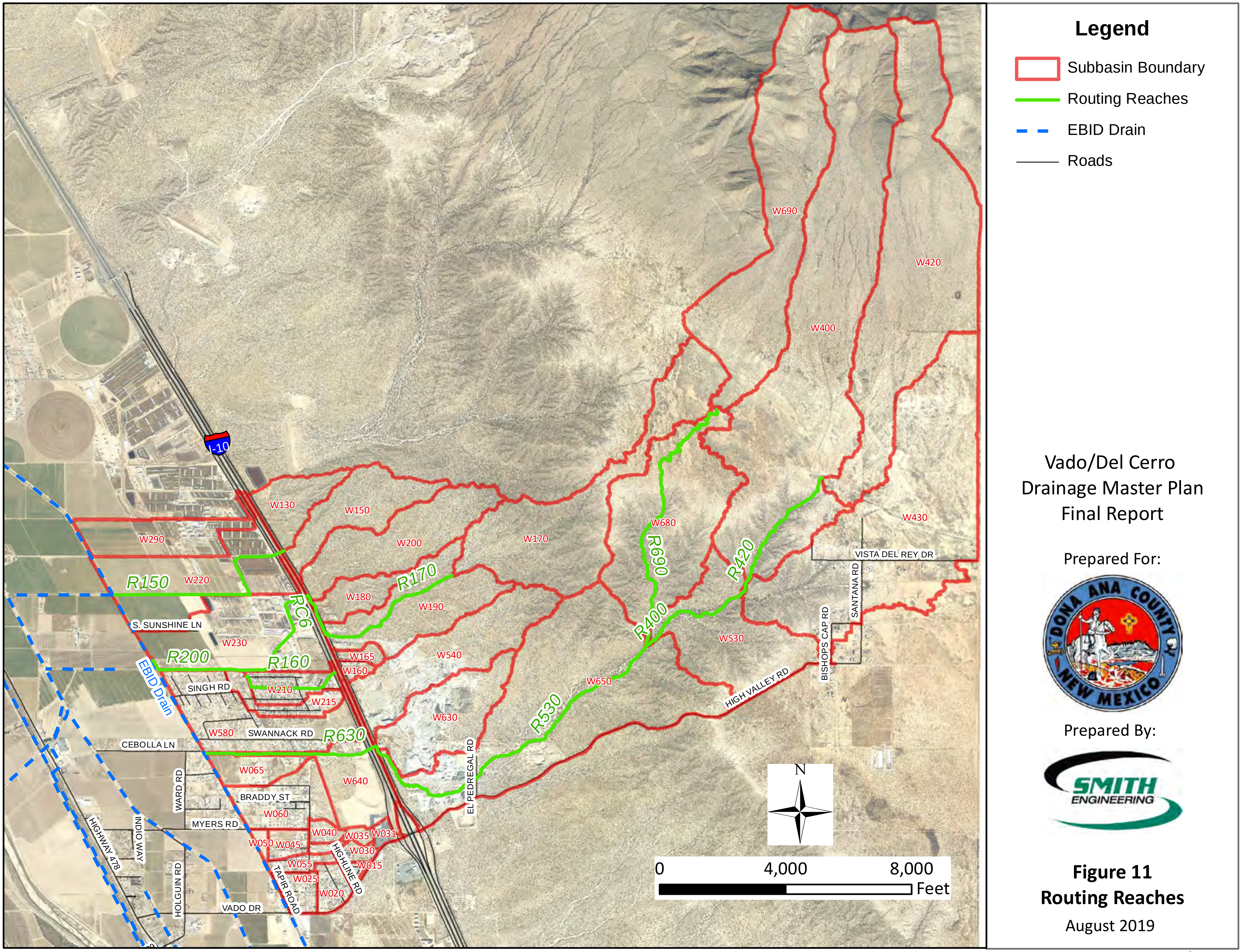


**Figure 11**
**Routing Reaches**
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## 2.8 SEDIMENT BULKING

The HEC-HMS models simulate clear water hydrographs unless a “Flow Ratio” is applied to simulate sediment volume within hydrographs. This parameter is also called sediment bulking. A sediment bulking value of about 19% is considered the limit before mud flow would occur. Refer to the "References" section of **Appendix C** that contains a portion of the "Sediment and Erosion Design Guide, and Figure 3.8 (Mussetter Engineering Inc. Nov. 2008), that is the basis of the 19% limit.

For this basin, Flow Ratio values were assumed based on engineering experience and judgement. The surrounding area is largely undeveloped with field conditions showing, even on roads, sediment deposits. Based on this and on visual estimates based on the orthophotography presented in the Drainage Basin Map, **Figure 5**, a 10% sediment bulking factor was used. That assumption is based on review of information presented in Mussetter Engineering, Inc. (2008). **Appendix C** contains a copy of relevant pages from that document. **Table C5** included in **Appendix C** represents the flow ratio assumptions for each subbasin

## 2.9 HYDROLOGIC DATA SUMMARY

**Tables C5** in **Appendix C** provides a summary table for all the input data required for the HEC-HMS model.

## 2.10 COMPUTATION TIME INCREMENT FOR HEC-HMS MODELS

For this project, a 5-minute computational time step was utilized.

## 2.11 UPSTREAM DETENTION AT CULVERT STRUCTURES

Typically, culvert structures that cross under major highways are built up against elevated embankments. This allows water to pond against the inlet side of the structure. In some instances, the culverts are under capacity and cannot convey the peak discharges and as such, the embankments act as detention ponds where the water ponds and spreads laterally**.** Consequently, the discharge rates to the downstream analysis points at these locations are purely a function of maximum culvert capacity. Upstream ponding due to under capacity culverts provides a significant downstream benefit in the higher return period storms since the peak discharges can be attenuated due to upstream ponding. Upstream ponding was utilized for Culvert C1- C2 particularly due to the topographic layout upstream of the culvert and the severe meandering transition of the channel approach to the culvert. A 2-dimensional surface water model was used to determine the magnitude of the upstream ponding. A more detailed description of the modeling procedure is discussed in Section 3.

## 2.12 HEC-HMS HYDROLOGIC MODELS AND SUMMARY RESULTS

**Table 2**, below contains a summary of the subbasin hydrologic data that were applied in the HEC-HMS hydrologic models and the 10 and 100-yr. 24-hr. storm runoff peak discharges for each subbasin

**Table D-1** through **D-4** included in **Appendix D** present HEC-HMS summary results for existing conditions for each representative storm event. **Table D-8** through **D-11,** in **Appendix D,** present HEC-HMS summary results for the proposed conditions.

### Table 2: Subbasin Existing Conditions Hydrologic Data Summary (HEC-HMS) Input

| Vado/Del Cerro DMP<br>Subbasin Hydrologic Data Summary (HEC-HMS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| HEC-HMS Input Parameters | | | | | | 10 yr.-24 Hr Storm | | 100 yr.-24 Hr Storm | |
| Basin No. | Basin Area | Runoff Curve Number Based on ARC II Conditions | Time of Concentration (Tc) | Lag Time | Flow Ratio | Peak Discharge | Runoff Volume | Peak Discharge | Runoff Volume |
| | sq mi | | minutes | minutes | | cfs | ac-ft | cfs | ac-ft |
| a | a | b | c | c | d | | | | |
| W430 | 1.225 | 69 | 148 | 88.7 | 1.1 | 70 | 24.8 | 249 | 77.6 |
| W400 | 1.679 | 76 | 94 | 56.1 | 1.1 | 274 | 58.4 | 748 | 149.3 |
| W420 | 1.187 | 77 | 87 | 52.4 | 1.1 | 222 | 44.2 | 588 | 110.4 |
| W690 | 0.878 | 77 | 65 | 38.9 | 1.1 | 201 | 32.7 | 536 | 81.6 |
| W680 | 0.648 | 68 | 154 | 92.5 | 1.1 | 32 | 12.0 | 119 | 38.9 |
| W530 | 0.442 | 64 | 71 | 42.6 | 1.1 | 21 | 5.5 | 105 | 21.0 |
| W650 | 1.134 | 74 | 87 | 52 | 1.1 | 162 | 34.2 | 475 | 92.0 |
| W540 | 0.393 | 77 | 49 | 29.5 | 1.1 | 108 | 14.7 | 287 | 36.6 |
| W630 | 0.303 | 79 | 37 | 21.9 | 1.1 | 118 | 12.9 | 297 | 30.7 |
| W640 | 0.215 | 72 | 63 | 38 | 1.1 | 31 | 5.6 | 99 | 15.9 |
| W065 | 0.088 | 74 | 33 | 19.8 | 1.1 | 21 | 2.4 | 62 | 6.5 |
| W170 | 0.649 | 69 | 127 | 75.9 | 1.1 | 42 | 13.1 | 149 | 41.1 |
| W190 | 0.336 | 74 | 42 | 25.3 | 1.1 | 76 | 10.1 | 227 | 27.3 |
| W200 | 0.346 | 65 | 43 | 25.8 | 1.1 | 25 | 4.8 | 120 | 17.5 |
| W150 | 0.237 | 67 | 35 | 21 | 1.1 | 25 | 4.0 | 109 | 13.5 |
| W180 | 0.096 | 70 | 27 | 16 | 1.1 | 16 | 1.9 | 58 | 5.8 |
| W165 | 0.026 | 80 | 18 | 10.6 | 1.1 | 15 | 1.1 | 36 | 2.5 |
| W230 | 0.429 | 68 | 81 | 48.5 | 1.1 | 33 | 8.0 | 127 | 25.8 |
| W210 | 0.092 | 64 | 40 | 23.8 | 1.1 | 5 | 1.0 | 28 | 4.0 |
| W160 | 0.020 | 66 | 13 | 7.7 | 1.1 | 2 | 0.3 | 12 | 1.0 |
| W220 | 0.421 | 72 | 80 | 47.8 | 1.1 | 52 | 10.9 | 165 | 31.0 |
| W130 | 0.014 | 67 | 24 | 14.6 | 1.1 | 2 | 0.2 | 8 | 0.8 |
| W580 | 0.327 | 67 | 47 | 28.1 | 1.1 | 30 | 5.5 | 127 | 18.6 |
| W215 | 0.072 | 65 | 27 | 16 | 1.1 | 6 | 0.9 | 29 | 3.3 |
| W290 | 0.206 | 71 | 60 | 35.8 | 1.1 | 27 | 4.9 | 92 | 14.5 |
| W020 | 0.054 | 59 | 14 | 8.5 | 1.1 | 2 | 0.4 | 16 | 1.8 |
| W015 | 0.015 | 65 | 12 | 7.2 | 1.1 | 1 | 0.2 | 8 | 0.7 |
| W025 | 0.055 | 68 | 23 | 13.8 | 1.1 | 8 | 1.0 | 34 | 3.3 |
| W030 | 0.027 | 63 | 18 | 11 | 1.1 | 2 | 0.3 | 11 | 1.1 |
| W031 | 0.018 | 98 | 12 | 7.2 | 1.1 | 37 | 2.0 | 60 | 3.4 |
| W055 | 0.033 | 62 | 23 | 13.5 | 1.1 | 2 | 0.3 | 12 | 1.4 |
| W060 | 0.171 | 73 | 42 | 25.2 | 1.1 | 35 | 4.8 | 109 | 13.3 |
| W035 | 0.016 | 63 | 12 | 7.2 | 1.1 | 1 | 0.2 | 8 | 0.7 |
| W034 | 0.012 | 63 | 12 | 7.2 | 1.1 | 1 | 0.1 | 6 | 0.5 |
| W045 | 0.041 | 69 | 23 | 13.9 | 1.1 | 7 | 0.8 | 28 | 2.6 |
| W040 | 0.025 | 63 | 12 | 7.2 | 1.1 | 2 | 0.3 | 13 | 1.1 |
| W050 | 0.013 | 77 | 12 | 7.2 | 1.1 | 7 | 0.5 | 20 | 1.2 |

**a** - See Drainage Basin Map (Figure A in map pocket) for Subbasins **b** - See Table C2 located in Appendix C

**c** - See Table C3 located in Appendix C

Note: Flow Ratios simulate sediment volume within the hydrograph clear water volume. Values are assumed a value of 10% for all subbasins . Refer to Appendix C "Sediment and Erosion Design Guide, Figure 3.8 (Mussetter Engineering Inc. Nov. 2008)

## 2.13 PERFORMANCE OF EXISTING DRAINAGE INFRASTRUCTURE

### A. Existing Culvert Capacities

All existing culverts, shown in **Figure 4**, convey flows under I-10 were evaluated for maximum discharge capacity. A 15% clogging factor was applied to account for debris. However, it should be noted that the culverts need to be maintained and from photos shown in **Appendix A** are experiencing clogging factors as high as 100%. See **Appendix H** for Culvert Master calculation reports and detailed data summary table. The peak inflow at these culverts was compared against their peak discharge capacity determining the flow that could be passed to the west side during the various storms. For culverts C1 and C2, upstream ponding was simulated and is discussed in Section 3. Other than culverts C1 and C2, the culvert crossings under the I-10 have enough capacity to convey flows from the east side of I-10. **Table 3** below summarizes the discharges from the 10 and 100-yr 24-hr storm event for each culvert. **Section 3** contains the hydraulic analysis completed on Vado Channel.

Table 3: Summary of Existing Culvert Capacity

| **Existing Culvert Data and 10 & 100-yr Storm Event Results**<br>**Vado/Del Cerro Drainage Master Plan** | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CULVERT DATA FOR CULVERT MASTER | | | | | | | | Culvert Capacity | | | | 10-yr 24-hr storm | | | | 100-yr 24-hr storm | | | |
| Culvert Name / Location Description | Existing or Proposed | No. of Culverts | Material | Culvert size | Length | Slope | Maximum Available Headwater Elev. | Assumed Tailwater Elev. | Maximum Culvert Capacity from Culvert Master | Maximum Culvert Capacity 15% Clogging Factor | Discharge Per Culvert | HEC-HMS Analysis Point Name | Peak Discharge | Spill flow (Max. Capacity minus peak discharge) - positive means excess capacity) | Extra Culverts Required Y or N | No. of Extra Culverts to pass flow (same as existing) | Peak Discharge | Spill flow (Max. Capacity minus peak discharge) - positive means excess capacity | Extra Culverts Required Y or N | No. of Extra Culverts to pass flow (same as existing) |
| | | | | inches | ft | ft / ft | feet | ft | cfs | cfs | cfs | | cfs | | | | cfs | | | |
| | | | | | | | | e | | f | i | | | | | | | | | |
| C1: NMDOT Crossing | Existing | 2 | CBC | 7-ft x10-ft | 195 | 0.02308 | 3888.00 | 3881.25 | 1323 | 1125 | 562 | J630 | 908 | 217 | N | | | | | |
| C2: Frontage Road | Existing | 4 | RCP | 48 | 65 | 0.02615 | 3882.25 | 3878.86 | 568 | 482 | 121 | J630 | | | | | | | | |
| C2: Frontage Road | Existing | 3 | RCP | 60 | 65 | 0.02615 | 3882.25 | 3878.86 | 607 | 516 | 172 | J630 | | | | | | | | |
| C2: Frontage Road | **Total** | | | | | | | | 1175 | 998 | 293 | J630 | 908 | 90 | N | - | 1175 | -177 | Y | 1 |
| C3 | Existing | 3 | RCP | 48 | 220 | 0.02705 | 3922 | 3916.5 | 497 | 422 | 141 | This Culvert was not modeled due to the HEC-RAS 2d model showing runoff from subbasin W540 Flows to C1 | | | | | | | | |
| C3 Frontage Road | Existing | 3 | CMP | 48 | 35 | 0.09143 | 3922.50 | 3918.35 | 167 | 142 | 47 | | | | | | | | | |
| C4a | Existing | 1 | RCP | 36 | 220 | 0.03182 | 3923.00 | 3911.50 | 80 | 68 | 68 | JC2 | 3 | 65 | N | 0 | 12 | 56 | N | 0 |
| C4a Frontage Road | Existing | 1 | CMP | 30 | 35 | 0.09143 | 3923.50 | 3916.75 | 38 | 32 | 32 | JC2 | 3 | 29 | N | 0 | 12 | 20 | N | 0 |
| C4b | Existing | 3 | RCP | 36 | 220 | 0.02545 | 3923.50 | 3913.50 | 236 | 201 | 67 | JC2 | 3 | 198 | N | 0 | 12 | 189 | N | 0 |
| C4b Frontage Road | Existing | 3 | CMP | 30 | 35 | 0.04029 | 3924.00 | 3919.00 | 107 | 91 | 30 | JC2 | 3 | 88 | N | 0 | 12 | 79 | N | 0 |
| C5 | Existing | 3 | RCP | 36 | 220 | 0.02545 | 3922.00 | 3913.50 | 182 | 155 | 52 | JC4 | 15 | 140 | N | 0 | 36 | 119 | N | 0 |
| C5 Frontage Road | Existing | 2 | CMP | 30 | 50 | 0.07600 | 3924.00 | 3918.75 | 30 | 26 | 13 | JC4 | 15 | 11 | N | 0 | 36 | -11 | Y | 1 |
| C6 | Existing | 2 | RCP | 48 | 220 | 0.04091 | 3916.50 | 3904.00 | 235 | 200 | 100 | JC5 | 76 | 124 | N | 0 | 230 | -30 | Y | 0 |
| C6 Frontage Road | Existing | 2 | CMP | 36 | 35 | 0.02857 | 3916.50 | 3913.50 | 75 | 64 | 32 | JC5 | 76 | -12 | Y | 0 | 230 | -166 | Y | 5 |
| C7 | Existing | 3 | RCP | 30 | 220 | 0.02273 | 3911.00 | 3898.75 | 220 | 187 | 62 | JC6 | 13 | 174 | N | 0 | 272 | -85 | Y | 1 |

a - See Figure 4 for culvert locations

b- See HEC-RAS Model Schematic for HEC-HMS analysis point locations

c - The maximum available headwater depth for the significant culverts were measured by Smith Engineering engineers

d- NMDOT crossing's downstream depth of 3.76 ft was assumed as the Maximum Available Headwater Elevation for the Frontage Road Crossings.

e - Assume tailwater elevation = the downstream invert elevation + 75% of the maximum available headwater depth.

f - Assume a 15% clogging factor at inlet due to sediment and debris / vegetation.

g - See HEC-HMS Summary output tables included in Appendix D

h - CulvertMaster output is included in Appendix G, assume a 15% clogging factor at inlet due to sediment and debris / vegetation

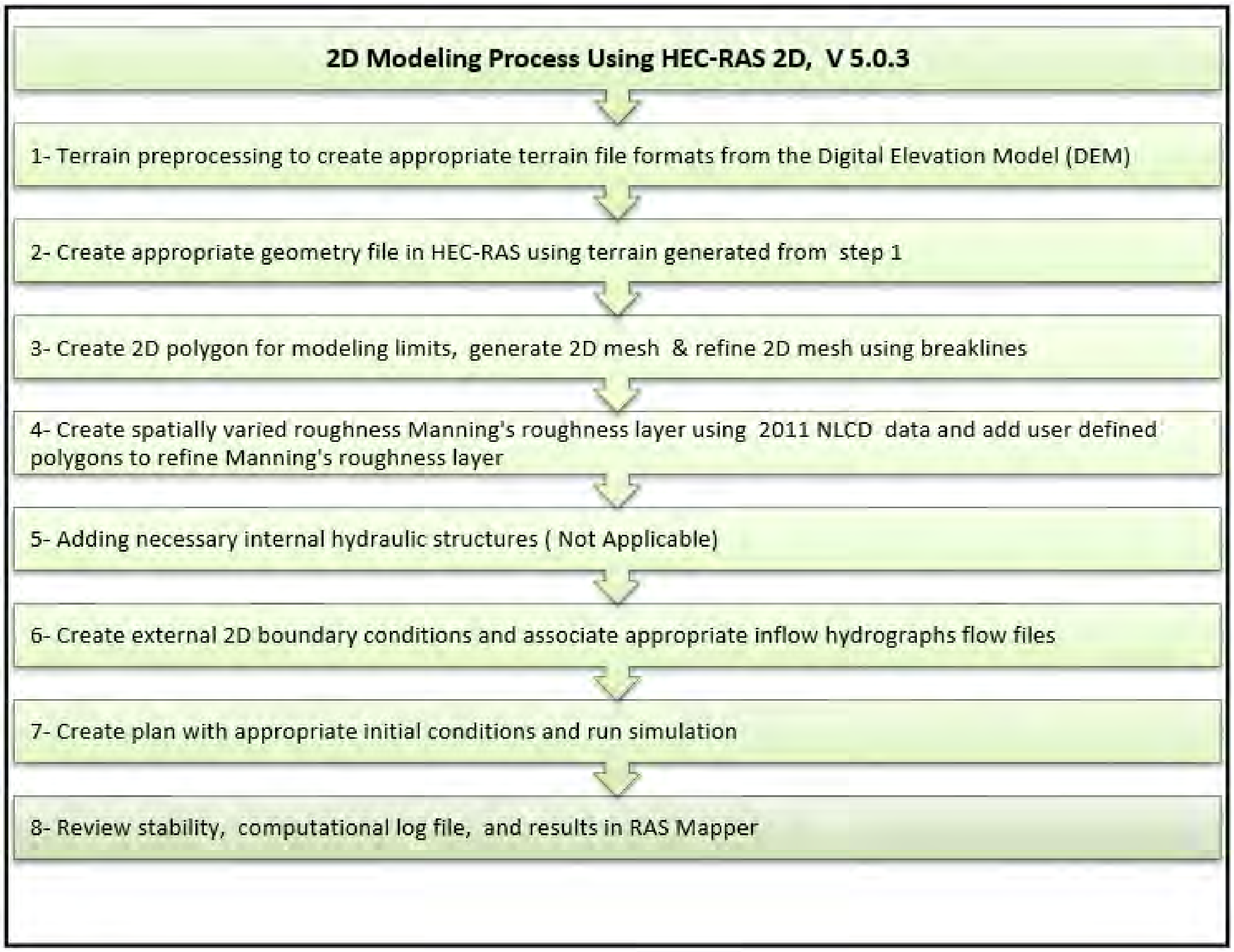
i -Compute as spill flow divided by Culvert Capacity.

Note: Culvert C1 is a box the units shown for this culvert are in feet as specified. The culvert rise is 7-ft and the span is 10-ft

## SECTION 3. HYDRAULIC ANALYSIS OF VADO CHANNEL

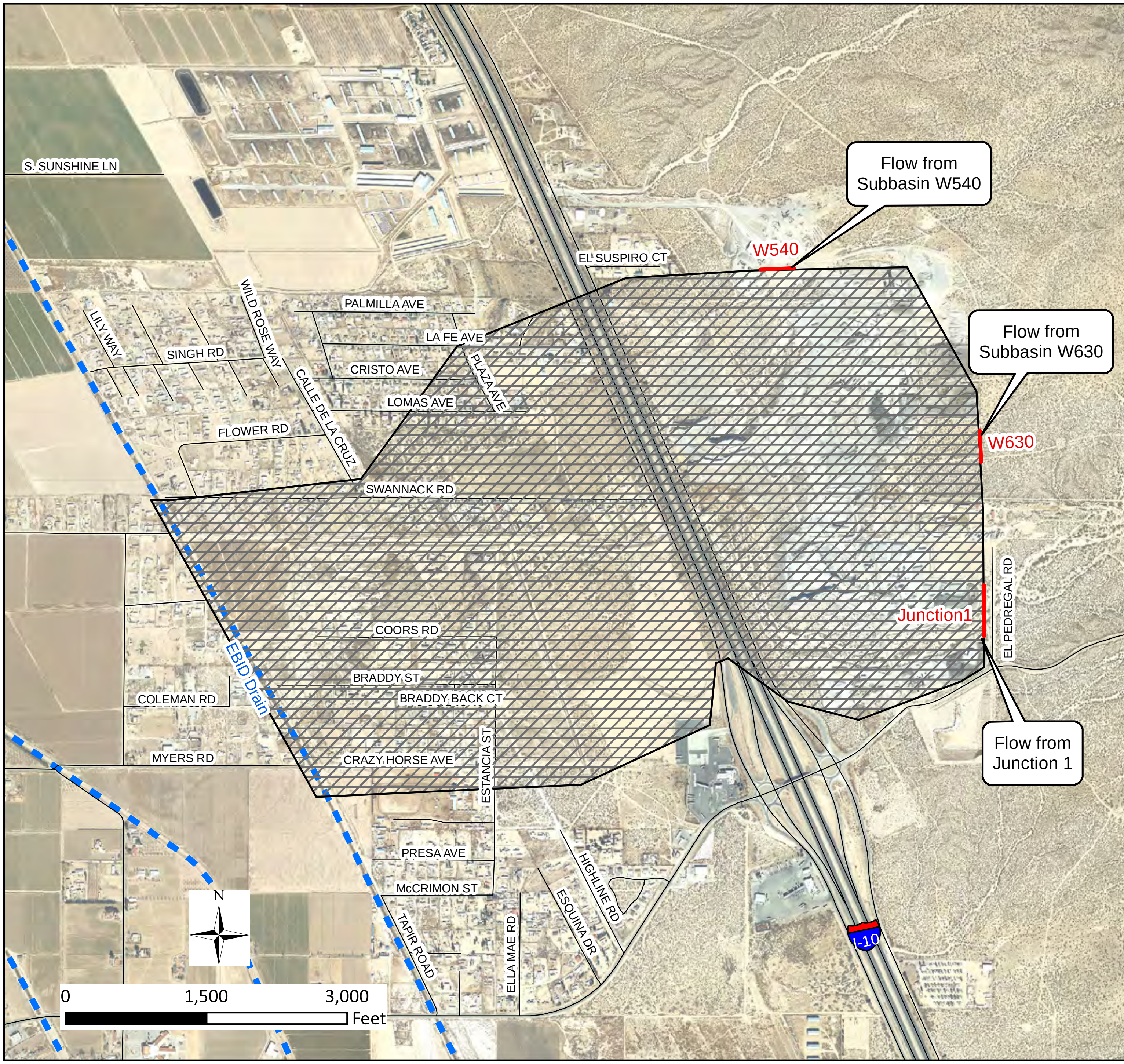
### 3.1 2-DIMENSIONAL SURFACE WATER MODELING

To understand the full impact of the inflows from the subbasins from the east side of I-10, a 2-dimensional HEC-RAS surface water model was created (as shown in **Figure 12**) to simulate surface flow directions and concentration points throughout shown study area. The following flow chart illustrates the process implemented to build a 2D model.




#### A. 2D Mesh Generation

Terrain preprocessing as outlined in Chapter 2 of the HEC-RAS user manual was performed after the data was incorporated as part of the geometry file in HEC-RAS. Using the bounding polygon, a 2D mesh was generated that consists of grids that are defined by the user to be a certain size. A 50 ft X 50 ft grid size was chosen for this study. The terrain model was further refined using break lines to simulate the high points in the terrain that would act as a barrier to flow. The 2D mesh was then saved as a geometry file to be used within HEC-RAS. **Figure 12** shows a 2D mesh created for the 2D study area.




**Legend**

- HEC-RAS 2D Mesh
- Upstream Boundary Condition
- Roads
- EBID Drain

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**Figure 12**
**2D Limits**
**of**
**Existing**
**HEC-RAS Model**

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### B. Spatially Varied Manning's Roughness Layer

A uniform 'n' value of 0.06 was assumed for the entire 2D mesh since the area being modeled was primarily undeveloped.

### C. Internal Hydraulic Structures

No internal hydraulic structures were modeled for the 2D mesh area. The requirement to model a hydraulic structure inside the 2D mesh is to have the culvert span only 2 adjacent cells. This works well for short culverts. In this case, C1 spans almost 200 ft. A lot of mesh manipulation would be required which could create modeling instability because of the attempt to capture the variation in the terrain over 2 cells. However, after several sensitivity analyses of simulations without a hydraulic structure in the mesh, it was clear that the model was overpredicting flow depths and showing overtopping of the highway at the lower return period storms. This was due to a lack of an opening for the flows to drain from the east to the west side of I-10.

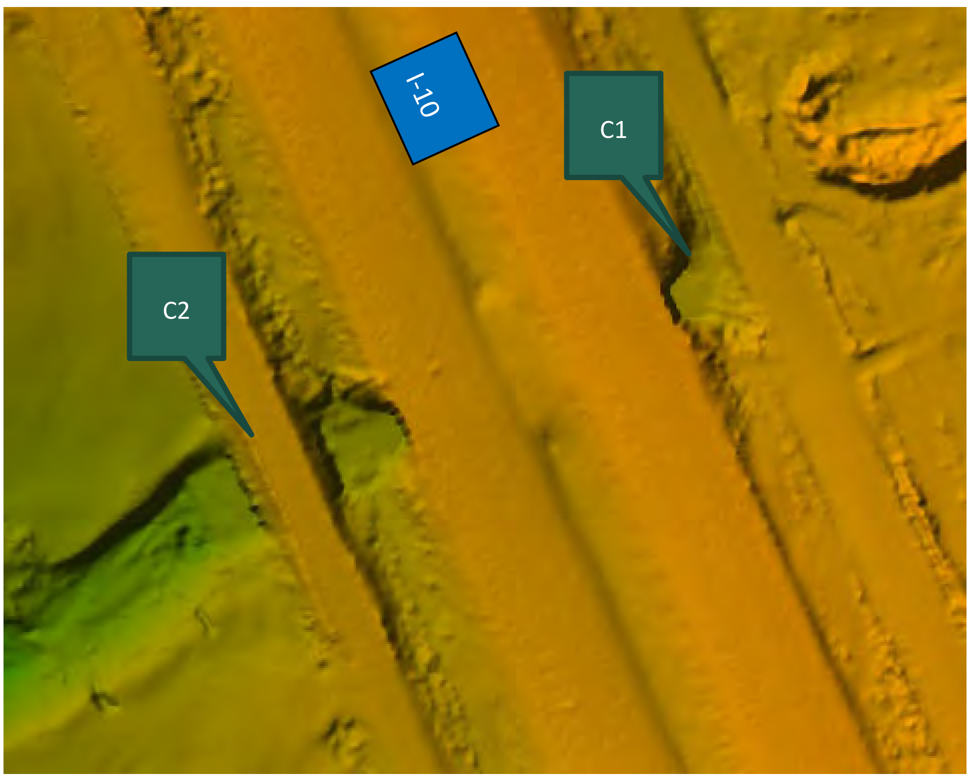



**Figure 13: Snapshot of Existing Terrain**

**Figure 13**: Snapshot of Existing Terrain shows the snapshot of what the existing terrain looks like. The inlet and outlet of the culverts are clearly defined in the terrain. However, there is no flow path to allow upstream flows to drain west underneath the highway like the culverts would allow. Therefore, the depth of the water predicted in this scenario is not accurate.

Smith developed a work around solution by using terrain manipulation tools available in Civil-Geo HEC-RAS which is a proprietary version of HEC-RAS that has a GIS based user interface. One of the available tools in the software allows the user to burn a stream of a user defined width into the terrain. Smith performed a series of culvert hydraulic computations based on the maximum head water depth to determine discharges for both culverts C1 and C2. Based on results summarized in **Table 1**, the conveyance restriction will be created by C2 at 1175 cfs. Due to the terrain the maximum headwater depth for C2 cannot exceed 7ft. C2 is comprised of an array of 48-inch and 60-inch culverts with a total span of 31 ft.

Therefore, a stream with a width of 31 ft was burned into the terrain allowing the software to interpolate a slope between the upstream and downstream invert elevations. This stream would mimic the flows that would flow through the culverts C1 and C2. Careful evaluation of the upstream headwater depths at both culverts were made based on the simulation results. The model results were compared against the culvert analysis done to ensure there was good correlation between the 2D model and Culvert Master in terms of headwater depth.

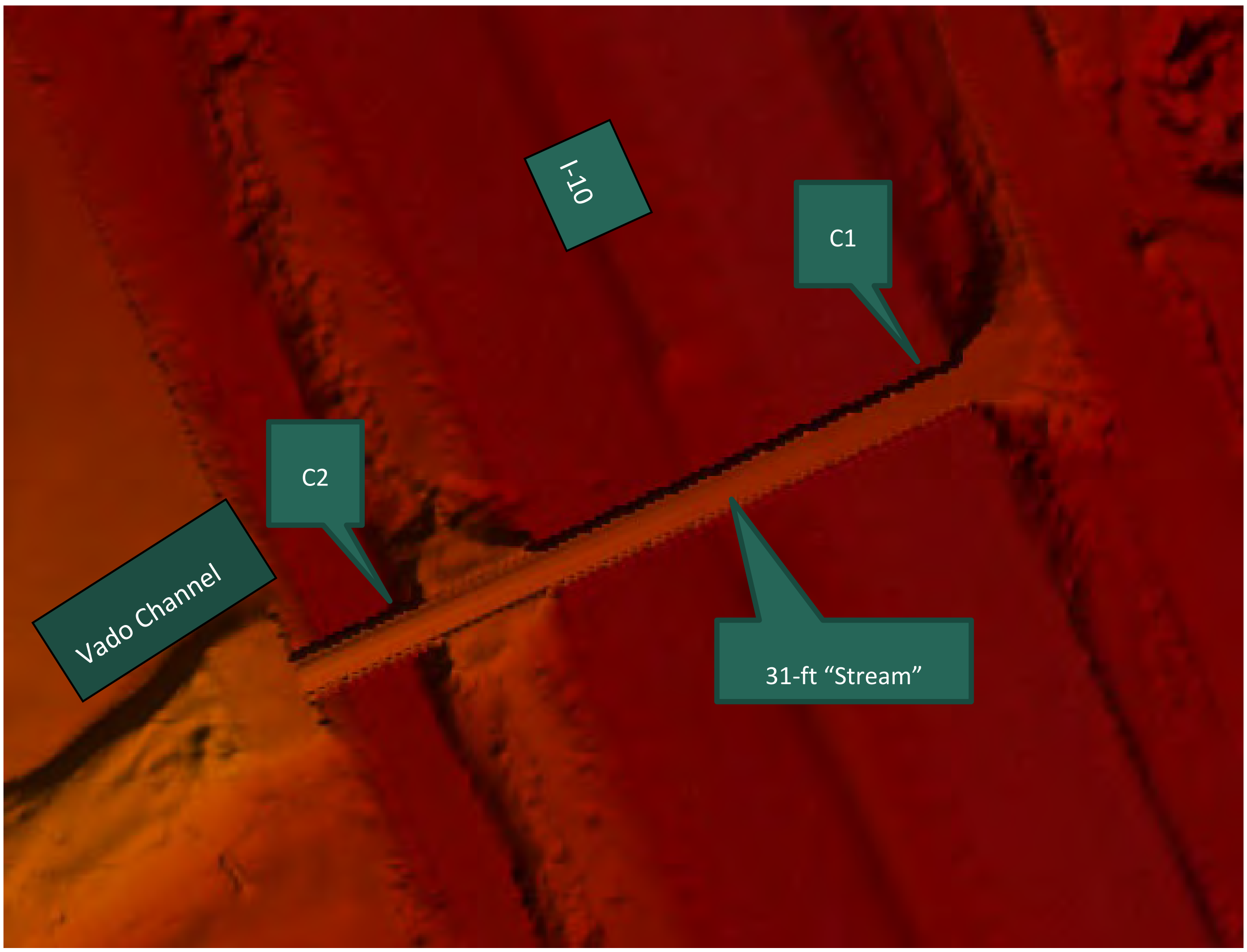



**Figure 14:Snapshot of Existing Terrain with Modified Stream Burned to Replicate Existing Culverts**

### D. External 2D Flow Area Boundary Conditions

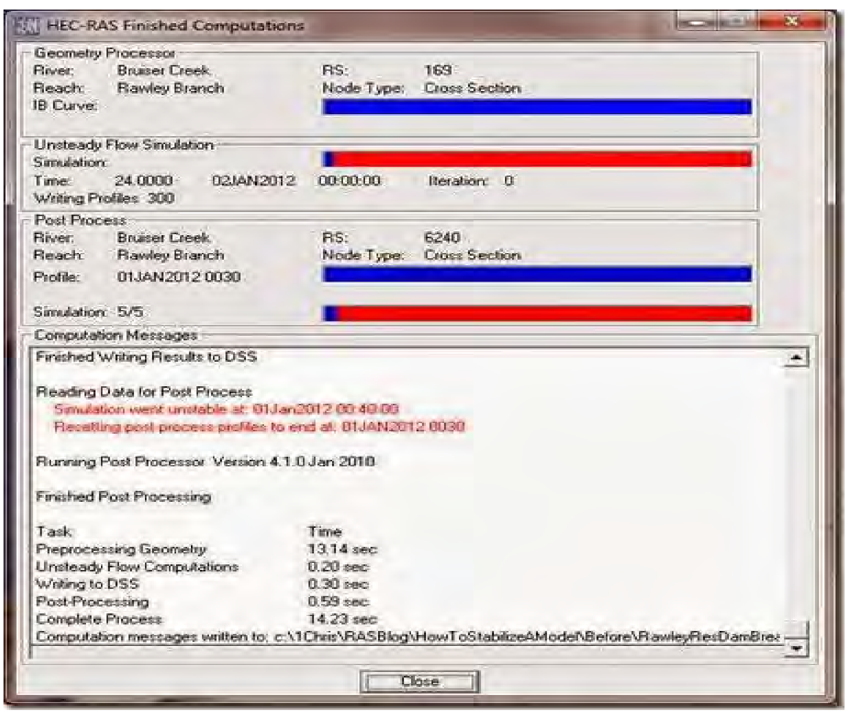
The 2D flow area must have upstream and downstream boundary conditions specified. For areas where flow leaves the model, normal depth was specified. Since the downstream areas are typically flat agricultural fields, a typical energy slope of 1% was specified. The upstream boundary conditions simulate locations where flows are added into the mesh. The hydrographs from the HEC-HMS hydrologic model, at the appropriate junctions representing Junction-1, subbasins W540 and W630, were imported into an unsteady flow file in HEC-RAS to simulate I-25 culvert crossing discharges. The energy slope within the unsteady flow file was assumed at 1%.

### E. Setting Up Plan Initial Conditions

An unsteady analysis plan was then set up and initial conditions for the 2D analysis was defined. All the default values for 2D flow options were assumed. The 2D area was assumed to have dry initial conditions. The program allows the 2D computations to be based on either the Diffusion Wave equation or the Full Momentum equation. There are guidelines in the user manual for HEC-RAS 2D on when to use the Full Momentum equation vs. Diffusion Wave. In this instance, the full momentum was used to compute subbasins with actual flow hydrographs from subbasins W540 and W630, and Junction-1. Based on the guidelines for Full Momentum Equation, a time step of 1 second was selected. At this point, the hydraulic properties for the cells within RAS Mapper were computed.

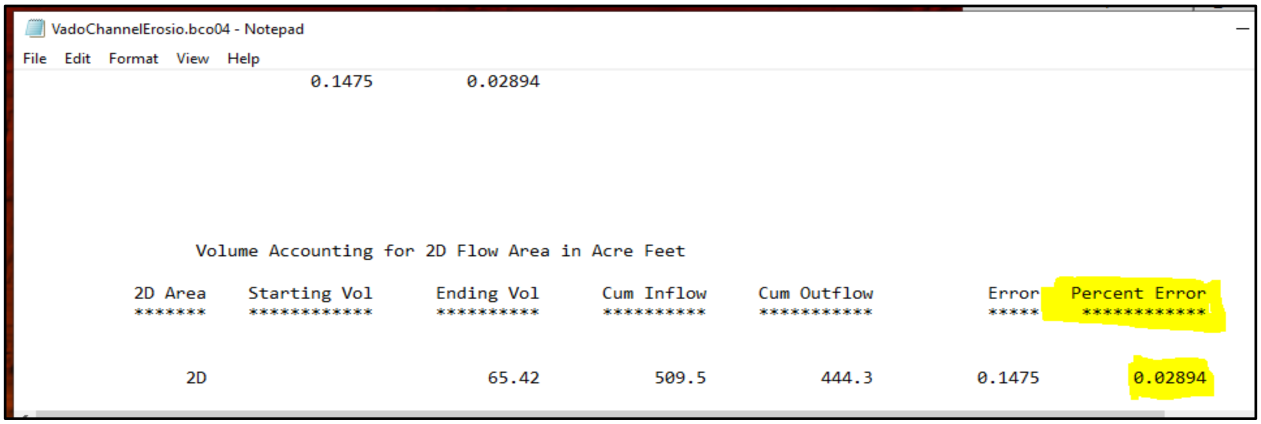
### F. Simulation Run and Results

The results from the 2D analysis are best viewed dynamically in RAS Mapper to see how the flow distributes over the terrain for the duration of the hydrograph. There are many variables that can be queried within RAS Mapper. The ones that are provided by default are depth, velocity, and water surface elevation. Typically, if the model has 2D mesh errors or incorrect simulation time step interval, it will be unable to converge the solution for the 2D mesh becoming unstable and a message appears as shown.



In this case, the above window did not occur proving the model was performing the computations and achieving convergence for all the cells. Upon completing the simulation run successfully, a window opens indicating that results are now ready to be viewed in RAS Mapper. The next check was to view the computational log file which is accessed through the Options tab in the Unsteady Flow Analysis window. The analysis does a volume continuity check for the simulation. The key number here is the percent error during the run shown in the box below.

This number should be very small if the model is running correctly. Because it covers a larger area the 2D model had an approximate error of 0.028% which is an excellent value. The output from the log is shown below with the percent error highlighted.


VadoChannelErosio.bco04 - Notepad

File Edit Format View Help

0.1475 0.02894

Volume Accounting for 2D Flow Area in Acre Feet

| 2D Area | Starting Vol | Ending Vol | Cum Inflow | Cum Outflow | Error | Percent Error |
|---|---|---|---|---|---|---|
| 2D | | 65.42 | 509.5 | 444.3 | 0.1475 | 0.02894 |

Figure 15:Computational Output Log

**Figure 16 through Figure 19** show the limits of inundation and flow depth from the 10, 25, 50 and 100-year storms. Based on the results of the 2D model, it could be concluded that culvert C2 will be the point of restriction. The results also show that the upstream area becomes inundated extensively and due to the discharge restriction created by C2, upstream ponding does occur. The HMS model was modified accordingly, and enough volume was created so that the upstream pond in HMS would only allow a peak discharge of 1175 cfs. The 10-year peak discharge is 914 cfs whereas the 25-year peak discharge is 1581 cfs. The ponding area in between I-10 and Stern Dr also undergoes significant backwatering. To the extent that it creates the perfect scenario for Culvert C2 to discharge at maximum capacity.

Based on the above analysis, the maximum design flow for the Vado channel should be 1175 cfs since this is the maximum flow that will pass through culverts C1 and C2 due to upstream ponding.


## Legend

**Depth**

High : 13.0 (ft)

Low : 0.5 (ft)

Upstream Boundary Condition

EBID Drain

Roads

Vado/Del Cerro Drainage Master Plan Final Report

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**Figure 16**
**Existing Conditions 2D Inundation From 10yr-24hr Storm**

August 2019


## Legend

**Depth**

High : 14.8 (ft)

Low : 0.5 (ft)

Upstream Boundary Condition

EBID Drain

Roads

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**Figure 17**
**Existing Conditions**
**2D Inundation From**
**25yr-24hr**
**Storm**

August 2019


## Legend

**Depth**

High : 16.2 (ft)

Low : 0.5 (ft)

Upstream Boundary Condition

EBID Drain

Roads

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**Figure 18**
**Existing Conditions 2D Inundation From 50yr-24hr Storm**

August 2019


**Legend**

**Depth**

High : 17.5 (ft)

Low : 0.5 (ft)

Upstream Boundary Condition

EBID Drain

Roads

Vado/Del Cerro
Drainage Master Plan
Final Report

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Prepared By:

**Figure 19**
**Existing Conditions**
**2D Inundation From**
**100yr-24hr**
**Storm**

August 2019

## 3.2 1-DIMENSIONAL HYDRAULIC MODELING ASSUMPTIONS AND DATA

HEC-RAS Version 5.0.6 was used to perform hydraulic analysis of the Vado Channel. General assumptions and data inputs used to perform the steady flow hydraulic analysis (single peak discharge value for the river reach at every profile) are as discussed below:

- River Reach: The centerline of the channel being evaluated must either be defined manually or extracted from the survey/DEM data for existing condition and modified terrain data with proposed improvement options for proposed condition. The centerline of the Vado channel was defined using the terrain created from the DACFC-provided 2018 DEM data.
- Cross Section Data: Cross section data defines cross sectional geometry of the channel. This should reflect any low flow channels, overbanks, floodplains, and levees. Cross section data requires the user to define where the channel bank stations are and how the Manning's 'n' values vary throughout the cross section. Cross section data was extracted from the survey data for the existing conditions and modified terrain data with proposed improvement options for proposed conditions.
- Geometry Data for Hydraulic Structures: If the reach being studied has culvert crossings, these can be defined within the HEC-RAS model. Information for structures can be obtained from the survey data or record drawings, supplemented with field measurements. No structures were modeled.
- Flow Data: Peak discharges for each storm event was based on HEC-HMS modeling results.
- Boundary Conditions: For this analysis, the normal depth boundary condition was selected for downstream. Normal depth uses Manning's equation to estimate a stage for each computed flow and requires a friction slope (slope of energy grade) for the reach near the boundary condition. The average bed slope near the boundary condition location is a good estimate of the friction slope. The model uses the defined boundary conditions to solve the Energy Equation iteratively in what is called the "standard step method".
- Flow Regime: The HEC-RAS solver was set to complete a mixed flow regime.
- Manning's 'n' values: Manning's 'n' value of 0.035 was adopted through the course of the channel for existing conditions. For proposed conditions, Manning's 'n' value of 0.013 was adopted where concrete lining is proposed. Manning's 'n' values adopted Table 5-6 of the *Open channel hydraulics* reference book included in **Appendix C** (Chow, 1959).
- Design Flow: Smith recommends that the Vado Channel be designed for 1175 cfs based on the findings from the 2D modeling.

The existing channel was evaluated for its hydraulic capacity, channel velocity and shear stress. Based on the existing analysis, the channel can convey the design flow of 1175 cfs. Vertical slope stability was also evaluated as early efforts to establish grade control structures have failed. The rip rap structures have required constant maintenance. **Appendix F** contains the 1D HEC-RAS model as well as the outputs for various storm events, including summary tables, cross section views, and profile plots for the channel.

**Table 4** below summarizes some of the critical output from the Existing Conditions HEC-RAS model.

### Table 4: Summary of Existing Conditions HEC-RAS Output

| EXISTING CONDITIONS HEC-RAS OUTPUT | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| River Sta | Profile | Q Total | Min Ch El | W.S. Elev | E.G. Slope | Vel Chnl | Froude # Chl | Mann Wtd Total | Power Total | Shear Chan | Invert Slope |
| | | (cfs) | (ft) | (ft) | (ft/ft) | (ft/s) | | | (lb/ft s) | (lb/sq ft) | |
| 4958 | 10YR | 908 | 3868.65 | 3870.11 | 0.056637 | 24.88 | 4.67 | 0.013 | 76.94 | 3.09 | 0.0048 |
| 4958 | 100YR | 1175 | 3868.65 | 3870.27 | 0.056678 | 27.13 | 4.77 | 0.013 | 95.57 | 3.52 | 0.0048 |
| 4911 | 10YR | 908 | 3868.43 | 3870.3 | 0.119216 | 16.42 | 2.65 | 0.035 | 144.91 | 8.82 | 0.0026 |
| 4911 | 100YR | 1175 | 3868.43 | 3870.44 | 0.142915 | 19.08 | 2.94 | 0.035 | 220.74 | 11.57 | 0.0026 |
| 4867 | 10YR | 908 | 3868.32 | 3871.27 | 0.014636 | 8.01 | 1.01 | 0.035 | 14.26 | 1.78 | 0.0594 |
| 4867 | 100YR | 1175 | 3868.32 | 3871.34 | 0.022264 | 10.04 | 1.25 | 0.035 | 27.86 | 2.77 | 0.0594 |
| 4806 | 10YR | 908 | 3864.65 | 3866.94 | 0.066388 | 14.84 | 2.07 | 0.035 | 97.11 | 6.55 | 0.1348 |
| 4806 | 100YR | 1175 | 3864.65 | 3867.42 | 0.049349 | 14.66 | 1.84 | 0.035 | 87.51 | 5.97 | 0.1348 |
| 4748 | 10YR | 908 | 3856.87 | 3860.25 | 0.076408 | 19.25 | 2.24 | 0.035 | 192.97 | 10.02 | 0.0026 |
| 4748 | 100YR | 1175 | 3856.87 | 3860.78 | 0.069976 | 20.16 | 2.18 | 0.035 | 211.75 | 10.5 | 0.0026 |
| 4675 | 10YR | 908 | 3856.68 | 3861.39 | 0.006986 | 7.4 | 0.74 | 0.035 | 9.72 | 1.31 | 0.0047 |
| 4675 | 100YR | 1175 | 3856.68 | 3862.53 | 0.001339 | 3.65 | 0.33 | 0.034 | 0.7 | 0.3 | 0.0047 |
| 4614 | 10YR | 908 | 3856.39 | 3860.22 | 0.01394 | 9.43 | 1.01 | 0.035 | 21.15 | 2.24 | -0.0027 |
| 4614 | 100YR | 1175 | 3856.39 | 3860.79 | 0.013107 | 10.08 | 1 | 0.035 | 24.63 | 2.44 | -0.0027 |
| 4536 | 10YR | 908 | 3856.6 | 3860.56 | 0.001936 | 3.94 | 0.39 | 0.034 | 0.92 | 0.37 | 0.0046 |
| 4536 | 100YR | 1175 | 3856.6 | 3861.13 | 0.001641 | 3.97 | 0.37 | 0.034 | 0.97 | 0.36 | 0.0046 |
| 4230 | 10YR | 908 | 3855.19 | 3858.86 | 0.007278 | 7.18 | 0.74 | 0.035 | 9.09 | 1.27 | 0.0047 |
| 4230 | 100YR | 1175 | 3855.19 | 3859.23 | 0.008392 | 8.23 | 0.81 | 0.035 | 13.26 | 1.61 | 0.0047 |
| 4085 | 10YR | 908 | 3854.51 | 3857.22 | 0.014769 | 7.93 | 1.01 | 0.035 | 13.92 | 1.76 | 0.0447 |
| 4085 | 100YR | 1175 | 3854.51 | 3857.61 | 0.014114 | 8.53 | 1.01 | 0.035 | 16.52 | 1.94 | 0.0447 |
| 3880 | 10YR | 908 | 3845.33 | 3847.17 | 0.103282 | 16.63 | 2.51 | 0.035 | 144.19 | 8.67 | 0.0076 |
| 3880 | 100YR | 1175 | 3845.33 | 3847.46 | 0.099105 | 17.61 | 2.51 | 0.035 | 164.69 | 9.35 | 0.0076 |
| 3745 | 10YR | 908 | 3844.31 | 3847.53 | 0.011275 | 8.66 | 0.91 | 0.035 | 16.24 | 1.88 | 0.0105 |
| 3745 | 100YR | 1175 | 3844.31 | 3847.97 | 0.012066 | 9.66 | 0.96 | 0.035 | 21.72 | 2.25 | 0.0105 |
| 3448 | 10YR | 908 | 3841.18 | 3843.83 | 0.014054 | 8.52 | 1 | 0.035 | 16.48 | 1.93 | 0.0117 |
| 3448 | 100YR | 1175 | 3841.18 | 3844.27 | 0.013544 | 9.21 | 1.01 | 0.035 | 19.79 | 2.15 | 0.0117 |
| 3202 | 10YR | 908 | 3838.29 | 3840.86 | 0.011501 | 7.65 | 0.91 | 0.035 | 11.95 | 1.56 | 0.0122 |
| 3202 | 100YR | 1175 | 3838.29 | 3841.26 | 0.011493 | 8.39 | 0.93 | 0.035 | 15.06 | 1.8 | 0.0122 |
| 2936 | 10YR | 908 | 3835.05 | 3837.53 | 0.013477 | 7.78 | 0.97 | 0.035 | 13 | 1.67 | 0.0093 |
| 2936 | 100YR | 1175 | 3835.05 | 3837.88 | 0.013756 | 8.55 | 1 | 0.035 | 16.51 | 1.93 | 0.0093 |
| 2425 | 10YR | 908 | 3830.3 | 3832.97 | 0.007014 | 5.82 | 0.71 | 0.035 | 5.33 | 0.92 | 0.007 |
| 2425 | 100YR | 1175 | 3830.3 | 3833.35 | 0.007007 | 6.37 | 0.72 | 0.035 | 6.69 | 1.05 | 0.007 |
| 1913 | 10YR | 908 | 3826.74 | 3829.44 | 0.006877 | 5.66 | 0.7 | 0.035 | 4.96 | 0.88 | 0.0048 |
| 1913 | 100YR | 1175 | 3826.74 | 3829.79 | 0.007009 | 6.26 | 0.72 | 0.035 | 6.41 | 1.02 | 0.0048 |
| 1401 | 10YR | 908 | 3824.29 | 3827.04 | 0.00376 | 4.31 | 0.52 | 0.035 | 2.15 | 0.5 | 0.0059 |
| 1401 | 100YR | 1175 | 3824.29 | 3827.43 | 0.003694 | 4.71 | 0.53 | 0.035 | 2.68 | 0.57 | 0.0059 |
| 1000 | 10YR | 908 | 3821.93 | 3824.87 | 0.006779 | 5.53 | 0.69 | 0.035 | 4.65 | 0.84 | |
| 1000 | 100YR | 1175 | 3821.93 | 3825.23 | 0.006781 | 6.03 | 0.7 | 0.035 | 5.77 | 0.96 | |

There are several sections where the channel velocity exceeds 11 ft/s. which are highlighted in red in **Table 4**. These are primarily at the outlet structure of the culverts which have grouted rip rap and the two drops in the channel bed. The overall average channel velocity is around 11 ft/s, which for an unlined channel is high. The average shear stress is also significantly high due to the higher velocities in the channel. The average slope is approximately 1.8 %.

Vertical Slope Stability was evaluated using guidelines in the 'Sediment and Erosion Guide' by Mussetter Engineering Inc, 2008. The equilibrium slope is defined as a function of what is called the 'Dominant Discharge' in Equation 3.33.

The equation is defined as:

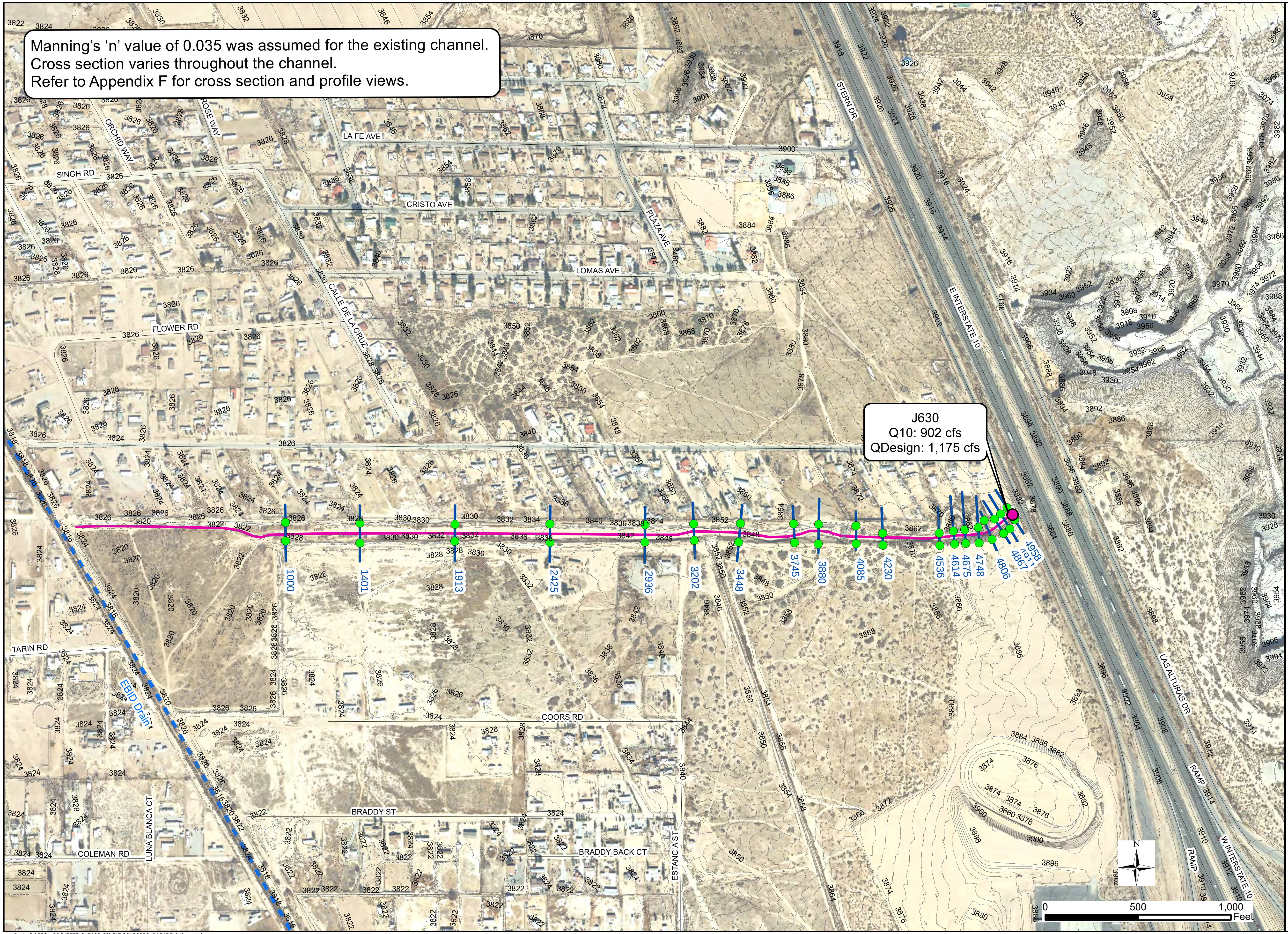
$$Ss = CQ_D^{-0.133} \quad \text{(Equation 3.33)}$$

$$C = 18.28n^2F_D^{0.133}F_r^{2.133} \quad \text{(Equation 3.34)}$$

The variables in the equation are defined as follows:

Ss = maximum stable slope, ft/ft
n = Manning's roughness coefficient
Fr = Froude Number (0.7 to 1.0)
QD = dominant discharge, cfs
FD = width-depth ratio of the flowing water, ft, which is typically assumed to be 40.
C = Chezy's Discharge Coefficient

Based on the above equation, the equilibrium slope for Vado Channel was computed to be 1.8%. Notwithstanding the two large elevation drops in the channel, physical inspection of the channel agrees with this calculation. Since the channel invert cannot physically get any lower, without cutting an outlet into the Mesquite Drain, the channel is attempting to become vertically stable. When a channel is vertically stable but still has high velocities and shear stresses, it will migrate laterally over time. The large oxbow at the outlet of culverts C2 is evidence of this fact. Culvert computations predict outlet velocities of around 16 ft/s at this location. While the DACFC has been able to contain the oxbow, aerial imagery and latest topography points to the development of sinuosity in the channel between HEC-RAS stations 4085 to 2936. There is a significant oxbow starting to develop towards the north at station 3880 as shown in **Figure 20.**




**Legend**

- Analysis Point
- Bank Stations
- 2ft Contours
- EBID Drain
- Cross Sections
- River Reaches
- Roads

Vado/Del Cerro
Drainage Master Plan
Final Report

Prepared for

DOÑA ANA COUNTY NEW MEXICO

Prepared by

SMITH ENGINEERING

**Figure 20**
**Existing Conditions**
**1D HEC-RAS**
**Overview Map**

August 2019

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# SECTION 4. PROPOSED OPTIONS HYDROLOGIC AND HYDRAULIC ANALYSES

## 4.1 PROPOSED OPTIONS HYDROLOGIC DATA

No modeling changes were made that would affect the existing subbasins. Therefore, the reservoir routing results remain unchanged from the existing conditions model. The existing HEC-HMS model was modified to simulate proposed facilities including three detention ponds and one diversion channel. Conceptual level grading plans were developed for all the facilities. Based on these grading plans, stage-storage-discharge rating curves were developed and refined to simulate reservoir routings in HEC-HMS model. **Appendix D** documents the data tables used for these rating curves. The proposed ponds were incorporated into the proposed model and differences in peak discharges were reevaluated. **Appendix D** summarizes the pond routing results.

## 4.2 ALTERNATIVES CONSIDERED

Proposed alternatives were considered based on the following factors:

- Hydraulic design options for the Vado Channel for channel stability and safe conveyance
- Ponding and detention at the outfall of Vado Channel to mitigate flows into the Mesquite Drain
- Various drainage improvements that would address complaints by residents raised at the public meeting as shown in **Figure 21** including alternatives for ponding and roadway/storm drain improvements

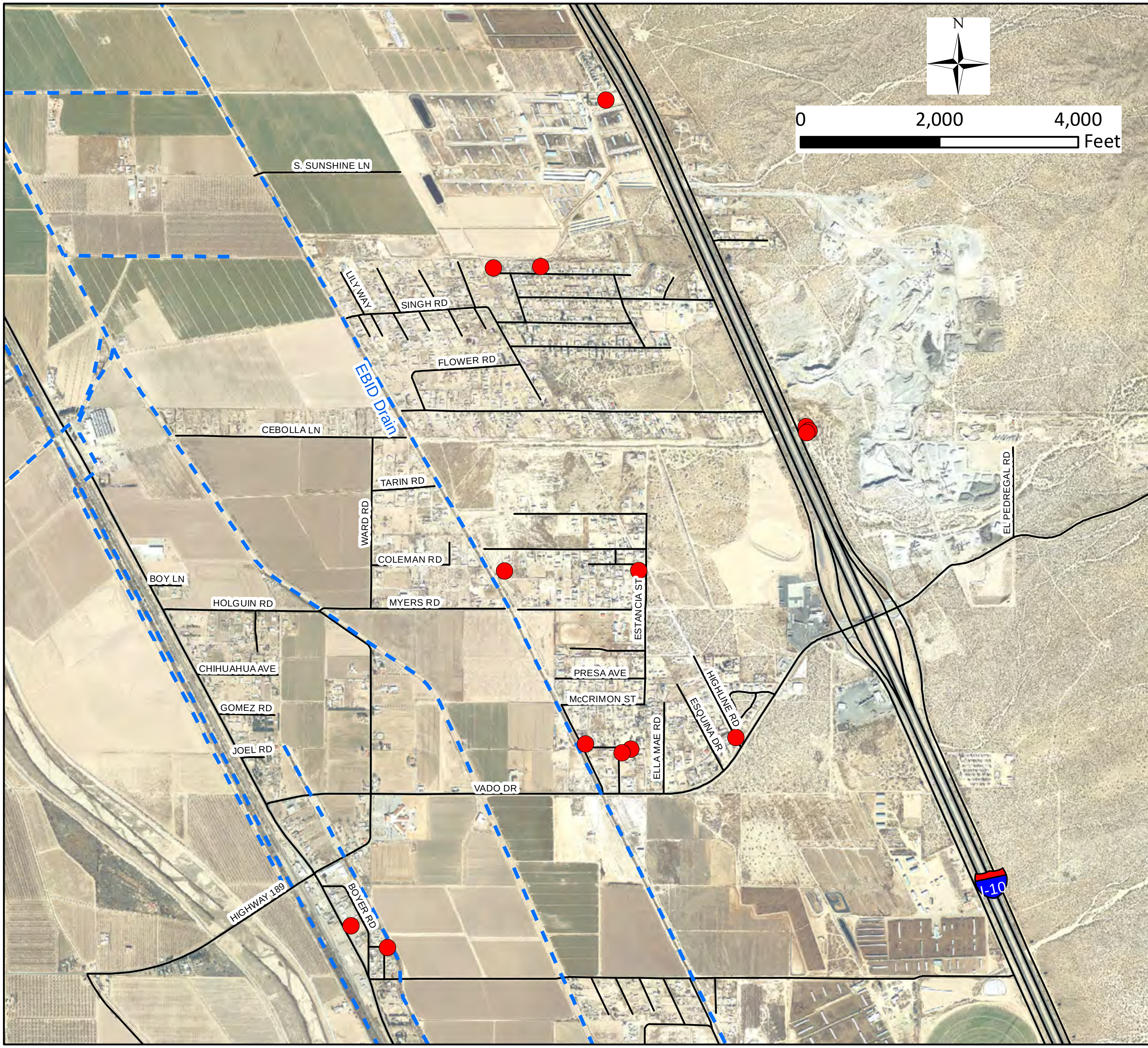
Several alternatives were considered to mitigate flooding for the 100-year storm**.** However, many were deemed unfeasible due to the excessive cost that the facilities would incur. All proposed ponds are designed to be non-jurisdictional ponds. The alternatives were modeled in HEC-RAS and in HEC-HMS to see how they would improve drainage conditions in Vado.

The greatest challenge in the design of the conceptual ponding facility improvements was the high runoff volume that arrived from culvert C1-C2 on the order of 247-acre feet (AF) for the 10-year storm. The amount of real estate required to size a pond that would handle this volume is substantial. Secondly, there is very little elevation drop at the western boundary of the watershed both in the Vado and Del Cerro areas. The lack of slope severely hampers the design of gravity facilities such as storm drains and roadside ditches. The Mesquite Drain also is limited in how much flow it can receive, however in a large event, it is most likely that flows will enter the drain and eventually the entire western boundary will become flooded. This is also demonstrated in the 2D model. Near Vado Rd, the embankments of the Mesquite Drain have been graded and tampered with by surrounding residents to create access for vehicles and ATVs. The channel section through that reach is very shallow and high flows will escape at these locations.

Considering these factors, ponds were sized to control the 10-year storm. Storm drains were sized for the 10-year storm while the 100-year storm was used as a check to ensure that the Hydraulic Grade Line (HGL) remains at grade elevation.

The channel itself was designed to convey 1175 cfs as this is the maximum flow that the culverts C1-C2 can discharge into the channel.

For some facilities to work a drainage easement will be required or property will have to be acquired as well.




**Legend**

- Resident Complaints
- EBID Drain
- Roads

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**Figure 21 Summary of Reported Complaints in the area**

August 2019

### A. Alternative 1: Detention Pond and Off Channel Storage Using a Lateral Weir

Summary of Features and Main Assumptions – Alternative 1 is proposed to convey runoff coming from the I-10 culverts through the existing channel to Tapir Pond, diverting flows to Vado Pond in large storm events. This facility consists of two detention ponds, one channel, and associated structures. **Figure 22** shows the conceptual layout for Alternative 1.

**Vado Pond:** Vado Pond outfalls into the Vado Channel. This pond is located between the Stern Dr, Estancia Rd and Swannack Rd and would serve as a detention facility for larger storm events. Vado Pond will require a lateral weir structure to divert water from Vado Channel into the Vado Pond during large storm events. During small events, the weir structure would allow for low flows to continue down Vado channel into Tapir Pond. An emergency spillway made of reinforced concrete was sized to direct overflow from Vado Pond into the Vado channel.

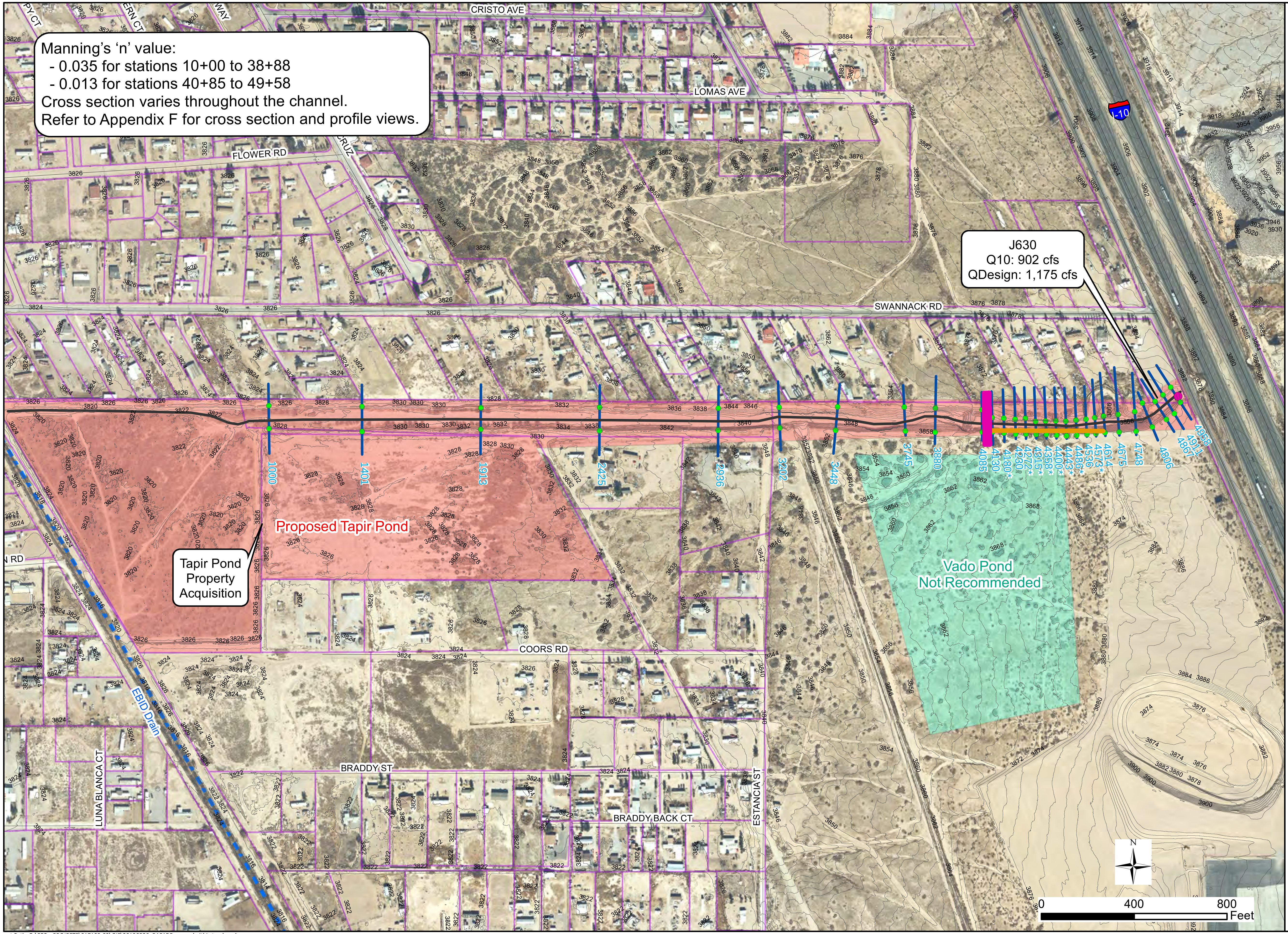
**Tapir Pond:** This pond is located at the end of Vado Channel between Coors Rd and Swannack Rd and west of Vado Pond. Currently the Vado Channel conveys flows to this point, the flows then start to sheet flow and pond in this area. For this alternative Tapir Pond would serve as a non-jurisdictional detention pond. The designed footprint allows the pond to retain up to approximately 71.4 ac-ft. The pond is 6 ft deep and is graded to have 3H:1V side slopes from the top of the pond to the pond bottom to maximize volume. Tapir Pond will require a rundown structure from the Vado channel. All run-down structures will have to be wire enclosed riprap since the soil conditions in this area is cohesion less. An emergency spillway made of reinforced concrete was sized to direct overflow into the EBID drain.

**Vado Channel:** The Vado channel is an existing channel that runs parallel to Swannack Rd running east to west from I-10 down to the EBID Mesquite Drain. For this Alternative, Vado Channel would incorporate a diversion structure and a lateral weir structure to allow smaller flows to bypass Vado Pond whereas the large flows would be diverted into Vado Pond. The idea behind an off-channel storage structure is to only contain the peak of the hydrograph instead of trying to detain the entire volume of the hydrograph. The hydraulic modeling was performed using HEC RAS 1D. and are included in **Appendix E and F.** The flow splits from the lateral weir were applied to the HEC-HMS model. Unfortunately, the combined effects of both ponds and the weir structure were insufficient to mitigate the magnitude of the flows downstream of the pond and diversion structure. Drop structures would still be required at the two current locations and the channel from Vado Pond to Tapir Pond would still have to be lined.

Issues with Alternative– This structure will be costly and may have jurisdictional issues. Vado Pond would only be used during large storm events but would not provide detainment of the 100-yr event***. While this pond was initially conceptually designed and modeled due to the large potential cost and little benefit, this alternative is not recommended.***

Property – Vado Pond is proposed to be built on land that as shown on is owned by the State of New Mexico. A portion of this land appears to be developed as a racetrack. However, it is unclear if this portion is still owned by the state. Tapir Pond is on land owned by DACFC as well as approximately 19-acres of private land. Either acquiring a drainage easement or purchase of this lot is recommended in order to build and maintain this structure. **Figure 22** also shows the necessary parcels that will have to be acquired.

Maintenance – Will be minimal as this structure will be designed to be stable and to avoid undermining due to scour and head cutting. However, sediment removal after large storm events is expected.




**Legend**

- Analysis Point
- Bank Stations
- Diversion Structure
- Lateral Structure
- 2ft Contours
- River Reaches
- Cross Sections
- Roads
- EBID Drain
- Parcel
- Inline Pond Structure
- Proposed Tapir Pond
- 4958: Cross Section ID

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**Figure 22 Conceptual Layout of Alternative 1**

August 2019

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### B. Alternative 2: Detention Tapir Pond and Vado Channel

Summary of Features and Main Assumptions – Alternative 2 is proposed to convey runoff coming from I-10 through Vado Channel to Tapir Pond. This facility consists of one detention pond, one channel, and associated structures. **Figure 23** provides an overview of the conceptual layout for Alternative 2. **Figure 24** provides an overview of the HEC-RAS schematic.

**Tapir Pond:** The design plan for Tapir Pond for Alternative 2 was modified to maximize the available land. As such the storage volume was increased to a total of 338 ac-ft. **Table 5** summarizes the impact Tapir Pond will have on detaining the various storm events. A more detailed summary is included in **Appendix D.** The pond is able to detain the 10-yr. storm. A conceptual grading plan is shown on **Figure 25.**

**Vado Channel:** For this alternative, Vado Channel would need to be lined with strategically placed energy dissipation structures at the two drops in the existing channel. The channel has to be lined to prevent future lateral migration. Due to the high energy and velocity in the channel, if it remains unlined, issues will persist in the future. Smith proposes that the channel be redesigned with either concrete or shotcrete lining. The existing channel currently holds mostly a 1H:1V side slope for the most part. By matching the existing cross-section work can be completed in the existing right of way (ROW). The steeper cross section may also deter residents from attempting to ride motorized vehicles across. The channel will have to be transitioned into Tapir Pond with a grade control/energy dissipator. Building a channel with steep side slopes does present constructability issues especially with materials other than concrete or shotcrete. As such the side slopes were modified during the conceptual design to be 3H:1V. The two materials utilized for modeling were concrete and soil cement. Soil cement and shotcrete have comparable hydraulic properties. The use of soils cement will require 3H:1V side slopes due to compaction requirements. On average the channel velocity in the soil cement lined channel will be approximately 11.5 ft/s as opposed to 17.9 ft/s in a concrete lined channel. Detailed HEC-RAS output is provided in **Appendix F.** The images below show isometric views of the conceptual energy dissipators for both concrete dragons teeth style energy dissipators and the alternative soil cement stepped energy dissipators.

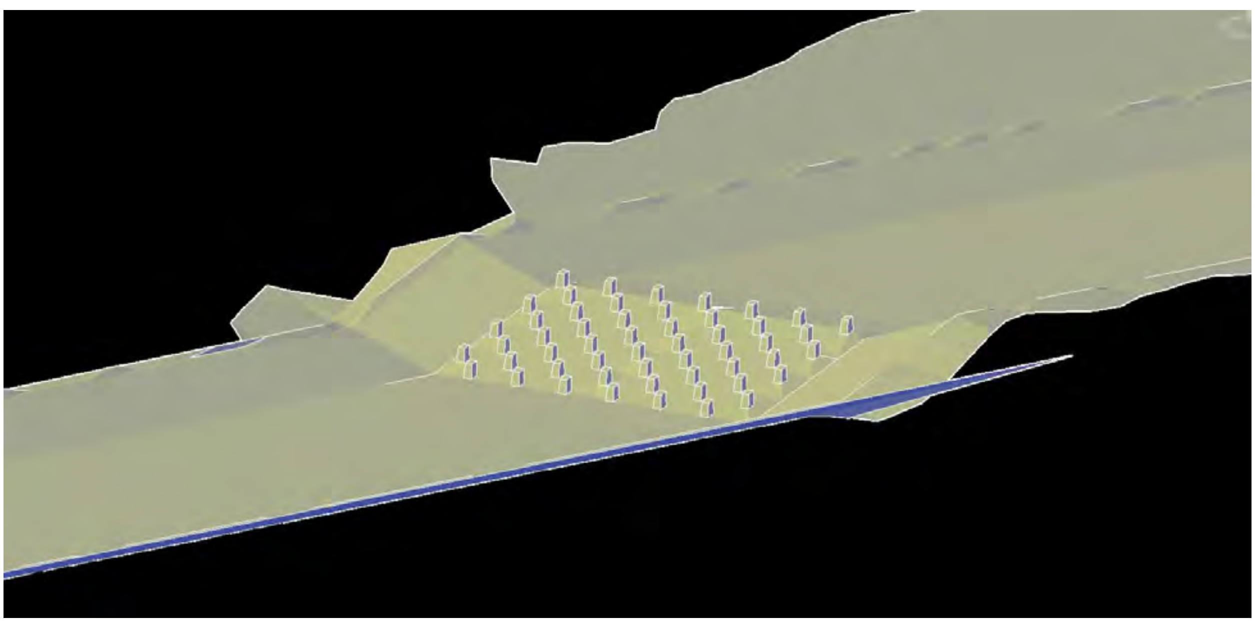


**Image 1: Conceptual Downstream Concrete Baffle Energy Dissipator**

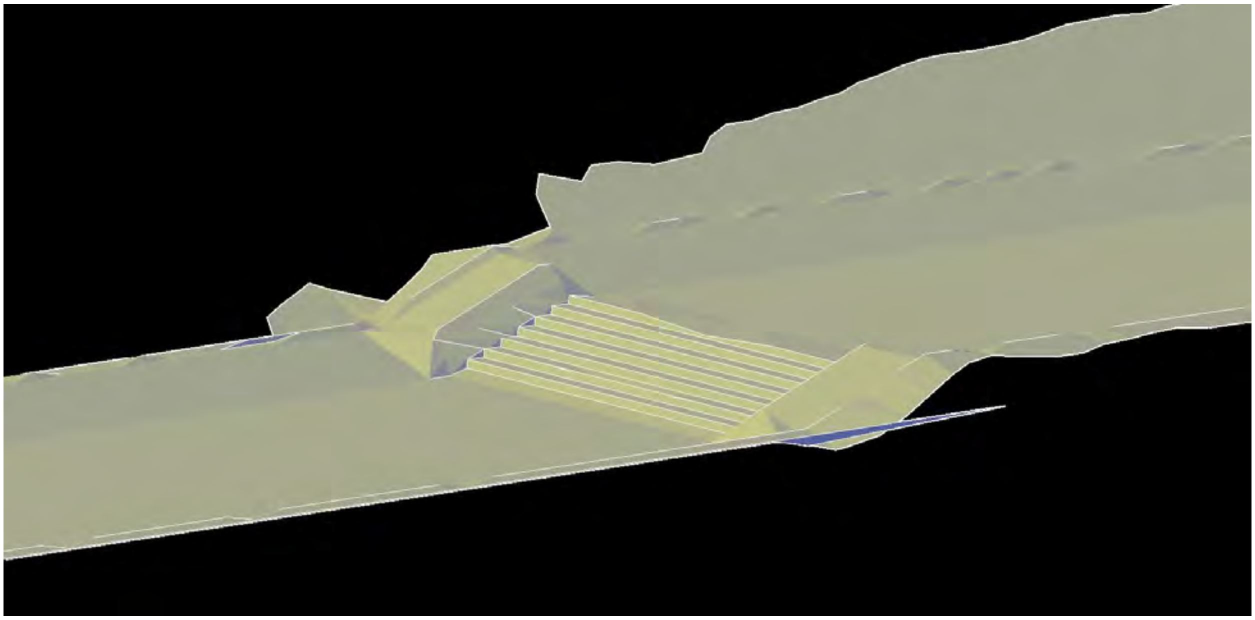


**Image 2: Conceptual Downstream Soil Cement Stepped Energy Dissipator**

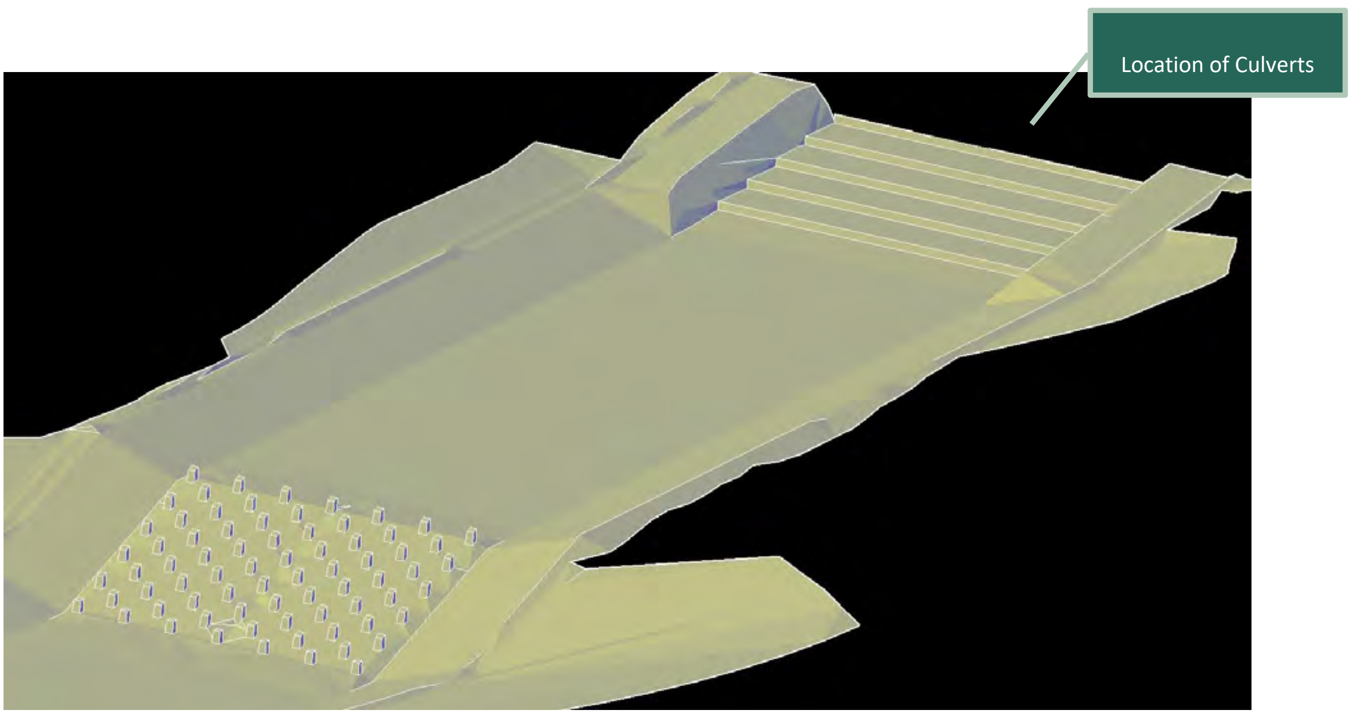



**Image 3: Upstream Concrete Baffle Energy Dissipator at Outlet of Culverts**

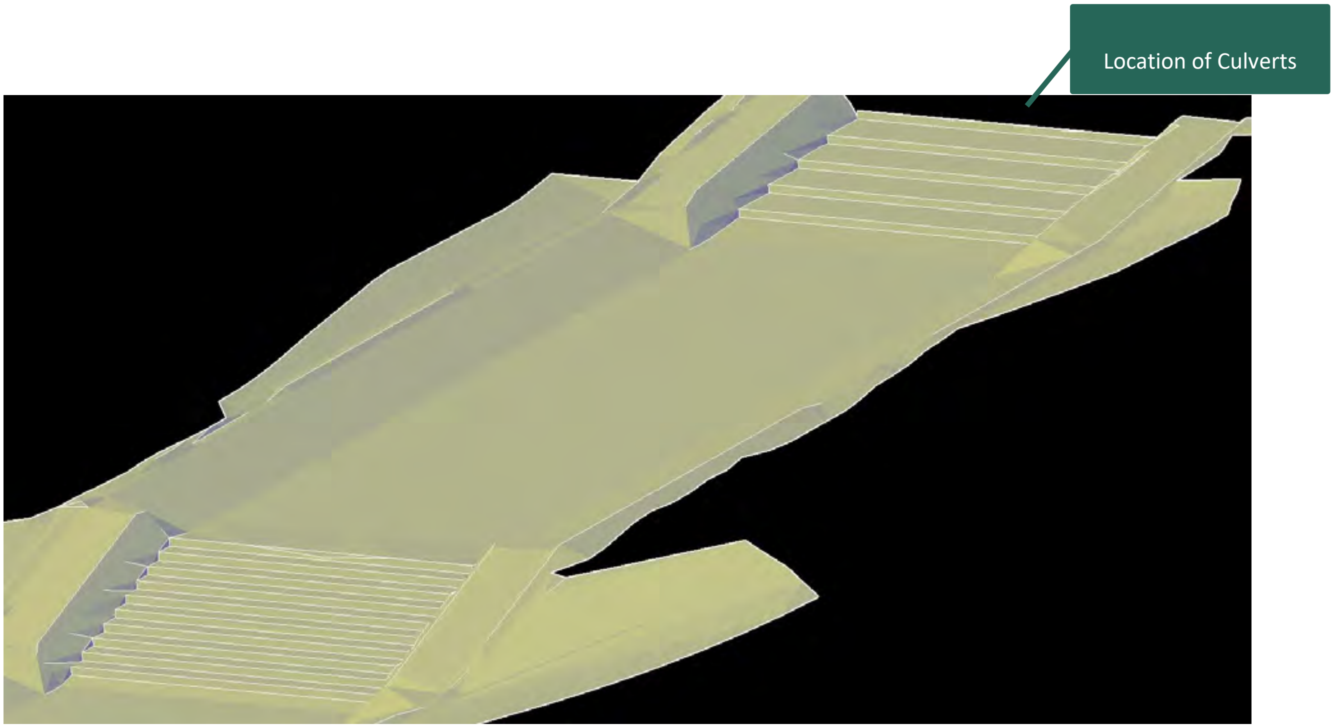



**Image 4: Upstream Soil Cement Stepped Energy Dissipator at Outlet of Culverts**

Issues and Problems – Vado Channel would need to be lined and protected for the entire length. The emergency spillway is used in 25 to 100-yr storm events due to lack of pond volume.

Goal – Stabilize the arroyo bed and banks, provide containment for storm events and reduce flooding of surrounding area.

Is the Alternative Feasible without Other alternatives? – Yes, this alternative presents all structures necessary to work on its own.

Property – Tapir Pond is on land owned by Doña Ana County Flood Commission and on approximately 19-acres of private land. Either acquiring a drainage easement or purchase of this lot is recommended in order to build and maintain this structure.

Maintenance – Will be minimal as this structure will be designed to be stable and to avoid undermining due to scour and head cutting. However, sediment removal after large storm events is expected

Project Cost – The project cost was computed based on both material alternatives.

Tapir Pond will cost approximately $3,567,000

Vado Channel Using Soil Cement will cost approximately $1,574,000

Vado Channel Using Concrete will cost approximately $1,915,000

The overall project using soil cement will be approximately $5,141,000

The overall project using concrete will be approximately $5,482,00

**Table 5: Tapir Pond Routing Summary for Alternative 2**

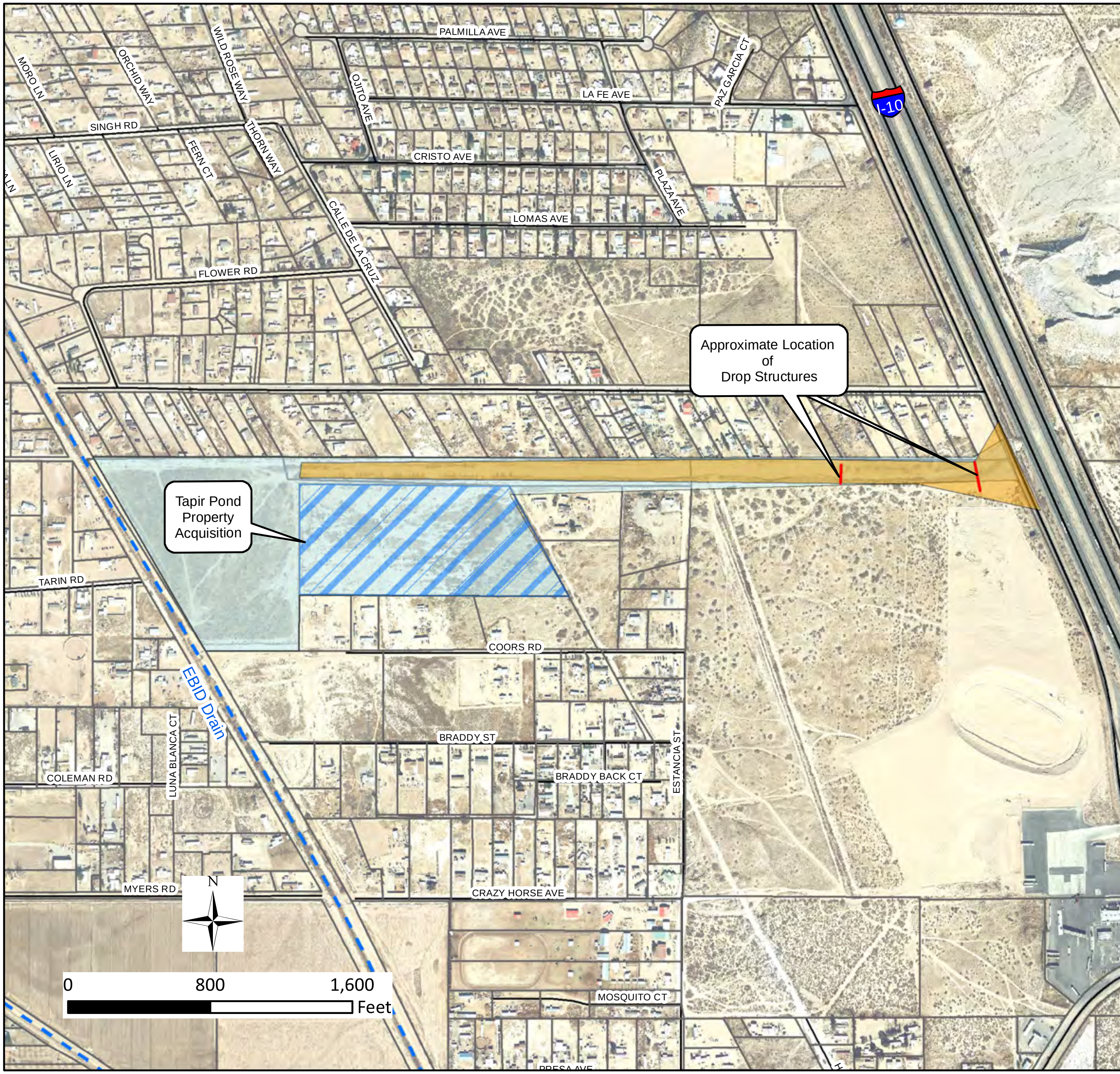
| Alternative 2: Tapir Pond Routing Summary[d] | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Attenuated | Inflow Runoff Volume | Outflow Runoff Volume | Peak Storage Volume for Storm Event | Peak Water Surface Elevation | Emergency Spillway Elevation | Pond Invert Elevation | Peak Water Depth | Top of Pond Embankment Elevation | Freeboard to Emergency Spillway Elevation | Freeboard to top of Pond Embankment |
| yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ft | ft | ft | ft | ft | ft | ft |
| a | | a | a | | a | a | a | a | b | b | | b | c | c |
| 10 / 24 | 8.17 | 912 | 46 | 866 | 247.8 | 192.7 | 183.8 | 3822.1 | 3824 | 3815 | 7 | 3826.0 | 1.9 | 3.9 |
| 25 / 24 | 8.17 | 986 | 111.7 | 874.3 | 395.4 | 327.1 | 266.7 | 3824.2 | 3824 | 3815 | 9 | 3826.0 | -0.2 | 1.8 |
| 50 / 24 | 8.17 | 1190 | 705 | 485 | 523.8 | 455.0 | 300.2 | 3825.0 | 3824 | 3815 | 10 | 3826.0 | -1.0 | 1.0 |
| 100 / 24 | 8.17 | 1211 | 984 | 226.9 | 661.8 | 592.6 | 311.6 | 3825.3 | 3824 | 3815 | 10 | 3826.0 | -1.3 | 0.7 |

( a ) Refer to Appendix D for the HEC-HMS model output for the pond routing results.

( b ) See Appendix D for all Elevation - Storage Volume - Discharge Data Tables

( c ) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

( d ) This is a proposed pond with 3:1 side slopes and a maximum Design Storage Volume (top of embankment) of 338.5 ac-ft and maximum pond depth of 11-ft




## Legend

- Private Property
- Drop Structures
- Vado Channel
- Proposed Tapir Pond
- Parcel
- EBID Drain

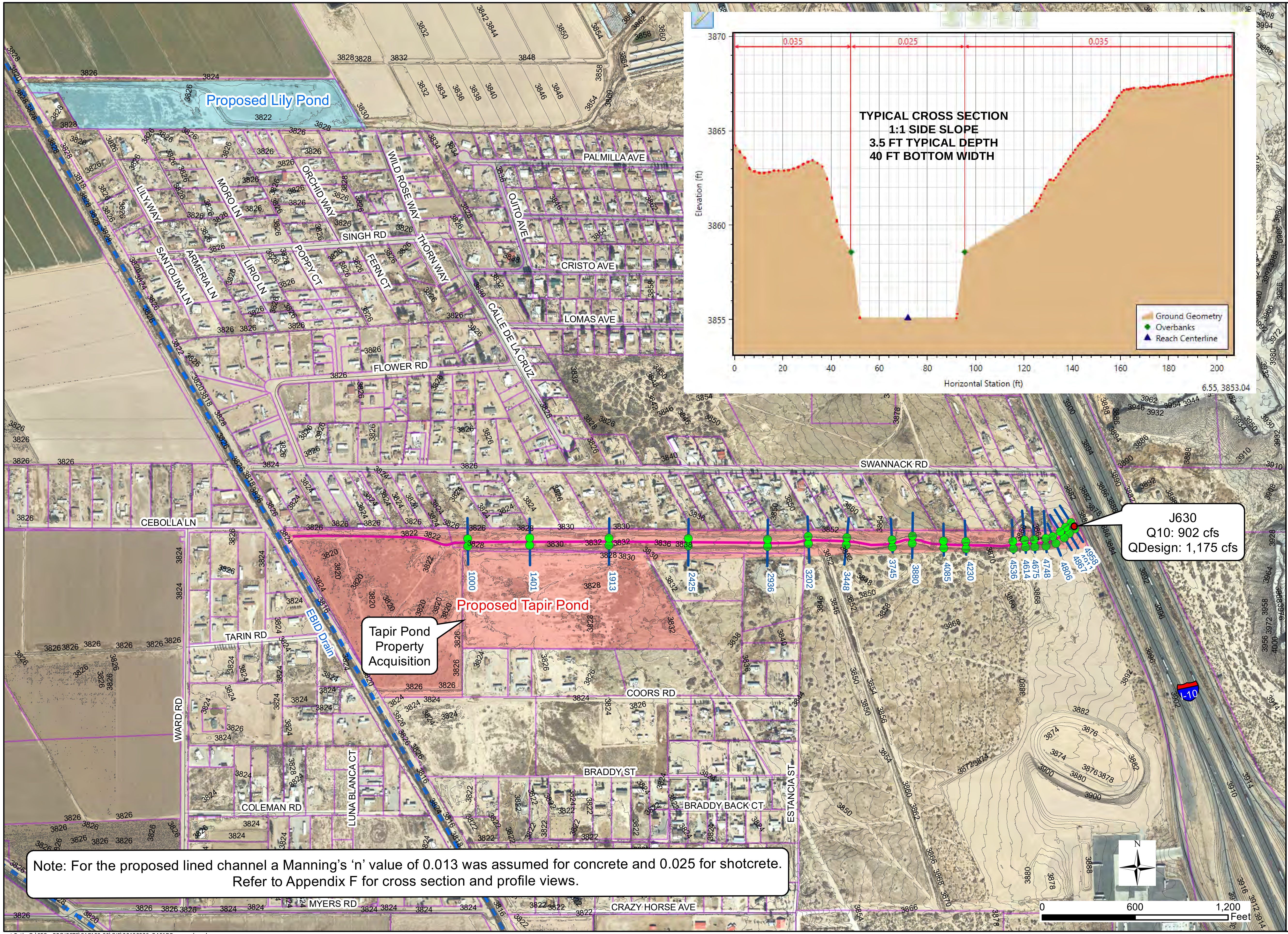
Vado/Del Cerro Drainage Master Plan Final Report

Prepared For:

Prepared By:

**Figure 23 Conceptual Layout of Alternative 2**

August 2019




**Legend**

- Analysis Point
- Bank Stations
- 2ft Contours
- Cross Sections
- River Reaches
- Roads
- EBID Drain
- Parcel
- Proposed Lily Pond
- Proposed Tapir Pond

4958: Cross Section ID

Vado/Del Cerro Drainage Master Plan Final Report

Prepared for

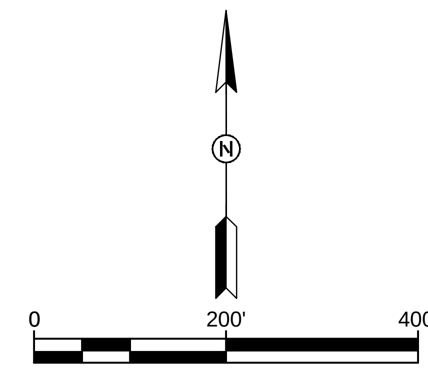
Prepared by

**Figure 24 Proposed HEC-RAS Schematic for Vado Channel**

August 2019

## Alternative 2: Tapir Pond Routing Summary

| Detention Pond Name | Existing or Proposed Pond | Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Attenuated | Inflow Runoff Volume | Outflow Runoff Volume | Maximum Design Storage Volume (top of embankment) | Peak Storage Volume for Storm Event | **Peak Water Surface Elevation** | Emergency Spillway Elevation | Pond Invert Elevation | Maximum Pond Depth | Peak Water Depth | Top of Pond Embankment Elevation | **Freeboard to Emergency Spillway Elevation** | **Freeboard to top of Pond Embankment** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ac-ft | ft | ft | ft | ft | ft | ft | ft | ft |
| | | a | | a | a | | a | a | b | a | a | b | b | b | | b | c | c |
| Tapir Pond | Proposed 3:1 | 10 / 24 | 8.17 | 912 | 46 | 866 | 247.8 | 192.7 | 338.5 | 183.8 | **3822.1** | 3824 | 3815 | 11 | 7 | 3826.0 | **1.9** | **3.9** |
| Tapir Pond | Proposed 3:1 | 25 / 24 | 8.17 | 986 | 111.7 | 874.3 | 395.4 | 327.1 | 338.5 | 266.7 | **3824.2** | 3824 | 3815 | 11 | 9 | 3826.0 | -0.2 | **1.8** |
| Tapir Pond | Proposed 3:1 | 50 / 24 | 8.17 | 1190 | 705 | 485 | 523.8 | 455.0 | 338.5 | 300.2 | **3825.0** | 3824 | 3815 | 11 | 10 | 3826.0 | -1.0 | **1.0** |
| Tapir Pond | Proposed 3:1 | 100 / 24 | 8.17 | 1211 | 984 | 226.9 | 661.8 | 592.6 | 338.5 | 311.6 | **3825.3** | 3824 | 3815 | 11 | 10 | 3826.0 | -1.3 | **0.7** |





SMITH ENGINEERING

LEGEND:

EXISTING PROPERTY LINE

FIVE STRAND NON-BARB WIRE FENCE

BASE COURSE 6" THICK

VADO/DEL CERRO DRAINAGE MASTER PLAN FINAL REPORT

FIGURE 25

CONCEPTUAL GRADING PLAN FOR TAPIR POND

PROJECT NO: 817103-03

DATE: August 2019

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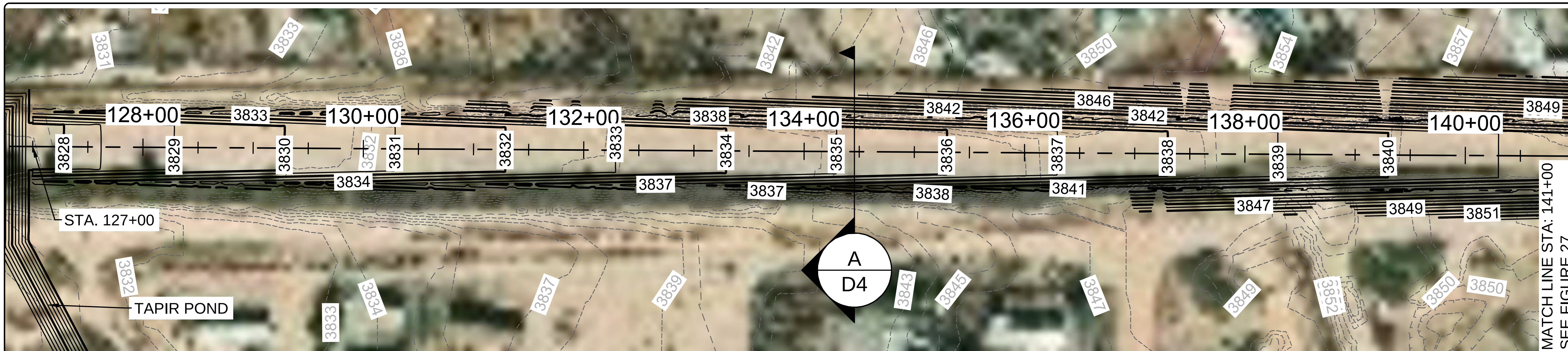
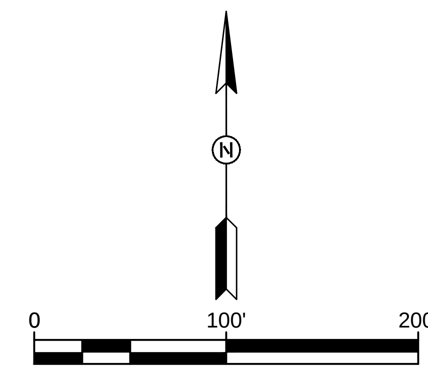
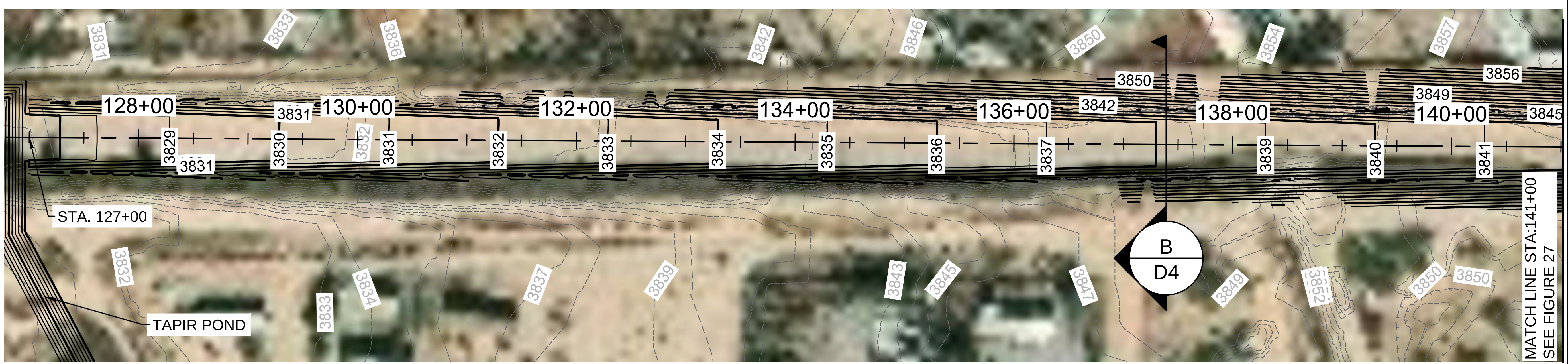



VADO CHANNEL - SOIL CEMENT STEPS




VADO CHANNEL - CONCRETE STEPS WITH BAFFLES

SMITH ENGINEERING

LEGEND:

VADO/DEL CERRO DRAINAGE MASTER PLAN FINAL REPORT

FIGURE 26

PROPOSED VADO CHANNEL GRADING PLAN STA. 127+00 TO 141+00

PROJECT NO:
817103-03

DATE:
August 2019

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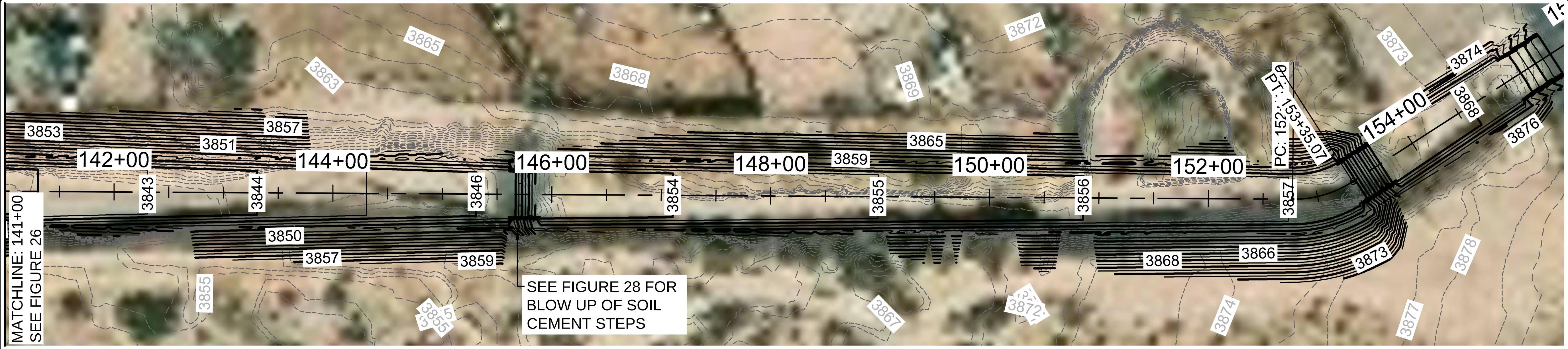
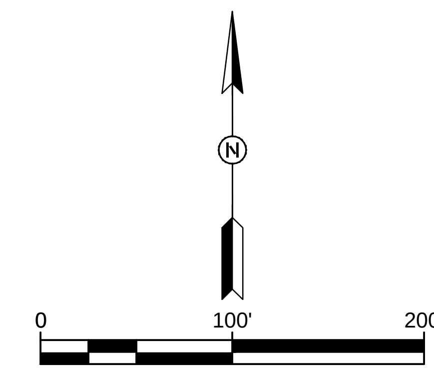
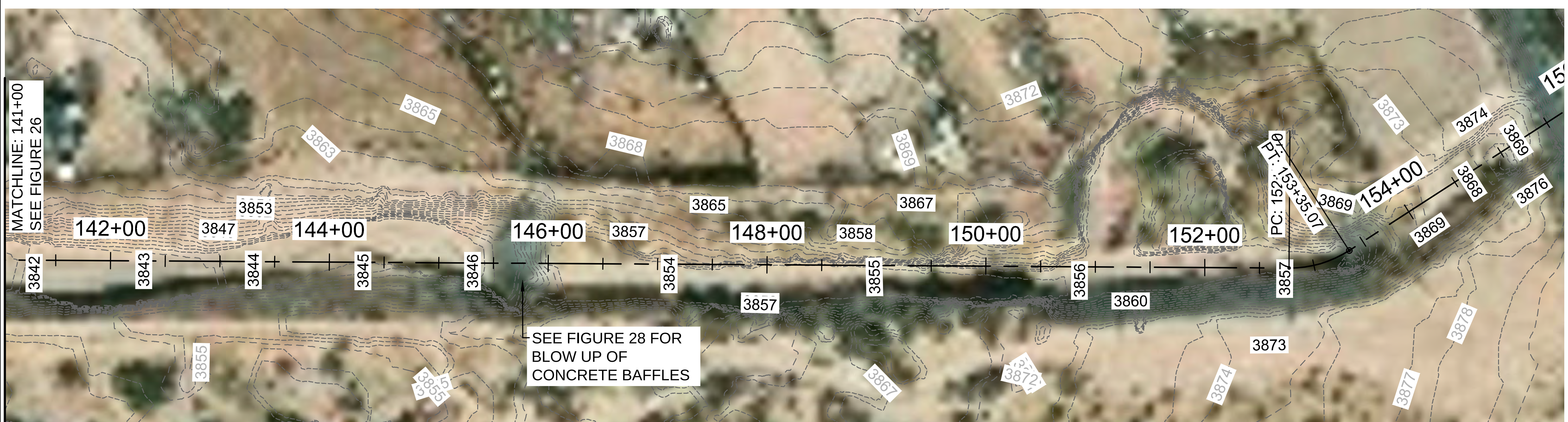



VADO CHANNEL - SOIL CEMENT STEPS




VADO CHANNEL - CONCRETE STEPS WITH BAFFLES

SMITH ENGINEERING

LEGEND:

VADO/DEL CERRO DRAINAGE MASTER PLAN FINAL REPORT

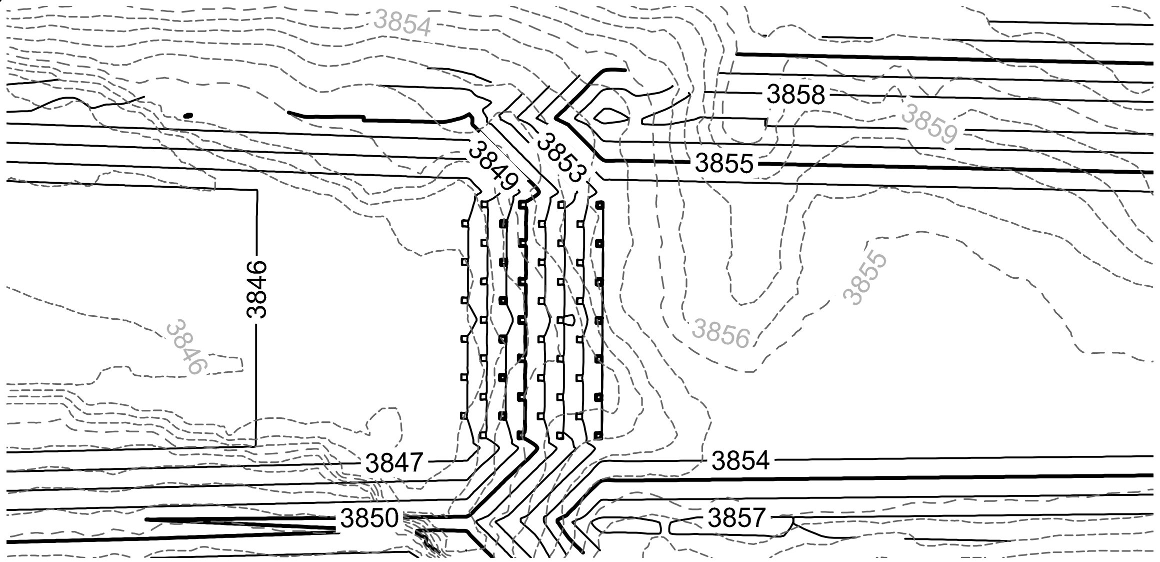
FIGURE 27

PROPOSED VADO CHANNEL GRADING PLAN STA. 141+00 TO 155+50

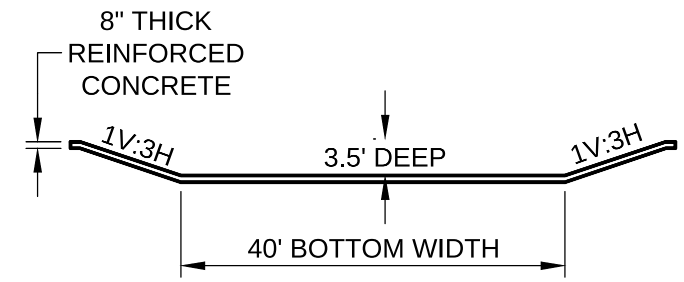
PROJECT NO:
817103-03

DATE:
August 2019

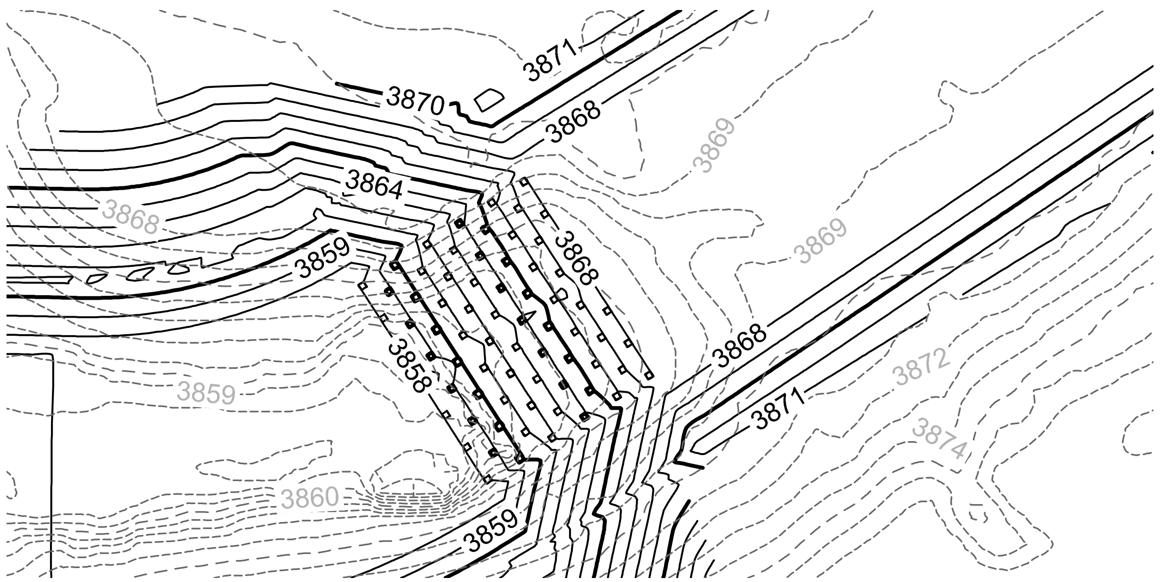
Q:\SEC----PROJECTS\817103-03\CADD\PLANSET\PROPOSED VADO CHANNEL 2.DWG



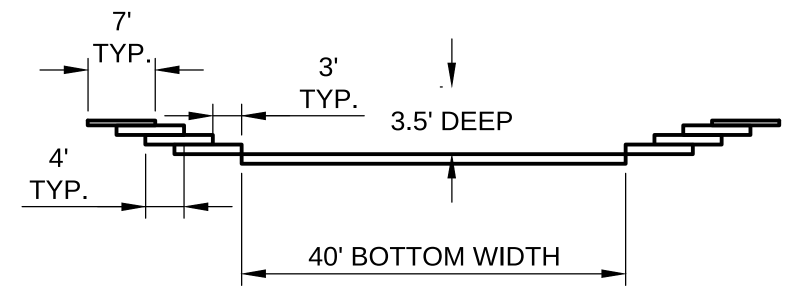

CONCRETE CHANNEL BAFFLE ENLARGEMENT
SCALE: 1" = 30'



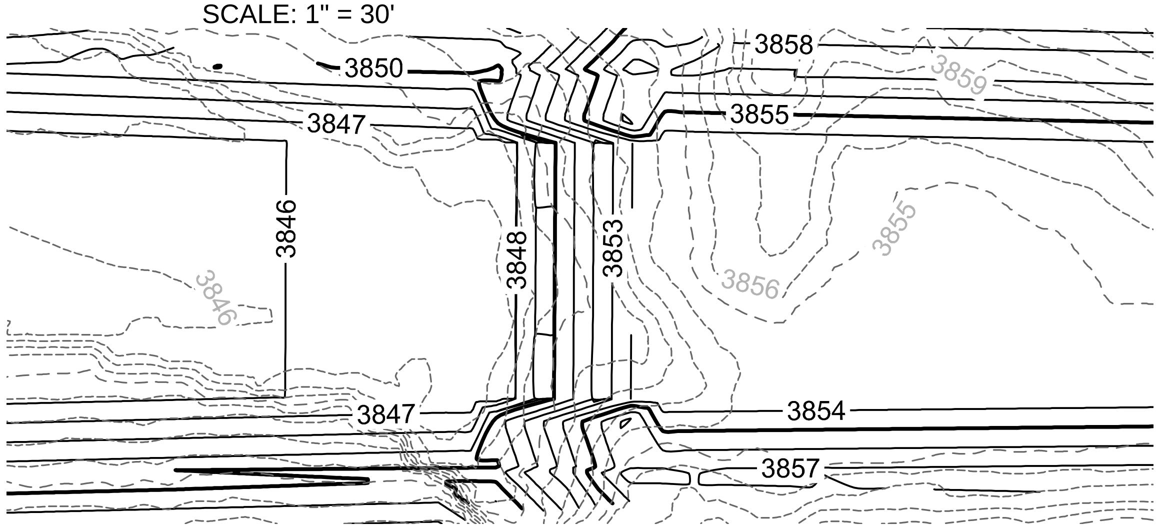

TYPICAL CHANNEL SECTION B - CONCRETE
N.T.S.



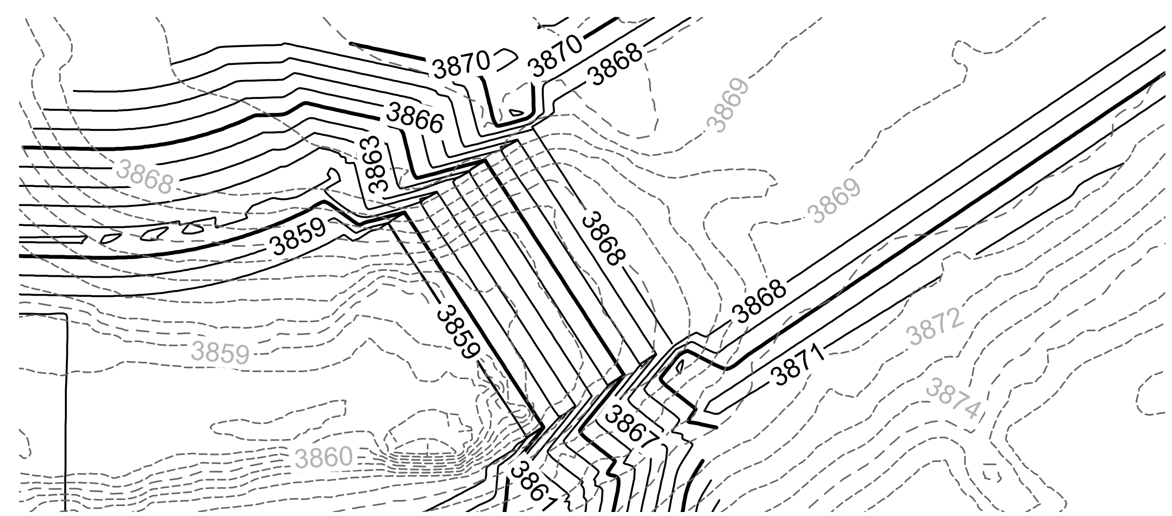

CONCRETE CHANNEL BAFFLE ENLARGEMENT
SCALE: 1" = 30'




TYPICAL CHANNEL SECTION A - SOIL CEMENT STEPS
N.T.S.




SOIL CEMENT STEPS ENLARGEMENT
SCALE: 1" = 30'




SOIL CEMENT STEPS ENLARGEMENT
SCALE: 1" = 30'

SMITH ENGINEERING

LEGEND:

VADO/DEL CERRO DRAINAGE MASTER PLAN FINAL REPORT

FIGURE 28

PROPOSED VADO CHANNEL ENERGY DISSIPATOR AND CROSS SECTION DETAILS

PROJECT NO:
817103-03

DATE:
August 2019

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### C. Alternative 3: Lily Pond with Storm Drain

Summary of Features and Main Assumptions – Alternative 3 is proposed to help reduce flooding in the residential communities located in subbasins W210 and W215. This alternative will help alleviate the stagnant water that residents have complained about at the terminus of subbasin 230. This alternative consists of one detention pond, a storm drain system and associated structures. **Figure 29** provides and overview of the alternative.

**Lily Pond:** Currently the private property in subbasin W230 routes the majority of runoff from subbasins W200, W180, W190, W170 down to an existing low spot where the proposed Lily Pond is located, see **Figure 30** below. The low spot is ideal for stormwater detention. The proposed pond will be able to detain the 10-Yr. storm.

**Storm Drain Improvements**: A storm drain system is recommended to help convey runoff from subbasins W210 and W215 to Lily Pond. The control point for the storm drain was held to the elevation at the Mesquite Drain with a minimum slope of 0.3%. This will allow for the storm drain to work in conjunction with the Lily Pond improvements. The grading plan for Lily Pond is shown on **Figure 31**. Due to site restrictions having a storm drain for the entire area was not feasible without creating a retention pond. Therefore, Smith analyzed a short storm drain section shown in **Figure 31**, below.

**Roadway Improvements**: For this storm drain system to capture the majority of runoff from the subbasins W210 and W215 the residential roads will need to be redesigned into inverted crown sections. This will allow for the road to act as a channel, directing runoff into the proposed catch basins shown on **Figure 31.**

Issues and Problems – A drainage easement for a portion of the storm drain would be necessary. This is show in Figure 28.

Goal – Convey water away from and reduce flooding in the residential community. Allow proper drainage of existing retention pond.

Is the alternative Feasible without Other alternatives – Yes, this alternative can function independently from Alternative 2.

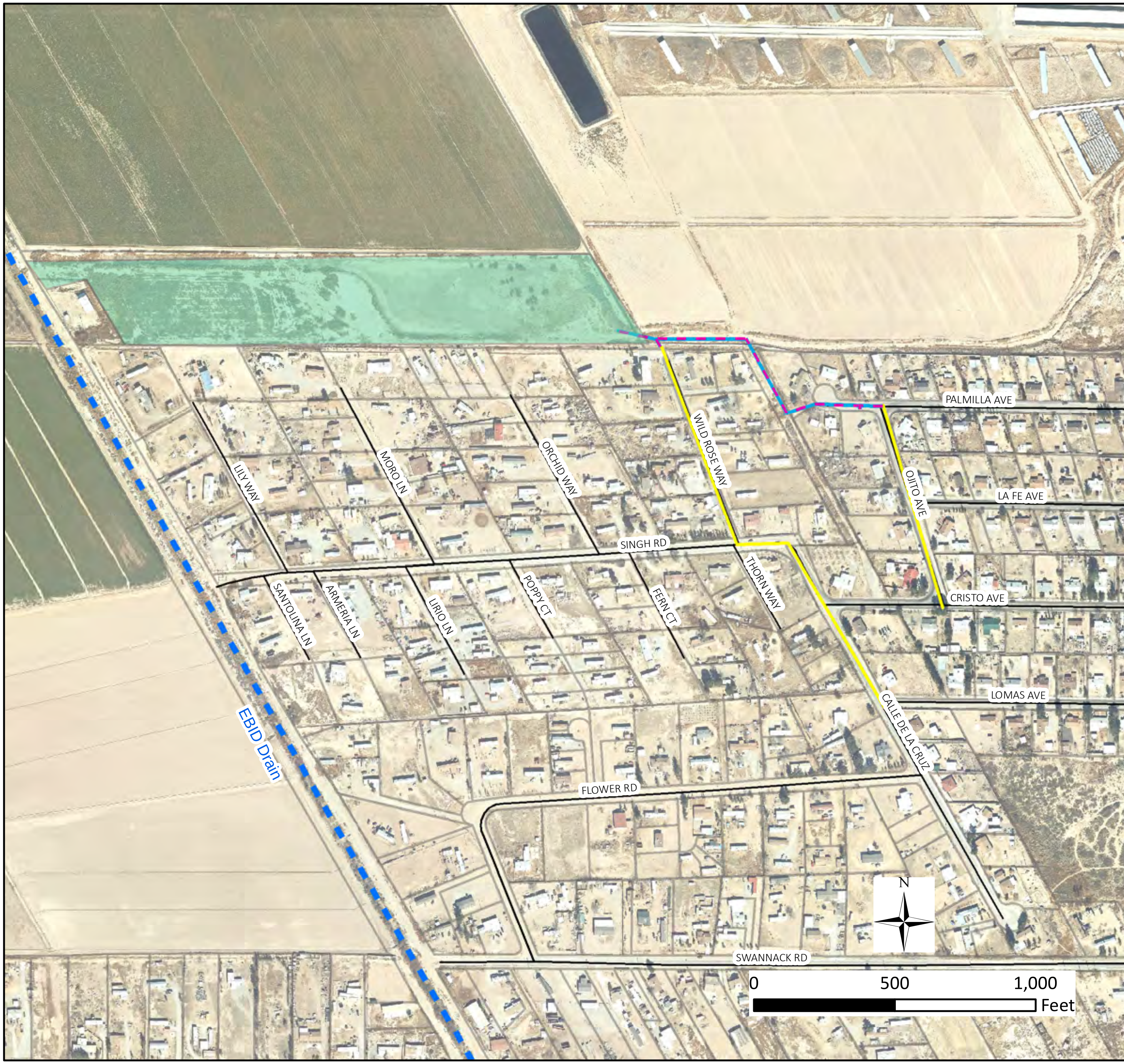
Property –Acquiring a drainage easement is recommended in order to build and maintain this alternative.

Maintenance –The catch basins will need regular maintenance to ensure no clogging from sediment and debris.

Cost – The cost of Lily Pond is approximately $495,000

The cost of the roadway and storm drain improvements is approximately $569,000

The total cost of Alternative 3 is $1,064,000




**Legend**

Proposed Lily Pond
Parcel
Storm Drain
EBID Drain
Inverted Crown Road
Roads

Vado/Del Cerro
Drainage Master Plan
Final Report

Prepared For:

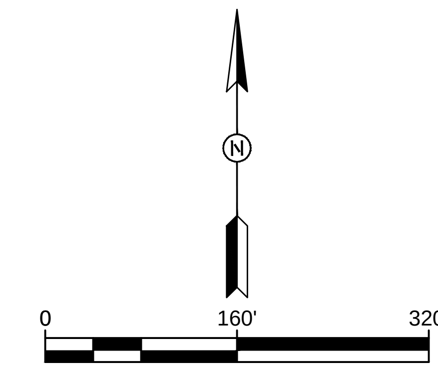
Prepared By:

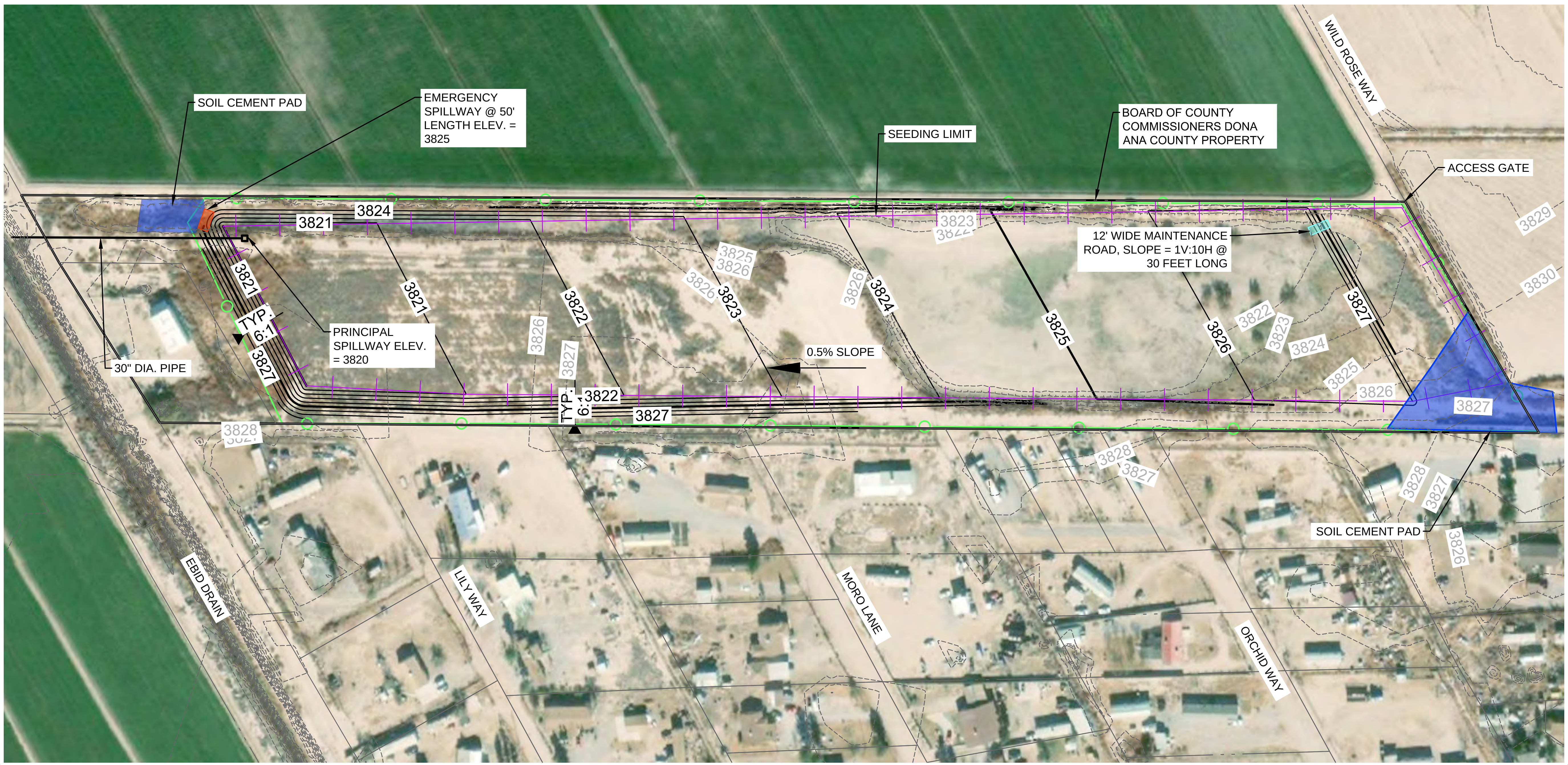
**Figure 29**
**Conceptual Layout of Alternative 3**

August 2019

## Alternative 3: Lily Pond Routing Summary

| Detention Pond Name | Existing or Proposed Pond | Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Atneuated | Inflow Runoff Volume | Outflow Runoff Volume | Maximum Design Storage Volume (top of embankment) | Peak Storage Volume for Storm Event | **Peak Water Surface Elevation** | Emergency Spillway Elevation | Pond Invert Elevation | Maximum Pond Depth | Peak Water Depth | Top of Pond Embankment Elevation | **Freeboard to Emergency Spillway Elevation** | **Freeboard to top of Pond Embankment** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ac-ft | **ft** | ft | ft | ft | ft | ft | **ft** | **ft** |
| | | a | | a | a | | a | a | b | a | a | b | b | b | | b | c | c |
| Lily Pond | Proposed 6:1 | 10 / 24 | 43.4 | 176 | 43 | 133 | 45.2 | 44.7 | 35.1 | 16 | **3824.8** | 3825 | 3820 | 7 | 5 | 3827.0 | **0.2** | **2.2** |
| Lily Pond | Proposed 6:1 | 25 / 24 | 43.4 | 358 | 155 | 203 | 78.7 | 78.1 | 35.1 | 23.5 | **3825.8** | 3825 | 3820 | 7 | 6 | 3827.0 | -0.8 | **1.2** |
| Lily Pond | Proposed 6:1 | 50 / 24 | 43.4 | 517 | 274 | 243 | 108.8 | 108.2 | 35.1 | 28 | **3826.3** | 3825 | 3820 | 7 | 6 | 3827.0 | -1.3 | **0.7** |
| Lily Pond | Proposed 6:1 | 100 / 24 | 43.4 | 660 | 391 | 269 | 141.7 | 141 | 35.1 | 32.1 | **3826.7** | 3825 | 3820 | 7 | 7 | 3827.0 | -1.7 | **0.3** |




LEGEND:

EXISTING PROPERTY LINE

FIVE STRAND NON-BARB WIRE FENCE

BASE COURSE 6" THICK

VADO/DEL CERRO DRAINAGE MASTER PLAN FINAL REPORT

FIGURE 30

CONCEPTUAL GRADING PLAN FOR LILY POND

PROJECT NO: 817103-03

DATE: August 2019

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Note:
The storm drain system collects runoff created from subbasins
W215 (Q10=5.6 cfs, Q100=29.3 cfs) and W210 (Q10=5.2 cfs, Q100= 27.9 cfs)
Refer to StormCAD output for profiles and tables and Flow Master output for inlet and curb/gutter calculations (Appendix G).
NMDOT details are used, related pages are included in Appendix G.


## Legend

- Manholes
- Storm Inlets
- Storm Drain
- Parcel
- Inverted Crown Road
- Analysis Point
- Roads
- Proposed Drainage Easement

Vado/Del Cerro
Drainage Master Plan
Final Report

Prepared for

Prepared by

**Figure 31**
**Overview of Storm Drain and Roadway Improvements**

August 2019

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**Table 6: Lily Pond Routing Summary for Alternative 3**

| Alternative 3: Lily Pond Routing Summary[d] | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Attneuated | Inflow Runoff Volume | Outflow Runoff Volume | Peak Storage Volume for Storm Event | Peak Water Surface Elevation | Emergency Spillway Elevation | Pond Invert Elevation | Peak Water Depth | Top of Pond Embank ment Elevation | Freeboard to Emergency Spillway Elevation | Freeboard to top of Pond Embankment |
| yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ft | ft | ft | ft | ft | ft | ft |
| a | | a | a | | a | a | a | a | b | b | | b | c | c |
| 10 / 24 | 43.4 | 176 | 43 | 133 | 45.2 | 44.7 | 16 | 3824.8 | 3825 | 3820 | 5 | 3827.0 | 0.2 | 2.2 |
| 25 / 24 | 43.4 | 358 | 155 | 203 | 78.7 | 78.1 | 23.5 | 3825.8 | 3825 | 3820 | 6 | 3827.0 | -0.8 | 1.2 |
| 50 / 24 | 43.4 | 517 | 274 | 243 | 108.8 | 108.2 | 28 | 3826.3 | 3825 | 3820 | 6 | 3827.0 | -1.3 | 0.7 |
| 100 / 24 | 43.4 | 660 | 391 | 269 | 141.7 | 141 | 32.1 | 3826.7 | 3825 | 3820 | 7 | 3827.0 | -1.7 | 0.3 |

( a ) Refer to Appendix D for the HEC-HMS model output for the pond routing results.

( b ) See Appendix D for all Elevation - Storage Volume - Discharge Data Tables

( c ) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

( d ) This is a proposed pond with 6:1 side slopes and a maximum Design Storage Volume (top of embankment) of 35.1 ac-ft and maximum pond depth of 7-ft

### D. Alternative 4:

Alternative 4 presents two options. The first is a system of two ponds, a collection system that includes storm drains and open channels. The purpose of this alternative is to address the flooding that has occurred south of Crazy Horse Ave, between Crazy Horse Ave and Vado Dr. **Figure 32** shows the overview of Alternative 4 with both options.

Option 1 Summary of Features and Main Assumptions –

**Estancia Pond:** Estancia Pond was developed to capture runoff from subbasins W031, W030, W034, W035, W040. However, to divert runoff from these subbasins, a collection system will be required. The design storage volume of the pond will be 3.4 ac-ft and the pond will detain all return period storms below the emergency spillway. The pond will outfall into the EBID Mesquite Drain via a 24-inch storm drain that will drain. The lack of slope between the two points of discharge only permits a slope of 0.25%. The flow out of Estancia Pond should be fairly sediment free however the velocity in the pipe will be close to 3 ft/s which is the threshold for sediment deposition. **Figure 33** shows the conceptual grading plan for Estancia Pond. **Figure 34** shows the plan and profile (PNP) of the outfall storm drain. **Table 7** summarizes the pond routing data for Estancia Pond.

**Crazy Horse Pond**: This pond will be discussed in further detail in Option 2.

**Storm Drain Improvements**: A storm drain system is recommended to help convey runoff from subbasins W031, W030, W034, W035 and W040 to Estancia Pond on Estancia St. and High line Rd. The control point for the storm drains was held to the elevation at the invert of Estancia Pond with an average slope of 1.3%. At this slope the average velocity in the system will be around 8.8 ft/s. This should prevent sediment build up in the pipe. PNP's for the two storm drains are shown on **Figure 35 and Figure 36.**

**Roadside Swales along Tapir Rd:** This feature will be discussed further in Option 2.

Issues and Problems – Property acquisition will be required for Estancia and Crazy Horse Pond. The current roads in the area are unpaved and do not fall under County jurisdiction. This is a major concern for this option. The County will have to take ownership of Estancia St. and High line Rd. Furthermore, both roads are currently unpaved. Under existing conditions, Smith recommends use of NMDOT median drop inlets (MDI's) as they are best suited for storm water interception under existing conditions. If the roadway was paved with curb and gutter, curb drop inlets may be a consideration. Sediment deposition in the Estancia Pond will be an issue.

Goal – Convey water away from and reduce flooding in the residential community. Allow proper drainage of proposed Estancia Pond.

Is the alternative Feasible without Other alternatives – Yes, this alternative can function independently.

Property –Acquiring property will be required to build and maintain the ponds proposed in this alternative. If the County does not acquire the roads, a drainage easement will be required to build the storm drains.

Maintenance –The MDI's will need regular maintenance to ensure no clogging from sediment and debris. Estancia Pond will have to have sediment removed on a regular basis.

Cost of Alternative 4 Option 1 –

Crazy Horse Pond and Earth Lined Channels $512,000

Estancia Pond $224,000

Crazy Horse Storm Drain $528,000

Estancia Storm Drain $216,000

Highline Storm Drain $492,000

**Total Cost $1,972,000**

Alternative 4 Option 1 will not meet appropriate levels of cost benefit in this area. Significant easement and property acquisition will be required to implement the projects. Roadway acquisition from the County is also a very real possibility. Estancia Pond while effective for the various return period storms will require significant storm drain improvements to function. Smith does not recommend Option 1. If the roads remain unpaved, sediment build up in Estancia Pond will be a constant maintenance hassle for the County's maintenance crew.

**Table 7: Routing Summary for Estancia Pond Alternative 4 Option 1**

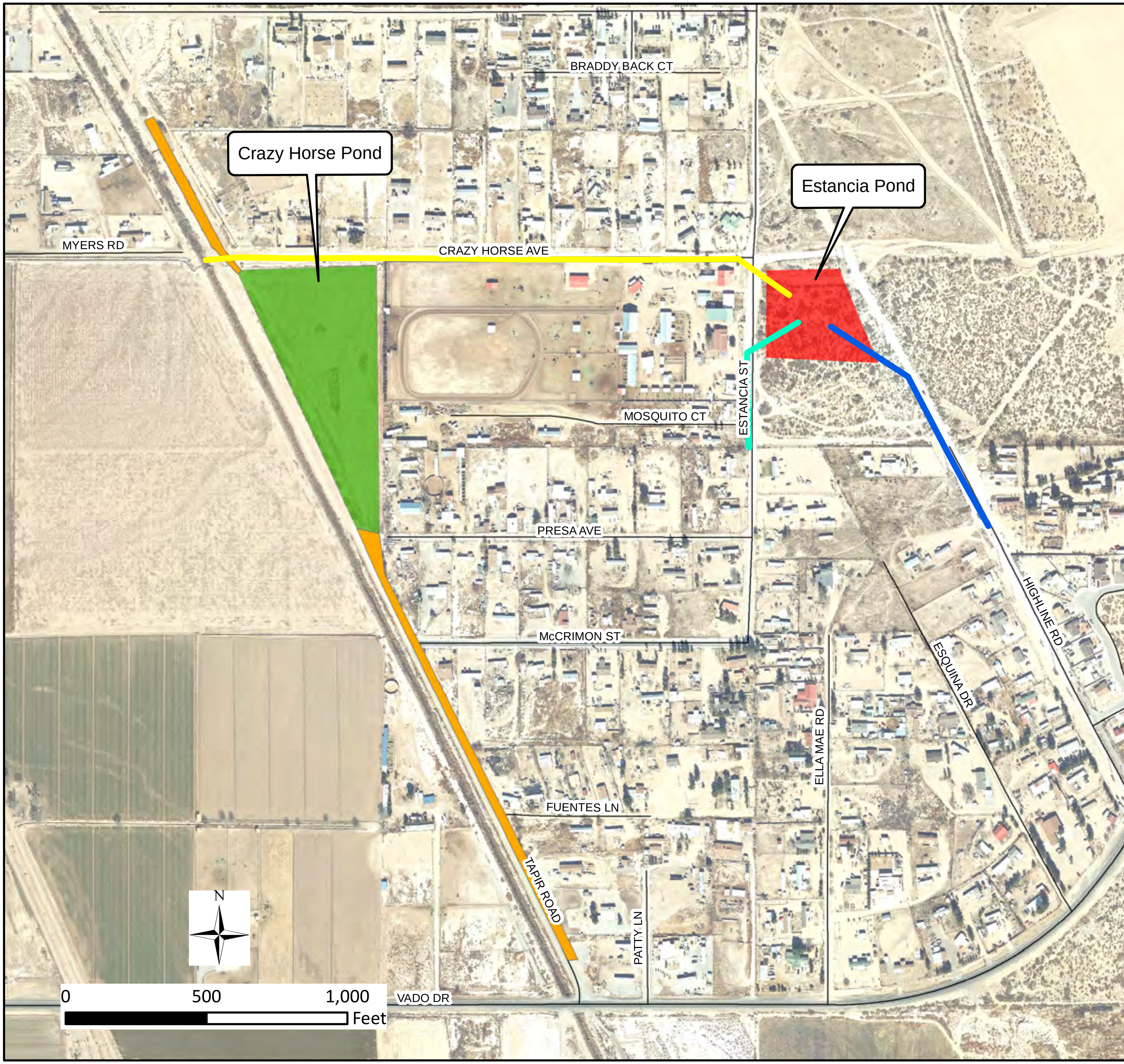
| Alternative 4 -Option 1: Estancia Pond Routing Summary[d] | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Attneuated | Inflow Runoff Volume | Outflow Runoff Volume | Peak Storage Volume for Storm Event | Peak Water Surface Elevation | Emergency Spillway Elevation | Pond Invert Elevation | Peak Water Depth | Top of Pond Embank ment Elevation | Freeboard to Emergency Spillway Elevation | Freeboard to top of Pond Embankment |
| yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ft | ft | ft | ft | ft | ft | ft |
| a | | a | a | | a | a | a | a | b | b | | b | c | c |
| 10 / 24 | 0.0735 | 4 | 3 | 1 | 2.7 | 2.7 | 0.1 | 3827.8 | 3832 | 3827 | 0.8 | 3833.0 | 4.2 | 5.2 |
| 25 / 24 | 0.0735 | 11 | 7 | 4 | 3.8 | 3.8 | 0.3 | 3828.4 | 3832 | 3827 | 1.4 | 3833.0 | 3.6 | 4.6 |
| 50 / 24 | 0.0735 | 35 | 14 | 21 | 4.8 | 4.8 | 0.6 | 3829.2 | 3832 | 3827 | 2.2 | 3833.0 | 2.8 | 3.8 |
| 100 / 24 | 0.0735 | 55 | 18 | 37 | 5.9 | 5.9 | 0.9 | 3829.7 | 3832 | 3827 | 3 | 3833.0 | 2.3 | 3.3 |

( a ) Refer to Appendix D for the HEC-HMS model output for the pond routing results.

( b ) See Appendix D for all Elevation - Storage Volume - Discharge Data Tables

( c ) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

( d ) This is a proposed pond with 4:1 side slopes and a maximum Design Storage Volume (top of embankment) of 3.4 ac-ft and maximum pond depth of 6-ft




**Legend**

- Estancia Pond
- Crazy Horse Channels
- Crazy Horse Pond
- Estancia Storm Drain
- High Line Storm Drain
- Crazy Horse Storm Drain
- Roads

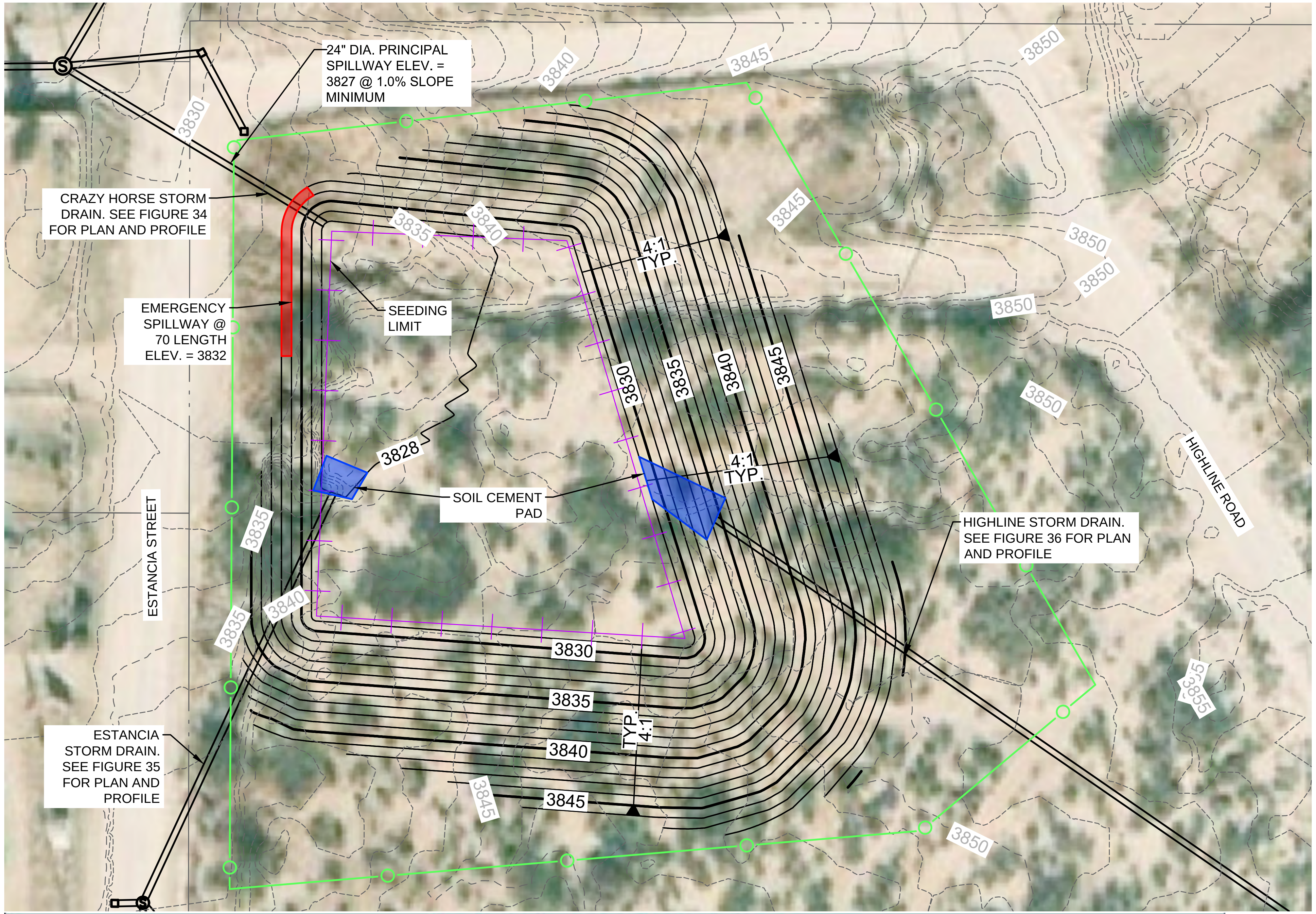
Vado/Del Cerro
Drainage Master Plan
Final Report

Prepared For:

Prepared By:

**Figure 32**
**Conceptual Layout of Alternative 4**

August 2019

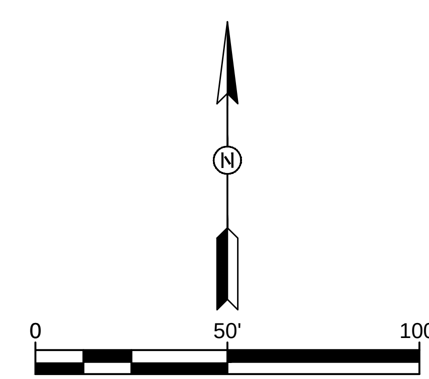



NOTES:

POND SIDE SLOPES: 1V:4H
TOP OF EMBANKMENT ELEV. = 3833'
EMERGENCY SPILLWAY ELEV. = 3832'
POND BOTTOM/PRINCIPAL SPILLWAY = 3827'
POND STORAGE VOLUME: 3.4 AC-FT

**Alternative 4 -Option 1: Estancia Pond Routing Summary**

| Detention Pond Name | Existing or Proposed Pond | Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Atteneuated | Inflow Runoff Volume | Outflow Runoff Volume | Maximum Design Storage Volume (top of embankment) | Peak Storage Volume for Storm Event | **Peak Water Surface Elevation** | Emergency Spillway Elevation | Pond Invert Elevation | Maximum Pond Depth | Peak Water Depth | Top of Pond Embank ment Elevation | **Freeboard to Emergency Spillway Elevation** | **Freeboard to top of Pond Embankment** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ac-ft | ft | ft | ft | ft | ft | ft | ft | ft |
| | | a | | a | a | | a | a | b | a | a | b | b | b | | b | c | c |
| Estancia Pond | Proposed 4:1 | 10 / 24 | 0.0735 | 4 | 3 | 1 | 2.7 | 2.7 | 3.4 | 0.1 | **3827.8** | 3832 | 3827 | 6 | 0.8 | 3833.0 | **4.2** | **5.2** |
| Estancia Pond | Proposed 4:1 | 25 / 24 | 0.0735 | 11 | 7 | 4 | 3.8 | 3.8 | 3.4 | 0.3 | **3828.4** | 3832 | 3827 | 6 | 1.4 | 3833.0 | **3.6** | **4.6** |
| Estancia Pond | Proposed 4:1 | 50 / 24 | 0.0735 | 35 | 14 | 21 | 4.8 | 4.8 | 3.4 | 0.6 | **3829.2** | 3832 | 3827 | 6 | 2.2 | 3833.0 | **2.8** | **3.8** |
| Estancia Pond | Proposed 4:1 | 100 / 24 | 0.0735 | 55 | 18 | 37 | 5.9 | 5.9 | 3.4 | 0.9 | **3829.7** | 3832 | 3827 | 6 | 3 | 3833.0 | **2.3** | **3.3** |




SMITH ENGINEERING

LEGEND:

EXISTING PROPERTY LINE

FIVE STRAND NON-BARB WIRE FENCE

BASE COURSE 6" THICK

VADO/DEL CERRO DRAINAGE MASTER PLAN FINAL REPORT

FIGURE 33

CONCEPTUAL GRADING PLAN FOR ESTANCIA POND

PROJECT NO:
817103-03

DATE:
August 2019

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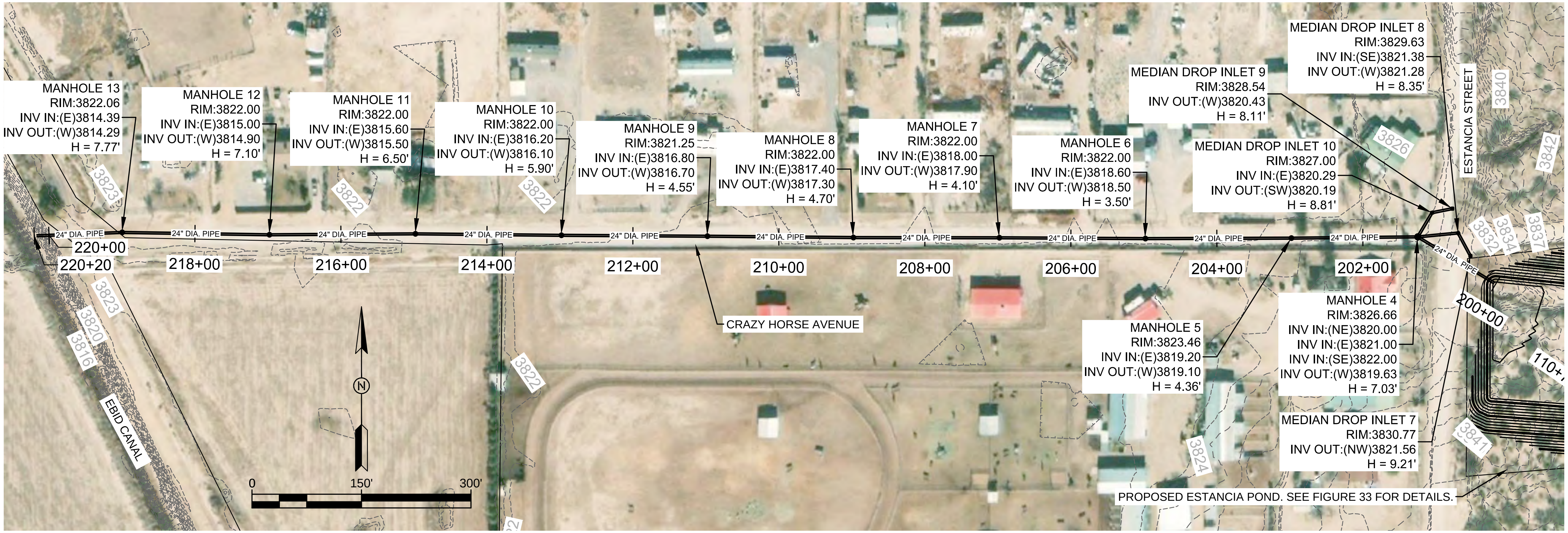


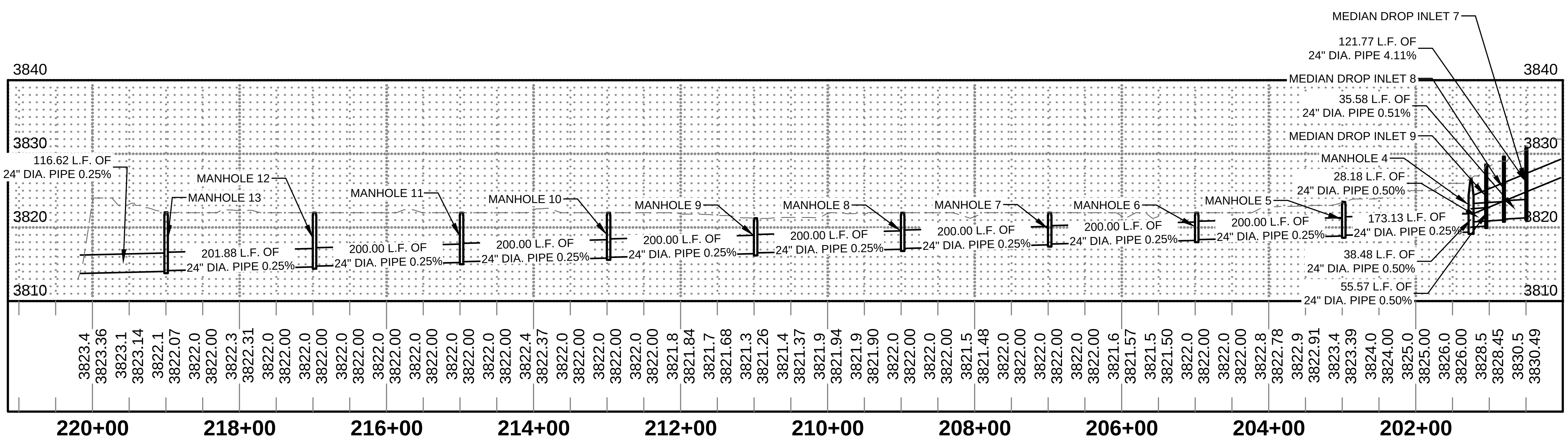


SMITH ENGINEERING

LEGEND:

SUBBASIN BOUNDARY

EXISTING PROPERTY LINE

VADO/DEL CERRO DRAINAGE MASTER PLAN FINAL REPORT

FIGURE 34

PLAN AND PROFILE FOR ESTANCIA POND OUTLET WORKS

PROJECT NO:
817103-03

DATE:
August 2019

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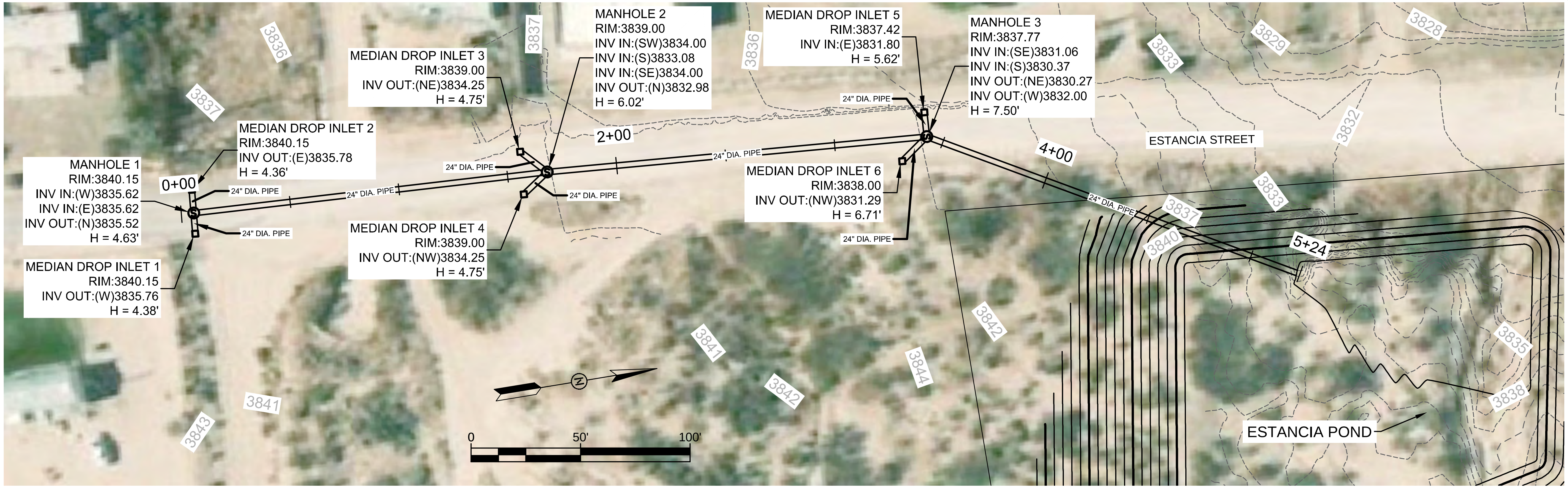


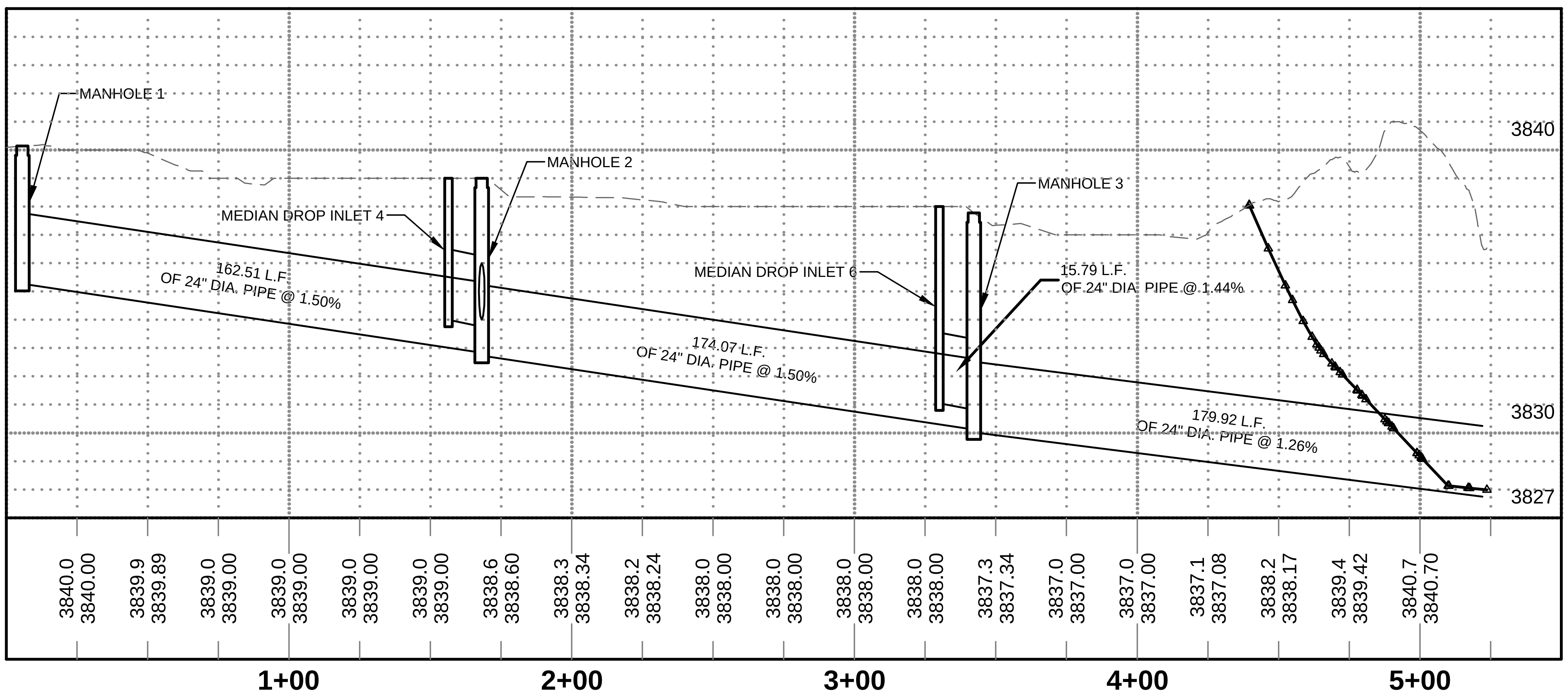


SMITH ENGINEERING

LEGEND:

EXISTING PROFILE

PROPOSED PROFILE

VADO/DEL CERRO DRAINAGE MASTER PLAN FINAL REPORT

FIGURE 35

PLAN AND PROFILE FOR ESTANCIA STORM DRAIN

PROJECT NO:
817103-03

DATE:
August 2019

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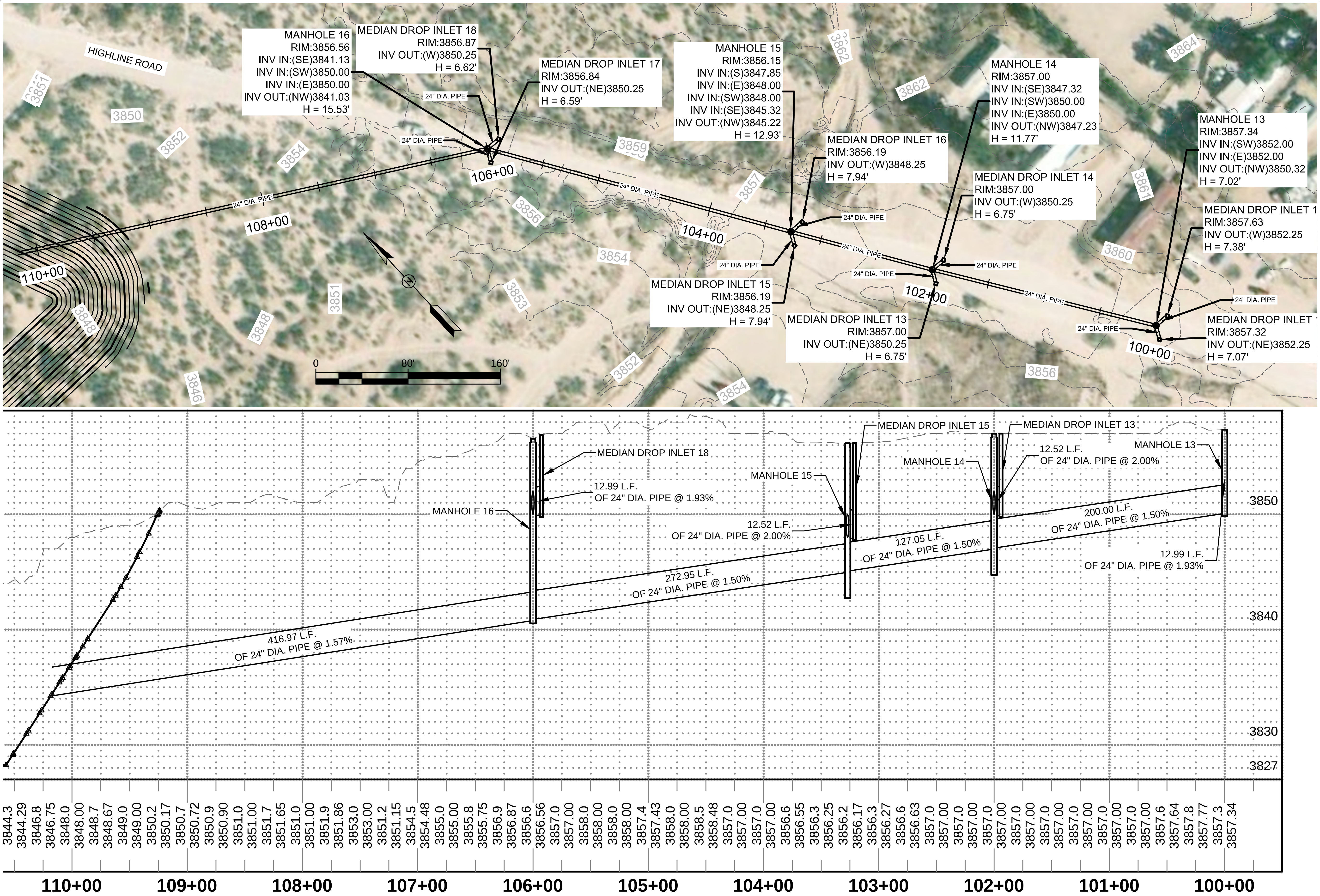


SMITH ENGINEERING

LEGEND:

PROPOSED PROFILE

EXISTING PROFILE

VADO/DEL CERRO DRAINAGE MASTER PLAN FINAL REPORT

FIGURE 36

PLAN AND PROFILE FOR HIGHLINE STORM DRAIN

PROJECT NO:
817103-03

DATE:
August 2019

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Option 2 Summary of Features and Main Assumptions –

**Crazy Horse Pond**: The 22.5 ac-ft pond is located at the intersection of Tapir Rd and Crazy Horse Ave. This area has a history of flooding complaints. The west side of Tapir Rd abuts the EBID Mesquite Drain and there are no outlets in the area that allow storm water to drain into the EBID drain. In the past, residents have made cuts in the embankment of the EBID drain to allow ponded storm water to drain. The proposed location for the Crazy Horse Pond is naturally the low spot for most of the subbasins south of Crazy Horse Ave. This is an ideal collection and detention location which would rule out the need for upstream storm drains. **Figure 37** shows the conceptual layout for the pond. **Table 8** provides the routing summary for Crazy Horse Pond. The pond is able to provide successful detention for all return period storms with significant peak flow attenuation.

**Storm Drain Improvements**: Topographically the subbasins drain towards Tapir Rd. This eliminates the need for building storm drains within the limits of all the privately-owned roads.

**Roadside Swales along Tapir Rd:** Roadside swales will be utilized to divert the surface runoff that drains to Tapir Rd between Crazy Horse Ave. and Vado Rd. There is very little slope in the north – south direction and an open channel system would be the most efficient in terms of operations and maintenance. **Figures 38 and 39** show the conceptual layout of the roadside swales.

Issues and Problems – Property acquisition will be required for Crazy Horse Pond. Easements maybe required for the roadside swales depending on actual property boundary surveys. The swales and the pond will be prone to sedimentation. The pond will be in a residential area so proper fencing will be required to control access especially in the monsoon season.

Goal – Convey water away from and reduce flooding in the residential community. Allow proper drainage of proposed Crazy Horse Ave and all areas south to Vado Dr.

Is the alternative Feasible without Other alternatives – Yes, this alternative can function independently from other alternatives.

Property –Acquiring property will be required to build and maintain the pond proposed in this alternative.

Maintenance –Sediment deposition will be a long-term issue with the pond and swales. A regular maintenance schedule will be necessary.

Cost –

The entire project cost is approximately $512,000

**Table 8: Routing Summary Table for Crazy Horse Pond**

| Alternative 4 - Option 2: Crazy Horse Pond Routing Summary | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Attenuated | Inflow Runoff Volume | Outflow Runoff Volume | Peak Storage Volume for Storm Event | Peak Water Surface Elevation | Emergency Spillway Elevation | Pond Invert Elevation | Peak Water Depth | Top of Pond Embankment Elevation | Freeboard to Emergency Spillway Elevation | Freeboard to top of Pond Embankment |
| yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ft | ft | ft | ft | ft | ft | ft |
| a | | a | a | | a | a | a | a | b | b | | b | c | c |
| 10 / 24 | 0.4120 | 57 | 10 | 47.0 | 10.5 | 10.4 | 3.5 | 3817.8 | 3821 | 3816 | 1.8 | 3822.0 | 3.2 | 4.2 |
| 25 / 24 | 0.4120 | 112 | 20 | 92.0 | 16.8 | 16.7 | 6.6 | 3818.9 | 3821 | 3816 | 2.9 | 3822.0 | 2.1 | 3.1 |
| 50 / 24 | 0.4120 | 180 | 26 | 154.0 | 22.6 | 22.5 | 9.6 | 3819.9 | 3821 | 3816 | 3.9 | 3822.0 | 1.1 | 2.1 |
| 100 / 24 | 0.4120 | 239 | 28 | 210.5 | 28.7 | 28.7 | 12.6 | 3820.4 | 3821 | 3816 | 4.4 | 3822.0 | 0.6 | 1.6 |

( a ) Refer to Appendix D for the HEC-HMS model output for the pond routing results.

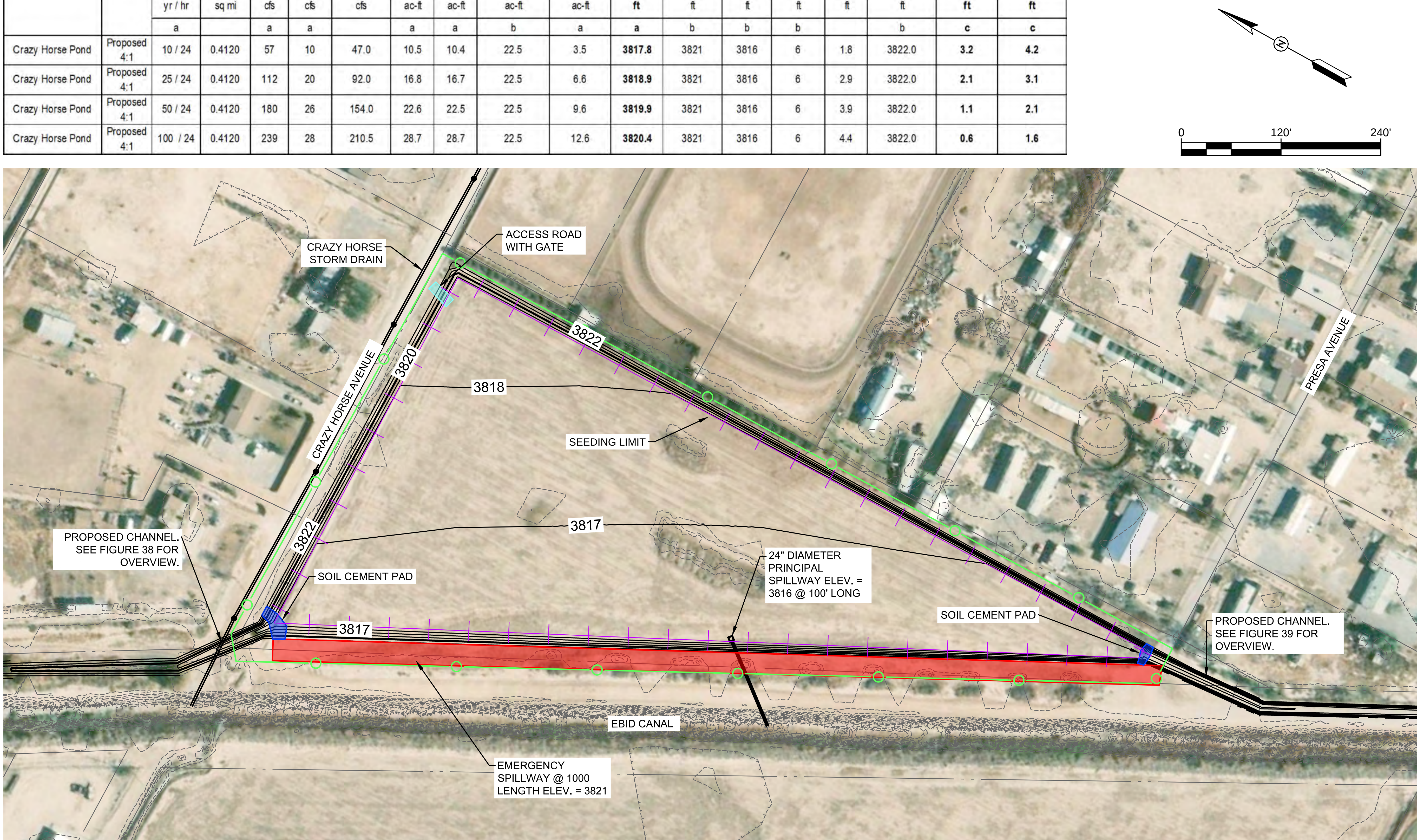
( b ) See Appendix D for all Elevation - Storage Volume - Discharge Data Tables

( c ) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

( d ) This is a proposed pond with 4:1 side slopes and a maximum Design Storage Volume (top of embankment) of 22.5 ac-ft and maximum pond depth of 6-ft

**Alternative 4 - Option 2: Crazy Horse Pond Routing Summary**

| Detention Pond Name | Existing or Proposed Pond | Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Attenuated | Inflow Runoff Volume | Outflow Runoff Volume | Maximum Design Storage Volume (top of embankment) | Peak Storage Volume for Storm Event | **Peak Water Surface Elevation** | Emergency Spillway Elevation | Pond Invert Elevation | Maximum Pond Depth | Peak Water Depth | Top of Pond Embankment Elevation | **Freeboard to Emergency Spillway Elevation** | **Freeboard to top of Pond Embankment** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ac-ft | **ft** | ft | ft | ft | ft | ft | **ft** | **ft** |
| | | a | | a | a | | a | a | b | a | a | b | b | b | | b | c | c |
| Crazy Horse Pond | Proposed 4:1 | 10 / 24 | 0.4120 | 57 | 10 | 47.0 | 10.5 | 10.4 | 22.5 | 3.5 | **3817.8** | 3821 | 3816 | 6 | 1.8 | 3822.0 | **3.2** | **4.2** |
| Crazy Horse Pond | Proposed 4:1 | 25 / 24 | 0.4120 | 112 | 20 | 92.0 | 16.8 | 16.7 | 22.5 | 6.6 | **3818.9** | 3821 | 3816 | 6 | 2.9 | 3822.0 | **2.1** | **3.1** |
| Crazy Horse Pond | Proposed 4:1 | 50 / 24 | 0.4120 | 180 | 26 | 154.0 | 22.6 | 22.5 | 22.5 | 9.6 | **3819.9** | 3821 | 3816 | 6 | 3.9 | 3822.0 | **1.1** | **2.1** |
| Crazy Horse Pond | Proposed 4:1 | 100 / 24 | 0.4120 | 239 | 28 | 210.5 | 28.7 | 28.7 | 22.5 | 12.6 | **3820.4** | 3821 | 3816 | 6 | 4.4 | 3822.0 | **0.6** | **1.6** |




SMITH ENGINEERING

LEGEND:

SUBBASIN BOUNDARY

EXISTING PROPERTY LINE

FIVE STRAND NON-BARB WIRE FENCE

BASE COURSE 6" THICK

VADO/DEL CERRO DRAINAGE MASTER PLAN FINAL REPORT

FIGURE 37

CONCEPTUAL GRADING PLAN FOR CRAZY HORSE POND

PROJECT NO: 817103-03

DATE: August 2019

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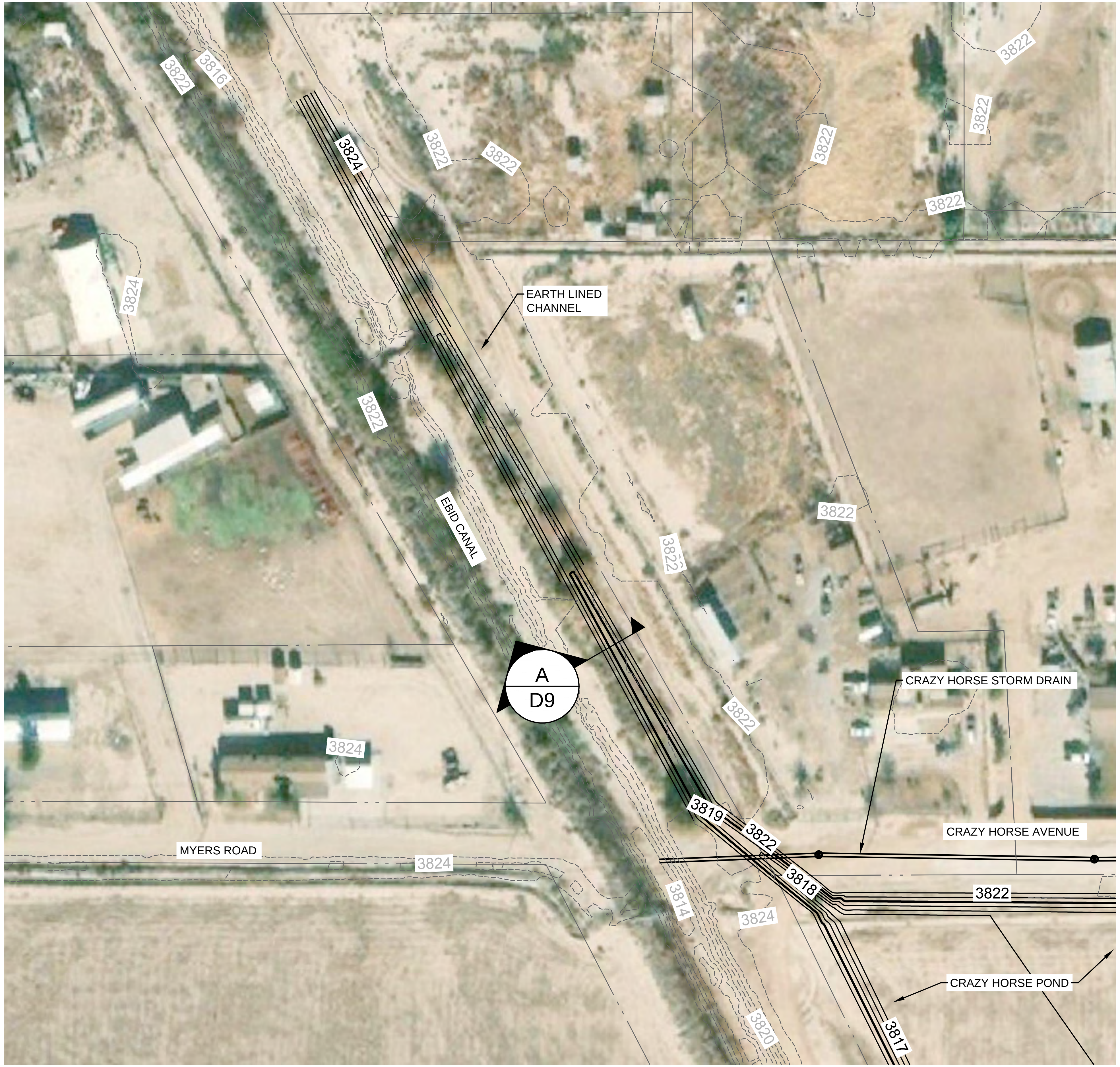
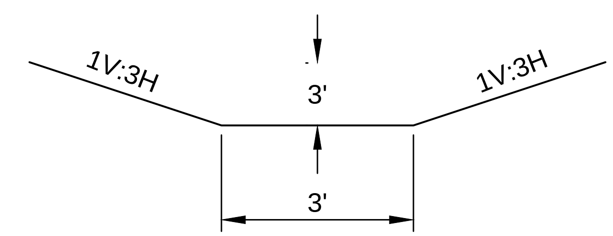
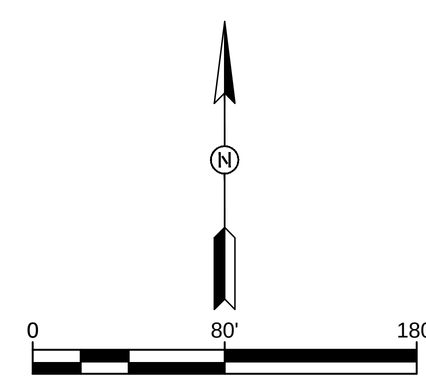



NOTES:

CHANNEL BOTTOM WIDTH: 3 FEET
CHANNEL DEPTH: 3 FEET
CHANNEL SIDE SLOPES: 1V:3H
LONGITUDINAL SLOPE: 0.5%
CHARACTERISTICS: EARTH LINED CHANNEL, "n" VALUE = 0.045
POND CUT/FILL VOLUME: INCLUDED IN CRAZY HORSE POND




TYPICAL CHANNEL SECTION A
N.T.S.




SMITH ENGINEERING

LEGEND:

EXISTING PROPERTY LINE

VADO/DEL CERRO DRAINAGE MASTER PLAN FINAL REPORT

FIGURE 38

CONCEPTUAL GRADING PLAN FOR CRAZY HORSE CHANNEL - NORTH

PROJECT NO:
817103-03

DATE:
August 2019

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NOTES:

CHANNEL BOTTOM WIDTH: 1 FEET
CHANNEL DEPTH: 1.25 FEET
CHANNEL SIDE SLOPES: 1V:4H
LONGITUDINAL SLOPE: 0.25%
CHARACTERISTICS: EARTH LINED (GRAVELLY) CHANNEL, "n" VALUE = 0.025
POND CUT/FILL VOLUME: INCLUDED IN CRAZY HORSE POND

SMITH ENGINEERING

LEGEND:

EXISTING PROPERTY LINE

VADO/DEL CERRO DRAINAGE MASTER PLAN FINAL REPORT

FIGURE 39

CONCEPTUAL GRADING PLAN FOR CRAZY HORSE CHANNEL - SOUTH

PROJECT NO:
817103-03

DATE:
August 2019

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# SECTION 5. PRIORITIZATION OF OPTIONS

## 5.1 VIABLE OPTIONS

A full overview of all the recommended alternatives is presented in **Figure 40.** Based on severity and frequency of complaints that are shown in **Figure 21**, the following priority of projects is suggested. This is subject to approval from the DACFC.

**Alternative 4 Option 2:** The Crazy Horse Pond and the two roadside swales can be constructed together to reduce mobilization and demobilization costs.

**Alternative 2 Phase 1:** Typically, downstream pond improvements should be constructed first. However, since an existing ponding area already exists and seems to have coped well with runoff that's draining to it, Smith recommends improving the outlet works for Tapir Pond to reduce the impact of mosquitoes. Channel improvements should be made concurrently. Channel improvements are subject to preliminary and final design. A more detailed cost analysis between design materials should be made as part of the design analysis report. Currently, for this conceptual planning report, the cost of a soil cement channel is slightly lower and therefore recommended.

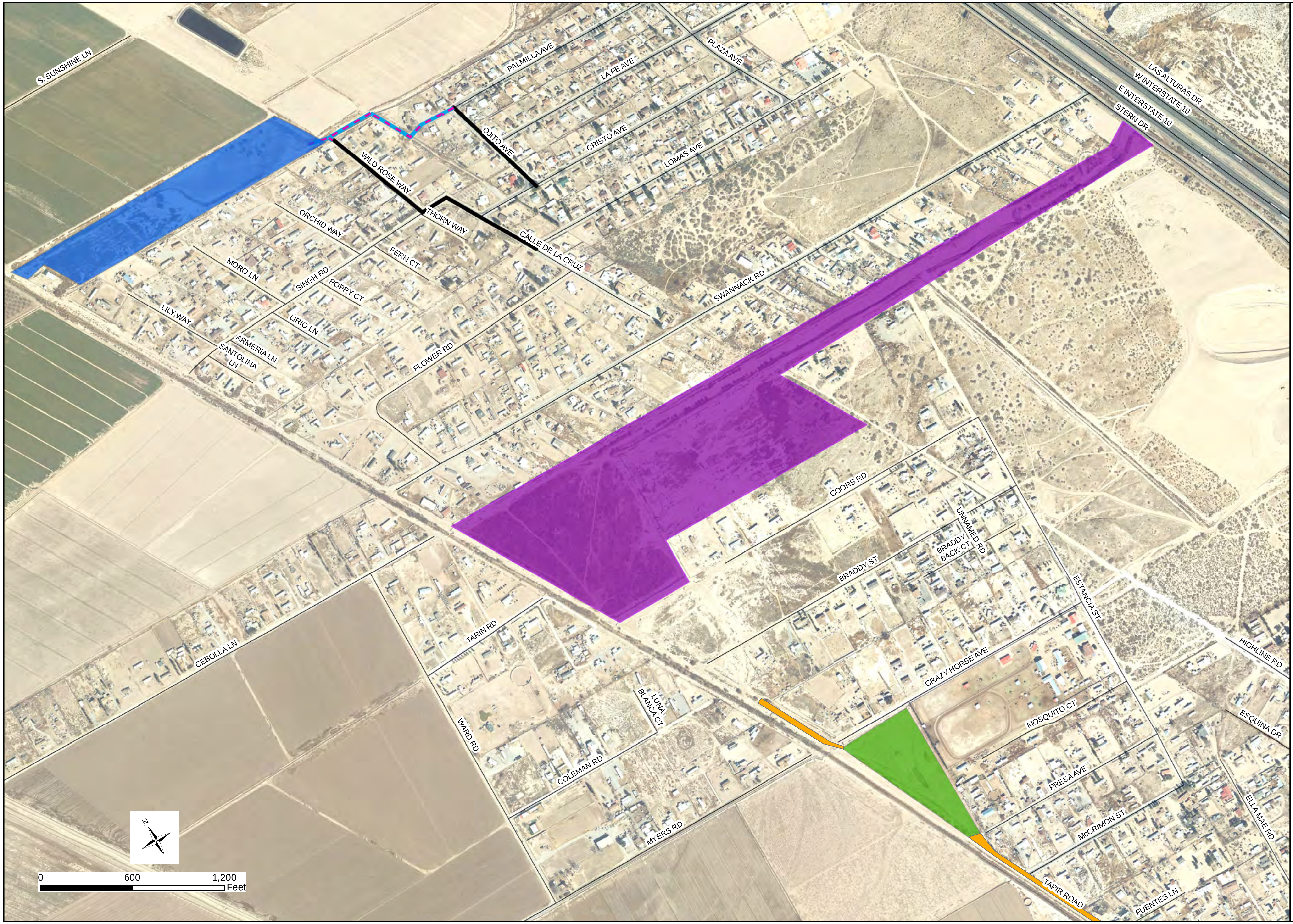
**Alternative 2 Phase 2:** This phase would be the expansion of the Tapir Pond to the limits prescribed in this study. A detailed design survey should be completed to determine the exact elevations along the Mesquite Drain to verify jurisdictional status and final footprint of the Tapir Pond.

**Alternative 3 Phase 1:** Lilly Pond should be remediated with a gravity outfall and graded out to the footprint prescribed in this study.

**Alternative 3 Phase 2:** Roadway and storm drain improvements should be implemented as prescribed in this study.

**Table 9: Summary of Costs for Recommended Alternatives**

| Summary of Engineer's Opinion of Probable Cost For All Recommended Options<br>Vado/Del Cerro Drainage Master Plan | | | | |
|---|---|---|---|---|
| | Priority | Phase | Description | Cost |
| Alternative 4 - Option 2 | 1 | 1 | Crazy Horse Pond and Earth Lined Channels | $ 512,000 |
| | | | | |
| Alternative 2 | 2 | 1 | Vado Channel - Soil Cement and Tapir Pond Outlet Works | $ 1,574,000 |
| Alternative 2 | 3 | 2 | Tapir Pond Expansion | $ 3,567,000 |
| | | | | |
| Alternative 3 | 4 | 1 | Lily Pond | $ 495,000 |
| Alternative 3 | 5 | 2 | Storm Drain and Roadway Improvements | $ 569,000 |
| | | | | |
| Total Cost of Phased Capital Improvement Projects | | | | $ 6,717,000 |




Vado/Del Cerro Drainage Master Plan Final Report

Prepared for

DOÑA ANA COUNTY NEW MEXICO

Prepared by

SMITH ENGINEERING

**Figure 40**
**Overview of All Recommended Options**

August 2019

Document Path: Q:\SEC---PROJECTS\817103-03\GIS\817103-03_SummaryofOptions.mxd

## 5.2 CONCLUSIONS AND RECOMMENDATIONS

The facilities presented in this report will provide significant flood mitigation for the design storm. They may be refined further if required to control a different return period storm.

All conceptual grading plans are based off 2018 DACFC elevation data. A design analysis report, preliminary and final design construction plans, design survey, utility locations and surveyed platting information will be required for the construction of these projects.

# SECTION 6. REFERENCES

1. NOAA Atlas 14 Point Precipitation Frequency Estimates Output (printed from NOAA Atlas 14 internet site).

2. Figure 14, Depth-Area Curves (Source: NOAA Atlas 2 Vol. IV, New Mexico 1973).

3. Urban Hydrology for Small Watersheds, U.S. Department of Agricultural Soil Conservation Service, Technical Release 55, June 1986.

Approximate Geographic Boundaries for SCS Rainfall Distributions (FOR REFERENCE ONLY – The HEC-HMS Rainfall 25% Frequency Distribution was adopted).

Table 2-2a Runoff Curve Numbers for Urban Areas.

Table 2-2b Runoff Curve Numbers for Cultivated Agricultural Land.

Table 2-2c Runoff Curve Numbers for Other Agricultural Lands.

Table 2-2d Runoff Curve Numbers for Arid and Semiarid Rangelands.

Chapter 3 - Time of Concentration and Travel Time Computation Procedure

4. National Engineering Handbook, Part 630, Chapter 15 - Time of Concentration. Natural Resources Conservation Service. May 2010. (Documentation that Lag Time = 0.6 Time of Concentration).

5. Sediment Bulking Factors were assumed based select pages - Figure 3.8 within - Sediment and Erosion Design Guide, November 2008. Prepared by Mussetter Engineering Inc. Prepared for the Southern Sandoval County Arroyo Flood Control Authority.

6. HEC-HMS Computation Time Interval Guidance.

7. Manning's "n" Values from - Open Channel Hydraulics, Ven T. Chow, 1959.

8. Soils Data Summary for: Soil Map Unit Descriptions and Hydrologic Soil Groups from Natural Resources Conservation Service (NRCS) Web Soil Survey – National Cooperative Soil Survey.

# APPENDIX A

## ANNOTATED PHOTOGRAPHS

Figure A1: Culvert and Photo Locations

Annotated Photos


**Legend**

- Annotated Photos
- Culverts
- Roads

Vado/Del Cerro
Drainage Master Plan
Final Report

Prepared For:

Prepared By:

**Figure A1**
**Culvert and Photo Locations**

August 2019

*Figure 1: Culvert C3 - no culvert under west frontage road.*

*Figure 2: Culvert C4a and C4b – no culvert under west frontage road. There is a channel that end before La Fe Ave.*

*Figure 3: Where the channel at the downstream of C4a and C4b starts getting shallower. It ends just before La Fe Ave.*

*Figure 4:Culvert under west frontage road downstream of Culvert C5. It is supposed to be 36” CMP but upstream is deflected so the culvert rise is reduced to approximately 24” (see next picture).*

*Figure 5: Culvert under west frontage road downstream of Culvert C5. It is supposed to be 36" CMP but upstream is deflected so the culvert rise is reduced to approximately 24"*

*Figure 6:Channel at the downstream of culvert C5. It stays within W230 and does not appear to flow to W580.*

*Figure 7: Culvert 1 ( 1 @ 24" CMP) under east frontage road (near CBCs). Upstream: full of debris, hard to find! Downstream: is shown above*


*Figure 8: Culvert 1 (1 @ 24" CMP) under east frontage road (near CBCs)  Downstream: is shown here (full of debris). Upstream is shown above.*

*Figure 9: Culvert C3*

*Figure 10: Culvert C3*

*Figure 11: Culvert C3*

*Figure 12: Culvert 3*

*Figure 13: Culvert 4a*

*Figure 14: Culvert 4b*

*Figure 15: Culvert 4b*

*Figure 16: Culvert 4b*

*Figure 17: Culvert 5*

*Figure 18: Culvert C5*

*Figure 19: Culvert C6*

*Figure 20: Culvert C6-Frontage Road*


*Figure 21: Culvert C6 - Frontage Road*

*Figure 22: Culvert C7*

*Figure 23: Culvert C7*

*Figure 24: Intersection of Lomas Ave. and Calle De La Cruz Rd*

*Figure 25:Intersection of Lomas Ave. and Calle De La Cruz Rd noting where sediment is indication of runoff direction*

# APPENDIX B

## PREVIOUS PLANS AND REPORTS

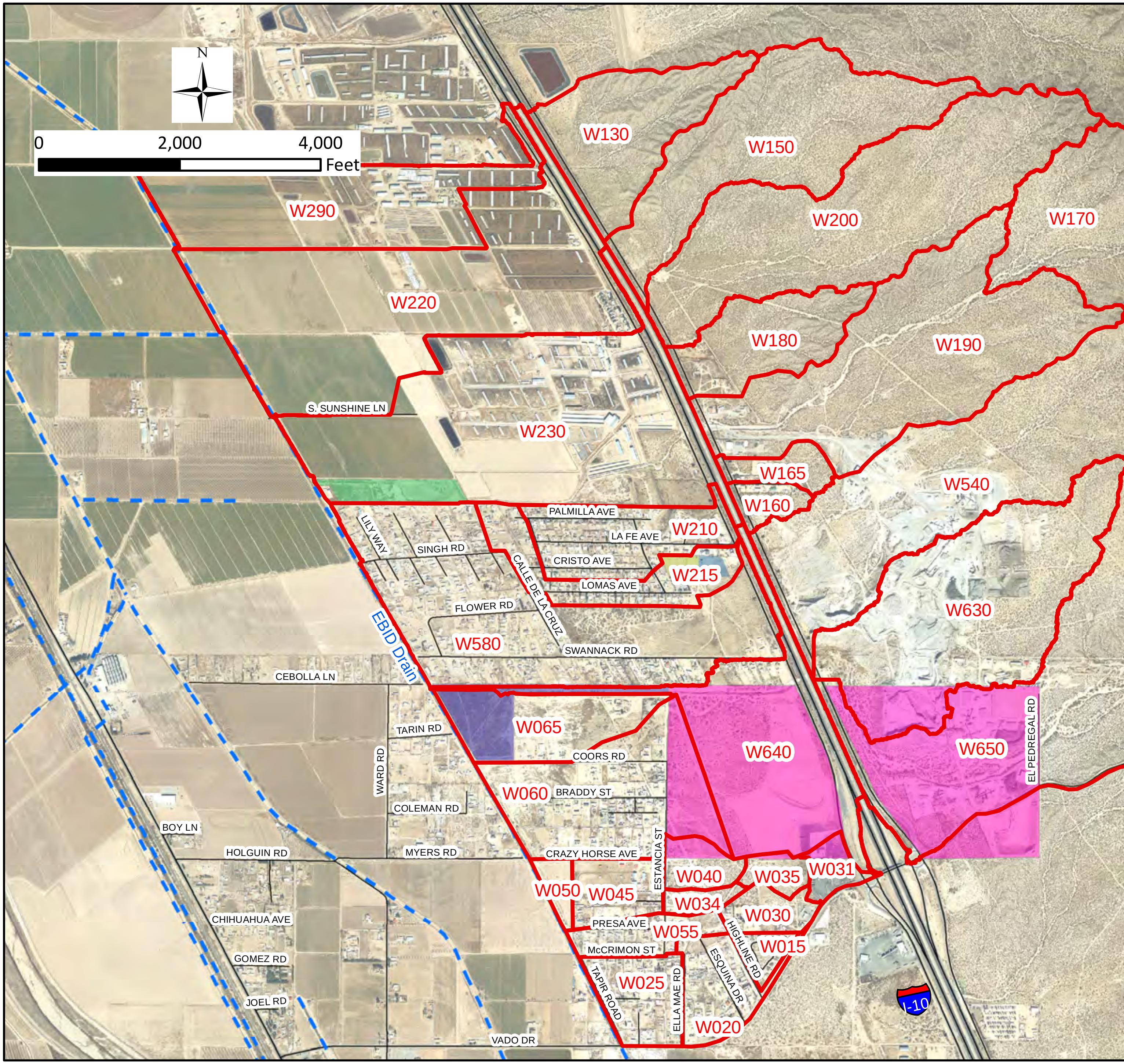
Figure B1 – Land Ownership Map

EBID Construction Plans

-

FEMA Flood Insurance Rate Maps (Dated July 6,2016):

- FEMA FIRM No. 35013C1325G
- FEMA FIRM No. 35013C1350G
- FEMA FIRM No. 35013C1525G




## Legend

Subbasin Boundary

W220 Subbasin Name

Board of County Commissioners Dona Ana County

County of Dona Ana

Dona Ana County

Dona Ana County Flood Commission

State of New Mexico

EBID Drain

Roads

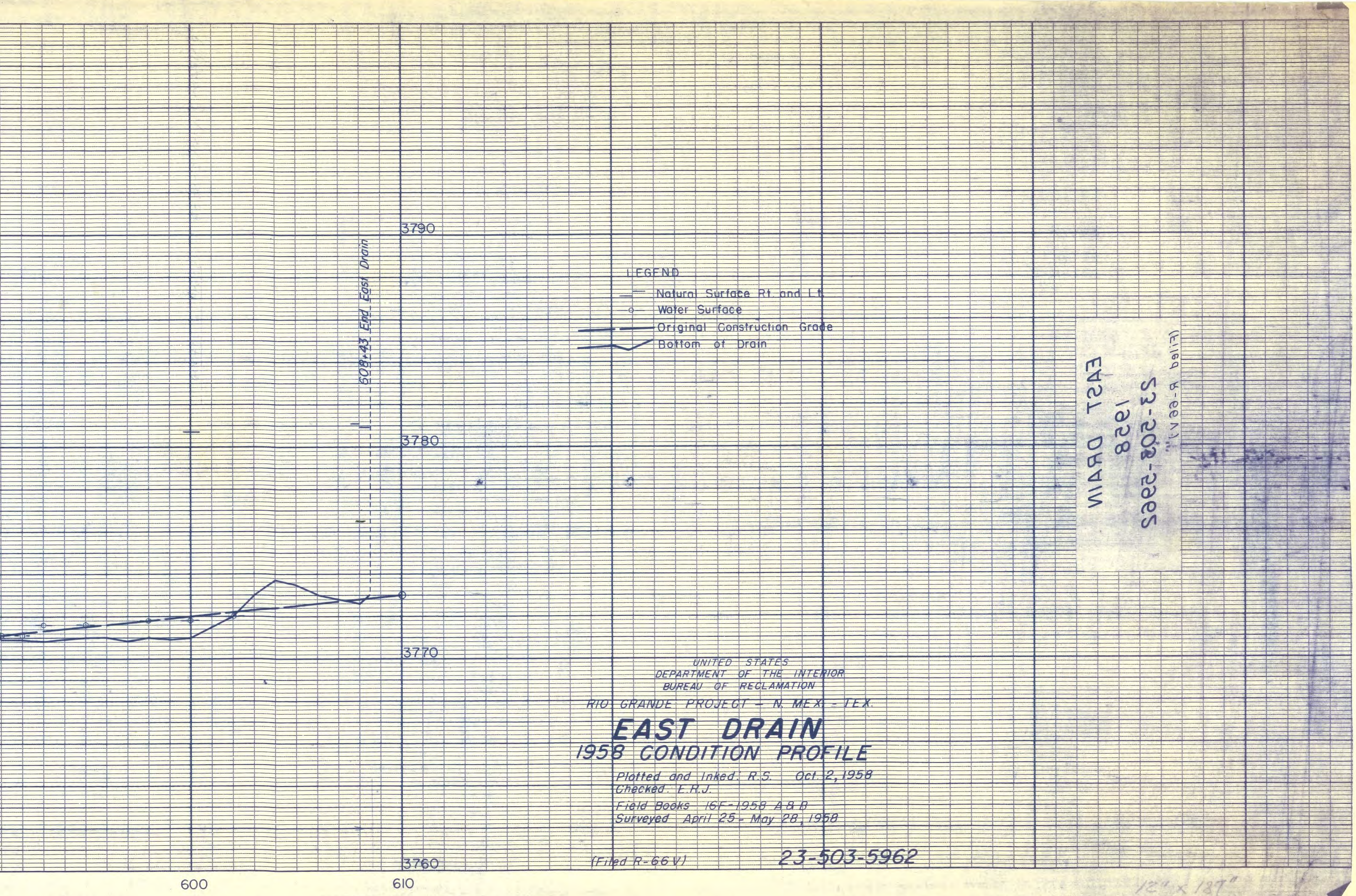
Vado/Del Cerro Drainage Master Plan Final Report

Prepared For:

Prepared By:

**Figure B1 Land Ownership**

August 2019



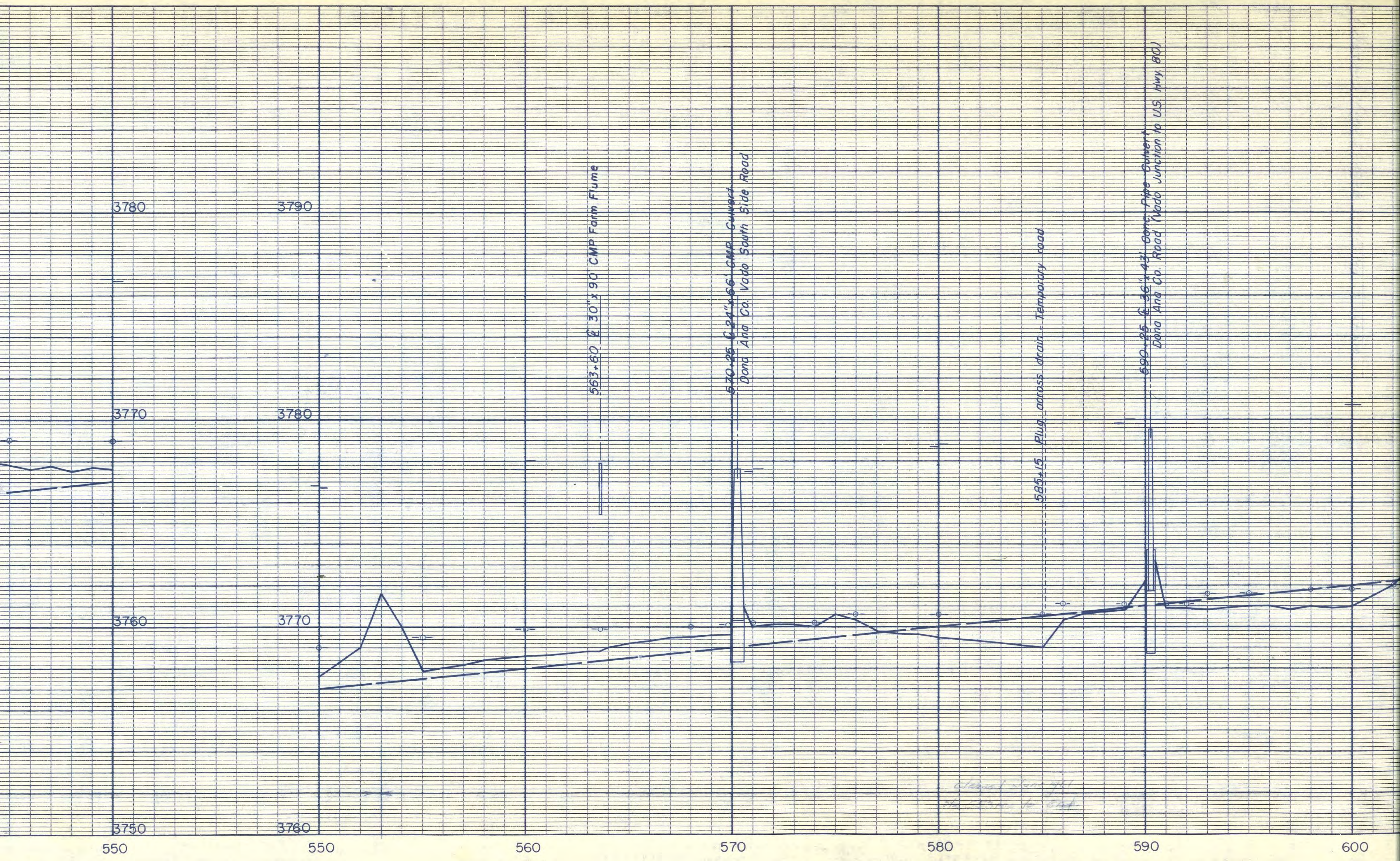

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RIO GRANDE PROJECT – N. MEX. – TEX.

# EAST DRAIN

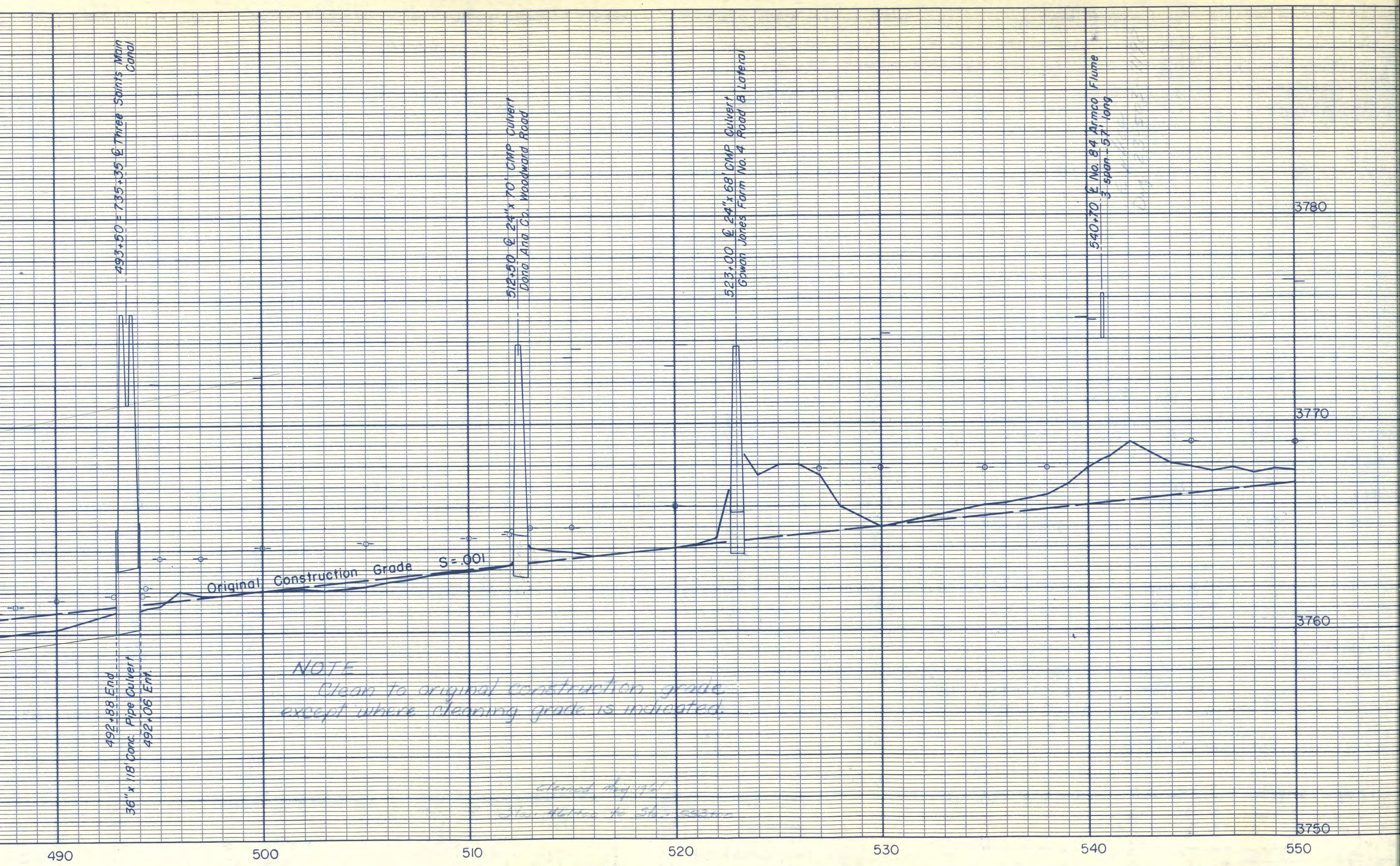
## 1958 CONDITION PROFILE

Plotted and Inked: R.S. Oct. 2, 1958
Checked: E.R.J.
Field Books 16F-1958 A & B
Surveyed April 25 - May 28, 1958

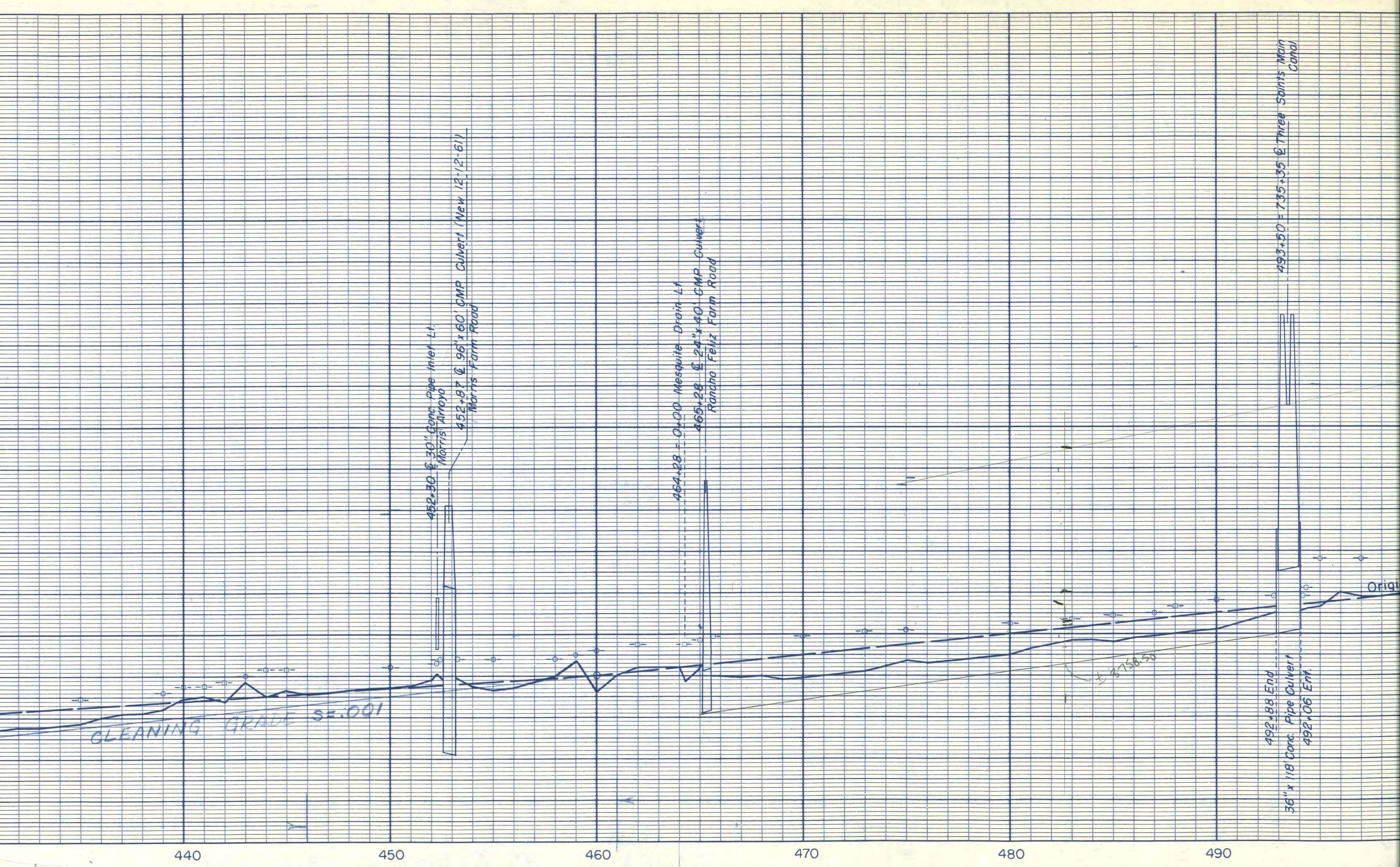
(Filed R-66V) 23-503-5962

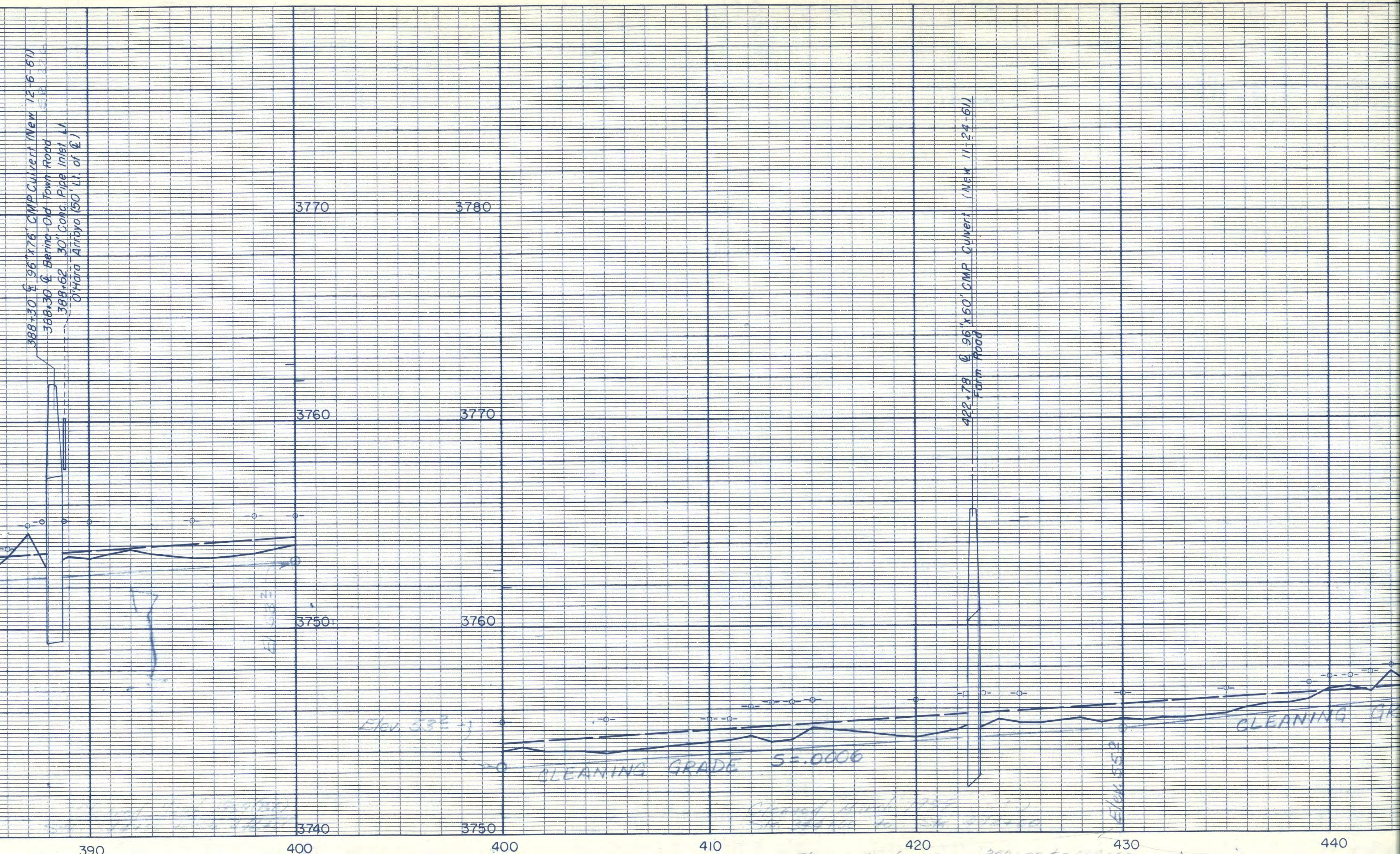


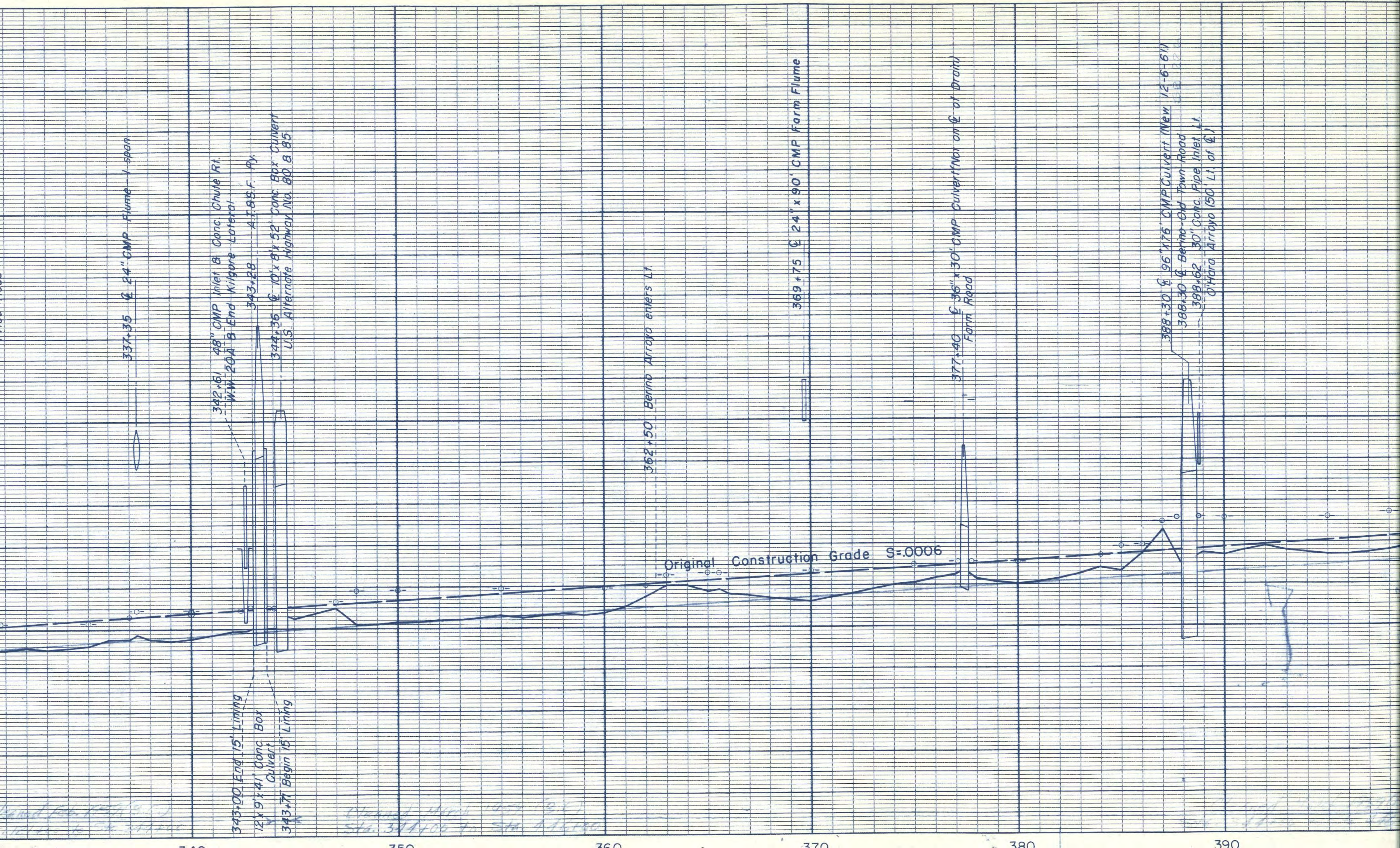
3780
3790
3770
3780
3760
3770
3750
3760
563+60 ℄ 30" x 90' CMP Farm Flume
570+25 ℄ 24" x 66' CMP Culvert
Dona Ana Co. Vado South Side Road
585+15 Plug across drain - Temporary road
590+25 ℄ 36" x 43' Conc. Pipe Culvert
Dona Ana Co. Road (Vado Junction to U.S. Hwy. 80)
550
550
560
570
580
590
600

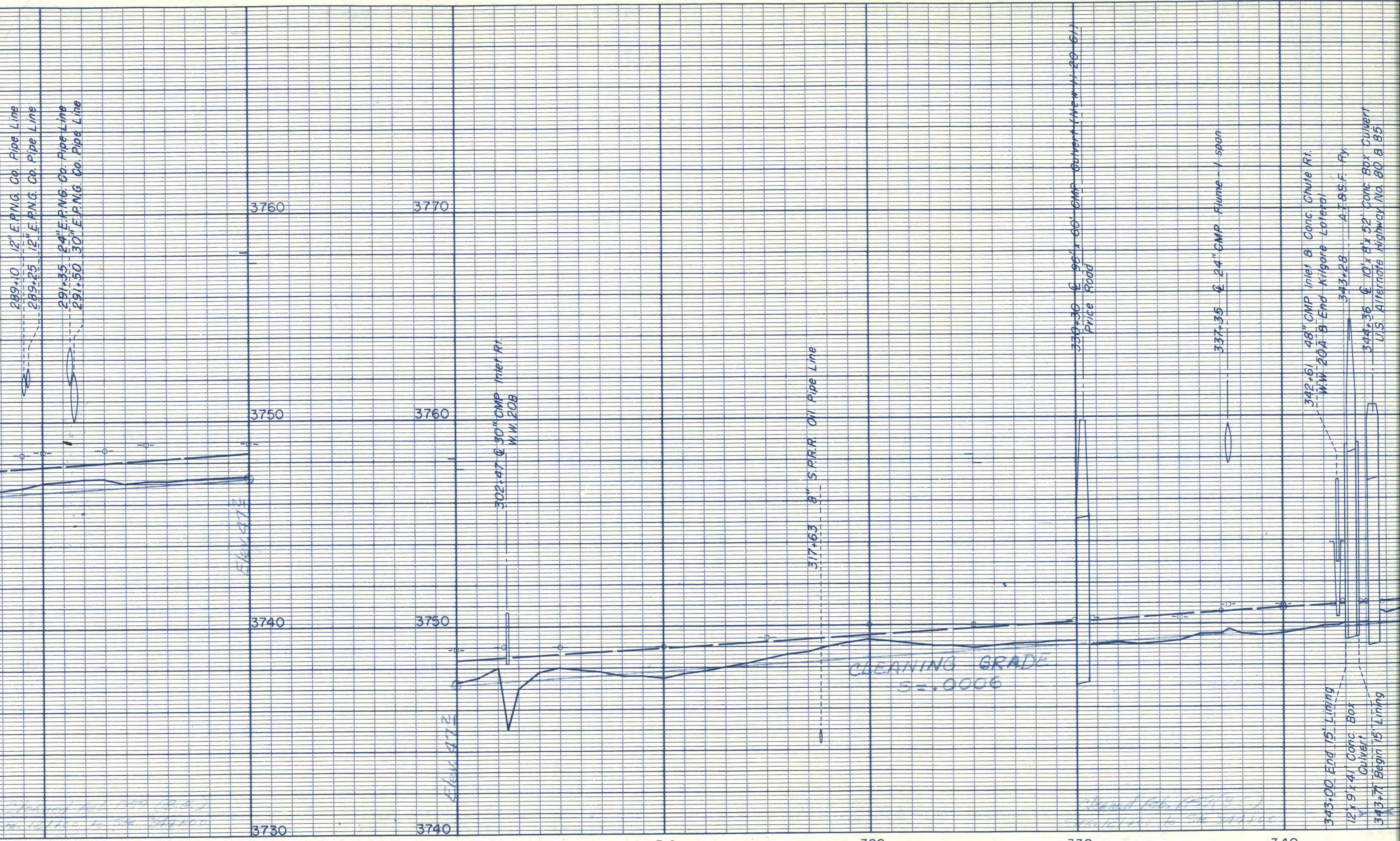


493+50 = 735+35 ℄ Three Saints Main Canal
512+50 ℄ 24"x 70' CMP Culvert
Dona Ana Co. Woodward Road
523+00 ℄ 24"x 68' CMP Culvert
Gowan Jones Farm No. 4 Road & Lateral
540+70 ℄ No. 84 Armco Flume
3 span - 57' long
Original Construction Grade
S = .001
492+88 End
36" x 118' Conc. Pipe Culvert
492+06 Ent
NOTE
Clean to original construction grade
except where cleaning grade is indicated.
3780
3770
3760
3750
490
500
510
520
530
540
550

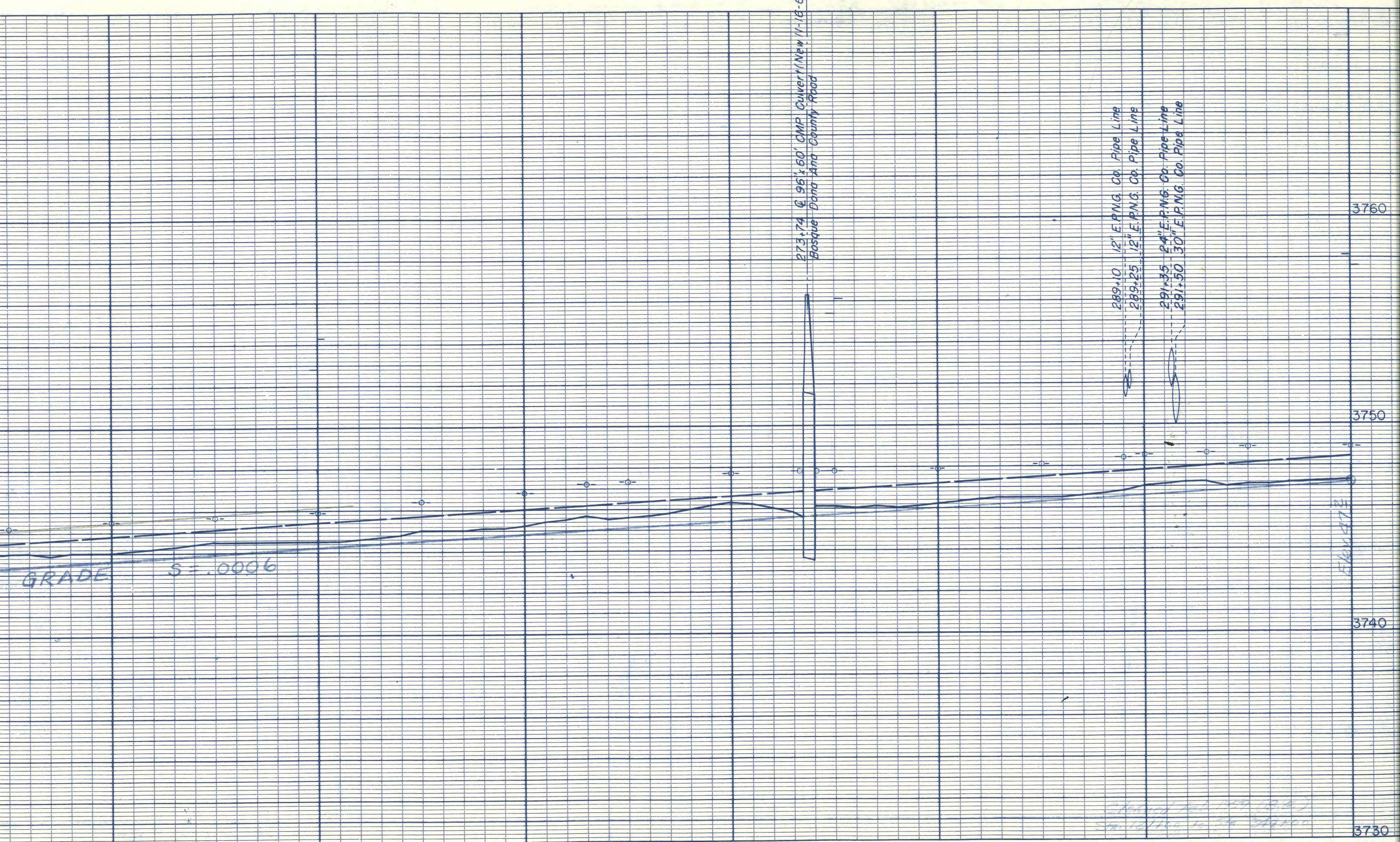

452+30 ℄ 30" Conc. Pipe Inlet Lt.
Morris Arroyo
452+87 ℄ 96"x60' CMP Culvert (New 12-12-61)
Morris Farm Road
464+28 - 0+00 Mesquite Drain Lt.
465+28 ℄ 24"x40' CMP Culvert
Rancho Feliz Farm Road
493+50 = 735+35 ℄ Three Saints Main Canal
492+88 End
36"x 118 Conc. Pipe Culvert
492+06 Ent.
CLEANING GRADE S=.001
± 3758.50
Origi
440
450
460
470
480
490

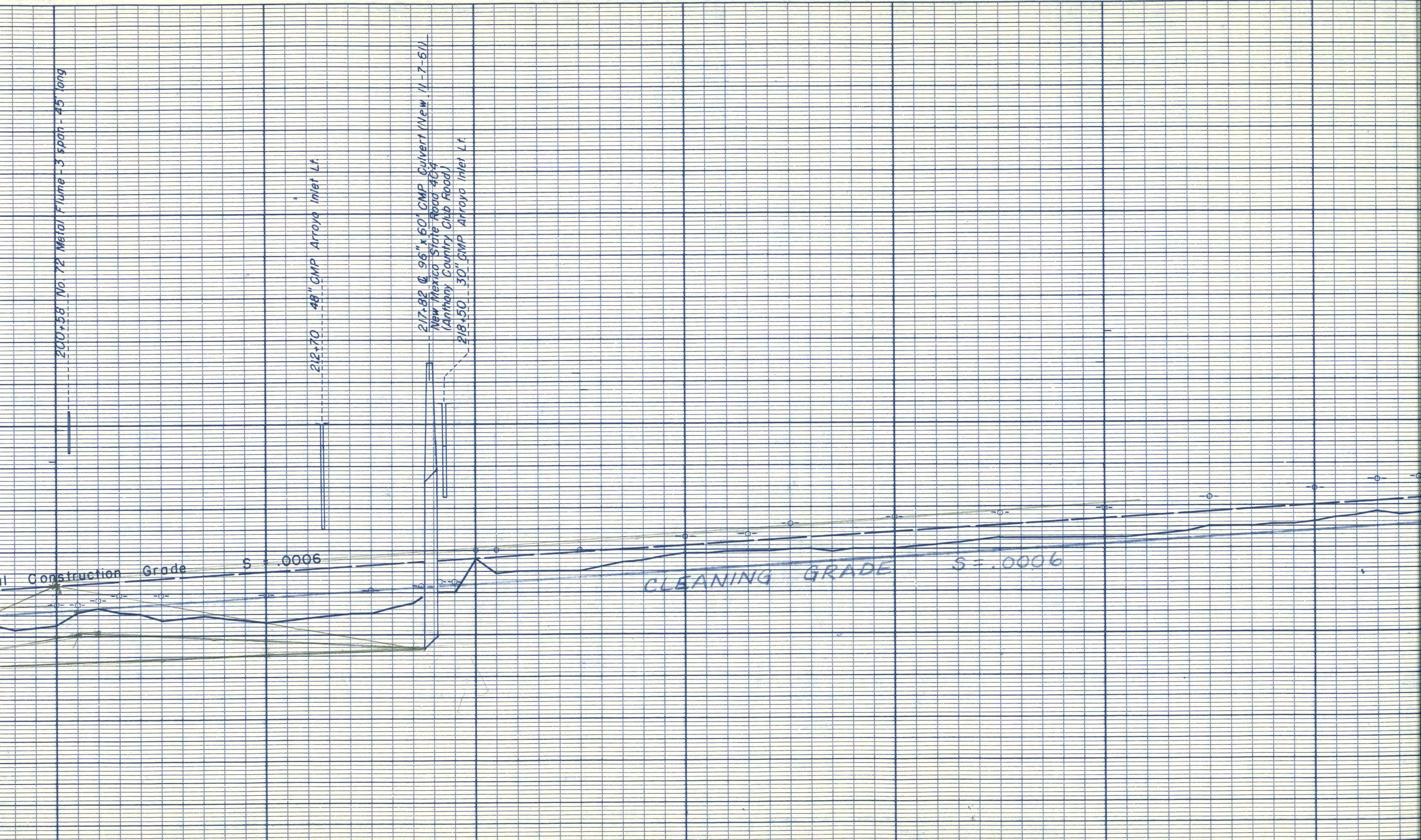

388+30 ℄ 96"x76' CMP Culvert (New 12-6-61)
388+30 ℄ Berino-Old Town Road
388+62 30' Conc. Pipe Inlet Lt.
O'Hara Arroyo (50' Lt. of ℄)
422+78 ℄ 96"x60' CMP Culvert (New 11-24-61)
Farm Road
3770
3760
3750
3740
3780
3770
3760
3750
CLEANING GRADE S=.0006
CLEANING GR
390
400
400
410
420
430
440

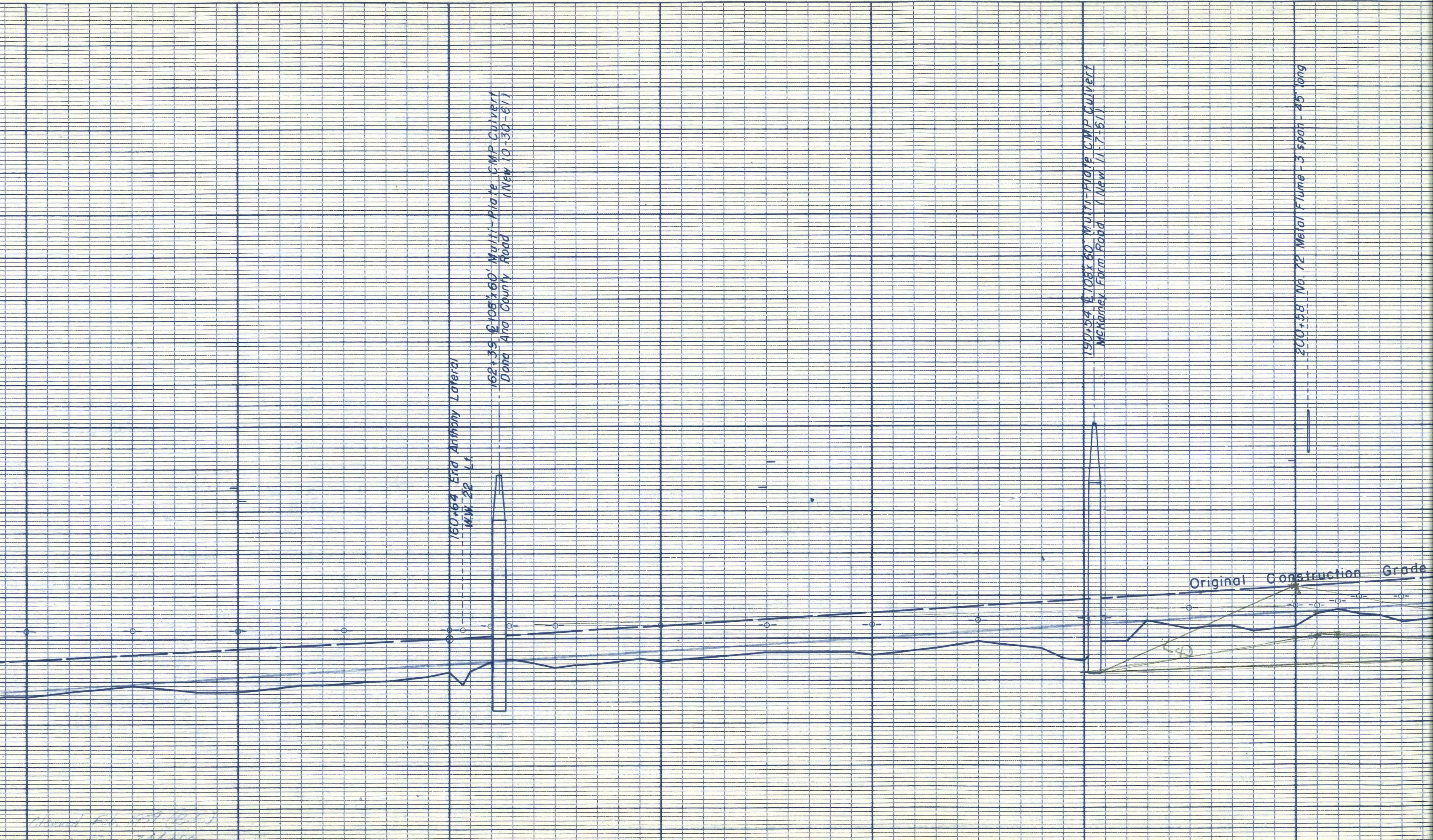

337+35 ℄ 24" CMP Flume - 1 span
342+61 48" CMP Inlet & Conc. Chute Rt.
W.W. 20A & End Kilgore Lateral
343+28 A.T.&S.F. Ry.
344+36 ℄ 10'x 8'x 52' Conc. Box Culvert
U.S. Alternate Highway No. 80 & 85
362+50 Berino Arroyo enters Lt.
369+75 ℄ 24" x 90' CMP Farm Flume
377+40 ℄ 36" x 30' CMP Culvert (Not on ℄ of Drain)
Farm Road
388+30 ℄ 96"x76" CMP Culvert (New 12-6-61)
388+30 ℄ Berino-Old Town Road
388+62 30" Conc. Pipe Inlet Lt.
O'Hara Arroyo (50' Lt. of ℄)
Original Construction Grade S=.0006
343+00 End 15' Lining
12'x 9'x 41' Conc. Box Culvert
343+71 Begin 15' Lining
340
350
360
370
380
390

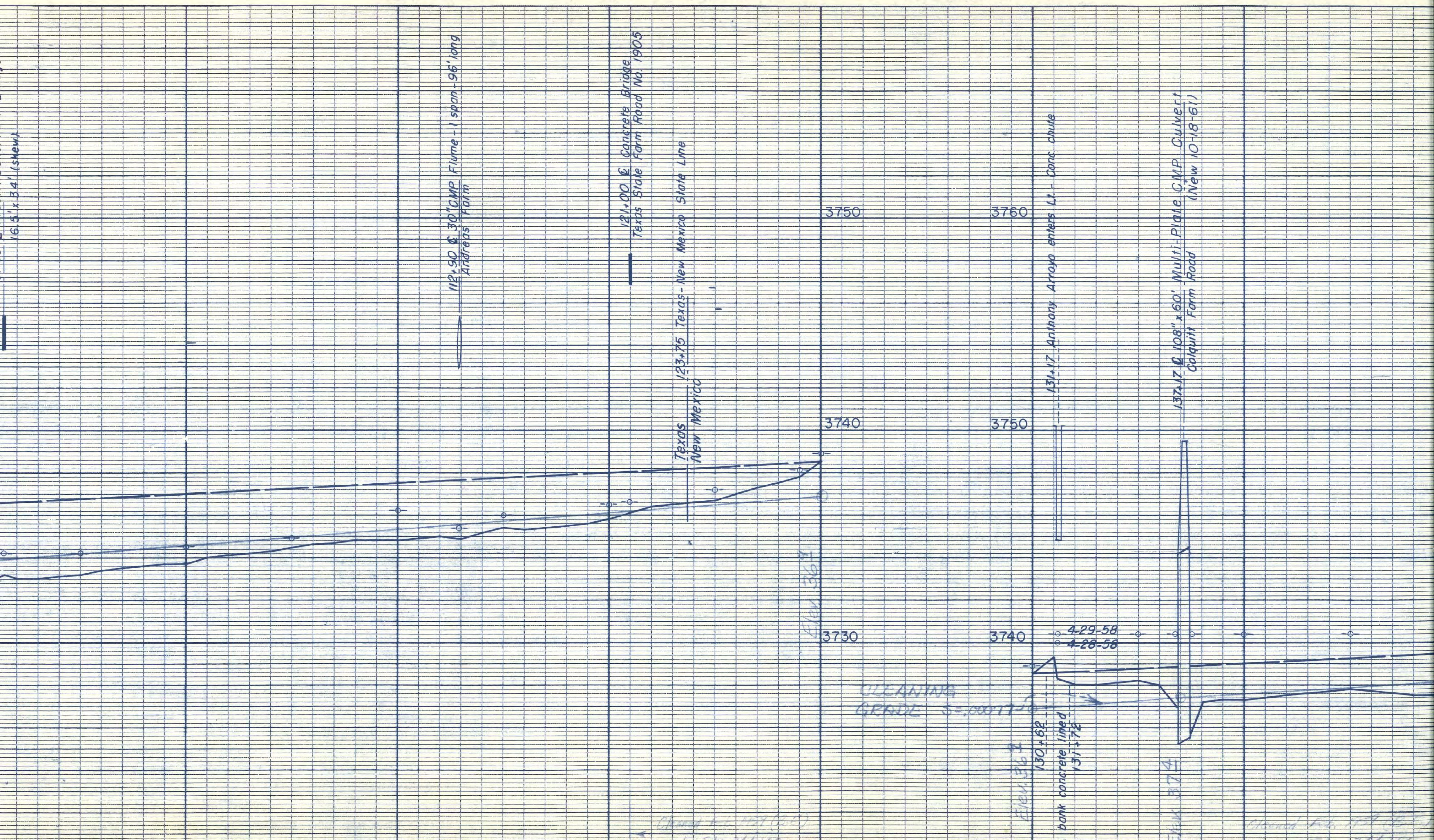


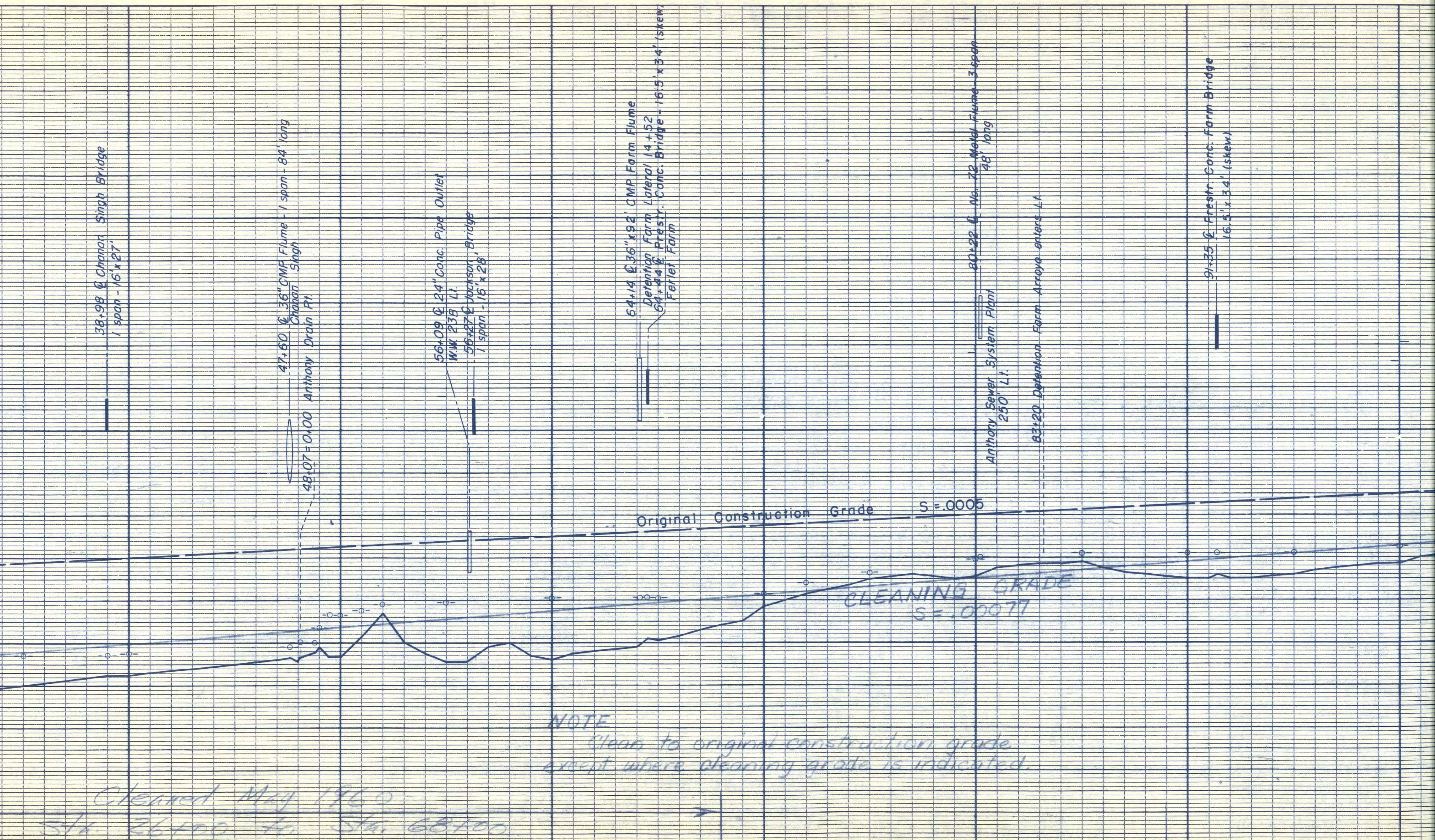
289+10 12" E.P.N.G. Co. Pipe Line
289+25 12" E.P.N.G. Co. Pipe Line
291+35 24" E.P.N.G. Co. Pipe Line
291+50 30" E.P.N.G. Co. Pipe Line
3760
3750
3740
3730
3770
3760
3750
3740
302+47 ℄ 30" CMP Inlet Rt. W.W. 20B
317+63 8" S.P.R.R. Oil Pipe Line
330+30 ℄ 96" x 60" CMP Culvert
Price Road
337+35 ℄ 24" CMP Flume - 1 span
342+61 48" CMP Inlet & Conc. Chute Rt.
W.W. 20A & End Kilgore Lateral
343+28 A.T.&S.F. Ry.
344+36 ℄ 10' x 8' x 52' Conc. Box Culvert
U.S. Alternate Highway No. 80 & 85
CLEANING GRADE
S=.0006
343+00 End 15' Lining
12' x 9' x 4' Conc. Box Culvert
343+71 Begin 15' Lining


273+74 ℄ 96"x60' CMP Culvert (New 11-16-61)
Bosque Dono And County Road
289+10 12" E.P.N.G. Co. Pipe Line
289+25 12" E.P.N.G. Co. Pipe Line
291+35 24" E.P.N.G. Co. Pipe Line
291+50 30" E.P.N.G. Co. Pipe Line
GRADE S = .0006
3760
3750
3740
3730

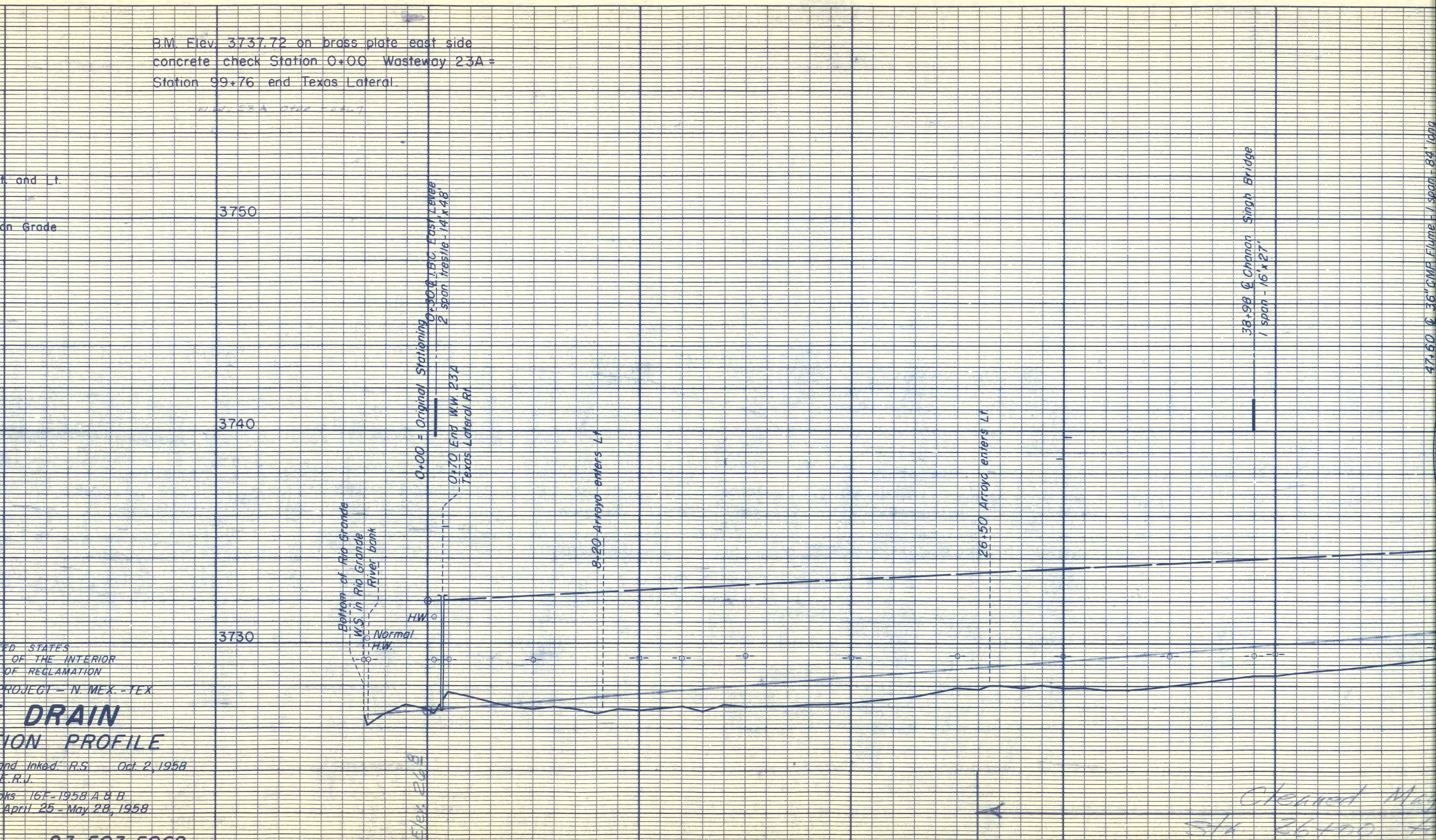

200+58 No 72 Metal Flume-3 span-45' long
212+70 48" CMP Arroyo Inlet Lt.
217+82 ℄ 96"x60' CMP Culvert (New 11-7-61)
New Mexico State Road 404
(Anthony Country Club Road)
218+50 30" CMP Arroyo Inlet Lt.
l Construction Grade S = .0006
CLEANING GRADE S = .0006

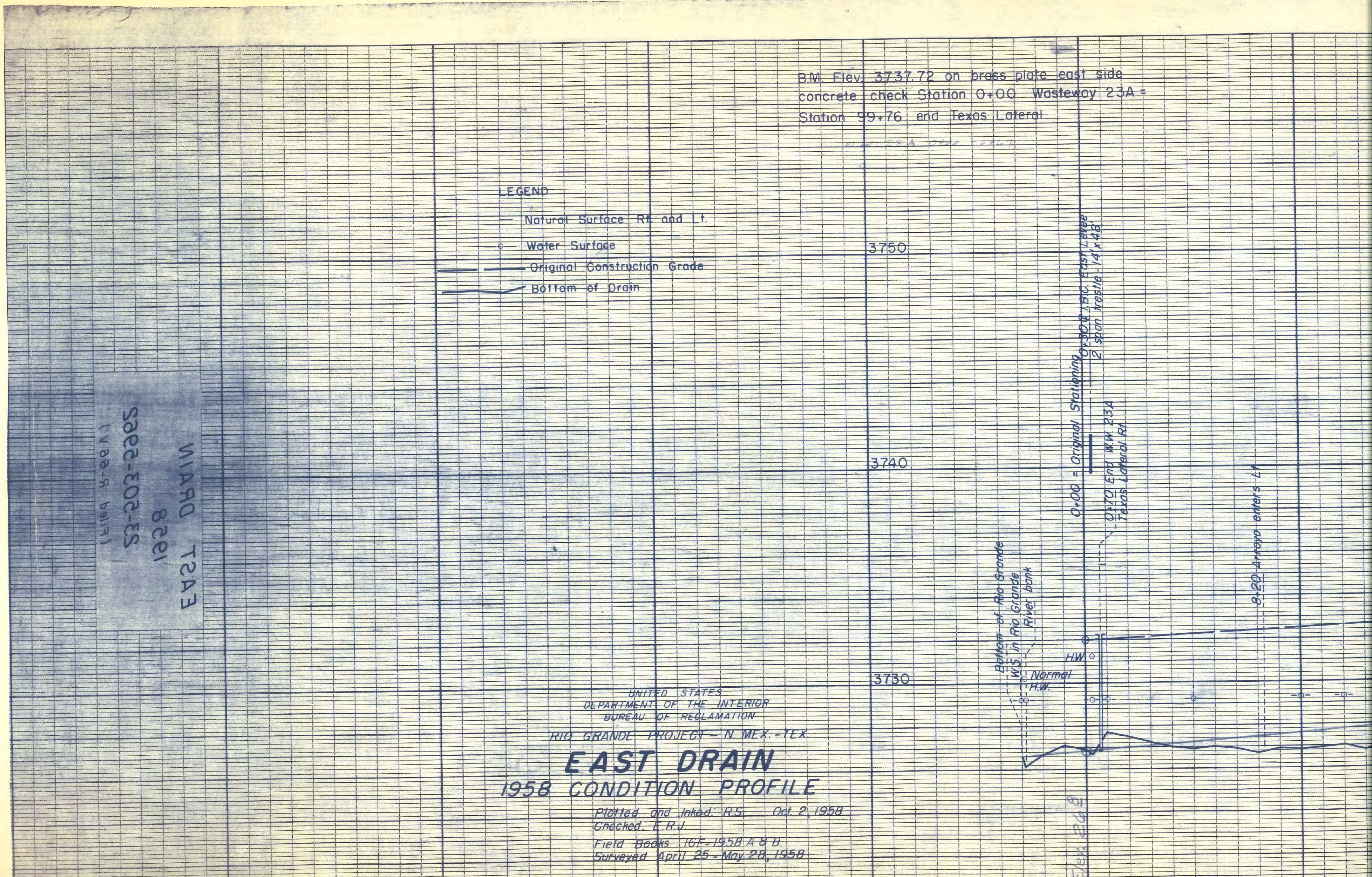

160+64 End Anthony Lateral
W.W. 22 Lt.
162+39 ℄ 108"x60' Multi-Plate CMP Culvert
Dona Ana County Road (New 10-30-61)
190+54 ℄ 108"x60' Multi-Plate CMP Culvert
McKamey Farm Road (New 11-7-61)
200+58 No. 72 Metal Flume - 3 span - 45' long
Original Construction Grade


16.5' x 34' (skew)
112+90 ℄ 30" CMP Flume - 1 span - 96' long
Andreas Farm
121+00 ℄ Concrete Bridge
Texas State Farm Road No. 1905
123+75 Texas-New Mexico State Line
Texas
New Mexico
3750
3740
3730
3760
3750
3740
131+17 Anthony Arroyo enters Lt. - Conc. chute
137+17 ℄ 108" x 60' Multi-Plate CMP Culvert
Colquitt Farm Road
(New 10-18-61)
4-29-58
4-28-58
CLEANING
GRADE
130+62
bank concrete lined
131+72



38+98 ℄ Chanan Singh Bridge
1 span - 16'x27'
47+60 ℄ 36" CMP Flume - 1 span - 84' long
Chanan Singh
48+07 = 0+00 Anthony Drain Rt.
56+09 ℄ 24" Conc. Pipe Outlet
W.W. 23B Lt.
56+27 ℄ Jackson Bridge
1 span - 16'x 28'
64+14 ℄ 36"x 92' CMP Farm Flume
Detention Farm Lateral 14+52
64+44 ℄ Prestr. Conc. Bridge - 16.5'x 34' (skew)
Ferlet Farm
80+22 ℄ No. 72 Metal Flume 3 span
48' long
Anthony Sewer System Plant
250' Lt.
83+20 Detention Farm Arroyo enters Lt.
91+35 ℄ Prestr. Conc. Farm Bridge
16.5'x 34' (skew)
Original Construction Grade S = .0005
CLEANING GRADE
S = .00077
NOTE
Clean to original construction grade
except where cleaning grade is indicated.
Cleaned May 1960
Sta. 26+00 to Sta. 68+00


B.M. Elev. 3737.72 on brass plate east side concrete check Station 0+00 Wasteway 23A = Station 99+76 end Texas Lateral.
t. and Lt.
on Grade
3750
3740
3730
0+00 = Original Stationing
0+30 ℄ L.B.C. East Levee
2 span trestle - 14'x48'
0+70 End W.W. 23A
Texas Lateral Rt.
8+20 Arroyo enters Lt.
26+50 Arroyo enters Lt.
38+98 ℄ Chanon Singh Bridge
1 span - 16'x27'
47+60 ℄ 36" CMP Flume - 1 span - 84' long
Bottom of Rio Grande
W.S. in Rio Grande
River bank
H.W.
Normal
H.W.
ED STATES
OF THE INTERIOR
OF RECLAMATION
ROJECT - N. MEX.-TEX
DRAIN
ION PROFILE
nd Inked R.S. Oct. 2, 1958
R.J.
ks 16F-1958 A & B
April 25 - May 28, 1958
Elev. 26.8
Cleaned Ma
S/4 26+00



B.M. Elev. 3737.72 on brass plate east side concrete check Station 0+00 Wasteway 23A = Station 99+76 end Texas Lateral.
LEGEND
Natural Surface Rt. and Lt.
Water Surface
Original Construction Grade
Bottom of Drain
3750
3740
3730
0+00 = Original Stationing
0+30 A.T.&S.F. East Levee 2 span trestle 14'x48'
0+70 End W.W. 23A Texas Lateral Rt.
8+20 Arroyo enters Lt.
Bottom of Rio Grande
W.S. in Rio Grande
River bank
HW
Normal H.W.
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RIO GRANDE PROJECT – N. MEX.-TEX.
EAST DRAIN
1958 CONDITION PROFILE
Plotted and Inked: R.S. Oct. 2, 1958
Checked: E.R.J.
Field Books 16F-1958 A & B
Surveyed April 25 - May 28, 1958
East Drain

RGP - 4
(Aug. 1951)

# Department of the Interior
## BUREAU OF RECLAMATION – RIO GRANDE PROJECT
### Structure Record

File 21-N Book 3
Revised April, 1957

"919"

4-48 GPO 844569

FEATURE East Drain | FROM STA. 0+00 | =STA. Rio Grande Left Bank | TO STA. 608+43 | LENGTH 60843 FT. | 11.52 MILES

| STRUCTURE | STATION | SIDE | DIMENSIONS | TYPE | INSTALLED | REPAIRED | REPLACED | TYPE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Heading | 0-290' | East-Left | Channel bank Rio Grande - original C/L location stationing | | | | | | |
| Bridge | 0+30 | C/L | 14' x 48', 3 span, all timber trestle - IBB East (Left) levee | | | | | | |
| W.W. #23A | 0+70 | Left | End W.W. #23A left (Texas Lateral ) conc. chute | | | | | | |
| Flume - Private | 9+40 | C/L | 18" x 70' CMP, 4 span, all timber | | | | | | |
| Culvert- Flume | 34+60 | C/L | 18" x 60' CMP, private irrigation pump permit | | | | | | |
| Bridge | 38+98 | C/L | 16' x 27', 1 span, conc. abutements, Channon Singh Farm road | | | | | | |
| Culvert- Flume | 47+73 | C/L | 36" x 84' CMP, 1 span conc. hd'wls | | 10/55 | Channon Singh Farm Lat. | | | |
| | 48+07 | Sta. 0+00 | Anthony Drain left (West) open entrance | | | | | | |
| Bridge | 57+74 | C/L | 16' x 28', 1 span, timber, conc. piers & abuts. 4/57 | | | | Jackson Farm Road | | |
| Flume | 64+14 | ℄ | 36" x 92' GMP Conc. hd'wl Trans. 3 span 1963 USBR Detention Farm Lat. | | | | | | |
| Bridge | 64+44 | ℄ | 18' x 33' GMP 1 span Prestressed Conc. 2/64 | | | | | | |
| Flume | 79+00 | C/L | #72 Armco flume x 48', 3 spans, all timber support, Ferlet farm lat. crossing | | | | | | |
| Bridge | 91+35 | ℄ | 18' x 33' 1 span Prestressed Conc. 2/64 | | | | | | |
| Flume-Farm Lat. | 112+90 | C/L | 30' x 93' CIP, conc. hd'wls. | | | | | | |
| Bridge-tex. Hwy. | 121+00 | C/L | 42' x 45', 3 span, all conc., Tex. Farm Road #1905, Anthoy - Rio - Gadsden Road | | | | | | |
| Anthony-Valley | High School- State Highway Bridge | | | | | | | | |
| State Line* | 123+75 | | Texas - New Mexico State line | | | | | | |
| Arroyo Inlet | 131+17 | | Anthony Arroyo enters right (East) conc. chute entrance | | | | | | |
| Culvert | 137+17 | C/L | 108" x 60' Multi-Plate-No Hd'wls | | 11/30/61 | Colquitt Farm road culvert | | | |
| W.W. # 22 | 160+39 | C/L | 30" x 60' Galv. Metal pipe USBR Anthony Lateral #22 right Installed 6/62 | | | | | | |
| Culvert | 162+39 | C/L | 108" x 60' Multi-Plate, No hd'wls | | 11/61 | Hay's County road | | | |
| Culvert | 190+54 | C/L | 108" x 60' Multi-Plate CMP, no hd'wls | | 4/57 | McKamy Farm road | | | |
| Flume | 200+58 | C/L | #72" Armco flume x 45', 3 span, all timber sub structures | | | | | | |
| Culvert | 217+82 | C/L | 96" x 60' CMP, no hd'wls, Anthony - County Club County highway State Road 404 | | | | | | |
| Chute | 218+50 | C/L | Arroyo entrance right (East) conc. chute | | | | | | |

EAST DRAIN

RGP - 4
(Aug. 1961)

# Department of the Interior
## BUREAU OF RECLAMATION – RIO GRANDE PROJECT
### Structure Record

File 21-N Book 3
Revised April, 1957

GPO 844569

| FEATURE | FROM STA. | =STA. | TO STA. | LENGTH | FT. |
|---|---|---|---|---|---|
| East Drain | 0+00 | Rio Grande Left Bank | 608+43 | 60843 | 11.52 MILES |

| STRUCTURE | STATION | SIDE | DIMENSIONS | TYPE | INSTALLED | REPAIRED | REPLACED | TYPE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Culvert | 273+74 | C/L | 96" x 60' GMP, no hd'wls, Bosque County Road 11/61 | | | Co. Rd. 1386 | | | |
| Gas Line Crossing | 289+10 | C/L | 12" steel pipe, 1 span, El Paso Natural Gas Co. | | | | | | |
| " " " | 289+25 | C/L | 12" " " | " " " " | " " | | | | |
| " " " | 291+35 | C/L | 24" " " | " " " " | " " | | | | |
| " " " | 291+50 | C/L | 30" " " | " " " " | " " | | | | |
| Oil Pipe Line | 317+34 | C/L | 8" Steel pipe line, So. Pacific Gas Lines Inc. | | | | | | |
| " " " | 317+25 | C/L | 12" " " " | " " " " | " " | | | | |
| W.W. #20B | 302+47 | Left | 30" CIP W.W. #20B entrance left (West) USBR Bullock Lateral | | | | | | |
| Culvert | 330+30 | C/L | 96" x 60' GMP, no hd'wls - Price County road 11/61 | | | Co. Rd. 144 | | | |
| Flume | 337+35 | C/L | 24" x 100' CIP, L span (21') conc. piers & hd'wls. | | | | | | |
| W.W. #20A | 342+61 | C/L-End | USBR Kilgore Lateral W.W. #20A left (North), conc. chute | | | | | | |
| Conc. Lining | 343+00 | End | Conc. Lining | | | | | | |
| Culvert | 343+15 | End | 12' wd. x 9' dp. x 41' long, conc. box culv., conc. hd'wl. | | | | | | |
| Trestle Culvert | 343+28 | C/L | 12' x 9' x 41' conc. box. & hd'wls, A.T. & S. F. Rwy, trestle #132-2 | | | | | | |
| Culvert | 343+56 | Ent. | 144" x 108" x 41' conc. box, conc. hd'wl & 15' conc. lining | | | | | | |
| Culvert | 344+10 | End | 10' x 8' x 52' box culvert, conc. hd'wl & wings | | | | | | |
| Highway #80-85 | 344+36 | C/L | U.S.Highway #80-85 Alternate | | | | | | |
| Culvert | 344+62 | Ent. | 10' x 8' x 52' conc. box, conc. hd'wls & wings | | | | | | |
| Flume | 369+25 | ℄ | 24" x 90' CMP Conc. hd'wls | | 9/64 | Steel Gate installed 3/65 | | | |
| Culvert | 387+85 | End | 96" x 76' GMP, conc. hd'wls & wings transition11/61 | | | | | | |
| Farm Ditch | 388+05 | C/L | 30" x 80' CMP farm ditch | | 12/61 | | | | |
| Culvert-Road | 388+30 | C/L | Berino County road & farm lat. crossing | | | SP 226 | | | |
| Culvert | 388+52 | Ent. | 96" x 76' GMP, conc. hd'wls & wings transition | | | | | | |
| Arroyo | 388+62 | Right | O'Hara Arroyo enters right | | | | | | |
| Culvert | 422+78 | C/L | 96" x 60' GMP, no hd'wls -Price Farm Road | | | | | | |
| Arroyo | 452+30 | Right | 30" conc. pipe - Morris Arroyo enters right | | | | | | |
| Culvert | 452+87 | C/L | 96" x 60' GMP, no hd'wls, Morris Farm Road 11/61 | | | Co Rd 154 | | | |
| Drain Entrance | 464+28 | 0+00 | Mesquite Drain right (East) | | | | | | |
| Culvert | 465+28 | C/L | 24" x 40' CIP, no hd'wls, Rancho Feliz Farm road | | | | | | |
| Culvert | 492+88 | End | 36" x 118' conc. tube, hd'wl & wood wings | | | | | | |
| 3Saints Main | 493+50 | C/L | USBR East Side Canal (3 Saints) conc. lined crossing Sta. 735+53 | | | | | | |
| Culvert | 494+06 | Ent. | 36" c 118' conc. tubes hd'wls. & wood wings | | | | | | |
| Culvert | 512+50 | C/L | 24" x 70' CIP, no hd'wls, Woodward D.A. Co. Road | | | 159W | | | |

RGP - 4
(Aug. 1951)

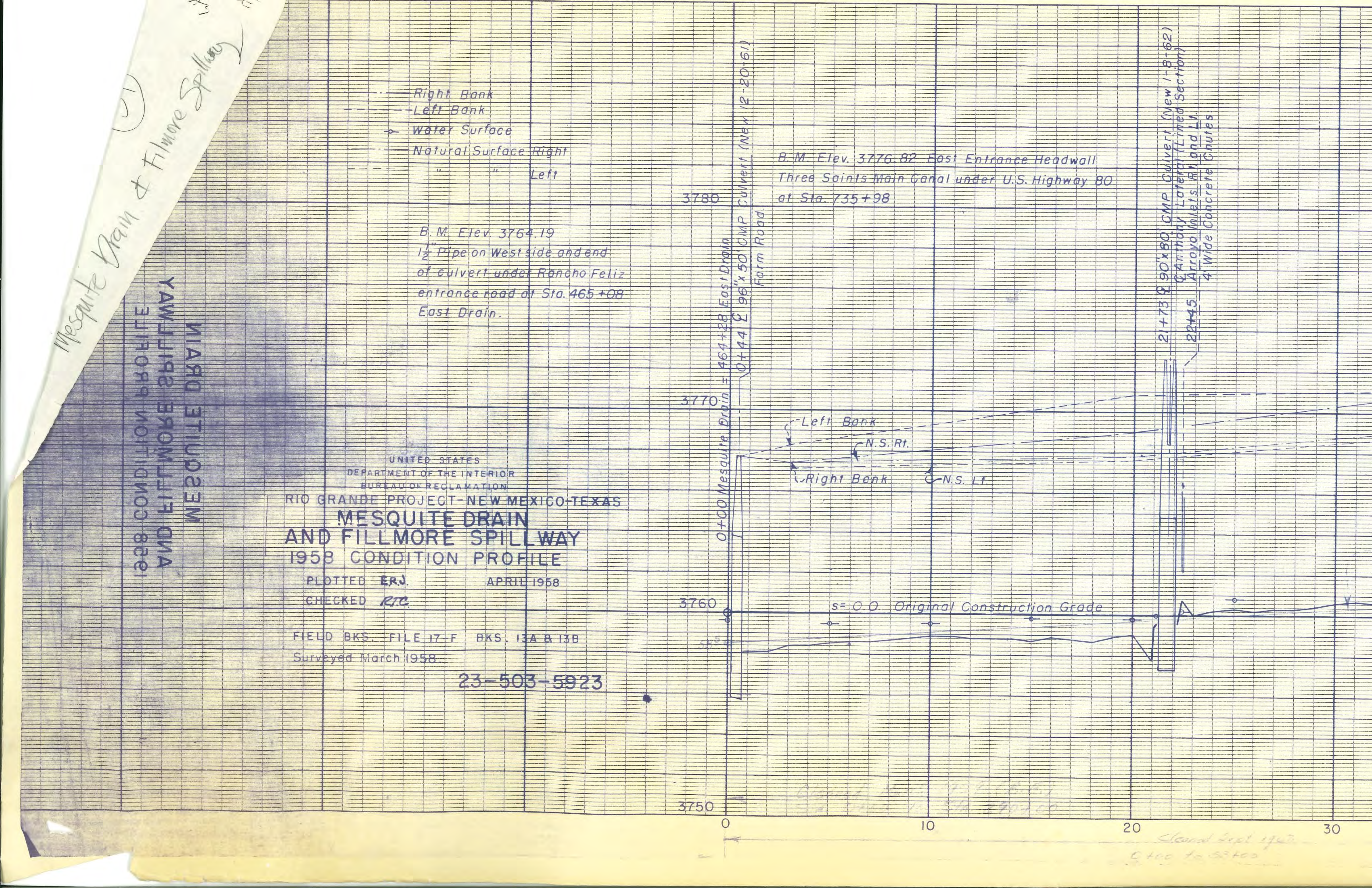
# Department of the Interior
## BUREAU OF RECLAMATION – RIO GRANDE PROJECT
### Structure Record

File 21-N Book 3
Revised April, 1957

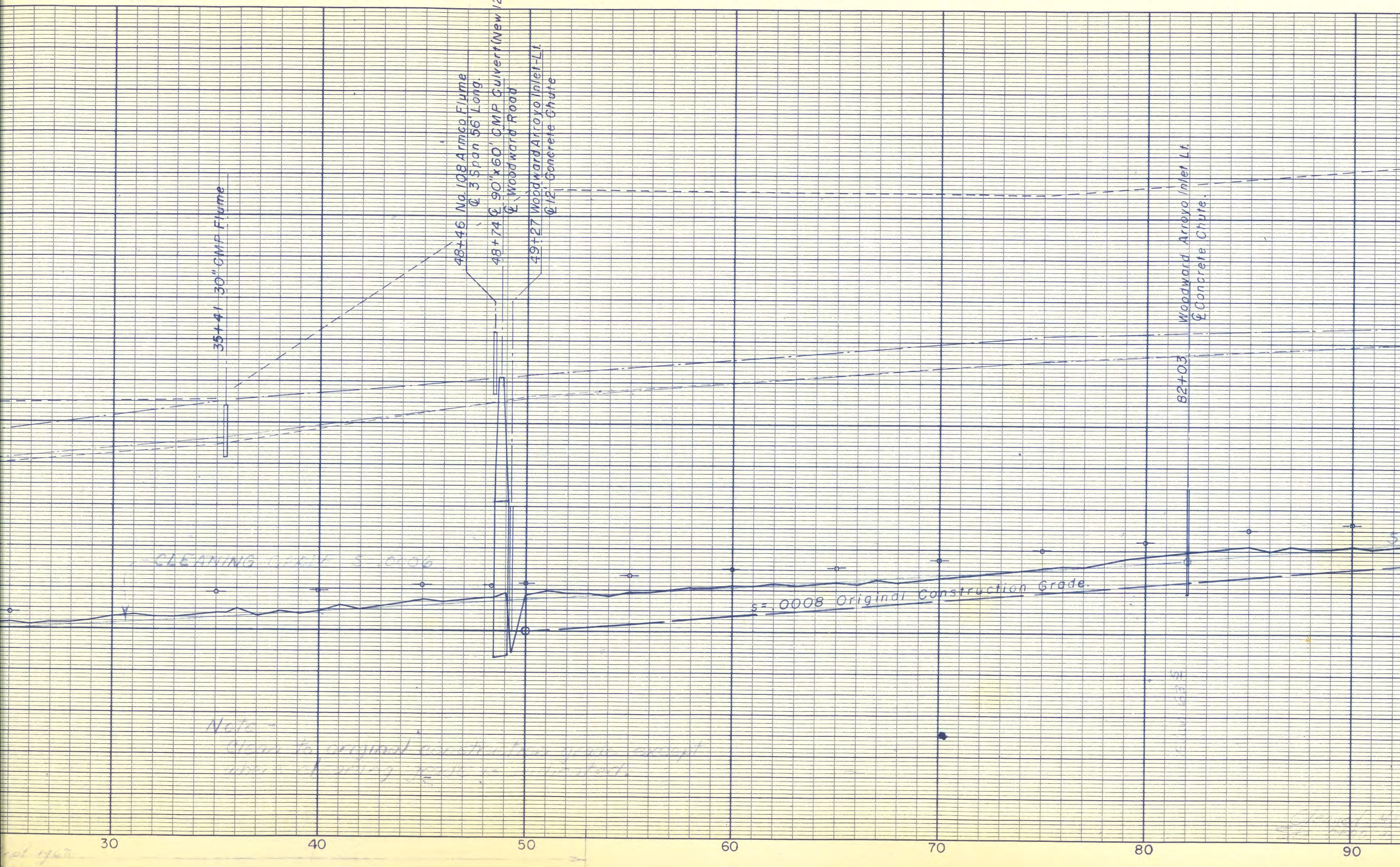
GPO 844569

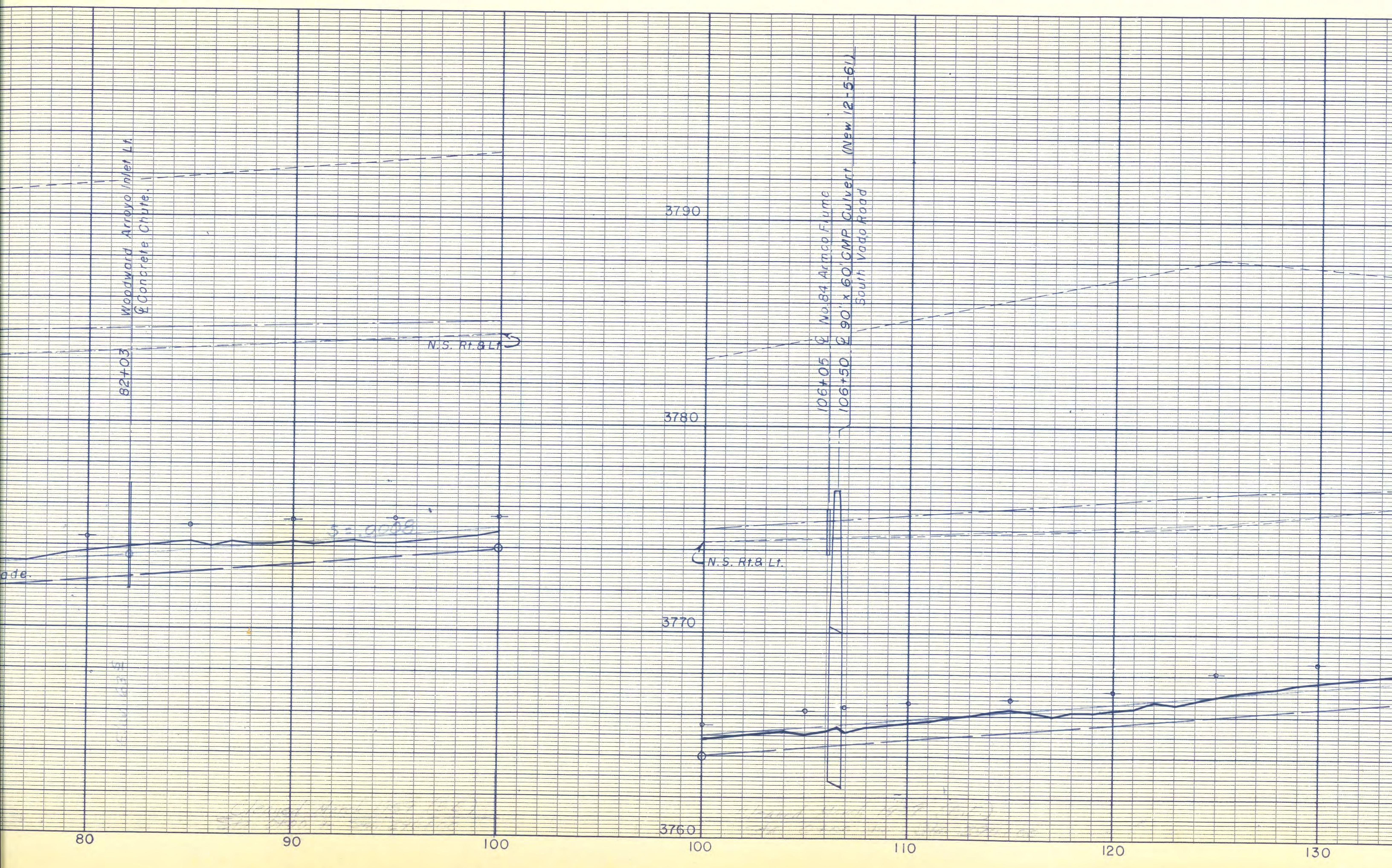
FEATURE East Drain | FROM STA. 0+00 | =STA. Rio Grande Left Bank | TO STA. 608+43 | LENGTH 60843 FT. | 11.52 MILES

| STRUCTURE | STATION | SIDE | DIMENSIONS | TYPE | INSTALLED | REPAIRED | REPLACED | TYPE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Culvert | 523+00 | C/L | 24" x 68' conc. tube, no hd'wls, Farm road & farm ditch - Gowan Jones Farm #4 | | | | | | |
| Flume | 540+70 | C/L | 30" x 82' CMP . Conc. Headwalls | | 1/67 | | | | |
| Flume | 563+60 | C/L | 30" x 90' CMP * Conc. Headwalls | | 5/28/64 | | | | |
| Culvert | 570+25 | C/L | 24" x 66' CIP, o hd'wls, South side Vado - Mesa Co. Road 66 | | | | | | |
| Culvert | 585+03 | End | 36" x 43' conc. pipe, conc. hd'wl | | | | | | |
| Culvert- Co. Rd. | 585+25 | Vado School - Mesa Co. Road to U. S. #80-85 | | | | | | | |
| Culvert | 585+46 | Ent. | 36" x 43' conc. pipe, conc. hd'wl | | | | | | |
| Culvert | 600+50 | [illegible] | 36" x conc. pipe | | S.R. 277 | | | | |
| End Drain | 608+43 | End | East Drain | | | | | | |

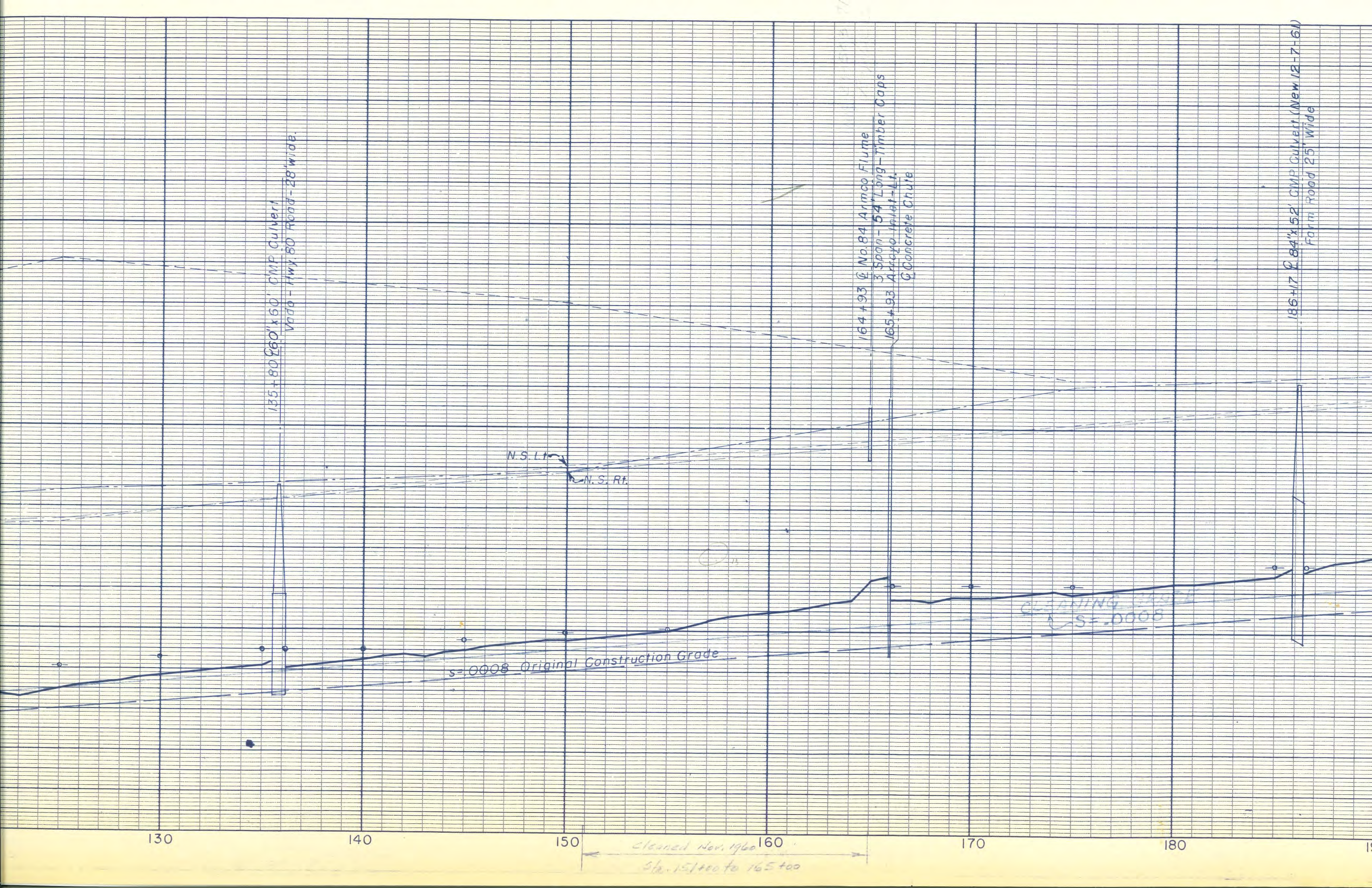


Mesquite Drain & Filmore Spillway
MESQUITE DRAIN
AND FILLMORE SPILLWAY
1958 CONDITION PROFILE
Right Bank
Left Bank
Water Surface
Natural Surface Right
" " Left
B.M. Elev. 3764.19
1½" Pipe on West side and end
of culvert under Rancho Feliz
entrance road at Sta. 465+08
East Drain.
B.M. Elev. 3776.82 East Entrance Headwall
Three Saints Main Canal under U.S. Highway 80
at Sta. 735+98
0+00 Mesquite Drain = 464+28 East Drain
0+44 ℄ 96"x50' CMP Culvert (New 12-20-61)
Farm Road.
21+73 ℄ 90"x80' CMP Culvert (New 1-8-62)
℄ Anthony Lateral (Lined Section)
22+45 Arroyo Inlets Rt. and Lt.
4' Wide Concrete Chutes.
Left Bank
N.S. Rt.
Right Bank
N.S. Lt.
s= 0.0 Original Construction Grade
3780
3770
3760
3750
0
10
20
30
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RIO GRANDE PROJECT-NEW MEXICO-TEXAS
MESQUITE DRAIN
AND FILLMORE SPILLWAY
1958 CONDITION PROFILE
PLOTTED E.R.J.
APRIL 1958
CHECKED R.T.C.
FIELD BKS. FILE 17-F BKS. 13A & 13B
Surveyed March 1958.
23-503-5923
Cleaned Sept 1963
0+00 to 53+00

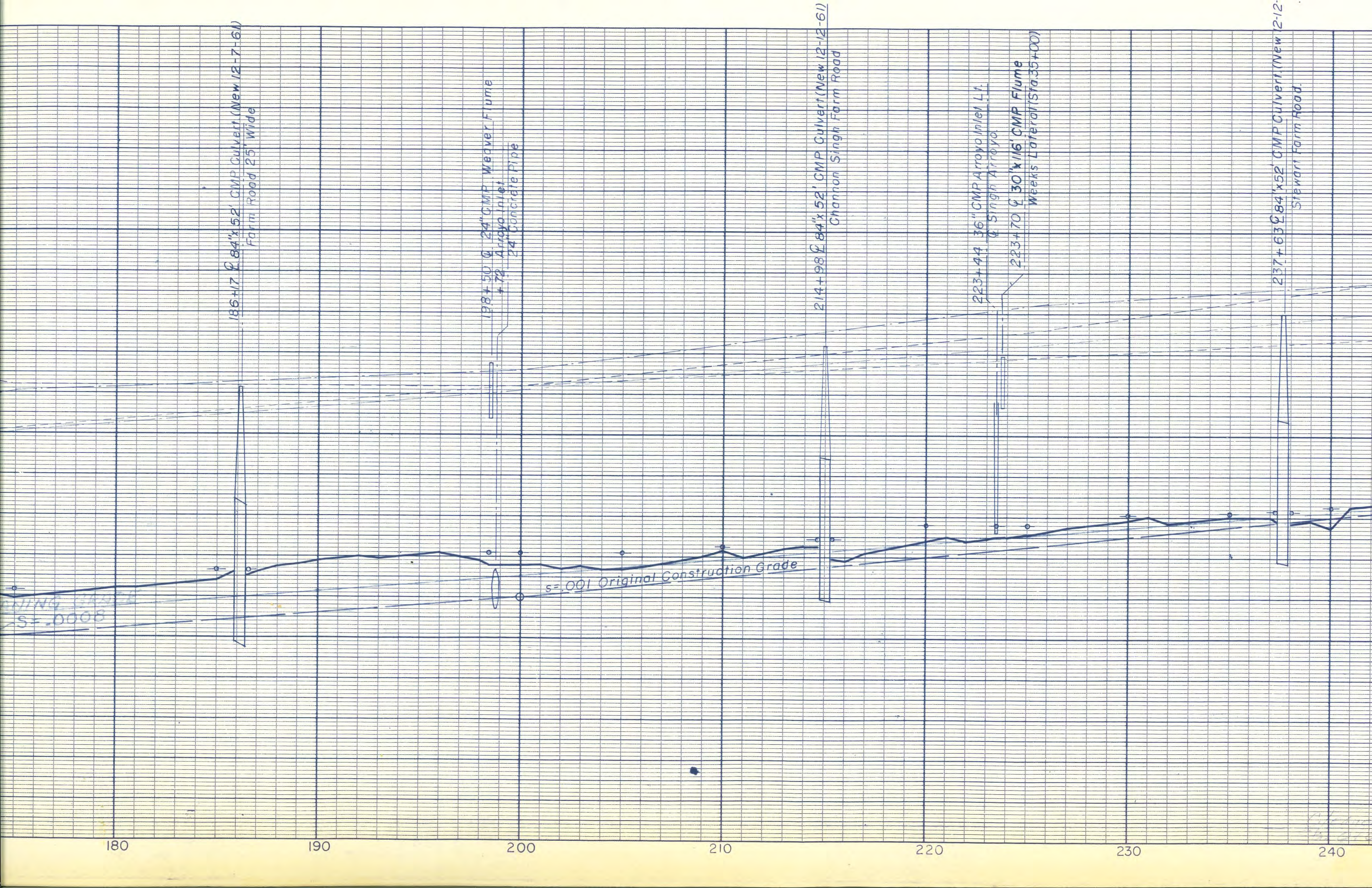

35+41 30" CMP Flume
48+46 No. 108 Armco Flume
℄ 3 Span 56' Long.
48+74 ℄ 90"x60" CMP Culvert (New
℄ Woodward Road
49+27 Woodward Arroyo Inlet-Lt.
℄ 12' Concrete Chute
82+03 Woodward Arroyo Inlet Lt.
℄ Concrete Chute.
CLEANING GRADE S .0006
s=.0008 Original Construction Grade.
30
40
50
60
70
80
90

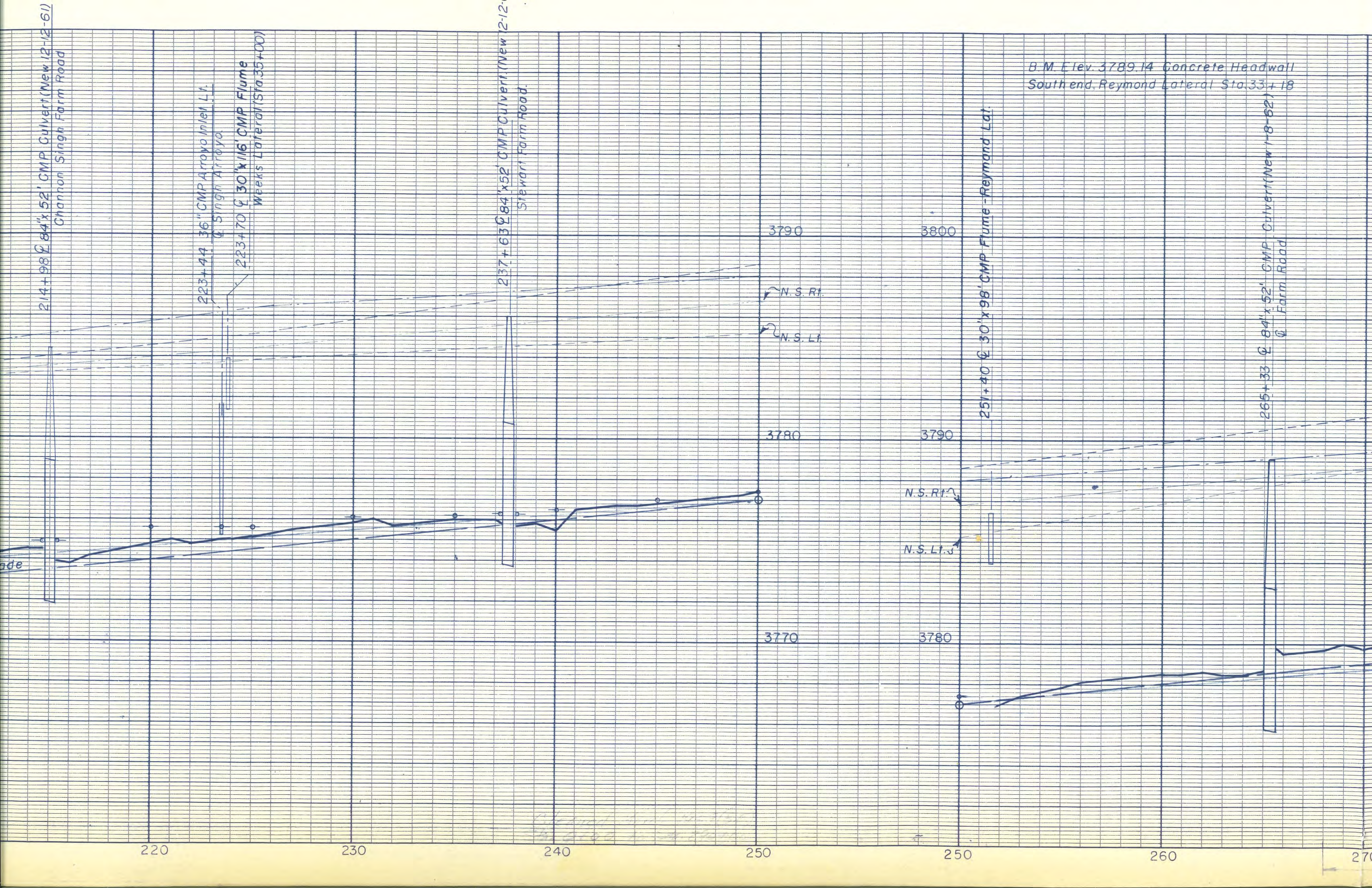


82+03 Woodward Arroyo Inlet Lt.
℄ Concrete Chute.
N.S. Rt.& Lt.
S=.0008
...ade.
3790
3780
3770
3760
106+05 ℄ No.84 Armco Flume
106+50 ℄ 90' x 60' CMP Culvert (New 12-5-61)
South Vado Road
N.S. Rt.& Lt.
80
90
100
100
110
120
130

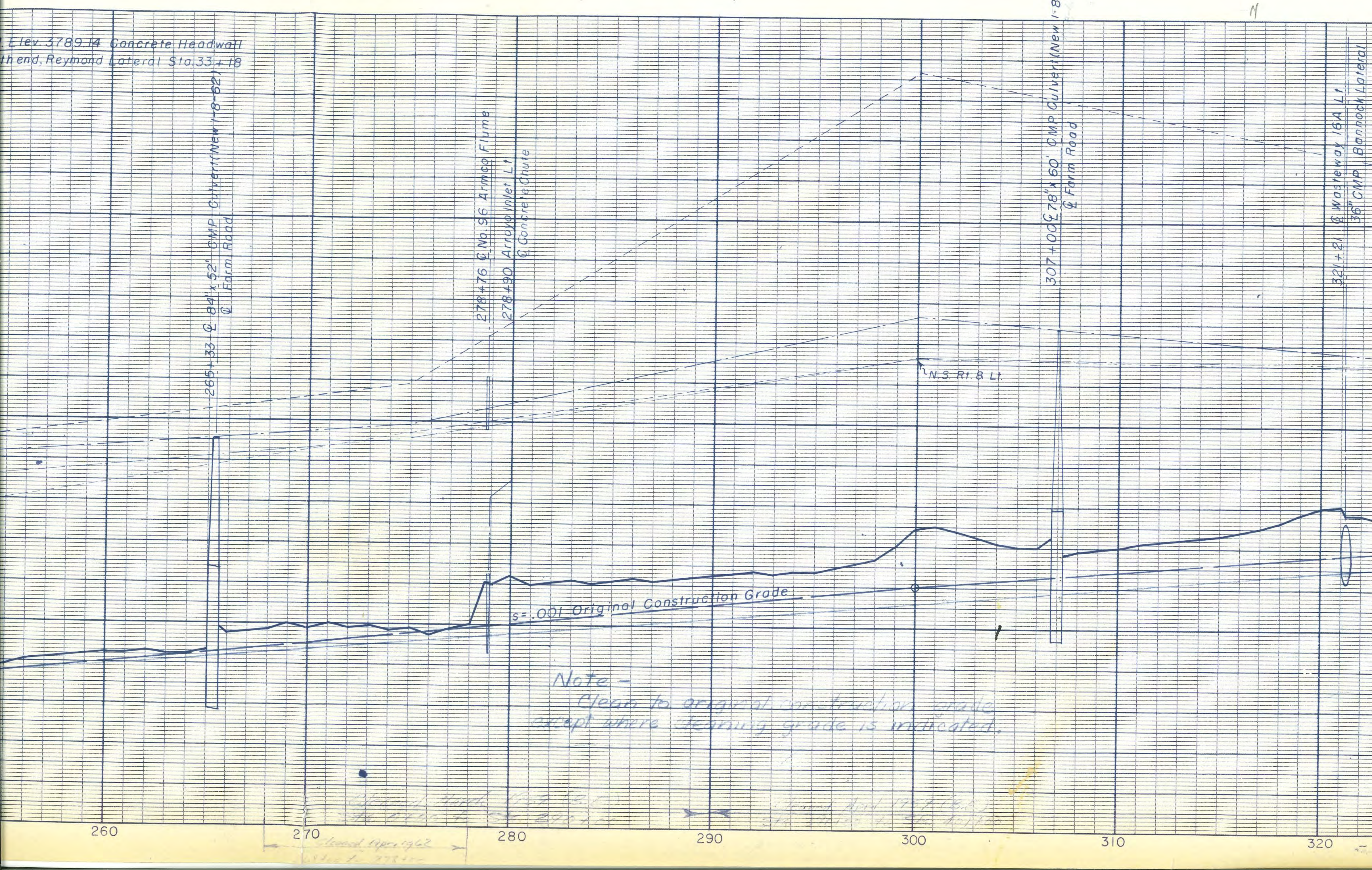


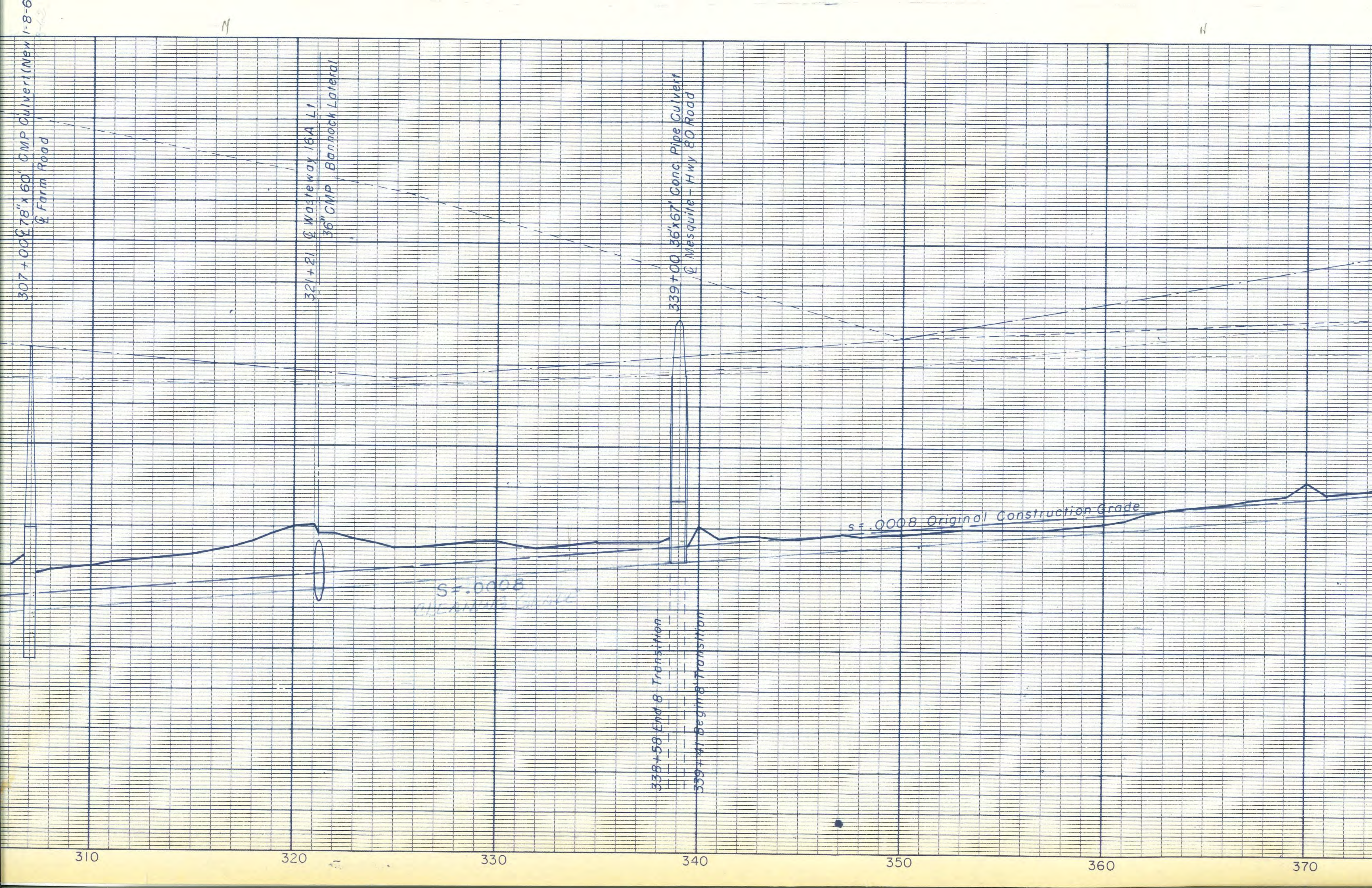
135+80 ℄ 60"x60' CMP Culvert
Vado - Hwy. 80 Road - 28' wide.
164+93 ℄ No. 84 Armco Flume
3 Span - 54' Long - Timber Caps
165+93 Armco Inlet - Lt.
℄ Concrete Chute
186+17 ℄ 84"x 52' CMP Culvert (New 12-7-61)
Farm Road 25' Wide
N.S. Lt.
N.S. Rt.
S=.0008 Original Construction Grade
CLEANING GRADE
S=.0008
130
140
150
160
170
180
Cleaned Nov. 1960
Sta. 151+00 to 165+00

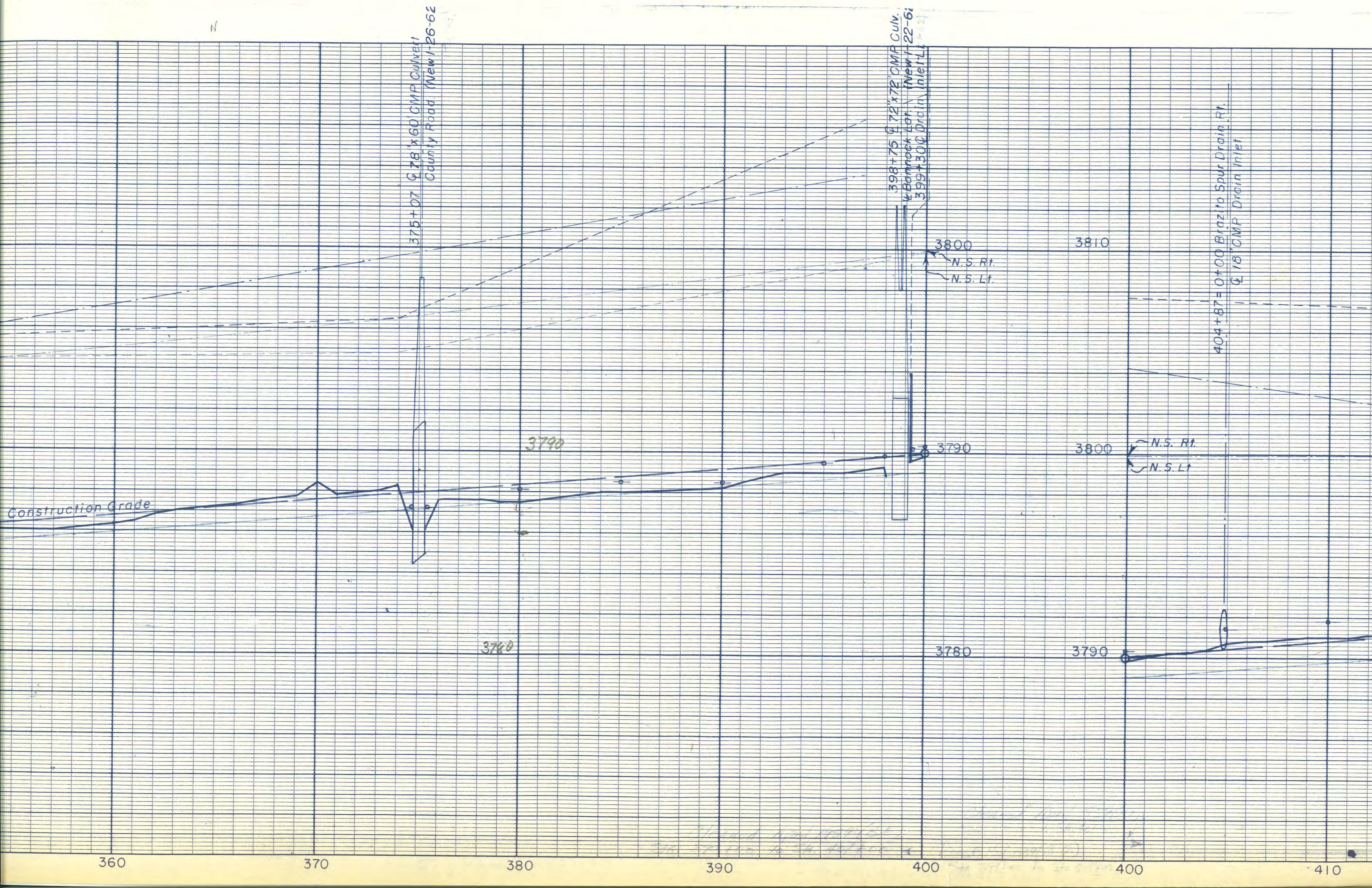

186+17 ℄ 84"x52' CMP Culvert (New 12-7-61)
Farm Road 25' Wide
198+50 ℄ 24" CMP Weaver Flume
+72 Arroyo Inlet
24" Concrete Pipe
214+98 ℄ 84"x52' CMP Culvert (New 12-12-61)
Channon Singh Farm Road
223+44 36" CMP Arroyo Inlet Lt.
℄ Singh Arroyo
223+70 ℄ 30"x116' CMP Flume
Weeks Lateral (Sta 35+00)
237+63 ℄ 84"x52' CMP Culvert (New 12-12-
Stewart Farm Road.
s=.001 Original Construction Grade
S=.0008
180
190
200
210
220
230
240



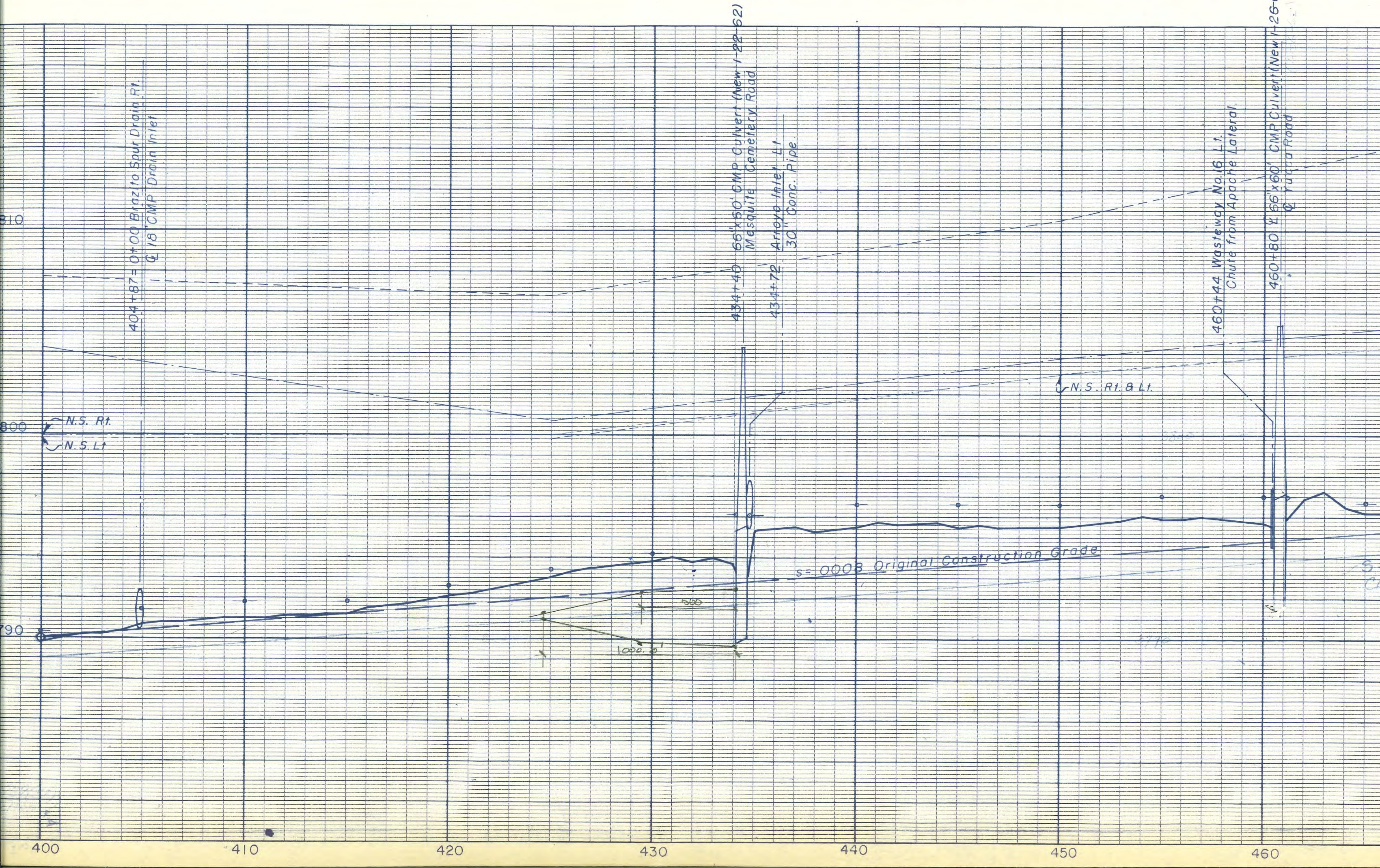
214+98 ℄ 84"x52' CMP Culvert (New 12-12-61)
Chanion Singh Farm Road
223+44 36" CMP Arroyo Inlet Lt.
℄ Singh Arroyo
223+70 ℄ 30"x116' CMP Flume
Weeks Lateral (Sta 35+00)
237+63 ℄ 84"x52' CMP Culvert (New 12-12-
Stewart Farm Road.
B.M. Elev. 3789.14 Concrete Headwall
South end, Reymond Lateral Sta 33+18
251+40 ℄ 30"x98' CMP Flume - Reymond Lat.
265+33 ℄ 84"x52' CMP Culvert (New 1-8-62)
℄ Farm Road
3790
3780
3770
3800
3790
3780
N.S. Rt.
N.S. Lt.
N.S. Rt.
N.S. Lt.
ade
220
230
240
250
250
260
270

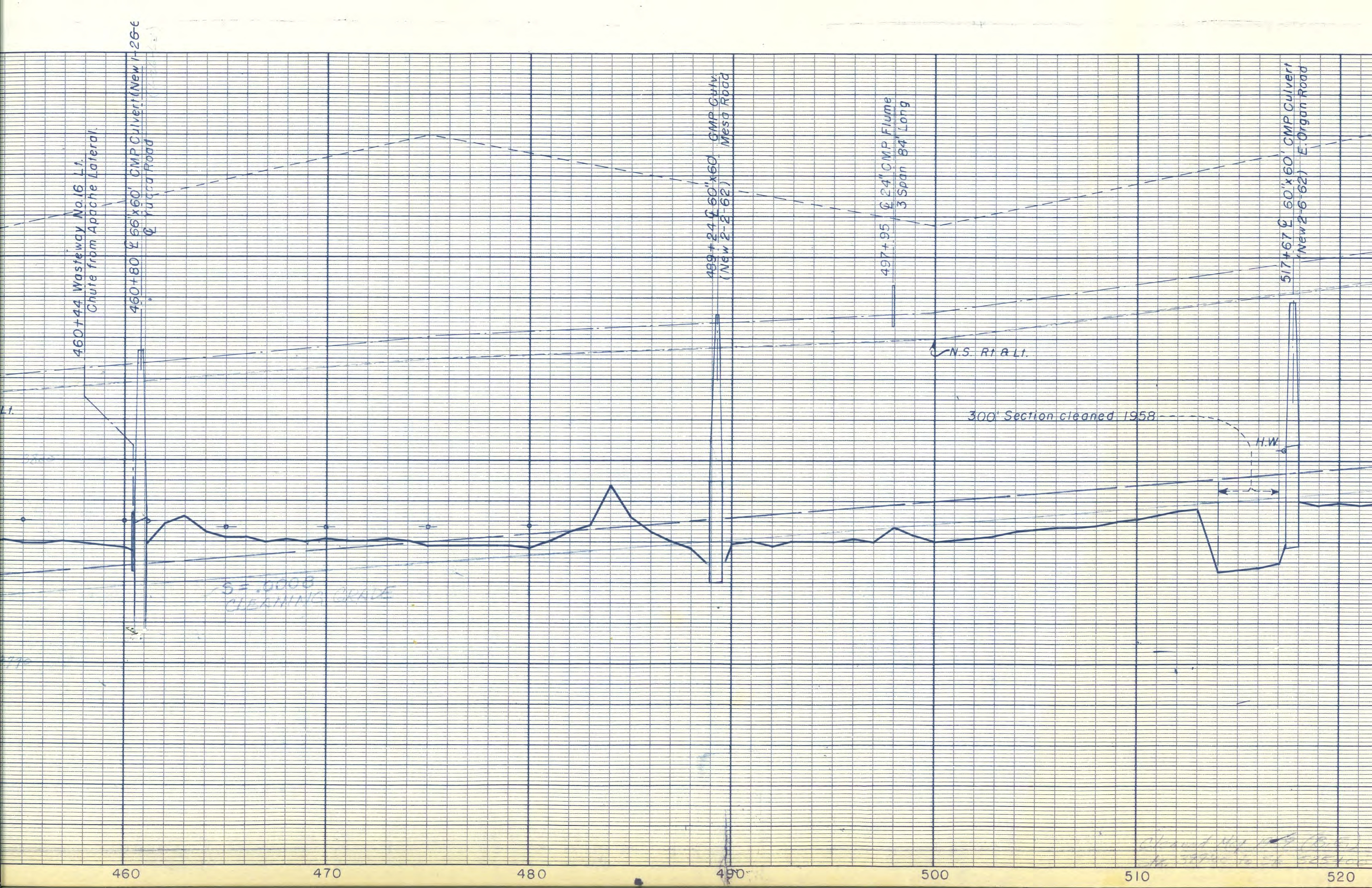

Elev. 3789.14 Concrete Headwall
th end, Reymond Lateral Sta. 33+18
265+33 ℄ 84"x52' CMP Culvert (New 1-8-62)
℄ Farm Road
278+76 ℄ No. 96 Armco Flume
278+90 Arroyo Inlet Lt.
℄ Concrete Chute
307+00 ℄ 78"x60' CMP Culvert (New 1-8-6
℄ Farm Road
321+21 ℄ Wasteway 16A Lt.
36" CMP Bannock Lateral
N.S. Rt. 8 Lt.
S=.001 Original Construction Grade
Note –
Clean to original construction grade
except where cleaning grade is indicated.
260
270
280
290
300
310
320

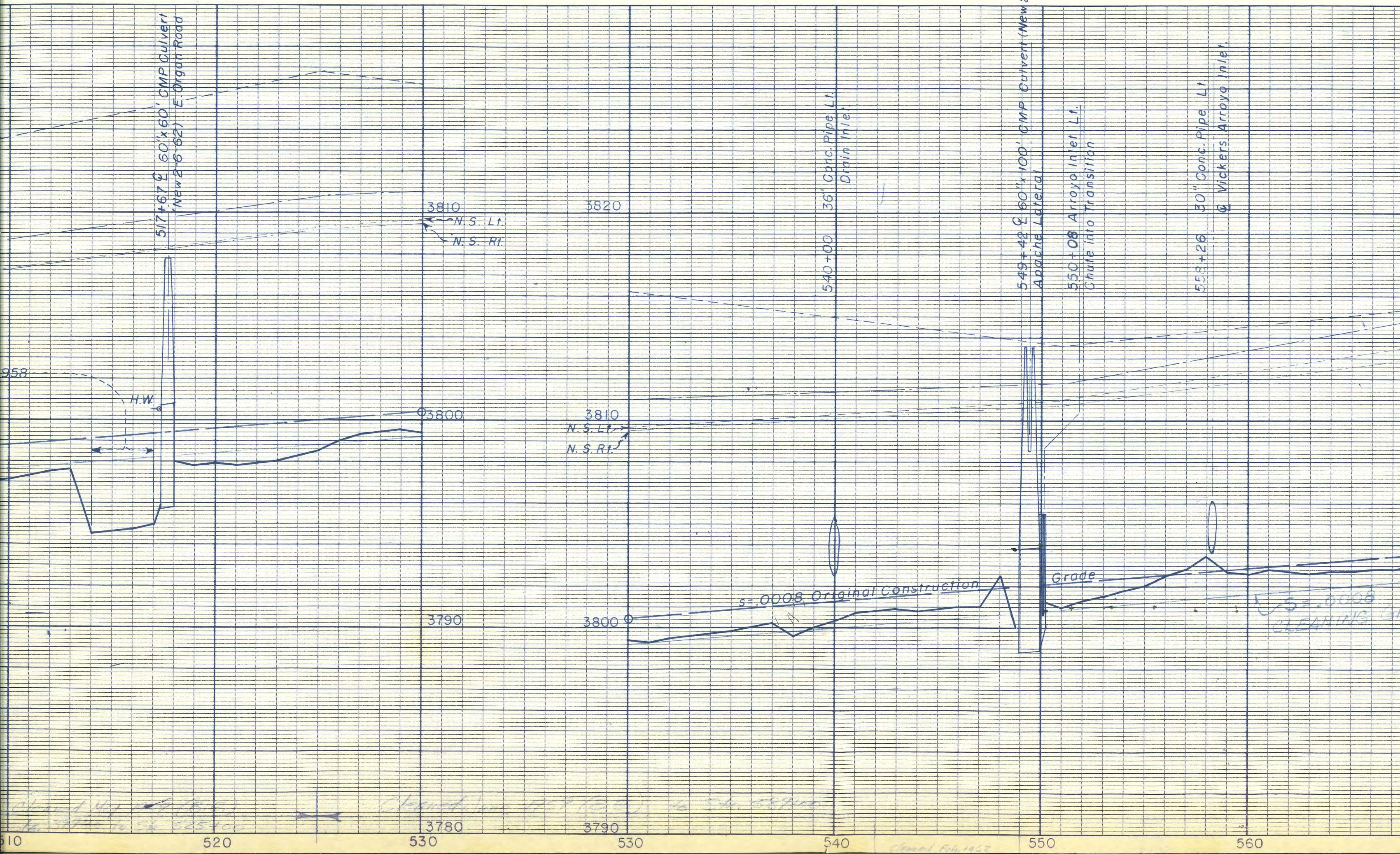

307+00 ℄ 78"x60' CMP Culvert (New 1-8-6
℄ Farm Road
321+21 ℄ Wasteway 16A L1
36" CMP Bannock Lateral
339+00 36"x67" Conc. Pipe Culvert
℄ Mesquite - Hwy 80 Road
S=.0008 Original Construction Grade
S=.0008
338+58 End β Transition
339+41 Begin β Transition
310
320
330
340
350
360
370



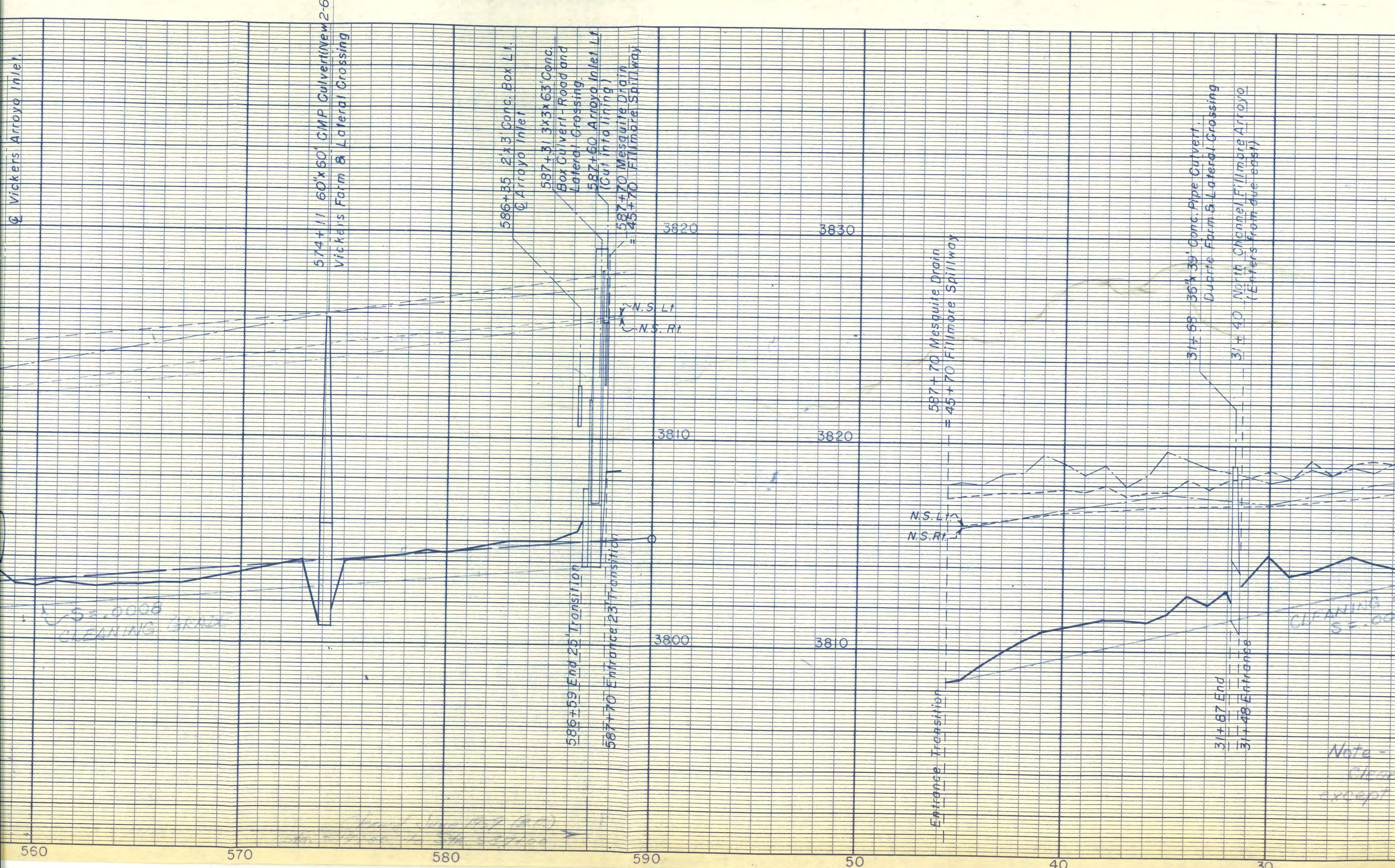
375+07 ℄ 78"x60" CMP Culvert
County Road (New 1-26-62
398+75 ℄ 72"x72" CMP Culv.
℄ Bannock Lat. (New 1-22-62
399+30 ℄ Drain Inlet Lt.
404+87 = 0+00 Braz'to Spur Drain Rt.
℄ 18" CMP Drain Inlet
3800
3810
N.S. Rt.
N.S. Lt.
3790
3800
N.S. Rt.
N.S. Lt.
Construction Grade
3780
3790
360
370
380
390
400
400
410


404+87 = 0+00 Braz to Spur Drain Rt.
℄ 18" CMP Drain Inlet
434+40 66"x60' CMP Culvert (New 1-22-62)
Mesquite Cemetery Road
434+72 Arroyo Inlet, Lt.
30" Conc. Pipe
460+44 Wasteway No.16 Lt.
Chute from Apache Lateral
460+80 ℄ 66"x60' CMP Culvert (New 1-26-6
℄ Yucca Road
N.S. Rt.
N.S. Lt.
N.S. Rt. & Lt.
s=.0008 Original Construction Grade
500
1000.0'
810
800
790
400
410
420
430
440
450
460

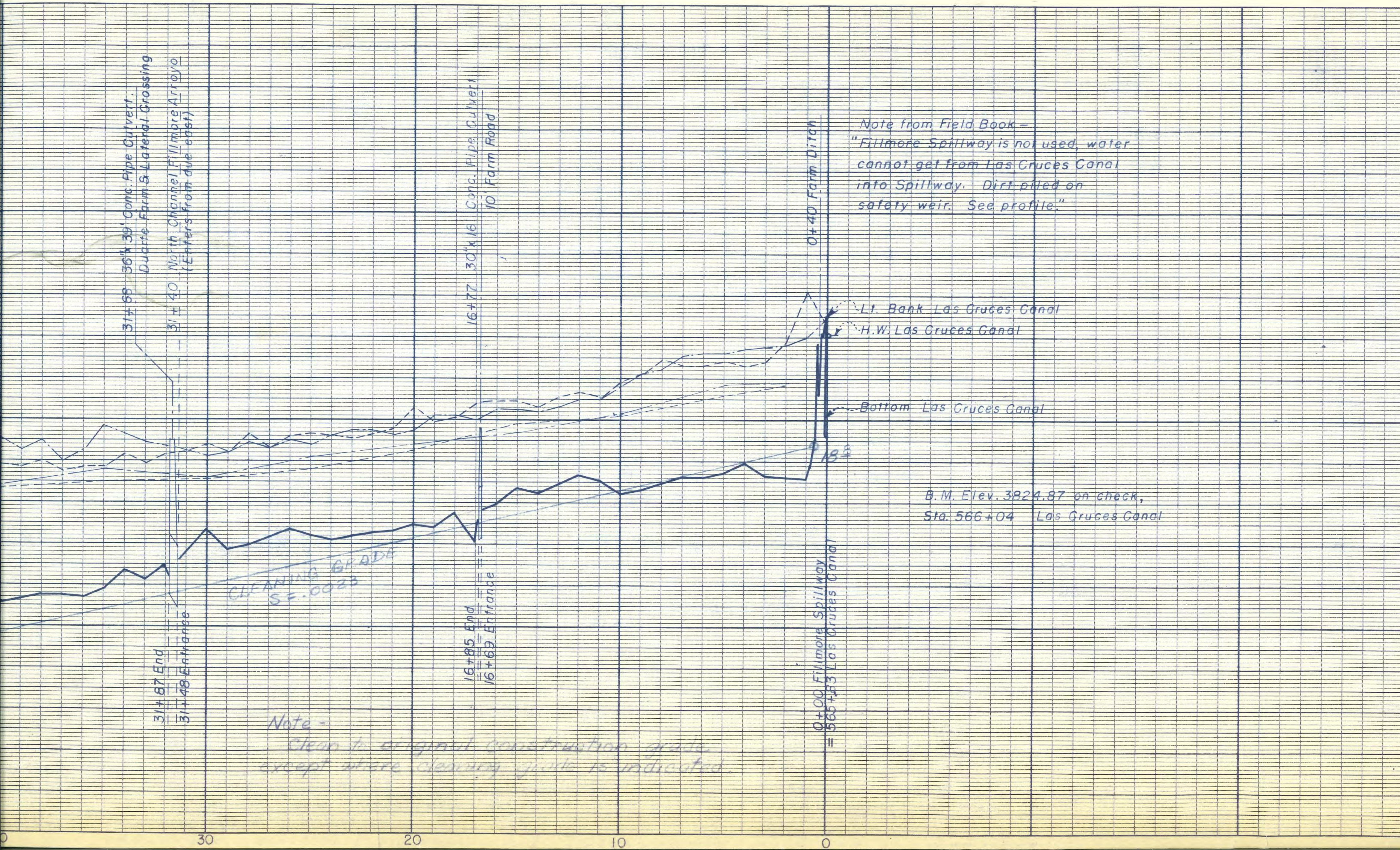

460+44 Wasteway No.16 Lt.
Chute from Apache Lateral
460+80 ℄ 66"x60' CMP Culvert (New 1-26-6
℄ Yucca Road
489+24 ℄ 60"x60' CMP Culv.
(New 2-2-62) Mesa Road
497+95 ℄ 24" CMP Flume
3 Span 84' Long
N.S. Rt & Lt.
300' Section cleaned 1958
H.W.
517+67 ℄ 60"x60' CMP Culvert
(New 2-6-62) E. Organ Road
S=.0008
CLEANING GRADE
460
470
480
490
500
510
520



517+67 ℄ 60"x60' CMP Culvert
(New 2-6-62) E. Organ Road
3810
N.S. Lt.
N.S. Rt.
3820
540+00 36" Conc. Pipe Lt.
Drain Inlet
549+42 ℄ 60"x100' CMP Culvert (New 2-6-
Apache Lateral
550+08 Arroyo Inlet Lt.
Chute into Transition
558+26 30" Conc. Pipe Lt.
℄ Vickers Arroyo Inlet
958
H.W.
3800
3810
N.S. Lt.
N.S. Rt.
s=.0008 Original Construction Grade
3790
3800
3780
3790
510
520
530
530
540
550
560



℄ Vickers Arroyo Inlet.
574+11 60"x50' CMP Culvert(New 2-6-
Vickers Farm & Lateral Crossing
586+35 2'x3' Conc. Box Lt.
℄ Arroyo Inlet
587+31 3'x3'x63' Conc.
Box Culvert - Road and
Lateral Crossing.
587+60 Arroyo Inlet Lt
(Cut into lining)
587+70 Mesquite Drain
= 45+70 Fillmore Spillway
3820
3830
N.S. Lt.
N.S. Rt.
3810
3820
3800
3810
586+59 End 25' Transition
587+70 Entrance 23' Transition
S = .0008
CLEANING GRADE
587+70 Mesquite Drain
= 45+70 Fillmore Spillway
Entrance Transition
31+68 36"x 30' Conc. Pipe Culvert.
Duarte Farm & Lateral Crossing
31+40 North Channel Fillmore Arroyo
(Enters from due east)
31+87 End
31+48 Entrance
CLEANING
S = .00
Note -
Clea
except
560
570
580
590
50
40
30


31+68 36"x39' Conc. Pipe Culvert.
Duarte Farm & Lateral Crossing
31+40 North Channel Fillmore Arroyo
(Enters from due east)
16+77 30"x16' Conc. Pipe Culvert
10' Farm Road
0+40 Farm Ditch
Note from Field Book –
"Fillmore Spillway is not used, water cannot get from Las Cruces Canal into Spillway. Dirt piled on safety weir. See profile."
Lt. Bank Las Cruces Canal
H.W. Las Cruces Canal
Bottom Las Cruces Canal
B.M. Elev. 3824.87 on check,
Sta. 566+04 Las Cruces Canal
CLEANING GRADE
S=.0023
31+87 End
= 31+48 Entrance
16+85 End
= 16+69 Entrance
0+00 Fillmore Spillway
= 566+83 Las Cruces Canal
Note -
Clean to original construction grade except where cleaning grade is indicated.
30
20
10
0

0+40 Farm Ditch

Note from Field Book –
"Fillmore Spillway is not used, water cannot get from Las Cruces Canal into Spillway. Dirt piled on safety weir. See profile."

Lt. Bank Las Cruces Canal

H.W. Las Cruces Canal

Bottom Las Cruces Canal

B.M. Elev. 3824.87 on check,
Sta. 566+04 Las Cruces Canal

0+00 Fillmore Spillway
= 566+23 Las Cruces Canal

0

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RIO GRANDE PROJECT—NEW MEX.-TEX.

# MESQUITE DRAIN AND FILLMORE SPILLWAY

## 1958 CONDITION PROFILE

PLOTTED ERJ

CHECKED [signature] APR. 16, 1958

From Field Book File 17-F, Bks. 13A & 13B.
Surveyed March 1958

23-503-5923
(Filed R66V)

BGP - 4
(Aug. 1951)

Department of the Interior

# BUREAU OF RECLAMATION – RIO GRANDE PROJECT

## Structure Record

File 21-N Book 3
Revised May, 1957

934

3A

GPO 844569

FEATURE Mesquite Drain | FROM STA. 0+00 | =STA. 464+28 East Drain | TO STA. 586+84 | LENGTH 58684 FT. | 11.11 MILES

| STRUCTURE | STATION | SIDE | DIMENSIONS | TYPE | INSTALLED | REPAIRED | REPLACED | TYPE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Heading | 0+00 | | Mewquite Drain = Sta. 464+28 C/L East Drain | | | | | | |
| Culvert | 0+19 | End | 96" x 50' GMP Culvert | | | | | | |
| Farm Road | 0+44 | C/L | Farm road & dragline crossing | | | | Rancho Feliz | | |
| Culvert | 0+69 | Ent. | 96" x 50' CMP, no hd'wls. | | | | | | |
| Culvert | 21+21 | End | 90" x 80' GMP in Drain | | 12/61 | | | | |
| Lateral | 21+73 | C/L | USBR conc. lined Anthony Lateral = Sta. 31+00 48" x 28' CMP. | | | | | | |
| Culvert | 22+25 | Ent. | 90" x 80' GMP in Drain | | 12/61 | | | | |
| Arroyo Entrance | 22+47 | Right | 24" C.M.P. Arroyo enters right | | | | | | |
| Flume | 35+41 | C/L | 30" CIP flume 50' lg. - conc. hd'wls, conc. piers, 3 span, timber frame | | | | | | |
| Flume | 48+46 | C/L | 36" x 90' CMP Conc. hd'wls | | 12/61 | | | | |
| Culvert | 48+74 | C/L | 90" x 60' GMP , no hd'wls | | 12/61 | Co. Road 159W | | | |
| Arroyo Inlet | 49+27 | Right | C/L concl lined arroyo inlet right (East) conc. chute - Woodward Arroyo | | | | | | |
| Arroyo Inlet | 82+03 | Right | C/L conc. lined arroyo inlet right (Woodward) conc. chute | | | | | | |
| Flume | 106+05 | C/L | #84Armco flume x 50' lg., conc. piling & caps, 3 span timber frame | | | | 3/65 | | |
| Culvert-Co. Rd. | 106+50 | C/L | 90" x 60' GMP, South side Vado - Mesa | | 12/61 | Co Rd 166 | | | |
| School Culvert | 135+80 | C/L | 60" x 60' CIP culvert, Vado-School-Mesa Co. hwy. | | | SR 227 | | | |
| Flume | 164+93 | C/L | 24" x 90' CMP, Concl headwalls | | 1/67 | | | | |
| Arroyo Inlet | 165+43 | Right | Conclined Arroyo inlet right, conc. chute | | | | | | |
| Culvert | 186+17 | C/L | 84" x 52' CMP & 30" x 90' over | | 12/61 | Drain 4-60 | | | |
| Road & Farm Lat. | 186+17 | C/L | Farm road & ditch culvert 30" x 90' over | | | | | | |
| Flume-Private | 198+50 | C/L | 24" x 60' CIP, conc. hd'wls, 3 span timber frame, irrigation pump permit | | | 1/78 | | | |
| Arroyo Outlet | 198+72 | Right | 24" CIP arroyo outlet culvert, right | | | | | | |
| Singh Road Culv. | 214+98 | C/L | Singh Farm road culvert, 90" x 60' Galv. Metal Pipe 12/61 | | | | | Channon Singh | |
| Arroyo - Singh | 223+44 | Right | 36" CIP, Singh arroyo inlet culvert right, conc. hd'wl. | | | | | | |
| Lateral - Weeks | 223+70 | C/L | 30" x 16' CMP Flume | | | | 5/62 | | |
| Road-Culvert | 237+63 | C/L | Farm road culvert | 84" x 52' Galv. Metal Pipe | | 12/61 | | C.V. Stewart | |
| Sweet-Culvert | 237+63 | C/L | 84" x 52' Galv. Metal Pipe Jake Sweet farm road & ditch culvert 12/61 - El Rancho Dulce | | | | GR 181 | | |

MESQUITE DRAIN

RGP - 4
(Aug. 1951)

# Department of the Interior
## BUREAU OF RECLAMATION – RIO GRANDE PROJECT
### Structure Record

File 21-N Book 3
Revised May, 1957

4A GPO 844569

FEATURE Mesquite Drain | FROM STA. 0+00 | =STA. 464+28 East Drain | TO STA. 586+84 | LENGTH 58684 FT. | 11.11 MILES

| STRUCTURE | STATION | SIDE | DIMENSIONS | TYPE | INSTALLED | REPAIRED | REPLACED | TYPE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Fuller Road | 265+33 | C/L | 84" x 52' Galv. Metal Pipe | | 1/62 | | | | |
| Flume | 278+76 | C/L | #96" Armco Flume X 77' Fullers farm flume, timber frame, 4 span timber piling 6/66 | | | 6/70 1/71; 2/73; 1/75 12/76 | | 9/77 10/78 | Domingus |
| Arroyo Inlet | 288+90 | Right | Conc. lined arroyo inlet, right (Fuller) conc. chute | | | | | | |
| Sweet Rd. Culv. | 307+00 | C/L | Jake Sweet upper farm road and ditch culver 78" x 60' CIP 1/62 | | | ← 24" x ' CMP. | | | |
| Lateral, W.W. #16A | 321+21 | C/L | New Bannock Later W.W. #16A right, 36" CIP culvert | | | | | | |
| Culvert | 338+66 | End | 78" x 90' conc. pipe, conc. hd'wls & wings transition | | | | | | |
| Paved Road | 339+00 | C/L | Mesquite - Mesa Rd. culvert, 36" x 67' conc. tube, conc. hd'wls (oiled country hwy.) S.R. 228 | | | | | | Ø |
| Culvert | 339+33 | Ent. | 78" x 90' conc. pipe, conc. hd'wls & wings transition | | | | | | |
| Culvert | 375+07 | C/L | 18X 60' CIP, D.A. Co. road 208 | | 1/62 | | | | |
| Culvert | 398+29 | End | 72" x 72' x 92' CmP, conc. tube, culvert, conc. hd'wls. | | | | | | |
| Lateral | 398+75 | C/L | USBR conc. lined Bannock Lateral crossing | | | | | | |
| Culvert | 399+21 | Entrance | 72" x 72' CMP, culvert, conc. hd'wls. | | | | | | |
| Arroyo Inlet | 399+30 | Right | C/L conc. lined arroyo inlet right, conc. chute | | | | | | |
| Brazito Drain | 404+87 | Left | Sta. 0+00 Brazito Spur Drain (left) West | | | | | | |
| Cemetery road | 434+40 | C/L | Mesquite cemetary county road culvert 66" x 60' CMP, 1/62 Co Rd 212 | | | | | Ø | |
| Arroyo Inlet | 434+71 | Right | 30" x 80' CMP D.A. County Arroyo inlet, culvert right 1-62 | | | | | | |
| Lateral W.W.#16 | 460+44 | Right | USBR conc. lined Apache Lat. W.W. #16 right, conc. chute, end Apache Lateral | | | | | | |
| Culvert-D.A. Co. | 460+80 | C/L | 66" x 60' CIP, Yucca D.A. Co. Road | | 1-62 | Co. Rd. 220 | | Ø | |
| Culvert | 488+95 | End | 60" x 60' CMP. | | | | | | |
| D.A. Co. Road | 489+24 | C/L | Brazito - Mesa County highway | | Co Rd 209 | | | | |
| Culvert | 489+53 | Ent. | 60" x 60' CMP. | | | | | | |
| Private Flume | 497+95 | C/L | 24" x 84' C.M.P., 1 span, conc. footing, Dr. Shipman pvt. flume | | | | | | |
| Carpenters Rd. | 517+67 | C/L | Carpenters Store Country road & culvert 60" x 60' Co Rd 230 | | | | | | |
| Culvert | 548+98 | End | 60" x 100' conc. tube culvert, conc. hd'wls. | | | | | | |
| Lateral | 549+42 | C/L | USBR conc. lined Apache Lateral crossing & W.W. 30" x 55' C.M.P. & Conc. Pipe | | | | | | |
| Culvert | 549+89 | Ent. | 60" x 100' conc. tube, conc. hd'wls. | | | | | | |
| Arroyo Inlet | 550+08 | Right | C/L 30" conc. pipe, Vickers Arroyo right | | | | | | |
| Arroyo Inlet | 558+26 | Right | C/L Vickers Arroyo inlet right, 30" conc. tube culvert, conc. hd'wls. | | | | | | |
| Culvert - Flume | 573+70 | C/L | 60" x 60' in drain & 36" x 126' CIP for flume 5/54 Vickers farm road & lateral (← ADD 28' R.C.P. 11/68) | | | | | | |

EGP - 4
(Aug. 1951)

# Department of the Interior
## BUREAU OF RECLAMATION – RIO GRANDE PROJECT
### Structure Record

File 21-N Book 3
Revised May, 1957

GPO 844569

FEATURE Mesquite Drain | FROM STA. 0+00 | =STA. 464+28 East Drain | TO STA. 586+84 | LENGTH 58684 FT. | 11.11 MILES

| STRUCTURE | STATION | SIDE | DIMENSIONS | TYPE | INSTALLED | REPAIRED | REPLACED | TYPE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| End | 586+84 | End | Mesquite Drain | | | | | | |
| Arroyo Outlet | 586+84 | End | 36" x 36" conc. box arroyo culvert, conc. hd'wls - Fillmore Arroyo outlet | | | | | | |
| Road | 587+31 | C/L | Conke Viramontes - Vickers Road | | Co. Rd 234 | | | | |
| Arroyo Outlet | 587+47 | Ent. | 36" x 36' conc. box Arroyo culvert, conc. hd'wls. - Arroyo outlet | | | | | | |

# NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

**Coastal Base Flood Elevations** shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction, and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures in this jurisdiction.

The **projection** used in the preparation of this map was New Mexico State Plane, Central Zone (FIPS 3002). The **horizontal datum** was NAD 83, GRS80 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey, SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242**, or visit their website at http://www.ngs.noaa.gov.

**Base map** information shown on this FIRM was provided by the Dona Ana County Flood Commission, 2004 and 2010; Bureau of Land Management, 2004; U.S. Geological Survey, 1989 and 2005; NGS, 2004; and U.S. Census Bureau, 2009. Additional information was compiled from U.S. Department of Agriculture aerial photography, 2009 at a scale of 1:12,000.

Based on updated topographic information, this map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. As a result, the Flood Profiles and Floodway Data tables for the Flood Insurance Study report may reflect stream channel distances that differ from what is shown on the map. Also, the road to floodplain relationships for unrevised streams may differ from what is shown on previous maps.

**Corporate limits** shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

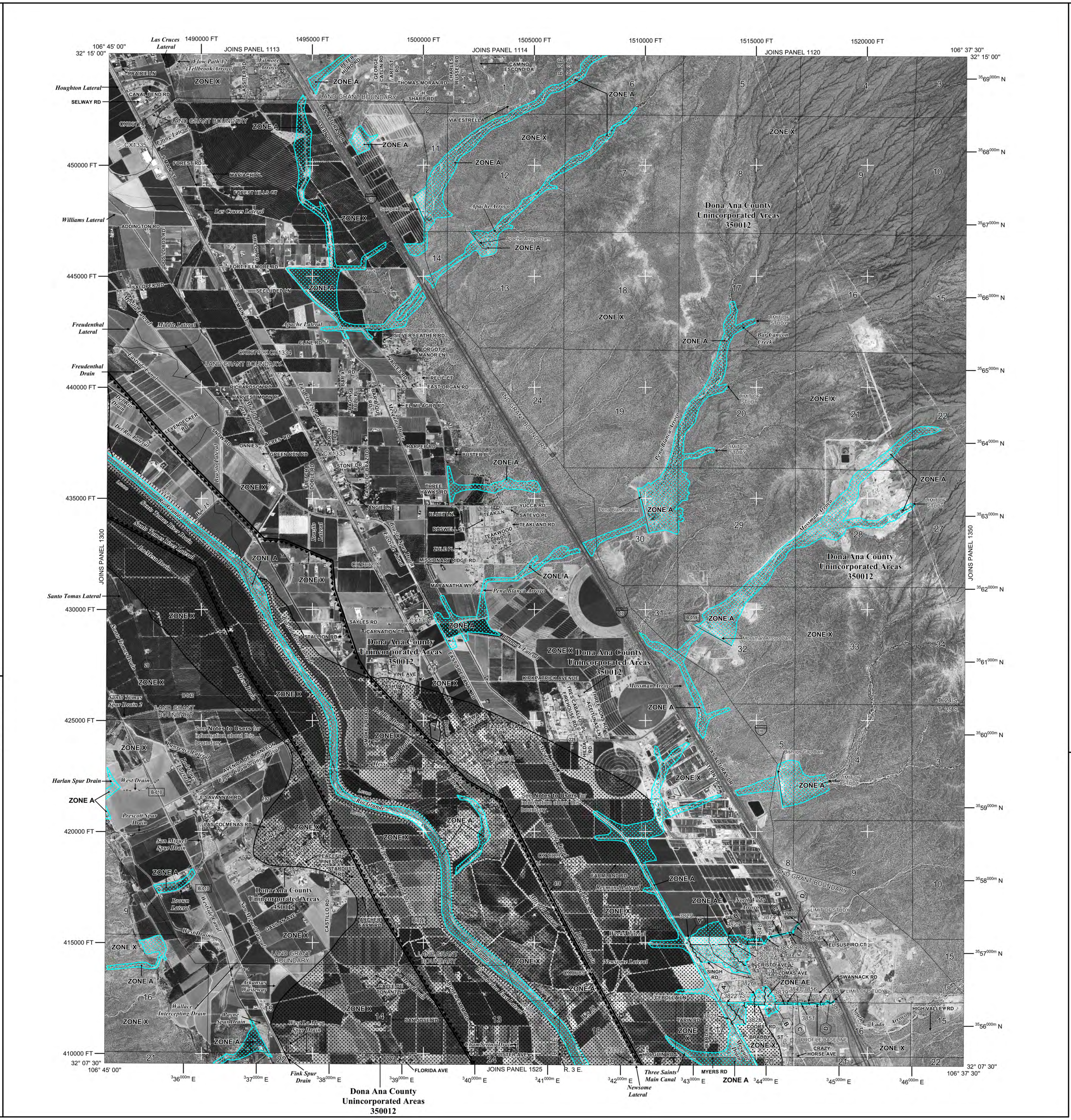
Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map**, how to order products or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at **1-877-FEMA-MAP** (1-877-336-2627) or visit the FEMA website at to http://www.fema.gov/national-flood-insurance-program

ATTENTION: The levee, dike, or other structure that impacts flood hazards inside this boundary has not been shown to comply with Section 65.10 of the NFIP Regulations. As such, this FIRM panel will be revised at a later date to update the flood hazard information associated with this structure.

The flood hazard data inside this boundary on the FIRM panel has been re-published from the previous effective (historic) FIRM for this area, after being converted from NGVD 29 to NAVD 88.




## LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

**ZONE A** No Base Flood Elevations determined.

**ZONE AE** Base Flood Elevations determined.

**ZONE AH** Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

**ZONE AO** Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

**ZONE AR** Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

**ZONE A99** Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.

**ZONE VE** Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

**FLOODWAY AREAS IN ZONE AE**

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

**OTHER FLOOD AREAS**

**ZONE X** Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

**OTHER AREAS**

**ZONE X** Areas determined to be outside the 0.2% annual chance floodplain.
**ZONE D** Areas in which flood hazards are undetermined, but possible.

**COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS**

**OTHERWISE PROTECTED AREAS (OPAs)**

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% annual chance floodplain boundary
0.2% annual chance floodplain boundary
Floodway boundary
Zone D Boundary
CBRS and OPA Boundary
Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
513 — Base Flood Elevation line and value; elevation in feet*
(EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

A — A Cross section line
23 - - - 23 Transect line
97° 07' 30", 32° 22' 30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
42 76 000m E — 1000-meter Universal Transverse Mercator grid values, zone 13N
600000 FT — 5000-foot grid ticks: New Mexico State Plane coordinate system, Central zone (FIPSZONE 3002), Transverse Mercator
DX5510 × — Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5 — River Mile

MAP REPOSITORIES
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EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP PANEL
SEPTEMBER 27, 1991

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
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**MAP SCALE 1" = 2000'**

1000 0 2000 4000 FEET
600 0 600 1200 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

**PANEL 1325G**

# FIRM

## FLOOD INSURANCE RATE MAP

## DONA ANA COUNTY, NEW MEXICO
AND INCORPORATED AREAS

**PANEL 1325 OF 1925**

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| DONA ANA COUNTY (UNINCORPORATED AREAS) | 350012 | 1325 | G |

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

**MAP NUMBER**
**35013C1325G**

**MAP REVISED**
**JULY 6, 2016**

Federal Emergency Management Agency

# NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

**Coastal Base Flood Elevations** shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction, and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures in this jurisdiction.

The **projection** used in the preparation of this map was New Mexico State Plane, Central Zone (FIPS 3002). The **horizontal datum** was NAD 83, GRS80 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

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NGS Information Services
NOAA, N/NGS12
National Geodetic Survey, SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242**, or visit their website at http://www.ngs.noaa.gov.

**Base map** information shown on this FIRM was provided by the Dona Ana County Flood Commission, 2004 and 2010; Bureau of Land Management, 2004; U.S. Geological Survey, 1989 and 2005; NGS, 2004; and U.S. Census Bureau, 2009. Additional information was compiled from U.S. Department of Agriculture aerial photography, 2009 at a scale of 1:12,000.

Based on updated topographic information, this map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. As a result, the Flood Profiles and Floodway Data tables for the Flood Insurance Study report may reflect stream channel distances that differ from what is shown on the map. Also, the road to floodplain relationships for unrevised streams may differ from what is shown on previous maps.

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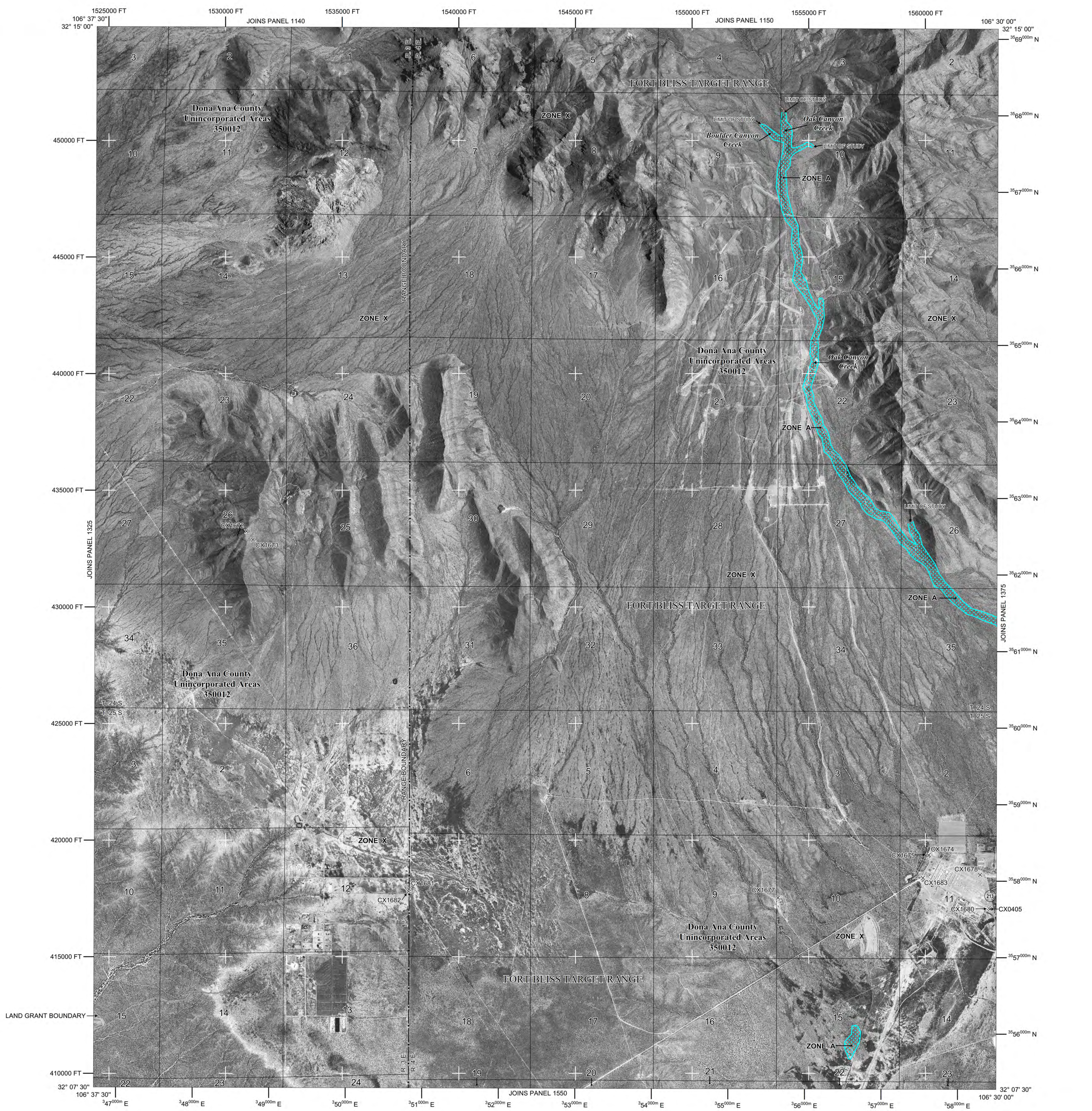


## LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

| | |
|---|---|
| **ZONE A** | No Base Flood Elevations determined. |
| **ZONE AE** | Base Flood Elevations determined. |
| **ZONE AH** | Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined. |
| **ZONE AO** | Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined. |
| **ZONE AR** | Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood. |
| **ZONE A99** | Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined. |
| **ZONE VE** | Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined. |

**FLOODWAY AREAS IN ZONE AE**

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

**OTHER FLOOD AREAS**

**ZONE X** Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

**OTHER AREAS**

**ZONE X** Areas determined to be outside the 0.2% annual chance floodplain.
**ZONE D** Areas in which flood hazards are undetermined, but possible.

**COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS**

**OTHERWISE PROTECTED AREAS (OPAs)**

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% annual chance floodplain boundary
0.2% annual chance floodplain boundary
Floodway boundary
Zone D Boundary
CBRS and OPA Boundary
Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.

| | |
|---|---|
| 513 | Base Flood Elevation line and value; elevation in feet* |
| (EL 987) | Base Flood Elevation value where uniform within zone; elevation in feet* |

*Referenced to the North American Vertical Datum of 1988

| | |
|---|---|
| A — A | Cross section line |
| 23 - - - - 23 | Transect line |
| 97° 07' 30", 32° 22' 30" | Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere |
| $^{42}76^{000m}$E | 1000-meter Universal Transverse Mercator grid values, zone 13N |
| 600000 FT | 5000-foot grid ticks: New Mexico State Plane coordinate system, Central zone (FIPSZONE 3002), Transverse Mercator |
| DX5510 × | Bench mark (see explanation in Notes to Users section of this FIRM panel) |
| • M1.5 | River Mile |

MAP REPOSITORIES
Refer to Map Repositories list on Map Index.

EFFECTIVE DATE OF COUNTYWIDE FLOOD
INSURANCE RATE MAP PANEL
SEPTEMBER 27, 1991

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
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**MAP SCALE 1" = 2000'**

1000 0 2000 4000 FEET

600 0 600 1200 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

**PANEL 1350G**

# FIRM

## FLOOD INSURANCE RATE MAP

## DONA ANA COUNTY, NEW MEXICO AND INCORPORATED AREAS

**PANEL 1350 OF 1925**

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| DONA ANA COUNTY (UNINCORPORATED AREAS) | 350012 | 1350 | G |

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

**MAP NUMBER 35013C1350G**

**MAP REVISED JULY 6, 2016**

Federal Emergency Management Agency

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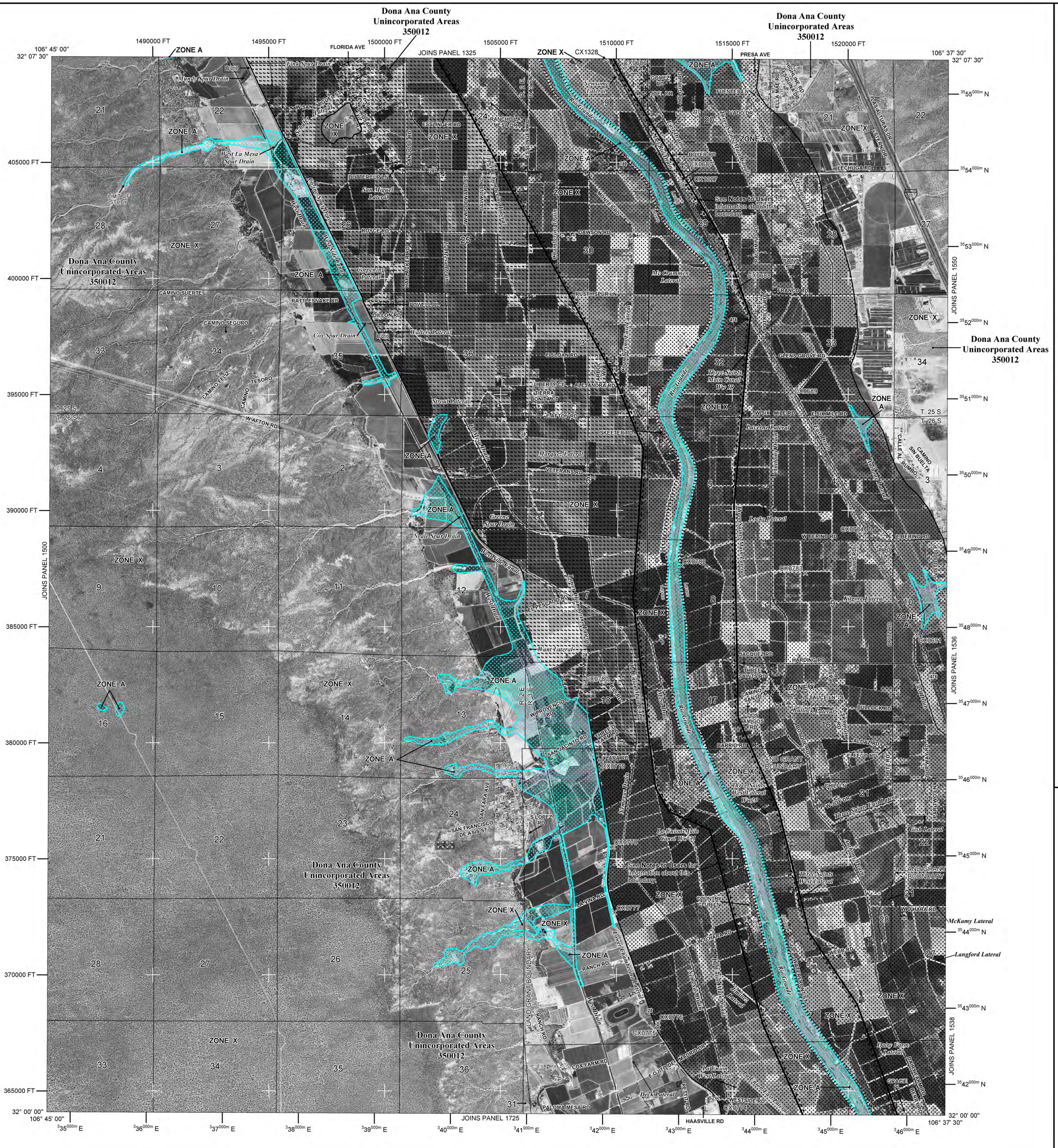
ATTENTION: The levee, dike, or other structure that impacts flood hazards inside this boundary has [illegible] Section 65.10 of the NFIP Regulations. As su[illegible]vised at a later date to update the flood hazard ir[illegible]sociated with this structure.

**SEE NOTES TO USERS FOR INFORMATION ABOUT THIS BOUNDARY**

The flood hazard data inside this boundary on the FIRM panel has been re-published from the previous effective (historic) FIRM for this area, after being converted from NGVD 29 to NAVD 88.




# LEGEND

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0.2% annual chance floodplain boundary
Floodway boundary
Zone D Boundary
CBRS and OPA Boundary
Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.

| | |
|---|---|
| 513 | Base Flood Elevation line and value; elevation in feet* |
| (EL 987) | Base Flood Elevation value where uniform within zone; elevation in feet* |

*Referenced to the North American Vertical Datum of 1988

| | |
|---|---|
| (A)———(A) | Cross section line |
| (23)- - - - -(23) | Transect line |
| 97° 07' 30", 32° 22' 30" | Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere |
| 42 76 000m E | 1000-meter Universal Transverse Mercator grid values, zone 13N |
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| DX5510 × | Bench mark (see explanation in Notes to Users section of this FIRM panel) |
| • M1.5 | River Mile |

MAP REPOSITORIES
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EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP PANEL
SEPTEMBER 27, 1991

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

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**MAP SCALE 1" = 2000'**

1000 0 2000 4000 FEET
600 0 600 1200 METERS

NATIONAL FLOOD INSURANCE PROGRAM

NFIP

**PANEL 1525G**

# FIRM

## FLOOD INSURANCE RATE MAP

## DONA ANA COUNTY, NEW MEXICO AND INCORPORATED AREAS

**PANEL 1525 OF 1925**

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| DONA ANA COUNTY (UNINCORPORATED AREAS) | 350012 | 1525 | G |

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

**MAP NUMBER 35013C1525G**

**MAP REVISED JULY 6, 2016**

**Federal Emergency Management Agency**

# APPENDIX C

EXISTING CONDITIONS

HYDROLOGIC AND HYDRAULIC DATA,

CALCULATIONS

AND

REFERENCES

# Existing Conditions
# Hydrologic/Hydraulic Data Tables

Table C1 Rainfall Depth Data

Table C2 Runoff Curve Number (CN) Assumptions and Calculations

Table C3 Time of Concentration and Lag Time Calculations

Table C3.1 Time of Concentration and Lag Time Calculations for Additional Subbasins

Table C4 Channel Routing Data

Table C5 Subbasin Hydrologic Data Summary (HEC-HMS)

Table C6 Existing Subbasin W031 Detention Pond Elev-Stage-Discharge Calculations

| TABLE C1<br>RAINFALL DEPTH DATA<br>Vado/Del Cerro Drainage Master Plan | | | | | | | |
|---|---|---|---|---|---|---|---|
| Duration | Average recurrence interval (years) (a) | | | | | | |
| | Point Precipitation Depths - 2-year | Point Precipitation Depths 5-year | Point Precipitation Depths - 10-year | Point Precipitation Depths - 25-year | Point Precipitation Depths - 50-year | Point Precipitation Depths - 100-year | Point Precipitation Depths - 500-year |
| **5-min** | 0.289 | 0.389 | 0.466 | 0.569 | 0.652 | 0.739 | 0.952 |
| **10-min** | 0.439 | 0.591 | 0.708 | 0.866 | 0.993 | 1.120 | 1.450 |
| **15-min** | 0.544 | 0.732 | 0.878 | 1.070 | 1.230 | 1.390 | 1.800 |
| **30-min** | 0.733 | 0.986 | 1.180 | 1.450 | 1.660 | 1.880 | 2.420 |
| **60-min** | 0.907 | 1.220 | 1.460 | 1.790 | 2.050 | 2.320 | 2.990 |
| **2-hr** | 1.040 | 1.410 | 1.700 | 2.090 | 2.400 | 2.730 | 3.550 |
| **3-hr** | 1.100 | 1.470 | 1.750 | 2.150 | 2.470 | 2.800 | 3.630 |
| **6-hr** | 1.240 | 1.630 | 1.930 | 2.330 | 2.650 | 2.980 | 3.780 |
| **12-hr** | 1.370 | 1.780 | 2.090 | 2.510 | 2.830 | 3.150 | 3.930 |
| **24-hr** | 1.510 | 1.980 | 2.350 | 2.870 | 3.290 | 3.740 | 4.880 |

a - NOAA Atlas 14, Volume 1, Version 5 Point Precipitation Data - Included in Appendix C.

**Note:**

(NOAA Atlas 2 Vol. IV. New Mexico) within the References Section in Appendix C.

Partial Duration - Point Precipitation Depths (inches) with 90% Confidence Intervals (a)

# TABLE C2
## RUNOFF CURVE NUMBER (CN) ASSUMPTIONS AND CALCULATIONS
## Vado/Del Cerro Drainage Master Plan

| | | | | | | HSG A | | | HSG B | | | HSG C | | | HSG D | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subbasin No. | Basin Area (sq. mi.) | Basin Area (acres) | Land Use Description | Visual percentage of Land Use in Sub-basin | Hydrologic Condition (poor, fair, good) | Visual Fraction in HSG A | Area of HSG A (acres) | CN ARC II | Visual Fraction in HSG B | Area of HSG B (acres) | CN ARC II | Visual Fraction in HSG C | Area of HSG C (acres) | CN ARC II | Visual Fraction in HSG D | Area of HSG D (acres) | CN ARC II | **CN (Areal Weighting)** |
| a | a | a | a b | | b | | c | b | | c | b | | c | b | | c | b | |
| W015 | 0.01458 | 9.33 | Residential (approximately 1/4 acre) | 70% | N/A | 1.00 | 6.53 | 61 | 0.00 | 0.00 | 75 | 0.00 | 0.00 | 83 | 0.00 | 0.00 | 87 | 61 |
| | | | Semi-Arid Rangeland - Desert Shrub | 20% | poor | 1.00 | 1.87 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |
| | | | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 10% | N/A | 1.00 | 0.93 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 98 |
| | | | | | | | | | | | | | | | | | | **65** |
| W020 | 0.05428 | 34.74 | Residential (approximately 1/4 acre) | 20% | N/A | 0.95 | 6.60 | 61 | 0.00 | 0.00 | 75 | 0.00 | 0.00 | 83 | 0.05 | 0.35 | 87 | 62 |
| | | | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 10% | N/A | 0.95 | 3.30 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.05 | 0.17 | 98 | 98 |
| | | | Residential (approximately 1 acre) | 70% | N/A | 0.95 | 23.10 | 51 | 0.00 | 0.00 | 68 | 0.00 | 0.00 | 79 | 0.05 | 1.22 | 84 | 53 |
| | | | | | | | | | | | | | | | | | | **59** |
| W025 | 0.05322 | 34.06 | Residential (approximately 1/2 acre) | 10% | N/A | 0.45 | 1.53 | 54 | 0.25 | 0.85 | 70 | 0.20 | 0.68 | 80 | 0.10 | 0.34 | 85 | 66 |
| | | | Residential (approximately 1 acre) | 80% | N/A | 0.45 | 12.26 | 51 | 0.25 | 6.81 | 68 | 0.20 | 5.45 | 79 | 0.10 | 2.72 | 84 | 64 |
| | | | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 10% | N/A | 0.45 | 1.53 | 98 | 0.25 | 0.85 | 98 | 0.20 | 0.68 | 98 | 0.10 | 0.34 | 98 | 98 |
| | | | | | | | | | | | | | | | | | | **68** |
| W030 | 0.02660 | 17.02 | Residential (approximately 1/2 acre) | 30% | N/A | 1.00 | 5.11 | 54 | 0.00 | 0.00 | 70 | 0.00 | 0.00 | 80 | 0.00 | 0.00 | 85 | 54 |
| | | | Commercial and business | 10% | N/A | 1.00 | 1.70 | 89 | 0.00 | 0.00 | 92 | 0.00 | 0.00 | 96 | 0.00 | 0.00 | 96 | 89 |
| | | | Semi-Arid Rangeland - Desert Shrub | 60% | poor | 1.00 | 10.21 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |
| | | | | | | | | | | | | | | | | | | **63** |
| W031 | 0.01815 | 11.62 | Residential (approximately 1/4 acre) | 0% | N/A | 1.00 | 0.00 | 61 | 0.00 | 0.00 | 75 | 0.00 | 0.00 | 83 | 0.00 | 0.00 | 87 | 0 |
| | | | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 100% | N/A | 1.00 | 11.62 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 98 |
| | | | | | | | | | | | | | | | | | | **98** |
| W034 | 0.01238 | 7.92 | Residential (approximately 1/4 acre) | 20% | N/A | 1.00 | 1.58 | 61 | 0.00 | 0.00 | 75 | 0.00 | 0.00 | 83 | 0.00 | 0.00 | 87 | 61 |
| | | | Semi-Arid Rangeland - Desert Shrub | 80% | poor | 1.00 | 6.34 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |
| | | | | | | | | | | | | | | | | | | **63** |
| W035 | 0.01635 | 10.46 | Residential (approximately 1/4 acre) | 0% | N/A | 1.00 | 0.00 | 61 | 0.00 | 0.00 | 75 | 0.00 | 0.00 | 83 | 0.00 | 0.00 | 87 | 0 |
| | | | Semi-Arid Rangeland - Desert Shrub | 100% | poor | 1.00 | 10.46 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |
| | | | | | | | | | | | | | | | | | | **63** |
| W040 | 0.02534 | 16.22 | Residential (approximately 1/4 acre) | 0% | N/A | 1.00 | 0.00 | 61 | 0.00 | 0.00 | 75 | 0.00 | 0.00 | 83 | 0.00 | 0.00 | 87 | 0 |
| | | | Semi-Arid Rangeland - Desert Shrub | 100% | poor | 1.00 | 16.22 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |
| | | | | | | | | | | | | | | | | | | **63** |
| W045 | 0.04146 | 26.54 | Residential (approximately 1 acre) | 30% | N/A | 0.25 | 1.99 | 51 | 0.45 | 3.58 | 68 | 0.30 | 2.39 | 79 | 0.00 | 0.00 | 84 | 67 |
| | | | Semi-Arid Rangeland - Desert Shrub | 70% | poor | 0.60 | 11.15 | 63 | 0.25 | 4.64 | 77 | 0.15 | 2.79 | 85 | 0.00 | 0.00 | 88 | 70 |
| | | | | | | | | | | | | | | | | | | **69** |
| W050 | 0.01318 | 8.44 | Semi-Arid Rangeland - Desert Shrub | 100% | poor | 0.00 | 0.00 | 63 | 1.00 | 8.44 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 77 |
| | | | | | | | | | | | | | | | | | | **77** |
| W055 | 0.03451 | 22.09 | Residential (approximately 1/2 acre) | 35% | N/A | 0.60 | 4.64 | 54 | 0.25 | 1.93 | 70 | 0.15 | 1.16 | 80 | 0.00 | 0.00 | 85 | 62 |
| | | | Semi-Arid Rangeland - Desert Shrub | 15% | poor | 0.60 | 1.46 | 63 | 0.25 | 0.61 | 77 | 0.15 | 0.36 | 85 | 0.00 | 0.00 | 88 | 70 |
| | | | Residential (approximately 1 acre) | 50% | N/A | 0.60 | 7.96 | 51 | 0.25 | 3.32 | 68 | 0.15 | 1.99 | 79 | 0.00 | 0.00 | 84 | 59 |
| | | | | | | | | | | | | | | | | | | **62** |
| W060 | 0.17119 | 109.56 | Residential (approximately 1/2 acre) | 10% | N/A | 0.10 | 1.10 | 54 | 0.45 | 4.93 | 70 | 0.45 | 4.93 | 80 | 0.00 | 0.00 | 85 | 73 |
| | | | Residential (approximately 1 acre) | 30% | N/A | 0.10 | 3.29 | 51 | 0.45 | 14.79 | 68 | 0.45 | 14.79 | 79 | 0.00 | 0.00 | 84 | 71 |
| | | | Semi-Arid Rangeland - Desert Shrub | 60% | poor | 0.35 | 23.01 | 63 | 0.35 | 23.01 | 77 | 0.30 | 19.72 | 85 | 0.00 | 0.00 | 88 | 75 |
| | | | | | | | | | | | | | | | | | | **73** |
| W065 | 0.08768 | 56.11 | Residential (approximately 1/2 acre) | 10% | N/A | 0.00 | 0.00 | 54 | 1.00 | 5.61 | 70 | 0.00 | 0.00 | 80 | 0.00 | 0.00 | 85 | 70 |
| | | | Residential (approximately 1 acre) | 20% | N/A | 0.50 | 5.61 | 51 | 0.50 | 5.61 | 68 | 0.00 | 0.00 | 79 | 0.00 | 0.00 | 84 | 60 |
| | | | Semi-Arid Rangeland - Desert Shrub | 70% | poor | 0.10 | 3.93 | 63 | 0.60 | 23.57 | 77 | 0.15 | 5.89 | 85 | 0.15 | 5.89 | 88 | 78 |
| | | | | | | | | | | | | | | | | | | **74** |
| W130 | 0.13760 | 88.07 | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 10% | N/A | 1.00 | 8.81 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 98 |
| | | | Semi-Arid Rangeland - Desert Shrub | 90% | poor | 1.00 | 79.26 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |
| | | | | | | | | | | | | | | | | | | **67** |

# TABLE C2
## RUNOFF CURVE NUMBER (CN) ASSUMPTIONS AND CALCULATIONS
## Vado/Del Cerro Drainage Master Plan

| | | | | | | HSG A | | | HSG B | | | HSG C | | | HSG D | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subbasin No. | Basin Area (sq. mi.) | Basin Area (acres) | Land Use Description | Visual percentage of Land Use in Sub-basin | Hydrologic Condition (poor, fair, good) | Visual Fraction in HSG A | Area of HSG A (acres) | CN ARC II | Visual Fraction in HSG B | Area of HSG B (acres) | CN ARC II | Visual Fraction in HSG C | Area of HSG C (acres) | CN ARC II | Visual Fraction in HSG D | Area of HSG D (acres) | CN ARC II | **CN (Areal Weighting)** |
| a | a | a | a b | | b | | c | b | | c | b | | c | b | | c | b | |
| W150 | 0.23708 | 151.73 | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 10% | N/A | 1.00 | 15.17 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 98 |
| | | | Semi-Arid Rangeland - Desert Shrub | 90% | poor | 1.00 | 136.56 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |
| | | | | | | | | | | | | | | | | | | **67** |
| W160 | 0.01998 | 12.79 | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 10% | N/A | 1.00 | 1.28 | 98 | | 0.00 | 98 | | 0.00 | 98 | | 0.00 | 98 | 98 |
| | | | Semi-Arid Rangeland - Desert Shrub | 60% | poor | 1.00 | 7.67 | 63 | | 0.00 | 77 | | 0.00 | 85 | | 0.00 | 88 | 63 |
| | | | Residential (approximately 1/4 acre) | 30% | N/A | 1.00 | 3.84 | 61 | | 0.00 | 75 | | 0.00 | 83 | | 0.00 | 87 | 61 |
| | | | | | | | | | | | | | | | | | | **66** |
| W165 | 0.02560 | 16.38 | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 50% | N/A | 1.00 | 8.19 | 98 | | 0.00 | 98 | | 0.00 | 98 | | 0.00 | 98 | 98 |
| | | | Semi-Arid Rangeland - Desert Shrub | 40% | poor | 1.00 | 6.55 | 63 | | 0.00 | 77 | | 0.00 | 85 | | 0.00 | 88 | 63 |
| | | | Residential (approximately 1/4 acre) | 10% | N/A | 1.00 | 1.64 | 61 | | 0.00 | 75 | | 0.00 | 83 | | 0.00 | 87 | 61 |
| | | | | | | | | | | | | | | | | | | **80** |
| W170 | 0.64847 | 415.02 | Semi-Arid Rangeland - Desert Shrub | 100% | poor | 0.60 | 249.01 | 63 | 0.40 | 166.01 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 69 |
| | | | | | | | | | | | | | | | | | | **69** |
| W180 | 0.09629 | 61.62 | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 20% | N/A | 1.00 | 12.32 | 98 | | 0.00 | 98 | | 0.00 | 98 | | 0.00 | 98 | 98 |
| | | | Semi-Arid Rangeland - Desert Shrub | 80% | poor | 1.00 | 49.30 | 63 | | 0.00 | 77 | | 0.00 | 85 | | 0.00 | 88 | 63 |
| | | | | | | | | | | | | | | | | | | **70** |
| W190 | 0.33645 | 215.33 | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 30% | N/A | 1.00 | 64.60 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 98 |
| | | | Semi-Arid Rangeland - Desert Shrub | 70% | poor | 1.00 | 150.73 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |
| | | | | | | | | | | | | | | | | | | **74** |
| W200 | 0.34597 | 221.42 | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 5% | N/A | 1.00 | 11.07 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 98 |
| | | | Semi-Arid Rangeland - Desert Shrub | 95% | poor | 1.00 | 210.35 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |
| | | | | | | | | | | | | | | | | | | **65** |
| W220 | 0.42075 | 269.28 | Farmsteads-buildings, lanes, driveways, and surrounding lots | 30% | N/A | 1.00 | 80.78 | 59 | 0.00 | 0.00 | 74 | 0.00 | 0.00 | 82 | 0.00 | 0.00 | 86 | 59 |
| | | | Agricultural Fields with Straight Row Crops | 70% | poor | 0.60 | 113.10 | 72 | 0.05 | 9.42 | 81 | 0.35 | 65.97 | 88 | 0.00 | 0.00 | 91 | 78 |
| | | | | | | | | | | | | | | | | | | **72** |
| W230 | 0.42919 | 274.68 | Farmsteads-buildings, lanes, driveways, and surrounding lots | 68% | N/A | 1.00 | 186.79 | 59 | 0.00 | 0.00 | 74 | 0.00 | 0.00 | 82 | 0.00 | 0.00 | 86 | 59 |
| | | | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 2% | N/A | 1.00 | 5.49 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 98 |
| | | | Agricultural Fields with Straight Row Crops | 30% | poor | 0.00 | 0.00 | 72 | 0.30 | 24.72 | 81 | 0.45 | 37.08 | 88 | 0.25 | 20.60 | 91 | 87 |
| | | | | | | | | | | | | | | | | | | **68** |
| W290 | 0.20588 | 131.76 | Farmsteads-buildings, lanes, driveways, and surrounding lots | 45% | N/A | 1.00 | 59.29 | 59 | 0.00 | 0.00 | 74 | 0.00 | 0.00 | 82 | 0.00 | 0.00 | 86 | 59 |
| | | | Agricultural Fields with Straight Row Crops | 55% | poor | 0.30 | 21.74 | 72 | 0.35 | 25.36 | 81 | 0.30 | 21.74 | 88 | 0.05 | 3.62 | 91 | 81 |
| | | | | | | | | | | | | | | | | | | **71** |
| W400 | 1.67904 | 1074.59 | Semi-Arid Rangeland - Desert Shrub | 100% | poor | 0.10 | 107.46 | 63 | 0.90 | 967.13 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 76 |
| | | | | | | | | | | | | | | | | | | **76** |
| W420 | 1.18686 | 759.59 | Semi-Arid Rangeland - Desert Shrub | 100% | poor | 0.00 | 0.00 | 63 | 1.00 | 759.59 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 77 |
| | | | | | | | | | | | | | | | | | | **77** |
| W430 | 1.22517 | 784.11 | Residential (approximately 2 acre) | 40% | N/A | 0.05 | 15.68 | 46 | 0.95 | 297.96 | 65 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 82 | 64 |
| | | | Semi-Arid Rangeland - Desert Shrub | 60% | poor | 0.30 | 141.14 | 63 | 0.70 | 329.33 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 73 |
| | | | | | | | | | | | | | | | | | | **69** |
| W530 | 0.44219 | 283.00 | Semi-Arid Rangeland - Desert Shrub | 100% | poor | 0.90 | 254.70 | 63 | 0.10 | 28.30 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 64 |
| | | | | | | | | | | | | | | | | | | **64** |
| W540 | 0.39338 | 251.76 | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 55% | N/A | 1.00 | 138.47 | 89 | 0.00 | 0.00 | 92 | 0.00 | 0.00 | 94 | 0.00 | 0.00 | 95 | 89 |
| | | | Semi-Arid Rangeland - Desert Shrub | 45% | poor | 1.00 | 113.29 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |

## TABLE C2
## RUNOFF CURVE NUMBER (CN) ASSUMPTIONS AND CALCULATIONS
## Vado/Del Cerro Drainage Master Plan

| | | | | | | HSG A | | | HSG B | | | HSG C | | | HSG D | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subbasin No. | Basin Area (sq. mi.) | Basin Area (acres) | Land Use Description | Visual percentage of Land Use in Sub-basin | Hydrologic Condition (poor, fair, good) | Visual Fraction in HSG A | Area of HSG A (acres) | CN ARC II | Visual Fraction in HSG B | Area of HSG B (acres) | CN ARC II | Visual Fraction in HSG C | Area of HSG C (acres) | CN ARC II | Visual Fraction in HSG D | Area of HSG D (acres) | CN ARC II | **CN (Areal Weighting)** |
| a | a | a | a b | | b | | c | b | | c | b | | c | b | | c | b | |
| | | | | | | | | | | | | | | | | | | **77** |
| W210 | 0.09189 | 58.81 | Residential (approximately 1/4 acre) | 80% | N/A | 1.00 | 47.05 | 61 | 0.00 | 0.00 | 75 | 0.00 | 0.00 | 83 | 0.00 | 0.00 | 87 | 61 |
| | | | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 2% | N/A | 1.00 | 1.18 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 98 |
| | | | Residential (approximately 1 acre) | 18% | N/A | 0.10 | 1.06 | 51 | 0.30 | 3.18 | 68 | 0.30 | 3.18 | 79 | 0.30 | 3.18 | 84 | 74 |
| | | | | | | | | | | | | | | | | | | **64** |
| W215 | 0.07190 | 46.02 | Residential (approximately 1/4 acre) | 40% | N/A | 1.00 | 18.41 | 61 | 0.00 | 0.00 | 75 | 0.00 | 0.00 | 83 | 0.00 | 0.00 | 87 | 61 |
| | | | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 20% | N/A | 1.00 | 9.20 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 98 |
| | | | Residential (approximately 1 acre) | 40% | N/A | 0.95 | 17.49 | 51 | 0.00 | 0.00 | 68 | 0.05 | 0.92 | 79 | 0.00 | 0.00 | 84 | 52 |
| | | | | | | | | | | | | | | | | | | **65** |
| W580 | 0.32688 | 209.21 | Residential (approximately 1/4 acre) | 40% | N/A | 1.00 | 83.68 | 61 | 0.00 | 0.00 | 75 | 0.00 | 0.00 | 83 | 0.00 | 0.00 | 87 | 61 |
| | | | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 2% | N/A | 1.00 | 4.18 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 98 |
| | | | Semi-Arid Rangeland - Desert Shrub | 18% | poor | 1.00 | 37.66 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |
| | | | Residential (approximately 1 acre) | 40% | N/A | 0.10 | 8.37 | 51 | 0.30 | 25.10 | 68 | 0.30 | 25.10 | 79 | 0.30 | 25.10 | 84 | 74 |
| | | | | | | | | | | | | | | | | | | **67** |
| W630 | 0.30320 | 194.04 | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 60% | N/A | 1.00 | 116.43 | 89 | 0.00 | 0.00 | 92 | 0.00 | 0.00 | 94 | 0.00 | 0.00 | 95 | 89 |
| | | | Semi-Arid Rangeland - Desert Shrub | 40% | poor | 1.00 | 77.62 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |
| | | | | | | | | | | | | | | | | | | **79** |
| W640 | 0.21515 | 137.69 | Residential (approximately 1 acre) | 10% | N/A | 1.00 | 13.77 | 51 | 0.00 | 0.00 | 68 | 0.00 | 0.00 | 79 | 0.00 | 0.00 | 84 | 51 |
| | | | Open space (Poor conditions) | 80% | poor | 0.80 | 88.12 | 68 | 0.05 | 5.51 | 79 | 0.10 | 11.02 | 86 | 0.05 | 5.51 | 89 | 71 |
| | | | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 10% | N/A | 1.00 | 13.77 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 98 |
| | | | | | | | | | | | | | | | | | | **72** |
| W650 | 1.13394 | 725.72 | Commercial A= 89, B=92, C=94, D=95 : Highway & Streets - All HSGs=98 | 30% | N/A | 1.00 | 217.72 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 0.00 | 0.00 | 98 | 98 |
| | | | Semi-Arid Rangeland - Desert Shrub | 70% | poor | 1.00 | 508.01 | 63 | 0.00 | 0.00 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 63 |
| | | | | | | | | | | | | | | | | | | **74** |
| W680 | 0.64822 | 414.86 | Semi-Arid Rangeland - Desert Shrub | 100% | poor | 0.65 | 269.66 | 63 | 0.35 | 145.20 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 68 |
| | | | | | | | | | | | | | | | | | | **68** |
| W690 | 0.87758 | 561.65 | Semi-Arid Rangeland - Desert Shrub | 100% | poor | 0.00 | 0.00 | 63 | 1.00 | 561.65 | 77 | 0.00 | 0.00 | 85 | 0.00 | 0.00 | 88 | 77 |
| | | | | | | | | | | | | | | | | | | **77** |

( a ) See Figure A for Drainage Basin Map
( b ) The Runoff Curve Numbers for Land Use Types and Hydrologic Condition were obtained from Tables 2-2a, 2-2b, 2-2c and 2-2d from "Urban Hydrology for Small Watersheds (TR-55), 1986. Copies are included with this Appendix C.
( c ) Areas from the NRCS Web Soil Survey, see output in Appendix C.

**TABLE C3**

**TIME OF CONCENTRATION AND LAG TIME COMPUTATIONS**

Vado/Del Cerro Drainage Master Plan

| Subbasin Name | | W005 | W010 | W130 | W150 | W160 | W165 | W180 | W170 | W190 | W200 | 210 | 215 | W220 | W230 | W290 | W400 | W420 | W430 | W530 | W540 | W580 | W630 | W640 | W650 | W680 | W690 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of Reaches | | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **1 - SHEET FLOW** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Surface Description (a) | | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE | RANGE |
| Manning's Coeff., n (a - Table 3-1) | | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 |
| Flow Length (L) (b) | ft | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 100 | 100 | 100 | 100 | 100 | 100 |
| Highest Elevation (b) | ft | 3892 | 3924 | 4032 | 4154 | 3965 | 3972 | 4029 | 4215 | 4155 | 4175 | 3914 | 3918 | 3927 | 3926 | 3922 | 5098 | 5195 | 4258 | 4199 | 4176 | 3907 | 4128 | 3928 | 4190 | 4210 | 5108 |
| Lowest Elevation (b) | ft | 3886 | 3920 | 4028 | 4144 | 3955 | 3967 | 4018 | 4214 | 4141 | 4167 | 3913 | 3914 | 3921 | 3921 | 3916 | 5057 | 5121 | 4256 | 4198 | 4170 | 3902 | 4122 | 3925 | 4189 | 4209 | 5104 |
| Slope (S) | ft / ft | 0.060 | 0.037 | 0.042 | 0.107 | 0.101 | 0.048 | 0.114 | 0.008 | 0.143 | 0.074 | 0.008 | 0.039 | 0.057 | 0.050 | 0.064 | 0.410 | 0.740 | 0.015 | 0.016 | 0.058 | 0.051 | 0.056 | 0.026 | 0.012 | 0.010 | 0.033 |
| 2-year 24-hour rainfall depth (P2) ( c ) | inches | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 |
| Travel Time Tt = (0.007(n L)^0.8) / ((P2 )^0.5 (S^0.4 ) ) (a) | hours | 0.14 | 0.17 | 0.16 | 0.11 | 0.11 | 0.15 | 0.11 | 0.30 | 0.10 | 0.13 | 0.30 | 0.16 | 0.14 | 0.15 | 0.13 | 0.06 | 0.05 | 0.24 | 0.23 | 0.14 | 0.15 | 0.14 | 0.19 | 0.26 | 0.28 | 0.17 |
| **2 - SHALLOW CONCENTRATED FLOW** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Surface Description (a) | | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED | UNPAVED |
| Flow Length (L) (b) | ft | 2000 | 2000 | 2000 | 2000 | 1058 | 1493 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Highest Elevation (b) | ft | 3886 | 3920 | 4028 | 4144 | 3955 | 3967 | 4018 | 4214 | 4141 | 4167 | 3913 | 3914 | 3921 | 3921 | 3916 | 5057 | 5121 | 4256 | 4198 | 4170 | 3902 | 4122 | 3925 | 4189 | 4209 | 5104 |
| Lowest Elevation (b) | ft | 3823 | 3861 | 3952 | 4060 | 3921 | 3919 | 3943 | 4209 | 4063 | 4093 | 3871 | 3859 | 3895 | 3913 | 3887 | 4568 | 4592 | 4237 | 4189 | 4104 | 3850 | 4053 | 3899 | 4147 | 4208 | 4615 |
| Slope (S) | ft / ft | 0.032 | 0.030 | 0.038 | 0.042 | 0.032 | 0.032 | 0.037 | 0.003 | 0.039 | 0.037 | 0.021 | 0.028 | 0.013 | 0.004 | 0.014 | 0.245 | 0.265 | 0.010 | 0.004 | 0.033 | 0.026 | 0.034 | 0.013 | 0.021 | 0.001 | 0.245 |
| Average Velocity ( e - Figure 15-4 ) | ft / sec | 2.86 | 2.77 | 3.14 | 3.31 | 2.89 | 2.89 | 3.12 | 0.81 | 3.19 | 3.10 | 2.33 | 2.68 | 1.84 | 1.02 | 1.93 | 7.98 | 8.30 | 1.58 | 1.07 | 2.94 | 2.60 | 3.00 | 1.86 | 2.34 | 0.39 | 7.98 |
| Travel Time Tt = Tt = L / ( 3600*V ) (a) | hours | 0.19 | 0.20 | 0.18 | 0.17 | 0.10 | 0.14 | 0.18 | 0.69 | 0.17 | 0.18 | 0.24 | 0.21 | 0.30 | 0.54 | 0.29 | 0.07 | 0.07 | 0.35 | 0.52 | 0.19 | 0.21 | 0.19 | 0.30 | 0.24 | 1.42 | 0.07 |
| **3 - OPEN CHANNELS** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Channel Description (a) | | CHANNEL | CHANNEL | CHANNEL | CHANNEL | | | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL | CHANNEL |
| Manning's n (d) | | 0.045 | 0.045 | 0.045 | 0.045 | | | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 |
| Channel Shape (b) | | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | | | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS |
| Side Slopes ( b ) | 1V:XH | 5 | 5 | 5 | 5 | | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Bottom Width (b) | ft | 50 | 50 | 50 | 50 | | | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| Depth (D) | ft | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Top Width (T) | ft | 60 | 60 | 60 | 60 | | | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| Wetted Perimeter (P) | ft | 60 | 60 | 60 | 60 | | | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| Area (A) | sq ft | 55 | 55 | 55 | 55 | | | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 |
| Hydraulic Radius (A / P ) | ft | 0.91 | 0.91 | 0.91 | 0.91 | | | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 |
| Hydraulic Depth (y) = A / T | ft | 0.92 | 0.92 | 0.92 | 0.92 | | | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Entire Flowpath Length | ft | 4864 | 4746 | 3387 | 7695 | | | 3804 | 15827 | 9171 | 9416 | 3987 | 3372 | 11068 | 10092 | 8240 | 24301 | 22727 | 18347 | 8090 | 10760 | 5973 | 7579 | 8834 | 16333 | 12334 | 17420 |
| Open Channel Flow Length (L) (b) | ft | 2764 | 2646 | 1287 | 5595 | | | 1704 | 13727 | 7071 | 7316 | 1887 | 1272 | 8968 | 7992 | 6140 | 22201 | 20627 | 16247 | 5990 | 8661 | 3873 | 5479 | 6734 | 14233 | 10234 | 15320 |
| Highest Elevation (b) | ft | 3823 | 3861 | 3952 | 4060 | | | 3943 | 4209 | 4063 | 4093 | 3871 | 3859 | 3895 | 3913 | 3887 | 4568 | 4592 | 4237 | 4189 | 4104 | 3850 | 4053 | 3899 | 4147 | 4208 | 4615 |
| Lowest Elevation (b) | ft | 3816 | 3821 | 3918 | 3911 | | | 3927 | 4045 | 3911 | 3911 | 3836 | 3830 | 3822 | 3819 | 3832 | 4141 | 4204 | 4141 | 4096 | 3891 | 3824 | 3891 | 3823 | 3891 | 4096 | 4209 |
| Slope (S) | ft / ft | 0.002 | 0.015 | 0.027 | 0.026 | | | 0.009 | 0.012 | 0.021 | 0.025 | 0.018 | 0.023 | 0.008 | 0.012 | 0.009 | 0.019 | 0.019 | 0.006 | 0.015 | 0.025 | 0.007 | 0.030 | 0.011 | 0.018 | 0.011 | 0.026 |
| Average Velocity (a) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| V = ( 1.49 R ^ 0.666 S ^ 0.5 ) / n (a) | ft / sec | 1.54 | 3.83 | 5.09 | 5.08 | | | 2.97 | 3.41 | 4.56 | 4.92 | 4.24 | 4.69 | 2.81 | 3.38 | 2.97 | 4.32 | 4.28 | 2.40 | 3.87 | 4.89 | 2.56 | 5.37 | 3.31 | 4.18 | 3.25 | 5.07 |
| Froude Number Fr = V/ (g y)^0.5 | | 0.28 | 0.71 | 0.94 | 0.93 | | | 0.55 | 0.63 | 0.84 | 0.91 | 0.78 | 0.86 | 0.52 | 0.62 | 0.55 | 0.80 | 0.79 | 0.44 | 0.71 | 0.90 | 0.47 | 0.99 | 0.61 | 0.77 | 0.60 | 0.93 |
| Travel Time Tt (a) = Tt = L / ( 3600*V ) (a) | hours | 0.50 | 0.19 | 0.07 | 0.31 | | | 0.16 | 1.12 | 0.43 | 0.41 | 0.12 | 0.08 | 0.89 | 0.66 | 0.58 | 1.43 | 1.34 | 1.88 | 0.43 | 0.49 | 0.42 | 0.28 | 0.56 | 0.95 | 0.87 | 0.84 |
| **Total Flowpath Length** | ft. | 4864 | 4746 | 3387 | 7695 | 1158 | 1593 | 3804 | 15827 | 9171 | 9416 | 3987 | 3372 | 11068 | 10092 | 8240 | 24301 | 22727 | 18347 | 8090 | 10760 | 5973 | 7579 | 8834 | 16333 | 12334 | 17420 |
| **Total Subbasin Tc** | hours | 0.83 | 0.56 | 0.41 | 0.58 | 0.21 | 0.29 | 0.44 | 2.11 | 0.70 | 0.72 | 0.66 | 0.44 | 1.33 | 1.35 | 1.00 | 1.56 | 1.46 | 2.46 | 1.18 | 0.82 | 0.78 | 0.61 | 1.05 | 1.44 | 2.57 | 1.08 |
| **Total Subbasin Tc** | minutes | 50 | 34 | 24 | 35 | 13 | 18 | 27 | 127 | 42 | 43 | 40 | 27 | 80 | 81 | 60 | 94 | 87 | 148 | 71 | 49 | 47 | 37 | 63 | 87 | 154 | 65 |
| **If Tc < 12 min, assume 12 min. = 0.2 hours** | minutes | 50 | 34 | 24 | 35 | 13 | 18 | 27 | 127 | 42 | 43 | 40 | 27 | 80 | 81 | 60 | 94 | 87 | 148 | 71 | 49 | 47 | 37 | 63 | 87 | 154 | 65 |
| **Lag Time Tlag ( e ) = 0.6 Tc** | minutes | 29.8 | 20.1 | 14.6 | 21.0 | 7.7 | 10.6 | 16.0 | 75.9 | 25.3 | 25.8 | 23.8 | 16.0 | 47.8 | 48.5 | 35.8 | 56.1 | 52.4 | 88.7 | 42.6 | 29.5 | 28.0 | 21.9 | 38.0 | 51.9 | 92.5 | 38.9 |
| **Average Slope** | ft/ft | 3.13% | 2.70% | 3.54% | 5.86% | 6.67% | 4.00% | 5.34% | 0.76% | 6.79% | 4.54% | 1.59% | 2.99% | 2.61% | 2.19% | 2.90% | 22.46% | 34.11% | 1.03% | 1.19% | 3.86% | 2.78% | 4.01% | 1.69% | 1.70% | 0.72% | 10.15% |
| **Average Velocity (a)** | ft./s | 1.63 | 2.36 | 2.32 | 3.67 | 1.51 | 1.51 | 2.38 | 2.08 | 3.63 | 3.64 | 1.67 | 2.11 | 2.32 | 2.08 | 2.30 | 4.33 | 4.33 | 2.07 | 1.90 | 3.65 | 2.12 | 3.46 | 2.33 | 3.15 | 1.33 | 4.47 |
| **Subbasin ID** | | W005 | W010 | W130 | W150 | W160 | W165 | W180 | W170 | W190 | W200 | 210 | 215 | W220 | W230 | W290 | W400 | W420 | W430 | W530 | W540 | W580 | W630 | W640 | W650 | W680 | W690 |

( a ) Cronshey, R. (1986). Urban Hydrology for Small Watersheds. U.S. Department of Agriculture Soil Conservation Service, Engineering Division, *Technical Release 55; Chapter 3, Time of Concentration and Travel Time.* Retrieved from https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044171.pdf.

( b ) Measured from digital elevation model (DEM).

The TR-55 Method allows for the sheet flow length to range from 100 ft up to a maximum of 300 ft subject to the overland characteristics of the upper parts of the subbasins. For these computations, 100 ft was assumed to be standard for all subbasins in order to simplify the computations and to make the review process simple.

The TR-55 Method allows for the shallow concentrated flow length to range from 1600 ft up to a maximum of 2000 ft subject to the overland characteristics of the upper parts of the subbasins. For these computations, 2000 ft was assumed to be standard for all subbasins in order to simplify the computations and to make the review process simple.

( c ) NOAA Atlas 14 rainfall data

( d ) Ven, T. (1959). Chow: Open Channel Hydraulics. Mc-Graw Mill Book Co., New York, pp 110-113.

( e ) U.S. Department of Agriculture Natural Resources Conservation Service (2010). National Engineering Handbook: Part 630 Hydrology; Chapter 15, Time of Concentration. Retrieved from https://www.wcc.nrcs.usda.gov/ftpref/wntsc/H&H/NEHhydrology/ch15.pdf.

**Cells that have formulas.**

**TABLE C3.1**
**TIME OF CONCENTRATION AND LAG TIME COMPUTATIONS**
Vado/Del Cerro Drainage Master Plan

| Subbasin Name | | W015 | W020 | W025 | W030 | W031 | W034 | W035 | W040 | W045 | W050 | W055 | W060 | W065 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of Reaches | | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 |
| **1 - SHEET FLOW** | | | | | | | | | | | | | | |
| Surface Description (a) | | | SMOOTHSURFA( | SMOOTHSURFACE | RANGE | RANGE | | | | RANGE | | RANGE | SMOOTHSURFACE | RANGE |
| Manning's Coeff., n (a - Table 3-1) | | | 0.011 | 0.011 | 0.13 | 0.13 | | | | 0.13 | | 0.13 | 0.011 | 0.13 |
| Flow Length (L) (b) | ft | | 100 | 100 | 100 | 100 | | | | 100 | | 100 | 100 | 100 |
| Highest Elevation (b) | ft | | 3883 | 3842 | 3893 | 3926 | | | | 3838 | | 3857 | 3850 | 3871 |
| Lowest Elevation (b) | ft | | 3880 | 3840 | 3887 | 3922 | | | | 3835 | | 3855 | 3848 | 3866 |
| Slope (S) | ft / ft | | 0.030 | 0.020 | 0.060 | 0.040 | | | | 0.030 | | 0.020 | 0.020 | 0.050 |
| 2-year 24-hour rainfall depth (P2) ( c ) | inches | | 1.51 | 1.51 | 1.51 | 3.51 | | | | 2.51 | | 2.51 | 2.51 | 3.51 |
| Travel Time Tt = (0.007(n L)^0.8) / ((P2 )^0.5 (S^0.4 ) ) (a) | hours | | 0.02 | 0.03 | 0.14 | 0.11 | | | | 0.14 | | 0.16 | 0.02 | 0.10 |
| **2 - SHALLOW CONCENTRATED FLOW** | | | | | | | | | | | | | | |
| Surface Description (a) | | | PAVED | PAVED | UNPAVED | UNPAVED | | | | UNPAVED | | PAVED | UNPAVED | UNPAVED |
| Flow Length (L) (b) | ft | | 2000 | 2000 | 1421 | 902 | | | | 1451 | | 2000 | 2000 | 2000 |
| Highest Elevation (b) | ft | | 3880 | 3840 | 3887 | 3922 | | | | 3835 | | 3855 | 3848 | 3866 |
| Lowest Elevation (b) | ft | | 3834 | 3822 | 3857 | 3894 | | | | 3820 | | 3821 | 3826 | 3825 |
| Slope (S) | ft / ft | | 0.023 | 0.009 | 0.021 | 0.031 | | | | 0.010 | | 0.017 | 0.011 | 0.021 |
| Average Velocity ( e - Figure 15-4 ) | ft / sec | | 3.08 | 1.94 | 2.34 | 2.84 | | | | 1.64 | | 2.65 | 1.69 | 2.31 |
| Travel Time Tt = Tt = L / ( 3600*V ) (a) | hours | | 0.18 | 0.29 | 0.17 | 0.09 | | | | 0.25 | | 0.21 | 0.33 | 0.24 |
| **3 - OPEN CHANNELS** | | | | | | | | | | | | | | |
| Channel Description (a) | | | CHANNEL | CHANNEL | CHANNEL | CHANNEL | | | | CHANNEL | | CHANNEL | CHANNEL | CHANNEL |
| Manning's n (d) | | | 0.045 | 0.045 | 0.045 | 0.045 | | | | 0.045 | | 0.045 | 0.045 | 0.045 |
| Channel Shape (b) | | | CHANNEL XS | CHANNEL XS | CHANNEL XS | CHANNEL XS | | | | CHANNEL XS | | CHANNEL XS | CHANNEL XS | CHANNEL XS |
| Side Slopes ( b ) | 1V:XH | | 5 | 5 | | | | | | | | | 5 | 5 |
| Bottom Width (b) | ft | | 20 | 20 | | | | | | | | | 30 | 20 |
| Depth (D) | ft | | 1 | 1 | | | | | | | | | 1 | 1 |
| Top Width (T) | ft | | 30 | 30 | | | | | | | | | 40 | 30 |
| Wetted Perimeter (P) | ft | | 30 | 30 | | | | | | | | | 40 | 30 |
| Area (A) | sq ft | | 25 | 25 | | | | | | | | | 35 | 25 |
| Hydraulic Radius (A / P ) | ft | | 0.83 | 0.83 | | | | | | | | | 0.87 | 0.83 |
| Hydraulic Depth (y) = A / T | ft | | 0.83 | 0.83 | | | | | | | | | 0.88 | 0.83 |
| Entire Flowpath Length | ft | | 2576 | 2544 | | | | | | | | | 4355 | 3453 |
| Open Channel Flow Length (L) (b) | ft | | 476 | 444 | | | | | | | | | 2255 | 1353 |
| Highest Elevation (b) | ft | | 3834 | 3822 | | | | | | | | | 3826 | 3825 |
| Lowest Elevation (b) | ft | | 3823 | 3820 | | | | | | | | | 3818 | 3820 |
| Slope (S) | ft / ft | | 0.023 | 0.004 | | | | | | | | | 0.004 | 0.004 |
| Average Velocity (a) | | | | | | | | | | | | | | |
| V = ( 1.49 R ^ 0.666 S ^ 0.5 ) / n (a) | ft / sec | | 4.44 | 1.81 | | | | | | | | | 1.80 | 1.77 |
| Froude Number Fr = V/ (g y)^0.5 | | | 0.86 | 0.35 | | | | | | | | | 0.34 | 0.34 |
| Travel Time Tt (a) = Tt = L / ( 3600*V ) (a) | hours | | 0.03 | 0.07 | | | | | | | | | 0.35 | 0.21 |
| **Total Flowpath Length** | ft. | | 2576 | 2544 | 1521 | 1002 | | | | 1551 | | 2100 | 4355 | 3453 |
| **Total Subbasin Tc** | hours | | 0.23 | 0.38 | 0.30 | 0.19 | | | | 0.39 | | 0.37 | 0.70 | 0.55 |
| **Total Subbasin Tc** | minutes | | 14 | 23 | 18 | 12 | | | | 23 | | 22 | 42 | 33 |
| **If Tc < 12 min, assume 12 min. = 0.2 hours** | minutes | | 14 | 23 | 18 | 12 | | | | 23 | | 22 | 42 | 33 |
| **Lag Time Tlag ( e ) = 0.6 Tc** | minutes | | 8.5 | 13.8 | 11.0 | 7.2 | | | | 13.9 | | 13.5 | 25.2 | 19.8 |
| **Average Slope** | ft/ft | | 2.54% | 1.10% | 4.06% | 3.55% | | | | 2.02% | | 1.85% | 1.15% | 2.47% |
| **Average Velocity (a)** | ft./s | | 3.05 | 1.84 | 1.39 | 1.44 | | | | 1.12 | | 1.56 | 1.73 | 1.75 |
| **Subbasin ID** | | | W020 | W025 | W030 | W031 | | | | W045 | | W055 | W060 | W065 |

( a ) Cronshey, R. (1986). Urban Hydrology for Small Watersheds. U.S. Department of Agriculture Soil Conservation Service, Engineering Division, *Technical Release 55; Chapter 3, Time of Concentration and Travel Time.* Retrieved from https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044171.pdf.

( b ) Measured from digital elevation model (DEM).

The TR-55 Method allows for the sheet flow length to range from 100 ft up to a maximum of 300 ft subject to the overland characteristics of the upper parts of the subbasins. For these computations, 100 ft was assumed to be standard for all subbasins in order to simplify the computations and to make the review process simple.

The TR-55 Method allows for the shallow concentrated flow length to range from 1600 ft up to a maximum of 2000 ft subject to the overland characteristics of the upper parts of the subbasins. For these computations, 2000 ft was assumed to be standard for all subbasins in order to simplify the computations and to make the review process simple.

( c ) NOAA Atlas 14 rainfall data

( d ) Ven, T. (1959). Chow: Open Channel Hydraulics. Mc-Graw Mill Book Co., New York, pp 110-113.

( e ) U.S. Department of Agriculture Natural Resources Conservation Service (2010). National Engineering Handbook: Part 630 Hydrology; Chapter 15, Time of Concentration. Retrieved from https://www.wcc.nrcs.usda.gov/ftpref/wntsc/H&H/NEHhydrology/ch15.pdf.

Cells that have formulas.

(Grey cells:) Assumed 12 minute Time of Concentration due to these basins being smaller than basin W036 area, therefore, assumed Tc will be minimum Tc.

| TABLE C4<br>CHANNEL ROUTING DATA<br>Vado/Del Cerro Drainage Master Plan | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Routing Reach Name | River Length | ELEV 1 | ELEV 2 | Slope | Manning's n | Channel Shape | Channel Width | Channel Side Slope | Route Method |
| | ft | ft | ft | ft/ft | | | ft | 1V:?H | |
| | a | | | a | b c | b | b c | b c | |
| R150 | 7128 | 3911.4 | 3830.0 | 0.0114 | 0.045 | Trapezoid | 8 | 4 | Muskingum-Cunge |
| R170 | 6,761 | 4,046 | 3,906 | 0.0206 | 0.045 | Trapezoid | 42 ft BW 56 ft TW | 5 | Muskingum-Cunge |
| R200 | 4,198 | 3,860 | 3,817 | 0.010 | 0.045 | Trapezoid | 9 ft Bottom 30 ft top width | 2 | Muskingum-Cunge |
| RC6 | 2,998 | 3,911 | 3,860 | 0.017 | 0.045 | Trapezoid | 10 ft Bottom 30 ft top width | 2 | Muskingum-Cunge |
| R160 | 3,288 | 3,917 | 3,835 | 0.025 | 0.011 | Rectangle | 24 | 1 | Muskingum-Cunge |
| R420 | 5,636 | 4,205 | 4,141 | 0.011 | 0.045 | Trapezoid | 10 ft BW 25 ft TW | 4 | Muskingum-Cunge |
| R400 | 4,293 | 4,141 | 4,096 | 0.010 | 0.045 | Trapezoid | 36 ft BW 44 ft TW | 4 | Muskingum-Cunge |
| R530 | 12,778 | 4,096 | 3,880 | 0.017 | 0.045 | Trapezoid | 23-ft BW 36-ft TW | 5 | Muskingum-Cunge |
| R630 | 5,576 | 3,880 | 3,818 | 0.011 | 0.045 | Trapezoid | 28 ft BW 85 FT TW | 3 | Muskingum-Cunge |
| R690 | 12,025 | 4,209 | 4,096 | 0.009 | 0.045 | Trapezoid | 5 ft bw 14 ft tw | 3 | Muskingum-Cunge |

( a ) All routing lengths and slopes were determined using ArcMap 10.2.
( b ) Channel width, depth, side slopes and Manning's "n" vary throughout the entire reach. Therefore, these are typical values assumed to represent the entire routing reach. Manning's "n" values were selected based on guidance provided in Urban Hydrology for Small Watersheds (NRCS) and Open Channel Hydraulics (Chow).
( c ) Based on field work, ortho photography, and values provided in "Ven, T. (1959). Chow: Open Channel Hydraulics. Mc-Graw Mill Book Co., New York, pp 110-113", included in Appendix C.

| TABLE C5<br>Subbasin Hydrologic Data Summary (HEC-HMS)<br>Vado/Del Cerro Drainage Master Plan | | | | | | |
|---|---|---|---|---|---|---|
| Basin No. | Basin Area | Basin Area | Runoff Curve Number Based on ARC II Conditions | Time of Concentration (Tc) | Lag Time | Flow Ratio |
| | sq mi | acres | | minutes | minutes | |
| a | a | a | b | c | c | d |
| W430 | 1.2252 | 784.13 | 69 | 148 | 88.7 | 1.1 |
| W400 | 1.679 | 1074.56 | 76 | 94 | 56.1 | 1.1 |
| W420 | 1.1869 | 759.62 | 77 | 87 | 52.4 | 1.1 |
| W690 | 0.877584 | 561.65 | 77 | 65 | 38.9 | 1.1 |
| W680 | 0.648218 | 414.86 | 68 | 154 | 92.5 | 1.1 |
| W530 | 0.44219 | 283.00 | 64 | 71 | 42.6 | 1.1 |
| W650 | 1.13394 | 725.72 | 74 | 87 | 52 | 1.1 |
| W540 | 0.393375 | 251.76 | 77 | 49 | 29.5 | 1.1 |
| W630 | 0.303195 | 194.04 | 79 | 37 | 21.9 | 1.1 |
| W640 | 0.215145 | 137.69 | 72 | 63 | 38 | 1.1 |
| W065 | 0.087675 | 56.11 | 74 | 33 | 19.8 | 1.1 |
| W170 | 0.6485 | 415.04 | 69 | 127 | 75.9 | 1.1 |
| W190 | 0.33645 | 215.33 | 74 | 42 | 25.3 | 1.1 |
| W200 | 0.345967 | 221.42 | 65 | 43 | 25.8 | 1.1 |
| W150 | 0.23715 | 151.78 | 67 | 35 | 21 | 1.1 |
| W180 | 0.09629 | 61.63 | 70 | 27 | 16 | 1.1 |
| W165 | 0.0256 | 16.38 | 80 | 18 | 10.6 | 1.1 |
| W230 | 0.429194 | 274.68 | 68 | 81 | 48.5 | 1.1 |
| W210 | 0.091886 | 58.81 | 64 | 40 | 23.8 | 1.1 |
| W160 | 0.01998 | 12.79 | 66 | 13 | 7.7 | 1.1 |
| W220 | 0.420751 | 269.28 | 72 | 80 | 47.8 | 1.1 |
| W130 | 0.0137602 | 8.81 | 67 | 24 | 14.6 | 1.1 |
| W580 | 0.326884 | 209.21 | 67 | 47 | 28.1 | 1.1 |
| W215 | 0.071903 | 46.02 | 65 | 27 | 16 | 1.1 |
| W290 | 0.205881 | 131.76 | 71 | 60 | 35.8 | 1.1 |
| W020 | 0.054275 | 34.74 | 59 | 14 | 8.5 | 1.1 |
| W015 | 0.0149 | 9.54 | 65 | 12 | 7.2 | 1.1 |
| W025 | 0.054771 | 35.05 | 68 | 23 | 13.8 | 1.1 |
| W030 | 0.026601 | 17.02 | 63 | 18 | 11 | 1.1 |
| W031 | 0.018152 | 11.62 | 98 | 12 | 7.2 | 1.1 |
| W055 | 0.033101 | 21.18 | 62 | 23 | 13.5 | 1.1 |
| W060 | 0.17119 | 109.56 | 73 | 42 | 25.2 | 1.1 |
| W035 | 0.016349 | 10.46 | 63 | 12 | 7.2 | 1.1 |
| W034 | 0.012379 | 7.92 | 63 | 12 | 7.2 | 1.1 |

**TABLE C5**
**Subbasin Hydrologic Data Summary (HEC-HMS)**
**Vado/Del Cerro Drainage Master Plan**

| Basin No. | Basin Area | Basin Area | Runoff Curve Number Based on ARC II Conditions | Time of Concentration (Tc) | Lag Time | Flow Ratio |
|---|---|---|---|---|---|---|
| | sq mi | acres | | minutes | minutes | |
| a | a | a | b | c | c | d |
| W430 | 1.2252 | 784.13 | 69 | 148 | 88.7 | 1.1 |
| W045 | 0.041463 | 26.54 | 69 | 23 | 13.9 | 1.1 |
| W040 | 0.02534 | 16.22 | 63 | 12 | 7.2 | 1.1 |
| W050 | 0.013181 | 8.44 | 77 | 12 | 7.2 | 1.1 |

a - See Drainage Basin Map (Figure A in map pocket) for Subbasins

b - See Table C2 located in Appendix C

c - See Table C3 located in Appendix C

d - Flow Ratios simulate sediment volume within the hydrograph clear water volume. Values are assumed a value of 10% for all subbasins . Refer to the "References" section of Appendix C that contains a portion of the "Sediment and Erosion Design Guide, see Figure 3.8 (Mussetter Engineering Inc. Nov. 2008)

# TABLE C6 Existing Subbasin W031 Detention Pond

Elevation - Discharge Data and Computations

grey box means must input data

Hydraulic Calculations to Develop the Total Principal Spillway Elevation-Discharge

TABLE

Proposed Detention Pond Diversion Structure

Elevation - Volume - Discharge Data and Computations

| Relative Elevations (NAVD 1988) | Depth | Contour Area | Incremental Volume | Incremental Volume | Cumulative Volume | Principal Spillway Outfall Pipe Discharge (RCP) | Total Discharge through pond bottom | Emergency Spillway Discharge | Total Discharge Rating Curve | COMMENTS | VALUES FOR HEC-HMS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | A | A | A | | | | | | | | |
| Princ.spill.orifice dia. or vert. height (in.) | | | | | | 30 | | | | | | | |
| Number of orifices or weirs | | | | | | 1 | | | | | | | |
| Assumed flow reduction factor (f) | | | | | | - | | | | | VALUES ONLY TO PAST INTO HEC-HMS | | |
| ft | | sq ft | cu ft | ac-ft | ac-ft | cfs | cfs | | cfs | | ELEV | CUM VOL | DISCHARGE |
| | | | | | | c | 0 | | | | ft | ac-ft | cfs |
| 3884.00 | 0.0 | 0 | 0 | 0.0000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | Pond Bottom | 3884.0 | 0.0 | 0.0 |
| 3885.00 | 1.0 | 2,023 | 1,012 | 0.0232 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | | 3885.0 | 0.1 | 0.1 |
| 3886.00 | 2.0 | 5,310 | 3,667 | 0.0842 | 0.2 | 0.0 | 0.2 | 0.0 | 0.2 | | 3886.0 | 0.2 | 0.2 |
| 3887.00 | 3.0 | 7,165 | 6,238 | 0.1432 | 0.4 | 0.0 | 0.2 | 0.0 | 0.2 | | 3887.0 | 0.4 | 0.2 |
| 3888.00 | 4.0 | 8,188 | 7,677 | 0.1762 | 0.6 | 0.0 | 0.2 | 0.0 | 0.2 | | 3888.0 | 0.6 | 0.2 |
| 3889.00 | 5.0 | 9,157 | 8,673 | 0.1991 | 0.8 | 0.0 | 0.3 | 0.0 | 0.3 | | 3889.0 | 0.8 | 0.3 |
| 3890.00 | 6.0 | 10,082 | 9,620 | 0.2208 | 1.1 | 0.0 | 0.3 | 0.0 | 0.3 | | 3890.0 | 1.1 | 0.3 |
| 3891.00 | 7.0 | 11,060 | 10,571 | 0.2427 | 1.4 | 0.0 | 0.3 | 0.0 | 0.3 | | 3891.0 | 1.4 | 0.3 |
| 3892.00 | 8.0 | 12,180 | 11,620 | 0.2668 | 1.7 | 0.0 | 0.4 | 0.0 | 0.4 | | 3892.0 | 1.7 | 0.4 |
| 3893.00 | 9.0 | 13,631 | 12,906 | 0.2963 | 2.0 | 0.0 | 0.4 | 0 | 0.4 | Top of Embankment | 3893.0 | 2.0 | 0.4 |
| 3893.20 | 9.2 | 13,645 | 2,728 | 0.0626 | 2.1 | 0.0 | 0.5 | 51 | 51.5 | | 3893.2 | 2.1 | 51.5 |
| 3893.40 | 9.4 | 13,659 | 2,730 | 0.0627 | 2.2 | 0.0 | 0.5 | 144 | 144.7 | | 3893.4 | 2.2 | 144.7 |
| 3893.60 | 9.6 | 13,672 | 2,733 | 0.0627 | 2.3 | 0.0 | 0.5 | 265 | 265.5 | | 3893.6 | 2.3 | 265.5 |
| 3893.80 | 9.8 | 13,686 | 2,736 | 0.0628 | 2.4 | 0.0 | 0.6 | 408 | 408.5 | | 3893.8 | 2.4 | 408.5 |
| 3894.00 | 10.0 | 13,700 | 2,739 | 0.0629 | 2.5 | 0.0 | 0.7 | 570 | 570.7 | *Assumed 1' higher to make HEC-HMS model run | 3894.0 | 2.5 | 570.7 |

( c ) Assume RCP, the discharge rating curve was computed with Culvert Master. Headwater & tailwater assumptions and Culvert Master output are included in the Appendices.

g - Emergergency Spillway C = 3.0 L = 190

**Principal Spillway -** Interpolate discharges at increments from emerg. Spillway to top of pond embankment to attain a better principal spillway rating curve

| ELEV | | Discharge | Delta Discharge | Discharge |
|---|---|---|---|---|
| 3893.00 | | 0.0 | | 0.0 |
| 3893.20 | | | 0.0 | 0.0 |
| 3893.40 | | | 0.0 | 0.0 |
| 3893.60 | | | 0.0 | 0.0 |
| 3893.80 | | | 0.0 | 0.0 |
| 3894.00 | | 0.0 | 0.0 | 0.0 |

**Emergency Spillway -** Interpolate areas at increments to top of pond embankment to attain a better emergency spillway rating curve

| ELEV | | AREA | Delta Area | AREAS |
|---|---|---|---|---|
| 3893.00 | | 13,631 | | 13,631 |
| 3893.20 | | | 14 | 13,645 |
| 3893.40 | | | 14 | 13,659 |
| 3893.60 | | | 14 | 13,672 |
| 3893.80 | | | 14 | 13,686 |
| 3894.00 | | 13,700 | 14 | 13,700 |

# References


1. NOAA Atlas 14 Point Precipitation Frequency Data Server Inter Site – Interned Printout of Point Precipitation Rainfall Depths based on frequency analysis of "partial duration series"

   Point Rainfall Depths
   Figure R1 Cumulative Rainfall Distribution*
   Figure R2 Incremental Rainfall Distribution*
   *The HEC-HMS Rainfall 25% Frequency Distribution storm was adopted

2. Figure 14 Rainfall Loss Areal Reduction Factors. Source: Miller, J.F., R.H. Fredrick and R.J. Tracy (1973). NOAA Atlas 2 Volume 4, Precipitation-Frequency Atlas of the Wester United States. National Weather Service, Silver Spring, MD, p.13.

3. Cronshey, R (1986). Urban Hydrology for Small Watersheds, U.S. Dept. of Agricultural, Natural Resources Conservation Service, Engineering Division, Technical Release 55.
   Figure B-2, Approximate Geographic Boundaries for SCS Rainfall Distributions;
   Table 2-2a Runoff Curve Numbers for Urban Areas;
   Table 2-2b Runoff Curve Numbers for Cultivated Agricultural Land;
   Table 2-2c Runoff Curve Numbers for Other Agricultural Lands;
   Table 2-2d Runoff Curve Numbers for Arid and Semiarid Rangelands;
   Chapter 3 - Time of Concentration and Travel Time Computation Procedure;
   Appendix F Equations for figures and exhibits;
   Table 5-1 Initial Abstraction ($I_a$) Value for Runoff Curve Numbers.

4. U.S. Department of Agriculture Natural Resources Conservation Service (2010). National Engineering Handbook, Part 630; Chapter 15 - Time of Concentration. (Documentation that Lag Time = 0.6 Time of Concentration).

5. HEC-HMS Computation Time Interval Guidance

6. Chow, Ven T. (1959) Open Channel Hydraulics. McGraw-Hill Book Company, Inc; New York., pp 110-113.

7. U.S. Department of Agriculture Natural Resources Conservation Service (2004). National Engineering Handbook: Part 630 Hydrology; Chapter 10, Estimation of Direct Runoff from Storm Rainfall, Table 10-1, p. 10-6.

8. Mussetter Engineering, Inc. (2008). Sediment and Erosion Design Guide, Prepared for the Southern Sandoval County Arroyo Flood Control Authority. p. 3.24.

9. U.S. Department of Agriculture Natural Resources Conservation, Custom Soil Resources Report for Dona Ana County, New Mexico.

**NOAA Atlas 14, Volume 1, Version 5**
**Location name: Vado, New Mexico, USA***
**Latitude: 32.1723°, Longitude: -106.5968°**
**Elevation: 4268.78 ft****
* source: ESRI Maps
** source: USGS

## POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

## PF tabular

**PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]**

| Duration | Average recurrence interval (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | 0.223 (0.195-0.253) | 0.289 (0.253-0.328) | 0.389 (0.341-0.441) | 0.466 (0.407-0.528) | 0.569 (0.494-0.644) | 0.652 (0.564-0.738) | 0.739 (0.634-0.835) | 0.829 (0.708-0.938) | 0.952 (0.805-1.08) | 1.05 (0.885-1.20) |
| 10-min | 0.339 (0.296-0.385) | 0.439 (0.386-0.500) | 0.591 (0.518-0.671) | 0.708 (0.618-0.803) | 0.866 (0.752-0.980) | 0.993 (0.858-1.12) | 1.12 (0.965-1.27) | 1.26 (1.08-1.43) | 1.45 (1.23-1.64) | 1.60 (1.35-1.82) |
| 15-min | 0.420 (0.367-0.477) | 0.544 (0.478-0.620) | 0.732 (0.642-0.832) | 0.878 (0.767-0.996) | 1.07 (0.932-1.22) | 1.23 (1.06-1.39) | 1.39 (1.20-1.58) | 1.56 (1.34-1.77) | 1.80 (1.52-2.03) | 1.99 (1.67-2.25) |
| 30-min | 0.565 (0.494-0.643) | 0.733 (0.643-0.834) | 0.986 (0.865-1.12) | 1.18 (1.03-1.34) | 1.45 (1.25-1.64) | 1.66 (1.43-1.88) | 1.88 (1.61-2.12) | 2.11 (1.80-2.38) | 2.42 (2.05-2.74) | 2.68 (2.25-3.04) |
| 60-min | 0.700 (0.611-0.796) | 0.907 (0.796-1.03) | 1.22 (1.07-1.39) | 1.46 (1.28-1.66) | 1.79 (1.55-2.03) | 2.05 (1.77-2.32) | 2.32 (1.99-2.63) | 2.61 (2.23-2.95) | 2.99 (2.53-3.39) | 3.31 (2.78-3.76) |
| 2-hr | 0.803 (0.709-0.910) | 1.04 (0.922-1.18) | 1.41 (1.25-1.60) | 1.70 (1.49-1.91) | 2.09 (1.82-2.35) | 2.40 (2.08-2.70) | 2.73 (2.34-3.06) | 3.07 (2.61-3.44) | 3.55 (2.97-3.98) | 3.92 (3.25-4.41) |
| 3-hr | 0.853 (0.758-0.962) | 1.10 (0.976-1.24) | 1.47 (1.30-1.66) | 1.75 (1.55-1.98) | 2.15 (1.89-2.42) | 2.47 (2.15-2.77) | 2.80 (2.42-3.14) | 3.15 (2.69-3.53) | 3.63 (3.06-4.08) | 4.01 (3.35-4.51) |
| 6-hr | 0.973 (0.870-1.09) | 1.24 (1.11-1.40) | 1.63 (1.46-1.83) | 1.93 (1.71-2.15) | 2.33 (2.06-2.61) | 2.65 (2.32-2.96) | 2.98 (2.59-3.32) | 3.32 (2.86-3.71) | 3.78 (3.22-4.23) | 4.15 (3.51-4.66) |
| 12-hr | 1.08 (0.965-1.20) | 1.37 (1.23-1.53) | 1.78 (1.59-1.99) | 2.09 (1.87-2.33) | 2.51 (2.22-2.79) | 2.83 (2.49-3.14) | 3.15 (2.77-3.51) | 3.49 (3.04-3.88) | 3.93 (3.39-4.39) | 4.28 (3.67-4.80) |
| 24-hr | 1.18 (1.08-1.31) | 1.51 (1.37-1.67) | 1.98 (1.79-2.20) | 2.35 (2.11-2.62) | 2.87 (2.54-3.23) | 3.29 (2.86-3.75) | 3.74 (3.19-4.34) | 4.21 (3.52-4.99) | 4.88 (3.97-5.98) | 5.43 (4.29-6.88) |
| 2-day | 1.27 (1.16-1.41) | 1.63 (1.47-1.80) | 2.13 (1.93-2.37) | 2.54 (2.28-2.83) | 3.13 (2.76-3.52) | 3.61 (3.13-4.11) | 4.12 (3.50-4.79) | 4.68 (3.88-5.53) | 5.48 (4.38-6.69) | 6.16 (4.78-7.76) |
| 3-day | 1.36 (1.24-1.51) | 1.74 (1.58-1.93) | 2.29 (2.07-2.54) | 2.73 (2.44-3.03) | 3.34 (2.95-3.75) | 3.83 (3.34-4.35) | 4.36 (3.72-5.04) | 4.92 (4.11-5.79) | 5.74 (4.64-6.95) | 6.43 (5.06-8.00) |
| 4-day | 1.45 (1.32-1.61) | 1.86 (1.69-2.06) | 2.45 (2.21-2.71) | 2.91 (2.61-3.23) | 3.55 (3.14-3.98) | 4.06 (3.55-4.60) | 4.60 (3.95-5.29) | 5.16 (4.34-6.04) | 6.00 (4.90-7.21) | 6.70 (5.34-8.25) |
| 7-day | 1.66 (1.51-1.84) | 2.13 (1.93-2.36) | 2.81 (2.55-3.11) | 3.36 (3.02-3.73) | 4.12 (3.65-4.61) | 4.73 (4.14-5.35) | 5.38 (4.62-6.17) | 6.07 (5.11-7.06) | 7.04 (5.76-8.41) | 7.82 (6.25-9.57) |
| 10-day | 1.84 (1.67-2.04) | 2.37 (2.15-2.63) | 3.15 (2.85-3.49) | 3.77 (3.38-4.18) | 4.64 (4.10-5.18) | 5.33 (4.64-6.02) | 6.07 (5.19-6.95) | 6.85 (5.75-7.97) | 7.94 (6.47-9.45) | 8.82 (7.03-10.7) |
| 20-day | 2.35 (2.13-2.58) | 3.01 (2.74-3.32) | 3.96 (3.60-4.36) | 4.68 (4.22-5.17) | 5.66 (5.04-6.28) | 6.41 (5.65-7.18) | 7.18 (6.25-8.14) | 7.97 (6.83-9.15) | 9.11 (7.63-10.7) | 10.0 (8.23-11.9) |
| 30-day | 2.80 (2.55-3.08) | 3.59 (3.26-3.95) | 4.67 (4.24-5.14) | 5.48 (4.95-6.04) | 6.57 (5.87-7.29) | 7.40 (6.55-8.28) | 8.23 (7.19-9.32) | 9.07 (7.81-10.4) | 10.2 (8.61-12.0) | 11.1 (9.23-13.3) |
| 45-day | 3.39 (3.08-3.71) | 4.33 (3.95-4.75) | 5.58 (5.08-6.13) | 6.50 (5.89-7.15) | 7.70 (6.91-8.53) | 8.60 (7.65-9.59) | 9.50 (8.36-10.7) | 10.4 (9.03-11.8) | 11.6 (9.86-13.4) | 12.4 (10.5-14.6) |
| 60-day | 3.89 (3.55-4.26) | 4.98 (4.54-5.46) | 6.41 (5.84-7.03) | 7.45 (6.76-8.18) | 8.78 (7.90-9.69) | 9.76 (8.70-10.8) | 10.7 (9.47-12.0) | 11.7 (10.2-13.2) | 12.9 (11.1-14.9) | 13.8 (11.7-16.2) |

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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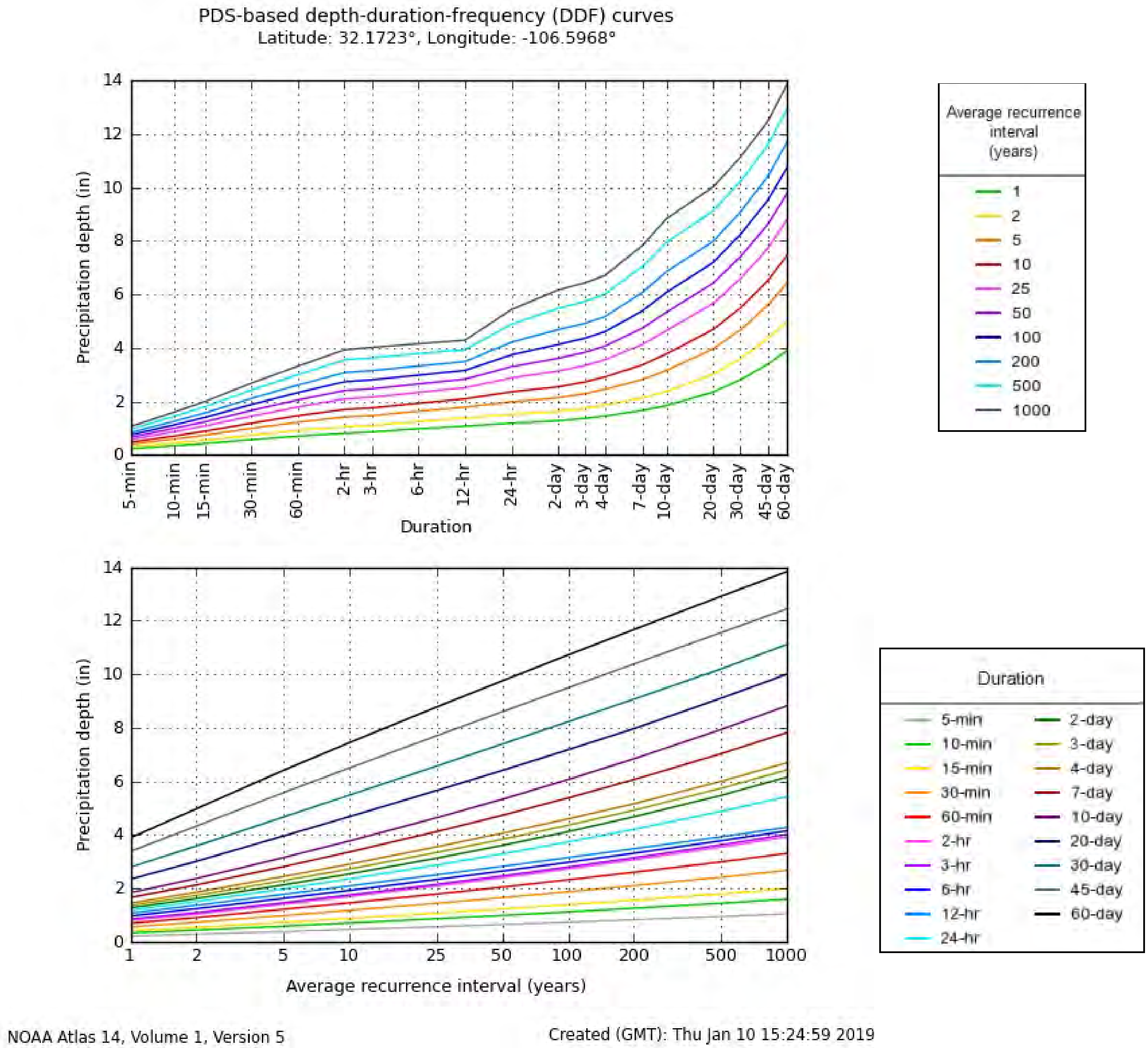
## PF graphical

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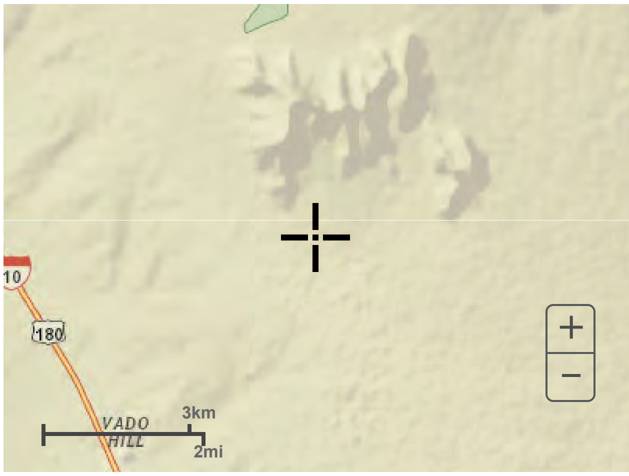
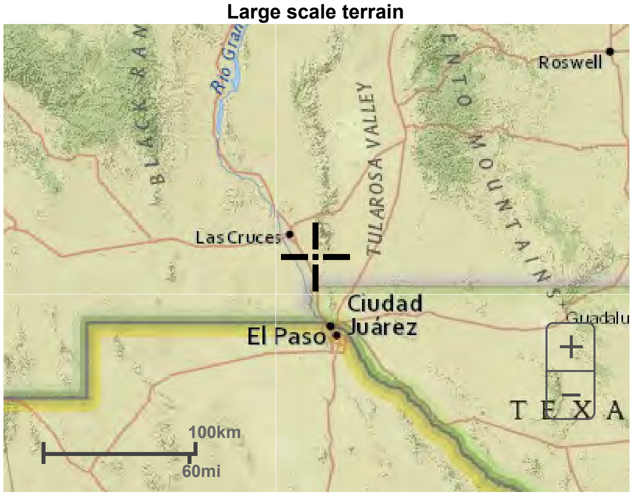
## Maps & aerials

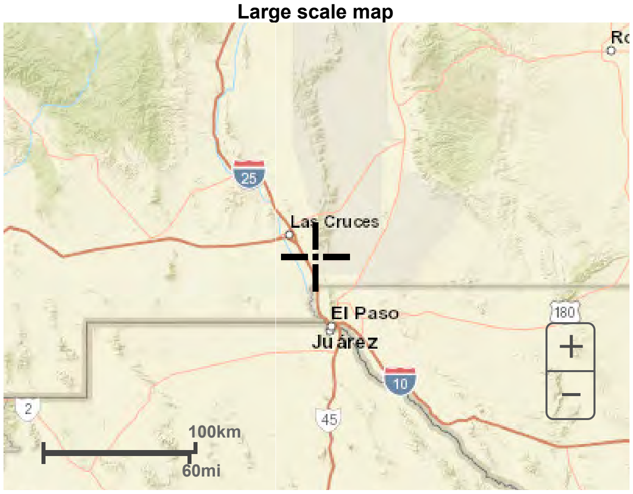
**Small scale terrain**



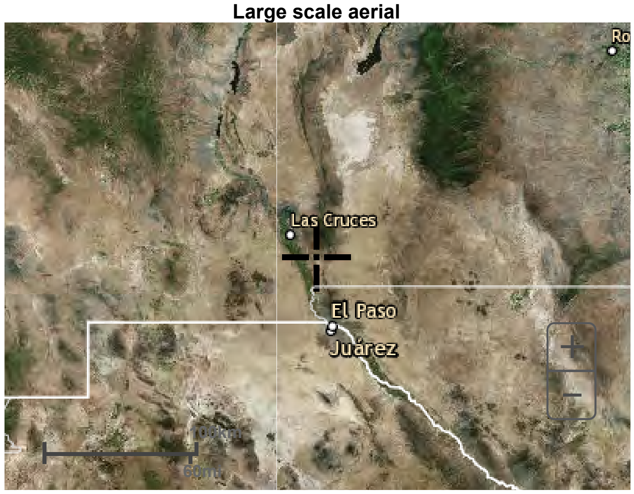

**Large scale terrain**




**Large scale map**



**Large scale aerial**

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National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
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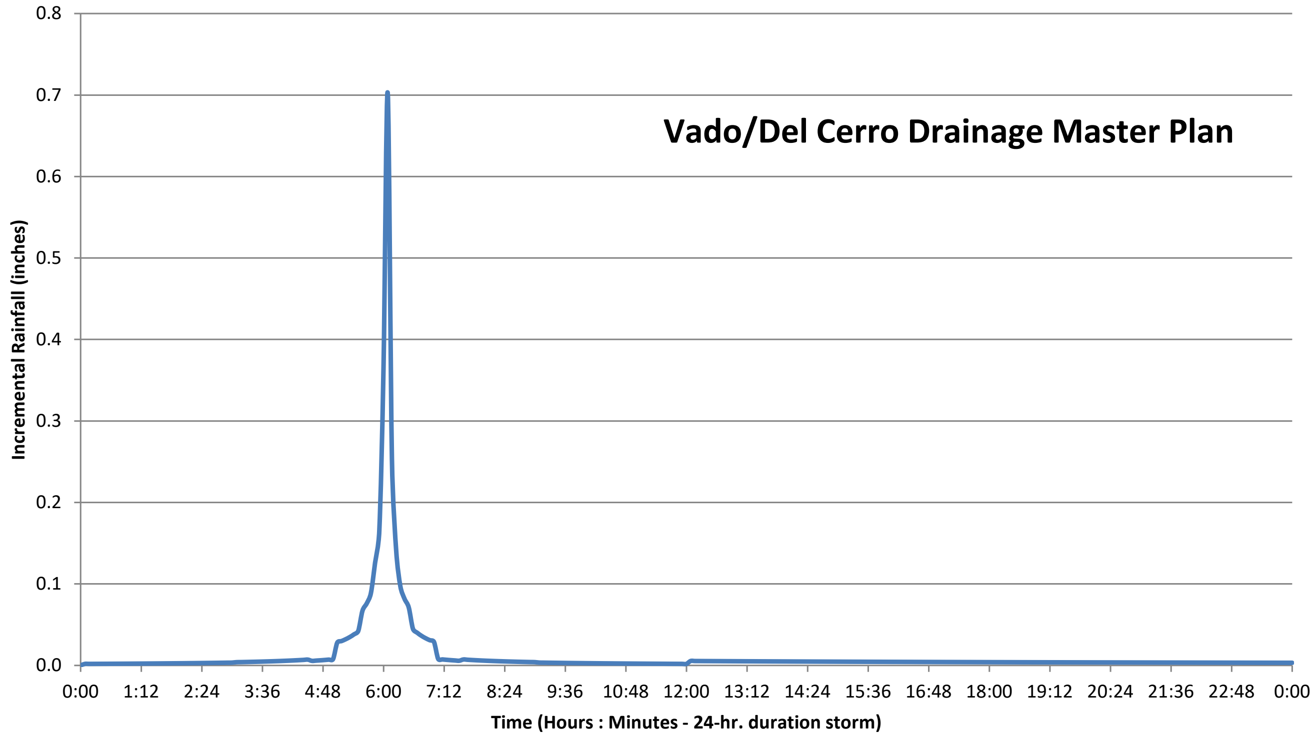
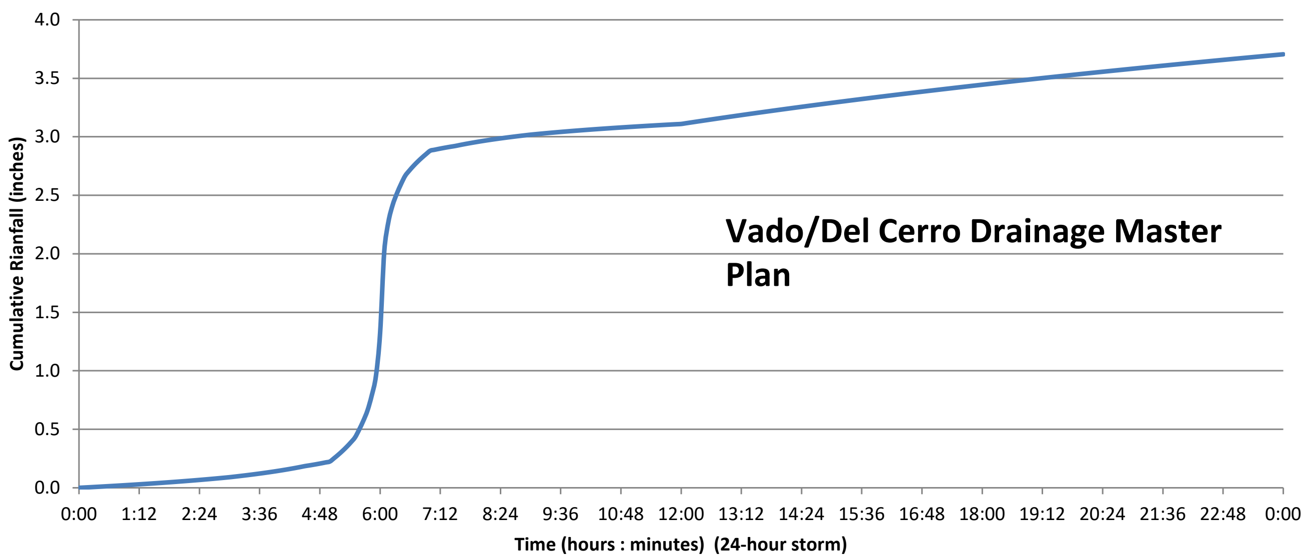
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

## FIGURE R2 - 100-yr. 24-hr. Incremental Rainfall (25% Frequency Storm)




## FIGURE R1 - 100-yr. 24-hr. Cumulative Rainfall (25% Frequency Storm)



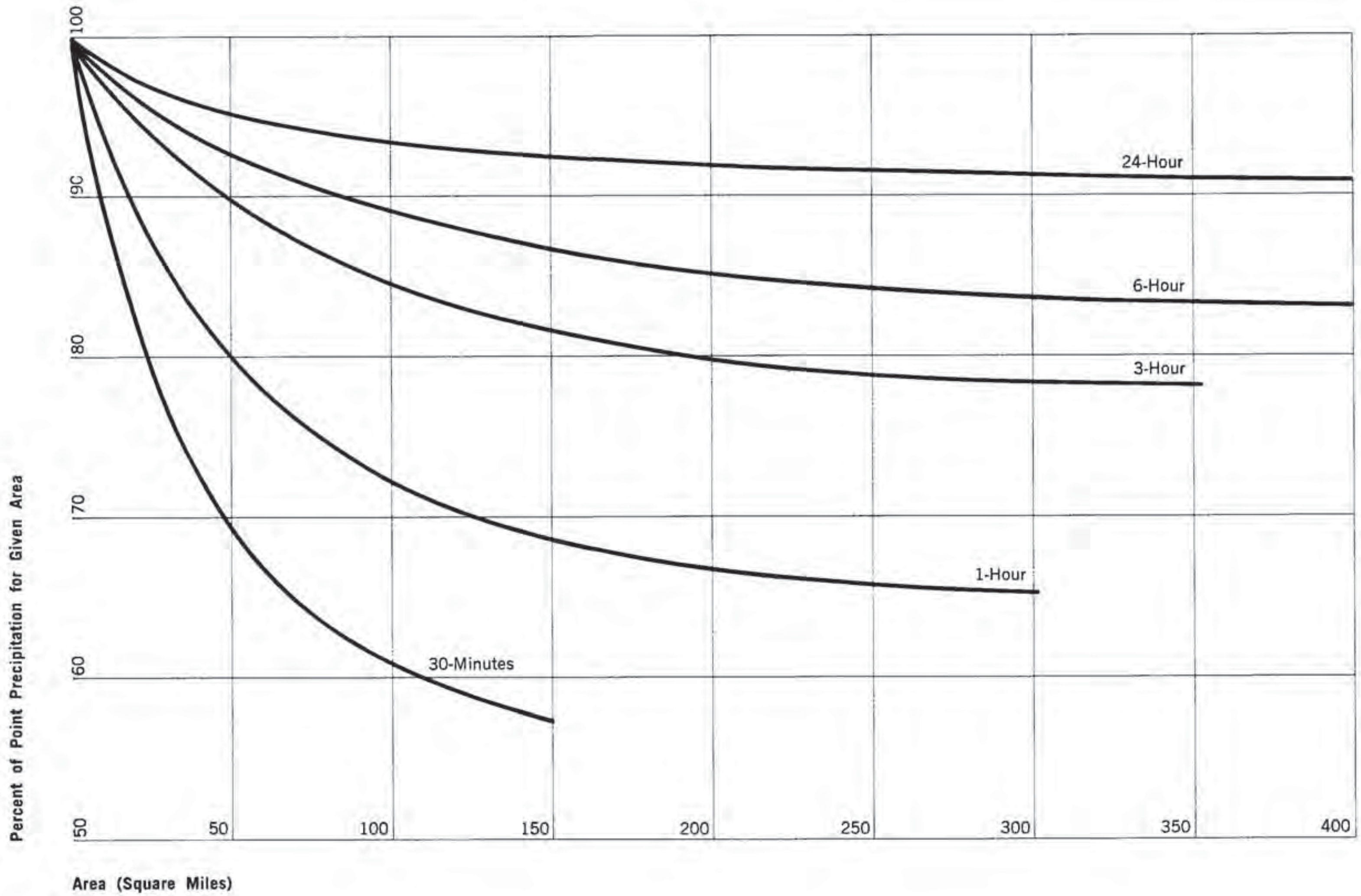



**Figure 14.** *Depth-Area curves.*

USDA

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Department of
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Natural
Resources
Conservation
Service

Conservation
Engineering
Division

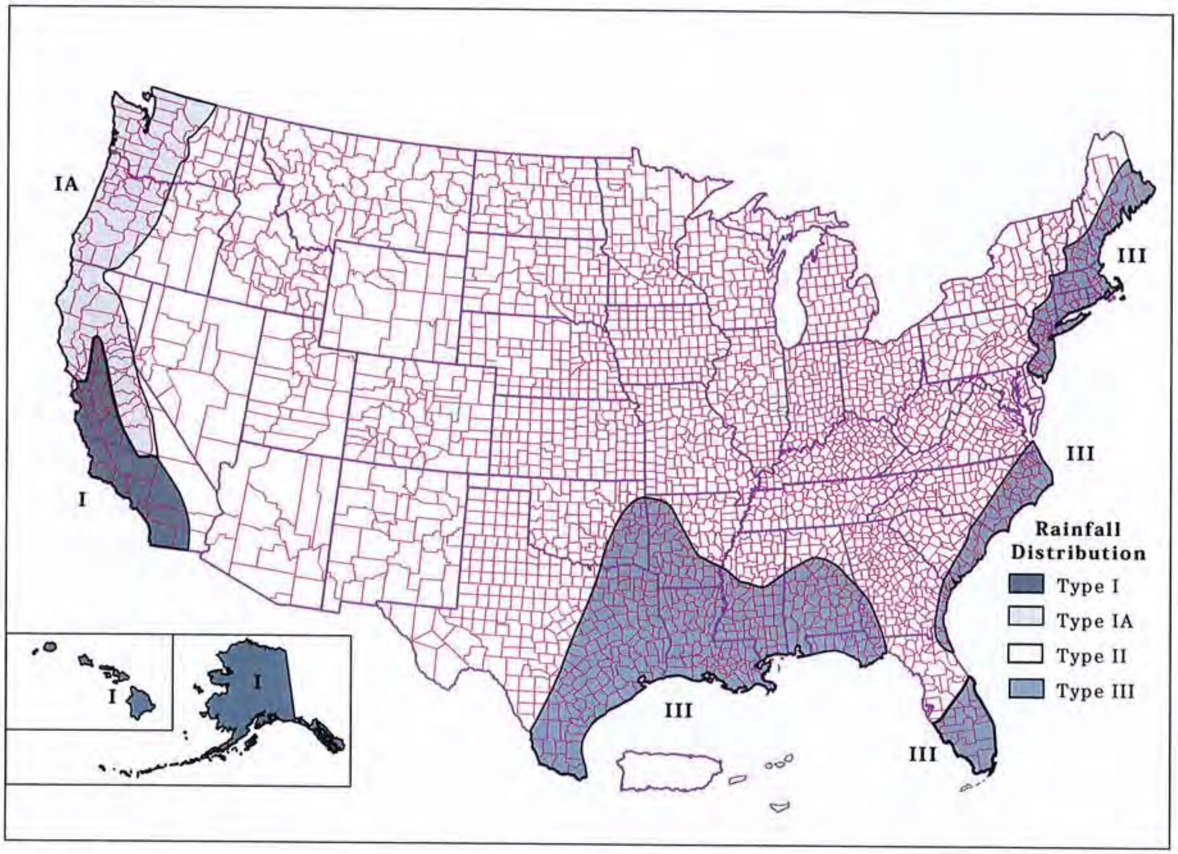
Technical
Release 55

June 1986

# Urban Hydrology for Small Watersheds

## TR-55

**Figure B-2** Approximate geographic boundaries for NRCS (SCS) rainfall distributions




## Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Ocean and Atmospheric Administration.

### East of 105th meridian

Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 155 p.

### West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I Montana; Vol. II, Wyoming; Vol III, Colorado; Vol. IV, New Mexico; Vol V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dept. of Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

### Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. of Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

### Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

### Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 P.

**Table 2-2a** Runoff curve numbers for urban areas [1]

| Cover description | | Curve numbers for hydrologic soil group | | | |
|---|---|---|---|---|---|
| Cover type and hydrologic condition | Average percent impervious area [2] | A | B | C | D |
| *Fully developed urban areas (vegetation established)* | | | | | |
| Open space (lawns, parks, golf courses, cemeteries, etc.) [3]: | | | | | |
| Poor condition (grass cover < 50%) | | 68 | 79 | 86 | 89 |
| Fair condition (grass cover 50% to 75%) | | 49 | 69 | 79 | 84 |
| Good condition (grass cover > 75%) | | 39 | 61 | 74 | 80 |
| Impervious areas: | | | | | |
| Paved parking lots, roofs, driveways, etc. (excluding right-of-way) | | 98 | 98 | 98 | 98 |
| Streets and roads: | | | | | |
| Paved; curbs and storm sewers (excluding right-of-way) | | 98 | 98 | 98 | 98 |
| Paved; open ditches (including right-of-way) | | 83 | 89 | 92 | 93 |
| Gravel (including right-of-way) | | 76 | 85 | 89 | 91 |
| Dirt (including right-of-way) | | 72 | 82 | 87 | 89 |
| Western desert urban areas: | | | | | |
| Natural desert landscaping (pervious areas only) [4] | | 63 | 77 | 85 | 88 |
| Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders) | | 96 | 96 | 96 | 96 |
| Urban districts: | | | | | |
| Commercial and business | 85 | 89 | 92 | 94 | 95 |
| Industrial | 72 | 81 | 88 | 91 | 93 |
| Residential districts by average lot size: | | | | | |
| 1/8 acre or less (town houses) | 65 | 77 | 85 | 90 | 92 |
| 1/4 acre | 38 | 61 | 75 | 83 | 87 |
| 1/3 acre | 30 | 57 | 72 | 81 | 86 |
| 1/2 acre | 25 | 54 | 70 | 80 | 85 |
| 1 acre | 20 | 51 | 68 | 79 | 84 |
| 2 acres | 12 | 46 | 65 | 77 | 82 |
| *Developing urban areas* | | | | | |
| Newly graded areas (pervious areas only, no vegetation) [5] | | 77 | 86 | 91 | 94 |
| Idle lands (CN's are determined using cover types similar to those in table 2-2c). | | | | | |

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

**Table 2-2b** Runoff curve numbers for cultivated agricultural lands [1]

| Cover description | | | Curve numbers for hydrologic soil group | | | |
|---|---|---|---|---|---|---|
| Cover type | Treatment [2] | Hydrologic condition [3] | A | B | C | D |
| Fallow | Bare soil | — | 77 | 86 | 91 | 94 |
| | Crop residue cover (CR) | Poor | 76 | 85 | 90 | 93 |
| | | Good | 74 | 83 | 88 | 90 |
| Row crops | Straight row (SR) | Poor | 72 | 81 | 88 | 91 |
| | | Good | 67 | 78 | 85 | 89 |
| | SR + CR | Poor | 71 | 80 | 87 | 90 |
| | | Good | 64 | 75 | 82 | 85 |
| | Contoured (C) | Poor | 70 | 79 | 84 | 88 |
| | | Good | 65 | 75 | 82 | 86 |
| | C + CR | Poor | 69 | 78 | 83 | 87 |
| | | Good | 64 | 74 | 81 | 85 |
| | Contoured & terraced (C&T) | Poor | 66 | 74 | 80 | 82 |
| | | Good | 62 | 71 | 78 | 81 |
| | C&T+ CR | Poor | 65 | 73 | 79 | 81 |
| | | Good | 61 | 70 | 77 | 80 |
| Small grain | SR | Poor | 65 | 76 | 84 | 88 |
| | | Good | 63 | 75 | 83 | 87 |
| | SR + CR | Poor | 64 | 75 | 83 | 86 |
| | | Good | 60 | 72 | 80 | 84 |
| | C | Poor | 63 | 74 | 82 | 85 |
| | | Good | 61 | 73 | 81 | 84 |
| | C + CR | Poor | 62 | 73 | 81 | 84 |
| | | Good | 60 | 72 | 80 | 83 |
| | C&T | Poor | 61 | 72 | 79 | 82 |
| | | Good | 59 | 70 | 78 | 81 |
| | C&T+ CR | Poor | 60 | 71 | 78 | 81 |
| | | Good | 58 | 69 | 77 | 80 |
| Close-seeded or broadcast legumes or rotation meadow | SR | Poor | 66 | 77 | 85 | 89 |
| | | Good | 58 | 72 | 81 | 85 |
| | C | Poor | 64 | 75 | 83 | 85 |
| | | Good | 55 | 69 | 78 | 83 |
| | C&T | Poor | 63 | 73 | 80 | 83 |
| | | Good | 51 | 67 | 76 | 80 |

1 Average runoff condition, and $I_a$=0.2S

2 Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

3 Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

**Table 2-2c** Runoff curve numbers for other agricultural lands [1]

| Cover description | | Curve numbers for hydrologic soil group | | | |
|---|---|---|---|---|---|
| Cover type | Hydrologic condition | A | B | C | D |
| Pasture, grassland, or range—continuous forage for grazing. [2] | Poor | 68 | 79 | 86 | 89 |
| | Fair | 49 | 69 | 79 | 84 |
| | Good | 39 | 61 | 74 | 80 |
| Meadow—continuous grass, protected from grazing and generally mowed for hay. | — | 30 | 58 | 71 | 78 |
| Brush—brush-weed-grass mixture with brush the major element. [3] | Poor | 48 | 67 | 77 | 83 |
| | Fair | 35 | 56 | 70 | 77 |
| | Good | 30 [4] | 48 | 65 | 73 |
| Woods—grass combination (orchard or tree farm). [5] | Poor | 57 | 73 | 82 | 86 |
| | Fair | 43 | 65 | 76 | 82 |
| | Good | 32 | 58 | 72 | 79 |
| Woods. [6] | Poor | 45 | 66 | 77 | 83 |
| | Fair | 36 | 60 | 73 | 79 |
| | Good | 30 [4] | 55 | 70 | 77 |
| Farmsteads—buildings, lanes, driveways, and surrounding lots. | — | 59 | 74 | 82 | 86 |

1 Average runoff condition, and $I_a = 0.2S$.

2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
*Fair:* 50 to 75% ground cover and not heavily grazed.
*Good:* > 75% ground cover and lightly or only occasionally grazed.

3 *Poor:* <50% ground cover.
*Fair:* 50 to 75% ground cover.
*Good:* >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
*Fair:* Woods are grazed but not burned, and some forest litter covers the soil.
*Good:* Woods are protected from grazing, and litter and brush adequately cover the soil.

**Table 2-2d** Runoff curve numbers for arid and semiarid rangelands [1]

| Cover description | | Curve numbers for hydrologic soil group | | | |
|---|---|---|---|---|---|
| Cover type | Hydrologic condition [2] | A [3] | B | C | D |
| Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element. | Poor | | 80 | 87 | 93 |
| | Fair | | 71 | 81 | 89 |
| | Good | | 62 | 74 | 85 |
| Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush. | Poor | | 66 | 74 | 79 |
| | Fair | | 48 | 57 | 63 |
| | Good | | 30 | 41 | 48 |
| Pinyon-juniper—pinyon, juniper, or both; grass understory. | Poor | | 75 | 85 | 89 |
| | Fair | | 58 | 73 | 80 |
| | Good | | 41 | 61 | 71 |
| Sagebrush with grass understory. | Poor | | 67 | 80 | 85 |
| | Fair | | 51 | 63 | 70 |
| | Good | | 35 | 47 | 55 |
| Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus. | Poor | 63 | 77 | 85 | 88 |
| | Fair | 55 | 72 | 81 | 86 |
| | Good | 49 | 68 | 79 | 84 |

1 Average runoff condition, and $I_a = 0.2S$. For range in humid regions, use table 2-2c.
2 Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
3 Curve numbers for group A have been developed only for desert shrub.

# Chapter 3 Time of Concentration and Travel Time

Travel time ( $T_t$ ) is the time it takes water to travel from one location to another in a watershed. $T_t$ is a component of time of concentration ( $T_c$ ), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. $T_c$ is computed by summing all the travel times for consecutive components of the drainage conveyance system.

$T_c$ influences the shape and peak of the runoff hydrograph. Urbanization usually decreases $T_c$, thereby increasing the peak discharge. But $T_c$ can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

## Factors affecting time of concentration and travel time

### Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

### Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

### Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

## Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time ( $T_t$ ) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600V} \qquad \text{[eq. 3-1]}$$

where:

$T_t$ = travel time (hr)
L = flow length (ft)
V = average velocity (ft/s)
3600 = conversion factor from seconds to hours.

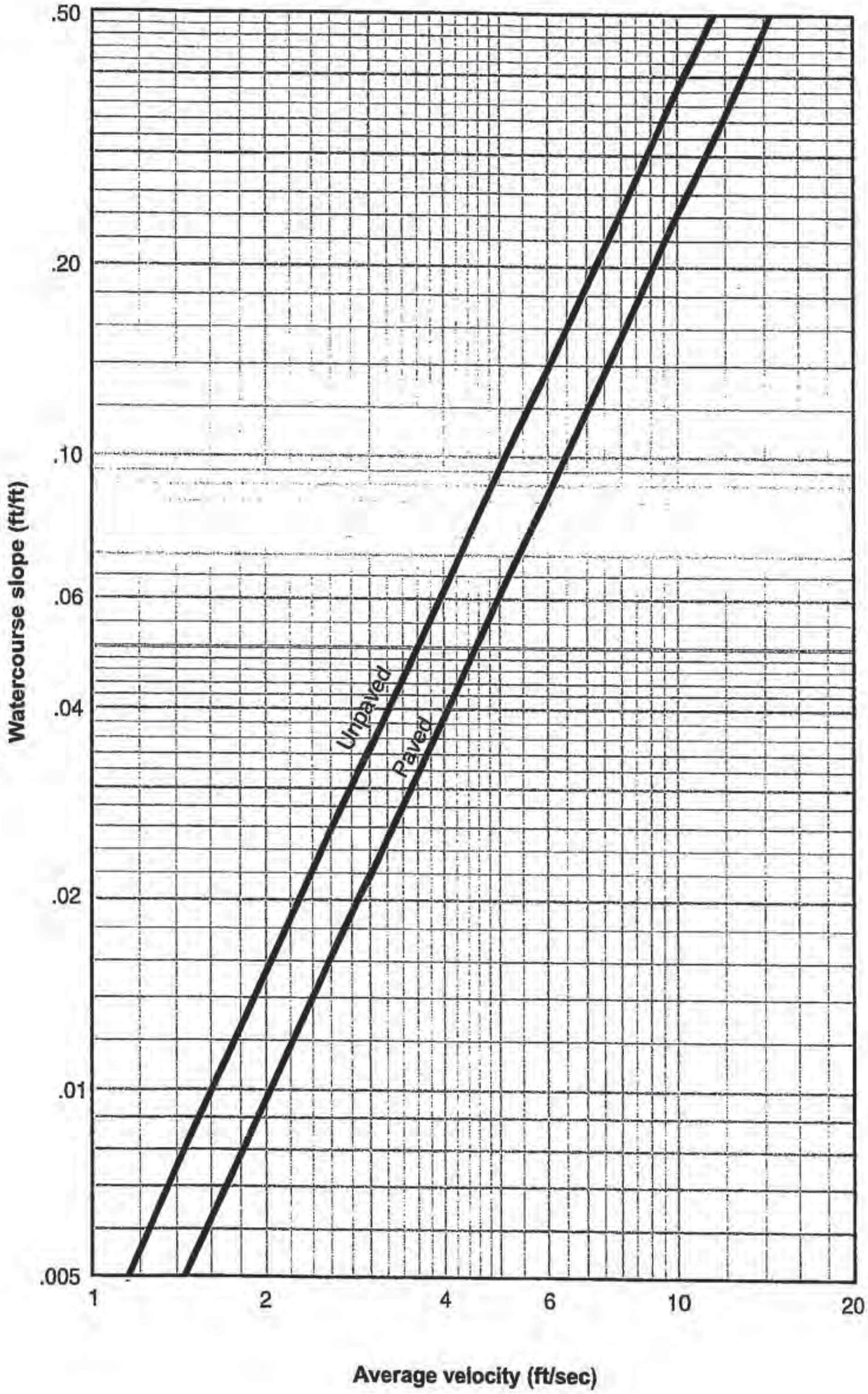
Time of concentration ( $T_c$ ) is the sum of $T_t$ values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[eq. 3-2]}$$

where:

$T_c$ = time of concentration (hr)
m = number of flow segments

**Figure 3-1** Average velocities for estimating travel time for shallow concentrated flow



## Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

**Table 3-1** Roughness coefficients (Manning's n) for sheet flow

| Surface description | n [1] |
|---|---|
| Smooth surfaces (concrete, asphalt, gravel, or bare soil) | 0.011 |
| Fallow (no residue) | 0.05 |
| Cultivated soils: | |
| Residue cover ≤20% | 0.06 |
| Residue cover >20% | 0.17 |
| Grass: | |
| Short grass prairie | 0.15 |
| Dense grasses [2] | 0.24 |
| Bermudagrass | 0.41 |
| Range (natural) | 0.13 |
| Woods:[3] | |
| Light underbrush | 0.40 |
| Dense underbrush | 0.80 |

1 The n values are a composite of information compiled by Engman (1986).

2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

3 When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute $T_t$:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{[eq. 3-3]}$$

where:

$T_t$ = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
$P_2$ = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

## Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

## Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Manning's equation is:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{[eq. 3-4]}$$

where:

- $V$ = average velocity (ft/s)
- $r$ = hydraulic radius (ft) and is equal to $a/p_w$
  - $a$ = cross sectional flow area (ft$^2$)
  - $p_w$ = wetted perimeter (ft)
- $s$ = slope of the hydraulic grade line (channel slope, ft/ft)
- $n$ = Manning's roughness coefficient for open channel flow.

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Linsley et al. (1982). After average velocity is computed using equation 3-4, $T_t$ for the channel segment can be estimated using equation 3-1.

### Reservoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

## Limitations

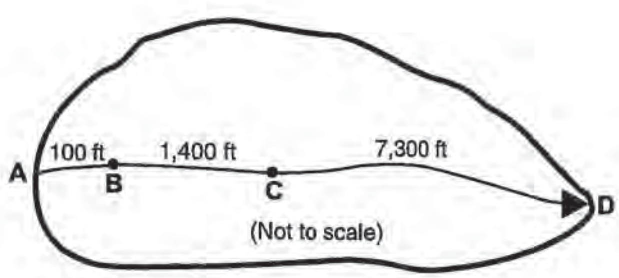
- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 3-3 was developed for use with the four standard rainfall intensity-duration relationships.
- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate $T_c$. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.
- The minimum $T_c$ used in TR-55 is 0.1 hour. = 6 minutes
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

## Example 3-1

The sketch below shows a watershed in Dyer County, northwestern Tennessee. The problem is to compute $T_c$ at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 3.6 inches. All three types of flow occur from the hydraulically most distant point (A) to the point of interest (D). To compute $T_c$, first determine $T_t$ for each segment from the following information:

Segment AB: Sheet flow; dense grass; slope (s) = 0.01 ft/ft; and length (L) = 100 ft. Segment BC: Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L = 1,400 ft. Segment CD: Channel flow; Manning's n = .05; flow area (a) = 27 ft$^2$; wetted perimeter ($p_w$) = 28.2 ft; s = 0.005 ft/ft; and L = 7,300 ft.

See figure 3-2 for the computations made on worksheet 3.



# Appendix F Equations for figures and exhibits

This appendix presents the equations used in procedure applications to generate figures and exhibits in TR-55.

Figure 2-1 (runoff equation):

$$Q = \frac{\left[P - .2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)}$$

where

Q = runoff (in)
P = rainfall (in)
CN = runoff curve number

Figure 2-3 (composite CN with connected impervious area):

$$CN_c = CN_p + \left(\frac{P_{imp}}{100}\right)(98 - CN_p)$$

where

$CN_c$ = composite runoff curve number
$CN_p$ = pervious runoff curve number
$P_{imp}$ = percent imperviousness.

Figure 2-4 (composite CN with unconnected impervious areas and total impervious area less than 30%):

$$CN_c = CN_p + \left(\frac{P_{imp}}{100}\right)(98 - CN_p)(1 - 0.5R)$$

where

R = ratio of unconnected impervious area to total impervious area.

Figure 3-1 (average velocities for estimating travel time for shallow concentrated flow):

Unpaved $V = 16.1345\,(s)^{0.5}$
Paved $V = 20.3282\,(s)^{0.5}$

where

V= average velocity (ft/s)
s = slope of hydraulic grade line (watercourse slope, ft/ft)

These two equations are based on the solution of Manning's equation (eq. 3-4) with different assumptions for n (Manning's roughness coefficient) and r (hydraulic radius, ft). For unpaved areas, n is 0.05 and r is 0.4; for paved areas, n is 0.025 and r is 0.2.

Exhibit 4 (unit peak discharges for SCS tvpe I, IA, II, and III distributions):

$$\log(q_u) = C_o + C_1 \log(T_c) + C_2\left[\log(T_c)\right]^2$$

where

$q_u$ = unit peak discharge (csm/in)
$T_c$ = time of concentration (hr) (minimum, 0.1; maximum, 10.0)
$C_0$, $C_1$, $C_2$ = coefficients from table F-1

Figure 6-1 (approximate detention basin routing through single- and multiple-stage structures for 24-hour rainfalls of the indicated type):

$$\frac{V_S}{V_r} = C_o + C_1\left(\frac{q_o}{q_1}\right) + C_2\left(\frac{q_o}{q_1}\right)^2 + C_3\left(\frac{q_o}{q_1}\right)^3$$

where

$V_s/V_r$ = ratio of storage volume ($V_s$) to runoff volume ($V_r$)
$q_o/q_i$ = ratio of peak outflow discharge ($q_o$) to peak inflow discharge ($q_i$)
$C_0$, $C_1$, $C_2$, $C_3$ = coefficients from table F-2

**Table F-1** Coefficients for the equation used to generate exhibits 4-I through 4-III

| Rainfall type | $I_a/P$ | $C_0$ | $C_1$ | $C_2$ |
|---|---|---|---|---|
| I | 0.10 | 2.30550 | -0.51429 | -0.11750 |
| | 0.20 | 2.23537 | -0.50387 | -0.08929 |
| | 0.25 | 2.18219 | -0.48488 | -0.06589 |
| | 0.30 | 2.10624 | -0.45695 | -0.02835 |
| | 0.35 | 2.00303 | -0.40769 | 0.01983 |
| | 0.40 | 1.87733 | -0.32274 | 0.05754 |
| | 0.45 | 1.76312 | -0.15644 | 0.00453 |
| | 0.50 | 1.67889 | -0.06930 | 0.0 |
| IA | 0.10 | 2.03250 | -0.31583 | -0.13748 |
| | 0.20 | 1.91978 | -0.28215 | -0.07020 |
| | 0.25 | 1.83842 | -0.25543 | -0.02597 |
| | 0.30 | 1.72657 | -0.19826 | 0.02633 |
| | 0.50 | 1.63417 | -0.09100 | 0.0 |
| II | 0.10 | 2.55323 | -0.61512 | -0.16403 |
| | 0.30 | 2.46532 | -0.62257 | -0.11657 |
| | 0.35 | 2.41896 | -0.61594 | -0.08820 |
| | 0.40 | 2.36409 | -0.59857 | -0.05621 |
| | 0.45 | 2.29238 | -0.57005 | -0.02281 |
| | 0.50 | 2.20282 | -0.51599 | -0.01259 |
| III | 0.10 | 2.47317 | -0.51848 | -0.17083 |
| | 0.30 | 2.39628 | -0.51202 | -0.13245 |
| | 0.35 | 2.35477 | -0.49735 | - 0.11985 |
| | 0.40 | 2.30726 | -0.46541 | -0.11094 |
| | 0.45 | 2.24876 | -0.41314 | -0.11508 |
| | 0.50 | 2.17772 | - 0.36803 | - 0.09525 |

**Table F-2** Coefficients for the equation used to generate figure 6-1

| Rainfall distribution (appendix B) | $C_0$ | $C_1$ | $C_2$ | $C_3$ |
|---|---|---|---|---|
| I, IA | 0.660 | -1.76 | 1.96 | -0.730 |
| II, III | 0.682 | -1.43 | 1.64 | -0.804 |

# Development of composite flood hydrograph

This section describes the procedure for developing the peak discharge and selected discharge values of a composite flood hydrograph.

## Selecting $T_c$ and $T_t$

First, use worksheet 5a to develop a summary of basic watershed data by subarea. Then use worksheet 5b to develop a tabular hydrograph discharge summary; this summary displays the effect of individual subarea hydrographs as routed to the watershed point of interest. Use $\Sigma T_t$ for each subarea as the total reach travel time from that subarea through the watershed to the point of interest. Compute the hydrograph coordinates for selected $\Sigma T_t$'s using the appropriate sheets in exhibit 5. The flow at any time is:

$$q = q_t A_m Q \qquad \text{[eq. 5-1]}$$

where:

$q$ = hydrograph coordinate (cfs) at hydrograph time t
$q_t$ = tabular hydrograph unit discharge from exhibit 5 (csm/in)
$A_m$ = drainage area of individual subarea ($mi^2$)
$Q$ = runoff (in)

Since the timing of peak discharge changes with $T_c$ and $T_t$, interpolation of peak discharge for $T_c$ and $T_t$ values for use in exhibit 5 is not recommended. Interpolation may result in an estimate of peak discharge that would be invalid because it would be lower than either of the hydrographs. Therefore, round the actual values of $T_c$ and $T_t$ to values presented in exhibit 5. Perform this rounding so that the sum of the selected table values is close to the sum of actual $T_c$ and $T_t$. An acceptable procedure is to select the results of one of three rounding operations:

1. Round $T_c$ and $T_t$ separately to the nearest table value and sum,
2. Round $T_c$ down and $T_t$ up to nearest table value and sum,
3. Round $T_c$ up and $T_t$ down to nearest table value and sum.

From these three alternatives, choose the pair of rounded $T_c$ and $T_t$ values whose sum is closest to the sum of the actual $T_c$ and $T_t$. If two rounding methods produce sums equally close to the actual sum, use the combination in which rounded $T_c$ is closest to actual $T_c$. An illustration of the rounding procedure is as follows:

**Table 5-1** $I_a$ values for runoff curve numbers

| Curve number | $I_a$ (in) | Curve number | $I_a$ (in) |
|---|---|---|---|
| 40 | 3.000 | 70 | 0.857 |
| 41 | 2.878 | 71 | 0.817 |
| 42 | 2.762 | 72 | 0.778 |
| 43 | 2.651 | 73 | 0.740 |
| 44 | 2.545 | 74 | 0.703 |
| 45 | 2.444 | 75 | 0.667 |
| 46 | 2.348 | 76 | 0.632 |
| 47 | 2.255 | 77 | 0.597 |
| 48 | 2.167 | 78 | 0.564 |
| 49 | 2.082 | 79 | 0.532 |
| 50 | 2.000 | 80 | 0.500 |
| 51 | 1.922 | 81 | 0.469 |
| 52 | 1.846 | 82 | 0.439 |
| 53 | 1.774 | 83 | 0.410 |
| 54 | 1.704 | 84 | 0.381 |
| 55 | 1.636 | 85 | 0.353 |
| 56 | 1.571 | 86 | 0.326 |
| 57 | 1.509 | 87 | 0.299 |
| 58 | 1.448 | 88 | 0.273 |
| 59 | 1.390 | 89 | 0.247 |
| 60 | 1.333 | 90 | 0.222 |
| 61 | 1.279 | 91 | 0.198 |
| 62 | 1.226 | 92 | 0.174 |
| 63 | 1.175 | 93 | 0.151 |
| 64 | 1.125 | 94 | 0.128 |
| 65 | 1.077 | 95 | 0.105 |
| 66 | 1.030 | 96 | 0.083 |
| 67 | 0.985 | 97 | 0.062 |
| 68 | 0.941 | 98 | 0.041 |
| 69 | 0.899 | | |

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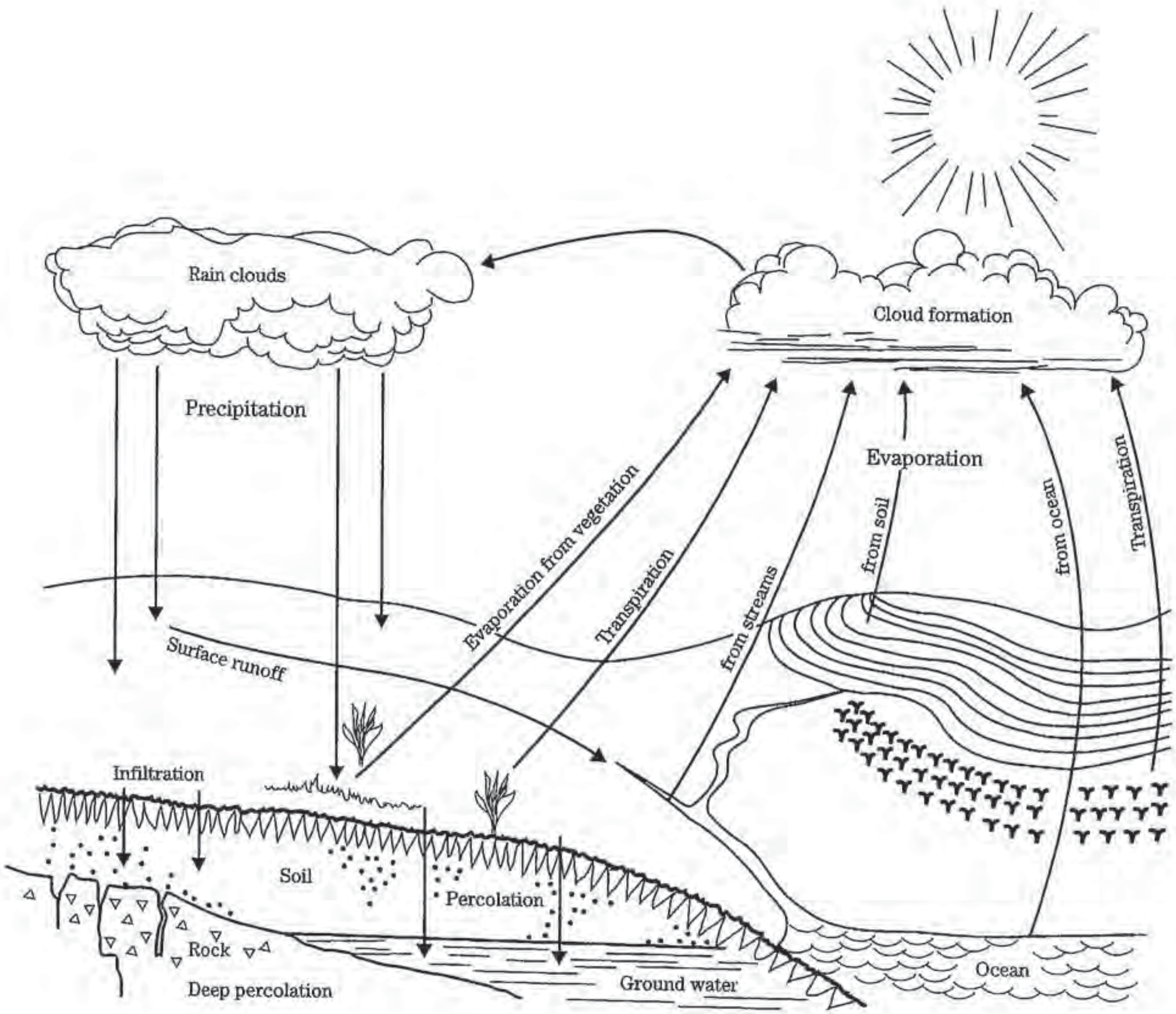
# Part 630 Hydrology
# National Engineering Handbook

# Chapter 15 Time of Concentration



# Chapter 15 Time of Concentration

## 630.1500 Introduction

This chapter contains information on the watershed characteristics called travel time, lag, and time of concentration. These watershed characteristics influence the shape and peak of the runoff hydrograph. The National Engineering Handbook, Part 630, Hydrology, Chapter 16, Hydrographs (NEH630.16) contains information on development of runoff hydrographs. The methods presented in this chapter are suitable for use with any hydrologic model which uses time of concentration or lag as an input parameter. Users of models are cautioned to be mindful of specific model input parameters and limitations, which may not be the same as limitations of a particular time of concentration estimation tool. Limitations of specific models are not described in this chapter.

## 630.1501 Definitions and basic relations

### (a) Types of flow

Rainfall over a watershed that reaches the ground will follow one of four potential paths. Some will be intercepted by vegetation and evaporate into the atmosphere. Some will fall onto the ground surface and evaporate. Some will infiltrate into the soil. Some will run directly off from the ground surface. Depending on total storm rainfall and a variety of other factors, a portion of the water will find its way to the stream system. Of the portion that makes its way to the stream system, there are four types of flow that may occur singly or in combination throughout the watershed. Figure 15–1 illustrates these types of flow.

*Surface flow*—In figure 15–1, point 1 represents a location where precipitation falls on a watershed. Surface runoff is represented by lines with arrows showing travel along the surface of the watershed from point 1 to point 2. Surface flow takes the form of sheet flow, shallow concentrated flow, and/or channel flow.

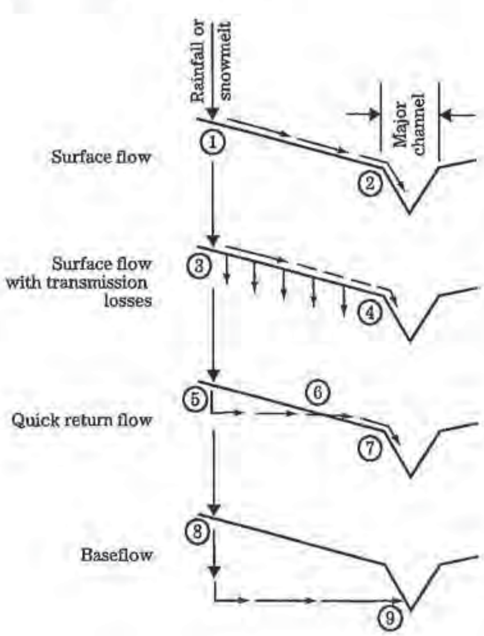
*Surface flow with transmission losses*—In figure 15–1, point 3 represents a location where precipitation falls on a watershed. Surface flow is represented by the lines with arrows showing travel along the surface of the watershed from point 3 to point 4, while the transmission losses are represented by the lines with arrows indicating water infiltrating into the ground surface. In this type of flow, runoff is largely infiltrated into the ground before reaching the stream channel. This type of flow is common in arid, semiarid and subhumid climates, and in karst areas. The distance from point 3 to point 4 depends on the amount of runoff, moisture characteristics of the soil, topography, and hydraulic features of the flow.

*Interflow or quick return flow*—In figure 15–1, point 5 represents a location where precipitation falls on a watershed. Water is infiltrated at this point, flows rapidly underground, and eventually returns to the surface at point 6. From point 6, it continues as surface flow until reaching the stream channel at point 7. This flow appears rapidly in comparison to baseflow and is generally much in excess of normal baseflow. It is common in humid climates and in watersheds with soils having high infiltration capacities and moderate to steep slopes.

*Baseflow*—In figure 15–1, point 8 represents a location where precipitation falls on a watershed, infiltrates directly into the ground, and enters the ground water table. From there, it flows slowly until it eventually reappears, entering a stream channel at point 9. This type of flow has little effect on flood peaks in small watersheds. However, if baseflow is a factor in flood flows, it is usually added to the base of the hydrograph.

In figure 15–1, flows from points 1 to 2, 3 to 4, and 6 to 7 can be measured directly. Flow from points 5 to 6 and 8 to 9 are usually determined indirectly by storm and hydrograph analyses or by field observation of rainfall and runoff. Ground water movement is determined indirectly by analyses of precipitation, soil moisture movements, and evapotranspiration.

**Figure 15–1** Types of flow




## (b) Travel time

Travel time ($T_t$) is the time it takes water to travel from one location to another. Travel time between two points is determined using the following relationship:

$$T_t = \frac{\ell}{3{,}600V} \qquad \text{(eq. 15–1)}$$

where:

$T_t$ = travel time, h

$\ell$ = distance between the two points under consideration, ft

V = average velocity of flow between the two points, ft/s

3,600 = conversion factor, s to h

## (c) Lag

Lag is the delay between the time runoff from a rainfall event over a watershed begins until runoff reaches its maximum peak. Conceptually, lag may be thought of as a weighted time of concentration where, if for a given storm, the watershed is divided into bands of area (fig. 15–2), the travel times from the centroids of the areas to the main watershed outlet may be represented by the following relationship:

$$L = \frac{\sum(a_x Q_x T_{tx})}{\sum(a_x Q_x)} \qquad \text{(eq. 15–2a)}$$

$$L = \frac{\sum(a_x Q_x T_{tx})}{AQ_a} \qquad \text{(eq. 15–2b)}$$

where:

L = lag, h

$a_x$ = increment of watershed area, mi$^2$

$Q_x$ = runoff in inches from area $a_x$, in

$T_{tx}$ = travel time from the centroid of $a_x$ to the point of reference, h

A = total area of the watershed above the point of reference, mi$^2$

$Q_a$ = total runoff, in

In general hydrologic modeling practice, lag is not computed using equation 15–2a or 15–2b. Instead, time of concentration is estimated using one of the methods in this chapter. In cases where only a peak discharge and/or hydrograph are desired at the watershed outlet and watershed characteristics are fairly homogenous, the watershed may be treated as a single area. A time of concentration for that single area is required. A hydrograph is then developed using the methods described in NEH630.16. However, if land use, hydrologic soil group, slope, or other watershed characteristics are not homogeneous throughout the watershed, the approach is to divide the watershed into a number of smaller subareas, which requires a time of concentration estimation for each subarea. Hydrographs are then developed for each subarea by the methods described in NEH630.16 and routed appropriately to a point of reference using the methods described in NEH630.17, Flood Routing.

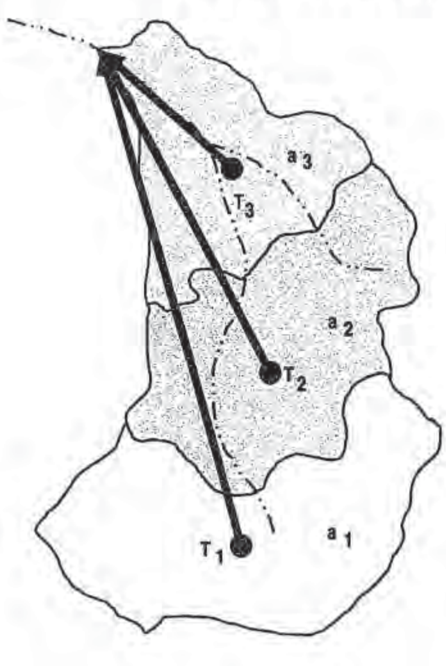
In hydrograph analysis, lag is the time interval between the center of mass of the excess rainfall and the peak runoff rate (fig. 15–3).

## (d) Time of concentration

Time of concentration ($T_c$) is the time required for runoff to travel from the hydraulically most distant point in the watershed to the outlet. The hydraulically most distant point is the point with the longest travel time to the watershed outlet, and not necessarily the point with the longest flow distance to the outlet. Time of concentration is generally applied only to surface runoff and may be computed using many different methods. Time of concentration will vary depending upon slope and character of the watershed and the flow path.

In hydrograph analysis, time of concentration is the time from the end of excess rainfall to the point on the falling limb of the dimensionless unit hydrograph (point of inflection) where the recession curve begins (fig. 15–3).

**Figure 15–2** Conceptual watershed illustrating travel time from the centroid (gray dot) of each band of area to the watershed outlet




## (e) Relation between lag and time of concentration

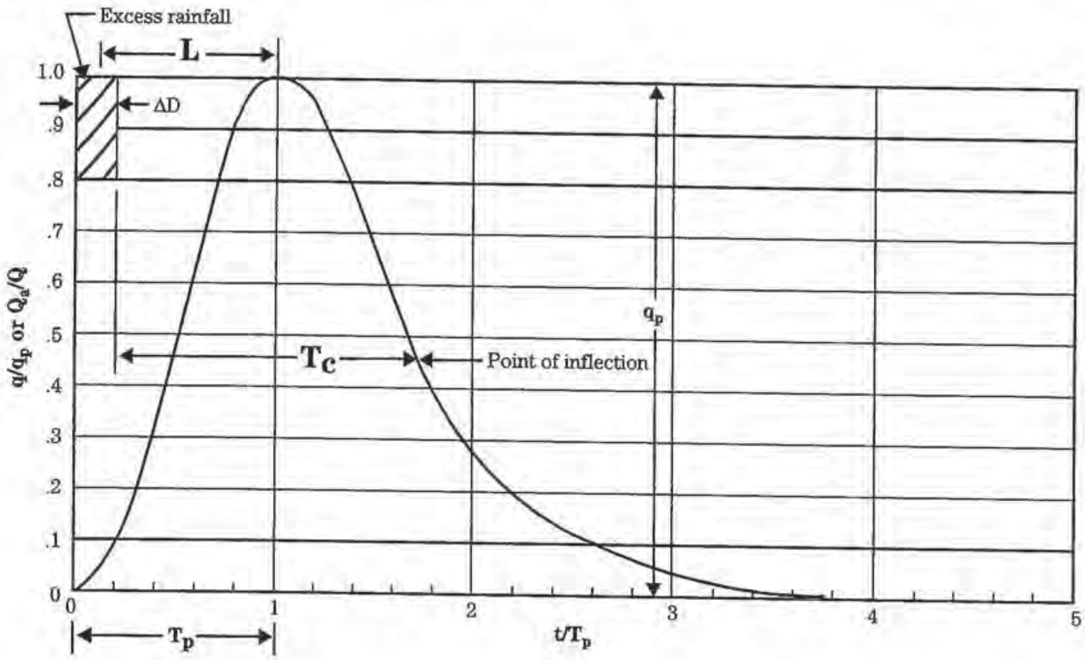
Various researchers (Mockus 1957; Simas 1996) found that for average natural watershed conditions and an approximately uniform distribution of runoff:

$$L = 0.6T_c \quad \text{(eq. 15–3)}$$

where:
L = lag, h
$T_c$ = time of concentration, h

When runoff is not uniformly distributed, the watershed can be subdivided into areas with nearly uniform flow so that equation 15–3 can be applied to each of the subareas.

**Figure 15–3** The relation of time of concentration ($T_c$) and lag (L) to the dimensionless unit hydrograph




where:
L = Lag, h
$T_c$ = time of concentration, h
$T_p$ = time to peak, h
$\Delta D$ = duration of excess rainfall, h
$t/T_p$ = dimensionless ratio of any time to time to peak
q = discharge rate at time t, $ft^3/s$
$q_p$ = peak discharge rate at time $T_p$, $ft^3/s$
$Q_a$ = runoff volume up to t, in
Q = total runoff volume, in

## HEC-HMS Computation Time Interval Guidance

The computation interval or time step for modeling within HEC-HMS can be specified for a range of intervals as follows:

| | | |
|---|---|---|
| Minutes | - | 1, 2, 3, 4, 5, 6, 10, 15, 20, 30 |
| Hours | - | 1, 2, 3, 6, 8, 12, 24 |

Selection of the appropriate computation interval can affect the modeling results with extreme peak discharge differences possible for very large drainage basins. The HEC-HMS (v 4.1) Technical Reference Manual states: "*that for adequate definition of the ordinates on the rising limb of the SCS Unit Hydrograph, a computational interval, Δt, that is less than 29% of* $t_{lag}$*must be used (USACE 1998)".*

Therefore, if basin Lag=0.6 $T_c$, then the maximum computational interval for use within HEC-HMS to adequately define the rising limb of the hydrograph (and often to capture the peak) is given by:

$$\Delta t = 0.29 \text{ x } 0.60\ T_c = 0.17\ T_c. \qquad \textbf{405-2}$$

The following is offered as additional guidance for selecting the minimum model computation interval selection:

1. Generally, the computation interval "*Δt*" should relate to the time of concentration of the smallest subbasin in the model and follow equation **405-2.**
2. Unless the computed "*Δt*" is less than 5 minutes, use 5 minutes or greater for all storm durations particularly for 24 hour or greater duration storms, as there are other compelling reasons for doing so (see 3.)
3. It should be noted that the shortest rainfall interval available from NOAA Atlas 14 is 5 minutes, selecting a shorter computation interval will require HEC-HMS to extrapolate to find a smaller than 5 minute rainfall increment.
4. Note that shorter and more numerous computation intervals do not always result in better answers (accuracy verses precision).

## HEC-HMS Hydrograph Duration Guidance

1. The model simulation duration (the beginning and ending date and time) should be long enough to *capture the entire storm runoff duration*. Review the terminal basin outfall hydrograph to evaluate if the discharge has ceased at zero discharge. If not extend the model duration and simulate again until reaching zero discharge. Duration greater than 24-hours will generally be required for larger basins (greater than 10 square miles) and for models that contain reservoir routings with long detention times.

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT *n*
(Boldface figures are values generally recommended in design)

| Type of channel and description | Minimum | Normal | Maximum |
|---|---|---|---|
| A. CLOSED CONDUITS FLOWING PARTLY FULL | | | |
| A-1. Metal | | | |
| *a*. Brass, smooth | 0.009 | 0.010 | 0.013 |
| *b*. Steel | | | |
| 1. Lockbar and welded | 0.010 | 0.012 | 0.014 |
| 2. Riveted and spiral | 0.013 | 0.016 | 0.017 |
| *c*. Cast iron | | | |
| 1. Coated | 0.010 | 0.013 | 0.014 |
| 2. Uncoated | 0.011 | 0.014 | 0.016 |
| *d*. Wrought iron | | | |
| 1. Black | 0.012 | 0.014 | 0.015 |
| 2. Galvanized | 0.013 | 0.016 | 0.017 |
| *e*. Corrugated metal | | | |
| 1. Subdrain | 0.017 | 0.019 | 0.021 |
| 2. Storm drain | 0.021 | 0.024 | 0.030 |
| A-2. Nonmetal | | | |
| *a*. Lucite | 0.008 | 0.009 | 0.010 |
| *b*. Glass | 0.009 | 0.010 | 0.013 |
| *c*. Cement | | | |
| 1. Neat, surface | 0.010 | 0.011 | 0.013 |
| 2. Mortar | 0.011 | 0.013 | 0.015 |
| *d*. Concrete | | | |
| 1. Culvert, straight and free of debris | 0.010 | 0.011 | 0.013 |
| 2. Culvert with bends, connections, and some debris | 0.011 | 0.013 | 0.014 |
| 3. Finished | 0.011 | 0.012 | 0.014 |
| 4. Sewer with manholes, inlet, etc., straight | 0.013 | 0.015 | 0.017 |
| 5. Unfinished, steel form | 0.012 | 0.013 | 0.014 |
| 6. Unfinished, smooth wood form | 0.012 | 0.014 | 0.016 |
| 7. Unfinished, rough wood form | 0.015 | 0.017 | 0.020 |
| *e*. Wood | | | |
| 1. Stave | 0.010 | 0.012 | 0.014 |
| 2. Laminated, treated | 0.015 | 0.017 | 0.020 |
| *f*. Clay | | | |
| 1. Common drainage tile | 0.011 | 0.013 | 0.017 |
| 2. Vitrified sewer | 0.011 | 0.014 | 0.017 |
| 3. Vitrified sewer with manholes, inlet, etc. | 0.013 | 0.015 | 0.017 |
| 4. Vitrified subdrain with open joint | 0.014 | 0.016 | 0.018 |
| *g*. Brickwork | | | |
| 1. Glazed | 0.011 | 0.013 | 0.015 |
| 2. Lined with cement mortar | 0.012 | 0.015 | 0.017 |
| *h*. Sanitary sewers coated with sewage slimes, with bends and connections | 0.012 | 0.013 | 0.016 |
| *i*. Paved invert, sewer, smooth bottom | 0.016 | 0.019 | 0.020 |
| *j*. Rubble masonry, cemented | 0.018 | 0.025 | 0.030 |

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT *n* (*continued*)

| Type of channel and description | Minimum | Normal | Maximum |
|---|---|---|---|
| B. LINED OR BUILT-UP CHANNELS | | | |
| B-1. Metal | | | |
| *a*. Smooth steel surface | | | |
| 1. Unpainted | 0.011 | 0.012 | 0.014 |
| 2. Painted | 0.012 | 0.013 | 0.017 |
| *b*. Corrugated | 0.021 | 0.025 | 0.030 |
| B-2. Nonmetal | | | |
| *a*. Cement | | | |
| 1. Neat, surface | 0.010 | 0.011 | 0.013 |
| 2. Mortar | 0.011 | 0.013 | 0.015 |
| *b*. Wood | | | |
| 1. Planed, untreated | 0.010 | 0.012 | 0.014 |
| 2. Planed, creosoted | 0.011 | 0.012 | 0.015 |
| 3. Unplaned | 0.011 | 0.013 | 0.015 |
| 4. Plank with battens | 0.012 | 0.015 | 0.018 |
| 5. Lined with roofing paper | 0.010 | 0.014 | 0.017 |
| *c*. Concrete | | | |
| 1. Trowel finish | 0.011 | 0.013 | 0.015 |
| 2. Float finish | 0.013 | 0.015 | 0.016 |
| 3. Finished, with gravel on bottom | 0.015 | 0.017 | 0.020 |
| 4. Unfinished | 0.014 | 0.017 | 0.020 |
| 5. Gunite, good section | 0.016 | 0.019 | 0.023 |
| 6. Gunite, wavy section | 0.018 | 0.022 | 0.025 |
| 7. On good excavated rock | 0.017 | 0.020 | |
| 8. On irregular excavated rock | 0.022 | 0.027 | |
| *d*. Concrete bottom float finished with sides of | | | |
| 1. Dressed stone in mortar | 0.015 | 0.017 | 0.020 |
| 2. Random stone in mortar | 0.017 | 0.020 | 0.024 |
| 3. Cement rubble masonry, plastered | 0.016 | 0.020 | 0.024 |
| 4. Cement rubble masonry | 0.020 | 0.025 | 0.030 |
| 5. Dry rubble or riprap | 0.020 | 0.030 | 0.035 |
| *e*. Gravel bottom with sides of | | | |
| 1. Formed concrete | 0.017 | 0.020 | 0.025 |
| 2. Random stone in mortar | 0.020 | 0.023 | 0.026 |
| 3. Dry rubble or riprap | 0.023 | 0.033 | 0.036 |
| *f*. Brick | | | |
| 1. Glazed | 0.011 | 0.013 | 0.015 |
| 2. In cement mortar | 0.012 | 0.015 | 0.018 |
| *g*. Masonry | | | |
| 1. Cemented rubble | 0.017 | 0.025 | 0.030 |
| 2. Dry rubble | 0.023 | 0.032 | 0.035 |
| *h*. Dressed ashlar | 0.013 | 0.015 | 0.017 |
| *i*. Asphalt | | | |
| 1. Smooth | 0.013 | 0.013 | |
| 2. Rough | 0.016 | 0.016 | |
| *j*. Vegetal lining | 0.030 | ..... | 0.500 |

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT $n$ (*continued*)

| Type of channel and description | Minimum | Normal | Maximum |
|---|---|---|---|
| C. EXCAVATED OR DREDGED | | | |
| *a*. Earth, straight and uniform | | | |
| 1. Clean, recently completed | 0.016 | 0.018 | 0.020 |
| 2. Clean, after weathering | 0.018 | 0.022 | 0.025 |
| 3. Gravel, uniform section, clean | 0.022 | 0.025 | 0.030 |
| 4. With short grass, few weeds | 0.022 | 0.027 | 0.033 |
| *b*. Earth, winding and sluggish | | | |
| 1. No vegetation | 0.023 | 0.025 | 0.030 |
| 2. Grass, some weeds | 0.025 | 0.030 | 0.033 |
| 3. Dense weeds or aquatic plants in deep channels | 0.030 | 0.035 | 0.040 |
| 4. Earth bottom and rubble sides | 0.028 | 0.030 | 0.035 |
| 5. Stony bottom and weedy banks | 0.025 | 0.035 | 0.040 |
| 6. Cobble bottom and clean sides | 0.030 | 0.040 | 0.050 |
| *c*. Dragline-excavated or dredged | | | |
| 1. No vegetation | 0.025 | 0.028 | 0.033 |
| 2. Light brush on banks | 0.035 | 0.050 | 0.060 |
| *d*. Rock cuts | | | |
| 1. Smooth and uniform | 0.025 | 0.035 | 0.040 |
| 2. Jagged and irregular | 0.035 | 0.040 | 0.050 |
| *e*. Channels not maintained, weeds and brush uncut | | | |
| 1. Dense weeds, high as flow depth | 0.050 | 0.080 | 0.120 |
| 2. Clean bottom, brush on sides | 0.040 | 0.050 | 0.080 |
| 3. Same, highest stage of flow | 0.045 | 0.070 | 0.110 |
| 4. Dense brush, high stage | 0.080 | 0.100 | 0.140 |
| D. NATURAL STREAMS | | | |
| D-1. Minor streams (top width at flood stage <100 ft) | | | |
| *a*. Streams on plain | | | |
| 1. Clean, straight, full stage, no rifts or deep pools | 0.025 | 0.030 | 0.033 |
| 2. Same as above, but more stones and weeds | 0.030 | 0.035 | 0.040 |
| 3. Clean, winding, some pools and shoals | 0.033 | 0.040 | 0.045 |
| 4. Same as above, but some weeds and stones | 0.035 | 0.045 | 0.050 |
| 5. Same as above, lower stages, more ineffective slopes and sections | 0.040 | 0.048 | 0.055 |
| 6. Same as 4, but more stones | 0.045 | 0.050 | 0.060 |
| 7. Sluggish reaches, weedy, deep pools | 0.050 | 0.070 | 0.080 |
| 8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush | 0.075 | 0.100 | 0.150 |

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT $n$ (*continued*)

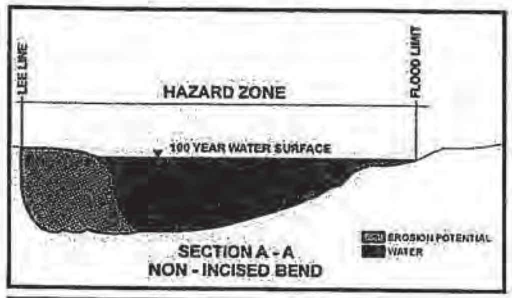
| Type of channel and description | Minimum | Normal | Maximum |
|---|---|---|---|
| *b.* Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages | | | |
| 1. Bottom: gravels, cobbles, and few boulders | 0.030 | 0.040 | 0.050 |
| 2. Bottom: cobbles with large boulders | 0.040 | 0.050 | 0.070 |
| D-2. Flood plains | | | |
| *a.* Pasture, no brush | | | |
| 1. Short grass | 0.025 | 0.030 | 0.035 |
| 2. High grass | 0.030 | 0.035 | 0.050 |
| *b.* Cultivated areas | | | |
| 1. No crop | 0.020 | 0.030 | 0.040 |
| 2. Mature row crops | 0.025 | 0.035 | 0.045 |
| 3. Mature field crops | 0.030 | 0.040 | 0.050 |
| *c.* Brush | | | |
| 1. Scattered brush, heavy weeds | 0.035 | 0.050 | 0.070 |
| 2. Light brush and trees, in winter | 0.035 | 0.050 | 0.060 |
| 3. Light brush and trees, in summer | 0.040 | 0.060 | 0.080 |
| 4. Medium to dense brush, in winter | 0.045 | 0.070 | 0.110 |
| 5. Medium to dense brush, in summer | 0.070 | 0.100 | 0.160 |
| *d.* Trees | | | |
| 1. Dense willows, summer, straight | 0.110 | 0.150 | 0.200 |
| 2. Cleared land with tree stumps, no sprouts | 0.030 | 0.040 | 0.050 |
| 3. Same as above, but with heavy growth of sprouts | 0.050 | 0.060 | 0.080 |
| 4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches | 0.080 | 0.100 | 0.120 |
| 5. Same as above, but with flood stage reaching branches | 0.100 | 0.120 | 0.160 |
| D-3. Major streams (top width at flood stage >100 ft). The $n$ value is less than that for minor streams of similar description, because banks offer less effective resistance. | | | |
| *a.* Regular section with no boulders or brush | 0.025 | ..... | 0.060 |
| *b.* Irregular and rough section | 0.035 | ..... | 0.100 |

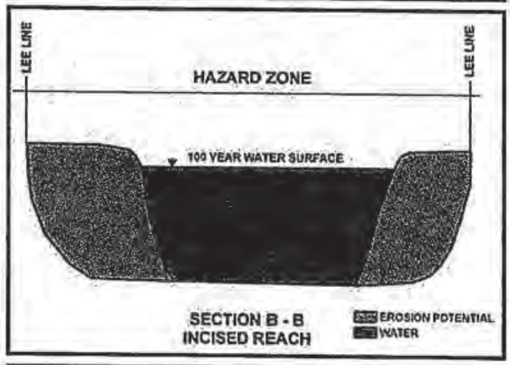
**Table 10–1** Curve numbers (CN) and constants for the case $I_a = 0.2S$

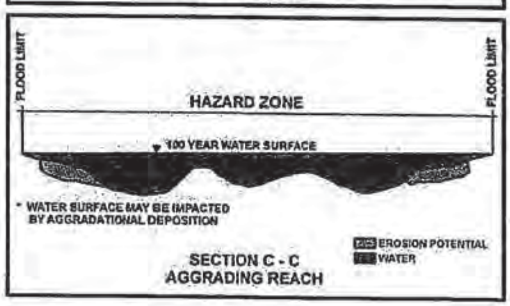
| 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| CN for ARC II | - - CN for ARC - - I | III | S values* (in) | Curve* starts where P = (in) | CN for ARC II | - - CN for ARC - - I | III | S values* (in) | Curve* starts where P = (in) |
| 100 | 100 | 100 | 0 | 0 | 60 | 40 | 78 | 6.67 | 1.33 |
| 99 | 97 | 100 | .101 | .02 | 59 | 39 | 77 | 6.95 | 1.39 |
| 98 | 94 | 99 | .204 | .04 | 58 | 38 | 76 | 7.24 | 1.45 |
| 97 | 91 | 99 | .309 | .06 | 57 | 37 | 75 | 7.54 | 1.51 |
| 96 | 89 | 99 | .417 | .08 | 56 | 36 | 75 | 7.86 | 1.57 |
| 95 | 87 | 98 | .526 | .11 | 55 | 35 | 74 | 8.18 | 1.64 |
| 94 | 85 | 98 | .638 | .13 | 54 | 34 | 73 | 8.52 | 1.70 |
| 93 | 83 | 98 | .753 | .15 | 53 | 33 | 72 | 8.87 | 1.77 |
| 92 | 81 | 97 | .870 | .17 | 52 | 32 | 71 | 9.23 | 1.85 |
| 91 | 80 | 97 | .989 | .20 | 51 | 31 | 70 | 9.61 | 1.92 |
| 90 | 78 | 96 | 1.11 | .22 | 50 | 31 | 70 | 10.0 | 2.00 |
| 89 | 76 | 96 | 1.24 | .25 | 49 | 30 | 69 | 10.4 | 2.08 |
| 88 | 75 | 95 | 1.36 | .27 | 48 | 29 | 68 | 10.8 | 2.16 |
| 87 | 73 | 95 | 1.49 | .30 | 47 | 28 | 67 | 11.3 | 2.26 |
| 86 | 72 | 94 | 1.63 | .33 | 46 | 27 | 66 | 11.7 | 2.34 |
| 85 | 70 | 94 | 1.76 | .35 | 45 | 26 | 65 | 12.2 | 2.44 |
| 84 | 68 | 93 | 1.90 | .38 | 44 | 25 | 64 | 12.7 | 2.54 |
| 83 | 67 | 93 | 2.05 | .41 | 43 | 25 | 63 | 13.2 | 2.64 |
| 82 | 66 | 92 | 2.20 | .44 | 42 | 24 | 62 | 13.8 | 2.76 |
| 81 | 64 | 92 | 2.34 | .47 | 41 | 23 | 61 | 14.4 | 2.88 |
| 80 | 63 | 91 | 2.50 | .50 | 40 | 22 | 60 | 15.0 | 3.00 |
| 79 | 62 | 91 | 2.66 | .53 | 39 | 21 | 59 | 15.6 | 3.12 |
| 78 | 60 | 90 | 2.82 | .56 | 38 | 21 | 58 | 16.3 | 3.26 |
| 77 | 59 | 89 | 2.99 | .60 | 37 | 20 | 57 | 17.0 | 3.40 |
| 76 | 58 | 89 | 3.16 | .63 | 36 | 19 | 56 | 17.8 | 3.56 |
| 75 | 57 | 88 | 3.33 | .67 | 35 | 18 | 55 | 18.6 | 3.72 |
| 74 | 55 | 88 | 3.51 | .70 | 34 | 18 | 54 | 19.4 | 3.88 |
| 73 | 54 | 87 | 3.70 | .74 | 33 | 17 | 53 | 20.3 | 4.06 |
| 72 | 53 | 86 | 3.89 | .78 | 32 | 16 | 52 | 21.2 | 4.24 |
| 71 | 52 | 86 | 4.08 | .82 | 31 | 16 | 51 | 22.2 | 4.44 |
| 70 | 51 | 85 | 4.28 | .86 | 30 | 15 | 50 | 23.3 | 4.66 |
| 69 | 50 | 84 | 4.49 | .90 | 25 | 12 | 43 | 30.0 | 6.00 |
| 68 | 48 | 84 | 4.70 | .94 | 20 | 9 | 37 | 40.0 | 8.00 |
| 67 | 47 | 83 | 4.92 | .98 | 15 | 6 | 30 | 56.7 | 11.34 |
| 66 | 46 | 82 | 5.15 | 1.03 | 10 | 4 | 22 | 90.0 | 18.00 |
| 65 | 45 | 82 | 5.38 | 1.08 | 5 | 2 | 13 | 190.0 | 38.00 |
| 64 | 44 | 81 | 5.62 | 1.12 | 0 | 0 | 0 | infinity | infinity |
| 63 | 43 | 80 | 5.87 | 1.17 | | | | | |
| 62 | 42 | 79 | 6.13 | 1.23 | | | | | |
| 61 | 41 | 78 | 6.39 | 1.28 | | | | | |

* For CN in column 1.

# SEDIMENT AND EROSION DESIGN GUIDE




Prepared for **Southern Sandoval County Arroyo Flood Control Authority**
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relatively low wash-load concentrations. Results from this equation are often in the lower range of realistic values. Because they are simple and have a history of successful use in the greater Albuquerque area, these equations are described in more detail in **Appendix C.**

### 3.3.6. Bulking Factors for the SSCAFCA Area

Discharges estimated using standard rainfall-runoff procedures typically do not account for the presence of sediment in the flow. At high sediment loads, the total volume of the water/sediment mixture, and thus, the peak design discharges, can be substantially higher than the corresponding clear-water values. The following relation provides a means of adjusting the clear-water discharges for the presence of the transported sediment if the sediment load is known:

$$B_f = \frac{Q + Q_{S_{total}}}{Q} = \frac{1}{1 - \dfrac{C_s / 10^6}{S_g - \left(C_s / 10^6\right)\left(S_g - 1\right)}} \tag{3.24}$$

where $B_f$ = bulking factor,
$Q$ = clear-water discharge,
$Q_{s\,total}$ = **total** sediment load (i.e., combination of bed material and wash load),
$C_s$ = **total** sediment concentration by weight, and
$S_g$ = specific gravity of the sediment.

This relationship indicates that the bulked discharge for a water/sediment mixture at the upper limit of concentrations for water floods (200,000 ppm by volume or 410,000 ppm by weight) would be about 25 percent greater than the clear water discharge (i.e., a bulking factor of 1.25) (**Figure 3.8**).

Because specific knowledge of the sediment load is often not available, conservative estimates of the bulking factor that can be applied to a range of potential design discharges were made by applying the MPM-Woo procedure for a typical, rectangular cross section with width-depth ratio ($F_D$) at the dominant discharge ($Q_D$) of 40, assuming critical flow conditions and a range of median ($D_{50}$) particle sizes. (Dominant discharge is defined, and a method for estimating its magnitude is provided in the text box on the next page.) The assumed width-depth ratio (F) of 40 is based on data from a variety of existing, naturally adjusted arroyos (Leopold and Miller, 1956; Harvey et al., 1985). The assumption of critical flow is based on the observation that average Froude Numbers ($F_r$) in stable sand-bed streams rarely exceed 0.7 to 1.0 (Richardson, personal communication) at high discharges. It should also be noted that current FEMA procedures for evaluating hydraulic conditions on alluvial fans is based on the assumption of critical flow ($F_r$ = 1). Based on analysis of a wide range of arroyos in the greater Rio Rancho and Albuquerque area, the dominant discharge typically has a recurrence interval in the range of 5 to 10 years under relatively undeveloped conditions, and this decreases to 3 to 5 years under highly developed conditions due, primarily, to the increase in runoff during frequently occurring storms. The peak discharge associated with other recurrence interval flows was estimated using average ratios for conditions in the greater Rio Rancho and Albuquerque area. The 100-year peak discharge, for example, averages about five times the dominant discharge. Bulking factors estimated using the above assumptions for the 100-year peak are shown in **Figure 3.9** for channels with dominant discharge ranging from 50 to 1,000 cfs and median ($D_{50}$) bed-material sizes ranging from 0.5 to 4 mm. As shown in the figure, the bulking factors range from about 1.01 for small arroyos ($W_d$< = 50 cfs) with relatively coarse bed material ($D_{50}$ = 4 mm) to a maximum of 1.19 for larger channels ($Q_D$> = 500 cfs) and relatively fine bed material ($D_{50}$ <= 0.5 mm). Estimated bulking factors for other recurrence interval events for the same range of channel and median bed-material sizes are provided in **Table 3.6**.

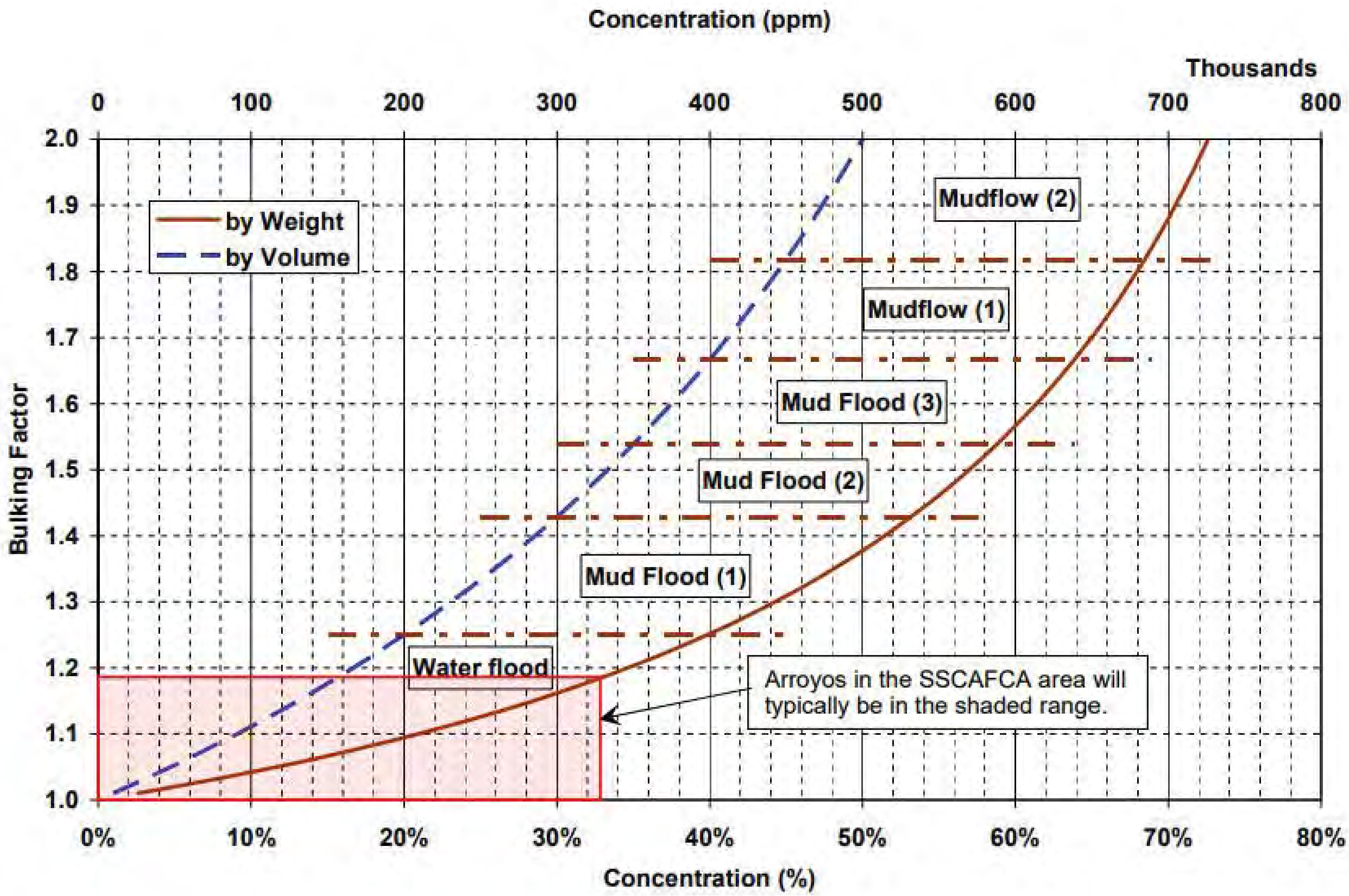



Figure 3.8. Relationship between total sediment concentration and bulking factor.

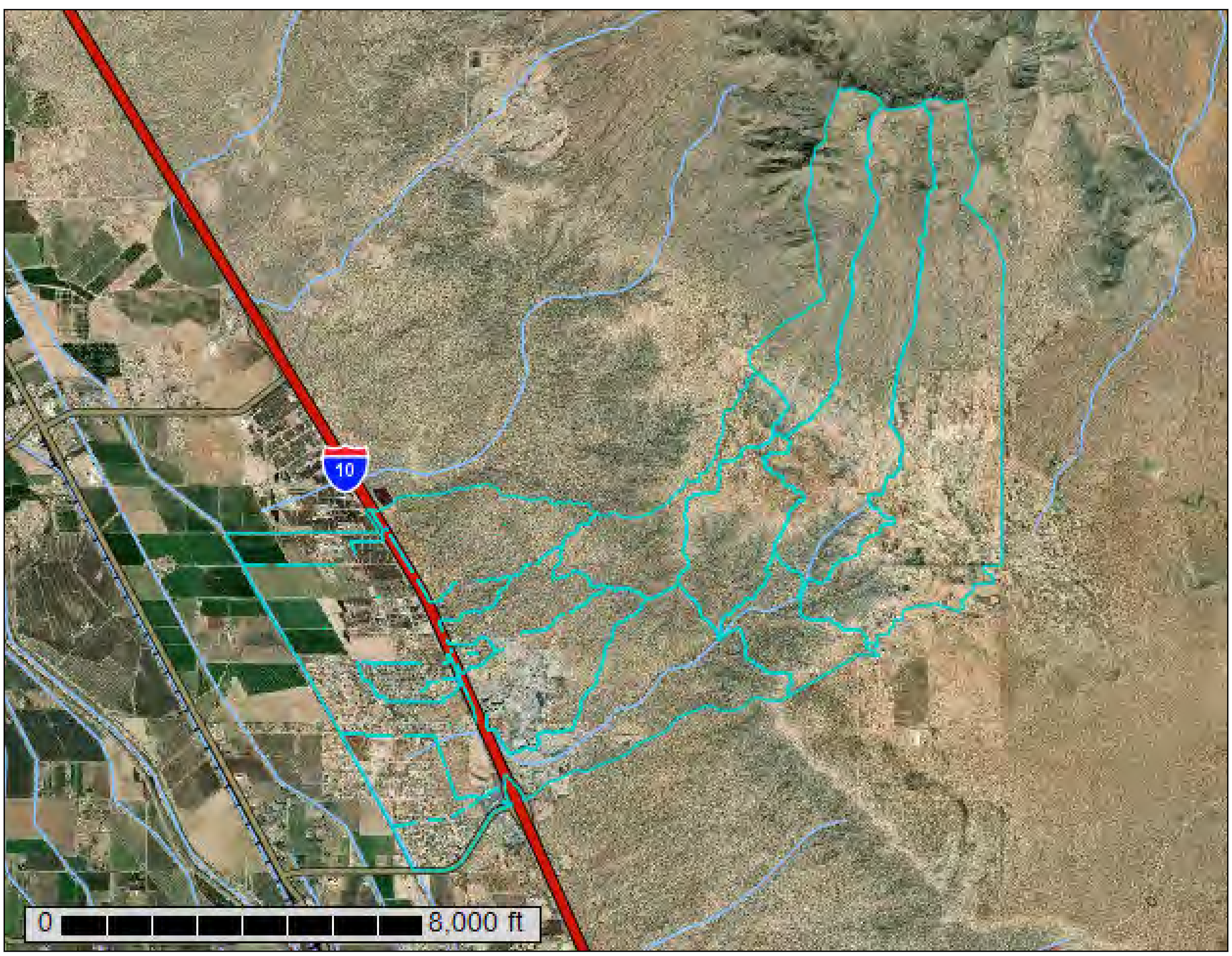
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

# Custom Soil Resource Report for Dona Ana County Area, New Mexico, and Fort Bliss Military Reservation, New Mexico and Texas




March 27, 2019

# Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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# Contents

# How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

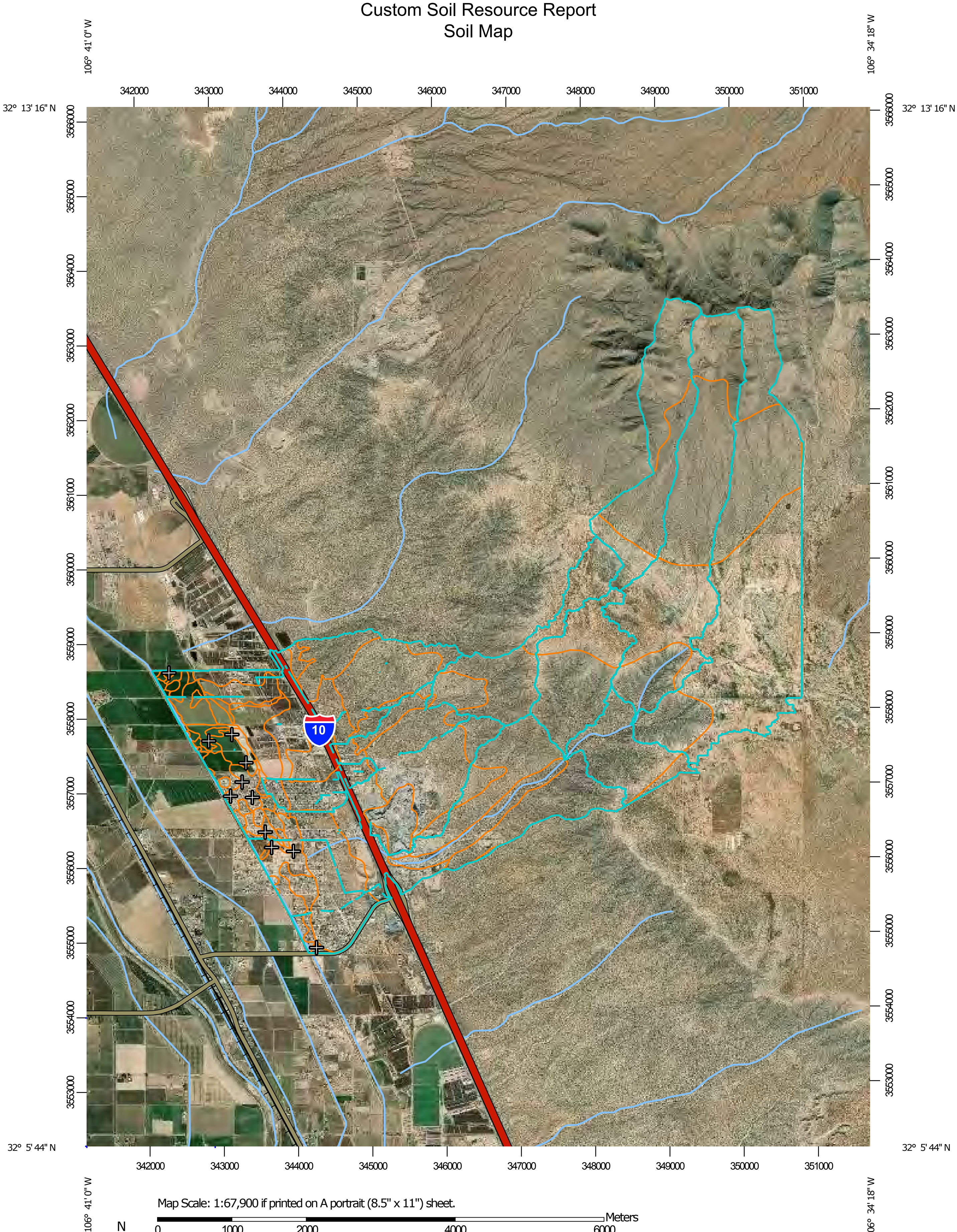
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

# Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map




Map Scale: 1:67,900 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 1000, 2000, 4000, 6000

Feet: 0, 3000, 6000, 12000, 18000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

## MAP LEGEND

**Area of Interest (AOI)**

Area of Interest (AOI)

**Soils**

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

**Special Point Features**

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

**Water Features**

Streams and Canals

**Transportation**

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

**Background**

Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Dona Ana County Area, New Mexico
Survey Area Data: Version 14, Sep 12, 2018

Soil Survey Area: Fort Bliss Military Reservation, New Mexico and Texas
Survey Area Data: Version 14, Sep 12, 2018

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 30, 2015—Dec 8, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

| MAP LEGEND | MAP INFORMATION |
| --- | --- |
| | imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident. |

# Map Unit Legend

| Map Unit Symbol | Map Unit Name | Acres in AOI | Percent of AOI |
|---|---|---|---|
| Ag | Agua silt loam, 0 to 2 percent slopes | 2.6 | 0.0% |
| Ap | Anthony-Vinton fine sandy loams | 11.1 | 0.1% |
| Ar | Anthony-Vinton loams, 0 to 1 percent slopes | 9.4 | 0.1% |
| Aw | Armijo clay loam | 70.4 | 0.9% |
| Bg | Belen clay | 31.3 | 0.4% |
| BK | Berino-Dona Ana association | 1,646.0 | 21.3% |
| Bm | Bluepoint loamy sand, 0 to 5 percent slopes | 598.3 | 7.7% |
| Bn | Bluepoint loamy sand, 5 to 15 percent slopes MLRA 42 | 387.2 | 5.0% |
| BO | Bluepoint loamy sand, 1 to 15 percent slopes MLRA 42 | 726.6 | 9.4% |
| BP | Bluepoint-Caliza-Yturbide complex | 1,803.2 | 23.3% |
| Bs | Brazito very fine sandy loam, thick surface | 12.3 | 0.2% |
| Cb | Canutio and Arizo gravelly sandy loams MLRA 42 | 28.4 | 0.4% |
| Ge | Glendale loam | 52.8 | 0.7% |
| Gf | Glendale clay loam, 0 to 1 percent slopes | 8.7 | 0.1% |
| Gg | Glendale clay loam, alkali | 130.0 | 1.7% |
| Hg | Harkey loam | 27.2 | 0.4% |
| Hh | Harkey loam, saline-alkali | 174.1 | 2.3% |
| Hk | Harkey clay loam | 4.7 | 0.1% |
| Pa | Pajarito fine sandy loam | 204.5 | 2.6% |
| RF | Riverwash-Arizo complex | 125.9 | 1.6% |
| RL | Rock outcrop-Lozier association | 672.8 | 8.7% |
| TE | Tencee-Upton association | 999.2 | 12.9% |
| **Subtotals for Soil Survey Area** | | **7,726.7** | **100.0%** |
| **Totals for Area of Interest** | | **7,729.0** | **100.0%** |

| Map Unit Symbol | Map Unit Name | Acres in AOI | Percent of AOI |
|---|---|---|---|
| 12 | Infantry-Sonic complex, 3 to 10 percent slopes | 1.5 | 0.0% |
| 28 | Crossen-Tinney complex, 1 to 3 percent slopes | 0.0 | 0.0% |

| Map Unit Symbol | Map Unit Name | Acres in AOI | Percent of AOI |
|---|---|---|---|
| 29 | Tinney loam, 1 to 3 percent slopes | 0.0 | 0.0% |
| **Subtotals for Soil Survey Area** | | **1.6** | **0.0%** |
| **Totals for Area of Interest** | | **7,729.0** | **100.0%** |

# Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

# Dona Ana County Area, New Mexico

## Ag—Agua silt loam, 0 to 2 percent slopes

### Map Unit Setting

*National map unit symbol:* 2sq27
*Elevation:* 3,740 to 4,470 feet
*Mean annual precipitation:* 6 to 12 inches
*Mean annual air temperature:* 64 to 70 degrees F
*Frost-free period:* 180 to 240 days
*Farmland classification:* Farmland of statewide importance

### Map Unit Composition

*Agua and similar soils:* 85 percent
*Minor components:* 15 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Agua

#### Setting

*Landform:* Flood plains
*Landform position (two-dimensional):* Toeslope
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Loamy alluvium over sandy alluvium

#### Typical profile

*Ap - 0 to 12 inches:* silt loam
*C1 - 12 to 23 inches:* silt loam
*2C2 - 23 to 66 inches:* fine sand

#### Properties and qualities

*Slope:* 0 to 2 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Very low
*Capacity of the most limiting layer to transmit water (Ksat):* High (1.98 to 5.95 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Gypsum, maximum in profile:* 2 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 2.0
*Available water storage in profile:* Moderate (about 6.2 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 2s
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* A
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

**Minor Components**

**Brazito**

*Percent of map unit:* 3 percent
*Landform:* Flood plains
*Landform position (two-dimensional):* Toeslope
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Hydric soil rating:* No

**Harkey**

*Percent of map unit:* 3 percent
*Landform:* Flood plains
*Landform position (two-dimensional):* Toeslope
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Hydric soil rating:* No

**Vinton**

*Percent of map unit:* 3 percent
*Landform:* Flood plains
*Landform position (two-dimensional):* Toeslope
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Hydric soil rating:* No

**Agua**

*Percent of map unit:* 3 percent
*Landform:* Flood plains
*Landform position (two-dimensional):* Toeslope
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Hydric soil rating:* No

**Anthony**

*Percent of map unit:* 3 percent
*Landform:* Flood plains
*Landform position (two-dimensional):* Toeslope
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Hydric soil rating:* No

## Ap—Anthony-Vinton fine sandy loams

### Map Unit Setting

*National map unit symbol:* p991
*Elevation:* 1,100 to 5,000 feet
*Mean annual precipitation:* 7 to 12 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 165 to 275 days
*Farmland classification:* Farmland of statewide importance

### Map Unit Composition

*Anthony and similar soils:* 45 percent
*Vinton and similar soils:* 30 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Anthony

#### Setting

*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed stratified coarse-loamy alluvium

#### Typical profile

*H1 - 0 to 18 inches:* fine sandy loam
*H2 - 18 to 38 inches:* fine sandy loam
*H3 - 38 to 60 inches:* loamy very fine sand

#### Properties and qualities

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Negligible
*Capacity of the most limiting layer to transmit water (Ksat):* High (1.98 to 5.95 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Salinity, maximum in profile:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Moderate (about 7.8 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 2e
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* A
*Ecological site:* Sandy (R042XB012NM)
*Hydric soil rating:* No

### Description of Vinton

#### Setting

*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed sandy alluvium

#### Typical profile

*H1 - 0 to 13 inches:* fine sandy loam
*H2 - 13 to 41 inches:* loamy fine sand
*H3 - 41 to 60 inches:* very fine sandy loam

#### Properties and qualities

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Negligible
*Capacity of the most limiting layer to transmit water (Ksat):* High (1.98 to 5.95 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Moderate (about 6.7 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 2e
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* A
*Ecological site:* Sandy (R042XB012NM)
*Hydric soil rating:* No

### Minor Components

#### Vinton

*Percent of map unit:*
*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

#### Anthony

*Percent of map unit:*
*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

#### Agua

*Percent of map unit:*
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

## Ar—Anthony-Vinton loams, 0 to 1 percent slopes

**Map Unit Setting**

*National map unit symbol:* 2tm52
*Elevation:* 3,740 to 4,980 feet
*Mean annual precipitation:* 8 to 10 inches
*Mean annual air temperature:* 57 to 64 degrees F
*Frost-free period:* 180 to 220 days
*Farmland classification:* Farmland of statewide importance

**Map Unit Composition**

*Anthony and similar soils:* 50 percent
*Vinton and similar soils:* 30 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Anthony**

**Setting**

*Landform:* Flood plains
*Landform position (two-dimensional):* Toeslope
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed alluvium

**Typical profile**

*Ap1 - 0 to 9 inches:* loam
*Ap2 - 9 to 17 inches:* loam
*C1 - 17 to 39 inches:* fine sandy loam
*C2 - 39 to 60 inches:* loamy fine sand

**Properties and qualities**

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Low
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.57 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Gypsum, maximum in profile:* 2 percent
*Salinity, maximum in profile:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 2.0
*Available water storage in profile:* Moderate (about 7.4 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 2s

*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* C
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

**Description of Vinton**

**Setting**

*Landform:* Flood plains
*Landform position (two-dimensional):* Toeslope
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed alluvium

**Typical profile**

*Ap - 0 to 14 inches:* silt loam
*C1 - 14 to 22 inches:* fine sand
*C2 - 22 to 45 inches:* loamy fine sand
*C3 - 45 to 50 inches:* fine sand
*C4 - 50 to 60 inches:* loamy sand

**Properties and qualities**

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Somewhat excessively drained
*Runoff class:* Very low
*Capacity of the most limiting layer to transmit water (Ksat):* High (1.98 to 5.95 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 4 percent
*Gypsum, maximum in profile:* 2 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 2.0
*Available water storage in profile:* Moderate (about 6.3 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 3s
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* A
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

**Minor Components**

**Agua**

*Percent of map unit:*
*Hydric soil rating:* No

**Harkey**

*Percent of map unit:*

## Aw—Armijo clay loam

### Map Unit Setting

*National map unit symbol:* p995
*Elevation:* 1,800 to 5,500 feet
*Mean annual precipitation:* 8 to 14 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 180 to 275 days
*Farmland classification:* Farmland of statewide importance

### Map Unit Composition

*Armijo and similar soils:* 85 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Armijo

#### Setting

*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Clayey alluvium

#### Typical profile

*H1 - 0 to 15 inches:* clay loam
*H2 - 15 to 42 inches:* clay
*H3 - 42 to 60 inches:* very fine sandy loam

#### Properties and qualities

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* High
*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately low (0.00 to 0.06 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Salinity, maximum in profile:* Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 16.0
*Available water storage in profile:* Moderate (about 8.1 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 4s
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* D
*Ecological site:* Loamy (R042XA052NM)

*Hydric soil rating:* No

### Minor Components

#### Armijo

*Percent of map unit:*
*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Ecological site:* Bottomland (R042XA057NM)
*Hydric soil rating:* No

#### Anapra

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

#### Belen

*Percent of map unit:*
*Ecological site:* Clayey (R042XB023NM)
*Hydric soil rating:* No

#### Glendale

*Percent of map unit:*
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

## Bg—Belen clay

### Map Unit Setting

*National map unit symbol:* p999
*Elevation:* 1,800 to 5,500 feet
*Mean annual precipitation:* 8 to 14 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 180 to 275 days
*Farmland classification:* Farmland of statewide importance

### Map Unit Composition

*Belen and similar soils:* 85 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Belen

#### Setting

*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed clayey alluvium over mixed loamy alluvium

#### Typical profile

*H1 - 0 to 11 inches:* clay
*H2 - 11 to 30 inches:* clay

*H3 - 30 to 60 inches:* very fine sandy loam

**Properties and qualities**

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* High
*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately low (0.00 to 0.06 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Salinity, maximum in profile:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 13.0
*Available water storage in profile:* Moderate (about 7.4 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 3s
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* D
*Ecological site:* Clayey (R042XB023NM)
*Hydric soil rating:* No

### Minor Components

**Belen**

*Percent of map unit:*
*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Ecological site:* Clayey (R042XB023NM)
*Hydric soil rating:* No

**Anapra**

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Glendale**

*Percent of map unit:*
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

**Armijo**

*Percent of map unit:*
*Ecological site:* Loamy (R042XA052NM)
*Hydric soil rating:* No

## BK—Berino-Dona Ana association

### Map Unit Setting

*National map unit symbol:* p99d

*Elevation:* 1,500 to 5,500 feet
*Mean annual precipitation:* 7 to 17 inches
*Mean annual air temperature:* 60 to 64 degrees F
*Frost-free period:* 180 to 240 days
*Farmland classification:* Farmland of statewide importance

**Map Unit Composition**

*Berino and similar soils:* 50 percent
*Dona ana and similar soils:* 30 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Berino**

**Setting**

*Landform:* Alluvial fans
*Landform position (three-dimensional):* Rise
*Down-slope shape:* Linear
*Across-slope shape:* Convex
*Parent material:* Mixed fine-loamy alluvium

**Typical profile**

*H1 - 0 to 5 inches:* fine sandy loam
*H2 - 5 to 60 inches:* sandy clay loam

**Properties and qualities**

*Slope:* 1 to 5 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Low
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.60 to 2.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 40 percent
*Salinity, maximum in profile:* Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Moderate (about 8.8 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 3e
*Land capability classification (nonirrigated):* 7e
*Hydrologic Soil Group:* B
*Ecological site:* Sandy (R042XB012NM)
*Hydric soil rating:* No

**Description of Dona Ana**

**Setting**

*Landform:* Alluvial fans
*Landform position (three-dimensional):* Rise
*Down-slope shape:* Linear
*Across-slope shape:* Convex
*Parent material:* Mixed sedimentary fine-loamy alluvium

**Typical profile**

*H1 - 0 to 8 inches:* fine sandy loam
*H2 - 8 to 22 inches:* sandy clay loam
*H3 - 22 to 60 inches:* sandy clay loam

**Properties and qualities**

*Slope:* 1 to 5 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Low
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.60 to 2.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 40 percent
*Salinity, maximum in profile:* Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Moderate (about 8.7 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 2e
*Land capability classification (nonirrigated):* 7e
*Hydrologic Soil Group:* B
*Ecological site:* Sandy (R042XB012NM)
*Hydric soil rating:* No

### Minor Components

**Bucklebar**

*Percent of map unit:*
*Ecological site:* Sandy (R042XB012NM)
*Hydric soil rating:* No

**Simona**

*Percent of map unit:*
*Ecological site:* Shallow Sandy (R042XB015NM)
*Hydric soil rating:* No

**Cacique**

*Percent of map unit:*
*Ecological site:* Sandy (R042XB012NM)
*Hydric soil rating:* No

**Reagan**

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Stellar**

*Percent of map unit:*
*Ecological site:* Clayey (R042XB023NM)
*Hydric soil rating:* No

## Bm—Bluepoint loamy sand, 0 to 5 percent slopes

**Map Unit Setting**

*National map unit symbol:* 2sy16
*Elevation:* 3,720 to 4,420 feet
*Mean annual precipitation:* 6 to 12 inches
*Mean annual air temperature:* 64 to 75 degrees F
*Frost-free period:* 180 to 240 days
*Farmland classification:* Farmland of statewide importance

**Map Unit Composition**

*Bluepoint and similar soils:* 85 percent
*Minor components:* 15 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Bluepoint**

**Setting**

*Landform:* Stream terraces
*Landform position (two-dimensional):* Toeslope
*Landform position (three-dimensional):* Riser
*Down-slope shape:* Linear
*Across-slope shape:* Convex
*Parent material:* Sandy alluvium

**Typical profile**

*A - 0 to 3 inches:* loamy sand
*C1 - 3 to 15 inches:* loamy sand
*C2 - 15 to 24 inches:* loamy fine sand
*C3 - 24 to 31 inches:* loamy fine sand
*C4 - 31 to 39 inches:* loamy fine sand
*C5 - 39 to 55 inches:* loamy fine sand
*C6 - 55 to 79 inches:* loamy sand

**Properties and qualities**

*Slope:* 0 to 5 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Somewhat excessively drained
*Runoff class:* Very low
*Capacity of the most limiting layer to transmit water (Ksat):* High to very high (5.95 to 19.98 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 4 percent
*Gypsum, maximum in profile:* 2 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

*Sodium adsorption ratio, maximum in profile:* 2.0
*Available water storage in profile:* Low (about 5.2 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 3s
*Land capability classification (nonirrigated):* 7c
*Hydrologic Soil Group:* A
*Ecological site:* Deep Sand (R042XB011NM)
*Hydric soil rating:* No

**Minor Components**

**Riverwash**

*Percent of map unit:* 3 percent
*Landform:* Channels
*Hydric soil rating:* No

**Canutio**

*Percent of map unit:* 3 percent
*Hydric soil rating:* No

**Arizo**

*Percent of map unit:* 3 percent
*Hydric soil rating:* No

**Caliza**

*Percent of map unit:* 3 percent
*Hydric soil rating:* No

**Mimbres**

*Percent of map unit:* 2 percent
*Hydric soil rating:* No

**Hondale**

*Percent of map unit:* 1 percent
*Hydric soil rating:* No

## Bn—Bluepoint loamy sand, 5 to 15 percent slopes MLRA 42

**Map Unit Setting**

*National map unit symbol:* 2spsf
*Elevation:* 2,500 to 5,200 feet
*Mean annual precipitation:* 4 to 12 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 180 to 260 days
*Farmland classification:* Not prime farmland

**Map Unit Composition**

*Bluepoint and similar soils:* 75 percent
*Minor components:* 1 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Bluepoint

#### Setting

*Landform:* Alluvial fans, valley sides
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Convex, concave
*Across-slope shape:* Convex, linear
*Parent material:* Wind-modified sandy alluvium

#### Typical profile

*H1 - 0 to 18 inches:* loamy sand
*H2 - 18 to 60 inches:* loamy fine sand

#### Properties and qualities

*Slope:* 5 to 15 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Somewhat excessively drained
*Runoff class:* Very low
*Capacity of the most limiting layer to transmit water (Ksat):* High to very high (6.00 to 20.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 5 percent
*Salinity, maximum in profile:* Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 13.0
*Available water storage in profile:* Low (about 4.8 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 4e
*Land capability classification (nonirrigated):* 6e
*Hydrologic Soil Group:* A
*Ecological site:* Deep Sand (R042XB011NM)
*Hydric soil rating:* No

### Minor Components

#### Riverwash

*Percent of map unit:* 1 percent
*Landform:* Drainageways
*Landform position (three-dimensional):* Tread, talf
*Down-slope shape:* Linear
*Across-slope shape:* Concave
*Hydric soil rating:* No

#### Canutio

*Percent of map unit:*
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

#### Bluepoint hummocky

*Percent of map unit:*
*Ecological site:* Deep Sand (R042XB011NM)
*Hydric soil rating:* No

**Caliza**

*Percent of map unit:*
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

**Arizo**

*Percent of map unit:*
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

## BO—Bluepoint loamy sand, 1 to 15 percent slopes MLRA 42

### Map Unit Setting

*National map unit symbol:* 2spsg
*Elevation:* 2,500 to 5,000 feet
*Mean annual precipitation:* 4 to 12 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 180 to 260 days
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Bluepoint and similar soils:* 75 percent
*Minor components:* 1 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Bluepoint

**Setting**

*Landform:* Valley sides, alluvial fans
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Concave, convex
*Across-slope shape:* Linear, convex
*Parent material:* Wind-modified sandy alluvium

**Typical profile**

*H1 - 0 to 17 inches:* loamy sand
*H2 - 17 to 60 inches:* loamy sand

**Properties and qualities**

*Slope:* 1 to 15 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Somewhat excessively drained
*Runoff class:* Very low
*Capacity of the most limiting layer to transmit water (Ksat):* High to very high (6.00 to 20.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 5 percent

*Salinity, maximum in profile:* Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 13.0
*Available water storage in profile:* Low (about 4.8 inches)

**Interpretive groups**
*Land capability classification (irrigated):* 4e
*Land capability classification (nonirrigated):* 6e
*Hydrologic Soil Group:* A
*Ecological site:* Deep Sand (R042XB011NM)
*Hydric soil rating:* No

**Minor Components**

**Riverwash**
*Percent of map unit:* 1 percent
*Landform:* Drainageways
*Landform position (three-dimensional):* Tread
*Down-slope shape:* Linear
*Across-slope shape:* Concave
*Hydric soil rating:* No

**Caliza**
*Percent of map unit:*
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

**Arizo**
*Percent of map unit:*
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

**Canutio**
*Percent of map unit:*
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

## BP—Bluepoint-Caliza-Yturbide complex

**Map Unit Setting**
*National map unit symbol:* p99k
*Elevation:* 2,400 to 6,000 feet
*Mean annual precipitation:* 4 to 12 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 180 to 260 days
*Farmland classification:* Not prime farmland

**Map Unit Composition**
*Bluepoint and similar soils:* 25 percent
*Caliza and similar soils:* 25 percent
*Yturbide and similar soils:* 20 percent

*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Bluepoint

#### Setting

*Landform:* Alluvial fans, valley sides
*Landform position (three-dimensional):* Rise
*Down-slope shape:* Convex, concave
*Across-slope shape:* Convex, linear
*Parent material:* Wind-modified sandy alluvium

#### Typical profile

*H1 - 0 to 19 inches:* loamy sand
*H2 - 19 to 60 inches:* loamy sand

#### Properties and qualities

*Slope:* 5 to 15 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Somewhat excessively drained
*Runoff class:* Very low
*Capacity of the most limiting layer to transmit water (Ksat):* High to very high (6.00 to 20.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 5 percent
*Salinity, maximum in profile:* Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 13.0
*Available water storage in profile:* Low (about 4.8 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 4e
*Land capability classification (nonirrigated):* 6e
*Hydrologic Soil Group:* A
*Ecological site:* Deep Sand (R042XB011NM)
*Hydric soil rating:* No

### Description of Caliza

#### Setting

*Landform:* Alluvial fans, drainageways
*Landform position (three-dimensional):* Rise, talf
*Down-slope shape:* Linear, convex
*Across-slope shape:* Convex
*Parent material:* Mixed sandy and gravelly alluvium

#### Typical profile

*H1 - 0 to 7 inches:* very gravelly sandy loam
*H2 - 7 to 12 inches:* very gravelly sandy loam
*H3 - 12 to 60 inches:* very gravelly sand

#### Properties and qualities

*Slope:* 15 to 40 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Medium

*Capacity of the most limiting layer to transmit water (Ksat):* High (2.00 to 6.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 40 percent
*Salinity, maximum in profile:* Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Very low (about 2.6 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 7e
*Hydrologic Soil Group:* A
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

**Description of Yturbide**

**Setting**

*Landform:* Alluvial fans
*Landform position (three-dimensional):* Rise
*Down-slope shape:* Linear
*Across-slope shape:* Convex
*Parent material:* Mixed sandy and gravelly alluvium

**Typical profile**

*H1 - 0 to 15 inches:* gravelly loamy sand
*H2 - 15 to 26 inches:* gravelly loamy sand
*H3 - 26 to 60 inches:* gravelly sand

**Properties and qualities**

*Slope:* 1 to 8 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Excessively drained
*Runoff class:* Very low
*Capacity of the most limiting layer to transmit water (Ksat):* High to very high (6.00 to 20.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Low (about 3.3 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 4s
*Land capability classification (nonirrigated):* 7e
*Hydrologic Soil Group:* A
*Ecological site:* Deep Sand (R042XB011NM)
*Hydric soil rating:* No

**Minor Components**

**Arizo**

*Percent of map unit:*
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

**Canutio**

*Percent of map unit:*
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

**Tencee**

*Percent of map unit:*
*Ecological site:* Gravelly (R042XB010NM)
*Hydric soil rating:* No

**Nickel**

*Percent of map unit:*
*Ecological site:* Gravelly (R042XB010NM)
*Hydric soil rating:* No

## Bs—Brazito very fine sandy loam, thick surface

**Map Unit Setting**

*National map unit symbol:* p99m
*Elevation:* 1,100 to 5,000 feet
*Mean annual precipitation:* 4 to 12 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 165 to 280 days
*Farmland classification:* Farmland of statewide importance

**Map Unit Composition**

*Brazito and similar soils:* 80 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Brazito**

**Setting**

*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed sandy alluvium

**Typical profile**

*H1 - 0 to 15 inches:* very fine sandy loam
*H2 - 15 to 60 inches:* fine sand

**Properties and qualities**

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Negligible
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.60 to 2.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 5 percent
*Salinity, maximum in profile:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Low (about 5.1 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 4e
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* B
*Ecological site:* Sandy (R042XB012NM)
*Hydric soil rating:* No

**Minor Components**

**Anthony**

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Agua**

*Percent of map unit:*
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

**Brazito**

*Percent of map unit:*
*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Ecological site:* Sandy (R042XB012NM)
*Hydric soil rating:* No

**Vinton**

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

## Cb—Canutio and Arizo gravelly sandy loams MLRA 42

**Map Unit Setting**

*National map unit symbol:* 2spsh
*Elevation:* 3,000 to 6,000 feet

*Mean annual precipitation:* 7 to 12 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 180 to 220 days
*Farmland classification:* Farmland of statewide importance

**Map Unit Composition**

*Canutio and similar soils:* 40 percent
*Arizo and similar soils:* 30 percent
*Minor components:* 1 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Canutio**

**Setting**

*Landform:* Terraces, alluvial fans
*Landform position (three-dimensional):* Rise
*Down-slope shape:* Linear
*Across-slope shape:* Linear, convex
*Parent material:* Mixed gravelly loamy alluvium

**Typical profile**

*H1 - 0 to 10 inches:* gravelly sandy loam
*H2 - 10 to 60 inches:* very gravelly sandy loam

**Properties and qualities**

*Slope:* 1 to 5 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Very low
*Capacity of the most limiting layer to transmit water (Ksat):* High (2.00 to 6.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Low (about 3.8 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* A
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

**Description of Arizo**

**Setting**

*Landform:* Valley floors
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed sandy and gravelly alluvium

**Typical profile**

*H1 - 0 to 15 inches:* gravelly sandy loam
*H2 - 15 to 60 inches:* very gravelly sand

**Properties and qualities**

*Slope:* 1 to 5 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Excessively drained
*Runoff class:* Negligible
*Capacity of the most limiting layer to transmit water (Ksat):* High to very high (6.00 to 20.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Low (about 3.6 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* A
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

### Minor Components

**Riverwash**

*Percent of map unit:* 1 percent
*Landform:* Drainageways
*Landform position (three-dimensional):* Tread
*Down-slope shape:* Linear
*Across-slope shape:* Concave
*Hydric soil rating:* No

**Yturbide**

*Percent of map unit:*
*Ecological site:* Deep Sand (R042XB011NM)
*Hydric soil rating:* No

**Bluepoint**

*Percent of map unit:*
*Ecological site:* Deep Sand (R042XB011NM)
*Hydric soil rating:* No

## Ge—Glendale loam

### Map Unit Setting

*National map unit symbol:* p99t
*Elevation:* 1,800 to 5,000 feet
*Mean annual precipitation:* 8 to 14 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 180 to 275 days
*Farmland classification:* Farmland of statewide importance

### Map Unit Composition

*Glendale and similar soils:* 85 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Glendale

#### Setting

*Landform:* Terraces, flood plains
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed stratified fine-silty alluvium

#### Typical profile

*H1 - 0 to 12 inches:* loam
*H2 - 12 to 40 inches:* clay loam
*H3 - 40 to 60 inches:* very fine sandy loam

#### Properties and qualities

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Low
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.60 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Salinity, maximum in profile:* Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* High (about 10.0 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 1
*Land capability classification (nonirrigated):* 7c
*Hydrologic Soil Group:* C
*Ecological site:* Bottomland (R042XB018NM)

*Hydric soil rating:* No

### Minor Components

#### Harkey

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

#### Glendale

*Percent of map unit:*
*Landform:* Flood plains, terraces
*Landform position (three-dimensional):* Talf
*Ecological site:* Salt Flats (R042XC036NM)
*Hydric soil rating:* No

#### Anapra

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

#### Glendale

*Percent of map unit:*
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

## Gf—Glendale clay loam, 0 to 1 percent slopes

### Map Unit Setting

*National map unit symbol:* 2t8vx
*Elevation:* 3,730 to 4,460 feet
*Mean annual precipitation:* 8 to 10 inches
*Mean annual air temperature:* 57 to 64 degrees F
*Frost-free period:* 180 to 220 days
*Farmland classification:* Farmland of statewide importance

### Map Unit Composition

*Glendale and similar soils:* 85 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Glendale

#### Setting

*Landform:* Flood plains
*Landform position (two-dimensional):* Toeslope
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Fine-silty alluvium

#### Typical profile

*Ap - 0 to 14 inches:* clay loam

*AC - 14 to 25 inches:* clay loam
*C - 25 to 59 inches:* silt
*2C - 59 to 60 inches:* loamy very fine sand

**Properties and qualities**

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Low
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.57 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Gypsum, maximum in profile:* 2 percent
*Salinity, maximum in profile:* Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 2.0
*Available water storage in profile:* High (about 11.0 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 1
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* C
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

### Minor Components

**Belen**

*Percent of map unit:*

**Harkey**

*Percent of map unit:*

**Armijo**

*Percent of map unit:*

**Anapra**

*Percent of map unit:*

## Gg—Glendale clay loam, alkali

### Map Unit Setting

*National map unit symbol:* p99w
*Elevation:* 1,800 to 5,500 feet
*Mean annual precipitation:* 8 to 12 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 180 to 240 days
*Farmland classification:* Farmland of statewide importance

**Map Unit Composition**

*Glendale and similar soils:* 85 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Glendale**

**Setting**

*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed stratified fine-silty alluvium

**Typical profile**

*H1 - 0 to 12 inches:* clay loam
*H2 - 12 to 34 inches:* clay loam
*H3 - 34 to 60 inches:* clay loam

**Properties and qualities**

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Low
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.60 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Salinity, maximum in profile:* Slightly saline to strongly saline (4.0 to 16.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 13.0
*Available water storage in profile:* High (about 11.4 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 3s
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* C
*Ecological site:* Salt Flats (R042XC036NM)
*Hydric soil rating:* No

**Minor Components**

**Harkey**

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Anapra**

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Belen**

*Percent of map unit:*
*Ecological site:* Clayey (R042XB023NM)
*Hydric soil rating:* No

**Glendale sodium affected**

*Percent of map unit:*
*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Ecological site:* Salty Bottomland (R042XB033NM)
*Hydric soil rating:* No

## Hg—Harkey loam

**Map Unit Setting**

*National map unit symbol:* p9b0
*Elevation:* 1,100 to 5,000 feet
*Mean annual precipitation:* 4 to 14 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 165 to 280 days
*Farmland classification:* Not prime farmland

**Map Unit Composition**

*Harkey and similar soils:* 85 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Harkey**

**Setting**

*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed stratified coarse-silty alluvium

**Typical profile**

*H1 - 0 to 18 inches:* loam
*H2 - 18 to 38 inches:* very fine sandy loam
*H3 - 38 to 60 inches:* silt loam

**Properties and qualities**

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Negligible
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.57 to 1.98 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 5 percent
*Salinity, maximum in profile:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* High (about 9.6 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 1
*Land capability classification (nonirrigated):* 7c
*Hydrologic Soil Group:* B
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

### Minor Components

**Brazito**

*Percent of map unit:*
*Ecological site:* Sandy (R042XB012NM)
*Hydric soil rating:* No

**Agua**

*Percent of map unit:*
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

**Harkey**

*Percent of map unit:*
*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Glendale**

*Percent of map unit:*
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

**Anthony**

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Vinton**

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

## Hh—Harkey loam, saline-alkali

### Map Unit Setting

*National map unit symbol:* p9b1
*Elevation:* 2,500 to 5,000 feet
*Mean annual precipitation:* 8 to 14 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 180 to 275 days
*Farmland classification:* Farmland of statewide importance

**Map Unit Composition**

*Harkey and similar soils:* 90 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Harkey**

**Setting**

*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed stratified coarse-silty alluvium

**Typical profile**

*H1 - 0 to 10 inches:* loam
*H2 - 10 to 47 inches:* stratified very fine sandy loam
*H3 - 47 to 60 inches:* loamy sand

**Properties and qualities**

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Negligible
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.60 to 2.00 in/hr)
*Depth to water table:* About 48 to 72 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 5 percent
*Salinity, maximum in profile:* Slightly saline to strongly saline (4.0 to 16.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 13.0
*Available water storage in profile:* Low (about 5.6 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 3s
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* B
*Ecological site:* Salty Bottomland (R042XB033NM)
*Hydric soil rating:* No

**Minor Components**

**Harkey**

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Harkey**

*Percent of map unit:*
*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Glendale**

*Percent of map unit:*

*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

## Hk—Harkey clay loam

**Map Unit Setting**

*National map unit symbol:* p9b2
*Elevation:* 1,100 to 5,000 feet
*Mean annual precipitation:* 4 to 14 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 165 to 280 days
*Farmland classification:* Farmland of statewide importance

**Map Unit Composition**

*Harkey and similar soils:* 85 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Harkey**

**Setting**

*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed stratified coarse-silty alluvium

**Typical profile**

*H1 - 0 to 12 inches:* clay loam
*H2 - 12 to 60 inches:* stratified fine sandy loam to silt loam

**Properties and qualities**

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Low
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.60 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 5 percent
*Salinity, maximum in profile:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* High (about 9.7 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 1
*Land capability classification (nonirrigated):* 7c
*Hydrologic Soil Group:* C
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Minor Components**

**Glendale**

*Percent of map unit:*
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

**Agua**

*Percent of map unit:*
*Ecological site:* Bottomland (R042XB018NM)
*Hydric soil rating:* No

**Anthony**

*Percent of map unit:*
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Harkey**

*Percent of map unit:*
*Landform:* Flood plains
*Landform position (three-dimensional):* Talf
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

## Pa—Pajarito fine sandy loam

**Map Unit Setting**

*National map unit symbol:* p9bc
*Elevation:* 3,500 to 6,000 feet
*Mean annual precipitation:* 7 to 12 inches
*Mean annual air temperature:* 58 to 62 degrees F
*Frost-free period:* 180 to 220 days
*Farmland classification:* Farmland of statewide importance

**Map Unit Composition**

*Pajarito and similar soils:* 85 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Pajarito**

**Setting**

*Landform:* Alluvial fans
*Landform position (three-dimensional):* Rise
*Down-slope shape:* Linear
*Across-slope shape:* Convex
*Parent material:* Mixed coarse-loamy alluvium

**Typical profile**

*H1 - 0 to 12 inches:* fine sandy loam
*H2 - 12 to 28 inches:* fine sandy loam
*H3 - 28 to 60 inches:* fine sandy loam

**Properties and qualities**

*Slope:* 1 to 3 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Very low
*Capacity of the most limiting layer to transmit water (Ksat):* High (2.00 to 6.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 5 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Moderate (about 8.4 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 2e
*Land capability classification (nonirrigated):* 7e
*Hydrologic Soil Group:* A
*Ecological site:* Sandy (R042XB012NM)
*Hydric soil rating:* No

### Minor Components

**Adelino**

*Percent of map unit:*
*Ecological site:* Loamy (R042XA052NM)
*Hydric soil rating:* No

**Bluepoint**

*Percent of map unit:*
*Ecological site:* Deep Sand (R042XB011NM)
*Hydric soil rating:* No

**Yturbide**

*Percent of map unit:*
*Ecological site:* Deep Sand (R042XB011NM)
*Hydric soil rating:* No

## RF—Riverwash-Arizo complex

### Map Unit Setting

*National map unit symbol:* p9bh
*Elevation:* 3,700 to 4,400 feet
*Mean annual precipitation:* 4 to 12 inches
*Mean annual air temperature:* 58 to 66 degrees F
*Frost-free period:* 180 to 260 days
*Farmland classification:* Not prime farmland

**Map Unit Composition**

*Riverwash, gravelly:* 45 percent
*Arizo and similar soils:* 35 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Riverwash, Gravelly**

**Setting**

*Landform:* Drainageways
*Landform position (three-dimensional):* Tread
*Down-slope shape:* Linear
*Across-slope shape:* Concave
*Parent material:* Mixed sandy and gravelly alluvium

**Typical profile**

*H1 - 0 to 18 inches:* gravelly loam
*H2 - 18 to 60 inches:* very fine sandy loam

**Properties and qualities**

*Natural drainage class:* Somewhat excessively drained
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.60 to 2.00 in/hr)
*Depth to water table:* About 0 to 24 inches
*Frequency of flooding:* Occasional
*Salinity, maximum in profile:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 2.0
*Available water storage in profile:* High (about 9.6 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 8
*Hydric soil rating:* No

**Description of Arizo**

**Setting**

*Landform:* Valley floors, arroyos
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear, convex
*Across-slope shape:* Concave, convex
*Parent material:* Mixed sandy and gravelly alluvium

**Typical profile**

*H1 - 0 to 12 inches:* gravelly loamy sand
*H2 - 12 to 60 inches:* very gravelly loamy sand

**Properties and qualities**

*Slope:* 0 to 3 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Excessively drained
*Runoff class:* Negligible
*Capacity of the most limiting layer to transmit water (Ksat):* High to very high (6.00 to 20.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent

*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 13.0
*Available water storage in profile:* Very low (about 2.0 inches)

#### Interpretive groups

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 7w
*Hydrologic Soil Group:* A
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

### Minor Components

#### Bluepoint

*Percent of map unit:*
*Ecological site:* Deep Sand (R042XB011NM)
*Hydric soil rating:* No

#### Arizo

*Percent of map unit:*
*Landform:* Inset fans
*Landform position (three-dimensional):* Rise
*Down-slope shape:* Convex
*Across-slope shape:* Linear
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

#### Canutio

*Percent of map unit:*
*Ecological site:* Gravelly Sand (R042XB024NM)
*Hydric soil rating:* No

#### Yturbide

*Percent of map unit:*
*Ecological site:* Deep Sand (R042XB011NM)
*Hydric soil rating:* No

## RL—Rock outcrop-Lozier association

### Map Unit Setting

*National map unit symbol:* p9bl
*Elevation:* 4,000 to 6,400 feet
*Mean annual precipitation:* 8 to 10 inches
*Mean annual air temperature:* 60 to 64 degrees F
*Frost-free period:* 190 to 230 days
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Rock outcrop:* 45 percent

*Lozier and similar soils:* 30 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Rock Outcrop

#### Setting

*Landform:* Hills
*Landform position (two-dimensional):* Backslope, footslope, shoulder, toeslope
*Landform position (three-dimensional):* Crest, nose slope, side slope, head slope
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Limestone

#### Interpretive groups

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 8s
*Hydric soil rating:* No

### Description of Lozier

#### Setting

*Landform:* Hills
*Landform position (two-dimensional):* Backslope, footslope, shoulder, toeslope
*Landform position (three-dimensional):* Crest, nose slope, side slope, head slope
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Calcareous very gravelly loamy residuum

#### Typical profile

*H1 - 0 to 11 inches:* very stony loam
*H2 - 11 to 60 inches:* bedrock

#### Properties and qualities

*Slope:* 10 to 50 percent
*Depth to restrictive feature:* 4 to 20 inches to lithic bedrock
*Natural drainage class:* Well drained
*Runoff class:* High
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to high (0.06 to 2.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 95 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Very low (about 0.9 inches)

#### Interpretive groups

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* D
*Ecological site:* Limestone Hills (R042XB021NM)
*Hydric soil rating:* No

## TE—Tencee-Upton association

### Map Unit Setting

*National map unit symbol:* p9bq
*Elevation:* 1,500 to 5,000 feet
*Mean annual precipitation:* 4 to 14 inches
*Mean annual air temperature:* 60 to 64 degrees F
*Frost-free period:* 180 to 240 days
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Tencee and similar soils:* 35 percent
*Upton and similar soils:* 20 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Tencee

#### Setting

*Landform:* Ridges on hills
*Landform position (two-dimensional):* Summit, shoulder, backslope
*Landform position (three-dimensional):* Rise
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Mixed very gravelly coarse-loamy alluvium

#### Typical profile

*H1 - 0 to 1 inches:* very gravelly sandy loam
*H2 - 1 to 7 inches:* very gravelly sandy loam
*H3 - 7 to 26 inches:* indurated
*H4 - 26 to 60 inches:* very gravelly sandy loam

#### Properties and qualities

*Slope:* 3 to 15 percent
*Depth to restrictive feature:* 3 to 20 inches to petrocalcic
*Natural drainage class:* Well drained
*Runoff class:* Very high
*Capacity of the most limiting layer to transmit water (Ksat):* Low to moderately low (0.01 to 0.06 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 95 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Very low (about 0.6 inches)

#### Interpretive groups

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 7e

*Hydrologic Soil Group:* D
*Ecological site:* Gravelly (R042XB010NM)
*Hydric soil rating:* No

### Description of Upton

#### Setting

*Landform:* Ridges on hills
*Landform position (two-dimensional):* Summit, shoulder, backslope
*Landform position (three-dimensional):* Nose slope, head slope, crest
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Calcareous gravelly loamy alluvium

#### Typical profile

*H1 - 0 to 8 inches:* gravelly sandy loam
*H2 - 8 to 16 inches:* gravelly sandy loam
*H3 - 16 to 36 inches:* cemented
*H4 - 36 to 60 inches:* very gravelly loam

#### Properties and qualities

*Slope:* 3 to 10 percent
*Depth to restrictive feature:* 7 to 20 inches to petrocalcic
*Natural drainage class:* Well drained
*Runoff class:* High
*Capacity of the most limiting layer to transmit water (Ksat):* Low to moderately high (0.01 to 0.60 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 95 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum in profile:* 1.0
*Available water storage in profile:* Very low (about 1.8 inches)

#### Interpretive groups

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* D
*Ecological site:* Gravelly (R042XB010NM)
*Hydric soil rating:* No

### Minor Components

#### Simona

*Percent of map unit:*
*Ecological site:* Shallow Sandy (R042XB015NM)
*Hydric soil rating:* No

#### Nickel

*Percent of map unit:*
*Ecological site:* Gravelly (R042XB010NM)
*Hydric soil rating:* No

#### Cave

*Percent of map unit:*
*Ecological site:* Gravelly (R042XB010NM)

*Hydric soil rating:* No

# Fort Bliss Military Reservation, New Mexico and Texas

## 12—Infantry-Sonic complex, 3 to 10 percent slopes

### Map Unit Setting

*National map unit symbol:* 1yh0
*Elevation:* 4,200 to 5,300 feet
*Mean annual precipitation:* 10 to 12 inches
*Mean annual air temperature:* 60 to 64 degrees F
*Frost-free period:* 170 to 210 days
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Infantry and similar soils:* 75 percent
*Sonic and similar soils:* 20 percent
*Minor components:* 5 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Infantry

#### Setting

*Landform:* Erosion remnants, fan piedmonts
*Landform position (three-dimensional):* Riser
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Alluvium derived from limestone and/or eolian sands

#### Typical profile

*A - 0 to 2 inches:* very gravelly sandy loam
*Bk - 2 to 10 inches:* extremely cobbly sandy loam
*Bkm - 10 to 14 inches:* cemented material
*2BCk1 - 14 to 22 inches:* extremely gravelly loamy coarse sand
*3BCk2 - 22 to 34 inches:* extremely gravelly sandy clay loam
*4BCk3 - 34 to 52 inches:* extremely cobbly loamy sand
*5BCk4 - 52 to 80 inches:* loamy sand

#### Properties and qualities

*Slope:* 3 to 10 percent
*Depth to restrictive feature:* 7 to 20 inches to petrocalcic
*Natural drainage class:* Well drained
*Runoff class:* Very high
*Capacity of the most limiting layer to transmit water (Ksat):* Low to moderately low (0.01 to 0.06 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 60 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Available water storage in profile:* Very low (about 0.3 inches)

#### Interpretive groups

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* D

*Ecological site:* Gravelly (R042XC001NM)
*Hydric soil rating:* No

**Description of Sonic**

**Setting**

*Landform:* Inset fans, fan aprons
*Landform position (three-dimensional):* Riser, rise
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Stratified alluvium derived from limestone

**Typical profile**

*A - 0 to 3 inches:* very gravelly fine sandy loam
*Bw1 - 3 to 11 inches:* gravelly fine sandy loam
*Bw2 - 11 to 26 inches:* extremely cobbly fine sandy loam
*Bw3 - 26 to 38 inches:* gravelly silt loam
*Bw4 - 38 to 80 inches:* extremely cobbly silt loam

**Properties and qualities**

*Slope:* 3 to 10 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* High
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.57 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* Rare
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 60 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Available water storage in profile:* Low (about 5.5 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 6c
*Hydrologic Soil Group:* C
*Ecological site:* Gravelly (R042XC001NM)
*Hydric soil rating:* No

**Minor Components**

**Tinney**

*Percent of map unit:* 2 percent
*Landform:* Inset fans on fan piedmonts
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Crossen**

*Percent of map unit:* 2 percent
*Landform:* Fan remnants
*Ecological site:* Gravelly (R042XB010NM)
*Hydric soil rating:* No

**Dozer**

*Percent of map unit:* 1 percent
*Landform:* Hills

*Landform position (two-dimensional):* Backslope, footslope, shoulder, toeslope
*Landform position (three-dimensional):* Crest, nose slope, side slope, head slope
*Ecological site:* Limestone Hills (R042XB021NM)
*Hydric soil rating:* No

## 28—Crossen-Tinney complex, 1 to 3 percent slopes

### Map Unit Setting

*National map unit symbol:* 1yh4
*Elevation:* 4,200 to 5,300 feet
*Mean annual precipitation:* 10 to 12 inches
*Mean annual air temperature:* 60 to 64 degrees F
*Frost-free period:* 170 to 210 days
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Crossen and similar soils:* 50 percent
*Tinney and similar soils:* 40 percent
*Minor components:* 10 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Crossen

#### Setting

*Landform:* Fan remnants
*Landform position (three-dimensional):* Rise
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Alluvium derived from limestone and/or colluvium derived from limestone

#### Typical profile

*A - 0 to 2 inches:* gravelly fine sandy loam
*Bk1 - 2 to 7 inches:* gravelly fine sandy loam
*Bk2 - 7 to 15 inches:* gravelly fine sandy loam
*Bkm - 15 to 28 inches:* cemented material
*BCk1 - 28 to 39 inches:* extremely gravelly loam
*BCk2 - 39 to 80 inches:* extremely gravelly sandy loam

#### Properties and qualities

*Slope:* 1 to 3 percent
*Depth to restrictive feature:* 6 to 20 inches to petrocalcic
*Natural drainage class:* Well drained
*Runoff class:* Very high
*Capacity of the most limiting layer to transmit water (Ksat):* Low to moderately low (0.01 to 0.06 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None

*Calcium carbonate, maximum in profile:* 40 percent
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
*Available water storage in profile:* Very low (about 1.8 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* D
*Ecological site:* Gravelly (R042XC001NM)
*Hydric soil rating:* No

**Description of Tinney**

**Setting**

*Landform:* Fan aprons, inset fans
*Landform position (three-dimensional):* Riser, rise
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Alluvium

**Typical profile**

*A - 0 to 3 inches:* loam
*Bw - 3 to 17 inches:* loam
*2Bt - 17 to 36 inches:* sandy clay loam
*3Bk1 - 36 to 45 inches:* loam
*3Bk2 - 45 to 57 inches:* loam
*3Bk3 - 57 to 80 inches:* loam

**Properties and qualities**

*Slope:* 1 to 3 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Medium
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.57 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 40 percent
*Salinity, maximum in profile:* Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
*Available water storage in profile:* High (about 9.4 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 6s
*Hydrologic Soil Group:* C
*Ecological site:* Loamy (R042XC007NM)
*Hydric soil rating:* No

**Minor Components**

**Reyab**

*Percent of map unit:* 5 percent
*Landform:* Fan aprons on fan piedmonts, inset fans on fan piedmonts
*Ecological site:* Loamy (R042XB014NM)

*Hydric soil rating:* No

**Mariola**

*Percent of map unit:* 5 percent
*Landform:* Erosion remnants on fan piedmonts
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

## 29—Tinney loam, 1 to 3 percent slopes

**Map Unit Setting**

*National map unit symbol:* 1yh5
*Elevation:* 4,200 to 5,300 feet
*Mean annual precipitation:* 10 to 12 inches
*Mean annual air temperature:* 60 to 64 degrees F
*Frost-free period:* 170 to 210 days
*Farmland classification:* Not prime farmland

**Map Unit Composition**

*Tinney and similar soils:* 85 percent
*Minor components:* 15 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Tinney**

**Setting**

*Landform:* Inset fans, fan aprons
*Landform position (three-dimensional):* Riser, rise
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Alluvium

**Typical profile**

*A - 0 to 3 inches:* loam
*Bw - 3 to 17 inches:* loam
*2Bt - 17 to 36 inches:* sandy clay loam
*3Bk1 - 36 to 45 inches:* loam
*3Bk2 - 45 to 57 inches:* loam
*3Bk3 - 57 to 80 inches:* loam

**Properties and qualities**

*Slope:* 1 to 3 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Medium
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.57 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None

*Calcium carbonate, maximum in profile:* 40 percent
*Salinity, maximum in profile:* Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
*Available water storage in profile:* High (about 9.4 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 6s
*Hydrologic Soil Group:* C
*Ecological site:* Loamy (R042XC007NM)
*Hydric soil rating:* No

**Minor Components**

**Reyab**

*Percent of map unit:* 5 percent
*Landform:* Fan aprons on fan piedmonts, inset fans on fan piedmonts
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

**Crossen**

*Percent of map unit:* 5 percent
*Landform:* Fan remnants
*Ecological site:* Gravelly (R042XB010NM)
*Hydric soil rating:* No

**Mariola**

*Percent of map unit:* 5 percent
*Landform:* Erosion remnants on fan piedmonts
*Ecological site:* Loamy (R042XB014NM)
*Hydric soil rating:* No

# Soil Information for All Uses

## Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

## Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

### Hydrologic Soil Group (Vado Drainage Master Plan)

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

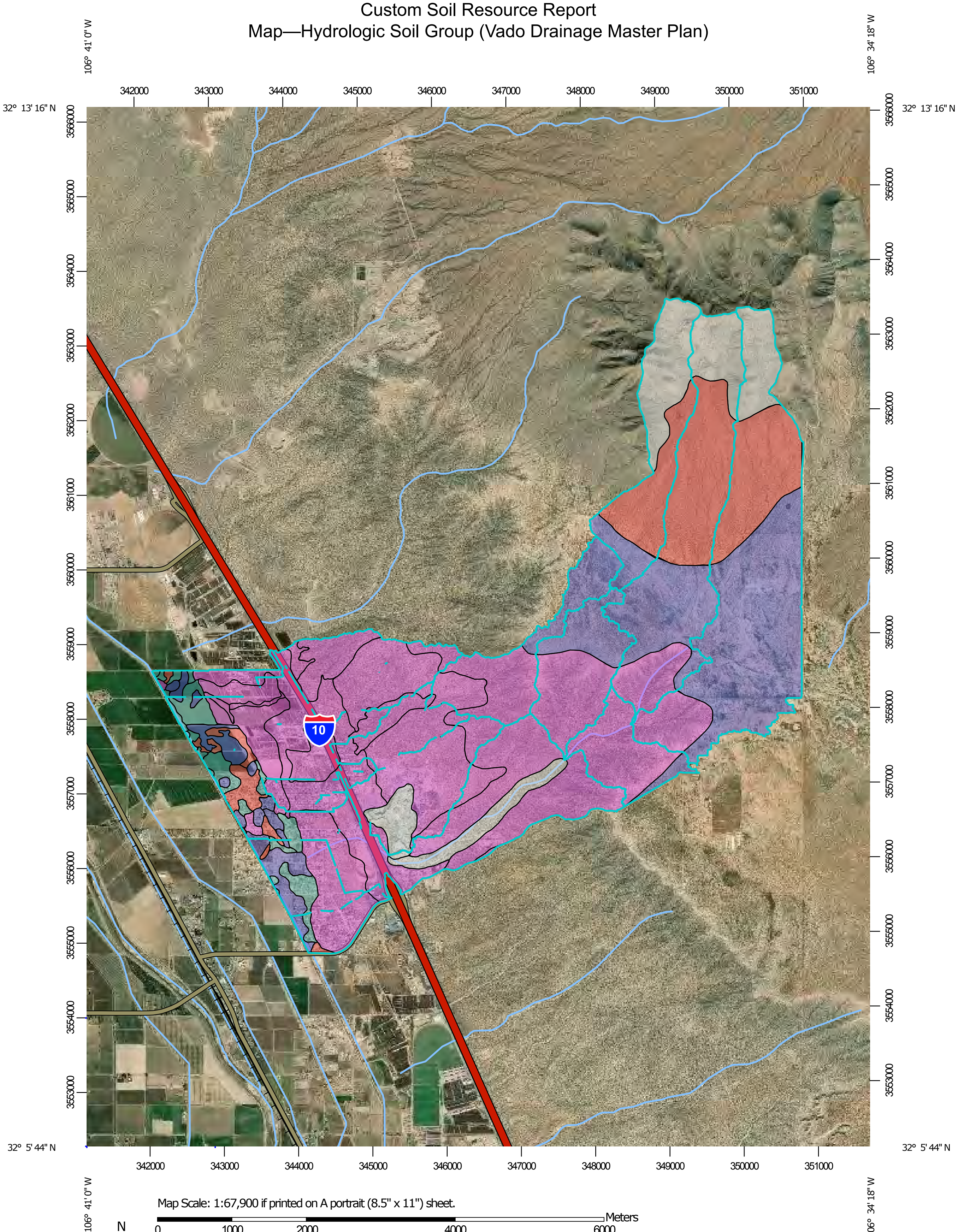
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Map—Hydrologic Soil Group (Vado Drainage Master Plan)




Map Scale: 1:67,900 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 1000, 2000, 4000, 6000

Feet: 0, 3000, 6000, 12000, 18000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

## MAP LEGEND

**Area of Interest (AOI)**

Area of Interest (AOI)

**Soils**

**Soil Rating Polygons**

A

A/D

B

B/D

C

C/D

D

Not rated or not available

**Soil Rating Lines**

A

A/D

B

B/D

C

C/D

D

Not rated or not available

**Soil Rating Points**

A

A/D

B

B/D

C

C/D

D

Not rated or not available

**Water Features**

Streams and Canals

**Transportation**

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

**Background**

Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Dona Ana County Area, New Mexico
Survey Area Data: Version 14, Sep 12, 2018

Soil Survey Area: Fort Bliss Military Reservation, New Mexico and Texas
Survey Area Data: Version 14, Sep 12, 2018

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 30, 2015—Dec 8, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

| MAP LEGEND | MAP INFORMATION |
| --- | --- |
| | imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident. |

## Table—Hydrologic Soil Group (Vado Drainage Master Plan)

| Map unit symbol | Map unit name | Rating | Acres in AOI | Percent of AOI |
|---|---|---|---|---|
| Ag | Agua silt loam, 0 to 2 percent slopes | A | 2.6 | 0.0% |
| Ap | Anthony-Vinton fine sandy loams | A | 11.1 | 0.1% |
| Ar | Anthony-Vinton loams, 0 to 1 percent slopes | C | 9.4 | 0.1% |
| Aw | Armijo clay loam | D | 70.4 | 0.9% |
| Bg | Belen clay | D | 31.3 | 0.4% |
| BK | Berino-Dona Ana association | B | 1,646.0 | 21.3% |
| Bm | Bluepoint loamy sand, 0 to 5 percent slopes | A | 598.3 | 7.7% |
| Bn | Bluepoint loamy sand, 5 to 15 percent slopes MLRA 42 | A | 387.2 | 5.0% |
| BO | Bluepoint loamy sand, 1 to 15 percent slopes MLRA 42 | A | 726.6 | 9.4% |
| BP | Bluepoint-Caliza-Yturbide complex | A | 1,803.2 | 23.3% |
| Bs | Brazito very fine sandy loam, thick surface | B | 12.3 | 0.2% |
| Cb | Canutio and Arizo gravelly sandy loams MLRA 42 | A | 28.4 | 0.4% |
| Ge | Glendale loam | C | 52.8 | 0.7% |
| Gf | Glendale clay loam, 0 to 1 percent slopes | C | 8.7 | 0.1% |
| Gg | Glendale clay loam, alkali | C | 130.0 | 1.7% |
| Hg | Harkey loam | B | 27.2 | 0.4% |
| Hh | Harkey loam, saline-alkali | B | 174.1 | 2.3% |
| Hk | Harkey clay loam | C | 4.7 | 0.1% |
| Pa | Pajarito fine sandy loam | A | 204.5 | 2.6% |
| RF | Riverwash-Arizo complex | | 125.9 | 1.6% |
| RL | Rock outcrop-Lozier association | | 672.8 | 8.7% |
| TE | Tencee-Upton association | D | 999.2 | 12.9% |
| **Subtotals for Soil Survey Area** | | | **7,726.7** | **100.0%** |
| **Totals for Area of Interest** | | | **7,729.0** | **100.0%** |

| Map unit symbol | Map unit name | Rating | Acres in AOI | Percent of AOI |
|---|---|---|---|---|
| 12 | Infantry-Sonic complex, 3 to 10 percent slopes | D | 1.5 | 0.0% |
| 28 | Crossen-Tinney complex, 1 to 3 percent slopes | D | 0.0 | 0.0% |
| 29 | Tinney loam, 1 to 3 percent slopes | C | 0.0 | 0.0% |
| **Subtotals for Soil Survey Area** | | | **1.6** | **0.0%** |
| **Totals for Area of Interest** | | | **7,729.0** | **100.0%** |

## Rating Options—Hydrologic Soil Group (Vado Drainage Master Plan)

*Aggregation Method:* Dominant Condition

*Component Percent Cutoff: None Specified*

*Tie-break Rule:* Higher

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# Glossary

Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the following National Soil Survey Handbook link: "National Soil Survey Handbook."

**ABC soil**

A soil having an A, a B, and a C horizon.

**Ablation till**

Loose, relatively permeable earthy material deposited during the downwasting of nearly static glacial ice, either contained within or accumulated on the surface of the glacier.

**AC soil**

A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

**Aeration, soil**

The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

**Aggregate, soil**

Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

**Alkali (sodic) soil**

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

**Alluvial cone**

A semiconical type of alluvial fan having very steep slopes. It is higher, narrower, and steeper than a fan and is composed of coarser and thicker layers of material deposited by a combination of alluvial episodes and (to a much lesser degree) landslides (debris flow). The coarsest materials tend to be concentrated at the apex of the cone.

**Alluvial fan**

A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes. It is shaped like an open fan or a segment of a cone. The material was deposited by a stream at the place where it issues from a narrow mountain valley or upland valley or where a tributary stream is near or at its junction with the main stream. The fan is steepest near its apex, which points upstream, and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

**Alluvium**

Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

**Alpha,alpha-dipyridyl**

A compound that when dissolved in ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction implies reducing conditions and the likely presence of redoximorphic features.

**Animal unit month (AUM)**

The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

**Aquic conditions**

Current soil wetness characterized by saturation, reduction, and redoximorphic features.

**Argillic horizon**

A subsoil horizon characterized by an accumulation of illuvial clay.

**Arroyo**

The flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed.

**Aspect**

The direction toward which a slope faces. Also called slope aspect.

**Association, soil**

A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

**Available water capacity (available moisture capacity)**

The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

*Very low:* 0 to 3
*Low:* 3 to 6
*Moderate:* 6 to 9
*High:* 9 to 12
*Very high:* More than 12

**Backslope**

The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

**Backswamp**

A flood-plain landform. Extensive, marshy or swampy, depressed areas of flood plains between natural levees and valley sides or terraces.

**Badland**

A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes and narrow interfluves. Badlands develop on surfaces that have little or no vegetative cover overlying unconsolidated or poorly cemented materials (clays, silts, or sandstones) with, in some cases, soluble minerals, such as gypsum or halite.

**Bajada**

A broad, gently inclined alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically, it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins.

**Basal area**

The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

**Base saturation**

The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

**Base slope (geomorphology)**

A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

**Bedding plane**

A planar or nearly planar bedding surface that visibly separates each successive layer of stratified sediment or rock (of the same or different lithology) from the preceding or following layer; a plane of deposition. It commonly marks a change in the circumstances of deposition and may show a parting, a color difference, a change in particle size, or various combinations of these. The term is commonly applied to any bedding surface, even one that is conspicuously bent or deformed by folding.

**Bedding system**

A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

**Bedrock**

The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

**Bedrock-controlled topography**

A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

**Bench terrace**

A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

**Bisequum**

Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

**Blowout (map symbol)**

A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand or loose soil or where protective vegetation is disturbed or destroyed. The adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Blowouts are commonly small.

**Borrow pit (map symbol)**

An open excavation from which soil and underlying material have been removed, usually for construction purposes.

**Bottom land**

An informal term loosely applied to various portions of a flood plain.

**Boulders**

Rock fragments larger than 2 feet (60 centimeters) in diameter.

**Breaks**

A landscape or tract of steep, rough or broken land dissected by ravines and gullies and marking a sudden change in topography.

**Breast height**

An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

**Brush management**

Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

**Butte**

An isolated, generally flat-topped hill or mountain with relatively steep slopes and talus or precipitous cliffs and characterized by summit width that is less than the height of bounding escarpments; commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks.

**Cable yarding**

A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

**Calcareous soil**

A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

**Caliche**

A general term for a prominent zone of secondary carbonate accumulation in surficial materials in warm, subhumid to arid areas. Caliche is formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in nonindurated forms to very strong in indurated forms. Other minerals (e.g., carbonates, silicate, and sulfate) may occur as accessory cements. Most petrocalcic horizons and some calcic horizons are caliche.

**California bearing ratio (CBR)**

The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

**Canopy**

The leafy crown of trees or shrubs. (See Crown.)

**Canyon**

A long, deep, narrow valley with high, precipitous walls in an area of high local relief.

**Capillary water**

Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

**Catena**

A sequence, or “chain,” of soils on a landscape that formed in similar kinds of parent material and under similar climatic conditions but that have different characteristics as a result of differences in relief and drainage.

**Cation**

An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

**Cation-exchange capacity**

The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

**Catsteps**

See Terracettes.

**Cement rock**

Shaly limestone used in the manufacture of cement.

**Channery soil material**

Soil material that has, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

**Chemical treatment**

Control of unwanted vegetation through the use of chemicals.

**Chiseling**

Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

**Cirque**

A steep-walled, semicircular or crescent-shaped, half-bowl-like recess or hollow, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain. It was produced by the erosive activity of a mountain glacier. It commonly contains a small round lake (tarn).

**Clay**

As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

**Clay depletions**

See Redoximorphic features.

**Clay film**

A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

**Clay spot (map symbol)**

A spot where the surface texture is silty clay or clay in areas where the surface layer of the soils in the surrounding map unit is sandy loam, loam, silt loam, or coarser.

**Claypan**

A dense, compact subsoil layer that contains much more clay than the overlying materials, from which it is separated by a sharply defined boundary. The layer restricts the downward movement of water through the soil. A claypan is commonly hard when dry and plastic and sticky when wet.

**Climax plant community**

The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

**Coarse textured soil**

Sand or loamy sand.

**Cobble (or cobblestone)**

A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

**Cobbly soil material**

Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

**COLE (coefficient of linear extensibility)**

See Linear extensibility.

**Colluvium**

Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

**Complex slope**

Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

**Complex, soil**

A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

**Concretions**

See Redoximorphic features.

**Conglomerate**

A coarse grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

**Conservation cropping system**

Growing crops in combination with needed cultural and management practices. In a good conservation cropping system, the soil-improving crops and practices more than offset the effects of the soil-depleting crops and practices. Cropping systems are needed on all tilled soils. Soil-improving practices in a conservation cropping system include the use of rotations that contain grasses and legumes and the return of crop residue to the soil. Other practices include the use of green manure crops of grasses and legumes, proper tillage, adequate fertilization, and weed and pest control.

**Conservation tillage**

A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

**Consistence, soil**

Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the “Soil Survey Manual.”

**Contour stripcropping**

Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

**Control section**

The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

**Coprogenous earth (sedimentary peat)**

A type of limnic layer composed predominantly of fecal material derived from aquatic animals.

**Corrosion (geomorphology)**

A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

**Corrosion (soil survey interpretations)**

Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

**Cover crop**

A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

**Crop residue management**

Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

**Cropping system**

Growing crops according to a planned system of rotation and management practices.

**Cross-slope farming**

Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

**Crown**

The upper part of a tree or shrub, including the living branches and their foliage.

**Cryoturbate**

A mass of soil or other unconsolidated earthy material moved or disturbed by frost action. It is typically coarser than the underlying material.

**Cuesta**

An asymmetric ridge capped by resistant rock layers of slight or moderate dip (commonly less than 15 percent slopes); a type of homocline produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope) that roughly parallels the inclined beds; on the other side, it has a relatively short and steep or clifflike slope (scarp) that cuts through the tilted rocks.

**Culmination of the mean annual increment (CMAI)**

The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

**Cutbanks cave**

The walls of excavations tend to cave in or slough.

**Decreasers**

The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

**Deferred grazing**

Postponing grazing or resting grazing land for a prescribed period.

**Delta**

A body of alluvium having a surface that is fan shaped and nearly flat; deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, generally a sea or lake.

**Dense layer**

A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

**Depression, closed (map symbol)**

A shallow, saucer-shaped area that is slightly lower on the landscape than the surrounding area and that does not have a natural outlet for surface drainage.

**Depth, soil**

Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

**Desert pavement**

A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments mantling a desert surface. It forms where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It typically protects the finer grained underlying material from further erosion.

**Diatomaceous earth**

A geologic deposit of fine, grayish siliceous material composed chiefly or entirely of the remains of diatoms.

**Dip slope**

A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

**Diversion (or diversion terrace)**

A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

**Divided-slope farming**

A form of field stripcropping in which crops are grown in a systematic arrangement of two strips, or bands, across the slope to reduce the hazard of water erosion. One strip is in a close-growing crop that provides protection from erosion, and the other strip is in a crop that provides less protection from erosion. This practice is used where slopes are not long enough to permit a full stripcropping pattern to be used.

**Drainage class (natural)**

Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*. These classes are defined in the "Soil Survey Manual."

**Drainage, surface**

Runoff, or surface flow of water, from an area.

**Drainageway**

A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

**Draw**

A small stream valley that generally is shallower and more open than a ravine or gulch and that has a broader bottom. The present stream channel may appear inadequate to have cut the drainageway that it occupies.

**Drift**

A general term applied to all mineral material (clay, silt, sand, gravel, and boulders) transported by a glacier and deposited directly by or from the ice or transported by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines and stratified deposits that form outwash plains, eskers, kames, varves, and glaciofluvial sediments. The term is generally applied to Pleistocene glacial deposits in areas that no longer contain glaciers.

**Drumlin**

A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It commonly has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition.

**Duff**

A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

**Dune**

A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand), either barren and capable of movement from place to place or covered and stabilized with vegetation but retaining its characteristic shape.

**Earthy fill**

See Mine spoil.

**Ecological site**

An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

**Eluviation**

The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

**Endosaturation**

A type of saturation of the soil in which all horizons between the upper boundary of saturation and a depth of 2 meters are saturated.

**Eolian deposit**

Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

**Ephemeral stream**

A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

**Episaturation**

A type of saturation indicating a perched water table in a soil in which saturated layers are underlain by one or more unsaturated layers within 2 meters of the surface.

**Erosion**

The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

**Erosion (accelerated)**

Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

**Erosion (geologic)**

Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

**Erosion pavement**

A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion.

**Erosion surface**

A land surface shaped by the action of erosion, especially by running water.

**Escarpment**

A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

**Escarpment, bedrock (map symbol)**

A relatively continuous and steep slope or cliff, produced by erosion or faulting, that breaks the general continuity of more gently sloping land surfaces. Exposed material is hard or soft bedrock.

**Escarpment, nonbedrock (map symbol)**

A relatively continuous and steep slope or cliff, generally produced by erosion but in some places produced by faulting, that breaks the continuity of more gently sloping land surfaces. Exposed earthy material is nonsoil or very shallow soil.

**Esker**

A long, narrow, sinuous, steep-sided ridge of stratified sand and gravel deposited as the bed of a stream flowing in an ice tunnel within or below the ice (subglacial) or between ice walls on top of the ice of a wasting glacier and left behind as high ground when the ice melted. Eskers range in length from less than a kilometer to more than 160 kilometers and in height from 3 to 30 meters.

**Extrusive rock**

Igneous rock derived from deep-seated molten matter (magma) deposited and cooled on the earth's surface.

**Fallow**

Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

**Fan remnant**

A general term for landforms that are the remaining parts of older fan landforms, such as alluvial fans, that have been either dissected or partially buried.

**Fertility, soil**

The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

**Fibric soil material (peat)**

The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

**Field moisture capacity**

The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

**Fill slope**

A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

**Fine textured soil**

Sandy clay, silty clay, or clay.

**Firebreak**

An area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of firefighters and equipment. Designated roads also serve as firebreaks.

**First bottom**

An obsolete, informal term loosely applied to the lowest flood-plain steps that are subject to regular flooding.

**Flaggy soil material**

Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

**Flagstone**

A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

**Flood plain**

The nearly level plain that borders a stream and is subject to flooding unless protected artificially.

**Flood-plain landforms**

A variety of constructional and erosional features produced by stream channel migration and flooding. Examples include backswamps, flood-plain splays, meanders, meander belts, meander scrolls, oxbow lakes, and natural levees.

**Flood-plain splay**

A fan-shaped deposit or other outspread deposit formed where an overloaded stream breaks through a levee (natural or artificial) and deposits its material (commonly coarse grained) on the flood plain.

**Flood-plain step**

An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. May occur individually or as a series of steps.

**Fluvial**

Of or pertaining to rivers or streams; produced by stream or river action.

**Foothills**

A region of steeply sloping hills that fringes a mountain range or high-plateau escarpment. The hills have relief of as much as 1,000 feet (300 meters).

**Footslope**

The concave surface at the base of a hillslope. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

**Forb**

Any herbaceous plant not a grass or a sedge.

**Forest cover**

All trees and other woody plants (underbrush) covering the ground in a forest.

**Forest type**

A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

**Fragipan**

A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

**Genesis, soil**

The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

**Gilgai**

Commonly, a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel with the slope. Typically, the microrelief of clayey soils that shrink and swell considerably with changes in moisture content.

**Glaciofluvial deposits**

Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur in the form of outwash plains, valley trains, deltas, kames, eskers, and kame terraces.

**Glaciolacustrine deposits**

Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are bedded or laminated.

**Gleyed soil**

Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

**Graded stripcropping**

Growing crops in strips that grade toward a protected waterway.

**Grassed waterway**

A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

**Gravel**

Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

**Gravel pit (map symbol)**

An open excavation from which soil and underlying material have been removed and used, without crushing, as a source of sand or gravel.

**Gravelly soil material**

Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

**Gravelly spot (map symbol)**

A spot where the surface layer has more than 35 percent, by volume, rock fragments that are mostly less than 3 inches in diameter in an area that has less than 15 percent rock fragments.

**Green manure crop (agronomy)**

A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

**Ground water**

Water filling all the unblocked pores of the material below the water table.

**Gully (map symbol)**

A small, steep-sided channel caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage whereas a rill is of lesser depth and can be smoothed over by ordinary tillage.

**Hard bedrock**

Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

**Hard to reclaim**

Reclamation is difficult after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

**Hardpan**

A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

**Head slope (geomorphology)**

A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

**Hemic soil material (mucky peat)**

Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

**High-residue crops**

Such crops as small grain and corn used for grain. If properly managed, residue from these crops can be used to control erosion until the next crop in the rotation is established. These crops return large amounts of organic matter to the soil.

**Hill**

A generic term for an elevated area of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

**Hillslope**

A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

**Horizon, soil**

A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the “Soil Survey Manual.” The major horizons of mineral soil are as follows:

*O horizon:* An organic layer of fresh and decaying plant residue.

*L horizon:* A layer of organic and mineral limnic materials, including coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

*A horizon:* The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

*E horizon:* The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

*B horizon:* The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

*C horizon:* The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

*Cr horizon:* Soft, consolidated bedrock beneath the soil.

*R layer:* Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

*M layer:* A root-limiting subsoil layer consisting of nearly continuous, horizontally oriented, human-manufactured materials.

*W layer:* A layer of water within or beneath the soil.

**Humus**

The well decomposed, more or less stable part of the organic matter in mineral soils.

**Hydrologic soil groups**

Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties include depth to a seasonal high water table, the infiltration rate, and depth to a layer that significantly restricts the downward movement of water. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

**Igneous rock**

Rock that was formed by cooling and solidification of magma and that has not been changed appreciably by weathering since its formation. Major varieties include plutonic and volcanic rock (e.g., andesite, basalt, and granite).

**Illuviation**

The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

**Impervious soil**

A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

**Increasers**

Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

**Infiltration**

The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

**Infiltration capacity**

The maximum rate at which water can infiltrate into a soil under a given set of conditions.

**Infiltration rate**

The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

**Intake rate**

The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

*Very low:* Less than 0.2
*Low:* 0.2 to 0.4
*Moderately low:* 0.4 to 0.75
*Moderate:* 0.75 to 1.25
*Moderately high:* 1.25 to 1.75
*High:* 1.75 to 2.5
*Very high:* More than 2.5

**Interfluve**

A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways.

**Interfluve (geomorphology)**

A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloping area of a hill; shoulders of backwearing hillslopes can narrow the upland or can merge, resulting in a strongly convex shape.

**Intermittent stream**

A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

**Invaders**

On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

**Iron depletions**

See Redoximorphic features.

**Irrigation**

Application of water to soils to assist in production of crops. Methods of irrigation are:

*Basin:* Water is applied rapidly to nearly level plains surrounded by levees or dikes.

*Border:* Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

*Controlled flooding:* Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

*Corrugation:* Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

*Drip (or trickle):* Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

*Furrow:* Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

*Sprinkler:* Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

*Subirrigation:* Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

*Wild flooding:* Water, released at high points, is allowed to flow onto an area without controlled distribution.

**Kame**

A low mound, knob, hummock, or short irregular ridge composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier; by a supraglacial stream in a low place or hole on the surface of the glacier; or as a ponded deposit on the surface or at the margin of stagnant ice.

**Karst (topography)**

A kind of topography that formed in limestone, gypsum, or other soluble rocks by dissolution and that is characterized by closed depressions, sinkholes, caves, and underground drainage.

**Knoll**

A small, low, rounded hill rising above adjacent landforms.

**Ksat**

See Saturated hydraulic conductivity.

**Lacustrine deposit**

Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

**Lake plain**

A nearly level surface marking the floor of an extinct lake filled by well sorted, generally fine textured, stratified deposits, commonly containing varves.

**Lake terrace**

A narrow shelf, partly cut and partly built, produced along a lakeshore in front of a scarp line of low cliffs and later exposed when the water level falls.

**Landfill (map symbol)**

An area of accumulated waste products of human habitation, either above or below natural ground level.

**Landslide**

A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

**Large stones**

Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

**Lava flow (map symbol)**

A solidified, commonly lobate body of rock formed through lateral, surface outpouring of molten lava from a vent or fissure.

**Leaching**

The removal of soluble material from soil or other material by percolating water.

**Levee (map symbol)**

An embankment that confines or controls water, especially one built along the banks of a river to prevent overflow onto lowlands.

**Linear extensibility**

Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at $^1/_3$- or $^1/_{10}$-bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

**Liquid limit**

The moisture content at which the soil passes from a plastic to a liquid state.

**Loam**

Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

**Loess**

Material transported and deposited by wind and consisting dominantly of silt-sized particles.

**Low strength**

The soil is not strong enough to support loads.

**Low-residue crops**

Such crops as corn used for silage, peas, beans, and potatoes. Residue from these crops is not adequate to control erosion until the next crop in the rotation is established. These crops return little organic matter to the soil.

**Marl**

An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also formed in more saline environments.

**Marsh or swamp (map symbol)**

A water-saturated, very poorly drained area that is intermittently or permanently covered by water. Sedges, cattails, and rushes are the dominant vegetation in marshes, and trees or shrubs are the dominant vegetation in swamps. Not used in map units where the named soils are poorly drained or very poorly drained.

**Mass movement**

A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

**Masses**

See Redoximorphic features.

**Meander belt**

The zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops.

**Meander scar**

A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream that impinged upon and undercut the bluff.

**Meander scroll**

One of a series of long, parallel, close-fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank.

**Mechanical treatment**

Use of mechanical equipment for seeding, brush management, and other management practices.

**Medium textured soil**

Very fine sandy loam, loam, silt loam, or silt.

**Mesa**

A broad, nearly flat topped and commonly isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal rocky material. The summit width is characteristically greater than the height of the bounding escarpments.

**Metamorphic rock**

Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth’s crust. Nearly all such rocks are crystalline.

**Mine or quarry (map symbol)**

An open excavation from which soil and underlying material have been removed and in which bedrock is exposed. Also denotes surface openings to underground mines.

**Mine spoil**

An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. Also called earthy fill.

**Mineral soil**

Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

**Minimum tillage**

Only the tillage essential to crop production and prevention of soil damage.

**Miscellaneous area**

A kind of map unit that has little or no natural soil and supports little or no vegetation.

**Miscellaneous water (map symbol)**

Small, constructed bodies of water that are used for industrial, sanitary, or mining applications and that contain water most of the year.

**Moderately coarse textured soil**

Coarse sandy loam, sandy loam, or fine sandy loam.

**Moderately fine textured soil**

Clay loam, sandy clay loam, or silty clay loam.

**Mollic epipedon**

A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

**Moraine**

In terms of glacial geology, a mound, ridge, or other topographically distinct accumulation of unsorted, unstratified drift, predominantly till, deposited primarily by the direct action of glacial ice in a variety of landforms. Also, a general term for a landform composed mainly of till (except for kame moraines, which are composed mainly of stratified outwash) that has been deposited by a glacier. Some types of moraines are disintegration, end, ground, kame, lateral, recessional, and terminal.

**Morphology, soil**

The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

**Mottling, soil**

Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

**Mountain**

A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can occur as a single, isolated mass or in a group forming a chain or range. Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

**Muck**

Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

**Mucky peat**

See Hemic soil material.

**Mudstone**

A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

**Munsell notation**

A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

**Natric horizon**

A special kind of argillic horizon that contains enough exchangeable sodium to have an adverse effect on the physical condition of the subsoil.

**Neutral soil**

A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

**Nodules**

See Redoximorphic features.

**Nose slope (geomorphology)**

A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

**Nutrient, plant**

Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

**Organic matter**

Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

*Very low:* Less than 0.5 percent
*Low:* 0.5 to 1.0 percent
*Moderately low:* 1.0 to 2.0 percent
*Moderate:* 2.0 to 4.0 percent
*High:* 4.0 to 8.0 percent
*Very high:* More than 8.0 percent

**Outwash**

Stratified and sorted sediments (chiefly sand and gravel) removed or “washed out” from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of a glacier. The coarser material is deposited nearer to the ice.

**Outwash plain**

An extensive lowland area of coarse textured glaciofluvial material. An outwash plain is commonly smooth; where pitted, it generally is low in relief.

**Paleoterrace**

An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to, a present-day stream or drainage network.

**Pan**

A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

**Parent material**

The unconsolidated organic and mineral material in which soil forms.

**Peat**

Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

**Ped**

An individual natural soil aggregate, such as a granule, a prism, or a block.

**Pedisediment**

A layer of sediment, eroded from the shoulder and backslope of an erosional slope, that lies on and is being (or was) transported across a gently sloping erosional surface at the foot of a receding hill or mountain slope.

**Pedon**

The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

**Percolation**

The movement of water through the soil.

**Perennial water (map symbol)**

Small, natural or constructed lakes, ponds, or pits that contain water most of the year.

**Permafrost**

Ground, soil, or rock that remains at or below 0 degrees C for at least 2 years. It is defined on the basis of temperature and is not necessarily frozen.

**pH value**

A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

**Phase, soil**

A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

**Piping**

Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

**Pitting**

Pits caused by melting around ice. They form on the soil after plant cover is removed.

**Plastic limit**

The moisture content at which a soil changes from semisolid to plastic.

**Plasticity index**

The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

**Plateau (geomorphology)**

A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

**Playa**

The generally dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation and runoff. Playa deposits are fine grained and may or may not have a high water table and saline conditions.

**Plinthite**

The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other diluents. It commonly appears as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on repeated wetting and drying, especially if it is exposed also to heat from the sun. In a moist soil, plinthite can be cut with a spade. It is a form of laterite.

**Plowpan**

A compacted layer formed in the soil directly below the plowed layer.

**Ponding**

Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

**Poorly graded**

Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

**Pore linings**

See Redoximorphic features.

**Potential native plant community**

See Climax plant community.

**Potential rooting depth (effective rooting depth)**

Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

**Prescribed burning**

Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

**Productivity, soil**

The capability of a soil for producing a specified plant or sequence of plants under specific management.

**Profile, soil**

A vertical section of the soil extending through all its horizons and into the parent material.

**Proper grazing use**

Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproduction capacity of the key plants and promotes the accumulation of litter and mulch necessary to conserve soil and water.

**Rangeland**

Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

**Reaction, soil**

A measure of acidity or alkalinity of a soil, expressed as pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

*Ultra acid:* Less than 3.5
*Extremely acid:* 3.5 to 4.4
*Very strongly acid:* 4.5 to 5.0
*Strongly acid:* 5.1 to 5.5
*Moderately acid:* 5.6 to 6.0
*Slightly acid:* 6.1 to 6.5
*Neutral:* 6.6 to 7.3
*Slightly alkaline:* 7.4 to 7.8
*Moderately alkaline:* 7.9 to 8.4
*Strongly alkaline:* 8.5 to 9.0
*Very strongly alkaline:* 9.1 and higher

**Red beds**

Sedimentary strata that are mainly red and are made up largely of sandstone and shale.

**Redoximorphic concentrations**

See Redoximorphic features.

**Redoximorphic depletions**

See Redoximorphic features.

**Redoximorphic features**

Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:
   A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*
   B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*
   C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.
2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:
   A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*
   B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).
3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

**Reduced matrix**

See Redoximorphic features.

**Regolith**

All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial, glacial, eolian, lacustrine, and pyroclastic deposits.

**Relief**

The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

**Residuum (residual soil material)**

Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

**Rill**

A very small, steep-sided channel resulting from erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. A rill generally is not an obstacle to wheeled vehicles and is shallow enough to be smoothed over by ordinary tillage.

**Riser**

The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, steplike landforms, such as successive stream terraces.

**Road cut**

A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

**Rock fragments**

Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

**Rock outcrop (map symbol)**

An exposure of bedrock at the surface of the earth. Not used where the named soils of the surrounding map unit are shallow over bedrock or where “Rock outcrop” is a named component of the map unit.

**Root zone**

The part of the soil that can be penetrated by plant roots.

**Runoff**

The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

**Saline soil**

A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

**Saline spot (map symbol)**

An area where the surface layer has an electrical conductivity of 8 mmhos/cm more than the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has an electrical conductivity of 2 mmhos/cm or less.

**Sand**

As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

**Sandstone**

Sedimentary rock containing dominantly sand-sized particles.

**Sandy spot (map symbol)**

A spot where the surface layer is loamy fine sand or coarser in areas where the surface layer of the named soils in the surrounding map unit is very fine sandy loam or finer.

**Sapric soil material (muck)**

The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

**Saturated hydraulic conductivity (Ksat)**

The ease with which pores of a saturated soil transmit water. Formally, the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy's Law, a law that describes the rate of water movement through porous media. Commonly abbreviated as "Ksat." Terms describing saturated hydraulic conductivity are:

*Very high:* 100 or more micrometers per second (14.17 or more inches per hour)

*High:* 10 to 100 micrometers per second (1.417 to 14.17 inches per hour)

*Moderately high:* 1 to 10 micrometers per second (0.1417 inch to 1.417 inches per hour)

*Moderately low:* 0.1 to 1 micrometer per second (0.01417 to 0.1417 inch per hour)

*Low:* 0.01 to 0.1 micrometer per second (0.001417 to 0.01417 inch per hour)

*Very low:* Less than 0.01 micrometer per second (less than 0.001417 inch per hour).

To convert inches per hour to micrometers per second, multiply inches per hour by 7.0572. To convert micrometers per second to inches per hour, multiply micrometers per second by 0.1417.

**Saturation**

Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

**Scarification**

The act of abrading, scratching, loosening, crushing, or modifying the surface to increase water absorption or to provide a more tillable soil.

**Sedimentary rock**

A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

**Sequum**

A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

**Series, soil**

A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

**Severely eroded spot (map symbol)**

An area where, on the average, 75 percent or more of the original surface layer has been lost because of accelerated erosion. Not used in map units in which “severely eroded,” “very severely eroded,” or “gullied” is part of the map unit name.

**Shale**

Sedimentary rock that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

**Sheet erosion**

The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

**Short, steep slope (map symbol)**

A narrow area of soil having slopes that are at least two slope classes steeper than the slope class of the surrounding map unit.

**Shoulder**

The convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

**Shrink-swell**

The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

**Shrub-coppice dune**

A small, streamlined dune that forms around brush and clump vegetation.

**Side slope (geomorphology)**

A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

**Silica**

A combination of silicon and oxygen. The mineral form is called quartz.

**Silica-sesquioxide ratio**

The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

**Silt**

As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

**Siltstone**

An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

**Similar soils**

Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

**Sinkhole (map symbol)**

A closed, circular or elliptical depression, commonly funnel shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, or salt) or by collapse of underlying caves within bedrock. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography.

**Site index**

A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

**Slickensides (pedogenic)**

Grooved, striated, and/or glossy (shiny) slip faces on structural peds, such as wedges; produced by shrink-swell processes, most commonly in soils that have a high content of expansive clays.

**Slide or slip (map symbol)**

A prominent landform scar or ridge caused by fairly recent mass movement or descent of earthy material resulting from failure of earth or rock under shear stress along one or several surfaces.

**Slope**

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

**Slope alluvium**

Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

**Slow refill**

The slow filling of ponds, resulting from restricted water transmission in the soil.

**Slow water movement**

Restricted downward movement of water through the soil. See Saturated hydraulic conductivity.

**Sodic (alkali) soil**

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

**Sodic spot (map symbol)**

An area where the surface layer has a sodium adsorption ratio that is at least 10 more than that of the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has a sodium adsorption ratio of 5 or less.

**Sodicity**

The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of $Na^{+}$ to $Ca^{++}$ + $Mg^{++}$. The degrees of sodicity and their respective ratios are:

*Slight:* Less than 13:1

*Moderate:* 13-30:1

*Strong:* More than 30:1

**Sodium adsorption ratio (SAR)**

A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

**Soft bedrock**

Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

**Soil**

A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief and by the passage of time.

**Soil separates**

Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

*Very coarse sand:* 2.0 to 1.0

*Coarse sand:* 1.0 to 0.5

*Medium sand:* 0.5 to 0.25

*Fine sand:* 0.25 to 0.10

*Very fine sand:* 0.10 to 0.05

*Silt:* 0.05 to 0.002

*Clay:* Less than 0.002

**Solum**

The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

**Spoil area (map symbol)**

A pile of earthy materials, either smoothed or uneven, resulting from human activity.

**Stone line**

In a vertical cross section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments (commonly a gravel- or cobble-sized lag concentration) that formerly was draped across a topographic surface and was later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface.

**Stones**

Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

**Stony**

Refers to a soil containing stones in numbers that interfere with or prevent tillage.

**Stony spot (map symbol)**

A spot where 0.01 to 0.1 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surrounding soil has no surface stones.

**Strath terrace**

A type of stream terrace; formed as an erosional surface cut on bedrock and thinly mantled with stream deposits (alluvium).

**Stream terrace**

One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

**Stripcropping**

Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind erosion and water erosion.

**Structure, soil**

The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are:

*Platy:* Flat and laminated
*Prismatic:* Vertically elongated and having flat tops
*Columnar:* Vertically elongated and having rounded tops
*Angular blocky:* Having faces that intersect at sharp angles (planes)
*Subangular blocky:* Having subrounded and planar faces (no sharp angles)
*Granular:* Small structural units with curved or very irregular faces

Structureless soil horizons are defined as follows:

*Single grained:* Entirely noncoherent (each grain by itself), as in loose sand
*Massive:* Occurring as a coherent mass

**Stubble mulch**

Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

**Subsoil**

Technically, the B horizon; roughly, the part of the solum below plow depth.

**Subsoiling**

Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

**Substratum**

The part of the soil below the solum.

**Subsurface layer**

Any surface soil horizon (A, E, AB, or EB) below the surface layer.

**Summer fallow**

The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

**Summit**

The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

**Surface layer**

The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the “plow layer,” or the “Ap horizon.”

**Surface soil**

The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

**Talus**

Rock fragments of any size or shape (commonly coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.

**Taxadjuncts**

Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

**Terminal moraine**

An end moraine that marks the farthest advance of a glacier. It typically has the form of a massive arcuate or concentric ridge, or complex of ridges, and is underlain by till and other types of drift.

**Terrace (conservation)**

An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

**Terrace (geomorphology)**

A steplike surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

**Terracettes**

Small, irregular steplike forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock, such as sheep or cattle.

**Texture, soil**

The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,” “fine,” or “very fine.”

**Thin layer**

Otherwise suitable soil material that is too thin for the specified use.

**Till**

Dominantly unsorted and nonstratified drift, generally unconsolidated and deposited directly by a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders; rock fragments of various lithologies are embedded within a finer matrix that can range from clay to sandy loam.

**Till plain**

An extensive area of level to gently undulating soils underlain predominantly by till and bounded at the distal end by subordinate recessional or end moraines.

**Tilth, soil**

The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

**Toeslope**

The gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

**Topsoil**

The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

**Trace elements**

Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

**Tread**

The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

**Tuff**

A generic term for any consolidated or cemented deposit that is 50 percent or more volcanic ash.

**Upland**

An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum.

**Valley fill**

The unconsolidated sediment deposited by any agent (water, wind, ice, or mass wasting) so as to fill or partly fill a valley.

**Variegation**

Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

**Varve**

A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

**Very stony spot (map symbol)**

A spot where 0.1 to 3.0 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surface of the surrounding soil is covered by less than 0.01 percent stones.

**Water bars**

Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

**Weathering**

All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth's surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered material.

**Well graded**

Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

**Wet spot (map symbol)**

A somewhat poorly drained to very poorly drained area that is at least two drainage classes wetter than the named soils in the surrounding map unit.

**Wilting point (or permanent wilting point)**

The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

**Windthrow**

The uprooting and tipping over of trees by the wind.

# APPENDIX D

## EXISTING HEC HMS OUTPUT TABLES
## PROPOSED HEC HMS OUTPUT TABLES
## PROPOSED IMPROVEMENTS DATA AND CALCULATIONS

# Existing HEC-HMS Output Tables

| Table D1: Existing Conditions HEC-HMS Output Summary<br>10-yr 24-hr 25% Frequency Distribution | | | | | |
|---|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume | Cfs/Acre |
| | sq mi | cfs | days hours | ac - ft | |
| W430 | 1.23 | 70 | 01Jan2000, 07:50 | 24.8 | 0.0893 |
| W400 | 1.68 | 274 | 01Jan2000, 07:10 | 58.4 | 0.2550 |
| W420 | 1.19 | 222 | 01Jan2000, 07:05 | 44.2 | 0.2923 |
| J420 | 1.19 | 222 | 01Jan2000, 07:05 | 44.2 | 0.2923 |
| R420 | 1.19 | 221 | 01Jan2000, 07:20 | 44.2 | 0.2909 |
| J400 | 4.09 | 544 | 01Jan2000, 07:20 | 127.4 | 0.2078 |
| R400 | 4.09 | 542 | 01Jan2000, 07:30 | 127.5 | 0.2070 |
| W690 | 0.88 | 201 | 01Jan2000, 06:50 | 32.7 | 0.3579 |
| J690 | 0.88 | 201 | 01Jan2000, 06:50 | 32.7 | 0.3579 |
| R690 | 0.88 | 199 | 01Jan2000, 07:25 | 32.7 | 0.3543 |
| W680 | 0.65 | 32 | 01Jan2000, 07:55 | 12.0 | 0.0771 |
| W530 | 0.44 | 21 | 01Jan2000, 07:05 | 5.5 | 0.0742 |
| J530 | 6.06 | 784 | 01Jan2000, 07:30 | 177.7 | 0.2022 |
| R530 | 6.06 | 782 | 01Jan2000, 07:50 | 177.8 | 0.2017 |
| W650 | 1.13 | 162 | 01Jan2000, 07:10 | 34.2 | 0.2232 |
| Junction-1 | 7.19 | 877 | 01Jan2000, 07:45 | 212.0 | 0.1905 |
| W540 | 0.39 | 108 | 01Jan2000, 06:40 | 14.7 | 0.4290 |
| Junction-2 | 0.39 | 108 | 01Jan2000, 06:40 | 14.7 | 0.4290 |
| W630 | 0.30 | 118 | 01Jan2000, 06:30 | 12.9 | 0.6081 |
| J1 | 0.30 | 118 | 01Jan2000, 06:30 | 12.9 | 0.6081 |
| C1 | 7.89 | 908 | 01Jan2000, 07:45 | 239.6 | 0.1798 |
| Upstream Ponding | 7.89 | 902 | 01Jan2000, 07:50 | 239.6 | 0.1786 |
| J630 | 7.89 | 902 | 01Jan2000, 07:50 | 239.6 | 0.1786 |
| R630 | 7.89 | 900 | 01Jan2000, 08:00 | 239.6 | 0.1782 |
| W640 | 0.22 | 31 | 01Jan2000, 06:55 | 5.6 | 0.2251 |
| W065 | 0.09 | 21 | 01Jan2000, 06:30 | 2.4 | 0.3743 |
| Outlet1 | 8.19 | 910 | 01Jan2000, 08:00 | 247.6 | 0.1736 |
| W170 | 0.65 | 42 | 01Jan2000, 07:40 | 13.1 | 0.1012 |
| J170 | 0.65 | 42 | 01Jan2000, 07:40 | 13.1 | 0.1012 |
| R170 | 0.65 | 42 | 01Jan2000, 08:05 | 13.1 | 0.1012 |
| W190 | 0.34 | 76 | 01Jan2000, 06:35 | 10.1 | 0.3529 |
| JC5 | 0.98 | 76 | 01Jan2000, 06:35 | 23.3 | 0.1206 |
| W200 | 0.35 | 25 | 01Jan2000, 06:45 | 4.8 | 0.1129 |
| W150 | 0.24 | 25 | 01Jan2000, 06:35 | 4.0 | 0.1647 |
| W180 | 0.10 | 16 | 01Jan2000, 06:25 | 1.9 | 0.2596 |

| Table D1: Existing Conditions HEC-HMS Output Summary<br>10-yr 24-hr 25% Frequency Distribution | | | | | |
|---|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume | Cfs/Acre |
| JC6 | 0.68 | 61 | 01Jan2000, 06:35 | 10.7 | 0.1403 |
| RC6 | 0.68 | 61 | 01Jan2000, 06:45 | 10.7 | 0.1403 |
| W165 | 0.03 | 15 | 01Jan2000, 06:15 | 1.1 | 0.9155 |
| JC4 | 0.03 | 15 | 01Jan2000, 06:15 | 1.1 | 0.9155 |
| J200 | 1.69 | 139 | 01Jan2000, 06:40 | 35.1 | 0.1285 |
| R200 | 1.69 | 137 | 01Jan2000, 06:50 | 35.1 | 0.1267 |
| W230 | 0.43 | 33 | 01Jan2000, 07:10 | 8.0 | 0.1201 |
| W210 | 0.09 | 5 | 01Jan2000, 06:45 | 1.0 | 0.0850 |
| W160 | 0.02 | 2 | 01Jan2000, 06:20 | 0.3 | 0.1564 |
| JC2 | 0.02 | 2 | 01Jan2000, 06:20 | 0.3 | 0.1564 |
| R160 | 0.02 | 2 | 01Jan2000, 06:35 | 0.3 | 0.1564 |
| J210 | 0.11 | 7 | 01Jan2000, 06:40 | 1.3 | 0.0978 |
| Sink-1 | 2.23 | 172 | 01Jan2000, 06:55 | 44.3 | 0.1205 |
| W220 | 0.42 | 52 | 01Jan2000, 07:05 | 10.9 | 0.1931 |
| W130 | 0.01 | 2 | 01Jan2000, 06:25 | 0.2 | 0.2271 |
| J130 | 0.01 | 2 | 01Jan2000, 06:25 | 0.2 | 0.2271 |
| R150 | 0.01 | 2 | 01Jan2000, 07:45 | 0.2 | 0.2271 |
| Sink-2 | 0.43 | 52 | 01Jan2000, 07:05 | 11.1 | 0.1870 |
| W580 | 0.33 | 30 | 01Jan2000, 06:45 | 5.5 | 0.1434 |
| W215 | 0.07 | 6 | 01Jan2000, 06:30 | 0.9 | 0.1304 |
| Sink-7 | 0.40 | 35 | 01Jan2000, 06:45 | 6.4 | 0.1371 |
| W290 | 0.21 | 27 | 01Jan2000, 06:50 | 4.9 | 0.2049 |
| Sink-3 | 0.21 | 27 | 01Jan2000, 06:50 | 4.9 | 0.2049 |
| W020 | 0.05 | 2 | 01Jan2000, 06:35 | 0.4 | 0.0576 |
| W015 | 0.01 | 1 | 01Jan2000, 06:20 | 0.2 | 0.1049 |
| J015 | 0.01 | 1 | 01Jan2000, 06:20 | 0.2 | 0.1049 |
| J020 | 0.07 | 3 | 01Jan2000, 06:30 | 0.5 | 0.0678 |
| W025 | 0.05 | 8 | 01Jan2000, 06:25 | 1.0 | 0.2282 |
| W030 | 0.03 | 2 | 01Jan2000, 06:25 | 0.3 | 0.1175 |
| W031 | 0.02 | 37 | 01Jan2000, 06:10 | 2.0 | 3.1849 |
| Ex.W031Pond | 0.02 | 0 | 01Jan2000, 10:00 | 1.9 | 0.0000 |
| J031 | 0.02 | 0 | 01Jan2000, 10:00 | 1.9 | 0.0000 |
| J030 | 0.04 | 2 | 01Jan2000, 06:25 | 2.2 | 0.0698 |
| W055 | 0.03 | 2 | 01Jan2000, 06:35 | 0.3 | 0.0944 |
| Sink-5 | 0.20 | 14 | 01Jan2000, 06:25 | 4.1 | 0.1084 |
| W060 | 0.17 | 35 | 01Jan2000, 06:35 | 4.8 | 0.3195 |

| Table D1: Existing Conditions HEC-HMS Output Summary<br>10-yr 24-hr 25% Frequency Distribution | | | | | |
|---|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume | Cfs/Acre |
| Sink-4 | 0.17 | 35 | 01Jan2000, 06:35 | 4.8 | 0.3195 |
| W035 | 0.02 | 1 | 01Jan2000, 06:20 | 0.2 | 0.0956 |
| J035 | 0.02 | 1 | 01Jan2000, 06:20 | 0.2 | 0.0956 |
| W034 | 0.01 | 1 | 01Jan2000, 06:20 | 0.1 | 0.1262 |
| J034 | 0.03 | 2 | 01Jan2000, 06:20 | 0.3 | 0.1088 |
| W045 | 0.04 | 7 | 01Jan2000, 06:25 | 0.8 | 0.2638 |
| W040 | 0.03 | 2 | 01Jan2000, 06:20 | 0.3 | 0.1233 |
| J040 | 0.03 | 2 | 01Jan2000, 06:20 | 0.3 | 0.1233 |
| J045 | 0.10 | 11 | 01Jan2000, 06:25 | 1.4 | 0.1799 |
| W050 | 0.01 | 7 | 01Jan2000, 06:10 | 0.5 | 0.8298 |
| Sink-6 | 0.11 | 16 | 01Jan2000, 06:20 | 1.9 | 0.2300 |

| Table D2: Existing Conditions HEC-HMS Output Summary<br>25-yr 24-hr 25% Frequency Distribution | | | | | |
|---|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume | Cfs/Acre |
| | sq mi | cfs | days hours | ac - ft | |
| W430 | 1.23 | 135 | 01Jan2000, 07:50 | 43.0 | 0.1722 |
| W400 | 1.68 | 458 | 01Jan2000, 07:10 | 91.0 | 0.4262 |
| W420 | 1.19 | 367 | 01Jan2000, 07:05 | 68.2 | 0.4831 |
| J420 | 1.19 | 367 | 01Jan2000, 07:05 | 68.2 | 0.4831 |
| R420 | 1.19 | 364 | 01Jan2000, 07:20 | 68.2 | 0.4792 |
| J400 | 4.09 | 922 | 01Jan2000, 07:15 | 202.3 | 0.3521 |
| R400 | 4.09 | 920 | 01Jan2000, 07:25 | 202.3 | 0.3514 |
| W690 | 0.88 | 336 | 01Jan2000, 06:50 | 50.4 | 0.5982 |
| J690 | 0.88 | 336 | 01Jan2000, 06:50 | 50.4 | 0.5982 |
| R690 | 0.88 | 332 | 01Jan2000, 07:20 | 50.5 | 0.5911 |
| W680 | 0.65 | 64 | 01Jan2000, 07:50 | 21.3 | 0.1543 |
| W530 | 0.44 | 50 | 01Jan2000, 07:00 | 10.7 | 0.1767 |
| J530 | 6.06 | 1339 | 01Jan2000, 07:25 | 284.8 | 0.3453 |
| R530 | 6.06 | 1334 | 01Jan2000, 07:40 | 284.9 | 0.3440 |
| W650 | 1.13 | 283 | 01Jan2000, 07:05 | 54.8 | 0.3900 |
| Junction-1 | 7.19 | 1518 | 01Jan2000, 07:40 | 339.8 | 0.3297 |
| W540 | 0.39 | 181 | 01Jan2000, 06:40 | 22.6 | 0.7189 |
| Junction-2 | 0.39 | 181 | 01Jan2000, 06:40 | 22.6 | 0.7189 |
| W630 | 0.30 | 193 | 01Jan2000, 06:30 | 19.5 | 0.9946 |
| J1 | 0.30 | 193 | 01Jan2000, 06:30 | 19.5 | 0.9946 |
| C1 | 7.89 | 1570 | 01Jan2000, 07:40 | 381.8 | 0.3109 |
| Upstream Ponding | 7.89 | 970 | 01Jan2000, 08:25 | 381.8 | 0.1921 |
| J630 | 7.89 | 970 | 01Jan2000, 08:25 | 381.8 | 0.1921 |
| R630 | 7.89 | 970 | 01Jan2000, 08:35 | 382.0 | 0.1921 |
| W640 | 0.22 | 57 | 01Jan2000, 06:50 | 9.2 | 0.4140 |
| W065 | 0.09 | 37 | 01Jan2000, 06:30 | 3.9 | 0.6594 |
| Outlet1 | 8.19 | 978 | 01Jan2000, 08:35 | 395.1 | 0.1865 |
| W170 | 0.65 | 81 | 01Jan2000, 07:35 | 22.8 | 0.1952 |
| J170 | 0.65 | 81 | 01Jan2000, 07:35 | 22.8 | 0.1952 |
| R170 | 0.65 | 81 | 01Jan2000, 07:55 | 22.8 | 0.1952 |
| W190 | 0.34 | 137 | 01Jan2000, 06:35 | 16.3 | 0.6362 |
| JC5 | 0.98 | 137 | 01Jan2000, 06:35 | 39.2 | 0.2173 |
| W200 | 0.35 | 59 | 01Jan2000, 06:40 | 9.1 | 0.2665 |
| W150 | 0.24 | 56 | 01Jan2000, 06:30 | 7.3 | 0.3690 |
| W180 | 0.10 | 33 | 01Jan2000, 06:25 | 3.3 | 0.5355 |

| Table D2: Existing Conditions HEC-HMS Output Summary<br>25-yr 24-hr 25% Frequency Distribution | | | | | |
|---|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume | Cfs/Acre |
| JC6 | 0.68 | 139 | 01Jan2000, 06:35 | 19.6 | 0.3197 |
| RC6 | 0.68 | 139 | 01Jan2000, 06:40 | 19.6 | 0.3197 |
| W165 | 0.03 | 24 | 01Jan2000, 06:15 | 1.6 | 1.4648 |
| JC4 | 0.03 | 24 | 01Jan2000, 06:15 | 1.6 | 1.4648 |
| J200 | 1.69 | 279 | 01Jan2000, 06:35 | 60.4 | 0.2580 |
| R200 | 1.69 | 276 | 01Jan2000, 06:50 | 60.4 | 0.2552 |
| W230 | 0.43 | 68 | 01Jan2000, 07:05 | 14.1 | 0.2476 |
| W210 | 0.09 | 13 | 01Jan2000, 06:40 | 2.0 | 0.2211 |
| W160 | 0.02 | 6 | 01Jan2000, 06:15 | 0.5 | 0.4692 |
| JC2 | 0.02 | 6 | 01Jan2000, 06:15 | 0.5 | 0.4692 |
| R160 | 0.02 | 6 | 01Jan2000, 06:25 | 0.5 | 0.4692 |
| J210 | 0.11 | 18 | 01Jan2000, 06:35 | 2.5 | 0.2514 |
| Sink-1 | 2.23 | 350 | 01Jan2000, 06:50 | 77.0 | 0.2451 |
| W220 | 0.42 | 96 | 01Jan2000, 07:00 | 18.0 | 0.3565 |
| W130 | 0.01 | 4 | 01Jan2000, 06:25 | 0.4 | 0.4542 |
| J130 | 0.01 | 4 | 01Jan2000, 06:25 | 0.4 | 0.4542 |
| R150 | 0.01 | 4 | 01Jan2000, 07:20 | 0.4 | 0.4542 |
| Sink-2 | 0.43 | 96 | 01Jan2000, 07:00 | 18.5 | 0.3452 |
| W580 | 0.33 | 66 | 01Jan2000, 06:40 | 10.0 | 0.3155 |
| W215 | 0.07 | 14 | 01Jan2000, 06:25 | 1.7 | 0.3042 |
| Sink-7 | 0.40 | 77 | 01Jan2000, 06:40 | 11.7 | 0.3017 |
| W290 | 0.21 | 52 | 01Jan2000, 06:50 | 8.3 | 0.3946 |
| Sink-3 | 0.21 | 52 | 01Jan2000, 06:50 | 8.3 | 0.3946 |
| W020 | 0.05 | 6 | 01Jan2000, 06:20 | 0.8 | 0.1727 |
| W015 | 0.01 | 4 | 01Jan2000, 06:15 | 0.4 | 0.4195 |
| J015 | 0.01 | 4 | 01Jan2000, 06:15 | 0.4 | 0.4195 |
| J020 | 0.07 | 10 | 01Jan2000, 06:20 | 1.2 | 0.2259 |
| W025 | 0.05 | 18 | 01Jan2000, 06:20 | 1.8 | 0.5135 |
| W030 | 0.03 | 5 | 01Jan2000, 06:20 | 0.5 | 0.2937 |
| W031 | 0.02 | 48 | 01Jan2000, 06:10 | 2.6 | 4.1318 |
| Ex.W031Pond | 0.02 | 1 | 01Jan2000, 09:00 | 2.3 | 0.0861 |
| J031 | 0.02 | 1 | 01Jan2000, 09:00 | 2.3 | 0.0861 |
| J030 | 0.04 | 5 | 01Jan2000, 06:20 | 2.8 | 0.1746 |
| W055 | 0.03 | 5 | 01Jan2000, 06:25 | 0.7 | 0.2360 |
| Sink-5 | 0.20 | 37 | 01Jan2000, 06:20 | 6.5 | 0.2865 |
| W060 | 0.17 | 64 | 01Jan2000, 06:35 | 7.8 | 0.5841 |

| Table D2: Existing Conditions HEC-HMS Output Summary<br>25-yr 24-hr 25% Frequency Distribution | | | | | |
|---|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume | Cfs/Acre |
| Sink-4 | 0.17 | 64 | 01Jan2000, 06:35 | 7.8 | 0.5841 |
| W035 | 0.02 | 4 | 01Jan2000, 06:15 | 0.4 | 0.3823 |
| J035 | 0.02 | 4 | 01Jan2000, 06:15 | 0.4 | 0.3823 |
| W034 | 0.01 | 2 | 01Jan2000, 06:15 | 0.3 | 0.2524 |
| J034 | 0.03 | 6 | 01Jan2000, 06:15 | 0.6 | 0.3263 |
| W045 | 0.04 | 15 | 01Jan2000, 06:20 | 1.5 | 0.5653 |
| W040 | 0.03 | 6 | 01Jan2000, 06:15 | 0.6 | 0.3700 |
| J040 | 0.03 | 6 | 01Jan2000, 06:15 | 0.6 | 0.3700 |
| J045 | 0.10 | 26 | 01Jan2000, 06:20 | 2.6 | 0.4253 |
| W050 | 0.01 | 13 | 01Jan2000, 06:10 | 0.8 | 1.5410 |
| Sink-6 | 0.11 | 36 | 01Jan2000, 06:15 | 3.4 | 0.5174 |

| Table D3: Existing Conditions HEC-HMS Output Summary<br>50-yr 24-hr 25% Frequency Distribution | | | | | |
|---|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume | Cfs/Acre |
| | sq mi | cfs | days hours | ac - ft | |
| W430 | 1.23 | 193 | 01Jan2000, 07:45 | 59.5 | 0.2461 |
| W400 | 1.68 | 608 | 01Jan2000, 07:10 | 119.2 | 0.5658 |
| W420 | 1.19 | 483 | 01Jan2000, 07:05 | 88.6 | 0.6358 |
| J420 | 1.19 | 483 | 01Jan2000, 07:05 | 88.6 | 0.6358 |
| R420 | 1.19 | 481 | 01Jan2000, 07:15 | 88.7 | 0.6332 |
| J400 | 4.09 | 1233 | 01Jan2000, 07:15 | 267.3 | 0.4709 |
| R400 | 4.09 | 1228 | 01Jan2000, 07:25 | 267.4 | 0.4690 |
| W690 | 0.88 | 442 | 01Jan2000, 06:50 | 65.6 | 0.7870 |
| J690 | 0.88 | 442 | 01Jan2000, 06:50 | 65.6 | 0.7870 |
| R690 | 0.88 | 437 | 01Jan2000, 07:15 | 65.6 | 0.7781 |
| W680 | 0.65 | 92 | 01Jan2000, 07:50 | 29.7 | 0.2218 |
| W530 | 0.44 | 78 | 01Jan2000, 07:00 | 15.6 | 0.2756 |
| J530 | 6.06 | 1798 | 01Jan2000, 07:20 | 378.3 | 0.4637 |
| R530 | 6.06 | 1791 | 01Jan2000, 07:40 | 378.5 | 0.4619 |
| W650 | 1.13 | 383 | 01Jan2000, 07:05 | 72.8 | 0.5278 |
| Junction-1 | 7.19 | 2052 | 01Jan2000, 07:35 | 451.2 | 0.4457 |
| W540 | 0.39 | 239 | 01Jan2000, 06:40 | 29.4 | 0.9493 |
| Junction-2 | 0.39 | 239 | 01Jan2000, 06:40 | 29.4 | 0.9493 |
| W630 | 0.30 | 251 | 01Jan2000, 06:30 | 25.0 | 1.2935 |
| J1 | 0.30 | 251 | 01Jan2000, 06:30 | 25.0 | 1.2935 |
| C1 | 7.89 | 2131 | 01Jan2000, 07:35 | 505.6 | 0.4220 |
| Upstream Ponding | 7.89 | 1175 | 01Jan2000, 08:05 | 505.6 | 0.2327 |
| J630 | 7.89 | 1175 | 01Jan2000, 08:05 | 505.6 | 0.2327 |
| R630 | 7.89 | 1175 | 01Jan2000, 08:30 | 505.7 | 0.2327 |
| W640 | 0.22 | 79 | 01Jan2000, 06:50 | 12.4 | 0.5737 |
| W065 | 0.09 | 51 | 01Jan2000, 06:25 | 5.1 | 0.9089 |
| Outlet1 | 8.19 | 1188 | 01Jan2000, 08:20 | 523.3 | 0.2266 |
| W170 | 0.65 | 116 | 01Jan2000, 07:35 | 31.5 | 0.2795 |
| J170 | 0.65 | 116 | 01Jan2000, 07:35 | 31.5 | 0.2795 |
| R170 | 0.65 | 116 | 01Jan2000, 07:50 | 31.6 | 0.2795 |
| W190 | 0.34 | 185 | 01Jan2000, 06:35 | 21.6 | 0.8592 |
| JC5 | 0.98 | 187 | 01Jan2000, 06:35 | 53.2 | 0.2967 |
| W200 | 0.35 | 91 | 01Jan2000, 06:40 | 13.1 | 0.4110 |
| W150 | 0.24 | 84 | 01Jan2000, 06:30 | 10.2 | 0.5534 |
| W180 | 0.10 | 47 | 01Jan2000, 06:25 | 4.5 | 0.7627 |

| Table D3: Existing Conditions HEC-HMS Output Summary<br>50-yr 24-hr 25% Frequency Distribution | | | | | |
|---|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume | Cfs/Acre |
| JC6 | 0.68 | 209 | 01Jan2000, 06:30 | 27.8 | 0.4807 |
| RC6 | 0.68 | 208 | 01Jan2000, 06:40 | 27.8 | 0.4784 |
| W165 | 0.03 | 31 | 01Jan2000, 06:15 | 2.0 | 1.8921 |
| JC4 | 0.03 | 31 | 01Jan2000, 06:15 | 2.0 | 1.8921 |
| J200 | 1.69 | 403 | 01Jan2000, 06:35 | 83.0 | 0.3726 |
| R200 | 1.69 | 400 | 01Jan2000, 06:45 | 83.0 | 0.3698 |
| W230 | 0.43 | 99 | 01Jan2000, 07:05 | 19.7 | 0.3604 |
| W210 | 0.09 | 21 | 01Jan2000, 06:35 | 2.9 | 0.3571 |
| W160 | 0.02 | 9 | 01Jan2000, 06:15 | 0.7 | 0.7038 |
| JC2 | 0.02 | 9 | 01Jan2000, 06:15 | 0.7 | 0.7038 |
| R160 | 0.02 | 9 | 01Jan2000, 06:25 | 0.7 | 0.7038 |
| J210 | 0.11 | 28 | 01Jan2000, 06:30 | 3.7 | 0.3911 |
| Sink-1 | 2.23 | 503 | 01Jan2000, 06:45 | 106.4 | 0.3523 |
| W220 | 0.42 | 132 | 01Jan2000, 07:00 | 24.3 | 0.4902 |
| W130 | 0.01 | 6 | 01Jan2000, 06:25 | 0.6 | 0.6813 |
| J130 | 0.01 | 6 | 01Jan2000, 06:25 | 0.6 | 0.6813 |
| R150 | 0.01 | 6 | 01Jan2000, 07:10 | 0.6 | 0.6813 |
| Sink-2 | 0.43 | 133 | 01Jan2000, 07:10 | 24.9 | 0.4783 |
| W580 | 0.33 | 98 | 01Jan2000, 06:40 | 14.1 | 0.4684 |
| W215 | 0.07 | 22 | 01Jan2000, 06:25 | 2.5 | 0.4781 |
| Sink-7 | 0.40 | 114 | 01Jan2000, 06:40 | 16.5 | 0.4467 |
| W290 | 0.21 | 73 | 01Jan2000, 06:50 | 11.3 | 0.5540 |
| Sink-3 | 0.21 | 73 | 01Jan2000, 06:50 | 11.3 | 0.5540 |
| W020 | 0.05 | 11 | 01Jan2000, 06:20 | 1.3 | 0.3167 |
| W015 | 0.01 | 6 | 01Jan2000, 06:15 | 0.5 | 0.6292 |
| J015 | 0.01 | 6 | 01Jan2000, 06:15 | 0.5 | 0.6292 |
| J020 | 0.07 | 17 | 01Jan2000, 06:15 | 1.8 | 0.3840 |
| W025 | 0.05 | 26 | 01Jan2000, 06:20 | 2.5 | 0.7417 |
| W030 | 0.03 | 8 | 01Jan2000, 06:20 | 0.8 | 0.4699 |
| W031 | 0.02 | 56 | 01Jan2000, 06:10 | 3.0 | 4.8204 |
| Ex.W031Pond | 0.02 | 10 | 01Jan2000, 06:40 | 2.7 | 0.8608 |
| J031 | 0.02 | 10 | 01Jan2000, 06:40 | 2.7 | 0.8608 |
| J030 | 0.04 | 14 | 01Jan2000, 06:40 | 3.5 | 0.4888 |
| W055 | 0.03 | 9 | 01Jan2000, 06:25 | 1.0 | 0.4248 |
| Sink-5 | 0.20 | 59 | 01Jan2000, 06:20 | 8.8 | 0.4568 |
| W060 | 0.17 | 88 | 01Jan2000, 06:35 | 10.4 | 0.8032 |

| Table D3: Existing Conditions HEC-HMS Output Summary<br>50-yr 24-hr 25% Frequency Distribution | | | | | |
|---|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume | Cfs/Acre |
| Sink-4 | 0.17 | 88 | 01Jan2000, 06:35 | 10.4 | 0.8032 |
| W035 | 0.02 | 6 | 01Jan2000, 06:15 | 0.5 | 0.5734 |
| J035 | 0.02 | 6 | 01Jan2000, 06:15 | 0.5 | 0.5734 |
| W034 | 0.01 | 4 | 01Jan2000, 06:15 | 0.4 | 0.5049 |
| J034 | 0.03 | 10 | 01Jan2000, 06:15 | 0.9 | 0.5439 |
| W045 | 0.04 | 22 | 01Jan2000, 06:20 | 2.0 | 0.8291 |
| W040 | 0.03 | 10 | 01Jan2000, 06:15 | 0.8 | 0.6166 |
| J040 | 0.03 | 10 | 01Jan2000, 06:15 | 0.8 | 0.6166 |
| J045 | 0.10 | 39 | 01Jan2000, 06:20 | 3.8 | 0.6379 |
| W050 | 0.01 | 17 | 01Jan2000, 06:10 | 1.0 | 2.0152 |
| Sink-6 | 0.11 | 54 | 01Jan2000, 06:15 | 4.7 | 0.7761 |

| Table D4: Existing Conditions HEC-HMS Output Summary<br>100-yr 24-hr 25% Frequency Distribution | | | | | |
|---|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume | Cfs/Acre |
| | sq mi | cfs | days hours | ac - ft | |
| W430 | 1.23 | 249 | 01Jan2000, 07:45 | 77.6 | 0.3176 |
| W400 | 1.68 | 748 | 01Jan2000, 07:10 | 149.3 | 0.6961 |
| W420 | 1.19 | 588 | 01Jan2000, 07:05 | 110.4 | 0.7741 |
| J420 | 1.19 | 588 | 01Jan2000, 07:05 | 110.4 | 0.7741 |
| R420 | 1.19 | 587 | 01Jan2000, 07:15 | 110.4 | 0.7728 |
| J400 | 4.09 | 1522 | 01Jan2000, 07:15 | 337.3 | 0.5813 |
| R400 | 4.09 | 1514 | 01Jan2000, 07:25 | 337.4 | 0.5782 |
| W690 | 0.88 | 536 | 01Jan2000, 06:50 | 81.6 | 0.9543 |
| J690 | 0.88 | 536 | 01Jan2000, 06:50 | 81.6 | 0.9543 |
| R690 | 0.88 | 531 | 01Jan2000, 07:15 | 81.7 | 0.9454 |
| W680 | 0.65 | 119 | 01Jan2000, 07:50 | 38.9 | 0.2868 |
| W530 | 0.44 | 105 | 01Jan2000, 07:00 | 21.0 | 0.3710 |
| J530 | 6.06 | 2219 | 01Jan2000, 07:20 | 479.0 | 0.5722 |
| R530 | 6.06 | 2208 | 01Jan2000, 07:35 | 479.3 | 0.5694 |
| W650 | 1.13 | 475 | 01Jan2000, 07:05 | 92.0 | 0.6545 |
| Junction-1 | 7.19 | 2543 | 01Jan2000, 07:35 | 571.3 | 0.5524 |
| W540 | 0.39 | 287 | 01Jan2000, 06:40 | 36.6 | 1.1400 |
| Junction-2 | 0.39 | 287 | 01Jan2000, 06:40 | 36.6 | 1.1400 |
| W630 | 0.30 | 297 | 01Jan2000, 06:30 | 30.7 | 1.5306 |
| J1 | 0.30 | 297 | 01Jan2000, 06:30 | 30.7 | 1.5306 |
| C1 | 7.89 | 2651 | 01Jan2000, 07:30 | 638.6 | 0.5250 |
| Upstream Ponding | 7.89 | 1175 | 01Jan2000, 07:40 | 638.6 | 0.2327 |
| J630 | 7.89 | 1175 | 01Jan2000, 07:40 | 638.6 | 0.2327 |
| R630 | 7.89 | 1175 | 01Jan2000, 08:05 | 638.7 | 0.2327 |
| W640 | 0.22 | 99 | 01Jan2000, 06:50 | 15.9 | 0.7190 |
| W065 | 0.09 | 62 | 01Jan2000, 06:25 | 6.5 | 1.1049 |
| Outlet1 | 8.19 | 1202 | 01Jan2000, 07:55 | 661.0 | 0.2293 |
| W170 | 0.65 | 149 | 01Jan2000, 07:35 | 41.1 | 0.3590 |
| J170 | 0.65 | 149 | 01Jan2000, 07:35 | 41.1 | 0.3590 |
| R170 | 0.65 | 149 | 01Jan2000, 07:50 | 41.1 | 0.3590 |
| W190 | 0.34 | 227 | 01Jan2000, 06:35 | 27.3 | 1.0542 |
| JC5 | 0.98 | 229 | 01Jan2000, 06:35 | 68.4 | 0.3633 |
| W200 | 0.35 | 120 | 01Jan2000, 06:40 | 17.5 | 0.5420 |
| W150 | 0.24 | 109 | 01Jan2000, 06:30 | 13.5 | 0.7182 |
| W180 | 0.10 | 58 | 01Jan2000, 06:25 | 5.8 | 0.9412 |

| Table D4: Existing Conditions HEC-HMS Output Summary<br>100-yr 24-hr 25% Frequency Distribution | | | | | |
|---|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume | Cfs/Acre |
| JC6 | 0.68 | 272 | 01Jan2000, 06:30 | 36.8 | 0.6255 |
| RC6 | 0.68 | 269 | 01Jan2000, 06:40 | 36.8 | 0.6186 |
| W165 | 0.03 | 36 | 01Jan2000, 06:15 | 2.5 | 2.1973 |
| JC4 | 0.03 | 36 | 01Jan2000, 06:15 | 2.5 | 2.1973 |
| J200 | 1.69 | 512 | 01Jan2000, 06:35 | 107.7 | 0.4734 |
| R200 | 1.69 | 508 | 01Jan2000, 06:45 | 107.7 | 0.4697 |
| W230 | 0.43 | 127 | 01Jan2000, 07:05 | 25.8 | 0.4623 |
| W210 | 0.09 | 28 | 01Jan2000, 06:35 | 4.0 | 0.4761 |
| W160 | 0.02 | 12 | 01Jan2000, 06:15 | 1.0 | 0.9384 |
| JC2 | 0.02 | 12 | 01Jan2000, 06:15 | 1.0 | 0.9384 |
| R160 | 0.02 | 12 | 01Jan2000, 06:25 | 1.0 | 0.9384 |
| J210 | 0.11 | 36 | 01Jan2000, 06:30 | 5.0 | 0.5028 |
| Sink-1 | 2.23 | 642 | 01Jan2000, 06:45 | 138.4 | 0.4496 |
| W220 | 0.42 | 165 | 01Jan2000, 07:00 | 31.0 | 0.6127 |
| W130 | 0.01 | 8 | 01Jan2000, 06:20 | 0.8 | 0.9084 |
| J130 | 0.01 | 8 | 01Jan2000, 06:20 | 0.8 | 0.9084 |
| R150 | 0.01 | 7 | 01Jan2000, 07:10 | 0.8 | 0.7949 |
| Sink-2 | 0.43 | 169 | 01Jan2000, 07:05 | 31.8 | 0.6077 |
| W580 | 0.33 | 127 | 01Jan2000, 06:40 | 18.6 | 0.6071 |
| W215 | 0.07 | 29 | 01Jan2000, 06:25 | 3.3 | 0.6302 |
| Sink-7 | 0.40 | 148 | 01Jan2000, 06:35 | 21.9 | 0.5799 |
| W290 | 0.21 | 92 | 01Jan2000, 06:45 | 14.5 | 0.6982 |
| Sink-3 | 0.21 | 92 | 01Jan2000, 06:45 | 14.5 | 0.6982 |
| W020 | 0.05 | 16 | 01Jan2000, 06:15 | 1.8 | 0.4606 |
| W015 | 0.01 | 8 | 01Jan2000, 06:15 | 0.7 | 0.8389 |
| J015 | 0.01 | 8 | 01Jan2000, 06:15 | 0.7 | 0.8389 |
| J020 | 0.07 | 25 | 01Jan2000, 06:15 | 2.5 | 0.5647 |
| W025 | 0.05 | 34 | 01Jan2000, 06:20 | 3.3 | 0.9699 |
| W030 | 0.03 | 11 | 01Jan2000, 06:20 | 1.1 | 0.6461 |
| W031 | 0.02 | 60 | 01Jan2000, 06:10 | 3.4 | 5.1647 |
| Ex.W031Pond | 0.02 | 22 | 01Jan2000, 06:30 | 3.1 | 1.8937 |
| J031 | 0.02 | 22 | 01Jan2000, 06:30 | 3.1 | 1.8937 |
| J030 | 0.04 | 30 | 01Jan2000, 06:30 | 4.1 | 1.0474 |
| W055 | 0.03 | 12 | 01Jan2000, 06:20 | 1.4 | 0.5664 |
| Sink-5 | 0.20 | 84 | 01Jan2000, 06:30 | 11.3 | 0.6504 |
| W060 | 0.17 | 109 | 01Jan2000, 06:35 | 13.3 | 0.9949 |

| Table D4: Existing Conditions HEC-HMS Output Summary<br>100-yr 24-hr 25% Frequency Distribution | | | | | |
|---|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume | Cfs/Acre |
| Sink-4 | 0.17 | 109 | 01Jan2000, 06:35 | 13.3 | 0.9949 |
| W035 | 0.02 | 8 | 01Jan2000, 06:15 | 0.7 | 0.7646 |
| J035 | 0.02 | 8 | 01Jan2000, 06:15 | 0.7 | 0.7646 |
| W034 | 0.01 | 6 | 01Jan2000, 06:15 | 0.5 | 0.7573 |
| J034 | 0.03 | 14 | 01Jan2000, 06:15 | 1.2 | 0.7615 |
| W045 | 0.04 | 28 | 01Jan2000, 06:20 | 2.6 | 1.0552 |
| W040 | 0.03 | 13 | 01Jan2000, 06:15 | 1.1 | 0.8016 |
| J040 | 0.03 | 13 | 01Jan2000, 06:15 | 1.1 | 0.8016 |
| J045 | 0.10 | 51 | 01Jan2000, 06:15 | 5.0 | 0.8342 |
| W050 | 0.01 | 20 | 01Jan2000, 06:10 | 1.2 | 2.3708 |
| Sink-6 | 0.11 | 69 | 01Jan2000, 06:15 | 6.2 | 0.9917 |

# Proposed HEC-HMS Output Tables and Figures

## Proposed Data Tables

Table D5 Proposed Pond 1 – Tapir Pond (24” Smooth Pipe) (Elevation-Storage-Discharge Data and Computations)

Table D6 Proposed Pond 2 Lily Pond (Elevation-Storage-Discharge Data and Computations)

Table D7 Proposed Pond 3 Crazy Horse Pond (Elevation-Storage-Discharge Data and Computations)

Table D8 Proposed Pond 4 Estancia Pond (Elevation-Storage-Discharge Data and Computations)

Table D9 & D10 24” and 30” Diameter Principal Spillway Elevation-Discharge Summary (Based on CulvertMaster Model) Results)

CulvertMaster Output for 24-inch RCP and CMP (Conceptual Spillway Pipe Hydraulics)
CulvertMaster Output for 30-inch RCP and CMP (Conceptual Spillway Pipe Hydraulics)

Table D11 – Proposed HMS Global Output Summary – Option 1 – 10yr-24hr

Table D12 – Proposed HMS Global Output Summary – Option 1 – 25yr-24hr

Table D13 – Proposed HMS Global Output Summary – Option 1 – 50yr-24hr

Table D14 – Proposed HMS Global Output Summary – Option 1 – 100yr-24hr

Table D15 – Proposed HMS Global Output Summary – Option 2 – 10yr-24hr

Table D16 – Proposed HMS Global Output Summary – Option 2 – 25yr-24hr

Table D17 – Proposed HMS Global Output Summary – Option 2 – 50yr-24hr

Table D18 – Proposed HMS Global Output Summary – Option 2 – 100yr-24hr

Table D19: Tapir Pond Routing Summary

Table D20: Lily Pond Routing Summary

Table D21: Crazy Horse Pond Option 1 Routing Summary

Table D22: Crazy Horse Pond Option 2 Routing Summary

Table D23: Estancia Pond Routing Summary

Figure D1 - Vado Pond Not Recommended

Table D24 - (Vado Pond) (30” Smooth Pipe) (Elevation-Storage-Discharge Data and Computations) – Not Recommended

# TABLE D5 Proposed Tapir Detention Pond

Elevation - Discharge Data and Computations

grey box means must input data

Hydraulic Calculations to Develop the Total Principal Spillway Elevation-Discharge

| Relative Elevations (NAVD 1988) | Depth | A<br>Contour Area | A<br>Incremental Volume | A<br>Incremental Volume | A<br>Cumulative Volume | Principal Spillway Outfall Pipe Discharge (RCP) | Total Discharge through pond bottom | Emergency Spillway Discharge | Total Discharge Rating Curve | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| Princ.spill.orifice dia. or vert. height (in.) | | | | | | 30 | | | | |
| Number of orifices or weirs | | | | | | 1 | | | | |
| Assumed flow reduction factor (f) | | | | | | - | | | | |
| ft | | sq ft | cu ft | ac-ft | ac-ft | cfs | cfs | | cfs | |
| | | | | | | c | 0 | | | |
| 3815.00 | 0.0 | 186,278 | 0 | 0.0000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | Pond Bottom |
| 3816.00 | 1.0 | 615,778 | 401,028 | 9.2063 | 9.3 | 0.0 | 0.1 | 0.0 | 0.1 | Sump Area (Sediment Deposit Area) |
| 3816.60 | 1.6 | 765,964 | 414,523 | 9.5161 | 18.9 | 0.0 | 0.4 | 0.0 | 0.4 | Invert of principal spillway |
| 3817.00 | 2.0 | 866,088 | 326,410 | 7.4934 | 26.4 | 1.0 | 0.3 | 0.0 | 1.3 | |
| 3818.00 | 3.0 | 1,074,323 | 970,206 | 22.2729 | 48.7 | 3.9 | 0.3 | 0.0 | 4.2 | |
| 3819.00 | 4.0 | 1,284,749 | 1,179,536 | 27.0784 | 75.8 | 14.0 | 0.3 | 0.0 | 14.3 | |
| 3820.00 | 5.0 | 1,509,445 | 1,397,097 | 32.0729 | 107.9 | 27.0 | 0.4 | 0.0 | 27.4 | |
| 3821.00 | 6.0 | 1,617,380 | 1,563,413 | 35.8910 | 143.8 | 37.7 | 0.4 | 0.0 | 38.1 | |
| 3822.00 | 7.0 | 1,664,851 | 1,641,116 | 37.6748 | 181.5 | 45.0 | 0.4 | 0.0 | 45.4 | |
| 3823.00 | 8.0 | 1,684,159 | 1,674,505 | 38.4413 | 220.0 | 51.2 | 0.4 | 0.0 | 51.6 | |
| 3824.00 | 9.0 | 1,703,600 | 1,693,880 | 38.8861 | 258.9 | 56.9 | 0.4 | 0 | 57.3 | Emergency Spillway Elevation |
| 3824.20 | 9.2 | 1,707,504 | 341,110 | 7.8308 | 266.8 | 57.9 | 0.5 | 54 | 112.1 | |
| 3824.40 | 9.4 | 1,711,407 | 341,891 | 7.8487 | 274.7 | 58.9 | 0.5 | 152 | 211.2 | |
| 3824.60 | 9.6 | 1,715,311 | 342,672 | 7.8667 | 282.6 | 59.9 | 0.5 | 279 | 339.3 | |
| 3824.80 | 9.8 | 1,719,214 | 343,453 | 7.8846 | 290.5 | 60.9 | 0.6 | 429 | 490.9 | |
| 3825.00 | 10.0 | 1,723,118 | 344,233 | 7.9025 | 298.5 | 61.9 | 0.4 | 600 | 662.3 | |
| 3825.20 | 10.2 | 1,724,494 | 344,761 | 7.9146 | 306.5 | 62.9 | 0.5 | 789 | 852.1 | |
| 3825.40 | 10.4 | 1,725,871 | 345,037 | 7.9209 | 314.5 | 63.8 | 0.5 | 994 | 1058.3 | |
| 3825.60 | 10.6 | 1,727,247 | 345,312 | 7.9273 | 322.5 | 64.8 | 0.5 | 1214 | 1279.6 | |
| 3825.80 | 10.8 | 1,728,624 | 345,587 | 7.9336 | 330.5 | 65.7 | 0.6 | 1449 | 1515.4 | |
| 3826.00 | 11.0 | 1,730,000 | 345,862 | 7.9399 | 338.5 | 66.7 | 0.7 | 1697 | 1764.5 | Top of Pond |

TABLE

Proposed Detention Pond Diversion Structure

Elevation - Volume - Discharge Data and Computations

VALUES FOR HEC-HMS

VALUES ONLY TO PAST INTO HEC-HMS

| ELEV | CUM VOL | DISCHARGE |
|---|---|---|
| ft | ac-ft | cfs |
| 3815.0 | 0.0 | 0.0 |
| 3816.0 | 9.3 | 0.1 |
| 3816.6 | 18.9 | 0.4 |
| 3817.0 | 26.4 | 1.3 |
| 3818.0 | 48.7 | 4.2 |
| 3819.0 | 75.8 | 14.3 |
| 3820.0 | 107.9 | 27.4 |
| 3821.0 | 143.8 | 38.1 |
| 3822.0 | 181.5 | 45.4 |
| 3823.0 | 220.0 | 51.6 |
| 3824.0 | 258.9 | 57.3 |
| 3824.2 | 266.8 | 112.1 |
| 3824.4 | 274.7 | 211.2 |
| 3824.6 | 282.6 | 339.3 |
| 3824.8 | 290.5 | 490.9 |
| 3825.0 | 298.5 | 662.3 |
| 3825.2 | 306.5 | 852.1 |
| 3825.4 | 314.5 | 1058.3 |
| 3825.6 | 322.5 | 1279.6 |
| 3825.8 | 330.5 | 1515.4 |
| 3826.0 | 338.5 | 1764.5 |

( c ) Assume RCP, the discharge rating curve was computed with Culvert Master. Headwater & tailwater assumptions and Culvert Master output are included in the Appendices.

g - Emergergency Spillway C = 3.0 L = 200

**Principal Spillway** - Interpolate discharges at increments from emerg. Spillway to top of pond embankment to attain a better principal spillway rating curve

| ELEV | | Discharge | Delta Discharge | Discharge |
|---|---|---|---|---|
| 3824.00 | | 56.9 | | 56.9 |
| 3824.20 | | | 1.0 | 57.9 |
| 3824.40 | | | 1.0 | 58.9 |
| 3824.60 | | | 1.0 | 59.9 |
| 3824.80 | | | 1.0 | 60.9 |
| 3825.00 | | 61.9 | 1.0 | 61.9 |
| 3825.20 | | | 1.0 | 62.9 |
| 3825.40 | | | 1.0 | 63.8 |
| 3825.60 | | | 1.0 | 64.8 |
| 3825.80 | | | 1.0 | 65.7 |
| 3826.00 | | 66.7 | 1.0 | 66.7 |

**Emergency Spillway** - Interpolate areas at increments to top of pond embankment to attain a better emergency spillway rating curve

| ELEV | | AREA | Delta Area | AREAS |
|---|---|---|---|---|
| 3824.00 | | 1,703,600 | | 1,703,600 |
| 3824.20 | | | 3,904 | 1,707,504 |
| 3824.40 | | | 3,904 | 1,711,407 |
| 3824.60 | | | 3,904 | 1,715,311 |
| 3824.80 | | | 3,904 | 1,719,214 |
| 3825.00 | | 1,723,118 | 3,904 | 1,723,118 |
| 3825.20 | | | 1,376 | 1,724,494 |
| 3825.40 | | | 1,376 | 1,725,871 |
| 3825.60 | | | 1,376 | 1,727,247 |
| 3825.80 | | | 1,376 | 1,728,624 |
| 3826.00 | | 1,730,000 | 1,376 | 1,730,000 |

# TABLE D6 Proposed Lily Pond - 3 ft tall: 48" & 66" RCP Double Pipe Ported Riser, 30-in. dia. outfall pipe, 6-in. dia. PVC rev. incline ports

Elevation - Discharge Data and Computations

Hydraulic Calculations to Develop the Total Principal Spillway Elevation-Discharge

grey box means must input data

| Relative Elevations (NAVD 1988) | Depth | A Contour Area | A Incremental Volume | A Incremental Volume | A Cumulative Volume | A 1st Row - Drain Ports Discharge (assume (f)) | A 2nd Row - Reverse Incline Ports Discharge | A 3rd Row - Reverse Incline Ports Discharge | A 4th Row - Reverse Incline Ports Discharge | A 5th Row - Reverse Incline Ports Discharge | A Rectangular Reverse Incline Weir Discharge | Top of Inner CMP Circular Vertical Pipe Radius (ft) Weir Discharge | Principal Spillway Outfall Pipe Discharge | Total Principal Spillway Discharge | Emergency Spillway Discharge | Total Discharge Rating Curve | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Princ.spill.orifice dia. or vert. height (in.) | | | | | | 6 | 6 | 6 | 6 | 6 | 0 | 2 | 30 | | | | |
| Number of orifices or weirs | | | | | | 4 | 7 | 6 | 7 | 6 | 0 | 1 | 1 | | | | |
| Assumed flow reduction factor (f) | | | | | | 0 | 0.85 | 0.85 | 0.85 | 0.85 | 0 | 0.85 | - | | | | |
| ft | | sq ft | cu ft | ac-ft | ac-ft | cfs | cfs | cfs | cfs | cfs | cfs | cfs | cfs | cfs | | cfs | |
| | | | | | | a | a | a | a | a | a | b | c | d | | | |
| 3820.00 | 0.0 | 0 | 0 | 0.0000 | 0.0000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | Pond Bottom - First row - drain ports |
| 3821.00 | 1.0 | 56,352 | 28,176 | 0.6468 | 0.6468 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.9 | 0.1 | 0.0 | 0.1 | |
| 3821.27 | 1.3 | 72,742 | 17,428 | 0.4001 | 1.0469 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.5 | 0.2 | 0.0 | 0.2 | Centroid 2nd row - reverse incline ports |
| 3822.00 | 2.0 | 117,054 | 69,275 | 1.5903 | 2.6373 | 0.0 | 4.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.0 | 4.7 | 0.0 | 4.7 | |
| 3822.33 | 2.3 | 138,051 | 42,092 | 0.9663 | 3.6036 | 0.0 | 5.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14.0 | 5.7 | 0.0 | 5.7 | Centroid 3rd row - reverse incline ports |
| 3823.00 | 3.0 | 180,681 | 106,775 | 2.4512 | 6.0548 | 0.0 | 7.3 | 3.9 | 0.0 | 0.0 | 0.0 | 0.0 | 27.0 | 11.2 | 0.0 | 11.2 | Top of vertical pipe elevation |
| 3824.00 | 4.0 | 247,158 | 213,920 | 4.9109 | 10.9657 | 0.0 | 9.1 | 6.1 | 0.0 | 0.0 | 0.0 | 27.8 | 37.7 | 37.7 | 0.0 | 37.7 | |
| 3825.00 | 5.0 | 316,814 | 281,986 | 6.4735 | 17.4392 | 0.0 | 10.7 | 7.7 | 0.0 | 0.0 | 0.0 | 78.6 | 45.0 | 45.0 | 0 | 45.0 | Emergency Spillway Elevation |
| 3825.20 | 5.2 | 331,247 | 64,806 | 1.4877 | 18.9270 | 0.0 | 11.0 | 8.0 | 0.0 | 0.0 | 0.0 | 78.6 | 46.2 | 46.2 | 13 | 59.7 | |
| 3825.40 | 5.4 | 339,908 | 67,116 | 1.5408 | 20.4677 | 0.0 | 11.2 | 8.3 | 0.0 | 0.0 | 0.0 | 78.6 | 47.5 | 47.5 | 38 | 85.4 | |
| 3825.60 | 5.6 | 346,259 | 68,617 | 1.5752 | 22.0429 | 0.0 | 11.5 | 8.6 | 0.0 | 0.0 | 0.0 | 78.6 | 48.7 | 48.7 | 70 | 118.4 | |
| 3825.80 | 5.8 | 350,993 | 69,725 | 1.6007 | 23.6436 | 0.0 | 11.8 | 8.8 | 0.0 | 0.0 | 0.0 | 78.6 | 50.0 | 50.0 | 107 | 157.3 | |
| 3826.00 | 6.0 | 388,983 | 73,998 | 1.6988 | 25.3424 | 0.0 | 12.0 | 9.1 | 0.0 | 0.0 | 0.0 | 78.6 | 51.2 | 51.2 | 150 | 201.2 | |
| 3826.20 | 6.2 | 403,670 | 79,265 | 1.8197 | 27.1620 | 0.0 | 12.3 | 9.3 | 0.0 | 0.0 | 0.0 | 78.6 | 52.3 | 52.3 | 197 | 249.5 | |
| 3826.40 | 6.4 | 418,357 | 82,203 | 1.8871 | 29.0491 | 0.0 | 12.5 | 9.6 | 0.0 | 0.0 | 0.0 | 78.6 | 53.5 | 53.5 | 248 | 302.0 | |
| 3826.60 | 6.6 | 433,044 | 85,140 | 1.9545 | 31.0037 | 0.0 | 12.8 | 9.8 | 0.0 | 0.0 | 0.0 | 78.6 | 54.6 | 54.6 | 304 | 358.2 | |
| 3826.80 | 6.8 | 447,731 | 88,078 | 2.0220 | 33.0257 | 0.0 | 13.0 | 10.0 | 0.0 | 0.0 | 0.0 | 78.6 | 55.8 | 55.8 | 362 | 418.0 | |
| 3827.00 | 7.0 | 462,419 | 91,015 | 2.0894 | 35.1151 | 0.0 | 13.2 | 10.2 | 0.0 | 0.0 | 0.0 | 78.6 | 56.9 | 56.9 | 424 | 481.2 | Top of Embankment |

TABLE

Proposed Detention Pond Diversion Structure

Elevation - Volume - Discharge Data and Computations

VALUES FOR HEC-HMS

VALUES ONLY TO PAST INTO HEC-HMS

| ELEV | CUM VOL | DISCHARGE |
|---|---|---|
| ft | ac-ft | cfs |
| 3820.00 | 0.00 | 0.0 |
| 3821.00 | 0.65 | 0.1 |
| 3821.27 | 1.05 | 0.2 |
| 3822.00 | 2.64 | 4.7 |
| 3822.33 | 3.60 | 5.7 |
| 3823.00 | 6.05 | 11.2 |
| 3824.00 | 10.97 | 37.7 |
| 3825.00 | 17.44 | 45.0 |
| 3825.20 | 18.93 | 59.7 |
| 3825.40 | 20.47 | 85.4 |
| 3825.60 | 22.04 | 118.4 |
| 3825.80 | 23.64 | 157.3 |
| 3826.00 | 25.34 | 201.2 |
| 3826.20 | 27.16 | 249.5 |
| 3826.40 | 29.05 | 302.0 |
| 3826.60 | 31.00 | 358.2 |
| 3826.80 | 33.03 | 418.0 |
| 3827.00 | 35.12 | 481.2 |

( a ) $Q = Ca\sqrt{2gh}$ C = discharge coefficient, a = area (sq ft), h = head (ft)

(f) Assume drain ports are plugged much of the time so zero discharge

Orifice equation and coefficient were obtained from Equation 4-10 and Table 4-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1976.

C = 0.590 g=32.2 ft/sec^2, a=area (sq ft) h=head (ft)

$a = \pi D^2 / 4$ (full pipe area formula)

Principal Spill. Pipe radius r in feet =

( b ) Top of vertical wall will act as a weir, computed with following weir equation

$Q = C(2*pi*R)*H^{3/2}$ C = circular crest coefficient, pi = 3.14159, R = radius (ft) , H = head (ft)

WEIR NOTE - The top of the inner vertical pipe will only function as a weir for a few moments, as the head increases, then the principal spillway pipe capacity will be exceeded, the vertical pipe will submerge and the weir will be submerged, and will NOT function as a weir.

Weir equation and "C" coefficients were obtained from Equation 28 and Figure 9-57 from "Design of Small Dams" Third Edition, by Bureau of Reclamation, 1987.

C = 2.6

( c ) Assume RCP, the discharge rating curve was computed with Culvert Master. Headwater & tailwater assumptions and Culvert Master output are included in the Appendices.

( d ) The combined discharge of the reverse incline ports and the top of vertical pipe (acts as a weir) will govern the discharge until the outfall pipe capacity is exceeded and/or when the pond water surface exceeds the top of the vertical pipe. At that point the ports and weir (top of vertical pipe) are submerged and will not function, and the outfall pipe is submerged and will govern the discharge. When the sum of the "A" columns is greater than the outfall pipe capacity, then the outfall pipe capacity governs the discharge.

g - Emergency Spillway C = 3.0 L = 50

**Principal Spillway** - Interpolate discharges at increments from emerg. Spillway to top of pond embankment to attain a better principal spillway rating curve

| ELEV | Discharge | Delta Discharge | Discharge |
|---|---|---|---|
| 3825.00 | 45.0 | | 45.0 |
| 3825.20 | | 1.2 | 46.2 |
| 3825.40 | | 1.2 | 47.5 |
| 3825.60 | | 1.2 | 48.7 |
| 3825.80 | | 1.2 | 50.0 |
| 3826.00 | 51.2 | 1.2 | 51.2 |
| 3826.20 | | 1.1 | 52.3 |
| 3826.40 | | 1.1 | 53.5 |
| 3826.60 | | 1.1 | 54.6 |
| 3826.80 | | 1.1 | 55.8 |
| 3827.00 | 56.9 | 1.1 | 56.9 |

**Emergency Spillway** - Interpolate areas at increments to top of pond embankment to attain a better emergency spillway rating curve

| ELEV | AREA | Delta Area | AREAS |
|---|---|---|---|
| 3824.00 | 316,814 | | 316,814 |
| 3825.00 | | 14,434 | 331,247 |
| 3825.20 | | 14,434 | 345,681 |
| 3825.40 | | 14,434 | 360,115 |
| 3825.60 | | 14,434 | 374,549 |
| 3825.00 | 388,983 | 14,434 | 388,983 |
| 3825.20 | | 14,687 | 403,670 |
| 3825.40 | | 14,687 | 418,357 |
| 3825.60 | | 14,687 | 433,044 |
| 3825.80 | | 14,687 | 447,731 |
| 3826.00 | 462,419 | 14,687 | 462,419 |

# TABLE D7 Proposed Crazy Horse Pond

Elevation - Discharge Data and Computations
grey box means must input data

Hydraulic Calculations to Develop the Total Principal Spillway Elevation-Discharge

TABLE
Proposed Detention Pond Diversion Structure
Elevation - Volume - Discharge Data and Computations

| Relative Elevations (NAVD 1988) | Depth | A Contour Area | A Incremental Volume | A Incremental Volume | A Cumulative Volume | Principal Spillway Outfall Pipe Discharge (RCP) @ 1% Slope | Total Discharge through pond bottom | Emergency Spillway Discharge | Total Discharge Rating Curve | COMMENTS | VALUES FOR HEC-HMS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Princ.spill.orifice dia. or vert. height (in.) | | | | | | 24 | | | | | | | |
| Number of orifices or weirs | | | | | | 1 | | | | | | | |
| Assumed flow reduction factor (f) | | | | | | - | | | | | VALUES ONLY TO PAST INTO HEC-HMS | | |
| ft | | sq ft | cu ft | ac-ft | ac-ft | cfs | cfs | | cfs | | ELEV | CUM VOL | DISCHARGE |
| | | | | | | c | 0 | | | | ft | ac-ft | cfs |
| 3816.00 | 0.0 | 0 | 0 | 0.0000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | Pond Bottom/Principal Spillway | 3816.0 | 0.0 | 0.0 |
| 3817.00 | 1.0 | 117,363 | 58,682 | 1.3471 | 1.4 | 3.4 | 0.1 | 0.0 | 3.6 | | 3817.0 | 1.4 | 3.6 |
| 3818.00 | 2.0 | 216,601 | 166,982 | 3.8334 | 3.9 | 11.6 | 0.2 | 0.0 | 11.9 | | 3818.0 | 3.9 | 11.9 |
| 3819.00 | 3.0 | 247,989 | 232,295 | 5.3328 | 6.8 | 20.4 | 0.3 | 0.0 | 20.7 | | 3819.0 | 6.8 | 20.7 |
| 3820.00 | 4.0 | 261,350 | 254,670 | 5.8464 | 9.8 | 25.7 | 0.4 | 0.0 | 26.2 | | 3820.0 | 9.8 | 26.2 |
| 3821.00 | 5.0 | 272,771 | 267,061 | 6.1309 | 16.0 | 30.2 | 0.4 | 0 | 30.6 | Emergency Spillway Elevation | 3821.0 | 16.0 | 30.6 |
| 3821.20 | 5.2 | 273,217 | 54,599 | 1.2534 | 17.3 | 30.9 | 0.5 | 268 | 299.8 | | 3821.2 | 17.3 | 299.8 |
| 3821.40 | 5.4 | 273,663 | 54,688 | 1.2555 | 18.6 | 31.7 | 0.5 | 759 | 791.2 | | 3821.4 | 18.6 | 791.2 |
| 3821.60 | 5.6 | 274,108 | 54,777 | 1.2575 | 19.9 | 32.5 | 0.5 | 1394 | 1427.3 | | 3821.6 | 19.9 | 1427.3 |
| 3821.80 | 5.8 | 274,554 | 54,866 | 1.2596 | 21.2 | 33.3 | 0.6 | 2147 | 2180.5 | | 3821.8 | 21.2 | 2180.5 |
| 3822.00 | 6.0 | 275,000 | 54,955 | 1.2616 | 22.5 | 34.0 | 0.7 | 3000 | 3034.8 | Top of Pond Embankment | 3822.0 | 22.5 | 3034.8 |

( c ) Assume RCP, the discharge rating curve was computed with Culvert Master. Headwater & tailwater assumptions and Culvert Master output are included in the Appendices.

g - Emergergency Spillway C = 3.0 L = 1000

**Principal Spillway** - Interpolate discharges at increments from emerg. Spillway to top of pond embankment to attain a better principal spillway rating curve

| ELEV | | Discharge | Delta Discharge | Discharge |
|---|---|---|---|---|
| 3821.00 | | 30.2 | | 30.2 |
| 3821.20 | | | 0.8 | 30.9 |
| 3821.40 | | | 0.8 | 31.7 |
| 3821.60 | | | 0.8 | 32.5 |
| 3821.80 | | | 0.8 | 33.3 |
| 3822.00 | | 34.0 | 0.8 | 34.0 |

**Emergency Spillway** - Interpolate areas at increments to top of pond embankment to attain a better emergency spillway rating curve

| ELEV | | AREA | Delta Area | AREAS |
|---|---|---|---|---|
| 3821.00 | | 272,771 | | 272,771 |
| 3821.20 | | | 446 | 273,217 |
| 3821.40 | | | 446 | 273,663 |
| 3821.60 | | | 446 | 274,108 |
| 3821.80 | | | 446 | 274,554 |
| 3822.00 | | 275,000 | 446 | 275,000 |

# TABLE D8 Proposed Estancia Pond

Elevation - Discharge Data and Computations

grey box means must input data

Hydraulic Calculations to Develop the Total Principal Spillway Elevation-Discharge

TABLE

Proposed Detention Pond Diversion Structure

Elevation - Volume - Discharge Data and Computations

| Relative Elevations (NAVD 1988) | Depth | Contour Area (A) | Incremental Volume (A) | Incremental Volume (A) | Cumulative Volume (A) | Principal Spillway Outfall Pipe Discharge (RCP) @ 0.5% Slope | Total Discharge through pond bottom | Emergency Spillway Discharge | Total Discharge Rating Curve | COMMENTS | VALUES FOR HEC-HMS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Princ.spill.orifice dia. or vert. height (in.) | | | | | | 24 | | | | | | | |
| Number of orifices or weirs | | | | | | 1 | | | | | | | |
| Assumed flow reduction factor (f) | | | | | | - | | | | | VALUES ONLY TO PAST INTO HEC-HMS | | |
| ft | | sq ft | cu ft | ac-ft | ac-ft | cfs | cfs | | cfs | | ELEV | CUM VOL | DISCHARGE |
| | | | | | | c | 0 | | | | ft | ac-ft | cfs |
| 3827.00 | 0.0 | 0 | 0 | 0.0000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | Pond Bottom/Principal Spillway | 3827.0 | 0.0 | 0.0 |
| 3828.00 | 1.0 | 5,536 | 2,768 | 0.0635 | 0.1 | 3.4 | 0.1 | 0.0 | 3.6 | | 3828.0 | 0.1 | 3.6 |
| 3829.00 | 2.0 | 20,816 | 13,176 | 0.3025 | 0.5 | 11.6 | 0.2 | 0.0 | 11.9 | | 3829.0 | 0.5 | 11.9 |
| 3830.00 | 3.0 | 23,205 | 22,011 | 0.5053 | 1.1 | 20.4 | 0.2 | 0.0 | 20.6 | | 3830.0 | 1.1 | 20.6 |
| 3831.00 | 4.0 | 25,693 | 24,449 | 0.5613 | 1.7 | 25.7 | 0.3 | 0.0 | 26.1 | | 3831.0 | 1.7 | 26.1 |
| 3832.00 | 5.0 | 27,990 | 26,842 | 0.6162 | 2.4 | 30.2 | 0.4 | 0 | 30.6 | Emergency Spillway Elevation | 3832.0 | 2.4 | 30.6 |
| 3832.20 | 5.2 | 28,309 | 5,630 | 0.1292 | 2.6 | 30.9 | 0.5 | 19 | 50.3 | | 3832.2 | 2.6 | 50.3 |
| 3832.40 | 5.4 | 28,629 | 5,694 | 0.1307 | 2.8 | 31.7 | 0.5 | 53 | 85.4 | | 3832.4 | 2.8 | 85.4 |
| 3832.60 | 5.6 | 28,948 | 5,758 | 0.1322 | 3.0 | 32.5 | 0.5 | 98 | 130.6 | | 3832.6 | 3.0 | 130.6 |
| 3832.80 | 5.8 | 29,268 | 5,822 | 0.1336 | 3.2 | 33.3 | 0.6 | 150 | 184.2 | | 3832.8 | 3.2 | 184.2 |
| 3833.00 | 6.0 | 29,587 | 5,885 | 0.1351 | 3.4 | 34.0 | 0.7 | 210 | 244.8 | Top of Pond Embankment | 3833.0 | 3.4 | 244.8 |

( c ) Assume RCP, the discharge rating curve was computed with Culvert Master. Headwater & tailwater assumptions and Culvert Master output are included in the Appendices.

g - Emergergency Spillway C = 3.0 L = 70

**Principal Spillway -** Interpolate discharges at increments from emerg. Spillway to top of pond embankment to attain a better principal spillway rating curve

F

| ELEV | Discharge | Delta Discharge | Discharge |
|---|---|---|---|
| 3832.00 | 30.2 | | 30.2 |
| 3832.20 | | 0.8 | 30.9 |
| 3832.40 | | 0.8 | 31.7 |
| 3832.60 | | 0.8 | 32.5 |
| 3832.80 | | 0.8 | 33.3 |
| 3833.00 | 34.0 | 0.8 | 34.0 |

**Emergency Spillway -** Interpolate areas at increments to top of pond embankment to attain a better emergency spillway rating curve

| ELEV | AREA | Delta Area | AREAS |
|---|---|---|---|
| 3832.00 | 27,990 | | 27,990 |
| 3832.20 | | 319 | 28,309 |
| 3832.40 | | 319 | 28,629 |
| 3832.60 | | 319 | 28,948 |
| 3832.80 | | 319 | 29,268 |
| 3833.00 | 29,587 | 319 | 29,587 |

| TABLE D9 24-inch RCP S=1.0 % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **RCP Principal Spillway Hydraulic Data and CulvertMaster Summary Results**<br>Data and Results to Develop a Principal Spillway Pipe Discharge Rating Curve<br>(computed with the CulvertMaster Program) | | | | | | | | |
| **Basic Data** | | | | | | | | |
| Principal Spillway outfall pipe begins in pond bottom | | | | | | | | |
| **Culvert data** | | | | **Assumptions** | | | | |
| culvert material = | | RCP | -- | Pipe is flush with headwall | | | | |
| culvert shape = | | round | -- | | | | | |
| **culvert diameter =** | | **24** | inches | Assume n = 0.013 | | | | |
| Manning's n = | | 0.013 | -- | | | | | |
| culvert length = | | 100 | ft | | | | | |
| upstream invert elev. | | 100 | ft | | | | | |
| downstream invert elev. | | 99 | ft | | | | | |
| culvert slope = | | 0.01 | ft / ft | | | | | |
| contour interval = | | 1 | ft | | | | | |
| multiplication factor (see note *b*) = | | 0.19 | -- | | | | | |
| addition factor (see note *b*) = | | 0.03 | | | | | | |
| Description | Elevation | Head Depth | Upstream Invert Elevation | Headwater Elevation | Downstream Invert Elevation | Tailwater Elevation | Tailwater Depth | 1- 24" Culvert Discharge from Culvert Master |
| | ft | ft | ft | ft | ft | ft | | |
| | | | a | a | | b | | c |
| Pond bottom elevation at principal spillway | 100.0 | 0 | 100 | 100.0 | 99.0 | 99.0 | 0.0 | 0.0 |
| | 101.0 | 1 | -- | 101.0 | -- | 99.2 | 0.2 | 3.4 |
| | 102.0 | 2 | -- | 102.0 | -- | 99.4 | 0.4 | 11.6 |
| | 103.0 | 3 | -- | 103.0 | -- | 99.6 | 0.6 | 20.4 |
| | 104.0 | 4 | -- | 104.0 | -- | 99.8 | 0.8 | 25.7 |
| | 105.0 | 5 | -- | 105.0 | -- | 100.0 | 1.0 | 30.2 |
| | 106.0 | 6 | -- | 106.0 | -- | 100.1 | 1.1 | 34.0 |
| | 107.0 | 7 | -- | 107.0 | -- | 100.3 | 1.3 | 37.4 |
| | 108.0 | 8 | -- | 108.0 | -- | 100.5 | 1.5 | 40.3 |
| | 109.0 | 9 | -- | 109.0 | -- | 100.7 | 1.7 | 43.1 |
| Assume TW=0.75 of pipe dia. at 10 ft HW | 110.0 | 10 | -- | 110.0 | -- | 100.9 | 1.9 | 45.7 |
| a - headwater elevation = head depth + upstream invert elevation | | | | | | | | |
| b - Tailwater elevation assumption, For HW depth up to and including 10 ft, TW = (0.19 * head depth ) + downstream invert elevation | | | | | | | | |
| c - CulvertMaster output included this Appendix | | | | | | | | |

**TABLE D10 30-inch RCP S=0.5%**

**RCP Principal Spillway Hydraulic Data and CulvertMaster Summary Results**
Data and Results to Develop a Principal Spillway Pipe Discharge Rating Curve
(computed with the CulvertMaster Program)

**Basic Data**

Principal Spillway outfall pipe begins in pond bottom

| **Culvert data** | | | **Assumptions** |
|---|---|---|---|
| culvert material = | RCP | -- | Pipe is flush with headwall |
| culvert shape = | round | -- | |
| **culvert diameter =** | **30** | inches | Assume n = 0.013 |
| Manning's n = | 0.013 | -- | |
| culvert length = | 100 | ft | |
| upstream invert elev. | 100 | ft | |
| downstream invert elev. | 99.5 | ft | |
| culvert slope = | 0.005 | ft / ft | |
| contour interval = | 0 | ft | |
| multiplication factor (see note b) = | 0.19 | -- | |
| addition factor (see note b) = | 0.03 | | |

| Description | Elevation (ft) | Head Depth (ft) | Upstream Invert Elevation (ft) a | Headwater Elevation (ft) a | Downstream Invert Elevation (ft) | Tailwater Elevation (ft) b | Tailwater Depth | 1- 30" Culvert Discharge from Culvert Master c |
|---|---|---|---|---|---|---|---|---|
| Pond bottom elevation at principal spillway | 100.0 | 0 | 100 | 100.0 | 99.5 | 99.5 | 0.0 | 0.0 |
| | 101.0 | 1 | -- | 101.0 | -- | 99.7 | 0.2 | 3.9 |
| | 102.0 | 2 | -- | 102.0 | -- | 99.9 | 0.4 | 14.0 |
| | 103.0 | 3 | -- | 103.0 | -- | 100.1 | 0.6 | 27.0 |
| | 104.0 | 4 | -- | 104.0 | -- | 100.3 | 0.8 | 37.7 |
| | 105.0 | 5 | -- | 105.0 | -- | 100.5 | 1.0 | 45.0 |
| | 106.0 | 6 | -- | 106.0 | -- | 100.6 | 1.1 | 51.2 |
| | 107.0 | 7 | -- | 107.0 | -- | 100.8 | 1.3 | 56.9 |
| | 108.0 | 8 | -- | 108.0 | -- | 101.0 | 1.5 | 61.9 |
| | 109.0 | 9 | -- | 109.0 | -- | 101.2 | 1.7 | 66.7 |

a - headwater elevation = head depth + upstream invert elevevation
b - Tailwater elevation assumption > 11 ft, TW at 10 ft + 0.03 ft, and continue to increase TW by 0.03 ft until soffit elevation
c - CulverMaster output included this Appendix

# Culvert Calculator Report
# 24-in. RCP S=1.0% HW=1

Solve For: Discharge

## Culvert Summary

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 101.00 ft | Headwater Depth/Height | 0.50 |
| Computed Headwater Elevation | 101.00 ft | Discharge | 3.42 cfs |
| Inlet Control HW Elev. | 100.88 ft | Tailwater Elevation | 99.15 ft |
| Outlet Control HW Elev. | 101.00 ft | Control Type | Entrance Control |

## Grades

| | | | |
|---|---|---|---|
| Upstream Invert | 100.00 ft | Downstream Invert | 99.00 ft |
| Length | 100.00 ft | Constructed Slope | 0.010000 ft/ft |

## Hydraulic Profile

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 0.53 ft |
| Slope Type | Steep | Normal Depth | 0.53 ft |
| Flow Regime | Supercritical | Critical Depth | 0.65 ft |
| Velocity Downstream | 5.19 ft/s | Critical Slope | 0.004463 ft/ft |

## Section

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 2.00 ft |
| Section Size | 24 inch | Rise | 2.00 ft |
| Number Sections | 1 | | |

## Outlet Control Properties

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 101.00 ft | Upstream Velocity Head | 0.24 ft |
| Ke | 0.50 | Entrance Loss | 0.12 ft |

## Inlet Control Properties

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 100.88 ft | Flow Control | N/A |
| Inlet Type | Square edge w/headwall | Area Full | 3.1 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Culvert Calculator Report
# 24-in. RCP S=1.0% HW=2

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 102.00 | ft | Headwater Depth/Height | 1.00 | |
| Computed Headwater Elevation | 102.00 | ft | Discharge | 11.63 | cfs |
| Inlet Control HW Elev. | 101.87 | ft | Tailwater Elevation | 99.30 | ft |
| Outlet Control HW Elev. | 102.00 | ft | Control Type | Entrance Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | S2 | | Depth, Downstream | 1.02 | ft |
| Slope Type | Steep | | Normal Depth | 1.02 | ft |
| Flow Regime | Supercritical | | Critical Depth | 1.22 | ft |
| Velocity Downstream | 7.25 | ft/s | Critical Slope | 0.005510 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.00 | ft |
| Section Size | 24 inch | | Rise | 2.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 102.00 | ft | Upstream Velocity Head | 0.52 | ft |
| Ke | 0.50 | | Entrance Loss | 0.26 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 101.87 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 3.1 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 24-in. RCP S=1.0% HW=3

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 103.00 | ft | Headwater Depth/Height | 1.50 | |
| Computed Headwater Elevation | 103.00 | ft | Discharge | 20.35 | cfs |
| Inlet Control HW Elev. | 103.00 | ft | Tailwater Elevation | 99.45 | ft |
| Outlet Control HW Elev. | 102.92 | ft | Control Type | Inlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | S2 | | Depth, Downstream | 1.48 | ft |
| Slope Type | Steep | | Normal Depth | 1.48 | ft |
| Flow Regime | Supercritical | | Critical Depth | 1.62 | ft |
| Velocity Downstream | 8.15 | ft/s | Critical Slope | 0.008280 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.00 | ft |
| Section Size | 24 inch | | Rise | 2.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 102.92 | ft | Upstream Velocity Head | 0.87 | ft |
| Ke | 0.50 | | Entrance Loss | 0.43 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 103.00 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 3.1 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 24-in. RCP S=1.0% HW=4

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 104.00 | ft | Headwater Depth/Height | 2.00 | |
| Computed Headwater Elevation | 104.00 | ft | Discharge | 25.73 | cfs |
| Inlet Control HW Elev. | 104.00 | ft | Tailwater Elevation | 99.60 | ft |
| Outlet Control HW Elev. | 103.70 | ft | Control Type | Inlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 1.78 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 1.78 | ft |
| Velocity Downstream | 8.71 | ft/s | Critical Slope | 0.011506 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.00 | ft |
| Section Size | 24 inch | | Rise | 2.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 103.70 | ft | Upstream Velocity Head | 1.04 | ft |
| Ke | 0.50 | | Entrance Loss | 0.52 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 104.00 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 3.1 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 24-in. RCP S=1.0% HW=5

Solve For: Discharge

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 105.00 ft | Headwater Depth/Height | 2.50 |
| Computed Headwater Elevation | 105.00 ft | Discharge | 30.17 cfs |
| Inlet Control HW Elev. | 105.00 ft | Tailwater Elevation | 99.75 ft |
| Outlet Control HW Elev. | 104.87 ft | Control Type | Inlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 100.00 ft | Downstream Invert | 99.00 ft |
| Length | 100.00 ft | Constructed Slope | 0.010000 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | CompositeM2PressureProfile | Depth, Downstream | 1.87 ft |
| Slope Type | Mild | Normal Depth | N/A ft |
| Flow Regime | Subcritical | Critical Depth | 1.87 ft |
| Velocity Downstream | 9.89 ft/s | Critical Slope | 0.015377 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 2.00 ft |
| Section Size | 24 inch | Rise | 2.00 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 104.87 ft | Upstream Velocity Head | 1.43 ft |
| Ke | 0.50 | Entrance Loss | 0.72 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 105.00 ft | Flow Control | N/A |
| Inlet Type | Square edge w/headwall | Area Full | 3.1 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Culvert Calculator Report
# 24-in. RCP S=1.0% HW=6

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 106.00 | ft | Headwater Depth/Height | 3.00 | |
| Computed Headwater Elevation | 106.00 | ft | Discharge | 34.03 | cfs |
| Inlet Control HW Elev. | 106.00 | ft | Tailwater Elevation | 99.90 | ft |
| Outlet Control HW Elev. | 105.96 | ft | Control Type | Inlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 1.91 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 1.91 | ft |
| Velocity Downstream | 11.00 | ft/s | Critical Slope | 0.019658 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.00 | ft |
| Section Size | 24 inch | | Rise | 2.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 105.96 | ft | Upstream Velocity Head | 1.82 | ft |
| Ke | 0.50 | | Entrance Loss | 0.91 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 106.00 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 3.1 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 24-in. RCP S=1.0% HW=7

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 107.00 | ft | Headwater Depth/Height | 3.50 | |
| Computed Headwater Elevation | 107.00 | ft | Discharge | 37.36 | cfs |
| Inlet Control HW Elev. | 106.96 | ft | Tailwater Elevation | 100.05 | ft |
| Outlet Control HW Elev. | 107.00 | ft | Control Type | Outlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 1.94 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 1.94 | ft |
| Velocity Downstream | 12.00 | ft/s | Critical Slope | 0.023974 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.00 | ft |
| Section Size | 24 inch | | Rise | 2.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 107.00 | ft | Upstream Velocity Head | 2.20 | ft |
| Ke | 0.50 | | Entrance Loss | 1.10 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 106.96 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 3.1 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 24-in. RCP S=1.0% HW=8

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 108.00 | ft | Headwater Depth/Height | 4.00 | |
| Computed Headwater Elevation | 108.00 | ft | Discharge | 40.32 | cfs |
| Inlet Control HW Elev. | 107.89 | ft | Tailwater Elevation | 100.20 | ft |
| Outlet Control HW Elev. | 108.00 | ft | Control Type | Outlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 1.95 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 1.95 | ft |
| Velocity Downstream | 12.91 | ft/s | Critical Slope | 0.028275 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.00 | ft |
| Section Size | 24 inch | | Rise | 2.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 108.00 | ft | Upstream Velocity Head | 2.56 | ft |
| Ke | 0.50 | | Entrance Loss | 1.28 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 107.89 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 3.1 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 24-in. RCP S=1.0% HW=9

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 109.00 | ft | Headwater Depth/Height | 4.50 | |
| Computed Headwater Elevation | 109.00 | ft | Discharge | 43.09 | cfs |
| Inlet Control HW Elev. | 108.82 | ft | Tailwater Elevation | 100.35 | ft |
| Outlet Control HW Elev. | 109.00 | ft | Control Type | Outlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 1.96 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 1.96 | ft |
| Velocity Downstream | 13.77 | ft/s | Critical Slope | 0.032643 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.00 | ft |
| Section Size | 24 inch | | Rise | 2.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 109.00 | ft | Upstream Velocity Head | 2.92 | ft |
| Ke | 0.50 | | Entrance Loss | 1.46 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 108.82 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 3.1 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 24-in. RCP S=1.0% HW=10

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 110.00 | ft | Headwater Depth/Height | 5.00 | |
| Computed Headwater Elevation | 110.00 | ft | Discharge | 45.69 | cfs |
| Inlet Control HW Elev. | 109.75 | ft | Tailwater Elevation | 100.50 | ft |
| Outlet Control HW Elev. | 110.00 | ft | Control Type | Outlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.00 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.010000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 1.97 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 1.97 | ft |
| Velocity Downstream | 14.59 | ft/s | Critical Slope | 0.037061 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.00 | ft |
| Section Size | 24 inch | | Rise | 2.00 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 110.00 | ft | Upstream Velocity Head | 3.29 | ft |
| Ke | 0.50 | | Entrance Loss | 1.64 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 109.75 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 3.1 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 30-in. RCP S=0.5% HW=1 ft

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 101.00 | ft | Headwater Depth/Height | 0.40 | |
| Computed Headwater Elevation | 101.00 | ft | Discharge | 3.93 | cfs |
| Inlet Control HW Elev. | 100.88 | ft | Tailwater Elevation | 99.70 | ft |
| Outlet Control HW Elev. | 101.00 | ft | Control Type | Entrance Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.50 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.005000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | S2 | | Depth, Downstream | 0.62 | ft |
| Slope Type | Steep | | Normal Depth | 0.62 | ft |
| Flow Regime | Supercritical | | Critical Depth | 0.65 | ft |
| Velocity Downstream | 4.13 | ft/s | Critical Slope | 0.004154 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.50 | ft |
| Section Size | 30 inch | | Rise | 2.50 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 101.00 | ft | Upstream Velocity Head | 0.23 | ft |
| Ke | 0.50 | | Entrance Loss | 0.12 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 100.88 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 4.9 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 30-in. RCP S=0.5% HW=2 ft

Solve For: Discharge

**Culvert Summary**

| | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 102.00 | ft | Headwater Depth/Height | 0.80 | |
| Computed Headwater Elevation | 102.00 | ft | Discharge | 13.96 | cfs |
| Inlet Control HW Elev. | 101.83 | ft | Tailwater Elevation | 99.90 | ft |
| Outlet Control HW Elev. | 102.00 | ft | Control Type | Entrance Control | |

**Grades**

| | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.50 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.005000 | ft/ft |

**Hydraulic Profile**

| | | | | | |
|---|---|---|---|---|---|
| Profile | S2 | | Depth, Downstream | 1.22 | ft |
| Slope Type | Steep | | Normal Depth | 1.22 | ft |
| Flow Regime | Supercritical | | Critical Depth | 1.26 | ft |
| Velocity Downstream | 5.85 | ft/s | Critical Slope | 0.004537 | ft/ft |

**Section**

| | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.50 | ft |
| Section Size | 30 inch | | Rise | 2.50 | ft |
| Number Sections | 1 | | | | |

**Outlet Control Properties**

| | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 102.00 | ft | Upstream Velocity Head | 0.49 | ft |
| Ke | 0.50 | | Entrance Loss | 0.25 | ft |

**Inlet Control Properties**

| | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 101.83 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 4.9 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 30-in. RCP S=0.5% HW=3 ft

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 103.00 | ft | Headwater Depth/Height | 1.20 | |
| Computed Headwater Elevation | 103.00 | ft | Discharge | 27.56 | cfs |
| Inlet Control HW Elev. | 102.93 | ft | Tailwater Elevation | 100.10 | ft |
| Outlet Control HW Elev. | 103.00 | ft | Control Type | Outlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.50 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.005000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | M2 | | Depth, Downstream | 1.79 | ft |
| Slope Type | Mild | | Normal Depth | 1.95 | ft |
| Flow Regime | Subcritical | | Critical Depth | 1.79 | ft |
| Velocity Downstream | 7.33 | ft/s | Critical Slope | 0.006076 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.50 | ft |
| Section Size | 30 inch | | Rise | 2.50 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 103.00 | ft | Upstream Velocity Head | 0.71 | ft |
| Ke | 0.50 | | Entrance Loss | 0.35 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 102.93 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 4.9 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 30-in. RCP S=0.5% HW=4 ft

Solve For: Discharge

**Culvert Summary**

| | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 104.00 | ft | Headwater Depth/Height | 1.60 | |
| Computed Headwater Elevation | 104.00 | ft | Discharge | 37.57 | cfs |
| Inlet Control HW Elev. | 104.00 | ft | Tailwater Elevation | 100.30 | ft |
| Outlet Control HW Elev. | 103.97 | ft | Control Type | Inlet Control | |

**Grades**

| | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.50 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.005000 | ft/ft |

**Hydraulic Profile**

| | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 2.07 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 2.07 | ft |
| Velocity Downstream | 8.63 | ft/s | Critical Slope | 0.008216 | ft/ft |

**Section**

| | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.50 | ft |
| Section Size | 30 inch | | Rise | 2.50 | ft |
| Number Sections | 1 | | | | |

**Outlet Control Properties**

| | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 103.97 | ft | Upstream Velocity Head | 0.91 | ft |
| Ke | 0.50 | | Entrance Loss | 0.46 | ft |

**Inlet Control Properties**

| | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 104.00 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 4.9 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 30-in. RCP S=0.5% HW=5 ft

Solve For: Discharge

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 105.00 ft | Headwater Depth/Height | 2.00 |
| Computed Headwater Elevation | 105.00 ft | Discharge | 44.75 cfs |
| Inlet Control HW Elev. | 104.98 ft | Tailwater Elevation | 100.50 ft |
| Outlet Control HW Elev. | 105.00 ft | Control Type | Outlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 100.00 ft | Downstream Invert | 99.50 ft |
| Length | 100.00 ft | Constructed Slope | 0.005000 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | CompositeM2PressureProfile | Depth, Downstream | 2.22 ft |
| Slope Type | Mild | Normal Depth | N/A ft |
| Flow Regime | Subcritical | Critical Depth | 2.22 ft |
| Velocity Downstream | 9.71 ft/s | Critical Slope | 0.010602 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 2.50 ft |
| Section Size | 30 inch | Rise | 2.50 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 105.00 ft | Upstream Velocity Head | 1.29 ft |
| Ke | 0.50 | Entrance Loss | 0.65 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 104.98 ft | Flow Control | N/A |
| Inlet Type | Square edge w/headwall | Area Full | 4.9 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Culvert Calculator Report
# 30-in. RCP S=0.5% HW=6 ft

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 106.00 | ft | Headwater Depth/Height | 2.40 | |
| Computed Headwater Elevation | 106.00 | ft | Discharge | 51.09 | cfs |
| Inlet Control HW Elev. | 105.98 | ft | Tailwater Elevation | 100.60 | ft |
| Outlet Control HW Elev. | 106.00 | ft | Control Type | Outlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.50 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.005000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 2.31 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 2.31 | ft |
| Velocity Downstream | 10.77 | ft/s | Critical Slope | 0.013441 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.50 | ft |
| Section Size | 30 inch | | Rise | 2.50 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 106.00 | ft | Upstream Velocity Head | 1.68 | ft |
| Ke | 0.50 | | Entrance Loss | 0.84 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 105.98 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 4.9 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
## 30-in. RCP S=0.5% HW=7 ft

Solve For: Discharge

**Culvert Summary**

| | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 107.00 | ft | Headwater Depth/Height | 2.80 | |
| Computed Headwater Elevation | 107.00 | ft | Discharge | 56.81 | cfs |
| Inlet Control HW Elev. | 107.00 | ft | Tailwater Elevation | 100.80 | ft |
| Outlet Control HW Elev. | 106.99 | ft | Control Type | Inlet Control | |

**Grades**

| | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.50 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.005000 | ft/ft |

**Hydraulic Profile**

| | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 2.37 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 2.37 | ft |
| Velocity Downstream | 11.81 | ft/s | Critical Slope | 0.016606 | ft/ft |

**Section**

| | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.50 | ft |
| Section Size | 30 inch | | Rise | 2.50 | ft |
| Number Sections | 1 | | | | |

**Outlet Control Properties**

| | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 106.99 | ft | Upstream Velocity Head | 2.08 | ft |
| Ke | 0.50 | | Entrance Loss | 1.04 | ft |

**Inlet Control Properties**

| | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 107.00 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 4.9 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 30-in. RCP S=0.5% HW=8 ft

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 108.00 | ft | Headwater Depth/Height | 3.20 | |
| Computed Headwater Elevation | 108.00 | ft | Discharge | 61.91 | cfs |
| Inlet Control HW Elev. | 108.00 | ft | Tailwater Elevation | 101.00 | ft |
| Outlet Control HW Elev. | 107.95 | ft | Control Type | Inlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.50 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.005000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 2.40 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 2.40 | ft |
| Velocity Downstream | 12.77 | ft/s | Critical Slope | 0.019884 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.50 | ft |
| Section Size | 30 inch | | Rise | 2.50 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 107.95 | ft | Upstream Velocity Head | 2.47 | ft |
| Ke | 0.50 | | Entrance Loss | 1.24 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 108.00 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 4.9 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 30-in. RCP S=0.5% HW=9 ft

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 109.00 | ft | Headwater Depth/Height | 3.60 | |
| Computed Headwater Elevation | 109.00 | ft | Discharge | 66.62 | cfs |
| Inlet Control HW Elev. | 109.00 | ft | Tailwater Elevation | 101.20 | ft |
| Outlet Control HW Elev. | 108.91 | ft | Control Type | Inlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.50 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.005000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 2.43 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 2.43 | ft |
| Velocity Downstream | 13.69 | ft/s | Critical Slope | 0.023264 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.50 | ft |
| Section Size | 30 inch | | Rise | 2.50 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 108.91 | ft | Upstream Velocity Head | 2.86 | ft |
| Ke | 0.50 | | Entrance Loss | 1.43 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 109.00 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 4.9 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 30-in. RCP S=0.5% HW=10 ft

Solve For: Discharge

**Culvert Summary**

| | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 110.00 | ft | Headwater Depth/Height | 4.00 | |
| Computed Headwater Elevation | 110.00 | ft | Discharge | 71.02 | cfs |
| Inlet Control HW Elev. | 110.00 | ft | Tailwater Elevation | 101.40 | ft |
| Outlet Control HW Elev. | 109.86 | ft | Control Type | Inlet Control | |

**Grades**

| | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.50 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.005000 | ft/ft |

**Hydraulic Profile**

| | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 2.44 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 2.44 | ft |
| Velocity Downstream | 14.55 | ft/s | Critical Slope | 0.026717 | ft/ft |

**Section**

| | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.50 | ft |
| Section Size | 30 inch | | Rise | 2.50 | ft |
| Number Sections | 1 | | | | |

**Outlet Control Properties**

| | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 109.86 | ft | Upstream Velocity Head | 3.25 | ft |
| Ke | 0.50 | | Entrance Loss | 1.63 | ft |

**Inlet Control Properties**

| | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 110.00 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 4.9 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

# Culvert Calculator Report
# 30-in. RCP S=0.5% HW=11 ft

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 111.00 | ft | Headwater Depth/Height | 4.40 | |
| Computed Headwater Elevation | 111.00 | ft | Discharge | 75.16 | cfs |
| Inlet Control HW Elev. | 111.00 | ft | Tailwater Elevation | 101.43 | ft |
| Outlet Control HW Elev. | 110.81 | ft | Control Type | Inlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 100.00 | ft | Downstream Invert | 99.50 | ft |
| Length | 100.00 | ft | Constructed Slope | 0.005000 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 2.45 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 2.45 | ft |
| Velocity Downstream | 15.37 | ft/s | Critical Slope | 0.030208 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.50 | ft |
| Section Size | 30 inch | | Rise | 2.50 | ft |
| Number Sections | 1 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 110.81 | ft | Upstream Velocity Head | 3.64 | ft |
| Ke | 0.50 | | Entrance Loss | 1.82 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 111.00 | ft | Flow Control | N/A | |
| Inlet Type | Square edge w/headwall | | Area Full | 4.9 | ft² |
| K | 0.00980 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 1 | |
| C | 0.03980 | | Equation Form | 1 | |
| Y | 0.67000 | | | | |

| Table D11: Proposed Conditions HEC-HMS Output Summary - Option 1<br>10-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| | sq mi | cfs | days hours | ac - ft |
| W430 | 1.23 | 70 | 01Jan2000, 07:50 | 24.8 |
| W400 | 1.68 | 274 | 01Jan2000, 07:10 | 58.4 |
| W420 | 1.19 | 222 | 01Jan2000, 07:05 | 44.2 |
| J420 | 1.19 | 222 | 01Jan2000, 07:05 | 44.2 |
| R420 | 1.19 | 221 | 01Jan2000, 07:20 | 44.2 |
| J400 | 4.09 | 544 | 01Jan2000, 07:20 | 127.4 |
| R400 | 4.09 | 542 | 01Jan2000, 07:30 | 127.5 |
| W690 | 0.88 | 201 | 01Jan2000, 06:50 | 32.7 |
| J690 | 0.88 | 201 | 01Jan2000, 06:50 | 32.7 |
| R690 | 0.88 | 199 | 01Jan2000, 07:25 | 32.7 |
| W680 | 0.65 | 32 | 01Jan2000, 07:55 | 12.0 |
| W530 | 0.44 | 21 | 01Jan2000, 07:05 | 5.5 |
| J530 | 6.06 | 784 | 01Jan2000, 07:30 | 177.7 |
| R530 | 6.06 | 782 | 01Jan2000, 07:50 | 177.8 |
| W650 | 1.13 | 162 | 01Jan2000, 07:10 | 34.2 |
| Junction-1 | 7.19 | 877 | 01Jan2000, 07:45 | 212.0 |
| W540 | 0.39 | 108 | 01Jan2000, 06:40 | 14.7 |
| Junction-2 | 0.39 | 108 | 01Jan2000, 06:40 | 14.7 |
| W630 | 0.30 | 118 | 01Jan2000, 06:30 | 12.9 |
| J1 | 0.30 | 118 | 01Jan2000, 06:30 | 12.9 |
| C1 | 7.89 | 908 | 01Jan2000, 07:45 | 239.6 |
| Upstream Ponding | 7.89 | 902 | 01Jan2000, 07:50 | 239.6 |
| W640 | 0.22 | 31 | 01Jan2000, 06:55 | 5.6 |
| J630 | 8.10 | 913 | 01Jan2000, 07:50 | 245.1 |
| R630 | 8.10 | 909 | 01Jan2000, 08:00 | 245.2 |
| W065 | 0.09 | 23 | 01Jan2000, 06:30 | 2.6 |
| Tapir Pond | 8.19 | 46 | 02Jan2000, 01:05 | 192.8 |
| Outlet1 | 8.19 | 46 | 02Jan2000, 01:05 | 192.8 |
| W170 | 0.65 | 42 | 01Jan2000, 07:40 | 13.1 |
| J170 | 0.65 | 42 | 01Jan2000, 07:40 | 13.1 |
| R170 | 0.65 | 42 | 01Jan2000, 08:05 | 13.1 |
| W190 | 0.34 | 76 | 01Jan2000, 06:35 | 10.1 |
| JC5 | 0.98 | 76 | 01Jan2000, 06:35 | 23.3 |
| W200 | 0.35 | 25 | 01Jan2000, 06:45 | 4.8 |
| W150 | 0.24 | 25 | 01Jan2000, 06:35 | 4.0 |

| Table D11: Proposed Conditions HEC-HMS Output Summary - Option 1<br>10-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| W180 | 0.10 | 16 | 01Jan2000, 06:25 | 1.9 |
| JC6 | 0.68 | 61 | 01Jan2000, 06:35 | 10.7 |
| RC6 | 0.68 | 61 | 01Jan2000, 06:45 | 10.7 |
| W165 | 0.03 | 15 | 01Jan2000, 06:15 | 1.1 |
| JC4 | 0.03 | 15 | 01Jan2000, 06:15 | 1.1 |
| J200 | 1.69 | 139 | 01Jan2000, 06:40 | 35.1 |
| R200 | 1.69 | 137 | 01Jan2000, 06:50 | 35.1 |
| W230 | 0.43 | 33 | 01Jan2000, 07:10 | 8.0 |
| W210 | 0.09 | 5 | 01Jan2000, 06:45 | 1.0 |
| W160 | 0.02 | 2 | 01Jan2000, 06:20 | 0.3 |
| JC2 | 0.02 | 2 | 01Jan2000, 06:20 | 0.3 |
| R160 | 0.02 | 2 | 01Jan2000, 06:35 | 0.3 |
| J210 | 0.11 | 7 | 01Jan2000, 06:40 | 1.3 |
| W215 | 0.07 | 6 | 01Jan2000, 06:30 | 0.9 |
| Lily Pond | 2.30 | 43 | 01Jan2000, 09:30 | 44.7 |
| Sink-1 | 2.30 | 43 | 01Jan2000, 09:30 | 44.7 |
| W220 | 0.42 | 52 | 01Jan2000, 07:05 | 10.9 |
| W130 | 0.01 | 2 | 01Jan2000, 06:25 | 0.2 |
| J130 | 0.01 | 2 | 01Jan2000, 06:25 | 0.2 |
| R150 | 0.01 | 2 | 01Jan2000, 07:45 | 0.2 |
| Sink-2 | 0.43 | 52 | 01Jan2000, 07:05 | 11.1 |
| W060 | 0.17 | 35 | 01Jan2000, 06:35 | 4.8 |
| W025 | 0.05 | 8 | 01Jan2000, 06:25 | 1.0 |
| W045 | 0.04 | 7 | 01Jan2000, 06:25 | 0.8 |
| W055 | 0.03 | 2 | 01Jan2000, 06:35 | 0.3 |
| W040 | 0.03 | 2 | 01Jan2000, 06:20 | 0.3 |
| W050 | 0.01 | 7 | 01Jan2000, 06:10 | 0.5 |
| Crazy Horse Pond | 0.34 | 10 | 01Jan2000, 07:35 | 7.7 |
| Sink-6 | 0.34 | 10 | 01Jan2000, 07:35 | 7.7 |
| W580 | 0.33 | 30 | 01Jan2000, 06:45 | 5.5 |
| Sink-7 | 0.33 | 30 | 01Jan2000, 06:45 | 5.5 |
| W290 | 0.21 | 27 | 01Jan2000, 06:50 | 4.9 |
| Sink-3 | 0.21 | 27 | 01Jan2000, 06:50 | 4.9 |
| W030 | 0.03 | 2 | 01Jan2000, 06:25 | 0.3 |
| W031 | 0.02 | 41 | 01Jan2000, 06:10 | 2.2 |
| Ex.W031Pond | 0.02 | 0 | 01Jan2000, 07:30 | 2.1 |

| Table D11: Proposed Conditions HEC-HMS Output Summary - Option 1<br>10-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| J031 | 0.02 | 0 | 01Jan2000, 07:30 | 2.1 |
| J030 | 0.04 | 2 | 01Jan2000, 06:30 | 2.4 |
| W035 | 0.02 | 1 | 01Jan2000, 06:20 | 0.2 |
| J035 | 0.02 | 1 | 01Jan2000, 06:20 | 0.2 |
| W034 | 0.01 | 1 | 01Jan2000, 06:20 | 0.1 |
| Estancia Pond | 0.07 | 3 | 01Jan2000, 06:45 | 2.7 |
| Sink-8 | 0.07 | 3 | 01Jan2000, 06:45 | 2.7 |
| W020 | 0.05 | 2 | 01Jan2000, 06:35 | 0.4 |
| W015 | 0.01 | 2 | 01Jan2000, 06:20 | 0.2 |
| J015 | 0.01 | 2 | 01Jan2000, 06:20 | 0.2 |
| J020 | 0.07 | 3 | 01Jan2000, 06:30 | 0.6 |
| Sink-5 | 0.07 | 3 | 01Jan2000, 06:30 | 0.6 |
| Sink-4 | 0.00 | 0 | 01Jan2000, 00:00 | 0.0 |

| Table D12: Proposed Conditions HEC-HMS Output Summary - Option 1<br>25-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| | sq mi | cfs | days hours | ac - ft |
| W430 | 1.23 | 135 | 01Jan2000, 07:50 | 43.0 |
| W400 | 1.68 | 458 | 01Jan2000, 07:10 | 91.0 |
| W420 | 1.19 | 367 | 01Jan2000, 07:05 | 68.2 |
| J420 | 1.19 | 367 | 01Jan2000, 07:05 | 68.2 |
| R420 | 1.19 | 364 | 01Jan2000, 07:20 | 68.2 |
| J400 | 4.09 | 922 | 01Jan2000, 07:15 | 202.3 |
| R400 | 4.09 | 920 | 01Jan2000, 07:25 | 202.3 |
| W690 | 0.88 | 336 | 01Jan2000, 06:50 | 50.4 |
| J690 | 0.88 | 336 | 01Jan2000, 06:50 | 50.4 |
| R690 | 0.88 | 332 | 01Jan2000, 07:20 | 50.5 |
| W680 | 0.65 | 64 | 01Jan2000, 07:50 | 21.3 |
| W530 | 0.44 | 50 | 01Jan2000, 07:00 | 10.7 |
| J530 | 6.06 | 1339 | 01Jan2000, 07:25 | 284.8 |
| R530 | 6.06 | 1334 | 01Jan2000, 07:40 | 284.9 |
| W650 | 1.13 | 283 | 01Jan2000, 07:05 | 54.8 |
| Junction-1 | 7.19 | 1518 | 01Jan2000, 07:40 | 339.8 |
| W540 | 0.39 | 181 | 01Jan2000, 06:40 | 22.6 |
| Junction-2 | 0.39 | 181 | 01Jan2000, 06:40 | 22.6 |
| W630 | 0.30 | 193 | 01Jan2000, 06:30 | 19.5 |
| J1 | 0.30 | 193 | 01Jan2000, 06:30 | 19.5 |
| C1 | 7.89 | 1570 | 01Jan2000, 07:40 | 381.8 |
| Upstream Ponding | 7.89 | 970 | 01Jan2000, 08:25 | 381.8 |
| W640 | 0.22 | 57 | 01Jan2000, 06:50 | 9.2 |
| J630 | 8.10 | 986 | 01Jan2000, 07:20 | 391.1 |
| R630 | 8.10 | 982 | 01Jan2000, 07:35 | 391.2 |
| W065 | 0.09 | 41 | 01Jan2000, 06:30 | 4.3 |
| Tapir Pond | 8.19 | 112 | 01Jan2000, 17:20 | 327.1 |
| Outlet1 | 8.19 | 112 | 01Jan2000, 17:20 | 327.1 |
| W170 | 0.65 | 81 | 01Jan2000, 07:35 | 22.8 |
| J170 | 0.65 | 81 | 01Jan2000, 07:35 | 22.8 |
| R170 | 0.65 | 81 | 01Jan2000, 07:55 | 22.8 |
| W190 | 0.34 | 137 | 01Jan2000, 06:35 | 16.3 |
| JC5 | 0.98 | 137 | 01Jan2000, 06:35 | 39.2 |
| W200 | 0.35 | 59 | 01Jan2000, 06:40 | 9.1 |
| W150 | 0.24 | 56 | 01Jan2000, 06:30 | 7.3 |

| Table D12: Proposed Conditions HEC-HMS Output Summary - Option 1<br>25-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| W180 | 0.10 | 33 | 01Jan2000, 06:25 | 3.3 |
| JC6 | 0.68 | 139 | 01Jan2000, 06:35 | 19.6 |
| RC6 | 0.68 | 139 | 01Jan2000, 06:40 | 19.6 |
| W165 | 0.03 | 24 | 01Jan2000, 06:15 | 1.6 |
| JC4 | 0.03 | 24 | 01Jan2000, 06:15 | 1.6 |
| J200 | 1.69 | 279 | 01Jan2000, 06:35 | 60.4 |
| R200 | 1.69 | 276 | 01Jan2000, 06:50 | 60.4 |
| W230 | 0.43 | 68 | 01Jan2000, 07:05 | 14.1 |
| W210 | 0.09 | 13 | 01Jan2000, 06:40 | 2.0 |
| W160 | 0.02 | 6 | 01Jan2000, 06:15 | 0.5 |
| JC2 | 0.02 | 6 | 01Jan2000, 06:15 | 0.5 |
| R160 | 0.02 | 6 | 01Jan2000, 06:25 | 0.5 |
| J210 | 0.11 | 18 | 01Jan2000, 06:35 | 2.5 |
| W215 | 0.07 | 14 | 01Jan2000, 06:25 | 1.7 |
| Lily Pond | 2.30 | 155 | 01Jan2000, 07:55 | 78.2 |
| Sink-1 | 2.30 | 155 | 01Jan2000, 07:55 | 78.2 |
| W220 | 0.42 | 96 | 01Jan2000, 07:00 | 18.0 |
| W130 | 0.01 | 4 | 01Jan2000, 06:25 | 0.4 |
| J130 | 0.01 | 4 | 01Jan2000, 06:25 | 0.4 |
| R150 | 0.01 | 4 | 01Jan2000, 07:20 | 0.4 |
| Sink-2 | 0.43 | 96 | 01Jan2000, 07:00 | 18.5 |
| W060 | 0.17 | 64 | 01Jan2000, 06:35 | 7.8 |
| W025 | 0.05 | 18 | 01Jan2000, 06:20 | 1.8 |
| W045 | 0.04 | 15 | 01Jan2000, 06:20 | 1.5 |
| W055 | 0.03 | 5 | 01Jan2000, 06:25 | 0.7 |
| W040 | 0.03 | 6 | 01Jan2000, 06:15 | 0.6 |
| W050 | 0.01 | 13 | 01Jan2000, 06:10 | 0.8 |
| Crazy Horse Pond | 0.34 | 18 | 01Jan2000, 07:30 | 13.1 |
| Sink-6 | 0.34 | 18 | 01Jan2000, 07:30 | 13.1 |
| W580 | 0.33 | 66 | 01Jan2000, 06:40 | 10.0 |
| Sink-7 | 0.33 | 66 | 01Jan2000, 06:40 | 10.0 |
| W290 | 0.21 | 52 | 01Jan2000, 06:50 | 8.3 |
| Sink-3 | 0.21 | 52 | 01Jan2000, 06:50 | 8.3 |
| W030 | 0.03 | 5 | 01Jan2000, 06:20 | 0.6 |
| W031 | 0.02 | 53 | 01Jan2000, 06:10 | 2.8 |
| Ex.W031Pond | 0.02 | 6 | 01Jan2000, 06:45 | 2.5 |

| Table D12: Proposed Conditions HEC-HMS Output Summary - Option 1<br>25-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| J031 | 0.02 | 6 | 01Jan2000, 06:45 | 2.5 |
| J030 | 0.04 | 8 | 01Jan2000, 06:45 | 3.1 |
| W035 | 0.02 | 4 | 01Jan2000, 06:15 | 0.4 |
| J035 | 0.02 | 4 | 01Jan2000, 06:15 | 0.4 |
| W034 | 0.01 | 3 | 01Jan2000, 06:15 | 0.3 |
| Estancia Pond | 0.07 | 7 | 01Jan2000, 07:00 | 3.8 |
| Sink-8 | 0.07 | 7 | 01Jan2000, 07:00 | 3.8 |
| W020 | 0.05 | 6 | 01Jan2000, 06:20 | 0.8 |
| W015 | 0.01 | 4 | 01Jan2000, 06:15 | 0.4 |
| J015 | 0.01 | 4 | 01Jan2000, 06:15 | 0.4 |
| J020 | 0.07 | 10 | 01Jan2000, 06:20 | 1.2 |
| Sink-5 | 0.07 | 10 | 01Jan2000, 06:20 | 1.2 |
| Sink-4 | 0.00 | 0 | 01Jan2000, 00:00 | 0.0 |

| Table D13: Proposed Conditions HEC-HMS Output Summary - Option 1<br>50-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| | sq mi | cfs | days hours | ac - ft |
| W430 | 1.23 | 193 | 01Jan2000, 07:45 | 59.5 |
| W400 | 1.68 | 608 | 01Jan2000, 07:10 | 119.2 |
| W420 | 1.19 | 483 | 01Jan2000, 07:05 | 88.6 |
| J420 | 1.19 | 483 | 01Jan2000, 07:05 | 88.6 |
| R420 | 1.19 | 481 | 01Jan2000, 07:15 | 88.7 |
| J400 | 4.09 | 1233 | 01Jan2000, 07:15 | 267.3 |
| R400 | 4.09 | 1228 | 01Jan2000, 07:25 | 267.4 |
| W690 | 0.88 | 442 | 01Jan2000, 06:50 | 65.6 |
| J690 | 0.88 | 442 | 01Jan2000, 06:50 | 65.6 |
| R690 | 0.88 | 437 | 01Jan2000, 07:15 | 65.6 |
| W680 | 0.65 | 92 | 01Jan2000, 07:50 | 29.7 |
| W530 | 0.44 | 78 | 01Jan2000, 07:00 | 15.6 |
| J530 | 6.06 | 1798 | 01Jan2000, 07:20 | 378.3 |
| R530 | 6.06 | 1791 | 01Jan2000, 07:40 | 378.5 |
| W650 | 1.13 | 383 | 01Jan2000, 07:05 | 72.8 |
| Junction-1 | 7.19 | 2052 | 01Jan2000, 07:35 | 451.2 |
| W540 | 0.39 | 239 | 01Jan2000, 06:40 | 29.4 |
| Junction-2 | 0.39 | 239 | 01Jan2000, 06:40 | 29.4 |
| W630 | 0.30 | 251 | 01Jan2000, 06:30 | 25.0 |
| J1 | 0.30 | 251 | 01Jan2000, 06:30 | 25.0 |
| C1 | 7.89 | 2131 | 01Jan2000, 07:35 | 505.6 |
| Upstream Ponding | 7.89 | 1175 | 01Jan2000, 08:05 | 505.6 |
| W640 | 0.22 | 79 | 01Jan2000, 06:50 | 12.4 |
| J630 | 8.10 | 1189 | 01Jan2000, 08:05 | 518.1 |
| R630 | 8.10 | 1188 | 01Jan2000, 08:20 | 518.2 |
| W065 | 0.09 | 56 | 01Jan2000, 06:25 | 5.6 |
| Tapir Pond | 8.19 | 705 | 01Jan2000, 10:30 | 455.0 |
| Outlet1 | 8.19 | 705 | 01Jan2000, 10:30 | 455.0 |
| W170 | 0.65 | 116 | 01Jan2000, 07:35 | 31.5 |
| J170 | 0.65 | 116 | 01Jan2000, 07:35 | 31.5 |
| R170 | 0.65 | 116 | 01Jan2000, 07:50 | 31.6 |
| W190 | 0.34 | 185 | 01Jan2000, 06:35 | 21.6 |
| JC5 | 0.98 | 187 | 01Jan2000, 06:35 | 53.2 |
| W200 | 0.35 | 91 | 01Jan2000, 06:40 | 13.1 |
| W150 | 0.24 | 84 | 01Jan2000, 06:30 | 10.2 |

| Table D13: Proposed Conditions HEC-HMS Output Summary - Option 1<br>50-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| W180 | 0.10 | 47 | 01Jan2000, 06:25 | 4.5 |
| JC6 | 0.68 | 209 | 01Jan2000, 06:30 | 27.8 |
| RC6 | 0.68 | 208 | 01Jan2000, 06:40 | 27.8 |
| W165 | 0.03 | 31 | 01Jan2000, 06:15 | 2.0 |
| JC4 | 0.03 | 31 | 01Jan2000, 06:15 | 2.0 |
| J200 | 1.69 | 403 | 01Jan2000, 06:35 | 83.0 |
| R200 | 1.69 | 400 | 01Jan2000, 06:45 | 83.0 |
| W230 | 0.43 | 99 | 01Jan2000, 07:05 | 19.7 |
| W210 | 0.09 | 21 | 01Jan2000, 06:35 | 2.9 |
| W160 | 0.02 | 9 | 01Jan2000, 06:15 | 0.7 |
| JC2 | 0.02 | 9 | 01Jan2000, 06:15 | 0.7 |
| R160 | 0.02 | 9 | 01Jan2000, 06:25 | 0.7 |
| J210 | 0.11 | 28 | 01Jan2000, 06:30 | 3.7 |
| W215 | 0.07 | 22 | 01Jan2000, 06:25 | 2.5 |
| Lily Pond | 2.30 | 274 | 01Jan2000, 07:40 | 108.3 |
| Sink-1 | 2.30 | 274 | 01Jan2000, 07:40 | 108.3 |
| W220 | 0.42 | 132 | 01Jan2000, 07:00 | 24.3 |
| W130 | 0.01 | 6 | 01Jan2000, 06:25 | 0.6 |
| J130 | 0.01 | 6 | 01Jan2000, 06:25 | 0.6 |
| R150 | 0.01 | 6 | 01Jan2000, 07:10 | 0.6 |
| Sink-2 | 0.43 | 133 | 01Jan2000, 07:10 | 24.9 |
| W060 | 0.17 | 88 | 01Jan2000, 06:35 | 10.4 |
| W025 | 0.05 | 26 | 01Jan2000, 06:20 | 2.5 |
| W045 | 0.04 | 22 | 01Jan2000, 06:20 | 2.0 |
| W055 | 0.03 | 9 | 01Jan2000, 06:25 | 1.0 |
| W040 | 0.03 | 10 | 01Jan2000, 06:15 | 0.8 |
| W050 | 0.01 | 17 | 01Jan2000, 06:10 | 1.0 |
| Crazy Horse Pond | 0.34 | 23 | 01Jan2000, 07:30 | 17.8 |
| Sink-6 | 0.34 | 23 | 01Jan2000, 07:30 | 17.8 |
| W580 | 0.33 | 98 | 01Jan2000, 06:40 | 14.1 |
| Sink-7 | 0.33 | 98 | 01Jan2000, 06:40 | 14.1 |
| W290 | 0.21 | 73 | 01Jan2000, 06:50 | 11.3 |
| Sink-3 | 0.21 | 73 | 01Jan2000, 06:50 | 11.3 |
| W030 | 0.03 | 9 | 01Jan2000, 06:20 | 0.9 |
| W031 | 0.02 | 61 | 01Jan2000, 06:10 | 3.3 |
| Ex.W031Pond | 0.02 | 22 | 01Jan2000, 06:30 | 3.0 |

| Table D13: Proposed Conditions HEC-HMS Output Summary - Option 1<br>50-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| J031 | 0.02 | 22 | 01Jan2000, 06:30 | 3.0 |
| J030 | 0.04 | 29 | 01Jan2000, 06:30 | 3.8 |
| W035 | 0.02 | 6 | 01Jan2000, 06:15 | 0.5 |
| J035 | 0.02 | 6 | 01Jan2000, 06:15 | 0.5 |
| W034 | 0.01 | 5 | 01Jan2000, 06:15 | 0.4 |
| Estancia Pond | 0.07 | 14 | 01Jan2000, 06:45 | 4.8 |
| Sink-8 | 0.07 | 14 | 01Jan2000, 06:45 | 4.8 |
| W020 | 0.05 | 11 | 01Jan2000, 06:20 | 1.3 |
| W015 | 0.01 | 7 | 01Jan2000, 06:15 | 0.6 |
| J015 | 0.01 | 7 | 01Jan2000, 06:15 | 0.6 |
| J020 | 0.07 | 18 | 01Jan2000, 06:15 | 1.9 |
| Sink-5 | 0.07 | 18 | 01Jan2000, 06:15 | 1.9 |
| Sink-4 | 0.00 | 0 | 01Jan2000, 00:00 | 0.0 |

| Table D14: Proposed Conditions HEC-HMS Output Summary - Option 1<br>100-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| | sq mi | cfs | days hours | ac - ft |
| W430 | 1.23 | 249 | 01Jan2000, 07:45 | 77.6 |
| W400 | 1.68 | 748 | 01Jan2000, 07:10 | 149.3 |
| W420 | 1.19 | 588 | 01Jan2000, 07:05 | 110.4 |
| J420 | 1.19 | 588 | 01Jan2000, 07:05 | 110.4 |
| R420 | 1.19 | 587 | 01Jan2000, 07:15 | 110.4 |
| J400 | 4.09 | 1522 | 01Jan2000, 07:15 | 337.3 |
| R400 | 4.09 | 1514 | 01Jan2000, 07:25 | 337.4 |
| W690 | 0.88 | 536 | 01Jan2000, 06:50 | 81.6 |
| J690 | 0.88 | 536 | 01Jan2000, 06:50 | 81.6 |
| R690 | 0.88 | 531 | 01Jan2000, 07:15 | 81.7 |
| W680 | 0.65 | 119 | 01Jan2000, 07:50 | 38.9 |
| W530 | 0.44 | 105 | 01Jan2000, 07:00 | 21.0 |
| J530 | 6.06 | 2219 | 01Jan2000, 07:20 | 479.0 |
| R530 | 6.06 | 2208 | 01Jan2000, 07:35 | 479.3 |
| W650 | 1.13 | 475 | 01Jan2000, 07:05 | 92.0 |
| Junction-1 | 7.19 | 2543 | 01Jan2000, 07:35 | 571.3 |
| W540 | 0.39 | 287 | 01Jan2000, 06:40 | 36.6 |
| Junction-2 | 0.39 | 287 | 01Jan2000, 06:40 | 36.6 |
| W630 | 0.30 | 297 | 01Jan2000, 06:30 | 30.7 |
| J1 | 0.30 | 297 | 01Jan2000, 06:30 | 30.7 |
| C1 | 7.89 | 2651 | 01Jan2000, 07:30 | 638.6 |
| Upstream Ponding | 7.89 | 1175 | 01Jan2000, 07:40 | 638.6 |
| W640 | 0.22 | 99 | 01Jan2000, 06:50 | 15.9 |
| J630 | 8.10 | 1211 | 01Jan2000, 07:40 | 654.5 |
| R630 | 8.10 | 1207 | 01Jan2000, 07:50 | 654.7 |
| W065 | 0.09 | 68 | 01Jan2000, 06:25 | 7.1 |
| Tapir Pond | 8.19 | 984 | 01Jan2000, 10:40 | 592.7 |
| Outlet1 | 8.19 | 984 | 01Jan2000, 10:40 | 592.7 |
| W170 | 0.65 | 149 | 01Jan2000, 07:35 | 41.1 |
| J170 | 0.65 | 149 | 01Jan2000, 07:35 | 41.1 |
| R170 | 0.65 | 149 | 01Jan2000, 07:50 | 41.1 |
| W190 | 0.34 | 227 | 01Jan2000, 06:35 | 27.3 |
| JC5 | 0.98 | 229 | 01Jan2000, 06:35 | 68.4 |
| W200 | 0.35 | 120 | 01Jan2000, 06:40 | 17.5 |
| W150 | 0.24 | 109 | 01Jan2000, 06:30 | 13.5 |

| Table D14: Proposed Conditions HEC-HMS Output Summary - Option 1<br>100-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| W180 | 0.10 | 58 | 01Jan2000, 06:25 | 5.8 |
| JC6 | 0.68 | 272 | 01Jan2000, 06:30 | 36.8 |
| RC6 | 0.68 | 269 | 01Jan2000, 06:40 | 36.8 |
| W165 | 0.03 | 36 | 01Jan2000, 06:15 | 2.5 |
| JC4 | 0.03 | 36 | 01Jan2000, 06:15 | 2.5 |
| J200 | 1.69 | 512 | 01Jan2000, 06:35 | 107.7 |
| R200 | 1.69 | 508 | 01Jan2000, 06:45 | 107.7 |
| W230 | 0.43 | 127 | 01Jan2000, 07:05 | 25.8 |
| W210 | 0.09 | 28 | 01Jan2000, 06:35 | 4.0 |
| W160 | 0.02 | 12 | 01Jan2000, 06:15 | 1.0 |
| JC2 | 0.02 | 12 | 01Jan2000, 06:15 | 1.0 |
| R160 | 0.02 | 12 | 01Jan2000, 06:25 | 1.0 |
| J210 | 0.11 | 36 | 01Jan2000, 06:30 | 5.0 |
| W215 | 0.07 | 29 | 01Jan2000, 06:25 | 3.3 |
| Lily Pond | 2.30 | 391 | 01Jan2000, 07:30 | 141.1 |
| Sink-1 | 2.30 | 391 | 01Jan2000, 07:30 | 141.1 |
| W220 | 0.42 | 165 | 01Jan2000, 07:00 | 31.0 |
| W130 | 0.01 | 8 | 01Jan2000, 06:20 | 0.8 |
| J130 | 0.01 | 8 | 01Jan2000, 06:20 | 0.8 |
| R150 | 0.01 | 7 | 01Jan2000, 07:10 | 0.8 |
| Sink-2 | 0.43 | 169 | 01Jan2000, 07:05 | 31.8 |
| W060 | 0.17 | 109 | 01Jan2000, 06:35 | 13.3 |
| W025 | 0.05 | 34 | 01Jan2000, 06:20 | 3.3 |
| W045 | 0.04 | 28 | 01Jan2000, 06:20 | 2.6 |
| W055 | 0.03 | 12 | 01Jan2000, 06:20 | 1.4 |
| W040 | 0.03 | 13 | 01Jan2000, 06:15 | 1.1 |
| W050 | 0.01 | 20 | 01Jan2000, 06:10 | 1.2 |
| Crazy Horse Pond | 0.34 | 27 | 01Jan2000, 07:30 | 22.9 |
| Sink-6 | 0.34 | 27 | 01Jan2000, 07:30 | 22.9 |
| W580 | 0.33 | 127 | 01Jan2000, 06:40 | 18.6 |
| Sink-7 | 0.33 | 127 | 01Jan2000, 06:40 | 18.6 |
| W290 | 0.21 | 92 | 01Jan2000, 06:45 | 14.5 |
| Sink-3 | 0.21 | 92 | 01Jan2000, 06:45 | 14.5 |
| W030 | 0.03 | 12 | 01Jan2000, 06:20 | 1.2 |
| W031 | 0.02 | 66 | 01Jan2000, 06:10 | 3.7 |
| Ex.W031Pond | 0.02 | 36 | 01Jan2000, 06:25 | 3.4 |

| Table D14: Proposed Conditions HEC-HMS Output Summary - Option 1<br>100-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| J031 | 0.02 | 36 | 01Jan2000, 06:25 | 3.4 |
| J030 | 0.04 | 46 | 01Jan2000, 06:25 | 4.6 |
| W035 | 0.02 | 8 | 01Jan2000, 06:15 | 0.7 |
| J035 | 0.02 | 8 | 01Jan2000, 06:15 | 0.7 |
| W034 | 0.01 | 6 | 01Jan2000, 06:15 | 0.6 |
| Estancia Pond | 0.07 | 18 | 01Jan2000, 06:45 | 5.9 |
| Sink-8 | 0.07 | 18 | 01Jan2000, 06:45 | 5.9 |
| W020 | 0.05 | 16 | 01Jan2000, 06:15 | 1.8 |
| W015 | 0.01 | 9 | 01Jan2000, 06:15 | 0.8 |
| J015 | 0.01 | 9 | 01Jan2000, 06:15 | 0.8 |
| J020 | 0.07 | 25 | 01Jan2000, 06:15 | 2.6 |
| Sink-5 | 0.07 | 25 | 01Jan2000, 06:15 | 2.6 |
| Sink-4 | 0.00 | 0 | 01Jan2000, 00:00 | 0.0 |

| Table D15: Proposed Conditions HEC-HMS Output Summary - Option 2<br>10-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| | sq mi | cfs | days hours | ac - ft |
| W430 | 1.23 | 70 | 01Jan2000, 07:50 | 24.8 |
| W400 | 1.68 | 274 | 01Jan2000, 07:10 | 58.4 |
| W420 | 1.19 | 222 | 01Jan2000, 07:05 | 44.2 |
| J420 | 1.19 | 222 | 01Jan2000, 07:05 | 44.2 |
| R420 | 1.19 | 221 | 01Jan2000, 07:20 | 44.2 |
| J400 | 4.09 | 544 | 01Jan2000, 07:20 | 127.4 |
| R400 | 4.09 | 542 | 01Jan2000, 07:30 | 127.5 |
| W690 | 0.88 | 201 | 01Jan2000, 06:50 | 32.7 |
| J690 | 0.88 | 201 | 01Jan2000, 06:50 | 32.7 |
| R690 | 0.88 | 199 | 01Jan2000, 07:25 | 32.7 |
| W680 | 0.65 | 32 | 01Jan2000, 07:55 | 12.0 |
| W530 | 0.44 | 21 | 01Jan2000, 07:05 | 5.5 |
| J530 | 6.06 | 784 | 01Jan2000, 07:30 | 177.7 |
| R530 | 6.06 | 782 | 01Jan2000, 07:50 | 177.8 |
| W650 | 1.13 | 162 | 01Jan2000, 07:10 | 34.2 |
| Junction-1 | 7.19 | 877 | 01Jan2000, 07:45 | 212.0 |
| W540 | 0.39 | 108 | 01Jan2000, 06:40 | 14.7 |
| Junction-2 | 0.39 | 108 | 01Jan2000, 06:40 | 14.7 |
| W630 | 0.30 | 118 | 01Jan2000, 06:30 | 12.9 |
| J1 | 0.30 | 118 | 01Jan2000, 06:30 | 12.9 |
| C1 | 7.89 | 908 | 01Jan2000, 07:45 | 239.6 |
| Upstream Ponding | 7.89 | 902 | 01Jan2000, 07:50 | 239.6 |
| W640 | 0.22 | 31 | 01Jan2000, 06:55 | 5.6 |
| J630 | 8.10 | 913 | 01Jan2000, 07:50 | 245.1 |
| R630 | 8.10 | 909 | 01Jan2000, 08:00 | 245.2 |
| W065 | 0.09 | 23 | 01Jan2000, 06:30 | 2.6 |
| Tapir Pond | 8.19 | 46 | 02Jan2000, 01:05 | 192.8 |
| Outlet1 | 8.19 | 46 | 02Jan2000, 01:05 | 192.8 |
| W170 | 0.65 | 42 | 01Jan2000, 07:40 | 13.1 |
| J170 | 0.65 | 42 | 01Jan2000, 07:40 | 13.1 |
| R170 | 0.65 | 42 | 01Jan2000, 08:05 | 13.1 |
| W190 | 0.34 | 76 | 01Jan2000, 06:35 | 10.1 |
| JC5 | 0.98 | 76 | 01Jan2000, 06:35 | 23.3 |
| W200 | 0.35 | 25 | 01Jan2000, 06:45 | 4.8 |
| W150 | 0.24 | 25 | 01Jan2000, 06:35 | 4.0 |

| Table D15: Proposed Conditions HEC-HMS Output Summary - Option 2<br>10-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| W180 | 0.10 | 16 | 01Jan2000, 06:25 | 1.9 |
| JC6 | 0.68 | 61 | 01Jan2000, 06:35 | 10.7 |
| RC6 | 0.68 | 61 | 01Jan2000, 06:45 | 10.7 |
| W165 | 0.03 | 15 | 01Jan2000, 06:15 | 1.1 |
| JC4 | 0.03 | 15 | 01Jan2000, 06:15 | 1.1 |
| J200 | 1.69 | 139 | 01Jan2000, 06:40 | 35.1 |
| R200 | 1.69 | 137 | 01Jan2000, 06:50 | 35.1 |
| W230 | 0.43 | 33 | 01Jan2000, 07:10 | 8.0 |
| W210 | 0.09 | 5 | 01Jan2000, 06:45 | 1.0 |
| W160 | 0.02 | 2 | 01Jan2000, 06:20 | 0.3 |
| JC2 | 0.02 | 2 | 01Jan2000, 06:20 | 0.3 |
| R160 | 0.02 | 2 | 01Jan2000, 06:35 | 0.3 |
| J210 | 0.11 | 7 | 01Jan2000, 06:40 | 1.3 |
| W215 | 0.07 | 6 | 01Jan2000, 06:30 | 0.9 |
| Lily Pond | 2.30 | 43 | 01Jan2000, 09:30 | 44.7 |
| Sink-1 | 2.30 | 43 | 01Jan2000, 09:30 | 44.7 |
| W220 | 0.42 | 52 | 01Jan2000, 07:05 | 10.9 |
| W130 | 0.01 | 2 | 01Jan2000, 06:25 | 0.2 |
| J130 | 0.01 | 2 | 01Jan2000, 06:25 | 0.2 |
| R150 | 0.01 | 2 | 01Jan2000, 07:45 | 0.2 |
| Sink-2 | 0.43 | 52 | 01Jan2000, 07:05 | 11.1 |
| W060 | 0.17 | 35 | 01Jan2000, 06:35 | 4.8 |
| W030 | 0.03 | 2 | 01Jan2000, 06:25 | 0.3 |
| W031 | 0.02 | 41 | 01Jan2000, 06:10 | 2.2 |
| Ex.W031Pond | 0.02 | 0 | 01Jan2000, 07:30 | 2.1 |
| J031 | 0.02 | 0 | 01Jan2000, 07:30 | 2.1 |
| J030 | 0.04 | 2 | 01Jan2000, 06:30 | 2.4 |
| W055 | 0.03 | 2 | 01Jan2000, 06:35 | 0.3 |
| J055 | 0.08 | 4 | 01Jan2000, 06:30 | 2.7 |
| W025 | 0.05 | 8 | 01Jan2000, 06:25 | 1.0 |
| W045 | 0.04 | 7 | 01Jan2000, 06:25 | 0.8 |
| W040 | 0.03 | 2 | 01Jan2000, 06:20 | 0.3 |
| W035 | 0.02 | 1 | 01Jan2000, 06:20 | 0.2 |
| J035 | 0.02 | 1 | 01Jan2000, 06:20 | 0.2 |
| W050 | 0.01 | 7 | 01Jan2000, 06:10 | 0.5 |
| W034 | 0.01 | 1 | 01Jan2000, 06:20 | 0.1 |

| Table D15: Proposed Conditions HEC-HMS Output Summary - Option 2<br>10-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| Crazy Horse Pond | 0.41 | 10 | 01Jan2000, 07:35 | 10.4 |
| Sink-6 | 0.41 | 10 | 01Jan2000, 07:35 | 10.4 |
| W580 | 0.33 | 30 | 01Jan2000, 06:45 | 5.5 |
| Sink-7 | 0.33 | 30 | 01Jan2000, 06:45 | 5.5 |
| W290 | 0.21 | 27 | 01Jan2000, 06:50 | 4.9 |
| Sink-3 | 0.21 | 27 | 01Jan2000, 06:50 | 4.9 |
| W020 | 0.05 | 2 | 01Jan2000, 06:35 | 0.4 |
| W015 | 0.01 | 2 | 01Jan2000, 06:20 | 0.2 |
| J015 | 0.01 | 2 | 01Jan2000, 06:20 | 0.2 |
| J020 | 0.07 | 3 | 01Jan2000, 06:30 | 0.6 |
| Sink-5 | 0.07 | 3 | 01Jan2000, 06:30 | 0.6 |

| Table D16: Proposed Conditions HEC-HMS Output Summary - Option 2<br>25-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| | sq mi | cfs | days hours | ac - ft |
| W430 | 1.23 | 135 | 01Jan2000, 07:50 | 43.0 |
| W400 | 1.68 | 458 | 01Jan2000, 07:10 | 91.0 |
| W420 | 1.19 | 367 | 01Jan2000, 07:05 | 68.2 |
| J420 | 1.19 | 367 | 01Jan2000, 07:05 | 68.2 |
| R420 | 1.19 | 364 | 01Jan2000, 07:20 | 68.2 |
| J400 | 4.09 | 922 | 01Jan2000, 07:15 | 202.3 |
| R400 | 4.09 | 920 | 01Jan2000, 07:25 | 202.3 |
| W690 | 0.88 | 336 | 01Jan2000, 06:50 | 50.4 |
| J690 | 0.88 | 336 | 01Jan2000, 06:50 | 50.4 |
| R690 | 0.88 | 332 | 01Jan2000, 07:20 | 50.5 |
| W680 | 0.65 | 64 | 01Jan2000, 07:50 | 21.3 |
| W530 | 0.44 | 50 | 01Jan2000, 07:00 | 10.7 |
| J530 | 6.06 | 1339 | 01Jan2000, 07:25 | 284.8 |
| R530 | 6.06 | 1334 | 01Jan2000, 07:40 | 284.9 |
| W650 | 1.13 | 283 | 01Jan2000, 07:05 | 54.8 |
| Junction-1 | 7.19 | 1518 | 01Jan2000, 07:40 | 339.8 |
| W540 | 0.39 | 181 | 01Jan2000, 06:40 | 22.6 |
| Junction-2 | 0.39 | 181 | 01Jan2000, 06:40 | 22.6 |
| W630 | 0.30 | 193 | 01Jan2000, 06:30 | 19.5 |
| J1 | 0.30 | 193 | 01Jan2000, 06:30 | 19.5 |
| C1 | 7.89 | 1570 | 01Jan2000, 07:40 | 381.8 |
| Upstream Ponding | 7.89 | 970 | 01Jan2000, 08:25 | 381.8 |
| W640 | 0.22 | 57 | 01Jan2000, 06:50 | 9.2 |
| J630 | 8.10 | 986 | 01Jan2000, 07:20 | 391.1 |
| R630 | 8.10 | 982 | 01Jan2000, 07:35 | 391.2 |
| W065 | 0.09 | 41 | 01Jan2000, 06:30 | 4.3 |
| Tapir Pond | 8.19 | 112 | 01Jan2000, 17:20 | 327.1 |
| Outlet1 | 8.19 | 112 | 01Jan2000, 17:20 | 327.1 |
| W170 | 0.65 | 81 | 01Jan2000, 07:35 | 22.8 |
| J170 | 0.65 | 81 | 01Jan2000, 07:35 | 22.8 |
| R170 | 0.65 | 81 | 01Jan2000, 07:55 | 22.8 |
| W190 | 0.34 | 137 | 01Jan2000, 06:35 | 16.3 |
| JC5 | 0.98 | 137 | 01Jan2000, 06:35 | 39.2 |
| W200 | 0.35 | 59 | 01Jan2000, 06:40 | 9.1 |
| W150 | 0.24 | 56 | 01Jan2000, 06:30 | 7.3 |

| Table D16: Proposed Conditions HEC-HMS Output Summary - Option 2<br>25-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| W180 | 0.10 | 33 | 01Jan2000, 06:25 | 3.3 |
| JC6 | 0.68 | 139 | 01Jan2000, 06:35 | 19.6 |
| RC6 | 0.68 | 139 | 01Jan2000, 06:40 | 19.6 |
| W165 | 0.03 | 24 | 01Jan2000, 06:15 | 1.6 |
| JC4 | 0.03 | 24 | 01Jan2000, 06:15 | 1.6 |
| J200 | 1.69 | 279 | 01Jan2000, 06:35 | 60.4 |
| R200 | 1.69 | 276 | 01Jan2000, 06:50 | 60.4 |
| W230 | 0.43 | 68 | 01Jan2000, 07:05 | 14.1 |
| W210 | 0.09 | 13 | 01Jan2000, 06:40 | 2.0 |
| W160 | 0.02 | 6 | 01Jan2000, 06:15 | 0.5 |
| JC2 | 0.02 | 6 | 01Jan2000, 06:15 | 0.5 |
| R160 | 0.02 | 6 | 01Jan2000, 06:25 | 0.5 |
| J210 | 0.11 | 18 | 01Jan2000, 06:35 | 2.5 |
| W215 | 0.07 | 14 | 01Jan2000, 06:25 | 1.7 |
| Lily Pond | 2.30 | 155 | 01Jan2000, 07:55 | 78.2 |
| Sink-1 | 2.30 | 155 | 01Jan2000, 07:55 | 78.2 |
| W220 | 0.42 | 96 | 01Jan2000, 07:00 | 18.0 |
| W130 | 0.01 | 4 | 01Jan2000, 06:25 | 0.4 |
| J130 | 0.01 | 4 | 01Jan2000, 06:25 | 0.4 |
| R150 | 0.01 | 4 | 01Jan2000, 07:20 | 0.4 |
| Sink-2 | 0.43 | 96 | 01Jan2000, 07:00 | 18.5 |
| W060 | 0.17 | 64 | 01Jan2000, 06:35 | 7.8 |
| W030 | 0.03 | 5 | 01Jan2000, 06:20 | 0.6 |
| W031 | 0.02 | 53 | 01Jan2000, 06:10 | 2.8 |
| Ex.W031Pond | 0.02 | 6 | 01Jan2000, 06:45 | 2.5 |
| J031 | 0.02 | 6 | 01Jan2000, 06:45 | 2.5 |
| J030 | 0.04 | 8 | 01Jan2000, 06:45 | 3.1 |
| W055 | 0.03 | 5 | 01Jan2000, 06:25 | 0.7 |
| J055 | 0.08 | 12 | 01Jan2000, 06:45 | 3.8 |
| W025 | 0.05 | 17 | 01Jan2000, 06:20 | 1.8 |
| W045 | 0.04 | 15 | 01Jan2000, 06:20 | 1.5 |
| W040 | 0.03 | 6 | 01Jan2000, 06:15 | 0.6 |
| W035 | 0.02 | 4 | 01Jan2000, 06:15 | 0.4 |
| J035 | 0.02 | 4 | 01Jan2000, 06:15 | 0.4 |
| W050 | 0.01 | 13 | 01Jan2000, 06:10 | 0.8 |
| W034 | 0.01 | 3 | 01Jan2000, 06:15 | 0.3 |

| Table D16: Proposed Conditions HEC-HMS Output Summary - Option 2<br>25-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| Crazy Horse Pond | 0.41 | 20 | 01Jan2000, 07:30 | 16.7 |
| Sink-6 | 0.41 | 20 | 01Jan2000, 07:30 | 16.7 |
| W580 | 0.33 | 66 | 01Jan2000, 06:40 | 10.0 |
| Sink-7 | 0.33 | 66 | 01Jan2000, 06:40 | 10.0 |
| W290 | 0.21 | 52 | 01Jan2000, 06:50 | 8.3 |
| Sink-3 | 0.21 | 52 | 01Jan2000, 06:50 | 8.3 |
| W020 | 0.05 | 6 | 01Jan2000, 06:20 | 0.8 |
| W015 | 0.01 | 4 | 01Jan2000, 06:15 | 0.4 |
| J015 | 0.01 | 4 | 01Jan2000, 06:15 | 0.4 |
| J020 | 0.07 | 10 | 01Jan2000, 06:20 | 1.2 |
| Sink-5 | 0.07 | 10 | 01Jan2000, 06:20 | 1.2 |

| Table D17: Proposed Conditions HEC-HMS Output Summary - Option 2<br>50-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| | sq mi | cfs | days hours | ac - ft |
| W430 | 1.23 | 193 | 01Jan2000, 07:45 | 59.5 |
| W400 | 1.68 | 608 | 01Jan2000, 07:10 | 119.2 |
| W420 | 1.19 | 483 | 01Jan2000, 07:05 | 88.6 |
| J420 | 1.19 | 483 | 01Jan2000, 07:05 | 88.6 |
| R420 | 1.19 | 481 | 01Jan2000, 07:15 | 88.7 |
| J400 | 4.09 | 1233 | 01Jan2000, 07:15 | 267.3 |
| R400 | 4.09 | 1228 | 01Jan2000, 07:25 | 267.4 |
| W690 | 0.88 | 442 | 01Jan2000, 06:50 | 65.6 |
| J690 | 0.88 | 442 | 01Jan2000, 06:50 | 65.6 |
| R690 | 0.88 | 437 | 01Jan2000, 07:15 | 65.6 |
| W680 | 0.65 | 92 | 01Jan2000, 07:50 | 29.7 |
| W530 | 0.44 | 78 | 01Jan2000, 07:00 | 15.6 |
| J530 | 6.06 | 1798 | 01Jan2000, 07:20 | 378.3 |
| R530 | 6.06 | 1791 | 01Jan2000, 07:40 | 378.5 |
| W650 | 1.13 | 383 | 01Jan2000, 07:05 | 72.8 |
| Junction-1 | 7.19 | 2052 | 01Jan2000, 07:35 | 451.2 |
| W540 | 0.39 | 239 | 01Jan2000, 06:40 | 29.4 |
| Junction-2 | 0.39 | 239 | 01Jan2000, 06:40 | 29.4 |
| W630 | 0.30 | 251 | 01Jan2000, 06:30 | 25.0 |
| J1 | 0.30 | 251 | 01Jan2000, 06:30 | 25.0 |
| C1 | 7.89 | 2131 | 01Jan2000, 07:35 | 505.6 |
| Upstream Ponding | 7.89 | 1175 | 01Jan2000, 08:05 | 505.6 |
| W640 | 0.22 | 79 | 01Jan2000, 06:50 | 12.4 |
| J630 | 8.10 | 1189 | 01Jan2000, 08:05 | 518.1 |
| R630 | 8.10 | 1188 | 01Jan2000, 08:20 | 518.2 |
| W065 | 0.09 | 56 | 01Jan2000, 06:25 | 5.6 |
| Tapir Pond | 8.19 | 705 | 01Jan2000, 10:30 | 455.0 |
| Outlet1 | 8.19 | 705 | 01Jan2000, 10:30 | 455.0 |
| W170 | 0.65 | 116 | 01Jan2000, 07:35 | 31.5 |
| J170 | 0.65 | 116 | 01Jan2000, 07:35 | 31.5 |
| R170 | 0.65 | 116 | 01Jan2000, 07:50 | 31.6 |
| W190 | 0.34 | 185 | 01Jan2000, 06:35 | 21.6 |
| JC5 | 0.98 | 187 | 01Jan2000, 06:35 | 53.2 |
| W200 | 0.35 | 91 | 01Jan2000, 06:40 | 13.1 |
| W150 | 0.24 | 84 | 01Jan2000, 06:30 | 10.2 |

| Table D17: Proposed Conditions HEC-HMS Output Summary - Option 2<br>50-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| W180 | 0.10 | 47 | 01Jan2000, 06:25 | 4.5 |
| JC6 | 0.68 | 209 | 01Jan2000, 06:30 | 27.8 |
| RC6 | 0.68 | 208 | 01Jan2000, 06:40 | 27.8 |
| W165 | 0.03 | 31 | 01Jan2000, 06:15 | 2.0 |
| JC4 | 0.03 | 31 | 01Jan2000, 06:15 | 2.0 |
| J200 | 1.69 | 403 | 01Jan2000, 06:35 | 83.0 |
| R200 | 1.69 | 400 | 01Jan2000, 06:45 | 83.0 |
| W230 | 0.43 | 99 | 01Jan2000, 07:05 | 19.7 |
| W210 | 0.09 | 21 | 01Jan2000, 06:35 | 2.9 |
| W160 | 0.02 | 9 | 01Jan2000, 06:15 | 0.7 |
| JC2 | 0.02 | 9 | 01Jan2000, 06:15 | 0.7 |
| R160 | 0.02 | 9 | 01Jan2000, 06:25 | 0.7 |
| J210 | 0.11 | 28 | 01Jan2000, 06:30 | 3.7 |
| W215 | 0.07 | 22 | 01Jan2000, 06:25 | 2.5 |
| Lily Pond | 2.30 | 274 | 01Jan2000, 07:40 | 108.3 |
| Sink-1 | 2.30 | 274 | 01Jan2000, 07:40 | 108.3 |
| W220 | 0.42 | 132 | 01Jan2000, 07:00 | 24.3 |
| W130 | 0.01 | 6 | 01Jan2000, 06:25 | 0.6 |
| J130 | 0.01 | 6 | 01Jan2000, 06:25 | 0.6 |
| R150 | 0.01 | 6 | 01Jan2000, 07:10 | 0.6 |
| Sink-2 | 0.43 | 133 | 01Jan2000, 07:10 | 24.9 |
| W060 | 0.17 | 88 | 01Jan2000, 06:35 | 10.4 |
| W030 | 0.03 | 9 | 01Jan2000, 06:20 | 0.9 |
| W031 | 0.02 | 61 | 01Jan2000, 06:10 | 3.3 |
| Ex.W031Pond | 0.02 | 22 | 01Jan2000, 06:30 | 3.0 |
| J031 | 0.02 | 22 | 01Jan2000, 06:30 | 3.0 |
| J030 | 0.04 | 29 | 01Jan2000, 06:30 | 3.8 |
| W055 | 0.03 | 9 | 01Jan2000, 06:25 | 1.1 |
| J055 | 0.08 | 37 | 01Jan2000, 06:30 | 4.9 |
| W025 | 0.05 | 26 | 01Jan2000, 06:20 | 2.4 |
| W045 | 0.04 | 22 | 01Jan2000, 06:20 | 2.0 |
| W040 | 0.03 | 10 | 01Jan2000, 06:15 | 0.8 |
| W035 | 0.02 | 6 | 01Jan2000, 06:15 | 0.5 |
| J035 | 0.02 | 6 | 01Jan2000, 06:15 | 0.5 |
| W050 | 0.01 | 17 | 01Jan2000, 06:10 | 1.0 |
| W034 | 0.01 | 5 | 01Jan2000, 06:15 | 0.4 |

| Table D17: Proposed Conditions HEC-HMS Output Summary - Option 2<br>50-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| Crazy Horse Pond | 0.41 | 26 | 01Jan2000, 07:30 | 22.5 |
| Sink-6 | 0.41 | 26 | 01Jan2000, 07:30 | 22.5 |
| W580 | 0.33 | 98 | 01Jan2000, 06:40 | 14.1 |
| Sink-7 | 0.33 | 98 | 01Jan2000, 06:40 | 14.1 |
| W290 | 0.21 | 73 | 01Jan2000, 06:50 | 11.3 |
| Sink-3 | 0.21 | 73 | 01Jan2000, 06:50 | 11.3 |
| W020 | 0.05 | 11 | 01Jan2000, 06:20 | 1.3 |
| W015 | 0.01 | 7 | 01Jan2000, 06:15 | 0.6 |
| J015 | 0.01 | 7 | 01Jan2000, 06:15 | 0.6 |
| J020 | 0.07 | 18 | 01Jan2000, 06:15 | 1.9 |
| Sink-5 | 0.07 | 18 | 01Jan2000, 06:15 | 1.9 |

| Table D18: Proposed Conditions HEC-HMS Output Summary - Option 2<br>100-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| | sq mi | cfs | days hours | ac - ft |
| W430 | 1.23 | 249 | 01Jan2000, 07:45 | 77.6 |
| W400 | 1.68 | 748 | 01Jan2000, 07:10 | 149.3 |
| W420 | 1.19 | 588 | 01Jan2000, 07:05 | 110.4 |
| J420 | 1.19 | 588 | 01Jan2000, 07:05 | 110.4 |
| R420 | 1.19 | 587 | 01Jan2000, 07:15 | 110.4 |
| J400 | 4.09 | 1522 | 01Jan2000, 07:15 | 337.3 |
| R400 | 4.09 | 1514 | 01Jan2000, 07:25 | 337.4 |
| W690 | 0.88 | 536 | 01Jan2000, 06:50 | 81.6 |
| J690 | 0.88 | 536 | 01Jan2000, 06:50 | 81.6 |
| R690 | 0.88 | 531 | 01Jan2000, 07:15 | 81.7 |
| W680 | 0.65 | 119 | 01Jan2000, 07:50 | 38.9 |
| W530 | 0.44 | 105 | 01Jan2000, 07:00 | 21.0 |
| J530 | 6.06 | 2219 | 01Jan2000, 07:20 | 479.0 |
| R530 | 6.06 | 2208 | 01Jan2000, 07:35 | 479.3 |
| W650 | 1.13 | 475 | 01Jan2000, 07:05 | 92.0 |
| Junction-1 | 7.19 | 2543 | 01Jan2000, 07:35 | 571.3 |
| W540 | 0.39 | 287 | 01Jan2000, 06:40 | 36.6 |
| Junction-2 | 0.39 | 287 | 01Jan2000, 06:40 | 36.6 |
| W630 | 0.30 | 297 | 01Jan2000, 06:30 | 30.7 |
| J1 | 0.30 | 297 | 01Jan2000, 06:30 | 30.7 |
| C1 | 7.89 | 2651 | 01Jan2000, 07:30 | 638.6 |
| Upstream Ponding | 7.89 | 1175 | 01Jan2000, 07:40 | 638.6 |
| W640 | 0.22 | 99 | 01Jan2000, 06:50 | 15.9 |
| J630 | 8.10 | 1211 | 01Jan2000, 07:40 | 654.5 |
| R630 | 8.10 | 1207 | 01Jan2000, 07:50 | 654.7 |
| W065 | 0.09 | 68 | 01Jan2000, 06:25 | 7.1 |
| Tapir Pond | 8.19 | 984 | 01Jan2000, 10:40 | 592.7 |
| Outlet1 | 8.19 | 984 | 01Jan2000, 10:40 | 592.7 |
| W170 | 0.65 | 149 | 01Jan2000, 07:35 | 41.1 |
| J170 | 0.65 | 149 | 01Jan2000, 07:35 | 41.1 |
| R170 | 0.65 | 149 | 01Jan2000, 07:50 | 41.1 |
| W190 | 0.34 | 227 | 01Jan2000, 06:35 | 27.3 |
| JC5 | 0.98 | 229 | 01Jan2000, 06:35 | 68.4 |
| W200 | 0.35 | 120 | 01Jan2000, 06:40 | 17.5 |
| W150 | 0.24 | 109 | 01Jan2000, 06:30 | 13.5 |

| Table D18: Proposed Conditions HEC-HMS Output Summary - Option 2<br>100-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| W180 | 0.10 | 58 | 01Jan2000, 06:25 | 5.8 |
| JC6 | 0.68 | 272 | 01Jan2000, 06:30 | 36.8 |
| RC6 | 0.68 | 269 | 01Jan2000, 06:40 | 36.8 |
| W165 | 0.03 | 36 | 01Jan2000, 06:15 | 2.5 |
| JC4 | 0.03 | 36 | 01Jan2000, 06:15 | 2.5 |
| J200 | 1.69 | 512 | 01Jan2000, 06:35 | 107.7 |
| R200 | 1.69 | 508 | 01Jan2000, 06:45 | 107.7 |
| W230 | 0.43 | 127 | 01Jan2000, 07:05 | 25.8 |
| W210 | 0.09 | 28 | 01Jan2000, 06:35 | 4.0 |
| W160 | 0.02 | 12 | 01Jan2000, 06:15 | 1.0 |
| JC2 | 0.02 | 12 | 01Jan2000, 06:15 | 1.0 |
| R160 | 0.02 | 12 | 01Jan2000, 06:25 | 1.0 |
| J210 | 0.11 | 36 | 01Jan2000, 06:30 | 5.0 |
| W215 | 0.07 | 29 | 01Jan2000, 06:25 | 3.3 |
| Lily Pond | 2.30 | 391 | 01Jan2000, 07:30 | 141.1 |
| Sink-1 | 2.30 | 391 | 01Jan2000, 07:30 | 141.1 |
| W220 | 0.42 | 165 | 01Jan2000, 07:00 | 31.0 |
| W130 | 0.01 | 8 | 01Jan2000, 06:20 | 0.8 |
| J130 | 0.01 | 8 | 01Jan2000, 06:20 | 0.8 |
| R150 | 0.01 | 7 | 01Jan2000, 07:10 | 0.8 |
| Sink-2 | 0.43 | 169 | 01Jan2000, 07:05 | 31.8 |
| W060 | 0.17 | 109 | 01Jan2000, 06:35 | 13.3 |
| W030 | 0.03 | 12 | 01Jan2000, 06:20 | 1.2 |
| W031 | 0.02 | 66 | 01Jan2000, 06:10 | 3.7 |
| Ex.W031Pond | 0.02 | 36 | 01Jan2000, 06:25 | 3.4 |
| J031 | 0.02 | 36 | 01Jan2000, 06:25 | 3.4 |
| J030 | 0.04 | 46 | 01Jan2000, 06:25 | 4.6 |
| W055 | 0.03 | 12 | 01Jan2000, 06:20 | 1.4 |
| J055 | 0.08 | 58 | 01Jan2000, 06:25 | 6.0 |
| W025 | 0.05 | 33 | 01Jan2000, 06:20 | 3.2 |
| W045 | 0.04 | 28 | 01Jan2000, 06:20 | 2.6 |
| W040 | 0.03 | 13 | 01Jan2000, 06:15 | 1.1 |
| W035 | 0.02 | 8 | 01Jan2000, 06:15 | 0.7 |
| J035 | 0.02 | 8 | 01Jan2000, 06:15 | 0.7 |
| W050 | 0.01 | 20 | 01Jan2000, 06:10 | 1.2 |
| W034 | 0.01 | 6 | 01Jan2000, 06:15 | 0.6 |

| Table D18: Proposed Conditions HEC-HMS Output Summary - Option 2<br>100-yr 24-hr 25% Frequency Distribution | | | | |
|---|---|---|---|---|
| Hydrologic Element | Area | Peak Discharge | Time to Peak | Runoff Volume |
| Crazy Horse Pond | 0.41 | 28 | 01Jan2000, 07:35 | 28.7 |
| Sink-6 | 0.41 | 28 | 01Jan2000, 07:35 | 28.7 |
| W580 | 0.33 | 127 | 01Jan2000, 06:40 | 18.6 |
| Sink-7 | 0.33 | 127 | 01Jan2000, 06:40 | 18.6 |
| W290 | 0.21 | 92 | 01Jan2000, 06:45 | 14.5 |
| Sink-3 | 0.21 | 92 | 01Jan2000, 06:45 | 14.5 |
| W020 | 0.05 | 16 | 01Jan2000, 06:15 | 1.8 |
| W015 | 0.01 | 9 | 01Jan2000, 06:15 | 0.8 |
| J015 | 0.01 | 9 | 01Jan2000, 06:15 | 0.8 |
| J020 | 0.07 | 25 | 01Jan2000, 06:15 | 2.6 |
| Sink-5 | 0.07 | 25 | 01Jan2000, 06:15 | 2.6 |

TABLE D19

Alternative 2: Tapir Pond Routing Summary[d]

| Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Attenuated | Inflow Runoff Volume | Outflow Runoff Volume | Peak Storage Volume for Storm Event | Peak Water Surface Elevation | Emergency Spillway Elevation | Pond Invert Elevation | Peak Water Depth | Top of Pond Embankment Elevation | Freeboard to Emergency Spillway Elevation | Freeboard to top of Pond Embankment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ft | ft | ft | ft | ft | ft | ft |
| a | | a | a | | a | a | a | a | b | b | | b | c | c |
| 10 / 24 | 8.17 | 912 | 46 | 866 | 247.8 | 192.7 | 183.8 | 3822.1 | 3824 | 3815 | 7 | 3826.0 | 1.9 | 3.9 |
| 25 / 24 | 8.17 | 986 | 111.7 | 874.3 | 395.4 | 327.1 | 266.7 | 3824.2 | 3824 | 3815 | 9 | 3826.0 | -0.2 | 1.8 |
| 50 / 24 | 8.17 | 1190 | 705 | 485 | 523.8 | 455.0 | 300.2 | 3825.0 | 3824 | 3815 | 10 | 3826.0 | -1.0 | 1.0 |
| 100 / 24 | 8.17 | 1211 | 984 | 226.9 | 661.8 | 592.6 | 311.6 | 3825.3 | 3824 | 3815 | 10 | 3826.0 | -1.3 | 0.7 |

( a ) Refer to Appendix D for the HEC-HMS model output for the pond routing results.

( b ) See Appendix D for all Elevation - Storage Volume - Discharge Data Tables

( c ) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

( d ) This is a proposed pond with 3:1 side slopes and a maximum Design Storage Volume (top of embankment) of 338.5 ac-ft and maximum pond depth of 11-ft

## TABLE D20

### Alternative 3: Lily Pond Routing Summary[d]

| Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Attneuated | Inflow Runoff Volume | Outflow Runoff Volume | Peak Storage Volume for Storm Event | Peak Water Surface Elevation | Emergency Spillway Elevation | Pond Invert Elevation | Peak Water Depth | Top of Pond Embank ment Elevation | Freeboard to Emergency Spillway Elevation | Freeboard to top of Pond Embankment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ft | ft | ft | ft | ft | ft | ft |
| a | | a | a | | a | a | a | a | b | b | | b | c | c |
| 10 / 24 | 43.4 | 176 | 43 | 133 | 45.2 | 44.7 | 16 | 3824.8 | 3825 | 3820 | 5 | 3827.0 | 0.2 | 2.2 |
| 25 / 24 | 43.4 | 358 | 155 | 203 | 78.7 | 78.1 | 23.5 | 3825.8 | 3825 | 3820 | 6 | 3827.0 | -0.8 | 1.2 |
| 50 / 24 | 43.4 | 517 | 274 | 243 | 108.8 | 108.2 | 28 | 3826.3 | 3825 | 3820 | 6 | 3827.0 | -1.3 | 0.7 |
| 100 / 24 | 43.4 | 660 | 391 | 269 | 141.7 | 141 | 32.1 | 3826.7 | 3825 | 3820 | 7 | 3827.0 | -1.7 | 0.3 |

( a ) Refer to Appendix D for the HEC-HMS model output for the pond routing results.
( b ) See Appendix D for all Elevation - Storage Volume - Discharge Data Tables
( c ) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

## TABLE D21

### Alternative 4 -Option 1: Crazy Horse Pond Routing Summary

| Detention Pond Name | Existing or Proposed Pond | Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Attenuated | Inflow Runoff Volume | Outflow Runoff Volume | Maximum Design Storage Volume (top of embankment) | Peak Storage Volume for Storm Event | Peak Water Surface Elevation | Emergency Spillway Elevation | Pond Invert Elevation | Maximum Pond Depth | Peak Water Depth | Top of Pond Embankment Elevation | Freeboard to Emergency Spillway Elevation | Freeboard to top of Pond Embankment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ac-ft | ft | ft | ft | ft | ft | ft | ft | ft |
| | | a | | a | a | | a | a | b | a | a | b | b | b | | b | c | c |
| Crazy Horse Pond | Proposed 4:1 | 10 / 24 | 0.3390 | 53 | 10 | 43.0 | 7.7 | 7.7 | 22.5 | 3.2 | 3817.7 | 3821 | 3816 | 6 | 1.7 | 3822.0 | 3.3 | 4.3 |
| Crazy Horse Pond | Proposed 4:1 | 25 / 24 | 0.3390 | 104 | 18 | 86.0 | 13.1 | 13.1 | 22.5 | 5.9 | 3818.7 | 3821 | 3816 | 6 | 2.7 | 3822.0 | 2.3 | 3.3 |
| Crazy Horse Pond | Proposed 4:1 | 50 / 24 | 0.3390 | 146 | 23 | 123.0 | 17.8 | 17.8 | 22.5 | 8.3 | 3819.5 | 3821 | 3816 | 6 | 3.5 | 3822.0 | 1.5 | 2.5 |
| Crazy Horse Pond | Proposed 4:1 | 100 / 24 | 0.3390 | 183 | 27 | 156.0 | 22.9 | 22.9 | 22.5 | 10.7 | 3820.1 | 3821 | 3816 | 6 | 4.1 | 3822.0 | 0.9 | 1.9 |

( a ) Refer to Appendix D for the HEC-HMS model output for the pond routing results.

( b ) See Appendix D for all Elevation - Storage Volume - Discharge Data Tables

( c ) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

| TABLE D22<br>Alternative 4 - Option 2: Crazy Horse Pond Routing Summary | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Attenuated | Inflow Runoff Volume | Outflow Runoff Volume | Peak Storage Volume for Storm Event | Peak Water Surface Elevation | Emergency Spillway Elevation | Pond Invert Elevation | Peak Water Depth | Top of Pond Embankment Elevation | Freeboard to Emergency Spillway Elevation | Freeboard to top of Pond Embankment |
| yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ft | ft | ft | ft | ft | ft | ft |
| a | | a | a | | a | a | a | a | b | b | | b | c | c |
| 10 / 24 | 0.4120 | 57 | 10 | 47.0 | 10.5 | 10.4 | 3.5 | 3817.8 | 3821 | 3816 | 1.8 | 3822.0 | 3.2 | 4.2 |
| 25 / 24 | 0.4120 | 112 | 20 | 92.0 | 16.8 | 16.7 | 6.6 | 3818.9 | 3821 | 3816 | 2.9 | 3822.0 | 2.1 | 3.1 |
| 50 / 24 | 0.4120 | 180 | 26 | 154.0 | 22.6 | 22.5 | 9.6 | 3819.9 | 3821 | 3816 | 3.9 | 3822.0 | 1.1 | 2.1 |
| 100 / 24 | 0.4120 | 239 | 28 | 210.5 | 28.7 | 28.7 | 12.6 | 3820.4 | 3821 | 3816 | 4.4 | 3822.0 | 0.6 | 1.6 |

( a ) Refer to Appendix D for the HEC-HMS model output for the pond routing results.

( b ) See Appendix D for all Elevation - Storage Volume - Discharge Data Tables

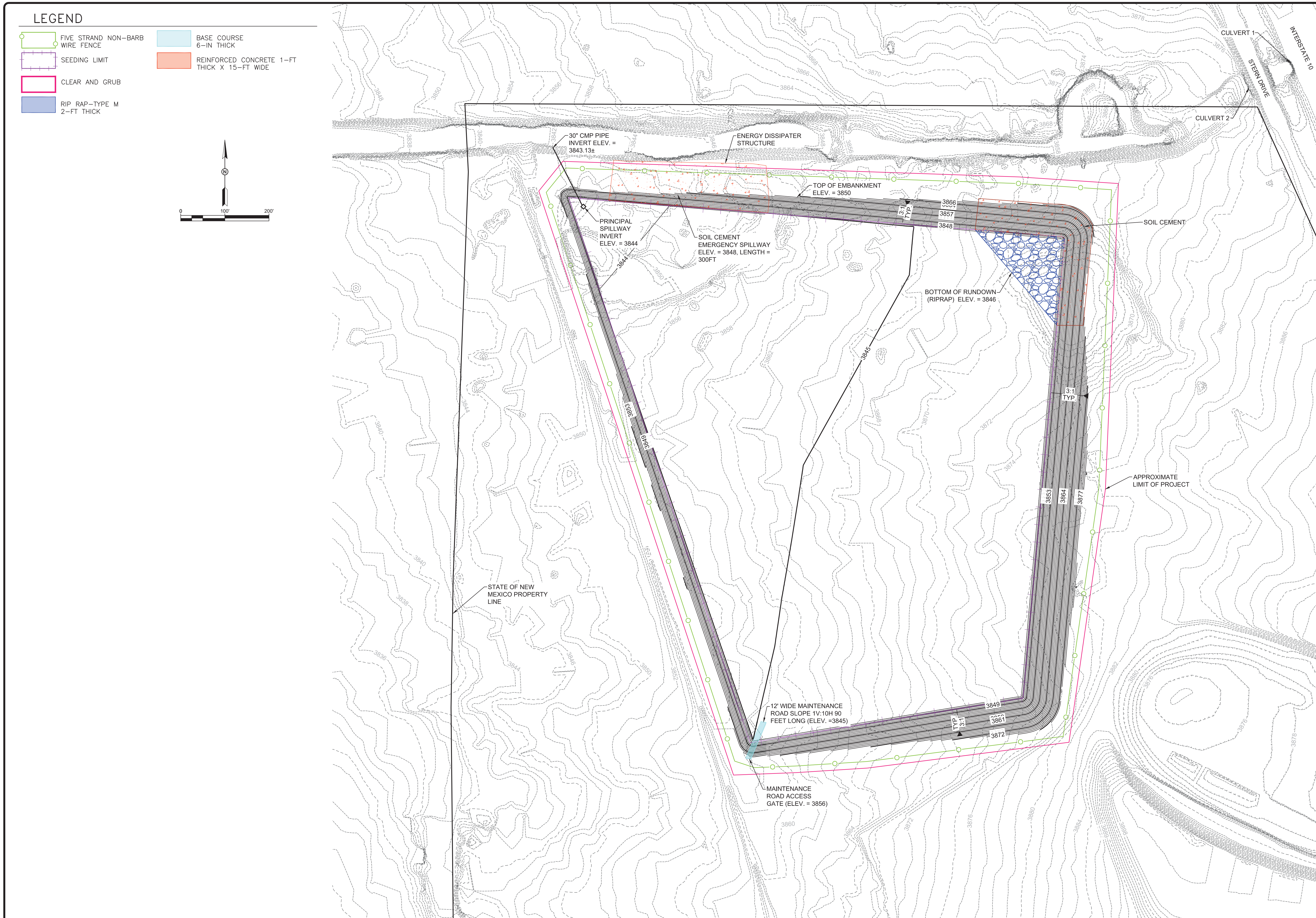
( c ) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

| TABLE D23 Alternative 4 -Option 1: Estancia Pond Routing Summary[d] | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Storm Return Period / Duration | Drainage Area | Peak Inflow | Peak Outflow | Peak Attneuated | Inflow Runoff Volume | Outflow Runoff Volume | Peak Storage Volume for Storm Event | Peak Water Surface Elevation | Emergency Spillway Elevation | Pond Invert Elevation | Peak Water Depth | Top of Pond Embank ment Elevation | Freeboard to Emergency Spillway Elevation | Freeboard to top of Pond Embankment |
| yr / hr | sq mi | cfs | cfs | cfs | ac-ft | ac-ft | ac-ft | ft | ft | ft | ft | ft | ft | ft |
| a | | a | a | | a | a | a | a | b | b | | b | c | c |
| 10 / 24 | 0.0735 | 4 | 3 | 1 | 2.7 | 2.7 | 0.1 | 3827.8 | 3832 | 3827 | 0.8 | 3833.0 | 4.2 | 5.2 |
| 25 / 24 | 0.0735 | 11 | 7 | 4 | 3.8 | 3.8 | 0.3 | 3828.4 | 3832 | 3827 | 1.4 | 3833.0 | 3.6 | 4.6 |
| 50 / 24 | 0.0735 | 35 | 14 | 21 | 4.8 | 4.8 | 0.6 | 3829.2 | 3832 | 3827 | 2.2 | 3833.0 | 2.8 | 3.8 |
| 100 / 24 | 0.0735 | 55 | 18 | 37 | 5.9 | 5.9 | 0.9 | 3829.7 | 3832 | 3827 | 3 | 3833.0 | 2.3 | 3.3 |

( a ) Refer to Appendix D for the HEC-HMS model output for the pond routing results.

( b ) See Appendix D for all Elevation - Storage Volume - Discharge Data Tables

( c ) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available




Name
Location

| NO | DATE | BY |
|---|---|---|
| 5 | #### | #### |
| 4 | #### | #### |
| 3 | #### | #### |
| 2 | #### | #### |
| 1 | #### | #### |

REVISION DESCRIPTION

VADO DRAINAGE MASTER PLAN

FIGURE D1 - VADO POND - NOT RECOMMENDED

SMITH ENGINEERING

JOB NO: 817103-03

DATE: August 2019

SHEET NO:

## Table D24 Vado Pond - 3 ft tall: 48" & 66" CMP Double Pipe Ported Riser, 30-in. dia. outfall pipe, 6-in. dia. PVC rev. incline ports (Not Recommended)

Elevation - Discharge Data and Computations

Hydraulic Calculations to Develop the Total Principal Spillway Elevation-Discharge

grey box means must input data

| | | A | A | A | A | A | A | A | A | A | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Relative Elevations (NAVD 1988) | Depth | Contour Area | Incremental Volume | Incremental Volume | Cumulative Volume | 1st Row - Drain Ports Discharge (assume (f)) | 2nd Row - Reverse Incline Ports Discharge | 3rd Row - Reverse Incline Ports Discharge | 4th Row - Reverse Incline Ports Discharge | 5th Row - Reverse Incline Ports Discharge | Rectangular Reverse Incline Weir Discharge | Top of Inner CMP Circular Vertical Pipe Radius (ft) Weir Discharge | Principal Spillway Outfall Pipe Discharge | Total Principal Spillway Discharge | Emergency Spillway Discharge | Total Discharge Rating Curve | COMMENTS |
| Princ.spill.orifice dia. or vert. height (in.) | | | | | | 6 | 6 | 6 | 6 | 6 | 0 | 2 | 30 | | | | |
| Number of orifices or weirs | | | | | | 4 | 7 | 6 | 7 | 6 | 0 | 1 | 1 | | | | |
| Assumed flow reduction factor (f) | | | | | | 0 | 0.85 | 0.85 | 0.85 | 0.85 | 0 | 0.85 | - | | | | |
| ft | | sq ft | cu ft | ac-ft | ac-ft | cfs | cfs | cfs | cfs | cfs | cfs | cfs | cfs | cfs | | cfs | |
| | | | | | | a | a | a | a | a | a | b | c | d | | | |
| 3844 | 0.0 | 33,023 | 0 | 0.0000 | 0.0000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | Pond Bottom 1st row - drain ports |
| 3845.00 | 1.0 | 385,322 | 0 | 0.0000 | 0.0000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.4 | 0.1 | | 0.1 | |
| 3845.27 | 1.3 | 500,731 | 119,617 | 2.7460 | 2.7460 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.3 | 0.2 | | 0.2 | Centroid 2nd row - reverse incline ports |
| 3846.00 | 2.0 | 812,764 | 479,426 | 11.0061 | 13.7521 | 0.0 | 4.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.0 | 4.7 | | 4.7 | |
| 3846.33 | 2.3 | 820,328 | 269,460 | 6.1860 | 19.9381 | 0.0 | 5.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 11.6 | 5.7 | | 5.7 | Centroid 3rd row - reverse incline ports |
| 3847.00 | 3.00 | 835,684 | 554,764 | 12.7356 | 32.6737 | 0.0 | 7.3 | 3.9 | 0.0 | 0.0 | 0.0 | 0.0 | 20.4 | 11.2 | | 11.2 | Top of vertical pipe elevation |
| 3848.00 | 4.0 | 858,827 | 847,255 | 19.4503 | 52.1240 | 0.0 | 9.1 | 6.1 | 0.0 | 0.0 | 0.0 | 27.8 | 25.7 | 25.7 | 0 | 25.7 | Emergency Spillway Elevation |
| 3848.20 | 4.2 | 863,500 | 172,233 | 3.9539 | 56.0779 | 0.0 | 9.5 | 6.5 | 0.0 | 0.0 | 0.0 | 36.5 | 26.0 | 26.0 | 80 | 26.0 | |
| 3848.40 | 4.4 | 868,173 | 173,167 | 3.9754 | 60.0533 | 0.0 | 9.8 | 6.8 | 0.0 | 0.0 | 0.0 | 46.0 | 45.0 | 45.0 | 228 | 45.0 | |
| 3848.60 | 4.6 | 872,846 | 174,102 | 3.9968 | 64.0501 | 0.0 | 10.1 | 7.1 | 0.0 | 0.0 | 0.0 | 56.2 | 51.2 | 51.2 | 418 | 469.5 | |
| 3848.80 | 4.8 | 877,519 | 175,036 | 4.0183 | 68.0684 | 0.0 | 10.4 | 7.5 | 0.0 | 0.0 | 0.0 | 67.1 | 20.6 | 20.6 | 644 | 664.6 | |
| 3849.00 | 5.0 | 882,192 | 175,971 | 4.0397 | 72.1082 | 0.0 | 10.7 | 7.7 | 0.0 | 0.0 | 0.0 | 78.6 | 15.4 | 15.4 | 900 | 915.4 | |
| 3849.20 | 5.2 | 882,193 | 176,438 | 4.0505 | 76.1586 | 0.0 | 11.0 | 8.0 | 0.0 | 0.0 | 0.0 | 90.6 | 10.3 | 10.3 | 1183 | 1193.4 | |
| 3849.40 | 5.4 | 882,194 | 176,439 | 4.0505 | 80.2091 | 0.0 | 11.2 | 8.3 | 0.0 | 0.0 | 0.0 | 103.3 | 5.1 | 5.1 | 1491 | 1496.0 | |
| 3849.60 | 5.6 | 882,195 | 176,439 | 4.0505 | 84.2596 | 0.0 | 11.5 | 8.6 | 0.0 | 0.0 | 0.0 | 116.4 | 0.0 | 0.0 | 1821 | 1821.5 | |
| 3849.80 | 5.8 | 882,196 | 176,439 | 4.0505 | 88.3101 | 0.0 | 11.8 | 8.8 | 0.0 | 0.0 | 0.0 | 130.1 | 0.0 | 0.0 | 2173 | 2173.5 | |
| 3850.00 | 6.0 | 882,197 | 176,439 | 4.0505 | 92.3606 | 0.0 | 12.0 | 9.1 | 0.0 | 0.0 | 0.0 | 144.3 | 0.0 | 0.0 | 2546 | 2545.6 | |

TABLE

Proposed Detention Pond Diversion Structure

Elevation - Volume - Discharge Data and Computations

VALUES FOR HEC-HMS

VALUES ONLY TO PAST INTO HEC-HMS

| ELEV | CUM VOL | DISCHARGE |
|---|---|---|
| ft | ac-ft | cfs |
| 3845.00 | 0.0 | 0.1 |
| 3845.27 | 2.7 | 0.2 |
| 3846.00 | 13.8 | 4.7 |
| 3846.33 | 19.9 | 5.7 |
| 3847.00 | 32.7 | 11.2 |
| 3848.00 | 52.1 | 25.7 |
| 3848.20 | 56.1 | 26.0 |
| 3848.40 | 60.1 | 45.0 |
| 3848.60 | 64.1 | 469.5 |
| 3848.80 | 68.1 | 664.6 |
| 3849.00 | 72.1 | 915.4 |
| 3849.20 | 76.2 | 1193.4 |
| 3849.40 | 80.2 | 1496.0 |
| 3849.60 | 84.3 | 1821.5 |
| 3849.80 | 88.3 | 2173.5 |
| 3850.00 | 92.4 | 2545.6 |

( a ) $Q = Ca\sqrt{2gh}$ C = discharge coefficient, a = area (sq ft), h = head (ft)

(f) Assume drain ports are plugged much of the time so zero discharge

Orifice equation and coefficient were obtained from Equation 4-10 and Table 4-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1976.

C = 0.590 g=32.2 ft/sec^2, a=area (sq ft) h=head (ft)

$a = \pi D^2 / 4$ (full pipe area formula)

Principal Spill. Pipe radius r in feet = 1.25

( b ) Top of vertical wall will act as a weir, computed with following weir equation

$Q = C(2*pi*R)*H^{3/2}$ C = circular crest coefficient, pi = 3.14159, R = radius (ft) , H = head (ft)

WEIR NOTE - The top of the inner vertical pipe will only function as a weir for a few moments, as the head increases, then the principal spillway pipe capacity will be exceeded, the vertical pipe will submerge and the weir will be submerged, and will NOT function as a weir.

Weir equation and "C" coefficients were obtained from Equation 28 and Figure 9-57 from "Design of Small Dams" Third Edition, by Bureau of Reclamation, 1987.

C = 2.6

( c ) Assume RCP, the discharge rating curve was computed with Culvert Master. Headwater & tailwater assumptions and Culvert Master output are included in the Appendices.

( d ) The combined discharge of the reverse incline ports and the top of vertical pipe (acts as a weir) will govern the discharge until the outfall pipe capacity is exceeded and/or when the pond water surface exceeds the top of the vertical pipe. At that point the ports and weir (top of vertical pipe) are submerged and will not function, and the outfall pipe is submerged and will govern the discharge. When the sum of the "A" columns is greater than the outfall pipe capacity, then the outfall pipe capacity governs the discharge.

g - Emergency Spillway C = 3.0 L = 300

**Principal Spillway** - Interpolate discharges at increments from emerg. Spillway to top of pond embankment to attain a better principal spillway rating curve

| ELEV | | Discharge | Delta Discharge | Discharge |
|---|---|---|---|---|
| 3848.00 | | 25.7 | | 25.7 |
| 3848.20 | | | -5.1 | 20.6 |
| 3848.40 | | | -5.1 | 15.4 |
| 3848.60 | | | -5.1 | 10.3 |
| 3848.80 | | | -5.1 | 5.1 |
| 3849.00 | | | -5.1 | 0.0 |

**Emergency Spillway** - Interpolate areas at increments to top of pond embankment to attain a better emergency spillway rating curve

| ELEV | | AREA | Delta Area | AREAS |
|---|---|---|---|---|
| 3848.40 | | 872,846 | | 872,846 |
| 3848.80 | | | -174,569 | 698,277 |
| 3849.00 | | | -174,569 | 523,708 |
| 3850.00 | | | -174,569 | 349,138 |
| 0.00 | | | -174,569 | 174,569 |
| 0.00 | | 0 | -174,569 | 0 |

# APPENDIX E

## Existing and Proposed HEC-RAS 2D Hydraulic Models (V5.0.7)

(Digital Copy Included)

SMITH ENGINEERING

# APPENDIX F

Existing Conditions HEC-RAS 1D Hydraulic Models (V5.0.7) Output

Proposed Conditions HEC-RAS 1D Hydraulic Models (V5.0.7) Output for Concrete Lined Channel

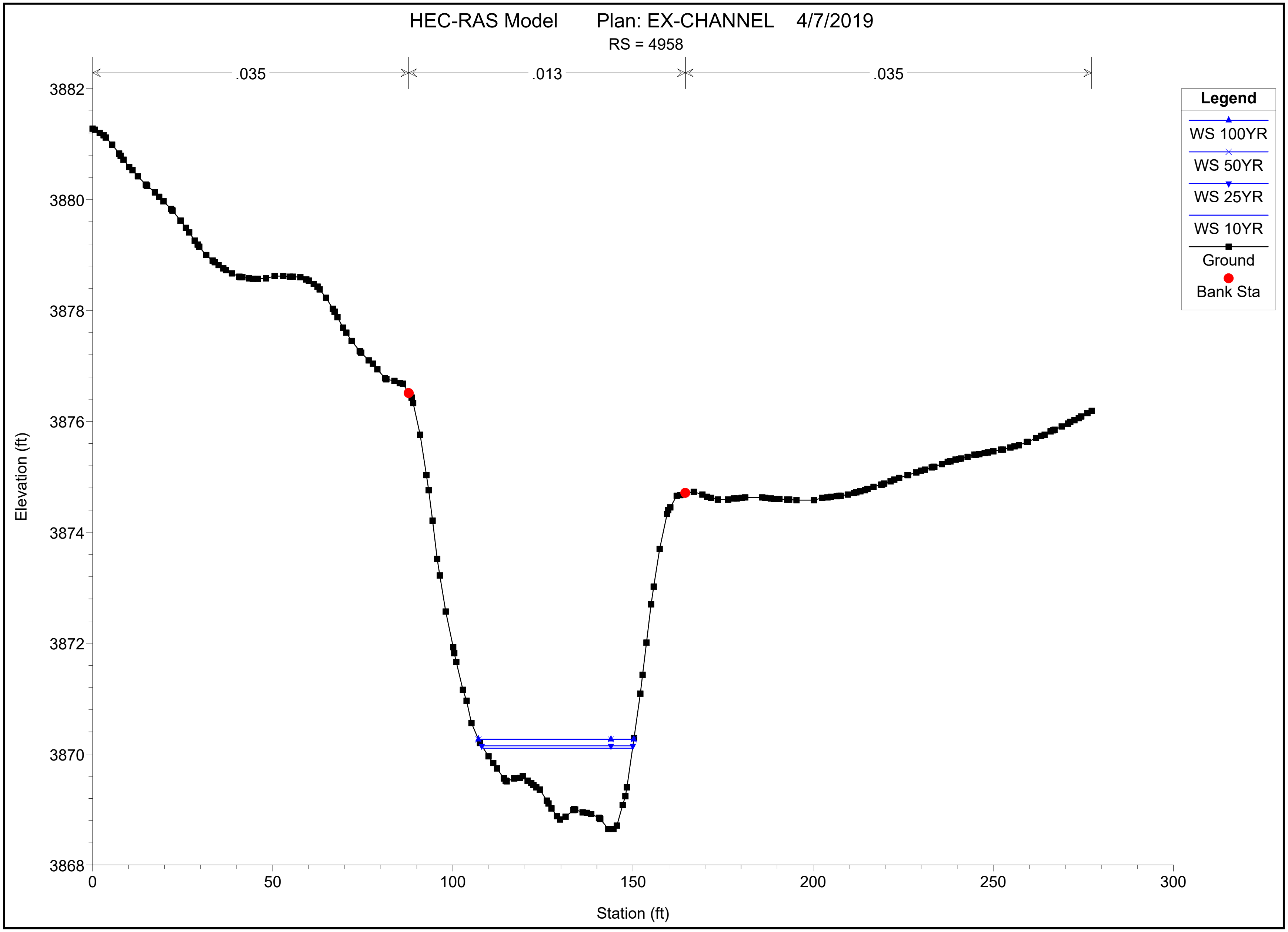
Proposed Conditions HEC-RAS 1D Hydraulic Models (V5.0.7) Output for Shotcrete Lined Channel

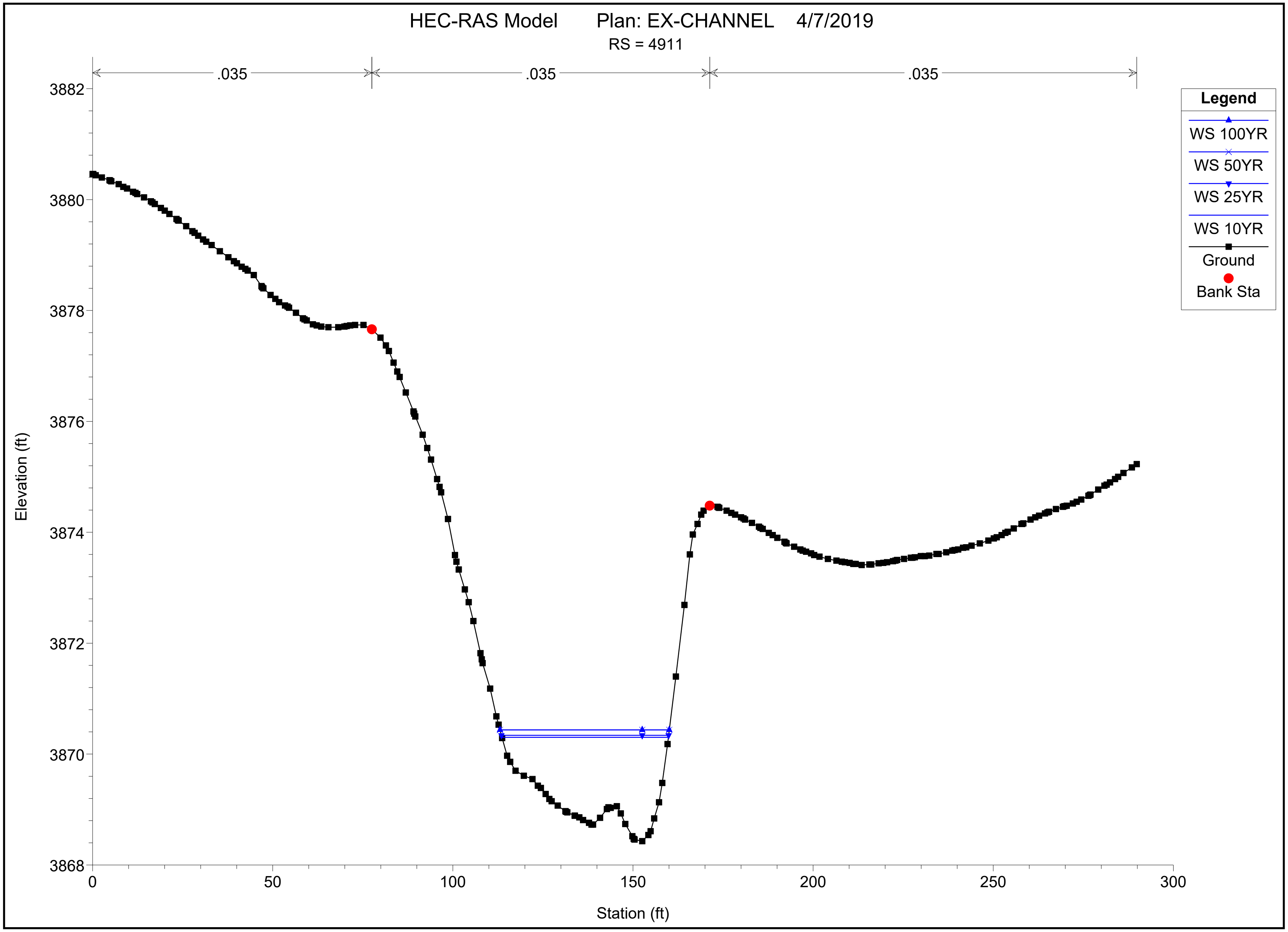
(Digital Copy Included)

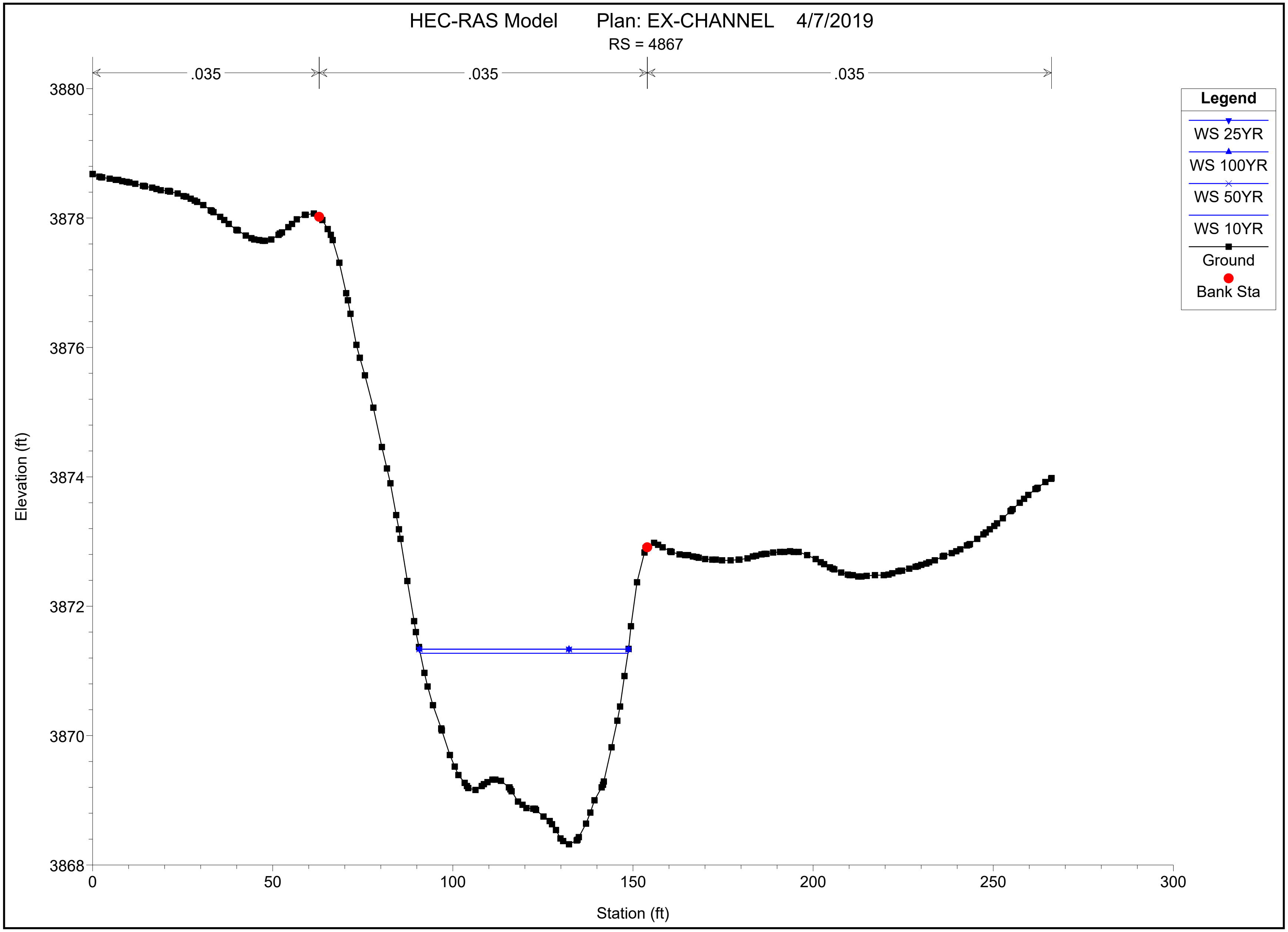
# Existing Conditions HEC-RAS 1D Hydraulic Models (V5.0.7) Output

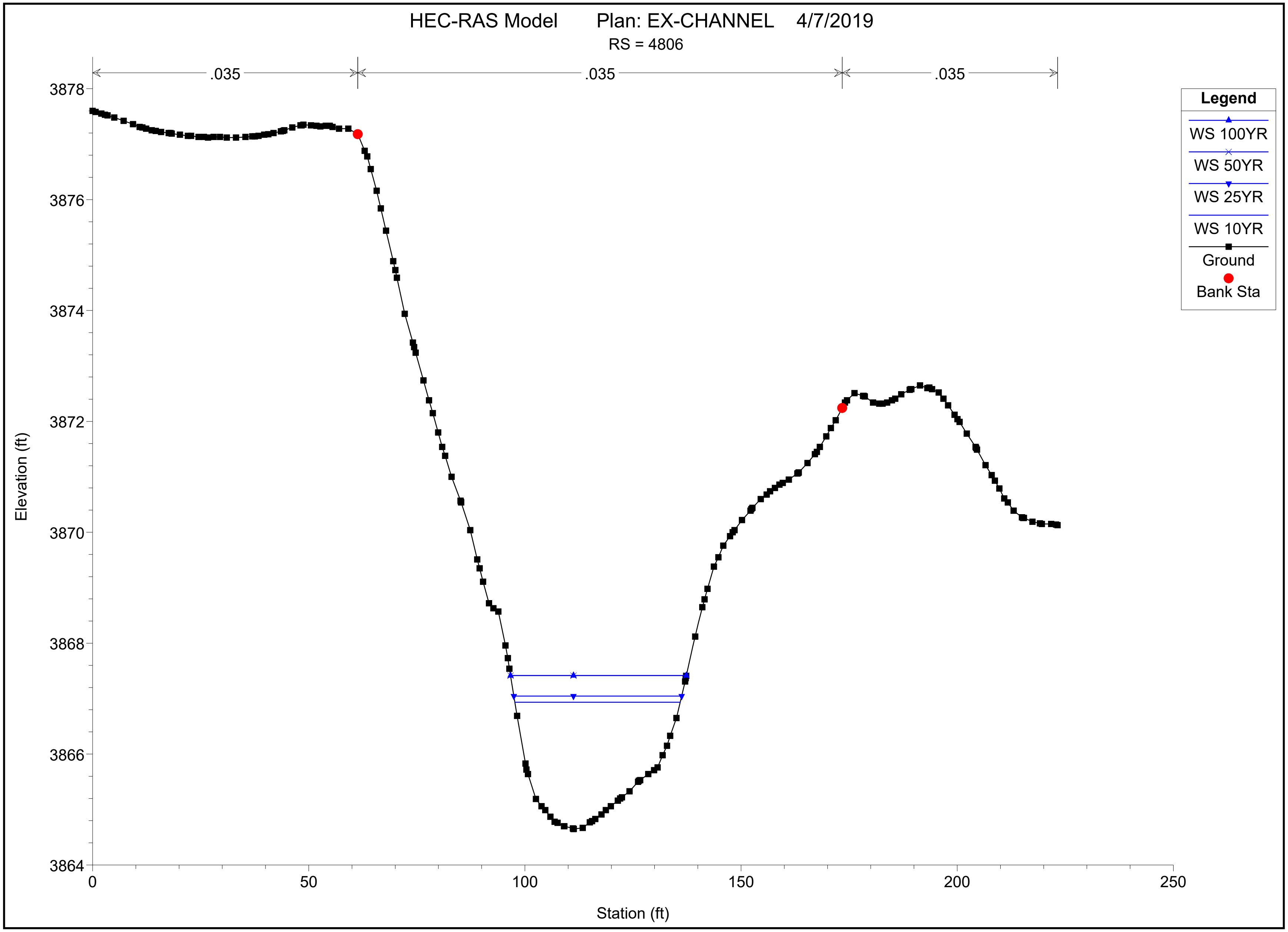
**EXISTING CONDTIONS HEC-RAS OUTPUT**

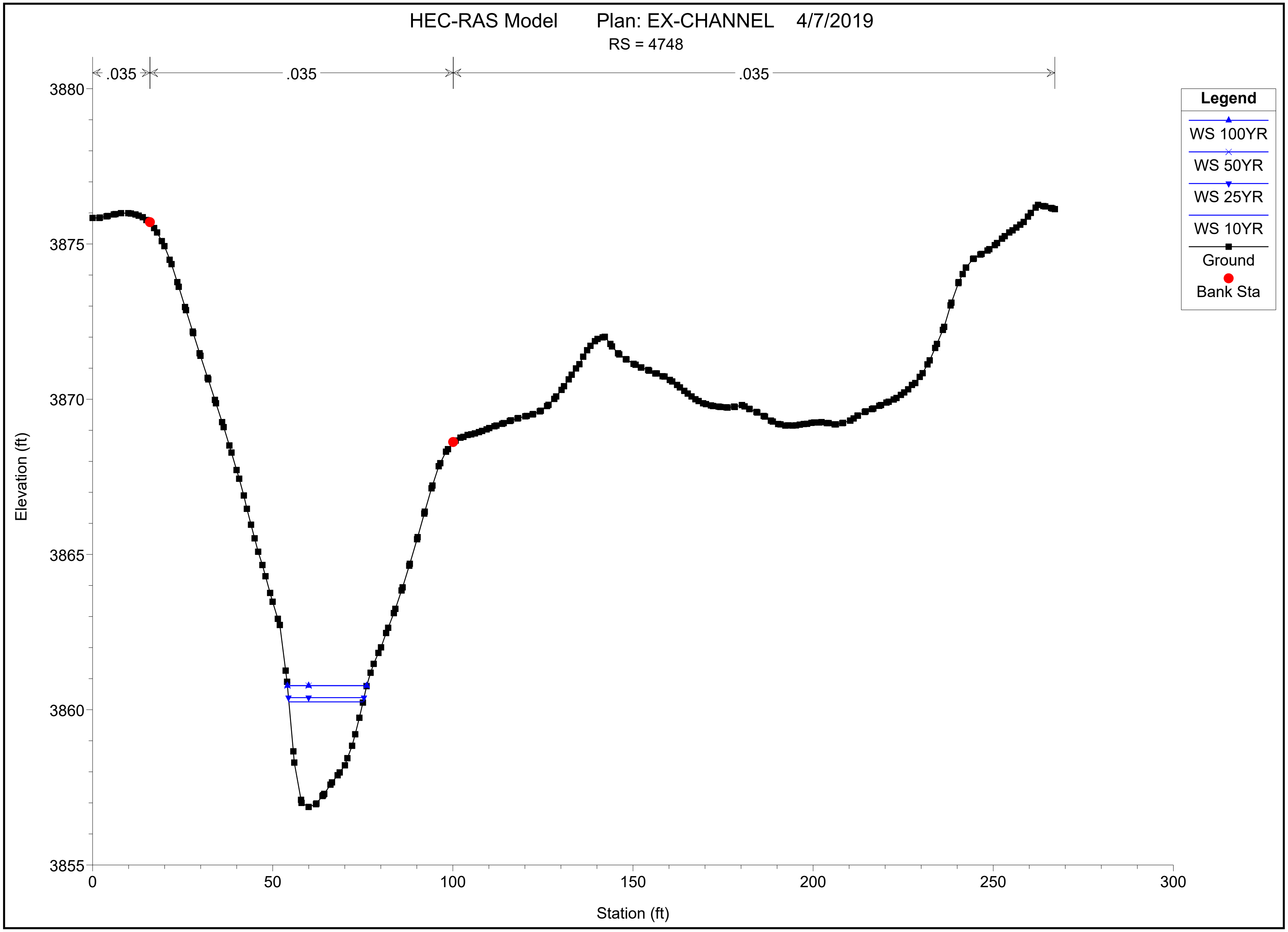
| River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl | Mann Wtd Total | Power Total | Shear Chan | Invert Slope |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | | | (lb/ft s) | (lb/sq ft) | |
| 4958 | 10YR | 908 | 3868.65 | 3870.11 | 3871.65 | 3879.72 | 0.056637 | 24.88 | 36.5 | 41.41 | 4.67 | 0.013 | 76.94 | 3.09 | 0.0048 |
| 4958 | 100YR | 1175 | 3868.65 | 3870.27 | 3872.07 | 3881.71 | 0.056678 | 27.13 | 43.31 | 43.14 | 4.77 | 0.013 | 95.57 | 3.52 | 0.0048 |
| 4911 | 10YR | 908 | 3868.43 | 3870.3 | 3871.41 | 3874.49 | 0.119216 | 16.42 | 55.29 | 46.19 | 2.65 | 0.035 | 144.91 | 8.82 | 0.0026 |
| 4911 | 100YR | 1175 | 3868.43 | 3870.44 | 3871.83 | 3876.1 | 0.142915 | 19.08 | 61.57 | 46.99 | 2.94 | 0.035 | 220.74 | 11.57 | 0.0026 |
| 4867 | 10YR | 908 | 3868.32 | 3871.27 | 3871.27 | 3872.27 | 0.014636 | 8.01 | 113.35 | 57.62 | 1.01 | 0.035 | 14.26 | 1.78 | 0.0594 |
| 4867 | 100YR | 1175 | 3868.32 | 3871.34 | 3871.66 | 3872.9 | 0.022264 | 10.04 | 117.01 | 58.03 | 1.25 | 0.035 | 27.86 | 2.77 | 0.0594 |
| 4806 | 10YR | 908 | 3864.65 | 3866.94 | 3867.96 | 3870.36 | 0.066388 | 14.84 | 61.21 | 38.23 | 2.07 | 0.035 | 97.11 | 6.55 | 0.1348 |
| 4806 | 100YR | 1175 | 3864.65 | 3867.42 | 3868.45 | 3870.76 | 0.049349 | 14.66 | 80.16 | 40.66 | 1.84 | 0.035 | 87.51 | 5.97 | 0.1348 |
| 4748 | 10YR | 908 | 3856.87 | 3860.25 | 3862.02 | 3866.01 | 0.076408 | 19.25 | 47.16 | 20.59 | 2.24 | 0.035 | 192.97 | 10.02 | 0.0026 |
| 4748 | 100YR | 1175 | 3856.87 | 3860.78 | 3862.73 | 3867.09 | 0.069976 | 20.16 | 58.29 | 22 | 2.18 | 0.035 | 211.75 | 10.5 | 0.0026 |
| 4675 | 10YR | 908 | 3856.68 | 3861.39 | 3860.75 | 3862.24 | 0.006986 | 7.4 | 122.71 | 39.12 | 0.74 | 0.035 | 9.72 | 1.31 | 0.0047 |
| 4675 | 100YR | 1175 | 3856.68 | 3862.53 | 3861.29 | 3862.7 | 0.001339 | 3.65 | 378.28 | 137.21 | 0.33 | 0.034 | 0.7 | 0.3 | 0.0047 |
| 4614 | 10YR | 908 | 3856.39 | 3860.22 | 3860.22 | 3861.6 | 0.01394 | 9.43 | 96.34 | 35.33 | 1.01 | 0.035 | 21.15 | 2.24 | -0.0027 |
| 4614 | 100YR | 1175 | 3856.39 | 3860.79 | 3860.79 | 3862.36 | 0.013107 | 10.08 | 116.57 | 36.55 | 1 | 0.035 | 24.63 | 2.44 | -0.0027 |
| 4536 | 10YR | 908 | 3856.6 | 3860.56 | 3859.49 | 3860.75 | 0.001936 | 3.94 | 271.33 | 118.78 | 0.39 | 0.034 | 0.92 | 0.37 | 0.0046 |
| 4536 | 100YR | 1175 | 3856.6 | 3861.13 | 3859.76 | 3861.33 | 0.001641 | 3.97 | 340.57 | 122.93 | 0.37 | 0.034 | 0.97 | 0.36 | 0.0046 |
| 4230 | 10YR | 908 | 3855.19 | 3858.86 | 3858.3 | 3859.66 | 0.007278 | 7.18 | 126.54 | 43.87 | 0.74 | 0.035 | 9.09 | 1.27 | 0.0047 |
| 4230 | 100YR | 1175 | 3855.19 | 3859.23 | 3858.77 | 3860.28 | 0.008392 | 8.23 | 142.84 | 44.61 | 0.81 | 0.035 | 13.26 | 1.61 | 0.0047 |
| 4085 | 10YR | 908 | 3854.51 | 3857.22 | 3857.22 | 3858.2 | 0.014769 | 7.93 | 114.54 | 59.58 | 1.01 | 0.035 | 13.92 | 1.76 | 0.0447 |
| 4085 | 100YR | 1175 | 3854.51 | 3857.61 | 3857.61 | 3858.74 | 0.014114 | 8.53 | 137.77 | 61.98 | 1.01 | 0.035 | 16.52 | 1.94 | 0.0447 |
| 3880 | 10YR | 908 | 3845.33 | 3847.17 | 3848.36 | 3851.46 | 0.103282 | 16.63 | 54.61 | 40.13 | 2.51 | 0.035 | 144.19 | 8.67 | 0.0076 |
| 3880 | 100YR | 1175 | 3845.33 | 3847.46 | 3848.78 | 3852.27 | 0.099105 | 17.61 | 66.74 | 43.59 | 2.51 | 0.035 | 164.69 | 9.35 | 0.0076 |
| 3745 | 10YR | 908 | 3844.31 | 3847.53 | 3847.34 | 3848.7 | 0.011275 | 8.66 | 104.82 | 37.29 | 0.91 | 0.035 | 16.24 | 1.88 | 0.0105 |
| 3745 | 100YR | 1175 | 3844.31 | 3847.97 | 3847.86 | 3849.42 | 0.012066 | 9.66 | 121.57 | 38.37 | 0.96 | 0.035 | 21.72 | 2.25 | 0.0105 |
| 3448 | 10YR | 908 | 3841.18 | 3843.83 | 3843.82 | 3844.96 | 0.014054 | 8.52 | 106.53 | 47.35 | 1 | 0.035 | 16.48 | 1.93 | 0.0117 |
| 3448 | 100YR | 1175 | 3841.18 | 3844.27 | 3844.27 | 3845.59 | 0.013544 | 9.21 | 127.65 | 48.98 | 1.01 | 0.035 | 19.79 | 2.15 | 0.0117 |
| 3202 | 10YR | 908 | 3838.29 | 3840.86 | 3840.72 | 3841.77 | 0.011501 | 7.65 | 118.74 | 53.65 | 0.91 | 0.035 | 11.95 | 1.56 | 0.0122 |
| 3202 | 100YR | 1175 | 3838.29 | 3841.26 | 3841.11 | 3842.35 | 0.011493 | 8.39 | 140.08 | 54.85 | 0.93 | 0.035 | 15.06 | 1.8 | 0.0122 |
| 2936 | 10YR | 908 | 3835.05 | 3837.53 | 3837.48 | 3838.47 | 0.013477 | 7.78 | 116.65 | 57.97 | 0.97 | 0.035 | 13 | 1.67 | 0.0093 |
| 2936 | 100YR | 1175 | 3835.05 | 3837.88 | 3837.86 | 3839.01 | 0.013756 | 8.55 | 137.45 | 60.18 | 1 | 0.035 | 16.51 | 1.93 | 0.0093 |
| 2425 | 10YR | 908 | 3830.3 | 3832.97 | 3832.52 | 3833.5 | 0.007014 | 5.82 | 156.15 | 74.11 | 0.71 | 0.035 | 5.33 | 0.92 | 0.007 |
| 2425 | 100YR | 1175 | 3830.3 | 3833.35 | 3832.85 | 3833.98 | 0.007007 | 6.37 | 184.39 | 76.11 | 0.72 | 0.035 | 6.69 | 1.05 | 0.007 |
| 1913 | 10YR | 908 | 3826.74 | 3829.44 | 3828.99 | 3829.94 | 0.006877 | 5.66 | 160.35 | 77.82 | 0.7 | 0.035 | 4.96 | 0.88 | 0.0048 |
| 1913 | 100YR | 1175 | 3826.74 | 3829.79 | 3829.3 | 3830.39 | 0.007009 | 6.26 | 187.59 | 79.24 | 0.72 | 0.035 | 6.41 | 1.02 | 0.0048 |
| 1401 | 10YR | 908 | 3824.29 | 3827.04 | 3826.25 | 3827.33 | 0.00376 | 4.31 | 210.84 | 98.45 | 0.52 | 0.035 | 2.15 | 0.5 | 0.0059 |
| 1401 | 100YR | 1175 | 3824.29 | 3827.43 | 3826.53 | 3827.78 | 0.003694 | 4.71 | 249.57 | 100.46 | 0.53 | 0.035 | 2.68 | 0.57 | 0.0059 |
| 1000 | 10YR | 908 | 3821.93 | 3824.87 | 3824.38 | 3825.34 | 0.006779 | 5.53 | 164.31 | 82.13 | 0.69 | 0.035 | 4.65 | 0.84 | |
| 1000 | 100YR | 1175 | 3821.93 | 3825.23 | 3824.71 | 3825.8 | 0.006781 | 6.03 | 195.01 | 85.57 | 0.7 | 0.035 | 5.77 | 0.96 | |

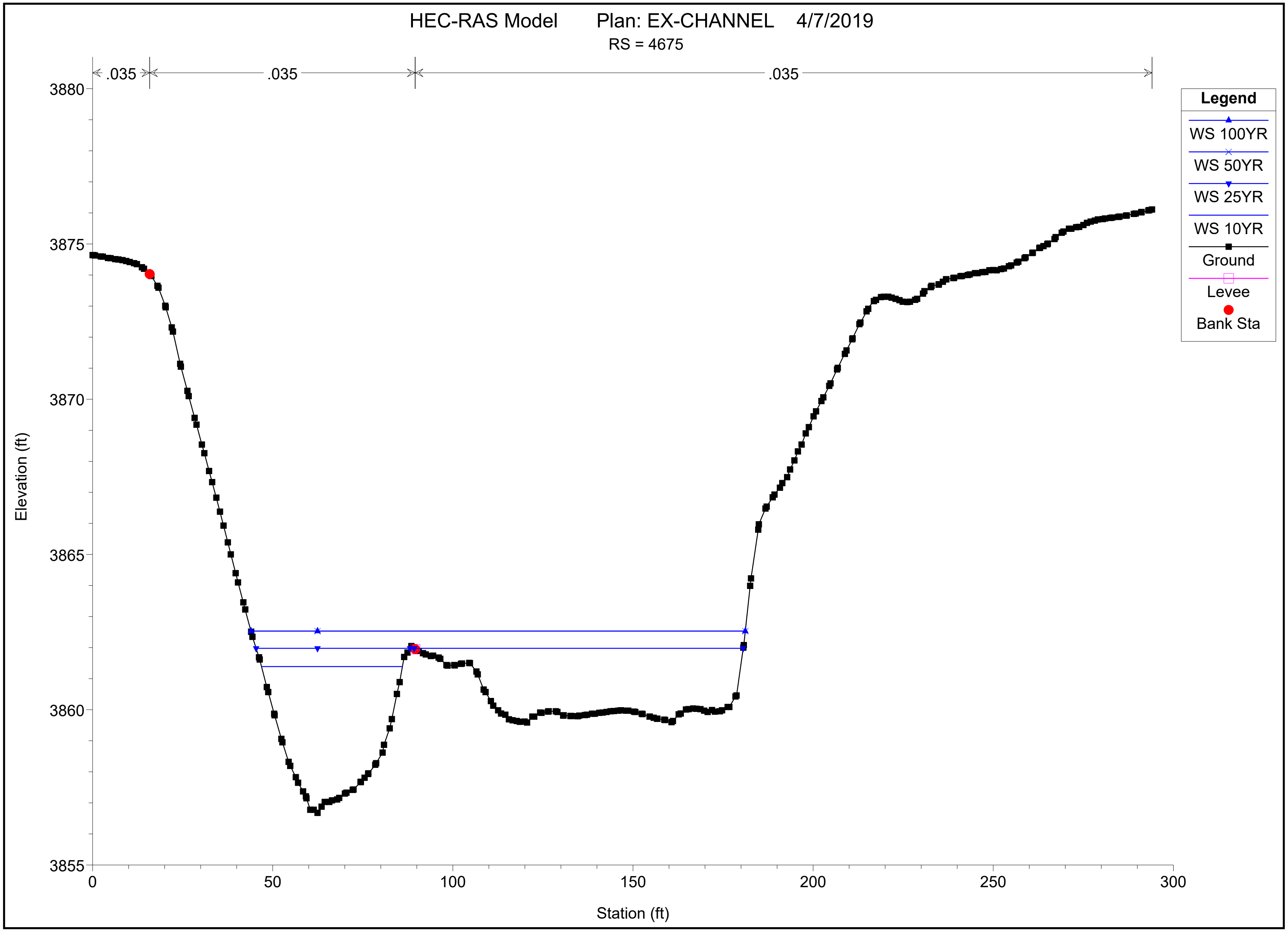

HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 4958
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3882
3880
3878
3876
3874
3872
3870
3868
0
50
100
150
200
250
300
Station (ft)


HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 4911
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3882
3880
3878
3876
3874
3872
3870
3868
0
50
100
150
200
250
300
Station (ft)

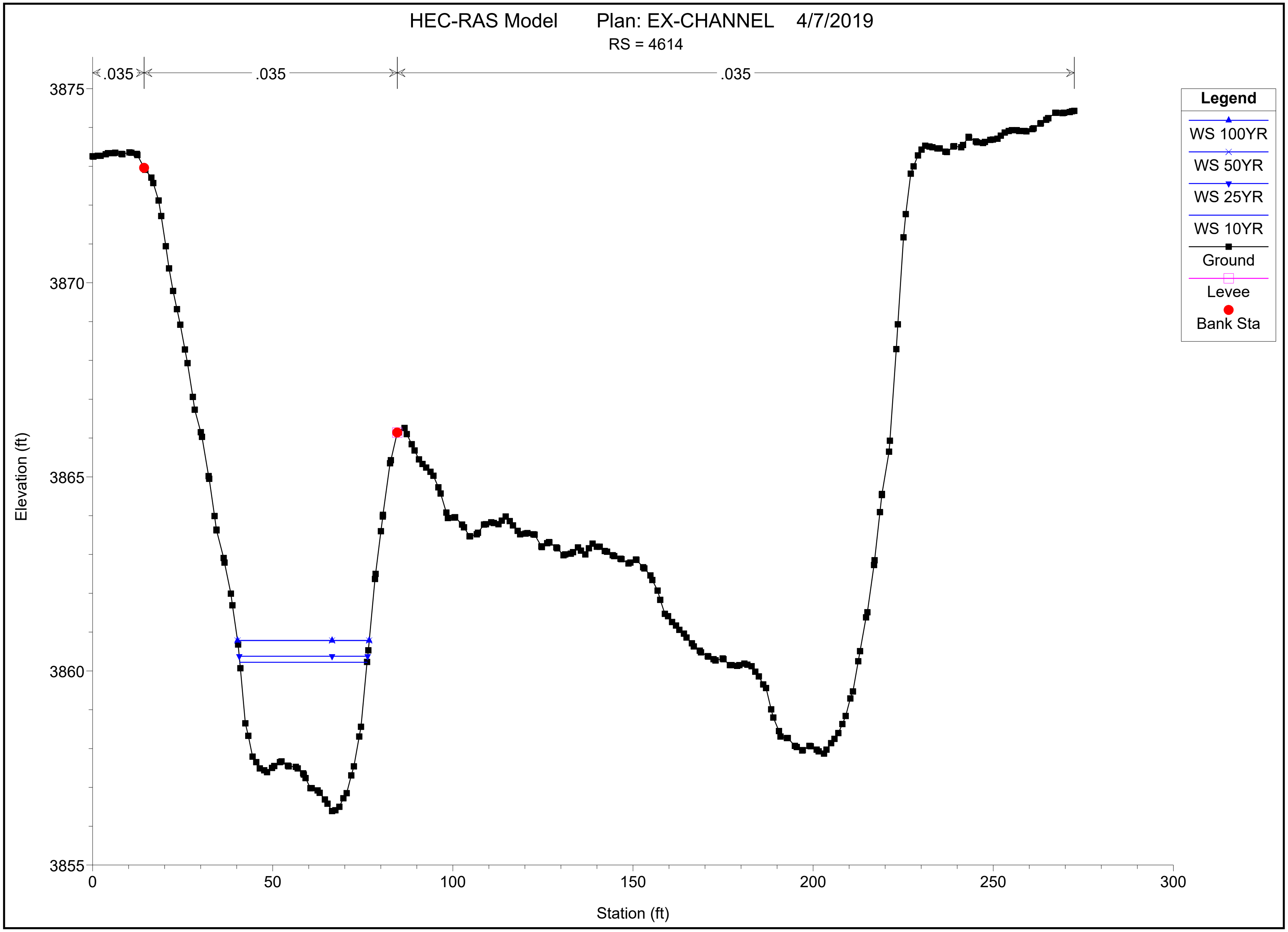

HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 4867
.035
.035
.035
Legend
WS 25YR
WS 100YR
WS 50YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
3880
3878
3876
3874
3872
3870
3868
0
50
100
150
200
250
300


HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 4806
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3878
3876
3874
3872
3870
3868
3866
3864
Station (ft)
0
50
100
150
200
250

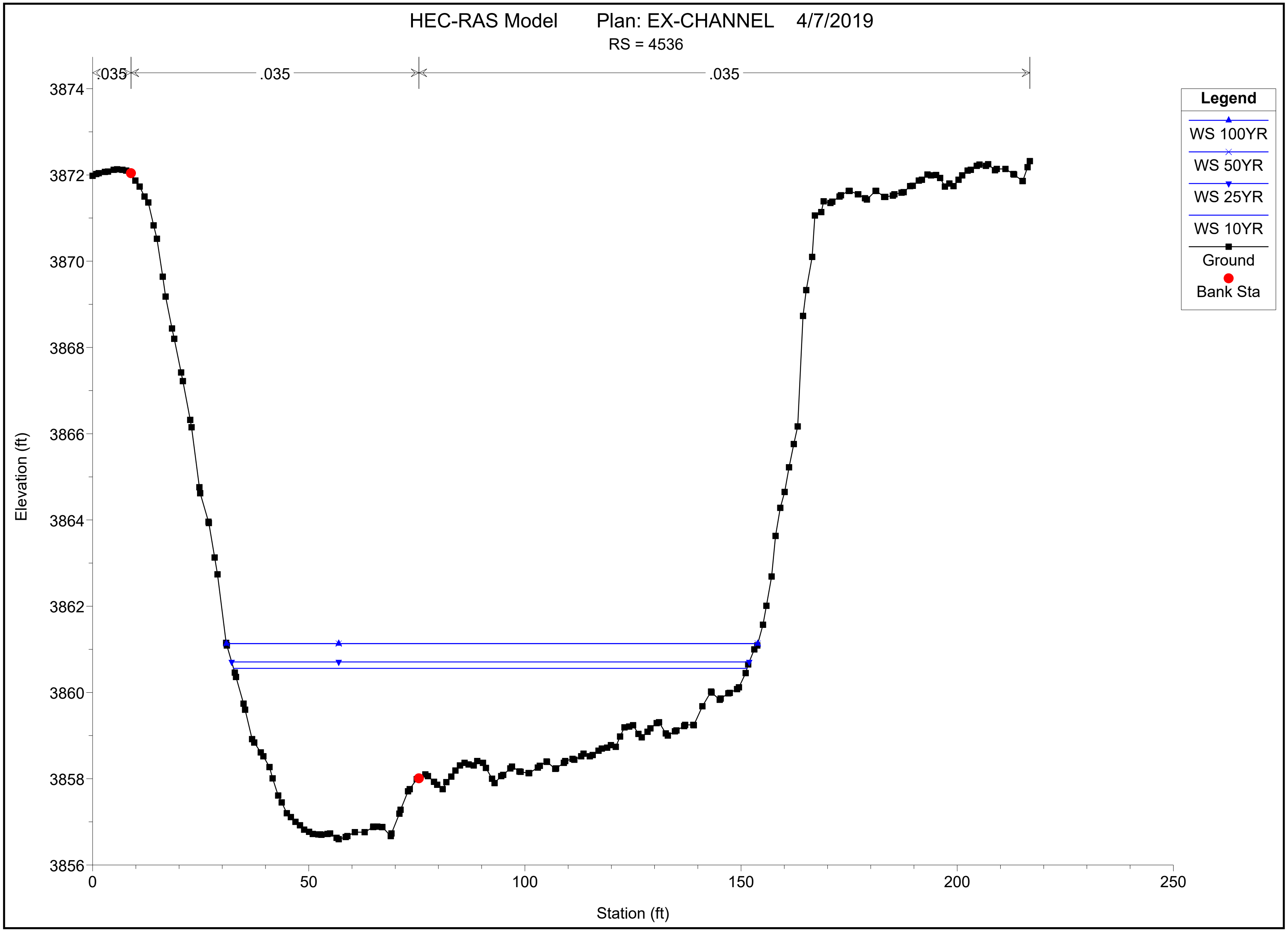

HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 4748
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
3880
3875
3870
3865
3860
3855
0
50
100
150
200
250
300

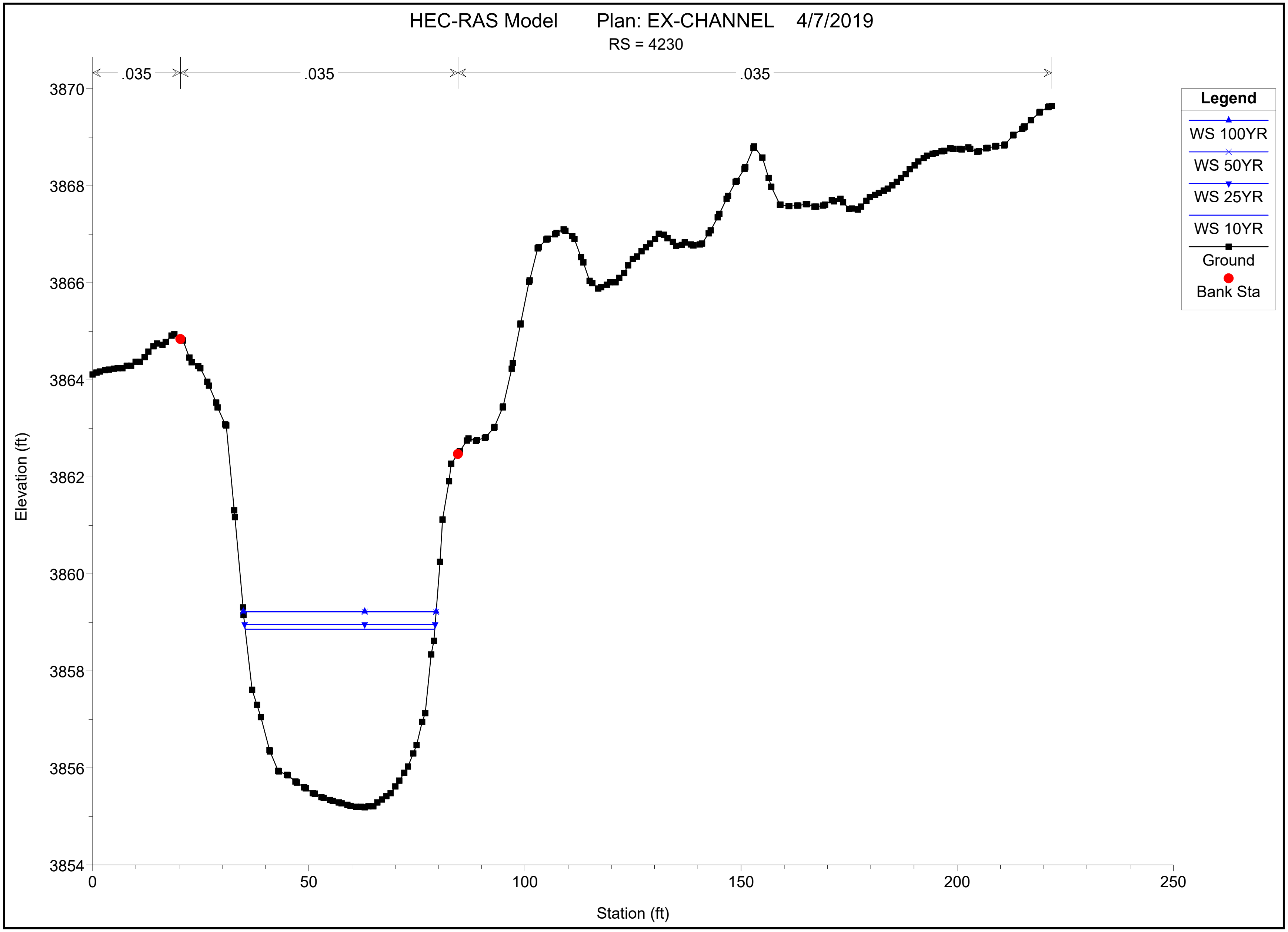


HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 4675
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3880
3875
3870
3865
3860
3855
Station (ft)
0
50
100
150
200
250
300

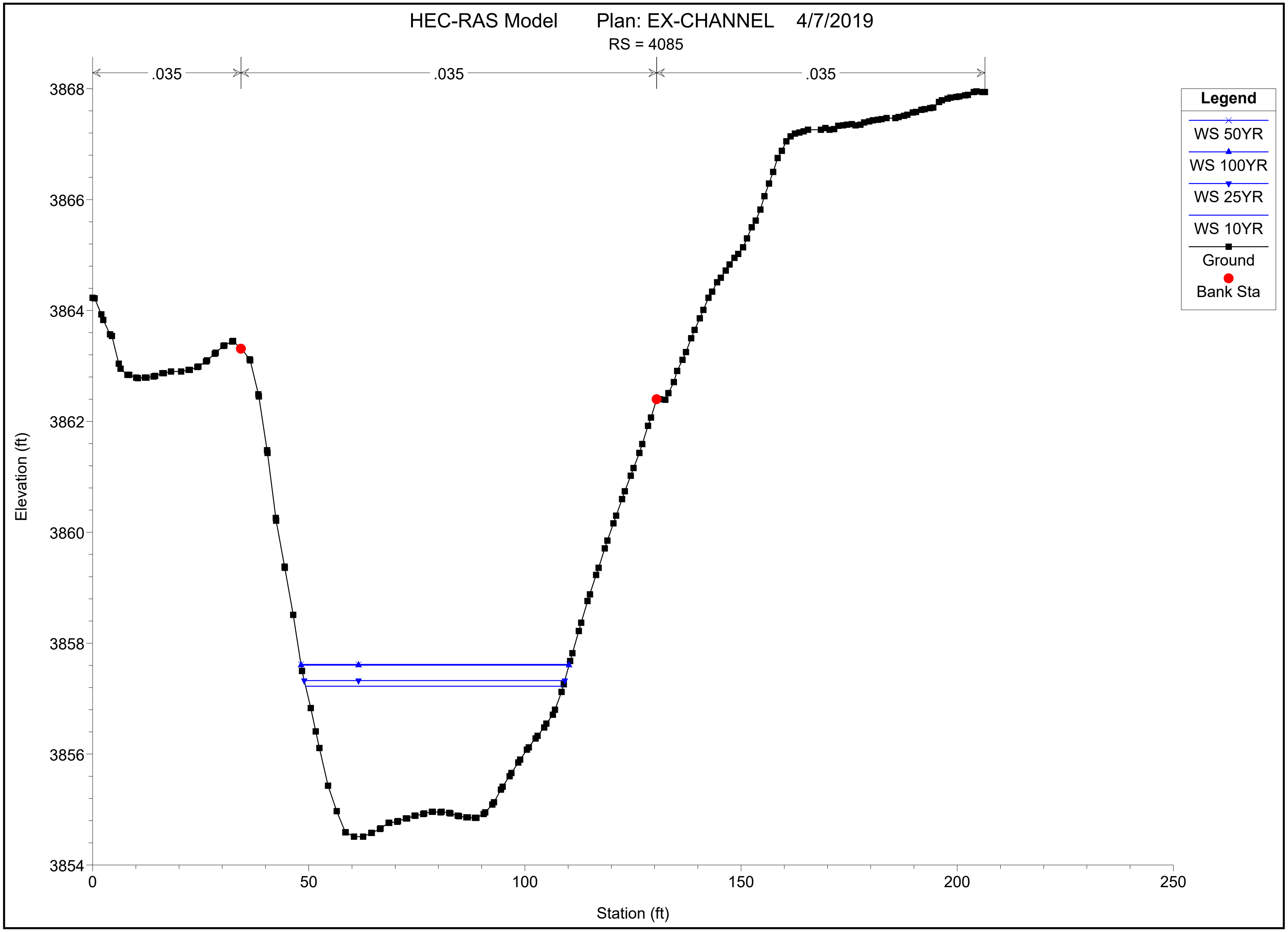


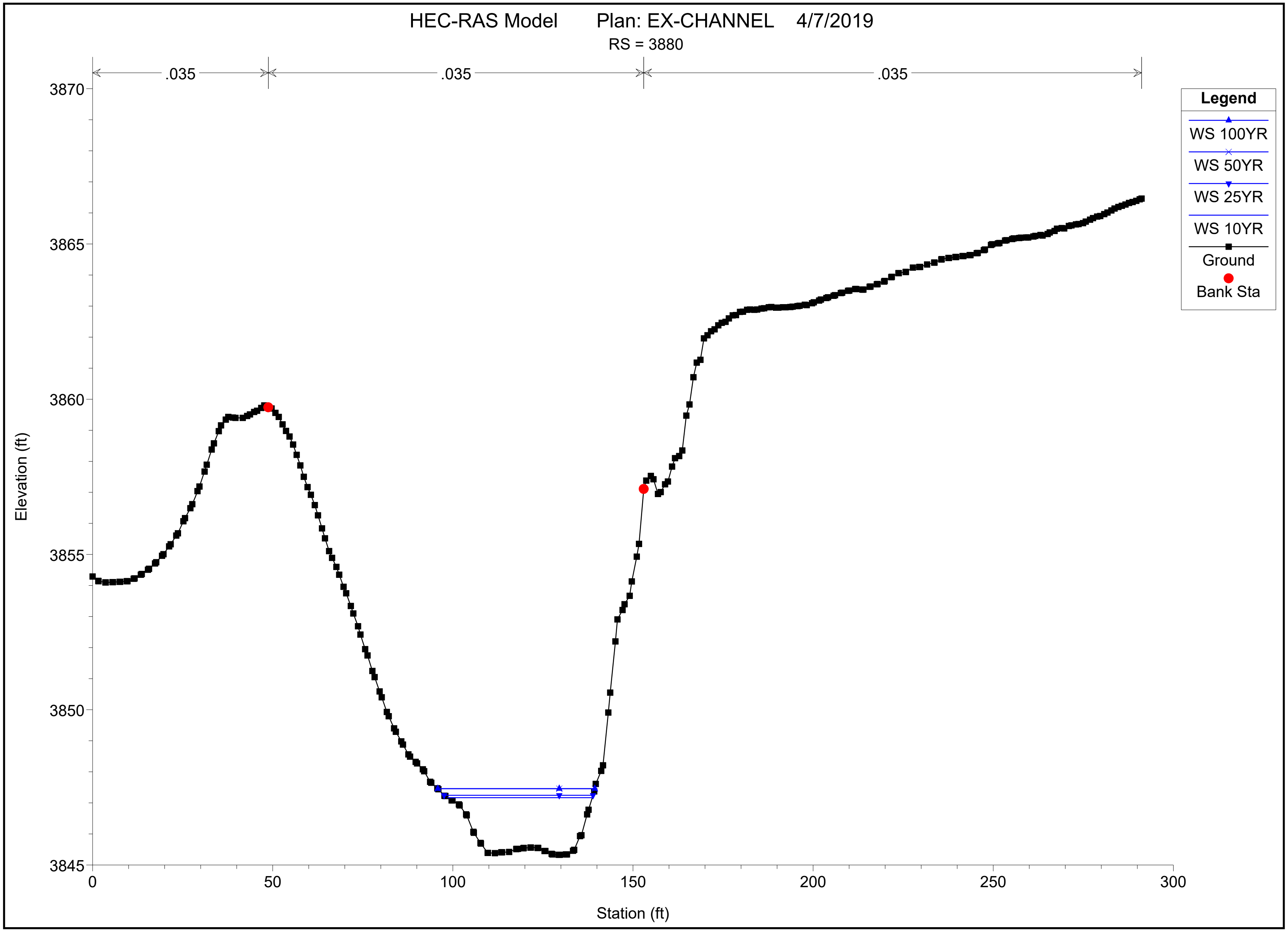
HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 4614
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3875
3870
3865
3860
3855
0
50
100
150
200
250
300
Station (ft)

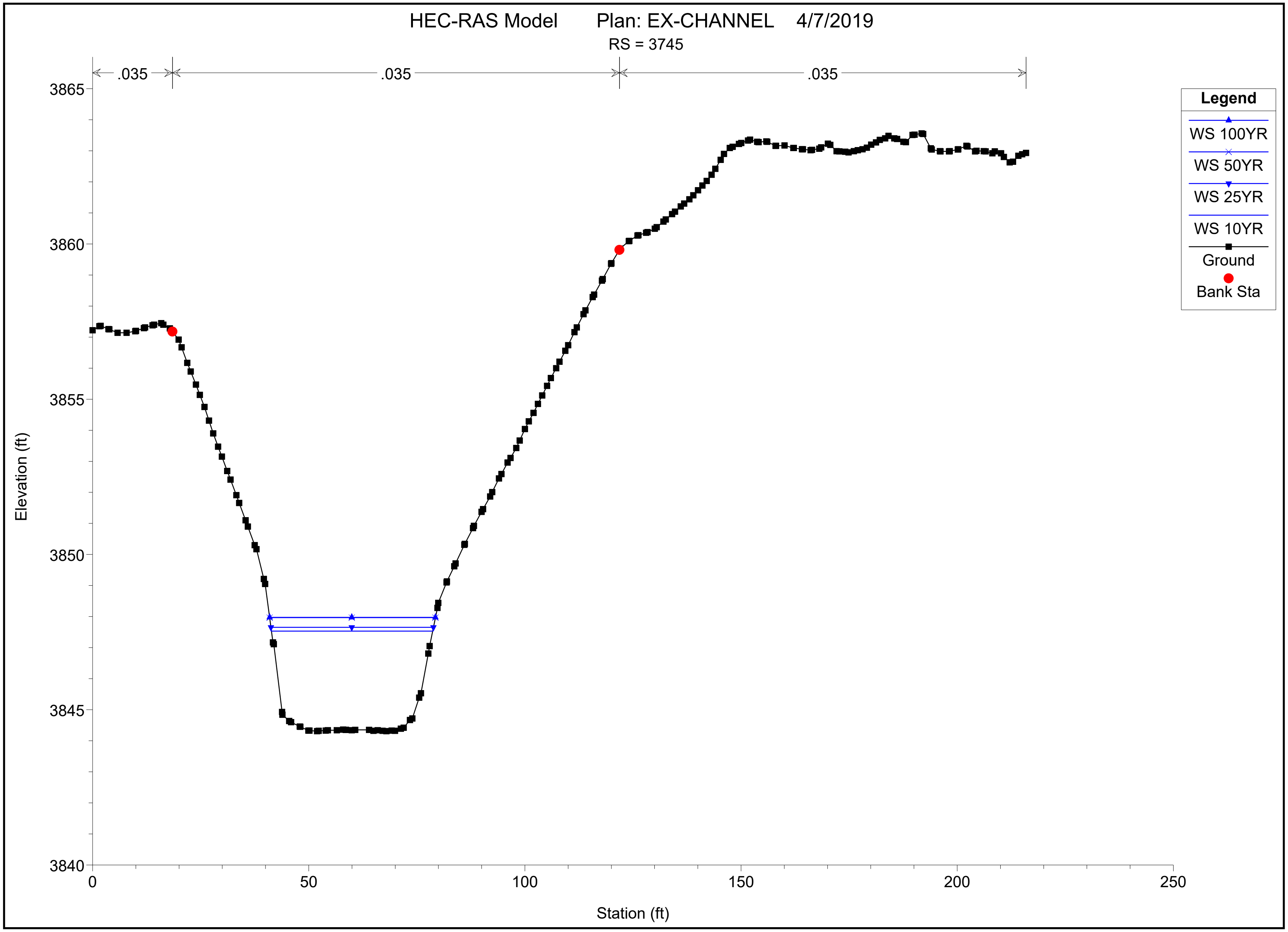

HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 4536
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3874
3872
3870
3868
3866
3864
3862
3860
3858
3856
0
50
100
150
200
250
Station (ft)



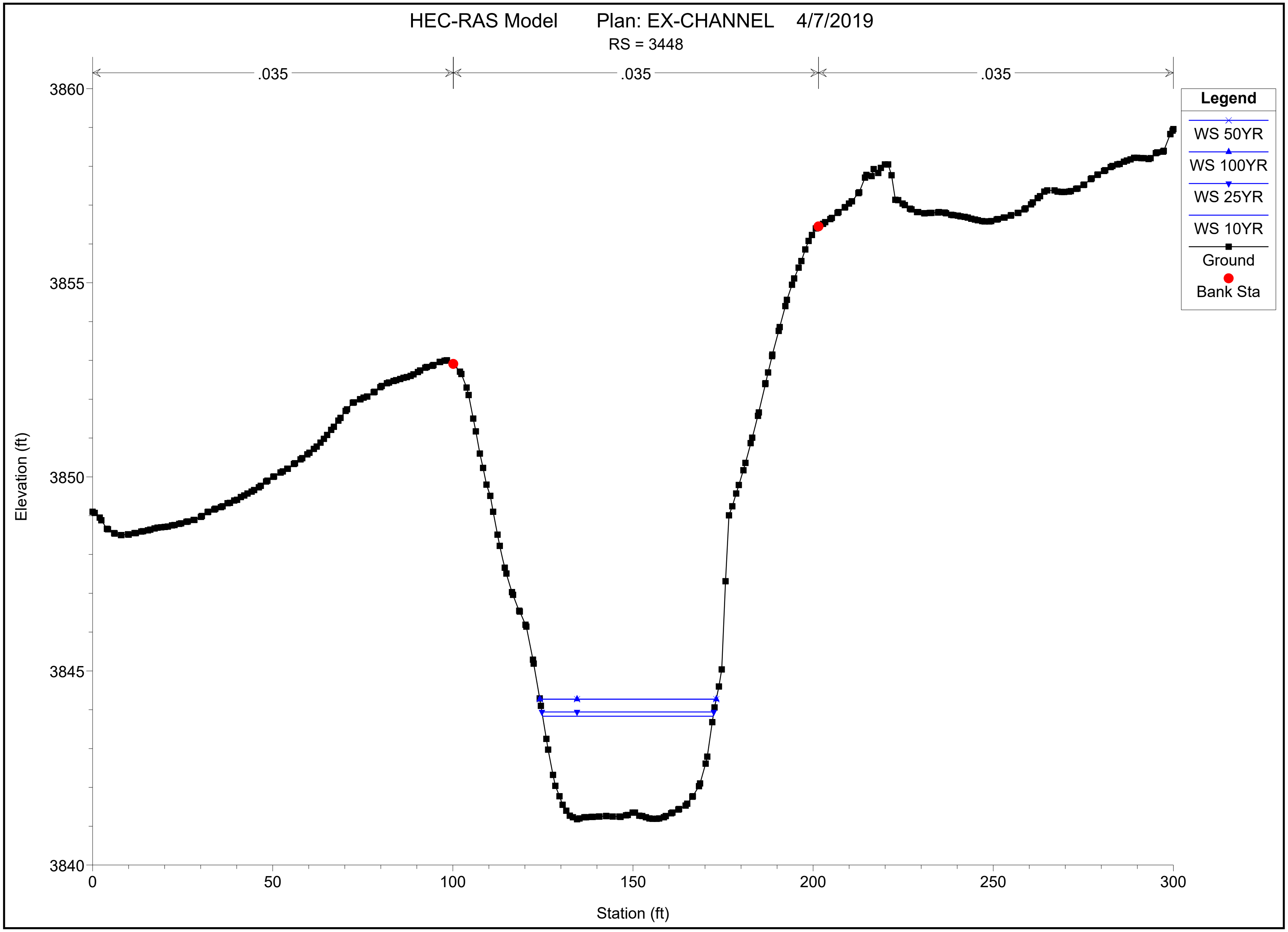
HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 4230
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3870
3868
3866
3864
3862
3860
3858
3856
3854
0
50
100
150
200
250
Station (ft)

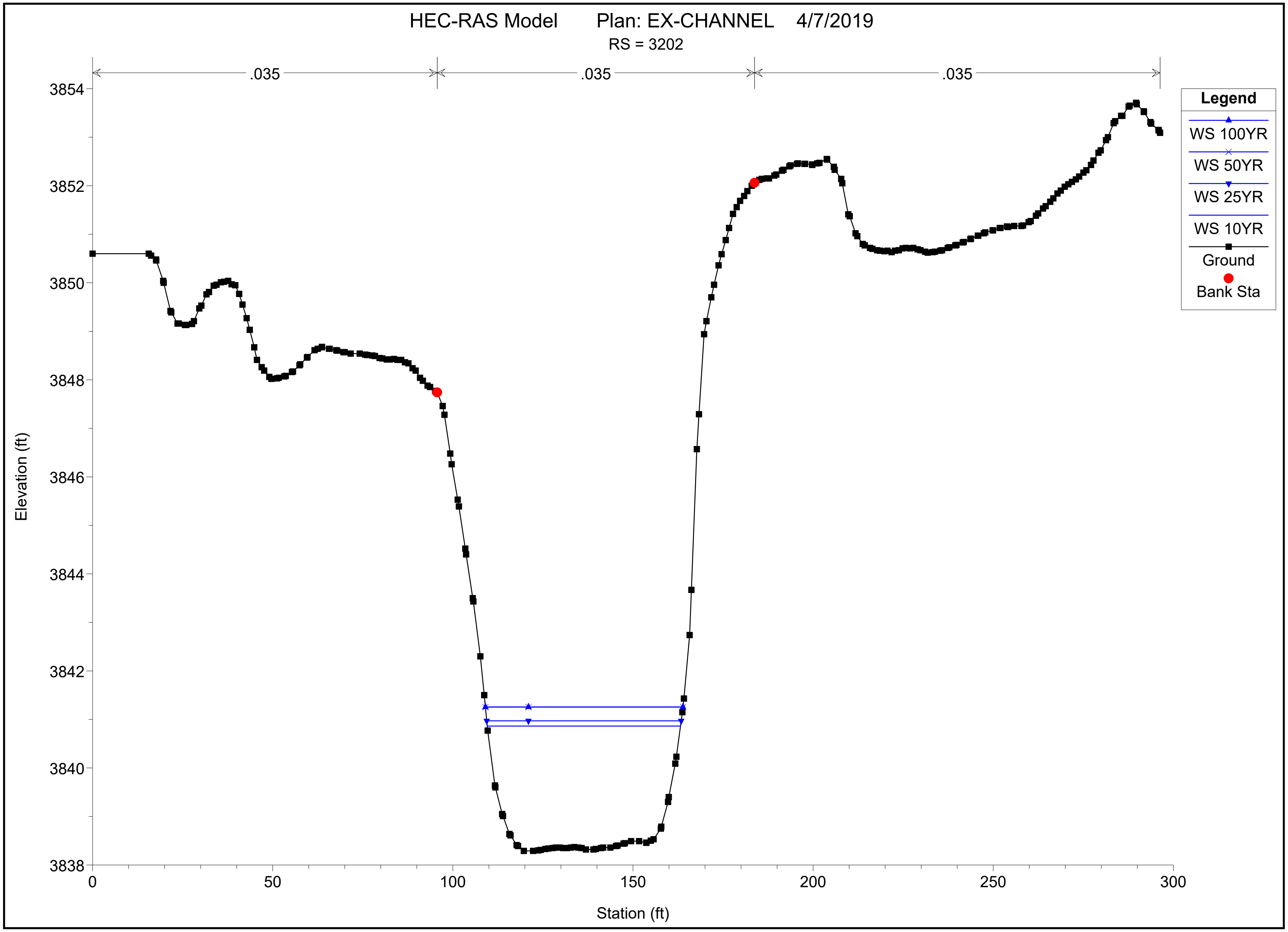

HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 4085
.035
.035
.035
Legend
WS 50YR
WS 100YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3868
3866
3864
3862
3860
3858
3856
3854
0
50
100
150
200
250
Station (ft)

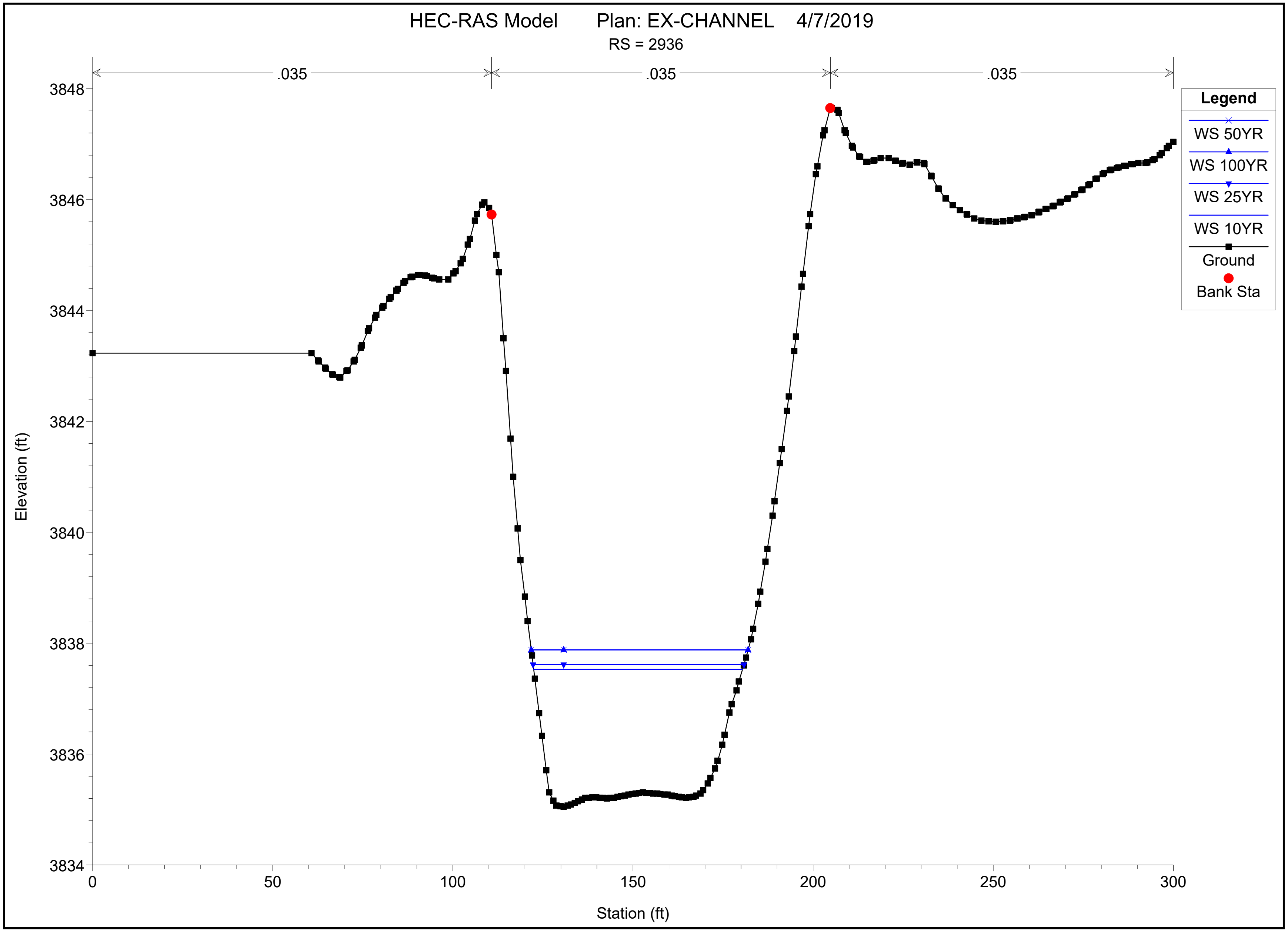

HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 3880
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3870
3865
3860
3855
3850
3845
0
50
100
150
200
250
300
Station (ft)

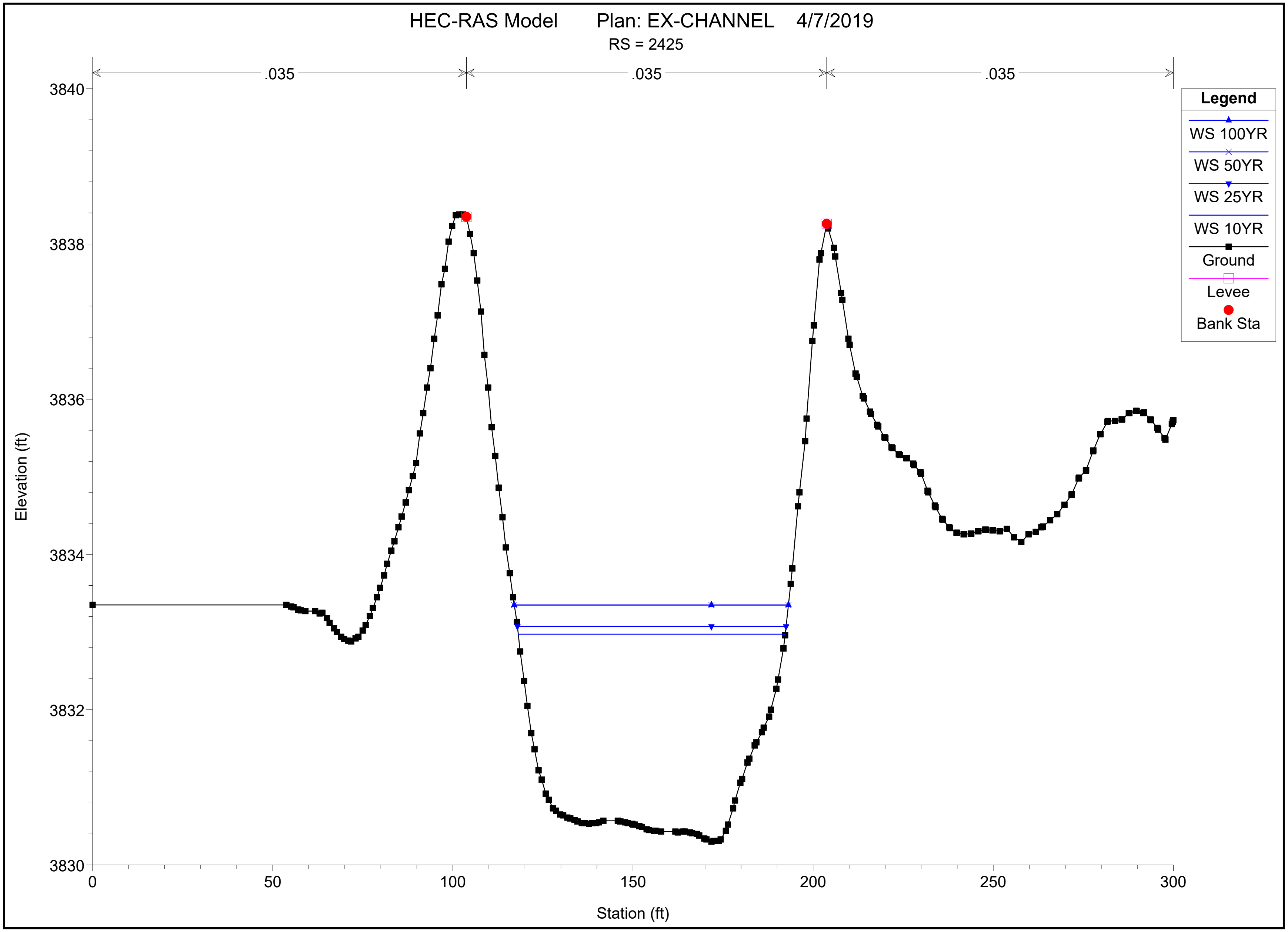


HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 3745
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3865
3860
3855
3850
3845
3840
0
50
100
150
200
250
Station (ft)

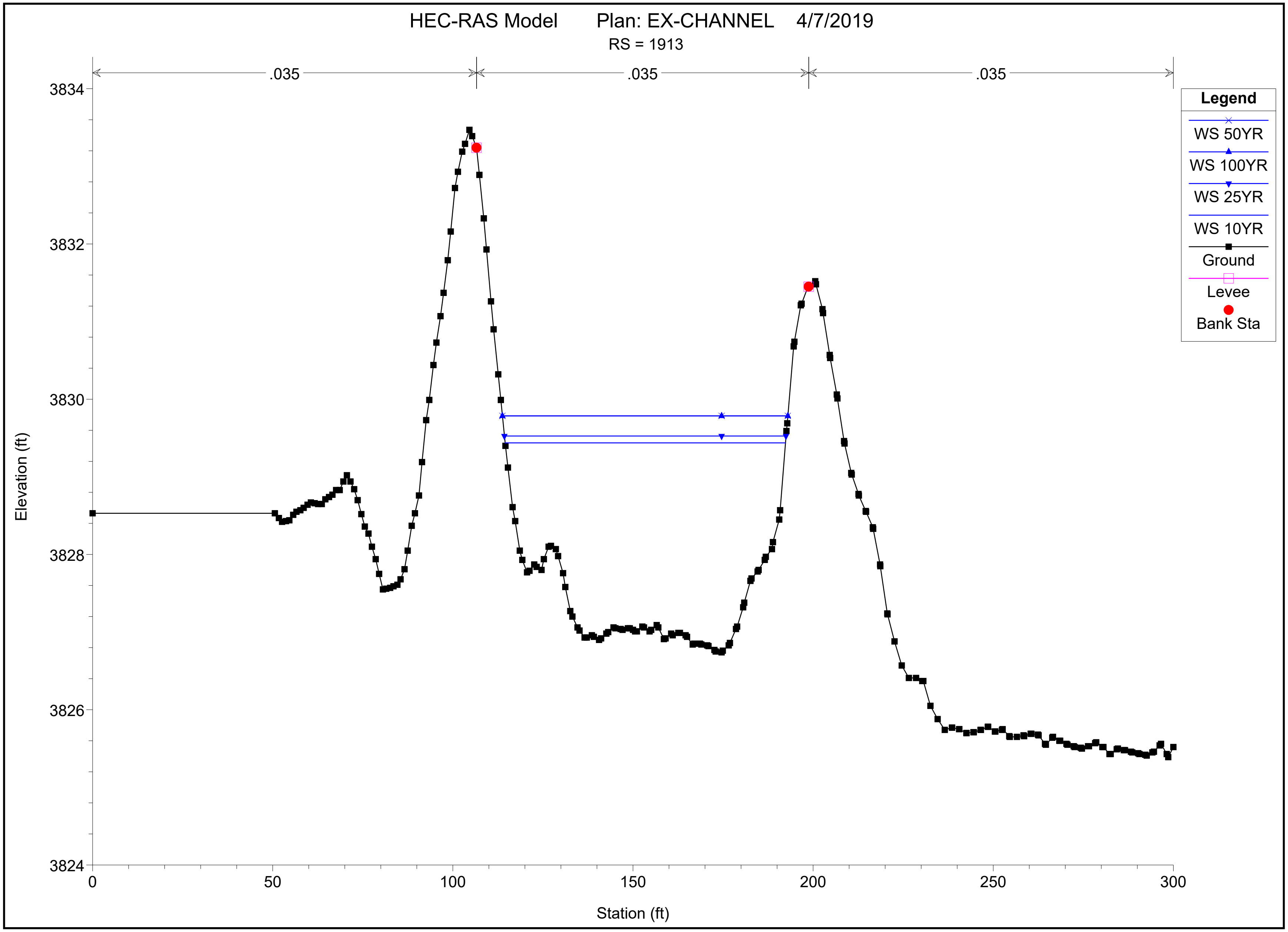

HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 3448
.035
.035
.035
Legend
WS 50YR
WS 100YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3860
3855
3850
3845
3840
0
50
100
150
200
250
300
Station (ft)


HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 3202
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3854
3852
3850
3848
3846
3844
3842
3840
3838
Station (ft)
0
50
100
150
200
250
300

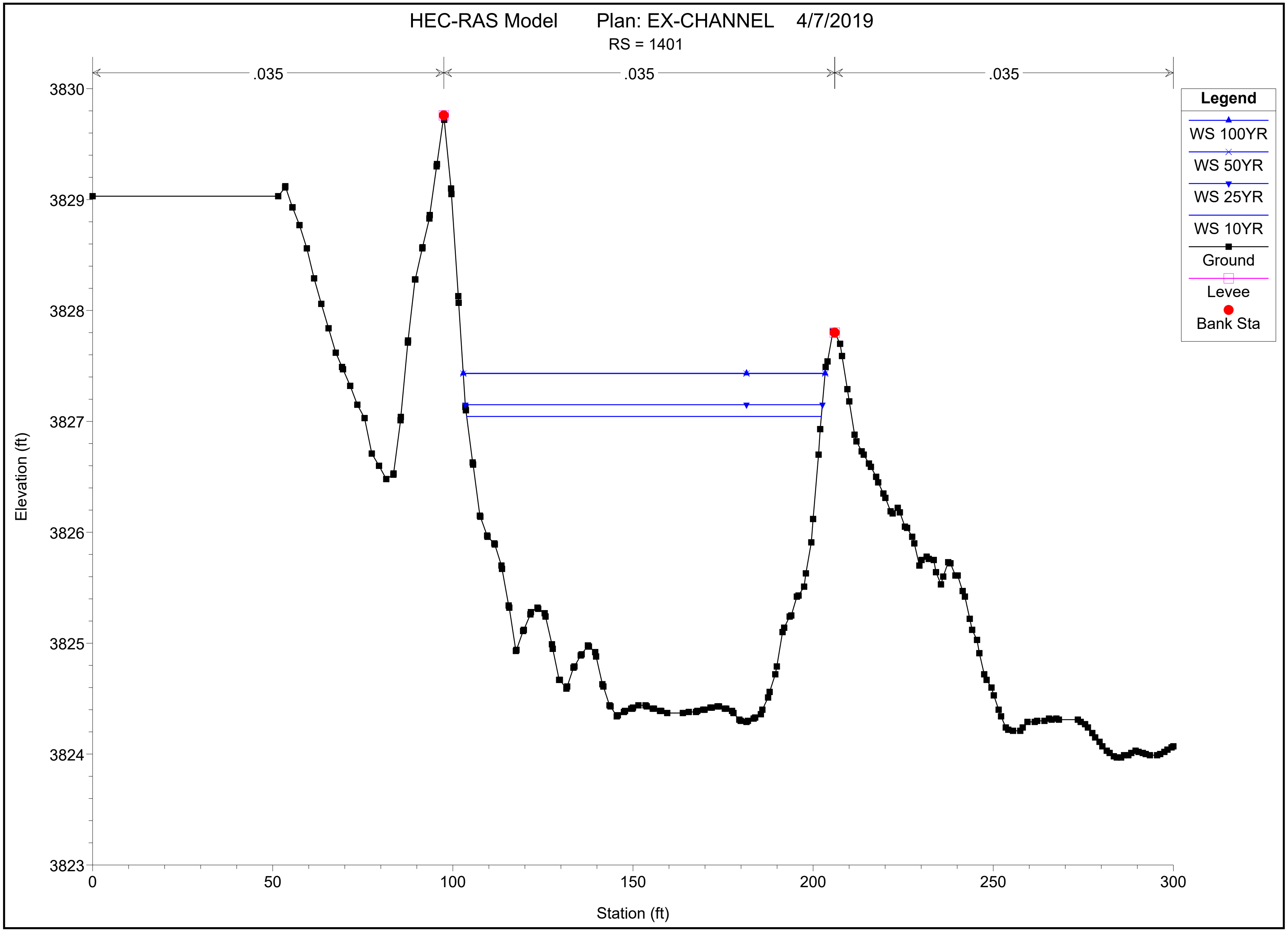

HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 2936
.035
.035
.035
Legend
WS 50YR
WS 100YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
3834
3836
3838
3840
3842
3844
3846
3848
0
50
100
150
200
250
300



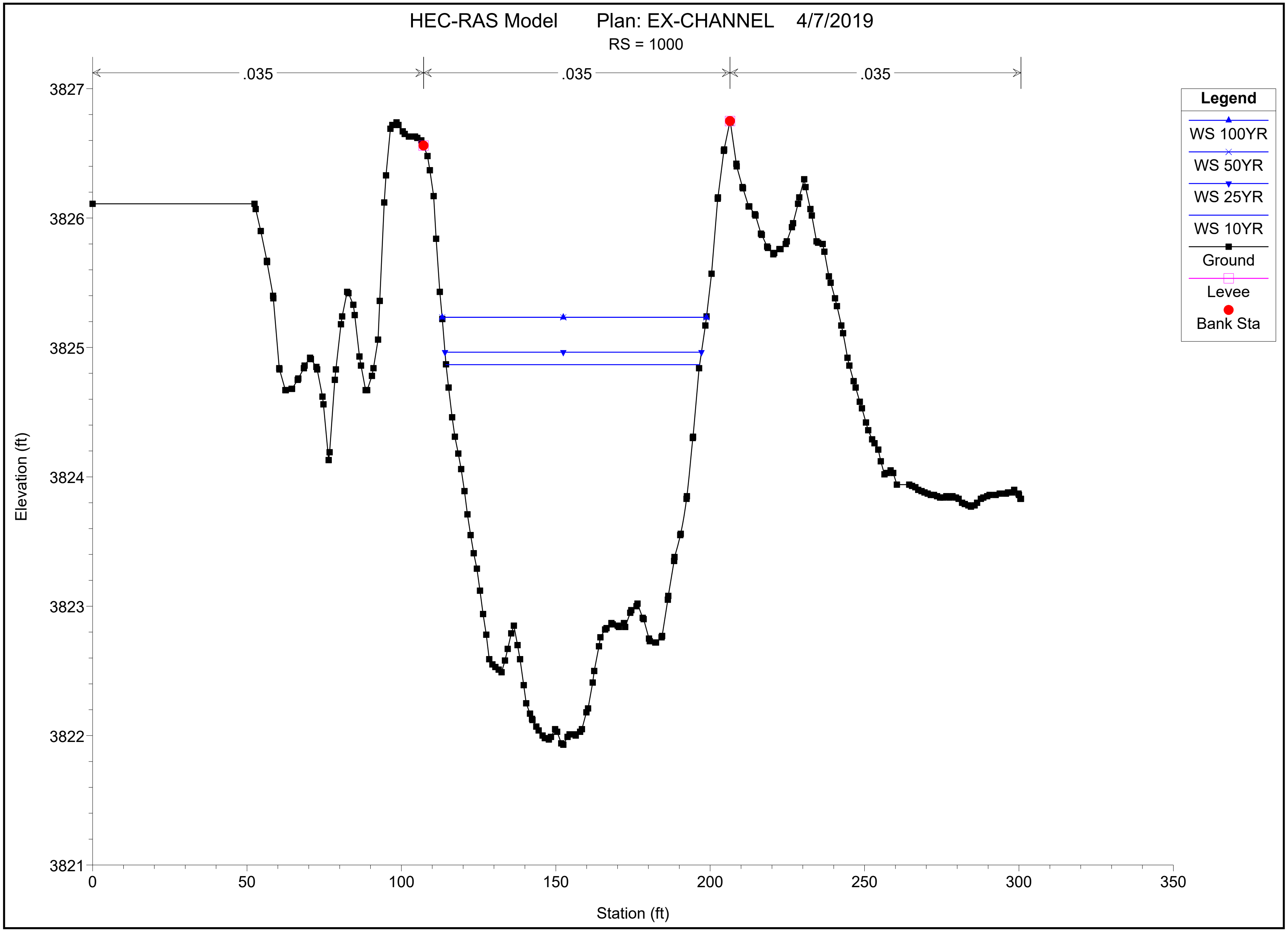
HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 2425
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3840
3838
3836
3834
3832
3830
0
50
100
150
200
250
300
Station (ft)



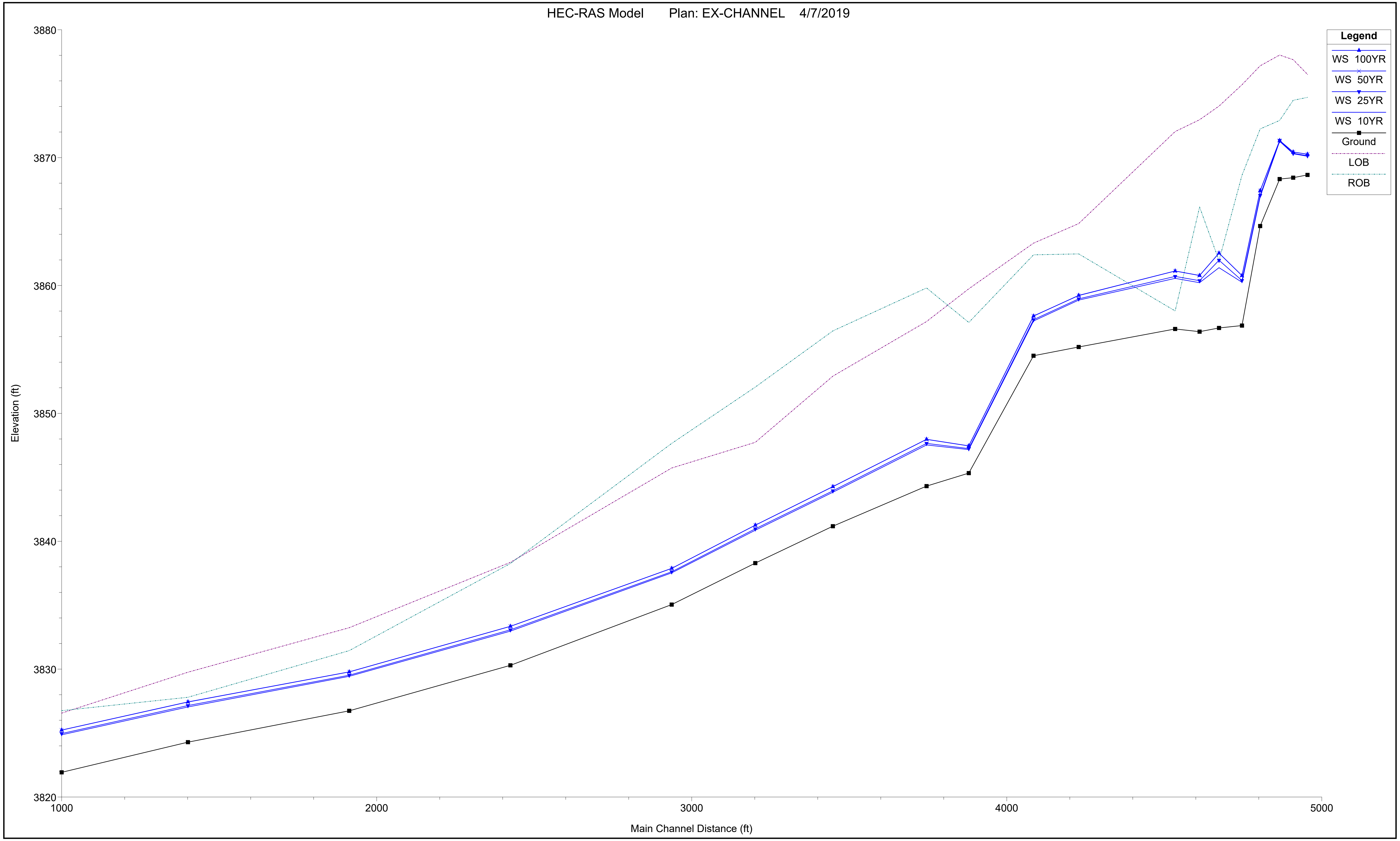
HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 1913
.035
.035
.035
Legend
WS 50YR
WS 100YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3834
3832
3830
3828
3826
3824
0
50
100
150
200
250
300
Station (ft)



HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 1401
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3830
3829
3828
3827
3826
3825
3824
3823
0
50
100
150
200
250
300
Station (ft)



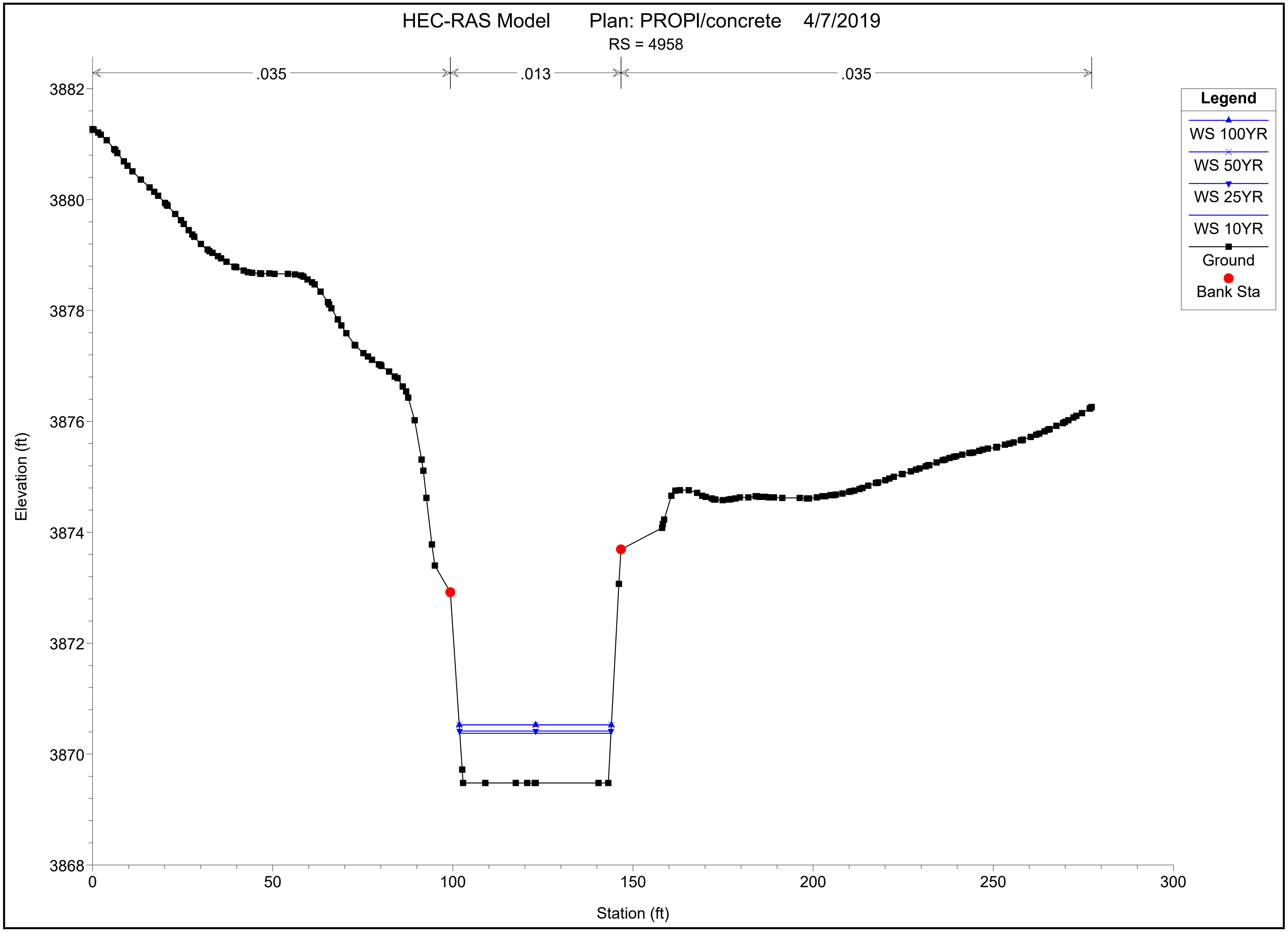
HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
RS = 1000
.035
.035
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3827
3826
3825
3824
3823
3822
3821
Station (ft)
0
50
100
150
200
250
300
350



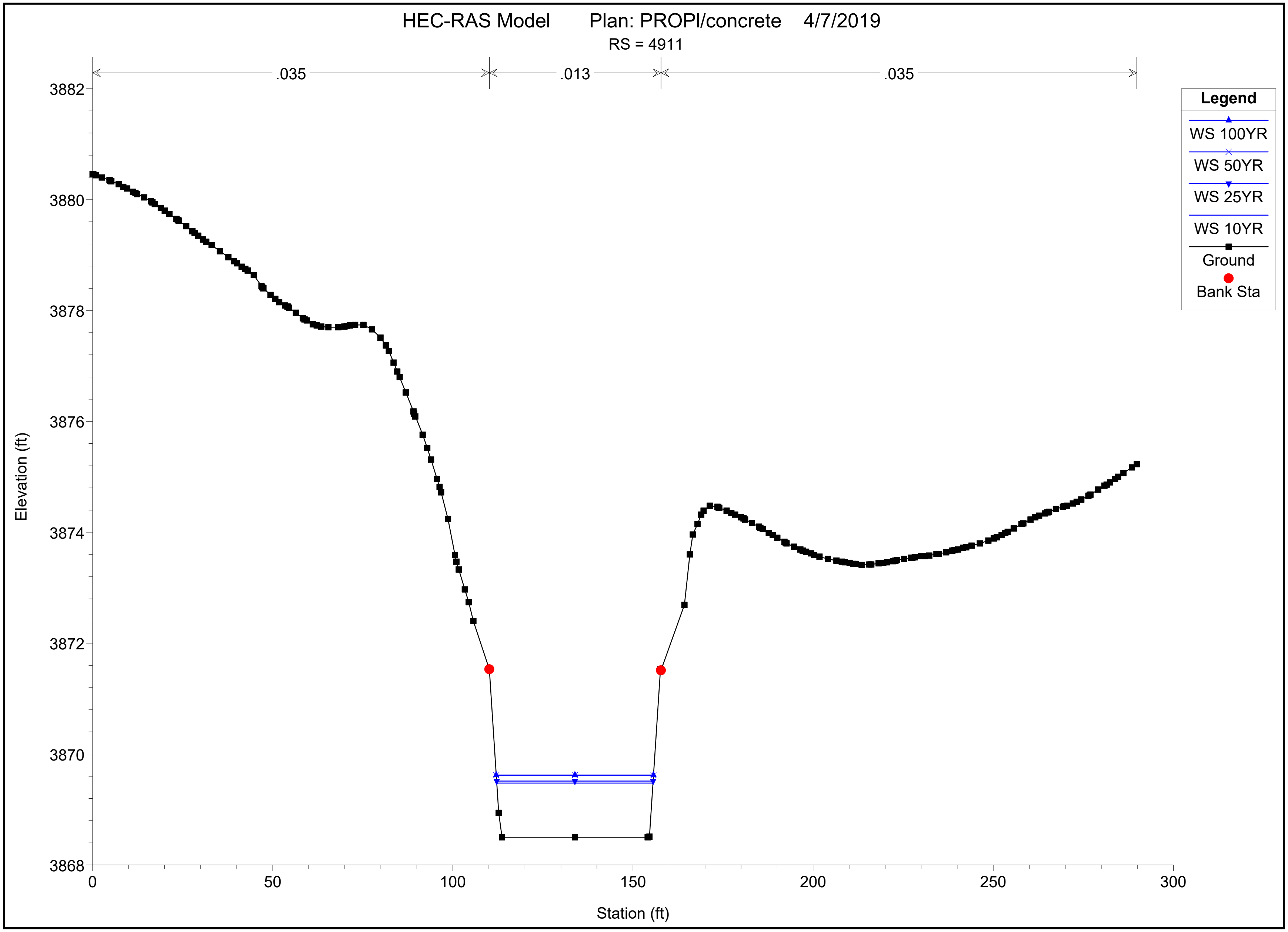
HEC-RAS Model Plan: EX-CHANNEL 4/7/2019
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
LOB
ROB
Elevation (ft)
Main Channel Distance (ft)
3880
3870
3860
3850
3840
3830
3820
1000
2000
3000
4000
5000

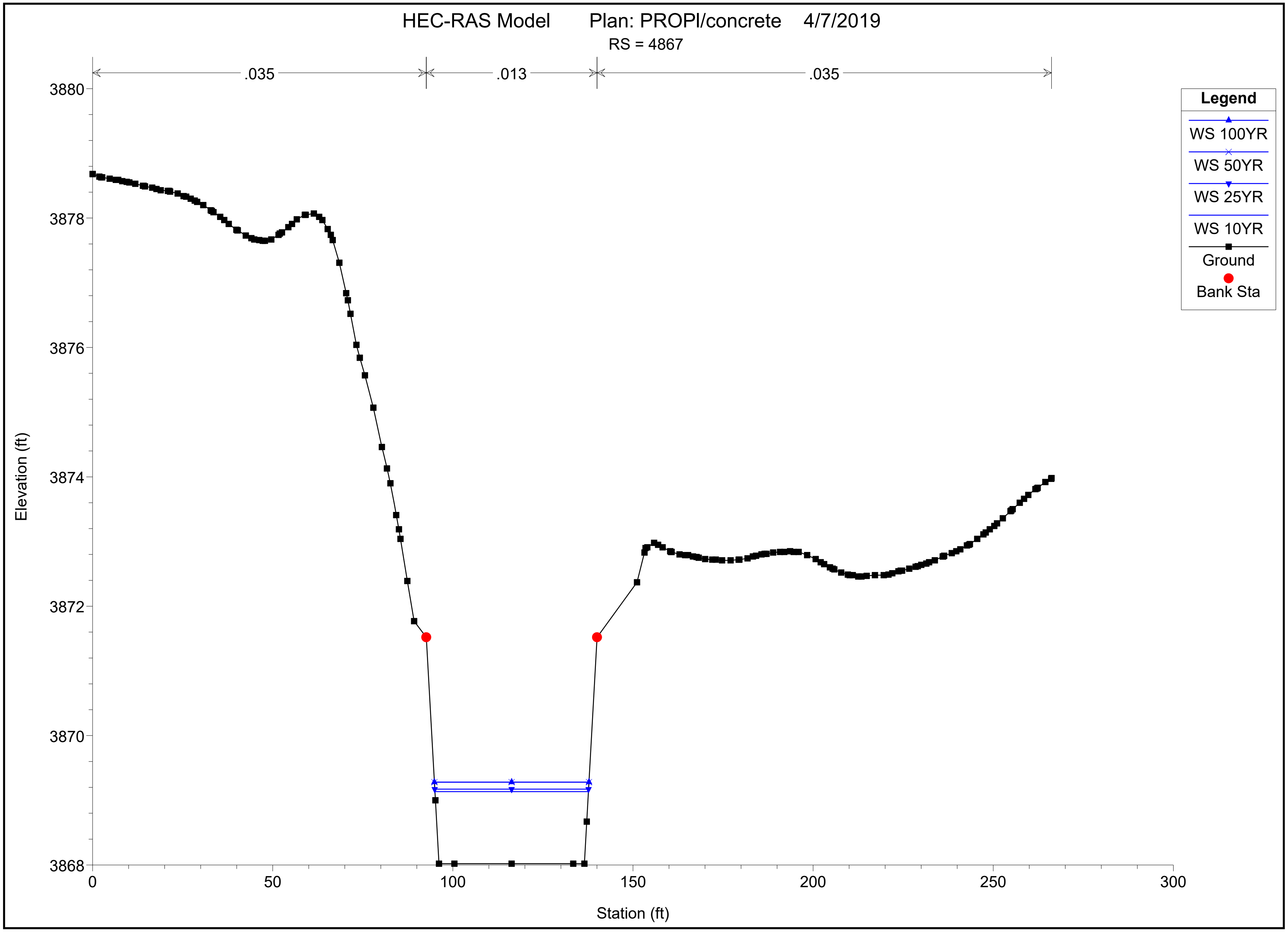
# Proposed Conditions HEC-RAS 1D Hydraulic Models (V5.0.7) Output for Concrete Lined Channel

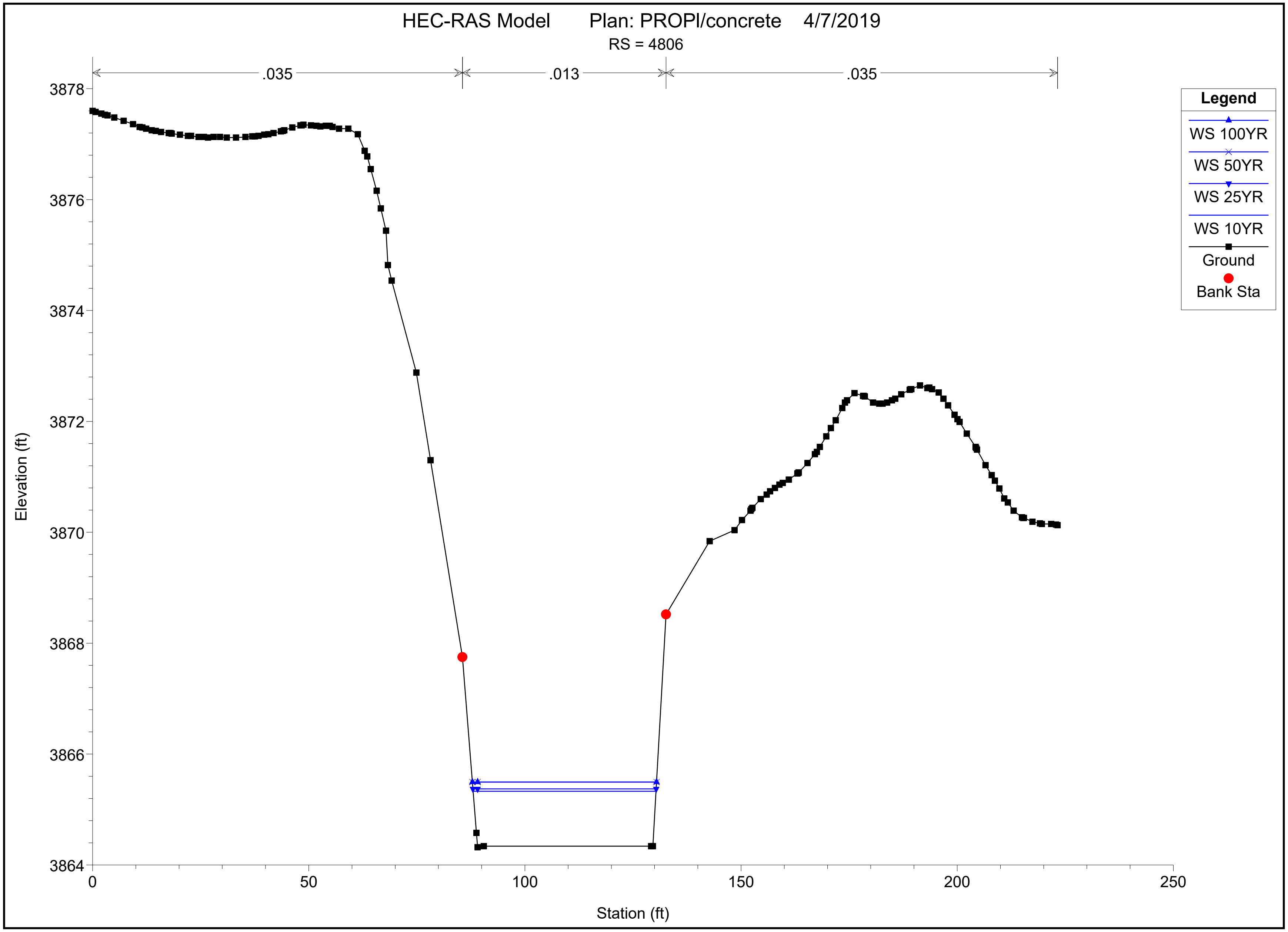
| PROPOSED CONDTIONS (CONCRETE LINING) HEC-RAS OUTPUT | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl | Mann Wtd Total | Power Total | Shear Chan | Invert Slope |
| | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | | | (lb/ft s) | (lb/sq ft) | |
| 4958 | 10YR | 908 | 3869.48 | 3870.38 | 3871.93 | 3879.82 | 0.056736 | 24.65 | 36.83 | 41.95 | 4.64 | 0.013 | 75.23 | 3.05 | 0.0208 |
| 4958 | 100YR | 1175 | 3869.48 | 3870.53 | 3872.38 | 3882.04 | 0.056714 | 27.22 | 43.16 | 42.23 | 4.75 | 0.013 | 96.4 | 3.54 | 0.0208 |
| 4911 | 10YR | 908 | 3868.5 | 3869.48 | 3870.91 | 3877 | 0.040442 | 22 | 41.27 | 43.36 | 3.98 | 0.013 | 52.01 | 2.36 | 0.0112 |
| 4911 | 100YR | 1175 | 3868.5 | 3869.62 | 3871.35 | 3879.12 | 0.042864 | 24.73 | 47.52 | 43.65 | 4.18 | 0.013 | 70.68 | 2.86 | 0.0112 |
| 4867 | 10YR | 908 | 3868.02 | 3869.13 | 3870.47 | 3875.13 | 0.027247 | 19.64 | 46.23 | 42.62 | 3.32 | 0.013 | 35.48 | 1.81 | 0.0599 |
| 4867 | 100YR | 1175 | 3868.02 | 3869.28 | 3870.91 | 3877.07 | 0.03031 | 22.39 | 52.47 | 42.92 | 3.57 | 0.013 | 50.59 | 2.26 | 0.0599 |
| 4806 | 10YR | 908 | 3864.32 | 3865.33 | 3866.79 | 3872.94 | 0.040212 | 22.14 | 41.02 | 42.31 | 3.96 | 0.013 | 52.74 | 2.38 | 0.1138 |
| 4806 | 100YR | 1175 | 3864.32 | 3865.5 | 3867.24 | 3874.78 | 0.04021 | 24.44 | 48.08 | 42.6 | 4.06 | 0.013 | 67.55 | 2.76 | 0.1138 |
| 4748 | 10YR | 908 | 3857.75 | 3858.6 | 3860.22 | 3869.56 | 0.072073 | 26.57 | 34.18 | 41.73 | 5.18 | 0.013 | 96.3 | 3.62 | 0.0089 |
| 4748 | 100YR | 1175 | 3857.75 | 3858.76 | 3860.67 | 3871.5 | 0.066533 | 28.63 | 41.04 | 42.06 | 5.11 | 0.013 | 113.8 | 3.97 | 0.0089 |
| 4675 | 10YR | 908 | 3857.1 | 3858.17 | 3859.59 | 3864.89 | 0.032565 | 20.8 | 43.66 | 42.24 | 3.61 | 0.013 | 42.82 | 2.06 | 0.0049 |
| 4675 | 100YR | 1175 | 3857.1 | 3858.33 | 3860.04 | 3866.82 | 0.034565 | 23.38 | 50.26 | 42.55 | 3.79 | 0.013 | 58.21 | 2.49 | 0.0049 |
| 4614 | 10YR | 908 | 3856.8 | 3858.06 | 3859.28 | 3862.82 | 0.018637 | 17.51 | 51.85 | 42.56 | 2.8 | 0.013 | 24.23 | 1.38 | 0.0041 |
| 4614 | 100YR | 1175 | 3856.8 | 3858.21 | 3859.72 | 3864.52 | 0.021382 | 20.15 | 58.3 | 42.87 | 3.05 | 0.013 | 35.62 | 1.77 | 0.0041 |
| 4536 | 10YR | 908 | 3856.48 | 3857.97 | 3858.96 | 3861.33 | 0.010652 | 14.72 | 61.68 | 43.02 | 2.17 | 0.013 | 13.65 | 0.93 | 0.0031 |
| 4536 | 100YR | 1175 | 3856.48 | 3858.11 | 3859.41 | 3862.74 | 0.013 | 17.26 | 68.08 | 43.32 | 2.43 | 0.013 | 21.35 | 1.24 | 0.0031 |
| 4230 | 10YR | 908 | 3855.52 | 3857.7 | 3857.98 | 3859.22 | 0.002989 | 9.89 | 91.82 | 44.32 | 1.21 | 0.013 | 3.67 | 0.37 | 0.0031 |
| 4230 | 100YR | 1175 | 3855.52 | 3857.88 | 3858.43 | 3860.03 | 0.003834 | 11.76 | 99.91 | 44.68 | 1.39 | 0.013 | 6.03 | 0.51 | 0.0031 |
| 4085 | 10YR | 908 | 3855.08 | 3857.24 | 3857.54 | 3858.79 | 0.003075 | 9.98 | 91.03 | 44.32 | 1.23 | 0.013 | 3.78 | 0.38 | 0.0471 |
| 4085 | 100YR | 1175 | 3855.08 | 3857.62 | 3857.99 | 3859.46 | 0.002995 | 10.87 | 108.09 | 45.08 | 1.24 | 0.013 | 4.66 | 0.43 | 0.0471 |
| 3880 | 10YR | 908 | 3845.4 | 3846.28 | 3847.86 | 3856.26 | 0.061698 | 25.34 | 35.83 | 41.75 | 4.82 | 0.013 | 82.33 | 3.25 | 0.008 |
| 3880 | 100YR | 1175 | 3845.4 | 3846.5 | 3848.31 | 3857.01 | 0.04862 | 26.01 | 45.18 | 42.2 | 4.43 | 0.013 | 82.73 | 3.18 | 0.008 |
| 3745 | 10YR | 908 | 3844.33 | 3845.58 | 3846.79 | 3850.44 | 0.019443 | 17.68 | 51.34 | 42.92 | 2.85 | 0.013 | 25.09 | 1.42 | 0.0102 |
| 3745 | 100YR | 1175 | 3844.33 | 3845.79 | 3847.24 | 3851.71 | 0.019499 | 19.52 | 60.2 | 43.33 | 2.92 | 0.013 | 32.13 | 1.65 | 0.0102 |
| 3448 | 10YR | 908 | 3841.31 | 3842.84 | 3843.77 | 3846 | 0.009588 | 14.25 | 63.71 | 43.07 | 2.07 | 0.013 | 12.26 | 0.86 | 0.0106 |
| 3448 | 100YR | 1175 | 3841.31 | 3843.07 | 3844.22 | 3847.05 | 0.010192 | 16 | 73.43 | 43.52 | 2.17 | 0.013 | 16.62 | 1.04 | 0.0106 |
| 3202 | 10YR | 908 | 3838.71 | 3840.22 | 3841.19 | 3843.54 | 0.010392 | 14.6 | 62.18 | 43.09 | 2.14 | 0.013 | 13.29 | 0.91 | 0.0104 |
| 3202 | 100YR | 1175 | 3838.71 | 3840.47 | 3841.63 | 3844.51 | 0.010449 | 16.11 | 72.92 | 43.59 | 2.2 | 0.013 | 17.02 | 1.06 | 0.0104 |
| 2936 | 10YR | 908 | 3835.95 | 3837.45 | 3838.41 | 3840.78 | 0.010453 | 14.64 | 62.02 | 42.99 | 2.15 | 0.013 | 13.4 | 0.92 | 0.0105 |
| 2936 | 100YR | 1175 | 3835.95 | 3837.7 | 3838.86 | 3841.73 | 0.010421 | 16.11 | 72.92 | 43.49 | 2.19 | 0.013 | 17.01 | 1.06 | 0.0105 |
| 2425 | 10YR | 908 | 3830.58 | 3832.07 | 3833.06 | 3835.42 | 0.010521 | 14.67 | 61.89 | 42.98 | 2.16 | 0.013 | 13.49 | 0.92 | 0.006 |
| 2425 | 100YR | 1175 | 3830.58 | 3832.32 | 3833.73 | 3836.38 | 0.010499 | 16.15 | 72.75 | 43.49 | 2.2 | 0.013 | 17.14 | 1.06 | 0.006 |
| 1913 | 10YR | 908 | 3827.52 | 3829.39 | 3830 | 3831.48 | 0.004934 | 11.58 | 78.43 | 43.75 | 1.52 | 0.013 | 6.17 | 0.53 | 0.0051 |
| 1913 | 100YR | 1175 | 3827.52 | 3829.68 | 3830.46 | 3832.28 | 0.005184 | 12.94 | 90.83 | 44.31 | 1.59 | 0.013 | 8.25 | 0.64 | 0.0051 |
| 1401 | 10YR | 908 | 3824.93 | 3826.8 | 3827.41 | 3828.92 | 0.005034 | 11.69 | 77.69 | 43.14 | 1.54 | 0.013 | 6.36 | 0.54 | 0.0043 |
| 1401 | 100YR | 1175 | 3824.93 | 3827.12 | 3827.86 | 3829.67 | 0.004969 | 12.81 | 91.72 | 43.68 | 1.56 | 0.013 | 7.97 | 0.62 | 0.0043 |
| 1000 | 10YR | 908 | 3823.22 | 3825.21 | 3825.7 | 3827.04 | 0.004014 | 10.85 | 83.71 | 44.04 | 1.39 | 0.013 | 4.98 | 0.46 | |
| 1000 | 100YR | 1175 | 3823.22 | 3825.53 | 3826.15 | 3827.77 | 0.004081 | 11.99 | 98 | 44.69 | 1.43 | 0.013 | 6.43 | 0.54 | |



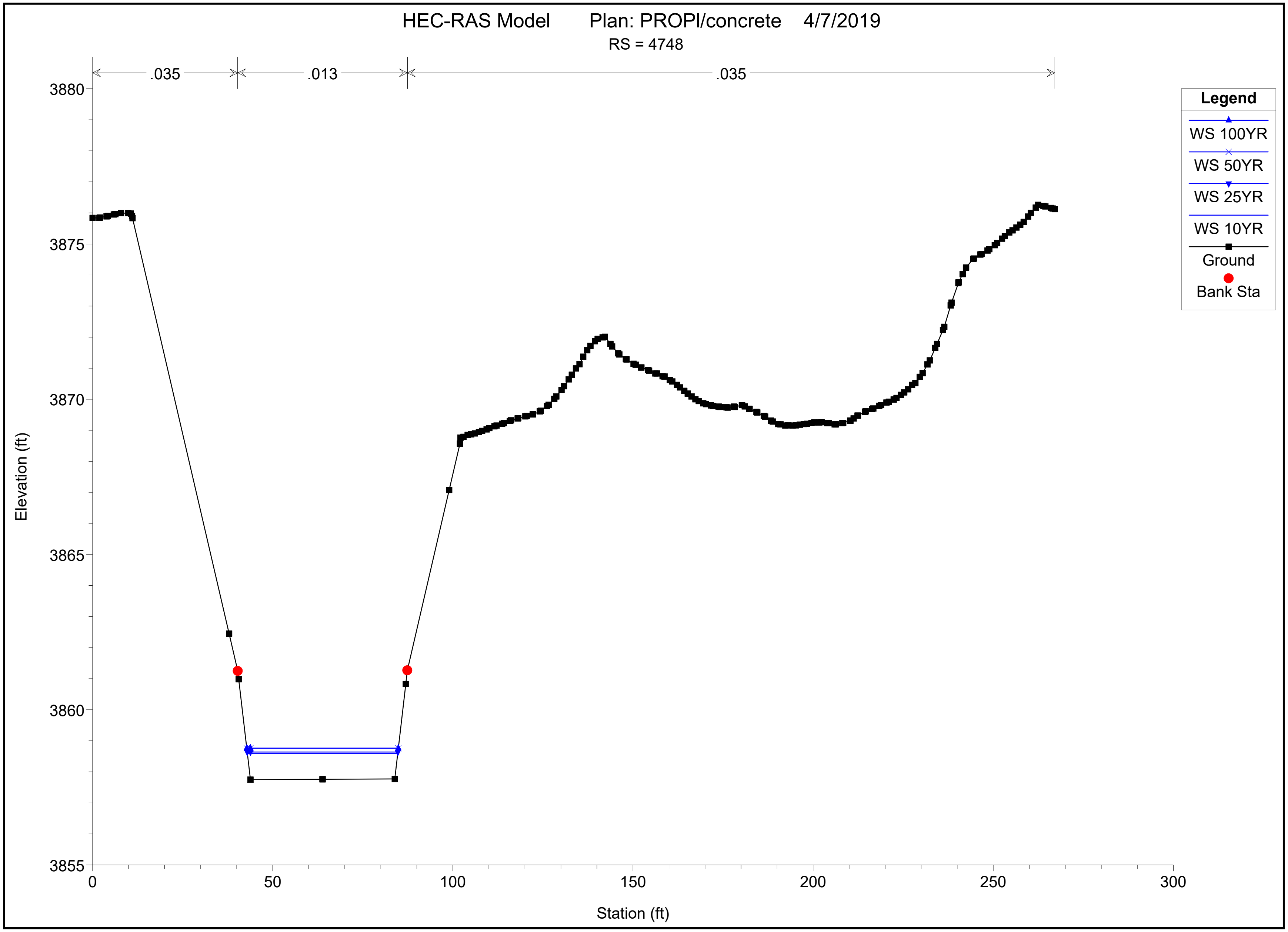
HEC-RAS Model Plan: PROPl/concrete 4/7/2019
RS = 4958
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3882
3880
3878
3876
3874
3872
3870
3868
0
50
100
150
200
250
300
Station (ft)


HEC-RAS Model Plan: PROPl/concrete 4/7/2019
RS = 4911
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3882
3880
3878
3876
3874
3872
3870
3868
0
50
100
150
200
250
300
Station (ft)

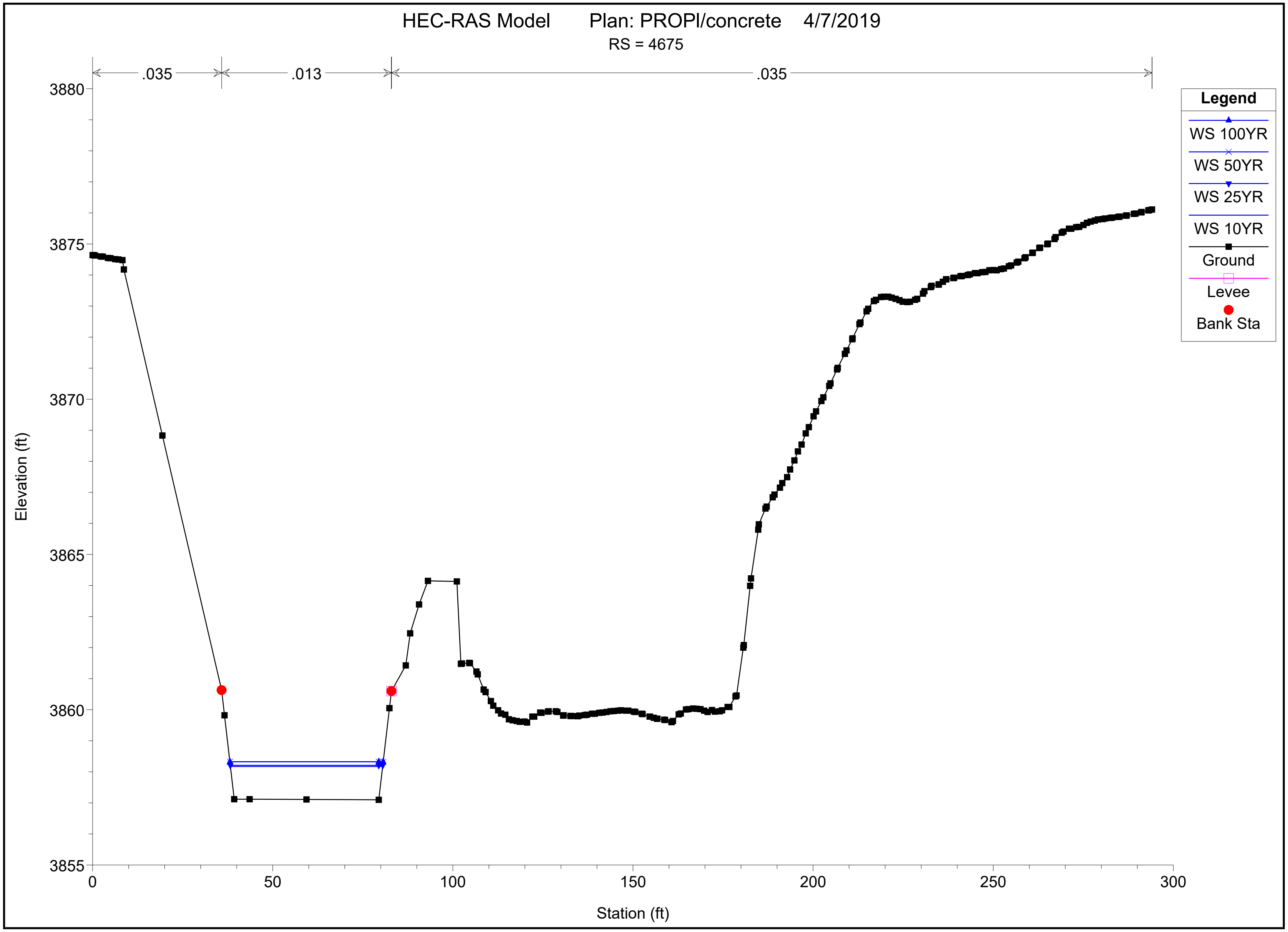

HEC-RAS Model Plan: PROPl/concrete 4/7/2019
RS = 4867
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3880
3878
3876
3874
3872
3870
3868
0
50
100
150
200
250
300
Station (ft)

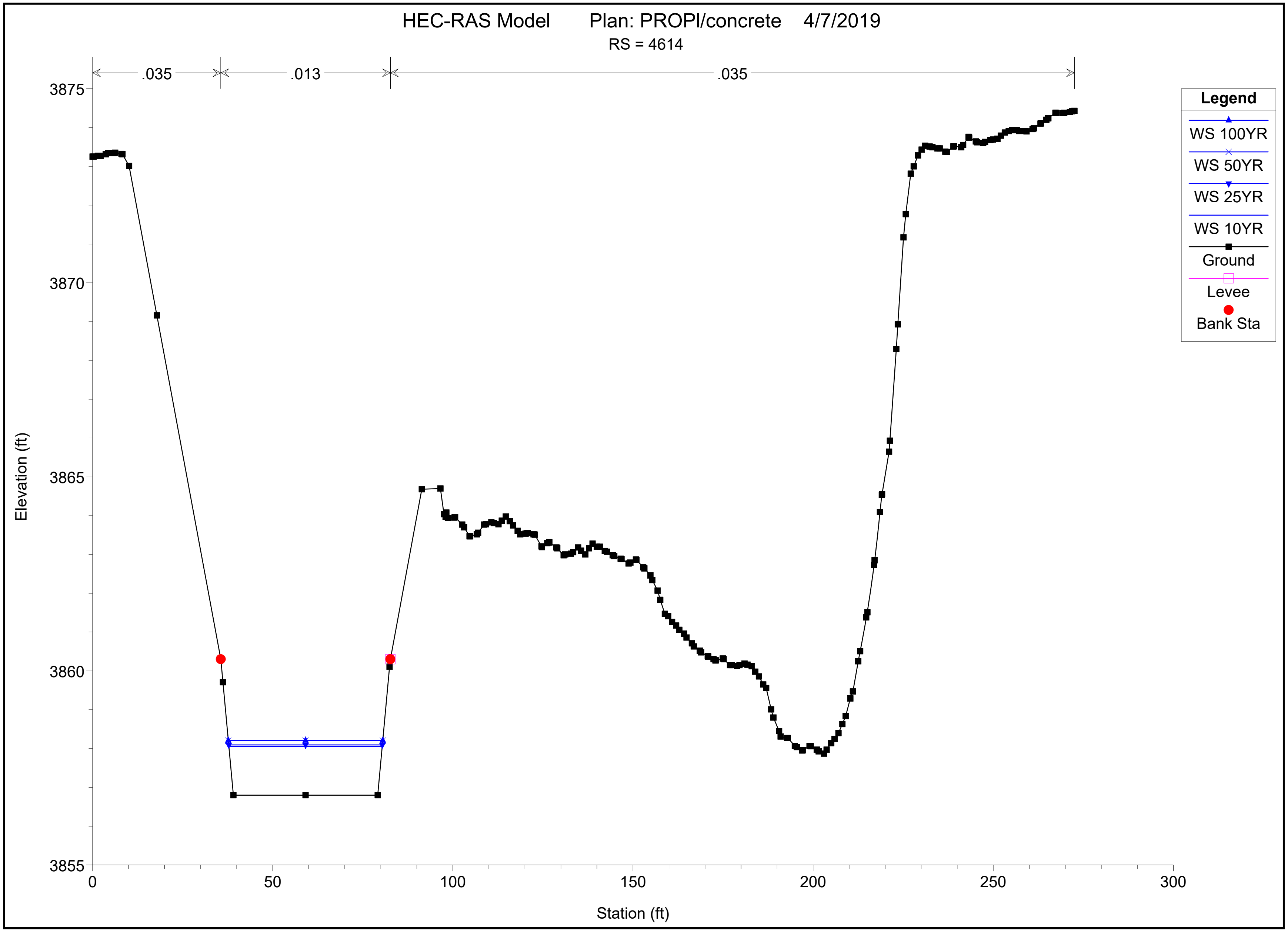


HEC-RAS Model Plan: PROPI/concrete 4/7/2019
RS = 4806
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3878
3876
3874
3872
3870
3868
3866
3864
0
50
100
150
200
250
Station (ft)

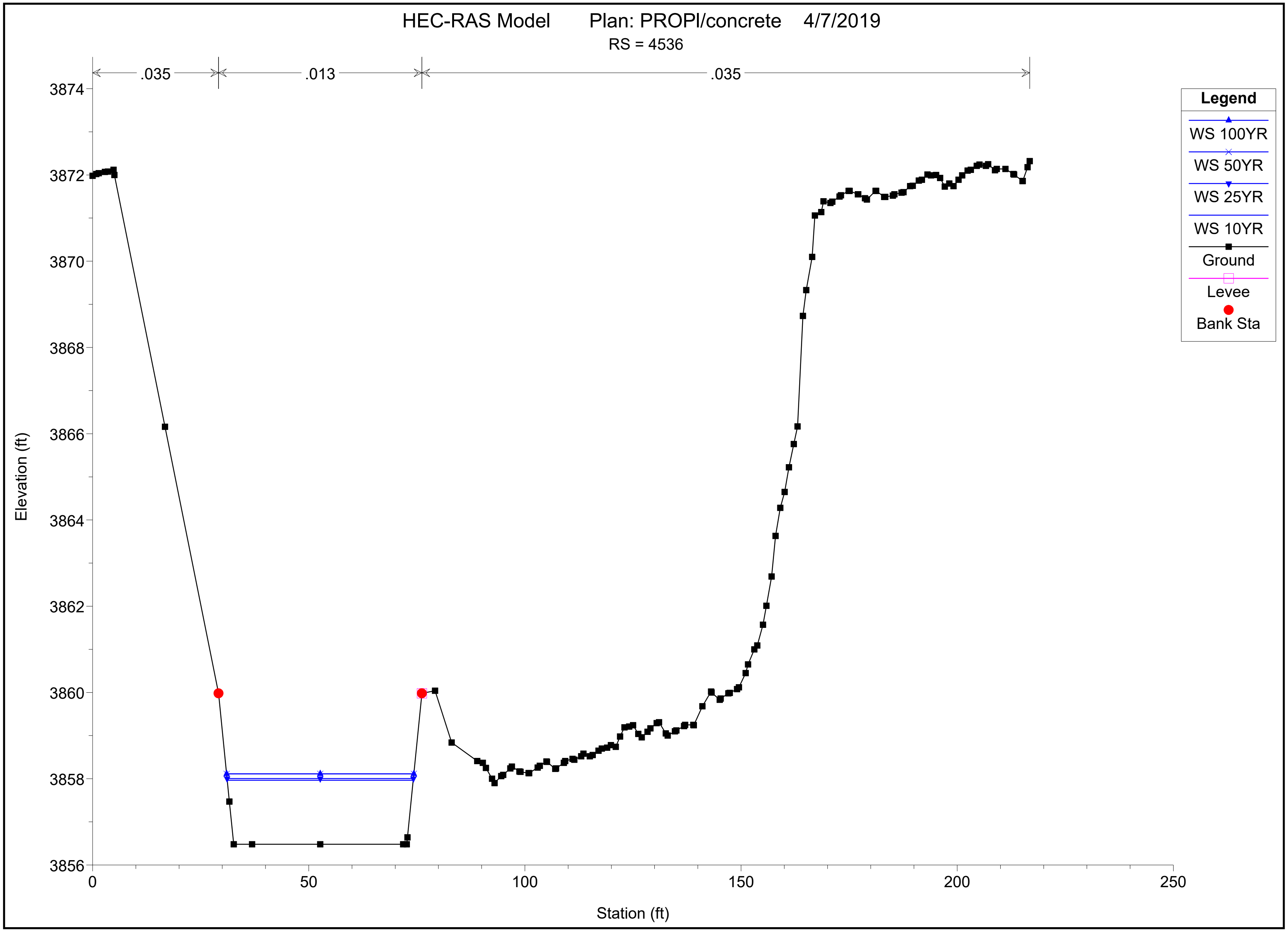


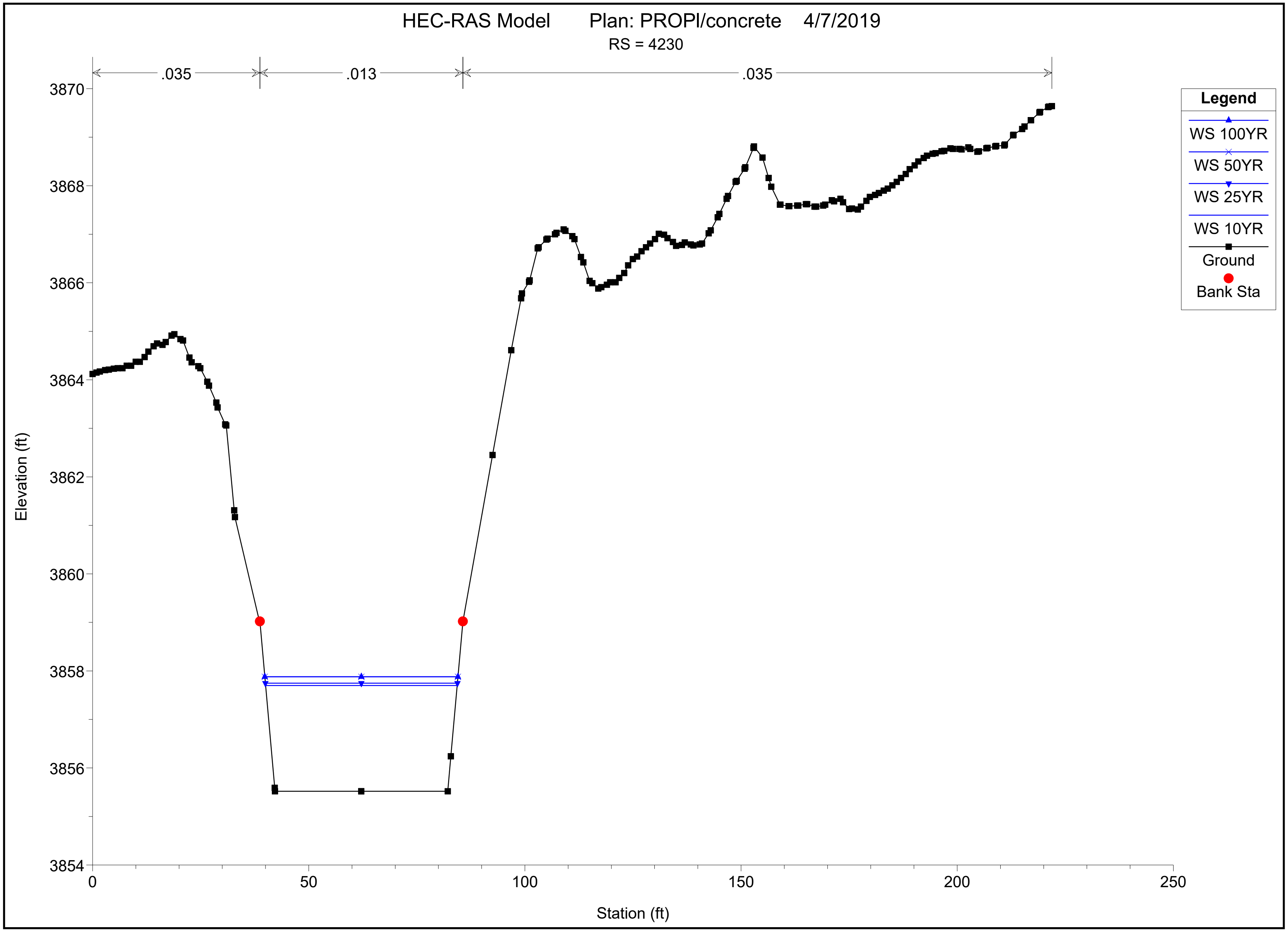
HEC-RAS Model Plan: PROPl/concrete 4/7/2019
RS = 4748
.035
.013
.035
3880
3875
3870
3865
3860
3855
Elevation (ft)
0
50
100
150
200
250
300
Station (ft)
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta

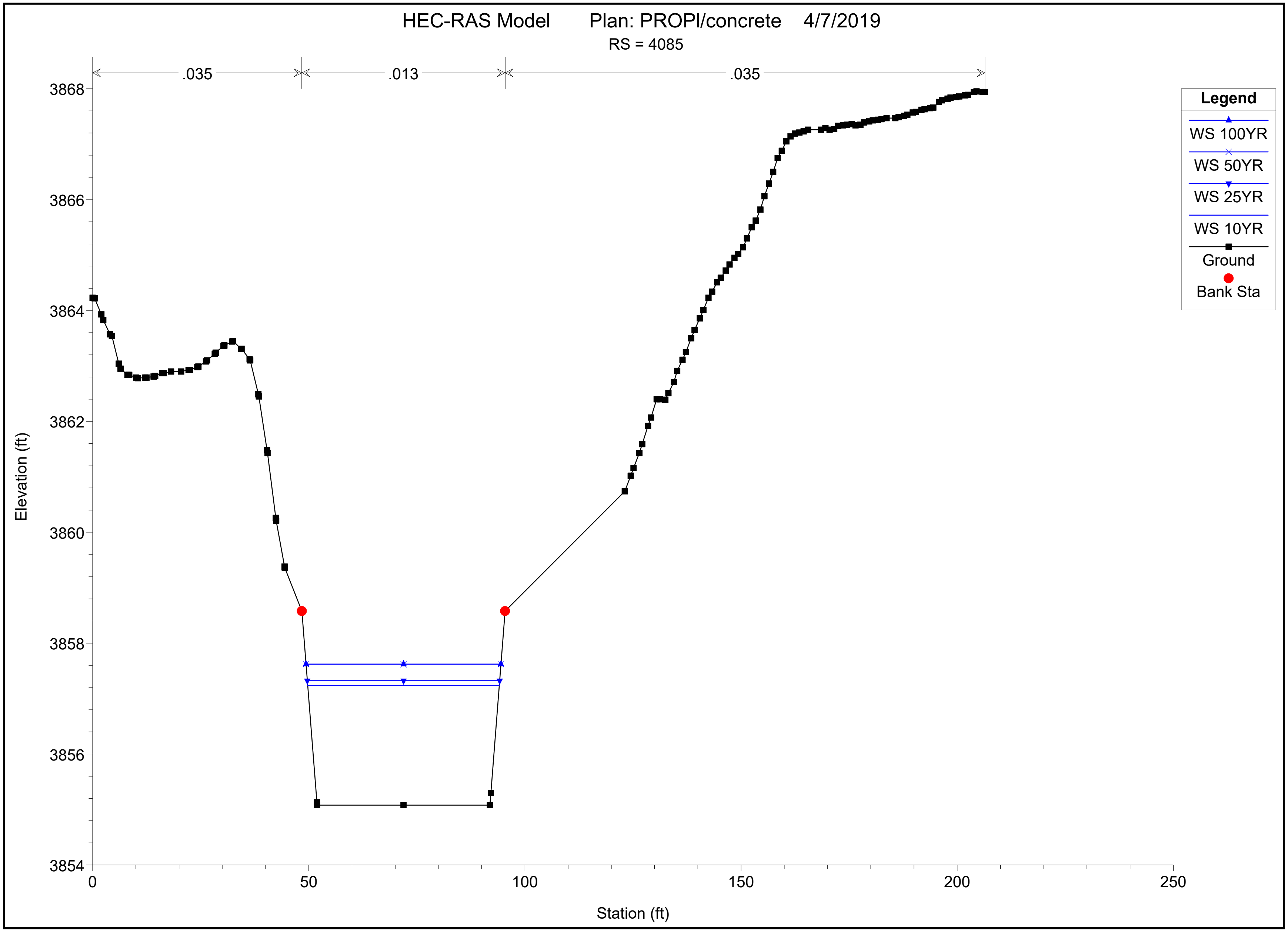

HEC-RAS Model Plan: PROPl/concrete 4/7/2019
RS = 4675
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
3855
3860
3865
3870
3875
3880
0
50
100
150
200
250
300

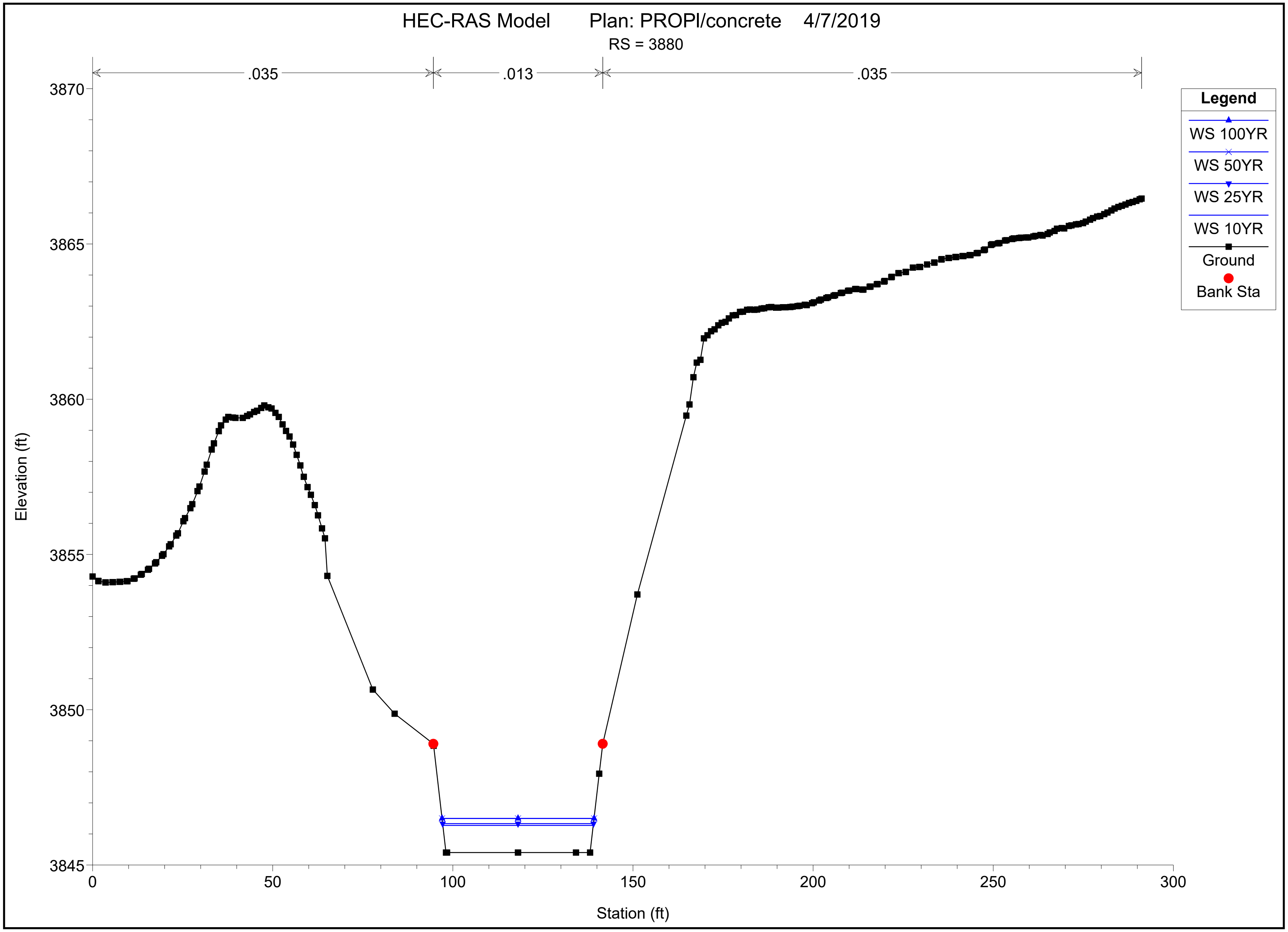


HEC-RAS Model Plan: PROPI/concrete 4/7/2019
RS = 4614
.035
.013
.035
3875
3870
3865
3860
3855
Elevation (ft)
0
50
100
150
200
250
300
Station (ft)
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta

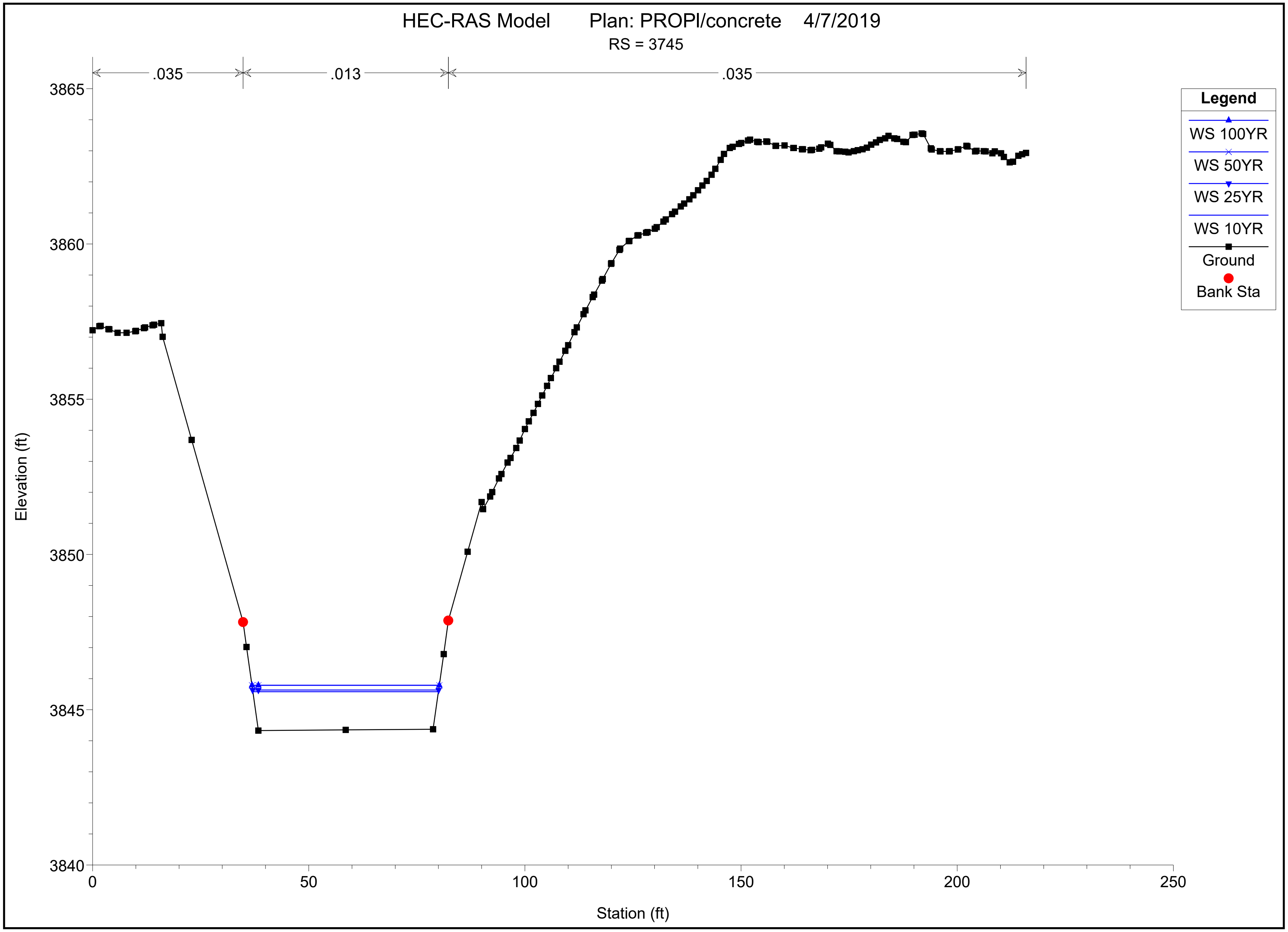

HEC-RAS Model Plan: PROPl/concrete 4/7/2019
RS = 4536
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
3874
3872
3870
3868
3866
3864
3862
3860
3858
3856
0
50
100
150
200
250


HEC-RAS Model Plan: PROPI/concrete 4/7/2019
RS = 4230
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3870
3868
3866
3864
3862
3860
3858
3856
3854
0
50
100
150
200
250
Station (ft)

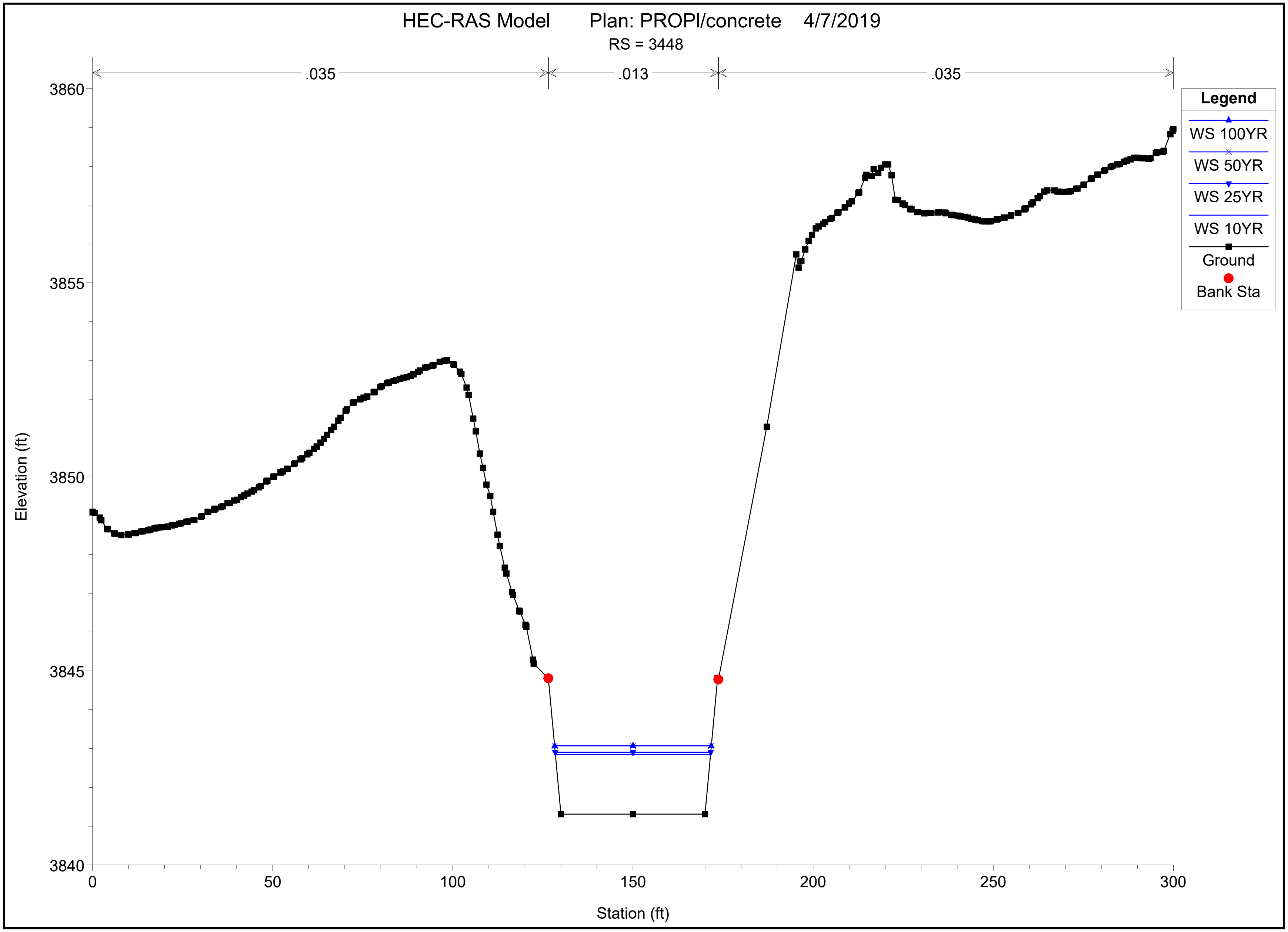

HEC-RAS Model Plan: PROPl/concrete 4/7/2019
RS = 4085
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3868
3866
3864
3862
3860
3858
3856
3854
0
50
100
150
200
250
Station (ft)

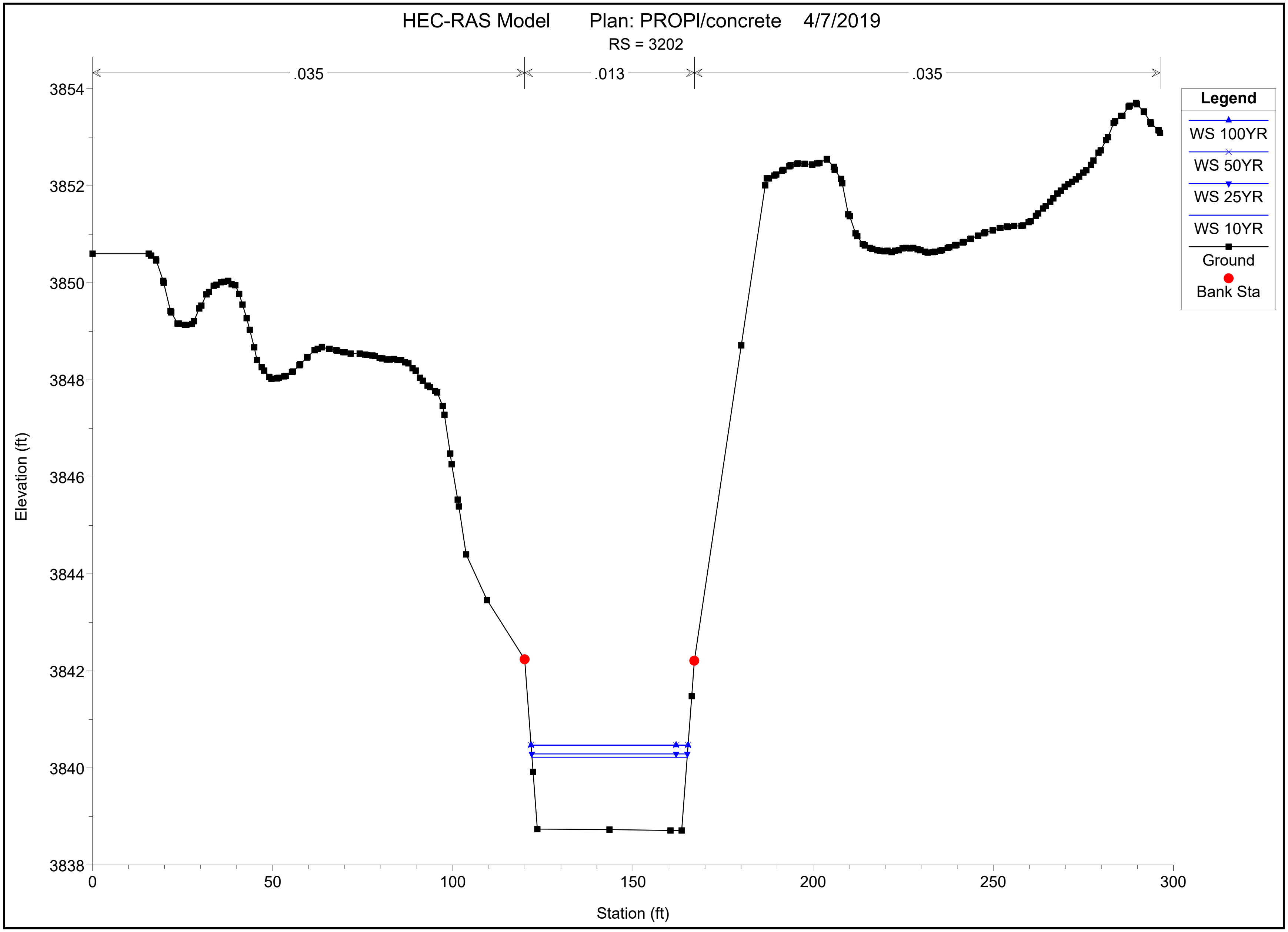


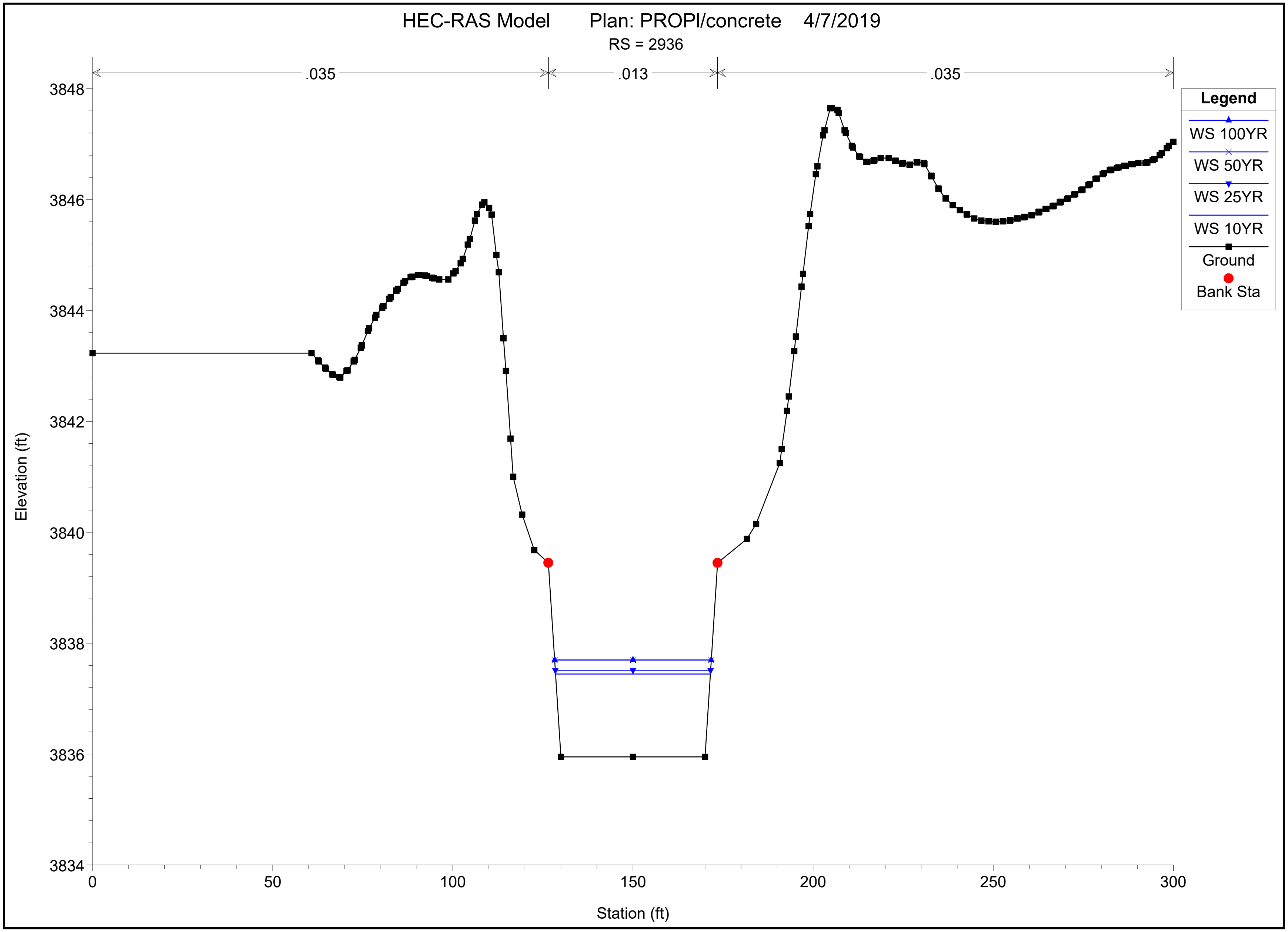
HEC-RAS Model Plan: PROPl/concrete 4/7/2019
RS = 3880
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3870
3865
3860
3855
3850
3845
0
50
100
150
200
250
300
Station (ft)

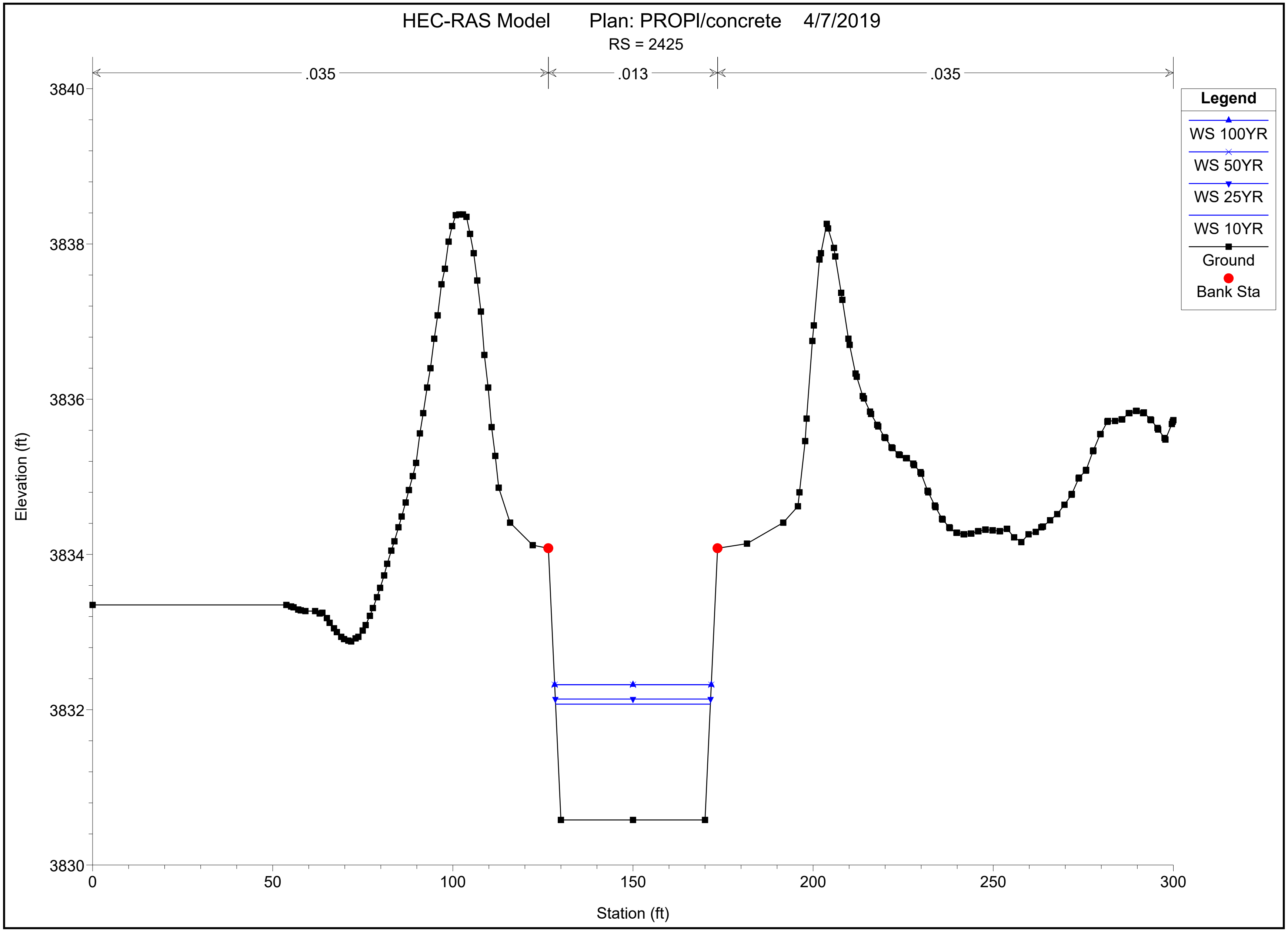


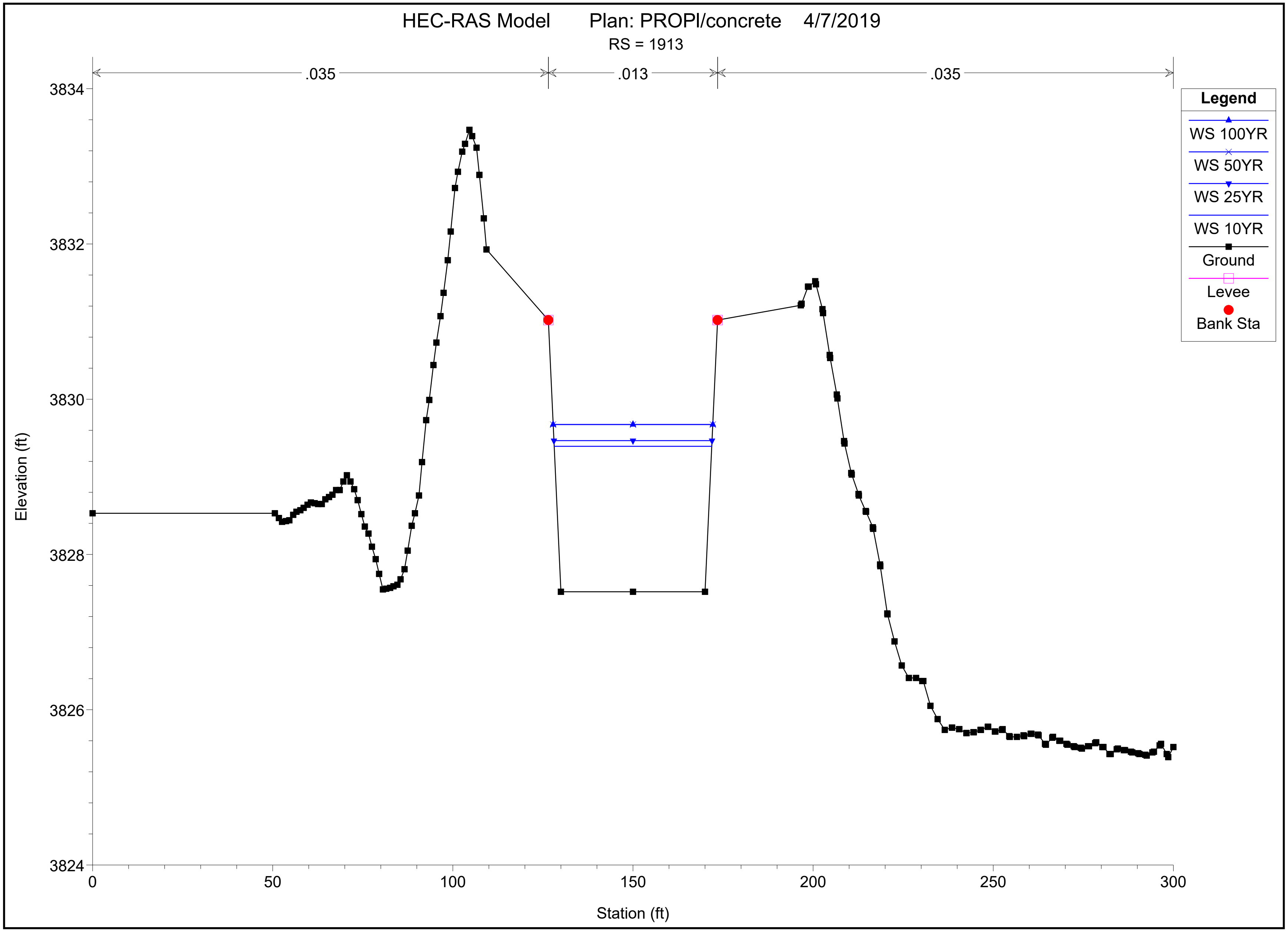
HEC-RAS Model Plan: PROPl/concrete 4/7/2019
RS = 3745
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3865
3860
3855
3850
3845
3840
0
50
100
150
200
250
Station (ft)


HEC-RAS Model Plan: PROPI/concrete 4/7/2019
RS = 3448
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
3860
3855
3850
3845
3840
Elevation (ft)
0
50
100
150
200
250
300
Station (ft)

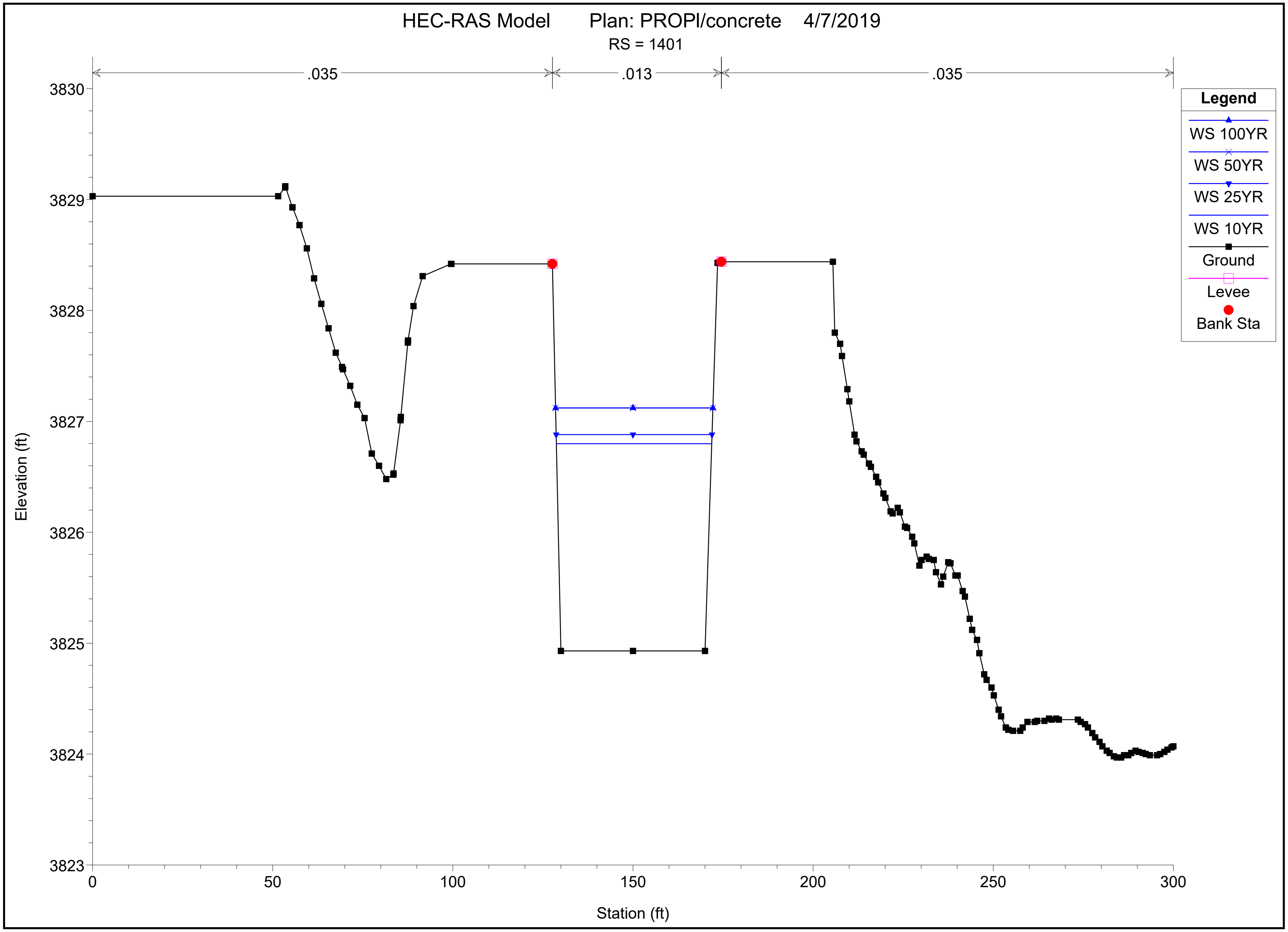

HEC-RAS Model Plan: PROPI/concrete 4/7/2019
RS = 3202
.035
.013
.035
Elevation (ft)
Station (ft)
3838
3840
3842
3844
3846
3848
3850
3852
3854
0
50
100
150
200
250
300
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta


HEC-RAS Model Plan: PROPI/concrete 4/7/2019
RS = 2936
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3848
3846
3844
3842
3840
3838
3836
3834
0
50
100
150
200
250
300
Station (ft)

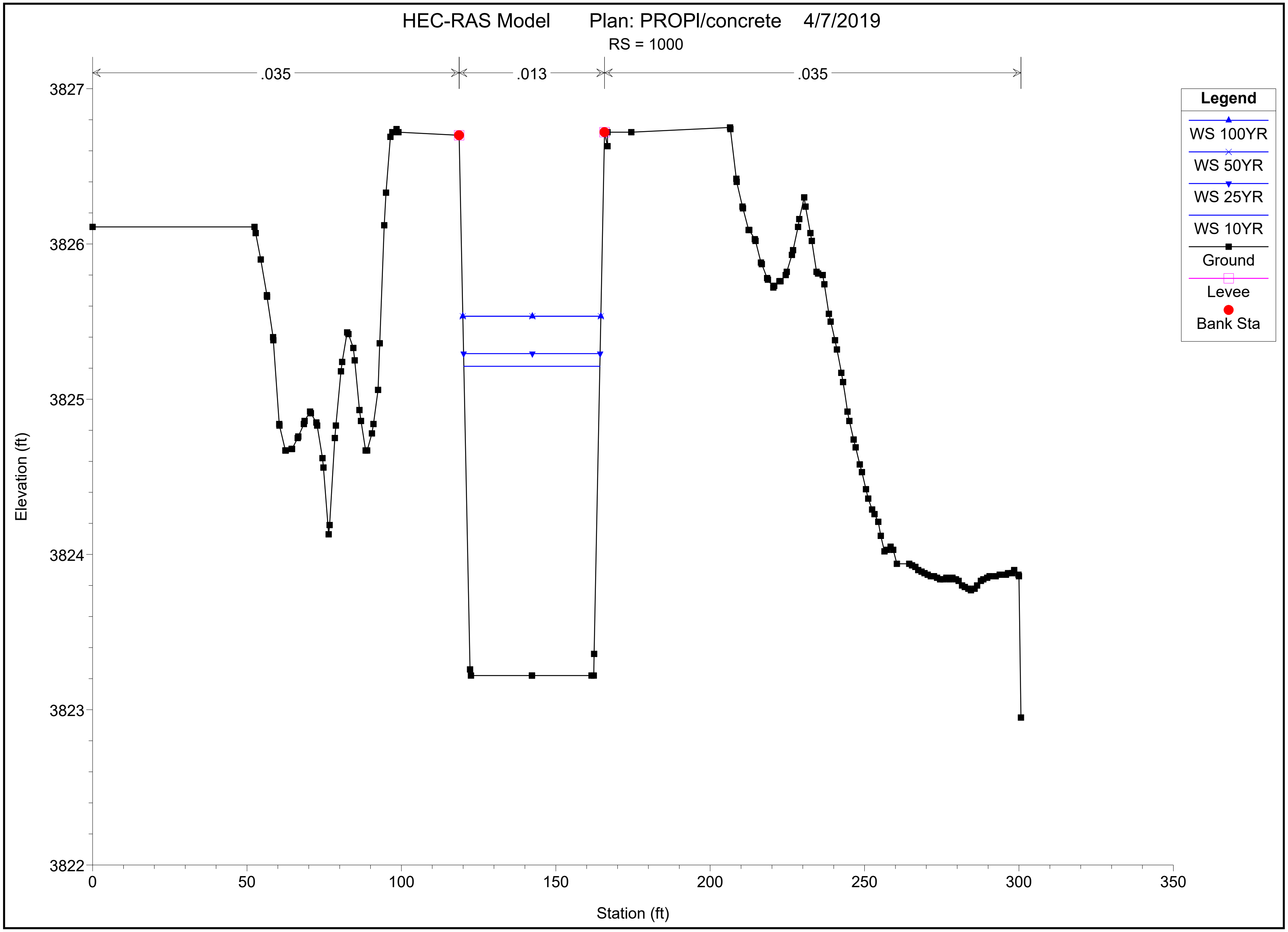

HEC-RAS Model Plan: PROPl/concrete 4/7/2019
RS = 2425
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
3840
3838
3836
3834
3832
3830
Elevation (ft)
0
50
100
150
200
250
300
Station (ft)



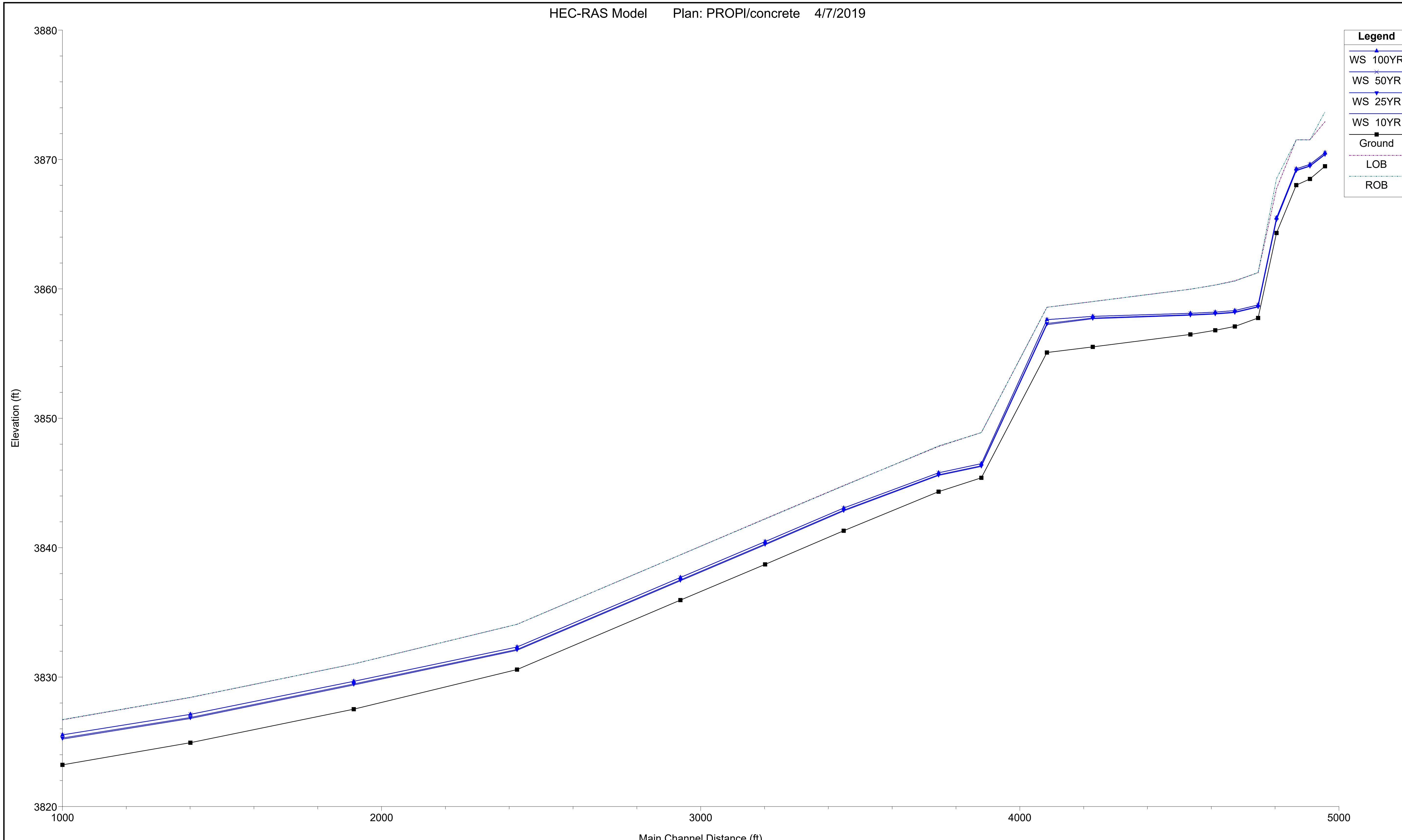
HEC-RAS Model Plan: PROPl/concrete 4/7/2019
RS = 1913
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3834
3832
3830
3828
3826
3824
0
50
100
150
200
250
300
Station (ft)



HEC-RAS Model Plan: PROPl/concrete 4/7/2019
RS = 1401
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3830
3829
3828
3827
3826
3825
3824
3823
0
50
100
150
200
250
300
Station (ft)



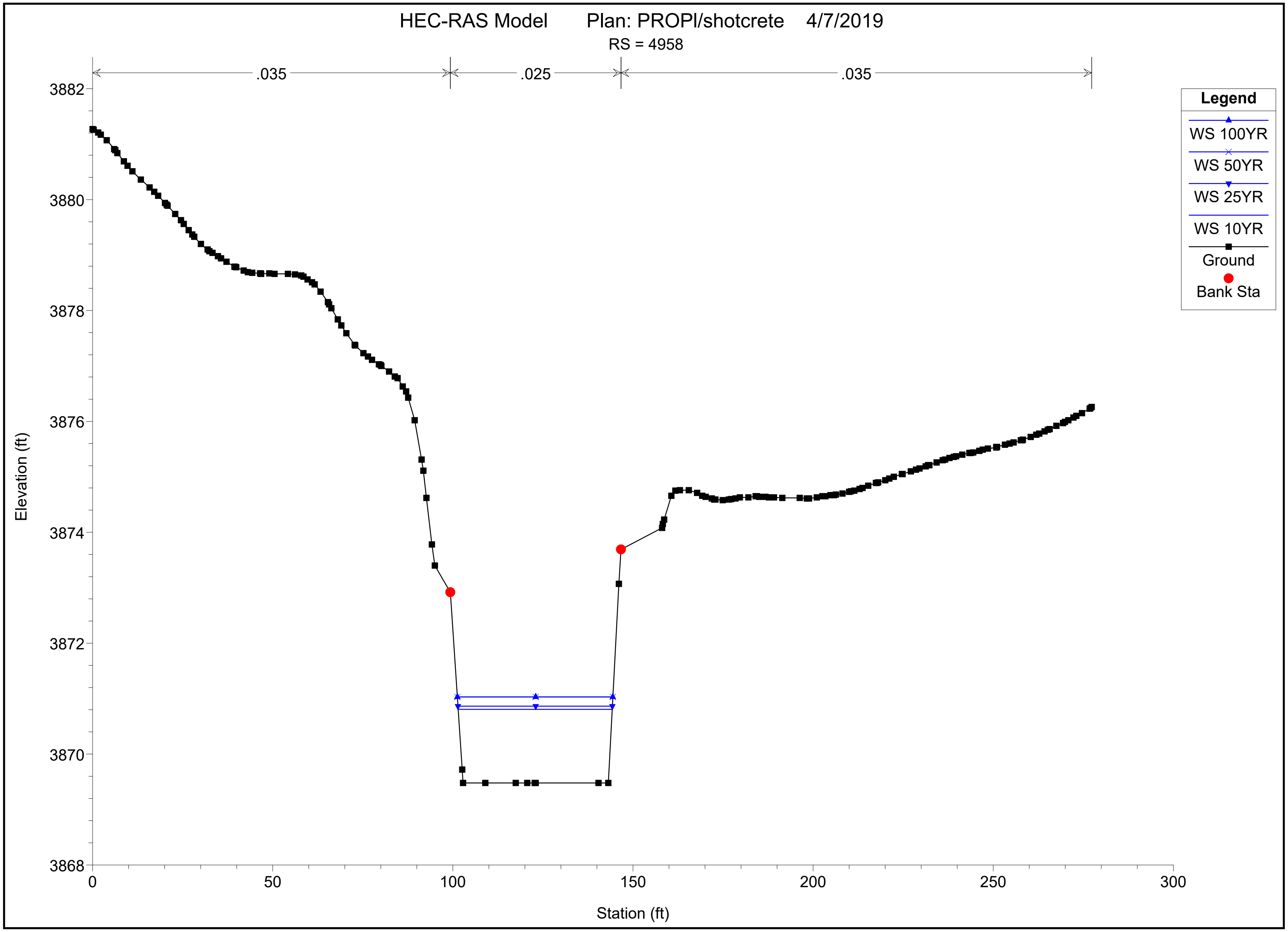
HEC-RAS Model Plan: PROPI/concrete 4/7/2019
RS = 1000
.035
.013
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3827
3826
3825
3824
3823
3822
Station (ft)
0
50
100
150
200
250
300
350

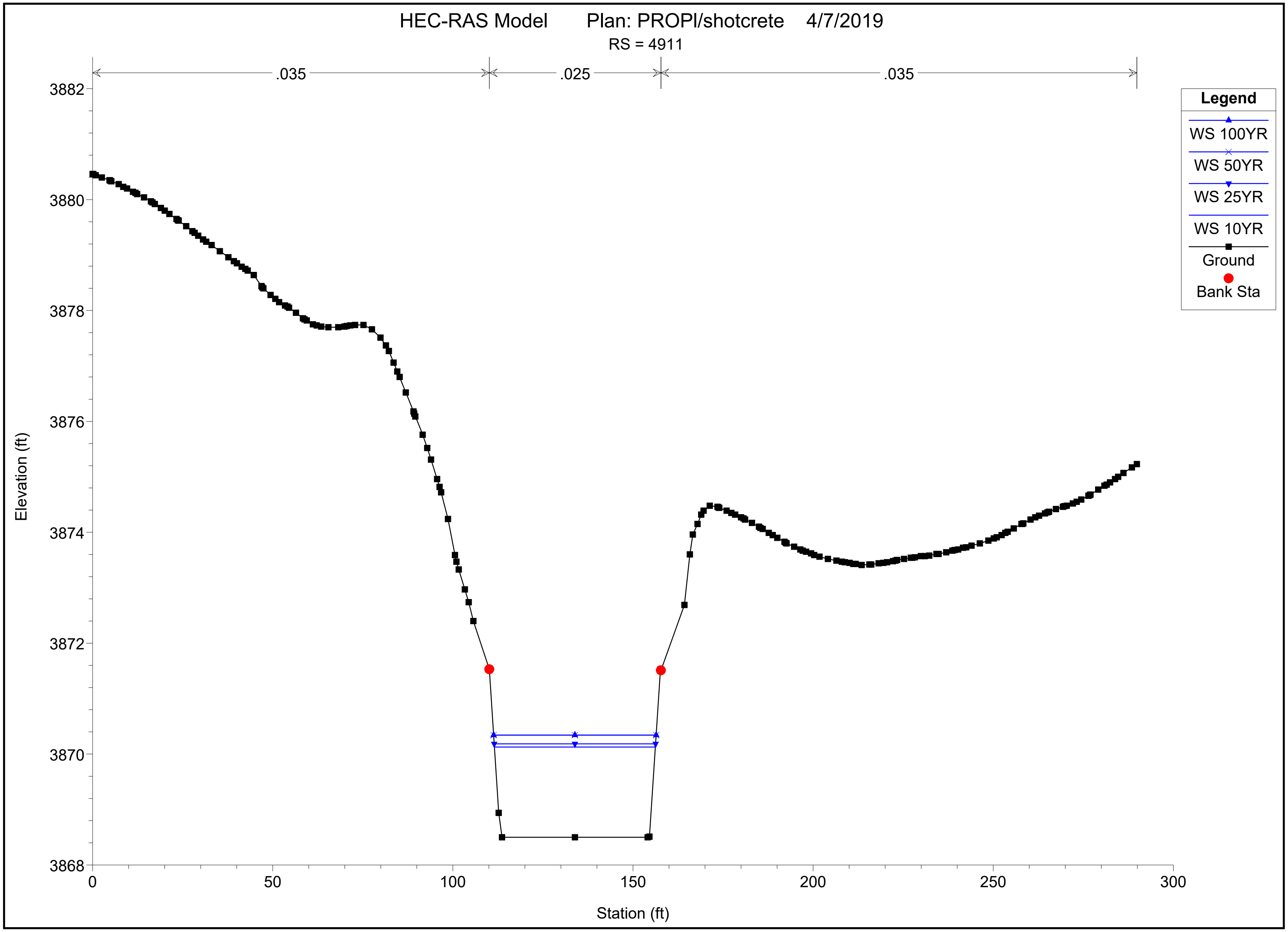


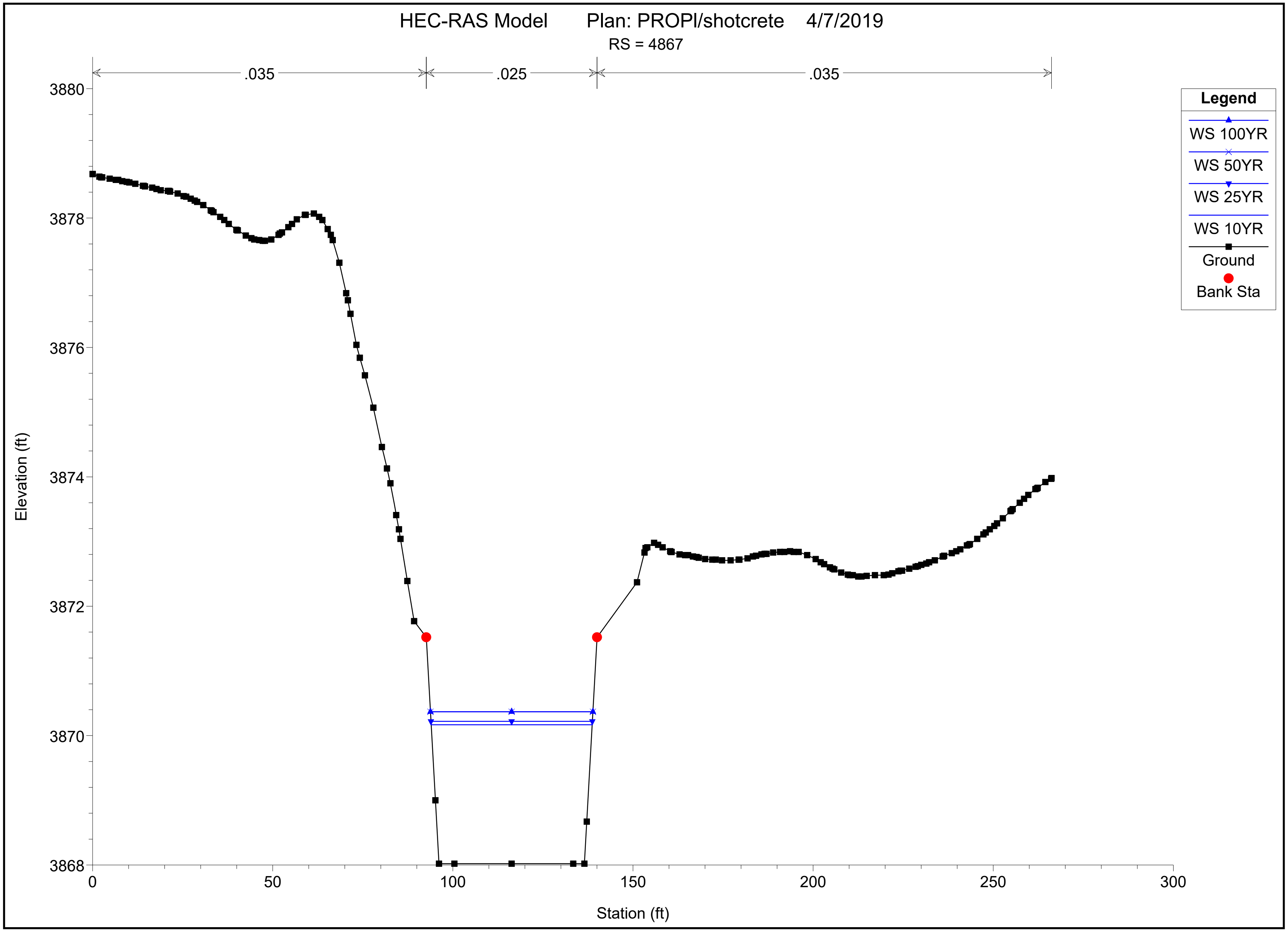
HEC-RAS Model Plan: PROPl/concrete 4/7/2019
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
LOB
ROB
Elevation (ft)
3880
3870
3860
3850
3840
3830
3820
1000
2000
3000
4000
5000
Main Channel Distance (ft)

# Proposed Conditions HEC-RAS 1D Hydraulic Models (V5.0.7) Output for Shotcrete Lined Channel

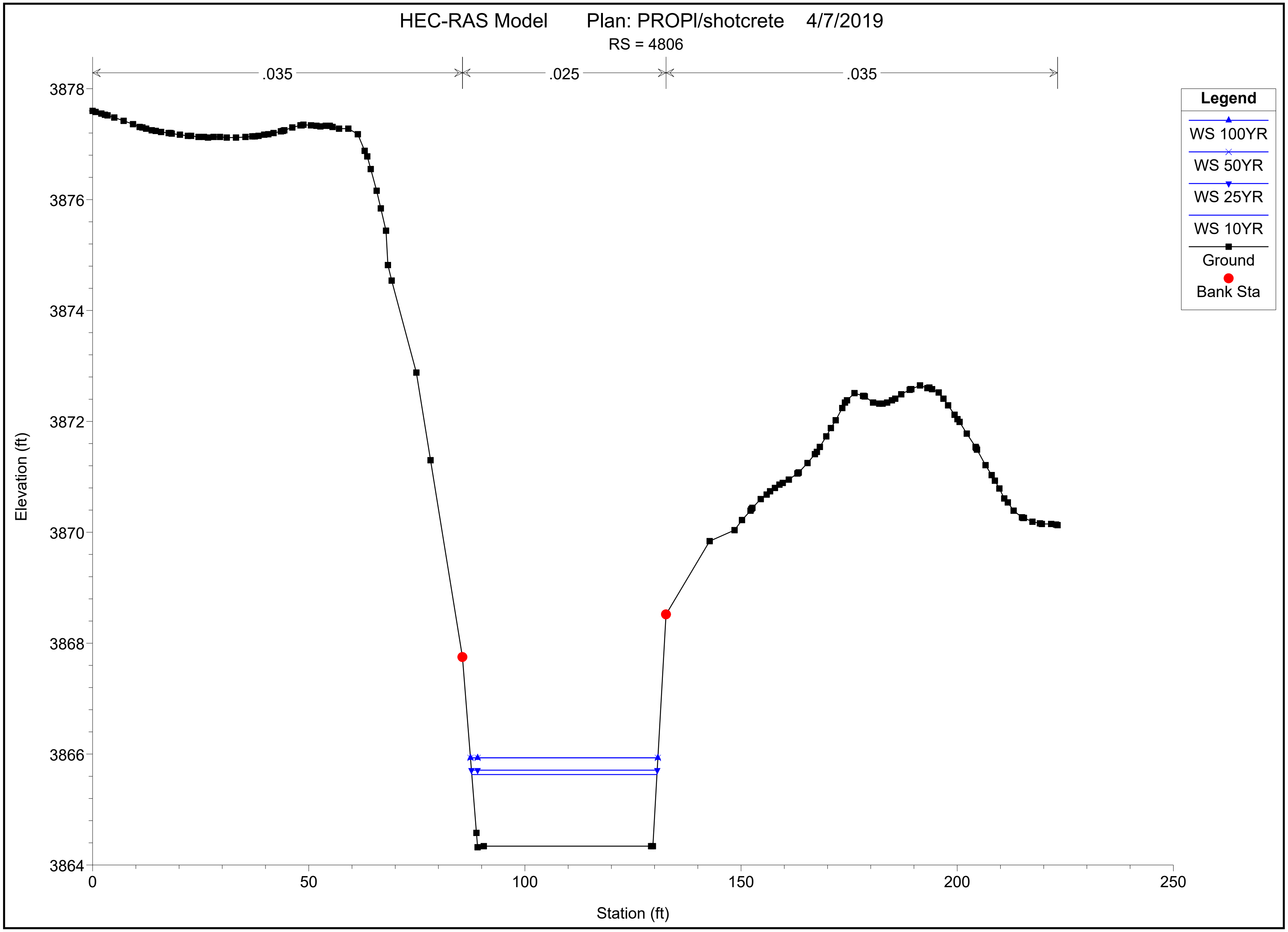
| PROPOSED CONDTIONS (SHOTCRETE LINING) HEC-RAS OUTPUT | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl | Mann Wtd Total | Power Total | Shear Chan | Invert Slope |
| | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | | | (lb/ft s) | (lb/sq ft) | |
| 4958 | 10YR | 908 | 3869.48 | 3870.81 | 3871.93 | 3875.02 | 0.05667 | 16.47 | 55.14 | 42.75 | 2.56 | 0.025 | 73.13 | 4.44 | 0.0208 |
| 4958 | 100YR | 1175 | 3869.48 | 3871.03 | 3872.38 | 3876.16 | 0.05674 | 18.16 | 64.7 | 43.16 | 2.62 | 0.025 | 93.46 | 5.15 | 0.0208 |
| 4911 | 10YR | 908 | 3868.5 | 3870.13 | 3870.91 | 3872.75 | 0.027242 | 12.98 | 69.93 | 44.68 | 1.83 | 0.025 | 33.62 | 2.59 | 0.0112 |
| 4911 | 100YR | 1175 | 3868.5 | 3870.34 | 3871.35 | 3873.73 | 0.030143 | 14.76 | 79.61 | 45.11 | 1.96 | 0.025 | 47.51 | 3.22 | 0.0112 |
| 4867 | 10YR | 908 | 3868.02 | 3870.17 | 3870.47 | 3871.7 | 0.011358 | 9.94 | 91.35 | 44.7 | 1.23 | 0.025 | 13.86 | 1.39 | 0.0599 |
| 4867 | 100YR | 1175 | 3868.02 | 3870.37 | 3870.91 | 3872.5 | 0.014093 | 11.7 | 100.43 | 45.11 | 1.38 | 0.025 | 21.98 | 1.88 | 0.0599 |
| 4806 | 10YR | 908 | 3864.32 | 3865.63 | 3866.79 | 3870.05 | 0.061505 | 16.86 | 53.85 | 42.83 | 2.65 | 0.025 | 79.19 | 4.7 | 0.1138 |
| 4806 | 100YR | 1175 | 3864.32 | 3865.93 | 3867.24 | 3870.73 | 0.05128 | 17.57 | 66.87 | 43.36 | 2.49 | 0.025 | 83.91 | 4.78 | 0.1138 |
| 4748 | 10YR | 908 | 3857.75 | 3858.85 | 3860.22 | 3865.21 | 0.109859 | 20.23 | 44.89 | 42.25 | 3.46 | 0.025 | 144.33 | 7.14 | 0.0089 |
| 4748 | 100YR | 1175 | 3857.75 | 3859.07 | 3860.67 | 3866.43 | 0.101418 | 21.77 | 53.97 | 42.67 | 3.41 | 0.025 | 170.04 | 7.81 | 0.0089 |
| 4675 | 10YR | 908 | 3857.1 | 3858.94 | 3859.59 | 3861.12 | 0.019723 | 11.85 | 76.62 | 43.78 | 1.58 | 0.025 | 24.69 | 2.08 | 0.0049 |
| 4675 | 100YR | 1175 | 3857.1 | 3859.16 | 3860.04 | 3862.04 | 0.022714 | 13.63 | 86.19 | 44.21 | 1.72 | 0.025 | 36.3 | 2.66 | 0.0049 |
| 4614 | 10YR | 908 | 3856.8 | 3859.89 | 3859.28 | 3860.61 | 0.003444 | 6.81 | 133.24 | 46.24 | 0.71 | 0.025 | 4 | 0.59 | 0.0041 |
| 4614 | 100YR | 1175 | 3856.8 | 3860.38 | 3859.72 | 3861 | 0.002711 | 6.62 | 210.39 | 89.54 | 0.64 | 0.025 | 2.13 | 0.53 | 0.0041 |
| 4536 | 10YR | 908 | 3856.48 | 3859.67 | 3858.96 | 3860.34 | 0.003098 | 6.59 | 137.85 | 46.44 | 0.67 | 0.025 | 3.58 | 0.54 | 0.0031 |
| 4536 | 100YR | 1175 | 3856.48 | 3860.38 | 3859.41 | 3860.77 | 0.001637 | 5.47 | 279.96 | 122.42 | 0.51 | 0.025 | 0.95 | 0.35 | 0.0031 |
| 4230 | 10YR | 908 | 3855.52 | 3858.75 | | 3859.41 | 0.002988 | 6.51 | 139.38 | 46.41 | 0.66 | 0.025 | 3.45 | 0.53 | 0.0031 |
| 4230 | 100YR | 1175 | 3855.52 | 3859.25 | | 3860.06 | 0.003029 | 7.21 | 163.18 | 48.13 | 0.68 | 0.025 | 4.35 | 0.62 | 0.0031 |
| 4085 | 10YR | 908 | 3855.08 | 3857.54 | 3857.54 | 3858.72 | 0.007373 | 8.7 | 104.42 | 44.92 | 1.01 | 0.025 | 8.9 | 1.02 | 0.0471 |
| 4085 | 100YR | 1175 | 3855.08 | 3857.99 | 3857.99 | 3859.37 | 0.007074 | 9.42 | 124.74 | 45.81 | 1.01 | 0.025 | 10.76 | 1.14 | 0.0471 |
| 3880 | 10YR | 908 | 3845.4 | 3846.4 | 3847.86 | 3854.03 | 0.147389 | 22.16 | 40.98 | 42 | 3.95 | 0.025 | 195.09 | 8.8 | 0.008 |
| 3880 | 100YR | 1175 | 3845.4 | 3846.64 | 3848.31 | 3854.91 | 0.122074 | 23.07 | 50.93 | 42.47 | 3.71 | 0.025 | 205.89 | 8.92 | 0.008 |
| 3745 | 10YR | 908 | 3844.33 | 3846.41 | 3846.79 | 3848.08 | 0.013032 | 10.38 | 87.52 | 44.59 | 1.31 | 0.025 | 15.96 | 1.54 | 0.0102 |
| 3745 | 100YR | 1175 | 3844.33 | 3846.69 | 3847.24 | 3848.83 | 0.01419 | 11.72 | 100.27 | 45.17 | 1.39 | 0.025 | 22.1 | 1.89 | 0.0102 |
| 3448 | 10YR | 908 | 3841.31 | 3843.7 | 3843.77 | 3844.95 | 0.008075 | 8.95 | 101.45 | 44.79 | 1.05 | 0.025 | 9.79 | 1.09 | 0.0106 |
| 3448 | 100YR | 1175 | 3841.31 | 3844.15 | 3844.22 | 3845.6 | 0.007652 | 9.66 | 121.64 | 45.68 | 1.04 | 0.025 | 11.69 | 1.21 | 0.0106 |
| 3202 | 10YR | 908 | 3838.71 | 3840.82 | 3841.19 | 3842.46 | 0.012508 | 10.27 | 88.4 | 44.29 | 1.28 | 0.025 | 15.41 | 1.5 | 0.0104 |
| 3202 | 100YR | 1175 | 3838.71 | 3841.17 | 3841.63 | 3843.16 | 0.01262 | 11.32 | 103.78 | 44.98 | 1.31 | 0.025 | 19.7 | 1.74 | 0.0104 |
| 2936 | 10YR | 908 | 3835.95 | 3838.28 | 3838.41 | 3839.6 | 0.008859 | 9.22 | 98.51 | 44.65 | 1.09 | 0.025 | 10.78 | 1.17 | 0.0105 |
| 2936 | 100YR | 1175 | 3835.95 | 3838.67 | 3838.86 | 3840.26 | 0.008832 | 10.11 | 116.19 | 45.44 | 1.11 | 0.025 | 13.58 | 1.34 | 0.0105 |
| 2425 | 10YR | 908 | 3830.58 | 3832.7 | 3833.08 | 3834.31 | 0.012051 | 10.16 | 89.38 | 44.24 | 1.26 | 0.025 | 14.85 | 1.46 | 0.006 |
| 2425 | 100YR | 1175 | 3830.58 | 3833.06 | 3833.84 | 3834.99 | 0.011979 | 11.14 | 106.35 | 53.57 | 1.28 | 0.025 | 15.79 | 1.68 | 0.006 |
| 1913 | 10YR | 908 | 3827.52 | 3830.12 | 3830 | 3831.16 | 0.00613 | 8.2 | 110.74 | 45.2 | 0.92 | 0.025 | 7.34 | 0.9 | 0.0051 |
| 1913 | 100YR | 1175 | 3827.52 | 3830.46 | 3830.46 | 3831.81 | 0.006833 | 9.32 | 126.13 | 45.88 | 0.99 | 0.025 | 10.38 | 1.11 | 0.0051 |
| 1401 | 10YR | 908 | 3824.93 | 3828.05 | 3827.41 | 3828.77 | 0.003429 | 6.84 | 132.73 | 45.23 | 0.7 | 0.025 | 4.04 | 0.59 | 0.0043 |
| 1401 | 100YR | 1175 | 3824.93 | 3828.62 | 3827.86 | 3828.71 | 0.000558 | 3.03 | 549.49 | 241.14 | 0.29 | 0.025 | 0.16 | 0.11 | 0.0043 |
| 1000 | 10YR | 908 | 3823.22 | 3825.74 | 3825.7 | 3826.85 | 0.006777 | 8.46 | 107.29 | 45.11 | 0.97 | 0.025 | 8.14 | 0.96 | |
| 1000 | 100YR | 1175 | 3823.22 | 3826.16 | 3826.15 | 3827.5 | 0.006781 | 9.29 | 126.48 | 45.97 | 0.99 | 0.025 | 10.28 | 1.11 | |

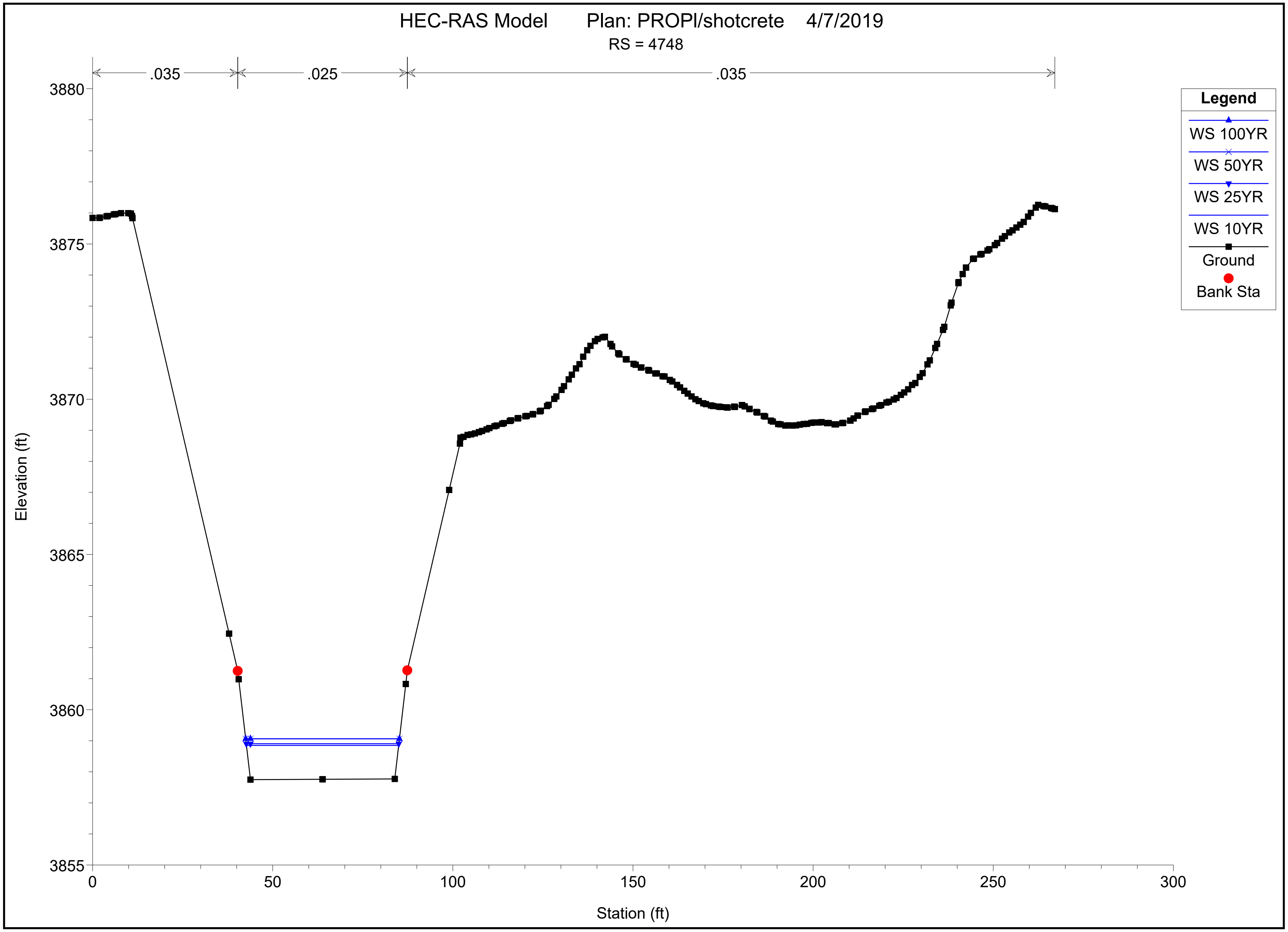

HEC-RAS Model Plan: PROPl/shotcrete 4/7/2019
RS = 4958
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3882
3880
3878
3876
3874
3872
3870
3868
0
50
100
150
200
250
300
Station (ft)

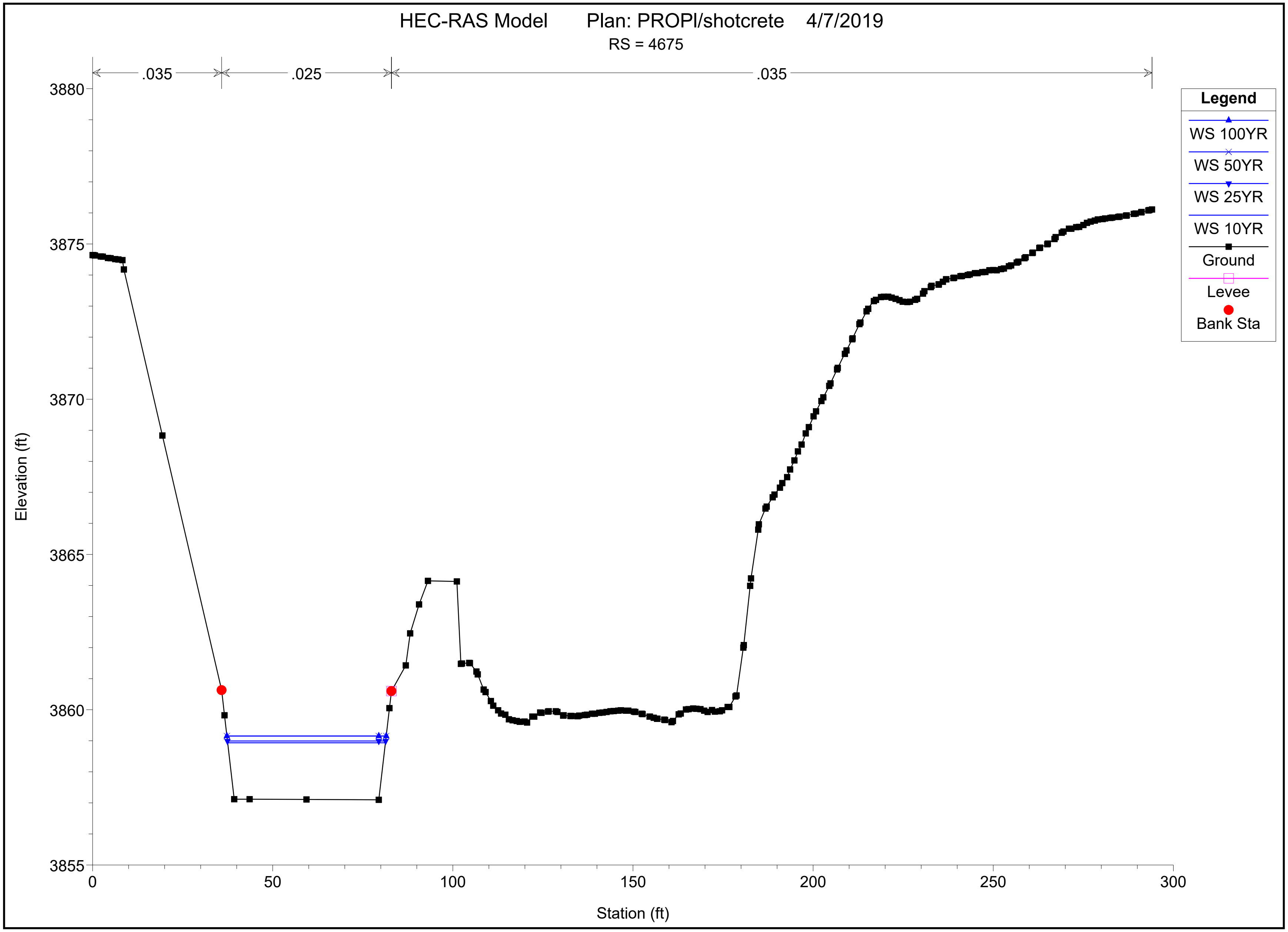

HEC-RAS Model Plan: PROPI/shotcrete 4/7/2019
RS = 4911
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3882
3880
3878
3876
3874
3872
3870
3868
0
50
100
150
200
250
300
Station (ft)

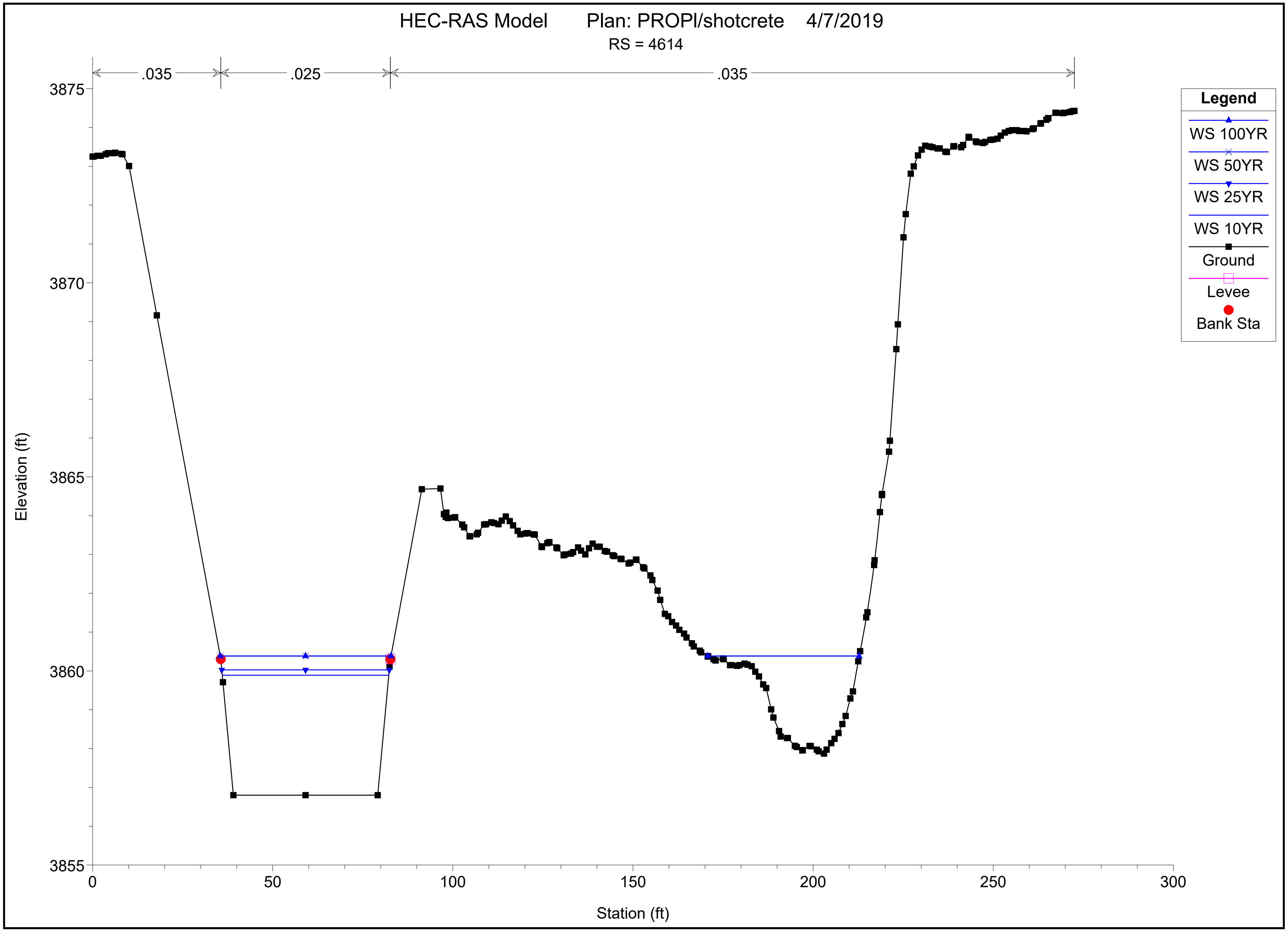


HEC-RAS Model Plan: PROPl/shotcrete 4/7/2019
RS = 4867
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3880
3878
3876
3874
3872
3870
3868
0
50
100
150
200
250
300
Station (ft)

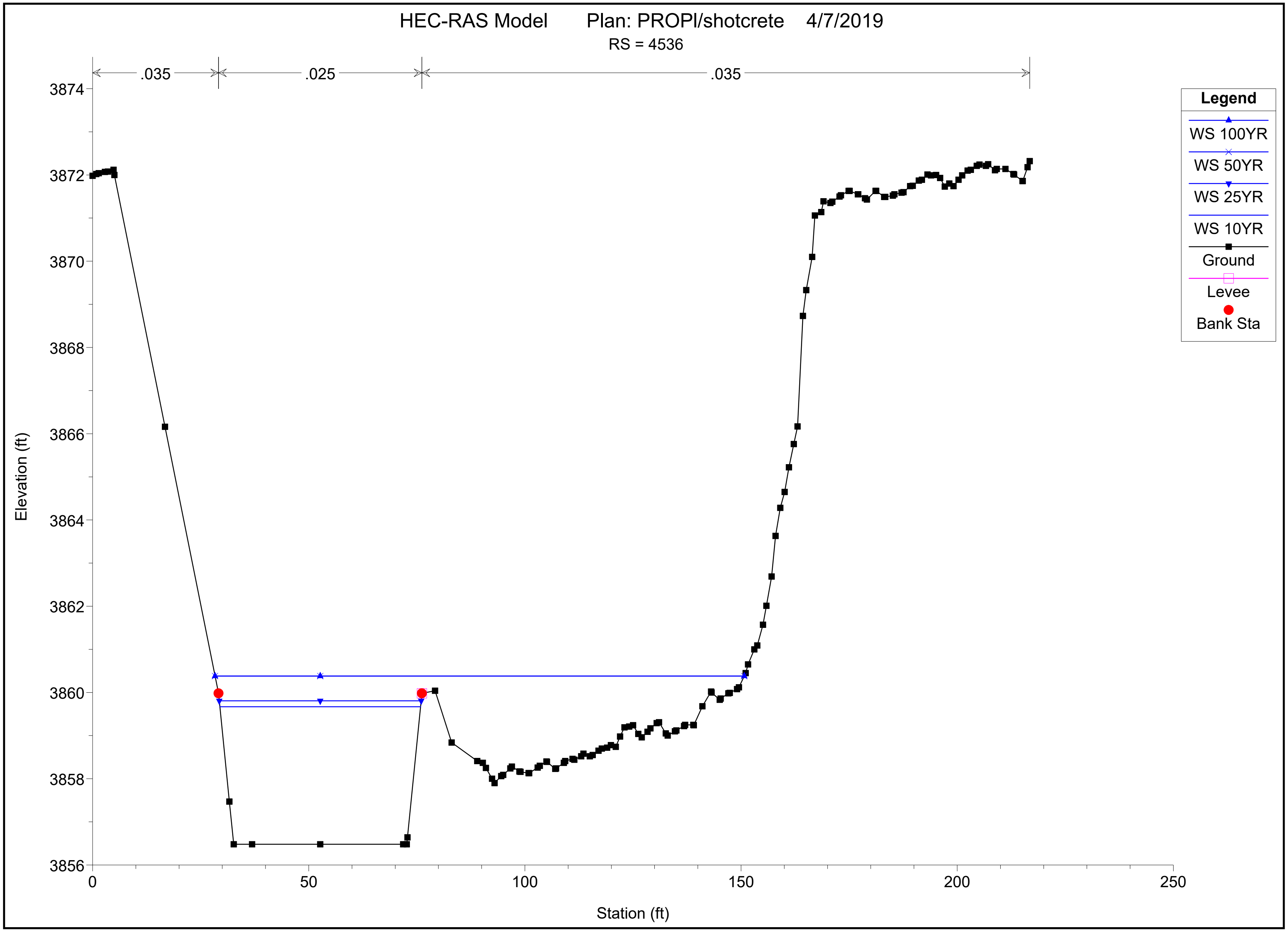

HEC-RAS Model    Plan: PROPl/shotcrete    4/7/2019
RS = 4806
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3878
3876
3874
3872
3870
3868
3866
3864
0
50
100
150
200
250
Station (ft)


HEC-RAS Model Plan: PROPl/shotcrete 4/7/2019
RS = 4748
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3880
3875
3870
3865
3860
3855
0
50
100
150
200
250
300
Station (ft)

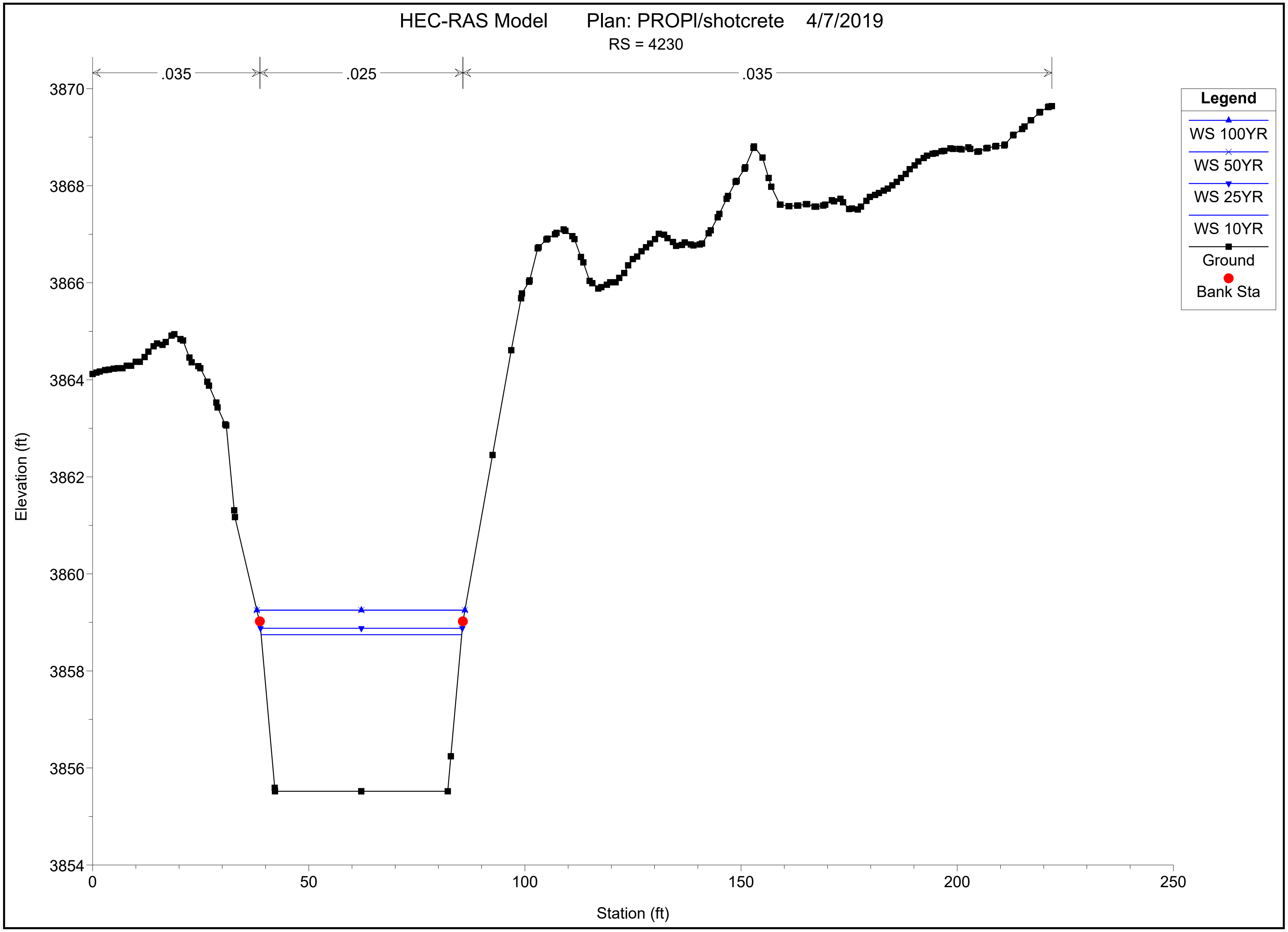

HEC-RAS Model Plan: PROPI/shotcrete 4/7/2019
RS = 4675
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
3880
3875
3870
3865
3860
3855
0
50
100
150
200
250
300



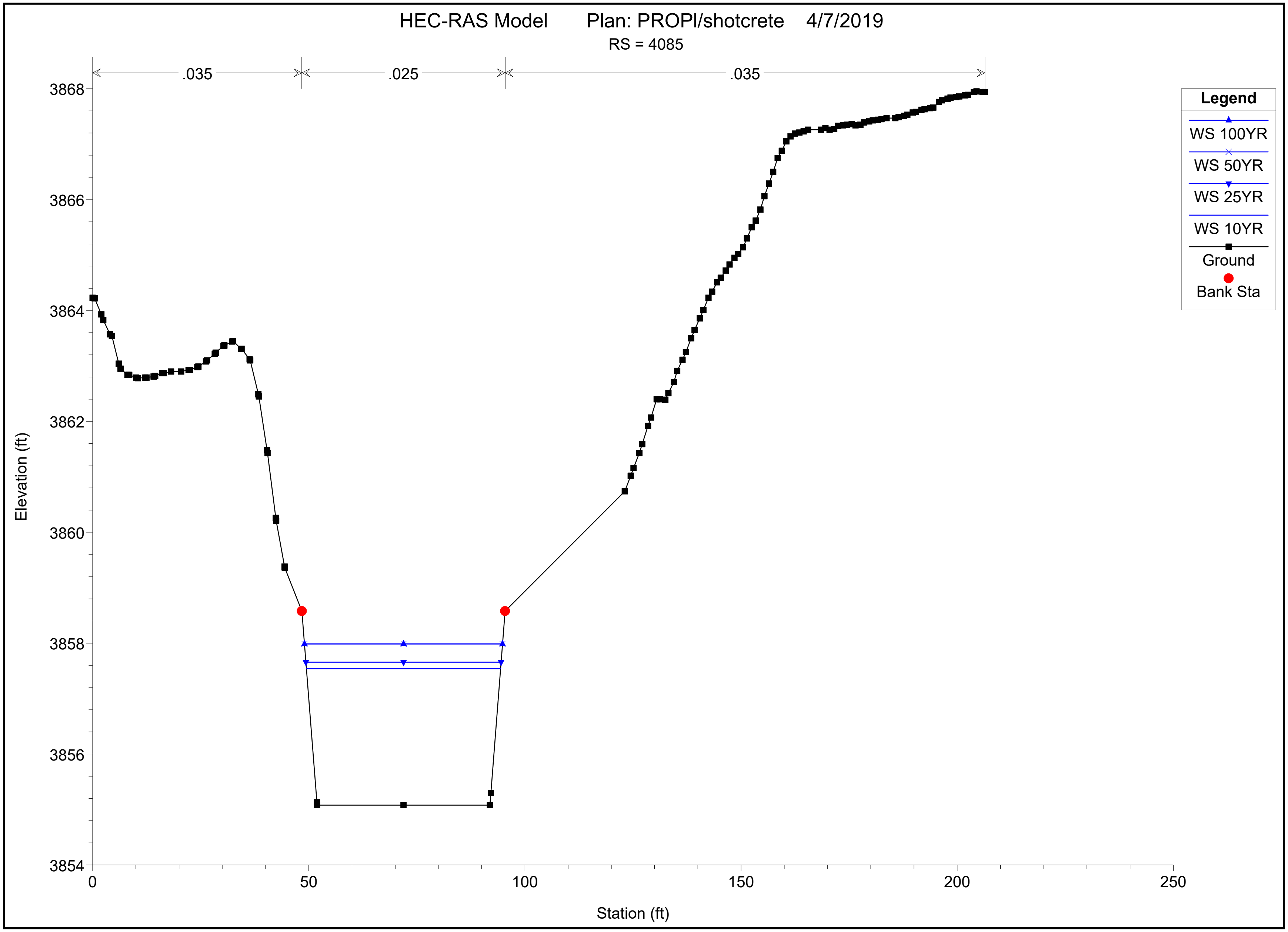
HEC-RAS Model Plan: PROPl/shotcrete 4/7/2019
RS = 4614
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3875
3870
3865
3860
3855
0
50
100
150
200
250
300
Station (ft)



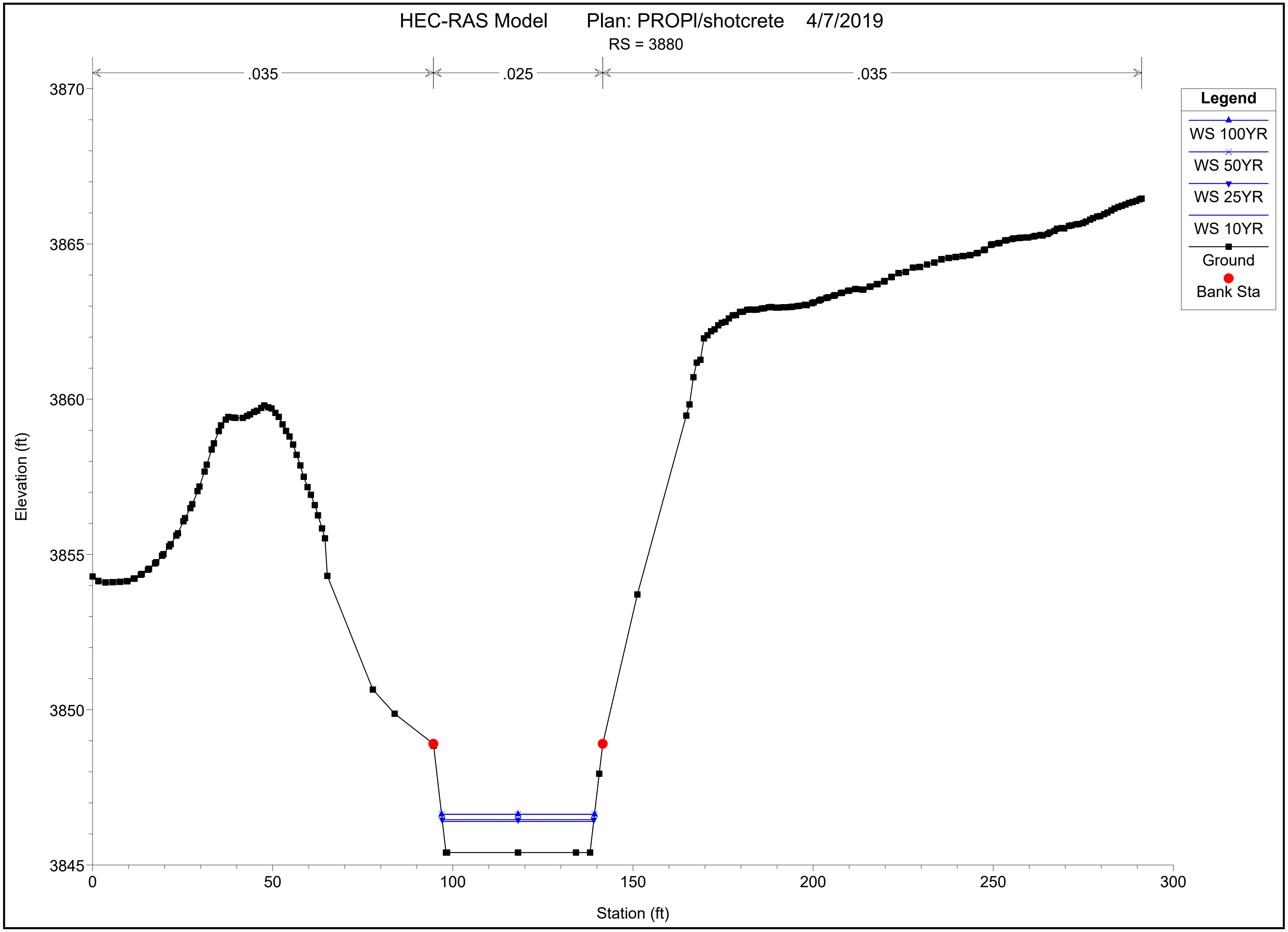
HEC-RAS Model Plan: PROPl/shotcrete 4/7/2019
RS = 4536
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3874
3872
3870
3868
3866
3864
3862
3860
3858
3856
0
50
100
150
200
250
Station (ft)

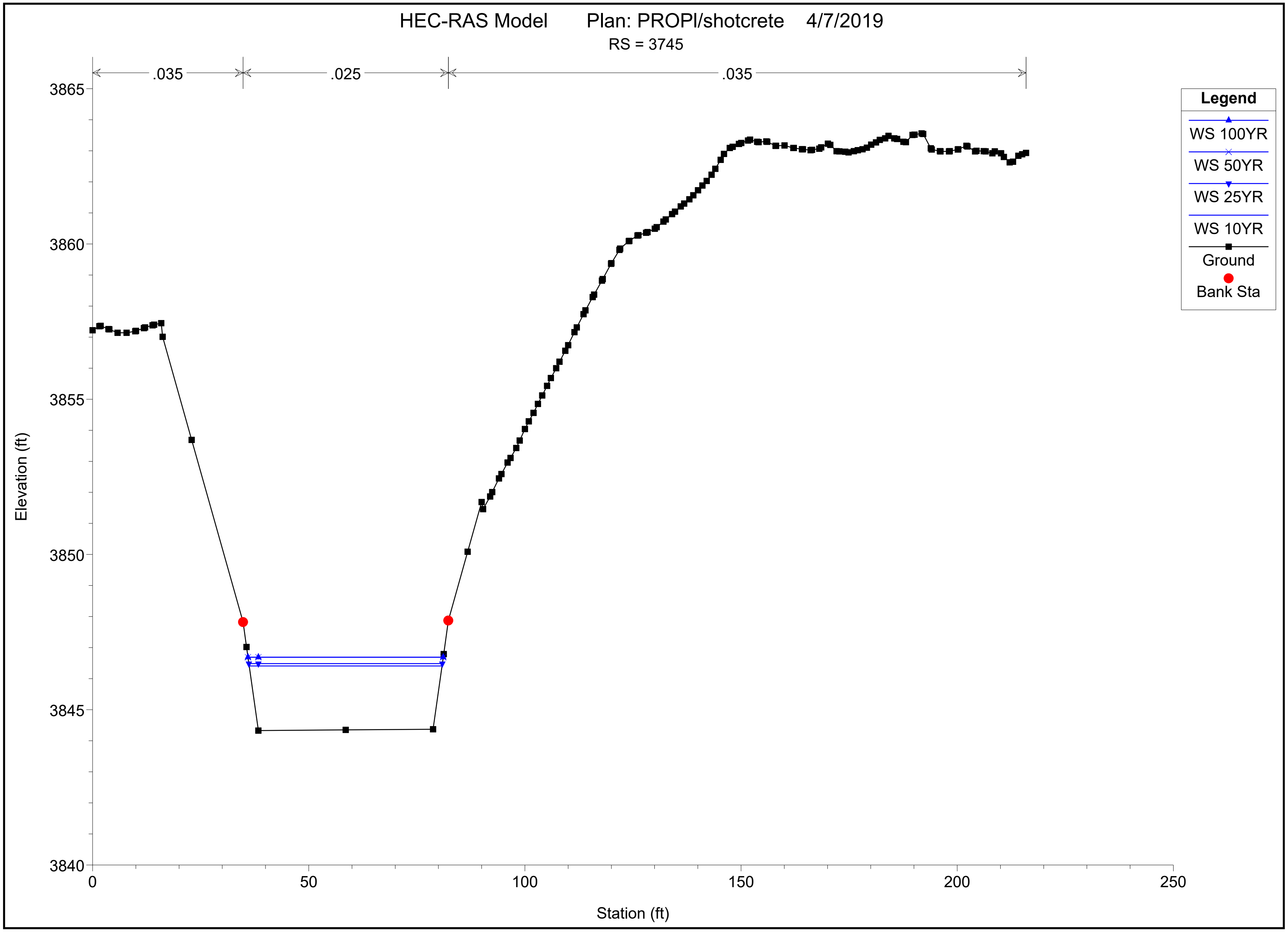


HEC-RAS Model Plan: PROPI/shotcrete 4/7/2019
RS = 4230
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
3870
3868
3866
3864
3862
3860
3858
3856
3854
0
50
100
150
200
250

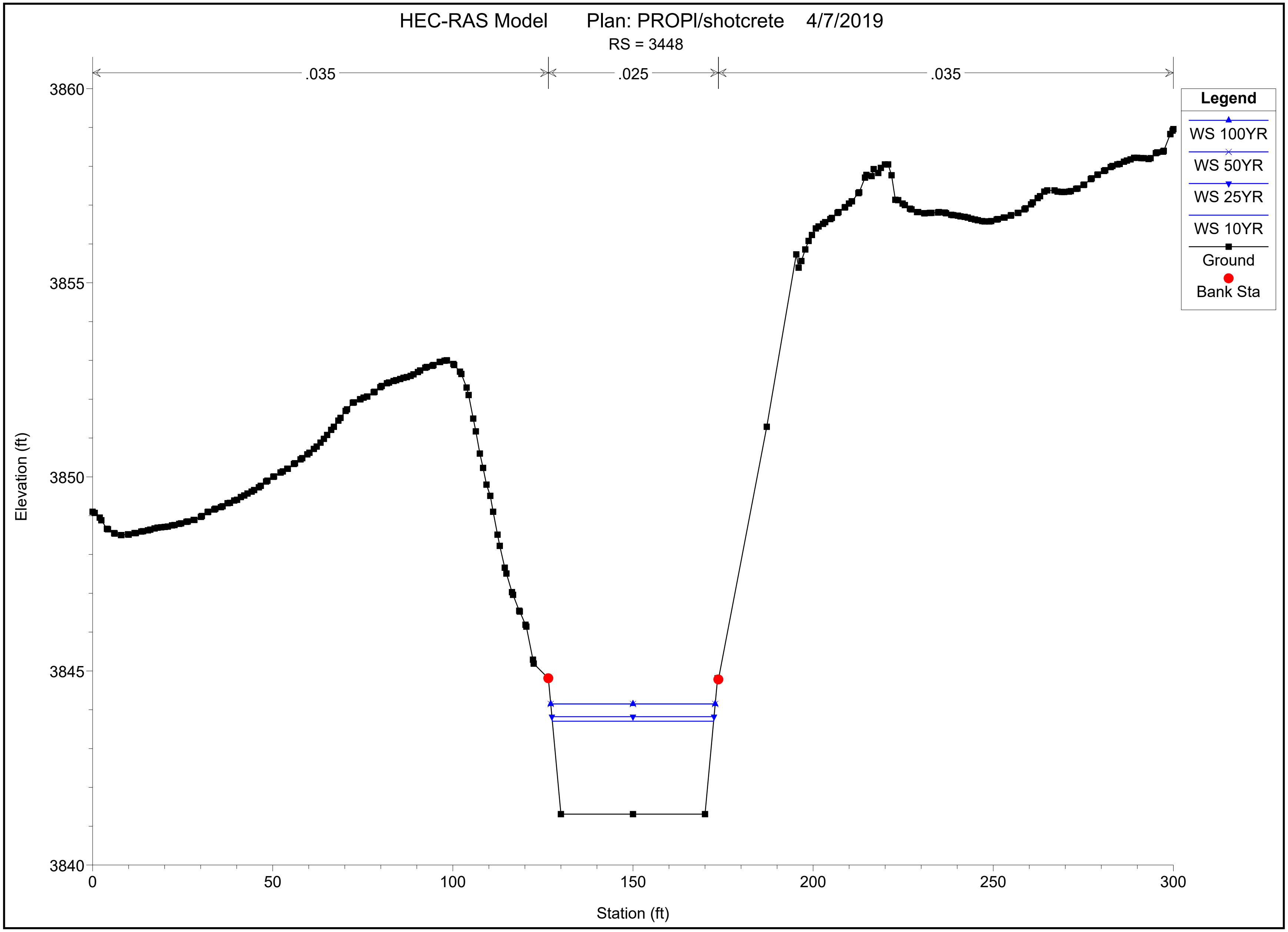


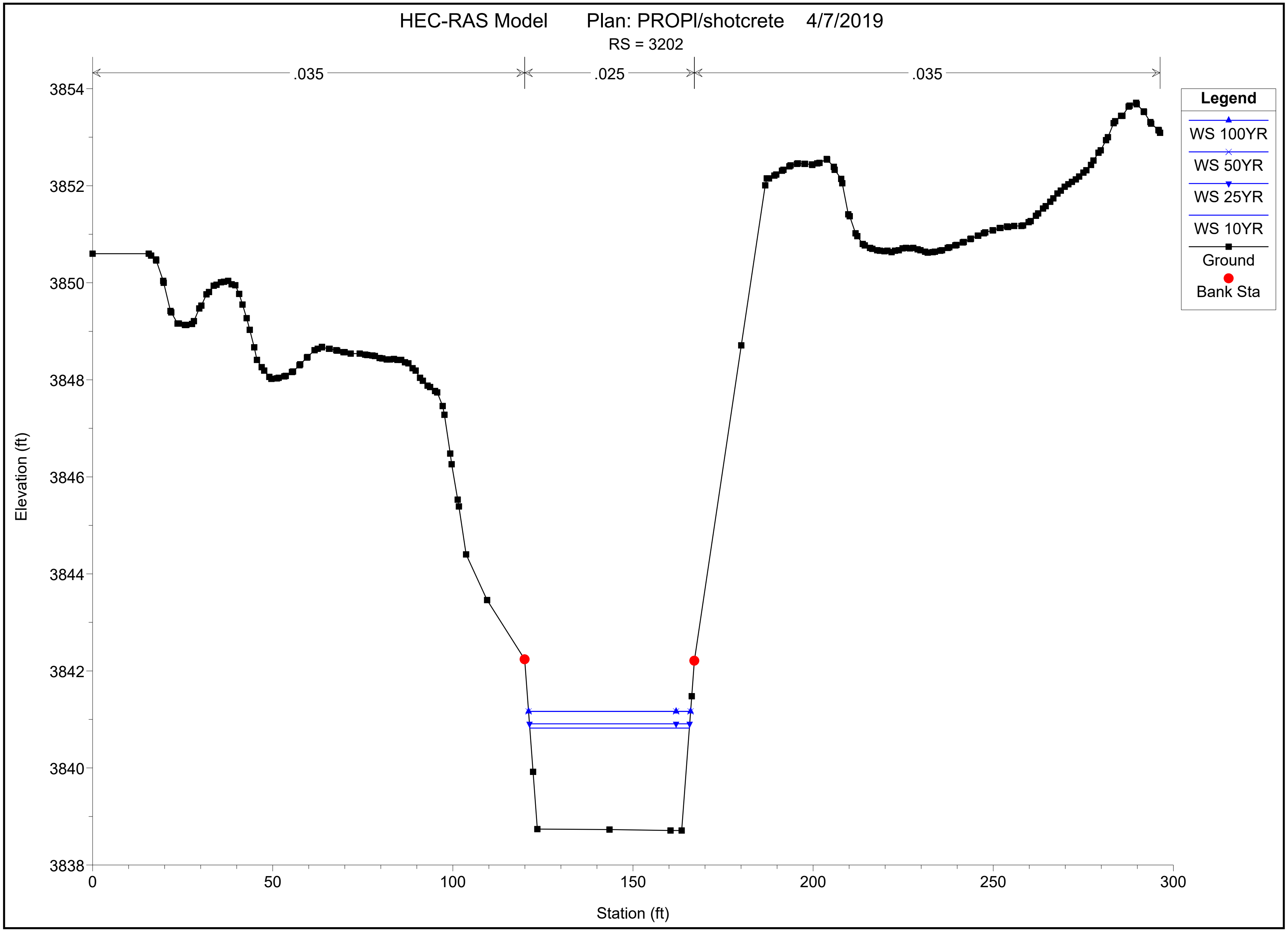
HEC-RAS Model Plan: PROPI/shotcrete 4/7/2019
RS = 4085
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3868
3866
3864
3862
3860
3858
3856
3854
0
50
100
150
200
250
Station (ft)


HEC-RAS Model Plan: PROPI/shotcrete 4/7/2019
RS = 3880
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
3870
3865
3860
3855
3850
3845
Elevation (ft)
0
50
100
150
200
250
300
Station (ft)

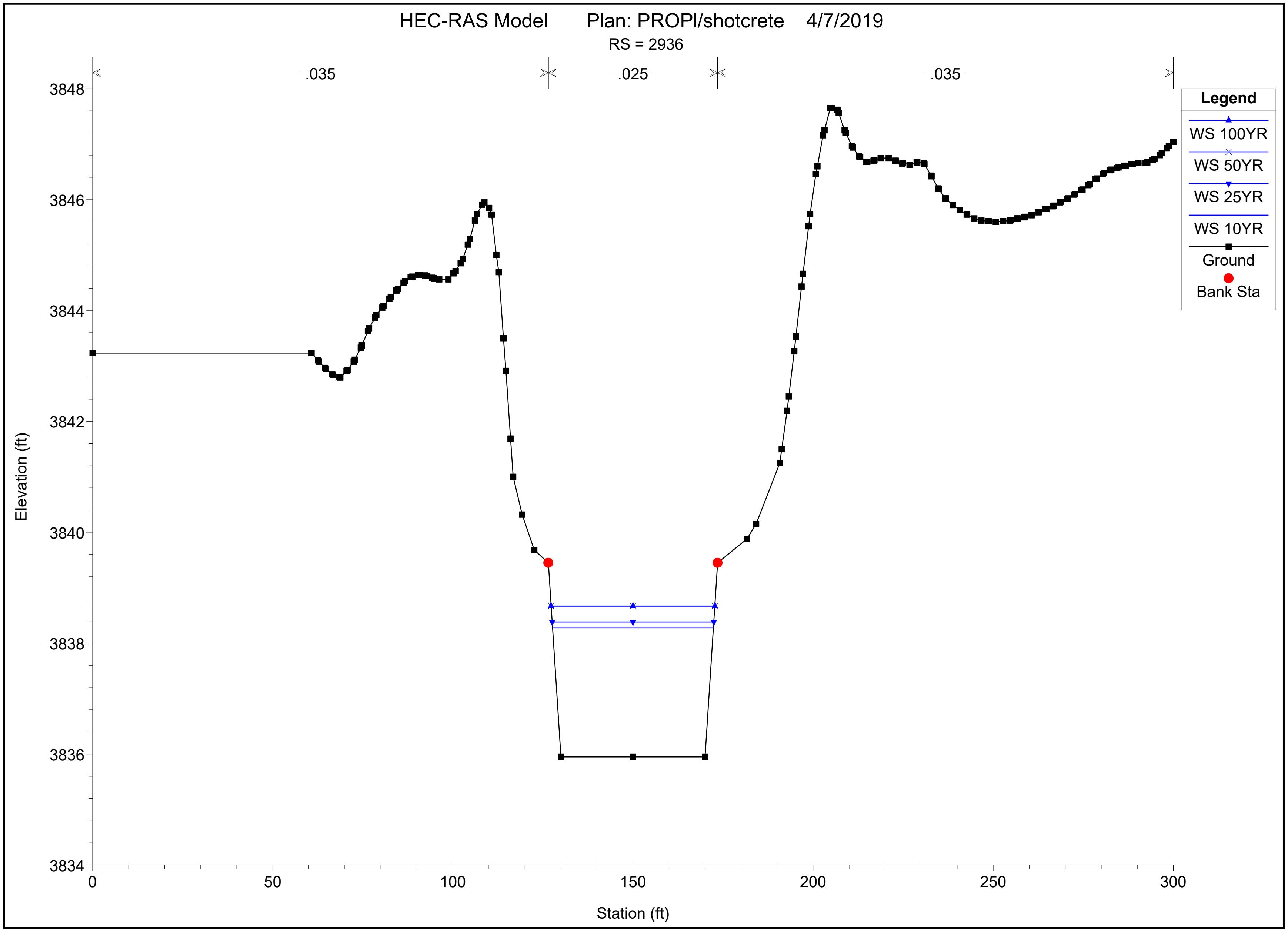


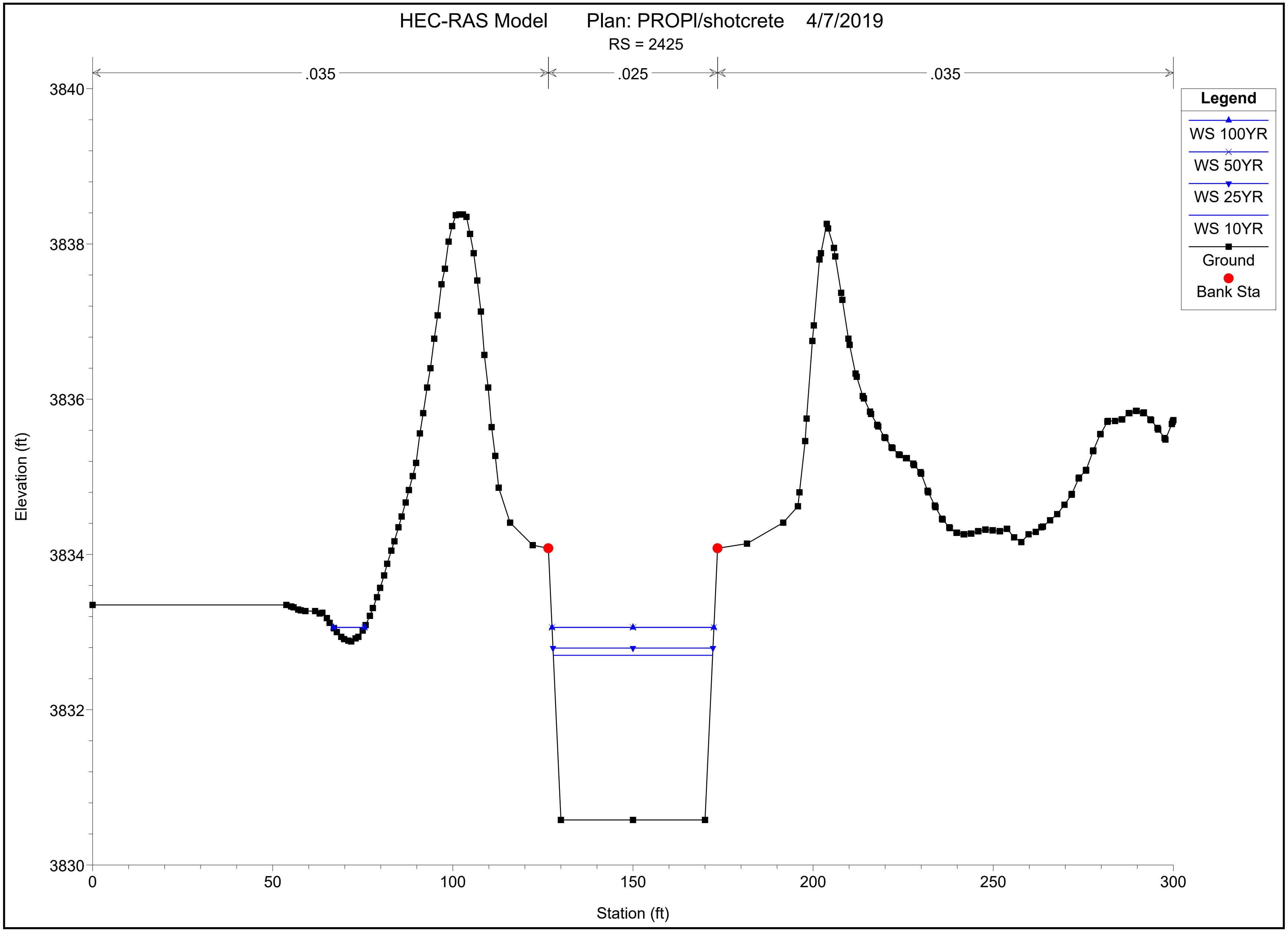
HEC-RAS Model Plan: PROPI/shotcrete 4/7/2019
RS = 3745
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3865
3860
3855
3850
3845
3840
0
50
100
150
200
250
Station (ft)


HEC-RAS Model Plan: PROPl/shotcrete 4/7/2019
RS = 3448
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
3860
3855
3850
3845
3840
Elevation (ft)
0
50
100
150
200
250
300
Station (ft)

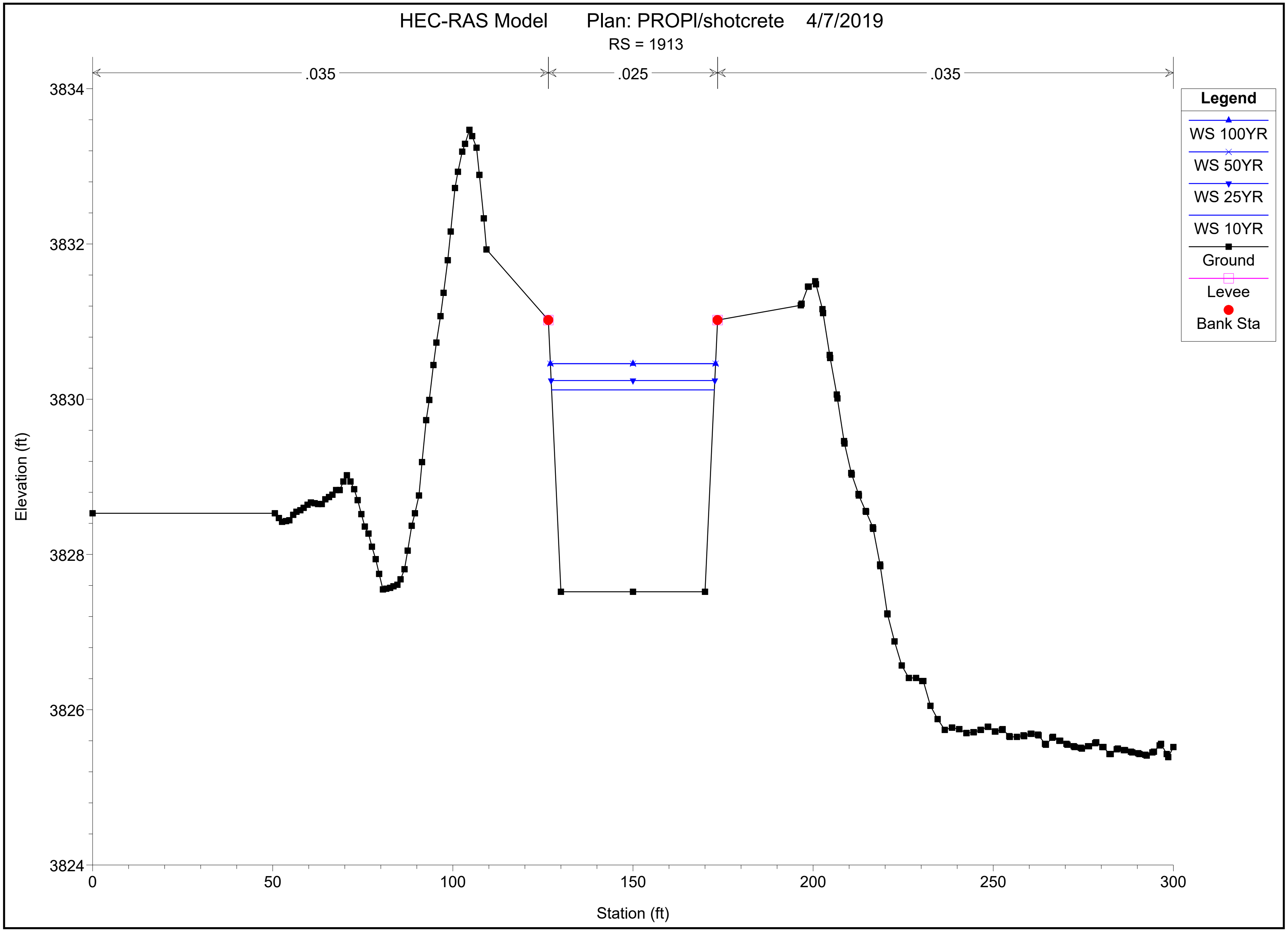


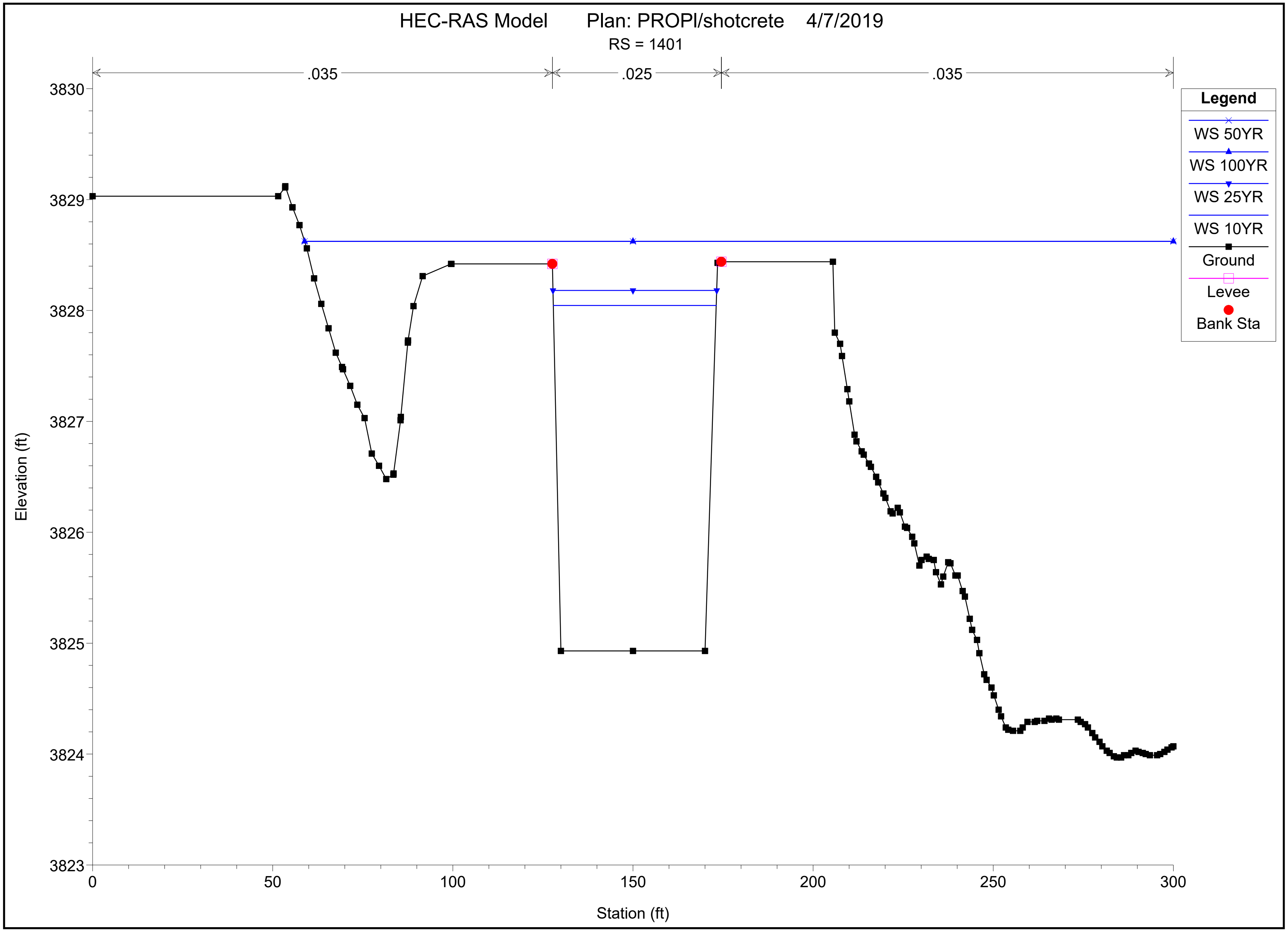
HEC-RAS Model Plan: PROPl/shotcrete 4/7/2019
RS = 3202
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
3854
3852
3850
3848
3846
3844
3842
3840
3838
0
50
100
150
200
250
300


HEC-RAS Model Plan: PROPl/shotcrete 4/7/2019
RS = 2936
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
Elevation (ft)
3848
3846
3844
3842
3840
3838
3836
3834
0
50
100
150
200
250
300
Station (ft)

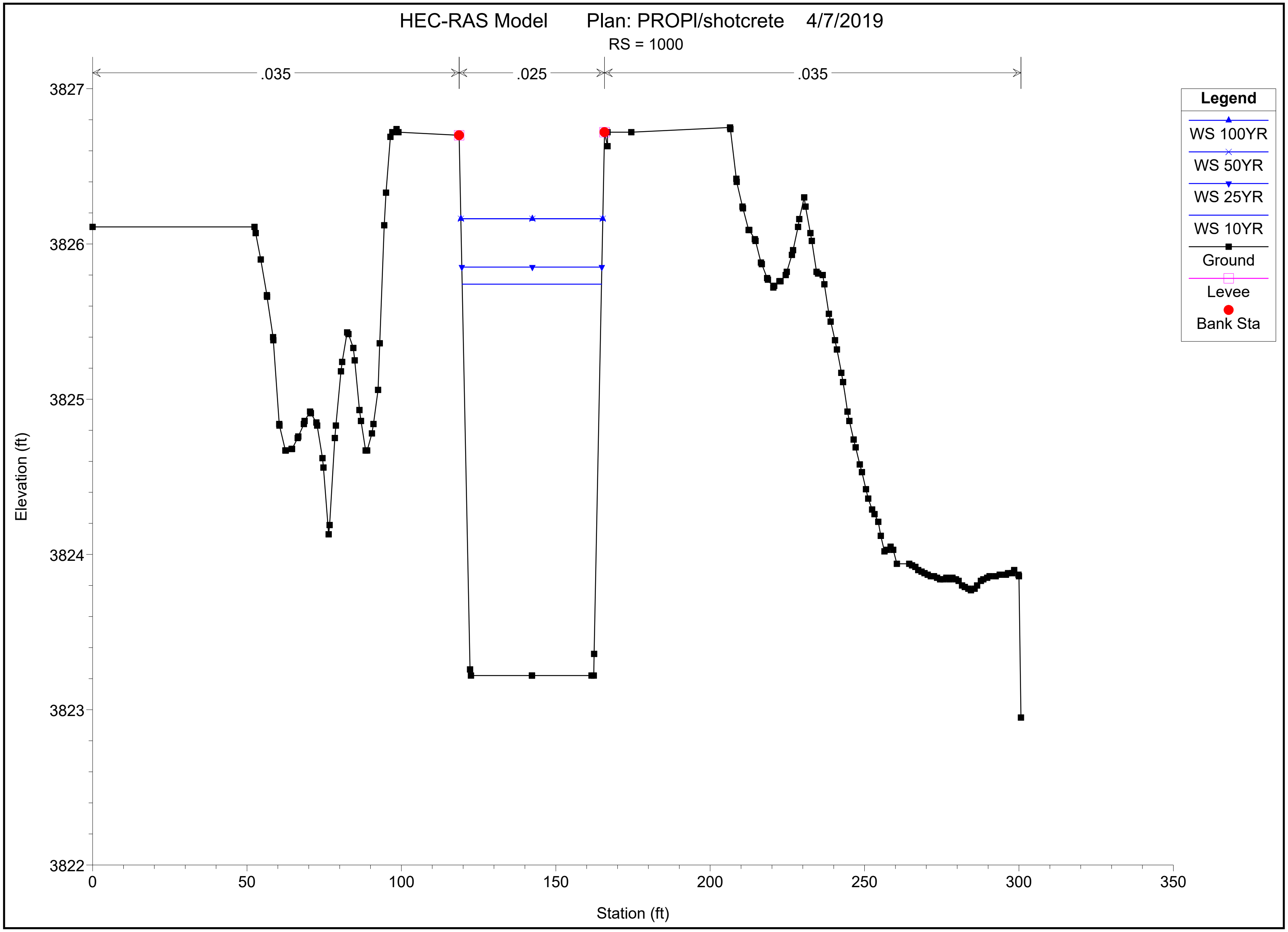


HEC-RAS Model Plan: PROPl/shotcrete 4/7/2019
RS = 2425
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Bank Sta
3840
3838
3836
3834
3832
3830
Elevation (ft)
0
50
100
150
200
250
300
Station (ft)

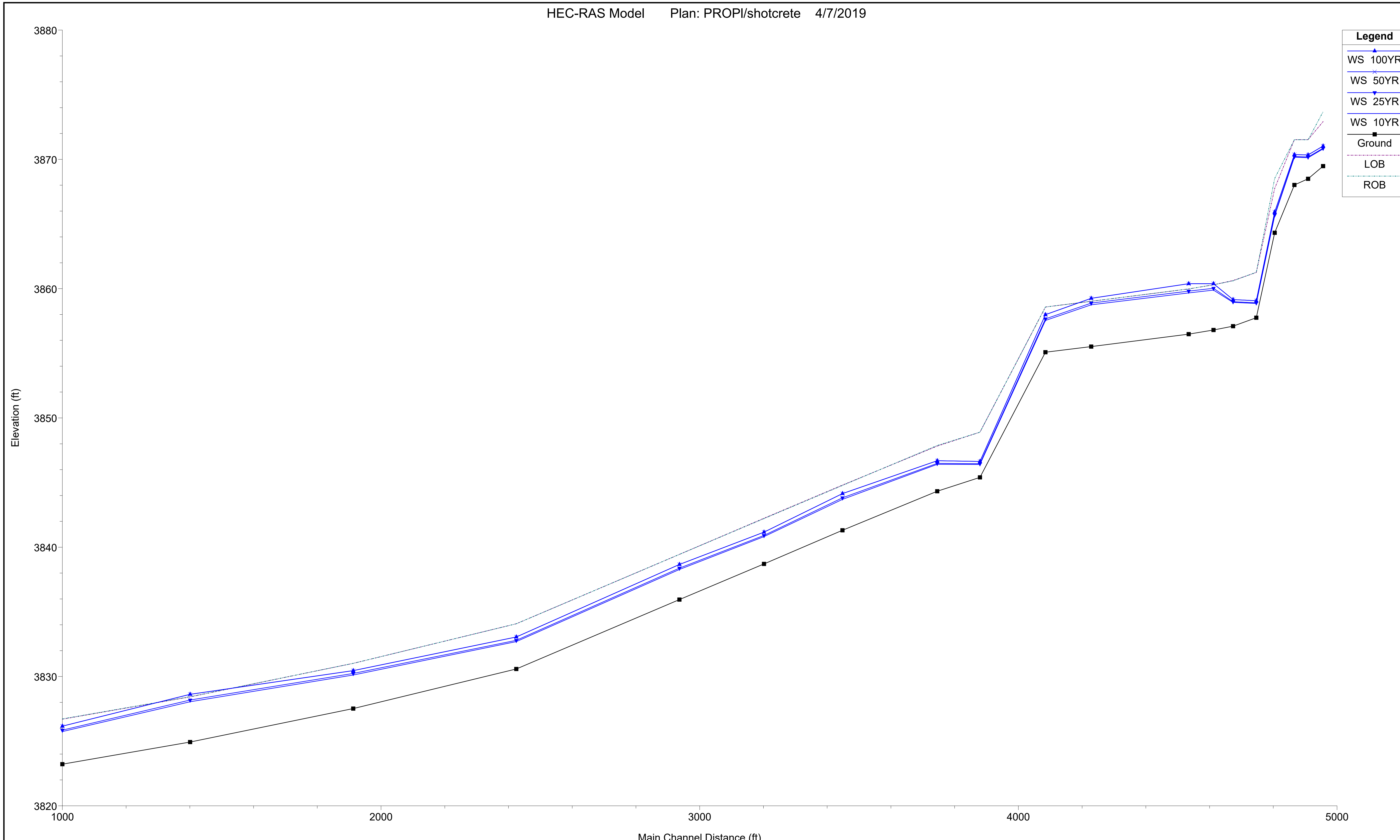

HEC-RAS Model Plan: PROPI/shotcrete 4/7/2019
RS = 1913
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3834
3832
3830
3828
3826
3824
0
50
100
150
200
250
300
Station (ft)



HEC-RAS Model Plan: PROPI/shotcrete 4/7/2019
RS = 1401
.035
.025
.035
Legend
WS 50YR
WS 100YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
3830
3829
3828
3827
3826
3825
3824
3823
0
50
100
150
200
250
300
Station (ft)



HEC-RAS Model Plan: PROPl/shotcrete 4/7/2019
RS = 1000
.035
.025
.035
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
3827
3826
3825
3824
3823
3822
0
50
100
150
200
250
300
350



HEC-RAS Model Plan: PROPI/shotcrete 4/7/2019
Legend
WS 100YR
WS 50YR
WS 25YR
WS 10YR
Ground
LOB
ROB
Elevation (ft)
3820
3830
3840
3850
3860
3870
3880
1000
2000
3000
4000
5000
Main Channel Distance (ft)

# APPENDIX G

## Miscellaneous Hydraulic Analysis

# Existing Data Analysis Tables and Figures:

Figure G1: EBID Canal Analysis Plan

Figure G2: EBID Canal Analysis: Cross Sections

Table G1: Existing Culvert Data and Results

CulvertMaster Output Reports for Existing Culverts

Table G2: Analysis of EBID Canal
FlowMaster Outputs

Table G3: Base Flow Calculations based on 10yr-24hr storm at 1 ft depth in EBID Canal
FlowMaster Outputs

SEE APPENDIX G FOR FLOW MASTER CALCULATIONS OF EBID CANAL. SECTIONS AT VARIOUS LOCATIONS ALONG ALIGNMENT ARE ON NEXT FIGURE. THE CALCULATIONS OF 84" CMP AT VADO ROAD ARE ALSO INCLUDED IN APPENDIX G.


N

0 500' 1000'

Name
Location

| NO | REVISION DESCRIPTION | DATE | BY |
|---|---|---|---|
| 1 | #### | #### | #### |
| 2 | #### | #### | #### |
| 3 | #### | #### | #### |
| 4 | #### | #### | #### |
| 5 | #### | #### | #### |

VADO DRAINAGE MASTER PLAN

FIGURE G1 - EBID CANAL ANALYSIS - PLAN

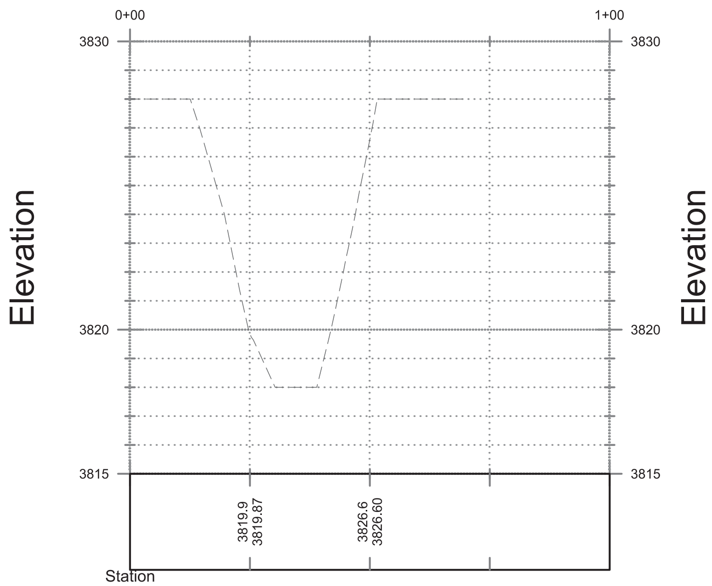
SMITH ENGINEERING

JOB NO:
817103-03

DATE:
August 2019

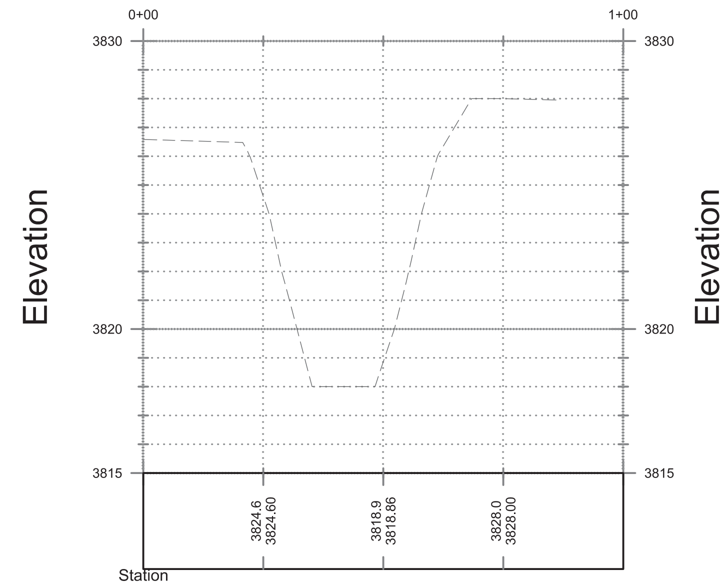
SHEET NO:

Profile View of 1+00 Station



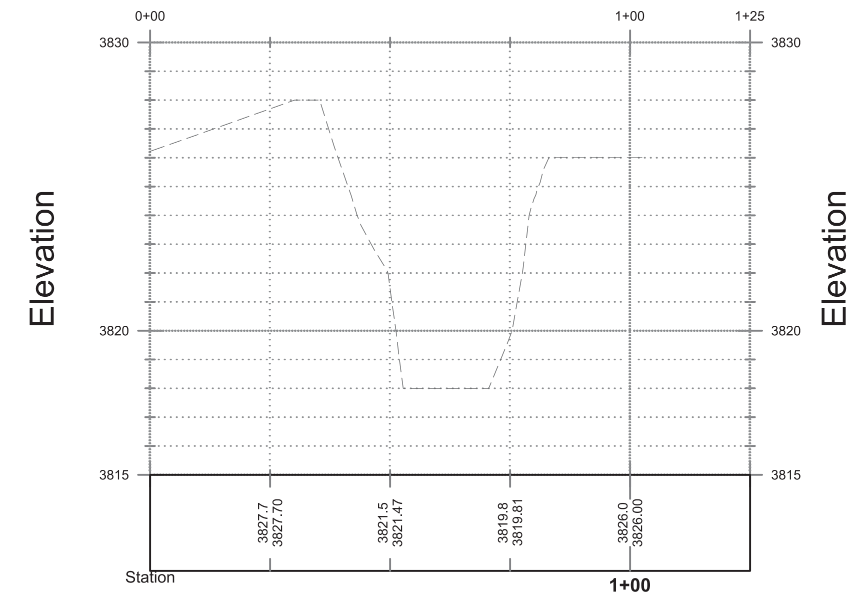

$Q_{MAX}$ = 447 CFS

Profile View of 10+00 Station



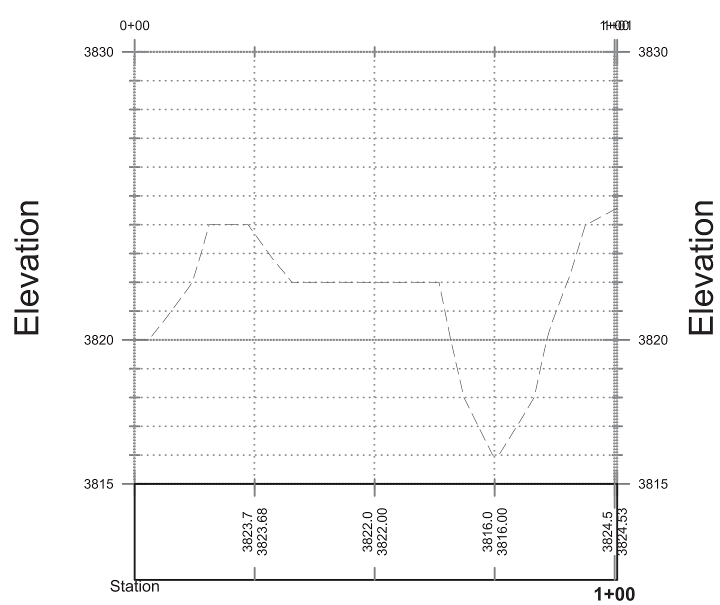

$Q_{MAX}$ = 373 CFS

Profile View of 27+40 Station



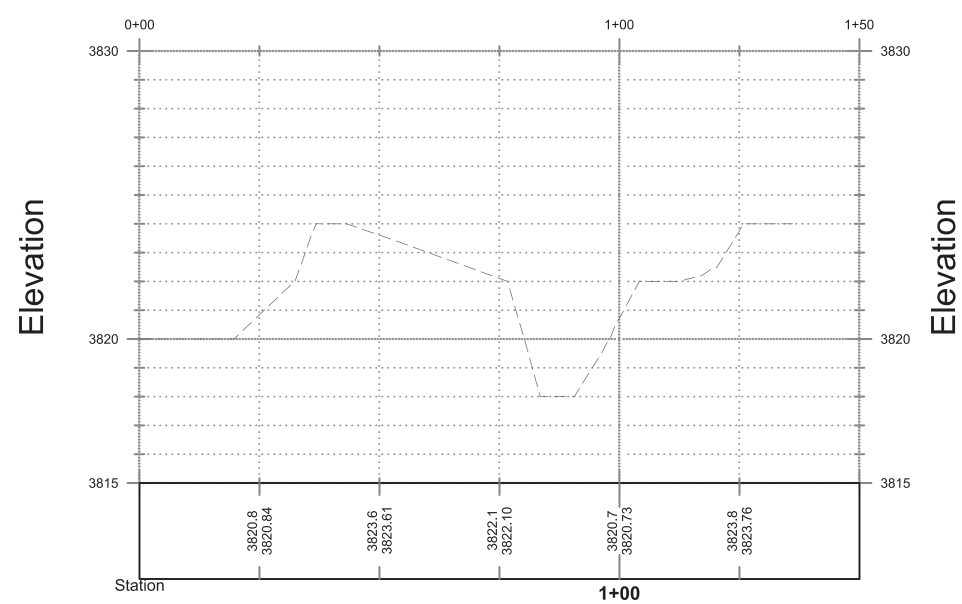

$Q_{MAX}$ = 355 CFS

Profile View of 39+00 Station



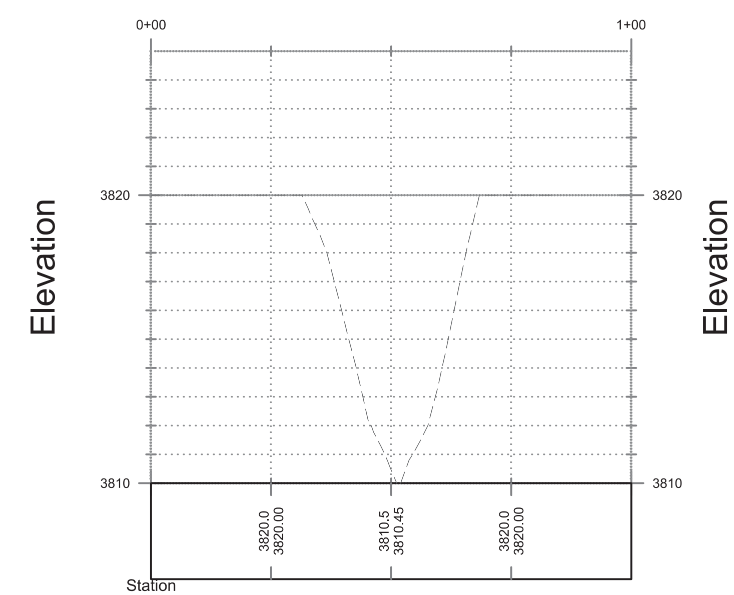

$Q_{MAX}$ = 73 CFS

Profile View of 43+00 Station




$Q_{MAX}$ = 85 CFS

Profile View of 92+00 Station




$Q_{MAX}$ = 367 CFS

0 20' 40'

| NO | REVISION DESCRIPTION | DATE | BY |
|---|---|---|---|
| 5 | | #### | #### |
| 4 | #### | #### | #### |
| 3 | #### | #### | #### |
| 2 | #### | #### | #### |
| 1 | #### | #### | #### |

Name
Location

VADO DRAINAGE MASTER PLAN

FIGURE G2 - EBID CANAL ANALYSIS - CROSS SECTIONS

SMITH ENGINEERING

JOB NO: 817103-03

DATE: August 2019

SHEET NO:

**TABLE G1**
**EXISTING CULVERT DATA AND RESULTS**
Vado/Del Cerro Drainage Master Plan

| | CULVERT DATA FOR CULVERT MASTER | | | | | | | | | | | | | | | | | Culvert Capacity | | | | 10-yr 24-hr storm | | | | 25-yr 24-hr storm | | | | 50-yr 24-hr storm | | | | 100-yr 24-hr storm | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Culvert Name / Location Description | Existing or Proposed | No. of Culverts | Material | Culvert size | Culvert Rise | Culvert Span | Culvert Span | Skew | Length | Invert Elev. Upstream | Invert Elev. Down stream | Slope | Crest Elevation | Maximum Available Headwater Depth | Maximum Available Headwater Depth | Maximum Available Headwater Elev. | Assumed Tailwater Elev. | Maximum Culvert Capacity from Culvert Master | Maximum Culvert Capacity 15% Clogging Factor | Discharge Per Culvert | HEC-HMS Analysis Point Name | Peak Discharge | Spill flow (Max. Capacity minus peak discharge) - positive means excess capacity) | Extra Culverts Required Y or N | No. of Extra Culverts to pass flow (same as existing) | Peak Discharge | Spill flow (Max. Capacity minus peak discharge) - positive means excess capacity | Extra Culverts Required Y or N | No. of Extra Culverts to pass flow (same as existing) | Peak Discharge | Spill flow (Max. Capacity minus peak discharge) - positive means excess capacity) | Extra Culverts Required Y or N | No. of Extra Culverts to pass flow (same as existing) | Peak Discharge | Spill flow (Max. Capacity minus peak discharge) - positive means excess capacity | Extra Culverts Required Y or N | No. of Extra Culverts to pass flow (same as existing) |
| | | | | inches | feet | inches | feet | degrees | ft | ft | ft | ft / ft | ft | inches | feet | feet | ft | cfs | cfs | cfs | | cfs | | | | cfs | | | | cfs | | | | cfs | | | |
| | | | | | | | | | | | | | | | a,c,d | a,c,d | e | h | f | i | g | g | i | | | g | i | | | g | i | | | g | i | | |
| C1: NMDOT Crossing | Existing | 2 | CBC | 7-ft x10-ft | | | 0 | 0 | 195 | 3879.00 | 3874.50 | 0.02308 | 3892.00 | 108.00 | 9.00 | 3888.00 | 3881.25 | 1323 | 1125 | 562 | J630 | 908 | 217 | N | 0 | 975 | 150 | N | 0 | 1175 | -50 | Y | 0 | 1175 | -50 | Y | 0 |
| C2: Frontage Road | Existing | 4 | RCP | 48 | 0 | 0 | 0 | 0 | 65 | 3875.50 | 3873.80 | 0.02615 | 3885.00 | 81.00 | 6.75 | 3882.25 | 3878.86 | 568 | 482 | 121 | J630 | | | | | | | | | | | | | | | | |
| C2: Frontage Road | Existing | 3 | RCP | 60 | 0 | 0 | 0 | 0 | 65 | 3875.50 | 3873.80 | 0.02615 | 3885.00 | 81.00 | 6.75 | 3882.25 | 3878.86 | 607 | 516 | 172 | J630 | | | | | | | | | | | | | | | | |
| C2: Frontage Road | Total | | | | | | | | | | | | | | | | | 1175 | 998 | 293 | J630 | 908 | 90 | N | 0 | 975 | 23 | N | 0 | 1175 | -177 | Y | 1 | 1175 | -177 | Y | 1 |
| C3 | Existing | 3 | RCP | 48 | - | - | | 0 | 220 | 3913.88 | 3907.93 | 0.02705 | 3916 | 97.44 | 8.12 | 3922 | 3916.5 | 497 | 422 | 141 | This Culvert was not modeled due to the HEC-RAS 2d model showing runoff from subbasin W540 Flows to C1 | | | | | | | | | | | | | | | | |
| C3 Frontage Road | Existing | 3 | CMP | 48 | - | - | | 0 | 35 | 3918.7 | 3915.5 | 0.09143 | 3906.00 | 45.60 | 3.80 | 3922.50 | 3918.35 | 167 | 142 | 47 | | | | | | | | | | | | | | | | | |
| C4a | Existing | 1 | RCP | 36 | - | - | | 0 | 220 | 3917 | 3910 | 0.03182 | 3925.00 | 72.00 | 6.00 | 3923.00 | 3911.50 | 80 | 68 | 68 | JC2 | 3 | 65 | N | 0 | 6 | 62 | N | 0 | 9 | 59 | N | 0 | 12 | 56 | N | 0 |
| C4a Frontage Road | Existing | 1 | CMP | 30 | - | - | | 0 | 35 | 3918.7 | 3915.5 | 0.09143 | 3910.00 | 57.60 | 4.80 | 3923.50 | 3916.75 | 38 | 32 | 32 | JC2 | 3 | 29 | N | 0 | 6 | 26 | N | 0 | 9 | 23 | N | 0 | 12 | 20 | N | 0 |
| C4b | Existing | 3 | RCP | 36 | - | - | | 0 | 220 | 3917.6 | 3912 | 0.02545 | 3925.00 | 70.80 | 5.90 | 3923.50 | 3913.50 | 236 | 201 | 67 | JC2 | 3 | 198 | N | 0 | 6 | 195 | N | 0 | 9 | 192 | N | 0 | 12 | 189 | N | 0 |
| C4b Frontage Road | Existing | 3 | CMP | 30 | - | - | | 0 | 35 | 3919.6 | 3918.19 | 0.04029 | 3910.00 | 52.80 | 4.40 | 3924.00 | 3919.00 | 107 | 91 | 30 | JC2 | 3 | 88 | N | 0 | 6 | 85 | N | 0 | 9 | 82 | N | 0 | 12 | 79 | N | 0 |
| C5 | Existing | 3 | RCP | 36 | - | - | | 0 | 220 | 3917.6 | 3912 | 0.02545 | 3922.70 | 52.80 | 4.40 | 3922.00 | 3913.50 | 182 | 155 | 52 | JC4 | 15 | 140 | N | 0 | 24 | 131 | N | 0 | 31 | 124 | N | 0 | 36 | 119 | N | 0 |
| C5 Frontage Road | Existing | 2 | CMP | 30 | - | - | | 0 | 50 | 3921.8 | 3918 | 0.07600 | 3914.20 | 26.40 | 2.20 | 3924.00 | 3918.75 | 30 | 26 | 13 | JC4 | 15 | 11 | N | 0 | 24 | 2 | N | 0 | 31 | -6 | Y | 0 | 36 | -11 | Y | 1 |
| C6 | Existing | 2 | RCP | 48 | - | - | | 0 | 220 | 3911 | 3902 | 0.04091 | 3917.92 | 66.00 | 5.50 | 3916.50 | 3904.00 | 235 | 200 | 100 | JC5 | 76 | 124 | N | 0 | 137 | 63 | N | 0 | 187 | 13 | N | 0 | 230 | -30 | Y | 0 |
| C6 Frontage Road | Existing | 2 | CMP | 36 | - | - | | 0 | 35 | 3913 | 3912 | 0.02857 | 3906.00 | 42.00 | 3.50 | 3916.50 | 3913.50 | 75 | 64 | 32 | JC5 | 76 | -12 | Y | 0 | 137 | -73 | Y | 2 | 187 | -123 | Y | 4 | 230 | -166 | Y | 5 |
| C7 | Existing | 3 | RCP | 30 | - | - | | 0 | 220 | 3903 | 3898 | 0.02273 | 3911.40 | 96.00 | 8.00 | 3911.00 | 3898.75 | 220 | 187 | 62 | JC6 | 13 | 174 | N | 0 | 139 | 48 | N | 0 | 209 | -22 | Y | 0 | 272 | -85 | Y | 1 |

a - See Figure 4 for culvert locations
b- See HEC-RAS Model Schematic for HEC-HMS analysis point locations
c - The maximum available headwater depth for the significant culverts were measured by Smith Engineering engineers
d- NMDOT crossing's downstream depth of 3.76 ft was assumed as the Maximum Available Headwater Elevation for the Frontage Road Crossings.
e - Assume tailwater elevation = the downstream invert elevation + 75% of the maximum available headwater depth.
f - Assume a 15% clogging factor at inlet due to sediment and debris / vegetation.
g - See HEC-HMS Summary output tables included in Appendix D
h - CulvertMaster output is included in Appendix G, assume a 15% clogging factor at inlet due to sediment and debris / vegetation
i -Compute as spill flow divided by Culvert Capacity.
Note: Culvert C1 is a box the units shown for this culvert are in feet as specified. The culvert rise is 7-ft and the span is 10-ft

# Culvert Calculator Report
# C1

Solve For: Discharge

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 3,888.00 ft | Headwater Depth/Height | 1.29 |
| Computed Headwater Elevation | 3,888.00 ft | Discharge | 1,323.09 cfs |
| Inlet Control HW Elev. | 3,887.41 ft | Tailwater Elevation | 3,881.25 ft |
| Outlet Control HW Elev. | 3,888.00 ft | Control Type | Entrance Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 3,879.00 ft | Downstream Invert | 3,874.50 ft |
| Length | 195.00 ft | Constructed Slope | 0.023077 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | CompositeS1S2 | Depth, Downstream | 6.75 ft |
| Slope Type | Steep | Normal Depth | 2.64 ft |
| Flow Regime | N/A | Critical Depth | 5.14 ft |
| Velocity Downstream | 9.80 ft/s | Critical Slope | 0.003664 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Box | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 10.00 ft |
| Section Size | 10 x 7 ft | Rise | 7.00 ft |
| Number Sections | 2 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 3,888.00 ft | Upstream Velocity Head | 2.57 ft |
| Ke | 0.50 | Entrance Loss | 1.29 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 3,887.41 ft | Flow Control | N/A |
| Inlet Type | 30 to 75° wingwall flares | Area Full | 140.0 ft² |
| K | 0.02600 | HDS 5 Chart | 8 |
| M | 1.00000 | HDS 5 Scale | 1 |
| C | 0.03470 | Equation Form | 1 |
| Y | 0.86000 | | |

# Culvert Calculator Report
# C2 - Frontage Road Crossing-48 in - Part 1 of 2

Solve For: Discharge

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 3,882.25 ft | Headwater Depth/Height | 1.69 |
| Computed Headwater Elevation | 3,882.25 ft | Discharge | 567.62 cfs |
| Inlet Control HW Elev. | 3,882.25 ft | Tailwater Elevation | 3,878.86 ft |
| Outlet Control HW Elev. | 3,881.87 ft | Control Type | Inlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 3,875.50 ft | Downstream Invert | 3,873.80 ft |
| Length | 65.00 ft | Constructed Slope | 0.026154 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | CompositePressureProfileS1 | Depth, Downstream | 2.65 ft |
| Slope Type | N/A | Normal Depth | 2.26 ft |
| Flow Regime | Subcritical | Critical Depth | 3.53 ft |
| Velocity Downstream | 16.03 ft/s | Critical Slope | 0.008760 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 4.00 ft |
| Section Size | 48 inch | Rise | 4.00 ft |
| Number Sections | 4 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 3,881.87 ft | Upstream Velocity Head | 2.27 ft |
| Ke | 0.20 | Entrance Loss | 0.40 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 3,882.25 ft | Flow Control | N/A |
| Inlet Type | Groove end projecting | Area Full | 50.3 ft² |
| K | 0.00450 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 3 |
| C | 0.03170 | Equation Form | 1 |
| Y | 0.69000 | | |

# Culvert Calculator Report
# C2 - Frontage Road Crossing-60 in Part 2 of 2

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 3,882.25 | ft | Headwater Depth/Height | 1.35 | |
| Computed Headwater Elevation | 3,882.25 | ft | Discharge | 606.93 | cfs |
| Inlet Control HW Elev. | 3,882.25 | ft | Tailwater Elevation | 3,878.86 | ft |
| Outlet Control HW Elev. | 3,882.18 | ft | Control Type | Inlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 3,875.50 | ft | Downstream Invert | 3,873.80 | ft |
| Length | 65.00 | ft | Constructed Slope | 0.026154 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositePressureProfileS1S2 | | Depth, Downstream | 2.98 | ft |
| Slope Type | N/A | | Normal Depth | 2.44 | ft |
| Flow Regime | N/A | | Critical Depth | 4.06 | ft |
| Velocity Downstream | 16.57 | ft/s | Critical Slope | 0.006144 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 5.00 | ft |
| Section Size | 60 inch | | Rise | 5.00 | ft |
| Number Sections | 3 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 3,882.18 | ft | Upstream Velocity Head | 2.18 | ft |
| Ke | 0.20 | | Entrance Loss | 0.44 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 3,882.25 | ft | Flow Control | N/A | |
| Inlet Type | Groove end projecting | | Area Full | 58.9 | ft² |
| K | 0.00450 | | HDS 5 Chart | 1 | |
| M | 2.00000 | | HDS 5 Scale | 3 | |
| C | 0.03170 | | Equation Form | 1 | |
| Y | 0.69000 | | | | |

# Culvert Calculator Report
# C3

Solve For: Discharge

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 3,922.00 ft | Headwater Depth/Height | 2.03 |
| Computed Headwater Elevation | 3,922.00 ft | Discharge | 497.00 cfs |
| Inlet Control HW Elev. | 3,922.00 ft | Tailwater Elevation | 3,910.00 ft |
| Outlet Control HW Elev. | 3,921.05 ft | Control Type | Inlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 3,913.88 ft | Downstream Invert | 3,907.93 ft |
| Length | 220.00 ft | Constructed Slope | 0.027045 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 2.59 ft |
| Slope Type | Steep | Normal Depth | 2.47 ft |
| Flow Regime | Supercritical | Critical Depth | 3.70 ft |
| Velocity Downstream | 19.26 ft/s | Critical Slope | 0.011522 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 4.00 ft |
| Section Size | 48 inch | Rise | 4.00 ft |
| Number Sections | 3 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 3,921.05 ft | Upstream Velocity Head | 2.89 ft |
| Ke | 0.20 | Entrance Loss | 0.58 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 3,922.00 ft | Flow Control | N/A |
| Inlet Type | Beveled ring, 45° bevels | Area Full | 37.7 ft² |
| K | 0.00180 | HDS 5 Chart | 3 |
| M | 2.50000 | HDS 5 Scale | A |
| C | 0.03000 | Equation Form | 1 |
| Y | 0.74000 | | |

# Culvert Calculator Report
# C3 Frontage Rd

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 3,922.00 | ft | Headwater Depth/Height | 0.83 | |
| Computed Headwater Elevation | 3,922.00 | ft | Discharge | 131.58 | cfs |
| Inlet Control HW Elev. | 3,921.89 | ft | Tailwater Elevation | 3,917.50 | ft |
| Outlet Control HW Elev. | 3,922.00 | ft | Control Type | Entrance Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 3,918.70 | ft | Downstream Invert | 3,915.50 | ft |
| Length | 35.00 | ft | Constructed Slope | 0.091429 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeS1S2 | | Depth, Downstream | 2.00 | ft |
| Slope Type | Steep | | Normal Depth | 1.17 | ft |
| Flow Regime | N/A | | Critical Depth | 1.98 | ft |
| Velocity Downstream | 6.98 | ft/s | Critical Slope | 0.013129 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.024 | |
| Section Material | CMP | | Span | 4.00 | ft |
| Section Size | 48 inch | | Rise | 4.00 | ft |
| Number Sections | 3 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 3,922.00 | ft | Upstream Velocity Head | 0.78 | ft |
| Ke | 0.70 | | Entrance Loss | 0.54 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 3,921.89 | ft | Flow Control | N/A | |
| Inlet Type | Mitered to slope | | Area Full | 37.7 | ft² |
| K | 0.02100 | | HDS 5 Chart | 2 | |
| M | 1.33000 | | HDS 5 Scale | 2 | |
| C | 0.04630 | | Equation Form | 1 | |
| Y | 0.75000 | | | | |

# Culvert Calculator Report
# C4A

Solve For: Discharge

## Culvert Summary

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 3,923.00 ft | Headwater Depth/Height | 2.00 |
| Computed Headwater Elevation | 3,923.00 ft | Discharge | 79.84 cfs |
| Inlet Control HW Elev. | 3,923.00 ft | Tailwater Elevation | 3,911.50 ft |
| Outlet Control HW Elev. | 3,922.33 ft | Control Type | Inlet Control |

## Grades

| | | | |
|---|---|---|---|
| Upstream Invert | 3,917.00 ft | Downstream Invert | 3,910.00 ft |
| Length | 220.00 ft | Constructed Slope | 0.031818 ft/ft |

## Hydraulic Profile

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 1.83 ft |
| Slope Type | Steep | Normal Depth | 1.80 ft |
| Flow Regime | Supercritical | Critical Depth | 2.77 ft |
| Velocity Downstream | 17.63 ft/s | Critical Slope | 0.012425 ft/ft |

## Section

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 3.00 ft |
| Section Size | 36 inch | Rise | 3.00 ft |
| Number Sections | 1 | | |

## Outlet Control Properties

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 3,922.33 ft | Upstream Velocity Head | 2.13 ft |
| Ke | 0.20 | Entrance Loss | 0.43 ft |

## Inlet Control Properties

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 3,923.00 ft | Flow Control | N/A |
| Inlet Type | Beveled ring, 45° bevels | Area Full | 7.1 ft² |
| K | 0.00180 | HDS 5 Chart | 3 |
| M | 2.50000 | HDS 5 Scale | A |
| C | 0.03000 | Equation Form | 1 |
| Y | 0.74000 | | |

# Culvert Calculator Report
# C4A Frontage Rd

Solve For: Discharge

### Culvert Summary

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 3,923.50 ft | Headwater Depth/Height | 1.92 |
| Computed Headwater Elevation | 3,923.50 ft | Discharge | 37.93 cfs |
| Inlet Control HW Elev. | 3,923.50 ft | Tailwater Elevation | 3,916.75 ft |
| Outlet Control HW Elev. | 3,922.77 ft | Control Type | Inlet Control |

### Grades

| | | | |
|---|---|---|---|
| Upstream Invert | 3,918.70 ft | Downstream Invert | 3,915.50 ft |
| Length | 35.00 ft | Constructed Slope | 0.091429 ft/ft |

### Hydraulic Profile

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 1.39 ft |
| Slope Type | Steep | Normal Depth | 1.34 ft |
| Flow Regime | Supercritical | Critical Depth | 2.08 ft |
| Velocity Downstream | 13.51 ft/s | Critical Slope | 0.028349 ft/ft |

### Section

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.024 |
| Section Material | CMP | Span | 2.50 ft |
| Section Size | 30 inch | Rise | 2.50 ft |
| Number Sections | 1 | | |

### Outlet Control Properties

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 3,922.77 ft | Upstream Velocity Head | 1.17 ft |
| Ke | 0.70 | Entrance Loss | 0.82 ft |

### Inlet Control Properties

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 3,923.50 ft | Flow Control | N/A |
| Inlet Type | Mitered to slope | Area Full | 4.9 ft² |
| K | 0.02100 | HDS 5 Chart | 2 |
| M | 1.33000 | HDS 5 Scale | 2 |
| C | 0.04630 | Equation Form | 1 |
| Y | 0.75000 | | |

# Culvert Calculator Report
# C4B

Solve For: Discharge

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 3,923.50 ft | Headwater Depth/Height | 1.97 |
| Computed Headwater Elevation | 3,923.50 ft | Discharge | 236.08 cfs |
| Inlet Control HW Elev. | 3,923.50 ft | Tailwater Elevation | 3,913.50 ft |
| Outlet Control HW Elev. | 3,922.86 ft | Control Type | Inlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 3,917.60 ft | Downstream Invert | 3,912.00 ft |
| Length | 220.00 ft | Constructed Slope | 0.025455 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 1.95 ft |
| Slope Type | Steep | Normal Depth | 1.92 ft |
| Flow Regime | Supercritical | Critical Depth | 2.76 ft |
| Velocity Downstream | 16.16 ft/s | Critical Slope | 0.012089 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 3.00 ft |
| Section Size | 36 inch | Rise | 3.00 ft |
| Number Sections | 3 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 3,922.86 ft | Upstream Velocity Head | 2.08 ft |
| Ke | 0.20 | Entrance Loss | 0.42 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 3,923.50 ft | Flow Control | N/A |
| Inlet Type | Beveled ring, 45° bevels | Area Full | 21.2 ft² |
| K | 0.00180 | HDS 5 Chart | 3 |
| M | 2.50000 | HDS 5 Scale | A |
| C | 0.03000 | Equation Form | 1 |
| Y | 0.74000 | | |

# Culvert Calculator Report
# C4B Frontage Rd

Solve For: Discharge

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 3,924.00 ft | Headwater Depth/Height | 1.76 |
| Computed Headwater Elevation | 3,924.00 ft | Discharge | 107.22 cfs |
| Inlet Control HW Elev. | 3,924.00 ft | Tailwater Elevation | 3,919.00 ft |
| Outlet Control HW Elev. | 3,923.48 ft | Control Type | Inlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 3,919.60 ft | Downstream Invert | 3,918.19 ft |
| Length | 35.00 ft | Constructed Slope | 0.040286 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 1.71 ft |
| Slope Type | Steep | Normal Depth | 1.69 ft |
| Flow Regime | Supercritical | Critical Depth | 2.03 ft |
| Velocity Downstream | 10.02 ft/s | Critical Slope | 0.026363 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.024 |
| Section Material | CMP | Span | 2.50 ft |
| Section Size | 30 inch | Rise | 2.50 ft |
| Number Sections | 3 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 3,923.48 ft | Upstream Velocity Head | 1.09 ft |
| Ke | 0.70 | Entrance Loss | 0.76 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 3,924.00 ft | Flow Control | N/A |
| Inlet Type | Mitered to slope | Area Full | 14.7 ft² |
| K | 0.02100 | HDS 5 Chart | 2 |
| M | 1.33000 | HDS 5 Scale | 2 |
| C | 0.04630 | Equation Form | 1 |
| Y | 0.75000 | | |

# Culvert Calculator Report
# C5

Solve For: Discharge

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 3,922.00 ft | Headwater Depth/Height | 1.47 |
| Computed Headwater Elevation | 3,922.00 ft | Discharge | 182.34 cfs |
| Inlet Control HW Elev. | 3,922.00 ft | Tailwater Elevation | 3,913.50 ft |
| Outlet Control HW Elev. | 3,921.84 ft | Control Type | Inlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 3,917.60 ft | Downstream Invert | 3,912.00 ft |
| Length | 220.00 ft | Constructed Slope | 0.025455 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 1.64 ft |
| Slope Type | Steep | Normal Depth | 1.62 ft |
| Flow Regime | Supercritical | Critical Depth | 2.52 ft |
| Velocity Downstream | 15.38 ft/s | Critical Slope | 0.007989 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 3.00 ft |
| Section Size | 36 inch | Rise | 3.00 ft |
| Number Sections | 3 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 3,921.84 ft | Upstream Velocity Head | 1.43 ft |
| Ke | 0.20 | Entrance Loss | 0.29 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 3,922.00 ft | Flow Control | N/A |
| Inlet Type | Beveled ring, 45° bevels | Area Full | 21.2 ft² |
| K | 0.00180 | HDS 5 Chart | 3 |
| M | 2.50000 | HDS 5 Scale | A |
| C | 0.03000 | Equation Form | 1 |
| Y | 0.74000 | | |

# Culvert Calculator Report
## C5 Frontage Rd

Solve For: Discharge

### Culvert Summary

| | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 3,924.00 | ft | Headwater Depth/Height | 0.88 | |
| Computed Headwater Elevation | 3,924.00 | ft | Discharge | 30.25 | cfs |
| Inlet Control HW Elev. | 3,923.89 | ft | Tailwater Elevation | 3,918.75 | ft |
| Outlet Control HW Elev. | 3,924.00 | ft | Control Type | Entrance Control | |

### Grades

| | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 3,921.80 | ft | Downstream Invert | 3,918.00 | ft |
| Length | 50.00 | ft | Constructed Slope | 0.076000 | ft/ft |

### Hydraulic Profile

| | | | | | |
|---|---|---|---|---|---|
| Profile | S2 | | Depth, Downstream | 0.85 | ft |
| Slope Type | Steep | | Normal Depth | 0.85 | ft |
| Flow Regime | Supercritical | | Critical Depth | 1.31 | ft |
| Velocity Downstream | 10.34 | ft/s | Critical Slope | 0.015767 | ft/ft |

### Section

| | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.024 | |
| Section Material | CMP | | Span | 2.50 | ft |
| Section Size | 30 inch | | Rise | 2.50 | ft |
| Number Sections | 2 | | | | |

### Outlet Control Properties

| | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 3,924.00 | ft | Upstream Velocity Head | 0.52 | ft |
| Ke | 0.70 | | Entrance Loss | 0.37 | ft |

### Inlet Control Properties

| | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 3,923.89 | ft | Flow Control | N/A | |
| Inlet Type | Mitered to slope | | Area Full | 9.8 | ft² |
| K | 0.02100 | | HDS 5 Chart | 2 | |
| M | 1.33000 | | HDS 5 Scale | 2 | |
| C | 0.04630 | | Equation Form | 1 | |
| Y | 0.75000 | | | | |

# Culvert Calculator Report
# C6

Solve For: Discharge

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 3,916.50 ft | Headwater Depth/Height | 1.38 |
| Computed Headwater Elevation | 3,916.50 ft | Discharge | 234.95 cfs |
| Inlet Control HW Elev. | 3,916.50 ft | Tailwater Elevation | 3,904.00 ft |
| Outlet Control HW Elev. | 3,916.40 ft | Control Type | Inlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 3,911.00 ft | Downstream Invert | 3,902.00 ft |
| Length | 220.00 ft | Constructed Slope | 0.040909 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 1.84 ft |
| Slope Type | Steep | Normal Depth | 1.77 ft |
| Flow Regime | Supercritical | Critical Depth | 3.27 ft |
| Velocity Downstream | 20.82 ft/s | Critical Slope | 0.006730 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 4.00 ft |
| Section Size | 48 inch | Rise | 4.00 ft |
| Number Sections | 2 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 3,916.40 ft | Upstream Velocity Head | 1.78 ft |
| Ke | 0.20 | Entrance Loss | 0.36 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 3,916.50 ft | Flow Control | N/A |
| Inlet Type | Beveled ring, 45° bevels | Area Full | 25.1 ft² |
| K | 0.00180 | HDS 5 Chart | 3 |
| M | 2.50000 | HDS 5 Scale | A |
| C | 0.03000 | Equation Form | 1 |
| Y | 0.74000 | | |

# Culvert Calculator Report
# C6 Frontage Rd

Solve For: Discharge

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 3,916.50 ft | Headwater Depth/Height | 1.17 |
| Computed Headwater Elevation | 3,916.50 ft | Discharge | 75.41 cfs |
| Inlet Control HW Elev. | 3,916.22 ft | Tailwater Elevation | 3,913.50 ft |
| Outlet Control HW Elev. | 3,916.50 ft | Control Type | Entrance Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 3,913.00 ft | Downstream Invert | 3,912.00 ft |
| Length | 35.00 ft | Constructed Slope | 0.028571 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 1.71 ft |
| Slope Type | Steep | Normal Depth | 1.71 ft |
| Flow Regime | Supercritical | Critical Depth | 2.00 ft |
| Velocity Downstream | 9.05 ft/s | Critical Slope | 0.017770 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.024 |
| Section Material | CMP | Span | 3.00 ft |
| Section Size | 36 inch | Rise | 3.00 ft |
| Number Sections | 2 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 3,916.50 ft | Upstream Velocity Head | 0.88 ft |
| Ke | 0.70 | Entrance Loss | 0.62 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 3,916.22 ft | Flow Control | N/A |
| Inlet Type | Mitered to slope | Area Full | 14.1 ft² |
| K | 0.02100 | HDS 5 Chart | 2 |
| M | 1.33000 | HDS 5 Scale | 2 |
| C | 0.04630 | Equation Form | 1 |
| Y | 0.75000 | | |

# Culvert Calculator Report
# C7

Solve For: Discharge

| Culvert Summary | | | | | |
|---|---|---|---|---|---|
| Allowable HW Elevation | 3,911.00 | ft | Headwater Depth/Height | 3.20 | |
| Computed Headwater Elevation | 3,911.00 | ft | Discharge | 211.33 | cfs |
| Inlet Control HW Elev. | 3,911.00 | ft | Tailwater Elevation | 3,898.75 | ft |
| Outlet Control HW Elev. | 3,910.80 | ft | Control Type | Inlet Control | |

| Grades | | | | | |
|---|---|---|---|---|---|
| Upstream Invert | 3,903.00 | ft | Downstream Invert | 3,898.00 | ft |
| Length | 220.00 | ft | Constructed Slope | 0.022727 | ft/ft |

| Hydraulic Profile | | | | | |
|---|---|---|---|---|---|
| Profile | CompositeM2PressureProfile | | Depth, Downstream | 2.44 | ft |
| Slope Type | Mild | | Normal Depth | N/A | ft |
| Flow Regime | Subcritical | | Critical Depth | 2.44 | ft |
| Velocity Downstream | 14.44 | ft/s | Critical Slope | 0.026249 | ft/ft |

| Section | | | | | |
|---|---|---|---|---|---|
| Section Shape | Circular | | Mannings Coefficient | 0.013 | |
| Section Material | Concrete | | Span | 2.50 | ft |
| Section Size | 30 inch | | Rise | 2.50 | ft |
| Number Sections | 3 | | | | |

| Outlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Outlet Control HW Elev. | 3,910.80 | ft | Upstream Velocity Head | 3.20 | ft |
| Ke | 0.20 | | Entrance Loss | 0.64 | ft |

| Inlet Control Properties | | | | | |
|---|---|---|---|---|---|
| Inlet Control HW Elev. | 3,911.00 | ft | Flow Control | N/A | |
| Inlet Type | Beveled ring, 45° bevels | | Area Full | 14.7 | ft² |
| K | 0.00180 | | HDS 5 Chart | 3 | |
| M | 2.50000 | | HDS 5 Scale | A | |
| C | 0.03000 | | Equation Form | 1 | |
| Y | 0.74000 | | | | |

## Table G2 Analysis of EBID Canal
## Vado/Del Cerro Drainage Master Plan

| Section/Name | Normal Depth | Left Side Slope | Right Side Slope | Slope | Bottom Width | Upstream Invert | Downstream Invert | "n" Value | Channel Section Capacity |
|---|---|---|---|---|---|---|---|---|---|
| a | | | | | | | | | |
| | ft | 1V:XH | 1V:XH | ft/ft | ft | ft | ft | | cfs |
| 1+00 | 10 | 2 | 2 | 0.00041 | 9 | - | - | 0.06 | 447 |
| 10+00 | 8.5 | 2 | 2 | 0.00041 | 13 | - | - | 0.06 | 373 |
| 27+40 | 8 | 2 | 1 | 0.00041 | 18 | - | - | 0.06 | 240 |
| 39+00 | 6 | 1 | 2 | 0.00041 | 3 | - | - | 0.06 | 73 |
| 43+00 | 6 | 1 | 1 | 0.00041 | 7 | - | - | 0.06 | 85 |
| 92+00 | 10 | 2 | 2 | 0.00041 | 5 | - | - | 0.06 | 367 |
| Vado 84" CMP* | 4.5 | - | - | 0.0027 | - | 3809.61 | 3809.41 | 0.024 | 447 |
| Mesquite Plans# | 5 | - | - | 0.0027 | - | 3809.61 | 3809.41 | 0.024 | 221 |

*Field Verified 3/26/2019 by M.J. at Vado Road and EBID Canal.

# Based on EBID Mesquite Drain and Fillmore Spillway April 1958. Elevations based on DACFC 2018 DEM provided by DACFC. 2ft contours were extracted from DEM.

(a) See plan view and cross sections in Figure G1

# Worksheet for Trap Channel 1+00 with Avg Slope

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.060 | |
| Channel Slope | 0.00041 | ft/ft |
| Normal Depth | 10.00 | ft |
| Left Side Slope | 2.00 | ft/ft (H:V) |
| Right Side Slope | 2.00 | ft/ft (H:V) |
| Bottom Width | 9.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 447.51 | ft³/s |
| Flow Area | 290.00 | ft² |
| Wetted Perimeter | 53.72 | ft |
| Hydraulic Radius | 5.40 | ft |
| Top Width | 49.00 | ft |
| Critical Depth | 3.31 | ft |
| Critical Slope | 0.04335 | ft/ft |
| Velocity | 1.54 | ft/s |
| Velocity Head | 0.04 | ft |
| Specific Energy | 10.04 | ft |
| Froude Number | 0.11 | |
| 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 | 10.00 | ft |
| Critical Depth | 3.31 | ft |
| Channel Slope | 0.00041 | ft/ft |

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.04335 | ft/ft |

# Worksheet for Trap Channel 10+00 with Avg Slope

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.060 | |
| Channel Slope | 0.00041 | ft/ft |
| Normal Depth | 8.50 | ft |
| Left Side Slope | 2.00 | ft/ft (H:V) |
| Right Side Slope | 2.00 | ft/ft (H:V) |
| Bottom Width | 13.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 373.84 | ft³/s |
| Flow Area | 255.00 | ft² |
| Wetted Perimeter | 51.01 | ft |
| Hydraulic Radius | 5.00 | ft |
| Top Width | 47.00 | ft |
| Critical Depth | 2.57 | ft |
| Critical Slope | 0.04454 | ft/ft |
| Velocity | 1.47 | ft/s |
| Velocity Head | 0.03 | ft |
| Specific Energy | 8.53 | ft |
| Froude Number | 0.11 | |
| 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 | 8.50 | ft |
| Critical Depth | 2.57 | ft |
| Channel Slope | 0.00041 | ft/ft |

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.04454 | ft/ft |

# Worksheet for Trap Channel 27+40 with Avg Slope

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.060 | |
| Channel Slope | 0.00041 | ft/ft |
| Normal Depth | 8.00 | ft |
| Left Side Slope | 2.00 | ft/ft (H:V) |
| Right Side Slope | 1.00 | ft/ft (H:V) |
| Bottom Width | 18.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 355.86 | ft³/s |
| Flow Area | 240.00 | ft² |
| Wetted Perimeter | 47.20 | ft |
| Hydraulic Radius | 5.08 | ft |
| Top Width | 42.00 | ft |
| Critical Depth | 2.16 | ft |
| Critical Slope | 0.04584 | ft/ft |
| Velocity | 1.48 | ft/s |
| Velocity Head | 0.03 | ft |
| Specific Energy | 8.03 | ft |
| Froude Number | 0.11 | |
| 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 | 8.00 | ft |
| Critical Depth | 2.16 | ft |
| Channel Slope | 0.00041 | ft/ft |

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.04584 | ft/ft |

# Worksheet for Trap Channel 39+00 with Avg Slope

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.060 | |
| Channel Slope | 0.00041 | ft/ft |
| Normal Depth | 6.00 | ft |
| Left Side Slope | 1.00 | ft/ft (H:V) |
| Right Side Slope | 2.00 | ft/ft (H:V) |
| Bottom Width | 3.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 73.28 | ft³/s |
| Flow Area | 72.00 | ft² |
| Wetted Perimeter | 24.90 | ft |
| Hydraulic Radius | 2.89 | ft |
| Top Width | 21.00 | ft |
| Critical Depth | 1.93 | ft |
| Critical Slope | 0.05752 | ft/ft |
| Velocity | 1.02 | ft/s |
| Velocity Head | 0.02 | ft |
| Specific Energy | 6.02 | ft |
| Froude Number | 0.10 | |
| 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 | 6.00 | ft |
| Critical Depth | 1.93 | ft |
| Channel Slope | 0.00041 | ft/ft |

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.05752 | ft/ft |

# Worksheet for Trap Channel 43+00 with Avg Slope

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.060 | |
| Channel Slope | 0.00041 | ft/ft |
| Normal Depth | 6.00 | ft |
| Left Side Slope | 1.00 | ft/ft (H:V) |
| Right Side Slope | 1.00 | ft/ft (H:V) |
| Bottom Width | 7.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 85.89 | ft³/s |
| Flow Area | 78.00 | ft² |
| Wetted Perimeter | 23.97 | ft |
| Hydraulic Radius | 3.25 | ft |
| Top Width | 19.00 | ft |
| Critical Depth | 1.55 | ft |
| Critical Slope | 0.05622 | ft/ft |
| Velocity | 1.10 | ft/s |
| Velocity Head | 0.02 | ft |
| Specific Energy | 6.02 | ft |
| Froude Number | 0.10 | |
| 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 | 6.00 | ft |
| Critical Depth | 1.55 | ft |
| Channel Slope | 0.00041 | ft/ft |

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.05622 | ft/ft |

# Worksheet for Trap Channel 92+00 with Avg Slope

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.060 | |
| Channel Slope | 0.00041 | ft/ft |
| Normal Depth | 10.00 | ft |
| Left Side Slope | 2.00 | ft/ft (H:V) |
| Right Side Slope | 2.00 | ft/ft (H:V) |
| Bottom Width | 5.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 367.94 | ft³/s |
| Flow Area | 250.00 | ft² |
| Wetted Perimeter | 49.72 | ft |
| Hydraulic Radius | 5.03 | ft |
| Top Width | 45.00 | ft |
| Critical Depth | 3.57 | ft |
| Critical Slope | 0.04479 | ft/ft |
| Velocity | 1.47 | ft/s |
| Velocity Head | 0.03 | ft |
| Specific Energy | 10.03 | ft |
| Froude Number | 0.11 | |
| 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 | 10.00 | ft |
| Critical Depth | 3.57 | ft |
| Channel Slope | 0.00041 | ft/ft |

# Worksheet for Trap Channel 92+00 with Avg Slope

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.04479 | ft/ft |

**Table G3 Base Flow Calculations based on 10-yr -24hr storm at 1ft depth in EBID Canal**
**Vado/ Del Cerro Drainage Master Plan**

| Section/Name | Channel Capacity at full flow depth | Baseflow at 1ft depth in Channel | Discharge from Tapir Pond at 10yr-storm | Channel Discharge Delta |
|---|---|---|---|---|
| a | cfs | cfs | cfs | cfs |
| 1+00 | 447 | 5 | 526 | -84 |
| 10+00 | 373 | 7 | 526 | -160 |
| 27+40 | 355 | 9 | 526 | -180 |
| 39+00 | 73 | 2 | 526 | -455 |
| 43+00 | 85 | 4 | 526 | -445 |
| 92+00 | 367 | 3 | 526 | -162 |

Purpose of table: If there was already 1ft of depth in canal at cross sections shown in this table. We have the capacity of the channel section (1+00, 10+00, etc.) if it flowed full, then did the same section at 1ft depth, then will add the 10yr-24hr Proposed Pond 1 Pond routing discharge rate of 24cfs and then will find the delta flow capacity after our pond discharges during the 10yr-24hr storm.

# Worksheet for Trap Channel 1+00 with Avg Slope - 1ft Baseflow

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.060 | |
| Channel Slope | 0.00041 | ft/ft |
| Normal Depth | 1.00 | ft |
| Left Side Slope | 2.00 | ft/ft (H:V) |
| Right Side Slope | 2.00 | ft/ft (H:V) |
| Bottom Width | 9.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 4.82 | ft³/s |
| Flow Area | 11.00 | ft² |
| Wetted Perimeter | 13.47 | ft |
| Hydraulic Radius | 0.82 | ft |
| Top Width | 13.00 | ft |
| Critical Depth | 0.20 | ft |
| Critical Slope | 0.09155 | ft/ft |
| Velocity | 0.44 | ft/s |
| Velocity Head | 0.00 | ft |
| Specific Energy | 1.00 | ft |
| Froude Number | 0.08 | |
| 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 | 1.00 | ft |
| Critical Depth | 0.20 | ft |
| Channel Slope | 0.00041 | ft/ft |

# Worksheet for Trap Channel 1+00 with Avg Slope - 1ft Baseflow

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.09155 | ft/ft |

# Worksheet for Trap Channel 10+00 with Avg Slope - 1ft Baseflow

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.060 | |
| Channel Slope | 0.00041 | ft/ft |
| Normal Depth | 1.00 | ft |
| Left Side Slope | 2.00 | ft/ft (H:V) |
| Right Side Slope | 2.00 | ft/ft (H:V) |
| Bottom Width | 13.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 6.79 | ft³/s |
| Flow Area | 15.00 | ft² |
| Wetted Perimeter | 17.47 | ft |
| Hydraulic Radius | 0.86 | ft |
| Top Width | 17.00 | ft |
| Critical Depth | 0.20 | ft |
| Critical Slope | 0.09115 | ft/ft |
| Velocity | 0.45 | ft/s |
| Velocity Head | 0.00 | ft |
| Specific Energy | 1.00 | ft |
| Froude Number | 0.09 | |
| 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 | 1.00 | ft |
| Critical Depth | 0.20 | ft |
| Channel Slope | 0.00041 | ft/ft |

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.09115 | ft/ft |

# Worksheet for Trap Channel 27+40 with Avg Slope - 1ft Baseflow

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.060 | |
| Channel Slope | 0.00041 | ft/ft |
| Normal Depth | 1.00 | ft |
| Left Side Slope | 2.00 | ft/ft (H:V) |
| Right Side Slope | 1.00 | ft/ft (H:V) |
| Bottom Width | 18.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 9.12 | ft³/s |
| Flow Area | 19.50 | ft² |
| Wetted Perimeter | 21.65 | ft |
| Hydraulic Radius | 0.90 | ft |
| Top Width | 21.00 | ft |
| Critical Depth | 0.20 | ft |
| Critical Slope | 0.09125 | ft/ft |
| Velocity | 0.47 | ft/s |
| Velocity Head | 0.00 | ft |
| Specific Energy | 1.00 | ft |
| Froude Number | 0.09 | |
| 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 | 1.00 | ft |
| Critical Depth | 0.20 | ft |
| Channel Slope | 0.00041 | ft/ft |

# Worksheet for Trap Channel 27+40 with Avg Slope - 1ft Baseflow

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.09125 | ft/ft |

# Worksheet for Trap Channel 39+00 with Avg Slope - 1ft Baseflow

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.060 | |
| Channel Slope | 0.00041 | ft/ft |
| Normal Depth | 1.00 | ft |
| Left Side Slope | 1.00 | ft/ft (H:V) |
| Right Side Slope | 2.00 | ft/ft (H:V) |
| Bottom Width | 3.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 1.74 | ft³/s |
| Flow Area | 4.50 | ft² |
| Wetted Perimeter | 6.65 | ft |
| Hydraulic Radius | 0.68 | ft |
| Top Width | 6.00 | ft |
| Critical Depth | 0.21 | ft |
| Critical Slope | 0.09544 | ft/ft |
| Velocity | 0.39 | ft/s |
| Velocity Head | 0.00 | ft |
| Specific Energy | 1.00 | ft |
| Froude Number | 0.08 | |
| 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 | 1.00 | ft |
| Critical Depth | 0.21 | ft |
| Channel Slope | 0.00041 | ft/ft |

# Worksheet for Trap Channel 39+00 with Avg Slope - 1ft Baseflow

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.09544 | ft/ft |

# Worksheet for Trap Channel 43+00 with Avg Slope - 1ft Baseflow

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.060 | |
| Channel Slope | 0.00041 | ft/ft |
| Normal Depth | 1.00 | ft |
| Left Side Slope | 1.00 | ft/ft (H:V) |
| Right Side Slope | 1.00 | ft/ft (H:V) |
| Bottom Width | 7.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 3.50 | ft³/s |
| Flow Area | 8.00 | ft² |
| Wetted Perimeter | 9.83 | ft |
| Hydraulic Radius | 0.81 | ft |
| Top Width | 9.00 | ft |
| Critical Depth | 0.20 | ft |
| Critical Slope | 0.09376 | ft/ft |
| Velocity | 0.44 | ft/s |
| Velocity Head | 0.00 | ft |
| Specific Energy | 1.00 | ft |
| Froude Number | 0.08 | |
| 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 | 1.00 | ft |
| Critical Depth | 0.20 | ft |
| Channel Slope | 0.00041 | ft/ft |

# Worksheet for Trap Channel 43+00 with Avg Slope - 1ft Baseflow

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.09376 | ft/ft |

# Worksheet for Trap Channel 92+00 with Avg Slope - 1ft Baseflow

## Project Description

| | |
|---|---|
| Friction Method | Manning Formula |
| Solve For | Discharge |

## Input Data

| | | |
|---|---|---|
| Roughness Coefficient | 0.060 | |
| Channel Slope | 0.00041 | ft/ft |
| Normal Depth | 1.00 | ft |
| Left Side Slope | 2.00 | ft/ft (H:V) |
| Right Side Slope | 2.00 | ft/ft (H:V) |
| Bottom Width | 5.00 | ft |

## Results

| | | |
|---|---|---|
| Discharge | 2.87 | $ft^3/s$ |
| Flow Area | 7.00 | $ft^2$ |
| Wetted Perimeter | 9.47 | ft |
| Hydraulic Radius | 0.74 | ft |
| Top Width | 9.00 | ft |
| Critical Depth | 0.21 | ft |
| Critical Slope | 0.09239 | ft/ft |
| Velocity | 0.41 | ft/s |
| Velocity Head | 0.00 | ft |
| Specific Energy | 1.00 | ft |
| Froude Number | 0.08 | |
| 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 | 1.00 | ft |
| Critical Depth | 0.21 | ft |
| Channel Slope | 0.00041 | ft/ft |

## GVF Output Data

| | | |
|---|---|---|
| Critical Slope | 0.09239 | ft/ft |

# Storm Drain Plan, Profiles and Calculations

**StormCAD Profiles and Tables:**

Profile 1: Storm Drain 10yr-24hr

Profile 1: Storm Drain 100yr-24hr

Profile 2: Storm Drain 10yr-24hr

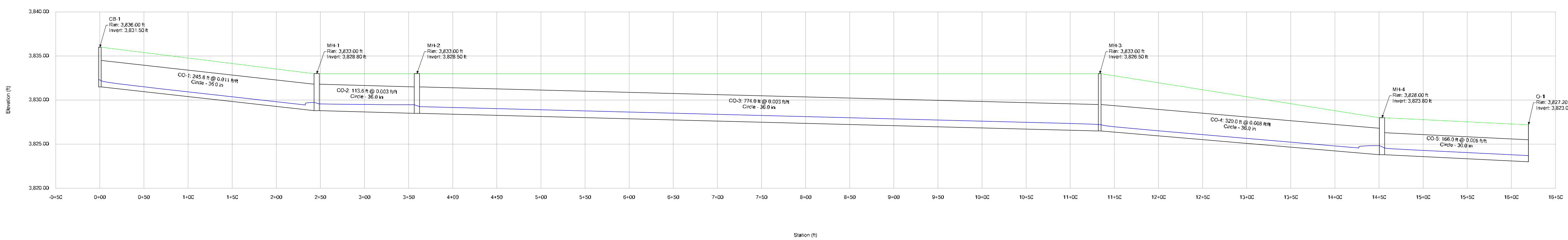
Profile 2: Storm Drain 100yr-24hr

FlowMaster Outputs

NMDOT Standard Drawings – Curb and Gutter

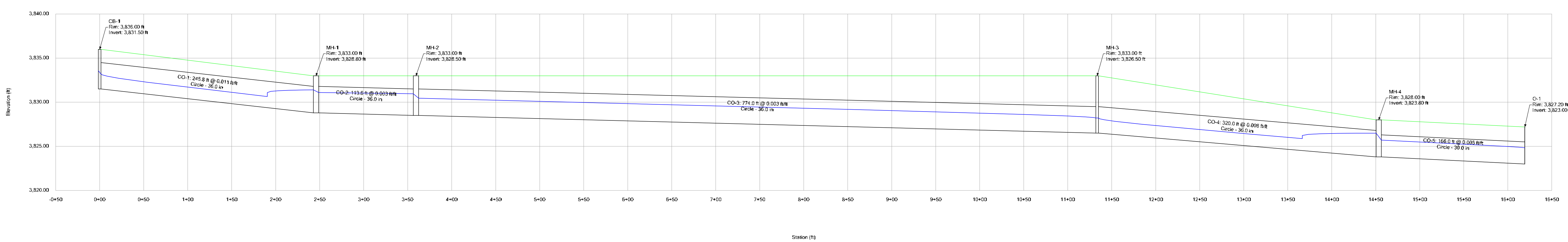
NMDOT Standard Drawings – Median Inlet

# Profile Report
## Engineering Profile - Profile - 1 (StormDrain-10YR.stsw)

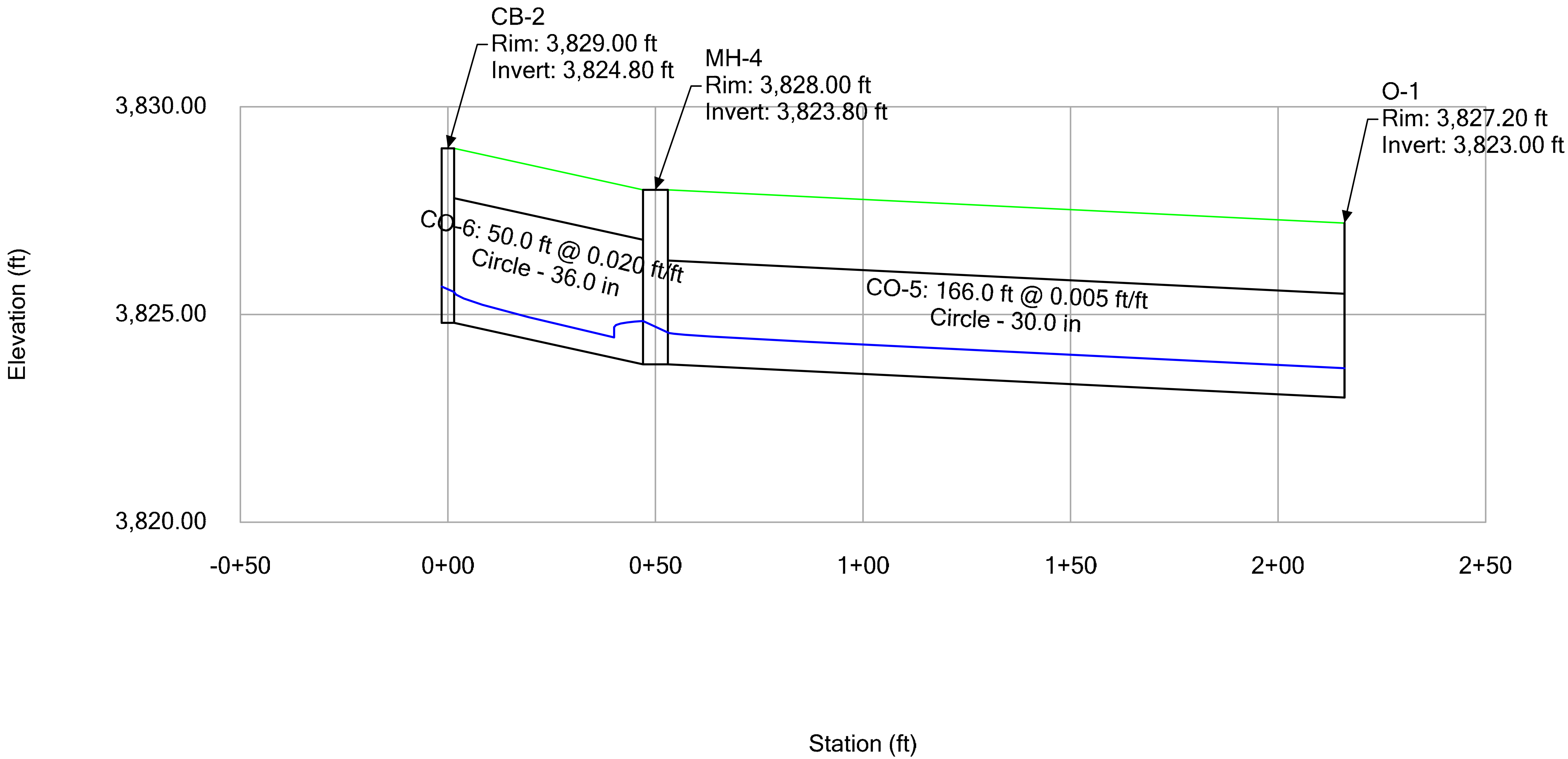


# Profile Report

## Engineering Profile - Profile - 1 (StormDrain-100YR.stsw)

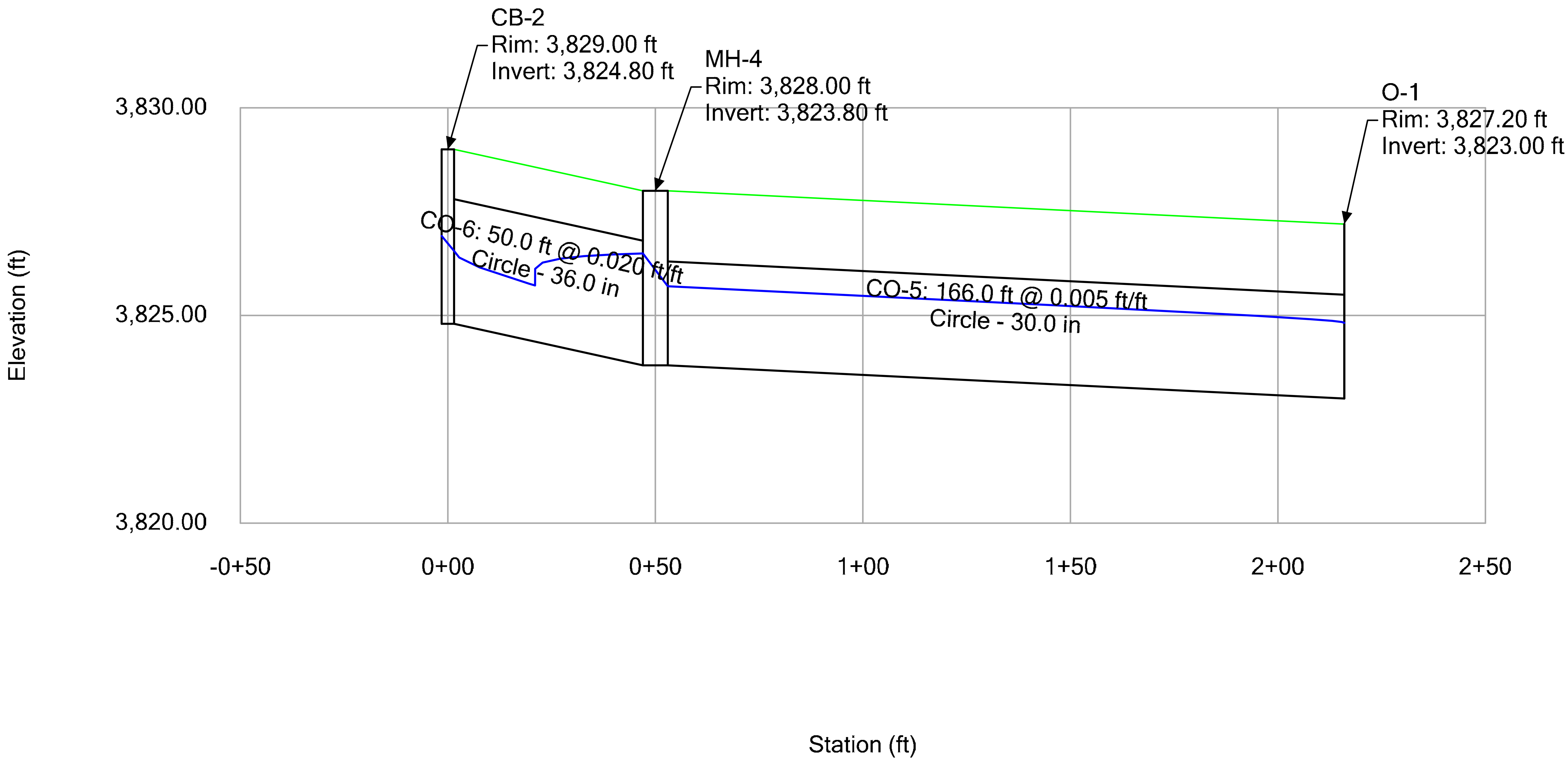


Profile Report
Engineering Profile - Profile - 2 (StormDrain-10YR.stsw)



Profile Report

Engineering Profile - Profile - 2 (StormDrain-100YR.stsw)



# Worksheet for Median Drop Inlet-Sag

## Project Description

| | |
|---|---|
| Solve For | Spread |

## Input Data

| | | | |
|---|---|---|---|
| Discharge | | 6.00 | ft³/s |
| Left Side Slope | | 3.00 | ft/ft (H:V) |
| Right Side Slope | | 3.00 | ft/ft (H:V) |
| Bottom Width | | 10.00 | ft |
| Grate Width | | 5.00 | ft |
| Grate Length | | 10.00 | ft |
| Local Depression | | 2.00 | in |
| Local Depression Width | | 2.00 | ft |
| Grate Type | P-50 mm (P-1-7/8") | | |
| Clogging | | 50.00 | % |

## Results

| | | |
|---|---|---|
| Spread | 10.11 | ft |
| Depth | 0.02 | ft |
| Wetted Perimeter | 10.12 | ft |
| Top Width | 10.11 | ft |
| Open Grate Area | 22.50 | ft² |
| Active Grate Weir Length | 25.00 | ft |

# Worksheet for Median Drop Inlet-Sag

## Project Description

| | |
|---|---|
| Solve For | Spread |

## Input Data

| | | |
|---|---|---|
| Discharge | 30.00 | ft³/s |
| Left Side Slope | 3.00 | ft/ft (H:V) |
| Right Side Slope | 3.00 | ft/ft (H:V) |
| Bottom Width | 10.00 | ft |
| Grate Width | 5.00 | ft |
| Grate Length | 10.00 | ft |
| Local Depression | 2.00 | in |
| Local Depression Width | 2.00 | ft |
| Grate Type | P-50 mm (P-1-7/8") | |
| Clogging | 50.00 | % |

## Results

| | | |
|---|---|---|
| Spread | 12.26 | ft |
| Depth | 0.38 | ft |
| Wetted Perimeter | 12.38 | ft |
| Top Width | 12.26 | ft |
| Open Grate Area | 22.50 | ft² |
| Active Grate Weir Length | 25.00 | ft |

# Worksheet for Mountable C&G-10YR

## Project Description

| | |
|---|---|
| Solve For | Spread |

## Input Data

| | | |
|---|---|---|
| Channel Slope | 0.00500 | ft/ft |
| Discharge | 3.00 | ft³/s |
| Gutter Width | 1.25 | ft |
| Gutter Cross Slope | 0.02 | ft/ft |
| Road Cross Slope | 0.02 | ft/ft |
| Roughness Coefficient | 0.015 | |

## Results

| | | |
|---|---|---|
| Spread | 12.10 | ft |
| Flow Area | 1.46 | ft² |
| Depth | 0.24 | ft |
| Gutter Depression | 0.00 | ft |
| Velocity | 2.05 | ft/s |

# Worksheet for Mountable C&G

## Project Description

| | |
|---|---|
| Solve For | Spread |

## Input Data

| | | |
|---|---|---|
| Channel Slope | 0.00500 | ft/ft |
| Discharge | 15.00 | ft³/s |
| Gutter Width | 1.25 | ft |
| Gutter Cross Slope | 0.02 | ft/ft |
| Road Cross Slope | 0.02 | ft/ft |
| Roughness Coefficient | 0.015 | |

## Results

| | | |
|---|---|---|
| Spread | 22.12 | ft |
| Flow Area | 4.89 | ft² |
| Depth | 0.44 | ft |
| Gutter Depression | 0.00 | ft |
| Velocity | 3.07 | ft/s |

# Worksheet for Standard C&G

## Project Description

| | |
|---|---|
| Solve For | Spread |

## Input Data

| | | |
|---|---|---|
| Channel Slope | 0.00500 | ft/ft |
| Discharge | 3.00 | ft³/s |
| Gutter Width | 1.25 | ft |
| Gutter Cross Slope | 0.02 | ft/ft |
| Road Cross Slope | 0.02 | ft/ft |
| Roughness Coefficient | 0.015 | |

## Results

| | | |
|---|---|---|
| Spread | 12.10 | ft |
| Flow Area | 1.46 | ft² |
| Depth | 0.24 | ft |
| Gutter Depression | 0.00 | ft |
| Velocity | 2.05 | ft/s |

# Worksheet for Standard C&G

## Project Description

| | |
|---|---|
| Solve For | Spread |

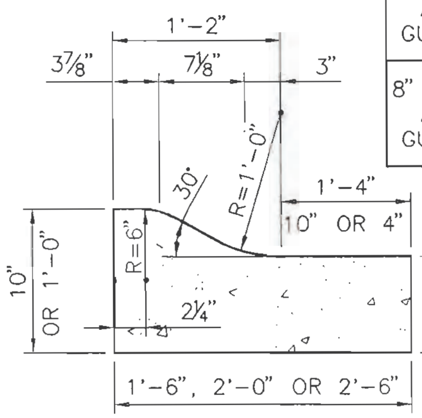
## Input Data

| | | |
|---|---|---|
| Channel Slope | 0.01000 | ft/ft |
| Discharge | 15.00 | ft³/s |
| Gutter Width | 1.25 | ft |
| Gutter Cross Slope | 0.02 | ft/ft |
| Road Cross Slope | 0.02 | ft/ft |
| Roughness Coefficient | 0.015 | |

## Results

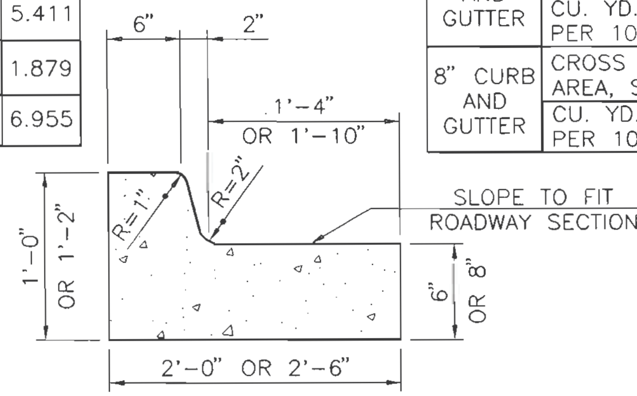
| | | |
|---|---|---|
| Spread | 19.42 | ft |
| Flow Area | 3.77 | ft² |
| Depth | 0.39 | ft |
| Gutter Depression | 0.00 | ft |
| Velocity | 3.98 | ft/s |

| | | 1'-6" | 2'-0" | 2'-6" |
|---|---|---|---|---|
| 6" CURB AND GUTTER | CROSS SECTION AREA, SQ. FT. | 0.961 | 1.211 | 1.461 |
| | CU. YD. VOLUME PER 100 LIN. FT. | 3.559 | 4.485 | 5.411 |
| 8" CURB AND GUTTER | CROSS SECTION AREA, SQ. FT. | 1.211 | 1.544 | 1.879 |
| | CU. YD. VOLUME PER 100 LIN. FT. | 4.485 | 5.719 | 6.955 |



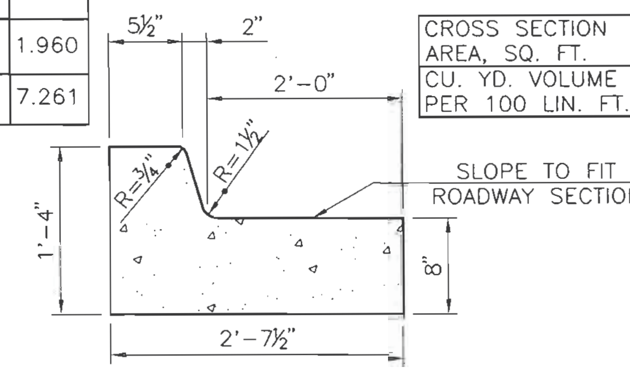

## CONCRETE MOUNTABLE CURB AND GUTTER TYPE "A"

| | | 2'-0" | 2'-6" |
|---|---|---|---|
| 6" CURB AND GUTTER | CROSS SECTION AREA, SQ. FT. | 1.294 | 1.544 |
| | CU. YD. VOLUME PER 100 LIN. FT. | 4.791 | 5.717 |
| 8" CURB AND GUTTER | CROSS SECTION AREA, SQ. FT. | 1.627 | 1.960 |
| | CU. YD. VOLUME PER 100 LIN. FT. | 6.026 | 7.261 |




## CONCRETE BARRIER CURB AND GUTTER TYPE "B"

| | |
|---|---|
| CROSS SECTION AREA, SQ. FT. | 2.113 |
| CU. YD. VOLUME PER 100 LIN. FT. | 7.824 |

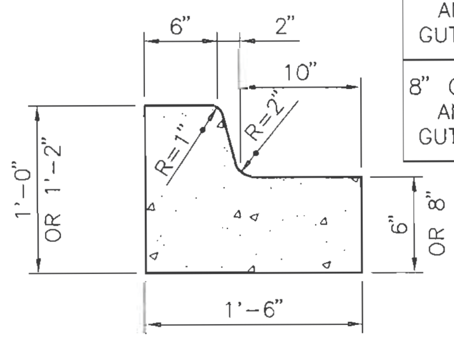



## CONCRETE BARRIER CURB AND GUTTER TYPE "C"

## GENERAL NOTES

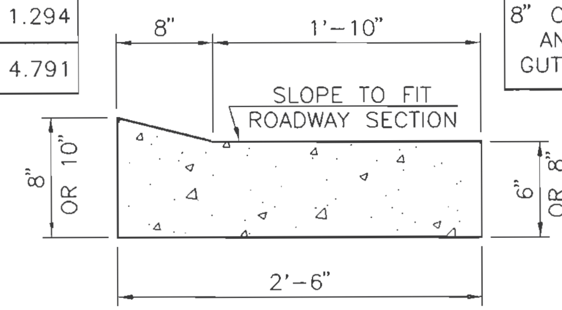
1. CONCRETE SHALL BE STRUCTURAL CONCRETE CLASS "A."
2. END OF DAYS POUR, 30 MINUTE INTERRUPTIONS, COLD JOINTS AND DROP INLETS SHALL DETERMINE THE LOCATION OF A CONSTRUCTION JOINT AND A 3/4" PREMOLDED BITUMINOUS JOINT IS REQUIRED.
3. PLACE TRANSVERSE CONTRACTION JOINTS AT 5'-0" INTERVALS AND AT THE END OF RADIUS POINTS OR ISLAND NOSES.
4. BED COURSE MATERIAL ON WHICH SIDEWALK IS TO BE PLACED SHALL BE COMPACTED TO 95% OF MAXIMUM DENSITY AS DETERMINED BY AASHTO T 99, METHOD C.
5. EXCAVATION AND PREMOLDED BITUMINOUS EXPANSION JOINTS TO BE INCLUDED IN THE UNIT PRICE BID FOR SIDEWALKS.
6. THE SILICONE SEALED JOINTS SHALL BE SEALED IN ACCORDANCE WITH SECTION 452 OF THE STANDARD SPECIFICATIONS.
7. FOR SLIP-FORMED CURB AND GUTTER, FURNISH 1" SEALED EXPANSION JOINTS AT 90' INTERVALS, AND TRANSVERSE CONSTRUCTION JOINTS AT 5' INTERVALS.
8. FOR SIDEWALKS AND NON-SLIP FORMED CURB AND GUTTER, FURNISH 3/4" SEALED EXPANSION JOINTS AT 30' INTERVALS, AND TRANSVERSE CONTRACTION JOINTS AT 5' INTERVALS.

| | | |
|---|---|---|
| 6" CURB AND GUTTER | CROSS SECTION AREA, SQ. FT. | 1.044 |
| | CU. YD. VOLUME PER 100 LIN. FT. | 3.866 |
| 8" CURB AND GUTTER | CROSS SECTION AREA, SQ. FT. | 1.294 |
| | CU. YD. VOLUME PER 100 LIN. FT. | 4.791 |



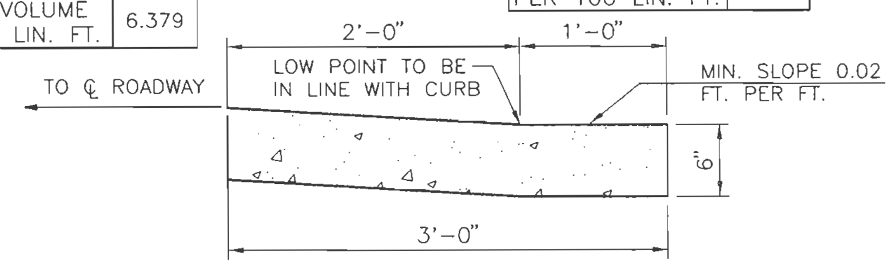

## CONCRETE BARRIER CURB AND GUTTER TYPE "D"

| | | |
|---|---|---|
| 6" CURB AND GUTTER | CROSS SECTION AREA, SQ. FT. | 1.306 |
| | CU. YD. VOLUME PER 100 LIN. FT. | 4.835 |
| 8" CURB AND GUTTER | CROSS SECTION AREA, SQ. FT. | 1.722 |
| | CU. YD. VOLUME PER 100 LIN. FT. | 6.379 |

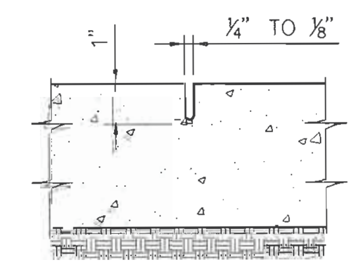



## CONCRETE LAYDOWN CURB TYPE "E"

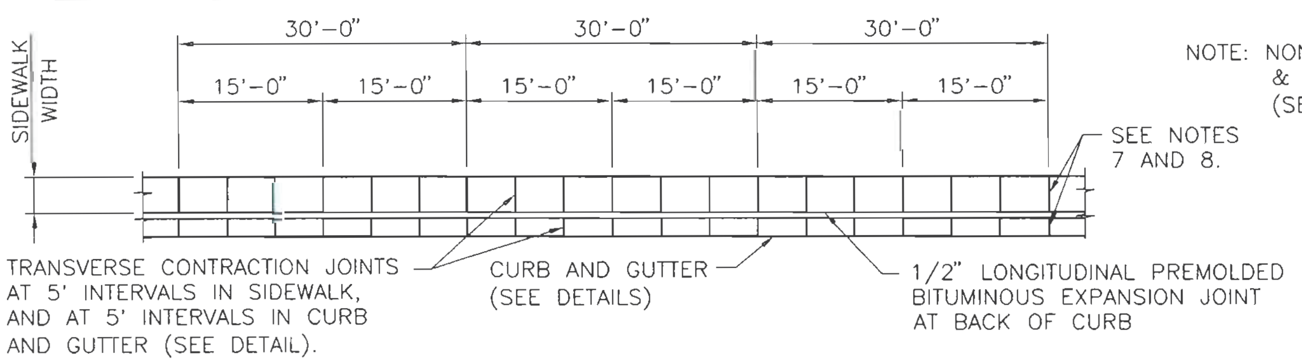
| | |
|---|---|
| CROSS SECTION AREA, SQ. FT. | 1.500 |
| CU. YD. VOLUME PER 100 LIN. FT. | 5.556 |




## CONCRETE VALLEY GUTTER

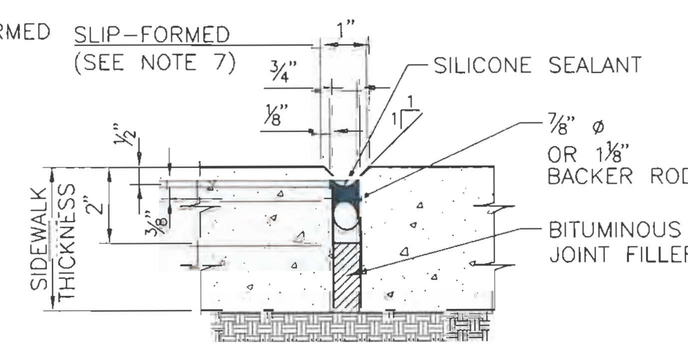



## TRANSVERSE CONTRACTION JOINT

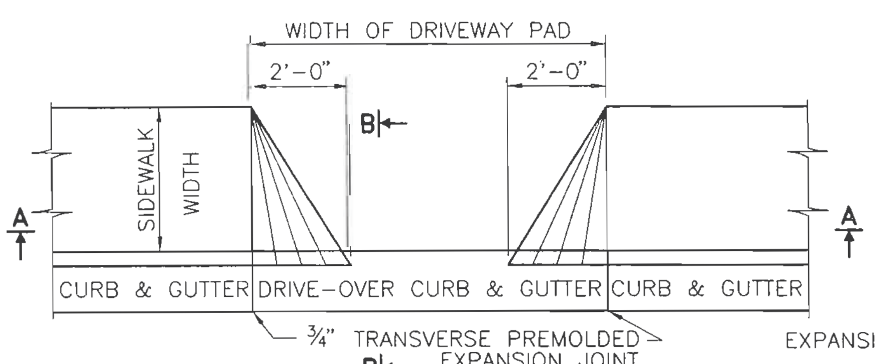



NOTE: NON-SLIP FORMED & SIDEWALKS (SEE NOTE 8)

## PLAN CURB AND GUTTER AND SIDEWALK

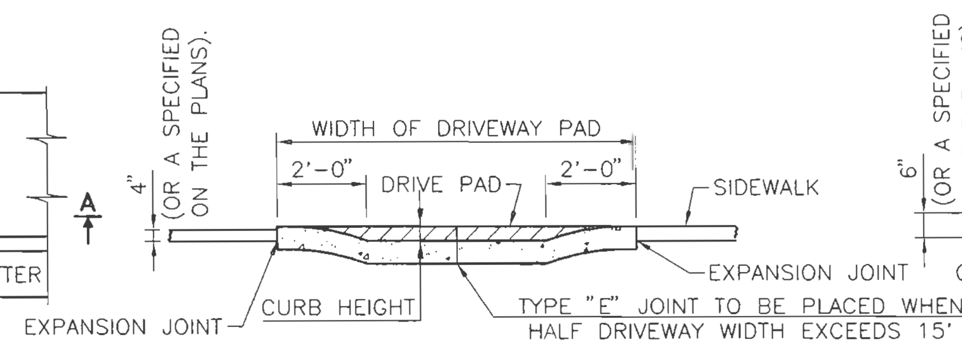



## SEALED EXPANSION JOINT

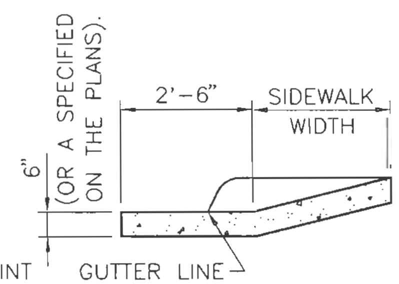



## PLAN DRIVE PAD

⚠1




## SECTION A-A




## SECTION B-B


| NO. | DATE | REV.BY | DESCRIPTION |
|---|---|---|---|
| ⚠1 | 9/9/09 | YML | ADDED DETAILS |

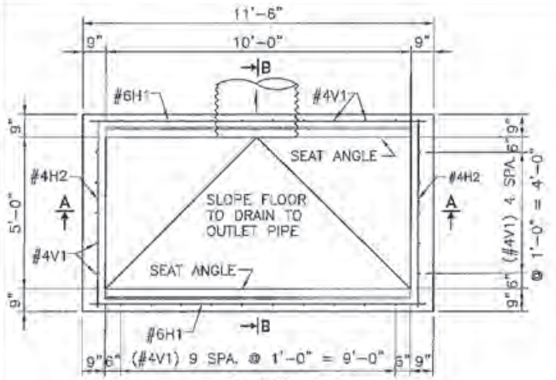
REVISIONS (OR CHANGE NOTICES)

NEW MEXICO DEPARTMENT OF TRANSPORTATION STANDARD DRAWING

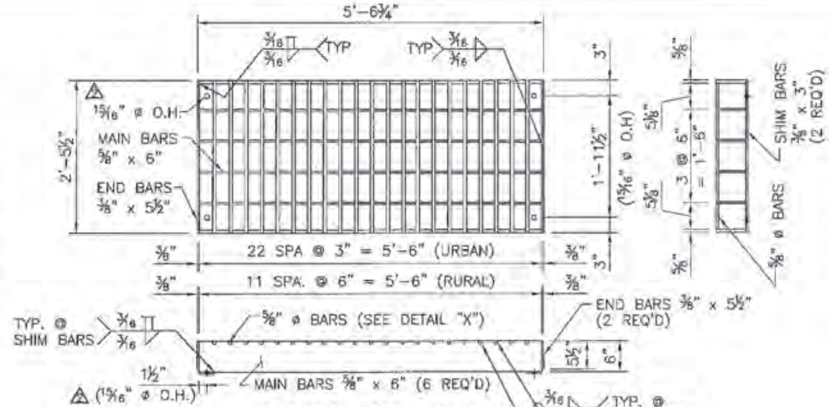
SIDEWALK CURB AND GUTTER

DESIGNED BY____ DRAWN BY SKL CHECKED BY YML

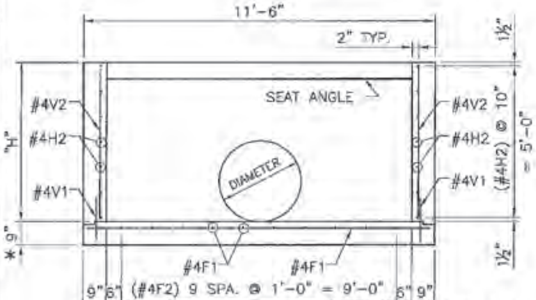
609-01-1/1




PLAN

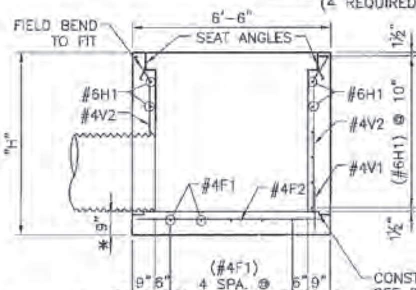



GRATE DETAILS
(4 REQUIRED)



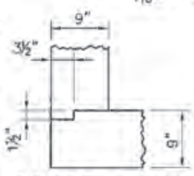

SECTION A-A

* AVERAGE BOTTOM THICKNESS USE 8 1/2" AT OUTLET AND 9 1/2" AT HIGH SIDE.

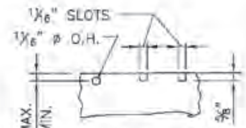



NOTE: FIELD CUT AND BEND REBAR AS REQUIRED TO CLEAR SEAT ANGLES AND PIPE OPENINGS. (2" MINIMUM CLEARANCE).

SECTION B-B




CONST. JOINT DETAIL

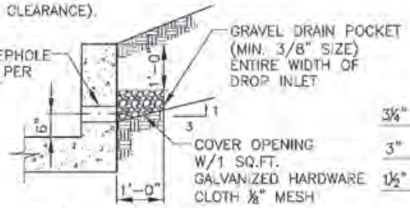



DETAIL "X"
(ALTERNATE METHODS)

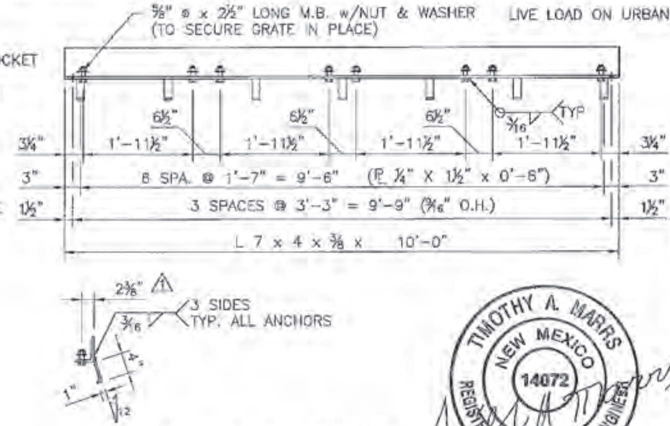
"H"= DIAMETER OR RISE OF PIPE + "Y" MINIMUM, AND 15'-0" MAXIMUM.

| "Y" | DIAMETERS AND RISES UP TO AND INCLUDING 48" | DIAMETERS AND RISES GREATER THAN 48". |
|---|---|---|
| | 1'-3" | 2'-0" |

NOTE: IF R.C.P. IS USED, ADD WALL THICKNESS TO DIMENSION "Y".




WEEP HOLE DETAIL




SEAT ANGLE DETAILS
(2 REQUIRED)

## ESTIMATED QUANTITIES

(FOR CONTRACTOR'S INFORMATION ONLY, NOT A BID ITEM)

| | |
|---|---|
| CLASS "A" CONCRETE | 1.932 + 0.917"H" CU.YDS. |
| REINFORCING STEEL | 151.53 + 70.61"H" LBS. |
| STRUCTURAL STEEL (URBAN) | 2394 LBS. |
| STRUCTURAL STEEL (RURAL) | 2280 LBS. |

NOTE: TO OBTAIN CLASS "A" CONCRETE QUANTITY, USE VALUE TABULATED ABOVE AND DEDUCT THE VOLUME OF THE PIPE OPENINGS FROM THE QUANTITY TABULATED.

| MARK | LENGTH | NO. REQD |
|---|---|---|
| * #6H1 | 11'-3" | 2+2.4"H" |
| * #4H2 | 8'-3" | 2+2.4"H" |
| #4V1 | 1'-9" | 30 |
| #4V2 | "H"-3" | 30 |
| #4F1 | 11'-3" | 5 |
| #4F2 | 6'-3" | 10 |

REINFORCING BAR SCHEDULE

* NOTE: ROUND OFF NUMBER REQUIRED TO THE NEAREST EVEN NUMBER.

## GENERAL NOTES

1. WORKMANSHIP AND MATERIALS SHALL CONFORM TO NEW MEXICO DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS FOR HIGHWAY AND BRIDGE CONSTRUCTION, CURRENT EDITION.
2. ALL CONCRETE SHALL BE CLASS "A." CHAMFER EXPOSED EDGES OF CONCRETE 3/4" UNLESS OTHERWISE NOTED ON THE DETAILS.
3. REINFORCING BARS SHALL CONFORM TO AASHTO SPECIFICATION M 31, GRADE 60. DIMENSIONS REFER TO THE CENTERLINE OF BAR UNLESS OTHERWISE NOTED ON THE DETAILS.
4. STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A 36 AND SHALL BE GIVEN A PROTECTIVE COATING IN CONFORMANCE WITH THE SPECIFICATIONS.
5. DROP INLETS MAY BE USED WITH EITHER R.C.P. OR C.M.P. C.M.P. IS SHOWN IN THE DETAILS.
6. PIPES MAY BE LOCATED ON ANY WALL AND MAY BE ANY SHAPE. DIAMETER OR SPAN OF THE PIPES WILL BE DETERMINED BY THE SKEW ANGLE AND A REQUIRED MINIMUM CLEARANCE OF 9" TO THE OUTSIDE FACE OF THE WALLS.
7. THE URBAN GRATING DETAIL SHALL BE USED IN ALL CASES UNLESS CALLED OUT ON THE PLANS.

## DRAWINGS REQUIRED

ROADWAY DESIGN DRAWINGS: FOR PIPE TYPE, LOCATION, HEIGHT, SKEW ANGLE, AND NUMBER REQUIRED.

## DESIGN DATA

DESIGN ACCORDING TO AASHTO SPECIFICATIONS CURRENT EDITION.

DESIGN STRESSES:

| | |
|---|---|
| REINFORCED CONCRETE: | f'c= 3,000 psi, fy= 60,000 psi, N= 10. |
| STRUCTURAL STEEL: | fs= 20,000 psi, fy= 36,000 psi. |

EARTH PRESSURE: 36 lbs./cu.ft. EQUIV. FLUID PRESSURE 2'-0" SURCHARGE.

LIVE LOAD ON URBAN GRATING: ONE 16,000 lbs. WHEEL PLUS 30% IMPACT, 15% OVERSTRESS.

NOTE: MEDIAN DROP INLETS, COMPLETE IN PLACE, WILL BE PAID FOR AT THE UNIT PRICE BID PER EACH.

| NO. | DATE | REV.BY | DESCRIPTION |
|---|---|---|---|
| 2 | 09/19/14 | TAM | REVISED DIAMETER |
| 1 | 5/11/09 | YML | CHANGED 2" TO 2 3/8" |

REVISIONS (OR CHANGE NOTICES)

NEW MEXICO DEPARTMENT OF TRANSPORTATION STANDARD DRAWING

MEDIAN DROP INLET
10'-0" x 5'-0"
DETAILS AND QUANTITIES

TIMOTHY A. MARRS NEW MEXICO 14072 REGISTERED PROFESSIONAL ENGINEER

2-23-14

DESIGNED BY ____ DRAWN BY SKL CHECKED BY YML/TM

623-05-1/1 1 of 1

# APPENDIX H

## ENGINEER'S OPINION OF PROBABLE COST AND QUANTITY ESTIMATES

| Table H1 SUMMARY OF ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR ALL OPTIONS<br>Vado/Del Cerro Drainage Master Plan | | | |
|---|---|---|---|
| | Phase | Description | Cost |
| Alternative 2 | 1 | Tapir Pond | $ 3,567,000 |
| | 2 | Vado Channel - Soil Cement | $ 1,574,000 |
| | | **Total Cost** | **$ 5,141,000** |
| | 1 | Tapir Pond | $ 3,567,000 |
| | 2 | Vado Channel - Reinforced Concrete with Baffles | $ 1,915,000 |
| | | **Total Cost** | **$ 5,482,000** |
| | | | |
| Alternative 3 | 1 | Lily Pond | $ 495,000 |
| | 2 | Storm Drain and Roadway Improvements | $ 569,000 |
| | | **Total Cost** | **$ 1,064,000** |
| | | | |
| Alternative 4 - Option 1 | 1 | Crazy Horse Pond and Earth Lined Channels | $ 512,000 |
| | 2 | Estancia Pond | $ 224,000 |
| | 3 | Crazy Horse Storm Drain | $ 528,000 |
| | 4 | Estancia Storm Drain | $ 216,000 |
| | | Highline Storm Drain | $ 492,000 |
| | | **Total Cost** | **$ 1,972,000** |
| | | | |
| Alternative 4 - Option 2 | | Crazy Horse Pond and Earth Lined Channels | $ 512,000 |
| | | **Total Cost** | **$ 512,000** |

| Table H2 SUMMARY OF ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR ALL RECOMMENDED OPTIONS WITH PRIORITIES<br><br>Vado/Del Cerro Drainage Master Plan | | | | |
|---|---|---|---|---|
| | Priority | Phase | Description | Cost |
| Alternative 4 - Option 2 | 1 | 1 | Crazy Horse Pond and Earth Lined Channels | $ 512,000 |
| | | | | |
| Alternative 2 | 2 | 1 | Outlet Works | $ 1,574,000 |
| Alternative 2 | 3 | 2 | Tapir Pond Expansion | $ 3,567,000 |
| | | | | |
| Alternative 3 | 4 | 1 | Lily Pond | $ 495,000 |
| Alternative 3 | 5 | 2 | Storm Drain and Roadway Improvements | $ 569,000 |
| | | | | |
| Total Cost of Phased Capital Improvement Projects | | | | $ 6,717,000 |

| Table H3<br>Tapir Pond<br>Engineers Estimate of Probable Cost For Vado/Del Cerro Drainage Master Plan | | | | | | |
|---|---|---|---|---|---|---|
| BID ITEM NUMBER | ITEM ID NUMBER | ITEM DESCRIPTION | ESTIMATED QUANTITY | UNIT | ESTIMATED UNIT PRICE | ESTIMATED AMOUNT |
| 1 | 201.01# | Clearing and Grubbing (Tapir Pond) | 43 | AC | $1,500 | $64,500 |
| 2 | 202000 | Excavation and Rough Grading (Tapir Pond) | 423,452 | CY | $4 | $1,693,808 |
| 3 | 303160 | Base Course 6" (Maintenance road - 20' x 40') | 89 | SY | $12 | $1,067 |
| 4 | 513000 | Soil Cement (Emergency spillway - 200' x 10' x1) | 12 | CY | $95 | $1,140 |
| 5 | 570449 | 30" Storm Drain Culvert RCP (Tapir pond principal spillway) | 336 | LF | $105 | $35,280 |
| 6 | 607046 | Chain Link Security Fence 6' | 6,700 | LF | $25 | $167,500 |
| 7 | 607314 | Standard Gate, 14' | 1 | EA | $1,000 | $1,000 |
| 8 | 632000 | Revegetation Class A seeding | 43 | AC | $7,200 | $309,600 |
| 9 | 701.10 | Trenching, backfilling, and Compaction up to 8' in depth for 18" to 36" diameter pipe (Crazy horse principal spillway pipe) | 336 | LF | $25 | $8,400 |
| | | | Subtotal of Bid Items 1 - 9 | | | $2,282,295 |
| 10 | 621000 | Mobilization (5% of Construction Costs) | 1 | LS | $114,115 | $114,115 |
| | a) **BASE BID:** Subtotal of Bid Item No. 1 through Bid Item No. 10 | | | | | $2,396,409 |
| | b) **CONTINGENCY** | | | | | |
| | Assume 25% Contingency | | | | $570,574 | $2,966,983 |
| | c) **BASE BID ALLOWANCES:** | | | | | |
| | Utility Relocation (assume 3% of construction costs) | | | | $69,000 | |
| | Lab Testing (assume 3% of construction costs) | | | | $69,000 | |
| | Land Acquisition | Assume $2500/acre | | 20 | $50,000 | |
| | | **Total Base Bid Allowances** | | | | $188,000 |
| | d) **SURVEY, STAKING & TRAFFIC CONTROL** | | | | | |
| | Construction Survey and staking, complete (assume 3% of construction costs) | | | | $69,000 | |
| | Construction Traffic Control & Barricading Incidental | | | | $69,000 | |
| | | | | | | $138,000 |
| | e) **BASE BID SUBTOTAL:** | | | | | |
| | Line a) Base Bid plus Line b) Contingencies plus Line c) Base Bid Allowances: | | | | | $3,292,983 |
| | f) **BASE BID - NEW MEXICO GROSS RECEIPTS TAX (NMGRT) - LAS CRUCES:** | | | | | |
| | on amount on Line e) Base Bid Subtotal at 8.3125% | | | | | $273,729 |
| | g) **BASE BID TOTAL: - Line e) Subtotal plus Line f) NMGRT:** | | | | | **$3,566,712** |
| | | | | **Total Cost Rounded Up:** | | **$3,567,000** |

Bid numbers and unit costs are based on NMDOT 2018 Average Bid Prices

# Bid item from City of Albuquerque 2018 City Engineer's Estimate Unit Prices

| Table H4<br>Vado Channel - Soil Cement Steps<br>Engineers Estimate of Probable Cost For Vado/Del Cerro Drainage Master Plan | | | | | | |
|---|---|---|---|---|---|---|
| **BID ITEM NUMBER** | **ITEM ID NUMBER** | **ITEM DESCRIPTION** | **ESTIMATED QUANTITY** | **UNIT** | **ESTIMATED UNIT PRICE** | **ESTIMATED AMOUNT** |
| 1 | 202000 | Excavation and Rough Grading (Vado Channel - soil cement steps included) | 20,093 | CY | $4 | $80,372 |
| 3 | 509000 | Portland Cement (12% minimum) Type II-LA for soil cement, complete | 1,348 | TON | $215 | $289,773 |
| 4 | 513000 | Soil Cement (Vado Channel & soil cement steps included) with on-site soils as aggregate including excavation, subgrade preparation, and backfill, C.I.P. | 6638 | CY | $95 | $630,610 |
| | | | Subtotal of Bid Items 1 - 4 | | | $1,000,755 |
| 5 | 621000 | Mobilization (5% of Construction Costs) | 1 | LS | $50,038 | $50,038 |
| | **a) BASE BID:** Subtotal of Bid Item No. 1 through Bid Item No. 5 | | | | | $1,050,792 |
| | **b) CONTINGENCY** | | | | | |
| | Assume 25% Contingency | | | | $262,698 | $1,313,490 |
| | **c) BASE BID ALLOWANCES:** | | | | | |
| | Utility Relocation (assume 3% of construction costs) | | | | $31,000 | |
| | Lab Testing (assume 3% of construction costs) | | | | $31,000 | |
| | Demolition & Cleanup of existing structures in channel | | | | $15,000 | |
| | Land Acquisition Assume $2500/acre | | | | $0 | |
| | **Total Base Bid Allowances** | | | | | $77,000 |
| | **d) SURVEY, STAKING & TRAFFIC CONTROL** | | | | | |
| | Construction Staking and Survey, complete (assume 3% of construction costs) | | | | $31,000 | |
| | Construction Traffic Control & Barricading Incidental | | | | $31,000 | |
| | | | | | | $62,000 |
| | **e) BASE BID SUBTOTAL:** | | | | | |
| | Line a) Base Bid plus Line b) Contingencies plus Line c) Base Bid Allowances: | | | | | $1,452,490 |
| | **f) BASE BID - NEW MEXICO GROSS RECEIPTS TAX (NMGRT) - LAS CRUCES:** | | | | | |
| | on amount on Line e) Base Bid Subtotal at 8.3125% | | | | | $120,738 |
| | **g) BASE BID TOTAL: - Line e) Subtotal plus Line f) NMGRT:** | | | | | **$1,573,229** |
| | | | **Total Cost Rounded Up:** | | | **$1,574,000** |

Bid numbers and unit costs are based on NMDOT 2018 Average Bid Prices

# Bid item from City of Albuquerque 2018 City Engineer's Estimate Unit Prices

| Table H5<br>Vado Channel - Reinforced Concrete Channel and Concrete Baffles<br>Engineers Estimate of Probable Cost For Vado/Del Cerro Drainage Master Plan | | | | | | |
|---|---|---|---|---|---|---|
| **BID ITEM NUMBER** | **ITEM ID NUMBER** | **ITEM DESCRIPTION** | **ESTIMATED QUANTITY** | **UNIT** | **ESTIMATED UNIT PRICE** | **ESTIMATED AMOUNT** |
| 1 | 202000 | Excavation and Rough Grading (Vado Channel - soil cement steps included) | 20,122 | CY | $4 | $80,488 |
| 2 | 207000 | Subgrade Preparation - 6" @ 95% | 15,834 | SY | $2.50 | $39,585 |
| 3 | 511000 | Structural Concrete, CL A" includes Rebar Grade 60 (Baffles only) | 10 | SY | $725 | $7,250 |
| 4 | 511000 | Structural Concrete, CL A-8" includes Rebar Grade 60 (Concrete channel only) | 14600 | SY | $75 | $1,095,000 |
| | | | Subtotal of Bid Items 1 - 4 | | | $1,222,323 |
| 5 | 621000 | Mobilization (5% of Construction Costs) | 1 | LS | $61,116 | $61,116 |
| | **a) BASE BID:** Subtotal of Bid Item No. 1 through Bid Item No. 5 | | | | | $1,283,439 |
| | **b) CONTINGENCY** | | | | | |
| | Assume 25% Contingency | | | | $320,860 | $1,604,299 |
| | **c) BASE BID ALLOWANCES:** | | | | | |
| | Utility Relocation (assume 3% of construction costs) | | | | $37,000 | |
| | Lab Testing (assume 3% of construction costs) | | | | $37,000 | |
| | Demolition of existing structures in channel | | | | $15,000 | |
| | Land Acquisition Assume $2500/acre | | | | $0 | |
| | | **Total Base Bid Allowances** | | | | $89,000 |
| | **d) SURVEY, STAKING & TRAFFIC CONTROL** | | | | | |
| | Construction Survey and Staking complete (assume 3% of construction costs) | | | | $37,000 | |
| | Construction Traffic Control & Barricading Incidental | | | | $37,000 | |
| | | | | | | $74,000 |
| | **e) BASE BID SUBTOTAL:** | | | | | |
| | Line a) Base Bid plus Line b) Contingencies plus Line c) Base Bid Allowances: | | | | | $1,767,299 |
| | **f) BASE BID - NEW MEXICO GROSS RECEIPTS TAX (NMGRT) - LAS CRUCES:** | | | | | |
| | on amount on Line e) Base Bid Subtotal at 8.3125% | | | | | $146,907 |
| | **g) BASE BID TOTAL: - Line e) Subtotal plus Line f) NMGRT:** | | | | | **$1,914,206** |
| | | | | | **Total Cost Rounded Up:** | **$1,915,000** |

Bid numbers and unit costs are based on NMDOT 2018 Average Bid Prices

# Bid item from City of Albuquerque 2018 City Engineer's Estimate Unit Prices

| Table H6<br>Lily Pond<br>Engineers Estimate of Probable Cost For Vado/Del Cerro Drainage Master Plan | | | | | | |
|---|---|---|---|---|---|---|
| **BID ITEM NUMBER** | **ITEM ID NUMBER** | **ITEM DESCRIPTION** | **ESTIMATED QUANTITY** | **UNIT** | **ESTIMATED UNIT PRICE** | **ESTIMATED AMOUNT** |
| 1 | 201.01[#] | Clearing and Grubbing (Lily Pond) | 10 | AC | $1,500 | $15,000 |
| 2 | 202000 | Excavation and Rough Grading (Lily Pond) | 17,678 | CY | $4 | $70,712 |
| 3 | 303160 | Base Course 6" (Maintenance road - 12' x 30') | 40 | SY | $12 | $480 |
| 4 | 511000 | Structural Concrete, CL A includes Rebar Grade 60 (Concrete Headwall and footing for Crazy Horse principal spillway - 3' height x 5' length x 8" thick) | 1 | CY | $725 | $725 |
| 5 | 513000 | Soil Cement (Pad at entrance of pond) | 38 | CY | $95 | $3,610 |
| 6 | 513000 | Soil Cement (Emergency spillway - 50' x 10' x1) | 19 | CY | $95 | $1,805 |
| 7 | 570449 | 30" Storm Drain Culvert RCP (Lily principal spillway) | 336 | LF | $105 | $35,280 |
| 8 | 607046 | Chain Link Security Fence 6' | 4,040 | LF | $25 | $101,000 |
| 9 | 607314 | Standard Gate, 14' | 1 | EA | $1,000 | $1,000 |
| 10 | 632000 | Revegetation Class A seeding | 11 | AC | $7,200 | $79,200 |
| 11 | 701.10 | Trenching, backfilling, and Compaction up to 8' in depth for 18" to 36" diameter pipe (Crazy horse principal spillway pipe) | 336 | LF | $25 | $8,400 |
| | | | Subtotal of Bid Items 1 - 11 | | | $317,212 |
| 12 | 621000 | Mobilization (5% of Construction Costs) | 1 | LS | $15,861 | $15,861 |
| | a) **BASE BID:** Subtotal of Bid Item No. 1 through Bid Item No. 12 | | | | | $333,073 |
| | b) **CONTINGENCY**<br>Assume 25% Contingency | | | | $83,268 | $416,341 |
| | c) **BASE BID ALLOWANCES:** | | | | | |
| | Utility Relocation (assume 3% of construction costs) | | | | $10,000 | |
| | Lab Testing (assume 3% of construction costs) | | | | $10,000 | |
| | Land Acquisition | Assume $2500/acre | | | $0 | |
| | | **Total Base Bid Allowances** | | | | $20,000 |
| | d) **SURVEY, STAKING & TRAFFIC CONTROL** | | | | | |
| | Construction Survey and Staking complete (assume 3% of construction costs) | | | | $10,000 | |
| | Construction Traffic Control & Barricading Incidental | | | | $10,000 | $20,000 |
| | e) **BASE BID SUBTOTAL:**<br>Line a) Base Bid plus Line b) Contingencies plus Line c) Base Bid Allowances: | | | | | $456,341 |
| | f) **BASE BID - NEW MEXICO GROSS RECEIPTS TAX (NMGRT) - LAS CRUCES:**<br>on amount on Line e) Base Bid Subtotal at 8.3125% | | | | | $37,933 |
| | g) **BASE BID TOTAL: - Line e) Subtotal plus Line f) NMGRT:** | | | | | **$494,274** |
| | | | | **Total Cost Rounded Up:** | | **$495,000** |

Bid numbers and unit costs are based on NMDOT 2018 Average Bid Prices

[#] Bid item from City of Albuquerque 2018 City Engineer's Estimate Unit Prices

## Table H7

Palmilla Storm Drain and Roadway Improvements

Engineers Estimate of Probable Cost For Vado/Del Cerro Drainage Master Plan

| BID ITEM NUMBER | ITEM ID NUMBER | ITEM DESCRIPTION | ESTIMATED QUANTITY | UNIT | ESTIMATED UNIT PRICE | ESTIMATED AMOUNT |
|---|---|---|---|---|---|---|
| 1 | 209000 | Blading and Reshaping (Inverse Crown on Wild Rose Way and Calle De La Cruz roadway), includes 6" subgrade prep. | 0.4 | MI | $50,000 | $20,000 |
| 2 | 209000 | Blading and Reshaping (Inverse Crown on Ojita Avenue roadway), includes 6" subgrade prep. | 0.2 | MI | $50,000 | $10,000 |
| 3 | 343.02[#] | Existing pavement, remove and dispose up to 4" thick, compl. (Inverse Crown on Wild Rose Way and Calle De La Cruz roadway) | 4,723 | SY | $7 | $33,061 |
| 4 | 343.02[#] | Existing pavement, remove and dispose up to 4" thick, compl. (Inverse Crown on Ojita Avenue roadway) | 2,123 | SY | $7 | $14,861 |
| 5 | 414125 | Cold Milling (Asphalt Replacement) 3" (Inverse Crown on Wild Rose Way and Calle De La Cruz roadway) | 4723 | SY | $8 | $37,784 |
| 6 | 414125 | Cold Milling (Asphalt Replacement) 3" (Inverse Crown on Ojita Avenue roadway) | 2123 | SY | $8 | $16,984 |
| 7 | 511000 | Structural Concrete, CL A includes Rebar Grade 60 (Concrete Headwall and footing) | 1 | CY | $725 | $725 |
| 8 | xxx.xx | 30" Storm Drain Culvert Pipe (ADS N-12 WT IB pipe with min 2' cover) | 166 | LF | $30 | $4,980 |
| 9 | xxx.xx | 36" Storm Drain Culvert Pipe (ADS N-12 WT IB pipe with min 2' cover) | 1454 | LF | $30 | $43,620 |
| 10 | 602000 | Riprap Class B (Erosion Control at Culvert Outlet) | 1 | CY | $105 | $105 |
| 11 | 609424 | Curb and Gutter, Type "B" - Wild Rose Way & Calle de la Cruz both sides of road | 3400 | LF | $25 | $85,000 |
| 12 | 609424 | Curb and Gutter, Type "B" - Ojita Ave both sides of road | 1528 | LF | $25 | $38,200 |
| 13 | 623011 | MDI Type I (Rural) H = 3'-1" to 6' | 2 | EA | $5,500 | $11,000 |
| 14 | 662010 | Manhole TY E-6' Dia Ov 0' to 6' depth | 3 | EA | $9,500 | $28,500 |
| 15 | 662072 | Manhole TY E-6' Dia Ov 6' to 10' depth | 1 | EA | $13,000 | $13,000 |
| | | | Subtotal of Bid Items 1 - 15 | | | $357,820 |
| 16 | 621000 | Mobilization (5% of Construction Costs) | 1 | LS | $17,891 | $17,891 |
| | | **a) BASE BID:** Subtotal of Bid Item No. 1 through Bid Item No. 16 | | | | $375,711 |
| | | **b) CONTINGENCY** | | | | |
| | | Assume 25% Contingency | | | $93,928 | $469,639 |
| | | **c) BASE BID ALLOWANCES:** | | | | |
| | | Utility Relocation (assume 3% of construction costs) | | | $11,000 | |
| | | Utility Easement | | | $11,000 | |
| | | Lab Testing (assume 3% of construction costs) | | | $11,000 | |
| | | **Total Base Bid Allowances** | | | | $33,000 |
| | | **d) SURVEY, STAKING & TRAFFIC CONTROL** | | | | |
| | | Construction Survey and Staking complete (assume 3% of construction costs) | | | $11,000 | |
| | | Construction Traffic Control & Barricading Incidental | | | $11,000 | |
| | | | | | | $22,000 |
| | | **e) BASE BID SUBTOTAL:** | | | | |
| | | Line a) Base Bid plus Line b) Contingencies plus Line c) Base Bid Allowances: | | | | $524,639 |
| | | **f) BASE BID - NEW MEXICO GROSS RECEIPTS TAX (NMGRT) - LAS CRUCES:** | | | | |
| | | on amount on Line e) Base Bid Subtotal at 8.3125% | | | | $43,611 |
| | | **g) BASE BID TOTAL: - Line e) Subtotal plus Line f) NMGRT:** | | | | **$568,249** |
| | | | | | **Total Cost Rounded Up:** | **$569,000** |

Bid numbers and unit costs are based on NMDOT 2018 Average Bid Prices

[#] Bid item from City of Albuquerque 2018 City Engineer's Estimate Unit Prices

| Table H8<br>Crazy Horse Pond & Earth Lined Channels<br>Engineers Estimate of Probable Cost For Vado/Del Cerro Drainage Master Plan | | | | | | |
|---|---|---|---|---|---|---|
| **BID ITEM NUMBER** | **ITEM ID NUMBER** | **ITEM DESCRIPTION** | **ESTIMATED QUANTITY** | **UNIT** | **ESTIMATED UNIT PRICE** | **ESTIMATED AMOUNT** |
| 1 | 201.01# | Clearing and Grubbing (Crazy Horse Pond and Channel) | 10 | AC | $1,500 | $15,000 |
| 2 | 202000 | Excavation and Rough Grading (Crazy Horse Pond and both earth lined channels that lead to Crazy Horse Pond) | 47,415 | CY | $4 | $189,660 |
| 3 | 303160 | Base Course 6" (Maintenance road - 12' x 30') | 40 | SY | $12 | $480 |
| 4 | 511000 | Structural Concrete, CL A includes Rebar Grade 60 (Concrete Headwall and footing for Crazy Horse principal spillway - 3' height x 5' length x 8" thick) | 1 | CY | $725 | $725 |
| 5 | 513000 | Soil Cement (Pad at entrance of pond for both channels) | 6 | CY | $95 | $570 |
| 6 | 513000 | Soil Cement (Emergency spillway - 1000' x 5' x 1') | 186 | CY | $95 | $17,670 |
| 7 | 570437 | 24" Storm Drain Culvert RCP (Crazy Horse principal spillway) | 100 | LF | $100 | $10,000 |
| 8 | 607046 | Chain Link Security Fence 6' | 1,700 | LF | $25 | $42,500 |
| 9 | 607314 | Standard Gate, 14' | 1 | EA | $1,000 | $1,000 |
| 10 | 632000 | Revegetation Class A seeding (Crazy Horse Pond) | 5 | AC | $7,200 | $36,000 |
| 11 | 701.10 | Trenching, backfilling, and Compaction up to 8' in depth for 18" to 36" diameter pipe (Crazy horse principal spillway pipe) | 100 | LF | $25 | $2,500 |
| | | | Subtotal of Bid Items 1 - 11 | | | $316,105 |
| 12 | 621000 | Mobilization (5% of Construction Costs) | 1 | LS | $15,805 | $15,805 |
| | a) **BASE BID:** Subtotal of Bid Item No. 1 through Bid Item No. 12 | | | | | $331,910 |
| | b) **CONTINGENCY** | | | | | |
| | Assume 25% Contingency | | | | $82,978 | $414,888 |
| | c) **BASE BID ALLOWANCES:** | | | | | |
| | Utility Relocation (assume 3% of construction costs) | | | | $10,000 | |
| | Lab Testing (assume 3% of construction costs) | | | | $10,000 | |
| | Land Acquisition Assume $2500/acre | | | 7 | $17,500 | |
| | | **Total Base Bid Allowances** | | | | $37,500 |
| | d) **SURVEY, STAKING & TRAFFIC CONTROL** | | | | | |
| | Construction Survey and Staking complete (assume 3% of construction costs) | | | | $10,000 | |
| | Construction Traffic Control & Barricading Incidental | | | | $10,000 | |
| | | | | | | $20,000 |
| | e) **BASE BID SUBTOTAL:** | | | | | |
| | Line a) Base Bid plus Line b) Contingencies plus Line c) Base Bid Allowances: | | | | | $472,388 |
| | f) **BASE BID - NEW MEXICO GROSS RECEIPTS TAX (NMGRT) - LAS CRUCES:** | | | | | |
| | on amount on Line e) Base Bid Subtotal at 8.3125% | | | | | $39,267 |
| | g) **BASE BID TOTAL: - Line e) Subtotal plus Line f) NMGRT:** | | | | | **$511,655** |
| | | | **Total Cost Rounded Up:** | | | **$512,000** |

Bid numbers and unit costs are based on NMDOT 2018 Average Bid Prices

# Bid item from City of Albuquerque 2018 City Engineer's Estimate Unit Prices

| Table H9<br>Estancia Pond<br>Engineers Estimate of Probable Cost For Vado/Del Cerro Drainage Master Plan | | | | | | |
|---|---|---|---|---|---|---|
| **BID ITEM NUMBER** | **ITEM ID NUMBER** | **ITEM DESCRIPTION** | **ESTIMATED QUANTITY** | **UNIT** | **ESTIMATED UNIT PRICE** | **ESTIMATED AMOUNT** |
| 1 | 201.01# | Clearing and Grubbing | 2 | AC | $1,500 | $3,000 |
| 2 | 202000 | Excavation and Rough Grading | 18,880 | CY | $4 | $75,520 |
| 3 | 303160 | Base Course 6" (Maintenance road - 12' x 30') | 40 | SY | $12 | $480 |
| 4 | 511000 | Structural Concrete, CL A includes Rebar Grade 60 (Concrete Headwall and footing for Crazy Horse principal spillway - 3' height x 5' length x 8" thick) | 1 | CY | $725 | $725 |
| 5 | 511000 | Structural Concrete, CL A includes Rebar Grade 60 (Concrete Headwall and footing for Estancia principal spillway - 3' height x 5' length x 8" thick) | 1 | CY | $725 | $725 |
| 6 | 513000 | Soil Cement (Pad at entrance of pond for both storm drains - 30' x 5') | 12 | CY | $95 | $1,140 |
| 7 | 513000 | Soil Cement (Emergency spillway - 60' x 10' x 1') | 23 | CY | $95 | $2,185 |
| 8 | 570437 | 24" Storm Drain Culvert RCP (Principal spillway) | 122 | LF | $100 | $12,200 |
| 9 | 607046 | Chain Link Security Fence 6' | 1,100 | LF | $25 | $27,500 |
| 10 | 607314 | Standard Gate, 14' | 1 | EA | $1,000 | $1,000 |
| 11 | 632000 | Revegetation Class A seeding (Crazy Horse Pond) | 1 | AC | $7,200 | $7,200 |
| 12 | 701.12 | Trenching, backfilling, and Compaction 12' to 16' in depth for 18" to 36" diameter pipe | 122 | LF | $35 | $4,270 |
| | | | Subtotal of Bid Items 1 - 12 | | | $135,945 |
| 13 | 621000 | Mobilization (5% of Construction Costs) | 1 | LS | $6,797 | $6,797 |
| | a) **BASE BID:** Subtotal of Bid Item No. 1 through Bid Item No. 13 | | | | | $142,742 |
| | b) **CONTINGENCY** | | | | | |
| | Assume 25% Contingency | | | | $35,686 | $178,428 |
| | c) **BASE BID ALLOWANCES:** | | | | | |
| | Utility Relocation (assume 3% of construction costs) | | | | $5,000 | |
| | Lab Testing (assume 3% of construction costs) | | | | $5,000 | |
| | Land Acquisition Assume $2500/acre | | | 3 | $7,500 | |
| | **Total Base Bid Allowances** | | | | | $17,500 |
| | d) **SURVEY, STAKING & TRAFFIC CONTROL** | | | | | |
| | Construction Survey and Staking complete (assume 3% of construction costs) | | | | $5,000 | |
| | Construction Traffic Control & Barricading Incidental | | | | $5,000 | |
| | | | | | | $10,000 |
| | e) **BASE BID SUBTOTAL:** | | | | | |
| | Line a) Base Bid plus Line b) Contingencies plus Line c) Base Bid Allowances: | | | | | $205,928 |
| | f) **BASE BID - NEW MEXICO GROSS RECEIPTS TAX (NMGRT) - LAS CRUCES:** | | | | | |
| | on amount on Line e) Base Bid Subtotal at 8.3125% | | | | | $17,118 |
| | g) **BASE BID TOTAL: - Line e) Subtotal plus Line f) NMGRT:** | | | | | **$223,046** |
| | | | **Total Cost Rounded Up:** | | | **$224,000** |

Bid numbers and unit costs are based on NMDOT 2018 Average Bid Prices

# Bid item from City of Albuquerque 2018 City Engineer's Estimate Unit Prices

| Table H10<br>Crazy Horse Storm Drain<br>Engineers Estimate of Probable Cost For Vado/Del Cerro Drainage Master Plan | | | | | | |
|---|---|---|---|---|---|---|
| **BID ITEM NUMBER** | **ITEM ID NUMBER** | **ITEM DESCRIPTION** | **ESTIMATED QUANTITY** | **UNIT** | **ESTIMATED UNIT PRICE** | **ESTIMATED AMOUNT** |
| 1 | 570437 | 24" Storm Drain Culvert RCP | 2053 | LF | $100 | $205,300 |
| 2 | 623012 | MDI Type I (Rural) H = 3'-1" to 6' | 4 | EA | $5,500 | $22,000 |
| 3 | 662000 | Manhole TY E-4' Dia 0' to 6' depth | 9 | EA | $5,000 | $45,000 |
| 4 | 662072 | Manhole TY E-6' Dia Ov 6' to 10' depth | 1 | EA | $13,000 | $13,000 |
| 5 | 701.10# | Trenching, backfilling, and Compaction up to 8' in depth for 18" to 36" diameter pipe | 1893 | LF | $25 | $47,325 |
| 6 | 701.11# | Trenching, backfilling, and Compaction 8' to 12' in depth for 18" to 36" diameter pipe | 160 | LF | $30 | $4,800 |
| | | | Subtotal of Bid Items 1 - 6 | | | $337,425 |
| 7 | 621000 | Mobilization (5% of Construction Costs) | 1 | LS | $16,871 | $16,871 |
| | **a) BASE BID:** Subtotal of Bid Item No. 1 through Bid Item No. 7 | | | | | $354,296 |
| | **b) CONTINGENCY** | | | | | |
| | Assume 25% Contingency | | | | $88,574 | $442,870 |
| | **c) BASE BID ALLOWANCES:** | | | | | |
| | Utility Relocation (assume 3% of construction costs) | | | | $11,000 | |
| | Lab Testing (assume 3% of construction costs) | | | | $11,000 | |
| | Land Acquisition Assume $2500/acre | | | | $0 | |
| | **Total Base Bid Allowances** | | | | | $22,000 |
| | **d) SURVEY, STAKING & TRAFFIC CONTROL** | | | | | |
| | Construction Survey and Staking complete (assume 3% of construction costs) | | | | $11,000 | |
| | Construction Traffic Control & Barricading Incidental | | | | $11,000 | |
| | | | | | | $22,000 |
| | **e) BASE BID SUBTOTAL:** | | | | | |
| | Line a) Base Bid plus Line b) Contingencies plus Line c) Base Bid Allowances: | | | | | $486,870 |
| | **f) BASE BID - NEW MEXICO GROSS RECEIPTS TAX (NMGRT) - LAS CRUCES:** | | | | | |
| | on amount on Line e) Base Bid Subtotal at 8.3125% | | | | | $40,471 |
| | **g) BASE BID TOTAL: - Line e) Subtotal plus Line f) NMGRT:** | | | | | **$527,341** |
| | | | **Total Cost Rounded Up:** | | | **$528,000** |

Bid numbers and unit costs are based on NMDOT 2018 Average Bid Prices

# Bid item from City of Albuquerque 2018 City Engineer's Estimate Unit Prices

| Table H11<br>Estancia Storm Drain<br>Engineers Estimate of Probable Cost For Vado/Del Cerro Drainage Master Plan | | | | | | |
|---|---|---|---|---|---|---|
| **BID ITEM NUMBER** | **ITEM ID NUMBER** | **ITEM DESCRIPTION** | **ESTIMATED QUANTITY** | **UNIT** | **ESTIMATED UNIT PRICE** | **ESTIMATED AMOUNT** |
| 1 | 511000 | Structural Concrete, CL A includes Rebar Grade 60 (Concrete Headwall and footing for outlet pipe into Estancia pond - 3' height x 5' length x 8" thick) | 1 | CY | $725 | $725 |
| 2 | 570437 | 24" Storm Drain Culvert RCP | 614 | LF | $100 | $61,400 |
| 3 | 602000 | Riprap Class B (Outlet protection at Estancia storm drain into Estancia Pond) | 1 | CY | $105 | $105 |
| 4 | 623012 | MDI Type I (Rural) H = 3'-1" to 6' | 4 | EA | $5,500 | $22,000 |
| 5 | 623013 | MDI Type I (Rural) H = 6'-1" to 9' | 2 | EA | $8,000 | $16,000 |
| 6 | 662000 | Manhole TY E-4' Dia 0' to 6' depth | 1 | EA | $5,000 | $5,000 |
| 7 | 662064 | Manhole TY E-4' Dia Ov 6' to 10' depth | 2 | EA | $7,000 | $14,000 |
| 8 | 701.10 | Trenching, backfilling, and Compaction up to 8' in depth for 18" to 36" diameter pipe | 434 | LF | $25 | $10,850 |
| 9 | 70.12 | Trenching, backfilling, and Compaction 12' to 16' in depth for 18" to 36" diameter pipe | 180 | LF | $35 | $6,300 |
| | | | Subtotal of Bid Items 1 - 9 | | | $136,380 |
| 10 | 621000 | Mobilization (5% of Construction Costs) | 1 | LS | $6,819 | $6,819 |
| | a) **BASE BID:** Subtotal of Bid Item No. 1 through Bid Item No. 10 | | | | | $143,199 |
| | b) **CONTINGENCY** | | | | | |
| | Assume 25% Contingency | | | | $35,800 | $178,999 |
| | c) **BASE BID ALLOWANCES:** | | | | | |
| | Utility Relocation (assume 3% of construction costs) | | | | $5,000 | |
| | Lab Testing (assume 3% of construction costs) | | | | $5,000 | |
| | Land Acquisition Assume $2500/acre | | | | $0 | |
| | **Total Base Bid Allowances** | | | | | $10,000 |
| | d) **SURVEY, STAKING & TRAFFIC CONTROL** | | | | | |
| | Construction Survey and Staking complete (assume 3% of construction costs) | | | | $5,000 | |
| | Construction Traffic Control & Barricading Incidental | | | | $5,000 | |
| | | | | | | $10,000 |
| | e) **BASE BID SUBTOTAL:** | | | | | |
| | Line a) Base Bid plus Line b) Contingencies plus Line c) Base Bid Allowances: | | | | | $198,999 |
| | f) **BASE BID - NEW MEXICO GROSS RECEIPTS TAX (NMGRT) - LAS CRUCES:** | | | | | |
| | on amount on Line e) Base Bid Subtotal at 8.3125% | | | | | $16,542 |
| | g) **BASE BID TOTAL: - Line e) Subtotal plus Line f) NMGRT:** | | | | | **$215,541** |
| | | | **Total Cost Rounded Up:** | | | **$216,000** |

Bid numbers and unit costs are based on NMDOT 2018 Average Bid Prices

# Bid item from City of Albuquerque 2018 City Engineer's Estimate Unit Prices

| Table H12<br>Highline Storm Drain<br>Engineers Estimate of Probable Cost For Vado/Del Cerro Drainage Master Plan | | | | | | |
|---|---|---|---|---|---|---|
| BID ITEM NUMBER | ITEM ID NUMBER | ITEM DESCRIPTION | ESTIMATED QUANTITY | UNIT | ESTIMATED UNIT PRICE | ESTIMATED AMOUNT |
| 1 | 511000 | Structural Concrete, CL A includes Rebar Grade 60 (Concrete Headwall and footing for culvert outlet into Estancia Pond - 3' height x 5' length x 8" thick) | 1 | CY | $725 | $725 |
| 2 | 570437 | 24" Storm Drain Culvert RCP | 1122 | LF | $100 | $112,200 |
| 3 | 602000 | Riprap Class B (Outlet protection at Highline storm drain into Estancia Pond) | 1 | CY | $105 | $105 |
| 4 | 623011 | MDI Type I (Rural) H = 6'-1" to 9' | 8 | EA | $9,000 | $72,000 |
| 5 | 662000 | Manhole TY E-4' Dia 6' to 10' depth | 1 | EA | $7,000 | $7,000 |
| 6 | 662064 | Manhole TY E-4' Dia Ov 10' to 14' depth | 2 | EA | $9,000 | $18,000 |
| 7 | 662066 | Manhole TY E-4' Dia Over 14' depth | 1 | EA | $12,000 | $12,000 |
| 8 | 662000 | Manhole TY E-4' Dia 0' to 6' depth | 9 | EA | $5,000 | $45,000 |
| 9 | 662072 | Manhole TY E-6' Dia Ov 6' to 10' depth | 1 | EA | $13,000 | $13,000 |
| 10 | 701.10 | Trenching, backfilling, and Compaction up to 8' in depth for 18" to 36" diameter pipe | 432 | LF | $25 | $10,800 |
| 11 | 70.12 | Trenching, backfilling, and Compaction 12' to 16' in depth for 18" to 36" diameter pipe | 690 | LF | $35 | $24,150 |
| | | | Subtotal of Bid Items 1 - 11 | | | $314,980 |
| 12 | 621000 | Mobilization (5% of Construction Costs) | 1 | LS | $15,749 | $15,749 |
| | **a) BASE BID:** Subtotal of Bid Item No. 1 through Bid Item No. 12 | | | | | $330,729 |
| | **b) CONTINGENCY**<br>Assume 25% Contingency | | | | $82,682 | $413,411 |
| | **c) BASE BID ALLOWANCES:** | | | | | |
| | Utility Relocation (assume 3% of construction costs) | | | | $10,000 | |
| | Lab Testing (assume 3% of construction costs) | | | | $10,000 | |
| | Land Acquisition Assume $2500/acre | | | | $0 | |
| | | **Total Base Bid Allowances** | | | | $20,000 |
| | **d) SURVEY, STAKING & TRAFFIC CONTROL** | | | | | |
| | Construction Survey and Staking complete (assume 3% of construction costs) | | | | $10,000 | |
| | Construction Traffic Control & Barricading Incidental | | | | $10,000 | |
| | | | | | | $20,000 |
| | **e) BASE BID SUBTOTAL:**<br>Line a) Base Bid plus Line b) Contingencies plus Line c) Base Bid Allowances: | | | | | $453,411 |
| | **f) BASE BID - NEW MEXICO GROSS RECEIPTS TAX (NMGRT) - LAS CRUCES:**<br>on amount on Line e) Base Bid Subtotal at 8.3125% | | | | | $37,690 |
| | **g) BASE BID TOTAL: - Line e) Subtotal plus Line f) NMGRT:** | | | | | **$491,101** |
| | | | **Total Cost Rounded Up:** | | | **$492,000** |

Bid numbers and unit costs are based on NMDOT 2018 Average Bid Prices

\# Bid item from City of Albuquerque 2018 City Engineer's Estimate Unit Prices