

# Final Drainage Report

for the

## McGehee Tract El Paso County, Colorado

April, 2021

### Comment from Review 1:

For the next submittal, please upload this report as a non-scanned PDF so it is searchable. If the signature page needs to be scanned, just scan that one page and add it to the rest of the non-scanned PDF electronically, or e-sign that page.

It is really hard to do a proper review of this document without being able to search through it (now and in the future).

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PCD No. SF2011

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**Certifications and Approvals**

**Engineer's Statement**

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report had been prepared according to the criteria established by El Paso County for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omission on my part in preparation this report

Signature \_\_\_\_\_ Seal  
(Kenneth C. Harrison, P.E.)

**Developer/Owner Statement**

I, the developer/owner, \_\_\_\_\_, have read and will comply with all of the requirements specified in this drainage report and plan.

\_\_\_\_\_  
(Business Name)

By: \_\_\_\_\_  
(Signature) (Date)

Print Name and Title \_\_\_\_\_

Address: \_\_\_\_\_

**El Paso County**

Filed in accordance with the requirements of the Drainage Criteria Manual, Volumes 1 and 2, El Paso County Engineering Criteria Manual and Land Development Code as amended.

For El Paso County Engineer

\_\_\_\_\_  
Jenner Irvine, P.E. (Date)  
County Engineer/ECM Administrator

**Flood Plain Statement**

See Section V of this report

## I. Report Purpose

The purpose of this report is to evaluate the existing and developed drainage characteristics for the McGehee Residence project site. This will include:

- The evaluation of offsite conditions both upstream and downstream of the project site.
- A description of the existing offsite and onsite drainage improvements.
- Hydrologic analysis for both the existing and developed conditions. The main purpose for the analysis of the developed conditions was to demonstrate the negligible increase in runoff as a result of development.
- A hydraulic analysis was performed for both the existing and proposed culverts, the onsite swales and the Thompson Road borrow ditch.
- Recommendations regarding onsite drainage improvements.
- Research and provide a summary of information provided by the State of Colorado Water Resources regarding the existing large stock pond located on the project site.
- Discussion regarding detention and storm water quality.
- General recommendations regarding erosion control.

## II. General Description

### Location

The site is a 10.5-acre tract is noted as Lot 3 (the site) of the Mountain Shadows Ranch Second Phase Subdivision which was platted December 12, 1999 (*Exhibit 1, Appendix*). Mountain Shadows Ranch Second Phase Subdivision is located in the northerly section of El Paso County in the Section 19, Township 11 South, Range 65 West of the 6<sup>th</sup> Principal Meridian, El Paso County, Colorado.

Lot 3 of the Mountain Shadows Ranch Second Phase Subdivision consists of approximately 10.5-acres. It is proposed to subdivide the site into 2 lots. The sizes of these lots are:

- Lot 1: 5.0-acres
- Lot 2: 5.5-acres

The property to the north of the site is unplatted. The property to the west and east of the site is Mountain Shadows Ranch Second Phase Lots 1 and 2. The property to the east of the site is the Thompson Road right-of-way with a varying right-of-way width.

### Topography

The topographic characteristics of the site were determined from GIS mapping provided by El Paso County. The majority of the runoff from the site is collected by a natural swale that traverses the site in a west to east to west direction. The swale is stable and vegetated with natural grasses and a few bushes and trees. There are several stock ponds located along the swale. The approximate

What about S3 that is shown on the map?  
Discuss or revise text/map as necessary.

locations of these ponds are shown on the Drainage Map included in the map pocket of this report.

The high point of the swale (S1) located west and offsite of the site is located approximately 2,200 feet west of the site's westerly property line. The average slope of the swale west of the site is 4.6%. Despite the relatively steep slope the existing swale (S1) appears to be stable with only minimal signs of erosion. The average slope of the swale (S2) within the site boundaries of Subbasin A is approximately 3.6%. Swale S2 outfalls into a large stock pond at DP5. The pond's embankment is located approximately 130 feet west of the easterly property line which is also the westerly right-of-way line of Thompson Road. It appears that the pond is typically dry since the vegetation throughout the bottom and sides of the pond is well established. The embankment of the stock pond is approximately 12 feet high. The outlet of the pond consists of a 24-inch corrugated metal pipe (STR1). The water from the pond is routed to the 30-inch culvert (STR2) under Thompson Road via Swale 4 (S4). Once under Thompson Road the water is routed in a northeasterly direction in another stable grass-lined swale (S7). A hydraulic analysis of swale east of the Thompson Road crossing is beyond the scope of this report.

Comment from Review #1:

At least describe the downstream conditions and/or the ultimate receiving waters. Although the difference between the existing and developed flowrates is not significant, it must be known whether the downstream conditions can handle the increase in flow.

Per the 3rd paragraph in DCM Vol 1, Chap 2.5.3

Additional runoff from a small easterly portion of the site is collected by the borrow ditch (S6) located along the west side of Thompson Road. Offsite runoff from OS8 is collected by another section of the Thompson Road borrow ditch (S5) located south of the culvert at DP14.

Only preliminary hydraulic analyses for the swales and culverts discussed above was conducted to obtain a "preliminary" estimation of the suitability of each drainage facility. A complete analysis of each drainage facility is outside the scope of this report since the increase in the runoff, based on the developed conditions, is only negligible.

### Structures (Existing and Proposed)

There are three (3) **existing** drainage culverts (see Existing Conditions Drainage Plan) and one (1) **proposed** culvert see (Developed Conditions Drainage Plan) to be installed. They are as follows:

- The **existing** 24 " culvert, noted as STR1, under the existing large stock pond.
- The **existing** 30", noted as STR2, is located under Thompson Road approximately 270 feet south of the northeasterly property corner. All of the runoff from the site drains to this culvert.
- The **existing** 18" culvert, noted as STR3, under the farm access road off of Thompson Road. This is located approximately 225-feet north of the southeasterly property corner.
- The **proposed** culvert, noted as (STR4), is proposed under the proposed driveway access to be constructed to access the proposed residences.

Review #2 clarification: It is understood that the area east of Thompson Rd is outside the scope of this report. But given the increase in flowrate, the capacity of the downstream conveyance system must be discussed. A simple statement would be acceptable, for example: "the small increase in flowrate from existing to proposed conditions (Q5 change = +0.5 cfs, Q100 change = +0.6cfs) is not significant enough to have negative downstream impacts, as the downstream conveyance system has sufficient capacity for the increased flows."

And if there is a historic drainage report/study that shows the capacity of any downstream conveyances, it would be very helpful to reference one.

This culvert is to be installed at approximately 150-feet south of the northeasterly property corner (see Developed Conditions Map).

### III. Design Criteria and Methodology

#### a. **Design Manuals**

Applicable excerpts from the following manuals are included in the Appendix of this report (*Exhibit 4, Appendix*) El Paso County Drainage Criteria Manual (EPCDCM), dated September 30, 1990, Revised July, 2019

- El Paso County Engineering Criteria Manual (EPCECM), Revised 2020
- Colorado Springs Drainage Criteria Manuals, Volume 1 and 2, dated May, 2014
- Urban Drainage and Flood Control Manual, Volumes 2 and 3, dated August 2018
- CDOT Erosion Control Field Handbook, dated April 20, 2017
- GIS mapping obtained from El Paso County. El Paso County Information Technologies at 325 South Cascade Avenue, Colorado Springs, 80903.

#### b. **Specific Criteria**

- Design storms

The design storms are as follows:

Minor storm: 5 year

Major storm: 100 year

Any recommended drainage facilities are sized for the 5-year storm event.

Routing of the 100-storm event is analyzed and discussed regarding the safe conveyance to offsite facilities.

- Drainage Areas

Areas for the offsite and onsite sub basins were delineated from available topographic GIS mapping obtained from El Paso County. El Paso County Information Technologies at 325 South Cascade Avenue, Colorado Springs, 80903.

- Runoff Estimation

- Rational Method: This method was used to determine runoff estimates since the Offsite and onsite drainage basins are less than 130 acres.
- Intensity-Duration-Frequency (IDF) curves were obtained from the CSDCM (*Appendix, Exhibit 4*)
- Time of concentration was determined using the equations provided in the EPC Drainage Criteria Manual (*Appendix, Exhibit 4*). The time of concentration values shown in the "Area Drainage

Summary” tables (*Appendix, Exhibit 7*) reflect the time it takes for all of the runoff from each individual sub basin to reach the DP for each sub basin. The time of concentration used to determine the total runoff for the entire site was determined from the cumulative time for water to travel from DP1 to DP7. This was based on the assumed velocity in the existing swale segments 1 through 4. This is summarized in the “Surface Routing Summary” table in *Exhibit 7 of the Appendix*.

- **Drainage swale and borrow ditch sizing**  
The only swale that drains this site is located approximately in the middle and it drains the site in a west to east direction. This entire swale is broken into segments, S1 through S4. The swale drains all the offsite and onsite runoff to an existing stock pond noted as STR1. The swale was evaluated for both the minor 5-year storm and the major 100-year storm events. The swale is a stable natural swale lined with native grasses with a few bushes and trees.
- The Froude Numbers are shown for both the 5 year and the 100-year storm events for information purposes only. By definition, values under 1.0 indicate sub critical flow which is stable. Values above 1.0 indicate super critical flow which can cause a substantial amount of erosion. Values from 0.9 to 1.1 are considered to be unstable. The Froude numbers indicated in this report are determined from a substantial number of assumptions regarding the physical characteristics of each swale. These characteristics were determined based on the topography made available from El Paso County. Additional field information is required in order to obtain a more accurate determination of the stability of each swale section. Based on visual observations, all swale sections appear to be relatively stable with only a minimal amount of erosion and down cutting.
- **Stock Ponds (see Appendix, Exhibit 8)**  
There is a total of four (4) stock ponds located along the existing swale. Three (3) of the stock ponds are small and therefore non-jurisdictional. The ponds located east of the largest pond are minor with embankment heights between 2 to 4 feet. The furthest easterly one is the largest and jurisdictional. Based on visual observations they appear to be stable with permanent stands of native vegetation. Evaluation of these ponds are outside the scope of this report. The State of Colorado Water Resources Department was contacted to obtain information regarding the largest of these ponds. This information is included in Exhibit 8 of the Appendix. It is also assumed that the property owner owns the ponds as well.

- **Culverts**

- The **existing** 24 " culvert, noted as STR1, functions as the outfall to the large stock pond.
- The **existing** 30", noted as STR2, is located under Thompson Road approximately 270 feet south of the northeasterly property corner. All of the runoff from the site drains to this culvert.
- The **existing** 18" culvert, noted as STR3, under the farm access road off of Thompson Road. This is located approximately 225-feet north of the southeasterly property corner.
- The **proposed** culvert, noted as (STR4), is proposed under the proposed driveway access to be constructed to access the proposed residences

The culvert under Thompson Road was evaluated as follows:

- Headwater to Depth Ratio = 1.5 for the 5-year storm
- One lane open along Thompson Road for the 100-year storm. Since this criteria typically produces substantial erosion at the outlet the allowable velocity in the culvert was limited to no greater than 10 fps.

It is assumed that the Owner will not be required to install any erosion control improvements at the outfall of the 30" culvert under Thompson

Road since the increase in runoff as a result of development is only negligible and therefore has little, if any, effect on the existing hydraulic condition of the culvert.

- **Detention/ Water Quality Pond**

A full spectrum detention pond is not required for this development. Reasons will be discussed in a subsequent section of this report. The reasons are based on El Paso County criteria as well as Colorado State criteria.

- **Erosion control**

The following facilities are anticipated to be required along the proposed driveway located as shown on the Developed Conditions Drainage Plan:

- Erosion Control Blankets
- Silt fences
- Staked hay bales
- Erosion control fabric
- Erosion control logs

Revise this statement per comment on Page 5 above (to just be more specific than it currently is).

**IV. EXISTING REPORTS, MAPPING AND INFORMATION**

No drainage reports have been prepared for the areas adjacent to the project site

**V. FEMA FLOODPLAIN**

The project site is located in FEMA map # 08041CO305G (eff 12/7/2018) (*Appendix, Exhibit 2*). The entire site is located outside the 100-year floodplain in Zone X which is an “Area of Minimal Disturbance” for which there are no special requirements for the construction of commercial or industrial structures.

**VI. HYDROLOGIC SOILS INFORMATION**

The hydrologic soils groups were obtained from the USDA National Resource Conservation Service website for soils types in El Paso County, Colorado (*Appendix, Exhibit 3*). The soils are identified as follows:

**a. Peyton Sandy Loam (Soil ID 67) which have the following characteristics:**

- Well drained
- Runoff Class; Medium
- Depth to water table: >80 inches
- Frequency of flooding: none
- Frequency of ponding: none
- Hydrologic Soil Group: B

A detailed description of each of the type soil is included in *Appendix Exhibit 3*.

**VII. EXISTING DRAINAGE CONDITIONS**

**a. Existing Drainage Reports**

The drainage report for Mountain Shadows Ranch Second Phase Subdivision was not available through the EDARP service from El Paso County.

**b. Offsite Drainage Areas for Existing Conditions**

- i. The hydrologic characteristics for both the existing and developed conditions of the site are included in the *Appendix (Exhibit 6)*. The hydraulic conditions for the existing swales and the existing and the proposed culverts are summarized in the tables included in the *Appendix (Exhibit 7)*.

**ii. Design Point 1  
Description**

DP1 is the collection point for runoff from Sub-basin OS1 (34.1 acres). This Sub-basin is vegetated with natural grasses with a few bushes and trees located along the flowline of the existing swale (S1). All the runoff is collected by an existing natural and stable swale (S1) that basically bisects the site in a west to east direction. The swale routes the water to DP1 located on the westerly property line 300-feet south of the northwesterly property corner of the study tract. The portion of the sub

basin to the north of the swale slopes from north to south at an average slope between 4.0% and 7%.

### **Hydrologic Summary**

The hydrologic characteristics of the runoff from OS1 at DP1 for the existing conditions is as follows:

- Drainage Area = 34.1 acres
- Runoff Coefficients: 5 year = 0.09, 100 year = 0.36
- Time of Concentration: 23.2 minutes
- Runoff: 5 year = 8.7 cfs, 100 year = 58.5 cfs

### **Hydraulic Summary for Offsite Swale 1 (S1) Calc Sheets CS1, CS2.**

- Runoff: 5 year = 8.7 cfs, 100 year = 58.5 cfs
- Average Bottom width: 5 feet
- Average Side Slope ratio: 20 to 1
- Average Slope: 4.7%
- Velocity: 5-year = 2.9 fps, 100 year = 4.9 fps
- Depth of Flow = 5-year = 0.3 ft, 100 year = 0.7 ft.
- Froude No.= 5-year = 1.21 (Supercritical), 100 year = 1.38 (Super critical)

### **iii. Design Point 2 (offsite)**

#### **Description**

DP2 is the collection point for runoff from Sub-basin OS3 (0.6 acres). Runoff at this DP flows to the south and enters swale 1 near DP1. The Sub-basin slopes from north to south at an average grade of 10%. Sub-basin OS3 is vegetated with natural grasses. All the runoff is collected by an existing natural and stable swale (S1) that basically bisects the Sub-basin in an east to west direction.

#### **Hydrologic Summary**

The hydrologic characteristics of the runoff from OS3 at DP1 for the existing conditions is as follows:

- Drainage Area = 0.6 acres
- Runoff Coefficients: 5 year = 0.08, 100 year = 0.35
- Time of Concentration: 15 minutes
- Runoff: 5 year = 0.2 cfs, 100 year = 1.2 cfs

### **iv. Design Point 3 (offsite)**

#### **Description**

DP3 is the collection point for runoff from Sub-basin OS4 (0.6 acres). Runoff at this DP flows to the north and enters swale 1 near DP1. The Sub basin slopes from south to north at an average grade of 8%. Sub-

basin OS4 is vegetated with natural grasses. All the runoff is collected by the existing natural and stable swale (S1).

#### **Hydrologic Summary**

The hydrologic characteristics of the runoff from OS4 at DP3 for the existing conditions is as follows:

- Drainage Area = 0.6 acres
- Runoff Coefficients: 5 year = 0.17, 100 year = 0.0.41
- Time of Concentration: 13.3 minutes
- Runoff: 5 year = 0.4 cfs, 100 year = 1.5 cfs

#### **v. Design Point 4 (offsite)**

##### **Description**

Runoff from Sub-basin OS7 (3.6 acres) sheet flows onto onsite Sub-basin A. There is not a specific collection point. DP4 only represents the total amount of sheet flow that enters onsite Sub-basin A. This DP is also located at the entrance to the large stock pond. Runoff at this DP flows to the north and enters swale 2 (S2) at DP4. Sub basin OS7 slopes from south to north at an average grade of 8.3%. Sub basin OS7 is vegetated with natural grasses. All the runoff is collected by the existing natural and stable swale (S2) which outfalls into the stock pond.

##### **Hydrologic Summary**

The hydrologic characteristics of the runoff from OS7 at DP4 for the existing conditions is as follows:

- Drainage Area = 3.6 acres
- Runoff Coefficients: 5 year = 0.12, 100 year = 0.38
- Time of Concentration: 15.5 minutes
- Runoff: 5 year = 1.5 cfs, 100 year = 8.0 cfs

The hydraulic characteristics for the swale that drains this study site are summarized in the Onsite Drainage Areas for Existing Conditions section of this report in order to account for all of the upstream runoff that contributes storm water to swale 2.

#### **v. Design Point 5 (see Onsite Drainage Areas for Existing Conditions)**

#### **vi. Design Point 6 (see Onsite Drainage Areas for Existing Conditions)**

**vii. Design Point 7 (see Onsite Drainage Areas for Existing Conditions)**

**viii. Design Point 8 (offsite)**

**Description**

Runoff from sub basin OS5 (0.4 acres) sheet flows onto onsite Sub-basin A. There is not a specific collection point. DP8 only represents the total amount of sheet flow that enters onsite Sub-basin A. Sub-basin OS5 slopes from north to south to north at an average grade of 1.2%. Sub basin OS5 is vegetated with natural grasses.

**Hydrologic Summary**

The hydrologic characteristics of the runoff from OS5 at DP8 for the existing conditions is as follows:

- Drainage Area = 0.4 acres
- Runoff Coefficients: 5 year = 0.08, 100 year = 0.35
- Time of Concentration: 10.9 minutes
- Runoff: 5 year = 0.1 cfs, 100 year = 0.9 cfs

**ix. Design Point 9 (offsite)**

**Description**

Runoff from Sub-basin OS6 (0.9 acres) sheet flows onto onsite Sub-basin B. There is not a specific collection point for the runoff from Sub-basin OS6. DP9 only represents the total amount of sheet flow that enters onsite sub basin B. Sub-basin OS6 slopes from north to south to north at an average grade of 5.0%. Sub-basin OS6 is vegetated with natural grasses.

**Hydrologic Summary**

The hydrologic characteristics of the runoff from OS5 at DP8 for the existing conditions is as follows:

- Drainage Area = 0.9 acres
- Runoff Coefficients: 5 year = 0.08, 100 year = 0.35
- Time of Concentration: 15.2 minutes
- Runoff: 5 year = 0.3 cfs, 100 year = 1.9 cfs

**x. Design Point 10 (offsite)**

**Description**

Runoff from Sub-basin OS2 (10.3 acres) sheet flows into the stock pond from the south. There is no specific collection point. DP10 only represents the total amount of sheet flow that enters the stock pond. Sub-basin OS2 slopes from south to north at an average grade of 7.3%. Sub-basin OS2 is vegetated with natural grasses. All the runoff is collected by the existing stock pond.

### Hydrologic Summary

The hydrologic characteristics of the runoff from OS2 at DP10 for the existing conditions is as follows:

- Drainage Area = 10.3 acres
- Runoff Coefficients: 5 year = 0.10, 100 year = 0.36
- Time of Concentration: 17.9 minutes
- Runoff: 5 year = 3.3 cfs, 100 year = 20.5 cfs

### xi. Design Point 11 (offsite)

#### Description

Runoff from Sub-basin OS8 (1.4 acres) sheet flows into an existing grass lined swale (S5) that routes the storm water from the outlet of the stock pond to the existing 30-inch culvert under Thompson Road. There is no specific collection point from OS8. DP11 only represents the total amount of sheet flow that enters S4. Sub-basin OS8 slopes from south to north at an average grade of 5.5%. Sub-basin OS8 is vegetated with natural grasses. All the runoff is collected by the existing swale (S4).

Unresolved. Please revise. It appears that runoff from OS8 drains to S4, and not S5, per the existing drainage map. S4 is downstream of stock pond referenced in this narrative.

#### Hydrologic Summary

The hydrologic characteristics of the runoff from OS8 at DP11 for the existing conditions is as follows:

- Drainage Area = 1.4 acres
- Runoff Coefficients: 5 year = 0.08, 100 year = 0.35
- Time of Concentration: 14.1 minutes
- Runoff: 5 year = 0.4 cfs, 100 year = 3.0 cfs

### xii. Design Point 12 (offsite)

#### Description

Runoff from Sub-basin OS10 (0.5 acres) is collected by the westerly borrow ditch (S4) along Thompson Road. The high point of the borrow ditch is located approximately 500-feet south of the culvert under Thompson Road at DP14. The water flows from south to north and joins the water flowing from the north from Sub-basin OS9. The water is then routed under Thompson Road via a 30-inch corrugated metal culvert at DP14.

Sub-basin OS10 is composed of native vegetation and asphalt roadway for Thompson Road. All the runoff is collected by the existing borrow ditch (S5) which routes the water under Thompson Road via a 30-inch CMP culvert.

### **Hydrologic Summary**

The hydrologic characteristics of the runoff from OS10 at DP12 for the existing conditions are as follows:

- Drainage Area = 0.5 acres
- Runoff Coefficients: 5 year = 0.57, 100 year = 0.72
- Time of Concentration: 5.3 minutes
- Runoff: 5 year = 1.5 cfs, 100 year = 3.1 cfs

### **Hydraulic Summary for Offsite Swale 5 (S5) Calc Sheets 3-4,**

- Runoff: 5 year = 1.5 cfs, 100 year = 3.1 cfs
- Average Bottom width: 2 feet
- Average Side Slope ratio: 3 to 1
- Average Slope: 5%
- Velocity: 5-year = 2.7 fps, 100 year = 3.5 fps
- Depth of Flow = 5-year = 0.2 ft, 100 year = 0.3 ft.
- Froude No. = 5-year = 1.2 (Supercritical), 100 year = 1.28 (Super critical)
- Swale Condition: the swale is in good and stable condition, with minimal erosion, despite the super critical flow range. This is due to the low velocities and the heavy vegetation.

### **xiii. Design Point 13 (offsite)**

#### **Description**

Runoff from Sub-basin OS9 (0.4 acres) is collected by the westerly borrow ditch (S6) for Thompson Road. The high point of the borrow ditch is located approximately 550-feet north of the culvert under Thompson Road at DP14. The water flows from north to the south and joins the water flowing from Sub-basin OS10. The water then is routed under Thompson Road via a 30-inch corrugated metal culvert at DP14.

Sub-basin OS9 is composed of native vegetation and asphalt roadway for Thompson Road. All the runoff is collected by the existing borrow ditch (S6) which routes the water under Thompson Road via a 30" CMP culvert

#### **Hydrologic Summary**

The hydrologic characteristics of the runoff from OS9 at DP13 for the existing conditions is as follows:

- Drainage Area = 0.4 acres
- Runoff Coefficients: 5 year = 0.70, 100 year = 0.81
- Time of Concentration: 6.1 minutes
- Runoff: 5 year = 1.4 cfs, 100 year = 2.6 cfs

**Hydraulic Summary for Offsite Swale 6 (S6) Calc Sheets CS13, 14.**

- Runoff: 5 year = 1.4 cfs, 100 year = 2.6 cfs
- Average Bottom width: 2 feet
- Average Side Slope ratio: 3 to 1
- Average Slope: 5.5%
- Velocity: 5-year = 2.8 fps, 100 year = 3.4 fps
- Depth of Flow = 5-year = 0.2 ft, 100 year = 0.3 ft.
- Froude No. = 5-year = 1.27 (Supercritical), 100 year = 1.32 (Super critical)
- Swale Condition: the swale is in good and stable condition, with minimal erosion, despite the super critical flow range. This is due to the low velocities and the heavy vegetation.

**Preliminary Hydraulic Summary for Proposed Driveway Culvert 150 south of NE Property Corner (Calc Sheet 9)**

- Runoff: 5 year = 1.4 cfs, 100 year = 2.6 cfs
- Culvert Size: 18- inches
- Conditions: inlet control
- Headwater to Depth Ratio: 5 year = neg, 100 year = 0.6
- Depth at inlet  
5 year = neg, 100 year = 0.9 ft

**xiv. Design Point 14 (offsite)**

**Description**

DP 14 is located at the entrance to the existing 30-inch culvert under Thompson Road. The hydraulic characteristics are discussed in the "Onsite Drainage Areas for Existing Conditions" in the **following** section of this report (Onsite Drainage Areas for Existing Conditions, sub section iv).

## **VIII. DEVELOPED ONSITE DRAINAGE CONDITIONS**

### **Supercritical vs. Subcritical Flow**

Sub critical flow is characterized by relatively stable energy flow. Supercritical flow is characterized by unstable flows that will typically go “through” a hydraulic jump in order to dissipate energy which can typically cause a lot of erosion. The state of flow is determined by the Froude number. A number less than 1 is considered subcritical and above 1 critical. The flow regime for the majority of the swale conditions evaluated were determined to be supercritical. Since there is very little erosion in the existing primary swale that is located in the center of the site, it is assumed that the flow is fairly stable even under the major storm event. It is assumed that is because the hydraulic program that was used only assumed that the flow was “straight” where in actuality it meanders through the “valley”. Photographs of the existing swale are included in Exhibit 9 of the Appendix.

### **i. Design Point 5 (Onsite)**

#### **Description**

Runoff from Sub-basins OS1 (34.1 acres), OS3 (0.6 acres), OS4 (0.6 acres), OS5 (0.4 acres), OS7 (3.6 acres) and onsite Sub-basin A (6.3 acres), resulting in a total drainage area of 45.6 acres, is collected at DP5 which is located at the entrance to the existing stock pond. The DP is also located where the existing swale (S2) routes the water outside the site along the southerly property line. The swale (S2) is grass lined and stable with only a minimal amount of erosion.

#### **Hydrologic Summary**

The hydrologic characteristics of the runoff DP1 for the existing conditions is as follows:

- Drainage Area = 45.6 acres
- CA: 5 year = 4.16, 100 year = 16.31
- Time of Concentration: 27 minutes
- Runoff: 5 year = 11.0 cfs, 100 year = 72.2 cfs

#### **Hydraulic Summary for Onsite Swale 2 (S2) (Calc Sheets 5 and 6)**

- Runoff: 5 year = 11.0 cfs, 100 year = 72.2 cfs
- Average Bottom width: 5 feet
- Average Side Slope ratio: 18
- Average Slope: 5.5%
- Velocity: 5-year = 3.4 fps, 100 year = 5.5 fps
- Depth of Flow = 5-year = 0.3 ft, 100 year = 0.7 ft.
- Froude No.= 5-year = 1.32 (Supercritical), 100 year = 1.5 (Supercritical)

ii. **Design Point 6 (Onsite)**

**Description**

DP6 is located at the 24-inch outlet for the stock pond. Runoff from Sub-basins B (3.5 acres) and OS2 (10.3 acres) and OS6 (0.9 acres) combines with runoff at DP 5 for a total contributing drainage acreage of 60.3 acres. The water from this acreage is collected in the stock pond and is routed under the pond embankment via a 24-inch CMP. The water in Swale 2 is routed to the south of the site's southerly property line along the bottom of the stock pond. Swale 2 swale routes the natural "low flow" section when there is no water in the pond. This pond may provide some type of "detention" should the flow into it become substantial. The structural and hydraulic evaluation of the stock pond is beyond the scope of this report.

**Hydrologic Summary**

The hydrologic characteristics of the runoff at DP6 for the existing conditions is as follows:

- Drainage Area = 60.3 acres
- CA: 5 year = 5.47, 100 year = 21.32
- Time of Concentration: 28.4 minutes
- Runoff: 5 year = 14.0 cfs, 100 year = 91.7 cfs

**Hydraulic Summary for Offsite Swale 3 (S3) (Calc Sheets 7 and 8)**

- Runoff: 5 year = 14 cfs, 100 year = 91.7 cfs
- Average Bottom width: 5 feet
- Average Side Slope ratio: 15
- Average Slope: 8.3%
- Velocity: 5-year = 4.4 fps, 100 year = 7.2 fps
- Depth of Flow = 5-year = 0.3 ft, 100 year = 0.8 ft.
- Froude No.= 5-year = 1.66 (super critical), 100 year = 1.89 (super critical)

**Preliminary Hydraulic Summary for Existing culvert at DP6 (Calc Sheet 9)**

- Runoff: 5 year = 14 cfs, 100 year = 91.7 cfs
- Culvert Size: 24- inches
- Conditions: inlet control
- Headwater to Depth Ratio: 5 year = 1.1, 100 year = out of range and roadway overtopping.

iii. **Design Point 7 (Onsite)**

**Description**

DP7 is located on the easterly property line between the pond outlet and the culvert under Thompson Road. DP7 is located approximately

530-feet north of the southeast property corner. Runoff from Sub-basins C (0.8 acres) and OS8 (1.4 acres) join with runoff at DP6 (60.3 acres) resulting in a total drainage area of 62.5 acres.

#### **Hydrologic Summary**

The hydrologic characteristics of the runoff at DP7 for the existing conditions is as follows:

- a. Drainage Area = 62.5 acres
- b. CA: 5 year = 5.71, 100 year = 22.37
- c. Time of Concentration: 29 minutes
- d. Runoff: 5 year = 14.5 cfs, 100 year = 95 cfs

#### **Hydraulic Summary for Offsite Swale 3 (S4) (Calc Sheets 11 and 12)**

- a. Runoff: 5 year = 14.5 cfs, 100 year = 95 cfs
- b. Average Bottom width: 5 feet
- c. Average Side Slope ratio: 10
- d. Average Slope: 8.3%
- e. Velocity: 5-year = 4.8 fps, 100 year = 8.0 fps
- f. Depth of Flow = 5-year = 0.4 ft, 100 year = 0.9 ft.
- g. Froude No. = 5-year = 1.69 (super critical), 100 year = 1.92 (super critical)

#### **iv. Design Point 14 (Onsite)**

##### **Description**

DP 14 is located at the upstream end of the 30" CMP culvert under Thompson Road. Runoff from OS9 (0.4 acres) and OS10 (0.5 acres) join the runoff at DP7 (62.5 acres) resulting in a total acreage of 63.4 acres.

##### **Hydrologic Summary**

The hydrologic characteristics of the runoff at DP14 for the existing condition is as follows:

- a. Drainage Area = 63.4 acres
- b. CA: 5 year = 6.28, 100 year = 23.05
- c. Time of Concentration: 29 minutes
- d. Runoff: 5 year = 15.9 cfs, 100 year = 97.9 cfs

##### **Preliminary Hydraulic Summary for Existing culvert at DP14 (Calc Sheet 10)**

- a. Runoff: 5 year = 15.9 cfs, 100 year = 97.9 cfs
- b. Culvert Size: 30-inches
- c. Conditions: inlet control
- d. Headwater to Depth Ratio: 5 year = 0.76, 100 year = >6.0
- e. Upstream Depth: 5 year = 1.9 ft, 100 year = roadway overtopping

## IX. EXISTING/DEVELOPED RUNOFF COMPARISON

### **Offsite Sub-basin Characteristics for Developed Conditions**

There are no plans to develop the tracts located upstream and/or adjacent to the project site. Therefore, the hydrologic conditions for the offsite sub basins will remain the same, as described *Section VII*.

#### **i. Onsite Sub-basin Characteristics for Developed Conditions**

The development of this site consists of the subdivision of the entire 10.495-acre into one 5-acre parcel (Lot 2) and a 5.5-acre parcel (Lot 1). Lot 1 is located in Sub-basin B and Lot 2 is located in Sub-basin A. The development includes a single-family residence, area landscaping, and a gravel driveway. The hydrologic parameters used to estimate runoff were determined based on the following parameters;

- Drainage Area Sub basins:
  - The only sub basins that will change to reflect proposed development will be onsite Subbasins B (Lot 1) and A (Lot 2).
  
- Runoff Coefficients
  - Gravel Driveway: Lot 1= 250 ft. Lot 2 = 420 feet; C5 = 0.59, C100 = 0.70
  - The driveways were conservatively sized at 20 feet wide.
  - The roof of each house was conservatively estimated to be 3,000 sf each with the following coefficients: C5 = 0.90, C100 = 0.96
  - It was conservatively assumed that ½ acre would be landscaped resulting in the following coefficients; C5 = 0.12, C100 = 0.39
  - The remaining area of each lot would remain as the native vegetation resulting in the following coefficients: C5 = 0.08, C100 = 0.35.
  
- Time of Concentration
  - The time of concentration for each sub-basin remains the same despite development since the time of concentration is defined as the time it takes for runoff from the farthest “corner” of the contributing drainage sub-basin to reach the design point.
  
- Rainfall Intensity
  - The rainfall intensity for each sub-basin remains the same since the time of concentration remains the same.

- Estimated Runoff
  - Based on the above assumptions, runoff for the minor (5 year) and major (100 year) storms were estimated for each sub-basin.

ii. **Runoff Comparison Summary**

a. **Drainage Area**

The areas are as follows:

- Lot 1: 5.000 acres (portion of sub basin A)
- Lot 2: 5.495 acres (portion of sub basin B)

b. **Composite Runoff Coefficients**

Exist Conditions

- Lot 1(sub basin B): C5 = 0.08, C100 = 0.35
- Lot 2 (sub basin A): C5 = 0.08, C100 = 0.35

Developed Conditions

- Lot 1(sub basin B): C5 = 0.11, C100 = 0.37
- Lot 2 (sub basin A): C5 = 0.11, C100 = 0.37

c. **Rainfall Intensity**

- i. The Rainfall Intensity is the same for both the existing and proposed conditions.

d. **Estimate Runoff for each Developed Lot**

Runoff from each lot will sheet flow to swales (S2, S3, S4) and the stock pond. The runoff for the existing and developed conditions are summarized as follows:

- i. Lot 1 (sub basin B)
  1. Existing Conditions: Q5 = 1.8 cfs, Q100 = 13.3 cfs
  2. Developed Conditions: Q5 = 2.5 cfs, Q100 = 14.1 cfs
- ii. Lot 2 (sub basin A)
  1. Existing Conditions: Q5 = 1.2 cfs, Q100 = 8.9 cfs
  2. Developed Conditions: Q5 = 1.9 cfs, Q100 = 11.1 cfs

e. **Total Discharge at Thompson Road Culvert**

Refer to Surface Routing Summary for table using the Times of Concentration applicable to determining cumulation runoff in the channel located in the center of the site.

- i. Existing Conditions: Q5 = 15.9 cfs, Q100 = 97.9 cfs
- ii. Developed Conditions: Q5 = 16.4 cfs, Q100 = 98.5 cfs

As demonstrated, the increase in runoff, as a result of development, is negligible and therefore has little, if any, impact on the existing facilities.

## **X FULL SPECTRUM DETENTION POND**

### **Criteria**

Reference is made to El Paso County Engineering Criteria Manual, Appendix 1, Page 1.18-19. According to El Paso County criteria a Water Quality Capture Volume (WQCV) pond is not required for lots 2.5 acres or larger. Also, since the area of disturbance is less than 1- acre a WQCV pond is not required.

The disturbed are was determined as follows:

- Gravel Drive: Lot 1 = 250 ft by 20 ft = 5,000 sf; Lot 2: 420 frt by 20 ft = 8,400 sf
- Residence footprint: Lot 1 = 3000 sf; Lot 2 =3000 sf
- Totals disturbed area: Lot 1 = 8,000 sf, Lot 2 = 8,820 sf, Total = 16,820 sf

## **XI FOUR STEP PROCESS**

Even though the 4-step process is not required for this project the following are descriptions of the steps that are being taken to address the 4-step process.

### **Large Lot Single Family Sites.**

A single-family residential lot, or agricultural zoned lands, greater than or equal to 2.5 acres in size per dwelling and having a total lot impervious area of less than 10 percent. A total lot imperviousness greater than 10 percent is allowed when a study specific to the watershed and/or MS4 shows that expected soil and vegetation conditions are suitable for infiltration/filtration of the WQCV for a typical site, and the permittee accepts such study as applicable within its MS4 boundaries. The maximum total lot impervious covered under this exclusion shall be 20 percent. In accordance with section 4.0 of chapter 1 of the El Paso County ECM Appendix 1.7.1, the four-step process applies to "projects with construction activities that disturb 1 acre or greater or that disturb less than 1 acre but are part of a larger plan of development or sale". Therefore, the four-step process does not apply to this development.

### **Step 1: Reduce runoff by disconnecting impervious area, eliminating "unnecessary" impervious area and encouraging infiltration into soils that are suitable.**

All of the downspouts for each residence is planned to discharge either within landscaped areas of natural areas.

### **Step 2: Treat and slowly release the WQCV.**

A Full Spectrum Water Quality Detention Pond is not required for this site and therefor does not have the WQCV component..

Revise. Step 2 is regarding stabilization of drainageways and step 3 is regarding WQ.

### **Step 3: Stabilize stream channels.**

An existing swale located in the center of the property is stable )see Exhibit 9, Appendix. And therefore, it can be safely assumed that the negligible increase in flow as a result of development will have minimal negative impact on the existing swale.

### **Step 4: Implement source controls.**

There are no water sources with the project limits or runoff

## **XII EROSION CONTROL**

The following erosion control measures are recommended for the proposed private driveway:

- Silt fence along the southerly side of the proposed driveway
- Erosion control fabric on all disturbed surfaces
- Buried riprap at the outlet end of the proposed culverts installed under the proposed driveway.

## **XIII STORMWATER MANAGEMENT PLAN (SWMP)**

A **SWMP** will not be required for this site since the improvements are limited to a shared private gravel driveway with a shared access off of Thompson Road.

## **XIV DRAINAGE/ BRIDGE FEES**

The site is located in the **Cherry Creek Drainage Basin** for which there are no established fees.

## **XVI. SUMMARY**

This report provides a thorough analysis of the historic and developed drainage conditions for the proposed McGehee Subdivision. The property is comprised of 10.5 acres and is located north of Hodgen Road and west of Thompson Road. The subdivision is to be subdivided into two (2) consisting of a 5-acre lot and a 5.5-acre lot.

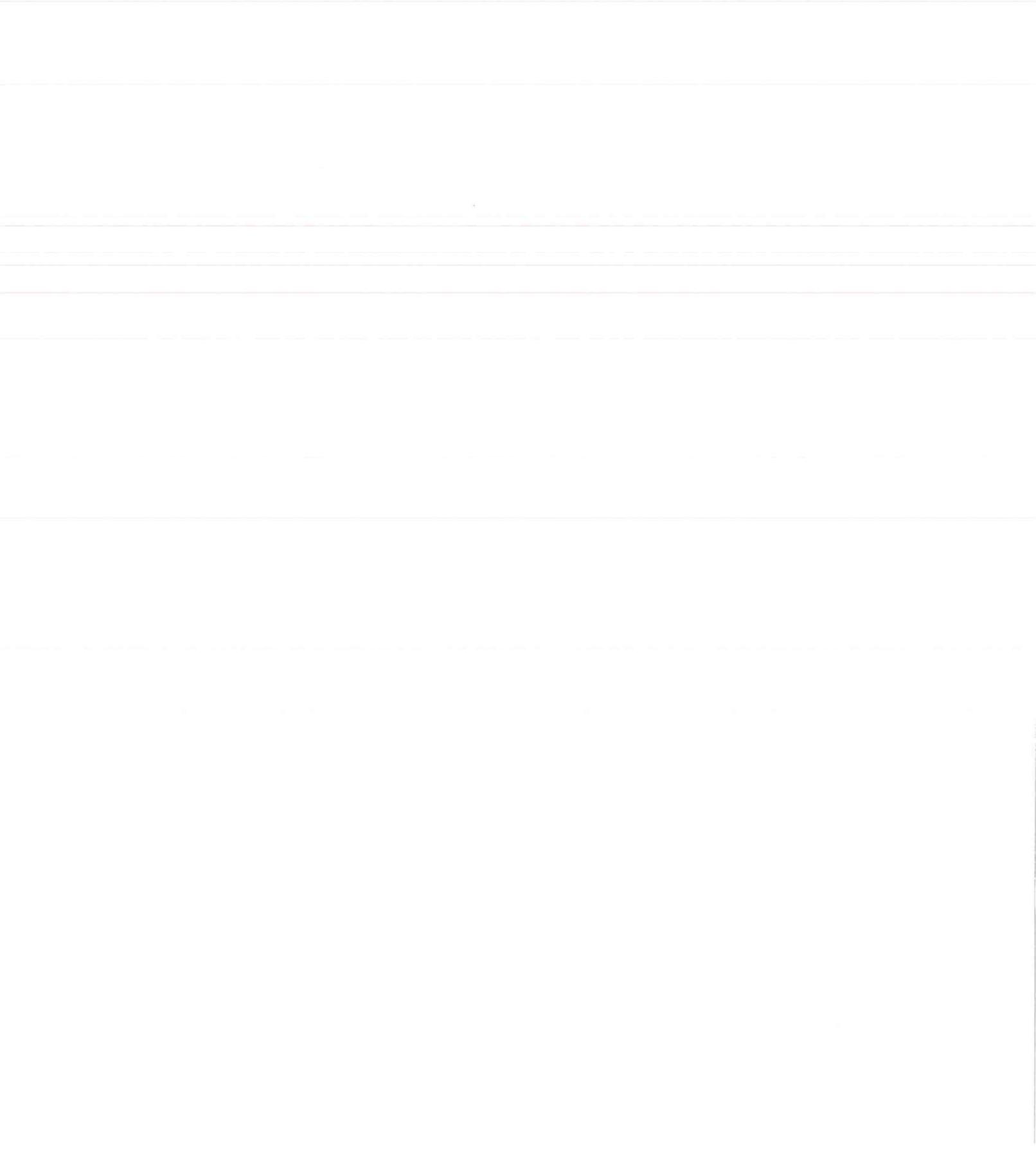
The vegetation consists of primarily prairie grass with no trees. There is a main natural drainage way that is located in the approximate middle of the site.

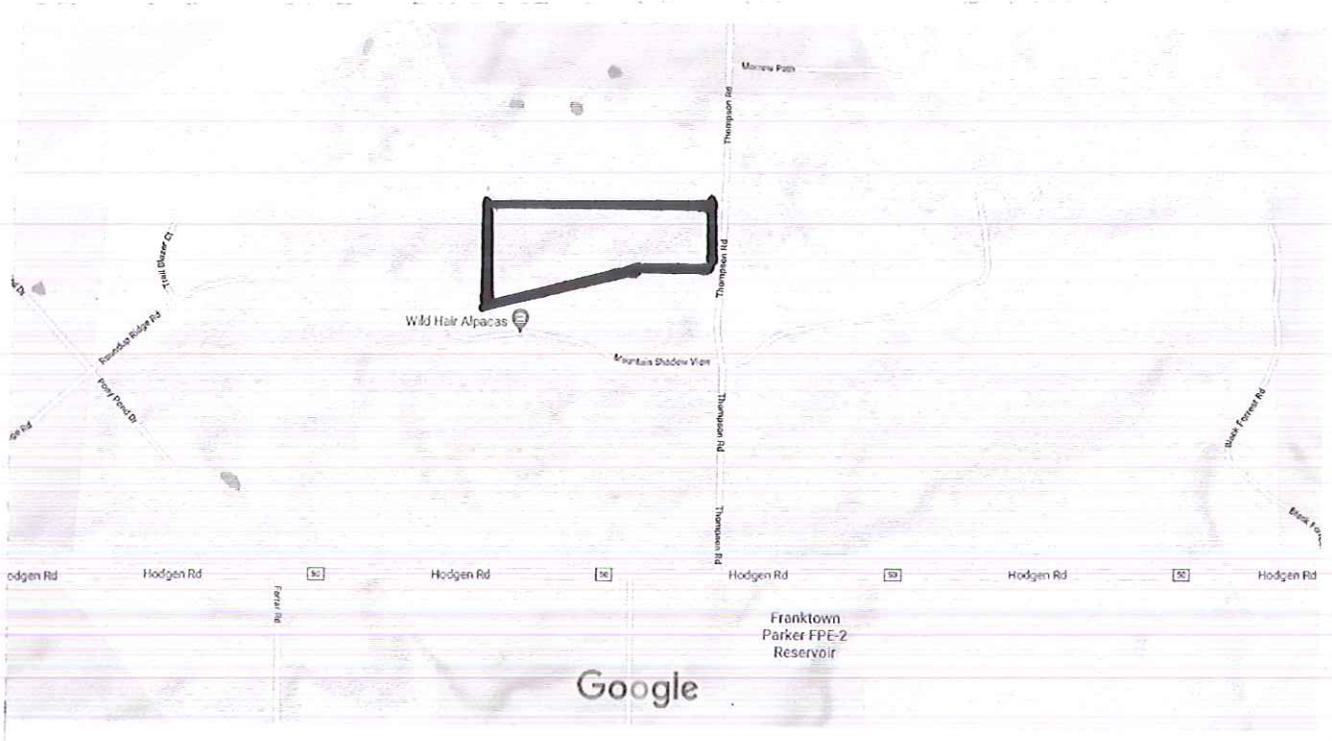
It has been demonstrated that there is only a negligible increase in runoff as a result of development. Also, based on the present engineering criteria for El Paso County a full spectrum detention pond is not required. Improvements are to be limited to two (2) residential homes, a common gravel driveway with a common access to Thompson Road, and a driveway culvert located approximately 150-foot south of the northeast property corner.

Included in the map pocket are drainage maps for the **Existing Drainage Conditions** and the **Developed Drainage Conditions**. No storm water structures are proposed for this subdivision.

# APPENDIX

## Exhibit 1: Location Map





## Vicinity Map

## Exhibit 2: FEMA FIRM Map

# National Flood Hazard Layer FIRMette

104°43'11"W 39°4'48"N



## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

**SPECIAL FLOOD HAZARD AREAS**

- Without Base Flood Elevation (BFE) Zone A, V, A99
- With BFE or Depth Zone AE, AO, AH, VE, AR
- Regulatory Floodway

**OTHER AREAS OF FLOOD HAZARD**

- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
- Future Conditions 1% Annual Chance Flood Hazard Zone X
- Area with Reduced Flood Risk due to Levee. See Notes, Zone X
- Area with Flood Risk due to Levee Zone D

**OTHER AREAS**

- NO SCREEN Area of Minimal Flood Hazard Zone X
- Effective LOMRS
- Area of Undetermined Flood Hazard Zone I

**GENERAL STRUCTURES**

- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

**OTHER FEATURES**

- Cross Sections with 1% Annual Chance Water Surface Elevation
- Coastal Transsect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transsect Baseline
- Profile Baseline
- Hydrographic Feature

**MAP PANELS**

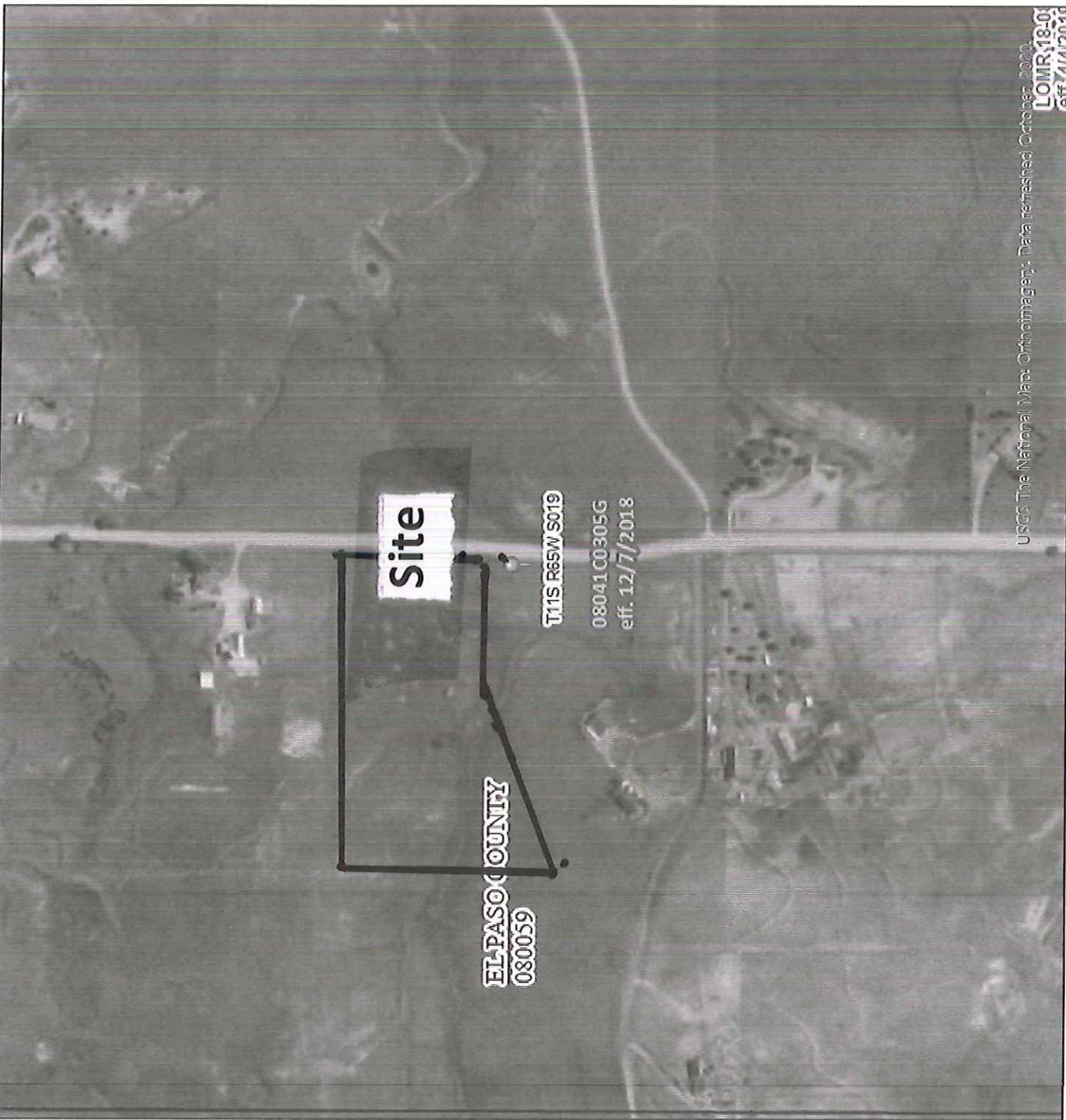
- Digital Data Available
- No Digital Data Available
- Unmapped

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 11/9/2020 at 8:17 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRW effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.



USGS The National Map, Orthoimagery, Data remastered October 2000  
 LOMR 1800  
 eff. 11/12/2016  
 104°42'33"W 39°4'20"N



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

Coastal Base Flood Elevations shown on this map apply only landward of 0' North American Vertical Datum of 1988 (NAVD83). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

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

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

The projection used in the preparation of this map was Universal Transverse Mercator (UTM) zone 13. The horizontal datum was NAD83, GRS80 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988 (NAVD83). These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at <http://www.ngs.noaa.gov> or contact the National Geodetic Survey at the following address:

NGS Information Services  
NOAA, NIMS12  
National Geodetic Survey  
SSMC-3, #9202  
1315 East-West Highway  
Silver Spring, MD 20910-3282

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

Base Map information shown on this FIRM was provided in digital format by El Paso County, Colorado Springs Utilities, City of Fountain, Bureau of Land Management, National Oceanic and Atmospheric Administration, United States Geological Survey, and Anderson Consulting Engineers, Inc. These data are current as of 2005.

This map reflects more detailed and up-to-date stream channel configurations and floodplain delineations than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map. The profile baselines depicted on this map represent the hydraulic modeling baselines that match the flood profiles and Floodway Data Tables if applicable, in the FIS report. As a result, the profile baselines may deviate significantly from the new base map channel representation and may appear outside of the floodplain.

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

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

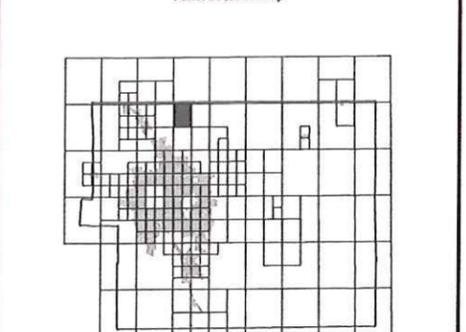
Contact FEMA Map Service Center (MSC) via the FEMA Map Information eXchange (FMIX) 1-877-338-2627 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. The MSC may also be reached by Fax at 1-800-358-6620 and its website at <http://www.msc.fema.gov>.

If you have questions about this map or questions concerning the National Flood Insurance Program in general, please call 1-877-FEMA-MAP (1-877-338-2627) or visit the FEMA website at <http://www.fema.gov/business/info>.

Flooding Source	Vertical Datum Offset (ft)

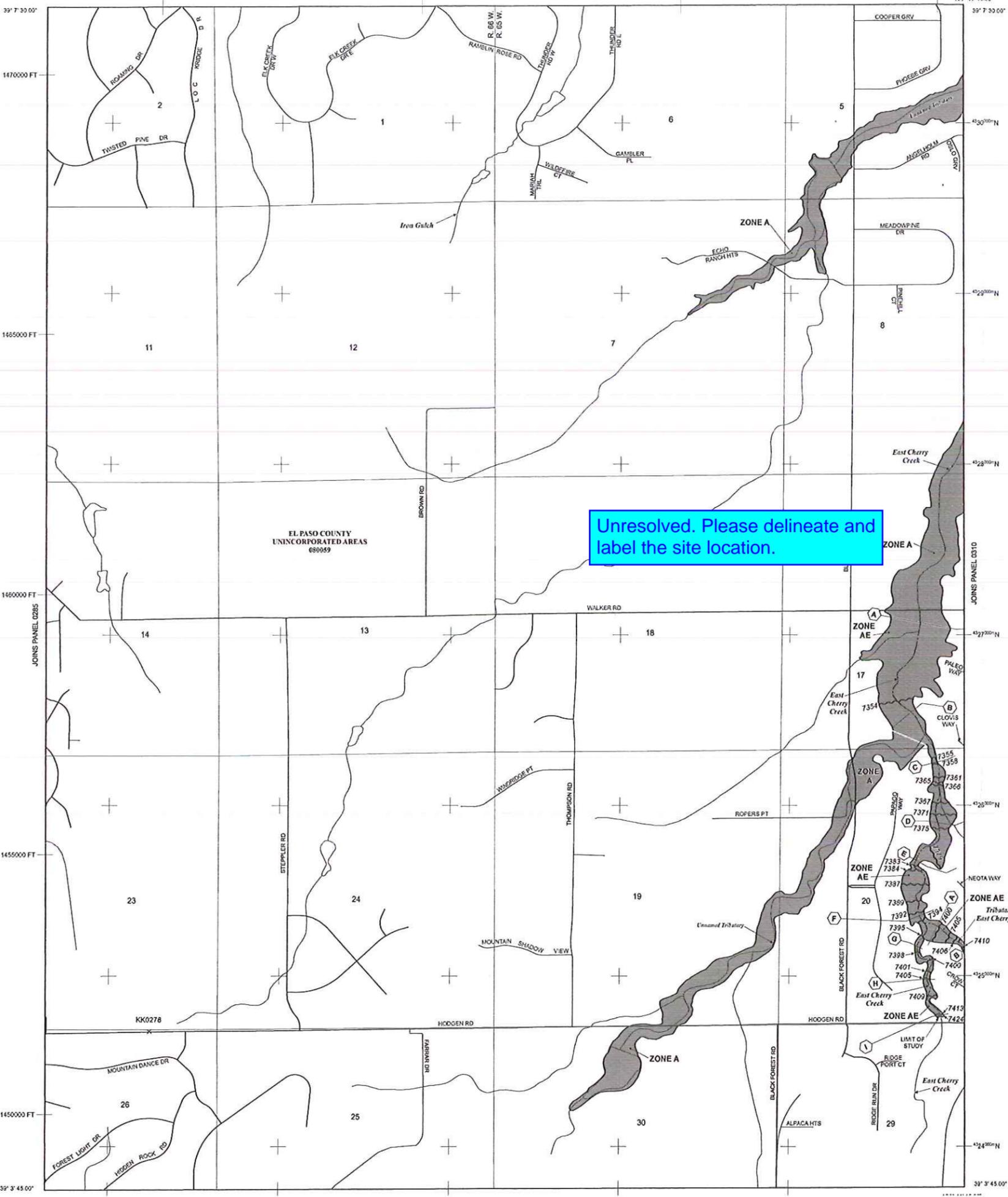
REFER TO SECTION 3.3 OF THE EL PASO COUNTY FLOOD INSURANCE STUDY FOR STREAM BY STREAM VERTICAL DATUM CONVERSION INFORMATION

Panel Location Map



This Digital Flood Insurance Rate Map (DFIRM) was produced through a Cooperating Technical Partner (CTP) agreement between the State of Colorado Water Conservation Board (CWCB) and the Federal Emergency Management Agency (FEMA).

Additional Flood Hazard information and resources are available from local communities and the Colorado Water Conservation Board.



This map is a 1% chance of being equaled or exceeded in any given year. The special flood hazard areas are the areas subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

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

**FLOODWAY AREAS IN ZONE AE**

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

**OTHER FLOOD AREAS**

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

**OTHER AREAS**

ZONE X Areas determined to be outside the 0.2% annual chance floodplains.

ZONE D Areas in which flood hazards are undetermined, but possible.

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

**OTHERWISE PROTECTED AREAS (OPAs)**

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

- Floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
- 513 (EL 517) Base Flood Elevation line and value; elevation in feet\*
- Base Flood Elevation value where uniform within zone; elevation in feet\*

\* Referenced to the North American Vertical Datum of 1988 (NAVD 83)

- A—A Cross section line
- 23—23 Transect line
- 97° 07' 30.00" 32° 22' 30.00" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
- 475m Grid ticks: 1000 meter Universal Transverse Mercator grid ticks, zone 13
- 600000 FT 5000-foot grid ticks: Colorado State Plane coordinate system, central zone (FIPS/SPRS 0503), Lambert Conformal Conic Projection
- DX5510, X Bench mark (see explanation in Notes to User's section of this FIRM panel)
- M1.5 River Mile

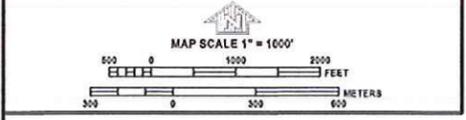
MAP REPOSITORIES  
Refer to Map Repository list on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP  
MARCH 17, 1997

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL  
DECEMBER 7, 2018 - to update corporate limits, to change Base Flood Elevations and Special Flood Hazard Areas, to update map format, to add roads and road names, and to incorporate previously issued Letters of Map Revision.

For community map revision history prior to countywide mapping, refer to the Community Map History Table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6633.



**NFIP** PANEL 0305G

**FIRM**  
FLOOD INSURANCE RATE MAP  
**EL PASO COUNTY,  
COLORADO  
AND INCORPORATED AREAS**

PANEL 305 OF 1300  
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:			
COMMUNITY	NUMBER	PANEL	SUFFIX
EL PASO COUNTY	0305	0305G	0

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

**MAP NUMBER**  
08041C0305G

### Exhibit 3: SCS Soils Map and Data



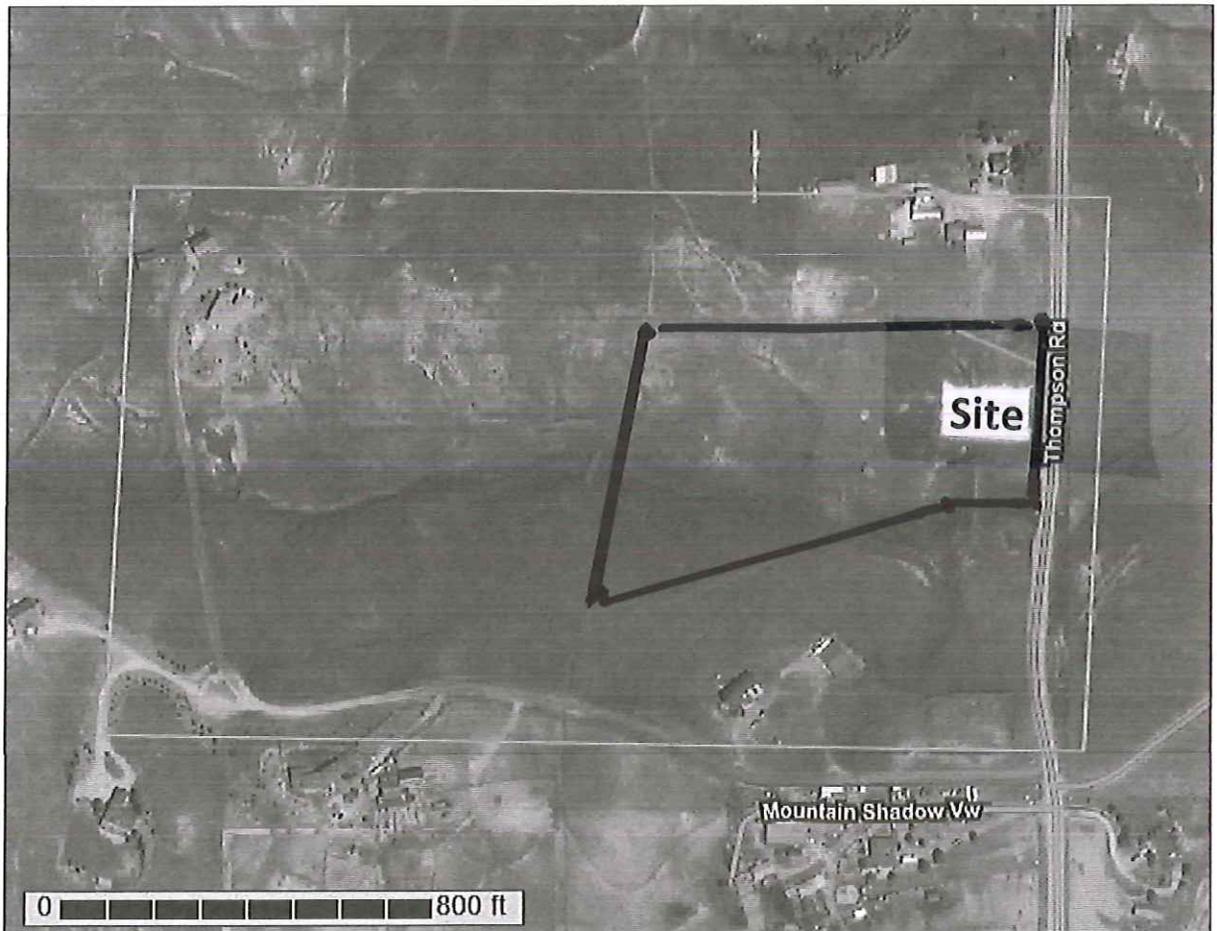
United States  
Department of  
Agriculture

**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 El Paso County Area, Colorado



October 24, 2020

# Contents

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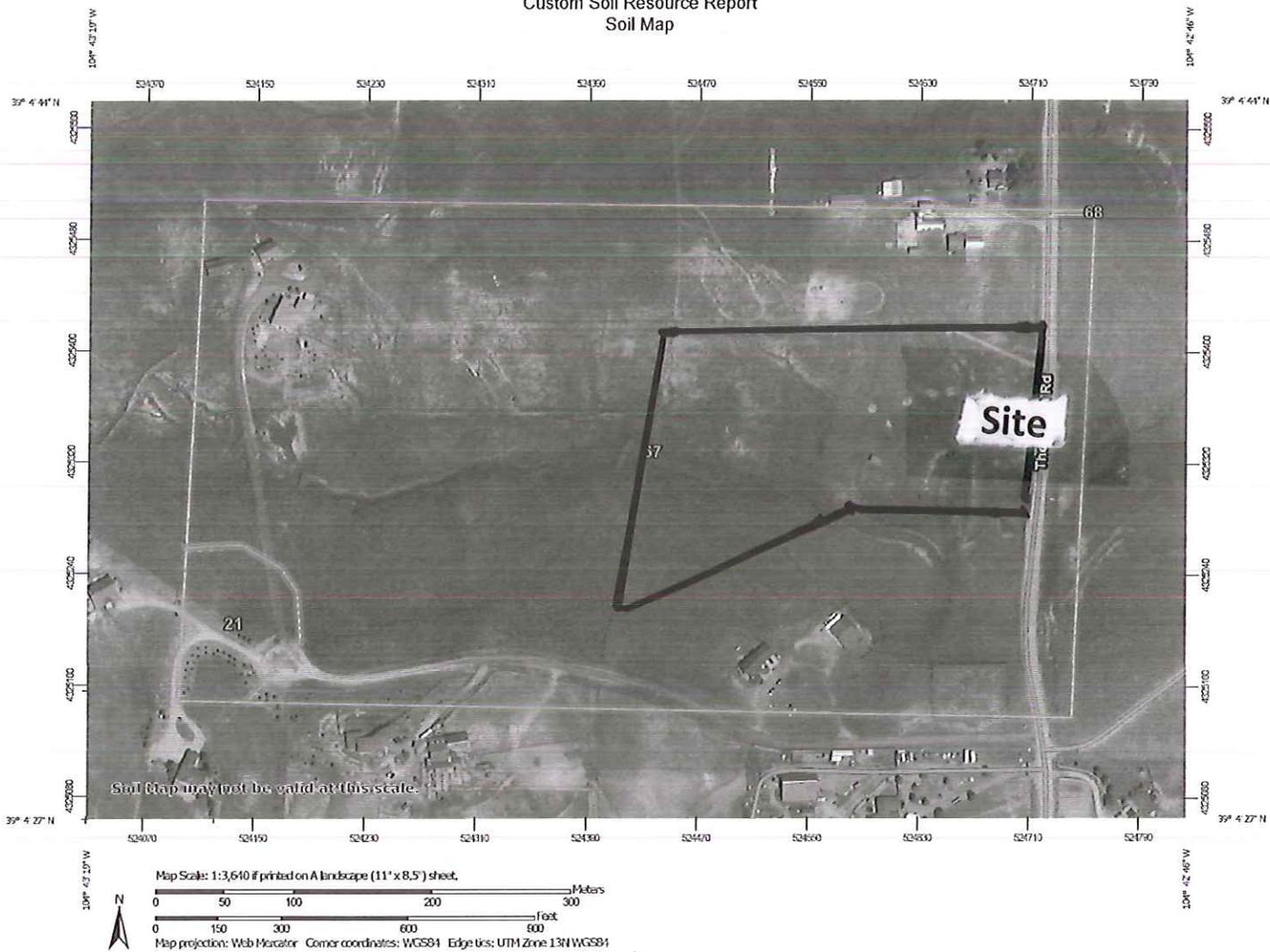
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# Soil Map

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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



Custom Soil Resource Report

MAP LEGEND		MAP INFORMATION
<p><b>Area of Interest (AOI)</b></p> <ul style="list-style-type: none"> <li> Area of Interest (AOI)</li> </ul> <p><b>Soils</b></p> <ul style="list-style-type: none"> <li> Soil Map Unit Polygons</li> <li> Soil Map Unit Lines</li> <li> Soil Map Unit Points</li> </ul> <p><b>Special Point Features</b></p> <ul style="list-style-type: none"> <li> Blowout</li> <li> Borrow Pit</li> <li> Clay Spot</li> <li> Closed Depression</li> <li> Gravel Pit</li> <li> Gravelly Spot</li> <li> Landfill</li> <li> Lava Flow</li> <li> Marsh or swamp</li> <li> Mine or Quarry</li> <li> Miscellaneous Water</li> <li> Perennial Water</li> <li> Rock Outcrop</li> <li> Saline Spot</li> <li> Sandy Spot</li> <li> Severely Eroded Spot</li> <li> Sinkhole</li> <li> Slide or Slip</li> <li> Sodic Spot</li> </ul>	<ul style="list-style-type: none"> <li> Spoil Area</li> <li> Stony Spot</li> <li> Very Stony Spot</li> <li> Wet Spot</li> <li> Other</li> <li> Special Line Features</li> </ul> <p><b>Water Features</b></p> <ul style="list-style-type: none"> <li> Streams and Canals</li> </ul> <p><b>Transportation</b></p> <ul style="list-style-type: none"> <li> Rails</li> <li> Interstate Highways</li> <li> US Routes</li> <li> Major Roads</li> <li> Local Roads</li> </ul> <p><b>Background</b></p> <ul style="list-style-type: none"> <li> Aerial Photography</li> </ul>	<p>The soil surveys that comprise your AOI were mapped at 1:24,000.</p> <div style="border: 1px solid black; padding: 5px;"> <p>Warning: Soil Map may not be valid at this scale.</p> <p>Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.</p> </div> <p>Please rely on the bar scale on each map sheet for map measurements.</p> <p>Source of Map: Natural Resources Conservation Service            Web Soil Survey URL:            Coordinate System: Web Mercator (EPSG:3857)</p> <p>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.</p> <p>This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.</p> <p>Soil Survey Area: El Paso County Area, Colorado            Survey Area Data: Version 18, Jun 5, 2020</p> <p>Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.</p> <p>Date(s) aerial images were photographed: Sep 8, 2018—May 26, 2019</p> <p>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.</p>

## Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
21	Cruckton sandy loam, 1 to 9 percent slopes	2.0	3.5%
67	Peyton sandy loam, 5 to 9 percent slopes	55.9	96.5%
68	Peyton-Pring complex, 3 to 8 percent slopes	0.0	0.0%
<b>Totals for Area of Interest</b>		<b>57.9</b>	<b>100.0%</b>

## 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

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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.

## El Paso County Area, Colorado

### 21—Cruckton sandy loam, 1 to 9 percent slopes

#### Map Unit Setting

*National map unit symbol:* 367s  
*Elevation:* 7,200 to 7,600 feet  
*Mean annual precipitation:* 16 to 18 inches  
*Mean annual air temperature:* 42 to 46 degrees F  
*Frost-free period:* 110 to 120 days  
*Farmland classification:* Not prime farmland

#### Map Unit Composition

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

#### Description of Cruckton

##### Setting

*Landform:* Flats, hills  
*Landform position (three-dimensional):* Side slope, talf  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Alluvium derived from arkose

##### Typical profile

*A - 0 to 11 inches:* sandy loam  
*Bt - 11 to 28 inches:* sandy loam  
*C - 28 to 60 inches:* loamy coarse sand

##### Properties and qualities

*Slope:* 1 to 9 percent  
*Depth to restrictive feature:* More than 80 inches  
*Drainage class:* Well drained  
*Runoff class:* Medium  
*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  
*Available water capacity:* Low (about 5.9 inches)

##### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 4e  
*Hydrologic Soil Group:* B  
*Ecological site:* R049XB216CO - Sandy Divide  
*Hydric soil rating:* No

#### Minor Components

##### Other soils

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

## 67—Peyton sandy loam, 5 to 9 percent slopes

### Map Unit Setting

*National map unit symbol:* 369d  
*Elevation:* 6,800 to 7,600 feet  
*Mean annual air temperature:* 43 to 45 degrees F  
*Frost-free period:* 115 to 125 days  
*Farmland classification:* Not prime farmland

### Map Unit Composition

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

### Description of Peyton

#### Setting

*Landform:* Hills  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Arkosic alluvium derived from sedimentary rock and/or arkosic residuum weathered from sedimentary rock

#### Typical profile

*A - 0 to 12 inches:* sandy loam  
*Bt - 12 to 25 inches:* sandy clay loam  
*BC - 25 to 35 inches:* sandy loam  
*C - 35 to 60 inches:* sandy loam

#### Properties and qualities

*Slope:* 5 to 9 percent  
*Depth to restrictive feature:* More than 80 inches  
*Drainage class:* Well drained  
*Runoff class:* Medium  
*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  
*Available water capacity:* Moderate (about 7.3 inches)

#### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 4e  
*Hydrologic Soil Group:* B  
*Ecological site:* R049XB216CO - Sandy Divide  
*Hydric soil rating:* No

**Minor Components**

**Pleasant**

*Percent of map unit:*  
*Landform:* Depressions  
*Hydric soil rating:* Yes

**Other soils**

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

**68—Peyton-Pring complex, 3 to 8 percent slopes**

**Map Unit Setting**

*National map unit symbol:* 369f  
*Elevation:* 6,800 to 7,600 feet  
*Farmland classification:* Not prime farmland

**Map Unit Composition**

*Peyton and similar soils:* 40 percent  
*Pring and similar soils:* 30 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Peyton**

**Setting**

*Landform:* Hills  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Arkosic alluvium derived from sedimentary rock and/or arkosic residuum weathered from sedimentary rock

**Typical profile**

*A - 0 to 12 inches:* sandy loam  
*Bt - 12 to 25 inches:* sandy clay loam  
*BC - 25 to 35 inches:* sandy loam  
*C - 35 to 60 inches:* sandy loam

**Properties and qualities**

*Slope:* 3 to 5 percent  
*Depth to restrictive feature:* More than 80 inches  
*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  
*Available water capacity:* Moderate (about 7.3 inches)

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### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 4c  
*Hydrologic Soil Group:* B  
*Ecological site:* R049XB216CO - Sandy Divide  
*Hydric soil rating:* No

### Description of Pring

#### Setting

*Landform:* Hills  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Arkosic alluvium derived from sedimentary rock

#### Typical profile

*A - 0 to 14 inches:* coarse sandy loam  
*C - 14 to 60 inches:* gravelly sandy loam

#### Properties and qualities

*Slope:* 3 to 8 percent  
*Depth to restrictive feature:* More than 80 inches  
*Drainage class:* Well drained  
*Runoff class:* 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  
*Available water capacity:* Low (about 6.0 inches)

### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 3e  
*Hydrologic Soil Group:* B  
*Ecological site:* R048AY222CO  
*Hydric soil rating:* No

### Minor Components

#### Pleasant

*Percent of map unit:*  
*Landform:* Depressions  
*Hydric soil rating:* Yes

#### Other soils

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

## Exhibit 4 Charts and Tables

**Table 6-6. Runoff Coefficients for Rational Method**  
(Source: UDFCD 2001)

Land Use or Surface Characteristics	Percent Impervious	Runoff Coefficients											
		2-year		5-year		10-year		25-year		50-year		100-year	
		HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D
<b>Business</b>													
Commercial Areas	95	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.87	0.87	0.88	0.88	0.89
Neighborhood Areas	70	0.45	0.49	0.49	0.53	0.53	0.57	0.58	0.62	0.60	0.65	0.62	0.68
<b>Residential</b>													
1/8 Acre or less	65	0.41	0.45	0.45	0.49	0.49	0.54	0.54	0.59	0.57	0.62	0.59	0.65
1/4 Acre	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
1/3 Acre	30	0.18	0.22	0.25	0.30	0.32	0.38	0.39	0.47	0.43	0.52	0.47	0.57
1/2 Acre	25	0.15	0.20	0.22	0.28	0.30	0.36	0.37	0.46	0.41	0.51	0.46	0.56
1 Acre	20	0.12	0.17	0.20	0.26	0.27	0.34	0.35	0.44	0.40	0.50	0.44	0.55
<b>Industrial</b>													
Light Areas	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
Heavy Areas	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
<b>Parks and Cemeteries</b>													
Parks and Cemeteries	7	0.05	0.09	0.12	0.19	0.20	0.29	0.30	0.40	0.34	0.46	0.39	0.52
Playgrounds	13	0.07	0.13	0.16	0.23	0.24	0.31	0.32	0.42	0.37	0.48	0.41	0.54
Railroad Yard Areas	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
<b>Undeveloped Areas</b>													
Historic Flow Analysis-- Greenbelts, Agriculture	2	0.03	0.05	0.09	0.16	0.17	0.26	0.26	0.38	0.31	0.45	0.36	0.51
Pasture/Meadow	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Forest	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Exposed Rock	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Offsite Flow Analysis (when landuse is undefined)	45	0.26	0.31	0.32	0.37	0.38	0.44	0.44	0.51	0.48	0.55	0.51	0.59
<b>Streets</b>													
Paved	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Gravel	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
<b>Drive and Walks</b>													
Drive and Walks	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Roofs	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
Lawns	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50

### 3.2 Time of Concentration

One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the hydraulically most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration can be an empirical value that results in reasonable and acceptable peak flow calculations.

For urban areas, the time of concentration ( $t_c$ ) consists of an initial time or overland flow time ( $t_i$ ) plus the travel time ( $t_t$ ) in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time ( $t_i$ ) plus the time of travel in a concentrated form, such as a swale or drainageway. The travel portion ( $t_t$ ) of the time of concentration can be estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainageway. Initial time, on the other hand, will vary with surface slope, depression storage, surface cover, antecedent rainfall, and infiltration capacity of the soil, as well as distance of surface flow. The time of concentration is represented by Equation 6-7 for both urban and non-urban areas.

$$t_c = t_i + t_t \quad (\text{Eq. 6-7})$$

Where:

$t_c$  = time of concentration (min)

$t_i$  = overland (initial) flow time (min)

$t_t$  = travel time in the ditch, channel, gutter, storm sewer, etc. (min)

### 3.2.1 Overland (Initial) Flow Time

The overland flow time,  $t_i$ , may be calculated using Equation 6-8.

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \quad (\text{Eq. 6-8})$$

Where:

$t_i$  = overland (initial) flow time (min)

$C_5$  = runoff coefficient for 5-year frequency (see Table 6-6)

$L$  = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)

$S$  = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

### 3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time,  $t_t$ , which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time,  $t_i$ , can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5} \quad (\text{Eq. 6-9})$$

Where:

$V$  = velocity (ft/s)

$C_v$  = conveyance coefficient (from Table 6-7)

$S_w$  = watercourse slope (ft/ft)

concentration, all other factors being equal. Although it is possible to calculate a longer time of concentration for a post-development condition versus a pre-development condition by increasing the length of the flow path, this is often a result of selecting unrealistic flow path lengths. As a matter of practice and for the sake of conservative design, it is required that the post-development time of concentration be less than or equal to the pre-development time of concentration. As a general rule and when sufficiently detailed development plans are not available, the post-development time of concentration can be estimated to be about 75% of the pre-development value.

### **3.2.6 Common Error in Calculating Time of Concentration**

A common error in estimating the time of concentration occurs when a designer does not check the peak runoff generated from smaller portions of the catchment that may have a significantly shorter time of concentration (and, therefore, a higher rainfall intensity) than the drainage basin as a whole. Sometimes calculations using the Rational Method for a lower, urbanized portion of a watershed will produce a higher peak runoff than the calculations for the drainage basin as a whole, especially if the drainage basin is long or the upper portion has little or no impervious cover.

## **3.3 Rainfall Intensity (I)**

The average rainfall intensity (I), in inches per hour, by recurrence interval, can be found from the Intensity-Duration-Frequency curves provided in Figure 6-5. The value for I is based on the assumption that the peak runoff will occur when the duration of the rainfall is equal to the time of concentration. For example, Figure 6-5 indicates a rainfall intensity of approximately 5.00 inches/hour for the 100-year event for a catchment with a time of concentration of 20 minutes. These curves are based on the rainfall depths for an elevation of 6,840 feet in the Colorado Springs area. IDF curves for other elevations or locations can be created using the UD-Rain spreadsheet based on 6-hour and 24-hour rainfall depths for each recurrence interval needed. The Z-1 (Zone 1) tab should be used for Arkansas River basin locations.

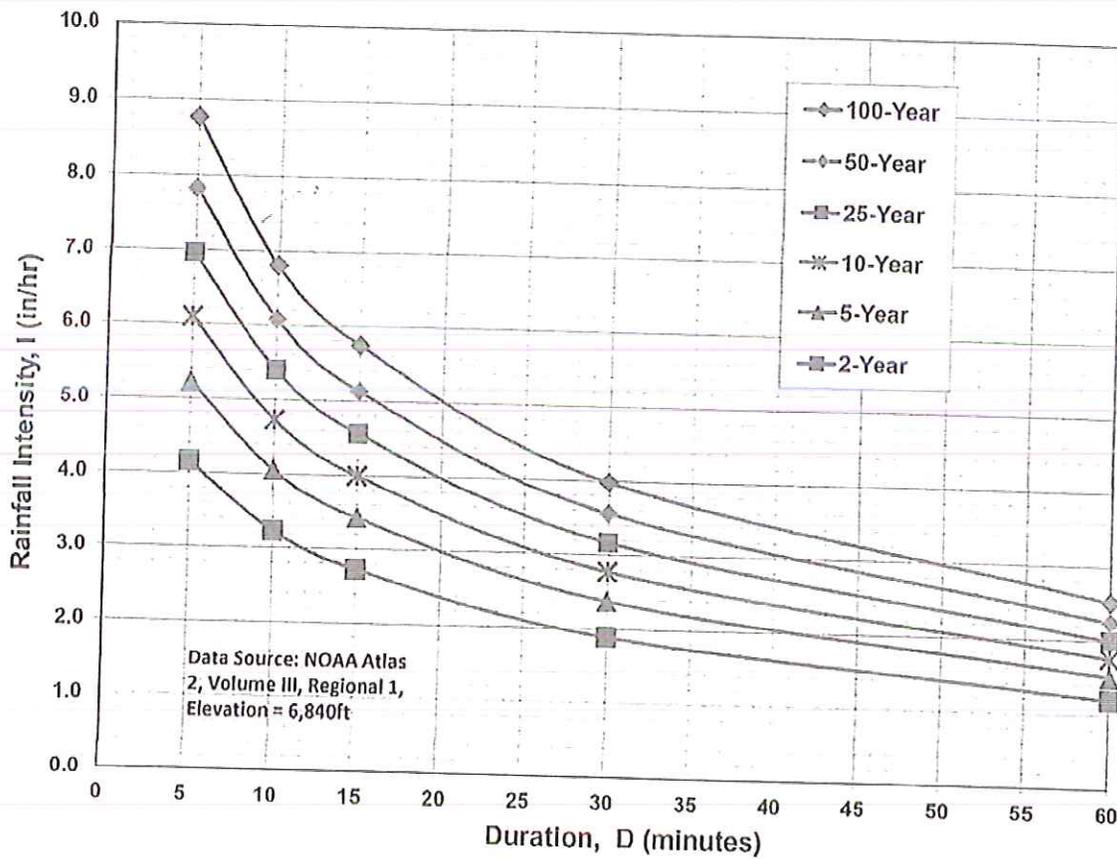
## **3.4 Drainage Basin Area (A)**

The size of a drainage basin contributing runoff to a design point, in acres, is used to calculate peak runoff in the Rational Method. Accurately delineating the area contributing to each design point is one of the most important tasks for hydrologic analyses since the estimated runoff is directly proportional to the basin area. The area may be determined through the use of planimetric-topographic maps, supplemented by field surveys where topographic data has changed or where the contour interval is too great to distinguish the direction of flow. The drainage basin lines are determined by the natural topography, pavement slopes, locations of downspouts and inlets, paved and unpaved yards, grading of lawns, and many other features found on the urban landscape. In areas where there are storm drains, the entire contributing drainage area can sometimes be greater than the drainage area determined by topographic analysis of the ground surface, due to storm drains collecting runoff from areas that lie outside of the surface topographic extent of the basin.

## **4.0 NRCS Curve Number Loss and Dimensionless Unit Hydrograph Method**

The NRCS curve number loss and dimensionless unit hydrograph method has been the most widely used method in the region. It can be applied for drainage basins as small as 10 acres and is the only method that should be applied for drainage basins larger than 640 acres. This method can be used to estimate peak flows or to produce a runoff hydrograph and also provides estimates of runoff volume.

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



**IDF Equations**

$$I_{100} = -2.52 \ln(D) + 12.735$$

$$I_{50} = -2.25 \ln(D) + 11.375$$

$$I_{25} = -2.00 \ln(D) + 10.111$$

$$I_{10} = -1.75 \ln(D) + 8.847$$

$$I_5 = -1.50 \ln(D) + 7.583$$

$$I_2 = -1.19 \ln(D) + 6.035$$

Note: Values calculated by equations may not precisely duplicate values read from figure.

**Table 6-7. Conveyance Coefficient,  $C_v$** 

Type of Land Surface	$C_v$
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

\*For buried riprap, select  $C_v$  value based on type of vegetative cover.

The travel time is calculated by dividing the flow distance (in feet) by the velocity calculated using Equation 6-9 and converting units to minutes.

The time of concentration ( $t_c$ ) is then the sum of the overland flow time ( $t_i$ ) and the travel time ( $t_t$ ) per Equation 6-7.

### 3.2.3 First Design Point Time of Concentration in Urban Catchments

Using this procedure, the time of concentration at the first design point (typically the first inlet in the system) in an urbanized catchment should not exceed the time of concentration calculated using Equation 6-10. The first design point is defined as the point where runoff first enters the storm sewer system.

$$t_c = \frac{L}{180} + 10 \quad (\text{Eq. 6-10})$$

Where:

$t_c$  = maximum time of concentration at the first design point in an urban watershed (min)

$L$  = waterway length (ft)

Equation 6-10 was developed using the rainfall-runoff data collected in the Denver region and, in essence, represents regional "calibration" of the Rational Method. Normally, Equation 6-10 will result in a lesser time of concentration at the first design point and will govern in an urbanized watershed. For subsequent design points, the time of concentration is calculated by accumulating the travel times in downstream drainageway reaches.

### 3.2.4 Minimum Time of Concentration

If the calculations result in a  $t_c$  of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum  $t_c$  for urbanized areas is 5 minutes.

### 3.2.5 Post-Development Time of Concentration

As Equation 6-8 indicates, the time of concentration is a function of the 5-year runoff coefficient for a drainage basin. Typically, higher levels of imperviousness (higher 5-year runoff coefficients) correspond to shorter times of concentration, and lower levels of imperviousness correspond to longer times of

trol were developed. These nomographs give headwater-discharge relationships for most conventional culverts flowing with inlet control through a range of headwater depths or discharges. An example of these nomographs is shown in Figure 3.25.

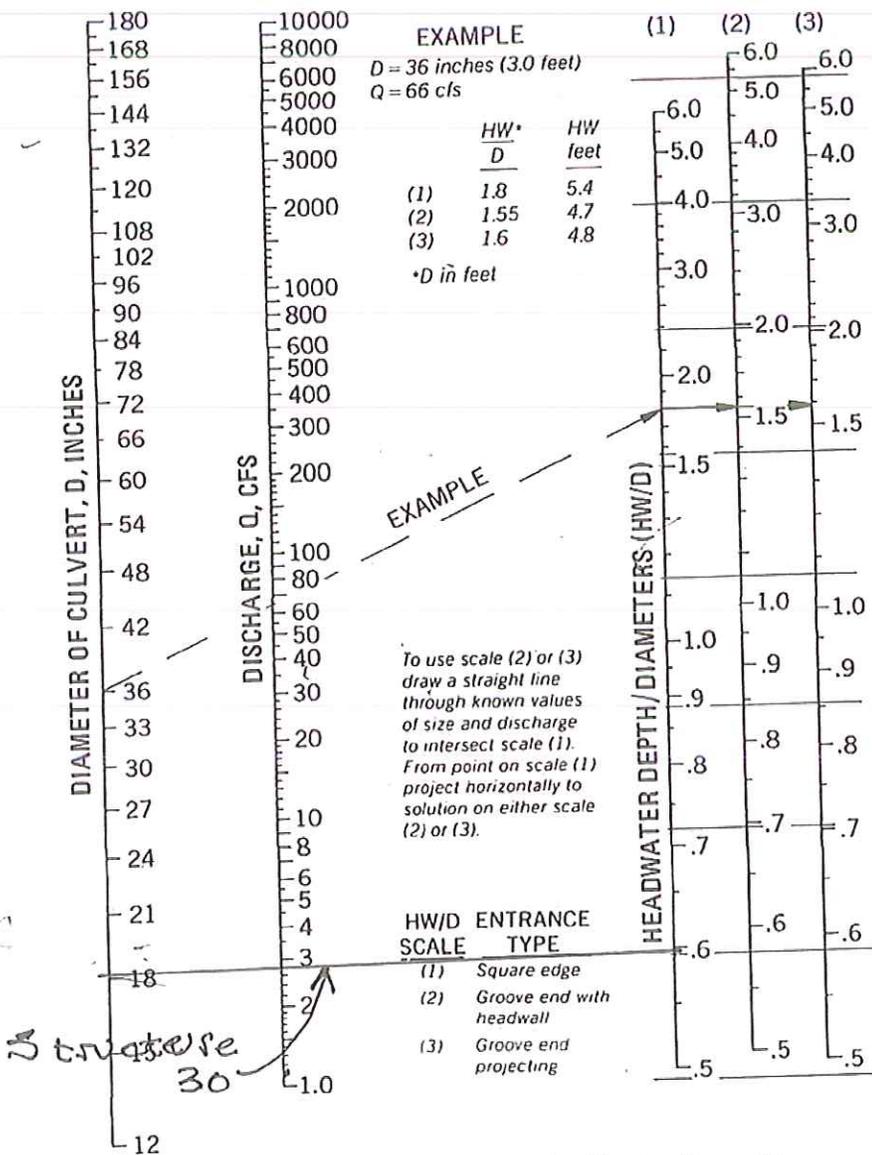


Figure 3.25. Headwater Depth for Circular Concrete Pipe Culverts with Inlet Control.



Developed Runoff Coefficients

Gravel Drive

Lot 1 -  $250\text{ft} \times 20\text{ft} = 0.11 \text{ Acres (Lot B)}$

Lot 2 -  $420\text{ft} \times 20\text{ft} = 0.19 \text{ Acres (Lot A)}$

$C_5 = 0.59$        $C_{100} = 0.70$

Roof:  $3000\text{ft}^2 / 43560 = 0.07 \text{ Acres per bath lot 1 \& 2}$

$C_5 = 0.90$        $C_{100} = 0.96$

Landscape

Each lot  $\frac{1}{2}$  acre  $C_5 = 0.12$        $C_{100} = 0.39$

Cumulative C

Lot A (5 acres)

5 yr  $(0.11 \times 0.59 + 0.07 \times 0.90 + 0.5 \times 0.12) + 4.3(0.08) / 5.0 = 0.11$

100 yr  $(0.11 \times 0.59 + 0.07 \times 0.96 + 0.5 \times 0.39) + 4.3(0.35) / 5.0 = 0.37$

Lot B (5.5 Acres)

5 yr:  $(0.19)(0.59 + 0.07(0.90) + 0.5(0.12) + 4.74(0.08) / 5.5 = 0.11$  5y

100 yr:  $0.19 \times 0.70 + 0.07 \times 0.96 + 0.5 \times 0.39 + 4.74 \times 0.35 / 5.5 = 0.37$

Cummulative Runoff

A. DP 1

1. Areas: 031, 03, 04 = 35.3 acres

2. Runoff Coef: see excel spreadsheet

3. Time of concentration = 23.2 min

B. DP 5

1. Areas: DP1 + 055 + 057 + A  
 35.3 + 0.4 + 3.6 = 39.3 acres

2. Runoff Coef: see excel spreadsheet

3.  $T_c$ : DP1 + channel from DP1 to DP5

$$V = C_v S_w^{0.5} \quad \text{where } C_v = 15 \text{ (grassed waterway)}$$

$$S = 20 \text{ ft} / 600 = 3.3\%$$

$$V = 15 (0.033)^{0.5} = 2.6 \text{ ft/s OK}$$

$$T_c = 600 / 2.6 * 60 = 3.8 \text{ min.}$$

$$\text{Total } T_c \text{ @ DP5} = 23.2 + 3.8 = \boxed{27.0 \text{ min}}$$

C. DP 6 (Pond Embankment Outlet pipe)

$$\begin{aligned} \text{A Area: DP 5} + \text{B} + 0.2 \\ = 39.3 + 3.5 + 10.3 = 53.1 \text{ acres} \end{aligned}$$

B  $T_c$ 

DP 6 + swale (DP 5 to DP 6)

Swale Travel Time

$$C_v = 15 \text{ (grassed lined swale)}$$

$$S_w = 5/200 = 2.5\%$$

$$\begin{aligned} T_T &= 75 * (0.025)^{1/2} \\ &= 2.4 \text{ min} \end{aligned}$$

$$\text{Travel Time} = 200 / 2.4 * 60 = 1.4 \text{ min}$$

$$\boxed{\text{Total } T_c \text{ @ DP 6} = 27.6 + 1.4 = 29.0 \text{ min}}$$

D. DP 7 (Thompson Road culvert)

$$\begin{aligned} \text{A} + \text{B} + \text{C} + \text{DP 6} + 0.56 + \text{D} + 0.59 + 0.510 + \text{E} \\ = 53.1 + 0.9 + 1.4 + 0.4 + 0.5 + 0.8 \\ = 57.1 \text{ Acres} \end{aligned}$$

2. Travel Time DP 6 to DP 7

$$\text{Channel Time } C_v * (L)^{1/2}$$

$$C_v = 15 \quad L = 100 \quad \text{Fall} = 4'$$

$$S_w = 4/100 = 4.0\%$$

$$V_f = 15 * (0.04)^{1/2} = 3.0 \text{ fps ok}$$

$$T_T = 100 / 3.0 * 60 = 0.6 \text{ min}$$

Time of concentration @ DP 7 =

$$\boxed{29.0 + 0.6 = 29.6 \text{ min}}$$

**KCH Engineering Solutions**

5228 Cracker Barrel Circle  
Colorado Springs, CO 80917  
(719) 246-4471

JOB Security Fire Station  
SHEET NO. 1 OF \_\_\_\_\_  
CALCULATED BY K. Harrison DATE 10-6-20  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE \_\_\_\_\_

## Inlet Sizing

1. Location = STR 1 (DP3)
2. Calc sheet = #24
3. Condition = Sump
4. Allowable depth  $\approx$  0.5 ft (6")
5. Inlet Size & type 12" standard
6. Design Flow (100 year) = 0.3 cfs
7. % clogging = 50%,
8. Updated Design Flow 0.75 cfs or 0.8 cfs
9. Headwater = 0.90 cfs

Inlets (cont)

1. Location: Sta<sup>n</sup> 19 DP 6 Subd. in E.
2. Design Flow:  $Q_{\text{dry}} = 1.0 \text{ cfs}$   $Q_{\text{100yr}} = 1.8 \text{ cfs}$  use 100 yr  
 for Subd. in E.  
 w/ clogging factor of 25% =  $1.8 + 0.25(1.8) = 2.25$  use 2.3 cfs
3. Design Values  
 cross slope = 2%  
 Max Depth @ inlet = 0.5'  
 slope = 1.6%  
 $T = 0.5' / 0.02 = 25 \text{ ft}$  use 1/2 of roadway width  
 $1/2 (22') = 11 \text{ ft}$
4. Type Inlet = 2' x 3' Myoplasta Comb Inlet Diagonal  
 Design Flow = 2.3 cfs  
 Interception = 1.7 cfs  
 Bypass = 0.6 cfs



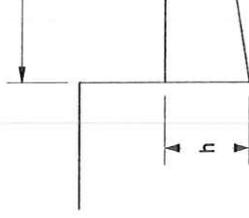
## Nyloplast Curb & Gutter Inlet Capacity Calculator - Uniform Cross Section

EQUATIONS AND CALCULATIONS ARE BASED OFF USDOT/FHWA URBAN DESIGN MANUAL, HYDRAULIC ENGINEERING CIRCULAR NO. 22, THIRD EDITION, PUBLICATION NO. FHWA-NHI-10-009.

CS # 26  
 At grade inlet STR 19  
 Q<sub>100</sub> 2.3 cfs (includes 25°)  
 Intersect 1.7 cfs Bypass = 0.6 cfs

### Curb & Gutter Design Inputs

Surface Type	Asphalt Pavement, rough texture	Drop Down
Mannings Coefficient for Street & Pavement Gutters	0.016	
T (ft)	11	Enter Units
S <sub>x</sub> (ft/ft)	0.020	Enter Units
S <sub>L</sub> (ft/ft)	0.016	Enter Units
h (in)	2.64	
Gutter Flow (cfs)	3.88	
Gutter Flow (gpm)	1743.62	
Gutter Velocity (fps)	3.18	



UNIF

### Output

	2'x3' Curb Inlet Diagonal	Drop Down
Grate Style		
Intercepted Flow (cfs)	1.706	
Intercepted Flow (gpm)	765.79	
Carryover Flow (cfs)	2.179	
Carryover Flow (gpm)	977.825	

DISCLAIMER: SAFETY FACTORS ARE NOT INCLUDED. ACTUAL CALCULATIONS SHOULD BE CARRIED OUT AND VERIFIED BY DESIGN ENGINEER TAKING INTO ACCOUNT ALL LOCAL CONDITIONS. FAA RECOMMENDS USING A SAFETY FACTOR OF 1.25 FOR PAVED AREAS AND 2.0 FOR TURF AREAS. ADS/NYLOPLAST IS NOT RESPONSIBLE FOR MISUSE OF THIS TOOL.

Inlets (Cont)

1 Location: STR 6, Subbasin J, DP 13

2. Design Flow:  $Q_5 = 0.7$   
25% clogging factor  
Bypass = STR 19  
Total Design Flow

$Q_{100} = 1.3$   
 $Q_{100} = 1.6 \text{ cfs}$   
 $Q_{100} = 0.6$   
 $Q_{60} = 2.2 \text{ cfs}$

3. Design Values  
Cross slope = 2%  
Inlet Depth @ inlet = 0.5'  
Slope = 4.8%  
T = assume 11 ft

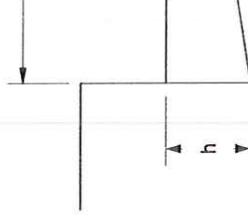
4. Type Inlet = 2' x 3' curb Inlet Diagonal  
Interception = 2.5 cfs  
Bypass = 0 cfs

## Nyloplast Curb & Gutter Inlet Capacity Calculator - Uniform Cross Section

EQUATIONS AND CALCULATIONS ARE BASED OFF USDOT/FHWA URBAN DESIGN MANUAL, HYDRAULIC ENGINEERING CIRCULAR NO. 22, THIRD EDITION, PUBLICATION NO. FHWA-NHI-10-009.

### Curb & Gutter Design Inputs

Surface Type	Asphalt Pavement, rough texture	Drop Down
Mannings Coefficient for Street & Pavement Gutters	0.016	
T (ft)	11	Enter Units
S <sub>x</sub> (ft/ft)	0.020	Enter Units
S <sub>L</sub> (ft/ft)	0.048	Enter Units
h (in)	2.64	
Gutter Flow (cfs)	6.73	
Gutter Flow (gpm)	3020.03	
Gutter Velocity (fps)	5.51	



UNIF

### Output

	2'x3' Curb Inlet Diagonal	Drop Down
Grate Style	2.532	
Intercepted Flow (cfs)	1136.26	
Intercepted Flow (gpm)	4.197	
Carryover Flow (gpm)	1883.771	

CS # 27  
 Inlet STR 6, DD 13  
 Interception = 2.532  
 Bypass = 0.00

DISCLAIMER: SAFETY FACTORS ARE NOT INCLUDED. ACTUAL CALCULATIONS SHOULD BE CARRIED OUT AND VERIFIED BY DESIGN ENGINEER TAKING INTO ACCOUNT ALL LOCAL CONDITIONS. FAA RECOMMENDS USING A SAFETY FACTOR OF 1.25 FOR PAVED AREAS AND 2.0 FOR TURF AREAS. ADS/NYLOPLAST IS NOT RESPONSIBLE FOR MISUSE OF THIS TOOL.

## Exhibit 6: Hydrologic Calculations

## Design Point Summary

### Existing Conditions

DP	Contributing Sub basins	Area	Tc	C5	C100	CA5	CA100	Q5	Q100
1	OS1	34.1	23.2	0.09	0.36			8.7	58.5
2	OS3	0.6	15	0.08	0.35			0.2	1.2
3	OS4	0.6	13.3	0.17	0.41			0.4	1.5
4	OS7	3.6	15.5	0.12	0.38			1.5	8.0
5	OS1,OS3, OS4, OS5,OS7,A	45.6	27			4.16	16.31	11.0	72.2
6	DP5,OS6,B,OS2	60.3	28.4			5.47	21.28	14.0	91.5
7	DP6, C, OS8	62.5	29			5.71	22.37	14.5	95.0
8	OS5	0.4	10.9	0.08	0.35			0.1	0.9
9	OS6	0.9	15.2	0.08	0.35			0.3	1.9
10	OS2	10.3	17.9	0.10	0.36			3.3	20.5
11	OS8	1.4	14.1	0.08	0.35			0.4	3.0
12	OS10	0.5	5.3	0.57	0.72			1.5	3.1
13	OS9	0.4	6.1	0.70	0.81			1.4	2.6
14	DP7, OS9, OS10	61.5	29			6.28	23.05	15.9	97.9
	Lot 1 located in sub basin B	5.5	12.9	0.08	0.35			1.8	13.3
	Lot 2 Located in sub basin A	5.0	14.8	0.08	0.35			1.2	8.9

## Design Point Summary

### Developed Conditions

DP	Contributing Sub basins	Area	Tc	C5	C100	CA5	CA100	Q5	Q100
1	OS1	34.1	23.2	0.09	0.36			8.7	58.5
2	OS3	0.6	15	0.08	0.35			0.2	1.2
3	OS4	0.6	13.5	0.17	0.41			0.3	1.3
4	OS7	3.6	15.5	0.12	0.38			1.5	8.0
5	OS1,OS3, OS4, OS5,OS7,A	45.6	27			4.28	16.39	11.3	72.6
6	DP5,OS6,B,OS2	60.3	28.4			5.66	21.42	14.5	92.1
7	DP6, C, OS8	62.5	29			5.71	22.37	14.5	95.0
8	OS5	0.4	10.9	0.08	0.35			0.1	0.9
9	OS6	0.9	15.2	0.08	0.35			0.3	1.9
10	OS2	10.3	17.9	0.10	0.36			3.3	20.5
11	OS8	1.4	14.1	0.08	0.35			0.4	3.0
12	OS10	0.5	5.3	0.57	0.72			1.5	3.1
13	OS9	0.4	6.1	0.70	0.81			1.4	2.6
14	DP7, OS9, OS10	63.4	29			6.47	23.18	16.4	98.5
	Lot 1 located in sub basin B	5.5	12.9	0.11	0.37			1.7	9.4
	Lot 2 Located in sub basin A	5.0	14.8	0.08	0.35			2.5	14.1

### Cummulative Acreage at Design Points

DP	Sub Basin ID	Sub basin Area	Sub total
1	OS1	34.1	34.1
5	OS1	34.1	
	OS3	0.6	
	OS4	0.6	
	OS5	0.4	
	A	6.3	
5	OS7	3.6	45.6
6	DP5	45.6	
	OS6	0.9	
	B	3.5	
6	OS2	10.3	60.3
7	DP6	60.3	
	C	0.8	
7	OS8	1.4	62.5
14	DP7	62.5	
	OS9	0.4	
14	OS10	0.5	63.4

## Stormwater Runoff Summary Comparison

### Existing Conditions

DP	Contributing Sub basins	Area	Tc	C5	C100	CA5	CA100	Q5	Q100
14	DP7, OS9, OS10	63.4	29			6.28	23.05	15.9	97.9
	Lot 1 (sub basin B)	5.5	12.9	0.11	0.37			1.8	13.3
	Lot 2 (Sub basin A)	5.0	14.8	0.11	0.37			1.2	8.9

### Developed Conditions

DP	Contributing Sub basins	Area	Tc	Rational					
				C5	C100	CA5	CA100	Q5	Q100
14	DP7, OS9, OS10	63.4	29			6.47	23.18	16.4	98.5
	Lot 1 (sub basin B)	5.5	12.9	0.11	0.37			2.5	14.1
	Lot 2 (Sub basin A)	5.0	14.8	0.11	0.37			1.7	9.4

#### Notes

- 1 Design Point 14 is located at the upstream end of the culvert under Thompson Road
- 2 The majority of Lot 2 is located in sub basin A.
- 3 The majority of Lot 1 is located in sub basin B.
- 4 All of the runoff from the sub basins not shown in the above table remains The same as shown on the Existing Conditions Drainage Plan
- 5 CA values are used in order to accurately reflect controlling Tc

# MCGEHEE TRACT FINAL DRAINAGE REPORT (Area Drainage Summary) Existing Conditions

See surface flow routing table for total combined flow at culvert under Thompson Road

BASIN	AREA TOTAL (Acres)	C <sub>s</sub>	C <sub>100</sub>	OVERLAND					CHANNEL FLOW					INTENSITY *				TOTAL FLOWS	
				C <sub>s</sub>	Length (ft)	Height (ft)	T <sub>c</sub> (min)	Length (ft)	Slope (%)	Velocity (fps)	T <sub>i</sub> (min)	TOTAL (min)	CHECK (min)	I <sub>5</sub> (in/hr)	I <sub>100</sub> (in/hr)	Q <sub>s</sub> (c.f.s.)	Q <sub>100</sub> (c.f.s.)		
OS1	34.10	0.09	0.36		300	40	13.4	1900	4.7%	3.3	9.7	23.2	22.2	2.9	4.8	8.7	58.5		
OS2	10.30	0.10	0.36		300	20	16.7	300	8.3%	4.3	1.2	17.9	13.3	3.3	5.5	3.3	20.5		
OS3	0.60	0.08	0.35		300	30	14.9	1	0.1%	0.5	0.0	15.0	11.7	3.5	5.9	0.2	1.2		
OS4	0.60	0.17	0.41		300	35	13.0	100	10.0%	4.7	0.4	13.3	12.2	3.7	6.2	0.4	1.5		
OS5	0.40	0.08	0.35		100	5	10.8	1	0.1%	0.5	0.0	10.9	10.6	4.0	6.7	0.1	0.9		
OS6	0.90	0.08	0.35		150	5	15.2	1	0.1%	0.5	0.0	15.2	10.8	3.5	5.9	0.3	1.9		
OS7	3.60	0.12	0.38		300	25	15.2	100	15.0%	5.8	0.3	15.5	12.2	3.5	5.8	1.5	8.0		
OS8	1.40	0.08	0.35		50	0.5	13.0	250	7.3%	4.1	1.0	14.1	11.7	3.6	6.1	0.4	3.0		
OS9	0.40	0.70	0.81		20	0.5	2.4	550	2.7%	2.5	3.7	6.1	13.2	4.9	8.2	1.4	2.6		
OS10	0.50	0.57	0.72		20	0.5	3.2	550	8.2%	4.3	2.1	5.3	13.2	5.1	8.5	1.5	3.1		
A	6.30	0.08	0.35		200	20	12.2	550	5.5%	3.5	2.6	14.8	14.2	3.5	5.9	1.8	13.1		
B	3.50	0.08	0.35		150	10	12.1	175	5.7%	3.6	0.8	12.9	11.8	3.8	6.3	1.1	7.7		
C	0.80	0.08	0.35		150	10	12.1	250	10.0%	4.7	0.9	12.9	12.2	3.7	6.3	0.2	1.8		
<b>Sub Total</b>	<b>63.40</b>																		
<i>Lots to be developed</i>																			
<b>Lot 2 located in Sub basin A</b>	5.00	0.08	0.35									14.8	10.0	3.1	5.1	1.2	8.9		
<b>Lot 1 located in Sub basin B</b>	5.50	0.08	0.35									12.9	10.0	4.1	6.9	1.8	13.3		

**MCGEHEE TRACT**  
**FINAL DRAINAGE REPORT**  
*(Surface Routing Summary- surface runoff)*  
**Existing Conditions**

From Area Runoff Coefficient Summary					Time of Travel (T <sub>t</sub> )	INTENSITY *			TOTAL FLOWS		COMMENTS
DESIGN POINT	Swale ID	CONTRIBUTING BASINS	CA <sub>5</sub>	CA <sub>100</sub>	TOTAL	I <sub>5</sub>	I <sub>100</sub>	Q <sub>5</sub>	Q <sub>100</sub>		
					(min)	(in/hr)	(in/hr)	(c.f.s.)	(c.f.s.)		
DP1	S1	OS1, OS3, OS4	3.18	12.60	23.2	2.9	4.8	9.1	60.6	west property line	
DP5	S2	DP1, OS5, OS7, A	4.16	16.31	27.0	2.6	4.4	11.0	72.2	entrance to the stock pond	
DP6	S3	DP5, B, OS2	5.47	21.28	28.4	2.6	4.3	14.0	91.5	outlet to the pond	
DP7	S4	DP6, OS6, C, OS8	5.71	22.37	29.0	2.5	4.2	14.5	95.0	Thompson Road culvert	
DP14	S4	DP7, OS9, OS10	6.28	23.05	29.0	2.5	4.2	15.9	97.9	Thompson Road culvert	
		<i>minimal change from DP7</i>									

**MCGEHEE TRACT  
DRAINAGE CALCULATIONS  
(Area Runoff Coefficient Summary)  
Existing Conditions**

See surface flow routing table for total combined flow at culvert under Thompson Road

BASIN	TOTAL AREA (Acre)		GRAVEL/ ASPHALT ROADS			DEVELOPED LOTS			NATURAL			RUNOFF COEFFICIENT			
	AREA (Acre)	C <sub>100</sub>	AREA (Acre)	C <sub>5</sub>	C <sub>100</sub>	AREA (Acre)	C <sub>5</sub>	C <sub>100</sub>	AREA (Acre)	C <sub>5</sub>	C <sub>100</sub>	C <sub>5</sub>	C <sub>100</sub>	C <sub>5</sub>	C <sub>100</sub>
OS1	34.10		0.60	0.59	0.70	0.00	0.38	0.57	33.50	0.08	0.35	0.09	0.36	0.09	0.36
OS2	10.30		0.40	0.59	0.70	0.00	0.38	0.57	9.90	0.08	0.35	0.10	0.36	0.10	0.36
OS3	0.80		0.00	0.59	0.70	0.00	0.38	0.57	0.60	0.08	0.35	0.08	0.35	0.08	0.35
OS4	0.80		0.10	0.59	0.70	0.00	0.38	0.57	0.50	0.08	0.35	0.17	0.41	0.17	0.41
OS5	0.40		0.00	0.59	0.70	0.00	0.38	0.57	0.40	0.08	0.35	0.08	0.35	0.08	0.35
OS6	0.90		0.00	0.59	0.70	0.00	0.38	0.57	0.90	0.08	0.35	0.08	0.35	0.08	0.35
OS7	3.60		0.30	0.59	0.70	0.00	0.38	0.57	3.30	0.08	0.35	0.12	0.38	0.12	0.38
OS8	1.40		0.00	0.59	0.70	0.00	0.38	0.57	1.40	0.08	0.35	0.08	0.35	0.08	0.35
OS9	0.40		0.30	0.90	0.96	0.00	0.38	0.57	0.10	0.08	0.35	0.70	0.81	0.70	0.81
OS10	0.50		0.30	0.90	0.96	0.00	0.38	0.57	0.20	0.08	0.35	0.57	0.72	0.57	0.72
A	6.30		0.00	0.59	0.70	0.00	0.38	0.57	6.30	0.08	0.35	0.08	0.35	0.08	0.35
B	3.50		0.00	0.59	0.70	0.00	0.38	0.57	3.50	0.08	0.35	0.08	0.35	0.08	0.35
C	0.80		0.00	0.59	0.70	0.00	0.38	0.57	0.80	0.08	0.35	0.08	0.35	0.08	0.35
Sub Total	63.40														
Lots to be developed															
Lot 2 located in Sub basin A	5.00											0.08	0.35	0.08	0.35
Lot 1 located in Sub basin B	5.50											0.08	0.35	0.08	0.35

**MCGEHEE TRACT**  
**DRAINAGE CALCULATIONS**  
*(Sub basin Runoff Coefficient Summary)*  
**Developed Conditions**

*See surface flow routing table for total combined flow at culvert under Thompson Road*

BASIN	TOTAL AREA (Acre)	GRAVEL/ASPHALT ROADS			ROOFS			NATURAL			RUNOFF COEFFICIENT	
		AREA (Acre)	C <sub>5</sub>	C <sub>100</sub>	AREA (Acre)	C <sub>5</sub>	C <sub>100</sub>	AREA (Acre)	C <sub>5</sub>	C <sub>100</sub>	C <sub>5</sub>	C <sub>100</sub>
OS1	34.10	0.60	0.59	0.70	0.00	0.38	0.57	33.50	0.08	0.35	0.09	0.36
OS2	10.30	0.40	0.59	0.70	0.00	0.38	0.57	9.90	0.08	0.35	0.10	0.36
OS3	0.60	0.00	0.59	0.70	0.00	0.38	0.57	0.60	0.08	0.35	0.08	0.35
OS4	0.60	0.10	0.59	0.70	0.00	0.38	0.57	0.40	0.08	0.35	0.15	0.35
OS5	0.40	0.00	0.59	0.70	0.00	0.38	0.57	0.50	0.08	0.35	0.10	0.44
OS6	0.90	0.00	0.59	0.70	0.00	0.38	0.57	0.90	0.08	0.35	0.08	0.35
OS7	3.60	0.30	0.59	0.70	0.00	0.38	0.57	3.30	0.08	0.35	0.12	0.38
OS8	1.40	0.00	0.59	0.70	0.00	0.38	0.57	1.40	0.08	0.35	0.08	0.35
OS9	0.40	0.30	0.90	0.96	0.00	0.38	0.57	0.10	0.08	0.35	0.70	0.81
OS10	0.50	0.30	0.90	0.96	0.00	0.38	0.57	0.20	0.08	0.35	0.57	0.72
A	6.90	0.19	0.59	0.70	0.07	0.38	0.57	6.04	0.08	0.35	0.10	0.36
B	3.50	0.11	0.59	0.70	0.07	0.38	0.57	3.32	0.08	0.35	0.10	0.37
C	0.90	0.00	0.59	0.70	0.00	0.38	0.57	0.80	0.08	0.35	0.08	0.35
Sub Total	63.40											
Lots to be developed												
Lot 2 located in Sub Basin A	5.00										0.11	0.37
Lot 1 located in Sub Basin B	5.50										0.11	0.37

# MCGEHEE TRACT FINAL DRAINAGE REPORT (Area Drainage Summary) Developed Conditions

See surface flow routing table for total combined flow at culvert under Thompson Road

BASIN	AREA TOTAL (Acres)		C <sub>s</sub>		C <sub>100</sub>		OVERLAND				CHANNEL FLOW				Time of Travel (T <sub>i</sub> )			TOTAL FLOWS		
	AREA TOTAL	(Acres)	C <sub>s</sub>	C <sub>100</sub>	C <sub>s</sub>	C <sub>100</sub>	Length (ft)	Height (ft)	T <sub>c</sub> (min)	Length (ft)	Slope (%)	Velocity (fps)	T <sub>i</sub> (min)	TOTAL (min)	I <sub>s</sub> (in/hr)	I <sub>100</sub> (in/hr)	Q <sub>s</sub> (c.f.s.)	Q <sub>100</sub> (c.f.s.)		
OS1	34.10	0.09	0.09	0.36	0.09	0.36	300	40	13.4	1900	4.7%	3.3	9.7	23.2	2.9	4.8	8.7	58.5		
OS2	10.30	0.10	0.10	0.36	0.10	0.36	300	20	16.7	300	8.3%	4.3	1.2	17.9	3.3	5.5	3.3	20.5		
OS3	0.80	0.08	0.08	0.35	0.08	0.35	300	30	14.9	1	0.1%	0.5	0.0	15.0	3.5	5.9	0.2	1.2		
OS4	0.80	0.15	0.15	0.35	0.15	0.35	300	35	13.2	100	10.0%	4.7	0.4	13.5	3.7	6.2	0.3	1.2		
OS5	0.40	0.10	0.10	0.44	0.10	0.44	100	5	10.6	1	0.1%	0.5	0.0	10.7	4.0	6.8	0.2	1.2		
OS6	0.80	0.08	0.08	0.35	0.08	0.35	150	5	15.2	1	0.1%	0.5	0.0	15.2	3.5	5.9	0.3	1.9		
OS7	3.80	0.12	0.12	0.38	0.12	0.38	300	25	15.2	100	15.0%	5.8	0.3	15.5	3.5	5.8	1.5	8.0		
OS8	1.40	0.08	0.08	0.35	0.08	0.35	50	0.5	13.0	250	7.3%	4.1	1.0	14.1	3.6	6.1	0.4	3.0		
OS9	0.40	0.70	0.70	0.81	0.70	0.81	20	0.5	2.4	550	2.7%	2.5	3.7	6.1	4.9	8.2	1.4	2.6		
OS10	0.50	0.57	0.57	0.72	0.57	0.72	20	0.5	3.2	550	8.2%	4.3	2.1	5.3	5.1	8.5	1.5	3.1		
A	6.30	0.10	0.10	0.36	0.10	0.36	200	20	12.0	550	5.9%	3.5	2.6	14.8	3.5	5.9	2.2	13.6		
B	3.50	0.10	0.10	0.37	0.10	0.37	150	10	11.8	175	5.7%	3.6	0.8	12.9	3.7	6.3	1.3	8.0		
C	0.80	0.08	0.08	0.35	0.08	0.35	150	10	12.1	250	10.0%	4.7	0.9	12.9	3.7	6.3	0.2	1.8		
<b>Sub Totals</b>	63.40																			
<i>Lots to be developed</i>																				
<i>Lot 2 located in Sub Easin A</i>	5.00	0.11	0.11	0.37										14.8	3.1	5.1	1.7	9.4		
<i>Lot 1 located in Sub Easin B</i>	5.50	0.11	0.11	0.37										12.9	4.1	6.9	2.5	14.1		

Date: 12/11/2019  
Checked by:

**MCGEHEE TRACT**  
**FINAL DRAINAGE REPORT**  
*(Surface Routing Summary- surface runoff)*  
**Developed Conditions**

<i>From Area Runoff Coefficient Summary</i>					<i>Time of Travel (T<sub>t</sub>)</i>		<i>INTENSITY *</i>		<i>TOTAL FLOWS</i>		COMMENTS
DESIGN POINT	Swale ID	CONTRIBUTING BASINS	CA <sub>5</sub>	CA <sub>100</sub>	TOTAL	I <sub>5</sub>	I <sub>100</sub>	Q <sub>5</sub>	Q <sub>100</sub>		
					(min)	(in/hr)	(in/hr)	(c.f.s.)	(c.f.s.)		
<i>DP1</i>	<i>S1</i>	OS1, OS3, OS4	3.17	12.57	23.2	2.9	4.8	<b>9.1</b>	<b>60.5</b>	west property line	
<i>DP5</i>	<i>S2</i>	DP1,OS5,OS7,A	4.28	16.39	27.0	2.6	4.4	<b>11.3</b>	<b>72.6</b>	entrance to the stock pond	
<i>DP6</i>	<i>S3</i>	DP5, B, OS2	5.66	21.42	28.4	2.6	4.3	<b>14.5</b>	<b>92.1</b>	outlet to the pond	
<i>DP7</i>	<i>S4</i>	DP6,C,,OS8	5.90	22.53	29.0	2.5	4.2	<b>14.9</b>	<b>95.7</b>		
<i>DP14</i>	<i>S5</i>	DP7,OS9,OS10	6.47	23.18	29.0	2.5	4.2	<b>16.4</b>	<b>98.5</b>	Thompson Road culvert	

## Exhibit 7: Hydraulic Calculations

## Swale Summary

### Existing Conditions (Negligible changes for developed conditions)

Swale #	Design Points	Contributing Subbasins	Slope %	Design Flow		Depth of Flow		Velocity		Froude Number (5 year)	Flow Regime
				Q5 cfs	Q100 cfs	Q5 ft	Q100 ft	Q5 fps	Q100 fps		
1	1	OS1	4.7	8.7	58.5	0.3	0.7	2.9	4.8	1.21	super
2	1 to 5	OS1, OS3, OS4, A, OS7	5.5	11	72.2	0.3	0.7	3.4	5.5	1.32	super
3	5 to 6	DP5, B, OS2	8.3	14	91.7	0.3	0.8	4.4	7.2	1.66	super
4	6 to 7	DP10, C, OS8	8.3	14.5	95	0.4	0.9	4.8	7.9	1.7	super
5	12	OS10	5.0	1.5	3.1	0.2	0.3	2.8	3.5	1.2	super
6	13	OS9	5.5	1.4	2.6	0.2	0.3	2.8	3.4	1.27	super

CS 1  
5 year  
swale 1

The open channel flow calculator

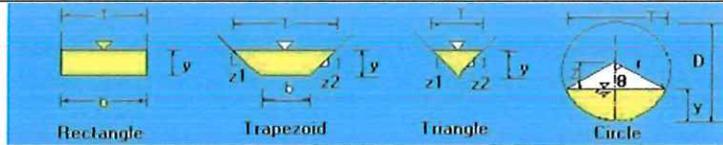
Select Channel Type: Trapezoid <input type="button" value="v"/>					
Depth from Q <input type="button" value="v"/>		Select unit system: Feet(ft) <input type="button" value="v"/>			
Channel slope: .047 <input type="text"/> ft/ft		Water depth(y): 0.28 <input type="text"/> ft		Bottom width(b): 5 <input type="text"/> ft	
Flow velocity: 2.9425 <input type="text"/> ft/s		LeftSlope (Z1): 20 <input type="text"/> to 1 (H:V)		RightSlope (Z2): 20 <input type="text"/> to 1 (H:V)	
Flow discharge: 8.7 <input type="text"/> ft <sup>3</sup> /s		Input n value: .035 <input type="text"/> or select r			
<input type="button" value="Calculate!"/>		Status: Calculation finished		<input type="button" value="Reset"/>	
Wetted perimeter: 16.19 <input type="text"/> ft		Flow area: 2.96 <input type="text"/> ft <sup>2</sup>		Top width(T): 16.17 <input type="text"/> ft	
Specific energy: 0.41 <input type="text"/> ft		Froude number: 1.21 <input type="text"/>		Flow status: Supercritical flow	
Critical depth: 0.31 <input type="text"/> ft		Critical slope: 0.0304 <input type="text"/> ft/ft		Velocity head: 0.13 <input type="text"/> ft	

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CS-2  
100 year  
swab 1

### The open channel flow calculator

Select Channel Type: Trapezoid ▾



Depth from Q ▾

Select unit system: Feet(ft) ▾

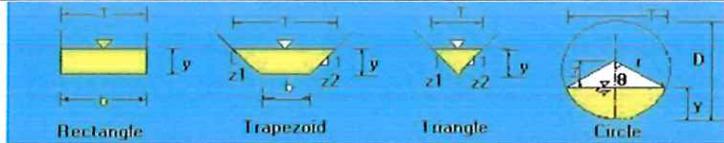
Channel slope: <input type="text" value="0.047"/> <input type="text" value="ft/ft"/>	Water depth(y): <input type="text" value="0.66"/> <input type="text" value="ft"/>	Bottom width(b): <input type="text" value="5"/> <input type="text" value="ft"/>
Flow velocity: <input type="text" value="4.851"/> <input type="text" value="ft/s"/>	LeftSlope (Z1): <input type="text" value="20"/> <input type="text" value="to 1 (H:V)"/>	RightSlope (Z2): <input type="text" value="20"/> <input type="text" value="to 1 (H:V)"/>
Flow discharge: <input type="text" value="58.5"/> <input type="text" value="ft^3/s"/>	Input n value: <input type="text" value="0.035"/> <input type="text" value="or select n"/>	
<input type="button" value="Calculate!"/>	Status: <input type="text" value="Calculation finished"/>	<input type="button" value="Reset"/>
Wetted perimeter: <input type="text" value="31.49"/> <input type="text" value="ft"/>	Flow area: <input type="text" value="12.06"/> <input type="text" value="ft^2"/>	Top width(T): <input type="text" value="31.46"/> <input type="text" value="ft"/>
Specific energy: <input type="text" value="1.03"/> <input type="text" value="ft"/>	Froude number: <input type="text" value="1.38"/>	Flow status: <input type="text" value="Supercritical flow"/>
Critical depth: <input type="text" value="0.77"/> <input type="text" value="ft"/>	Critical slope: <input type="text" value="0.0232"/> <input type="text" value="ft/ft"/>	Velocity head: <input type="text" value="0.37"/> <input type="text" value="ft"/>

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*C5A3*  
*Byed/02/2020*  
*swale 5*

### The open channel flow calculator

Select Channel Type: Trapezoid ▾



Depth from Q ▾

Select unit system: Feet(ft) ▾

Channel slope: <input type="text" value="0.05"/> ft/ft	Water depth(y): <input type="text" value="0.21"/> ft	Bottom width(b): <input type="text" value="2"/> ft
Flow velocity <input type="text" value="2.784683"/> ft/s	LeftSlope (Z1): <input type="text" value="3"/> to 1 (H:V)	RightSlope (Z2): <input type="text" value="3"/> to 1 (H:V)
Flow discharge <input type="text" value="1.5"/> ft <sup>3</sup> /s	Input n value <input type="text" value="0.035"/> or select n	
<input type="button" value="Calculate!"/>	Status: <input type="text" value="Calculation finished"/>	<input type="button" value="Reset"/>
Wetted perimeter <input type="text" value="3.3"/> ft	Flow area <input type="text" value="0.54"/> ft <sup>2</sup>	Top width(T) <input type="text" value="3.23"/> ft
Specific energy <input type="text" value="0.33"/> ft	Froude number <input type="text" value="1.2"/>	Flow status <input type="text" value="Supercritical flow"/>
Critical depth <input type="text" value="0.23"/> ft	Critical slope <input type="text" value="0.0321"/> ft/ft	Velocity head <input type="text" value="0.12"/> ft

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C574  
100% ✓  
Scale H5

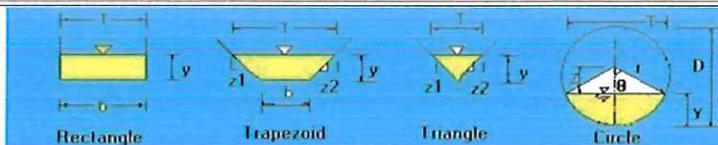
The open channel flow calculator		
Select Channel Type: <span style="border: 1px solid black; padding: 2px;">Trapezoid</span>		
Depth from Q <span style="border: 1px solid black; padding: 2px;">▼</span>	Select unit system: <span style="border: 1px solid black; padding: 2px;">Feet(ft)</span>	
Channel slope: <span style="border: 1px solid black; padding: 2px;">.05</span> <span style="border: 1px solid black; padding: 2px;">ft/ft</span>	Water depth(y): <span style="border: 1px solid black; padding: 2px;">0.3</span> <span style="border: 1px solid black; padding: 2px;">ft</span>	Bottom width(b): <span style="border: 1px solid black; padding: 2px;">2</span> <span style="border: 1px solid black; padding: 2px;">ft</span>
Flow velocity: <span style="border: 1px solid black; padding: 2px;">3.504871</span> <span style="border: 1px solid black; padding: 2px;">ft/s</span>	Left Slope (Z1): <span style="border: 1px solid black; padding: 2px;">3</span> <span style="border: 1px solid black; padding: 2px;">to 1 (H:V)</span>	Right Slope (Z2): <span style="border: 1px solid black; padding: 2px;">3</span> <span style="border: 1px solid black; padding: 2px;">to 1 (H:V)</span>
Flow discharge: <span style="border: 1px solid black; padding: 2px;">3.1</span> <span style="border: 1px solid black; padding: 2px;">ft^3/s</span>	Input n value: <span style="border: 1px solid black; padding: 2px;">.035</span> <span style="border: 1px solid black; padding: 2px;">or select n</span>	
<span style="border: 1px solid black; padding: 2px;">Calculate!</span>	Status: <span style="border: 1px solid black; padding: 2px; color: red;">Calculation finished</span>	<span style="border: 1px solid black; padding: 2px;">Reset</span>
Wetted perimeter: <span style="border: 1px solid black; padding: 2px;">3.92</span> <span style="border: 1px solid black; padding: 2px;">ft</span>	Flow area: <span style="border: 1px solid black; padding: 2px;">0.88</span> <span style="border: 1px solid black; padding: 2px;">ft^2</span>	Top width(T): <span style="border: 1px solid black; padding: 2px;">3.82</span> <span style="border: 1px solid black; padding: 2px;">ft</span>
Specific energy: <span style="border: 1px solid black; padding: 2px;">0.49</span> <span style="border: 1px solid black; padding: 2px;">ft</span>	Froude number: <span style="border: 1px solid black; padding: 2px;">1.28</span>	Flow status: <span style="border: 1px solid black; padding: 2px;">Supercritical flow</span>
Critical depth: <span style="border: 1px solid black; padding: 2px;">0.35</span> <span style="border: 1px solid black; padding: 2px;">ft</span>	Critical slope: <span style="border: 1px solid black; padding: 2px;">0.0283</span> <span style="border: 1px solid black; padding: 2px;">ft/ft</span>	Velocity head: <span style="border: 1px solid black; padding: 2px;">0.19</span> <span style="border: 1px solid black; padding: 2px;">ft</span>

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CS 5  
5 year  
swale 2

### The open channel flow calculator

Select Channel Type: Trapezoid ▾



Depth from Q ▾

Select unit system: Feet(ft) ▾

Channel slope: <input type="text" value=".055"/> <input type="text" value="ft/ft"/>	Water depth(y): <input type="text" value="0.31"/> <input type="text" value="ft"/>	Bottom width(b): <input type="text" value="5"/> <input type="text" value="ft"/>
Flow velocity: <input type="text" value="3.375452"/> <input type="text" value="ft/s"/>	LeftSlope (Z1): <input type="text" value="18"/> <input type="text" value="to 1 (H:V)"/>	RightSlope (Z2): <input type="text" value="18"/> <input type="text" value="to 1 (H:V)"/>
Flow discharge: <input type="text" value="11"/> <input type="text" value="ft^3/s"/>	Input n value: <input type="text" value=".035"/> <input type="text" value="or select n"/>	
<input type="button" value="Calculate!"/>	Status: <input type="text" value="Calculation finished"/>	<input type="button" value="Reset"/>
Wetted perimeter: <input type="text" value="16.13"/> <input type="text" value="ft"/>	Flow area: <input type="text" value="3.26"/> <input type="text" value="ft^2"/>	Top width(T): <input type="text" value="16.11"/> <input type="text" value="ft"/>
Specific energy: <input type="text" value="0.49"/> <input type="text" value="ft"/>	Froude number: <input type="text" value="1.32"/>	Flow status: <input type="text" value="Supercritical flow"/>
Critical depth: <input type="text" value="0.36"/> <input type="text" value="ft"/>	Critical slope: <input type="text" value="0.0287"/> <input type="text" value="ft/ft"/>	Velocity head: <input type="text" value="0.18"/> <input type="text" value="ft"/>

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*CS #6  
100 year  
swale 2*

The open channel flow calculator					
Select Channel Type: <span style="color: red;">Trapezoid</span> ▼					
Depth from Q ▼	Select unit system: <span style="color: red;">Feet(ft)</span> ▼				
Channel slope: <input type="text" value=".055"/> <input type="text" value="ft/ft"/>	Water depth(y): <input style="color: red;" type="text" value="0.73"/> <input type="text" value="ft"/>	Bottom width(b) <input type="text" value="5"/> <input type="text" value="ft"/>			
Flow velocity <input type="text" value="5.515"/> <input type="text" value="ft/s"/>	LeftSlope (Z1): <input type="text" value="18"/> to 1 (H:V)		RightSlope (Z2): <input type="text" value="18"/> to 1 (H:V)		
Flow discharge <input type="text" value="72.2"/> <input type="text" value="ft^3/s"/>	Input n value <input type="text" value=".035"/> or select n				
<input type="button" value="Calculate!"/>	Status: <span style="color: red;">Calculation finished</span>			<input type="button" value="Reset"/>	
Wetted perimeter <input type="text" value="31.15"/> <input type="text" value="ft"/>	Flow area <input type="text" value="13.09"/> <input type="text" value="ft^2"/>		Top width(T) <input type="text" value="31.11"/> <input type="text" value="ft"/>		
Specific energy <input type="text" value="1.2"/> <input type="text" value="ft"/>	Froude number <input type="text" value="1.5"/>		Flow status <span style="border: 1px solid black; padding: 2px;">Supercritical flow</span>		
Critical depth <input type="text" value="0.88"/> <input type="text" value="ft"/>	Critical slope <input type="text" value="0.022"/> <input type="text" value="ft/ft"/>		Velocity head <input type="text" value="0.47"/> <input type="text" value="ft"/>		

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0.37  
3.45  
Swale 3

### The open channel flow calculator

Select Channel Type: Trapezoid ▼

Depth from Q ▼

Select unit system: Feet(ft) ▼

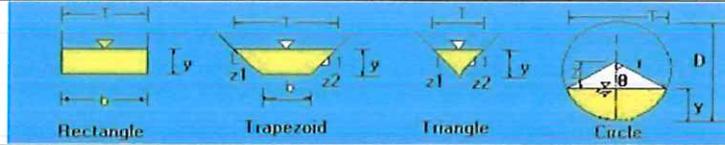
Channel slope: <span style="border: 1px solid black; padding: 2px;">.083</span> <span style="float: right;">ft/ft</span>	Water depth(y): <span style="border: 1px solid black; padding: 2px;">0.32</span> <span style="float: right;">ft</span>	Bottom width(b): <span style="border: 1px solid black; padding: 2px;">5</span> <span style="float: right;">ft</span>
Flow velocity: <span style="border: 1px solid black; padding: 2px;">4.394482</span> <span style="float: right;">ft/s</span>	Left Slope (Z1): <span style="border: 1px solid black; padding: 2px;">15</span> <span style="float: right;">to 1 (H:V)</span>	Right Slope (Z2): <span style="border: 1px solid black; padding: 2px;">15</span> <span style="float: right;">to 1 (H:V)</span>
Flow discharge: <span style="border: 1px solid black; padding: 2px;">14</span> <span style="float: right;">ft^3/s</span>	Input n value: <span style="border: 1px solid black; padding: 2px;">.035</span> <span style="float: right;">or select n</span>	
<span style="border: 1px solid black; padding: 2px;">Calculate!</span>	Status: <span style="border: 1px solid black; padding: 2px; color: red;">Calculation finished</span>	<span style="border: 1px solid black; padding: 2px;">Reset</span>
Wetted perimeter: <span style="border: 1px solid black; padding: 2px;">14.72</span> <span style="float: right;">ft</span>	Flow area: <span style="border: 1px solid black; padding: 2px;">3.19</span> <span style="float: right;">ft^2</span>	Top width(T): <span style="border: 1px solid black; padding: 2px;">14.7</span> <span style="float: right;">ft</span>
Specific energy: <span style="border: 1px solid black; padding: 2px;">0.62</span> <span style="float: right;">ft</span>	Froude number: <span style="border: 1px solid black; padding: 2px;">1.66</span>	Flow status: <span style="border: 1px solid black; padding: 2px;">Supercritical flow</span>
Critical depth: <span style="border: 1px solid black; padding: 2px;">0.42</span> <span style="float: right;">ft</span>	Critical slope: <span style="border: 1px solid black; padding: 2px;">0.0274</span> <span style="float: right;">ft/ft</span>	Velocity head: <span style="border: 1px solid black; padding: 2px;">0.3</span> <span style="float: right;">ft</span>

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CS 8  
100 yed  
swale 3

The open channel flow calculator

Select Channel Type: Trapezoid ▾



Depth from Q ▾

Select unit system: Feet(ft) ▾

Channel slope: <input type="text" value=".083"/> <input type="text" value="ft/ft"/>	Water depth(y): <input type="text" value="0.77"/> <input type="text" value="ft"/>	Bottom width(b): <input type="text" value="5"/> <input type="text" value="ft"/>
Flow velocity: <input type="text" value="7.207"/> <input type="text" value="ft/s"/>	LeftSlope (Z1): <input type="text" value="15"/> <input type="text" value="to 1 (H:V)"/>	RightSlope (Z2): <input type="text" value="15"/> <input type="text" value="to 1 (H:V)"/>
Flow discharge: <input type="text" value="91.7"/> <input type="text" value="ft^3/s"/>	Input n value: <input type="text" value=".035"/> <input type="text" value="or select n"/>	
<input type="button" value="Calculate!"/>	Status: <input type="text" value="Calculation finished"/>	<input type="button" value="Reset"/>
Wetted perimeter: <input type="text" value="28.13"/> <input type="text" value="ft"/>	Flow area: <input type="text" value="12.72"/> <input type="text" value="ft^2"/>	Top width(T): <input type="text" value="28.08"/> <input type="text" value="ft"/>
Specific energy: <input type="text" value="1.58"/> <input type="text" value="ft"/>	Froude number: <input type="text" value="1.89"/>	Flow status: <input type="text" value="Supercritical flow"/>
Critical depth: <input type="text" value="1.03"/> <input type="text" value="ft"/>	Critical slope: <input type="text" value="0.0211"/> <input type="text" value="ft/ft"/>	Velocity head: <input type="text" value="0.81"/> <input type="text" value="ft"/>

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### Improved Inlets

Culvert capacity may be increased through the use of special inlet designs. The Federal Highway Administration has developed extensive data<sup>19,20</sup> on these. While these designs increase the flow, their use has not been as expected. The increased costs of the special treatments is apparently responsible.

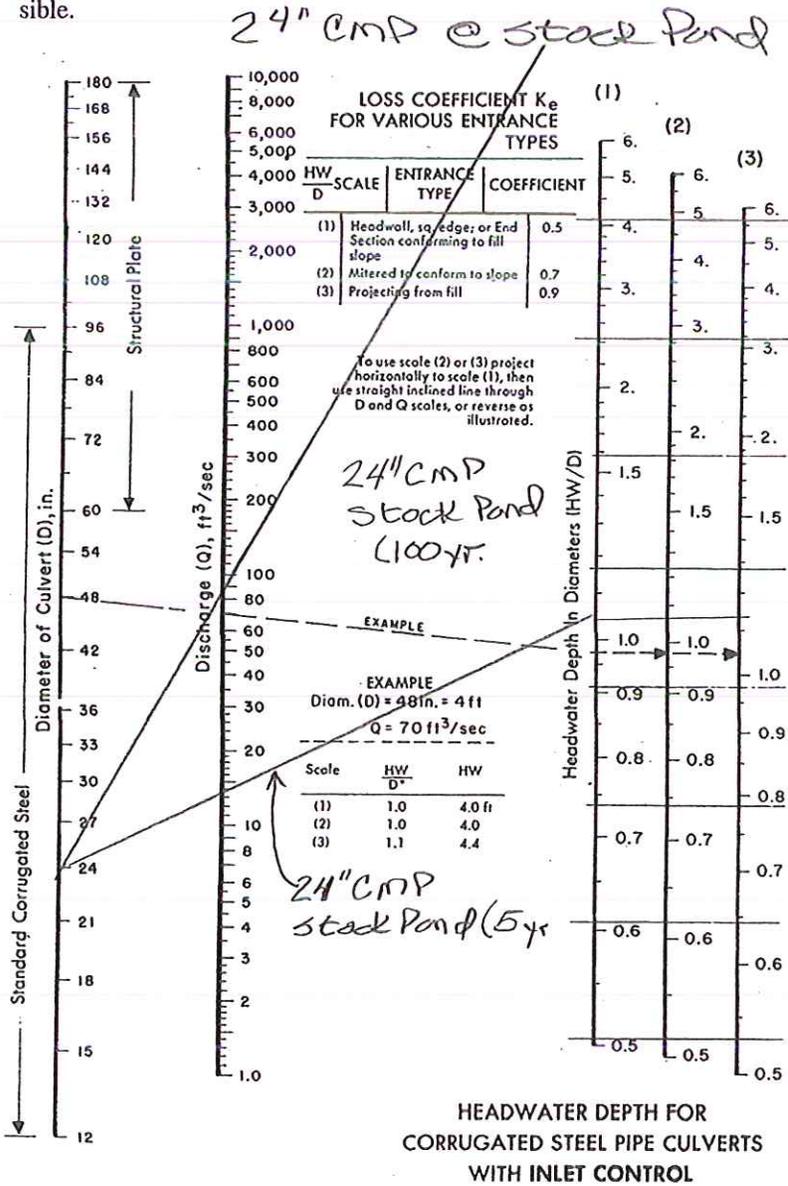


Figure 3.28 Inlet control nomograph for corrugated steel pipe culverts.<sup>13</sup> The manufacturers recommend keeping  $HW/D$  to a maximum of 1.5 and preferably to no more than 1.0 for diameters greater than 4 to 5 feet.

30" Culvert under Thompson Road / 18" Driveway Culvert CS 10

### Improved Inlets

Culvert capacity may be increased through the use of special inlet designs. The Federal Highway Administration has developed extensive data<sup>19,20</sup> on these. While these designs increase the flow, their use has not been as expected. The increased costs of the special treatments is apparently responsible.

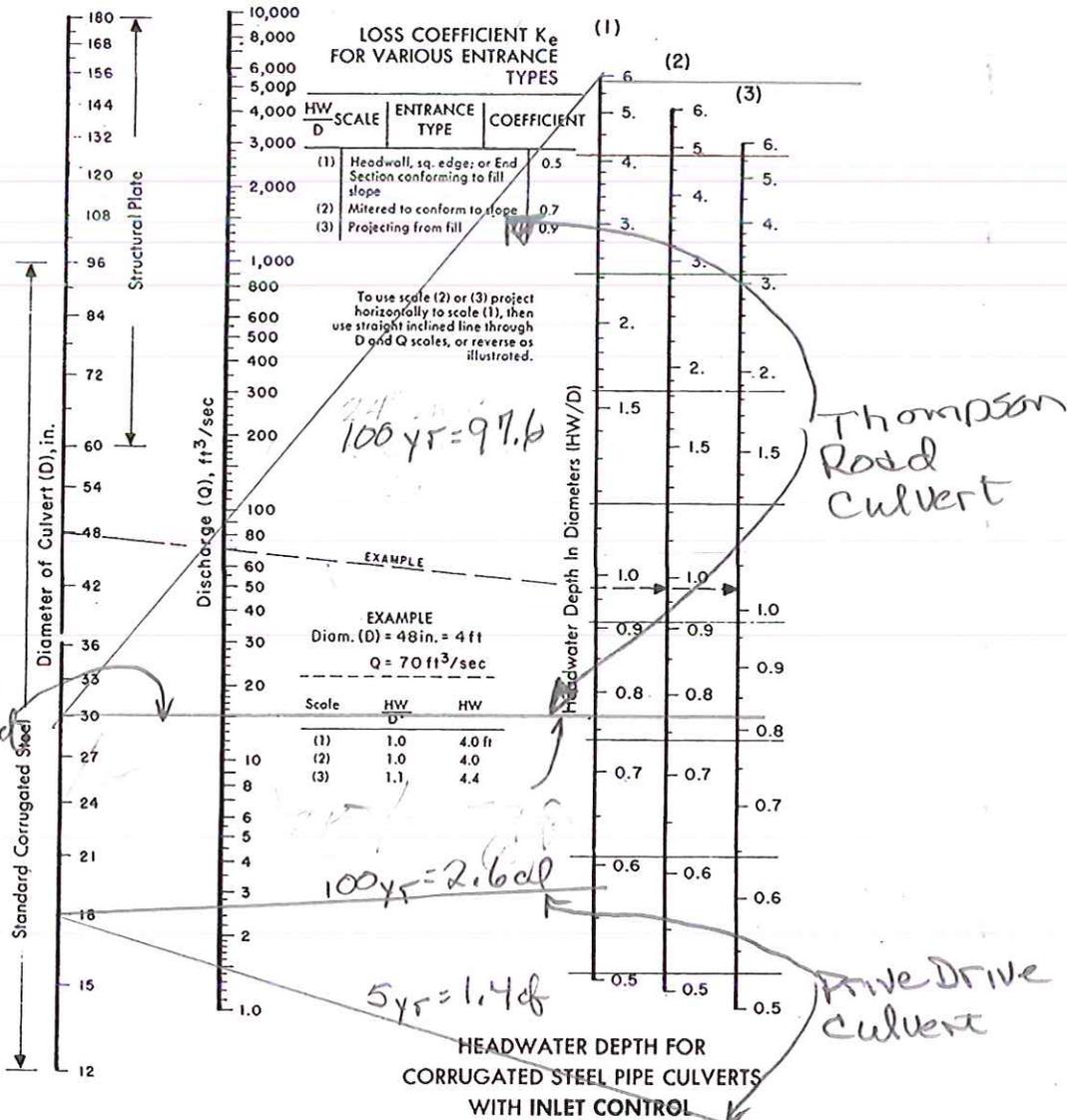
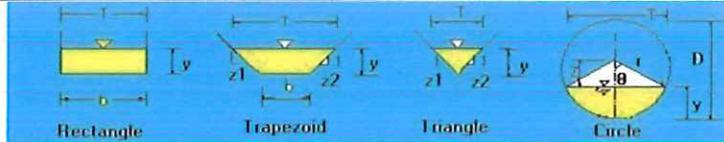


Figure 3.28 Inlet control nomograph for corrugated steel pipe culverts.<sup>13</sup> The manufacturers recommend keeping  $HW/D$  to a maximum of 1.5 and preferably to no more than 1.0 for diameters greater than 4 to 5 feet.

CSII  
5 year  
swale

The open channel flow calculator

Select Channel Type: Trapezoid ▾



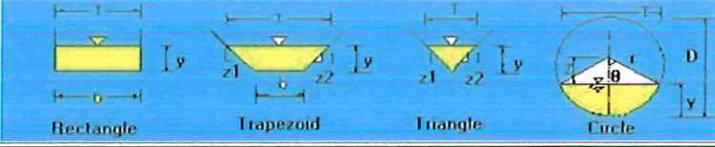
Depth from Q ▾

Select unit system: Feet(ft) ▾

Channel slope: <input type="text" value=".083"/> <input type="text" value="ft/ft"/>	Water depth(y): <input type="text" value="0.35"/> <input type="text" value="ft"/>	Bottom width(b): <input type="text" value="5"/> <input type="text" value="ft"/>
Flow velocity: <input type="text" value="4.819392"/> <input type="text" value="ft/s"/>	LeftSlope (Z1): <input type="text" value="10"/> <input type="text" value="to 1 (H:V)"/>	RightSlope (Z2): <input type="text" value="10."/> <input type="text" value="to 1 (H:V)"/>
Flow discharge: <input type="text" value="14.5"/> <input type="text" value="ft^3/s"/>	Input n value: <input type="text" value=".035"/> <input type="text" value="or select n"/>	
<input type="button" value="Calculate!"/>	Status: <input type="text" value="Calculation finished"/>	<input type="button" value="Reset"/>
Wetted perimeter: <input type="text" value="12.09"/> <input type="text" value="ft"/>	Flow area: <input type="text" value="3.01"/> <input type="text" value="ft^2"/>	Top width(T): <input type="text" value="12.06"/> <input type="text" value="ft"/>
Specific energy: <input type="text" value="0.71"/> <input type="text" value="ft"/>	Froude number: <input type="text" value="1.7"/>	Flow status: <input type="text" value="Supercritical flow"/>
Critical depth: <input type="text" value="0.47"/> <input type="text" value="ft"/>	Critical slope: <input type="text" value="0.026"/> <input type="text" value="ft/ft"/>	Velocity head: <input type="text" value="0.36"/> <input type="text" value="ft"/>

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CS 12  
100 year  
Swale ~~4~~

The open channel flow calculator		
Select Channel Type: <span style="color: red;">Trapezoid</span> ▼		
Depth from Q ▼	Select unit system: <span style="color: red;">Feet(ft)</span> ▼	
Channel slope: <input type="text" value=".083"/> <span style="font-size: small;">ft/ft</span>	Water depth(y): <input style="color: red;" type="text" value="0.87"/> <span style="font-size: small;">ft</span>	Bottom width(b) <input type="text" value="5"/> <span style="font-size: small;">ft</span>
Flow velocity <input type="text" value="7.938"/> <span style="font-size: small;">ft/s</span>	LeftSlope (Z1): <input type="text" value="10"/> to 1 (H:V)	RightSlope (Z2): <input type="text" value="10."/> to 1 (H:V)
Flow discharge <input type="text" value="95"/> <span style="font-size: small;">ft^3/s</span>	Input n value <input type="text" value=".035"/> or select n	
<input type="button" value="Calculate!"/>	Status: <span style="color: red;">Calculation finished</span>	<input type="button" value="Reset"/>
Wetted perimeter <input type="text" value="22.53"/> <span style="font-size: small;">ft</span>	Flow area <input type="text" value="11.97"/> <span style="font-size: small;">ft^2</span>	Top width(T) <input type="text" value="22.44"/> <span style="font-size: small;">ft</span>
Specific energy <input type="text" value="1.85"/> <span style="font-size: small;">ft</span>	Froude number <input type="text" value="1.92"/>	Flow status <span style="border: 1px solid black; padding: 2px;">Supercritical flow</span>
Critical depth <input type="text" value="1.19"/> <span style="font-size: small;">ft</span>	Critical slope <input type="text" value="0.02"/> <span style="font-size: small;">ft/ft</span>	Velocity head <input type="text" value="0.98"/> <span style="font-size: small;">ft</span>

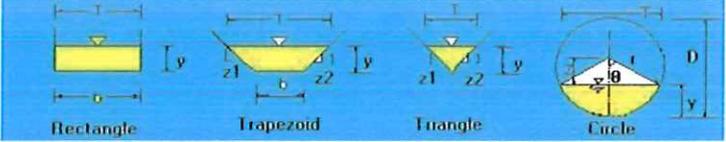
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CS 13  
5 yds  
5000 lb

### The open channel flow calculator

Select Channel Type: Trapezoid ▼

Depth from Q ▼



Channel slope: .055 ft/ft

Flow velocity 2.846931 ft/s

Flow discharge 1.4 ft^3/s

Calculate!

Wetted perimeter 3.21 ft

Specific energy 0.32 ft

Critical depth 0.23 ft

Select unit system: Feet(ft) ▼

Water depth(y): 0.19 ft

Left Slope (Z1): 3 to 1 (H:V)

Input n value .035 or select n

Status: Calculation finished

Flow area 0.49 ft^2

Froude number 1.27

Critical slope 0.0303 ft/ft

Bottom width(b) 2 ft

Right Slope (Z2): 3 to 1 (H:V)

Reset

Top width(T) 3.15 ft

Flow status Supercritical flow

Velocity head 0.13 ft

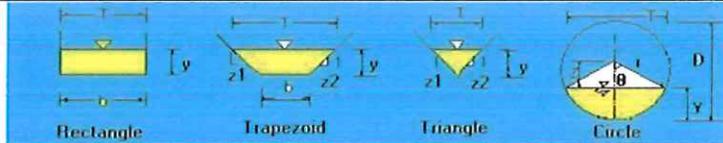
Copyright 2000 Dr. Xing Fang, Department of Civil Engineering, Lamar University.

CS 

100 year Swale

### The open channel flow calculator

Select Channel Type: Trapezoid ▾



Depth from Q ▾

Select unit system: Feet(ft) ▾

Channel slope: <input type="text" value=".055"/> <input type="text" value="ft/ft"/>	Water depth(y): <input type="text" value="0.27"/> <input type="text" value="ft"/>	Bottom width(b): <input type="text" value="2"/> <input type="text" value="ft"/>
Flow velocity: <input type="text" value="3.435106"/> <input type="text" value="ft/s"/>	LeftSlope (Z1): <input type="text" value="3"/> <input type="text" value="to 1 (H:V)"/>	RightSlope (Z2): <input type="text" value="3"/> <input type="text" value="to 1 (H:V)"/>
Flow discharge: <input type="text" value="2.6"/> <input type="text" value="ft^3/s"/>	Input n value: <input type="text" value=".035"/> <input type="text" value="or select n"/>	
<input type="button" value="Calculate!"/>	Status: <input type="text" value="Calculation finished"/>	<input type="button" value="Reset"/>
Wetted perimeter: <input type="text" value="3.7"/> <input type="text" value="ft"/>	Flow area: <input type="text" value="0.76"/> <input type="text" value="ft^2"/>	Top width(T): <input type="text" value="3.62"/> <input type="text" value="ft"/>
Specific energy: <input type="text" value="0.45"/> <input type="text" value="ft"/>	Froude number: <input type="text" value="1.32"/>	Flow status: <input type="text" value="Supercritical flow"/>
Critical depth: <input type="text" value="0.32"/> <input type="text" value="ft"/>	Critical slope: <input type="text" value="0.0293"/> <input type="text" value="ft/ft"/>	Velocity head: <input type="text" value="0.18"/> <input type="text" value="ft"/>

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**Exhibit 8: State of Colorado Water Tank Jurisdiction**

*Thompson*

RECEIPT NO. *5369* 1-8

*5369*

**STATE OF COLORADO**  
**DEPARTMENT OF WATER RESOURCES**  
**Office of State Engineer**

**Standard Plans, Drawings**  
**and**  
**SPECIFICATIONS**  
**Including**  
**RULES AND REGULATIONS**  
**Pertaining to**  
**THE FILING OF APPLICATIONS**  
**for**  
**THE APPROVAL**  
**of**  
**LIVESTOCK WATER TANKS**



**PURSUANT TO H.B. No. 750**  
**SESSION LAWS OF 1941**  
**DENVER, COLORADO, MAY 1, 1941**

1D-WK  
1-5  
60 21

# APPLICATION FOR APPROVAL OF LIVESTOCK WATER TANK

This application and Statement is made in conformity with provisions of the Livestock Water Tank Act of Colorado. 5369

This application must be accompanied by a filing fee of one dollar, payable to the State Engineer of Colorado.

Name of Owner Wilber Thompson P. O. Address Motor Rte #3 - Colo. Spgs., Colo.  
Location of Tank SW 1/4 Section 19, Township 11 SD, Range 65 W 6th P.M.  
Name of water course on which tank is located Trib. to East Cherry Creek  
Is water course normally dry Yes  
Approximate area of drainage basin above tank 80 acres.  
Nature of vegetative cover over drainage basin above tank Grass

Character of topography of drainage basin (steep, medium or flat) Medium

Character of surface formation of drainage basin (rock, rocky soil, or soil) Soil

Approximate elevation of drainage basin above sea level 7480 feet.

Is water course subject to floods at times No

Height of top of dam above bottom of water course 9.5 feet.

Height of bottom of spillway above bottom of water course 5.5 feet.

Approximate capacity of tank 2.2 0.22 acre feet.

Location of spillway with respect to dam Around Right side facing downstream

Bottom width of spillway at narrowest point 25 feet.

Distance of lower end of spillway below dam 75 feet.

Kind of formations in which spillway is located (rock, shale, clay, earth or mixture of soil and rock) Earth

Width of top of dam 8.0 feet.

Length of top of dam 202 feet.

Slope of upstream face of dam 3:1

Slope of downstream face of dam 2:1

Nature of riprap or other protection to be placed over water face of dam

Is the reservoir to be provided with an outlet pipe No  
If so, give kind and size of pipe

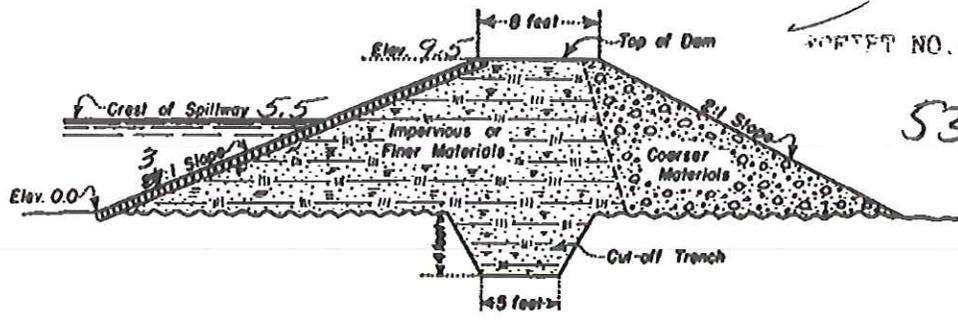
Give location by section, township and range, and size of every other stock tank now constructed in drainage basin in which this tank will be located

NOTE—Remainder of statements to be furnished by State Engineer's office, DEC 6 '57  
Date of receipt of application by State Engineer \_\_\_\_\_, 19\_\_\_\_  
Date of notice from applicant of completion of tank \_\_\_\_\_, 19\_\_\_\_  
Tank or site inspected by \_\_\_\_\_, 19\_\_\_\_  
Recommendation of Inspector \_\_\_\_\_  
Date of return of plans and specifications to applicant for correction or revision \_\_\_\_\_

Reasons therefor

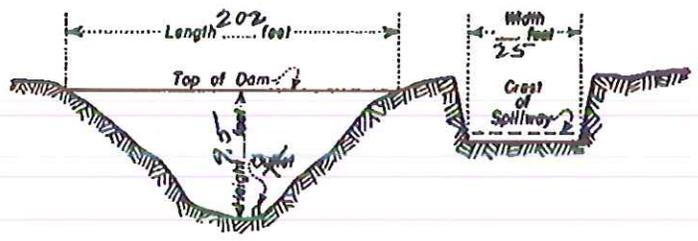
Filing Fee Paid \_\_\_\_\_, DEC 6 '57, 19\_\_\_\_  
Application approved this 16 day of December, 1957  
Number assigned this stock tank is \_\_\_\_\_

By J. B. Whittier  
State Engineer  
J. C. Agnew  
Deputy



MAXIMUM CROSS-SECTION OF DAM

PROJECT NO. 5369  
5369



CROSS-SECTION OF DAM SITE AND SPILLWAY  
Show length and height of dam and width of spillway on drawing

STATEMENT BY OWNER

Know all men by these presents: That the undersigned MILLEN T. THOMPSON whose postoffice address is Box 3, Colo. Spgs. Co., Colo. has caused to be located this Stock Water Tank, the essential features of which are shown by this map and plans, which together with the accompanying application and statements are hereby filed with the State Engineer pursuant to the provisions of law.

First: Height of dam above bottom of water-course is 9.15 feet.

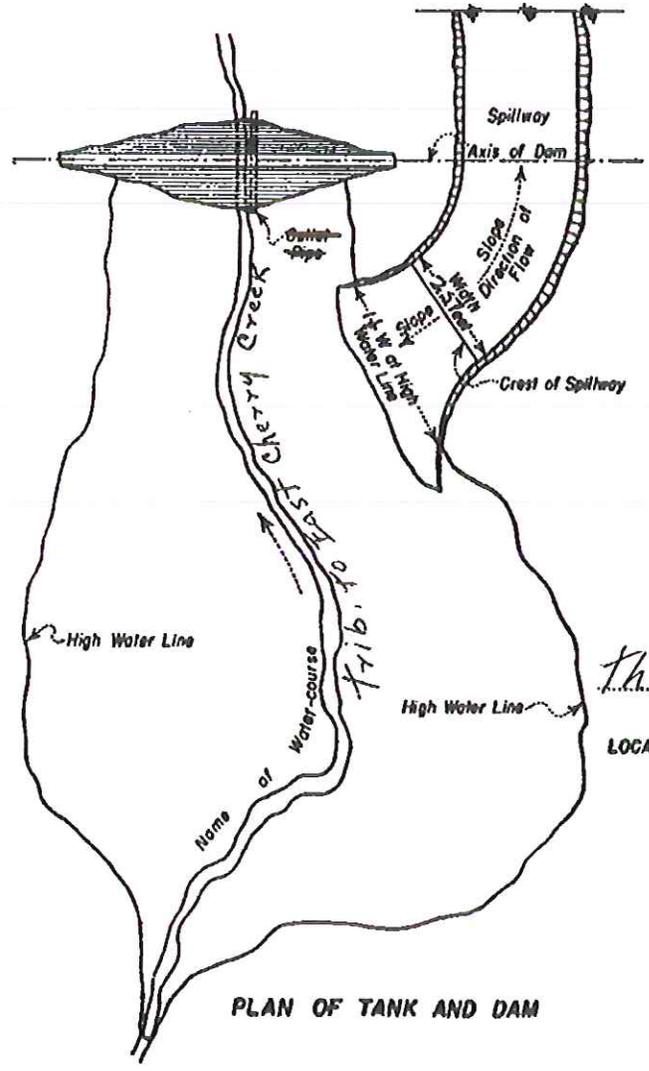
Second: Height of spillway above bottom of water-course is 5.55 feet.

Third: Total capacity of said Stock Water Tank is 222 acre feet.

Fourth: The source of supply for said Stock Water Tank is (name of stream) Trib. of East Cherry Creek

Fifth: Filing of this map and accompanying statements with the State Engineer was made on the 13 day of Dec., 1917

Milben Thompson  
Owner



PLAN OF TANK AND DAM

MAP AND PLANS

FOR

THOMPSON STOCK WATER TANK AND DAM

LOCATED IN SECTION 19 TWP. 11S RANGE 65 OF 6 PM.

El Paso COUNTY

DRAINAGE AREA ABOVE DAM 80 ACRES

Approved this 16<sup>th</sup> day of December, 1917

J. B. Whitham  
State Engineer  
G. B. Appenich  
Deputy

5369

**STATE OF COLORADO  
DEPARTMENT OF WATER RESOURCES  
OFFICE OF STATE ENGINEER**

**SPECIFICATIONS TO GOVERN THE CONSTRUCTION OF A LIVESTOCK WATER TANK  
IN COLORADO CONSTRUCTED AFTER APRIL 17, 1941**

The following specifications and attached general plans shall be followed in the construction of stock water tank No. \_\_\_\_\_, located in Sec. 19, Township 11 S, Range 65 W 6<sup>TH</sup> R.M., for which the undersigned on Dec. 13, 1957 filed an application with the State Engineer, as required by law.

**Preparation of Foundation for Dam**—All vegetable matter of every description, including roots to a depth of two feet, shall be removed from the entire area upon which the dam will rest, following which the top six-inch layer of soil, together with boggy or unstable materials shall be removed and deposited outside the toes of the dam. The banks of the stream channel shall be dressed to a slope of about 1½:1. A bonding trench, with sloping sides and a bottom width of not less than 5 feet and depth of 4 feet, shall then be excavated beneath the center line of the dam the full length thereof, which trench shall be refilled with the most impervious materials available. The foundation of the dam shall then be lightly plowed lengthwise of the dam, to provide proper contact between the foundation and the dam embankment.

**Placing of Dam Embankment**—The materials shall be placed in the bonding trench and in the embankment of the dam in layers not exceeding 6 inches in thickness, after which each layer shall be thoroughly compacted by a heavily loaded disc cultivator, a corrugated or sheep's foot roller, the treads of a caterpillar or trucks, or by livestock used in the construction. During the construction period, the top of the embankment shall be maintained as a horizontal plane the full width and length thereof, and no side dumping of materials shall be permitted. The materials shall at all times contain just sufficient moisture to provide proper compaction. Puddling of material with water shall not be permitted. No frozen material or large clods or stones shall be incorporated in the dam. The upstream face of the dam shall be constructed with a slope not steeper than 2½:1, and the downstream face on a slope not steeper than 2:1. The crest or top of the finished dam shall be not less than 8 feet in width.

The upstream two-thirds of the dam shall be constructed of the most impervious materials, such as clay loam, or a mixture of clay and sand, and the downstream one third of more pervious material, such as sand or gravel. The upstream face of the dam shall be adequately protected against wave action by stone riprap, or other suitable materials.

**Outlet**—Should the state engineer so require, there shall be located beneath the dam a galvanized, corrugated steel pipe of No. 14 gauge and not less than 8 inches in diameter, equipped with a suitable control valve attached to the upstream end of the pipe, together with suitable mechanism for operating the valve. Such outlet pipe, when required, shall be provided with concrete collars enclosing each joint of the pipe. The pipe shall be placed in a trench bottomed in stable formations, and shall be completely surrounded with well compacted impervious materials.

**Spillway**—For the protection of the dam, an adequate spillway or channel shall be constructed around one or both ends of the dam, of sufficient width to provide a capacity to carry the entire discharge from the drainage basin above the dam during periods of unusual runoff. The spillway shall be located in stable formations not easily eroded, and shall extend to a point well downstream from the dam. The following table shall be used to determine the necessary depth and width of spillway to meet the above requirements. The top of the dam at all points shall be not less than 4 feet above the bottom of the spillway.

Table Showing Required Freeboard, Widths and slopes of Spillways for small Earth Dams, with Drainage Areas above the Same as Shown, Based upon a maximum Peak Runoff of 640 Second Feet per Square Mile, or 1 Second Foot per Acre, with an Allowance of a Minimum Freeboard between the Maximum High Water Line and Top of Dam, of 2.3 Feet, and Maximum Velocities of 3.5 Feet per Second of Time.

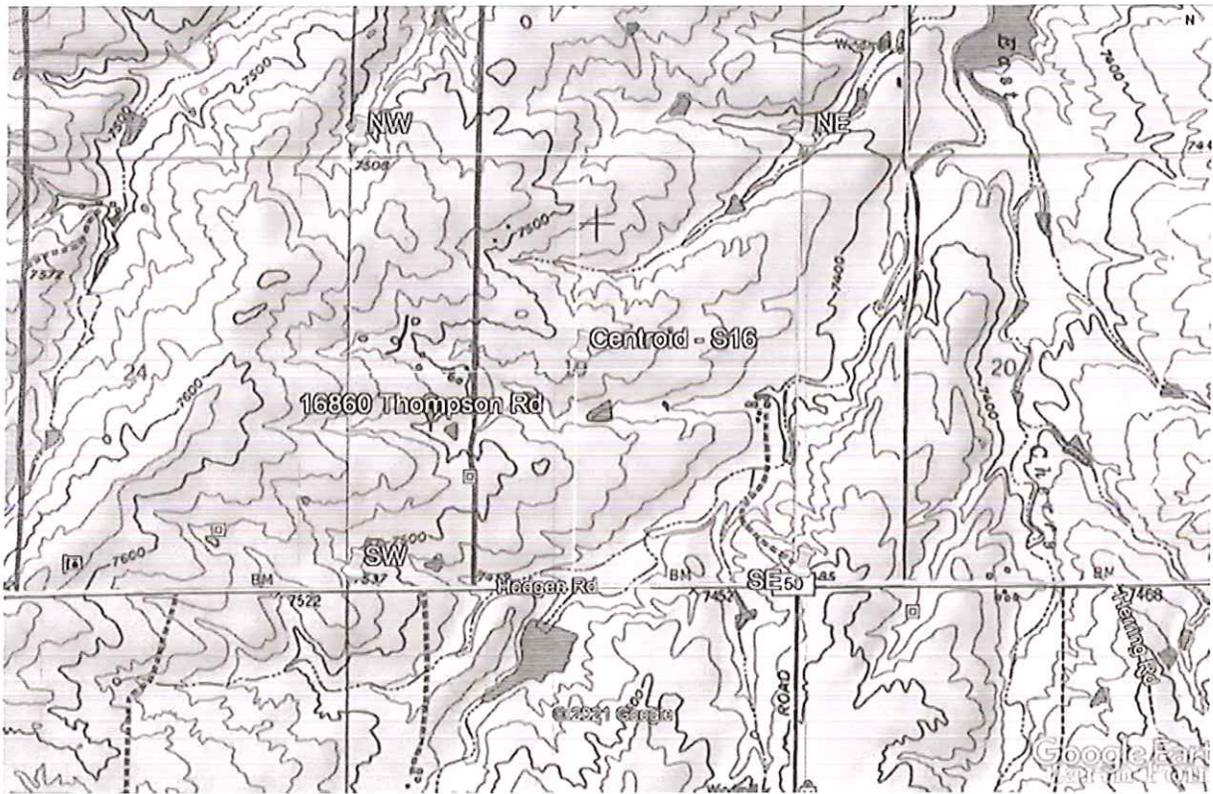
AREA OF DRAINAGE BASIN ABOVE DAM IN ACRES	PEAK RUNOFF IN CU. FT. PER SECOND	ASSUMED VELOCITY THROUGH SPILLWAY IN FEET PER SECOND	REQUIRED WIDTH OF SPILLWAY "W" AT NARROWEST POINT IN FEET	DEPTH OF WATER IN SPILLWAY IN FEET	SLOPE OF SPILLWAY IN FEET PER 100 FEET OF LENGTH
100	100	3.0	32	1.5	0.25
200	200	3.0	44	1.5	0.25
300	300	3.0	56	1.5	0.25
400	400	3.0	68	1.5	0.25
500	500	3.0	80	1.5	0.25
600	600	3.0	92	1.5	0.25
700	700	3.0	104	1.5	0.25
800	800	3.0	116	1.5	0.25
900	900	3.0	128	1.5	0.25
1000	1000	3.0	140	1.5	0.25
1100	1100	3.0	152	1.5	0.25
1200	1200	3.2	164	1.7	0.25
1300	1300	3.3	176	1.7	0.25
1400	1400	3.4	188	1.7	0.25
1500	1500	3.4	200	1.7	0.25
1600	1600	3.5	212	1.7	0.25
1700	1700	3.5	224	1.7	0.25
1800	1800	3.5	236	1.7	0.25
1900	1900	3.5	248	1.7	0.25
2000	2000	3.5	260	1.7	0.25

The above spillway widths may be reduced at a point 50 feet below intake, by 25 per cent, where the spillway is located the full length thereof in hard clay or shale, and by 50 per cent when located in hard rock formations, if the slope or grade of the bottom is increased accordingly. The grade for clay and shale formations should be 0.30 foot per 100 feet, and for rock formations 0.9 foot per 100 feet. The width of the entrance to the spillway must in all cases be one-third wider than shown in the Table, and the bottom should slope from the lower end of the funnel section, toward the reservoir 1.0 foot in the distance of 50 feet.

**Borrow Pits**—Borrow pits, from which materials are taken to build the dam, shall be cleared of all vegetable matter, and no material shall be borrowed within a distance of 50 feet of any part of the dam. Materials excavated from the spillway, when suitable, are to be used in building the dam.

Date Dec. 13, 1957

Wilbur C. Thompson ✓  
Owner  
Colorado Springs #13 Colo.  
Post Office Address



**Livestock Water Tank / Erosion Control Dam Report**

Receipt	Application Type	Application Status	Title	Title No.	Applicant Name	DIV	WD	County	Location				Tributary	
									Q160 Sec	TS	Range	PM		
5369	LIVESTOCK WATER TANK				THOMPSON	1	8	EL PASO	NW	19	11 S	65 W	S	
3084	LIVESTOCK WATER TANK		THOMPSON		THOMPSON	1	8	EL PASO	NW	19	11 S	65 W	S	

Receipt No.   WDD  County:

Application Date  Application Status  Division  WD:

Completion Date

Application for:  Title No.

Title

Applicant Name:

2nd Applicant Name:

Company Name:

Address:

City/ST/Zip:

Location: Q40 Q160 Section: Township: Range: Principal Meridian:

UTM Coordinates (NAD 83): Northing (utm\_y):  Easting (utm\_x):

**Tank Dimensions:**  
 Height of top of dam:  feet. *Dam Vertical Height + Spillway Freeboard*  
 Vertical height:  feet.

**Reservoir:**  
 Stream or Water Source:   
 Surface Area:  acres.  
 Capacity:  acre feet.  
 Drainage Area:  acres.

**Emergency Spillway:**  
 Bottom width:  feet.

**Outlet Conduit:**  
 Material Type:   
 Diameter:  inches.

Comments   Last modified on  by

Receipt No.   WDD  County:

Application Date  Application Status  Division  WD:

Completion Date

Application for:  Title No.

Title

Applicant Name:

2nd Applicant Name:

Company Name:

Address:

City/ST/Zip:

Location: Q40 Q160 Section: Township: Range: Principal Meridian:

UTM Coordinates (NAD 83): Northing (utm\_y):  Easting (utm\_x):

**Tank Dimensions:**  
 Height of top of dam:  feet. *Dam Vertical Height + Spillway Freeboard*  
 Vertical height:  feet.

**Reservoir:**  
 Stream or Water Source:   
 Surface Area:  acres.  
 Capacity:  acre feet.  
 Drainage Area:  acres.

**Emergency Spillway:**  
 Bottom width:  feet.

**Outlet Conduit:**  
 Material Type:   
 Diameter:  inches.

Comments   Last modified on  by

## Completion of Construction

RECEIPT NO. 7224

Upon the completion of the construction of the  
W. THOMPSON Live Stock Water Tank, located  
in Sec. 13 Twp. 11 So Rng. 65 W. 65 E the  
approved Plans and Specifications of which are hereto attached, indicate  
in the blank at the bottom of this form, the date of completion of con-  
struction and return to—

THE STATE ENGINEER, CAPITOL BLDG., DENVER, COLO-  
RADO, so that he may, if he desires, inspect said tank.

Date of completion 6<sup>th</sup> August 1947  
DAY MONTH YEAR

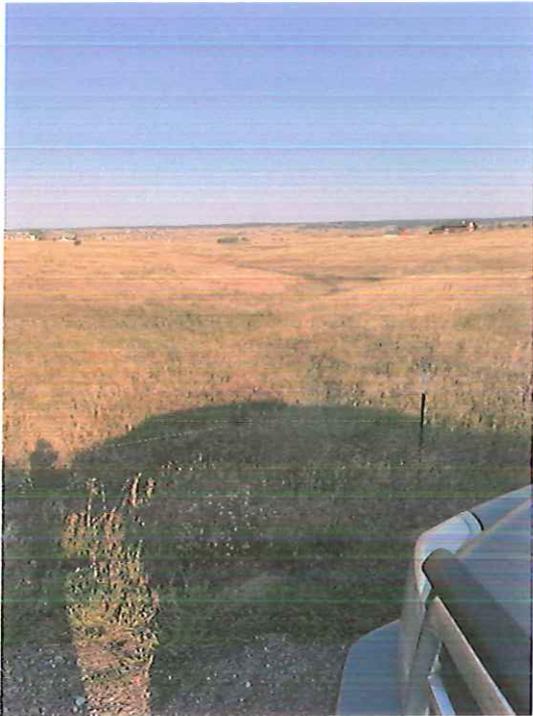
### Section - BLM database

<b>Section</b>	S19 T11S R65W
<b>Meridian</b>	Sixth
<b>State</b>	Colorado
<b>Source</b>	<u>BLM</u>
<b>GLO</b>	<u>GLO Township Records</u>

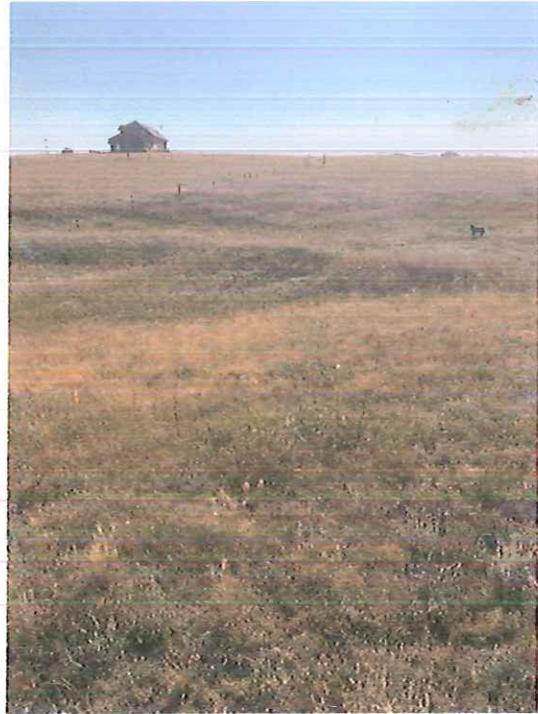
#### Calculated Values

<b>Acres</b>	670
<b>Centroid</b>	39.0783479, -104.7098090
<b>Corners</b>	NW 39.0855777, -104.7195110
	NE 39.0856382, -104.7000033
	SE 39.0711175, -104.7001627
	SW 39.0710445, -104.7195517

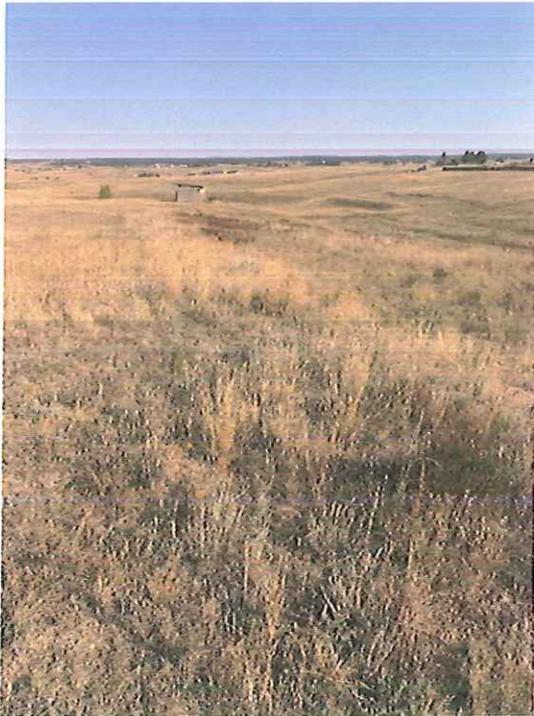
## Exhibit 9: Existing Swale Photographs



*Figure 1: facing east along central swale (S1, S2)*



*Figure 3: Facing NW from east side of property*



*Figure 2: Facing east along central swale*



*Figure 4: top of Stock Pond Embankment facing south*

**Exhibit 10: Historic Drainage Conditions (map pocket)**

DESIGN POINT SUMMARY

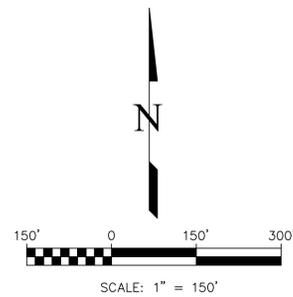
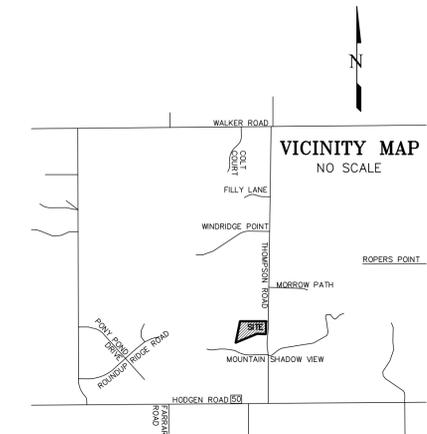
DESIGN POINT	CONTRIB SUB BASINS	AREA (ACRES)	Tc (CFS)	C5 (CFS)	C100 (CFS)	CA5 (CFS)	CA100 (CFS)	Q5 (CFS)	Q100 (CFS)
1	OS1	34.1	23.2	0.09	0.36			8.7	58.5
2	OS3	0.6	15	0.08	0.35			0.2	1.2
3	OS4	0.6	13.3	0.17	0.41			0.4	1.5
4	OS7	3.6	15.5	0.12	0.38			1.5	8.0
5	OS1,OS3,OS4,OS5,OS7,A	45.6	27			4.16	16.31	11.0	72.2
6	DP5,OS6,B,OS2	60.3	28.4			5.47	21.28	14.0	91.5
7	DP6,C,OS8	62.5	29			5.71	22.37	14.5	95.0
8	OS5	0.4	10.9	0.08	0.35			0.1	0.9
9	OS6	0.9	15.2	0.08	0.35			0.3	1.9
10	OS2	10.3	17.9	0.10	0.36			3.3	20.5
11	OS8	1.4	14.1	0.08	0.35			0.4	3.0
12	OS10	0.5	5.3	0.57	0.72			1.5	3.1
13	OS9	0.4	6.1	0.70	0.81			1.4	2.6
14	DP7,OS9,OS10	61.5	29			6.28	23.05	15.9	97.9
	Lot 1 located in sub basin B	5.5	12.9	0.08	0.35			1.8	13.3
	Lot 2 located in sub basin A	5.0	14.8	0.08	0.35			1.2	8.9

SWALE SUMMARY

SWALE #	DESIGN POINTS	CONTRIBUTING SUBBASINS	SLOPE %	DESIGN FLOW		DEPTH OF FLOW		VELOCITY		FROUDE NUMBER (5 YEAR)	FLOW REGIM e
				Q5 cfs	Q100 cfs	Q5 ft	Q100 ft	Q5 fps	Q100 fps		
1	1	OS1	4.7	8.7	58.5	0.3	0.7	2.9	4.8	1.21	SUPER
2	1 TO 5	OS1,OS3, OS4,A,OS7	5.5	11	72.2	0.3	0.7	3.4	5.5	1.32	SUPER
3	5 TO 6	DP5,B,OS2	8.3	14	91.7	0.3	0.8	4.4	7.2	1.66	SUPER
4	6 TO 7	DP10,C,OS8	8.3	14.5	95	0.4	0.9	4.8	7.9	1.7	SUPER
5	12	OS10	5.0	1.5	3.1	0.2	0.3	2.8	3.5	1.2	SUPER
6	13	OS9	5.5	1.4	2.6	0.2	0.3	2.8	3.4	1.27	SUPER

STORMWATER RUNOFF SUMMARY  
EXISTING CONDITIONS  
(NEGLECTIBLE CHANGES FOR DEVELOPED CONDITIONS)

DP	CONTRIBUTING SUB BASINS	AREA	Tc	C5	C100	CA5	CA100	Q5	Q100
14	DP7,OS9,OS10	63.4	29			6.28	23.05	15.9	97.9
	Lot 1 (sub basin B)	5.5	12.9	0.08	0.35			1.8	13.3
	Lot 2 (sub basin A)	5.0	14.8	0.08	0.35			1.2	8.9



LEGEND:

- XXX-- INDEX CONTOURS
- - - - - INTERMEDIATE CONTOURS
- - - - - SUBDIVISION BOUNDARY
- - - - - SUBBASIN BOUNDARY
- ← DIRECTION OF FLOW
- - - - - EXISTING SWALE CENTERLINE
- △ DESIGN POINT
- SWALE NUMBER
- SUBBASIN I.D.
- DRAINAGE STRUCTURE NUMBER
- STRX DRAINAGE STRUCTURE
- EXISTING BUILDING
- NO BUILD AREA BOUNDARY
- EXISTING STOCK POND

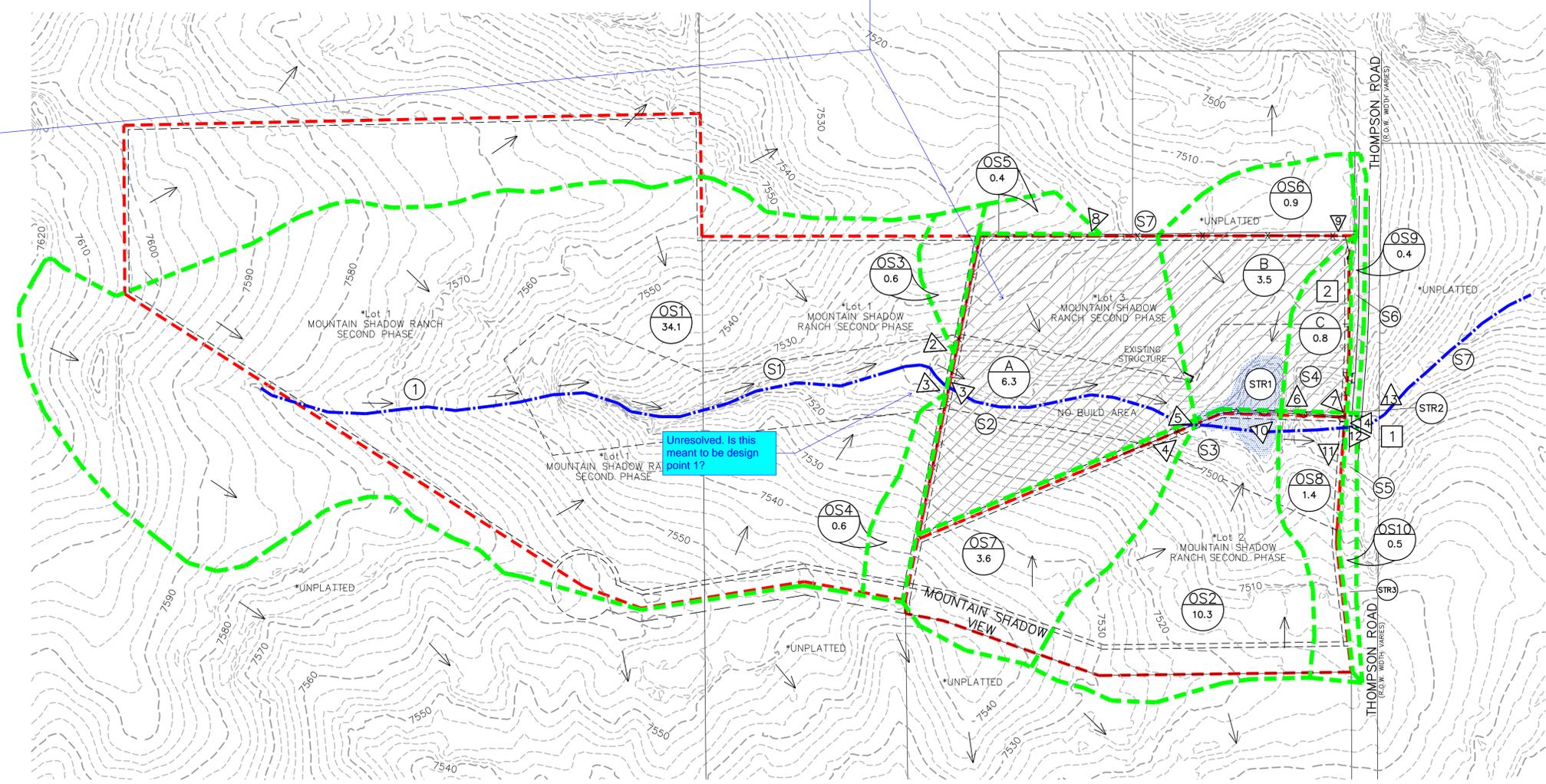
CUMMULATIVE ACREAGE AT DESIGN POINTS

SUB BASIN ID	SUB BASIN AREA	SUB TOTAL
DP1		
OS1	34.1	34.1
DP5		
OS1	34.1	
OS3	0.6	
OS4	0.6	
OS5	0.4	
A	6.3	
OS7	3.6	45.6
DP6		
DP5	45.6	
OS6	0.9	
B	3.5	
OS2	10.3	60.3
DP7		
DP6	60.3	
C	0.8	
OS8	1.4	62.5
DP14		
DP7	62.5	
OS9	0.4	
OS10	0.5	63.4

Unresolved. Design point 3 should show cumulative flows from OS1, OS3, and OS4.

Unresolved. Hatching is labeled as no build but is covering entire site. Update both drainage maps.

Unresolved. Is this meant to be design point 1?



According to Colorado law, legal action based upon any defect in this survey first discovered after you in no event, may any action based upon any defect in this survey more than ten years from the date of the certification shown herein.

**811** DIAL 811  
48 HOURS BEFORE YOU DIG. CALL UTILITY LOCATORS FOR LOCATING AND MARKING GAS, ELECTRIC, WATER AND WASTEWATER.

REVISIONS

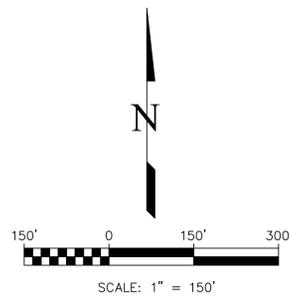
No.	Description	By	Date
1	COUNTY COMMENTS	BRH	04/09/21

H Scale: 1" = 150'	V Scale: N/A	Designed By: KH	TLC
		Drawn By: KH	KH
		Checked By: KH	
		Date: 11/12/2020	

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**MCGEHEE SUBDIVISION**  
DRAINAGE PLAN  
EXISTING CONDITIONS

**Exhibit 11:      Developed Drainage Conditions (map pocket)**



**LEGEND:**

- XXX-- INDEX CONTOURS
- XXX-- INTERMEDIATE CONTOURS
- - - - - SUBDIVISION BOUNDARY
- - - - - SUBBASIN BOUNDARY
- ← DIRECTION OF FLOW
- - - - - EXISTING SWALE CENTERLINE
- △ DESIGN POINT
- ⊗ SWALE NUMBER
- ⊗ SUBBASIN I.D.
- ⊗ DRAINAGE STRUCTURE NUMBER
- ⊗ DRAINAGE STRUCTURE
- █ EXISTING BUILDING
- ▨ NO BUILD AREA BOUNDARY
- EXISTING STOCK POND

**CUMMULATIVE ACREAGE AT DESIGN POINTS**

SUB BASIN ID	SUB BASIN AREA	SUB TOTAL
DP1		
OS1	34.1	34.1
DP5		
OS1	34.1	34.1
OS3	0.6	
OS4	0.6	
OS5	0.4	
A	6.3	
OS7	3.6	45.6
DP6		
DP5	45.6	
OS6	0.9	
B	3.5	
OS2	10.3	60.3
DP7		
DP6	60.3	
C	0.8	
OS8	1.4	62.5
DP14		
DP7	62.5	
OS9	0.4	
OS10	0.5	63.4

**DESIGN POINT SUMMARY**

DESIGN POINT	CONTRIB SUB BASINS	AREA (ACRES)	Tc	C5	C100	CA5	CA100	Q5	Q100
			(CFS)						
1	OS1	34.1	23.2	0.09	0.36			8.7	58.5
2	OS3	0.6	15	0.08	0.35			0.2	1.2
3	OS4	0.6	13.5	0.17	0.41			0.3	1.3
4	OS7	3.6	15.5	0.12	0.38			1.5	8.0
5	OS1,OS3,OS4,OS5,OS7,A	45.6	27			4.28	16.39	11.3	72.6
6	DP5,OS6,B,OS2	60.3	28.4			5.66	21.42	14.5	92.1
7	DP6,C,OS8	62.5	29			5.71	22.37	14.5	95.0
8	OS5	0.4	10.9	0.08	0.35			0.1	0.9
9	OS6	0.9	15.2	0.08	0.35			0.3	1.9
10	OS2	10.3	17.9	0.10	0.36			3.3	20.5
11	OS8	1.4	14.1	0.08	0.35			0.4	3.0
12	OS10	0.5	5.3	0.57	0.72			1.5	3.1
13	OS9	0.4	6.1	0.70	0.81			1.4	2.6
14	DP7,OS9,OS10	63.4	29			6.47	23.18	16.4	98.5
	Lot 1 located in sub basin B	5.5	12.9	0.11	0.37			1.7	9.4
	Lot 2 located in sub basin A	5.0	14.8	0.08	0.35			2.5	14.1

**SWALE SUMMARY**

SWALE #	DESIGN POINTS	CONTRIBUTING SUBBASINS	SLOPE %	DESIGN FLOW		DEPTH OF FLOW		VELOCITY		FROUDE NUMBER (5 YEAR)	FLOW REGIME
				Q5 cfs	Q100 cfs	Q5 ft	Q100 ft	Q5 fps	Q100 fps		
1	1	OS1	4.7	8.7	58.5	0.3	0.7	2.9	4.8	1.21	SUPER
2	1 TO 5	OS1,OS3,OS4,A,OS7	5.5	11	72.2	0.3	0.7	3.4	5.5	1.32	SUPER
3	5 TO 6	DP5,B,OS2	8.3	14	91.7	0.3	0.8	4.4	7.2	1.66	SUPER
4	6 TO 7	DP10,C,OS8	8.3	14.5	95	0.4	0.9	4.8	7.9	1.7	SUPER
5	12	OS10	5.0	1.5	3.1	0.2	0.3	2.8	3.5	1.2	SUPER
6	13	OS9	5.5	1.4	2.6	0.2	0.3	2.8	3.4	1.27	SUPER

Review 1 Comment: Revise to be in S1, S2... format for clarity (so it matches map below)

**STORMWATER RUNOFF SUMMARY EXISTING CONDITIONS**

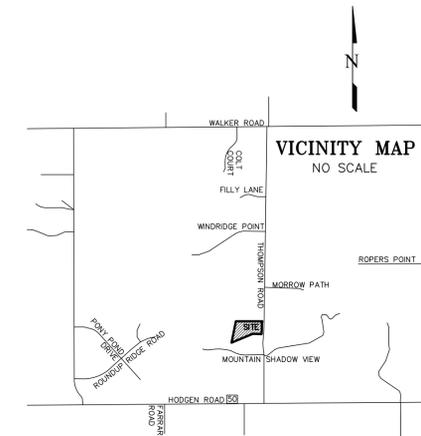
DP	CONTRIBUTING SUB BASINS	AREA	Tc	C5	C100	CA5	CA100	Q5	Q100
14	DP7,OS9,OS10	63.4	29			6.28	23.05	15.9	97.9
	Lot 1 (sub basin B)	5.5	12.9	0.08	0.35			1.8	13.3
	Lot 2 (sub basin A)	5.0	14.8	0.08	0.35			1.2	8.9

**DEVELOPED CONDITIONS**

DP	CONTRIBUTING SUB BASINS	AREA	Tc	C5	C100	CA5	CA100	Q5	Q100
14	DP7,OS9,OS10	63.4	29			6.47	23.18	16.4	98.5
	Lot 1 (sub basin B)	5.5	12.9	0.11	0.37			2.5	14.1
	Lot 2 (sub basin A)	5.0	14.8	0.11	0.37			1.7	9.4

**NOTES:**

- DESIGN POINT 14 IS LOCATED AT THE UPSTREAM END OF THE CULVERT UNDER THOMPSON ROAD.
- THE MAJORITY OF LOT 2 IS LOCATED IN BASIN A.
- THE MAJORITY OF LOT 1 IS LOCATED IN BASIN B.
- ALL OF THE OFFSITE SUB BASINS ARE UNCHANGED FROM EXSITING CONDITIONS.
- CA VALUES ARE USED IN ORDER TO ACCURATELY REFLECT CONTROLLING Tc.



According to Colorado law, any legal action based upon any defect in this survey within five years after you first discover the defect, or in no event, any action based upon any defect in this survey more than ten years from the date of the certification shown hereon.

**811** DIAL 811

48 HOURS BEFORE YOU DIG. CALL UTILITY LOCATORS FOR LOCATING AND MARKING GAS, ELECTRIC, WATER AND WASTEWATER.

**REVISIONS**

No.	Description	By	Date
1	COUNTY COMMENTS	BRH	04/09/21

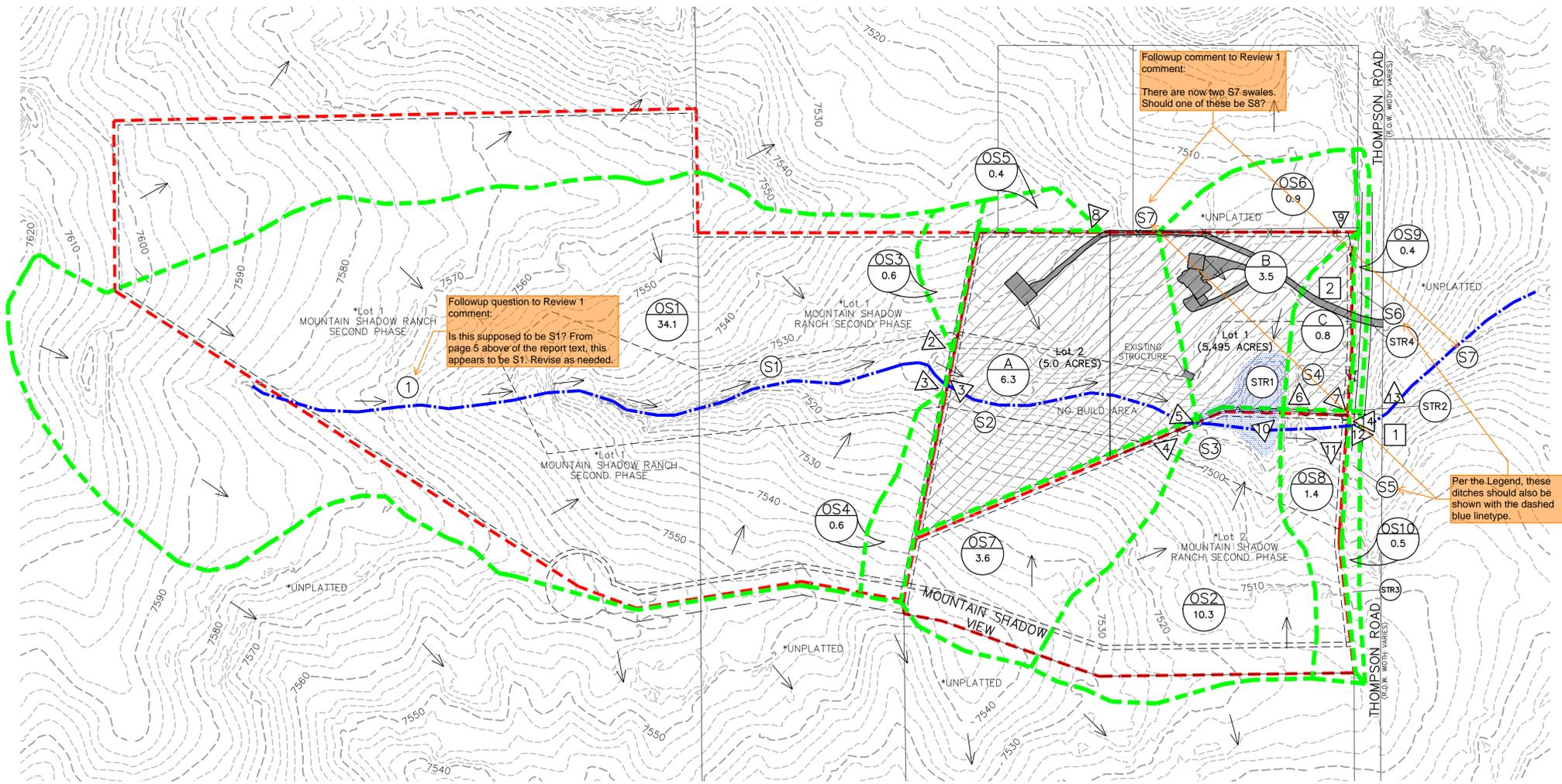
H Scale:	1" = 150'	N/A	KH	TLC	KH
V Scale:	N/A		Designed By:	Drawn By:	Checked By:
Date:	11/12/2020				

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**MCGEHEE SUBDIVISION DRAINAGE PLAN DEVELOPED CONDITIONS**

# KCH Engineering Solutions, LLC

April 9, 2021

Ms. Lupe Packman  
El Paso County  
Planning and Community Development  
2880 International Circle, Suite 110  
Colorado Springs, Colorado 80910

Re: McGehee tract PCD No. SF 2011

Dear Lupe;

The following is a summary of the items that were addressed based on the "redline" comments that were received from El Paso County in April, 2021.

## **Cover Sheet**

- The PCD No was added.
- The work "Preliminary" was removed from the title.

## **Sheet 2**

- The page numbers for each section was added

## **Sheet 3**

- El Paso County Signature Section was revised as required

## **Sheet 4**

- Correspondence with the State Engineers Office regarding the jurisdiction of the large stock pond is included in Exhibit 9 of the Appendix.

## **Sheet 7**

- According to the State Engineer the owner of the land is typically the owner of the stock ponds

## **Sheet 12**

- The typo of S5 was changed to S4

## **Sheet 16**

- A discussion was added to described the differences between subcritical and supercritical flow regimes. Included were possible reasons why the program that was used for this report was limited in its description of the identification of the two regimes. A significant amount of additional work, both survey and engineering, would be required in or to arrive at a more accurate assessment of the flow regime for each section of the existing swale. It was decided to not

## *KCH Engineering Solutions, LLC*

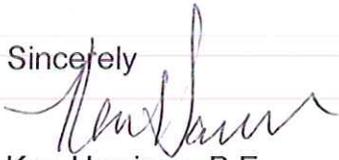
spend the extra time since the existing conditions are very stable and the increase in flow as a result of development is negligible.

### **Sheet 21**

- Additional narrative was added to the 'Four Step Process' section. Criteria from the El Paso County ECM was added for clarification.
- An estimate of disturbed area was also determined

If you have any more questions or need additional information please contact at the contact information included at the bottom of this sheet.

Sincerely



Ken Harrison, P.E.  
KCH Engineering Solutions, LLC

Cc: