RADIUM SPRINGS DRAINAGE MASTER PLAN

FINAL REPORT

DOÑA ANA COUNTY FLOOD COMMISSION

Smith Engineering Company
201 N. Church Street
Suite # 200A
Las Cruces, New Mexico 88001
www.smithengineering.pro

January 2018
Rev. January 2018
Smith Project No.: 817103-01

RADIUM SPRINGS DRAINAGE MASTER PLAN

FINAL REPORT

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, PE

SMITH ENGINEERING COMPANY

Solutions for Today…

Vision for Tomorrow

January 12, 2018

John Gwynne, PE
Michael Garza, EI
Doña Ana County Flood Commission
County Government Center
845 N. Motel Blvd., Room 1-250
Las Cruces, New Mexico 88007

Re: Radium Springs Drainage Master Plan

Smith #: 817103-01

Dear Mr. Gwynne and Mr. Garza:

I am pleased to submit the final report for the Radium Springs Drainage Master Plan for the Doña Ana County Flood Commission (DACFC). This report summarizes analyses of the existing watershed conditions. It identifies areas of elevated risk and includes options for proposed improvements. The hydrologic models and all related digital files for the watershed are included digitally as are all GIS shapefiles. This report also includes final cost estimates for all recommended options. We have also addressed all comments from the 90% submittal.

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

Sincerely,
Smith Engineering Company

E. Christian Naidu, PE
Project Manager

Enclosure: Radium Springs Drainage Master Plan Final report

cc: Carl Lukesh, DACFC

201 N. Church Street Suite 200 A Las Cruces, NM 88001
Tel: (575) 523-2395 Fax: (575) 523-2396

ACKNOWLEDGMENTS

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

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

EXECUTIVE SUMMARY

DESCRIPTION AND PURPOSE OF PROJECT

The Radium Springs Drainage Master Plan was prepared by Smith Engineering Company (**Smith**) for the Doña Ana County Flood Commission (DACFC) to study the Radium Springs watershed. The Radium Springs watershed is approximately 17 miles northwest of Las Cruces. An existing conditions hydrologic model was developed to determine peak runoff rates and discharge volumes. Based on the results of the existing conditions model, areas of potential flooding were identified, and proposed drainage improvement options were developed to mitigate flooding. The hydrologic conditions were evaluated using the HEC-HMS V4.2.1 hydrologic modeling software. Simulations were run for four storms as follows: 5-year, 10-year, 50-year and 100-year return periods of 24-hour duration. The watershed on the west side of Interstate 25 (I-25) exhibits unique characteristics with respect to overland flows splits at certain analysis points. Therefore, a HEC-RAS 2D surface water model was developed for these parts of the watershed to determine overland flow splits and concentration points. The results from the 2D model were used to refine the flow diversions in the HEC-HMS model.

The DACFC directed Smith to use the 10-year - 24-hour storm for flood mitigation therefore all options are designed for this return period and duration.

SUMMARY OF EXISTING BASIN AND EXISTING DRAINAGE INFRASTRUCTURE

The Radium Springs watershed has a total drainage area of 9.25 square miles. The basin is divided into two distinct sections by Interstate-25 (I-25). The subbasins located east of I-25 are undeveloped range lands with fair to steep topography. The subbasins located west of I-25 consist of a combination of low-density residential areas, semi-arid desert in poor conditions and some commercial development. The Radium Springs area contains one dam within the study area called "Lucero Dam." This dam is located at the terminus of the watershed and is owned by the Elephant Butte Irrigation District (EBID). The following table presents critical information for Lucero Dam.

Dam Name	Owner	Drainage Area	Pond Depth to Top of Dam	Maximum Storage Volume to Top of Dam	Principal Outflow Pipe Diameter	Emergency Spillway Dimensions
		sq. mi	ft	ac-ft	In.	ft
Lucero Dam	EBID	6.11	18	514.56	36" Reinforced Concrete Pipe (RCP)	10' (crest width) 4' (total head over the crest)

The Lucero Dam has sufficient capacity to contain the 10-year storm below the emergency spillway. **Table C6.1** included in **Appendix C** shows the Elevation - Storage - Discharge data and computations for Lucero Dam.

There are sixteen culverts under I-25 that convey flows from the east side of I-25 to the west side of the watershed. These structures were evaluated for maximum discharge capacity to determine how much flow could be conveyed under I-25 during the various storms that were simulated. The culvert structures are shown on **Figure 4** in the report along with their peak discharge capacity and the flows arriving at the structures during the 10 and 100-year storms.

SUMMARY OF EXISTING PROBLEM AREAS AND PROPOSED OPTIONS

Several problematic areas within Radium Springs were identified through field observations, meetings with the DACFC, and discussions with residents at the first public meeting. Some issues have been caused by lack of adequate drainage planning during development and flow diversions caused by private property owners. Most of the drainage problems occur in the area north of Fort Selden Rd. bounded by I-25 to the east, De Beers Rd. to the north and the railroad track to the west due to inflows from the culverts under I-25.

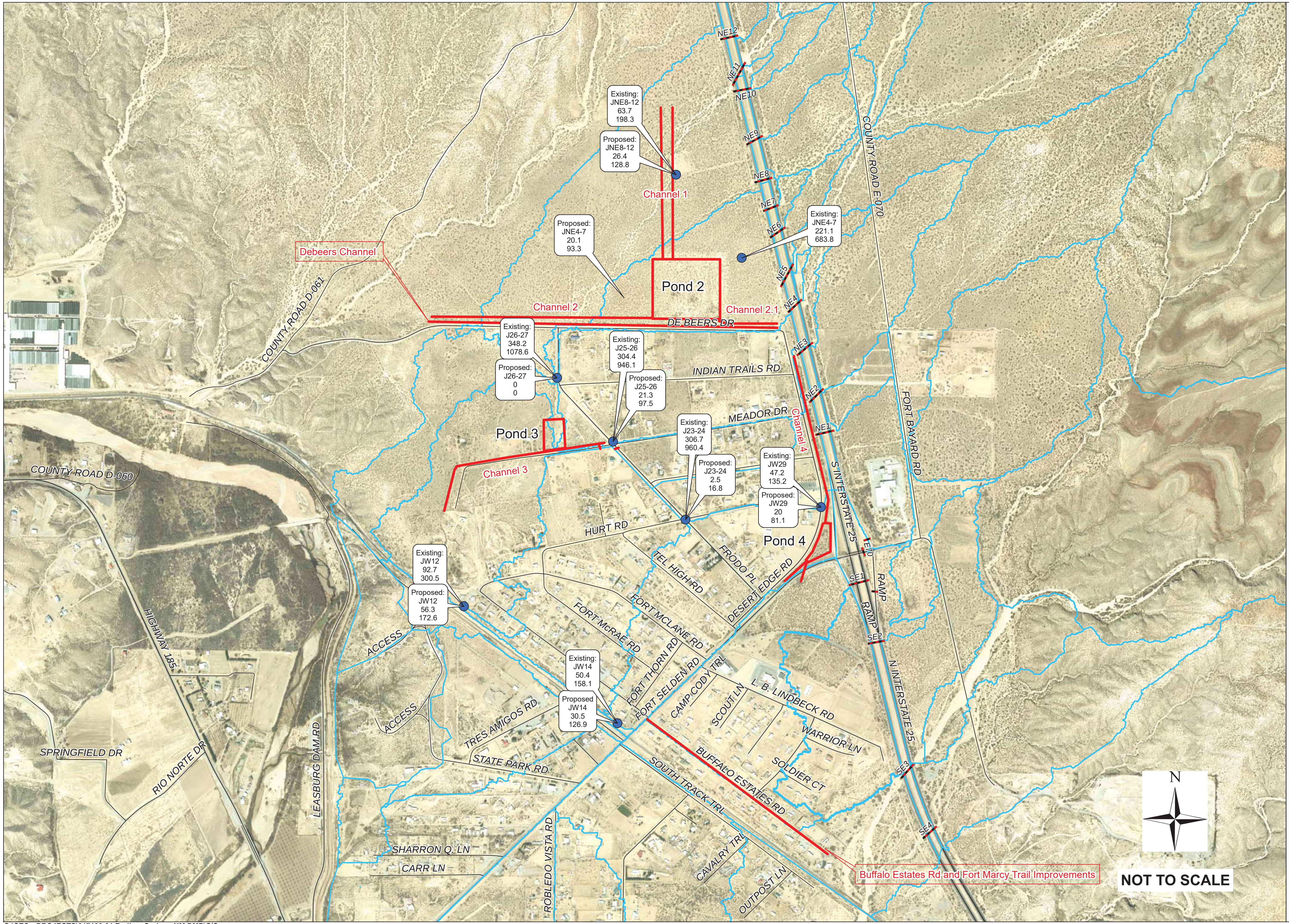
Based on the results from the existing conditions model, various detention ponds and diversion channels were simulated.

CONCLUSIONS AND RECOMMENDATIONS

Various configurations of ponds, channels and roadway improvements were considered. Engineers Opinion of Probable Costs were developed for the most beneficial facilities. The table below summarizes the best options in the order of highest to lowest priority. Two options were developed for the area north of DeBeers Rd. The DACFC will make the final selection on which option to implement upon preliminary design.

Facility Name	**Description**	**Cost**
Facility 1A	Pond 2 & Channel Diversion	$2,063,000
Facility 1B	DeBeers Diversion Channel without rip rap lining	$826,000
Facility 3	Pond 4 & Channel 4	$448,000
Facility 2	Pond 3 & Channel 3	$447,000
Facility 4	Buffalo Estates Roadway Improvements	$940,000
Total Cost of Facilities		**$4,724,000**

Figure E1 provides an overview map of where these facilities are in the community of Radium Springs.



RADIUM SPRINGS DRAINAGE MASTER PLAN

PREPARED FOR

PREPARED BY

1989 - 2014 SMITH ENGINEERING COMPANY 25th Anniversary

FIGURE E1

OVERVIEW OF PROPOSED OPTIONS

JANUARY 2018

Q:\SEC---PROJECTS\817103-01 Radium Springs NM DMP\GIS

TABLE OF CONTENTS

Acknowledgments i

Executive Summary ii

Description and Purpose of Project ii

Summary of Existing Basin and Existing Drainage Infrastructure ii

Summary of Existing Problem Areas and Proposed Options iii

Conclusions and Recommendations iii

Table of Contents v

List of Figures vi

Section 1. General Project Information 1

1.1 Description and Purpose of Project 1

1.2 Field Observation 2

Section 2. Existing Hydrologic and Hydraulic Analyses 2

2.1 Previous Studies 2

2.2 Existing Flood Control Structures 2

2.3 Drainage Basin Description and Basin Delineation 2

2.4 Drainage Analysis Criteria 4

2.5 Rainfall Data 5

2.6 Soils Data and Runoff Curve Numbers (CNs) 5

2.7 Travel Time (T_t), Time of Concentration (T_C), and Unit Hydrograph Lag Time (T_L) Computations and Unit Hydrograph 7

2.8 Channel Routing 8

2.9 Sediment Bulking 8

2.10 Hydrologic Data Summary 8

2.11 Computation Time Increment for HEC-HMS Models 8

2.12 Inflow-Diversion Functions & Upstream Detention at Culvert Structures 9

2.13 Reservoir Routing Data 9

2.14 HEC-HMS Hydrologic Models and Summary Results 9

2.15 Performance of Existing Drainage Infrastructure 10

2.16 Problem Areas Identified Under Existing Conditions 10

Section 3. 2-Dimensional Surface Water Modeling 13

Section 4. Proposed Options Hydrologic and Hydraulic Analyses 24

4.1 Proposed Options Hydrologic Data 24

4.2 Most Significant Drainage Problem Areas 24

4.3 Analyses and Options Summary ... 24
Section 5. Prioritization of Options ... 33
5.1 Viable Options ... 33
5.2 Conclusions and Recommendations ... 33
Section 6. References ... 34
Appendix A: Annotated Photographs ... A
Appendix B: Previous Plans and Reports ... B
Appendix C: Hydrologic Data Tables, Detention Ponds Data, Computations and References ... C
Appendix D: Existing and Proposed HEC-HMS Hydrologic Models (V4.2.1) ... D
Appendix E: CulvertMaster and FlowMaster Data and Output ... E
Appendix F: Proposed Improvements Quantity Cost and Estimates ... F

LIST OF FIGURES

Figure E1: Overview of Proposed Options ... iv
Figure 1: Project Vicinity Map ... 1
Figure 2: Drainage Basin Map ... 3
Figure 2.1: Drainage Basin Map ... Map Pocket
Figure 3: Hydrologic Soil Group Map ... 6
Figure 4: Existing Culvert Crossing Map ... 11
Figure 5: Existing problem Locations Map ... 12
Figure 6: 2D Limits of Model for 10 Year Storm ... 18
Figure 7: 10 Year Inundation based on 2D Model ... 19
Figure 8: 10 Year Inundation based on 2D Model ... 20
Figure 9: 2D Limits of Model for 100 Year Storm ... 21
Figure 10: 100 Year Inundation Based on 2D Model ... 22
Figure 11: 100 Year Inundation Based on 2D Model ... 23
Figure 12: Overview of Options ... 25
Figure 13: Facility 1A Grading Plan and Sub-Facilities ... 26
Figure 13-1: Facility 1B Grading Plan and Sub-Facilities ... 28
Figure 14: Facility 2 - Grading Plan and Sub-Facilities ... 30
Figure 15: Facility 3 - Grading Plan and Sub-Facilities ... 32

SECTION 1. GENERAL PROJECT INFORMATION

1.1 DESCRIPTION AND PURPOSE OF PROJECT

The Radium Drainage Master Plan was prepared by Smith Engineering Company (**Smith**) for the Doña Ana County Flood Commission (DACFC) to study the Radium Springs watershed. The Radium Springs watershed is approximately 17 miles northwest of Las Cruces. An existing conditions hydrologic model was developed. Based on the results of the existing conditions model, areas of potential flooding were identified, and proposed drainage improvement options were developed to mitigate flooding. The hydrologic conditions were evaluated using the HEC-HMS V 4.2.1 hydrologic modeling software. Simulations were run for four storms: 5-year, 10-year, 50-year and 100-year return periods of 24-hour duration. The DACFC directed Smith to use the 10-year – 24-hour storm for flood mitigation and therefore all flood mitigation facilities are designed for this return period storm. **Figure 1** shows the project vicinity map.

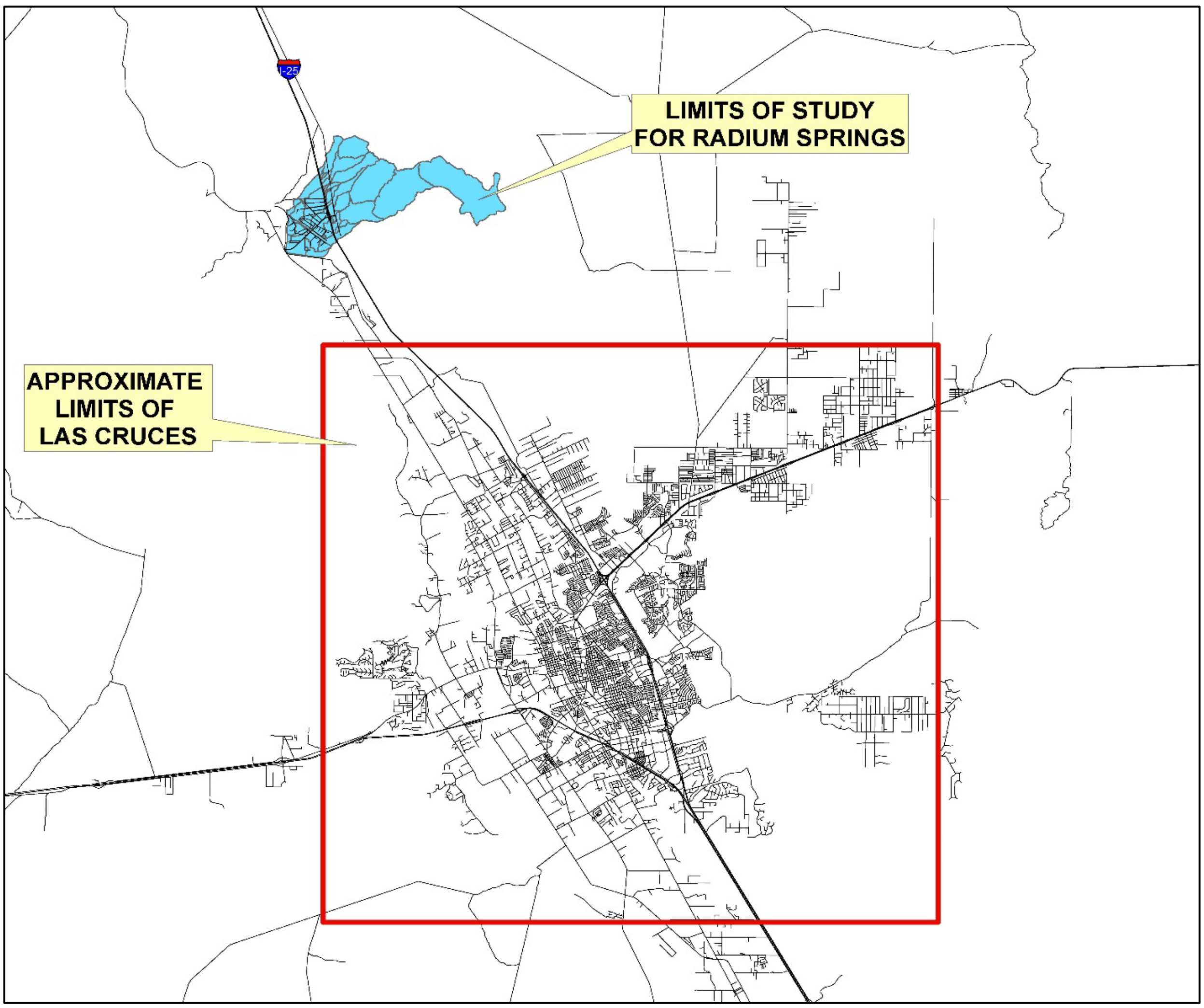


Figure 1: Project Vicinity Map

1.2 FIELD OBSERVATION

Smith conducted several field observations in March, May, and June 2017. **Appendix A** contains annotated photographs of the various locations in the Radium Springs watershed, existing drainage infrastructure, and various I-25 culvert crossings.

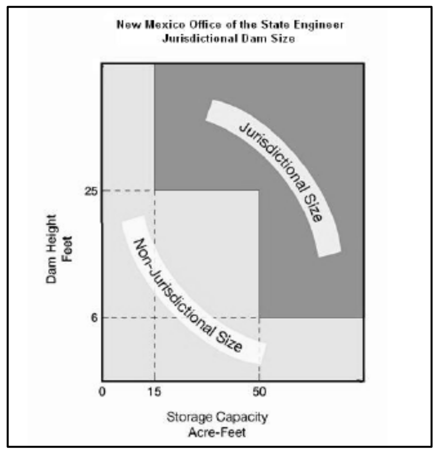
SECTION 2. EXISTING HYDROLOGIC AND HYDRAULIC ANALYSES

2.1 PREVIOUS STUDIES

No previous drainage master plans were available for review for the subject watershed. However, grading and drainage plans were reviewed for the Buffalo Estates subdivision and these are included in **Appendix B.** Additionally, FEMA Floodplain maps were reviewed and are included in **Appendix B.**

2.2 EXISTING FLOOD CONTROL STRUCTURES

The Radium Springs area contains the Lucero Dam as shown in **Figure 2**. The Lucero Dam, owned by the EBID, is located at the terminus of the watershed. This dam has a principal outflow pipe and an emergency overflow spillway. The principal outflow pipe is made of a 3-ft diameter Reinforced Concrete Pipe (RCP). The emergency spillway is reinforced concrete and has a crest length of 10 ft. The maximum head above the crest is 4 ft. **The dam has a total storage volume of 515 ac-ft and has an embankment height of 18 ft** and as such the Lucero dam is a jurisdictional dam as defined by the current criteria and regulations specified by the New Mexico State Engineers (NMOSE) Dam Safety Bureau (*Rules and Regulations Governing Dam Design, Construction and Dam Safety, December 31, 2010*). The NMOSE has the following definitions:



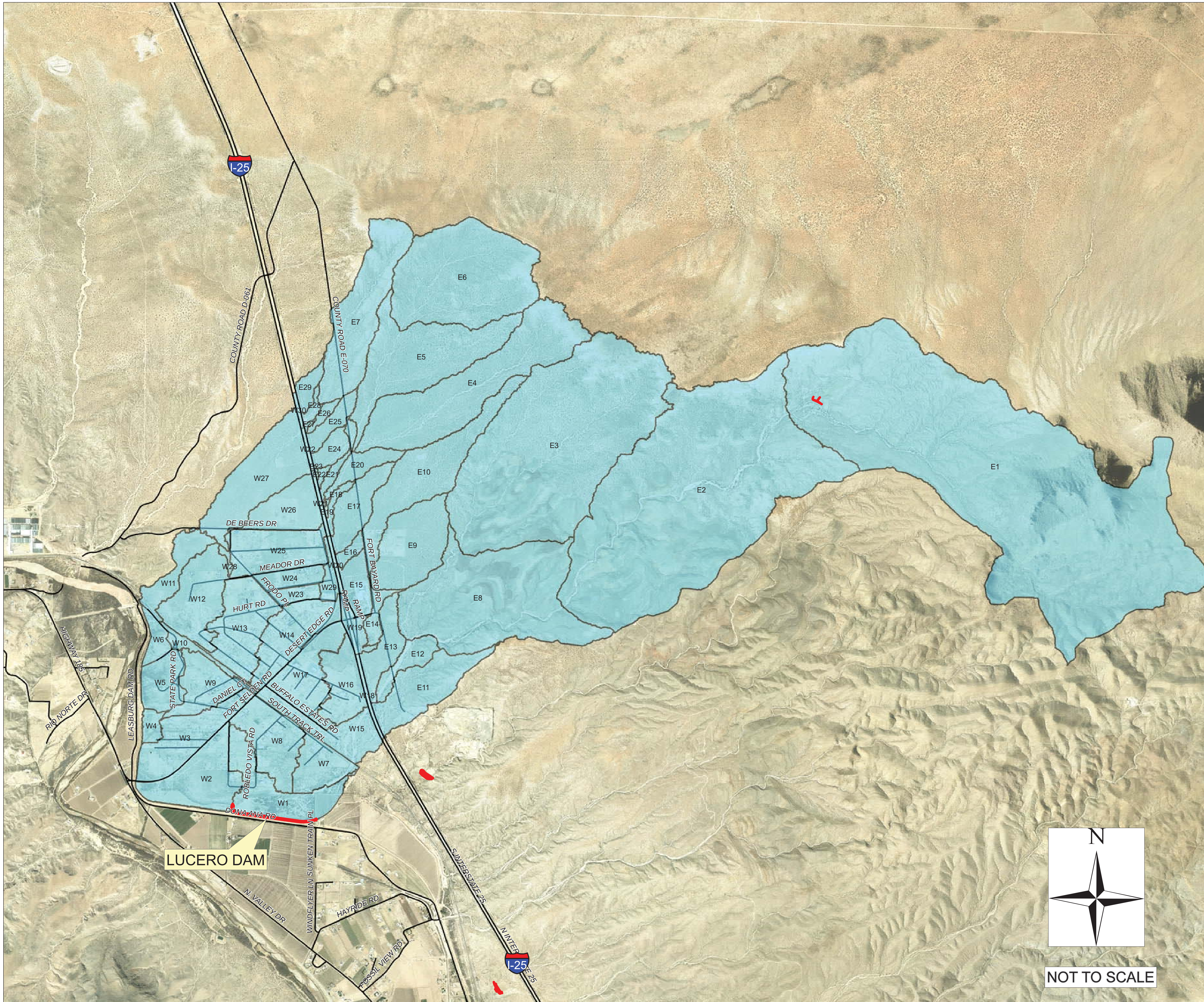
- Jurisdictional dam: Any dam 25 ft or greater in height, which impounds more than 15 ac-ft of water or a dam that impounds 50 ac-ft or more of water and is 6 ft or greater in height.
- Non-jurisdictional dam: Any dam not meeting the height and storage requirements of a jurisdictional dam.

There is also an unnamed retention pond of unknown jurisdiction in subbasin E14. The stage-storage data was computed from topographic data provided by DACFC. Smith denoted this pond as Reservoir-1 which has a total storage volume of 18 ac-ft. The elevation-storage-discharge data and computations, and reservoir routing summary for both dams are presented in **Tables C6.1 and Table C7** (included in **Appendix C)**, respectively.

2.3 DRAINAGE BASIN DESCRIPTION AND BASIN DELINEATION

A. Drainage Basin Description

The Radium Springs watershed has a total drainage area of 9.25 square miles. The basin is divided into two distinct sections by I-25. The basin east of I-25 is undeveloped semi-arid rangeland with fair to extremely steep and rocky areas, particularly on the uppermost parts of the basin. The west side of the basin primarily consists of a mixture of desert shrub in poor conditions and low density residential areas with minor commercial use in the valley area. **Figure 2** presents an overview of the drainage basin map. A detailed drainage basin map is also shown in **Figure 2.1** included in the Map Pocket.



Legend

Radium Springs Subbasins

Existing Dams

E1 Subbasin ID

10 FT CONTOUR DATA EXTRACTED FROM 2014 DIGITAL ELEVATION MODELS (DEM). 2014 DEM AND ORTHOPHOTOGRAPHY WAS PROVIDED BY DONA ANA COUNTY FLOOD COMMISSION

RADIUM SPRINGS DRAINAGE MASTER PLAN

PREPARED FOR

DONA ANA COUNTY NEW MEXICO

PREPARED BY

1989 - 2014 SMITH ENGINEERING COMPANY 25th Anniversary

FIGURE 2 DRAINAGE BASIN MAP

JANUARY 2018

Q:\SEC---PROJECTS\817103-01 Radium Springs NM DMP\GIS

B. FEMA Floodplains

FEMA floodplains (FEMA Maps No. 35013C0675G, No. 35013C0700G, No. 35013C0875G, No. 35013C0900G, dated July 6, 2016) were downloaded from the FEMA website. The panels are included in **Appendix B**.

C. Drainage Basin Delineation

The Radium Springs Watershed contains 59 subbasins which generally drains from east to west. The subbasins located east of I-25 are undeveloped, semi-arid rangeland with fair to extremely steep rocky areas, particularly in the uppermost parts of the basin. The west side of the basin consists primarily of a mixture of desert shrub in poor conditions and low-density residential areas with minor commercial use in the valley area.

To delineate the subbasins, Arc Hydro version 10.2 and HEC-Geo-HMS version 10.2, were used in conjunction with ESRI ArcGIS Version 10.2.2. The Arc Hydro tools were used to perform drainage analysis on the 2014 Digital Elevation Model (DEM) dataset provided by the DACFC to derive several data sets that collectively describe the drainage patterns of the watershed. Arc Hydro processes the terrain model, delineates the outer watershed boundary, and generates the stream network. Once the terrain processing was completed, HEC-GeoHMS was used to refine subbasin boundaries. Subbasin characteristics including area, slopes, longest flow path, etc. were derived using the geospatial tools described above. Analysis points used for basin processing were determined based on the following:

- Outfall locations based on topography
- Culvert locations
- Existing features such as dams, principal and emergency spillway outfall locations
- Drainage paths within the community of Radium Springs

The subbasin boundaries delineated by GeoHMS west of I-25 were field- verified during the site visits. **Figure 2** shows the overview of the subbasins for Radium Springs. **Figure 2.1** (Map Pocket) presents the subbasins in more detail and bigger scale.

2.4 DRAINAGE ANALYSIS CRITERIA

A. Storms Evaluated

The DACFC requested that 5-year, 10-year, 50-year and 100-year - 24-hour duration storms be simulated.

B. Design Storm

The DACFC directed Smith to use the 10-year 24-hour storm as the design storm. The proposed options will not include design for the 50-year and 100-year – 24-hour storms, although the results are included. However, reservoir routing results for all existing and proposed ponds include the 10 and 100-year storms.

C. Hydrologic Computer Program

The U.S. Army Corps of Engineers “HEC-HMS - Hydrologic Modeling System” program or commonly called “HEC-HMS” (Version 4.2.1) was selected for hydrologic modeling.

D. Existing Drainage Features

There are 16 culvert crossings under I-25. These were observed in the field and their critical dimensions were recorded. Maximum headwater depth was also measured. Maximum discharge capacity for each of the observed structures was computed using Culvert Master. The hydraulic calculations are presented in **Table E1** in **Appendix E**.

2.5 RAINFALL DATA

A. Rainfall Distribution

The study basin 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. Please refer to **Appendix C** for Figure B-2 that illustrates the Type II boundaries. However, the DACFC directed that the 25% Frequency Storm Distribution be adopted. This distribution is available in the HEC-HMS program and it places peak intensity of the rainfall in at 25% of the storm duration, or at 6 hours for a 24-hour storm.

B. Areal Reduction Factors

Areal reduction factors are required for watersheds greater than 10 square miles but since this watershed area is 9.25 square miles, no areal reduction was required.

C. Point Rainfall Data

Point rainfall data was obtained from NOAA Atlas 14 website. **Table C1** documents the appropriate point precipitation depths required as input for the HEC-HMS model. **Appendix C** contains the printouts from the NOAA Atlas 14 point rainfall data results.

2.6 SOILS DATA AND RUNOFF CURVE NUMBERS (CNs)

A. Hydrologic Soil Information

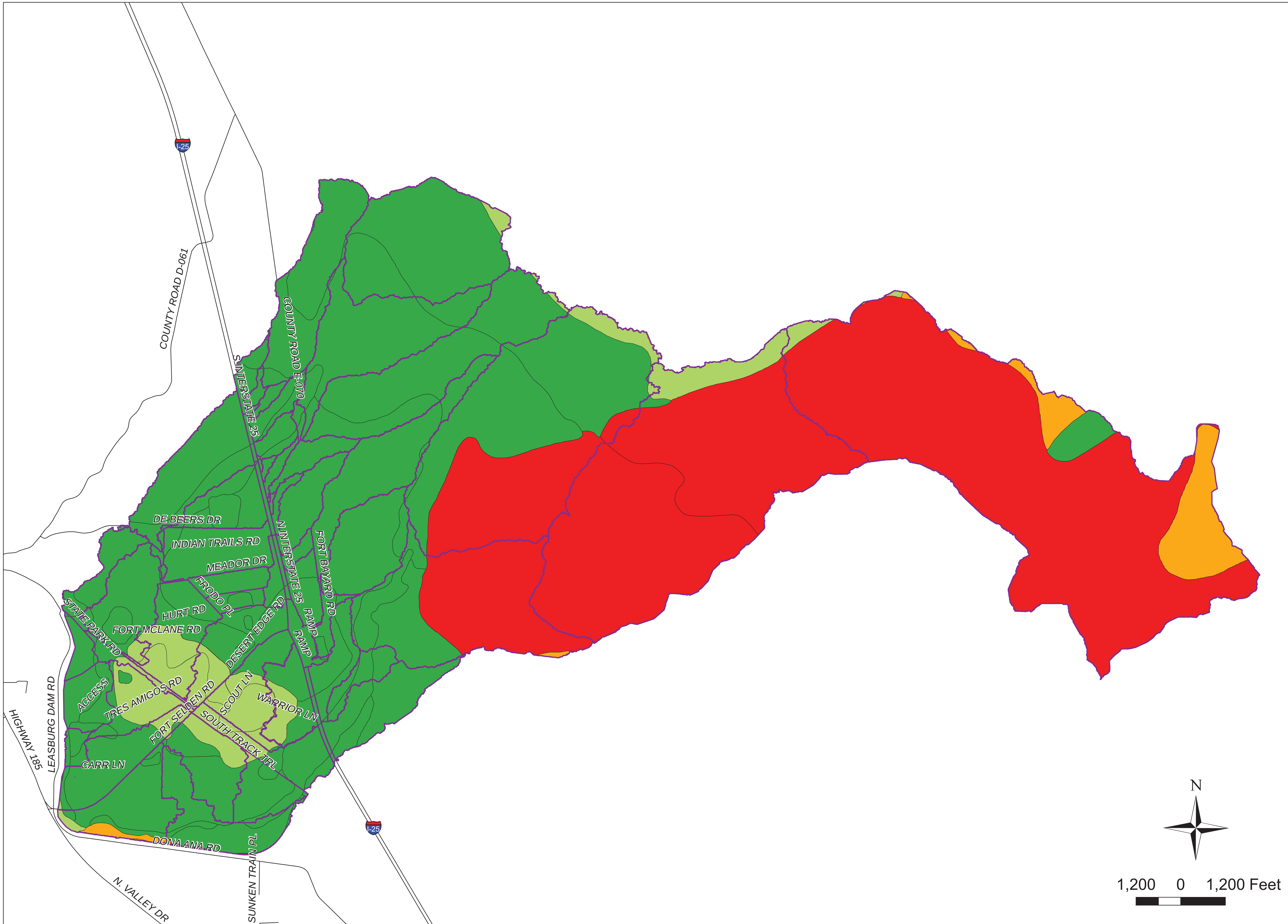
Information on the watersheds soils characteristics was obtained from the Natural Resources Conservation Service (NRCS) Web Soil Surveys as follows: ***http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx***

Appendix C contains the Web Soil Survey information including the soil map unit locations and tables that summarize the hydrologic soil groups (HSG) and cover types for the various soil map units. **Figure 3** shows the distribution of HSG for the Radium Springs area. The soil information was used to determine the Curve Number (CN) for the watershed subbasins. As shown on **Figure 3**, the upper watershed exhibits poor soil conditions, primarily hydrologic soil group (HSG) D. HSG D soils will promote the highest levels of runoff whereas HSG A and B promote the most infiltration. The HSG in conjunction with vegetation and cover help determine the runoff curve numbers for the various subbasins.

B. Curve Number Determination

The CN defines soil characteristics in terms of potential runoff including soil type, drainage conditions, land use, and types of vegetative species typically found within the area. In this study, the CN for each subbasin was estimated using the area-weighted CN technique. **Table C2** (**Appendix C**) contains a summary of the CN assumption and calculation results for each subbasin. The data and assumptions applied to develop **Table C2** are based on the following:

A. Antecedent Runoff Condition II (ARC II) is defined as the soil average runoff condition (moisture condition) by the NRCS. Antecedent Runoff Condition III (ARC III) is defined as the wetter soil condition. For all sub-basins denoted as “Arid and Semiarid Rangelands” with “Desert Shrub Cover Type” an average CN value between ARC II CN and ARC III CN was adopted.



Legend

Subbasin Boundary

Hydrologic Soil Group

- A
- B
- C
- D

Roads

RADIUM SPRINGS DRAINAGE MASTER PLAN

PREPARED FOR

DONA ANA COUNTY NEW MEXICO

PREPARED BY

1989 - 2014 SMITH ENGINEERING COMPANY 25th Anniversary

FIGURE 3

HYDROLOGIC SOIL GROUP MAP

JANUARY 2018

Q:\SEC---PROJECTS\817103-01 Radium Springs NM DMP\GIS

B. Hydrologic Soil Group (A, B, C, or D) – Determined by the NRCS per soil map unit (**Appendix C** contains the Web Soil Survey Data).

C. Land Use Type is either – arid rangeland (most sub-basins), urban (within the community of Radium Springs) or cultivated agricultural land. The orthophotography as presented on the Drainage Basin Maps (map pocket) was used to make the land use type determinations. The CN tables were obtained from "Urban Hydrology for Small Watersheds", US Dept. of Agricultural Soil Conservation Service, Technical Release 55 (TR-55), June 1986. *

D. The TR-55 CN tables are listed here:

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. *

***Copies are included in Appendix C**

E. Cover Type, Hydrologic Condition and Percent Imperviousness

Arid Rangeland - assumed Cover Type and Hydrologic Condition – Desert Shrub, etc., poor hydrologic condition (Table 2-2d applies)

Urban - assumed Cover Type and Average Impervious Area – 1/8 acre., 65% impervious (Table 2-2a applies)

Cultivated Agricultural Land - assumed Cover Type and Hydrologic Condition – Row Crops – Straight Row. 65%, poor hydrologic condition (Table 2-2b applies)

F. CN selections were based on the previous data, assumptions, and NRCS soils data and Tables.

G. Areal weighted CNs were computed by areal weighting the CN per soil map unit by the acreage of that map unit relative to the total subbasin acreage.

The watershed to the west of I-25 has low density residential housing interspersed with large areas of open space and desert shrub. This uneven distribution of land use made the weighting of curve numbers very time consuming and subjective. The curve numbers for desert shrub for HSG A are much higher than those of 1 acre lots therefore to simplify CN calculations, the curve number for desert shrub was adopted for all subbasins on the west side of I-25. As such, the runoff rates and discharge volumes from the hydrologic model are conservative.

2.7 TRAVEL TIME (T_t), TIME OF CONCENTRATION (T_C), AND UNIT HYDROGRAPH LAG TIME (T_L) COMPUTATIONS AND UNIT HYDROGRAPH

A water course may have up to three sub-reaches that comprise the longest flow path as defined by the TR-55 method.

- 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 Radium Springs, Smith picked a typical length of 100 ft.

- A shallow concentrated flow reach not to exceed 2000 ft. The maximum length of 2000 ft was selected for computations.

- A channel flow reach that comprises the remainder of the flow path.

The NRCS TR-55 (Tt) and (Tc) method was applied to each water course. The time of concentration (Tc) for the watercourse equals the summation of travel times (Tt) from each sub-reach. **Appendix C** contains the TR-55 description and procedures.

The NRCS Unit Hydrograph Lag Time Method (T_L) was applied to the Tc to compute the unit hydrograph Time to Peak (Tp). Note that Lag Time = 0.6 Tc. **Appendix C** contains the reference pages from NRCS Part 630 Hydrology, National Engineering Handbook, May 2015, Chapter 15 that describes the lag time concept and method.

The longest flow path for each subbasin was generated by the HEC-GeoHMS. Manning's Roughness Coefficients "n" assumptions were obtained from TR-55 and tables provided in 'Open Channel Hydraulics' by Ven T Chow, 1959 (copies included in **Appendix C**).

Channel slopes and length measurements were derived from elevation provided by DACFC. Typical channel widths were also measured from the ortho imagery provided by DACFC. **Tables C3** (**Appendix C**) summarizes time of concentration, lag time data and results. **Figure 2.1** (Map Pocket) shows the longest flow paths delineated for all the subbasins.

2.8 CHANNEL ROUTING

The "Muskingum-Cunge" channel routing method was applied to route hydrographs. Manning's "n" values were selected based on tables provided in 'Open Channel Hydraulics' by Ven T Chow, 1959. Typical bottom width assumptions were made based on data from orthophotography. **Table C4 (Appendix C)** presents the "Muskingum-Cunge" channel routing input data summary. Channel routing parameters were computed using elevation data provided by DACFC. Runoff losses due to channel bed infiltration and percolation were assumed to be small and were not simulated.

2.9 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. Note that a sediment bulking value of about 17% is considered the limit before mud flow would occur. A sediment bulking factor of 10% or a factor of 1.10 was assumed for all undeveloped subbasin hydrographs whereas a factor of 5% or 1.05 was assumed for urbanized subbasin hydrographs. That assumption is based on review of information presented in Sediment and Erosion Design Guide, Nov. 2008, Mussetter Engineering Inc. **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.

2.10 HYDROLOGIC DATA SUMMARY

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

2.11 COMPUTATION TIME INCREMENT FOR HEC-HMS MODELS

While various procedures are available for assigning the computational time increment, the DACFC prefers to use a time step of one minute. All simulations were run at a one-minute time increment.

2.12 INFLOW-DIVERSION FUNCTIONS & UPSTREAM DETENTION AT CULVERT STRUCTURES

A. Inflow-Diversion Functions

The subbasins west of I-25 have numerous issues as overland flows often split into different directions. The Inflow-Diversion Function within HEC-HMS provides the capability to divide a subbasin hydrograph into two hydrographs that may flow in different directions. Such an inflow-diversion was used at the intersection of Meador Rd. and Frodo Pl. The diversion function allows flows to be split at an 80:20 ratio so that 80% of the inflow hydrograph flows to the intersection of Hurt Rd. and Frodo Pl. The residents near this intersection have had flooding issues for some time.

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 structure. In some instances, the culverts are under capacity and cannot convey the peak discharges. As such, the embankments act as detention ponds where the water pools and spreads laterally**. Consequently, the discharge rates to the downstream analysis points at these locations are purely a function of maximum culvert capacity**. In past versions, the program required an outflow curve that would include stage-storage-discharge data to perform reservoir routings. The discharge rating curve for the outlet structure had to be computed externally to HMS and then input as a paired data set. With the latest version of HEC-HMS V4.2.1, there are new features developed for reservoirs. The program now allows users to designate an outlet structure, for example, a culvert outlet, as an outflow method. With the correct culvert parameters, HEC-HMS can compute an internal discharge rating curve based on inlet or outlet control flow regimes. However as in the past versions, the stage-storage data must be computed externally. As such, upstream ponding was simulated using reservoirs for RAMP1 culvert which carries the discharge from subbasin E15 and crosses the northeastern ramp of the E70/I-25 interchange. Stage data was assigned based on measured maximum available headwater depth, storage was artificially manipulated so that the outlet discharge matched the computed discharge capacity of the culverts.

Upstream ponding due to under capacity culverts provides a significant benefit especially in the higher return period storms when the high peak discharges could significantly affect downstream areas. The locations of the culverts are presented in **Figure 4**.

2.13 RESERVOIR ROUTING DATA

The reservoir routings were applied to the pond within subbasin E14 (Reservoir-1) and Lucero Dam located along Doña Ana Road at the west side of the watershed. Elevation-Storage-Discharge rating curves were developed from topographic data. Reservoir-1 has no principal spillway and it acts as a retention pond up to the 10- year storm. Excess discharges are passed through the emergency spillway. Lucero Dam has an emergency spillway and a principal outflow pipe, and it acts as a detention pond up to the 10-year storm. Excess discharges are passed through the emergency spillway for 50-year and 100-year storm events.

2.14 HEC-HMS HYDROLOGIC MODELS AND SUMMARY RESULTS

Unit peak discharges computed and evaluated to ensure that the numbers fell within an acceptable range for a watershed exhibiting the characteristics of semi-arid rangeland mixed with low density urban development for the 100-yr-24-hr. storm. Unit peak discharges were in the range of 1 to 5 cfs/ac which falls well within the acceptable range of unit peak discharge for this type of watershed. The only subbasins that had unit peak discharges around 5 cfs/ac were the roadway subbasins on I-25 which are predominantly impervious.

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

2.15 PERFORMANCE OF EXISTING DRAINAGE INFRASTRUCTURE

A. Existing Culvert Capacities

All existing culverts that convey flows under I-25 were evaluated for maximum discharge capacity. A 15% clogging factor was applied to account for debris. See **Appendix E** for Culvert Master calculation reports.

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 some culverts, upstream ponding was simulated as discussed in Section 2.12. The culvert crossings under the I-25 have sufficient capacity to convey flows for the 10-year storm from the east side of I-25. Culverts are shown in **Figure 4**.

B. Existing Dams

The Lucero Dam located along Dona Ana Road at the west edge of the watershed fully retains up to the 10-year peak discharge in the retention area of the dam and discharges through the emergency spillway for all higher return period storms.

The table below summarizes the routing results for the 10 and 100-year 24-hour storms. Table C7 in **Appendix C** provides pond routing data for all the return period storms simulated.

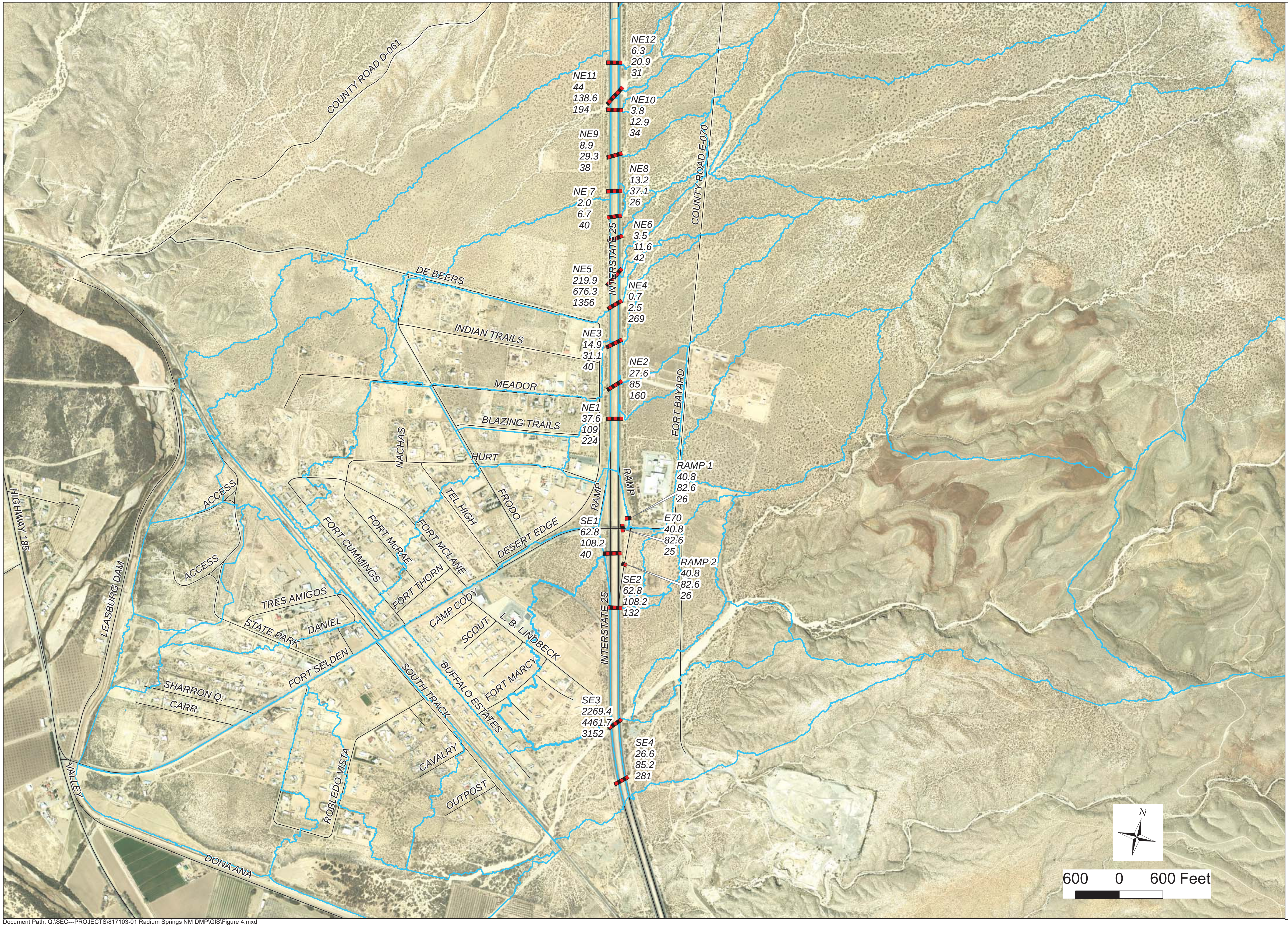
Reservoir Routing Summary - Existing Ponds
Radium Springs Drainage Master Plan

Detention Pond Name	Existing or Proposed Pond	Storm Return Period / Duration	Drainage Area	Peak Inflow	Peak Outflow	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 a	sq mi	cfs a	cfs a	ac-ft a	ac-ft a	ac-ft b	ac-ft a	ft a	ft b	ft b	ft b	ft	ft b	ft c	ft c
Lucero Dam	Existing	100 / 24	6.1100	4780	232	740.0	734.5	514.6	494.9	3975.7	3972.0	3958	18.0	17.7	3976.0	-3.7	0.3
Lucero Dam	Existing	10 / 24	6.1100	2393	117	383.2	379.4	514.6	260.6	3971.0	3972.0	3958	18.0	13.0	3976.0	1.0	5.0
Reservoir-1	Existing	100 / 24	0.4078	252	74	26.5	22.0	18.8	14.0	4050.2	4050.0	4040.0	12.0	10.2	4052.0	-0.2	1.8
Reservoir-1	Existing	10 / 24	0.4078	78	1	9.8	9.2	18.8	7.7	4046.7	4050.0	4040.0	12.0	6.7	4052.0	3.3	5.3

a - Refer to Figures included in report text for Proposed Retention Pond Conceptual Grading Plans (AutoCAD drawings of these grading plans are included in Appendix B)

2.16 PROBLEM AREAS IDENTIFIED UNDER EXISTING CONDITIONS

Four primary areas on the west side of I-25 were identified to be prone to potential flooding as shown in **Figure 5.** The key analysis points and appropriate discharges from the HMS model are also shown. The flooding experienced in these areas are primarily a result of inflows through the culverts NE1-NE12 conveying flows under I-25. The culvert analysis proves that all culvert structures listed above will convey 100% of the flows from the east side of I-25 up to the 100-year-24-hour storm. These flows eventually concentrate at the areas identified in red in **Figure 5**.



Legend

Culvert Crossings

Subbasin Boundary

Roads

Culvert ID: NE 11
Q10: 44
Q100: 138.6
Qp*: 195

(All culvert discharges are in units of cfs)

*Qp = Max Discharge Capacity of Existing Culvert Based on Max Headwater Depth.

RADIUM SPRINGS DRAINAGE MASTER PLAN

PREPARED FOR

DOÑA ANA COUNTY NEW MEXICO

PREPARED BY

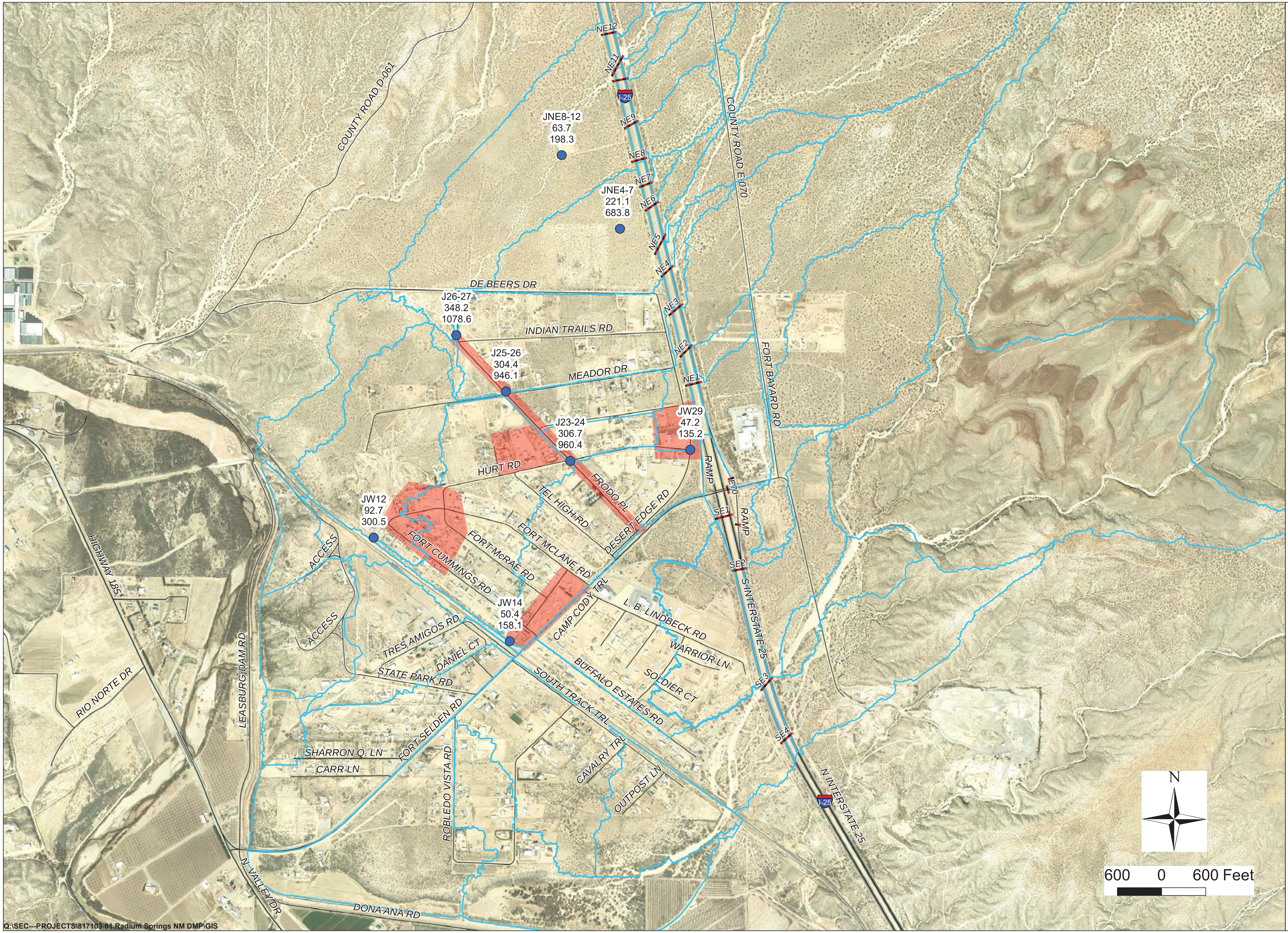
1989 - 2014 SMITH ENGINEERING COMPANY 25th Anniversary

FIGURE 4

EXISTING CULVERT CROSSINGS

JANUARY 2018

Document Path: Q:\SEC---PROJECTS\817103-01 Radium Springs NM DMP\GIS\Figure 4.mxd



Legend

- Analysis Points From HMS
- Culvert
- Subbasin Boundary
- Existing Flooding Problems
- Roads

Culvert ID: JW29
Q10: 47.2
Q100: 135.2

(All culvert discharges are in units of cfs)

RADIUM SPRINGS DRAINAGE MASTER PLAN

PREPARED FOR

DONA ANA COUNTY NEW MEXICO

PREPARED BY

1989 - 2014 SMITH ENGINEERING COMPANY 25th Anniversary

FIGURE 5

EXISTING PROBLEM LOCATIONS

JANUARY 2018

SECTION 3. 2-DIMENSIONAL SURFACE WATER MODELING

To understand the full impact of the inflows from the subbasins from the east side of I-25, a 2-dimensional HEC-RAS surface water model was created to simulate surface flow directions and concentration points. The purpose was to determine if the flows concentration points alluded to by residents at the public meeting would be verified by the 2D surface water model. The following flow chart illustrates the processes implemented to build a 2D model.

2D Modeling Process Using HEC-RAS 2D, V 5.0.3

1- Terrain preprocessing to create appropriate terrain file formats from the Digital Elevation Model (DEM)

2- Create appropriate geometry file in HEC-RAS using terrain generated from step 1

3- Create 2D polygon for modeling limits, generate 2D mesh & refine 2D mesh using breaklines

4- Create spatially varied roughness Manning's roughness layer using 2011 NLCD data and add user defined polygons to refine Manning's roughness layer

5- Adding necessary internal hydraulic structures (Not Applicable)

6- Create external 2D boundary conditions and associate appropriate inflow hydrographs flow files

7- Create plan with appropriate initial conditions and run simulation

8- Review stability, computational log file, and results in RAS Mapper

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. 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 5.1** shows a 2D mesh created for the 2D study area.

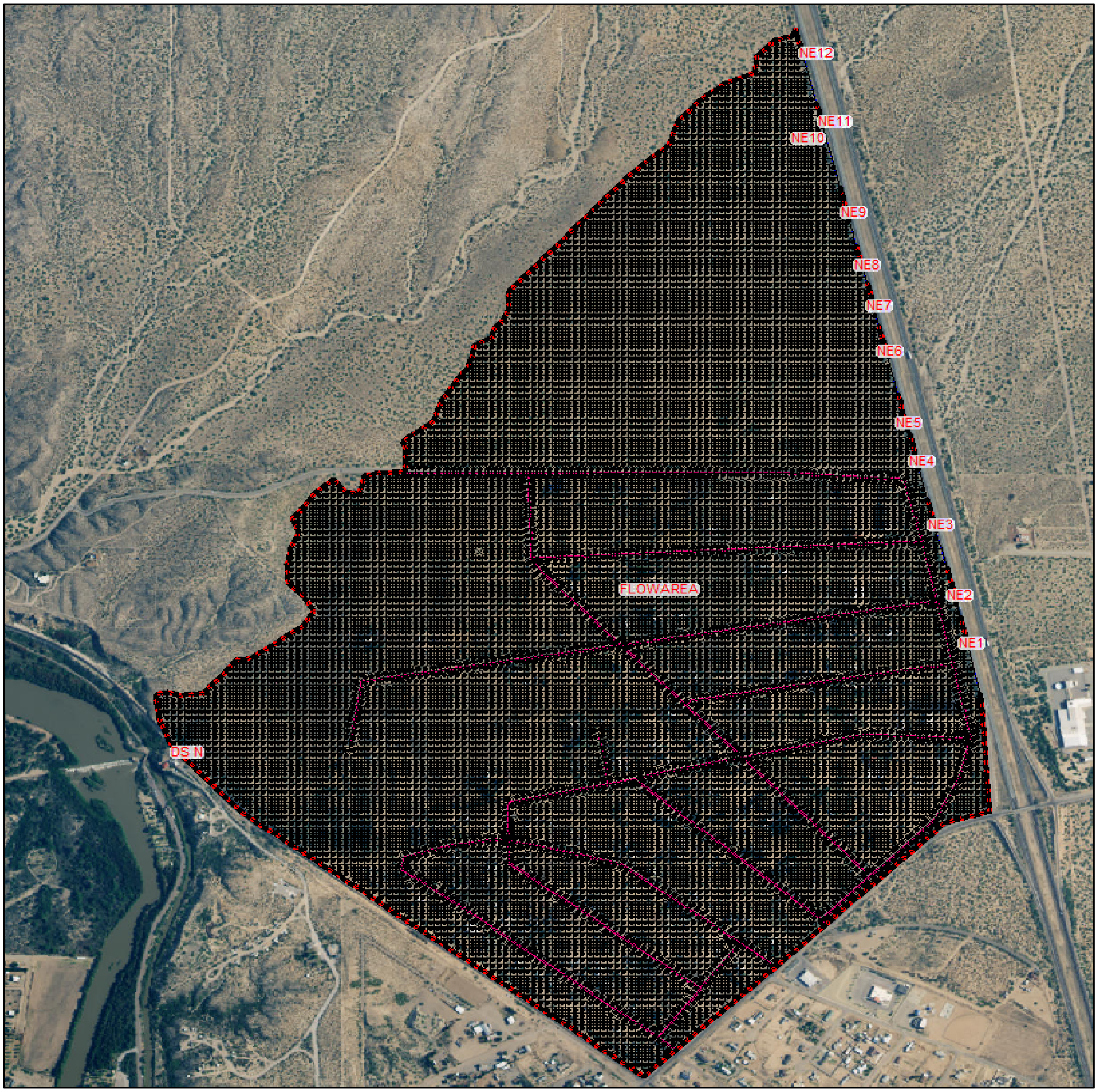


Figure 5.1: Typical 2D Mesh

B. Spatially Varied Manning's Roughness Layer

The 2011 National Land Cover Dataset (NLCD_2011) for the Radium Springs area was downloaded from the Natural Resources Conservation Service geospatial data gateway website. This raster data set provides a spatially varying 'n' value based on land use and classification created from a unique Value and Name assigned within the raster data set. The program is than able to apply the data to the 2D mesh as it performs the 2D flow computations. The table below summarizes the NLCD_2011 data.

The data distribution available for Radium Springs reflected land cover accurately enough to where no further refinement was performed. The table below shows the default NLCD_2011 that were utilized in the model.

Color	Value	Name	Default Manning's n
	0	nodata	
	1	255	0.055
	2	developed, low intensity	0.06
	3	developed, open space	0.06
	4	grassland/herbaceous	0.06
	5	shrub/scrub	0.06

C. Internal Hydraulic Structures

No internal hydraulic structures were modeled for the Radium Springs area.

D. External 2D Flow Area Boundary Conditions

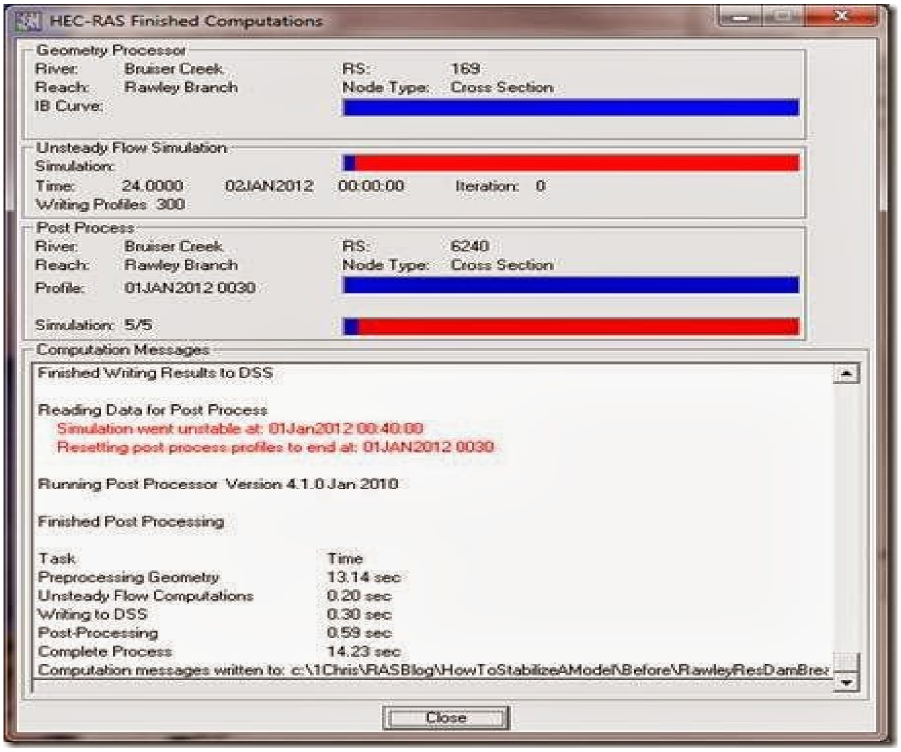
The 2D flow area must have upstream and downstream boundary conditions specified. For areas where flow leaves the model, normal depth was specified. Since the downstream areas are typically flat agricultural fields, a typical energy slope of 1% was specified. The upstream boundary conditions simulate locations where flows are added into the mesh. The hydrographs from the HEC-HMS hydrologic model, at the appropriate junctions representing culverts NE1-NE12, 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 culverts NE1-NE12. 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.

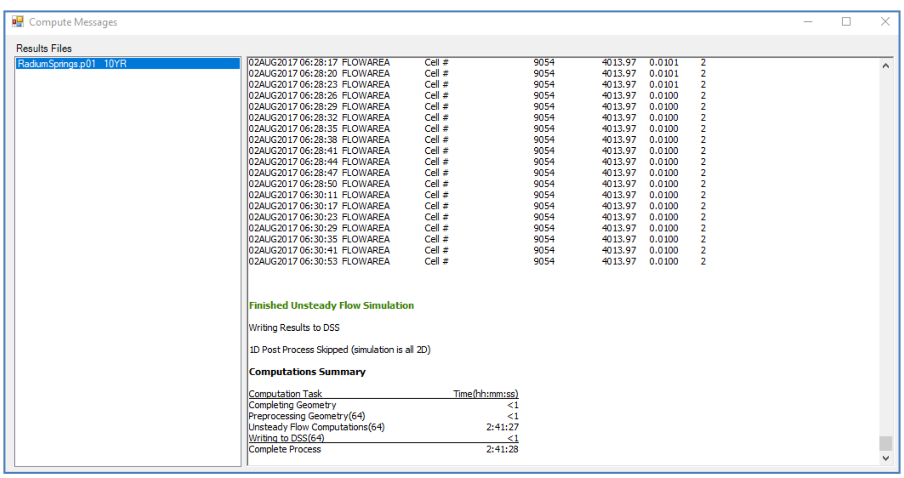
F. Simulation Run and Results

The results from the 2D analysis are best viewed dynamically in RAS Mapper to see how the flow distributes over the terrain over the duration of the hydrograph. There are many variables that can be queried within RAS Mapper. The values 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 and become unstable and a message appears as shown.



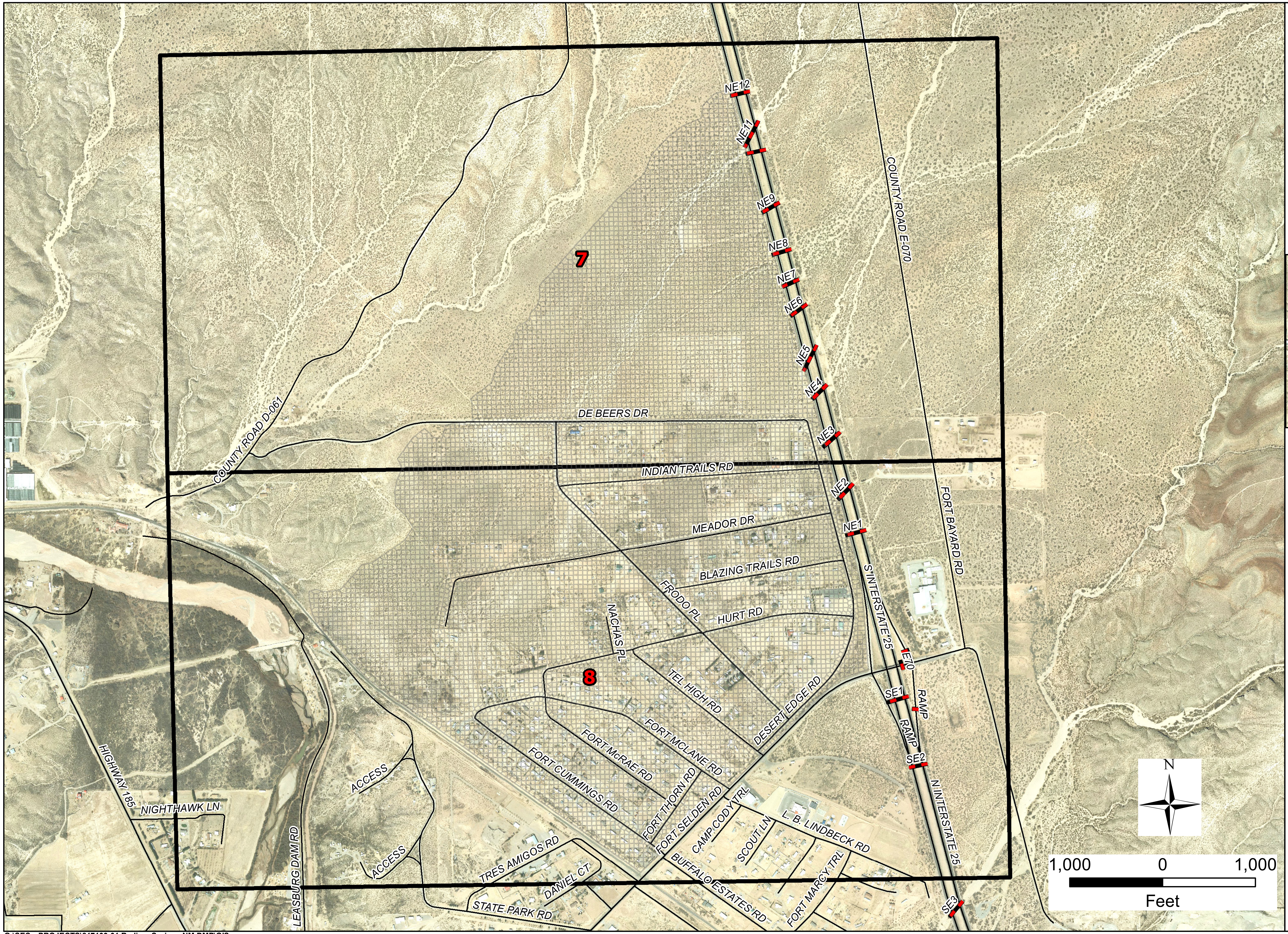
In this case, the above window did not occur proving the model was performing the computations and achieving convergence for all the cells. Upon completing the simulation run successfully, this window opens indicating that results are now ready to be viewed in RAS Mapper.

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 red box shown below. This number should be very small if the model is running correctly. The Radium Springs 2D model had errors below 0.5% which is acceptable. The log should look like below:



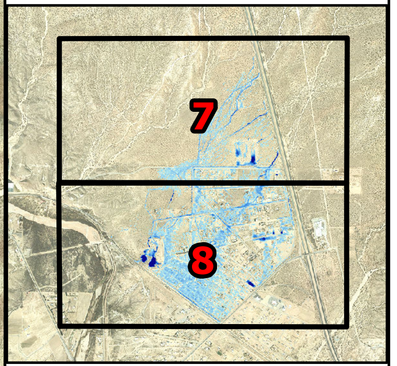
```
      Volume Accounting for 2D Flow Area in Acre Feet

  2D Area    Starting Vol    Ending Vol    Cum Inflow    Cum Outflow        Error    Percent Error
  *******    ************    **********    **********    ***********        *****    *************

 FLOWAREA                       11.09         46.08         35.15          0.1655           0.3592

ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
º                                             º
º                                             º
º               DSS-Writer                    º
º                                             º
º         For Unsteady Flow Module            º
º                                             º
º      HEC-RAS 5.0.3 September 2016           º
º                                             º
º          11SEP17 at 16:54:35                º
º                                             º
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼
```

The flow depths generated from the 10 and 100-year return periods indicated that the Radium Springs watershed has some points of concentration. **Figures 6** through **11** show the limits of inundation from the 10 and 100-year storms. The inflow discharges from I-25 culvert crossings are very high and cause ponding problems on the residential areas as indicated on **Figure 5.** The flow depths predicted for both the return period storms were very reasonable.



Legend

- 2D Flow Area
- Culvert
- Roads



RADIUM SPRINGS DRAINAGE MASTER PLAN

PREPARED FOR

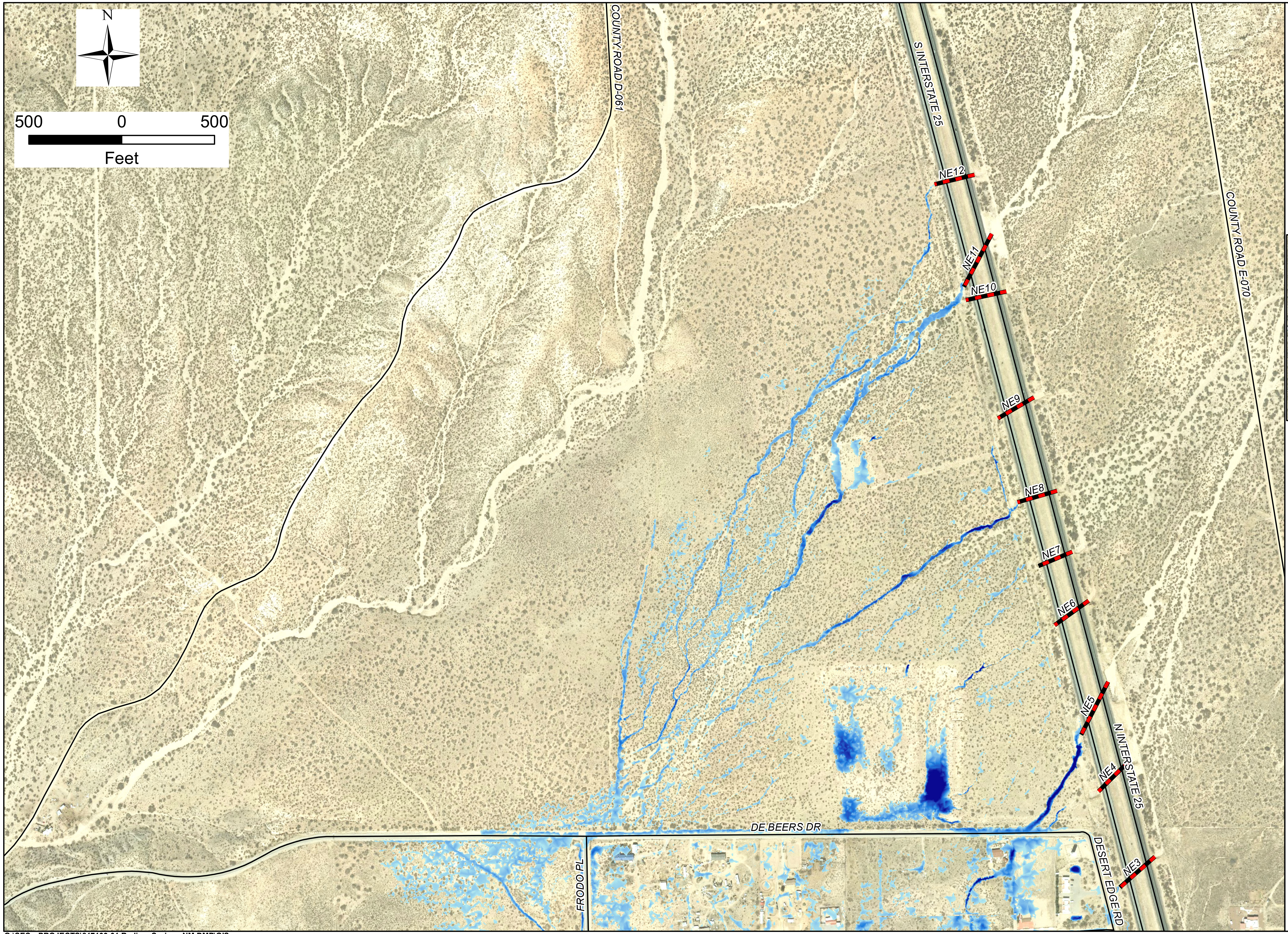
PREPARED BY

Figure 6

2D Limits of Model For 10-Year Storm

JANUARY 2018

Q:\SEC---PROJECTS\817103-01 Radium Springs NM DMP\GIS



Legend

Culvert

Roads

Depth

Value

High : 8.0 ft.

Low : 0.5 ft.

RADIUM SPRINGS DRAINAGE MASTER PLAN

PREPARED FOR

DOÑA ANA COUNTY NEW MEXICO

PREPARED BY

1989 - 2014 SMITH ENGINEERING COMPANY 25th Anniversary

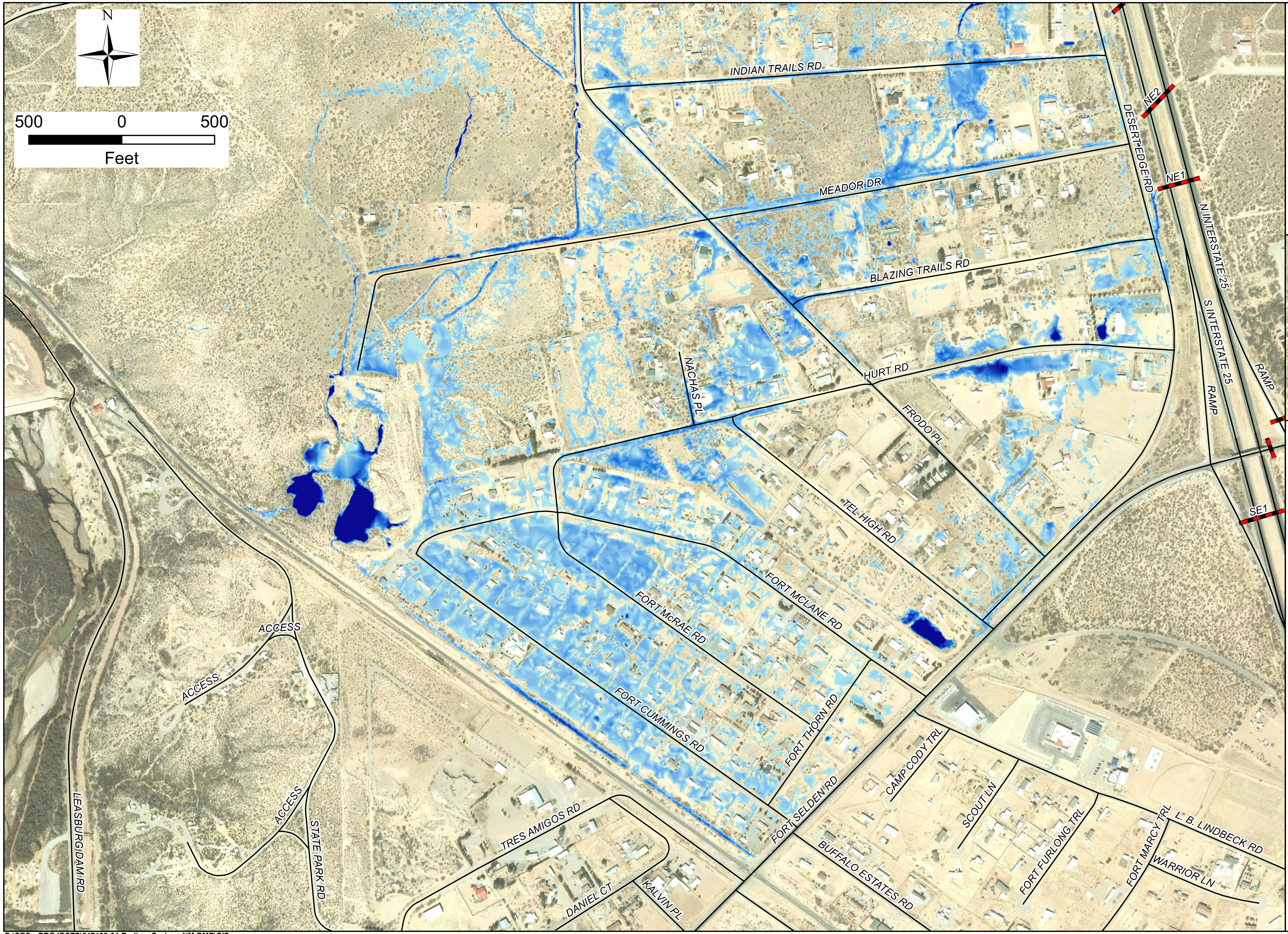
Figure

7

10 Yr Inundation Based on 2D Model

JANUARY 2018

Q:\SEC---PROJECTS\817103-01 Radium Springs NM DMP\GIS



Legend

Culvert

Roads

Depth

Value

High : 8.0 ft.

Low : 0.5 ft.

7

8

RADIUM SPRINGS DRAINAGE MASTER PLAN

PREPARED FOR

PREPARED BY

Figure

8

10 Yr Inundation Based on 2D Model

JANUARY 2018

Q:\SEC---PROJECTS\817103-01 Radium Springs NM DMP\GIS

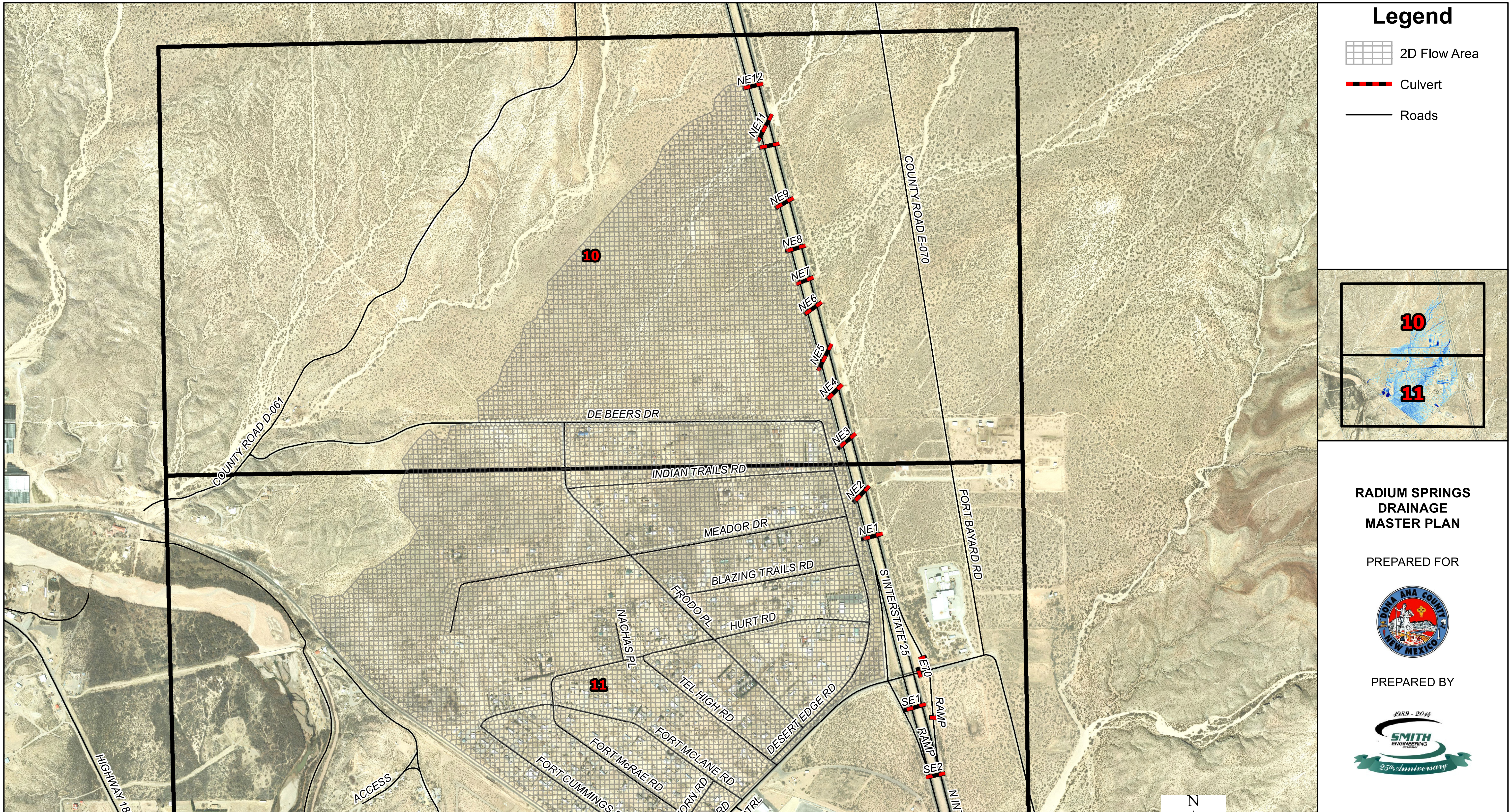
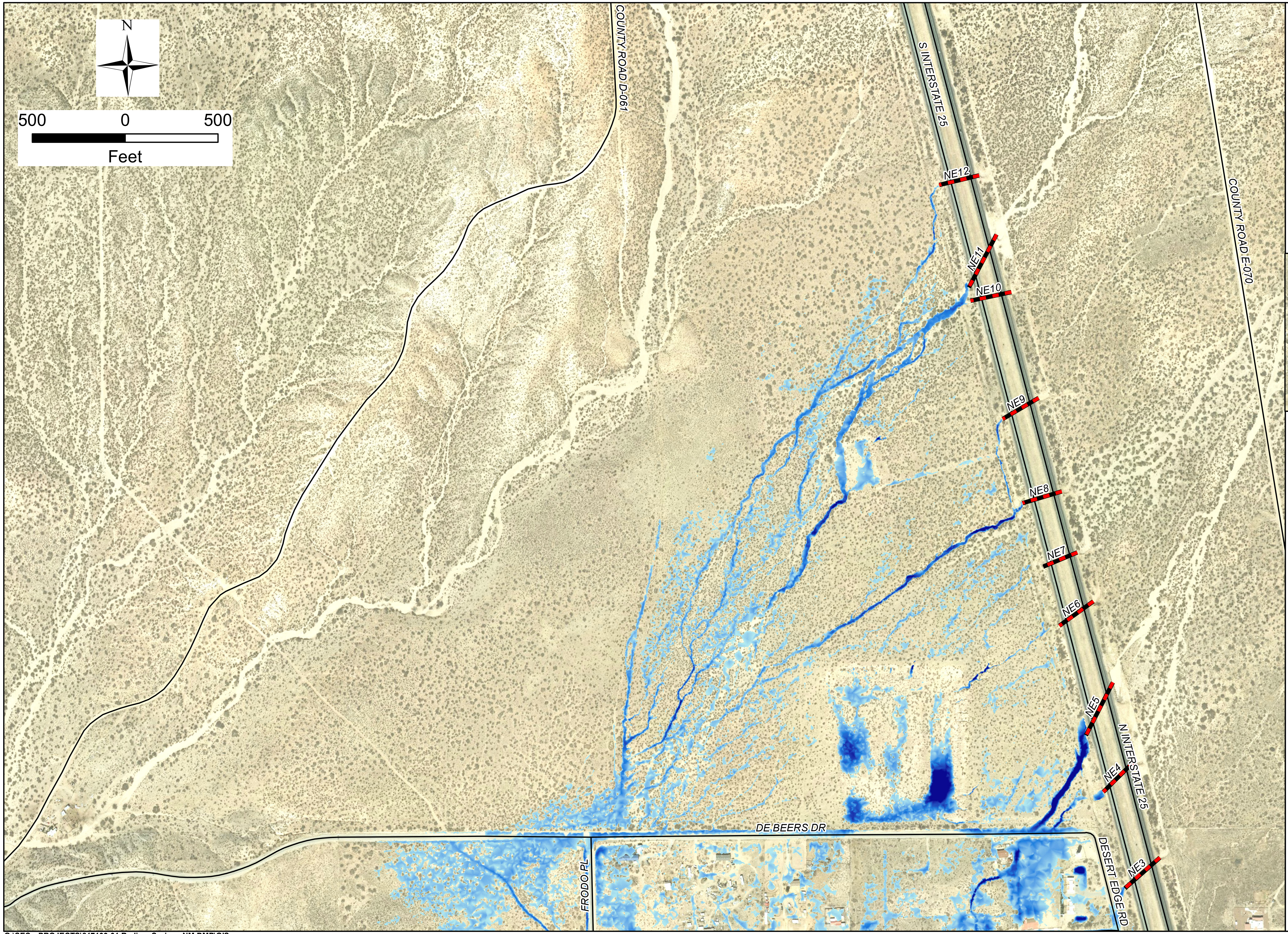


Figure
9
2D Limits of Model
For 100-Year Storm

JANUARY 2018



Legend

Culvert

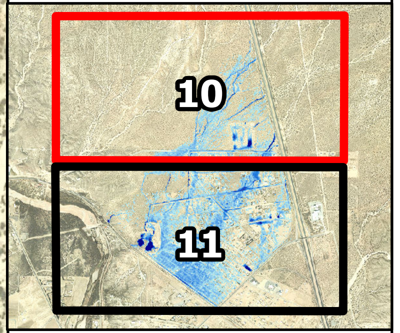
Roads

Depth

Value

High : 9 ft.

Low : 0.5 ft.



RADIUM SPRINGS
DRAINAGE
MASTER PLAN

PREPARED FOR

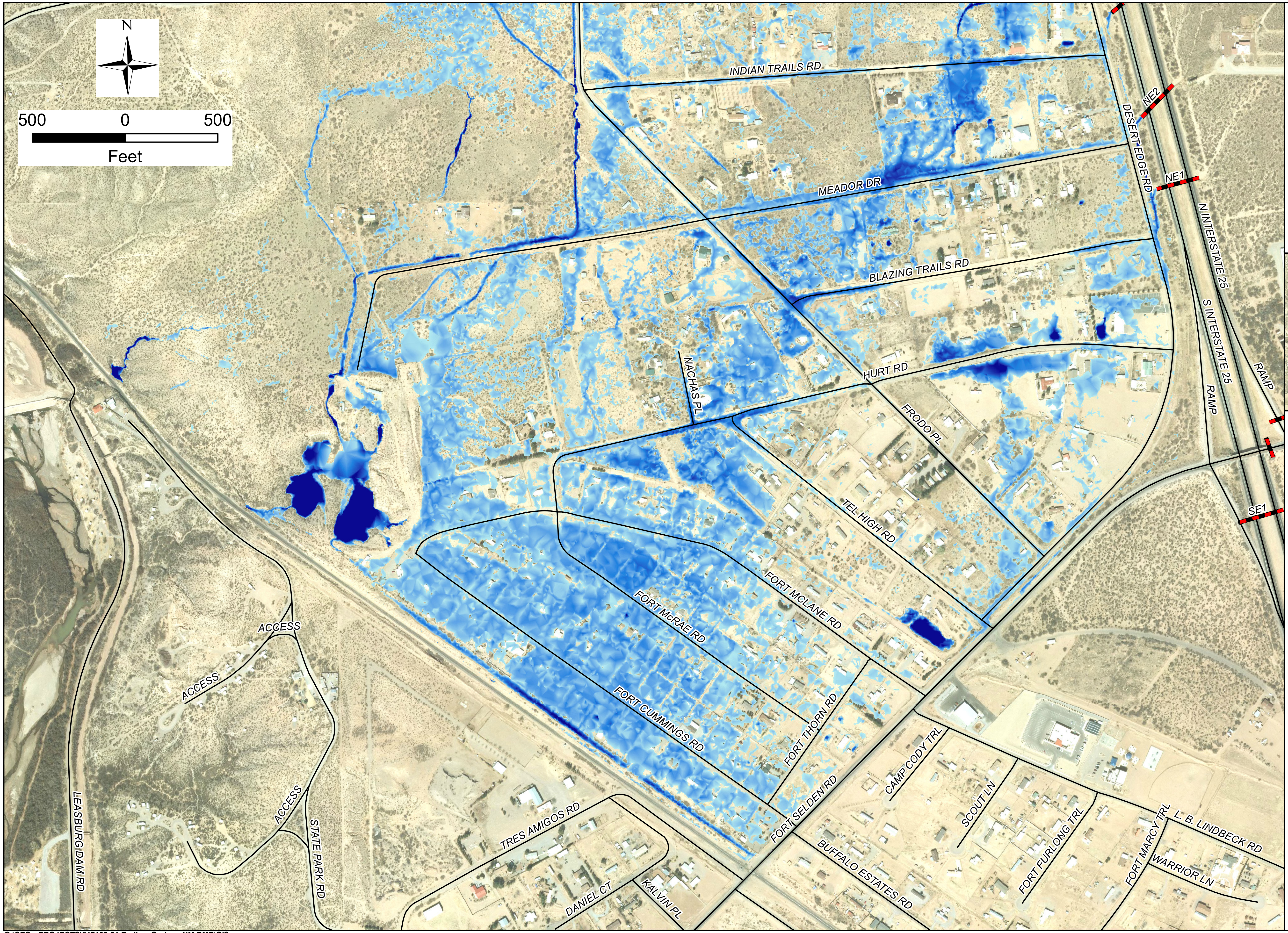
PREPARED BY

Figure
10

100 Yr Inundation
Based on 2D Model

JANUARY 2018

Q:\SEC---PROJECTS\817103-01 Radium Springs NM DMP\GIS



Legend

Culvert

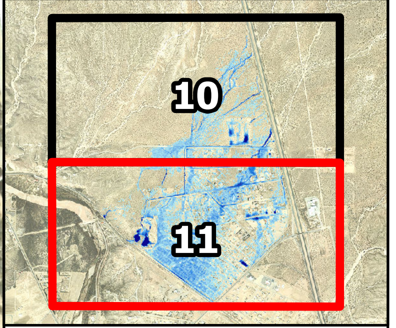
Roads

Depth

Value

High : 9 ft.

Low : 0.5 ft.



RADIUM SPRINGS DRAINAGE MASTER PLAN

PREPARED FOR

PREPARED BY

Figure

11

100 Yr Inundation Based on 2D Model

JANUARY 2018

Q:\SEC---PROJECTS\817103-01 Radium Springs NM DMP\GIS

SECTION 4. PROPOSED OPTIONS HYDROLOGIC AND HYDRAULIC ANALYSES

4.1 PROPOSED OPTIONS HYDROLOGIC DATA

No modeling changes were made that would affect the existing detention/retention structures. Therefore, the reservoir routing results remain unchanged from the existing conditions model. The existing HEC-HMS model was modified to simulate proposed facilities, including detention ponds and diversion channels. 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. Data tables for proposed ponds 2, 3 and 4 are included in **Tables C8-C11** in **Appendix C.** The proposed improvements were simulated in the proposed model and effects on peak discharges were evaluated.

4.2 MOST SIGNIFICANT DRAINAGE PROBLEM AREAS

Several facilities consisting of a combination of ponds and diversion channels were considered to mitigate flooding for the 10-year storm**.** All proposed ponds were designed to be non-jurisdictional ponds. The options were simulated within HEC-HMS to improve drainage conditions in Radium Springs. The primary goal behind the options was to divert inflows from I-25 culvert crossings around town and redirect and detain flows within town where possible. In the following sections, proposed ponds and diversion channels are categorized as facilities. **Figure 12** provides an overview of the locations of the proposed facilities and the effect they have on peak discharge reduction for the design storm.

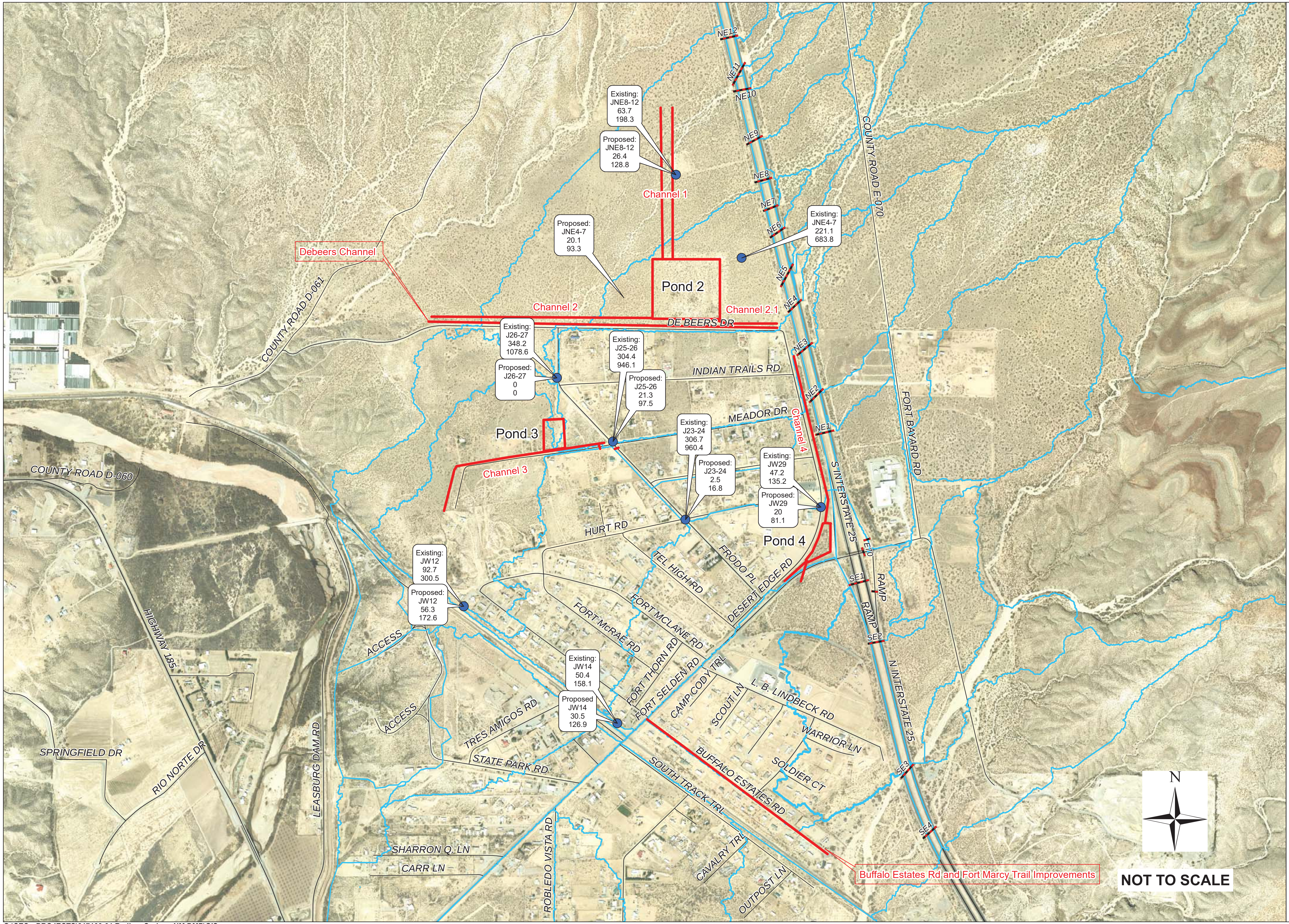
4.3 ANALYSES AND OPTIONS SUMMARY

Smith evaluated five facilities for flood mitigation. **Figure 12** shows an overview of the proposed facilities and reduction in peak discharges compared to existing conditions at the appropriate analysis points from HEC-HMS. Facilities 1A and 1B are two alternatives that provide significant benefit to the Radium Springs community however the final decision on which one to implement will rest with the DACFC as there are several considerations in terms of cost and property ownership. The DACFS indicated that they will address the final selection when these projects proceed to preliminary design phase in the future.

Below is a summary the components of the five facilities.

Facility 1A consists of:

A training berm, Pond 2, Channels 1, 2 and 2.1. The training berm and channels 1 and 2 will direct overland flows from culverts NE4-NE12 into Pond 2. The outflow from Pond 2 will be conveyed by Channel 2.1 to the west where it discharges into an existing arroyo. Based on the proposed layout, Pond 2 will fully control the inflow from the 10-year storm. Flows from the 100-year storm will discharge through the emergency spillway however Channel 2.1 is designed to convey this discharge. **The cost of this facility is $2 million dollars.**



Legend

- Analysis Points From HMS
- Proposed Improvements
- Culvert
- Subbasin Boundary
- Roads

HEC-HMS Junction ID: JW29
Q10: 47.2
Q100: 135.2

(All discharges are in units of cfs)

RADIUM SPRINGS DRAINAGE MASTER PLAN

PREPARED FOR

DONA ANA COUNTY NEW MEXICO

PREPARED BY

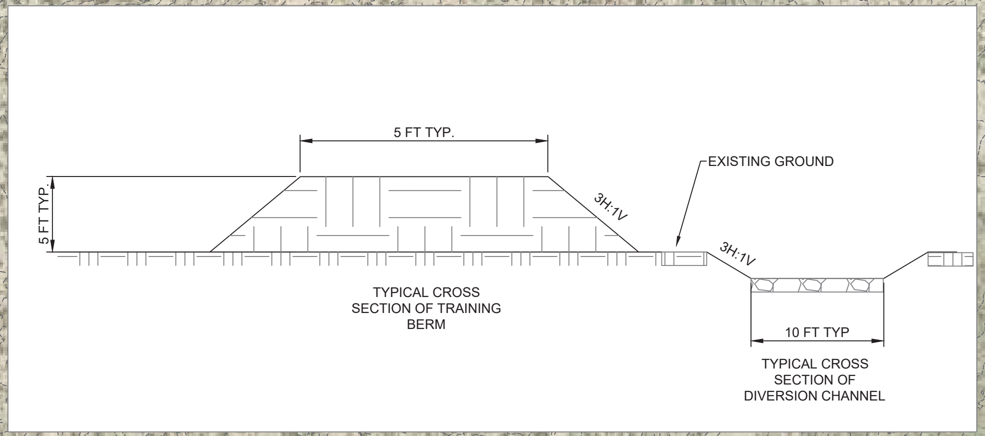
1989 - 2014 SMITH ENGINEERING COMPANY 25th Anniversary

FIGURE 12

OVERVIEW OF OPTIONS

JANUARY 2018

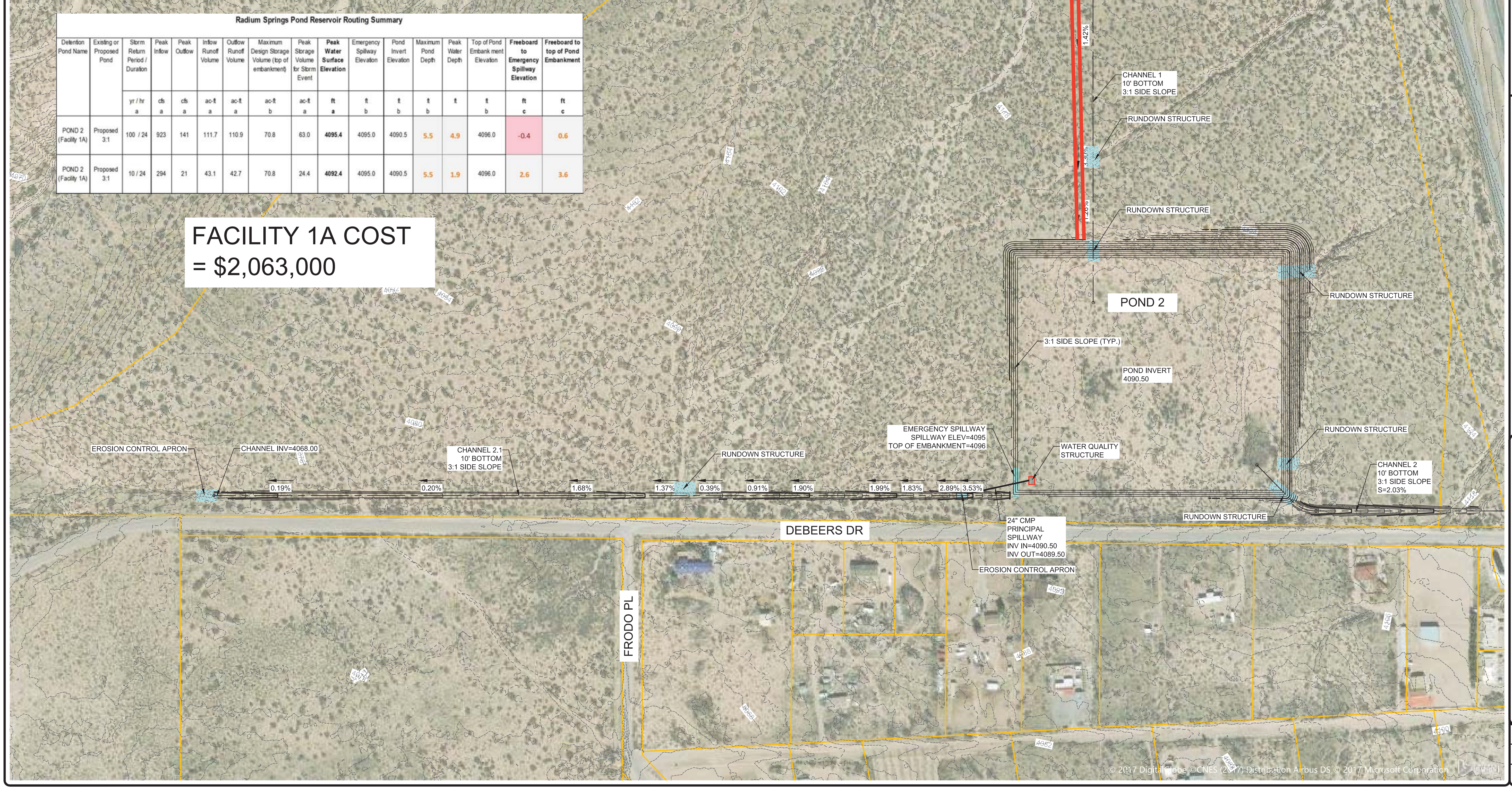
Q:\SEC---PROJECTS\817103-01 Radium Springs NM DMP\GIS



Radium Springs Pond Reservoir Routing Summary

Detention Pond Name	Existing or Proposed Pond	Storm Return Period / Duration	Peak Inflow	Peak Outflow	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 a	cfs a	cfs a	ac-ft a	ac-ft a	ac-ft b	ac-ft a	ft a	ft b	ft b	ft b	ft	ft b	ft c	ft c
POND 2 (Facility 1A)	Proposed 3:1	100 / 24	923	141	111.7	110.9	70.8	63.0	**4095.4**	4095.0	4090.5	5.5	4.9	4096.0	-0.4	0.6
POND 2 (Facility 1A)	Proposed 3:1	10 / 24	294	21	43.1	42.7	70.8	24.4	**4092.4**	4095.0	4090.5	5.5	1.9	4096.0	2.6	3.6

FACILITY 1A COST
= $2,063,000



RADIUM SPRINGS
DRAINAGE MASTER PLAN
FIGURE 13

FACILITY 1A

NO.	REVISION DESCRIPTION	DATE	BY
1			
2			
3			
4			
5			

SMITH ENGINEERING

JOB NO: 817103-01
DATE: JAN 2018
SHEET NO: 26

A. Facility 1B: DeBeers Diversion Channel

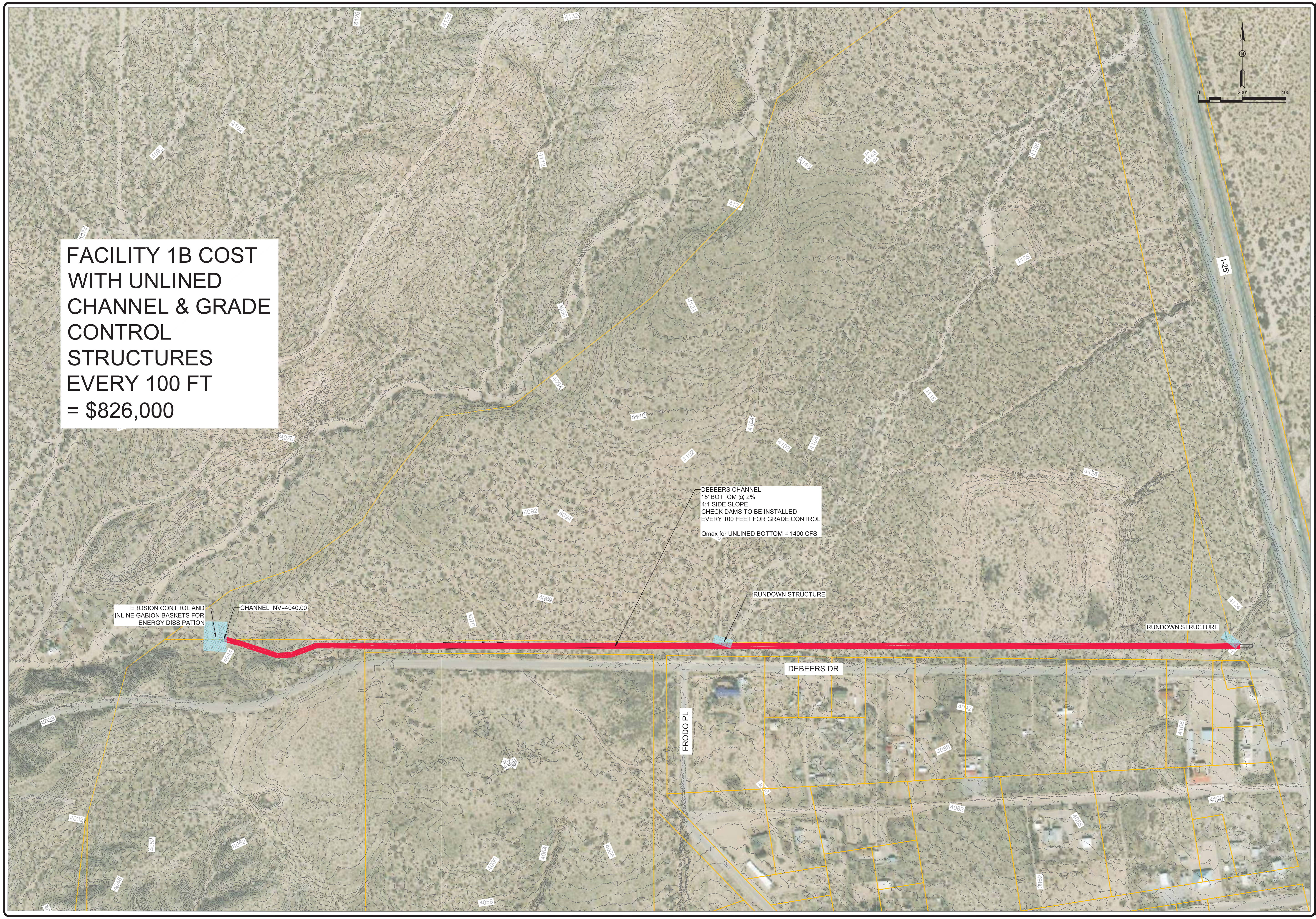
The DeBeers Diversion Channel on the north side of DeBeers Rd. will divert all offsite flows from culverts NE4 to NE12. The flows from these culverts under existing conditions enter Radium Springs at several points along DeBeers Rd., particularly at Frodo Pl. By building rundowns at these entry points and diverting flows into the DeBeers Diversion Channel, these flows can now be directed west towards the river where the surface flow can follow a natural existing path and drain into the Rio Grande. Hydraulic Analysis of the proposed channel was performed using Flow Master assuming the following parameters:

Channel Length	4000 ft.
Channel Slope	2%
Channel Side Slope	4H:1V to minimize embankment erosion
Channel Bottom Width	15 ft.
Channel Depth	5 ft.
Manning's n Value for Scenario 1	0.045 for rip rap lined bottom
Manning's n Value for Scenario 2	0.035 for sand bottom & grade controls every 100 ft.

Scenario 1 assumes that the channel bottom is lined with rip rap to minimize degradation and maintain channel velocity of approximately 8 ft/s. The peak channel capacity in this scenario is 1,000 cubic feet per second (cfs), which is greater than the peak inflow of 900 cfs. Due to the extensive quantity of rip rap required to line the entire length of the channel, the cost of this scenario is approximately **$1.5 million.**

Scenario 2 assumes that the channel bed is unlined (sand), however rip rap grade control structures are installed at 100 ft. intervals to control degradation. The rip rap grade control structures will be elevated a foot above the channel bed to create a tumbling effect in the channels hydraulics which would minimize channel velocities to approximately 7 ft/s. The outfall of the channel would also have above ground gabion baskets that would be staggered to provide in line energy dissipation while maintaining outlet velocities of around 4-5 ft/s. This channel would be very similar in nature to the Dragonfly Channel on the East Mesa area of Dona Ana County albeit with the rip rap grade controls and energy dissipation. The cost of this channel would be approximately **$826,000.** Detailed cost estimates are included in **Appendix F**.

Figure 13-1 shows the proposed alignment of the DeBeers Diversion Channel.



NO	REVISION DESCRIPTION	DATE	BY
1			
2			
3			
4			
5			

RADIUM SPRINGS
DRAINAGE MASTER PLAN

FIGURE 13-1

FACILITY 1B

SMITH ENGINEERING

JOB NO: 817103-01

DATE: JAN 2018

SHEET NO: 28

B. Facility 2: Pond and Diversion Channel

This facility consists of a diversion channel (Channel 3) located along Meador Rd., a small detention pond, Pond 3 and two speed bumps that would act as flow diversions as shown on **Figure 14.** Facility 2 is proposed to reduce the flooding problems generated at the intersection of Frodo Pl. and Hurt Rd. by capturing the runoff from Indian Trails Rd. and Meador Dr. and diverting it into Pond 3 rather than allowing the surface flows to drain south towards the intersection of Frodo Pl. and Hurt Rd. **Figure 14** shows the preliminary grading limits for Pond 3. The table below summarizes the crucial parameters of Pond 3 and its reservoir routing results.

Radium Springs Pond Reservoir Routing Summary

Detention Pond Name	Existing or Proposed Pond	Storm Return Period / Duration	Peak Inflow	Peak Outflow	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 a	cfs a	cfs a	ac-ft a	ac-ft a	ac-ft b	ac-ft a	**ft** **a**	ft b	ft b	ft b	ft	ft b	**ft** **c**	**ft** **c**
POND 3	Proposed 3:1	100 / 24	148	98	11.1	11.1	4.4	3.6	**4044.2**	4044.0	4040	**5.0**	**4.2**	4045.0	-0.2	**0.8**
POND 3	Proposed 3:1	10 / 24	55	21	4.6	4.6	4.4	1.7	**4042.1**	4044.0	4040	**5.0**	**2.1**	4045.0	**1.9**	**2.9**

Channel 3 would be trapezoidal in shape with a bottom width of 6 ft., 3H:1V side slopes, a slope of 1.41%, an overall length of approximately 2,300 ft, and a normal depth of 1.5 ft. The hydraulic calculations for the channel capacity were performed in the Flow Master and are included in **Appendix E.** The primary purpose of the channel would be to contain the outflow from the ponds and continue local runoff rather than spreading throughout the adjacent houses. Like the other proposed channels, conveyance capacity was evaluated under rough and smooth channel conditions. The hydraulic data and conceptual layout is shown on **Figure 14.**

The cost of Facility 2 is approximately **$447,000.**

Radium Springs Channel Summary

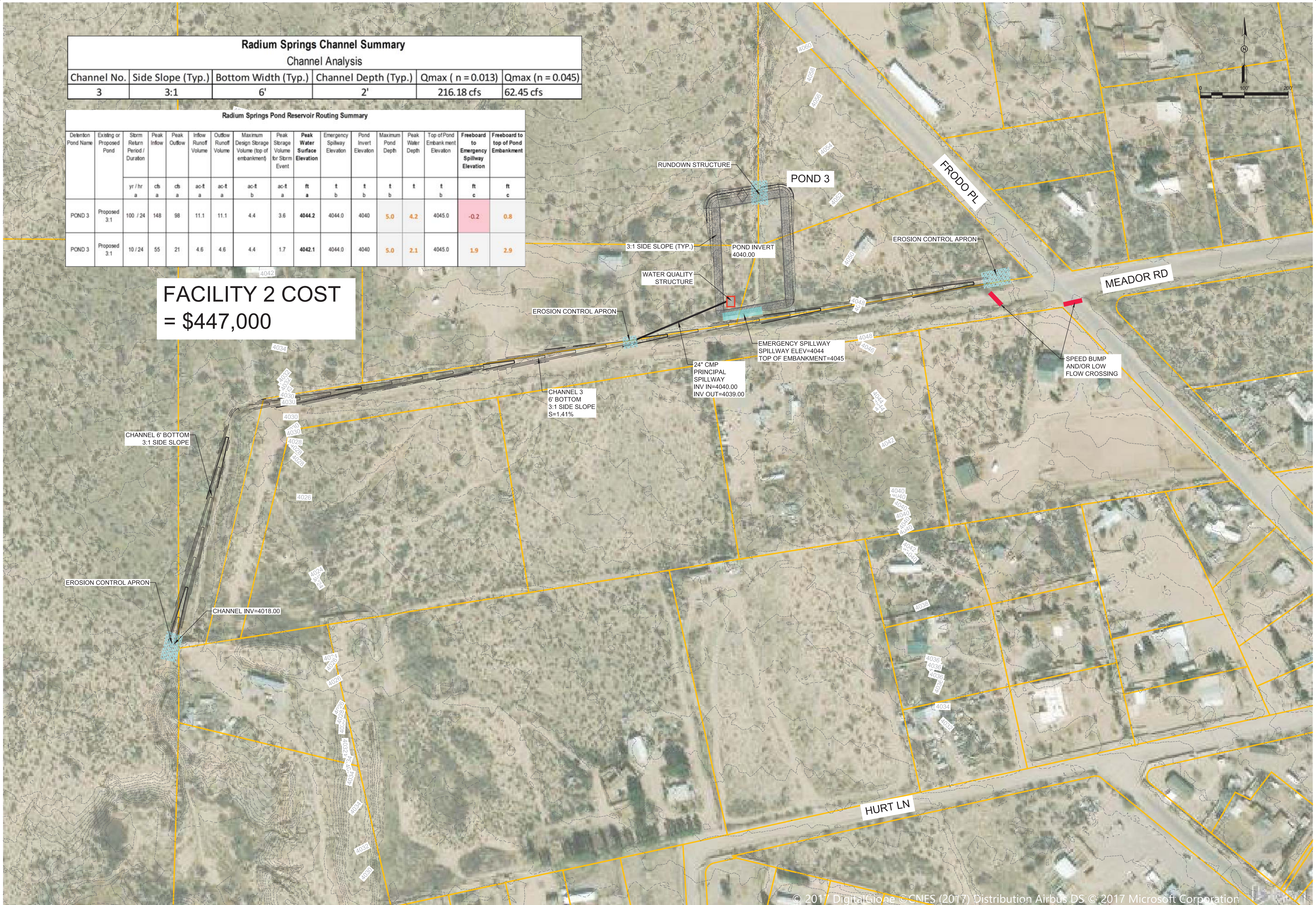
Channel Analysis

Channel No.	Side Slope (Typ.)	Bottom Width (Typ.)	Channel Depth (Typ.)	Qmax (n = 0.013)	Qmax (n = 0.045)
3	3:1	6'	2'	216.18 cfs	62.45 cfs

Radium Springs Pond Reservoir Routing Summary

Detention Pond Name	Existing or Proposed Pond	Storm Return Period / Duration	Peak Inflow	Peak Outflow	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 a	cfs a	cfs a	ac-ft a	ac-ft a	ac-ft b	ac-ft a	ft a	ft b	ft b	ft b	ft	ft b	ft c	ft c
POND 3	Proposed 3:1	100 / 24	148	98	11.1	11.1	4.4	3.6	**4044.2**	4044.0	4040	5.0	4.2	4045.0	-0.2	0.8
POND 3	Proposed 3:1	10 / 24	55	21	4.6	4.6	4.4	1.7	**4042.1**	4044.0	4040	5.0	2.1	4045.0	1.9	2.9

FACILITY 2 COST
= $447,000



NO		DATE	BY
5	####	####	####
4	####	####	####
3	####	####	####
2	####	####	####
1	####	####	####

REVISION DESCRIPTION

Name
Location

RADUIM SPRINGS
DRAINAGE MASTER PLAN
FIGURE 14

FACILITY 2

SMITH ENGINEERING

JOB NO:
817103-01

DATE:
JAN 2018

SHEET NO:
30

Q:\SEC—PROJECTS\817103-01 Radium Springs NM DMP\CADD\PLANSET\FACILITY 2.dwg Jan 12, 2018 - 9:10am Saved By: chrisa

C. Facility 3: Detention Pond and Diversion Channel

Pond 4: This pond is located near the northwestern ramp of the E70/I-25 interchange. The 2D model predicts that discharges from culverts NE1-NE3 will concentrate at this point. Pond 4 will serve as a non-jurisdictional detention pond which is able to fully detain the 10-year storm. The designed footprint allows the pond to detain up to approximately 4.8 ac-ft. The pond is 5 ft deep and is graded to have 3H:1V side slopes from the top of the pond to the pond bottom to maximize volume while minimizing the need for slope stabilization. Pond 4 will require a rundown structure to channel the water from the culverts into the pond. The rundown structure will have to be wire enclosed rip rap since the soil conditions in this area are cohesion less. An emergency spillway made of reinforced concrete was sized to direct the 100-year-24-hour peak discharge. Reservoir routing results are presented below. Channel 4 would be designed to prevent discharges from culverts NE1-NE3 from spilling across Desert Edge Rd. **Figure 15** shows the conceptual design of the facility.

Radium Springs Pond Reservoir Routing Summary

Detention Pond Name	Existing or Proposed Pond	Storm Return Period / Duration	Peak Inflow	Peak Outflow	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 a	cfs a	cfs a	ac-ft a	ac-ft a	ac-ft b	ac-ft a	**ft** **a**	ft b	ft b	ft b	ft	ft b	**ft** **c**	**ft** **c**
POND 4	Proposed 3:1	100 / 24	135	81	10.9	10.9	4.8	3.8	**4049.1**	4049.0	4045	5.0	4.1	4050.0	-0.1	0.9
POND 4	Proposed 3:1	10 / 24	47	20	4.5	4.5	4.8	1.6	**4047.0**	4049.0	4045	5.0	1.9	4050.0	2.1	3.1

The cost of Facility 3 is approximately **$448,000.**

D. Facility 4: Roadway Improvement's on Buffalo Estates Rd and Fort Marcy Trail

The roadway runoff from Buffalo Estates Rd. has in the past created issues for adjacent property owners. This is largely because the road is elevated higher than adjacent lots. Furthermore, there is not much grade from the intersection of Fort Selden Rd. and Buffalo Estates Rd. to the Lucero Arroyo on the south boundary of Radium Springs. Therefore, any kind of conveyance system would be highly inefficient, particularly a storm drain system. After considering several options, roadway repavement is the recommended facility. Buffalo Estates Rd. should be repaved with an inverted crown and curb/gutter. This will keep the impervious runoff from draining directly onto adjacent properties. Fort Marcy Trail also has an 18-inch culvert that is plugged with sediment and debris. It is recommended that this culvert be removed, and the road be redesigned to act as a low flow crossing for the drainage channel that runs along the back of the subdivision. The improvements are shown on **Figure 12.** The cost of this facility will be **$940,000.**

Smith also recommends that this channel be maintained to remove trash and debris that will obstruct flow and reduce conveyance capacity.

Radium Springs Channel Summary

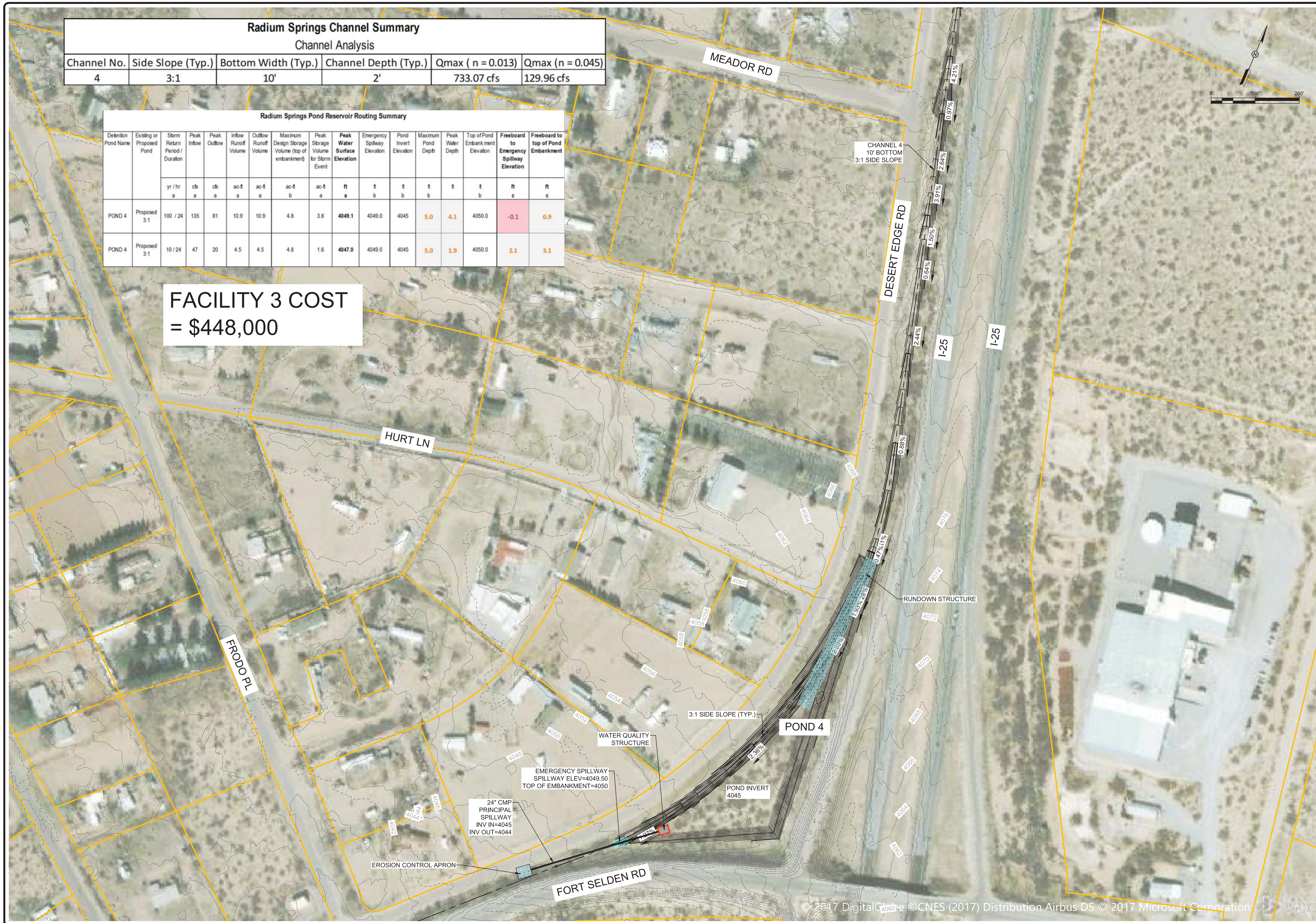
Channel Analysis

Channel No.	Side Slope (Typ.)	Bottom Width (Typ.)	Channel Depth (Typ.)	Qmax (n = 0.013)	Qmax (n = 0.045)
4	3:1	10'	2'	733.07 cfs	129.96 cfs

Radium Springs Pond Reservoir Routing Summary

Detention Pond Name	Existing or Proposed Pond	Storm Return Period / Duration	Peak Inflow	Peak Outflow	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 a	cfs a	cfs a	ac-ft a	ac-ft a	ac-ft b	ac-ft a	ft a	ft b	ft b	ft b	ft	ft b	ft c	ft c
POND 4	Proposed 3:1	100 / 24	135	81	10.9	10.9	4.8	3.8	**4049.1**	4049.0	4045	5.0	4.1	4050.0	-0.1	0.9
POND 4	Proposed 3:1	10 / 24	47	20	4.5	4.5	4.8	1.6	**4047.0**	4049.0	4045	5.0	1.9	4050.0	2.1	3.1

FACILITY 3 COST
= $448,000



Name
Location

NO.	REVISION DESCRIPTION	DATE	BY
5	####	####	####
4	####	####	####
3	####	####	####
2	####	####	####
1	####	####	####

RADUIM SPRINGS
DRAINAGE MASTER PLAN
FIGURE 15

FACILITY 3

SMITH ENGINEERING

JOB NO: 817103-01
DATE: JAN 2018
SHEET NO: 32

Q:\SEC---PROJECTS\817103-01 Radium Springs NM DMP\CADD\PLANSET\FACILITY 3.dwg Jan 12, 2018 - 9:07am Saved By: chrisa

SECTION 5. PRIORITIZATION OF OPTIONS

5.1 VIABLE OPTIONS

The facilities presented all provide significant flood mitigation for the community of Radium Springs. However, the DACFC must have a viable roadmap that will allow for planning and funding these projects in the long term. As such, based on the modeling analysis and testimonies from residents, we propose the following prioritization of facilities in order of highest to lowest importance

Facility Name	Description	Cost
Facility 1A	Pond 2 and diversion channels without rip rap lining	$2,063,000
Facility 1B	DeBeers Diversion Channel without rip rap lining	$826,000
Facility 3	Pond 4 & Channel 4	$448,000
Facility 2	Pond 3 & Channel 3	$447,000
Facility 4	Buffalo Estates Roadway Improvements	$940,000
Total Cost of Facilities		**$4,724,000**

5.2 CONCLUSIONS AND RECOMMENDATIONS

The facilities presented in this report will provide significant flood mitigation for the design storm. All facilities proposed in this DMP are presented at a conceptual level. Preliminary and final design are required prior to construction.

Smith recommends the projects in the order of importance shown in section 5.1.

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

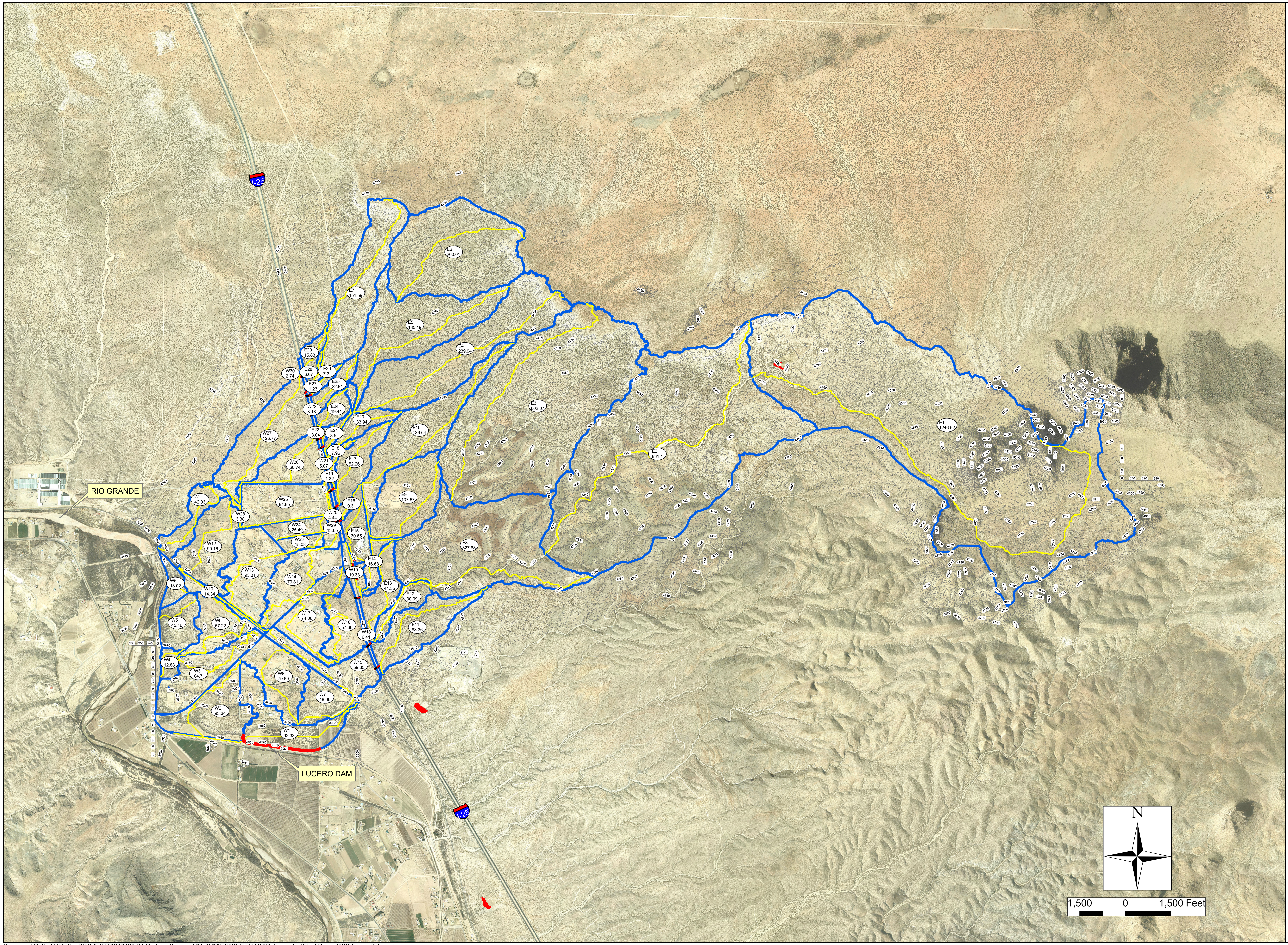
4. National Engineering Handbook, Part 630, Chapter 15 - Time of Concentration. Natural Resources Conservation Service. May 2010. (Documentation that Lag Time = 0.6 Time of Concentration).

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 Surve



Legend

- Culvert
- Subbasin Boundary
- 10-ft Contours
- Tc Lines
- Existing Dams
- E1 1246.62 — SUBBASIN ID & SUBBASIN ACRES (AC)

10 FT CONTOUR DATA EXTRACTED FROM 2014 DIGITAL ELEVATION MODELS (DEM). 2014 DEM AND ORTHOPHOTOGRAPHY WAS PROVIDED BY DONA ANA COUNTY FLOOD COMMISSION

RADIUM SPRINGS DRAINAGE MASTER PLAN

PREPARED FOR

DONA ANA COUNTY NEW MEXICO

PREPARED BY

1989 - 2014 SMITH ENGINEERING COMPANY 25th Anniversary

FIGURE 2.1 DRAINAGE BASIN MAP

JANUARY 2018

Document Path: Q:\SEC---PROJECTS\817103-01 Radium Springs NM DMP\ENGINEERING\Deliverables\Final Report\GIS\Figure 2.1.mxd

APPENDIX A

ANNOTATED PHOTOGRAPHS

Photo 1: 4 - 1.5’ x 14’ CBC pipe located on the east side of I-25. Flow is restricted due to the box culvert being filled with sediment. (NE 5.1/NW8)

Photo 2: 8 – 36 inch RCP pipe located also on the east side of I-25. Partially filled with sediment from upstream. (NE 5.2/NW8)

Photo 3: 1 – 30 inch RCP pipe located on the East side of I-25. Inlet was clean with very little sediment. (NE8)

Photo 4: Median drop inlet into culvert NE 8 located in the median of I-25.

Photo 5: 2 – 24 inch RCP pipe located on the East side of I-25. Inlet was partially filled with sediment. (NE9)

Photo 6: Median drop inlet into culvert NE 11 located in the median of I-25.

Photo 7: Median drop inlet into culvert NE 3 located in the median of I-25. Drop inlet partially blocked by sediment and debris.

Photo 8: Road side ditch between Fort Thorn and Fort Selden going North to South.

Photo 9: 1 – 54 inch RCP pipe located on the West side of I-25. Inlet was clean and no sign of being filled with sediment. (NW11)

Photo 10: Small ditch between I-25 and Desert Edge going East to West.

Photo 11: Earth arroyo at the corner of Indian Trails and Frodo Road, heading North to South. There is some debris along the sides and bottom of the arroyo.

Photo 12: Small ditch that goes along Frodo Road heading North to South and then travels into arroyo downstream, in photo 11.

Photo 13: Riprap along Frodo Road. on the West side of the street and the East side of the small ditch.

Photo 14: 2 – 36 inch RCP pipe located under the Railroad going East to West. Inlets have small amounts of sediment present in pipes. (Railroad 1)

Photo 15: 1 – 30 inch CMP inlet pipe located below State Park Road Inlet has small signs of sediment build up. (Railroad 2)

Photo 16: Lucero Dam emergency spillway looking at downstream side of dam located North of Dona Ana Road. EBID Canal with water.

Photo 17: Lucero Dam principle spillway invert within pond bottom.

Photo 18: 1 – 54 inch RCP (NE1.1) and 1 – 30 inch RCP (NE1.2) inlet pipes. Inlets have small signs of sediment build up and go under I-25.

Photo 19: 1 – 54 inch RCP (NE2) inlet pipe located below I-25. Inlet has signs of sediment build up.

Photo 20: 1 – 30 inch RCP (NE3/NW10) inlet pipe located below I-25. Inlet has small signs of sediment build up.

Photo 21: 3 – 48 inch RCP (NE4/NW9) inlet pipe located below I-25. Inlet has small signs of sediment build up.

Photo 22: 1 – 30 inch RCP (NE6/NW7) inlet pipe located below I-25. Inlet has small signs of sediment build up.

Photo 23: 1 – 30 inch RCP (NE7/NW6) inlet pipe located below I-25. Inlet has small signs of sediment build up.

Photo 24: 1 – 30 inch RCP (NE8/NW5) inlet pipe located below I-25. Inlet has a crack at the top of the pipe.

Photo 25: 2 – 24 inch RCP (NE9/NW4) inlet pipe located below I-25. Inlet has signs of sediment build up.

Photo 26: 2 – 24 inch RCP (NE10) inlet pipe located below I-25. Inlet has signs of sediment build up.

Photo 27: 3 – 36 inch RCP (NE11/NW3) inlet pipe located below I-25. Two of the three inlets are filled with sediment, and the third has sediment build up.

Photo 28: 1 – 30 inch RCP (NE12/NW2) inlet pipe located below I-25. Inlet has signs of sediment build up.

Photo 29: 4 – 36 inch RCP (SE4) inlet pipe located below I-25. Inlet has signs of sediment build up.

Photo 30: 4 – 10 ft. X 8 ft. CBC (SE3) located below I-25. Inlet has some signs of sediment build up.

Photo 31: 3 – 30 inch RCP (SE2/SW1) inlet pipe located below I-25. Inlet has some signs of sediment build up.

APPENDIX B

PREVIOUS PLANS AND REPORTS

Construction Plans **(Included Digitally)**

- Buffalo Estates Subdivision No. 2: Located in sections 11, 12, 13 and 14, Township 21 South Range 1 West, N.M.P.M of the U.S.G.L.O. Surveys East of Fort Selden, Dona Ana County, New Mexico September 3, 2001 47.993 acres Final Plat.

- Buffalo Estates Subdivision: A tract of Land situated in section 11, 14 and 13 T.21S., R.1W., N.M.P.M., of the U.S.G.L.O. Surveys Fort Selden, Dona Ana County, New Mexico 29.340 acres August, 1997.

Design Reports **(Included Digitally)**

- Terrain Management Plan & Drainage Study- Buffalo Estates 2 Subdivision: Dona Ana County, New Mexico. Prepared for: Kishor Lalloo, prepared by: Art Garcia, P.E. The Land Group, INC. Date: November 23, 1998. Revised June 30, 1999.

FEMA Flood Insurance Rate Maps **(Included Digitally)**

- Overview FEMA FIRM Panel Index Map

- FEMA FIRM 35013C0675G

- FEMA FIRM 35013C0700G

- FEMA FIRM 35013C0875G

- FEMA FIRM 35013C0900G

APPENDIX C

HYDROLOGIC DATA TABLES
DETENTION PONDS DATA and COMPUTATIONS
REFERENCES

HYDROLOGIC 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 C4 Channel Routing Data

Table C5 Subbasin Hydrologic Data Summary (HEC-HMS)

Lucero Dam: Elevation - Storage Volume - Discharge Data and Computations

Table C6.1 Lucero Dam Elev-Stor-Dis Data

Existing Reservoir-1: Elevation - Storage Volume - Discharge Data and Computations

Table C6.2 Existing Pond 1 Elev-Stor-Dis Data

Existing Routing Summary – Existing Ponds

Table C7 Reservoir Routing Summary

Proposed Pond Data Tables

Table C-8 Pond 1 Stage-Storage-Discharge

Table C-9 Pond 2 Stage-Storage-Discharge

Table C-10 Pond 3 Stage-Storage-Discharge

Table C-11 Pond 4 Stage-Storage-Discharge

Table C-12 Proposed Pond Routing Summary Table

TABLE C1
RAINFALL DEPTH DATA
Radium Springs Drainage Master Plan

<u>RAINFALL AREAL REDUCTION FACTORS</u> - Basin total area is approximately 9.25 sq. mi. , therefore, rainfall areal reduction factors were not applied as they would be very small, see Figure 14, Depth-Area Curves (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)

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.219** (0.191-0.249)	**0.285** (0.250-0.324)	**0.382** (0.335-0.433)	**0.458** (0.400-0.518)	**0.559** (0.487-0.631)	**0.641** (0.555-0.723)	**0.726** (0.624-0.819)	**0.813** (0.696-0.918)	**0.935** (0.792-1.06)	**1.03** (0.870-1.17)
10-min	**0.334** (0.290-0.378)	**0.433** (0.381-0.493)	**0.581** (0.511-0.659)	**0.696** (0.609-0.788)	**0.851** (0.741-0.960)	**0.976** (0.844-1.10)	**1.10** (0.950-1.25)	**1.24** (1.06-1.40)	**1.42** (1.21-1.61)	**1.57** (1.32-1.78)
15-min	**0.414** (0.360-0.469)	**0.537** (0.472-0.611)	**0.721** (0.633-0.817)	**0.863** (0.755-0.977)	**1.06** (0.919-1.19)	**1.21** (1.05-1.37)	**1.37** (1.18-1.54)	**1.54** (1.31-1.73)	**1.76** (1.49-1.99)	**1.95** (1.64-2.21)
30-min	**0.558** (0.485-0.632)	**0.723** (0.636-0.823)	**0.970** (0.852-1.10)	**1.16** (1.02-1.32)	**1.42** (1.24-1.60)	**1.63** (1.41-1.84)	**1.84** (1.59-2.08)	**2.07** (1.77-2.33)	**2.38** (2.01-2.69)	**2.63** (2.21-2.97)
60-min	**0.690** (0.600-0.782)	**0.895** (0.787-1.02)	**1.20** (1.06-1.36)	**1.44** (1.26-1.63)	**1.76** (1.53-1.98)	**2.02** (1.74-2.28)	**2.28** (1.96-2.57)	**2.56** (2.19-2.89)	**2.94** (2.49-3.32)	**3.25** (2.74-3.68)
2-hr	**0.794** (0.697-0.901)	**1.03** (0.906-1.17)	**1.38** (1.22-1.56)	**1.66** (1.45-1.87)	**2.02** (1.76-2.28)	**2.31** (1.99-2.59)	**2.61** (2.24-2.93)	**2.92** (2.48-3.27)	**3.34** (2.80-3.74)	**3.68** (3.05-4.12)
3-hr	**0.838** (0.743-0.949)	**1.08** (0.955-1.22)	**1.43** (1.26-1.62)	**1.70** (1.50-1.92)	**2.07** (1.81-2.33)	**2.36** (2.06-2.65)	**2.66** (2.30-2.99)	**2.98** (2.55-3.34)	**3.40** (2.88-3.82)	**3.74** (3.13-4.20)
6-hr	**0.959** (0.856-1.07)	**1.22** (1.09-1.37)	**1.59** (1.42-1.78)	**1.87** (1.66-2.09)	**2.25** (1.99-2.51)	**2.54** (2.23-2.83)	**2.84** (2.48-3.16)	**3.15** (2.73-3.50)	**3.56** (3.05-3.96)	**3.89** (3.30-4.33)
12-hr	**1.06** (0.951-1.18)	**1.35** (1.21-1.50)	**1.74** (1.56-1.93)	**2.03** (1.82-2.25)	**2.42** (2.15-2.68)	**2.71** (2.40-2.99)	**3.01** (2.65-3.33)	**3.31** (2.89-3.66)	**3.69** (3.20-4.10)	**4.00** (3.44-4.45)
24-hr	**1.18** (1.08-1.30)	**1.50** (1.37-1.65)	**1.93** (1.76-2.12)	**2.26** (2.05-2.49)	**2.72** (2.45-3.02)	**3.09** (2.74-3.46)	**3.48** (3.05-3.95)	**3.88** (3.35-4.49)	**4.46** (3.77-5.30)	**4.93** (4.08-6.01)

a - NOAA Atlas 14, Volume 1, Version 5 Rainfall Data - Included in Appendix C

TABLE C2
RUNOFF CURVE NUMBER (CN) ASSUMPTIONS AND CALCULATIONS
Radium Springs Drainage Master Plan

Basin No.	Basin Area	Basin Area	Area of HSG A	Area of HSG B	Area of HSG C	Area of HSG D	Basin Description	CN Areal Weighting	Runoff Curve Number Based on AMC II Condtions	Runoff Curve Number Based on AMC III Conditions	Runoff Curve Number Based on Average between AMC II & AMC III
	sq mi	acres									
a	a	a						b	b	b	
E1	1.9787	1266.37	31.39	11.75	138.48	1084.75	Desert shrub - Poor Conditions	87	87	95	91
E2	1.2991	831.42	3.77	53.28	0.00	774.37	Desert shrub - Poor Conditions	87	87	95	91
E3	0.9407	602.05	360.71	24.96	0.00	216.38	Desert shrub - Poor Conditions	73	73	87	80
E4	0.3749	239.94	151.49	88.45	0.00	0.00	Desert shrub - Poor Conditions	68	68	84	76
E5	0.2894	185.22	185.22	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E6	0.4063	260.03	253.08	6.95	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E7	0.2369	151.62	151.62	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E8	0.5123	327.87	115.98	0.00	2.11	209.78	Desert shrub - Poor Conditions	79	79	91	85
E9	0.1682	107.65	107.65	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E10	0.2135	136.64	136.64	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E11	0.1381	88.38	88.38	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E12	0.0470	30.08	30.08	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E13	0.0696	44.54	44.54	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E14	0.0261	16.70	16.70	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E15	0.0479	30.66	30.66	0.00	0.00	0.00	Desert shrub - Poor Conditions	81	81	92	87
E16	0.0145	9.28	9.28	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E17	0.0817	52.29	52.29	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E18	0.0124	7.94	7.94	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E19	0.0021	1.34	1.34	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E20	0.0530	33.92	33.92	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E21	0.0133	8.51	8.51	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E22	0.0048	3.07	3.07	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E23	0.0012	0.77	0.77	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E24	0.0304	19.46	19.46	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E25	0.0356	22.78	22.78	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E26	0.0114	7.30	7.30	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E27	0.0019	1.22	1.22	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E28	0.0104	6.66	6.66	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
E29	0.0247	15.83	15.83	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	72
W1	0.1443	92.35	81.19	0.00	10.11	1.05	1/2 acre lots w/ predominantly Desert shrub-Poor Conditions. Conservatively assumed Desert shrub.	66	66	82	79
W2	0.1458	93.31	79.48	3.90	9.93	0.00	1/2 acre lots w/ predominantly Desert shrub-Poor Conditions. Conservatively assumed Desert shrub.	66	66	82	79
W3	0.1323	84.67	74.66	10.01	0.00	0.00	1/2 acre lots, 1 industrial complex w/ predominantly Desert shrub-Poor Conditions. Conservatively assumed Desert	65	65	82	78
W4	0.0201	12.86	12.86	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	77
W5	0.0706	45.18	45.18	0.00	0.00	0.00	Desert shrub - Poor Conditions	63	63	80	77
W6	0.0282	18.05	18.05	0.00	0.00	0.00	Desert Shrub - Poor Conditions	63	63	80	77
W7	0.0760	48.64	47.32	1.32	0.00	0.00	1/2 acre lots w/ predominantly Desert shrub-Poor Conditions. Conservatively assumed Desert shrub.	63	63	80	77
W8	0.1245	79.68	57.82	21.86	0.00	0.00	2 acre lots w/ predominantly Desert shrub-Poor Conditions. Conservatively assumed Desert shrub.	67	67	83	80
W9	0.0894	57.22	16.77	40.44	0.00	0.00	1/2 acre lots, industrial complexes w/ predominantly Desert shrub-Poor Conditions. Conservatively assumed Desert shrub.	73	73	87	84
W10	0.0224	14.34	7.65	6.69	0.00	0.00	Desert Shrub - Poor Conditions includes railway	70	70	85	82
W11	0.0657	42.05	42.05	0.00	0.00	0.00	Desert Shrub - Poor Conditions	63	63	80	78
W12	0.1409	90.18	84.32	5.85	0.00	0.00	Desert Shrub - Poor Conditions w/ few residential lots	64	64	81	78
W13	0.1458	93.31	44.43	48.88	0.00	0.00	1 acre residential lots (average)	60	60	78	75
W14	0.1247	79.81	55.46	24.35	0.00	0.00	1 acre residential lots (average)	56	56	75	66
W15	0.0927	59.33	40.35	18.98	0.00	0.00	Desert Shrub - Poor Conditions w/ 1 acre residential lots	67	67	83	80
W16	0.0901	57.66	37.74	19.92	0.00	0.00	Desert Shrub - Poor Conditions w/ 1-2acre residential lots. Conservatively assumed desert shrub.	68	68	84	80
W17	0.1157	74.05	21.17	52.88	0.00	0.00	1 acre residential lots (average) w/ commercial complex	63	63	80	77
W18	0.0100	6.40	6.40	0.00	0.00	0.00	I-25 Paved Road w/ ROW	83	83	93	91
W19	0.0302	19.33	19.33	0.00	0.00	0.00	I-25 Interchange Paved Road w/ ROW and Desert Shrub	83	83	93	91
W20	0.0069	4.42	4.42	0.00	0.00	0.00	I-25 Paved Road w/ ROW	83	83	93	91
W21	0.0079	5.06	5.06	0.00	0.00	0.00	I-25 Paved Road w/ ROW	83	83	93	91
W22	0.0050	3.20	3.20	0.00	0.00	0.00	I-25 Paved Road w/ ROW	83	83	93	91
W23	0.0236	15.10	15.10	0.00	0.00	0.00	1 acre residential lots	51	51	70	61
W24	0.0398	25.47	25.47	0.00	0.00	0.00	1 acre residential lots	51	51	70	61
W25	0.1279	81.86	81.86	0.00	0.00	0.00	Desert Shrub - Poor Conditions w/ large lots. Assumed desert Shrub	63	63	80	77
W26	0.0949	60.74	60.74	0.00	0.00	0.00	Desert Shrub - Poor Conditions	63	63	80	77
W27	0.1981	126.78	126.78	0.00	0.00	0.00	Desert Shrub - Poor Conditions	63	63	80	77
W28	0.0053	3.39	3.39	0.00	0.00	0.00	Desert Shrub - Poor Conditions	63	63	80	77

TABLE C2
RUNOFF CURVE NUMBER (CN) ASSUMPTIONS AND CALCULATIONS
Radium Springs Drainage Master Plan

Basin No.	Basin Area	Basin Area	Area of HSG A	Area of HSG B	Area of HSG C	Area of HSG D	Basin Description	CN Areal Weighting	Runoff Curve Number Based on AMC II Condtions	Runoff Curve Number Based on AMC III Conditions	Runoff Curve Number Based on Average between AMC II & AMC III
	sq mi	acres									
a	a	a						b	b	b	
W29	0.0213	13.63	13.63	0.00	0.00	0.00	Desert Shrub - Poor Conditions w/ 2 residential lots and 1 commercial complex	63	63	80	77
W30	0.0043	2.75	2.75	0.00	0.00	0.00	I-25 Paved Road w/ ROW	83	83	93	91

(a) See Figures 2 and 3 for Drainage Basin Maps.

(b) Runoff curve numbers based on Tables 2-2A, 2-2B, and 2-2D from Urban Hydrology for Small Watersheds (TR-55).

(c) See Table C3 - Appendix C for Lag Time calculations

(d) Assumed by Smith Engineering as 10% or a 1.10 factor for undeveloped basins and 5% or 1.05 for developed basins. Note that a value of about 17% or 1.17 is considered the limit before mud flow would occur. Therefore, due to lack of site specific data Smith assumed 1.10.

TABLE C3

TIME OF CONCENTRATION AND LAG TIME COMPUTATIONS FOR RADIUM SPRINGS SUBBASINS

Radium Springs Drainage Master Plan

Subbasin Name		E7	E6	E4	E5	E3	E1	E2	E10	W19	E9	E14	E8	E12	E13	E11	E20	E29	E25	E26
Subbasin Name		W530	W540	W560	W570	W600	W710	W720	W820	W2290	W910	W920	W940	W980	W2340	W1020	W1590	W1350	W1390	W1450
Number of Reaches		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2
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
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
Flow Length (L) (b)	ft	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Highest Elevation (b)	ft	4439	4487	4488	4470	4489	5484	4496	4413	4078	4223	4413	4261	4096	4106	4144	4245	4269	4260	4239
Lowest Elevation (b)	ft	4438	4485	4488	4466	4487	5425	4492	4408	4075	4217	4410	4259	4064	4102	4142	4241	4267	4256	4235
Slope (S)	ft / ft	0.010	0.016	0.005	0.041	0.015	0.593	0.041	0.056	0.026	0.062	0.033	0.021	0.324	0.042	0.020	0.049	0.026	0.032	0.041
2-year 24-hour rainfall depth (P2) (c)	inches	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Travel Time Tt = (0.007(n L)^0.8) / ((P2)^0.5 (S^0.4)) (a)	hours	0.29	0.23	0.37	0.16	0.24	0.05	0.16	0.14	0.19	0.13	0.18	0.21	0.07	0.16	0.21	0.15	0.19	0.18	0.16
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
Flow Length (L) (b)	ft	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1697
Highest Elevation (b)	ft	4438	4485	4488	4466	4487	5425	4492	4408	4075	4217	4410	4259	4064	4102	4142	4241	4267	4256	4235
Lowest Elevation (b)	ft	4377	4419	4428	4368	4457	4852	4399	4328	4041	4137	4062	4173	4034	4053	4080	4175	4206	4196	4185
Slope (S)	ft / ft	0.030	0.033	0.030	0.049	0.015	0.286	0.047	0.040	0.017	0.040	0.174	0.043	0.015	0.024	0.031	0.033	0.030	0.030	0.030
Average Velocity (e - Figure 15-4)	ft / sec	2.80	2.93	2.79	3.57	1.99	8.63	3.48	3.23	2.11	3.22	6.73	3.35	1.97	2.51	2.84	2.92	2.80	2.81	2.78
Travel Time Tt = Tt = L / (3600*V) (a)	hours	0.20	0.19	0.20	0.16	0.28	0.06	0.16	0.17	0.26	0.17	0.08	0.17	0.28	0.22	0.20	0.19	0.20	0.20	0.17
3 - OPEN CHANNELS																				
Channel Description (a)		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	
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	
Side Slopes (b)	1V:XH	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	
Depth (D)	ft	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	
Wetted Perimeter (P)	ft	60.2	60.2	60.2	60.2	60.2	60.2	60.2	60.2	60.2	60.2	60.2	60.2	60.2	60.2	60.2	60.2	60.2	60.2	
Area (A)	sq ft	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	
Hyraulic 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	
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	
Entire Flowpath Length	ft	8024	6628	9849	8424	11129	21483	15067	10233	2194	4860	3222	8325	3649	4581	6225	3858	2484	3122	
Open Channel Flow Length (L) (b)	ft	5924	4528	7749	6324	9029	19383	12967	8133	94	2760	1122	6225	1549	2481	4125	1758	384	1022	
Highest Elevation (b)	ft	4377	4419	4428	4368	4457	4852	4399	4328	4041	4137	4062	4173	4034	4053	4080	4175	4206	4196	
Lowest Elevation (b)	ft	4212	4294	4185	4185	4137	4395	4160	4084	4040	4084	4043	4045	4019	4019	4010	4138	4198	4171	
Slope (S)	ft / ft	0.028	0.028	0.031	0.029	0.035	0.024	0.018	0.030	0.008	0.019	0.016	0.021	0.009	0.014	0.017	0.021	0.021	0.024	
Average Velocity (a)																				
V = (1.49 R ^ 0.666 S ^ 0.5) / n (a)	ft / sec	5.21	5.18	5.52	5.30	5.87	4.79	4.23	5.39	2.81	4.30	4.00	4.47	3.00	3.65	4.07	4.54	4.53	4.88	
Froude Number Fr = V/ (g y)^0.5		0.96	0.95	1.02	0.98	1.08	0.88	0.78	0.99	0.52	0.79	0.74	0.82	0.55	0.67	0.75	0.84	0.83	0.90	
Travel Time Tt (a) = Tt = L / (3600*V) (a)	hours	0.32	0.24	0.39	0.33	0.43	1.13	0.85	0.42	0.01	0.18	0.08	0.39	0.14	0.19	0.28	0.11	0.02	0.06	
Total Flowpath Length	ft.	8024	6628	9849	8424	11129	21483	15067	10233	2194	4860	3222	8325	3649	4581	6225	3858	2484	3122	1797
Total Subbasin Tc	hours	0.80	0.66	0.96	0.65	0.95	1.24	1.17	0.73	0.46	0.49	0.34	0.76	0.50	0.57	0.69	0.45	0.41	0.43	0.33
Total Subbasin Tc	minutes	48	40	57	39	57	75	70	44	28	29	20	46	30	34	41	27	25	26	20
If Tc < 12 min, assume 12 min. = 0.2 hours	minutes	48	40	57	39	57	75	70	44	28	29	20	46	30	34	41	27	25	26	20
Lag Time Tlag (e) = 0.6 Tc	minutes	28.8	23.9	34.4	23.3	34.0	44.8	42.1	26.4	16.7	17.5	12.1	27.4	17.8	20.5	24.8	16.1	14.9	15.6	11.8
Average Slope	ft/ft	2.26%	2.56%	2.21%	3.96%	2.19%	30.11%	3.53%	4.19%	1.71%	4.04%	7.44%	2.81%	11.62%	2.66%	2.27%	3.42%	2.56%	2.88%	3.55%
Average Velocity (a)	ft./s	2.79	2.77	2.86	3.62	3.27	4.80	3.58	3.88	1.31	2.78	2.67	3.03	2.05	2.24	2.51	2.40	1.66	2.00	1.52
Subbasin ID		E7	E6	E4	E5	E3	E1	E2	E10	W19	E9	E14	E8	E12	E13	E11	E20	E29	E25	E26

(a) Urban Hydrology for Small Watersheds (TR 55), June 1986 (see Chapt. 3).

(b) Measured from 2 foot lidar contour drainage basin maps.

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 charateristics 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 charateristics 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) Open Channel Hydraulics Chow, 1959.

(e) Part 630 Hydrology, National Engineering Handbook, Chapter 15 Time of Concentration, NRCS May 2010

Cells that have formulas.

TABLE C3

TIME OF CONCENTRATION AND LAG TIME COMPUTATIONS F

Radium Springs Drainage Master Plan

Subbasin Name		E27	E28	E21	E22	E23	E24	E19	E16	E18	E17	E15	W18	W27	W26	W25	W29	W17	W16	W15	W24	W23
Subbasin Name		W1490	W1530	W1640	W1690	W1890	W1950	W2000	W2240	W2200	W2250	W2300										
Number of Reaches		2	2	3	2	2	2	2	2	3	3	3	2	3	3	3	3	3	3	3	3	2
1 - SHEET FLOW																						
Surface Description (a)		RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	SMOOTHSURFACE	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	0.011	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	100	100
Highest Elevation (b)	ft	4203	4235	4193	4173	4165	4225	4149	4133	4177	4230	4118	4040	4210	4160	4131	4119	4077	4036	4015	4089	4070
Lowest Elevation (b)	ft	4199	4233	4189	4168	4159	4222	4144	4130	4174	4226	4114	4038	4208	4150	4125	4114	4055	4028	4012	4088	4068
Slope (S)	ft / ft	0.039	0.028	0.037	0.048	0.057	0.031	0.053	0.039	0.035	0.041	0.034	0.020	0.026	0.100	0.057	0.054	0.227	0.077	0.025	0.012	0.023
2-year 24-hour rainfall depth (P2) (c)	inches	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Travel Time Tt = (0.007(n L)^0.8) / ((P2)^0.5 (S^0.4)) (a)	hours	0.16	0.19	0.17	0.15	0.14	0.18	0.14	0.16	0.17	0.16	0.17	0.03	0.19	0.11	0.14	0.14	0.08	0.12	0.19	0.26	0.20
2 - SHALLOW CONCENTRATED FLOW																						
Surface Description (a)		UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	PAVED	UNPAVED	UNPAVED	PAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED
Flow Length (L) (b)	ft	581	1423	2000	878	481	1951	668	1552	2000	2000	2000	900	2000	2000	2000	2000	2000	2000	2000	2000	1600
Highest Elevation (b)	ft	4199	4233	4189	4168	4159	4222	4144	4130	4174	4226	4114	4038	4208	4150	4125	4114	4055	4028	4012	4088	4068
Lowest Elevation (b)	ft	4185	4191	4141	4149	4154	4159	4127	4085	4120	4155	4071	4021	4143	4101	4084	4064	4028	4018	4006	4055	4047
Slope (S)	ft / ft	0.025	0.029	0.024	0.022	0.011	0.032	0.025	0.029	0.027	0.036	0.022	0.019	0.032	0.025	0.021	0.025	0.013	0.005	0.003	0.017	0.013
Average Velocity (e - Figure 15-4)	ft / sec	2.54	2.76	2.51	2.38	1.70	2.90	2.55	2.73	2.64	3.04	2.38	2.79	2.90	2.53	2.91	2.53	1.86	1.16	0.86	2.08	1.87
Travel Time Tt = Tt = L / (3600*V) (a)	hours	0.06	0.14	0.22	0.10	0.08	0.19	0.07	0.16	0.21	0.18	0.23	0.09	0.19	0.22	0.19	0.22	0.30	0.48	0.65	0.27	0.24
3 - OPEN CHANNELS																						
Channel Description (a)				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	
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	
Side Slopes (b)	1V:XH			5						5	5	5		5	5	5	5	5	5	5	5	
Bottom Width (b)	ft			50						50	50	50		15	10	25	45	30	35	50	50	
Depth (D)	ft			1						1	1	1		3	3	3	3	3	3	3	3	
Top Width (T)	ft			60						60	60	60		45	40	55	75	60	65	80	80	
Wetted Perimeter (P)	ft			60.2						60.2	60.2	60.2		45.6	40.6	55.6	75.6	60.6	65.6	80.6	80.6	
Area (A)	sq ft			55						55	55	55		90	75	120	180	135	150	195	195	
Hyraulic Radius (A / P)	ft			0.91						0.91	0.91	0.91		1.97	1.85	2.16	2.38	2.23	2.29	2.42	2.42	
Hydraulic Depth (y) = A / T	ft			0.92						0.92	0.92	0.92		2.00	1.88	2.18	2.40	2.25	2.31	2.44	2.44	
Entire Flowpath Length	ft			2200						2388	4278	2964		6825	5012	4925	2570	6193	4527	3871	2510	
Open Channel Flow Length (L) (b)	ft			100						288	2178	864		4725	2912	2825	470	4093	2427	1771	410	
Highest Elevation (b)	ft			4141						4120	4155	4071		4143	4101	4084	4064	4028	4018	4006	4055	
Lowest Elevation (b)	ft			4138						4112	4098	4067		4060	4060	4044	4055	4004	4004	3989	4048	
Slope (S)	ft / ft			0.032						0.027	0.026	0.005		0.018	0.014	0.014	0.019	0.006	0.006	0.010	0.017	
Average Velocity (a)																						
V = (1.49 R ^ 0.666 S ^ 0.5) / n (a)	ft / sec			5.57						5.14	5.03	2.20		6.91	5.91	6.58	8.13	4.35	4.43	5.86	7.67	
Froude Number Fr = V/ (g y)^0.5				1.02						0.95	0.93	0.40		0.86	0.76	0.78	0.92	0.51	0.51	0.66	0.87	
Travel Time Tt (a) = Tt = L / (3600*V) (a)	hours			0.00						0.02	0.12	0.11		0.19	0.14	0.12	0.02	0.26	0.15	0.08	0.01	
Total Flowpath Length	ft.	681	1523	2200	978	581	2051	768	1652	2388	4278	2964	1000	6825	5012	4925	2570	6193	4527	3871	2510	1700
Total Subbasin Tc	hours	0.23	0.33	0.39	0.25	0.22	0.37	0.22	0.32	0.40	0.46	0.52	0.12	0.57	0.47	0.45	0.38	0.64	0.75	0.92	0.54	0.44
Total Subbasin Tc	minutes	14	20	24	15	13	22	13	19	24	28	31	7	34	28	27	23	38	45	55	33	26
If Tc < 12 min, assume 12 min. = 0.2 hours	minutes	14	20	24	15	13	22	13	19	24	28	31	12	34	28	27	23	38	45	55	33	26
Lag Time Tlag (e) = 0.6 Tc	minutes	8.1	11.9	14.2	9.1	7.9	13.2	7.8	11.6	14.2	16.7	18.5	7.2	20.6	16.9	16.2	13.6	23.0	27.2	33.3	19.5	15.8
Average Slope	ft/ft	3.21%	2.86%	3.09%	3.51%	3.39%	3.14%	3.91%	3.37%	2.97%	3.40%	2.02%	1.94%	2.53%	4.62%	3.06%	3.27%	8.22%	2.95%	1.25%	1.51%	1.81%
Average Velocity (a)	ft./s	0.84	1.28	1.55	1.08	0.74	1.56	0.98	1.43	1.68	2.57	1.60	2.33	3.31	2.97	3.04	1.89	2.69	1.67	1.16	1.28	1.07
Subbasin ID		E27	E28	E21	E22	E23	E24	E19	E16	E18	E17	E15	W18	W27	W26	W25	W29	W17	W16	W15	W24	W23

(a) Urban Hydrology for Small Watersheds (TR 55), June 1986 (see Chapt. 3).
(b) Measured from 2 foot lidar contour drainage basin maps.
The TR-55 Method allows for the sheet flow length to range from 100 ft. up to a ma
The TR-55 Method allows for the shallow concentrated flow length to range from 1
(c) NOAA Atlas 14 rainfall data
(d) Open Channel Hydraulics Chow, 1959.
(e) Part 630 Hydrology, National Engineering Handbook, Chapter 15 Time of Co

Cells that have formulas.

TABLE C3

TIME OF CONCENTRATION AND LAG TIME COMPUTATIONS F

Radium Springs Drainage Master Plan

Subbasin Name		W11	W12	W9	W13	W14	W7	W8	W1	W2	W3	W4	W10	W28	W6	W5	W19,W20,W21,W22,W23, AND W30
Subbasin Name																	W2301
Number of Reaches		3	3	3	3	3	3	3	3	3	3	2	3	2	2	2	3
1 - SHEET FLOW																	
Surface Description (a)		RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	SUBBASINS W18, W20, W21, W22, W23, AND W30 DEMONSTRATE VERY SIMILAR PHYSICAL CHARACTERISTICS. SUBBASIN W18 HAS THE LONGEST FLOWPATH LENGTH 1000 FT RELATIVE TO SUBBASINS W20, W21, W22, W23, AND W30. SINCE THE TC FOR SUBBASIN W19 IS 12 MINUTES ASSUME THAT THE SMALLER SUBBASINS WITH SHORTER FLOWPATH LENGTHS WILL BE AT THE MINIMUM OF 12 MINUTES. NO FURTHER TC CALCULATIONS WERE PERFORMED BASED ON THIS DATA.
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	
Flow Length (L) (b)	ft	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Highest Elevation (b)	ft	4072	4069	4016	4047	4055	3989	4015	3994	4011	4010	3993	4015	4071	4014	4013	
Lowest Elevation (b)	ft	4070	4067	4015	4044	4052	3988	4011	3992	4009	4010	3988	4013	4070	4013	4012	
Slope (S)	ft / ft	0.014	0.019	0.010	0.025	0.036	0.017	0.037	0.019	0.024	0.004	0.048	0.017	0.017	0.003	0.008	
2-year 24-hour rainfall depth (P2) (c)	inches	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	
Travel Time Tt = (0.007(n L)^0.8) / ((P2)^0.5 (S^0.4)) (a)	hours	0.25	0.22	0.28	0.20	0.17	0.23	0.17	0.22	0.20	0.39	0.15	0.23	0.23	0.45	0.31	
2 - SHALLOW CONCENTRATED FLOW																	
Surface Description (a)		UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	
Flow Length (L) (b)	ft	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1571	2000	1309	724	1480	
Highest Elevation (b)	ft	4070	4067	4015	4044	4052	3988	4011	3992	4009	4010	3988	4013	4070	4013	4012	
Lowest Elevation (b)	ft	4053	4028	4009	4021	4034	3971	3989	3974	3988	4008	3966	4008	4044	3974	3966	
Slope (S)	ft / ft	0.009	0.019	0.003	0.012	0.009	0.008	0.011	0.009	0.011	0.001	0.014	0.003	0.019	0.054	0.031	
Average Velocity (e - Figure 15-4)	ft / sec	1.50	2.24	0.85	1.74	1.53	1.47	1.69	1.54	1.65	0.44	1.89	0.81	2.25	3.75	2.85	
Travel Time Tt = Tt = L / (3600*V) (a)	hours	0.37	0.25	0.65	0.32	0.36	0.38	0.33	0.36	0.34	1.27	0.23	0.69	0.16	0.05	0.14	
3 - OPEN CHANNELS																	
Channel Description (a)		CHANNEL	CHANNEL	CHANNEL	CHANNEL	CHANNEL	CHANNEL	CHANNEL	CHANNEL	CHANNEL	CHANNEL		CHANNEL				
Manning's n (d)		0.05	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				
Side Slopes (b)	1V:XH	5	5	5	5	5	5	5	5	5	5		5				
Bottom Width (b)	ft	30	30	25	35	40	50	30	50	30	30		25				
Depth (D)	ft	3	3	3	3	3	3	3	3	3	3		4				
Top Width (T)	ft	60	60	55	65	70	80	60	80	60	60		65				
Wetted Perimeter (P)	ft	60.6	60.6	55.6	65.6	70.6	80.6	60.6	80.6	60.6	60.6		65.8				
Area (A)	sq ft	135	135	120	150	165	195	135	195	135	135		180				
Hyraulic Radius (A / P)	ft	2.23	2.23	2.16	2.29	2.34	2.42	2.23	2.42	2.23	2.23		2.74				
Hydraulic Depth (y) = A / T	ft	2.25	2.25	2.18	2.31	2.36	2.44	2.25	2.44	2.25	2.25		2.77				
Entire Flowpath Length	ft	4616	4207	5646	5107	5607	2538	3971	4617	4489	5434		3906				
Open Channel Flow Length (L) (b)	ft	2516	2107	3546	3007	3507	438	1871	2517	2389	3334		1806				
Highest Elevation (b)	ft	4053	4028	4009	4021	4034	3971	3989	3974	3988	4008		4008				
Lowest Elevation (b)	ft	3968	3999	3971	4013	4013	3969	3974	3966	3956	3971		4000				
Slope (S)	ft / ft	0.034	0.014	0.011	0.003	0.006	0.006	0.008	0.003	0.014	0.011		0.005				
Average Velocity (a)																	
V = (1.49 R ^ 0.666 S ^ 0.5) / n (a)	ft / sec	9.33	6.61	5.78	2.94	4.46	4.50	5.15	3.21	6.58	5.95		4.35				
Froude Number Fr = V/ (g y)^0.5		1.10	0.78	0.69	0.34	0.51	0.51	0.61	0.36	0.77	0.70		0.46				
Travel Time Tt (a) = Tt = L / (3600*V) (a)	hours	0.07	0.09	0.17	0.28	0.22	0.03	0.10	0.22	0.10	0.16		0.12				
Total Flowpath Length	ft.	4616	4207	5646	5107	5607	2538	3971	4617	4489	5434	1671	3906	1409	824	1580	
Total Subbasin Tc	hours	0.69	0.56	1.10	0.80	0.75	0.63	0.60	0.79	0.63	1.81	0.38	1.03	0.39	0.50	0.45	
Total Subbasin Tc	minutes	41	33	66	48	45	38	36	48	38	109	23	62	23	30	27	
If Tc < 12 min, assume 12 min. = 0.2 hours	minutes	41	33	66	48	45	38	36	48	38	109	23	62	23	30	27	
Lag Time Tlag (e) = 0.6 Tc	minutes	24.9	20.0	39.6	28.7	27.0	22.7	21.4	28.6	22.8	65.2	13.7	37.0	14.0	18.1	16.2	
Average Slope	ft/ft	1.88%	1.72%	0.80%	1.30%	1.69%	1.03%	1.88%	1.04%	1.60%	0.54%	3.07%	0.81%	1.82%	2.86%	1.96%	
Average Velocity (a)	ft./s	1.85	2.10	1.43	1.78	2.08	1.12	1.85	1.62	1.97	0.83	1.22	1.06	1.01	0.46	0.97	
Subbasin ID		W11	W12	W9	W13	W14	W7	W8	W1	W2	W3	W4	W10	W28	W6	W5	W19,W20,W21,W22,W23, AND W30

(a) Urban Hydrology for Small Watersheds (TR 55), June 1986 (see Chapt. 3).
(b) Measured from 2 foot lidar contour drainage basin maps.
The TR-55 Method allows for the sheet flow length to range from 100 ft. up to a ma
The TR-55 Method allows for the shallow concentrated flow length to range from 1
(c) NOAA Atlas 14 rainfall data
(d) Open Channel Hydraulics Chow, 1959.
(e) Part 630 Hydrology, National Engineering Handbook, Chapter 15 Time of Co

Cells that have formulas.

TABLE C4
CHANNEL ROUTING DATA
Radium Springs 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					
	a			a	b/c	b	b/c	b/c	
RE2	11,077	4,396	4,160	0.021	0.045	Trapezoid	50	5	Muskingum-Cunge
RE5	4,187	4,294	4,185	0.026	0.045	Trapezoid	50	5	Muskingum-Cunge
RE8_E3	3,995	4,138	4,045	0.023	0.045	Trapezoid	50	5	Muskingum-Cunge
RE12	2,036	4,045	4,017	0.014	0.045	Trapezoid	50	5	Muskingum-Cunge
RE14	1,670	4,084	4,041	0.026	1.045	Trapezoid	50	5	Muskingum-Cunge
RE20	1,757	4,185	4,135	0.028	0.045	Trapezoid	50	5	Muskingum-Cunge
RE8_E2	5,532	4,160	4,045	0.021	0.045	Trapezoid	50	5	Muskingum-Cunge
RW15	1,754	4,022	3,989	0.019	0.045	Trapezoid	50	5	Muskingum-Cunge
RW12	2,409	4,044	3,999	0.019	0.045	Trapezoid	30	5	Muskingum-Cunge
RW27	4,634	4,189	4,061	0.028	0.045	Trapezoid	15	5	Muskingum-Cunge

(a) All routing lengths and slopes were determined using GEO-HEC-HMS 10.2

(b) Channel width, depth and side slopes and Manning's "n" vary therefore this is an assumed typical cross-section to represent the typical section throughout the entire routing reach. Mannings "n" values were tailored based on guidance provided in Urban Hydrology and Open Channel Hydraulics by Chow

(c) Assumed based on visual observation, experience, and Chow "n" value tables (copies in Appendix C)

TABLE C5
SUBBASIN HYDROLOGIC DATA SUMMARY (HEC-HMS INPUT)
Radium Springs Drainage Master Plan

Basin No.	Basin Area	Basin Area	Runoff Curve Number Based on Average between AMC II & AMC III	Lag Time	Flow Ratio
	sq mi	acres		minutes	
a	a	a		c	d
E1	1.9787	1266.37	91	44.8	1.10
E2	1.2991	831.42	91	42.1	1.10
E3	0.9407	602.05	80	34.0	1.10
E4	0.3749	239.94	76	34.4	1.10
E5	0.2894	185.22	72	23.3	1.10
E6	0.4063	260.03	72	23.9	1.10
E7	0.2369	151.62	72	28.8	1.10
E8	0.5123	327.87	85	27.4	1.10
E9	0.1682	107.65	72	17.5	1.10
E10	0.2135	136.64	72	26.4	1.10
E11	0.1381	88.38	72	24.8	1.10
E12	0.0470	30.08	72	17.8	1.10
E13	0.0696	44.54	72	20.5	1.10
E14	0.0261	16.70	72	12.1	1.10
E15	0.0479	30.66	87	18.5	1.10
E16	0.0145	9.28	72	11.6	1.10
E17	0.0817	52.29	72	16.7	1.10
E18	0.0124	7.94	72	14.2	1.10
E19	0.0021	1.34	72	7.8	1.10
E20	0.0530	33.92	72	16.1	1.10
E21	0.0133	8.51	72	14.2	1.10
E22	0.0048	3.07	72	9.1	1.10
E23	0.0012	0.77	72	7.9	1.10
E24	0.0304	19.46	72	13.2	1.10
E25	0.0356	22.78	72	15.6	1.10
E26	0.0114	7.30	72	11.8	1.10
E27	0.0019	1.22	72	8.1	1.10
E28	0.0104	6.66	72	11.9	1.10
E29	0.0247	15.83	72	14.9	1.10
W1	0.1443	92.35	79	28.6	1.10
W2	0.1458	93.31	79	22.8	1.10
W3	0.1323	84.67	78	65.2	1.10
W4	0.0201	12.86	77	13.7	1.10
W5	0.0706	45.18	77	16.2	1.10
W6	0.0282	18.05	77	18.1	1.10
W7	0.0760	48.64	77	22.7	1.10
W8	0.1245	79.68	80	21.4	1.10
W9	0.0894	57.22	84	39.6	1.10
W10	0.0224	14.34	82	37.0	1.10
W11	0.0657	42.05	78	24.9	1.10
W12	0.1409	90.18	78	20.0	1.10
W13	0.1458	93.31	75	28.7	1.10
W14	0.1247	79.81	66	27.0	1.10
W15	0.0927	59.33	80	33.3	1.10
W16	0.0901	57.66	80	27.2	1.10

TABLE C5
SUBBASIN HYDROLOGIC DATA SUMMARY (HEC-HMS INPUT)
Radium Springs Drainage Master Plan

Basin No.	Basin Area	Basin Area	Runoff Curve Number Based on Average between AMC II & AMC III	Lag Time	Flow Ratio
	sq mi	acres		minutes	
a	a	a		c	d
W17	0.1157	74.05	77	23.0	1.10
W18	0.0100	6.40	91	7.2	1.05
W19	0.0302	19.33	91	7.2	1.05
W20	0.0069	4.42	91	7.2	1.05
W21	0.0079	5.06	91	7.2	1.05
W22	0.0050	3.20	91	7.2	1.05
W23	0.0236	15.10	61	7.2	1.10
W24	0.0398	25.47	61	19.5	1.10
W25	0.1279	81.86	77	16.2	1.10
W26	0.0949	60.74	77	16.9	1.10
W27	0.1981	126.78	77	20.6	1.10
W28	0.0053	3.39	77	14.0	1.10
W29	0.0213	13.63	77	13.6	1.10
W30	0.0043	2.75	91	7.2	1.05

TABLE C6.1
Elevation - Storage Volume - Discharge Data and Computations - Lucero Dam
Radium Springs Drainage Master plan

Grey box means must input elevation and area data

Contour Elevation From Lidar NAVD 1988	Depth	Contour Area from Lidar NAVD 1988	Incremental Volume	Incremental Volume	Cumulative Volume	Emergency Spillway Discharge	Comment
ft c	ft	sq ft c	cu ft	ac-ft	ac-ft	cfs a b	
3958	0.00	137,195	0	0.0000	0.0000	0	Pond bottom
3960	2.00	421,770	558,965	12.8321	12.8321	0	Principal Spillwaye (36" RCP)
3962	4.00	617,608	1,039,378	23.8608	36.6929	0	
3964	6.00	818,884	1,436,492	32.9773	69.6702	0	
3966	8.00	1,013,078	1,831,962	42.0561	111.7263	0	
3968	10.00	1,194,932	2,208,010	50.6889	162.4152	0	
3970	12.00	1,460,909	2,655,841	60.9697	223.3849	0	
3972	14.00	1,791,337	3,252,246	74.6613	298.0462	0	Emergency Spillway
3974	16.00	2,445,837	4,237,174	97.2721	395.3184	74	
3976	18.00	2,748,487	5,194,324	119.2453	514.5636	208	Top of Pond

(a) The Lucero Dam has an overflow emergency spillway with depth of 4 ft and crest length of 10 ft and a 36" RCP outfall pipe.

Weir Equation: Q = CLH^ 1.5 C = discharge coeffient, L = spillway length perpendicular to flow (ft), H = head (ft)

(b) Emergency Spillway C = 2.6 L (ft) = 10

(b) Weir equation and "C" coefficients were obtained from Equation 5-10 and Table 5-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1982.

(c) Data Source: 2 ft. contours from Lidar 2010 provided by DACFC.

TABLE C6.2
Elevation - Storage Volume - Discharge Data and Computations - Existing Reservoir-1
Radium Springs Drainage Master plan

Grey box means must input elevation and area data

Contour Elevation From Topo Survey NAVD 1988	Depth	Contour Area from Topo Survey NAVD 1988	Incremental Volume	Incremental Volume	Cumulative Volume	Emergency Spillway Discharge	Comment
ft	ft	sq ft	cu ft	ac-ft	ac-ft	cfs	
c		c				a b	
4040	0.00	15,049	0	0.0000	0.0000	0	Pond Bottom
4042	2.00	34,300	49,349	1.1329	1.1329	0	
4044	4.00	58,612	92,912	2.1330	3.2658	0	
4046	6.00	86,198	144,810	3.3244	6.5902	0	
4048	8.00	49,760	135,958	3.1212	9.7114	0	
4050	10.00	107,899	157,659	3.6194	13.3307	0	Emergency Spillway
4052	12.00	129,787	237,686	5.4565	18.7873	1912	Top of Pond

(a) Existing reservoir-1 is a retention pond with no emergency spillway. However, to enable the model to run, ficticious discharge has to be assigned assuming there is an emergency spillway on the southwest portion of pond at elevation of 4050. This allows the model to compute it's own discharge rating curve.

Weir Equation: Q = CLH^ 1.5 C = discharge coeffient, L = spillway length perpendicular to flow (ft), H = head (ft)

(b) Emergency Spillway C = 2.6 L (ft) = 260

(b) Weir equation and "C" coefficients were obtained from Equation 5-10 and Table 5-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1982.

(c) Data Source : 2 ft. contours from Lidar 2010 provided by DACFC

TABLE C7

Reservoir Routing Summary - Existing Ponds

Radium Springs Drainage Master Plan

Detention Pond Name	Existing or Proposed Pond	Storm Return Period / Duration	Drainage Area	Peak Inflow	Peak Outflow	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 a	sq mi	cfs a	cfs a	ac-ft a	ac-ft a	ac-ft b	ac-ft a	ft a	ft b	ft b	ft b	ft	ft b	ft c	ft c
Lucero Dam	Existing	100 / 24	6.1100	4780	232	740.0	734.5	514.6	494.9	3975.7	3972.0	3958	18.0	17.7	3976.0	-3.7	0.3
Lucero Dam	Existing	50 / 24	6.1100	4007	147	620.6	378.5	514.6	445.1	3974.8	3972.0	3958	18.0	16.8	3976.0	-2.8	1.2
Lucero Dam	Existing	10 / 24	6.1100	2393	117	383.2	379.4	514.6	260.6	3971.0	3972.0	3958	18.0	13.0	3976.0	1.0	5.0
Lucero Dam	Existing	5 / 24	6.1100	1083	15	162.1	94.6	514.6	140.4	3967.1	3972.0	3958	18.0	9.1	3976.0	4.9	8.9
Reservoir-1	Existing	100 / 24	0.4078	252	74	26.5	22.0	18.8	14.0	4050.2	4050.0	4040.0	12.0	10.2	4052.0	-0.2	1.8
Reservoir-1	Existing	50 / 24	0.4078	191	8	20.6	16.1	18.8	13.5	4050.0	4050.0	4040.0	12.0	10.0	4052.0	0.0	2.0
Reservoir-1	Existing	10 / 24	0.4078	78	1	9.8	9.2	18.8	7.7	4046.7	4050.0	4040.0	12.0	6.7	4052.0	3.3	5.3
Reservoir-1	Existing	5 / 24	0.4078	4	0	0.4	0.4	18.8	0.2	4040.4	4050.0	4040.0	12.0	0.4	4052.0	9.6	11.6

a - Refer to Figures included in report text for Proposed Retention Pond Conceptual Grading Plans (AutoCAD drawings of these grading plans are included in Appendix B)

(a) Refer to Appendix D for the HEC-HMS model output for the pond routing results. Dead storage was simulated for 2ft. below the principal spillway to account coservatively for heavy sediment loads therefore inflow volume is not equal to outflow volume

(b) See this Appendix for all Elevation - Storage Volume - Discharge Data Tables (Tables C6.1 and C6.2)

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

Table C8

OPTION DESCRIPTION - Pond Grading Assumes 3:1 slopes

Proposed - Pond 1

Elevation - Volume - Discharge Data and Computations

grey box means must input data

Contour Elevation NAVD 1988	Depth	Contour Area	Incremental Volume	Incremental Volume	Cumulative Volume	(A) 1st Row of Reverse Incline Ports Discharge	(A) 2nd Row of Reverse Incline Ports Discharge	(A) 3rd Row of Reverse Incline Ports Discharge	(A) Horizontal 10-in drain pipe at bottom of box	(A) Principal Spillway Grate Discharge	sum of A's SUMMATION of reverse incline ports, drain pipe & grate	Principal Spillway Outfall Pipe Discharge	Total Principal Spillway / Outfall Pipe Discharge	Emergency Spillway Discharge	Total Discharge Rating Curve	Comment
		Principal Spillway Orifice Diameter (inches)				12.0	12.0	8.0	10.0			24.0				
		Number of Orifices				12.0	12.0	0.0	1.0			1.0				
(ft)		(sq ft)	(cu ft)	(ac-ft)	(ac-ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	(cfs)	
(d)						(a)	(a)	(a)	(a)	(b)		(c)	(e)	(b)		
4090.50	0.00	536,417	0	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	Pond bottom and principal spillway structure invert & 10"pipe
4091.00	0.50	540,830	269,312	6.1825	6.1825	0.0	0.0	0.0	1.8	0.0	1.8	2.1	2	0	1	Highest Invert of 1st row of reverse incline ports
4092.00	1.50	549,709	545,269	12.5177	18.7002	44.6	0.0	0.0	3.2	0.0	47.8	18.2	18	0	18	Highest Invert of 2nd row of reverse incline ports
4093.00	2.50	558,660	554,184	12.7223	31.4225	63.1	44.6	0.0	4.1	0.0	111.8	23.5	24	0	24	
4094.00	3.50	567,683	563,171	12.9286	44.3512	77.3	63.1	0.0	4.8	0.0	145.2	27.8	28	0	28	Principal spillway grate
4095.00	4.50	576,778	572,230	13.1366	57.4877	89.2	77.3	0.0	5.5	90.0	262.0	31.6	32	0	32	Emergency Spillway
4096.00	5.50	585,945	581,361	13.3462	70.8340	99.8	89.2	0.0	6.1	254.6	449.6	34.9	35	260	295	

(a) Office equation and coefficient were obtained from Equation 4-10 and Table 4-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1976.

$$Q = Ca\sqrt{2gh}$$

C = 0.590 g=32.2 ft/sec^2, a=area (sq ft) h=head (ft)

$$a = \pi D^2/4$$

(full area formula)

(e) The combined discharge of the reverse incline ports, 10" pipe and the grate (A), will govern the discharge until the principal spillway outfall pipe becomes fully submerged. When the sum of (As) is greater than outfall pipe capacity then outfall pipe capacity governs the discharge

(b) Emergency Spillway flows were computed based on the following data used in the weir equation

Q = CLH^ 1.5 C = discharge coeffient, L = spillway length perp. to flow (ft), H = head (ft)

(b) Emergergency Spillway * C =	2.6	L =	100	Emer Spill Elev.=	4095.0		
* Notes							
(b) Grate (assume 3 sides) / Weir C =	3	L =	30	Grate Elev.=	4094.0	10' x 10' box - 3 sides as weir	

(b) Weir equation and "C" coefficients were obtained from Equation 5-10 and Table 5-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1976.

(d) Data Source : DACFC Lidar Contours

(c) - Use Partial Area Formula shown below, for principal spillway pipe when head is less than full pipe diameter, after head exceeds pipe diameter, apply basic orifice equation (a)

$$a = \frac{1}{2} r^2 \left\{ \left[2\cos^{-1}\left(\frac{r-d}{r}\right) \right] \frac{\pi}{180} - \sin\left[\left[2\cos^{-1}\left(\frac{r-d}{r}\right) \right] \frac{\pi}{180} \right] \right\}$$

Principal Spillway Orifice radius r in feet = 1.0 ft

d = depth of water in the pipe in feet, r = pipe radius in feet

NOTE: THE STORAGE AT ELEVATION 4091 IS HIGHLIGHTED IN RED BECAUSE THIS NUMBER HAD TO BE ARTIFICALLY REDUCED TO 2 AC-FT. IN THE HEC-HMS MODEL POND DATA TO PREVENT THE MODEL FROM LOSING VOLUME CONTINUITY.

Table C9

OPTION DESCRIPTION - Pond Grading Assumes 3:1 slopes

Proposed - Pond 2

Elevation - Volume - Discharge Data and Computations

grey box means must input data

Contour Elevation NAVD 1988	Depth	Contour Area	Incremental Volume	Incremental Volume	Cumulative Volume	(A) 1st Row of Reverse Incline Ports Discharge	(A) 2nd Row of Reverse Incline Ports Discharge	(A) 3rd Row of Reverse Incline Ports Discharge	(A) Horizontal 10-in drain pipe at bottom of box	(A) Principal Spillway Grate Discharge	sum of A's SUMMATION of reverse incline ports, drain pipe & grate	Principal Spillway Outfall Pipe Discharge	Total Principal Spillway / Outfall Pipe Discharge	Emergency Spillway Discharge	Total Discharge Rating Curve	Comment
		Principal Spillway Orifice Diameter (inches)				12.0	12.0	8.0	10.0			30.0				
		Number of Orifices				12.0	12.0	0.0	1.0			1.0				
(ft)		(sq ft)	(cu ft)	(ac-ft)	(ac-ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	(cfs)	
(d)						(a)	(a)	(a)	(a)	(b)		(c)	(e)	(b)		
4128.50	0.00	68,585	0	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	Pond bottom and principal spillway structure invert & 10"pipe
4129.00	0.50	70,180	34,691	0.7964	0.7964	0.0	0.0	0.0	1.8	0.0	1.8	2.3	2	0	1	Highest Invert of 1st row of reverse incline ports
4130.00	1.50	73,425	71,803	1.6484	2.4448	44.6	0.0	0.0	3.2	0.0	47.8	17.8	18	0	18	Highest Invert of 2nd row of reverse incline ports
4131.00	2.50	76,742	75,083	1.7237	4.1684	63.1	44.6	0.0	4.1	0.0	111.8	36.7	37	0	37	
4132.00	3.50	80,130	78,436	1.8006	5.9691	77.3	63.1	0.0	4.8	0.0	145.2	43.5	43	0	43	Principal spillway grate
4133.00	4.50	83,591	81,861	1.8793	7.8483	89.2	77.3	0.0	5.5	90.0	262.0	49.3	49	0	49	Emergency Spillway
4134.00	5.50	87,124	85,357	1.9595	9.8079	99.8	89.2	0.0	6.1	254.6	449.6	54.5	55	390	445	

(a) Office equation and coefficient were obtained from Equation 4-10 and Table 4-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1976.

$$Q = Ca\sqrt{2gh}$$

C = 0.590 g=32.2 ft/sec^2, a=area (sq ft) h=head (ft)

$$a = \pi D^2/4$$

(full area formula)

(e) The combined discharge of the reverse incline ports, 10" pipe and the grate (A), will govern the discharge until the principal spillway outfall pipe becomes fully submerged. When the sum of (As) is greater than outfall pipe capacity then outfall pipe capacity governs the discharge

(b) Emergency Spillway flows were computed based on the following data used in the weir equation

Q = CLH^ 1.5 C = discharge coefficient, L = spillway length perp. to flow (ft), H = head (ft)

(b) Emergergency Spillway * C =	2.6	L =	150	Emer Spill Elev.=	4133.0	
* Notes						
(b) Grate (assume 3 sides) / Weir C =	3	L =	30	Grate Elev.=	4132.0	10' x 10' box - 3 sides as weir

(b) Weir equation and "C" coefficients were obtained from Equation 5-10 and Table 5-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1976.

(d) Data Source : DACFC Lidar Contours

(c) - Use Partial Area Formula shown below, for principal spillway pipe when head is less than full pipe diameter, after head exceeds pipe diameter, apply basic orifice equation (a)

$$a = \frac{1}{2}r^2\left\{\left[2\cos^{-1}\left(\frac{r-d}{r}\right)\right]\frac{\pi}{180} - \sin\left[\left[2\cos^{-1}\left(\frac{r-d}{r}\right)\right]\frac{\pi}{180}\right]\right\}$$

Principal Spillway Orifice radius r in feet = 1.3 ft

d = depth of water in the pipe in feet, r = pipe radius in feet

Table C10

OPTION DESCRIPTION - Pond Grading Assumes 3:1 slopes

Proposed - Pond 3

Elevation - Volume - Discharge Data and Computations

grey box means must input data

Contour Elevation NAVD 1988	Depth	Contour Area	Incremental Volume	Incremental Volume	Cumulative Volume	1st Row of Reverse Incline Ports Discharge	2nd Row of Reverse Incline Ports Discharge	3rd Row of Reverse Incline Ports Discharge	Horizontal 10-in drain pipe at bottom of box	Principal Spillway Grate Discharge	SUMMATION of reverse incline ports, drain pipe & grate	Principal Spillway Outfall Pipe Discharge	Total Principal Spillway / Outfall Pipe Discharge	Emergency Spillway Discharge	Total Discharge Rating Curve	Comment
						(A)	(A)	(A)	(A)	(A)	sum of A's					
		Principal Spillway Orifice Diameter (inches)				12.0	12.0	8.0	10.0			24.0				
		Number of Orifices				12.0	12.0	0.0	1.0			1.0				
(ft)		(sq ft)	(cu ft)	(ac-ft)	(ac-ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	(cfs)	
(d)						(a)	(a)	(a)	(a)	(b)		(c)	(e)	(b)		
4045.00	0.00	33,053	0	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	Pond bottom and principal spillway structure invert & 10"pipe
4046.00	1.00	36,433	34,743	0.7976	0.7976	0.0	0.0	0.0	2.6	0.0	2.6	7.4	3	0	1	Highest Invert of 1st row of reverse incline ports
4047.00	2.00	40,008	38,220	0.8774	1.6750	44.6	0.0	0.0	3.7	0.0	48.3	21.0	21	0	21	Highest Invert of 2nd row of reverse incline ports
4048.00	3.00	43,786	41,897	0.9618	2.6368	63.1	44.6	0.0	4.5	0.0	112.2	25.8	26	0	26	Principal spillway grate
4049.00	4.00	47,774	45,780	1.0510	3.6878	77.3	63.1	0.0	5.2	90.0	235.6	29.7	30	0	30	Emergency Spillway
4050.00	5.00	51,982	49,878	1.1451	4.8328	89.2	77.3	0.0	5.8	254.6	426.9	33.3	33	390	423	

(a) Orfice equation and coefficient were obtained from Equation 4-10 and Table 4-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1976.

$$Q = Ca\sqrt{2gh}$$

C = 0.590 g=32.2 ft/sec^2, a=area (sq ft) h=head (ft)

$$a = \pi D^2 / 4$$

(full area formula)

(e) The combined discharge of the reverse incline ports, 10" pipe and the grate (A), will govern the discharge until the principal spillway outfall pipe becomes fully submerged. When the sum of (As) is greater than outfall pipe capacity then outfall pipe capacity governs the discharge

(b) Emergency Spillway flows were computed based on the following data used in the weir equation

Q = CLH^ 1.5 C = discharge coeffient, L = spillway length perp. to flow (ft), H = head (ft)

(b) Emergergency Spillway * C = 2.6 L = 150 Emer Spill Elev.= 4049.0

* Notes

(b) Grate (assume 3 sides) / Weir C = 3 L = 30 Grate Elev.= 4048.0 10' x 10' box - 3 sides as weir

(d) Data Source : DACFC Lidar Contours

(b) Weir equation and "C" coefficients were obtained from Equation 5-10 and Table 5-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1976.

(c) - Use Partial Area Formula shown below, for principal spillway pipe when head is less than full pipe diameter, after head exceeds pipe diameter, apply basic orifice equation (a)

$$a = \frac{1}{2}r^2\left\{\left[2\cos^{-1}\left(\frac{r-d}{r}\right)\right]\frac{\pi}{180} - \sin\left[\left[2\cos^{-1}\left(\frac{r-d}{r}\right)\right]\frac{\pi}{180}\right]\right\}$$

Principal Spillway Orifice radius r in feet = 1.0 ft

d = depth of water in the pipe in feet, r = pipe radius in feet

Table C11

OPTION DESCRIPTION - Pond Grading Assumes 3:1 slopes

Proposed - Pond 4

Elevation - Volume - Discharge Data and Computations

grey box means must input data

Contour Elevation NAVD 1988	Depth	Contour Area	Incremental Volume	Incremental Volume	Cumulative Volume	1st Row of Reverse Incline Ports Discharge	2nd Row of Reverse Incline Ports Discharge	3rd Row of Reverse Incline Ports Discharge	Horizontal 10-in drain pipe at bottom of box	Principal Spillway Grate Discharge	SUMMATION of reverse incline ports, drain pipe & grate	Principal Spillway Outfall Pipe Discharge	Total Principal Spillway / Outfall Pipe Discharge	Emergency Spillway Discharge	Total Discharge Rating Curve	Comment
						(A)	(A)	(A)	(A)	(A)	sum of A's					
		Principal Spillway Orifice Diameter (inches)				12.0	12.0	8.0	10.0			24.0				
		Number of Orifices				12.0	12.0	0.0	1.0			1.0				
(ft)		(sq ft)	(cu ft)	(ac-ft)	(ac-ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	(cfs)	
(d)						(a)	(a)	(a)	(a)	(b)		(c)	(e)	(b)		
4040.00	0.00	32,801	0	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	Pond bottom and principal spillway structure invert & 10"pipe
4041.00	1.00	35,074	33,938	0.7791	0.7791	0.0	0.0	0.0	2.6	0.0	2.6	7.4	3	0	1	Highest Invert of 1st row of reverse incline ports
4042.00	2.00	37,409	36,242	0.8320	1.6111	44.6	0.0	0.0	3.7	0.0	48.3	21.0	21	0	21	Highest Invert of 2nd row of reverse incline ports
4043.00	3.00	39,800	38,604	0.8862	2.4973	63.1	44.6	0.0	4.5	0.0	112.2	25.8	26	0	26	Principal spillway grate
4044.00	4.00	42,247	41,023	0.9418	3.4391	77.3	63.1	0.0	5.2	90.0	235.6	29.7	30	0	30	Emergency Spillway
4045.00	5.00	44,727	43,487	0.9983	4.4374	89.2	77.3	0.0	5.8	254.6	426.9	33.3	33	390	423	

(a) Office equation and coefficient were obtained from Equation 4-10 and Table 4-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1976.

$$Q = Ca\sqrt{2gh}$$ C = 0.590 g=32.2 ft/sec^2, a=area (sq ft) h=head (ft)

$$a = \pi D^2 / 4$$ (full area formula)

(b) Emergency Spillway flows were computed based on the following data used in the weir equation

Q = CLH^ 1.5 C = discharge coeffient, L = spillway length perp. to flow (ft), H = head (ft)

(b) Emergergency Spillway * C = 2.6 L = 150 Emer Spill Elev.= 4044.0

* Notes

(b) Grate (assume 3 sides) / Weir C = 3 L = 30 Grate Elev.= 4043.0 10' x 10' box - 3 sides as weir

(d) Data Source : DACFC Lidar Contours

(e) The combined discharge of the reverse incline ports, 10" pipe and the grate (A), will govern the discharge until the principal spillway outfall pipe becomes fully submerged. When the sum of (As) is greater than outfall pipe capacity then outfall pipe capacity governs the discharge

(b) Weir equation and "C" coefficients were obtained from Equation 5-10 and Table 5-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1976.

(c) - Use Partial Area Formula shown below, for principal spillway pipe when head is less than full pipe diameter, after head exceeds pipe diameter, apply basic orifice equation (a)

$$a = \frac{1}{2} r^2 \left\{ \left[2\cos^{-1}\left(\frac{r-d}{r}\right) \right] \frac{\pi}{180} - \sin\left[\left[2\cos^{-1}\left(\frac{r-d}{r}\right) \right] \frac{\pi}{180} \right] \right\}$$

Principal Spillway Orifice radius r in feet = 1.0 ft

d = depth of water in the pipe in feet, r = pipe radius in feet

TABLE C-12
Radium Springs Proposed Pond Reservoir Routing Summary

Detention Pond Name	Existing or Proposed Pond	Storm Return Period / Duration	Peak Inflow	Peak Outflow	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 a	cfs a	cfs a	ac-ft a	ac-ft a	ac-ft b	ac-ft a	ft a	ft b	ft b	ft b	ft	ft b	ft c	ft c
POND 1	Proposed 3:1	100 / 24	198	129	24.1	24.1	9.8	8.2	4133.2	4133.0	4128.5	5.5	4.7	4134.0	-0.2	0.8
POND 1	Proposed 3:1	10 / 24	64	26	9.1	9.1	9.8	3.2	4130.5	4133.0	4128.5	5.5	1.9	4134.0	2.6	3.6
POND 2 (Facility 1A)	Proposed 3:1	100 / 24	791	93	111.6	111.6	70.8	60.6	4095.2	4095.0	4090.5	5.5	4.7	4096.0	-0.2	0.8
POND 2 (Facility 1A)	Proposed 3:1	10 / 24	260	20	43.1	42.7	70.8	23.3	4092.4	4095.0	4090.5	5.5	1.9	4096.0	2.6	3.6
POND 2 (Facility 1B)	Proposed 3:1	100 / 24	923	141	111.7	110.9	70.8	63.0	4095.4	4095.0	4090.5	5.5	4.9	4096.0	-0.4	0.6
POND 2 (Facility 1B)	Proposed 3:1	10 / 24	294	21	43.1	42.7	70.8	24.4	4092.4	4095.0	4090.5	5.5	1.9	4096.0	2.6	3.6

TABLE C-12

Radium Springs Proposed Pond Reservoir Routing Summary

Detention Pond Name	Existing or Proposed Pond	Storm Return Period / Duration	Peak Inflow	Peak Outflow	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 a	cfs a	cfs a	ac-ft a	ac-ft a	ac-ft b	ac-ft a	ft a	ft b	ft b	ft b	ft	ft b	ft c	ft c
POND 3	Proposed 3:1	100 / 24	148	98	11.1	11.1	4.4	3.6	4044.2	4044.0	4040	5.0	4.2	4045.0	-0.2	0.8
POND 3	Proposed 3:1	10 / 24	55	21	4.6	4.6	4.4	1.7	4042.1	4044.0	4040	5.0	2.1	4045.0	1.9	2.9
POND 4	Proposed 3:1	100 / 24	135	81	10.9	10.9	4.8	3.8	4049.1	4049.0	4045	5.0	4.1	4050.0	-0.1	0.9
POND 4	Proposed 3:1	10 / 24	47	20	4.5	4.5	4.8	1.6	4047.0	4049.0	4045	5.0	1.9	4050.0	2.1	3.1

a - Refer to Figures included in report text for Proposed Retention Pond Conceptual Grading Plans

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

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

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

REFERENCES

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

   Figure R1 Cumulative Rainfall Distribution
   Figure R2 Incremental Rainfall Distribution
   (The HEC-HMS Rainfall 25% Frequency Distribution storm was adopted, see Figures R1 and R2 for this distribution)

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

3. Urban Hydrology for Small Watersheds, US Dept. of Agricultural, Natural Resources Conservation Service, Technical Release 55, June 1986.
   Figure B-2, Approximate Geographic Boundaries for SCS Rainfall Distributions (FOR REFERENCE ONLY –
   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

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

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

7. 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
   Dona Ana County Area, New Mexico.

8. Table 10-1 Curve Numbers (CN) and constants for the case $I_a = 0.2S$, Chapter 10 – Estimation of Direct Runoff from Storm Rainfall Part 630 Nation Engineering Handbook. (210-VI-NEH, July 2004)

NOAA Atlas 14, Volume 1, Version 5
Location name: Las Cruces, New Mexico, USA*
Latitude: 32.5086°, Longitude: -106.8864°
Elevation: 4293.88 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	**0.219** (0.191-0.249)	**0.285** (0.250-0.324)	**0.382** (0.335-0.433)	**0.458** (0.400-0.518)	**0.559** (0.487-0.631)	**0.641** (0.555-0.723)	**0.726** (0.624-0.819)	**0.813** (0.696-0.918)	**0.935** (0.792-1.06)	**1.03** (0.870-1.17)
10-min	**0.334** (0.290-0.378)	**0.433** (0.381-0.493)	**0.581** (0.511-0.659)	**0.696** (0.609-0.788)	**0.851** (0.741-0.960)	**0.976** (0.844-1.10)	**1.10** (0.950-1.25)	**1.24** (1.06-1.40)	**1.42** (1.21-1.61)	**1.57** (1.32-1.78)
15-min	**0.414** (0.360-0.469)	**0.537** (0.472-0.611)	**0.721** (0.633-0.817)	**0.863** (0.755-0.977)	**1.06** (0.919-1.19)	**1.21** (1.05-1.37)	**1.37** (1.18-1.54)	**1.54** (1.31-1.73)	**1.76** (1.49-1.99)	**1.95** (1.64-2.21)
30-min	**0.558** (0.485-0.632)	**0.723** (0.636-0.823)	**0.970** (0.852-1.10)	**1.16** (1.02-1.32)	**1.42** (1.24-1.60)	**1.63** (1.41-1.84)	**1.84** (1.59-2.08)	**2.07** (1.77-2.33)	**2.38** (2.01-2.69)	**2.63** (2.21-2.97)
60-min	**0.690** (0.600-0.782)	**0.895** (0.787-1.02)	**1.20** (1.06-1.36)	**1.44** (1.26-1.63)	**1.76** (1.53-1.98)	**2.02** (1.74-2.28)	**2.28** (1.96-2.57)	**2.56** (2.19-2.89)	**2.94** (2.49-3.32)	**3.25** (2.74-3.68)
2-hr	**0.794** (0.697-0.901)	**1.03** (0.906-1.17)	**1.38** (1.22-1.56)	**1.66** (1.45-1.87)	**2.02** (1.76-2.28)	**2.31** (1.99-2.59)	**2.61** (2.24-2.93)	**2.92** (2.48-3.27)	**3.34** (2.80-3.74)	**3.68** (3.05-4.12)
3-hr	**0.838** (0.743-0.949)	**1.08** (0.955-1.22)	**1.43** (1.26-1.62)	**1.70** (1.50-1.92)	**2.07** (1.81-2.33)	**2.36** (2.06-2.65)	**2.66** (2.30-2.99)	**2.98** (2.55-3.34)	**3.40** (2.88-3.82)	**3.74** (3.13-4.20)
6-hr	**0.959** (0.856-1.07)	**1.22** (1.09-1.37)	**1.59** (1.42-1.78)	**1.87** (1.66-2.09)	**2.25** (1.99-2.51)	**2.54** (2.23-2.83)	**2.84** (2.48-3.16)	**3.15** (2.73-3.50)	**3.56** (3.05-3.96)	**3.89** (3.30-4.33)
12-hr	**1.06** (0.951-1.18)	**1.35** (1.21-1.50)	**1.74** (1.56-1.93)	**2.03** (1.82-2.25)	**2.42** (2.15-2.68)	**2.71** (2.40-2.99)	**3.01** (2.65-3.33)	**3.31** (2.89-3.66)	**3.69** (3.20-4.10)	**4.00** (3.44-4.45)
24-hr	**1.18** (1.08-1.30)	**1.50** (1.37-1.65)	**1.93** (1.76-2.12)	**2.26** (2.05-2.49)	**2.72** (2.45-3.02)	**3.09** (2.74-3.46)	**3.48** (3.05-3.95)	**3.88** (3.35-4.49)	**4.46** (3.77-5.30)	**4.93** (4.08-6.01)
2-day	**1.28** (1.17-1.39)	**1.61** (1.48-1.76)	**2.07** (1.90-2.26)	**2.43** (2.22-2.66)	**2.93** (2.65-3.24)	**3.34** (2.98-3.73)	**3.77** (3.31-4.27)	**4.22** (3.65-4.86)	**4.85** (4.09-5.74)	**5.39** (4.45-6.52)
3-day	**1.37** (1.26-1.50)	**1.74** (1.60-1.89)	**2.23** (2.04-2.43)	**2.62** (2.38-2.86)	**3.15** (2.85-3.48)	**3.58** (3.20-3.98)	**4.03** (3.55-4.54)	**4.49** (3.90-5.15)	**5.17** (4.39-6.07)	**5.73** (4.77-6.87)
4-day	**1.47** (1.35-1.60)	**1.86** (1.71-2.03)	**2.39** (2.19-2.61)	**2.80** (2.55-3.06)	**3.37** (3.05-3.71)	**3.82** (3.42-4.24)	**4.28** (3.79-4.82)	**4.77** (4.15-5.44)	**5.48** (4.68-6.39)	**6.06** (5.08-7.21)
7-day	**1.69** (1.55-1.84)	**2.14** (1.96-2.33)	**2.75** (2.52-2.99)	**3.23** (2.95-3.52)	**3.89** (3.51-4.27)	**4.41** (3.95-4.89)	**4.96** (4.38-5.55)	**5.53** (4.82-6.27)	**6.33** (5.40-7.33)	**6.96** (5.84-8.22)
10-day	**1.87** (1.72-2.04)	**2.39** (2.19-2.60)	**3.09** (2.83-3.36)	**3.64** (3.31-3.96)	**4.40** (3.97-4.82)	**5.00** (4.46-5.53)	**5.64** (4.97-6.30)	**6.30** (5.47-7.13)	**7.23** (6.15-8.34)	**7.97** (6.66-9.36)
20-day	**2.38** (2.18-2.59)	**3.02** (2.78-3.29)	**3.87** (3.56-4.21)	**4.51** (4.13-4.92)	**5.38** (4.88-5.89)	**6.04** (5.44-6.66)	**6.72** (5.99-7.48)	**7.42** (6.54-8.34)	**8.36** (7.25-9.56)	**9.09** (7.77-10.6)
30-day	**2.85** (2.62-3.10)	**3.61** (3.32-3.93)	**4.58** (4.21-4.98)	**5.31** (4.86-5.78)	**6.28** (5.70-6.87)	**7.01** (6.32-7.71)	**7.75** (6.92-8.61)	**8.49** (7.50-9.53)	**9.48** (8.24-10.8)	**10.2** (8.79-11.9)
45-day	**3.44** (3.17-3.74)	**4.36** (4.02-4.73)	**5.48** (5.05-5.94)	**6.31** (5.80-6.84)	**7.38** (6.74-8.03)	**8.17** (7.42-8.95)	**8.96** (8.07-9.88)	**9.74** (8.70-10.8)	**10.8** (9.48-12.1)	**11.5** (10.0-13.2)
60-day	**3.99** (3.67-4.33)	**5.06** (4.66-5.48)	**6.34** (5.85-6.87)	**7.27** (6.69-7.88)	**8.46** (7.74-9.19)	**9.33** (8.48-10.2)	**10.2** (9.19-11.2)	**11.0** (9.85-12.2)	**12.1** (10.7-13.5)	**12.8** (11.3-14.6)

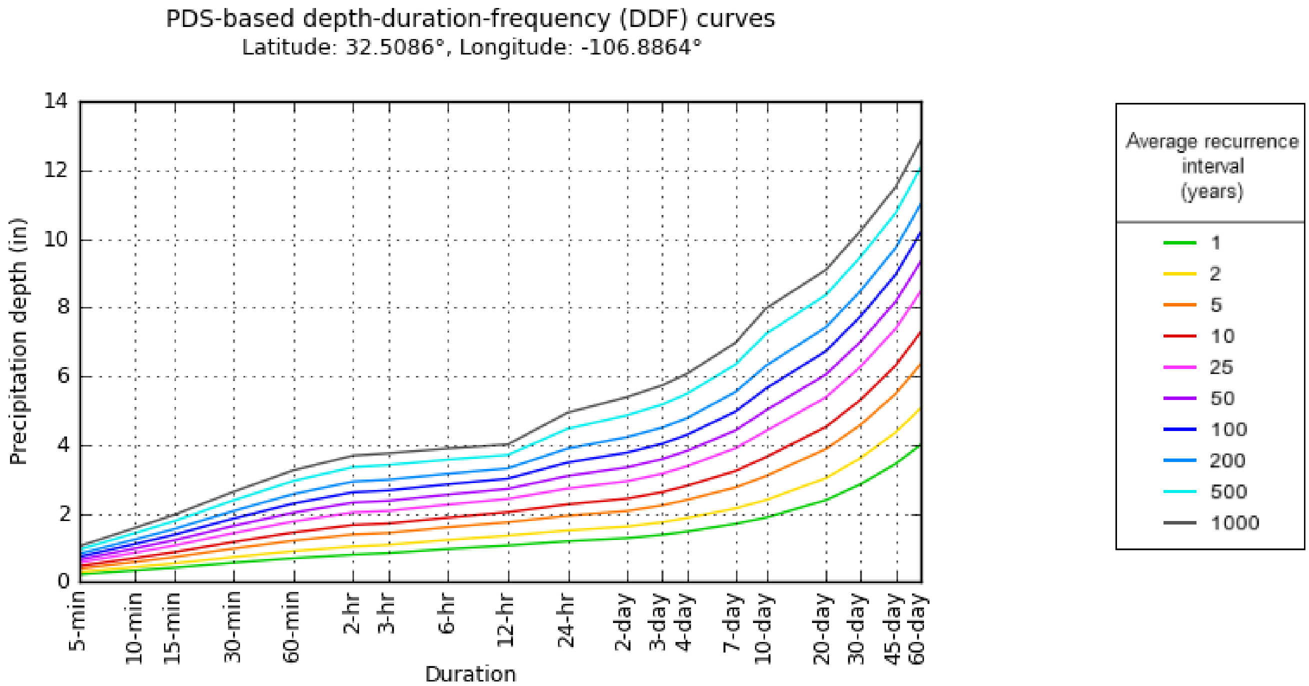
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

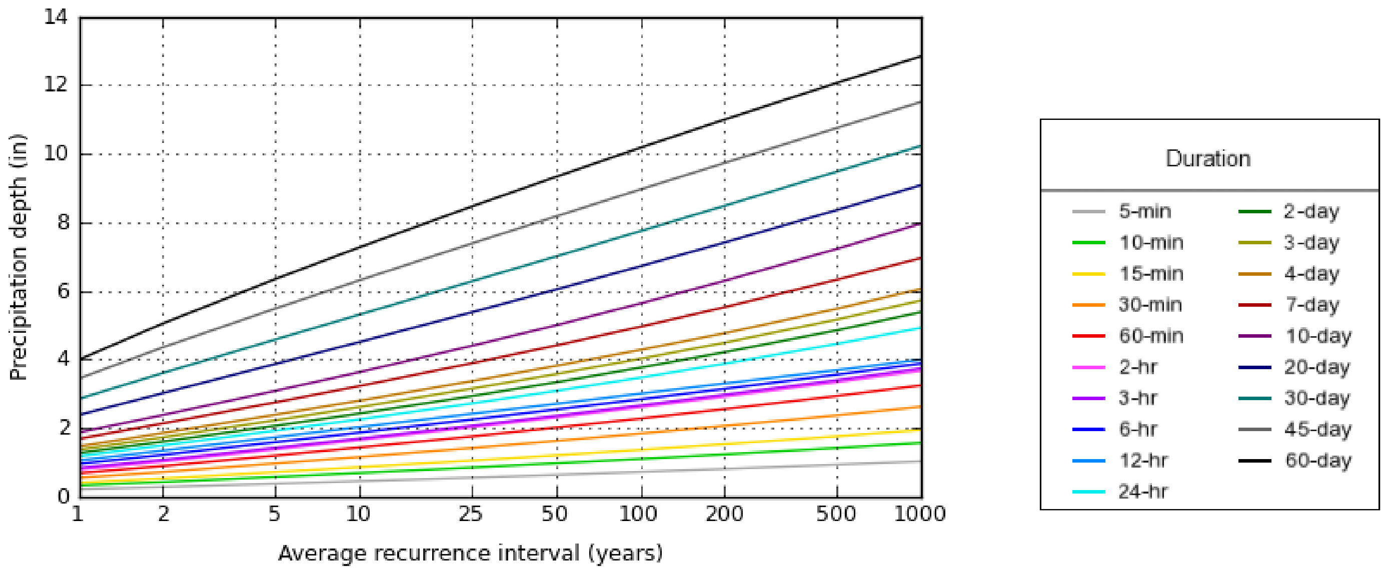
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper 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.

Back to Top

PF graphical



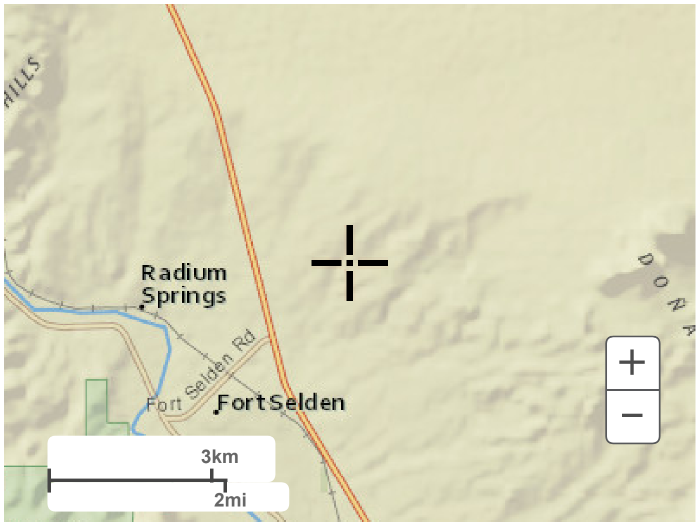


NOAA Atlas 14, Volume 1, Version 5 Created (GMT): Thu Aug 3 16:25:31 2017

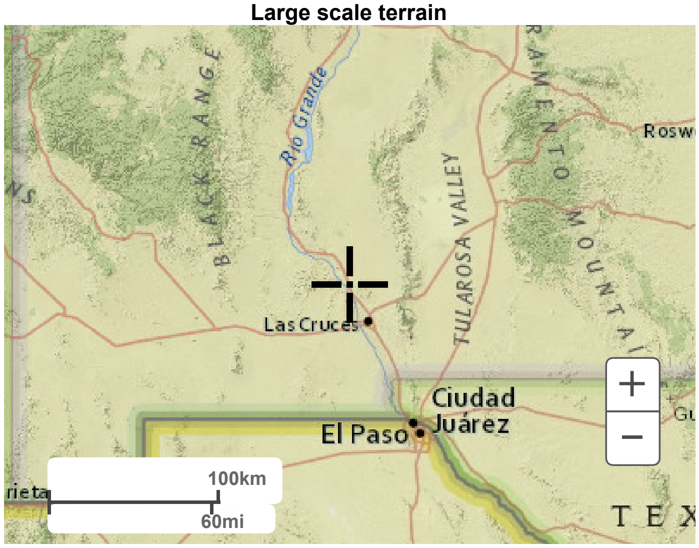
Back to Top

Maps & aerials

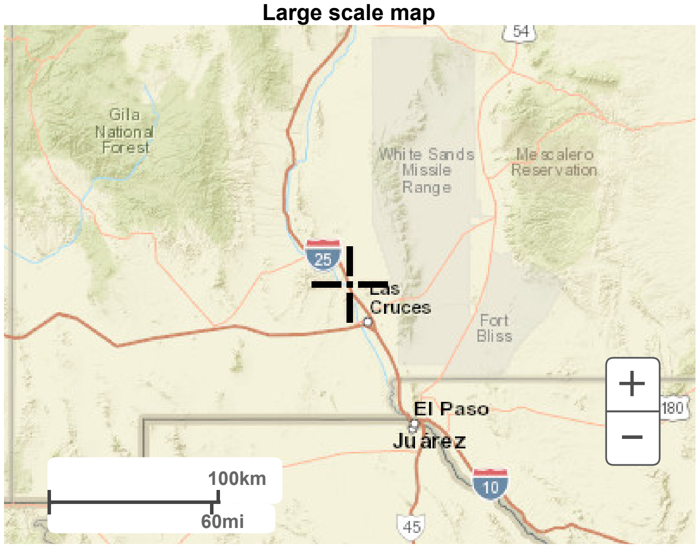
Small scale terrain



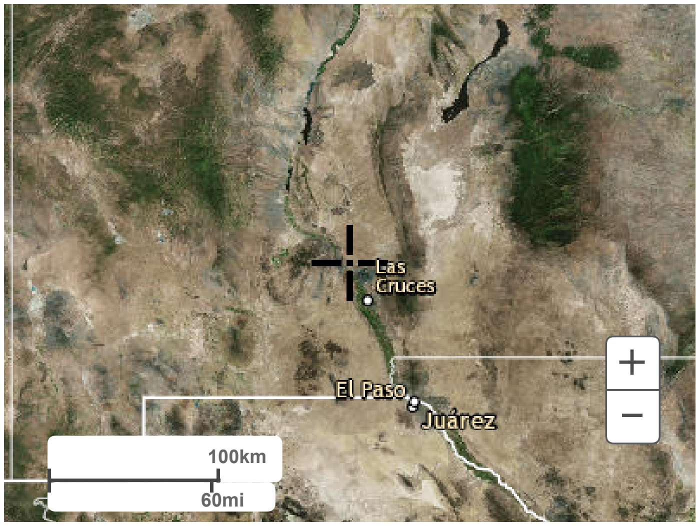
Large scale terrain



Large scale map



Large scale aerial

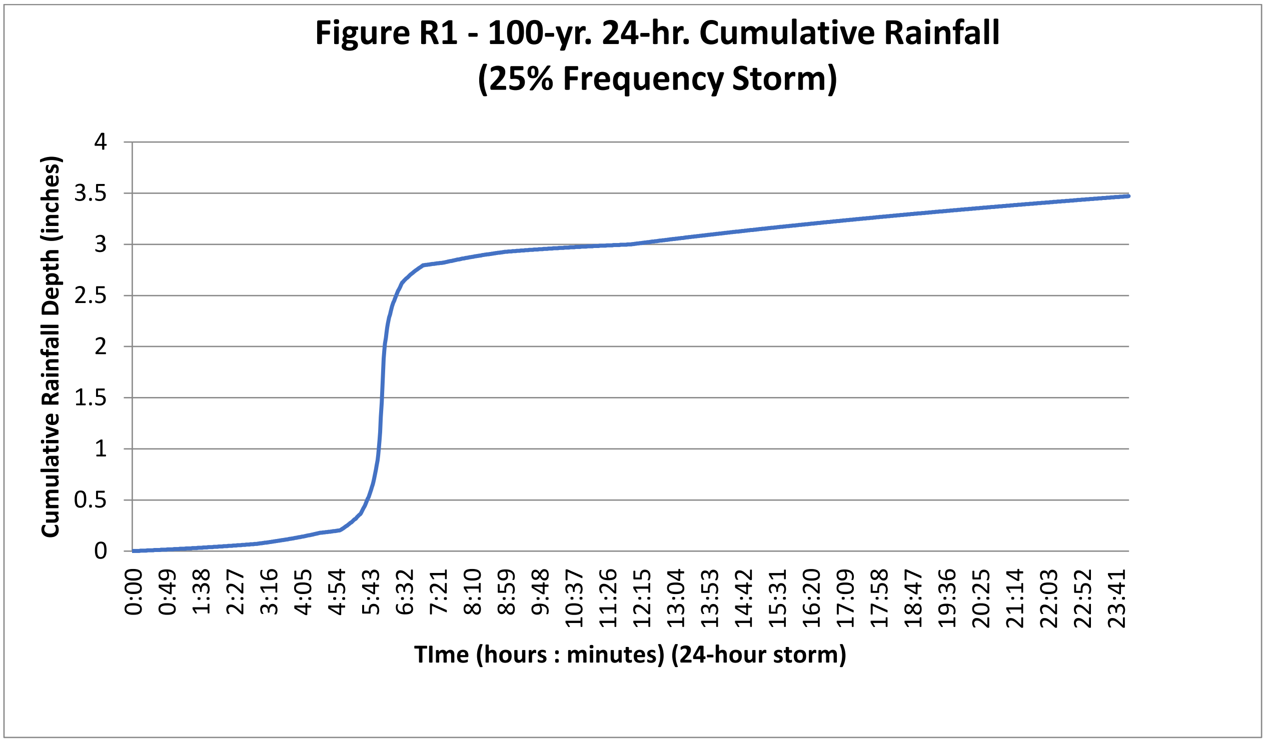


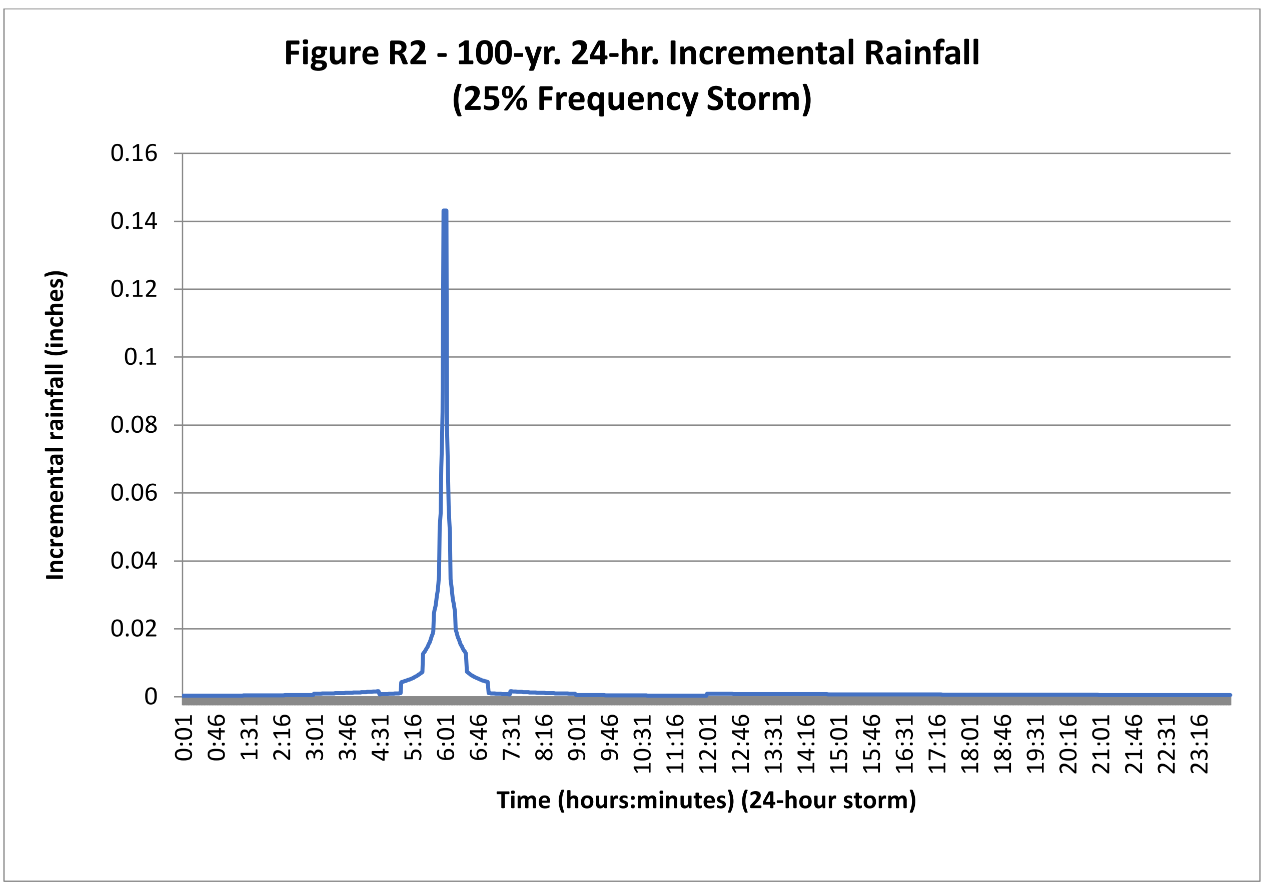
Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Figure R1 and R2: Frequency Storm Distribution





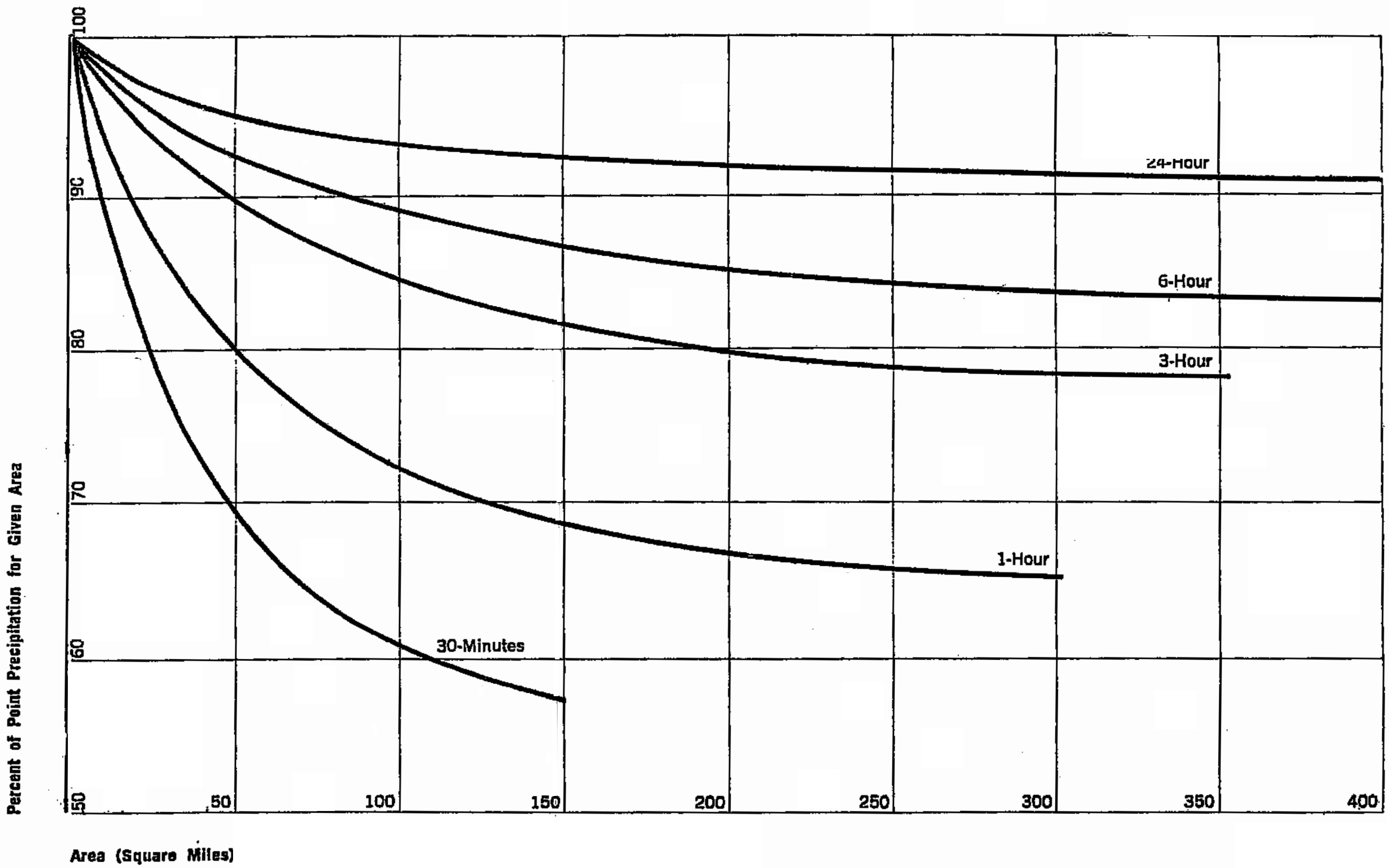


Figure 14. *Depth-Area curves.*
SOURCE:
NOAA Atlas 2, Vol. IV, New Mexico
Precipitation Frequency Atlas of the Western United States
U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration
National Weather Service. Silver Spring MD, 1973.

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

Conservation
Engineering
Division

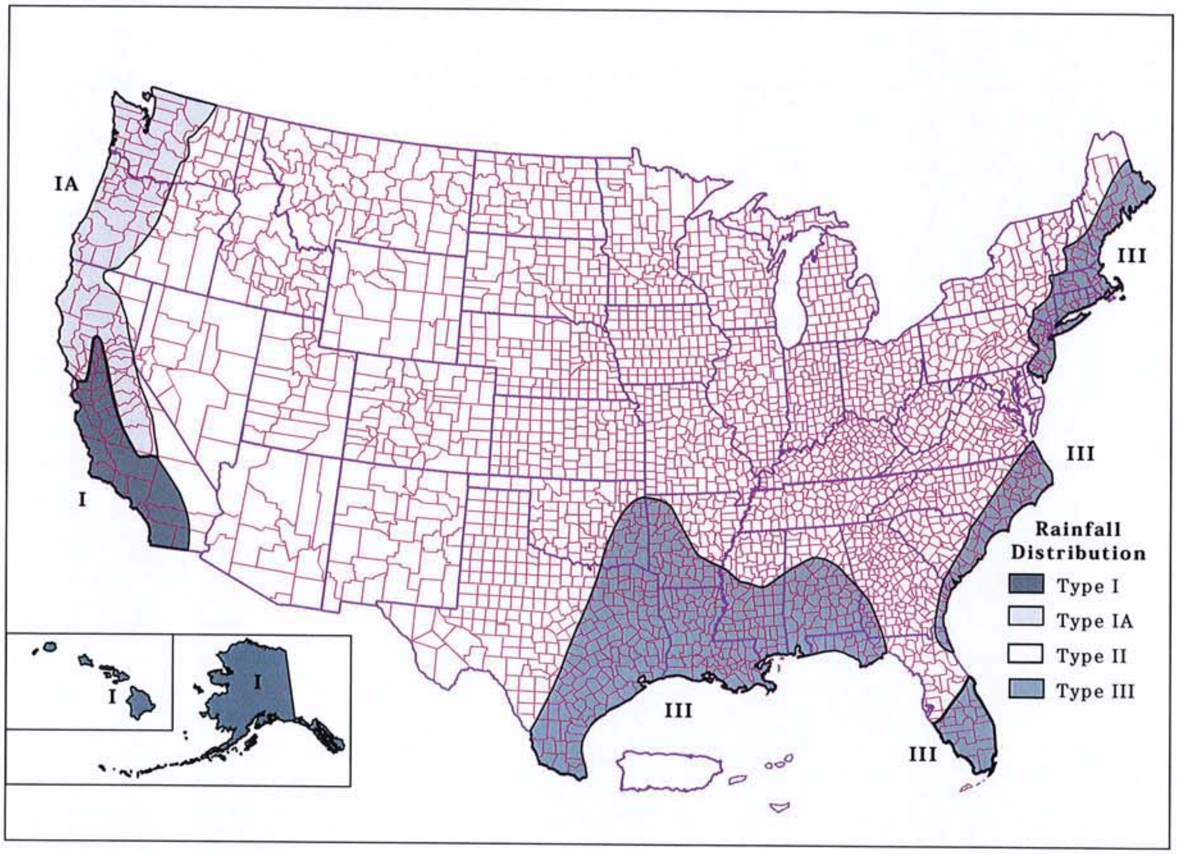
Technical
Release 55

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: Cover type	Hydrologic condition	Curve numbers for hydrologic soil group: 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.

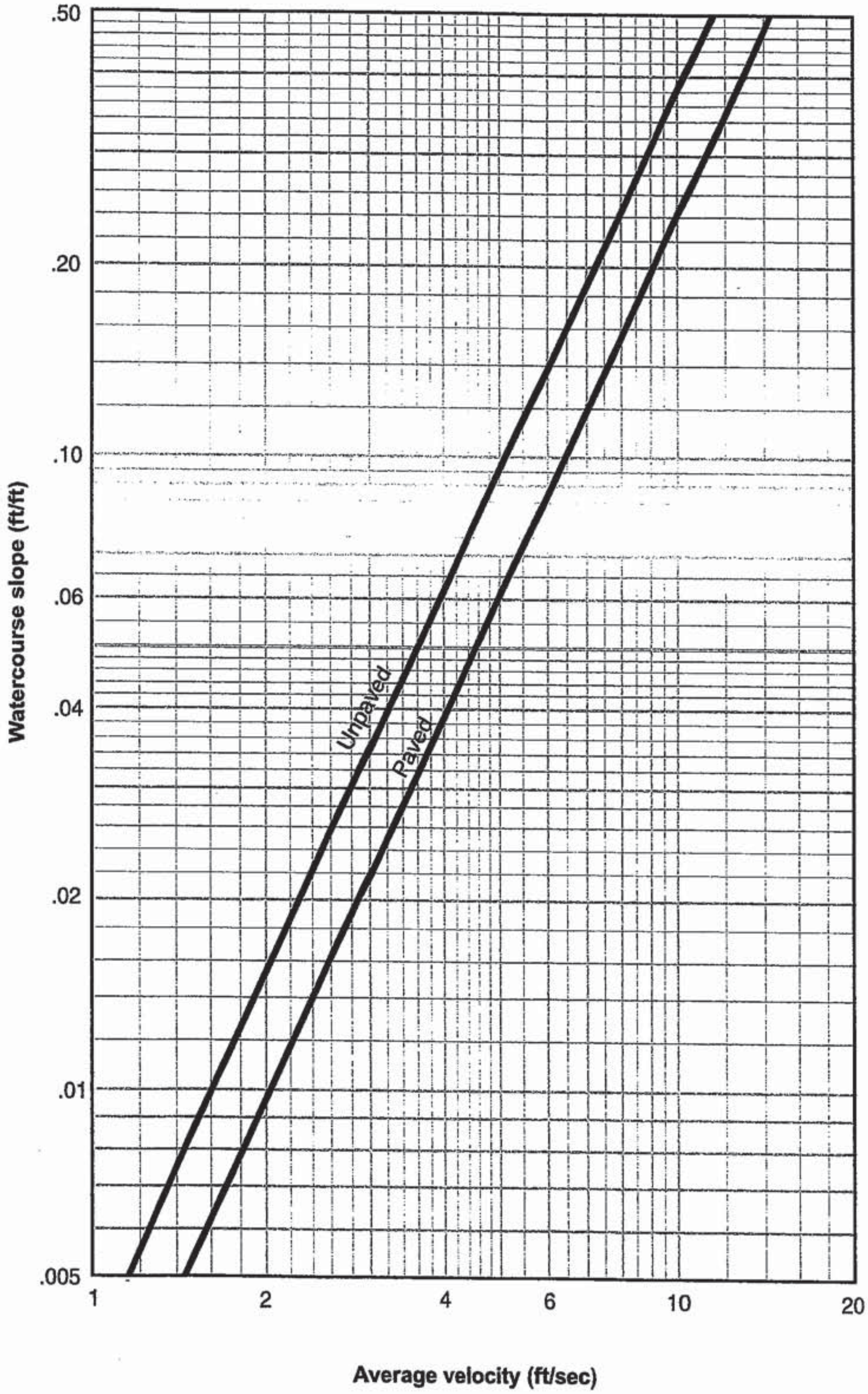
Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

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

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



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):

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

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

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 (ft²)
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

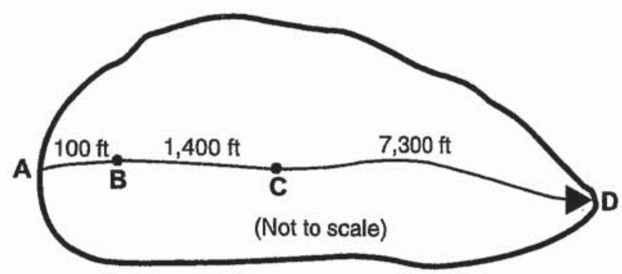
- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 3-3 was developed for use with the four standard rainfall intensity-duration relationships.
- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm 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 ft²; 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.

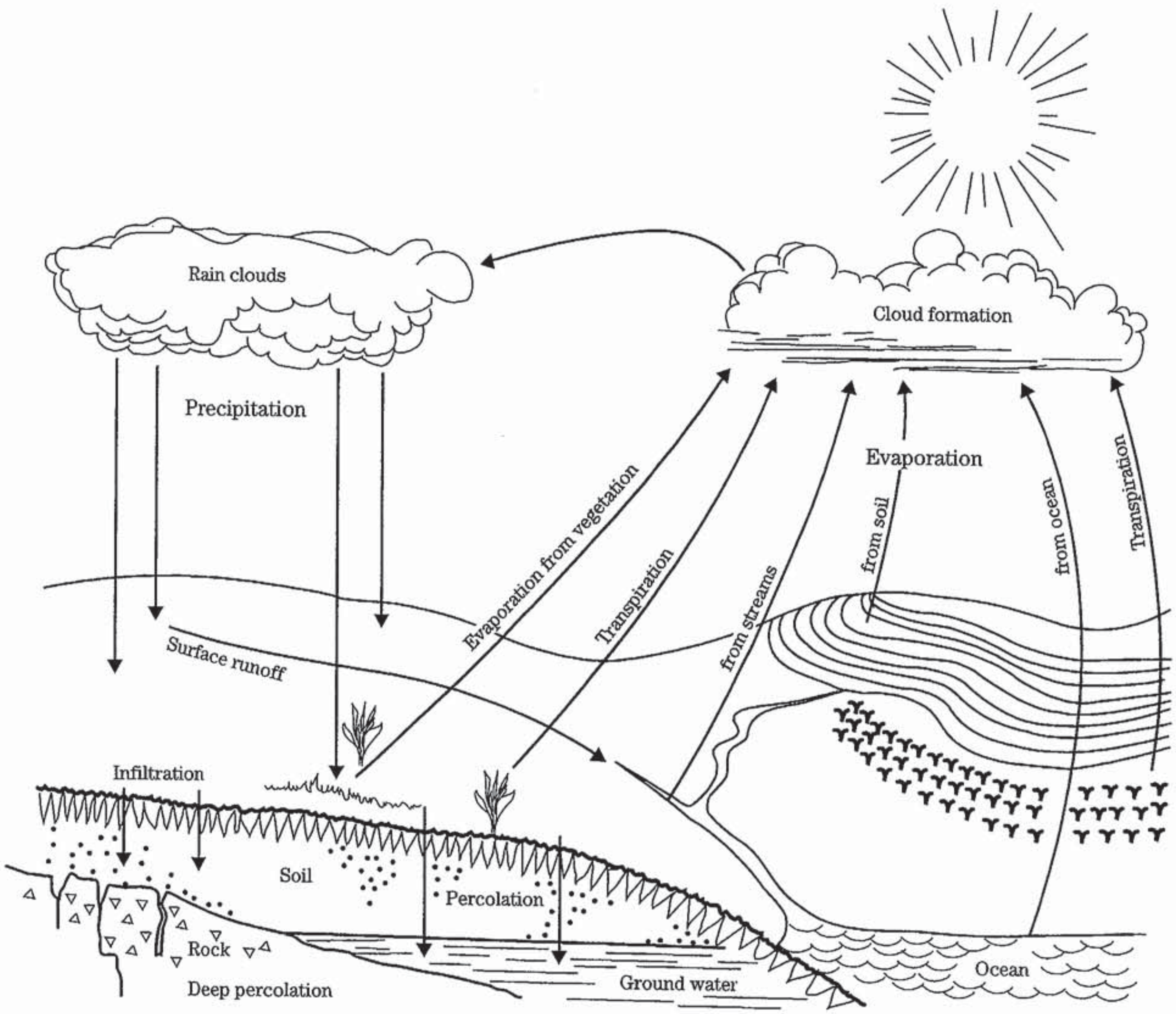


United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

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.

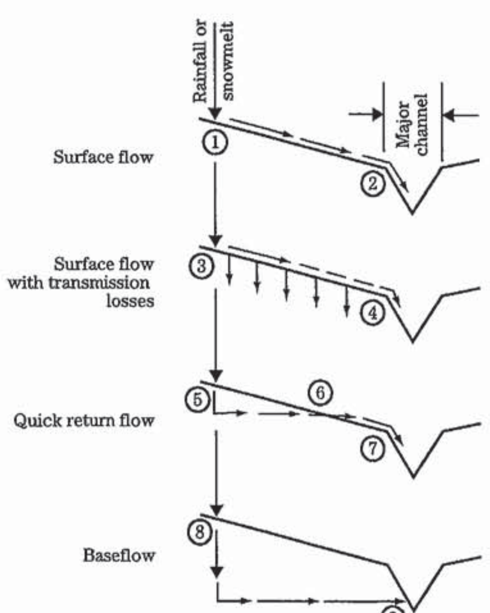
Surface flow with transmission losses—In figure 15–1, point 3 represents a location where precipitation falls on a watershed. Surface flow is represented by the lines with arrows showing travel along the surface of the watershed from point 3 to point 4, while the transmission losses are represented by 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
ℓ = 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:

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

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

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.

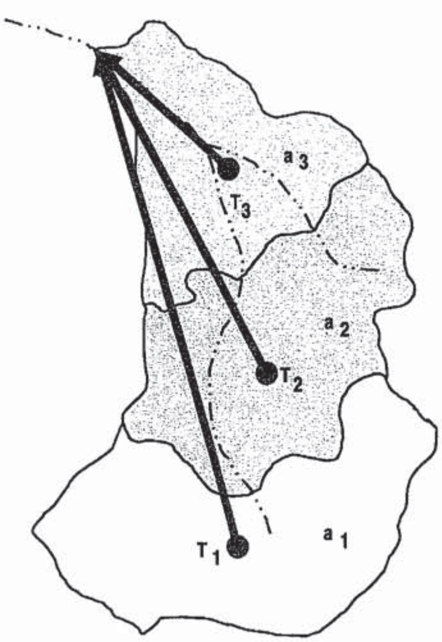
In hydrograph analysis, lag is the time interval between the center of mass of the excess rainfall and the peak runoff rate (fig. 15–3).

(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

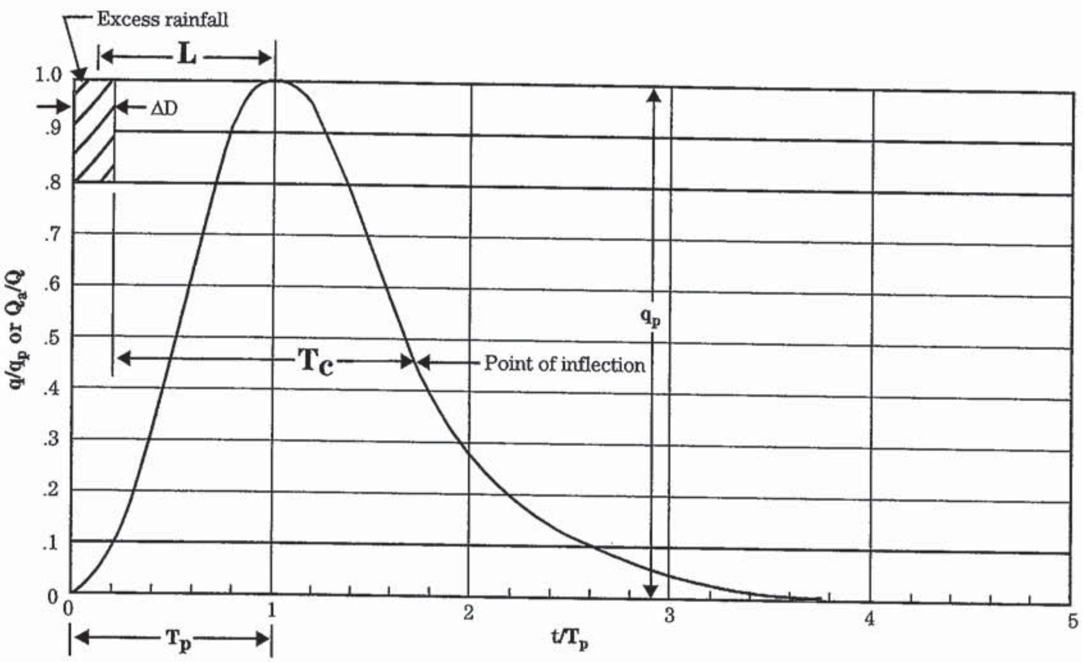
Various researchers (Mockus 1957; Simas 1996) found that for average natural watershed conditions and an approximately uniform distribution of runoff:

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

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

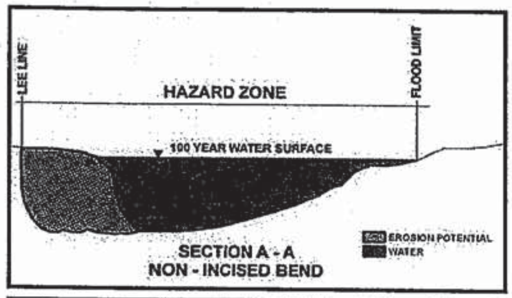
When runoff is not uniformly distributed, the watershed can be subdivided into areas with nearly uniform flow so that equation 15–3 can be applied to each of the subareas.

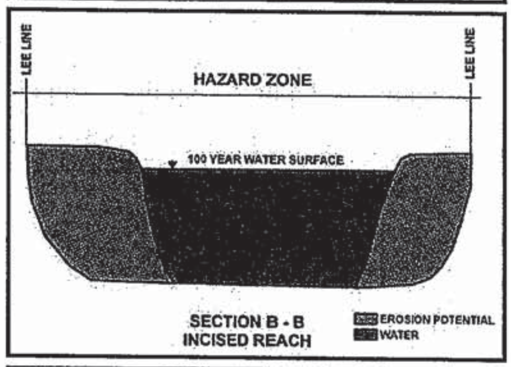
Figure 15–3 The relation of time of concentration (T_c) and lag (L) to the dimensionless unit hydrograph

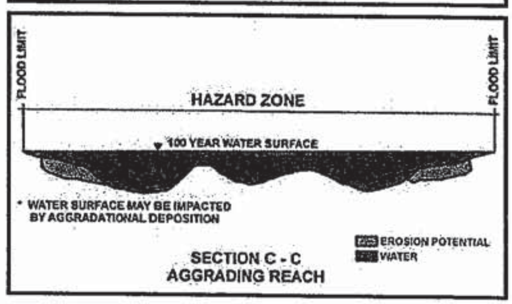


where:
L = Lag, h
T_c = time of concentration, h
T_p = time to peak, h
ΔD = duration of excess rainfall, h
t/T_p = dimensionless ratio of any time to time to peak
q = discharge rate at time t, ft^3/s
q_p = peak discharge rate at time T_p, ft^3/s
Q_a = runoff volume up to t, in
Q = total runoff volume,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

SEDIMENT AND EROSION DESIGN GUIDE







Prepared for **Southern Sandoval County Arroyo Flood Control Authority**
1041 Commercial Dr. SE
Rio Rancho, New Mexico 87124

Prepared by MEI™ Mussetter Engineering Inc.
1730 S. College Ave #100
Fort Collins, Colorado
80525

November 2008

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.**

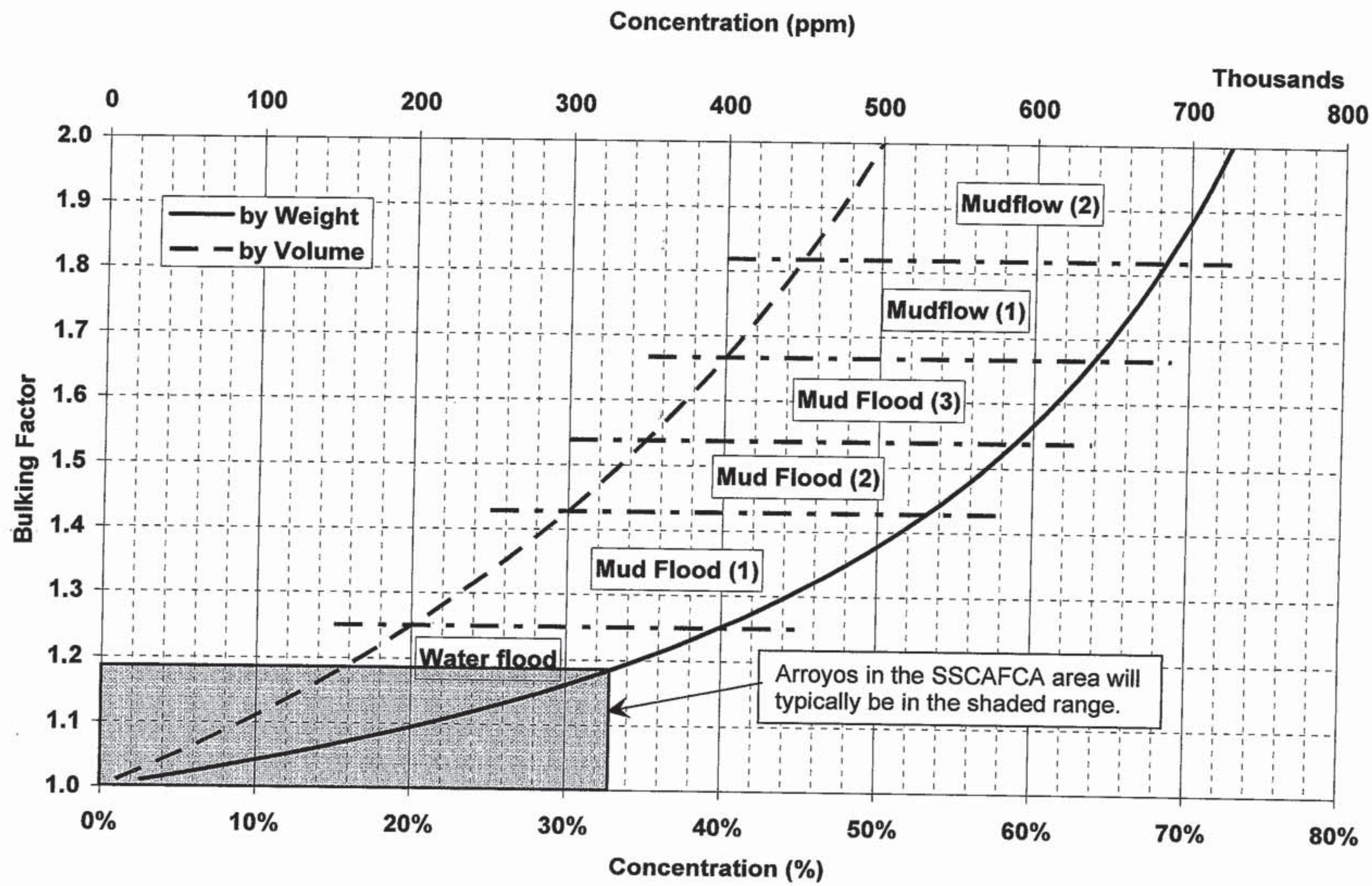


Figure 3.8. Relationship between total sediment concentration and bulking factor.

CHAPTER 4
HYDROLOGY FOR DRAINAGE SYSTEM DESIGN AND ANALYSIS

Jerome A. Westphal
Cottonwood, Arizona

4.1 PEAK RUNOFF ESTIMATES

4.1.1 The Rational Formula

The hydraulic sizing of drainage and conveyance structures in urban settings always requires estimation of peak flow rates. Historically, the venerable "*Rational method*" has been the tool of choice for most practicing engineers around the world. Although the method definitely has its place in hydrologic design, it is routinely misapplied and overextended.

The roots of this methodology date as far back as 1851 (Mulvaney, 1851), and certainly as far back as 1889 (Kuichling, 1889). See discussion on chapter 1. The concept is attractive and easy to understand. If rainfall occurs over a basin at a constant intensity for a period of time that is sufficient to produce steady state runoff at the outlet or design point, then the peak outflow rate will be proportional to the product of rainfall intensity and basin area. In the United States, the method is commonly expressed by the equation known as the "*Rational formula*":

$$Q = C \cdot I \cdot A \tag{4.1}$$

where Q = peak runoff rate (cfs)
C = dimensionless runoff coefficient used to adjust for abstractions from rainfall
I = rainfall intensity for a duration that equals time of concentration of the basin (in/hr)
A = basin area (ac)

In English units, it turns out that the dimensions of the product $I \cdot A$ are ac · in/hr, and 1.0 ac · in/hr is very nearly equivalent to 1.0 cfs. In SI units, the equation must be made dimensionally homogeneous (e.g. if A is hectares and I is cm/hr, then the product $C \cdot I \cdot A$ must be multiplied by 0.00278 to make the dimensions on Q equal to cms).

Since its inception, the Rational formula has been discussed extensively in the published literature and in theses. Most of its limitations and shortcomings are well documented, but these constraints are largely ignored by most practicing engineers. For credible engineering

The choice of reporting the SEP as a percentage has the advantage of informing the reader about the approximate scatter about the regression in a direct way. However, where it is reported as a single percentage, it may be somewhat misleading. For instance, in the previous example, the difference between the regression estimate and the lower bound is greater than the difference for the upper bound. The average difference is 47.7% [0.5 · (39100 + 58500)/100000]. Thus, reportage of a singe SEP percentage implies a symmetry about the regression estimate that doesn't exist, but it is still true that as the SEP increases, the reliability of the regression estimate decreases.

In any event, the SEP should be used as a qualitative indicator of the relative reliability of any particular peak flow equation. An informal scan of equations for a few states indicates that the SEP may vary from roughly 20% to 150%, with most being in the range of 30% to 50%. Although there seems to be no published formal guidance, alternative methods of estimating peak flow rates should be considered whenever the SEP is greater than 50%.

4.2 HYDROGRAPH METHODS

When watersheds are large, that is, when they are comprised of two or more smaller watersheds whose streamflow at the confluence with common collector channel can be expected to be displaced in time, where storage influences the time distribution of flow in a stream, or where storage is a part of the design problem, peak flow methods are inappropriate for hydrologic design. In these instances, it is necessary to estimate the entire flow hydrograph. A number of computer programs (models) are available to do the requisite hydrologic and hydraulic computations. Most of these programs have a number of options for each element of the process that begins with rainfall and ends with a hydrograph at some point in the system. Conceptually, the process starts with rainfall over a sub watershed(s) at the periphery of a larger system. The rainfall is transformed into a hydrograph of direct runoff at the outlet of the sub watershed. The hydrograph is then combined with a hydrograph from an adjacent basin and/or is routed through a channel to the next downstream point of interest.

There are two types of computer programs (models) for doing hydrologic and hydraulic computations for a system: continuous simulation models and event-based models. Event-based models are used for nearly all design problems. Discussion in this chapter will be restricted to methods embedded in event-based models. Furthermore, it will be restricted to elements related to hydrograph computations. Flood routing is covered in chapters 7 and 8.

4.2.1 Rainfall Events for Design—Design Hyetographs

The process of computing a hydrograph begins with selection of a design storm, the first step of which is to select a design frequency. In an event-based design using methods of synthetic hydrology, the frequency of the storm event is assumed to equal the frequency of the resulting computed peak flow rate on the hydrograph. This is probably not true for individual events, but it is hoped that it approaches reality over the long term. In any event, there is currently no acceptable alternative.

Often, the local approving authority (city, county, drainage district, etc.) will specify the level of design to be used for any particular type of structure. In the absence of statutory or regulatory specifications, the Table 4.5 (excerpted from Table 13.1.1 in Chow et al., 1988) shows recurrence intervals that are commonly used in the practice.

Next, duration of the rainfall event should be selected so as to be at least as long as the time of concentration of the entire system that is under analysis. Time of concentration has been discussed Section 4.1.1. In published rainfall atlases, depth of rain is directly proportional to duration while average intensity is inversely proportional to duration. Everything

TABLE 4.5 Common Design Frequencies for Hydraulic Structures

Type of structure	Return period (years)
Highway culverts:	
Low traffic	5–10
Intermediate traffic	10–25
High traffic	50–100
Highway bridges	
Secondary system	10–50
Primary system	50–100
Urban drainage	
Storm sewers in small cities	2–25
Storm sewers in large cities	25–50
Airfields	
Low traffic	5–10
Intermediate traffic	10–25
High traffic	50–100

being equal, higher rainfall intensities result in higher runoff rates, while greater rainfall depths result in greater volumes of runoff. It is seldom possible to know in advance whether design of a hydraulic structure will be more sensitive to peak runoff rates or to runoff volumes. Therefore, it is good practice to select several rainfall durations and compute the runoff for each.

Often, regulatory authorities will supply IDF or DDF data. However, peak flows computed by hydrograph methods do not require that rainfall durations equal time of concentration. Therefore, it is usually more efficient to choose durations that equal or exceed the time of concentration, and that are divisible by some convenient fraction of an hour (e.g. 15 minutes, 20 minutes, 30 minutes). As mentioned earlier, it is always best, but seldom practicable, to use rainfall frequency relations that are derived from local rainfall records, provided they have a sufficient period of record and suitable quality. Existing rainfall atlases (e.g. Hershfield, 1961; Miller, et al., 1973; Frederick, et al., 1977; Huff and Angel, 1992) show rainfall for a number of frequencies for a commensurate number of durations such that design values can be taken directly from an appropriate atlas.

The design rainfall must be distributed in time to approximate (in a gross sense) a naturally occurring event comprised of a series of short duration segments whose intensity varies from segment to segment. A histogram (or table) that depicts rainfall intensity versus time is called a *hyetograph.* In design, the sequential increments of rainfall must be of equal duration. A good rule of thumb is to select the time increment to be

$$\frac{t_c}{5} \leq \Delta t \leq \frac{t_c}{3} \tag{4.7}$$

where t_c = time of concentration

Δt = the duration of each time segment of the hyetograph (period of constant intensity)

This guideline ensures that steady state runoff cannot occur during any individual segment of constant intensity (as is the case in nature). At the same time, it gives reasonable detail to the mass arrival characteristics of the rainfall. For convenience of computation, Δt should

HYDROLOGY FOR DRAINAGE SYSTEM DESIGN AND ANALYSIS

be an integer number of minutes and the total event duration should be an integer multiple of Δt.

A number of procedures have been developed for synthesizing hyetographs. Hereafter, these will be called hyetograph methods. Some (Kiefer and Chu, 1957; Huff, 1967; Pilgrim and Cordery, 1975; Yen and Chow, 1980; Soil Conservation Service, 1986) have developed procedures that derive from an analysis of temporal distributions of naturally occurring rainfall. Pilgrim and Cordery (1975) take a quasi-probabilistic approach that tends to preserve the position in time of the periods of highest intensity. Their procedure usually results in a multimodal distribution, whereas the other methods derived from analysis of naturally occurring rainfall result in unimodal distributions. Other arbitrary methods such as the alternating block method (Chow, Maidment, Mays; 1988) and a similar unnamed approach for creating a Probable Maximum Precipitation hyetograph (U.S. Bureau of Reclamation, 1974) rearrange rainfall segments so that the greatest depth of rainfall occurs prior to the period of peak intensity, and peak intensity is centered in the storm.

Application of the Pilgrim and Cordery method (1975) requires analysis of local or regional rainfall. Because this is a time consuming process, and because applicable rainfall data are not always present, this method has not been widely applied in the U.S. However, it has been adopted as a standard method of hydrologic design in Australia (The Institution of Engineers Australia, 1987) and has been recommended by Greene County, Missouri (Green County Storm-Water Design Standards, 1999).

Kiefer and Chu's procedure (1957) is generally known as the Chicago method. It presupposes an IDF relation of the form

$$i = \frac{a}{t_D^b + c} \tag{4.8}$$

where i = rainfall intensity, in/hr
t_D = total duration of rainfall, hr
a,b,c = shape and location parameters, dimensionless

An equation taken from Modern Sewer Design (1980) proposes an IDF relation (which they attribute to Kiefer and Chu (1957) of the form

$$i = \frac{a}{(t_D + c)^b} \tag{4.9}$$

where the variables and parameters are as defined above. Hyetographs derived from the Modern Sewer Design formulation are very similar to those that are derived from Kiefer and Chu. The peak intensity is slightly smaller and intensities preceding and following the period of peak intensity are slightly larger than those that derive from the Kiefer and Chu procedure. However, the differences are small, and in the application they result in no practical differences in either the computed peak rate or volume of runoff. Furthermore, the Kiefer and Chu Method requires trial and error fitting of periods of peak intensity so as to approximate the continuous curve of intensity versus time that derives from the method. The Modern Sewer Design formulation results in equations that can be integrated to find the proper intensities directly. It also has the advantage that the dimensionless parameters can be determined directly from IDF data.

Figure 4.2 shows a hyetograph for a 25-year, 2-hour rainfall in Rolla, MO as derived from the Modern Sewer Design approach. Rather than a continuously changing rainfall intensity, practical applications demand a discrete representation. By shifting the origin to the time of occurrence of peak intensity, the following equations can be used to find the depth of rainfall under the curve. The following equation can be used to determine the rainfall depth between the peak intensity and any time prior to the peak,

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

United States Department of Agriculture

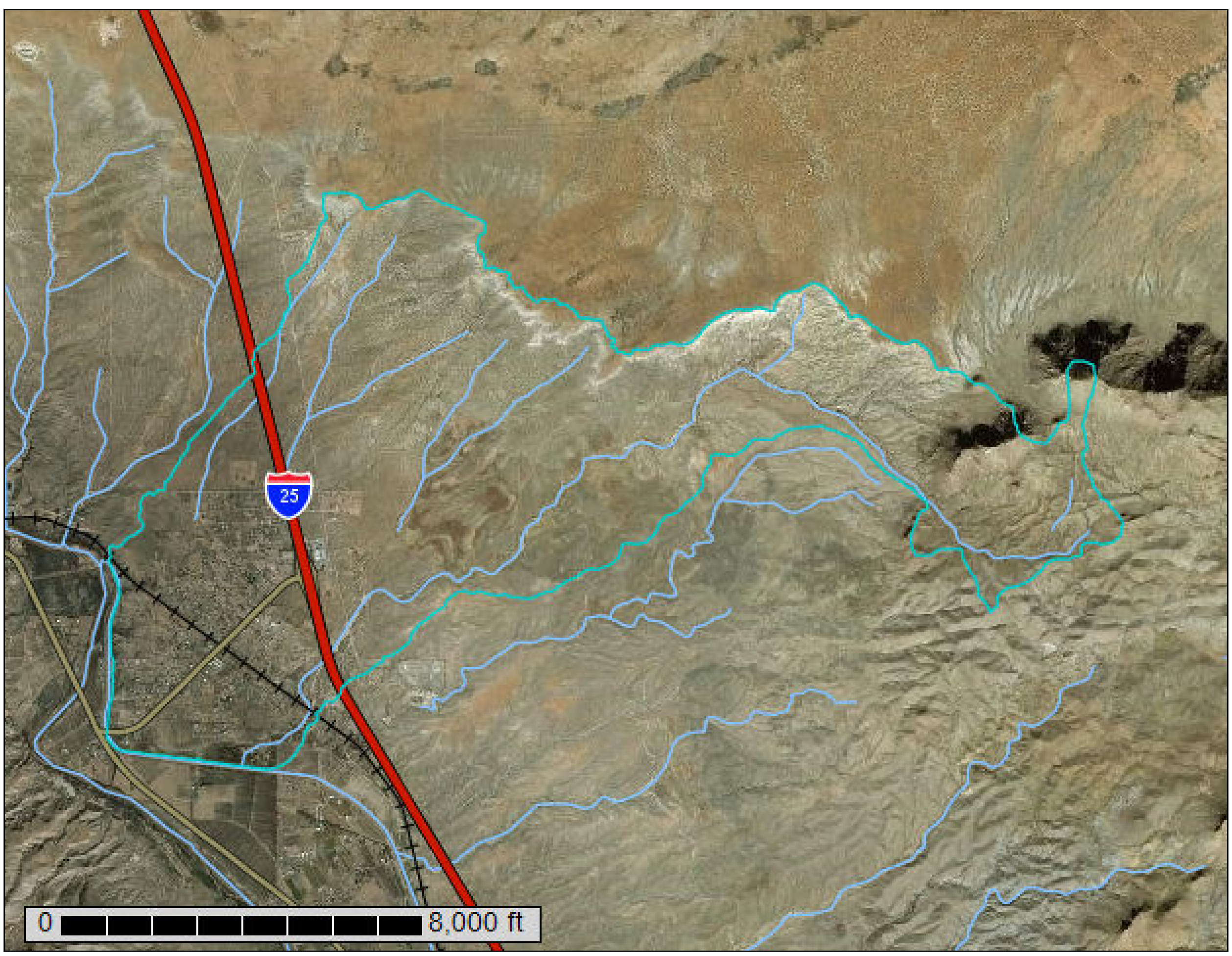
NRCS

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



August 21, 2017

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.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

Preface.......... 2
How Soil Surveys Are Made.......... 5
Soil Map.......... 8
Soil Map.......... 9
Legend.......... 10
Map Unit Legend.......... 11
Map Unit Descriptions.......... 11
Dona Ana County Area, New Mexico.......... 14
Ad—Adelino sandy clay loam.......... 14
Ae—Adelino clay loam.......... 15
Aw—Armijo clay loam.......... 16
BJ—Berino-Bucklebar association.......... 17
Bm—Bluepoint loamy sand, 0 to 5 percent slopes MLRA 42.......... 19
BO—Bluepoint loamy sand, 1 to 15 percent slopes MLRA 42.......... 20
BP—Bluepoint-Caliza-Yturbide complex.......... 21
Br—Brazito loamy fine sand, 0 to 1 percent slopes MLRA 42.2.......... 23
Ge—Glendale loam.......... 24
Gf—Glendale clay loam, 0 to 1 percent slopes MLRA 42.2.......... 25
GP—Gravel pit.......... 26
Hg—Harkey loam.......... 27
NU—Nickel-Upton association.......... 28
OP—Onite-Pajarito association.......... 30
Pa—Pajarito fine sandy loam.......... 32
RF—Riverwash-Arizo complex.......... 33
RG—Rock outcrop-Argids association.......... 34
RL—Rock outcrop-Lozier association.......... 36
RT—Rock outcrop-Torriorthents association MLRA 42.......... 38
Soil Information for All Uses.......... 40
Soil Properties and Qualities.......... 40
Soil Qualities and Features.......... 40
Hydrologic Soil Group (Radium Springs).......... 40
References.......... 45

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.

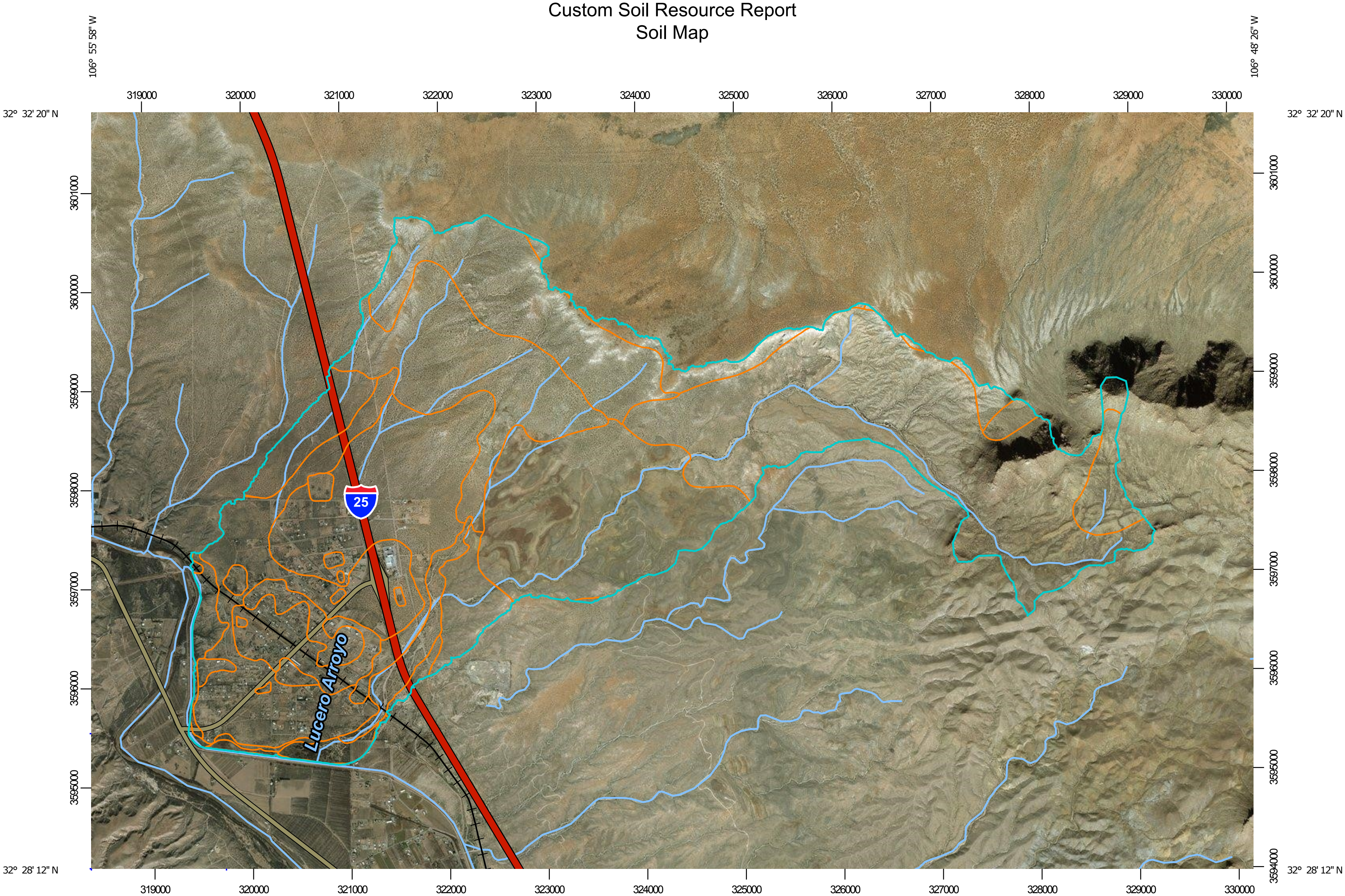
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree 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.

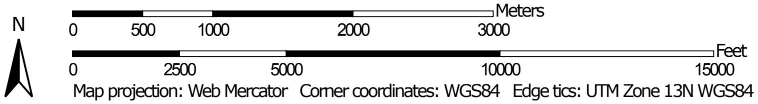
Soil Map

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: 1:53,900 if printed on A landscape (11" x 8.5") sheet.



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 12, Sep 26, 2014

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

Date(s) aerial images were photographed: Aug 3, 2011—Jan 31, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Dona Ana County Area, New Mexico (NM690)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Ad	Adelino sandy clay loam	78.5	1.3%
Ae	Adelino clay loam	172.4	2.9%
Aw	Armijo clay loam	1.1	0.0%
BJ	Berino-Bucklebar association	99.2	1.7%
Bm	Bluepoint loamy sand, 0 to 5 percent slopes MLRA 42	875.9	14.8%
BO	Bluepoint loamy sand, 1 to 15 percent slopes MLRA 42	604.3	10.2%
BP	Bluepoint-Caliza-Yturbide complex	765.5	12.9%
Br	Brazito loamy fine sand, 0 to 1 percent slopes MLRA 42.2	0.1	0.0%
Ge	Glendale loam	0.3	0.0%
Gf	Glendale clay loam, 0 to 1 percent slopes MLRA 42.2	10.2	0.2%
GP	Gravel pit	64.4	1.1%
Hg	Harkey loam	4.4	0.1%
NU	Nickel-Upton association	141.4	2.4%
OP	Onite-Pajarito association	31.4	0.5%
Pa	Pajarito fine sandy loam	668.9	11.3%
RF	Riverwash-Arizo complex	105.7	1.8%
RG	Rock outcrop-Argids association	1,452.5	24.5%
RL	Rock outcrop-Lozier association	842.5	14.2%
RT	Rock outcrop-Torriorthents association MLRA 42	2.9	0.0%
Totals for Area of Interest		**5,921.7**	**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

Ad—Adelino sandy clay loam

Map Unit Setting

National map unit symbol: p98p
Elevation: 3,800 to 4,200 feet
Mean annual precipitation: 8 to 10 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

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

Description of Adelino

Setting

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

Typical profile

H1 - 0 to 10 inches: sandy clay loam
H2 - 10 to 21 inches: sandy clay loam
H3 - 21 to 80 inches: 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): 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: 15 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: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 7c
Hydrologic Soil Group: B
Ecological site: Loamy (R042XA052NM)
Hydric soil rating: No

Ae—Adelino clay loam

Map Unit Setting

National map unit symbol: p98q
Elevation: 3,800 to 4,200 feet
Mean annual precipitation: 8 to 10 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

Adelino and similar soils: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Adelino

Setting

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

Typical profile

H1 - 0 to 5 inches: clay loam
H2 - 5 to 27 inches: clay loam
H3 - 27 to 60 inches: 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 (0.60 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: 15 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: High (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 7c
Hydrologic Soil Group: B
Ecological site: Loamy (R042XA052NM)
Hydric soil rating: No

Aw—Armijo clay loam

Map Unit Setting

National map unit symbol: p995
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 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

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

BJ—Berino-Bucklebar association

Map Unit Setting

National map unit symbol: p99c
Elevation: 4,000 to 5,000 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 60 to 64 degrees F
Frost-free period: 210 to 250 days
Farmland classification: Not prime farmland

Map Unit Composition

Berino and similar soils: 35 percent
Dona ana and similar soils: 25 percent
Bucklebar and similar soils: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Berino

Setting

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

Typical profile

H1 - 0 to 4 inches: loamy fine sand
H2 - 4 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 Bucklebar

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 2 inches: sandy loam
H2 - 2 to 25 inches: sandy clay loam
H3 - 25 to 38 inches: loam
H4 - 38 to 60 inches: silty 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: 15 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: High (about 9.1 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

Description of Dona Ana

Setting

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

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 46 inches: sandy clay loam
H3 - 46 to 60 inches: 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: 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): 2e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: Sandy (R042XB012NM)
Hydric soil rating: No

Bm—Bluepoint loamy sand, 0 to 5 percent slopes MLRA 42

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 70 degrees F
Frost-free period: 180 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Bluepoint and similar soils: 85 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

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

Map Unit Setting

National map unit symbol: 2spsg
Elevation: 3,720 to 4,300 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Bluepoint and similar soils: 75 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 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

BP—Bluepoint-Caliza-Yturbide complex

Map Unit Setting

National map unit symbol: p99k
Elevation: 3,800 to 4,400 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 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: Valley sides, alluvial fans
Landform position (three-dimensional): Rise
Down-slope shape: Concave, convex
Across-slope shape: Linear, convex
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

Br—Brazito loamy fine sand, 0 to 1 percent slopes MLRA 42.2

Map Unit Setting

National map unit symbol: 2t8vt
Elevation: 3,740 to 4,180 feet
Mean annual precipitation: 8 to 10 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

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

Typical profile

Ap - 0 to 13 inches: loamy fine sand
C - 13 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 1 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 (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: 2 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: Low (about 4.0 inches)

Interpretive groups

Land capability classification (irrigated): 4s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: Deep Sand (R042XB011NM)
Hydric soil rating: No

Ge—Glendale loam

Map Unit Setting

National map unit symbol: p99t
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 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

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

Description of Glendale

Setting

Landform: Flood plains, terraces
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

Gf—Glendale clay loam, 0 to 1 percent slopes MLRA 42.2

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

GP—Gravel pit

Map Unit Setting

National map unit symbol: p99x
Elevation: 4,000 to 5,000 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 60 to 64 degrees F

Frost-free period: 190 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Gravel pit: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Gravel Pit

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: Unranked

Hg—Harkey loam

Map Unit Setting

National map unit symbol: p9b0
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 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

NU—Nickel-Upton association

Map Unit Setting
National map unit symbol: p9b8
Elevation: 4,000 to 5,000 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
Nickel and similar soils: 50 percent
Upton and similar soils: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Nickel

Setting
Landform: Alluvial fans
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Mixed extremely gravelly coarse-loamy alluvium

Typical profile
H1 - 0 to 5 inches: very gravelly fine sandy loam
H2 - 5 to 60 inches: very gravelly sandy loam

Properties and qualities
Slope: 3 to 15 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 0.60 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)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Low (about 3.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7c
Hydrologic Soil Group: C
Ecological site: Gravelly (R042XB010NM)
Hydric soil rating: No

Description of Upton

Setting

Landform: Ridges
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 5 inches: gravelly sandy loam
H2 - 5 to 14 inches: gravelly sandy loam
H3 - 14 to 30 inches: cemented
H4 - 30 to 60 inches: very gravelly loam

Properties and qualities

Slope: 3 to 5 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: 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 1.6 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

OP—Onite-Pajarito association

Map Unit Setting

National map unit symbol: p9b9
Elevation: 4,000 to 5,000 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

Onite and similar soils: 40 percent
Pajarito and similar soils: 30 percent
Pintura and similar soils: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Onite

Setting

Landform: Basin floors
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Igneous derived coarse-loamy alluvium

Typical profile

H1 - 0 to 5 inches: loamy sand
H2 - 5 to 18 inches: sandy loam
H3 - 18 to 60 inches: loamy sand

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: 40 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 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7c
Hydrologic Soil Group: A

Ecological site: Sandy (R042XB012NM)
Hydric soil rating: No

Description of Pajarito

Setting

Landform: Dunes on basin floors
Landform position (three-dimensional): Rise
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Mixed coarse-loamy alluvium

Typical profile

H1 - 0 to 8 inches: fine sandy loam
H2 - 8 to 25 inches: fine sandy loam
H3 - 25 to 60 inches: fine sandy loam

Properties and qualities

Slope: 0 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: 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

Description of Pintura

Setting

Landform: Shrub-coppice dunes on basin floors
Landform position (three-dimensional): Rise
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Sandstone derived eolian sands

Typical profile

H1 - 0 to 8 inches: fine sand
H2 - 8 to 60 inches: fine 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: 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
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 4.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: Deep Sand (R042XB011NM)
Hydric soil rating: No

Pa—Pajarito fine sandy loam

Map Unit Setting

National map unit symbol: p9bc
Elevation: 3,750 to 4,200 feet
Mean annual precipitation: 8 to 10 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

RF—Riverwash-Arizo complex

Map Unit Setting
National map unit symbol: p9bh
Elevation: 3,700 to 4,400 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 190 to 230 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: Arroyos, valley floors
Landform position (three-dimensional): Talf
Down-slope shape: Convex, linear
Across-slope shape: Convex, concave
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

RG—Rock outcrop-Argids association

Map Unit Setting
National map unit symbol: p9bj
Elevation: 4,000 to 6,000 feet
Mean annual precipitation: 8 to 10 inches

Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 190 to 230 days
Farmland classification: Not prime farmland

Map Unit Composition

Rock outcrop: 40 percent
Argids and similar soils: 30 percent
Argids cool and similar soils: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rock Outcrop

Setting

Landform: Hills
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Igneous rock

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Description of Argids

Setting

Landform: Mountain slopes, hillslopes
Landform position (two-dimensional): Shoulder, footslope, summit, backslope, toeslope
Landform position (three-dimensional): Upper third of mountainflank, center third of mountainflank, lower third of mountainflank, 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 2 inches: loamy sand
H2 - 2 to 18 inches: fine sandy loam
H3 - 18 to 60 inches: bedrock

Properties and qualities

Slope: 15 to 80 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
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

Hydrologic Soil Group: D
Ecological site: Hills (R042XB027NM)
Hydric soil rating: No

Description of Argids Cool

Setting

Landform: Mountain slopes, hillslopes
Landform position (two-dimensional): Shoulder, footslope, summit, backslope, toeslope
Landform position (three-dimensional): Upper third of mountainflank, center third of mountainflank, lower third of mountainflank, 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 2 inches: loamy sand
H2 - 2 to 18 inches: fine sandy loam
H3 - 18 to 60 inches: bedrock

Properties and qualities

Slope: 15 to 80 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to low (0.00 to 0.01 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
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
Hydrologic Soil Group: D
Ecological site: Limestone Hills 13 to 16 inches (R042XE001NM)
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

RT—Rock outcrop-Torriorthents association MLRA 42

Map Unit Setting

National map unit symbol: 2spsk
Elevation: 4,000 to 6,000 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: 40 percent
Torriorthents 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: Basalt

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Description of Torriorthents

Setting

Landform: Hillslopes, mountain slopes
Landform position (two-dimensional): Backslope, footslope, shoulder, toeslope, summit
Landform position (three-dimensional): Upper third of mountainflank, center third of mountainflank, lower third of mountainflank, 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 6 inches: gravelly loam
H2 - 6 to 20 inches: gravelly sandy clay loam
H3 - 20 to 60 inches: bedrock

Properties and qualities

Slope: 15 to 50 percent
Depth to restrictive feature: 10 to 60 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to high (0.01 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: 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: Very low (about 2.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: Hills (R042XB027NM)
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 (Radium Springs)

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.

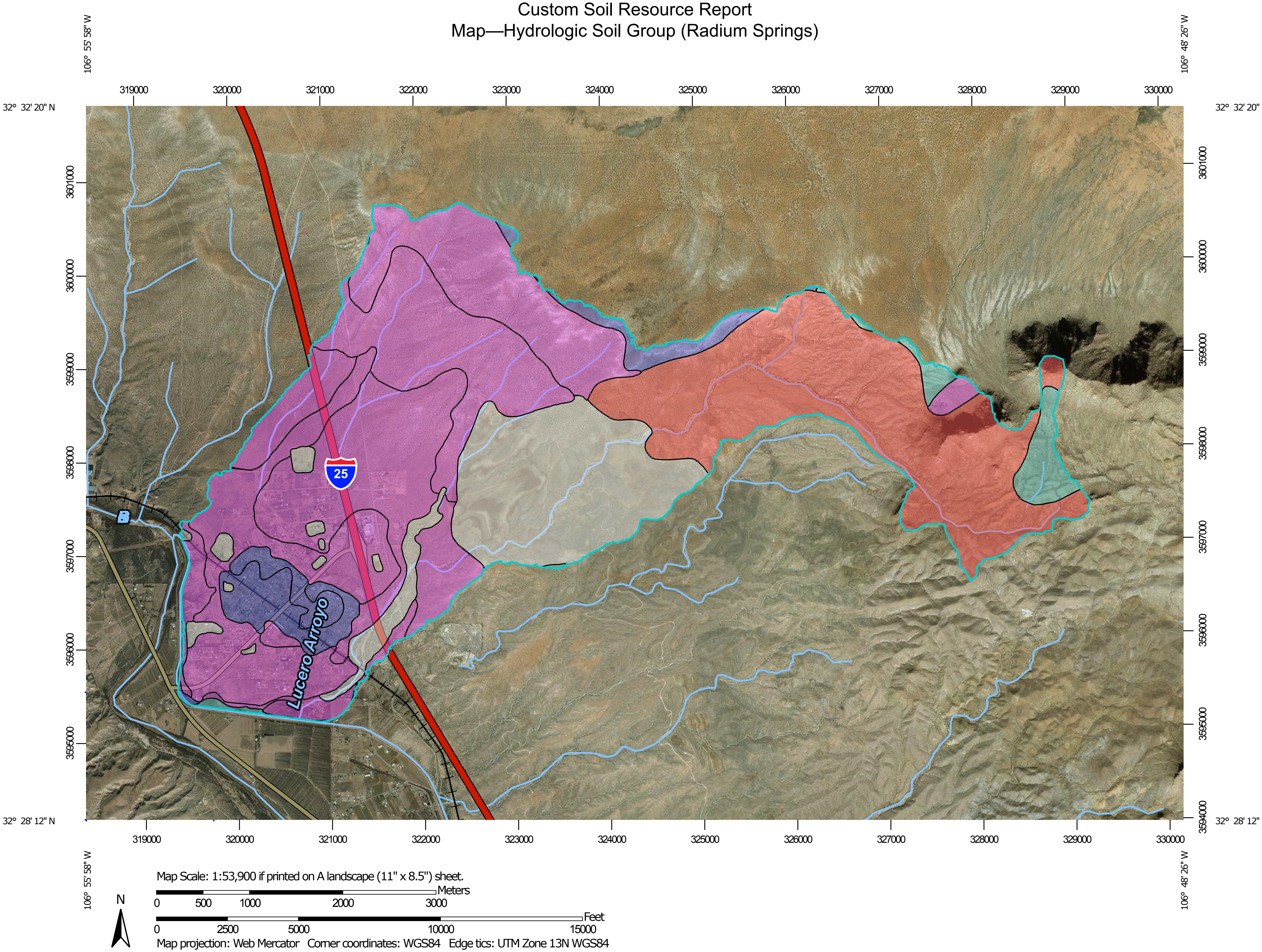
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

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 (Radium Springs)



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 12, Sep 26, 2014

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

Date(s) aerial images were photographed: Aug 3, 2011—Jan 31, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Hydrologic Soil Group (Radium Springs)

Hydrologic Soil Group— Summary by Map Unit — Dona Ana County Area, New Mexico (NM690)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
Ad	Adelino sandy clay loam	B	78.5	1.3%
Ae	Adelino clay loam	B	172.4	2.9%
Aw	Armijo clay loam	D	1.1	0.0%
BJ	Berino-Bucklebar association	B	99.2	1.7%
Bm	Bluepoint loamy sand, 0 to 5 percent slopes MLRA 42	A	875.9	14.8%
BO	Bluepoint loamy sand, 1 to 15 percent slopes MLRA 42	A	604.3	10.2%
BP	Bluepoint-Caliza-Yturbide complex	A	765.5	12.9%
Br	Brazito loamy fine sand, 0 to 1 percent slopes MLRA 42.2	A	0.1	0.0%
Ge	Glendale loam	C	0.3	0.0%
Gf	Glendale clay loam, 0 to 1 percent slopes MLRA 42.2	C	10.2	0.2%
GP	Gravel pit		64.4	1.1%
Hg	Harkey loam	B	4.4	0.1%
NU	Nickel-Upton association	C	141.4	2.4%
OP	Onite-Pajarito association	A	31.4	0.5%
Pa	Pajarito fine sandy loam	A	668.9	11.3%
RF	Riverwash-Arizo complex		105.7	1.8%
RG	Rock outcrop-Argids association	D	1,452.5	24.5%
RL	Rock outcrop-Lozier association		842.5	14.2%
RT	Rock outcrop-Torriorthents association MLRA 42		2.9	0.0%
Totals for Area of Interest			**5,921.7**	**100.0%**

Rating Options—Hydrologic Soil Group (Radium Springs)

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

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.

APPENDIX D

Existing and Proposed HEC-HMS Hydrologic Models (V4.2.1)

Digital Copies Only

Hydrologic Data Tables

Table D1 - 10yr-24 hr Exist Cond HEC-HMS Output
Table D2 - 50yr-24 hr Exist Cond HEC-HMS Output
Table D3 - 100yr-24 hr Exist Cond HEC-HMS Output

Table D4 - 10yr-24 hr Prop Cond HEC-HMS Output
Table D5 - 50yr-24 hr Prop Cond HEC-HMS Output
Table D6 - 100yr-24 hr Prop Cond HEC-HMS Output

TABLE D1 10-YR - 24 HR STORM HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
E1	1.98	1182	01Aug2017, 06:50	161.18
JE1	1.98	1182	01Aug2017, 06:50	161.18
RE2	1.98	1181	01Aug2017, 07:07	161.20
E2	1.30	816	01Aug2017, 06:47	105.96
JE2	3.28	1877	01Aug2017, 07:00	267.15
RE8_E2	3.28	1875	01Aug2017, 07:07	267.16
E3	0.94	314	01Aug2017, 06:43	40.03
JE3	0.94	314	01Aug2017, 06:43	40.03
RE8_E3	0.94	313	01Aug2017, 06:51	40.04
E8	0.51	293	01Aug2017, 06:33	29.73
JE8	4.73	2262	01Aug2017, 07:04	336.93
RE12	4.73	2261	01Aug2017, 07:07	336.93
E12	0.05	11	01Aug2017, 06:26	1.13
JE12	4.78	2264	01Aug2017, 07:07	338.05
E13	0.07	15	01Aug2017, 06:30	1.67
JE13	0.07	15	01Aug2017, 06:30	1.67
JSE3	4.85	2269	01Aug2017, 07:07	339.72
RW15	4.85	2269	01Aug2017, 07:09	339.73
E10	0.21	40	01Aug2017, 06:38	5.12
JE10	0.21	40	01Aug2017, 06:38	5.12
E9	0.17	39	01Aug2017, 06:26	4.03
JE9	0.17	39	01Aug2017, 06:26	4.03
J9-10	0.38	74	01Aug2017, 06:31	9.15
RE14	0.38	74	01Aug2017, 06:36	9.16
E14	0.03	7	01Aug2017, 06:19	0.63
JE14	0.41	78	01Aug2017, 06:36	9.78
Res-1	0.41	1	02Aug2017, 00:25	9.17
E15	0.05	41	01Aug2017, 06:22	3.13
Res-2	0.05	15	01Aug2017, 06:49	3.13
JE15	0.05	15	01Aug2017, 06:49	3.13
W19	0.03	53	01Aug2017, 06:09	2.36
JW19	0.08	63	01Aug2017, 06:09	5.48
JSE2	0.49	63	01Aug2017, 06:09	14.65
W16	0.09	35	01Aug2017, 06:35	3.84
JW16	0.58	68	01Aug2017, 06:10	18.49
W17	0.12	39	01Aug2017, 06:31	4.03
JW17	0.12	39	01Aug2017, 06:31	4.03
J16-17	0.69	100	01Aug2017, 06:31	22.53
E11	0.14	27	01Aug2017, 06:36	3.31
JSE4	0.14	27	01Aug2017, 06:36	3.31
W15	0.09	32	01Aug2017, 06:42	3.95

TABLE D1 10-YR - 24 HR STORM HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
JW15	5.77	2345	01Aug2017, 07:08	369.52
W7	0.08	26	01Aug2017, 06:30	2.65
JW7	5.85	2353	01Aug2017, 07:08	372.17
W1	0.14	50	01Aug2017, 06:37	5.76
W8	0.12	57	01Aug2017, 06:28	5.31
JW8	0.12	57	01Aug2017, 06:28	5.31
JW1	6.11	2393	01Aug2017, 07:08	383.24
LUCERO DAM	6.11	118	01Aug2017, 10:31	379.38
Sink-4	6.11	118	01Aug2017, 10:31	379.38
E6	0.41	80	01Aug2017, 06:35	9.74
JE6	0.41	80	01Aug2017, 06:35	9.74
RE5	0.41	80	01Aug2017, 06:48	9.74
E4	0.37	88	01Aug2017, 06:45	12.17
E5	0.29	58	01Aug2017, 06:34	6.94
JE5	1.07	214	01Aug2017, 06:44	28.85
RE20	1.07	214	01Aug2017, 06:48	28.86
E20	0.05	13	01Aug2017, 06:24	1.27
JE20	1.12	220	01Aug2017, 06:48	30.13
JNE5	1.12	220	01Aug2017, 06:48	30.13
E21	0.01	3	01Aug2017, 06:21	0.32
JE21	0.01	3	01Aug2017, 06:21	0.32
JNE6	0.01	3	01Aug2017, 06:21	0.32
E22	0.00	2	01Aug2017, 06:14	0.12
JE22	0.00	2	01Aug2017, 06:14	0.12
E23	0.00	0	01Aug2017, 06:13	0.03
JE23	0.00	0	01Aug2017, 06:13	0.03
JNE7	0.01	2	01Aug2017, 06:14	0.14
E19	0.00	1	01Aug2017, 06:13	0.05
JE19	0.00	1	01Aug2017, 06:13	0.05
JNE4	0.00	1	01Aug2017, 06:13	0.05
JNE 4-7	1.15	222	01Aug2017, 06:48	30.64
W26	0.09	38	01Aug2017, 06:23	3.31
JW26	1.24	239	01Aug2017, 06:47	33.95
E7	0.24	42	01Aug2017, 06:41	5.68
JE7	0.24	42	01Aug2017, 06:41	5.68
E28	0.01	3	01Aug2017, 06:18	0.25
JE28	0.25	43	01Aug2017, 06:40	5.93
W30	0.00	8	01Aug2017, 06:09	0.34
JW30	0.00	8	01Aug2017, 06:09	0.34
JNE11	0.25	44	01Aug2017, 06:39	6.27
E25	0.04	9	01Aug2017, 06:23	0.85

TABLE D1 10-YR - 24 HR STORM HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
JE25	0.04	9	01Aug2017, 06:23	0.85
JNE9	0.04	9	01Aug2017, 06:23	0.85
E24	0.03	8	01Aug2017, 06:20	0.73
JE24	0.03	8	01Aug2017, 06:20	0.73
W22	0.01	9	01Aug2017, 06:09	0.39
JW22	0.01	9	01Aug2017, 06:09	0.39
JNE8	0.04	13	01Aug2017, 06:13	1.12
E29	0.02	6	01Aug2017, 06:22	0.59
JE29	0.02	6	01Aug2017, 06:22	0.59
JNE12	0.02	6	01Aug2017, 06:22	0.59
E26	0.01	3	01Aug2017, 06:18	0.27
JE26	0.01	3	01Aug2017, 06:18	0.27
E27	0.00	1	01Aug2017, 06:13	0.05
JE27	0.00	1	01Aug2017, 06:13	0.05
JNE10	0.01	4	01Aug2017, 06:18	0.32
JNE8-12	0.36	64	01Aug2017, 06:33	9.15
RW27	0.36	64	01Aug2017, 06:45	9.15
W27	0.20	71	01Aug2017, 06:28	6.91
JW27	0.56	122	01Aug2017, 06:33	16.06
J26-27	1.80	348	01Aug2017, 06:45	50.01
Diversion-1	1.80	70	01Aug2017, 06:45	10.00
W28	0.01	2	01Aug2017, 06:19	0.18
JW28	1.80	71	01Aug2017, 06:44	10.19
RW12	1.80	70	01Aug2017, 06:58	10.19
W12	0.14	56	01Aug2017, 06:27	5.26
JW12	1.94	93	01Aug2017, 06:55	15.45
Sink-2	1.94	93	01Aug2017, 06:55	15.45
W25	0.13	53	01Aug2017, 06:22	4.46
JW25	0.13	53	01Aug2017, 06:22	4.46
J25-26	0.13	304	01Aug2017, 06:43	44.47
W24	0.04	2	01Aug2017, 06:40	0.30
JW24	0.04	2	01Aug2017, 06:40	0.30
J24-25	0.17	306	01Aug2017, 06:43	44.77
W23	0.02	1	01Aug2017, 06:22	0.18
JW23	0.02	1	01Aug2017, 06:22	0.18
J23-24	0.19	307	01Aug2017, 06:43	44.95
W13	0.15	35	01Aug2017, 06:39	4.41
JW13	0.15	35	01Aug2017, 06:39	4.41
J13-23	0.34	341	01Aug2017, 06:43	49.36
E17	0.08	20	01Aug2017, 06:25	1.96
JE17	0.08	20	01Aug2017, 06:25	1.96

TABLE D1 10-YR - 24 HR STORM HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
E18	0.01	3	01Aug2017, 06:21	0.30
JE18	0.01	3	01Aug2017, 06:21	0.30
W21	0.01	14	01Aug2017, 06:09	0.62
JW21	0.01	14	01Aug2017, 06:09	0.62
JNE3	0.02	15	01Aug2017, 06:10	0.91
JNE2	0.10	28	01Aug2017, 06:21	2.87
E16	0.01	4	01Aug2017, 06:18	0.35
JE16	0.01	4	01Aug2017, 06:18	0.35
W20	0.01	12	01Aug2017, 06:09	0.54
JW20	0.01	12	01Aug2017, 06:09	0.54
JNE1	0.12	38	01Aug2017, 06:17	3.76
W29	0.02	10	01Aug2017, 06:19	0.74
JW29	0.14	47	01Aug2017, 06:18	4.50
W14	0.12	11	01Aug2017, 06:43	1.73
JW14	0.27	50	01Aug2017, 06:20	6.24
J13-14	0.61	374	01Aug2017, 06:42	55.59
W10	0.02	8	01Aug2017, 06:45	1.09
JW10	0.63	382	01Aug2017, 06:42	56.68
W11	0.07	23	01Aug2017, 06:33	2.45
JW11	0.07	23	01Aug2017, 06:33	2.45
J10-11	0.69	402	01Aug2017, 06:42	59.13
Sink-3	0.69	402	01Aug2017, 06:42	59.13
W9	0.09	37	01Aug2017, 06:47	4.89
JW9	0.09	37	01Aug2017, 06:47	4.89
W5	0.07	29	01Aug2017, 06:22	2.46
JW5	0.07	29	01Aug2017, 06:22	2.46
W4	0.02	9	01Aug2017, 06:19	0.70
JW4	0.18	57	01Aug2017, 06:32	8.06
Sink-6	0.18	57	01Aug2017, 06:32	8.06
W2	0.15	59	01Aug2017, 06:30	5.82
JW2	0.15	59	01Aug2017, 06:30	5.82
Sink-1	0.15	59	01Aug2017, 06:30	5.82
W3	0.13	23	01Aug2017, 07:18	4.94
JW3	0.13	23	01Aug2017, 07:18	4.94

TABLE D2 50-YR - 24 HR STORM HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
E1	1.98	1869	01Aug2017, 06:50	249.30
JE1	1.98	1869	01Aug2017, 06:50	249.30
RE2	1.98	1867	01Aug2017, 07:04	249.32
E2	1.30	1291	01Aug2017, 06:47	163.87
JE2	3.28	3001	01Aug2017, 06:58	413.19
RE8_E2	3.28	2998	01Aug2017, 07:04	413.20
E3	0.94	608	01Aug2017, 06:41	72.57
JE3	0.94	608	01Aug2017, 06:41	72.57
RE8_E3	0.94	608	01Aug2017, 06:48	72.58
E8	0.51	514	01Aug2017, 06:32	49.96
JE8	4.73	3739	01Aug2017, 07:00	535.74
RE12	4.73	3737	01Aug2017, 07:03	535.73
E12	0.05	27	01Aug2017, 06:24	2.38
JE12	4.78	3744	01Aug2017, 07:03	538.11
E13	0.07	37	01Aug2017, 06:28	3.52
JE13	0.07	37	01Aug2017, 06:28	3.52
JSE3	4.85	3756	01Aug2017, 07:03	541.63
RW15	4.85	3754	01Aug2017, 07:04	541.63
E10	0.21	96	01Aug2017, 06:35	10.79
JE10	0.21	96	01Aug2017, 06:35	10.79
E9	0.17	97	01Aug2017, 06:24	8.50
JE9	0.17	97	01Aug2017, 06:24	8.50
J9-10	0.38	181	01Aug2017, 06:28	19.30
RE14	0.38	181	01Aug2017, 06:32	19.30
E14	0.03	19	01Aug2017, 06:17	1.32
JE14	0.41	191	01Aug2017, 06:32	20.62
Res-1	0.41	8	01Aug2017, 09:16	16.11
E15	0.05	69	01Aug2017, 06:22	5.11
Res-2	0.05	21	01Aug2017, 06:52	5.11
JE15	0.05	21	01Aug2017, 06:52	5.11
W19	0.03	83	01Aug2017, 06:09	3.64
JW19	0.08	94	01Aug2017, 06:09	8.75
JSE2	0.49	94	01Aug2017, 06:09	24.86
W16	0.09	68	01Aug2017, 06:33	6.96
JW16	0.58	108	01Aug2017, 06:10	31.83
W17	0.12	81	01Aug2017, 06:29	7.69
JW17	0.12	81	01Aug2017, 06:29	7.69
J16-17	0.69	186	01Aug2017, 06:30	39.52
E11	0.14	65	01Aug2017, 06:33	6.98
JSE4	0.14	65	01Aug2017, 06:33	6.98
W15	0.09	61	01Aug2017, 06:40	7.17

TABLE D2 50-YR - 24 HR STORM HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
JW15	5.77	3906	01Aug2017, 07:04	595.30
W7	0.08	54	01Aug2017, 06:29	5.05
JW7	5.85	3924	01Aug2017, 07:04	600.35
W1	0.14	100	01Aug2017, 06:35	10.62
W8	0.12	111	01Aug2017, 06:26	9.62
JW8	0.12	111	01Aug2017, 06:26	9.62
JW1	6.11	4007	01Aug2017, 07:03	620.59
LUCERO DAM	6.11	231	01Aug2017, 09:37	615.48
Sink-4	6.11	231	01Aug2017, 09:37	615.48
E6	0.41	194	01Aug2017, 06:32	20.53
JE6	0.41	194	01Aug2017, 06:32	20.53
RE5	0.41	194	01Aug2017, 06:42	20.54
E4	0.37	187	01Aug2017, 06:43	23.64
E5	0.29	141	01Aug2017, 06:31	14.63
JE5	1.07	501	01Aug2017, 06:39	58.81
RE20	1.07	501	01Aug2017, 06:42	58.82
E20	0.05	32	01Aug2017, 06:22	2.68
JE20	1.12	518	01Aug2017, 06:42	61.50
JNE5	1.12	518	01Aug2017, 06:42	61.50
E21	0.01	9	01Aug2017, 06:20	0.67
JE21	0.01	9	01Aug2017, 06:20	0.67
JNE6	0.01	9	01Aug2017, 06:20	0.67
E22	0.00	4	01Aug2017, 06:13	0.24
JE22	0.00	4	01Aug2017, 06:13	0.24
E23	0.00	1	01Aug2017, 06:11	0.06
JE23	0.00	1	01Aug2017, 06:11	0.06
JNE7	0.01	5	01Aug2017, 06:13	0.30
E19	0.00	2	01Aug2017, 06:11	0.11
JE19	0.00	2	01Aug2017, 06:11	0.11
JNE4	0.00	2	01Aug2017, 06:11	0.11
JNE 4-7	1.15	523	01Aug2017, 06:42	62.58
W26	0.09	81	01Aug2017, 06:22	6.31
JW26	1.24	565	01Aug2017, 06:41	68.89
E7	0.24	101	01Aug2017, 06:38	11.97
JE7	0.24	101	01Aug2017, 06:38	11.97
E28	0.01	7	01Aug2017, 06:17	0.53
JE28	0.25	104	01Aug2017, 06:37	12.50
W30	0.00	12	01Aug2017, 06:09	0.52
JW30	0.00	12	01Aug2017, 06:09	0.52
JNE11	0.25	105	01Aug2017, 06:37	13.02
E25	0.04	22	01Aug2017, 06:21	1.80

TABLE D2 50-YR - 24 HR STORM HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
JE25	0.04	22	01Aug2017, 06:21	1.80
JNE9	0.04	22	01Aug2017, 06:21	1.80
E24	0.03	21	01Aug2017, 06:18	1.54
JE24	0.03	21	01Aug2017, 06:18	1.54
W22	0.01	14	01Aug2017, 06:09	0.60
JW22	0.01	14	01Aug2017, 06:09	0.60
JNE8	0.04	29	01Aug2017, 06:15	2.14
E29	0.02	16	01Aug2017, 06:20	1.25
JE29	0.02	16	01Aug2017, 06:20	1.25
JNE12	0.02	16	01Aug2017, 06:20	1.25
E26	0.01	8	01Aug2017, 06:16	0.58
JE26	0.01	8	01Aug2017, 06:16	0.58
E27	0.00	2	01Aug2017, 06:12	0.10
JE27	0.00	2	01Aug2017, 06:12	0.10
JNE10	0.01	10	01Aug2017, 06:16	0.67
JNE8-12	0.36	151	01Aug2017, 06:30	18.88
RW27	0.36	151	01Aug2017, 06:40	18.89
W27	0.20	149	01Aug2017, 06:26	13.17
JW27	0.56	283	01Aug2017, 06:31	32.06
J26-27	1.80	824	01Aug2017, 06:39	100.95
Diversion-1	1.80	165	01Aug2017, 06:39	20.19
W28	0.01	5	01Aug2017, 06:18	0.35
JW28	1.80	167	01Aug2017, 06:38	20.54
RW12	1.80	167	01Aug2017, 06:49	20.55
W12	0.14	115	01Aug2017, 06:25	9.86
JW12	1.94	228	01Aug2017, 06:45	30.41
Sink-2	1.94	228	01Aug2017, 06:45	30.41
W25	0.13	112	01Aug2017, 06:21	8.51
JW25	0.13	112	01Aug2017, 06:21	8.51
J25-26	0.13	723	01Aug2017, 06:37	89.26
W24	0.04	7	01Aug2017, 06:31	0.93
JW24	0.04	7	01Aug2017, 06:31	0.93
J24-25	0.17	730	01Aug2017, 06:37	90.20
W23	0.02	7	01Aug2017, 06:14	0.55
JW23	0.02	7	01Aug2017, 06:14	0.55
J23-24	0.19	733	01Aug2017, 06:37	90.75
W13	0.15	77	01Aug2017, 06:37	8.72
JW13	0.15	77	01Aug2017, 06:37	8.72
J13-23	0.34	810	01Aug2017, 06:37	99.47
E17	0.08	49	01Aug2017, 06:23	4.13
JE17	0.08	49	01Aug2017, 06:23	4.13

TABLE D2 50-YR - 24 HR STORM HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
E18	0.01	8	01Aug2017, 06:20	0.63
JE18	0.01	8	01Aug2017, 06:20	0.63
W21	0.01	22	01Aug2017, 06:09	0.95
JW21	0.01	22	01Aug2017, 06:09	0.95
JNE3	0.02	26	01Aug2017, 06:10	1.58
JNE2	0.10	65	01Aug2017, 06:20	5.71
E16	0.01	11	01Aug2017, 06:16	0.73
JE16	0.01	11	01Aug2017, 06:16	0.73
W20	0.01	19	01Aug2017, 06:09	0.83
JW20	0.01	19	01Aug2017, 06:09	0.83
JNE1	0.12	84	01Aug2017, 06:18	7.28
W29	0.02	21	01Aug2017, 06:18	1.42
JW29	0.14	105	01Aug2017, 06:18	8.70
W14	0.12	33	01Aug2017, 06:38	4.30
JW14	0.27	120	01Aug2017, 06:21	13.00
J13-14	0.61	901	01Aug2017, 06:36	112.47
W10	0.02	15	01Aug2017, 06:44	1.91
JW10	0.63	916	01Aug2017, 06:36	114.37
W11	0.07	47	01Aug2017, 06:31	4.60
JW11	0.07	47	01Aug2017, 06:31	4.60
J10-11	0.69	961	01Aug2017, 06:36	118.97
Sink-3	0.69	961	01Aug2017, 06:36	118.97
W9	0.09	66	01Aug2017, 06:46	8.34
JW9	0.09	66	01Aug2017, 06:46	8.34
W5	0.07	62	01Aug2017, 06:21	4.70
JW5	0.07	62	01Aug2017, 06:21	4.70
W4	0.02	19	01Aug2017, 06:18	1.34
JW4	0.18	112	01Aug2017, 06:25	14.37
Sink-6	0.18	112	01Aug2017, 06:25	14.37
W2	0.15	117	01Aug2017, 06:28	10.73
JW2	0.15	117	01Aug2017, 06:28	10.73
Sink-1	0.15	117	01Aug2017, 06:28	10.73
W3	0.13	46	01Aug2017, 07:16	9.26
JW3	0.13	46	01Aug2017, 07:16	9.26
Sink-5	0.13	46	01Aug2017, 07:16	9.26
W6	0.03	23	01Aug2017, 06:23	1.88
JW6	0.03	23	01Aug2017, 06:23	1.88
Sink-7	0.03	23	01Aug2017, 06:23	1.88
W18	0.01	28	01Aug2017, 06:09	1.21
Sink-8	0.01	28	01Aug2017, 06:09	1.21

TABLE D3 100-YR - 24 HR STORM HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
E1	1.98	2186	01Aug2017, 06:50	291.78
JE1	1.98	2186	01Aug2017, 06:50	291.78
RE2	1.98	2184	01Aug2017, 07:03	291.80
E2	1.30	1510	01Aug2017, 06:47	191.79
JE2	3.28	3522	01Aug2017, 06:57	483.59
RE8_E2	3.28	3519	01Aug2017, 07:03	483.59
E3	0.94	755	01Aug2017, 06:41	89.24
JE3	0.94	755	01Aug2017, 06:41	89.24
RE8_E3	0.94	754	01Aug2017, 06:47	89.25
E8	0.51	620	01Aug2017, 06:32	60.02
JE8	4.73	4439	01Aug2017, 06:59	632.87
RE12	4.73	4436	01Aug2017, 07:01	632.85
E12	0.05	36	01Aug2017, 06:24	3.05
JE12	4.78	4446	01Aug2017, 07:01	635.90
E13	0.07	48	01Aug2017, 06:27	4.52
JE13	0.07	48	01Aug2017, 06:27	4.52
JSE3	4.85	4462	01Aug2017, 07:01	640.43
RW15	4.85	4460	01Aug2017, 07:03	640.43
E10	0.21	126	01Aug2017, 06:34	13.87
JE10	0.21	126	01Aug2017, 06:34	13.87
E9	0.17	129	01Aug2017, 06:23	10.93
JE9	0.17	129	01Aug2017, 06:23	10.93
J9-10	0.38	239	01Aug2017, 06:27	24.80
RE14	0.38	238	01Aug2017, 06:31	24.80
E14	0.03	25	01Aug2017, 06:16	1.70
JE14	0.41	252	01Aug2017, 06:31	26.50
Res-1	0.41	74	01Aug2017, 07:15	21.98
E15	0.05	83	01Aug2017, 06:22	6.08
Res-2	0.05	23	01Aug2017, 06:53	6.08
JE15	0.05	23	01Aug2017, 06:53	6.08
W19	0.03	97	01Aug2017, 06:09	4.27
JW19	0.08	108	01Aug2017, 06:09	10.35
JSE2	0.49	108	01Aug2017, 06:09	32.32
W16	0.09	85	01Aug2017, 06:33	8.56
JW16	0.58	127	01Aug2017, 06:10	40.89
W17	0.12	103	01Aug2017, 06:29	9.61
JW17	0.12	103	01Aug2017, 06:29	9.61
J16-17	0.69	228	01Aug2017, 06:29	50.49
E11	0.14	85	01Aug2017, 06:32	8.97
JSE4	0.14	85	01Aug2017, 06:32	8.97
W15	0.09	76	01Aug2017, 06:40	8.81

TABLE D3 100-YR - 24 HR STORM HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
JW15	5.77	4651	01Aug2017, 07:02	708.71
W7	0.08	68	01Aug2017, 06:28	6.31
JW7	5.85	4675	01Aug2017, 07:02	715.02
W1	0.14	124	01Aug2017, 06:35	13.12
W8	0.12	138	01Aug2017, 06:26	11.83
JW8	0.12	138	01Aug2017, 06:26	11.83
JW1	6.11	4780	01Aug2017, 07:02	739.97
LUCERO DAM	6.11	323	01Aug2017, 09:22	734.54
Sink-4	6.11	323	01Aug2017, 09:22	734.54
E6	0.41	256	01Aug2017, 06:31	26.38
JE6	0.41	256	01Aug2017, 06:31	26.38
RE5	0.41	256	01Aug2017, 06:40	26.39
E4	0.37	239	01Aug2017, 06:42	29.68
E5	0.29	186	01Aug2017, 06:30	18.79
JE5	1.07	655	01Aug2017, 06:38	74.87
RE20	1.07	654	01Aug2017, 06:41	74.87
E20	0.05	43	01Aug2017, 06:21	3.44
JE20	1.12	677	01Aug2017, 06:41	78.32
JNE5	1.12	677	01Aug2017, 06:41	78.32
E21	0.01	12	01Aug2017, 06:19	0.86
JE21	0.01	12	01Aug2017, 06:19	0.86
JNE6	0.01	12	01Aug2017, 06:19	0.86
E22	0.00	5	01Aug2017, 06:13	0.31
JE22	0.00	5	01Aug2017, 06:13	0.31
E23	0.00	1	01Aug2017, 06:11	0.08
JE23	0.00	1	01Aug2017, 06:11	0.08
JNE7	0.01	7	01Aug2017, 06:12	0.39
E19	0.00	2	01Aug2017, 06:11	0.14
JE19	0.00	2	01Aug2017, 06:11	0.14
JNE4	0.00	2	01Aug2017, 06:11	0.14
JNE 4-7	1.15	684	01Aug2017, 06:40	79.71
W26	0.09	103	01Aug2017, 06:21	7.88
JW26	1.24	739	01Aug2017, 06:39	87.59
E7	0.24	132	01Aug2017, 06:37	15.39
JE7	0.24	132	01Aug2017, 06:37	15.39
E28	0.01	10	01Aug2017, 06:16	0.68
JE28	0.25	136	01Aug2017, 06:37	16.06
W30	0.00	14	01Aug2017, 06:09	0.61
JW30	0.00	14	01Aug2017, 06:09	0.61
JNE11	0.25	139	01Aug2017, 06:36	16.67
E25	0.04	29	01Aug2017, 06:21	2.31

TABLE D3 100-YR - 24 HR STORM HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
JE25	0.04	29	01Aug2017, 06:21	2.31
JNE9	0.04	29	01Aug2017, 06:21	2.31
E24	0.03	28	01Aug2017, 06:18	1.98
JE24	0.03	28	01Aug2017, 06:18	1.98
W22	0.01	16	01Aug2017, 06:09	0.71
JW22	0.01	16	01Aug2017, 06:09	0.71
JNE8	0.04	37	01Aug2017, 06:15	2.68
E29	0.02	21	01Aug2017, 06:20	1.61
JE29	0.02	21	01Aug2017, 06:20	1.61
JNE12	0.02	21	01Aug2017, 06:20	1.61
E26	0.01	11	01Aug2017, 06:16	0.74
JE26	0.01	11	01Aug2017, 06:16	0.74
E27	0.00	2	01Aug2017, 06:11	0.12
JE27	0.00	2	01Aug2017, 06:11	0.12
JNE10	0.01	13	01Aug2017, 06:15	0.86
JNE8-12	0.36	198	01Aug2017, 06:28	24.14
RW27	0.36	198	01Aug2017, 06:38	24.14
W27	0.20	189	01Aug2017, 06:26	16.44
JW27	0.56	369	01Aug2017, 06:30	40.59
J26-27	1.80	1079	01Aug2017, 06:37	128.18
Diversion-1	1.80	216	01Aug2017, 06:37	25.64
W28	0.01	6	01Aug2017, 06:18	0.44
JW28	1.80	219	01Aug2017, 06:37	26.08
RW12	1.80	218	01Aug2017, 06:46	26.08
W12	0.14	145	01Aug2017, 06:25	12.25
JW12	1.94	300	01Aug2017, 06:42	38.33
Sink-2	1.94	300	01Aug2017, 06:42	38.33
W25	0.13	142	01Aug2017, 06:21	10.62
JW25	0.13	142	01Aug2017, 06:21	10.62
J25-26	0.13	946	01Aug2017, 06:36	113.16
W24	0.04	11	01Aug2017, 06:30	1.32
JW24	0.04	11	01Aug2017, 06:30	1.32
J24-25	0.17	956	01Aug2017, 06:36	114.48
W23	0.02	10	01Aug2017, 06:13	0.78
JW23	0.02	10	01Aug2017, 06:13	0.78
J23-24	0.19	960	01Aug2017, 06:36	115.26
W13	0.15	99	01Aug2017, 06:36	11.01
JW13	0.15	99	01Aug2017, 06:36	11.01
J13-23	0.34	1060	01Aug2017, 06:36	126.27
E17	0.08	64	01Aug2017, 06:22	5.31
JE17	0.08	64	01Aug2017, 06:22	5.31

TABLE D3 100-YR - 24 HR STORM HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
E18	0.01	11	01Aug2017, 06:19	0.81
JE18	0.01	11	01Aug2017, 06:19	0.81
W21	0.01	25	01Aug2017, 06:09	1.12
JW21	0.01	25	01Aug2017, 06:09	1.12
JNE3	0.02	31	01Aug2017, 06:10	1.92
JNE2	0.10	85	01Aug2017, 06:20	7.23
E16	0.01	14	01Aug2017, 06:16	0.94
JE16	0.01	14	01Aug2017, 06:16	0.94
W20	0.01	22	01Aug2017, 06:09	0.97
JW20	0.01	22	01Aug2017, 06:09	0.97
JNE1	0.12	109	01Aug2017, 06:18	9.15
W29	0.02	26	01Aug2017, 06:17	1.77
JW29	0.14	135	01Aug2017, 06:18	10.92
W14	0.12	46	01Aug2017, 06:37	5.77
JW14	0.27	158	01Aug2017, 06:21	16.69
J13-14	0.61	1184	01Aug2017, 06:35	142.96
W10	0.02	19	01Aug2017, 06:43	2.32
JW10	0.63	1201	01Aug2017, 06:35	145.28
W11	0.07	59	01Aug2017, 06:31	5.71
JW11	0.07	59	01Aug2017, 06:31	5.71
J10-11	0.69	1258	01Aug2017, 06:34	150.99
Sink-3	0.69	1258	01Aug2017, 06:34	150.99
W9	0.09	79	01Aug2017, 06:46	10.06
JW9	0.09	79	01Aug2017, 06:46	10.06
W5	0.07	78	01Aug2017, 06:21	5.86
JW5	0.07	78	01Aug2017, 06:21	5.86
W4	0.02	25	01Aug2017, 06:18	1.67
JW4	0.18	140	01Aug2017, 06:24	17.60
Sink-6	0.18	140	01Aug2017, 06:24	17.60
W2	0.15	146	01Aug2017, 06:28	13.26
JW2	0.15	146	01Aug2017, 06:28	13.26
Sink-1	0.15	146	01Aug2017, 06:28	13.26
W3	0.13	58	01Aug2017, 07:15	11.50
JW3	0.13	58	01Aug2017, 07:15	11.50
Sink-5	0.13	58	01Aug2017, 07:15	11.50
W6	0.03	29	01Aug2017, 06:23	2.34
JW6	0.03	29	01Aug2017, 06:23	2.34
Sink-7	0.03	29	01Aug2017, 06:23	2.34
W18	0.01	32	01Aug2017, 06:09	1.41
Sink-8	0.01	32	01Aug2017, 06:09	1.41

TABLE D4 10-YR - 24 HR STORM HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
E1	1.98	1182	01Aug2017, 06:50	161.18
JE1	1.98	1182	01Aug2017, 06:50	161.18
RE2	1.98	1181	01Aug2017, 07:07	161.20
E2	1.30	816	01Aug2017, 06:47	105.96
JE2	3.28	1877	01Aug2017, 07:00	267.15
RE8_E2	3.28	1875	01Aug2017, 07:07	267.16
E3	0.94	314	01Aug2017, 06:43	40.03
JE3	0.94	314	01Aug2017, 06:43	40.03
RE8_E3	0.94	313	01Aug2017, 06:51	40.04
E8	0.51	293	01Aug2017, 06:33	29.73
JE8	4.73	2262	01Aug2017, 07:04	336.93
RE12	4.73	2261	01Aug2017, 07:07	336.93
E12	0.05	11	01Aug2017, 06:26	1.13
JE12	4.78	2264	01Aug2017, 07:07	338.05
E13	0.07	15	01Aug2017, 06:30	1.67
JE13	0.07	15	01Aug2017, 06:30	1.67
JSE3	4.85	2269	01Aug2017, 07:07	339.72
RW15	4.85	2269	01Aug2017, 07:09	339.73
E10	0.21	40	01Aug2017, 06:38	5.12
JE10	0.21	40	01Aug2017, 06:38	5.12
E9	0.17	39	01Aug2017, 06:26	4.03
JE9	0.17	39	01Aug2017, 06:26	4.03
J9-10	0.38	74	01Aug2017, 06:31	9.15
RE14	0.38	74	01Aug2017, 06:36	9.16
E14	0.03	7	01Aug2017, 06:19	0.63
JE14	0.41	78	01Aug2017, 06:36	9.78
Res-1	0.41	1	02Aug2017, 00:25	9.17
E15	0.05	41	01Aug2017, 06:22	3.13
Res-2	0.05	15	01Aug2017, 06:49	3.13
JE15	0.05	15	01Aug2017, 06:49	3.13
W19	0.03	53	01Aug2017, 06:09	2.36
JW19	0.08	63	01Aug2017, 06:09	5.48
JSE2	0.49	63	01Aug2017, 06:09	14.65
W16	0.09	35	01Aug2017, 06:35	3.84
JW16	0.58	68	01Aug2017, 06:10	18.49
W17	0.12	39	01Aug2017, 06:31	4.03
JW17	0.12	39	01Aug2017, 06:31	4.03
J16-17	0.69	100	01Aug2017, 06:31	22.53
E11	0.14	27	01Aug2017, 06:36	3.31
JSE4	0.14	27	01Aug2017, 06:36	3.31
W15	0.09	32	01Aug2017, 06:42	3.95
JW15	5.77	2345	01Aug2017, 07:08	369.52
W7	0.08	26	01Aug2017, 06:30	2.65

TABLE D4 10-YR - 24 HR STORM HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
JW7	5.85	2353	01Aug2017, 07:08	372.17
W1	0.14	50	01Aug2017, 06:37	5.76
W8	0.12	57	01Aug2017, 06:28	5.31
JW8	0.12	57	01Aug2017, 06:28	5.31
JW1	6.11	2393	01Aug2017, 07:08	383.24
LUCERO DAM	6.11	118	01Aug2017, 10:31	379.38
Sink-4	6.11	118	01Aug2017, 10:31	379.38
E6	0.41	80	01Aug2017, 06:35	9.74
JE6	0.41	80	01Aug2017, 06:35	9.74
RE5	0.41	80	01Aug2017, 06:48	9.74
E4	0.37	88	01Aug2017, 06:45	12.17
E5	0.29	58	01Aug2017, 06:34	6.94
JE5	1.07	214	01Aug2017, 06:44	28.85
RE20	1.07	214	01Aug2017, 06:48	28.86
E20	0.05	13	01Aug2017, 06:24	1.27
JE20	1.12	220	01Aug2017, 06:48	30.13
JNE5	1.12	220	01Aug2017, 06:48	30.13
E21	0.01	3	01Aug2017, 06:21	0.32
JE21	0.01	3	01Aug2017, 06:21	0.32
JNE6	0.01	3	01Aug2017, 06:21	0.32
E19	0.00	1	01Aug2017, 06:13	0.05
JE19	0.00	1	01Aug2017, 06:13	0.05
JNE4	0.00	1	01Aug2017, 06:13	0.05
JNE 4-7	1.14	222	01Aug2017, 06:48	30.50
E7	0.24	42	01Aug2017, 06:41	5.68
JE7	0.24	42	01Aug2017, 06:41	5.68
E28	0.01	3	01Aug2017, 06:18	0.25
JE28	0.25	43	01Aug2017, 06:40	5.93
W30	0.00	8	01Aug2017, 06:09	0.34
JW30	0.00	8	01Aug2017, 06:09	0.34
JNE11	0.25	44	01Aug2017, 06:39	6.27
E25	0.04	9	01Aug2017, 06:23	0.85
JE25	0.04	9	01Aug2017, 06:23	0.85
JNE9	0.04	9	01Aug2017, 06:23	0.85
E29	0.02	6	01Aug2017, 06:22	0.59
JE29	0.02	6	01Aug2017, 06:22	0.59
JNE12	0.02	6	01Aug2017, 06:22	0.59
E26	0.01	3	01Aug2017, 06:18	0.27
JE26	0.01	3	01Aug2017, 06:18	0.27
E27	0.00	1	01Aug2017, 06:13	0.05
JE27	0.00	1	01Aug2017, 06:13	0.05
JNE10	0.01	4	01Aug2017, 06:18	0.32
JNE8-12	0.33	57	01Aug2017, 06:35	8.03

TABLE D4 10-YR - 24 HR STORM HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
W26	0.09	38	01Aug2017, 06:23	3.31
E24	0.03	8	01Aug2017, 06:20	0.73
JE24	0.03	8	01Aug2017, 06:20	0.73
W22	0.01	9	01Aug2017, 06:09	0.39
JW22	0.01	9	01Aug2017, 06:09	0.39
JNE8	0.04	13	01Aug2017, 06:13	1.12
Channel	0.46	99	01Aug2017, 06:26	12.46
Pond 1	1.59	21	01Aug2017, 09:40	39.71
W24	0.04	2	01Aug2017, 06:40	0.30
JW24	0.04	2	01Aug2017, 06:40	0.30
J24-25	0.04	2	01Aug2017, 06:40	0.30
W23	0.02	1	01Aug2017, 06:22	0.18
JW23	0.02	1	01Aug2017, 06:22	0.18
J23-24	0.06	2	01Aug2017, 06:34	0.49
W13	0.15	35	01Aug2017, 06:39	4.41
JW13	0.15	35	01Aug2017, 06:39	4.41
J13-23	0.21	37	01Aug2017, 06:38	4.89
E17	0.08	20	01Aug2017, 06:25	1.96
JE17	0.08	20	01Aug2017, 06:25	1.96
E18	0.01	3	01Aug2017, 06:21	0.30
JE18	0.01	3	01Aug2017, 06:21	0.30
W21	0.01	14	01Aug2017, 06:09	0.62
JW21	0.01	14	01Aug2017, 06:09	0.62
JNE3	0.02	15	01Aug2017, 06:10	0.91
JNE2	0.10	28	01Aug2017, 06:21	2.87
E16	0.01	4	01Aug2017, 06:18	0.35
JE16	0.01	4	01Aug2017, 06:18	0.35
W20	0.01	12	01Aug2017, 06:09	0.54
JW20	0.01	12	01Aug2017, 06:09	0.54
JNE1	0.12	38	01Aug2017, 06:17	3.76
W29	0.02	10	01Aug2017, 06:19	0.74
JW29	0.14	47	01Aug2017, 06:18	4.50
Pond 4	0.14	20	01Aug2017, 06:45	4.50
W14	0.12	11	01Aug2017, 06:43	1.73
JW14	0.27	31	01Aug2017, 06:44	6.24
J13-14	0.48	67	01Aug2017, 06:41	11.13
W10	0.02	8	01Aug2017, 06:45	1.09

TABLE D4 10-YR - 24 HR STORM HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
JW10	0.50	76	01Aug2017, 06:41	12.21
W11	0.07	23	01Aug2017, 06:33	2.45
JW11	0.07	23	01Aug2017, 06:33	2.45
J10-11	0.57	97	01Aug2017, 06:39	14.67
Sink-3	0.57	97	01Aug2017, 06:39	14.67
W12	0.14	56	01Aug2017, 06:27	5.26
W25	0.13	53	01Aug2017, 06:22	4.46
JW25	0.13	53	01Aug2017, 06:22	4.46
J25-26	0.13	53	01Aug2017, 06:22	4.46
J26-27	0.00	0	01Aug2017, 00:00	0.00
Diversion-1	0.00	0	01Aug2017, 00:00	0.00
W28	0.01	2	01Aug2017, 06:19	0.18
JW28	0.01	2	01Aug2017, 06:19	0.18
Pond 3	0.13	21	01Aug2017, 06:49	4.64
RW12	0.13	21	01Aug2017, 07:09	4.65
JW12	0.27	56	01Aug2017, 06:27	9.91
Sink-2	0.27	56	01Aug2017, 06:27	9.91
W27	0.20	71	01Aug2017, 06:28	6.91
JW27	0.20	71	01Aug2017, 06:28	6.91
Sink-9	0.20	71	01Aug2017, 06:28	6.91
W9	0.09	37	01Aug2017, 06:47	4.89
JW9	0.09	37	01Aug2017, 06:47	4.89
W5	0.07	29	01Aug2017, 06:22	2.46
JW5	0.07	29	01Aug2017, 06:22	2.46
W4	0.02	9	01Aug2017, 06:19	0.70
JW4	0.18	57	01Aug2017, 06:32	8.06
Sink-6	0.18	57	01Aug2017, 06:32	8.06
W2	0.15	59	01Aug2017, 06:30	5.82
JW2	0.15	59	01Aug2017, 06:30	5.82
Sink-1	0.15	59	01Aug2017, 06:30	5.82
W3	0.13	23	01Aug2017, 07:18	4.94
JW3	0.13	23	01Aug2017, 07:18	4.94
Sink-5	0.13	23	01Aug2017, 07:18	4.94
W6	0.03	11	01Aug2017, 06:25	0.98
JW6	0.03	11	01Aug2017, 06:25	0.98
Sink-7	0.03	11	01Aug2017, 06:25	0.98
W18	0.01	17	01Aug2017, 06:09	0.78
Sink-8	0.01	17	01Aug2017, 06:09	0.78
E22	0.00	2	01Aug2017, 06:14	0.12
JE22	0.00	2	01Aug2017, 06:14	0.12
E23	0.00	0	01Aug2017, 06:13	0.03
JE23	0.00	0	01Aug2017, 06:13	0.03
JNE7	0.01	2	01Aug2017, 06:14	0.14

TABLE D5 50-YR - 24 HR STORM HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
E1	1.98	1869	01Aug2017, 06:50	249.30
JE1	1.98	1869	01Aug2017, 06:50	249.30
RE2	1.98	1867	01Aug2017, 07:04	249.32
E2	1.30	1291	01Aug2017, 06:47	163.87
JE2	3.28	3001	01Aug2017, 06:58	413.19
RE8_E2	3.28	2998	01Aug2017, 07:04	413.20
E3	0.94	608	01Aug2017, 06:41	72.57
JE3	0.94	608	01Aug2017, 06:41	72.57
RE8_E3	0.94	608	01Aug2017, 06:48	72.58
E8	0.51	514	01Aug2017, 06:32	49.96
JE8	4.73	3739	01Aug2017, 07:00	535.74
RE12	4.73	3737	01Aug2017, 07:03	535.73
E12	0.05	27	01Aug2017, 06:24	2.38
JE12	4.78	3744	01Aug2017, 07:03	538.11
E13	0.07	37	01Aug2017, 06:28	3.52
JE13	0.07	37	01Aug2017, 06:28	3.52
JSE3	4.85	3756	01Aug2017, 07:03	541.63
RW15	4.85	3754	01Aug2017, 07:04	541.63
E10	0.21	96	01Aug2017, 06:35	10.79
JE10	0.21	96	01Aug2017, 06:35	10.79
E9	0.17	97	01Aug2017, 06:24	8.50
JE9	0.17	97	01Aug2017, 06:24	8.50
J9-10	0.38	181	01Aug2017, 06:28	19.30
RE14	0.38	181	01Aug2017, 06:32	19.30
E14	0.03	19	01Aug2017, 06:17	1.32
JE14	0.41	191	01Aug2017, 06:32	20.62
Res-1	0.41	8	01Aug2017, 09:16	16.11
E15	0.05	69	01Aug2017, 06:22	5.11
Res-2	0.05	21	01Aug2017, 06:52	5.11
JE15	0.05	21	01Aug2017, 06:52	5.11
W19	0.03	83	01Aug2017, 06:09	3.64
JW19	0.08	94	01Aug2017, 06:09	8.75
JSE2	0.49	94	01Aug2017, 06:09	24.86
W16	0.09	68	01Aug2017, 06:33	6.96
JW16	0.58	108	01Aug2017, 06:10	31.83
W17	0.12	81	01Aug2017, 06:29	7.69
JW17	0.12	81	01Aug2017, 06:29	7.69
J16-17	0.69	186	01Aug2017, 06:30	39.52
E11	0.14	65	01Aug2017, 06:33	6.98
JSE4	0.14	65	01Aug2017, 06:33	6.98
W15	0.09	61	01Aug2017, 06:40	7.17
JW15	5.77	3906	01Aug2017, 07:04	595.30
W7	0.08	54	01Aug2017, 06:29	5.05

TABLE D5 50-YR - 24 HR STORM HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
JW7	5.85	3924	01Aug2017, 07:04	600.35
W1	0.14	100	01Aug2017, 06:35	10.62
W8	0.12	111	01Aug2017, 06:26	9.62
JW8	0.12	111	01Aug2017, 06:26	9.62
JW1	6.11	4007	01Aug2017, 07:03	620.59
LUCERO DAM	6.11	231	01Aug2017, 09:37	615.48
Sink-4	6.11	231	01Aug2017, 09:37	615.48
E6	0.41	194	01Aug2017, 06:32	20.53
JE6	0.41	194	01Aug2017, 06:32	20.53
RE5	0.41	194	01Aug2017, 06:42	20.54
E4	0.37	187	01Aug2017, 06:43	23.64
E5	0.29	141	01Aug2017, 06:31	14.63
JE5	1.07	501	01Aug2017, 06:39	58.81
RE20	1.07	501	01Aug2017, 06:42	58.82
E20	0.05	32	01Aug2017, 06:22	2.68
JE20	1.12	518	01Aug2017, 06:42	61.50
JNE5	1.12	518	01Aug2017, 06:42	61.50
E21	0.01	9	01Aug2017, 06:20	0.67
JE21	0.01	9	01Aug2017, 06:20	0.67
JNE6	0.01	9	01Aug2017, 06:20	0.67
E19	0.00	2	01Aug2017, 06:11	0.11
JE19	0.00	2	01Aug2017, 06:11	0.11
JNE4	0.00	2	01Aug2017, 06:11	0.11
JNE 4-7	1.14	522	01Aug2017, 06:42	62.27
E7	0.24	101	01Aug2017, 06:38	11.97
JE7	0.24	101	01Aug2017, 06:38	11.97
E28	0.01	7	01Aug2017, 06:17	0.53
JE28	0.25	104	01Aug2017, 06:37	12.50
W30	0.00	12	01Aug2017, 06:09	0.52
JW30	0.00	12	01Aug2017, 06:09	0.52
JNE11	0.25	105	01Aug2017, 06:37	13.02
E25	0.04	22	01Aug2017, 06:21	1.80
JE25	0.04	22	01Aug2017, 06:21	1.80
JNE9	0.04	22	01Aug2017, 06:21	1.80
E29	0.02	16	01Aug2017, 06:20	1.25
JE29	0.02	16	01Aug2017, 06:20	1.25
JNE12	0.02	16	01Aug2017, 06:20	1.25
E26	0.01	8	01Aug2017, 06:16	0.58
JE26	0.01	8	01Aug2017, 06:16	0.58
E27	0.00	2	01Aug2017, 06:12	0.10
JE27	0.00	2	01Aug2017, 06:12	0.10
JNE10	0.01	10	01Aug2017, 06:16	0.67
JNE8-12	0.33	135	01Aug2017, 06:33	16.74

TABLE D5 50-YR - 24 HR STORM HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
W26	0.09	81	01Aug2017, 06:22	6.31
E24	0.03	21	01Aug2017, 06:18	1.54
JE24	0.03	21	01Aug2017, 06:18	1.54
W22	0.01	14	01Aug2017, 06:09	0.60
JW22	0.01	14	01Aug2017, 06:09	0.60
JNE8	0.04	29	01Aug2017, 06:15	2.14
Channel	0.46	228	01Aug2017, 06:24	25.19
Pond 1	1.59	30	01Aug2017, 09:27	83.46
W24	0.04	7	01Aug2017, 06:31	0.93
JW24	0.04	7	01Aug2017, 06:31	0.93
J24-25	0.04	7	01Aug2017, 06:31	0.93
W23	0.02	7	01Aug2017, 06:14	0.55
JW23	0.02	7	01Aug2017, 06:14	0.55
J23-24	0.06	11	01Aug2017, 06:28	1.49
W13	0.15	77	01Aug2017, 06:37	8.72
JW13	0.15	77	01Aug2017, 06:37	8.72
J13-23	0.21	87	01Aug2017, 06:35	10.21
E17	0.08	49	01Aug2017, 06:23	4.13
JE17	0.08	49	01Aug2017, 06:23	4.13
E18	0.01	8	01Aug2017, 06:20	0.63
JE18	0.01	8	01Aug2017, 06:20	0.63
W21	0.01	22	01Aug2017, 06:09	0.95
JW21	0.01	22	01Aug2017, 06:09	0.95
JNE3	0.02	26	01Aug2017, 06:10	1.58
JNE2	0.10	65	01Aug2017, 06:20	5.71
E16	0.01	11	01Aug2017, 06:16	0.73
JE16	0.01	11	01Aug2017, 06:16	0.73
W20	0.01	19	01Aug2017, 06:09	0.83
JW20	0.01	19	01Aug2017, 06:09	0.83
JNE1	0.12	84	01Aug2017, 06:18	7.28
W29	0.02	21	01Aug2017, 06:18	1.42
JW29	0.14	105	01Aug2017, 06:18	8.70
Pond 4	0.14	29	01Aug2017, 06:52	8.69
W14	0.12	33	01Aug2017, 06:38	4.30
JW14	0.27	62	01Aug2017, 06:40	13.00
J13-14	0.48	148	01Aug2017, 06:37	23.21
W10	0.02	15	01Aug2017, 06:44	1.91

TABLE D5 50-YR - 24 HR STORM HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
JW10	0.50	163	01Aug2017, 06:37	25.11
W11	0.07	47	01Aug2017, 06:31	4.60
JW11	0.07	47	01Aug2017, 06:31	4.60
J10-11	0.57	208	01Aug2017, 06:36	29.71
Sink-3	0.57	208	01Aug2017, 06:36	29.71
W12	0.14	115	01Aug2017, 06:25	9.86
W25	0.13	112	01Aug2017, 06:21	8.51
JW25	0.13	112	01Aug2017, 06:21	8.51
J25-26	0.13	112	01Aug2017, 06:21	8.51
J26-27	0.00	0	01Aug2017, 00:00	0.00
Diversion-1	0.00	0	01Aug2017, 00:00	0.00
W28	0.01	5	01Aug2017, 06:18	0.35
JW28	0.01	5	01Aug2017, 06:18	0.35
Pond 3	0.13	47	01Aug2017, 06:45	8.86
RW12	0.13	47	01Aug2017, 07:01	8.87
JW12	0.27	116	01Aug2017, 06:25	18.73
Sink-2	0.27	116	01Aug2017, 06:25	18.73
W27	0.20	149	01Aug2017, 06:26	13.17
JW27	0.20	149	01Aug2017, 06:26	13.17
Sink-9	0.20	149	01Aug2017, 06:26	13.17
W9	0.09	66	01Aug2017, 06:46	8.34
JW9	0.09	66	01Aug2017, 06:46	8.34
W5	0.07	62	01Aug2017, 06:21	4.70
JW5	0.07	62	01Aug2017, 06:21	4.70
W4	0.02	19	01Aug2017, 06:18	1.34
JW4	0.18	112	01Aug2017, 06:25	14.37
Sink-6	0.18	112	01Aug2017, 06:25	14.37
W2	0.15	117	01Aug2017, 06:28	10.73
JW2	0.15	117	01Aug2017, 06:28	10.73
Sink-1	0.15	117	01Aug2017, 06:28	10.73
W3	0.13	46	01Aug2017, 07:16	9.26
JW3	0.13	46	01Aug2017, 07:16	9.26
Sink-5	0.13	46	01Aug2017, 07:16	9.26
W6	0.03	23	01Aug2017, 06:23	1.88
JW6	0.03	23	01Aug2017, 06:23	1.88
Sink-7	0.03	23	01Aug2017, 06:23	1.88
W18	0.01	28	01Aug2017, 06:09	1.21
Sink-8	0.01	28	01Aug2017, 06:09	1.21
E22	0.00	4	01Aug2017, 06:13	0.24
JE22	0.00	4	01Aug2017, 06:13	0.24
E23	0.00	1	01Aug2017, 06:11	0.06
JE23	0.00	1	01Aug2017, 06:11	0.06
JNE7	0.01	5	01Aug2017, 06:13	0.30

TABLE D6 100-YR - 24 HR STORM HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
E1	1.98	2186	01Aug2017, 06:50	291.78
JE1	1.98	2186	01Aug2017, 06:50	291.78
RE2	1.98	2184	01Aug2017, 07:03	291.80
E2	1.30	1510	01Aug2017, 06:47	191.79
JE2	3.28	3522	01Aug2017, 06:57	483.59
RE8_E2	3.28	3519	01Aug2017, 07:03	483.59
E3	0.94	755	01Aug2017, 06:41	89.24
JE3	0.94	755	01Aug2017, 06:41	89.24
RE8_E3	0.94	754	01Aug2017, 06:47	89.25
E8	0.51	620	01Aug2017, 06:32	60.02
JE8	4.73	4439	01Aug2017, 06:59	632.87
RE12	4.73	4436	01Aug2017, 07:01	632.85
E12	0.05	36	01Aug2017, 06:24	3.05
JE12	4.78	4446	01Aug2017, 07:01	635.90
E13	0.07	48	01Aug2017, 06:27	4.52
JE13	0.07	48	01Aug2017, 06:27	4.52
JSE3	4.85	4462	01Aug2017, 07:01	640.43
RW15	4.85	4460	01Aug2017, 07:03	640.43
E10	0.21	126	01Aug2017, 06:34	13.87
JE10	0.21	126	01Aug2017, 06:34	13.87
E9	0.17	129	01Aug2017, 06:23	10.93
JE9	0.17	129	01Aug2017, 06:23	10.93
J9-10	0.38	239	01Aug2017, 06:27	24.80
RE14	0.38	238	01Aug2017, 06:31	24.80
E14	0.03	25	01Aug2017, 06:16	1.70
JE14	0.41	252	01Aug2017, 06:31	26.50
Res-1	0.41	74	01Aug2017, 07:15	21.98
E15	0.05	83	01Aug2017, 06:22	6.08
Res-2	0.05	23	01Aug2017, 06:53	6.08
JE15	0.05	23	01Aug2017, 06:53	6.08
W19	0.03	97	01Aug2017, 06:09	4.27
JW19	0.08	108	01Aug2017, 06:09	10.35
JSE2	0.49	108	01Aug2017, 06:09	32.32
W16	0.09	85	01Aug2017, 06:33	8.56
JW16	0.58	127	01Aug2017, 06:10	40.89
W17	0.12	103	01Aug2017, 06:29	9.61
JW17	0.12	103	01Aug2017, 06:29	9.61
J16-17	0.69	228	01Aug2017, 06:29	50.49
E11	0.14	85	01Aug2017, 06:32	8.97
JSE4	0.14	85	01Aug2017, 06:32	8.97
W15	0.09	76	01Aug2017, 06:40	8.81
JW15	5.77	4651	01Aug2017, 07:02	708.71
W7	0.08	68	01Aug2017, 06:28	6.31

TABLE D6 100-YR - 24 HR STORM HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
JW7	5.85	4675	01Aug2017, 07:02	715.02
W1	0.14	124	01Aug2017, 06:35	13.12
W8	0.12	138	01Aug2017, 06:26	11.83
JW8	0.12	138	01Aug2017, 06:26	11.83
JW1	6.11	4780	01Aug2017, 07:02	739.97
LUCERO DAM	6.11	323	01Aug2017, 09:22	734.54
Sink-4	6.11	323	01Aug2017, 09:22	734.54
E6	0.41	256	01Aug2017, 06:31	26.38
JE6	0.41	256	01Aug2017, 06:31	26.38
RE5	0.41	256	01Aug2017, 06:40	26.39
E4	0.37	239	01Aug2017, 06:42	29.68
E5	0.29	186	01Aug2017, 06:30	18.79
JE5	1.07	655	01Aug2017, 06:38	74.87
RE20	1.07	654	01Aug2017, 06:41	74.87
E20	0.05	43	01Aug2017, 06:21	3.44
JE20	1.12	677	01Aug2017, 06:41	78.32
JNE5	1.12	677	01Aug2017, 06:41	78.32
E21	0.01	12	01Aug2017, 06:19	0.86
JE21	0.01	12	01Aug2017, 06:19	0.86
JNE6	0.01	12	01Aug2017, 06:19	0.86
E19	0.00	2	01Aug2017, 06:11	0.14
JE19	0.00	2	01Aug2017, 06:11	0.14
JNE4	0.00	2	01Aug2017, 06:11	0.14
JNE 4-7	1.14	682	01Aug2017, 06:40	79.32
E7	0.24	132	01Aug2017, 06:37	15.39
JE7	0.24	132	01Aug2017, 06:37	15.39
E28	0.01	10	01Aug2017, 06:16	0.68
JE28	0.25	136	01Aug2017, 06:37	16.06
W30	0.00	14	01Aug2017, 06:09	0.61
JW30	0.00	14	01Aug2017, 06:09	0.61
JNE11	0.25	139	01Aug2017, 06:36	16.67
E25	0.04	29	01Aug2017, 06:21	2.31
JE25	0.04	29	01Aug2017, 06:21	2.31
JNE9	0.04	29	01Aug2017, 06:21	2.31
E29	0.02	21	01Aug2017, 06:20	1.61
JE29	0.02	21	01Aug2017, 06:20	1.61
JNE12	0.02	21	01Aug2017, 06:20	1.61
E26	0.01	11	01Aug2017, 06:16	0.74
JE26	0.01	11	01Aug2017, 06:16	0.74
E27	0.00	2	01Aug2017, 06:11	0.12
JE27	0.00	2	01Aug2017, 06:11	0.12
JNE10	0.01	13	01Aug2017, 06:15	0.86
JNE8-12	0.33	177	01Aug2017, 06:32	21.45

TABLE D6 100-YR - 24 HR STORM HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
W26	0.09	103	01Aug2017, 06:21	7.88
E24	0.03	28	01Aug2017, 06:18	1.98
JE24	0.03	28	01Aug2017, 06:18	1.98
W22	0.01	16	01Aug2017, 06:09	0.71
JW22	0.01	16	01Aug2017, 06:09	0.71
JNE8	0.04	37	01Aug2017, 06:15	2.68
Channel	0.46	296	01Aug2017, 06:24	32.02
Pond 1	1.59	139	01Aug2017, 07:43	107.13
W24	0.04	11	01Aug2017, 06:30	1.32
JW24	0.04	11	01Aug2017, 06:30	1.32
J24-25	0.04	11	01Aug2017, 06:30	1.32
W23	0.02	10	01Aug2017, 06:13	0.78
JW23	0.02	10	01Aug2017, 06:13	0.78
J23-24	0.06	17	01Aug2017, 06:24	2.10
W13	0.15	99	01Aug2017, 06:36	11.01
JW13	0.15	99	01Aug2017, 06:36	11.01
J13-23	0.21	114	01Aug2017, 06:34	13.11
E17	0.08	64	01Aug2017, 06:22	5.31
JE17	0.08	64	01Aug2017, 06:22	5.31
E18	0.01	11	01Aug2017, 06:19	0.81
JE18	0.01	11	01Aug2017, 06:19	0.81
W21	0.01	25	01Aug2017, 06:09	1.12
JW21	0.01	25	01Aug2017, 06:09	1.12
JNE3	0.02	31	01Aug2017, 06:10	1.92
JNE2	0.10	85	01Aug2017, 06:20	7.23
E16	0.01	14	01Aug2017, 06:16	0.94
JE16	0.01	14	01Aug2017, 06:16	0.94
W20	0.01	22	01Aug2017, 06:09	0.97
JW20	0.01	22	01Aug2017, 06:09	0.97
JNE1	0.12	109	01Aug2017, 06:18	9.15
W29	0.02	26	01Aug2017, 06:17	1.77
JW29	0.14	135	01Aug2017, 06:18	10.92
Pond 4	0.14	81	01Aug2017, 06:34	10.92
W14	0.12	46	01Aug2017, 06:37	5.77
JW14	0.27	127	01Aug2017, 06:34	16.69
J13-14	0.48	241	01Aug2017, 06:34	29.80
W10	0.02	19	01Aug2017, 06:43	2.32

TABLE D6 100-YR - 24 HR STORM HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY Radium Springs Drainage Master Plan				
Hydrologic Element	Area	Peak Discharge	Time of Peak	Volume
	sq mi	cfs		ac-ft
JW10	0.50	258	01Aug2017, 06:35	32.12
W11	0.07	59	01Aug2017, 06:31	5.71
JW11	0.07	59	01Aug2017, 06:31	5.71
J10-11	0.57	316	01Aug2017, 06:34	37.83
Sink-3	0.57	316	01Aug2017, 06:34	37.83
W12	0.14	145	01Aug2017, 06:25	12.25
W25	0.13	142	01Aug2017, 06:21	10.62
JW25	0.13	142	01Aug2017, 06:21	10.62
J25-26	0.13	142	01Aug2017, 06:21	10.62
J26-27	0.00	0	01Aug2017, 00:00	0.00
Diversion-1	0.00	0	01Aug2017, 00:00	0.00
W28	0.01	6	01Aug2017, 06:18	0.44
JW28	0.01	6	01Aug2017, 06:18	0.44
Pond 3	0.13	97	01Aug2017, 06:34	11.06
RW12	0.13	96	01Aug2017, 06:46	11.07
JW12	0.27	173	01Aug2017, 06:46	23.32
Sink-2	0.27	173	01Aug2017, 06:46	23.32
W27	0.20	189	01Aug2017, 06:26	16.44
JW27	0.20	189	01Aug2017, 06:26	16.44
Sink-9	0.20	189	01Aug2017, 06:26	16.44
W9	0.09	79	01Aug2017, 06:46	10.06
JW9	0.09	79	01Aug2017, 06:46	10.06
W5	0.07	78	01Aug2017, 06:21	5.86
JW5	0.07	78	01Aug2017, 06:21	5.86
W4	0.02	25	01Aug2017, 06:18	1.67
JW4	0.18	140	01Aug2017, 06:24	17.60
Sink-6	0.18	140	01Aug2017, 06:24	17.60
W2	0.15	146	01Aug2017, 06:28	13.26
JW2	0.15	146	01Aug2017, 06:28	13.26
Sink-1	0.15	146	01Aug2017, 06:28	13.26
W3	0.13	58	01Aug2017, 07:15	11.50
JW3	0.13	58	01Aug2017, 07:15	11.50
Sink-5	0.13	58	01Aug2017, 07:15	11.50
W6	0.03	29	01Aug2017, 06:23	2.34
JW6	0.03	29	01Aug2017, 06:23	2.34
Sink-7	0.03	29	01Aug2017, 06:23	2.34
W18	0.01	32	01Aug2017, 06:09	1.41
Sink-8	0.01	32	01Aug2017, 06:09	1.41
E22	0.00	5	01Aug2017, 06:13	0.31
JE22	0.00	5	01Aug2017, 06:13	0.31
E23	0.00	1	01Aug2017, 06:11	0.08
JE23	0.00	1	01Aug2017, 06:11	0.08
JNE7	0.01	7	01Aug2017, 06:12	0.39

APPENDIX E

Culvert Master

TABLE E1: CULVERT INPUT DATA AND RESULTS

DIGITAL MODELS for EXISTING CULVERTS

TABLE E1
EXISTING CULVERT DATA AND RESULTS
Radium Springs Draiange Master Plan

	CULVERT DATA FOR CULVERT MASTER														Culvert Capacity				5-yr 24-hr storm	10-yr 24-hr storm	50-yr 24-hr storm	100-yr 24-hr storm
Culvert Name / Location Description	Existing or Proposed	Comment on Inlet Sediment or Debris	No. of Culverts	Material	Culvert Rise	Culvert Span	Length	Invert Elevation Upstream	Invert Elevation Down stream	Slope (assume 1%)	Maximum Available Headwater Depth	Maximum Available Headwater Depth	Maximum Available Headwater Elevation	Assumed Tailwater Elevation	Maximum Culvert Capacity from Culvert Master	Maximum Cuvlert Capacity assuming 15% Clogging Factor	Discharge Per Culvert	HEC-HMS Analysis Point Name	Peak Discharge	Peak Discharge	Peak Discharge	Peak Discharge
					inches	inches	ft	ft	ft	ft / ft	inches	feet	feet	ft	cfs	cfs	cfs		cfs	cfs	cfs	cfs
a b		d						c	c	c	d			e	f	f		a b	g	g	g	g
SE4	Existing	Fully open	4	RCP	36	36	221	100.00	97.79	0.0100	90	7.50	107.50	101.54	331	281	70	Junction JSE4	14.8	26.6	64.6	85.2
SE3	Existing	Fully open	4	CBC	120	96	227	100.00	97.73	0.0100	138	11.50	111.50	103.48	3708	3152	788	Junction JSE3	969.9	2269.4	3755.6	4461.7
SE2	Existing	Fully open	3	RCP	30	30	204	100.00	97.96	0.0100	78	6.50	106.50	101.21	155	132	44	Junction JSE2	-	-	-	-
SE1	Existing	Fully open	1	RCP	30	30	253	100.00	97.47	0.0100	60	5.00	105.00	99.97	47	40	40	Junction JSE2	-	-	-	-
SE1 & SE2 (Note: SE1 & SE2 have the same anaylsis point)	---	---	---	---	---	---	---	---	---	---	---	---	Total		202	172	84	Junction JSE2	55.2	62.8	93.7	108.2
E70	Existing	Fully open	1	RCP	24	24	111	100.00	98.89	0.0100	60	5.00	105.00	101.39	30	25	25	Subbasin E15	13.1	40.8	20.8	82.6
RAMP1	Existing	Fully open	1	RCP	24	24	88	100.00	99.12	0.0100	60	5.00	105.00	101.62	31	26	26	Subbasin E15	13.1	40.8	20.8	82.6
RAMP2	Existing	Fully open	1	RCP	24	24	79	100.00	99.21	0.0100	60	5.00	105.00	101.71	31	26	26	Subbasin E15	13.1	40.8	20.8	82.6
NE1.1	Existing	Fully open	1	RCP	54	54	235	100.00	97.65	0.0100	102	8.50	108.50	101.90	208	177	177	Junction JNE1	-	-	-	-
NE1.2	Existing	Fully open	1	RCP	30	30	235	100.00	97.65	0.0100	102	8.50	108.50	101.90	55	47	47	Junction JNE1	-	-	-	-
NE1.1 & NE1.2 (Note: NE1.1 & NE1.2 are located at same anaylsis)	---	---	---	---	---	---	---	---	---	---	---	---	Total		263	224	224	Junction JNE1	24.0	37.6	84.1	109.0
NE2	Existing	Fully open	1	RCP	54	54	242	100.00	97.58	0.0100	90	7.50	107.50	101.33	188	160	160	Junction JNE2	15.9	27.6	65.0	85.0
NE3	Existing	Fully open	1	RCP	30	30	247	100.00	97.53	0.0100	60	5.00	105.00	100.03	47	40	40	Junction JNE3	11.1	14.9	25.7	31.1
NE4	Existing	Fully open	3	RCP	48	48	230	100.00	97.70	0.0100	60	5.00	105.00	100.20	317	269	90	Junction JNE4	0.4	0.7	1.9	2.5
NE5.1*	Existing	Fully open	4	CBC	18	168	275	100.00	97.25	0.0100	78	6.50	106.50	100.50	973	827	207	Junction JNE5	-	-	-	-
NE5.2*	Existing	Fully open	8	RCP	36	36	275	100.00	97.25	0.0100	78	6.50	106.50	100.50	622	529	66	Junction JNE5	-	-	-	-
NE5.1 & NE5.2 (Note: 5.1 & 5.2 are located at same anaylsis)	---	---	---	---	---	---	---	---	---	---	---	---	Total		1595	1356	273	Junction JNE5	122.4	219.9	517.4	676.3
NE6	Existing	Fully open	1	RCP	30	30	230	100.00	97.70	0.0100	66	5.50	105.50	100.45	49	42	42	Junction JNE6	1.9	3.5	8.7	11.6
NE7	Existing	Fully open	1	RCP	30	30	227	100.00	97.73	0.0100	60	5.00	105.00	100.23	47	40	40	Junction JNE7	1.0	2.0	5.0	6.7
NE8	Exisitng	Fully open	1	RCP	30	30	220	100.00	97.80	0.0100	36	3.00	103.00	99.30	31	26	26	Junction JNE8	8.5	13.2	28.8	37.1
NE9	Existing	Fully open	2	RCP	24	24	245	100.00	97.55	0.0100	36	3.00	103.00	99.05	45	38	19	Junction JNE9	4.8	8.9	22.1	29.3
NE10	Exisitng	Fully open	2	RCP	24	24	215	100.00	97.85	0.0100	32	2.67	102.67	99.18	40	34	17	Junction JNE10	2.1	3.8	9.7	12.9
NE11	Exisitng	Fully open	3	RCP	36	36	280	100.00	97.20	0.0100	72	6.00	106.00	100.20	228	194	65	Junction JNE11	6.4	44.0	105.5	138.6
NE12	Exisitng	Fully open	1	RCP	30	30	222	100.00	97.78	0.0100	42	3.50	103.50	99.53	37	31	31	Junction JNE12	3.4	6.3	15.7	20.9

a - See Drainage Basin Map for culvert locations
b- See HEC-RAS Model Schematic for HEC-HMS analysis point locations
c - Assume all relative usptream cuvlert invert elevations as elev. 100, compute downstream elevation based on culvert length and an assumed 1 % slope
d - The maximum available headwater depth for the signficant culverts were measured by Smith Engineering engineers
e - Assume tailwater elevation = the downstream invert elevation + 0.5 (Culvert Diameter)
f - CulvertMaser output is included in Appendix, assume a 15% clogging factor at inlet due to sediment and debris / vegetation
g - See HEC-HMS Summary output tables included in Appendix D
f - CulvertMaster output is included in this Appendix E, assume a 15% clogging factor at inlet due to sediment and debris / vegetation
h - Compute as spill flow divided by Culvert Capacity
i - Our discharge analysis in CulvertMaster was based on 28 - 2' x 2' CBC. In the field, culverts measured to be 4 - 1.5' x 14' to top of culvert (NE5.1).

Culvert Calculator Report
E70

Solve For: Discharge

Culvert Summary						
Allowable HW Elevation	105.00	ft	Headwater Depth/Height	2.50	
Computed Headwater Eleva	105.00	ft	Discharge	29.82	cfs
Inlet Control HW Elev.	104.23	ft	Tailwater Elevation	101.39	ft
Outlet Control HW Elev.	105.00	ft	Control Type	Outlet Control	

Grades					
Upstream Invert	100.00	ft	Downstream Invert	98.89	ft
Length	111.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	2.50	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	1.86	ft
Velocity Downstream	9.49	ft/s	Critical Slope	0.015036	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.	105.00	ft	Upstream Velocity Head	1.40	ft
Ke	0.20		Entrance Loss	0.28	ft

Inlet Control Properties					
Inlet Control HW Elev.	104.23	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	3.1	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
NE1.1

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	108.50	ft	Headwater Depth/Height	1.89	
Computed Headwater Eleva	108.50	ft	Discharge	207.91	cfs
Inlet Control HW Elev.	108.50	ft	Tailwater Elevation	101.90	ft
Outlet Control HW Elev.	107.59	ft	Control Type	Inlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	97.65	ft
Length	235.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	CompositeS1S2		Depth, Downstream	3.98	ft
Slope Type	Steep		Normal Depth	3.98	ft
Flow Regime	N/A		Critical Depth	4.09	ft
Velocity Downstream	13.97	ft/s	Critical Slope	0.009776	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	4.50	ft
Section Size	54 inch		Rise	4.50	ft
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	107.59	ft	Upstream Velocity Head	2.92	ft
Ke	0.20		Entrance Loss	0.58	ft

Inlet Control Properties

Inlet Control HW Elev.	108.50	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	15.9	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
NE1.2

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	108.50	ft	Headwater Depth/Height	3.40	
Computed Headwater Eleva	108.50	ft	Discharge	55.14	cfs
Inlet Control HW Elev.	105.71	ft	Tailwater Elevation	101.90	ft
Outlet Control HW Elev.	108.50	ft	Control Type	Outlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	97.65	ft
Length	235.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	PressureProfile		Depth, Downstream	4.25	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	2.36	ft
Velocity Downstream	11.23	ft/s	Critical Slope	0.015622	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.	108.50	ft	Upstream Velocity Head	1.96	ft
Ke	0.20		Entrance Loss	0.39	ft

Inlet Control Properties

Inlet Control HW Elev.	105.71	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	4.9	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
NE2

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	107.50	ft	Headwater Depth/Height	1.67	
Computed Headwater Eleva	107.50	ft	Discharge	187.74	cfs
Inlet Control HW Elev.	107.50	ft	Tailwater Elevation	101.33	ft
Outlet Control HW Elev.	106.95	ft	Control Type	Inlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	97.58	ft
Length	242.00	ft	Constructed Slope	0.009917	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	3.55	ft
Slope Type	Steep		Normal Depth	3.53	ft
Flow Regime	Supercritical		Critical Depth	3.95	ft
Velocity Downstream	13.96	ft/s	Critical Slope	0.008231	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	4.50	ft
Section Size	54 inch		Rise	4.50	ft
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	106.95	ft	Upstream Velocity Head	2.50	ft
Ke	0.20		Entrance Loss	0.50	ft

Inlet Control Properties

Inlet Control HW Elev.	107.50	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	15.9	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
NE3

Solve For: Discharge

Culvert Summary						
Allowable HW Elevation	105.00	ft	Headwater Depth/Height	2.00	
Computed Headwater Eleva	105.00	ft	Discharge	47.08	cfs
Inlet Control HW Elev.	104.63	ft	Tailwater Elevation	100.03	ft
Outlet Control HW Elev.	105.00	ft	Control Type	Outlet Control	

Grades					
Upstream Invert	100.00	ft	Downstream Invert	97.53	ft
Length	247.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	2.50	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	2.26	ft
Velocity Downstream	9.59	ft/s	Critical Slope	0.011563	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	1.43	ft
Ke	0.20		Entrance Loss	0.29	ft

Inlet Control Properties					
Inlet Control HW Elev.	104.63	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	4.9	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
NE4

Solve For: Discharge

Culvert Summary					
Allowable HW Elevation	105.00	ft	Headwater Depth/Height	1.25	
Computed Headwater Eleva	105.00	ft	Discharge	316.61	cfs
Inlet Control HW Elev.	104.98	ft	Tailwater Elevation	100.20	ft
Outlet Control HW Elev.	105.00	ft	Control Type	Entrance Control	

Grades					
Upstream Invert	100.00	ft	Downstream Invert	97.70	ft
Length	230.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	2.56	ft
Slope Type	Steep		Normal Depth	2.55	ft
Flow Regime	Supercritical		Critical Depth	3.11	ft
Velocity Downstream	12.41	ft/s	Critical Slope	0.005992	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.	105.00	ft	Upstream Velocity Head	1.58	ft
Ke	0.20		Entrance Loss	0.32	ft

Inlet Control Properties					
Inlet Control HW Elev.	104.98	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	37.7	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
NE5.1

Solve For: Discharge

Culvert Summary					
Allowable HW Elevation	106.50	ft	Headwater Depth/Height	3.25	
Computed Headwater Eleva	106.50	ft	Discharge	973.25	cfs
Inlet Control HW Elev.	104.82	ft	Tailwater Elevation	100.50	ft
Outlet Control HW Elev.	106.50	ft	Control Type	Outlet Control	

Grades					
Upstream Invert	100.00	ft	Downstream Invert	97.25	ft
Length	275.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	3.25	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	2.00	ft
Velocity Downstream	8.69	ft/s	Critical Slope	0.014564	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.00	ft
Section Size	2 x 2 ft		Rise	2.00	ft
Number Sections	28				

Outlet Control Properties					
Outlet Control HW Elev.	106.50	ft	Upstream Velocity Head	1.17	ft
Ke	0.70		Entrance Loss	0.82	ft

Inlet Control Properties					
Inlet Control HW Elev.	104.82	ft	Flow Control	N/A	
Inlet Type	0° wingwall flares		Area Full	112.0	ft²
K	0.06100		HDS 5 Chart	8	
M	0.75000		HDS 5 Scale	3	
C	0.04230		Equation Form	1	
Y	0.82000				

Culvert Calculator Report
NE5.2

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	106.50	ft	Headwater Depth/Height	2.17	
Computed Headwater Eleva	106.50	ft	Discharge	622.34	cfs
Inlet Control HW Elev.	105.89	ft	Tailwater Elevation	100.50	ft
Outlet Control HW Elev.	106.50	ft	Control Type	Outlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	97.25	ft
Length	275.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	PressureProfile		Depth, Downstream	3.25	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	2.75	ft
Velocity Downstream	11.01	ft/s	Critical Slope	0.011833	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	8				

Outlet Control Properties

Outlet Control HW Elev.	106.50	ft	Upstream Velocity Head	1.88	ft
Ke	0.20		Entrance Loss	0.38	ft

Inlet Control Properties

Inlet Control HW Elev.	105.89	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	56.5	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
NE6

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	105.50	ft	Headwater Depth/Height	2.20	
Computed Headwater Eleva	105.50	ft	Discharge	48.56	cfs
Inlet Control HW Elev.	104.82	ft	Tailwater Elevation	100.45	ft
Outlet Control HW Elev.	105.50	ft	Control Type	Outlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	97.70	ft
Length	230.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	PressureProfile		Depth, Downstream	2.75	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	2.28	ft
Velocity Downstream	9.89	ft/s	Critical Slope	0.012225	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.	105.50	ft	Upstream Velocity Head	1.52	ft
Ke	0.20		Entrance Loss	0.30	ft

Inlet Control Properties

Inlet Control HW Elev.	104.82	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	4.9	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
NE7

Solve For: Discharge

Culvert Summary						
Allowable HW Elevation	105.00	ft	Headwater Depth/Height	2.00	
Computed Headwater Eleva	105.00	ft	Discharge	47.40	cfs
Inlet Control HW Elev.	104.67	ft	Tailwater Elevation	100.23	ft
Outlet Control HW Elev.	105.00	ft	Control Type	Outlet Control	

Grades					
Upstream Invert	100.00	ft	Downstream Invert	97.73	ft
Length	227.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	2.50	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	2.26	ft
Velocity Downstream	9.66	ft/s	Critical Slope	0.011701	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	1.45	ft
Ke	0.20		Entrance Loss	0.29	ft

Inlet Control Properties					
Inlet Control HW Elev.	104.67	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	4.9	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
NE8

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	103.00	ft	Headwater Depth/Height	1.20	
Computed Headwater Eleva	103.00	ft	Discharge	30.71	cfs
Inlet Control HW Elev.	102.96	ft	Tailwater Elevation	99.30	ft
Outlet Control HW Elev.	103.00	ft	Control Type	Entrance Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	97.80	ft
Length	220.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	1.61	ft
Slope Type	Steep		Normal Depth	1.61	ft
Flow Regime	Supercritical		Critical Depth	1.89	ft
Velocity Downstream	9.17	ft/s	Critical Slope	0.006629	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	0.93	ft
Ke	0.20		Entrance Loss	0.19	ft

Inlet Control Properties

Inlet Control HW Elev.	102.96	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	4.9	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
NE9

Solve For: Discharge

Culvert Summary					
Allowable HW Elevation	103.00	ft	Headwater Depth/Height	1.50	
Computed Headwater Eleva	103.00	ft	Discharge	45.06	cfs
Inlet Control HW Elev.	103.00	ft	Tailwater Elevation	99.05	ft
Outlet Control HW Elev.	102.87	ft	Control Type	Inlet Control	

Grades					
Upstream Invert	100.00	ft	Downstream Invert	97.55	ft
Length	245.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	1.63	ft
Slope Type	Steep		Normal Depth	1.63	ft
Flow Regime	Supercritical		Critical Depth	1.69	ft
Velocity Downstream	8.21	ft/s	Critical Slope	0.009407	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	2				

Outlet Control Properties					
Outlet Control HW Elev.	102.87	ft	Upstream Velocity Head	0.98	ft
Ke	0.20		Entrance Loss	0.20	ft

Inlet Control Properties					
Inlet Control HW Elev.	103.00	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	6.3	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
NE10

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	102.67	ft	Headwater Depth/Height	1.34	
Computed Headwater Eleva	102.67	ft	Discharge	40.24	cfs
Inlet Control HW Elev.	102.67	ft	Tailwater Elevation	99.18	ft
Outlet Control HW Elev.	102.64	ft	Control Type	Inlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	97.85	ft
Length	215.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	1.47	ft
Slope Type	Steep		Normal Depth	1.47	ft
Flow Regime	Supercritical		Critical Depth	1.61	ft
Velocity Downstream	8.14	ft/s	Critical Slope	0.008173	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	2				

Outlet Control Properties

Outlet Control HW Elev.	102.64	ft	Upstream Velocity Head	0.86	ft
Ke	0.20		Entrance Loss	0.17	ft

Inlet Control Properties

Inlet Control HW Elev.	102.67	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	6.3	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
NE11

Solve For: Discharge

Culvert Summary					
Allowable HW Elevation	106.00	ft	Headwater Depth/Height	2.00	
Computed Headwater Eleva	106.00	ft	Discharge	228.16	cfs
Inlet Control HW Elev.	105.72	ft	Tailwater Elevation	100.20	ft
Outlet Control HW Elev.	106.00	ft	Control Type	Outlet Control	

Grades					
Upstream Invert	100.00	ft	Downstream Invert	97.20	ft
Length	280.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	3.00	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	2.73	ft
Velocity Downstream	10.76	ft/s	Critical Slope	0.011354	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.	106.00	ft	Upstream Velocity Head	1.80	ft
Ke	0.20		Entrance Loss	0.36	ft

Inlet Control Properties					
Inlet Control HW Elev.	105.72	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	21.2	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
NE12

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	103.50	ft	Headwater Depth/Height	1.40	
Computed Headwater Eleva	103.50	ft	Discharge	36.86	cfs
Inlet Control HW Elev.	103.50	ft	Tailwater Elevation	99.53	ft
Outlet Control HW Elev.	103.41	ft	Control Type	Inlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	97.78	ft
Length	222.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	1.85	ft
Slope Type	Steep		Normal Depth	1.85	ft
Flow Regime	Supercritical		Critical Depth	2.06	ft
Velocity Downstream	9.45	ft/s	Critical Slope	0.008024	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.	103.41	ft	Upstream Velocity Head	1.13	ft
Ke	0.20		Entrance Loss	0.23	ft

Inlet Control Properties

Inlet Control HW Elev.	103.50	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	4.9	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
RAMP1

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	105.00	ft	Headwater Depth/Height	2.50	
Computed Headwater Eleva	105.00	ft	Discharge	30.60	cfs
Inlet Control HW Elev.	104.38	ft	Tailwater Elevation	101.62	ft
Outlet Control HW Elev.	105.00	ft	Control Type	Outlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	99.12	ft
Length	88.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	PressureProfile		Depth, Downstream	2.50	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	1.87	ft
Velocity Downstream	9.74	ft/s	Critical Slope	0.015817	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.	105.00	ft	Upstream Velocity Head	1.47	ft
Ke	0.20		Entrance Loss	0.29	ft

Inlet Control Properties

Inlet Control HW Elev.	104.38	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	3.1	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
RAMP2

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	105.00	ft	Headwater Depth/Height	2.50	
Computed Headwater Eleva	105.00	ft	Discharge	30.96	cfs
Inlet Control HW Elev.	104.45	ft	Tailwater Elevation	101.71	ft
Outlet Control HW Elev.	105.00	ft	Control Type	Outlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	99.21	ft
Length	79.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	PressureProfile		Depth, Downstream	2.50	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	1.88	ft
Velocity Downstream	9.85	ft/s	Critical Slope	0.016183	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.	105.00	ft	Upstream Velocity Head	1.51	ft
Ke	0.20		Entrance Loss	0.30	ft

Inlet Control Properties

Inlet Control HW Elev.	104.45	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	3.1	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
SE1

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	105.00	ft	Headwater Depth/Height	2.00	
Computed Headwater Eleva	105.00	ft	Discharge	46.99	cfs
Inlet Control HW Elev.	104.62	ft	Tailwater Elevation	99.97	ft
Outlet Control HW Elev.	105.00	ft	Control Type	Outlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	97.47	ft
Length	253.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	PressureProfile		Depth, Downstream	2.50	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	2.26	ft
Velocity Downstream	9.57	ft/s	Critical Slope	0.011524	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	1.42	ft
Ke	0.20		Entrance Loss	0.28	ft

Inlet Control Properties

Inlet Control HW Elev.	104.62	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	4.9	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
SE2

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	106.50	ft	Headwater Depth/Height	2.60	
Computed Headwater Eleva	106.50	ft	Discharge	154.81	cfs
Inlet Control HW Elev.	105.22	ft	Tailwater Elevation	101.21	ft
Outlet Control HW Elev.	106.50	ft	Control Type	Outlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	97.96	ft
Length	204.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	PressureProfile		Depth, Downstream	3.25	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	2.32	ft
Velocity Downstream	10.51	ft/s	Critical Slope	0.013701	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.	106.50	ft	Upstream Velocity Head	1.72	ft
Ke	0.20		Entrance Loss	0.34	ft

Inlet Control Properties

Inlet Control HW Elev.	105.22	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	14.7	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
SE3

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	111.50	ft	Headwater Depth/Height	1.44	
Computed Headwater Eleva	111.50	ft	Discharge	3,708.33	cfs
Inlet Control HW Elev.	111.50	ft	Tailwater Elevation	103.48	ft
Outlet Control HW Elev.	111.27	ft	Control Type	Inlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	97.73	ft
Length	227.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	4.94	ft
Slope Type	Steep		Normal Depth	4.55	ft
Flow Regime	Supercritical		Critical Depth	6.44	ft
Velocity Downstream	18.78	ft/s	Critical Slope	0.003991	ft/ft

Section

Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	10.00	ft
Section Size	10 x 8 ft		Rise	8.00	ft
Number Sections	4				

Outlet Control Properties

Outlet Control HW Elev.	111.27	ft	Upstream Velocity Head	3.22	ft
Ke	0.50		Entrance Loss	1.61	ft

Inlet Control Properties

Inlet Control HW Elev.	111.50	ft	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares		Area Full	320.0	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
SE4

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	107.50	ft	Headwater Depth/Height	2.50	
Computed Headwater Eleva	107.50	ft	Discharge	331.06	cfs
Inlet Control HW Elev.	106.40	ft	Tailwater Elevation	101.54	ft
Outlet Control HW Elev.	107.50	ft	Control Type	Outlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	97.79	ft
Length	221.00	ft	Constructed Slope	0.010000	ft/ft

Hydraulic Profile

Profile	PressureProfile		Depth, Downstream	3.75	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	2.79	ft
Velocity Downstream	11.71	ft/s	Critical Slope	0.013317	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	4				

Outlet Control Properties

Outlet Control HW Elev.	107.50	ft	Upstream Velocity Head	2.13	ft
Ke	0.20		Entrance Loss	0.43	ft

Inlet Control Properties

Inlet Control HW Elev.	106.40	ft	Flow Control	N/A	
Inlet Type	Groove end projecting		Area Full	28.3	ft²
K	0.00450		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	3	
C	0.03170		Equation Form	1	
Y	0.69000				

APPENDIX F

PROPOSED QUANTITY AND COST ESTIMATES

FACILITY 1A: Pond 2 and Earth Berm Construction
FACILITY 1B: DeBeer Channel without Rip Rap Lining
FACILITY 2: Pond 3 and Channel 3 Construction
FACILITY 3: Pond 4 and Channel 4 Construction
FACILITY 4: Road Repavement

Facility 1A: Pond 2 and Earth Berm Construction

ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN

ITEM NO.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST
1	CLEARING AND GRUBBING, Complete in Place	ACRES	38.0	$2,500.00	$95,000.00
2	SEEDING, Complete	ACRES	1.98	$1,650.00	$3,271.92
3	SOIL BULK EXCAVATION FOR POND EMBANKMENT, CHANNELS / ROADWAY and FILL CONSTRUCTION FOR EMBANKMENTS, (incl. excavation, haul, disposal, fill placement and compaction), Complete in Place	CY	115,911	$6.00	$695,466.67
4	FINAL GRADING, Complete in Place	SY	86,333	$2.50	$215,833.33
5	12" SUBGRADE PREPARATION, Complete in Place	SY	200	$5.00	$1,000.00
6	TRENCHING, BACKFILL, & COMPACTION FOR 18" TO 36" PIPE, UP TO 8' IN DEPTH, Complete	LF	190	$25.00	$4,750.00
7	TRENCHING, BACKFILL, & COMPACTION FOR 42" TO 60" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$30.00	$0.00
8	24" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	190	$63.00	$11,970.00
9	36" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$58.00	$0.00
10	48" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$76.00	$0.00
11	60" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$110.00	$0.00
12	24" DIAMETER CMP, END SECTION, Complete	EA	1	$575.00	$575.00
13	36" DIAMETER CMP, END SECTION, Complete	EA	0	$400.00	$0.00
14	48" DIAMETER CMP, END SECTION, Complete	EA	0	$800.00	$0.00
15	60" DIAMETER CMP, END SECTION, Complete	EA	0	$1,400.00	$0.00
16	CHANNEL CHECK DAMS RIP-RAP, Complete in Place	CY	38	$227.00	$8,601.27
17	RIP-RAP CLASS A FOR CULVERT OUTLET PROTECTION, Complete in Place	CY	44	$227.00	$10,088.89
18	TRAPEZOIDAL CHANNEL RUNDOWN RIP RAP Complete in Place	CY	585	$100.00	$58,459.26
19	TRAPEZOIDAL CHANNEL RUNDOWN SOIL EXCAVATION Complete in Place	CY	585	$6.00	$3,507.56
20	RUNDOWN GRUB AND CLEAR Complete in Place	ACRES	0.00	$2,500.00	$0.00
21	CHANNEL SUBGRADE PREPERATION Complete in Place	SY	0	$5.00	$0.00
22	REINFORCED CONCRETE CHANNEL 6", Complete in Place	SF	0	$9.28	$0.00
23	REINFORCED STRUCTURAL CONCRETE, Complete in Place (For Spillway)	CY	45	$600.00	$27,200.00
24	PRINCIPAL SPILLWAYCONCRETE PORTER RISER - including concrete slab, Complete in Place	EA	1	$5,000.00	$5,000.00
25	GABIONS, Complete in Place	CY	0	$275.00	$0.00
26	2" HMA SP III, Complete	SY	0	$15.00	$0.00
27	BASE COURSE 6", Complete	SY	1,111	$8.00	$8,888.89
28	SAWCUT, REMOVE AND DISPOSE OF EXISTING ASPHALT PAVEMENT, up to 4" thick, Complete	SY	0	$7.00	$0.00
29	SECURITY SIGNING	LUMP SUM	1	$500.00	$500.00
30	CONSTRUCTION TRAFFIC CONTROL	LUMP SUM	1	$2,500.00	$2,500.00
31	NPDES PERMITTING AND SWPPP PREPARATION AND IMPLEMENTATION	LUMP SUM	1	$15,000.00	$15,000.00
	SUBTOTAL OF CONSTRUCTION LINE ITEMS				$1,167,612.77
	MOBILIZATION / DEMOBILIZATION	LUMP SUM	1	6.00%	$70,056.77
	CONSTRUCTION STAKING (incl. LAYOUT, QUANTITY VERIFICATION, AS-BUILT INFORMATION), Complete	LUMP SUM	1	2.00%	$23,352.26
	MATERIALS TESTING	ALLOW	1	2.00%	$23,352.26
A	SUBTOTAL OF CONSTRUCTION COST				$1,284,374.05

Facility 1A: Pond 2 and Earth Berm Construction					
B	CONTINGENCY @ 30%:				$385,312.22
C	SUBTOTAL OF CONSTRUCTION COST PLUS CONTINGENCY:				$1,669,686.27
D	PRE-CONSTRUCTION COSTS: (DESIGN, SURVEY, GEOTECHNICAL, & SUE = 10% of C)				$166,968.63
E	SUBTOTAL , CONTINGENCY, AND PRE-CONSTRUCTION COSTS: (C + D)				$1,836,654.89
	ALLOWANCES				
F	ASSUMED UTILITY RELOCATION (IF APPLICABLE)				$0.00
G	LAND ACQUISITION (ASSUMED VALUE OF $2,500/AC)	ACRE	38	$2,500.00	$95,000.00
H	SUBTOTAL : (E + F +G)				$1,931,654.89
I	NEW MEXICO GROSS RECEIPTS TAX (Dona Ana County) (NMGRT - JANUARY 2017) - 6.7500%				$130,386.71
J	TOTAL EOPC w/ TAX (NMGRT 2017): (H + I)				$2,062,042
	COST ROUNDED UP TO:				$2,062,042

Facility 1B: DeBeers Channel without Rip Rap Lining

ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN

ITEM NO.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST
1	CLEARING AND GRUBBING, Complete in Place	ACRES	12.0	$2,500.00	$30,000.00
2	SEEDING, Complete	ACRES	6.00	$1,650.00	$9,900.00
3	SOIL BULK EXCAVATION FOR POND EMBANKMENT, CHANNELS / ROADWAY and FILL CONSTRUCTION FOR EMBANKMENTS, (incl. excavation, haul, disposal, fill placement and compaction), Complete in Place	CY	35,000	$6.00	$210,000.00
4	FINAL GRADING, Complete in Place	SY	39,000	$2.50	$97,500.00
5	12" SUBGRADE PREPARATION, Complete in Place	SY	0	$5.00	$0.00
6	TRENCHING, BACKFILL, & COMPACTION FOR 18" TO 36" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$25.00	$0.00
7	TRENCHING, BACKFILL, & COMPACTION FOR 42" TO 60" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$30.00	$0.00
8	24" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$63.00	$0.00
9	36" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$58.00	$0.00
10	48" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$76.00	$0.00
11	60" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$110.00	$0.00
12	24" DIAMETER CMP, END SECTION, Complete	EA	0	$575.00	$0.00
13	36" DIAMETER CMP, END SECTION, Complete	EA	0	$400.00	$0.00
14	48" DIAMETER CMP, END SECTION, Complete	EA	0	$800.00	$0.00
15	60" DIAMETER CMP, END SECTION, Complete	EA	0	$1,400.00	$0.00
16	CHANNEL RIP-RAP, Complete in Place	CY	257	$227.00	$58,302.50
17	RIP-RAP CLASS A FOR CULVERT OUTLET PROTECTION, Complete in Place	CY	136	$227.00	$30,897.22
18	TRAPEZOIDAL CHANNEL RUNDOWN RIP RAP Complete in Place	CY	111	$100.00	$11,111.11
19	TRAPEZOIDAL CHANNEL RUNDOWN SOIL EXCAVATION Complete in Place	CY	111	$6.00	$666.67
20	RUNDOWN GRUB AND CLEAR Complete in Place	ACRES	0.00	$2,500.00	$0.00
21	CHANNEL SUBGRADE PREPERATION Complete in Place	SY	0	$5.00	$0.00
22	REINFORCED CONCRETE CHANNEL 6", Complete in Place	SF	0	$9.28	$0.00
23	REINFORCED STRUCTURAL CONCRETE, Complete in Place (For Spillway)	CY	0	$600.00	$0.00
24	PRINCIPAL SPILLWAYCONCRETE PORTER RISER - including concrete slab, Complete in Place	EA	0	$10,000.00	$0.00
25	GABIONS, Complete in Place	CY	204	$275.00	$56,222.22
26	2" HMA SP III, Complete	SY	0	$15.00	$0.00
27	BASE COURSE 6", Complete	SY	0	$8.00	$0.00
28	SAWCUT, REMOVE AND DISPOSE OF EXISTING ASPHALT PAVEMENT, up to 4" thick, Complete	SY	0	$7.00	$0.00
29	SECURITY SIGNING	LUMP SUM	1	$500.00	$500.00
30	CONSTRUCTION TRAFFIC CONTROL	LUMP SUM	1	$2,500.00	$2,500.00
31	NPDES PERMITTING AND SWPPP PREPARATION AND IMPLEMENTATION	LUMP SUM	1	$15,000.00	$15,000.00
	SUBTOTAL OF CONSTRUCTION LINE ITEMS				$466,377.50
	MOBILIZATION / DEMOBILIZATION	LUMP SUM	1	6.00%	$27,982.65
	CONSTRUCTION STAKING (incl. LAYOUT, QUANTITY VERIFICATION, AS-BUILT INFORMATION), Complete	LUMP SUM	1	2.00%	$9,327.55
	MATERIALS TESTING	ALLOW	1	2.00%	$9,327.55

Facility 1B: DeBeers Channel without Rip Rap Lining

A	SUBTOTAL OF CONSTRUCTION COST				$513,015.25
B	CONTINGENCY @ 30%:				$153,904.57
C	SUBTOTAL OF CONSTRUCTION COST PLUS CONTINGENCY:				$666,919.82
D	PRE-CONSTRUCTION COSTS: (DESIGN, SURVEY, GEOTECHNICAL, & SUE = 10% of C)				$66,691.98
E	SUBTOTAL , CONTINGENCY, AND PRE-CONSTRUCTION COSTS: (C + D)				$733,611.81
	ALLOWANCES				
F	ASSUMED UTILITY RELOCATION (IF APPLICABLE)				$0.00
G	LAND ACQUISITION (ASSUMED VALUE OF $2,500/AC)	ACRE	16	$2,500.00	$40,000.00
H	SUBTOTAL : (E + F +G)				$773,611.81
I	NEW MEXICO GROSS RECEIPTS TAX (Dona Ana County) (NMGRT - JANUARY 2017) - 6.7500%				$52,218.80
J	TOTAL EOPC w/ TAX (NMGRT 2017): (H + I)				$825,830.60
	COST ROUNDED UP TO:				$826,000.00

Facility 2: Pond 3 & Channel 3 Construction

ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN

ITEM NO.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST
1	CLEARING AND GRUBBING, Complete in Place	ACRES	4.00	$2,500.00	$10,000.00
2	SEEDING, Complete	ACRES	4.00	$1,650.00	$6,600.00
3	SOIL BULK EXCAVATION FOR POND EMBANKMENT, CHANNELS / ROADWAY and FILL CONSTRUCTION FOR EMBANKMENTS, (incl. excavation, haul, disposal, fill placement and compaction), Complete in Place	CY	7,200	$6.00	$43,200.00
4	FINAL GRADING, Complete in Place	SY	5,977	$2.50	$14,942.71
5	12" SUBGRADE PREPARATION, Complete in Place	SY	182	$5.00	$910.00
6	TRENCHING, BACKFILL, & COMPACTION FOR 18" TO 36" PIPE, UP TO 8' IN DEPTH, Complete	LF	220	$25.00	$5,500.00
7	TRENCHING, BACKFILL, & COMPACTION FOR 42" TO 60" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$30.00	$0.00
8	24" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	454	$63.00	$28,602.00
9	36" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$58.00	$0.00
10	48" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$76.00	$0.00
11	60" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$110.00	$0.00
12	24" DIAMETER CMP, END SECTION, Complete	EA	6	$575.00	$3,450.00
13	36" DIAMETER CMP, END SECTION, Complete	EA	0	$400.00	$0.00
14	48" DIAMETER CMP, END SECTION, Complete	EA	0	$800.00	$0.00
15	60" DIAMETER CMP, END SECTION, Complete	EA	0	$1,400.00	$0.00
16	RIP-RAP CLASS A	CY	20	$227.00	$4,540.00
17	TRAPEZOIDAL CHANNEL RUNDOWN RIP RAP Complete in Place	CY	284	$100.00	$28,414.81
18	TRAPEZOIDAL CHANNEL RUNDOWN SOIL EXCAVATION Complete in Place	CY	284	$3.00	$852.44
19	RUNDOWN GRUB AND CLEAR Complete in Place	ACRES	0.00	$2,500.00	$0.00
20	CHANNEL SUBGRADE PREPERATION Complete in Place	SY	5,525	$5.00	$27,626.67
21	REINFORCED CONCRETE CHANNEL 6", Complete in Place	SF	0	$9.28	$0.00
22	REINFORCED STRUCTURAL CONCRETE, Complete in Place (For Spillway)	CY	73	$600.00	$43,600.00
23	PRINCIPAL SPILLWAYCONCRETE PORTER RISER - including concrete slab, Complete in Place	EA	1	$10,000.00	$10,000.00
24	GABIONS, Complete in Place	CY	0	$275.00	$0.00
25	2" HMA SP III, Complete	SY	613	$15.00	$9,193.33
26	BASE COURSE 6", Complete	SY	550	$8.00	$4,400.00
27	SAWCUT, REMOVE AND DISPOSE OF EXISTING ASPHALT PAVEMENT, up to 4" thick, Complete	SY	0	$7.00	$0.00
28	SECURITY SIGNING	LUMP SUM	1	$500.00	$500.00
29	CONSTRUCTION TRAFFIC CONTROL	LUMP SUM	1	$2,500.00	$2,500.00
30	NPDES PERMITTING AND SWPPP PREPARATION AND IMPLEMENTATION	LUMP SUM	1	$15,000.00	$15,000.00
	SUBTOTAL OF CONSTRUCTION LINE ITEMS				$259,831.98
	MOBILIZATION / DEMOBILIZATION	LUMP SUM	1	6.00%	$15,589.92
	CONSTRUCTION STAKING (incl. LAYOUT, QUANTITY VERIFICATION, AS-BUILT INFORMATION), Complete	LUMP SUM	1	2.00%	$5,196.64
	MATERIALS TESTING	ALLOW	1	2.00%	$5,196.64

Facility 2: Pond 3 & Channel 3 Construction					
A	SUBTOTAL OF CONSTRUCTION COST				$285,815.17
B	CONTINGENCY @ 30%:				$85,744.55
C	SUBTOTAL OF CONSTRUCTION COST PLUS CONTINGENCY:				$371,559.73
D	PRE-CONSTRUCTION COSTS: (DESIGN, SURVEY, GEOTECHNICAL, & SUE = 10% of C)				$37,155.97
E	SUBTOTAL , CONTINGENCY, AND PRE-CONSTRUCTION COSTS: (C + D)				$408,715.70
	ALLOWANCES				
F	ASSUMED UTILITY RELOCATION (IF APPLICABLE)				$0.00
G	LAND ACQUISITION (ASSUMED VALUE OF $2,500/AC)	ACRE	4	$2,500.00	$10,000.00
H	SUBTOTAL : (E + F +G)				$418,715.70
I	NEW MEXICO GROSS RECEIPTS TAX (Dona Ana County) (NMGRT - JANUARY 2017) - 6.7500%				$28,263.31
J	TOTAL EOPC w/ TAX (NMGRT 2017): (H + I)				$446,979.01

Facility 3 Pond 4 & Channel 4 Construction

ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN

ITEM NO.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST
1	CLEARING AND GRUBBING, Complete in Place	ACRES	5.00	$2,500.00	$12,500.00
2	SEEDING, Complete	ACRES	5.00	$1,650.00	$8,250.00
3	SOIL BULK EXCAVATION FOR POND EMBANKMENT, CHANNELS / ROADWAY and FILL CONSTRUCTION FOR EMBANKMENTS, (incl. excavation, haul, disposal, fill placement and compaction), Complete in Place	CY	15,000	$6.00	$90,000.00
4	FINAL GRADING, Complete in Place	SY	5,776	$2.50	$14,439.53
5	12" SUBGRADE PREPARATION, Complete in Place	SY	68	$5.00	$340.00
6	TRENCHING, BACKFILL, & COMPACTION FOR 18" TO 36" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$25.00	$0.00
7	TRENCHING, BACKFILL, & COMPACTION FOR 42" TO 60" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$30.00	$0.00
8	24" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	110	$38.00	$4,180.00
9	36" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$58.00	$0.00
10	48" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$76.00	$0.00
11	60" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$110.00	$0.00
12	24" DIAMETER CMP, END SECTION, Complete	EA	1	$275.00	$275.00
13	36" DIAMETER CMP, END SECTION, Complete	EA	0	$400.00	$0.00
14	48" DIAMETER CMP, END SECTION, Complete	EA	0	$800.00	$0.00
15	60" DIAMETER CMP, END SECTION, Complete	EA	0	$1,400.00	$0.00
16	RIP-RAP CLASS A FOR CULVERT OUTLET PROTECTION, Complete in Place	CY	354	$100.00	$35,410.35
17	TRAPEZOIDAL CHANNEL RUNDOWN RIP RAP Complete in Place	CY	354	$100.00	$35,410.35
18	TRAPEZOIDAL CHANNEL RUNDOWN SOIL EXCAVATION Complete in Place	CY	510	$6.00	$3,057.95
19	RUNDOWN GRUB AND CLEAR Complete in Place	ACRES	0	$2,500.00	$0.00
20	CHANNEL SUBGRADE PREPERATION Complete in Place	SY	708	$5.00	$3,541.04
21	Rip Rap for Grade Control Structures, Complete in Place	CY	8	$227.00	$1,816.00
22	REINFORCED STRUCTURAL CONCRETE, Complete in Place (For Spillway)	CY	35	$600.00	$20,800.00
23	PRINCIPAL SPILLWAYCONCRETE PORTER RISER - including concrete slab, Complete in Place	EA	1	$10,000.00	$10,000.00
24	GABIONS, Complete in Place	CY	0	$275.00	$0.00
25	2" HMA SP III, Complete	SY	0	$15.00	$0.00
26	BASE COURSE 6", Complete	SY	0	$8.00	$0.00
27	SAWCUT, REMOVE AND DISPOSE OF EXISTING ASPHALT PAVEMENT, up to 4" thick, Complete	SY	0	$7.00	$0.00
28	SECURITY SIGNING	LUMP SUM	1	$500.00	$500.00
29	CONSTRUCTION TRAFFIC CONTROL	LUMP SUM	1	$2,500.00	$2,500.00
30	NPDES PERMITTING AND SWPPP PREPARATION AND IMPLEMENTATION	LUMP SUM	1	$15,000.00	$15,000.00
	SUBTOTAL OF CONSTRUCTION LINE ITEMS				$258,020.22
	MOBILIZATION / DEMOBILIZATION	LUMP SUM	1	6.00%	$15,481.21
	CONSTRUCTION STAKING (incl. LAYOUT, QUANTITY VERIFICATION, AS-BUILT INFORMATION), Complete	LUMP SUM	1	2.00%	$5,160.40
	MATERIALS TESTING	ALLOW	1	2.00%	$5,160.40
A	SUBTOTAL OF CONSTRUCTION COST				$283,822.24
B	CONTINGENCY @ 30%:				$85,146.67
C	SUBTOTAL OF CONSTRUCTION COST PLUS CONTINGENCY:				$368,968.92

Facility 3 Pond 4 & Channel 4 Construction

D	PRE-CONSTRUCTION COSTS: (DESIGN, SURVEY, GEOTECHNICAL, & SUE = 10% of C)				$36,896.89
E	SUBTOTAL , CONTINGENCY, AND PRE-CONSTRUCTION COSTS: (C + D)				$405,865.81
	ALLOWANCES				
F	ASSUMED UTILITY RELOCATION (IF APPLICABLE)				$0.00
G	LAND ACQUISITION (ASSUMED VALUE OF $2,500/AC)	ACRE	5	$2,500.00	$13,512.63
H	SUBTOTAL : (E + F +G)				$419,378.43
I	NEW MEXICO GROSS RECEIPTS TAX (Dona Ana County) (NMGRT - JANUARY 2017) - 6.7500%				$28,308.04
J	TOTAL EOPC w/ TAX (NMGRT 2017): (H + I)				$447,686.48

Facility 4 Road Repavement

ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN

ITEM NO.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST
8	6" SUBGRADE PREPARATION, CIP(Fort Marcy Trail)	SY	30	$2.50	$75.00
9	SAWCUT, REMOVE AND DISPOSE OF EXISTING ASPHALT PAVEMENT, Complete (Fort Marcy Taril)	SY	30	$7.00	$210.00
10	REMOVE AND DISPOSE 18" CMP CULVERT, COMPLETE (Fort Marcy Trail)	LF	50	$20.00	$1,000.00
11	2" HMA SP III, CIP (Fort Marcy Trail)	SY	30	$15.00	$450.00
	PRIME COAT, CIP (Buffalo Estate Rd)	SY	30	$1.00	$30.00
12	6" BASE COURSE, CIP (Fort Marcy Trail)	SY	30	$8.00	$240.00
	Fort Marcy Trail Repair Total				$2,005.00
1	REMOVE AND DISPOSE ASPHALT PAVEMENT, COMPLETE (Buffalo Estate Rd)	SY	9,000	$4.00	$36,000.00
2	CURB AND GUTTER ALL TYPES, CIP (Buffalo Estate Rd)	LF	5,400	$18.00	$97,200.00
3	6" SUBGRADE PREPARATION, CIP (Buffalo Estate Rd)	SY	9,000	$2.50	$22,500.00
4	6" BASE COURSE, CIP (Buffalo Estate Rd)	SY	9,000	$8.00	$72,000.00
5	2" HMA SP III, CIP (Buffalo Estate Rd)	SY	9,000	$15.00	$135,000.00
6	PRIME COAT, CIP (Buffalo Estate Rd)	SY	9,000	$1.00	$9,000.00
7	DRIVEPAD, CIP (Buffalo Estate Rd)	SY	2,500	$64.00	$160,000.00
13	SECURITY SIGNING	LUMP SUM	1	$500.00	$500.00
14	CONSTRUCTION TRAFFIC CONTROL	LUMP SUM	1	$10,000.00	$10,000.00
15	NPDES PERMITTING AND SWPPP PREPARATION AND IMPLEMENTATION	LUMP SUM	1	$15,000.00	$15,000.00
	SUBTOTAL OF CONSTRUCTION LINE ITEMS				$559,205.00
16	MOBILIZATION / DEMOBILIZATION	LUMP SUM	1	6.00%	$33,552.30
17	CONSTRUCTION STAKING (incl. LAYOUT, QUANTITY VERIFICATION, AS-BUILT INFORMATION), Complete	LUMP SUM	1	2.00%	$11,184.10
18	MATERIALS TESTING	ALLOW	1	2.00%	$11,184.10
A	SUBTOTAL OF CONSTRUCTION COST				$615,125.50
B	CONTINGENCY @ 30%:				$184,537.65
C	SUBTOTAL OF CONSTRUCTION COST PLUS CONTINGENCY:				$799,663.15
D	PRE-CONSTRUCTION COSTS: (DESIGN, SURVEY, GEOTECHNICAL, & SUE = 10% of C)				$79,966.32
E	SUBTOTAL , CONTINGENCY, AND PRE-CONSTRUCTION COSTS: (C + D)				$879,629.47
	ALLOWANCES				
F	ASSUMED UTILITY RELOCATION (IF APPLICABLE)				$0.00
G	LAND ACQUISITION (ASSUMED VALUE OF $2,500/AC)	ACRE	0.0	$2,500.00	$0.00
H	SUBTOTAL : (E + F +G)				$879,629.47
I	NEW MEXICO GROSS RECEIPTS TAX (Dona Ana County) (NMGRT - JANUARY 2017) - 6.7500%				$59,374.99
J	TOTAL EOPC w/ TAX (NMGRT 2017): (H + I)				$939,004.45
	COST ROUNDED UP TO:				$940,000