INNOVATIVE DESIGN. **CLASSIC RESULTS.**

Engineering Review

07/06/2021 8:29:48 PM
dsdrice
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EPC Planning & Community Development Department

See comment letter also

PCD-ENGINEERING REVIEW COMMENTS IN BLUE BOXES WITH BLUE TEXT

FINAL DRAINAGE REPORT FOR RETREAT AT TIMBERRIDGE FILING NO. 2

Prepared for:
TIMBERRIDGE DEVELOPMENT GROUP, LLC
2138 FLYING HORSE CLUB DRIVE
COLORADO SPRINGS CO 80921
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Prepared by:
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Job No. 1185.20

PCD Project No. SF-21-XXX

FINAL DRAINAGE REPORT FOR

RETREAT AT TIMBERRIDGE FILING NO. 2

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 has been prepared according to the criteria established by the County for drainage reports and said report is in conformity with the applicable master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors, or omissions on my part in preparing this report.

____ ____________________

Marc A. Whorton Colorado P.E. #37155 Date

OWNER'S/DEVELOPER'S STATEMENT:

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

Business Name: TIMBERRIDGE DEVELOPMENT GROUP, LLC

By: ____________________________________

Title: ____________________________________

Address: 2138 Flying Horse Club Drive

Colorado Springs, CO 80921

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 County Engineer, / ECM Administrator Date

Conditions:

FINAL DRAINAGE REPORT FOR
RETREAT AT TIMBERRIDGE FILING NO. 2

TABLE OF CONTENTS:

APPENDICES

PURPOSE

The purpose of this Final Drainage Report is to address on-site and off-site drainage patterns and identify specific drainage improvements and facilities required to minimize impacts to the adjacent properties.

GENERAL DESCRIPTION

The Retreat at TimberRidge Filing No. 2 is 75.829-acre site located in portions sections 27 and 28, township 12 south, range 65 west of the sixth principal meridian. The site is bounded on the north by future development phases within the TimberRidge property, to the south, east and west by Sterling Ranch property (zoned for future urban development), TimberRidge Filing No. 1 and Vollmer Road. The site is in the upper portion of the Sand Creek Drainage Basin. Both large lot rural single family residential and urban single family residential are proposed in this Filing.

The average soil condition reflects Hydrologic Group "B" (Pring coarse sandy loam and Kettle gravelly loamy sand) as determined by the "Web Soil Survey of El Paso County Area," prepared by the Natural Resources Conservation Service (see map in Appendix).

EXISTING DRAINAGE CONDITIONS

The Retreat at TimberRidge Filing No. 2 property is located in the upper portion of the Sand Creek drainage basin on the south edge of Black Forest. Nearly the entire site, other than the Sand Creek corridor, is mainly covered with native grasses with few or no pine trees. The Sand Creek channel bisects the site in a north-south direction. A wetlands delineation was prepared by CORE Consultants, Inc., which included the entire TimberRidge property and submitted along with Filing No. 1. (See Appendix) This document reflects some wetlands throughout the Sand Creek channel. Any effect on these wetlands within jurisdictional waters will be described later in this report along with the appropriate permitting.

Portions of this site have been previously studied in the "Sand Creek Drainage Basin Planning Study" (DBPS) prepared by Kiowa Engineering Corporation, March 1996. The portion of Sand Creek that traverses the site is defined as Reach SC-9 in the DBPS. 1000+ acres north of this property is tributary to this reach of the channel. (See Off-site Drainage Map in Appendix)

According to the DBPS, this reach of Sand Creek all contained within the channel has the following flow characteristics: Q_{10} = 630 cfs Q_{100} = 2170 cfs. However, the 100 yr. flow recognized by FEMA in the LOMR 08-08-0541P with effective date of July 23, 2009, equals nearly Q_{100} = 2600 cfs. Also, Sterling Ranch has finalized their MDDP which includes modeling of this property as well as the large acreage north up to the top of the Sand Creek Basin. The MDDP proposes developed flows within Sand Creek that are significantly lower than both the DBPS and FEMA currently show. These flows are as follows: At Arroya Lane crossing Q_{10} = 430 cfs Q_{100} = 1487 cfs and TimberRidge south property line Q_{10} = 452 cfs Q_{100} = 1523 cfs. Even with the County approval of the MDDP and these adjusted flows, a CLOMR/LOMR will be required to be prepared, submitted and approved by FEMA prior to utilizing these flows in any Final Drainage Reports within this development. Based on the anticipated 12-18 month timing of the CLOMR/LOMR process, this development will continue to utilize the much larger FEMA recognized flows for all proposed channel improvements through this property, including the culvert crossing at Poco Road. This is how Filing No. 1 was developed as well.

The majority of these off-site flows enter the property at the north end of the site conveying flows from the northwest (Black Forest area) and the off-site stock ponds to the north (both tributary to hundreds of acres of property in Black Forest). There are multiple existing culvert crossings of Vollmer Rd. just north of Arroya Lane to facilitate these historic flow patterns. The following are the few key culverts that directly feed the Sand Creek channel north of Arroya Lane: Approximately 1,000 feet north of Arroya Lane, an existing 36" CMP crosses Vollmer Road (Basin SC-1 on Off-site Drainage Map). A small basin and natural ravine just west of Vollmer feeds this facility. From a recent field visit, this small facility seems to be in good working condition, however, not labeled in the DBPS. Another 700 feet+ north along Vollmer a much larger basin exists west of the roadway. This off-site basin is approximately 350+ acres northwest of Vollmer Road (Basin SC-2 on Off-site Drainage Map). As shown within the DBPS, this existing crossing is a 60" CMP with some very dense and tall vegetation at both the entrance and exit of this facility. But, based on a recent field visit this facility seems to be in good working condition. The DBPS depicts this facility and recommends an additional 60" CMP at this location. However, there are no signs of erosion or over topping the road at this location at this time based on the current development within the tributary area to this facility. Based on the existing surrounding topography and roadway configuration, the 100 yr. historic flows at this location would appear to spill over the roadway and continue in their historic drainage pattern downstream within the upper reach of Sand Creek.

The following descriptions represent the pre-development flow design points for the property excluding the major off-site flows within Sand Creek just described:

EX DP-1 (Q_2 = 1 cfs, Q_5 = 3 cfs, Q_{100} = 18 cfs) consists of small portion of the property at the SE corner that currently sheet flows in a southwesterly direction. These pre-development flows travel off-site directly onto Sterling Ranch property prior to eventually entering the Sand Creek channel.

Basin EX-2 (Q_2 = 2 cfs, Q_5 = 7 cfs, Q_{100} = 44 cfs) consists of approximately 50% off-site and 50% on-site property. The off-site property is part of the future Sterling Ranch development and is conveyed in a southwesterly direction directly on-site via a natural ravine. Portions of the on-site property were graded along with Filing No. 1 to allow for this area to be captured in two temporary sediment basins and away from the Filing No. 1 lot development. These two facilities will be removed along with Filing No. 2 construction.

Basin EX-3 (Q_2 = 1 cfs, Q_5 = 2 cfs, Q_{100} = 16 cfs) consists of again both off-site and on-site property. These flows are conveyed in a southwesterly direction and captured in a graded ditch and routed towards another temporary sediment basin constructed with Filing No. 1. This facility will remain during Filing No. 2 construction as it captures undeveloped flows further north.

Basin EX-4 (Q_2 = 4 cfs, Q_5 = 13 cfs, Q_{100} = 90 cfs) consists of the remaining portion of the yet undeveloped TimberRidge property along with off-site future Sterling Ranch property. This entire area sheet flows in a southwesterly direction towards Sand Creek. Along with the development of Filing No. 1 and the secondary emergency access road up to Arroya Lane, several storm system were installed to convey portions of these flows under the access road. The existing on-site stock pond will continue to remain as it captures much of the off-site tributary area.

EX DP-5 (Q_2 = 3 cfs, Q_5 = 11 cfs, Q_{100} = 69 cfs) consists of combined flows from basins EX-5 and EX-7. Basin EX-5 is the northwest portion of the TimberRidge property with some spruce trees and a very defined natural ravine that conveys flows in a southeast direction towards Sand Creek. Vollmer Road is the westerly boundary of this basin. Basin EX-7 (Q_2 = 3 cfs Q_5 = 8 cfs, Q_{100} = 42 cfs) consists of an off-site basin west of Vollmer Road (not a part of this development) that drains under Vollmer into the TimberRidge property via an existing 48” CMP culvert. These off-site flows enter Basin EX-5 and then travel within the on-site ravine towards Sand Creek. Dual 30” culverts were installed along with Filing No. 1 where the future road crosses this ravine. This condition will remain with the development of Filing 2 and these off-site flows will be accounted for in downstream design.

PROPOSED DRAINAGE CONDITIONS

Proposed development within the Retreat at TimberRidge Filing No. 2 will consist of a variety of different residential lot sizes ranging from 1.0 – 2.5 acre large rural lots to 12,000 SF min. urban lots. The rural lots will have paved streets and roadside ditches while the urban lots paved streets with County standard curb, gutter and sidewalk. Development of the urban lots proposed will consist of overlot grading for the planned roadways and lots. Development of rural lots proposed within the site will be limited to roadways and building pads, conserving the natural feature areas. Individual home sites on these lots are to be left generally in their natural condition with minimal disturbance to existing conditions per individual lot construction. Per the El Paso County

ECM, Section I.7.1.B.5, rural lots of 2.5 ac. and larger are not required to provide Water Quality Capture Volume (WQCV). However, based on the current County/Urban Drainage stormwater quality standards, a WQCV component is automatically built into the UD Detention spreadsheet utilized in the detention basin design. Thus, the proposed facilities within both the rural and urban portions of this development will provide WQCV along with an Excess Urban Runoff Volume (EURV) in the lower portion of the facility storage volume with an outlet control device. Frequent and infrequent inflows are released at rates approximating undeveloped conditions. This concept provides some mitigation of increased runoff volume by releasing a portion of the increased runoff at a low rate over an extended period of time, up to 72 hours. This means that frequent storms, smaller than the 2-year event, will be reduced to very low flows near or below the sediment carrying threshold value for downstream drainage ways. Also, by incorporating an outlet structure that limits the 100-year runoff to the undeveloped condition rate, the discharge hydrograph for storms between the 2 year and the 100-year event will approximate the hydrograph for the undeveloped conditions and will help effectively mitigate the effects of development. To the greatest extent possible, WQCV will be provided for all new roads and urban lots. The following describes how this development proposes to handle both the off-site and on-site drainage conditions:

Is this correct with areas draining offsite?

As mentioned previously, the majority of the off-site flows are already within the Sand Creek channel prior to entering the property. However, the few off-site basins that must travel through the proposed site development areas prior to entering Sand Creek have been accounted for.

The following represent the basins and design points west of Sand Creek:

Basins OS-1 (Q_2 = 1 cfs Q_5 = 2 cfs, Q_{100} = 9 cfs) and OS-2 (Q_2 = 1 cfs Q_5 = 2 cfs, Q_{100} = 7 cfs) represent off-site flows from future TimberRidge development adjacent to Vollmer Rd. and Arroya Lane. These flows calculated as future development flows will continue to travel in a southerly direction within the existing natural ravine and enter Basin B. As mentioned previously, Basin Ex-7 (Q_2 = 3 cfs Q_5 = 8 cfs, Q_{100} = 42 cfs) consists of the off-site basin west of Vollmer Road (not a part of this development) that drains under Vollmer into the TimberRidge property via an existing 48” CMP culvert. These flows are then combined with the flows from basins OS-1 and OS-2. **Design Point 1 (Q_5 = 12 cfs, Q_{100} = 57 cfs)** represents this combined total where the existing dual 30” RCP culverts crossing Aspen Valley Rd. will convey the flows under the road and towards Design Point 3. (See Appendix for culvert and rip-rap calculations) The natural ravine within lots 4 and 5 is contained within a drainage esmt. as shown on the drainage map and final plat.

Basin D (Q_2 = 1 cfs Q_5 = 2 cfs, Q_{100} = 6 cfs) represents a portion of the proposed 2.5 ac. rural lots adjacent to Aspen Valley Road. Developed flows from this basin will continue to sheet flow in a southeasterly direction towards Design Point 3 and combine with the upstream flows. **Design Point 3 (Q_5 = 13 cfs, Q_{100} = 60 cfs)** represents this combined flow total where proposed dual 30” RCP culverts will convey the developed flows under Falcon Nest Court towards Pond 3. (See Appendix for culvert and rip-rap calculations) The natural ravine within lot 7 is contained within a drainage esmt. as shown on the drainage map and final plat. Basin C (Q_2 = 2 cfs Q_5 = 3 cfs, Q_{100} = 8 cfs) represents a portion of the proposed 2.5 ac. rural lots with developed flows that sheet flow in a southeasterly direction towards Design Point 4. At this location a proposed 24” RCP culvert will convey these flows under Falcon Nest Court and combine with the previously mentioned developed flows.

Design Point 2 (Q_5 = 5 cfs, Q_{100} = 20 cfs) represents developed flows from Basin A. At this location a proposed 24” RCP culvert crossing Aspen Valley Rd. will convey the flows under the road into the side road ditch towards Pond 3. (See Appendix for culvert and rip-rap calculations) Basin E (Q_2 = 2 cfs Q_5 = 5 cfs, Q_{100} = 18 cfs) represents a portion of the proposed 2.5 ac. rural lots that sheet flow in a southerly direction and combine with the upstream developed flows. Basin OS-3 (Q_2 = 0.1 cfs Q_5 = 0.4 cfs, Q_{100} = 2 cfs) represents a small portion of the proposed lot 12 that continues to sheet flow towards Sand Creek as originally anticipated.

See comment letter regarding location of the pond

Design Point 5 (Q_5 = 20 cfs, Q_{100} = 83 cfs) represents the total developed flows entering the proposed **Pond 3.** A proposed full-spectrum EDB is proposed at this location to release less than the pre-development flows currently seen. The following describes the design of this facility. (See Appendix for MHFD-Detention pond design sheets):

Detention Pond 3 (Full Spectrum EDB – see multiple storm release data below)

0.44 Ac.-ft. WQCV required

0.35 Ac.-ft. EURV required with 4:1 max. slopes

1.88 Ac.-ft. 100-yr. Storage

2.68 Ac.-ft. Total

Total In-flow:	**Q_2 = 11.3 cfs,**	**Q_5 = 22.7 cfs,**	**Q_{100} = 80.8 cfs**
Pond Design Release:	**Q_2 = 1.1 cfs,**	**Q_5 = 11.1 cfs,**	**Q_{100} = 66.8 cfs**
Pre-development Release:	**Q_2 = 6.0 cfs,**	**Q_5 = 16.9 cfs,**	**Q_{100} = 74.9 cfs**

(Ownership and maintenance by the Retreat at TimberRidge Metro District)

At this proposed outfall location, the overall channel flows will not significantly change based on Detention Pond 3 release of Q_{100} = 66.8 cfs which is less than the predevelopment flows at this location of Q_{100} = 74.9 cfs. (See Appendix for culvert outlet and rip-rap calculations)

The following represent the basins east of Sand Creek:

Design Point 6 (Q_5 = 3 cfs, Q_{100} = 8 cfs) represents developed flows from on-site Basin G (Q_2 = 1.7 cfs Q_5 = 2.4 cfs, Q_{100} = 5 cfs) and off-site Basin OS-9 (Q_2 = 0.5 cfs Q_5 = 0.9 cfs, Q_{100} = 3 cfs). These flows remain consistent with the previous Filing No. 1 report where an existing 10' Type R at-grade inlet was installed with Filing No. 1. This facility continues to intercept 100% of the 5 yr. and 79% of the 100 yr. developed flows. The flow-by that will continue down the west side of the street into Filing No. 1 remains consistent with the previous report and equals Q_5 = 0 cfs, Q_{100} = 1.7 cfs. (See Appendix for calculations) Basins H1 (Q_2 = 0.6 cfs Q_5 = 0.9 cfs, Q_{100} = 2 cfs), H2 (Q_2 = 0.6 cfs Q_5 = 0.8 cfs, Q_{100} = 2 cfs) and I (Q_2 = 0.2 cfs Q_5 = 0.3 cfs, Q_{100} = 0.8 cfs) represents the rear lots of proposed lots 13-16. As previously accounted for in the Filing No. 1 report, these developed flows will sheet flow directly off-site and into the open space tract in Filing No. 1.

Design Point 7 (Q_5 = 9 cfs, Q_{100} = 39 cfs) represents developed flows from on-site Basin J (Q_2 = 4 cfs Q_5 = 7 cfs, Q_{100} = 18 cfs), off-site Basin OS-4 (Q_2 = 0.2 cfs Q_5 = 0.7 cfs, Q_{100} = 5 cfs) and a 70% portion of the anticipated future Sterling Ranch development within off-site Basin OS-5 (Q_2 = 1 cfs Q_5 = 4 cfs, Q_{100} = 26 cfs). These flows will combine and travel in a southerly direction to Design Point 7 where a proposed 15' Type R sump inlet will completely intercept both the 5 yr. and 100 yr. developed flows. The emergency overflow will be 12" and then down the street to the west within Elk Antler Lane.

How will this flow get to the inlet - is gutter capacity adequate? If developed flow is detained to this value a pipe is needed.

8

Design Point 8 (Q_5 = 2 cfs, Q_{100} = 10 cfs) represents developed flows from on-site Basin N (Q_2 = 0.7 cfs Q_5 = 1 cfs, Q_{100} = 2 cfs) and a 30% portion of the anticipated future Sterling Ranch development within off-site Basin OS-5 (Q_2 = 1 cfs Q_5 = 4 cfs, Q_{100} = 26 cfs). These flows will combine at Design Point 7 where a proposed 10' Type R sump inlet will completely intercept both the 5 yr. and 100 yr. developed flows. The emergency overflow will be 12" and then down the street to the west within Elk Antler Lane. However, prior to the development of this portion of the Sterling Ranch development, a temporary sediment basin is proposed off-site just east of Elk Antler Lane. This facility sizing is based on the 13.7 ac. off-site basin OS-5 and is shown on the grading and erosion control plan. Both the overflow spillway and outlet pipe will be routed into the proposed curb line of Elk Antler Lane. Appropriate temporary grading and drainage easements will be acquired from the adjacent property owner prior to construction.

Basin K (Q_2 = 1 cfs Q_5 = 2 cfs, Q_{100} = 5 cfs) represents a portion of the rear yards of proposed lots 21-26. These developed flows will continue to sheet flow in a westerly direction towards a temporary sediment basin constructed with Filing No. 1. Basin L (Q_2 = 0.3 cfs Q_5 = 0.6 cfs, Q_{100} =

permanent WQ is required

2 cfs) represents the rear yard of the proposed lot 27. These minor developed flows will continue to sheet flow in a westerly direction towards another temporary sediment basin constructed with Filing No. 1. Basin M (Q_2 = 0.9 cfs Q_5 = 1.2 cfs, Q_{100} = 3 cfs) represents the developed flows from proposed lots 19-20. These developed flows were accounted for in the Filing No. 1 report and will continue to sheet flow in a southwesterly direction directly into the north side of Elk Antler Lane. The existing downstream 15' Type R At-grade Inlet will continue to adequately collect these flows.

south of Elk Antler Lane (?)

Design Point 9 (Q_5 = 4 cfs, Q_{100} = 14 cfs) represents the developed flows from Basins OS-8 (Q_2 = 2 cfs Q_5 = 3 cfs, Q_{100} = 10 cfs) and Q (Q_2 = 0.4 cfs Q_5 = 1.2 cfs, Q_{100} = 6 cfs). At this location, an existing 10' Type R Sump Inlet was installed with Filing No. 1 to completely intercept both the 5 yr. and 100 yr. developed flows. These flows remain consistent with the Filing No. 1 report as anticipated as Q_5 = 5 cfs, Q_{100} = 15 cfs.

Design Point 10 (Q_5 = 3 cfs, Q_{100} = 11 cfs) represents developed flows from Basins O (Q_2 = 2 cfs Q_5 = 3 cfs, Q_{100} = 9 cfs) and OS-6 (Q_2 = 0.1 cfs Q_5 = 0.4 cfs, Q_{100} = 3 cfs). These developed flows sheet flow in a southwesterly direction towards Design Point 10 where a proposed 10' Type R Sump Inlet will be installed to completely intercept both the 5 yr. and 100 yr. developed flows. The emergency overflow will be 12" and then south over the highpoint. It is planned with this report that with the future development of this portion of Sterling Ranch (Basin OS-6) developed flows equal to pre-development quantities are accounted for downstream in the existing on-site Pond 2. These future flows quantities will be treated and detained within Pond 2. Any developed flows above these quantities will need to be routed further downstream within the Sterling Ranch development.

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Design Point 11 (Q_5 = 2 cfs, Q_{100} = 4 cfs) represents developed flows from Basin P. At this location, a proposed 5' Type R Sump Inlet will be installed to completely intercept both the 5 yr. and 100 yr. developed flows. The emergency overflow will be 12" and then southerly over the highpoint.

of Owl Perch Loop

Design Point 12 (Q_5 = 4 cfs, Q_{100} = 9 cfs) represents the developed flows from Basin R. At this location, a proposed 10' Type R At-grade Inlet will be installed to intercept 99% of the 5 yr. and 75% of the 100 yr. developed flows. The flow-by (Q_5 = 0 cfs, Q_{100} = 2.3 cfs) will then continue down the street towards Design Point 13. (See Appendix for calculations)

to the west

Design Point 13 (Q_5 = 8 cfs, Q_{100} = 23 cfs) represents flows from Basin S and the flow-by from Basin R mentioned above. At this location, a proposed 15' Type R Sump Inlet will be installed to completely intercept both the 5 yr. and 100 yr. developed flows. The emergency overflow will be 12" and then southerly over the highpoint.

of Bison Valley Trail? Why not into Pond 2 with a curb chase?

Design Point 14 (Q_5 = 1 cfs, Q_{100} = 3 cfs) represents flows from Basin T. At this location, a proposed 5' Type R Sump Inlet will be installed to completely intercept both the 5 yr. and 100 yr. developed flows. The emergency overflow will be 12" and then southerly over the highpoint.

Pipe Run 12 (Q_5 = 25 cfs, Q_{100} = 85 cfs) represents the total developed flows entering the existing Pond 2 at the NE corner via the existing 42" RCP storm stub provided with Filing No. 1 construction. These flows are compared to the anticipated flows at this location in the Filing No. 1 report of Q_5 = 19 cfs, Q_{100} = 74 cfs. The existing Pond 2 continues to adequately provide detention and stormwater quality per County criteria with these additional flows.

The following represents the existing Pond 2 with the minor adjusted developed flows:
(See revised MHFD-Detention Pond Design Sheets in Appendix)

Existing Detention Pond 2 (Full Spectrum EDB – see multiple storm release data below)

1.03 Ac.-ft. WQCV required

1.16 Ac.-ft. EURV required with 4:1 max. slopes

3.36 Ac.-ft. 100-yr. Storage

5.55 Ac.-ft. Total

Total In-flow:	**Q_2 = 24.5 cfs, Q_5 = 43.1 cfs, Q_{100} = 135.8 cfs**
Pond Design Release:	**Q_2 = 0.9 cfs, Q_5 = 13.5 cfs, Q_{100} = 96.2 cfs**
Pre-development Release:	**Q_2 = 9.1 cfs, Q_5 = 25.4 cfs, Q_{100} = 115.0 cfs**

(Existing ownership and maintenance by the Retreat at TimberRidge Metro District)

Basin U (Q_2 = 1 cfs Q_5 = 2 cfs, Q_{100} = 5 cfs) represents a portion of the rear yards of proposed lots 61-67. These developed flows were accounted for in the previous report for Filing No. 1 and remain consistent with the anticipated flows at this location of (Q_5 = 2 cfs, Q_{100} = 5 cfs). Basin V (Q_2 = 1 cfs Q_5 = 2 cfs, Q_{100} = 6 cfs) represents the rear yards of the proposed lots 44-53. These developed flows will sheet flow in a southeasterly direction off-site. Based on the large lot depths and as noted on the drainage map, these lots are required to have all impervious area constructed within Basin R with no impervious area allowed within Basin V. Basin OS-7 (Q_2 = 0.2 cfs Q_5 = 0.8 cfs, Q_{100} = 5 cfs) represents an off-site basin within the future Sterling Ranch development that will continue to sheet flow in its historic drainage pattern. The TimberRidge development will coordinate with the Sterling Ranch property owner for the acquisition of appropriate temporary grading and drainage easements along the eastern property line to facility this interim drainage condition. Basin W (Q_2 = 1 cfs Q_5 = 2 cfs, Q_{100} = 5 cfs) represents the rear yards of the proposed lots 54-60. While this basin exceeds the allowable 1.0 ac. of untreated developed area, we are coordinating with the Sterling Ranch property owner for the

And a permanent drainage easement(s)

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See comment letter.

acquisition of appropriate temporary grading and drainage easements along the southern property line to facilitate a temporary sediment basin in this interim condition. Ultimately, this basin will be treated further downstream prior to entering Sand Creek.

DETENTION / STORMWATER QUALITY FACILITES

As required, storm water quality measures will be utilized in order to reduce the amount of sediment, debris and pollutants that are allowed to enter Sand Creek. These features include but are not limited to Full Spectrum Detention Basins and temporary sediment basins. Site Planning and design techniques for the large lot, rural areas should help limit impervious area, minimize directly impervious area, lengthen time of travel and increase infiltration in order to decrease the rate and volume of stormwater runoff. Urban areas that require detention will provide a Water Quality Capture Volume (WQCV) and Excess Urban Runoff Volume (EURV) in the lower portion of the facility storage volume that will release the more frequent storms at a slower rate to help minimize the effects of development of the property. The proposed detention/SWQ facilities are to be private facilities with ownership and maintenance by the TimberRidge Metropolitan District. After completion of construction and upon the Board of County Commissioners acceptance, the Sand Creek channel will be owned and maintained by the El Paso County along with all drainage facilities within the public Right of Way.

SAND CREEK CHANNEL IMPROVEMENTS

As stated in the Sand Creek DBPS, this Reach SC-9 is recommended as a floodplain preservation design concept. Given the fact of the current requirements for detention/SWQ facilities planned for the property with designed release at or below pre-development flows, the existing Sand Creek drainageway is expected to remain stable. Existing FEMA FIS channel velocities as found in the LOMR 08-080541P seem to exceed recommended allowable velocities. Although, based on the findings from the CORE Consultants, Inc. Impact Identification Report, no significant erosion or channel degradation through this property currently exists at this time. Specifically located grade control structures (See Appendix) were specified in the DBPS through this reach in

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order to slow the cannel velocity to the DBPS recommended 7 feet per second and to prevent localized and long-term stream degradation affecting channel linings and overbanks. The allowable velocity and shear stress will vary depending upon the existing riparian vegetation/wetlands found within the channel and overbank floodplain terrace areas. A HEC-RAS hydraulic analysis for this portion of Reach SC-9 has been provided in order to determine the necessary channel improvements for the proposed Filing No. 2 development and future Filings. A separate wetland impact report along with the Section 404 permitting, prepared by CORE Consultants, has been developed based on these proposed channel improvements and submitted directly to the U.S. Army Corps of Engineers with necessary consult with U.S. Fish and Wildlife for their review and approval. This report and documentation can be found in the Appendix for El Paso County staff review.

update for this filing

HEC-RAS MODELING

HEC-RAS ver. 5.0.6 was used to perform a one-dimensional, steady flow hydraulic model of a portion of Reach SC-9 from Arroya Lane to approximately 650 feet downstream of the TimberRidge south property line. HEC-RAS was used to define the stream centerline, overbanks, cross-sections and manning's n values. The stream centerline follows the channel thalweg to define the reach network. Cross-section topography data was obtained by using the generated surface from the 2-ft. flown contours utilized for all site design. This data was then exported from AutoCAD containing three-dimensional coordinates for the stream centerline, cross-sections, reach stations, overbank stations, reach lengths and imported into HEC-RAS. Two separate models defining the existing condition and proposed condition were prepared using the same centerline stationing. The proposed model included the introduction of the ineffective flow area for the culvert added for the Poco Road crossing. Different Manning's n values were applied across the various channel cross-sections to reflect the changes in vegetative cover within the channel and overbanks. The selected Manning's n values for the channel and overbanks were determined using Tables 10-1 and 10-2 from the DCM and Table 3 from the USGS Guide for selecting Manning's Roughness Coefficients based on numerous site visits in an effort to photograph and document each cross-section. (See Appendix) The following table summarizes the selected Manning's n values:

Table 1 Manning's n Values

Feature	Manning's n Value
Main Channel	0.03 – 0.10
Overbank Floodplain Terraces	0.12 – 0.16

Steady flow data was entered starting at Arroya Lane, channel station 55+32.95, with a flow change location at station 15+07.91 representing the Sand Creek DBPS segment change from 171 to 170. Steady flow data corresponding to recurrence intervals of 10 Yr. and 100 Yr. for the FEMA, DBPS and Sterling Ranch MDDP conditions was entered. The models were run in subcritical mode to evaluate hydraulic conditions. Boundary conditions for the entire reach were based on normal depth calculations for the upstream and downstream channel slopes. The following table summarizes the flows used in the models:

Table 2 Model Flow Values

Flood Event / Location	Flow Value (cfs)
Arroya Lane (Sta: 55+32.95)	
FEMA 100 Yr.	2600
DBPS 100 Yr.	2170
DBPS 10 Yr.	630
Sterling MDDP 100 Yr.	1487
Sterling MDDP 10 Yr.	430
DBPS Segment 170 (Sta: 15+07.91)	

FEMA 100 Yr.	2600
DBPS 100 Yr.	2260
DBPS 10 Yr.	670
Sterling MDDP 100 Yr.	1520
Sterling MDDP 10 Yr.	450

Per the approved DBPS, the anticipated developed flows just upstream of this project are Q_{10} = 630 cfs and Q_{100} = 2170 cfs as depicted within DBPS segment no. 171. The anticipated developed flows exiting this property are Q_{10} = 670 cfs and Q_{100} = 2260 cfs as depicted within DBPS segment no. 170. As discussed earlier, the FEMA FIS flows appear to be significantly higher than both those presented in the DBPS and the Sterling Ranch MDDP. We understand that Sterling Ranch may be processing a CLOMR/LOMR in the near future, however, we have continued to utilize the significantly larger flows as determined by the FEMA FIS (2600 cfs) in the channel improvement designs. The proposed public roadway crossing of Sand Creek was constructed with Filing No. 1 and consisted of a two cell multi-plate steel single radius arch (24' x 10.33') with concrete headwalls to facilitate the conveyance of the 100 yr. flow.

Based on site visits during May and July of 2019, the entire Sand Creek drainage corridor through the Retreat at TimberRidge development was walked and photographed for documentation purposes and aide in the HEC-RAS modeling. (See Appendix) As discovered in the field and documented in the photos taken at each HES-RAS station, this reach of the Sand Creek channel appears very stable with no signs of erosion within the main channel or channel overbanks. This is mainly due to the significant vegetal cover throughout the reach. The classification of the vegetal cover seems to have a range from Retardance Class A-C as defined by HEC-15 chart (See Appendix) This type of vegetation retardance significantly increases the allowable shear stress within the channel while reducing the velocity. The following table defines the retardance level based on the vegetation class:

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Table 3

Vegetal Retardance Curve Index by SCS Retardance Class

SCS Retardance Class	Retardance Curve Index
A	10.0
B	7.64
C	5.60
D	4.44
E	2.88

Based on this information, the maximum allowable sheer stress is found by the flowing equation:

$$\tau = 0.75\text{Curve Index}$$

Thus, the range of shear stress for this reach of Sand Creek equals 4.2 – 7.5 (lb/ft^2).

Referencing the HES-RAS model calculations in the Appendix shows that only a few stations showed shear stress exceeding this limit. (Sta: 33+34.27, 20+83.66 and 18+79.67) All three of these stations were within the Filing 1 development area and with the proposed channel improvements and selective embankment lining, the shear stress at those locations will be reduced to the allowable range.

The proposed channel improvements within Filing No. 2 consist of two additional check structures located in the narrower portions of the creek. The DBPS only depicts one structure along this stretch of channel but the additional one is being planned to further limit degradation and help control the elevation of the channel invert. These check structures are designed to be sheet piling with a concrete cap per Urban Drainage Vol. 2 Figures 9-27 thru 9-28. The intent of these structures is to hold grade so if the stream wants to flatten its equilibrium slope, the incision is limited. Thus, the plan is for these structures to eventually become drop structures as dictated by future channel characteristics.

The DBPS also recommended to provide selective rip-rap channel stabilization located at culvert crossings, pipe outlets and outside bends of the channel. Based on the mean channel slope and maximum allowable velocity of 7.0 fps, Type L Rip-Rap stabilization will be provided at select locations within Filing No. 2. (See Appendix for tables describing slope, velocity, shear, Froude No., etc.) The existing channel slope throughout this reach ranges from 0.6% to 7.3%. These steeper slopes seem to represent numerous areas with isolated shallow pools within the main channel which help support the growth of the wetlands. These isolated areas will remain with only minimal disturbance taking place at the locations of the proposed improvements (i.e. check structures and culvert crossing). Per the HEC-RAS model, the proposed channel velocities range from 2.7 ft./sec. to 6.0 ft./sec. All stations are within the allowable velocity of 7.0 ft./sec.

The HEC-RAS model calculations shows no stations with Froude No. over 1.0 for this stretch of the creek within Filing No. 2. Thus, the Froude No. at all stations remains less than 1.0, with subcritical flow characteristics.

Describe channel and pond maintenance access.

DRAINAGE CRITERIA

Hydrologic calculations were performed using the City of Colorado Springs/El Paso County Drainage Criteria Manual, as revised in November 1991 and October 1994 with County adopted Chapter 6 and Section 3.2.1 of Chapter 13 of the City of Colorado Springs/El Paso County Drainage Criteria Manual as revised in May 2014. Individual on-site developed basin design used for detention/SWQ basin sizing, inlet sizing and storm system routing was calculated using the Rational Method. Runoff Coefficients are based on the imperviousness of the particular land use and the hydrologic soil type in accordance with Table 6-6. The average rainfall intensity, by recurrence interval found in the Intensity-Duration-Frequency (IDF) curves in Figure 6-5. (See Appendix)

The City of Colorado Springs/El Paso County DCM requires the Four Step Process for receiving water protection that focuses on reducing runoff volumes, treating the water quality capture volume (WQCV), stabilizing drainage ways, and implementing long-term source controls. The Four Step Process pertains to management of smaller, frequently occurring storm events, as opposed to larger storms for which drainage and flood control infrastructure are sized. Implementation of these four steps helps to achieve storm water permit requirements.

This site adheres to this **Four Step Process** as follows:

1. **Employ Runoff Reduction Practices:** Proposed rural lot impervious area (roof tops, patios, etc.) will sheet flow across lengthy landscape/natural areas within the large lots and proposed urban lot impervious areas (roof tops, patios, etc.) will sheet flow across landscaped yards and through open space areas to slow runoff and increase time of concentration prior to being conveyed to the proposed public streets or detention facilities. This will minimize directly connected impervious areas within the project site.

2. **Stabilize Drainageways:** After developed flows utilize the runoff reduction practices through the front and rear yards, developed flows will travel via roadside ditches in the large lot, rural portions of the development, curb and gutter within the public streets in the urban portions of the development and eventually public storm systems. These collected flows are then routed directly to multiple extended detention basins (full-spectrum facilities). Where developed flows are not able to be routed to public street, sheet flows will travel across landscaped rear yards and then through undeveloped property prior to entering Sand Creek. The Sand Creek channel corridor will be protected with various channel improvements as recommended in the Sand Creek DBPS and proposed with this Filing in order to reduce velocities to erosive levels.

3. **Provide Water Quality Capture Volume (WQCV):** Runoff from this development will be treated through capture and slow release of the WQCV and excess urban runoff volume (EURV) in the proposed Full-Spectrum permanent Extended Detention Basins designed per current El Paso County drainage criteria.

4. **Consider need for Industrial and Commercial BMPs**: No industrial or commercial uses are proposed within this development. However, a site-specific storm water quality and erosion control plan and narrative has been submitted along with the grading and erosion control plan. Details such as site-specific sediment and erosion control construction BMP's as well as temporary and permanent BMP's were detailed in this plan and narrative to protect receiving waters. Multiple temporary BMP's are proposed based on specific phasing of the overall development. BMP's will be constructed and maintained as the development has been graded and erosion control methods employed.

FLOODPLAIN STATEMENT

Portions of this site are located within a floodplain as determined by the Flood Insurance Rate Maps (F.I.R.M.) Map Number 08041C 0535G with effective date of December 7, 2018 and the previously mentioned LOMR 08-08-0541P with an effective date of July 23, 2009. (See Appendix).

DRAINAGE AND BRIDGE FEES

This site lies entirely within the Sand Creek Drainage Basin boundaries.

The fees are calculated using the following impervious acreage method approved by El Paso County. The Retreat at TimberRidge Filing No. 2 has a total area of 75.83 acres with the following different land uses proposed:

8.09 Ac.	Sand Creek Drainage corridor (Tract C)
0.64 Ac.	Detention Facility (Tract B)
34.27 Ac.	2.5 Ac. lots (Rural Lots 1-12 incl. Tract A)
32.83 Ac.	1/3 Ac. lots (Urban Lots 13-90 with avg. size 15,575 SF)
75.83	Total

The percent imperviousness for this subdivision is calculated as follows:

Fees for Sand Creek Drainage Corridor

(Per El Paso County Percent Impervious Chart: 2**%**)

8.09 Ac. x 2% = **0.16 Impervious Ac.**

Fees for Detention Facilities & Park

(Per El Paso County Percent Impervious Chart: 7**%**)

0.64 Ac. x 7% = **0.04 Impervious Ac.**

Fees for 2.5 Ac. lots

(Per El Paso County Percent Impervious Chart: 11**%** with

25% fee reduction for 2.5 ac. lots planned) – *Reduction for Drainage Fees only*

34.27 Ac. x 11% x 75% = **2.83 Impervious Ac.** (Drainage Fees)

34.27 Ac. x 11% = **3.77 Impervious Ac.** (Bridge Fees)

Fees for 1/3 Ac. lots (Avg. lot size of 15,575 SF)

(Per El Paso County Percent Impervious Chart: 30**%**)

32.83 Ac. x 30% = **9.85 Impervious Ac.**

Total Impervious Acreage: **12.88 Imp. Ac.** (Drainage Fees)

Total Impervious Acreage: **13.82 Imp. Ac.** (Bridge Fees)

The following calculations are based on the 2021 Sand Creek drainage/bridge fees:

ESTIMATED FEE TOTALS:

Bridge Fees

$ 8,339.00 x 13.82 Impervious Ac. = **$ 115,244.98**

Drainage Fees

$ 20,387.00 x 12.88 Impervious Ac. = **$ 262,584.56**

Per the ECM 3.10.5.a, this development requests a reduction of drainage fees based on the on-site regional channel improvements for this stretch of Sand Creek Reach SC-9 as shown in the DBPS. The following facilities within the Sand Creek Drainage Basin seem to meet the criteria for this reduction:

See comment letter

Sand Creek Channel Improvements per DBPS	=	$175,000

Proposed Sand Creek Channel Improvements:

Sheet Pile Check Structure w/ Conc. Cap	$45,000 EA x 2 =	$ 90,000
Selective Bank Stabilization (Buried Rip-Rap)	$100/LF x 535 LF =	$ 53,500
Selective Bank Stabilization (Grading & Reveg.)	=	$ 80,000
Total	=	**$223,500**

(Exact facility costs provided upon construction and acceptance by County. Any credits may be used for future Filings)

approved

Classic Consulting Engineers & Surveyors cannot and does not guarantee that the construction cost will not vary from these opinions of probable construction costs. These opinions represent our best judgment as design professionals familiar with the construction industry and this development in particular.

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SUMMARY

The proposed Retreat at TimberRidge Filing No. 2 is within the Sand Creek Drainage Basin. Recommendations are made within this report concerning necessary improvements that will be required as a result of development of this property. The points of storm water release from the proposed site are required to be at or below the calculated historic flow quantities. The development of the proposed site does not significantly impact any downstream facility or property to an extent greater than that which currently exists in the 'historic' conditions. All drainage facilities within this report were sized according to the Drainage Criteria Manuals and the full-spectrum storm water quality requirements.

PREPARED BY:

Classic Consulting Engineers & Surveyors, LLC

Marc A. Whorton, P.E.
Project Manager

maw/118520/FDR Fil. 2.doc

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REFERENCES

1. City of Colorado Springs/County of El Paso Drainage Criteria Manual as revised in November 1991 and October 1994 with County adopted Chapter 6 and Section 3.2.1 of Chapter 13 of the City of Colorado Springs/El Paso County Drainage Criteria Manual as revised in May 2014.

2. "Urban Storm Drainage Criteria Manual Volume 1, 2 & 3" Urban Drainage and Flood Control District, dated January 2016.

3. "Final Drainage Report for Forest Gate Subdivision" Law & Mariotti Consultants, Inc. dated October 2004.

4. "Sand Creek Drainage Basin Planning Study," Kiowa Engineering Corporation, dated March 1996.

5. "Master Development Drainage Plan for The Retreat at TimberRidge", Classic Consulting, approved March 2018.

6. "Preliminary Drainage Report for The Retreat at TimberRidge Preliminary Plan – South of Arroya Lane", Classic Consulting, approved October 2018.

7. "2018 Sterling Ranch MDDP", M&S Civil Consultants, Inc., June 2018

8. "Final Drainage Report for Retreat at Sand Creek Filing No. 1", Classic Consulting, approved November, 2020.

Timberridge

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APPENDIX

VICINITY MAP

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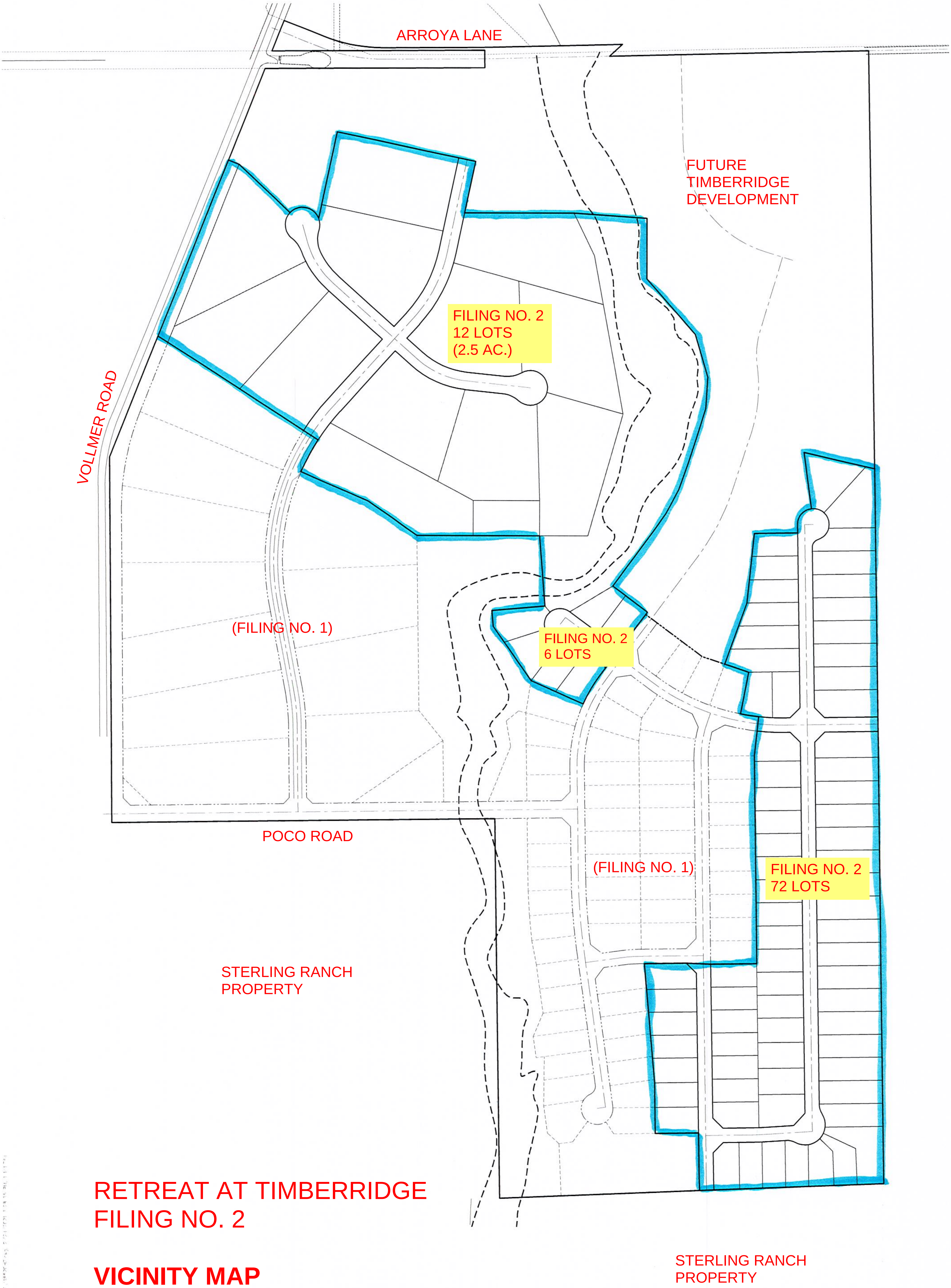
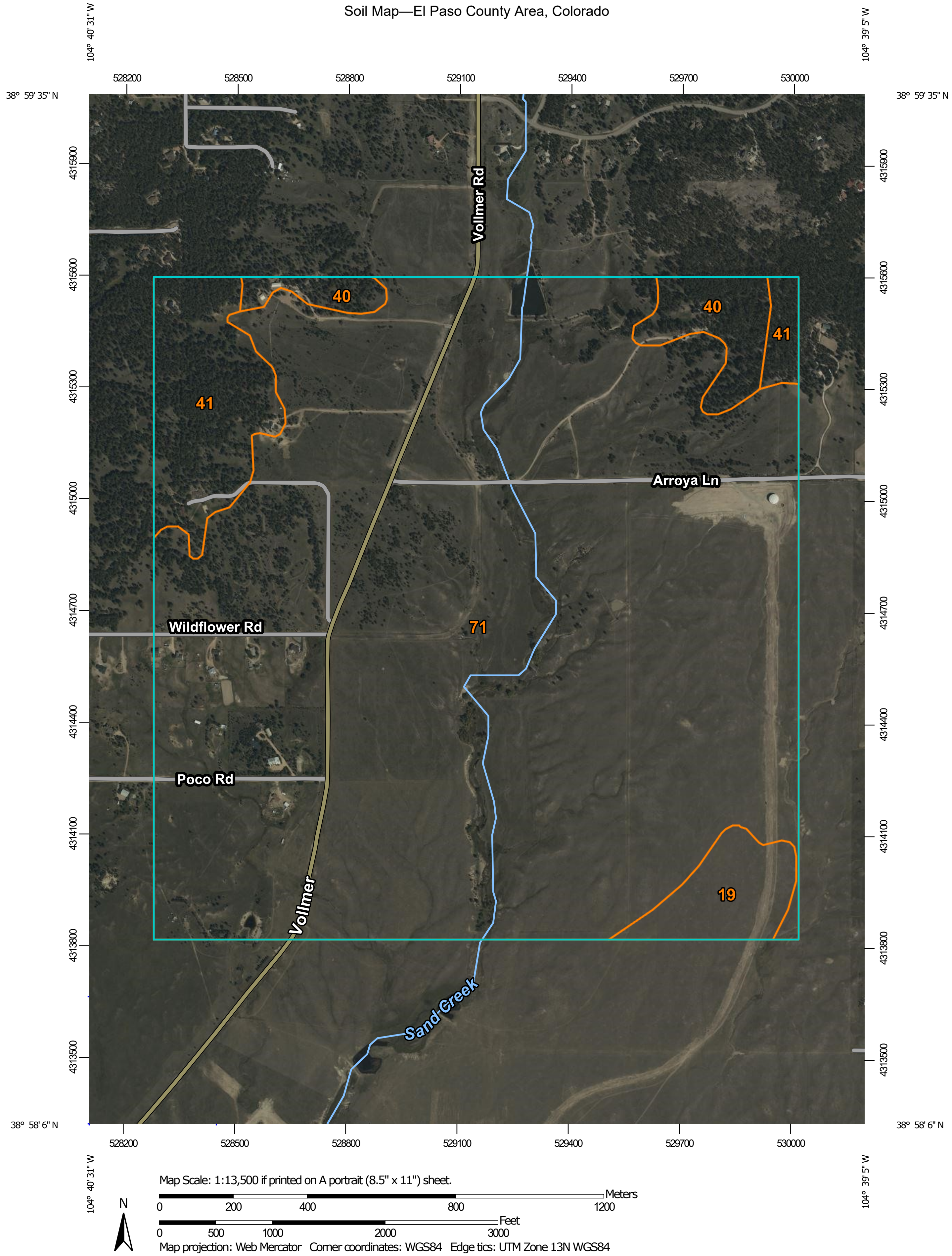


RETREAT AT TIMBERRIDGE FILING NO. 2

VICINITY MAP

SOILS MAP (S.C.S SURVEY)


104° 40' 31" W
104° 39' 5" W
38° 59' 35" N
38° 58' 6" N
528200
528500
528800
529100
529400
529700
530000
4315900
4315600
4315300
4315000
4314700
4314400
4314100
4313800
4313500
Vollmer Rd
Arroya Ln
Wildflower Rd
Poco Rd
Vollmer
Sand Creek
40
41
71
19
Map Scale: 1:13,500 if printed on A portrait (8.5" x 11") sheet.
Meters
0
200
400
800
1200
Feet
0
500
1000
2000
3000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

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

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

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

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

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

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 18, Jun 5, 2020

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

Date(s) aerial images were photographed: Sep 11, 2018—Oct 20, 2018

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
19	Columbine gravelly sandy loam, 0 to 3 percent slopes	21.7	2.8%
40	Kettle gravelly loamy sand, 3 to 8 percent slopes	26.1	3.4%
41	Kettle gravelly loamy sand, 8 to 40 percent slopes	51.7	6.7%
71	Pring coarse sandy loam, 3 to 8 percent slopes	667.8	87.0%
Totals for Area of Interest		**767.3**	**100.0%**

El Paso County Area, Colorado

71—Pring coarse sandy loam, 3 to 8 percent slopes

Map Unit Setting

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

Map Unit Composition

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

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

Data Source Information

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 18, Jun 5, 2020

F.E.M.A. MAP / LOMR (08-08-0541P)

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NOTES TO USERS

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

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

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD88). 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 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 effect the accuracy of this FIRM.

Flood elevations on this map are referenced to the **North American Vertical Datum of 1988 (NAVD88)**. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, 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, and Anderson Consulting Engineers, Inc. These data are current as of 2006.

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.

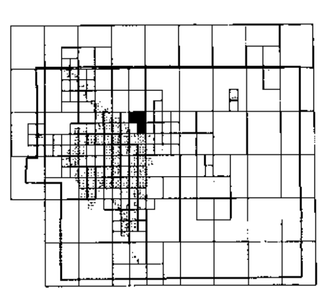
Contact **FEMA Map Service Center** (MSC) via the FEMA Map Information eXchange (FMIX) 1-877-336-2627 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. The MSC may also be reached by Fax at 1-800-358-9620 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** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.

El Paso County Vertical Datum Offset Table

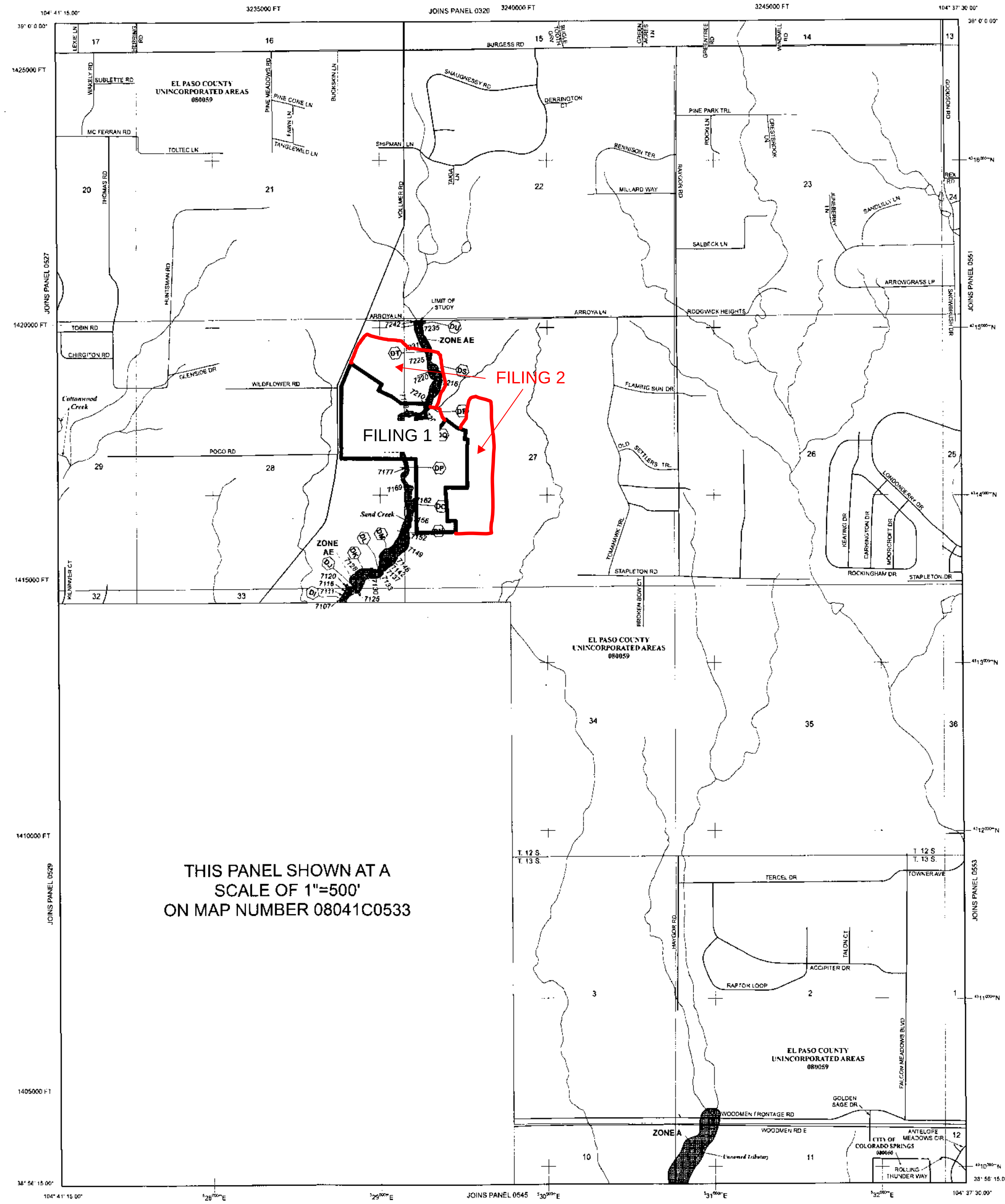
Flooding Source	Vertical Datum Offset (ft)
REFER TO SECTION 3.3 OF THE EL PASO COUNTY FLOOD INSURANCE STUDY FOR STREAM BY STREAM VERTICAL DATUM CONVERSION INFORMATION	

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



NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 12 SOUTH, RANGE 65 WEST, AND TOWNSHIP 13 SOUTH, RANGE 65 WEST.

LEGEND

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

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

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

OTHER FLOOD AREAS

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

OTHER AREAS

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

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

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

Floodplain boundary
Floodway boundary
Zone D Boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities
~~~ 513 ~~~ Base Flood Elevation line and value; elevation in feet*
(EL 987) Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

(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)
4275000mN 1000-meter Universal Transverse Mercator grid ticks, zone 13
6000000 FT 5000-foot grid ticks: Colorado State Plane coordinate system, central zone (FIPSZONE 0502), Lambert Conformal Conic Projection
DX5510 × Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5 River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
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 1-800-638-6620.

MAP SCALE 1" = 1000'

500 0 1000 2000 FEET
300 0 300 600 METERS

NFIP

PANEL 0535G

NATIONAL FLOOD INSURANCE PROGRAM

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

PANEL 535 OF 1300

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
COLORADO SPRINGS, CITY OF	080060	0535	G
EL PASO COUNTY	080059	0535	G

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

MAP NUMBER 08041C0535G

MAP REVISED DECEMBER 7, 2018

Federal Emergency Management Agency
~~~

Federal Emergency Management Agency
Washington, D.C. 20472

LETTER OF MAP REVISION DETERMINATION DOCUMENT

COMMUNITY AND REVISION INFORMATION		PROJECT DESCRIPTION	BASIS OF REQUEST
COMMUNITY	El Paso County Colorado (Unincorporated Areas) COMMUNITY NO.: 080059	NO PROJECT	HYDRAULIC ANALYSIS NEW TOPOGRAPHIC DATA
IDENTIFIER	Sand Creek Letter of Map Revision, Mustang Place to Arroya Lane	APPROXIMATE LATITUDE & LONGITUDE: 38.971, -104.668 SOURCE: USGS QUADRANGLE DATUM: NAD 27	

ANNOTATED MAPPING ENCLOSURES	ANNOTATED STUDY ENCLOSURES
TYPE: FIRM* NO.: 08041C0535 F DATE: March 17, 1997	DATE OF EFFECTIVE FLOOD INSURANCE STUDY: August 23, 1999 PROFILE(S): 204P(a), 204P(b), 204P(c) AND 204P(d) FLOODWAY DATA TABLE: 5

Enclosures reflect changes to flooding sources affected by this revision.
* FIRM - Flood Insurance Rate Map; ** FBFM - Flood Boundary and Floodway Map; *** FHBM - Flood Hazard Boundary Map

FLOODING SOURCE(S) & REVISED REACH(ES)

Sand Creek - from approximately 360 feet downstream of Mustang Place to just downstream of Arroya Lane

SUMMARY OF REVISIONS

Flooding Source	Effective Flooding	Revised Flooding	Increases	Decreases
Sand Creek	Zone A	Zone AE	YES	YES
	No BFEs*	BFEs	YES	NONE
	No Floodway	Floodway	YES	NONE

* BFEs - Base Flood Elevations

DETERMINATION

This document provides the determination from the Department of Homeland Security's Federal Emergency Management Agency (FEMA) regarding a request for a Letter of Map Revision (LOMR) for the area described above. Using the information submitted, we have determined that a revision to the flood hazards depicted in the Flood Insurance Study (FIS) report and/or National Flood Insurance Program (NFIP) map is warranted. This document revises the effective NFIP map, as indicated in the attached documentation. Please use the enclosed annotated map panels revised by this LOMR for floodplain management purposes and for all flood insurance policies and renewals in your community.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional Information about the NFIP is available on our website at http://www.fema.gov/nfip.

David N. Bascom

David N. Bascom, Program Specialist
Engineering Management Branch
Mitigation Directorate

Federal Emergency Management Agency

Washington, D.C. 20472

LETTER OF MAP REVISION DETERMINATION DOCUMENT (CONTINUED)

COMMUNITY INFORMATION

APPLICABLE NFIP REGULATIONS/COMMUNITY OBLIGATION

We have made this determination pursuant to Section 206 of the Flood Disaster Protection Act of 1973 (P.L. 93-234) and in accordance with the National Flood Insurance Act of 1968, as amended (Title XIII of the Housing and Urban Development Act of 1968, P.L. 90-448), 42 U.S.C. 4001-4128, and 44 CFR Part 65. Pursuant to Section 1361 of the National Flood Insurance Act of 1968, as amended, communities participating in the NFIP are required to adopt and enforce floodplain management regulations that meet or exceed NFIP criteria. These criteria, including adoption of the FIS report and FIRM, and the modifications made by this LOMR, are the minimum requirements for continued NFIP participation and do not supersede more stringent State/Commonwealth or local requirements to which the regulations apply.

We provide the floodway designation to your community as a tool to regulate floodplain development. Therefore, the floodway revision we have described in this letter, while acceptable to us, must also be acceptable to your community and adopted by appropriate community action, as specified in Paragraph 60.3(d) of the NFIP regulations.

COMMUNITY REMINDERS

We based this determination on the 1-percent-annual-chance flood discharges computed in the FIS for your community without considering subsequent changes in watershed characteristics that could increase flood discharges. Future development of projects upstream could cause increased flood discharges, which could cause increased flood hazards. A comprehensive restudy of your community's flood hazards would consider the cumulative effects of development on flood discharges subsequent to the publication of the FIS report for your community and could, therefore, establish greater flood hazards in this area.

Your community must regulate all proposed floodplain development and ensure that permits required by Federal and/or State/Commonwealth law have been obtained. State/Commonwealth or community officials, based on knowledge of local conditions and in the interest of safety, may set higher standards for construction or may limit development in floodplain areas. If your State/Commonwealth or community has adopted more restrictive or comprehensive floodplain management criteria, those criteria take precedence over the minimum NFIP requirements.

We will not print and distribute this LOMR to primary users, such as local insurance agents or mortgage lenders; instead, the community will serve as a repository for the new data. We encourage you to disseminate the information in this LOMR by preparing a news release for publication in your community's newspaper that describes the revision and explains how your community will provide the data and help interpret the NFIP maps. In that way, interested persons, such as property owners, insurance agents, and mortgage lenders, can benefit from the information.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional Information about the NFIP is available on our website at http://www.fema.gov/nfip.

David N. Bascom

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Engineering Management Branch
Mitigation Directorate

Federal Emergency Management Agency

Washington, D.C. 20472

LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)

We have designated a Consultation Coordination Officer (CCO) to assist your community. The CCO will be the primary liaison between your community and FEMA. For information regarding your CCO, please contact:

Ms. Jeanine D. Petterson
Director, Mitigation Division
Federal Emergency Management Agency, Region VIII
Denver Federal Center, Building 710
P.O. Box 25267
Denver, CO 80225-0267
(303) 235-4830

STATUS OF THE COMMUNITY NFIP MAPS

We will not physically revise and republish the FIRM and FIS report for your community to reflect the modifications made by this LOMR at this time. When changes to the previously cited FIRM panel(s) and FIS report warrant physical revision and republication in the future, we will incorporate the modifications made by this LOMR at that time.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional Information about the NFIP is available on our website at http://www.fema.gov/nfip.

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Engineering Management Branch
Mitigation Directorate

Federal Emergency Management Agency
Washington, D.C. 20472

LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)

PUBLIC NOTIFICATION OF REVISION

PUBLIC NOTIFICATION

FLOODING SOURCE	LOCATION OF REFERENCED ELEVATION	BFE (FEET NGVD 29)		MAP PANEL NUMBER(S)
		EFFECTIVE	REVISED	
Sand Creek	Just upstream of Mustang Place	None	6,984	08041C0535 F
	Just downstream of Arroya Lane	None	7,238	08041C0535 F

Within 90 days of the second publication in the local newspaper, a citizen may request that we reconsider this determination. Any request for reconsideration must be based on scientific or technical data. Therefore, this letter will be effective only after the 90-day appeal period has elapsed and we have resolved any appeals that we receive during this appeal period. Until this LOMR is effective, the revised BFEs presented in this LOMR may be changed.

A notice of changes will be published in the *Federal Register*. A short notice also will be published in your local newspaper on or about the dates listed below. Please refer to FEMA's website at https://www.floodmaps.fema.gov/fhm/Scripts/bfe_main.asp for a more detailed description of proposed BFE changes, which will be posted within a week of the date of this letter.

LOCAL NEWSPAPER Name: *El Paso County News*
Dates: 03/18/09 03/25/09

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional Information about the NFIP is available on our website at http://www.fema.gov/nfip.

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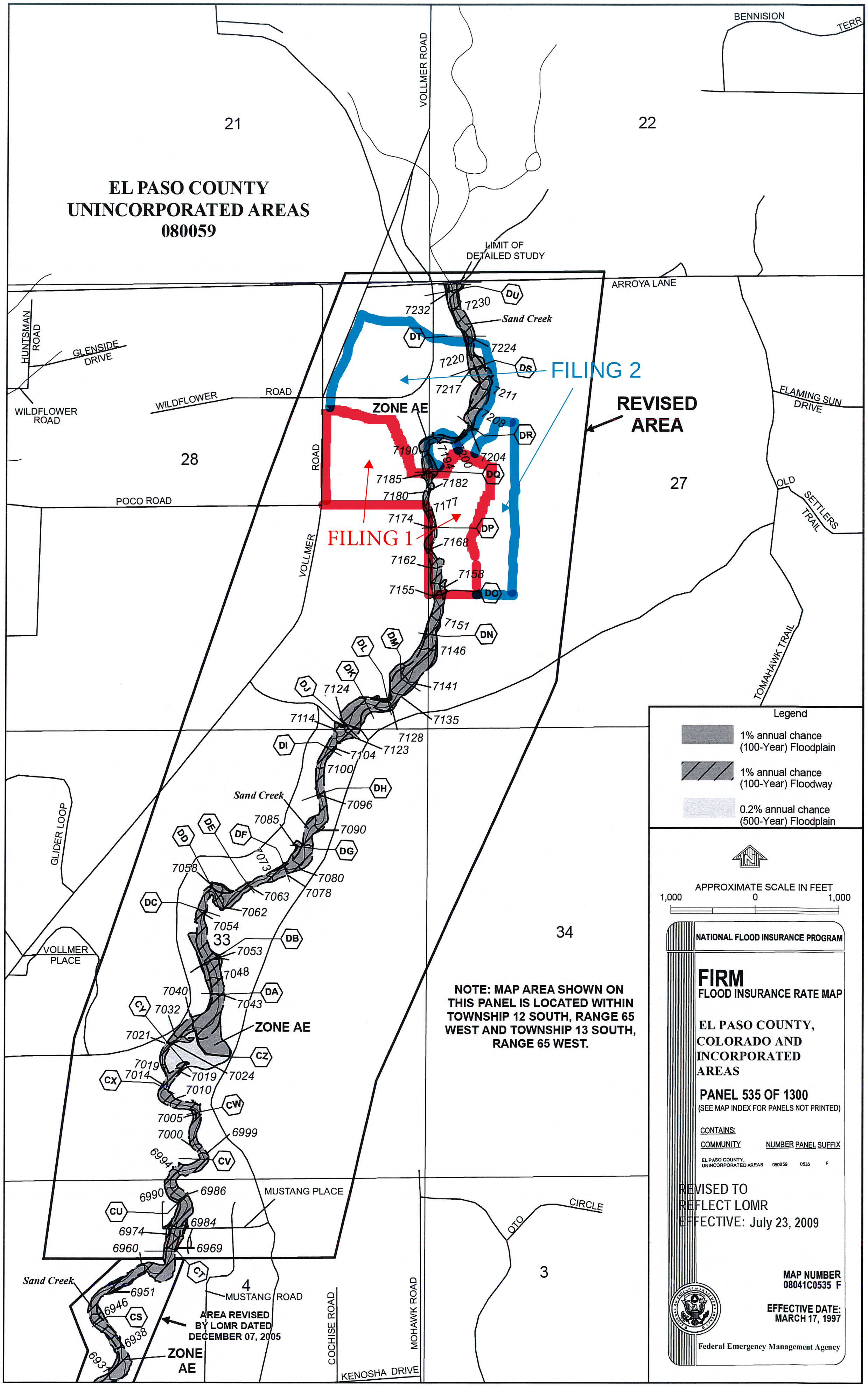


EL PASO COUNTY
UNINCORPORATED AREAS
080059
21
22
28
27
33
34
3
4
VOLLMER ROAD
BENNISION
TERR
LIMIT OF DETAILED STUDY
ARROYA LANE
Sand Creek
FILING 2
FILING 1
REVISED AREA
ZONE AE
HUNTSMAN ROAD
GLENSIDE DRIVE
WILDFLOWER ROAD
POCO ROAD
FLAMING SUN DRIVE
OLD SETTLERS TRAIL
TOMAHAWK TRAIL
GLIDER LOOP
VOLLMER PLACE
MUSTANG PLACE
MUSTANG ROAD
COCHISE ROAD
MOHAWK ROAD
KENOSHA DRIVE
OTO CIRCLE
AREA REVISED BY LOMR DATED DECEMBER 07, 2005
NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 12 SOUTH, RANGE 65 WEST AND TOWNSHIP 13 SOUTH, RANGE 65 WEST.
Legend
1% annual chance (100-Year) Floodplain
1% annual chance (100-Year) Floodway
0.2% annual chance (500-Year) Floodplain
APPROXIMATE SCALE IN FEET
1,000 0 1,000
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
EL PASO COUNTY, COLORADO AND INCORPORATED AREAS
PANEL 535 OF 1300
(SEE MAP INDEX FOR PANELS NOT PRINTED)
CONTAINS:
COMMUNITY NUMBER PANEL SUFFIX
EL PASO COUNTY, UNINCORPORATED AREAS 080059 0535 F
REVISED TO REFLECT LOMR EFFECTIVE: July 23, 2009
MAP NUMBER 08041C0535 F
EFFECTIVE DATE: MARCH 17, 1997
Federal Emergency Management Agency

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					FEET (NGVD)			
Sand Creek (cont'd)								
CA	65,292	164	427	6.1	6,748.7	6,748.7	6,749.4	0.7
CB	66,092	41	223	11.7	6,761.2	6,761.2	6,762.2	1.0
CC	66,247	90	270	9.6	6,773.6	6,773.6	6,773.7	0.1
CD	67,647	50	218	11.9	6,782.6	6,782.6	6,783.3	0.7
CE	68,297	65	284	8.8	6,793.9	6,793.9	6,794.4	0.5
CF	69,147	50	213	11.7	6,804.5	6,804.5	6,804.5	0.0
CG	70,157	50	213	11.7	6,815.1	6,815.1	6,815.3	0.2
CH	70,577	205	347	7.2	6,823.9	6,823.9	6,824.5	0.6
CI	70,627	180	267	9.4	6,826.7	6,826.7	6,827.7	1.0
CJ	70,727	210	340	7.3	6,831.1	6,831.1	6,831.1	0.0
CK	70,807	195	334	7.5	6,832.5	6,832.5	6,832.5	0.0
CL	71,162	90	255	9.8	6,838.0	6,838.0	6,839.0	1.0
CM	71,977	226	503	5.2	6,847.4	6,847.4	6,848.3	0.9
CN	73,052	174	328	7.9	6,861.1	6,861.1	6,861.2	0.1
CO	73,644	237	364	7.1	6,870.2	6,870.2	6,870.2	0.0
CP	75,142	172	324	8.0	6,888.5	6,888.5	6,888.7	0.2
CQ	76,161	109	283	9.2	6,903.5	6,903.5	6,903.7	0.2
CR	77,846	100	272	9.6	6,926.1	6,926.1	6,926.7	0.6
CS	79,187	117	287	9.1	6,944.1	6,944.1	6,944.1	0.0
CT	80,808	142	310	8.4	6,969.2	6,969.2	6,969.2	0.0
CU	81,501	120	342	7.6	6,986.1	6,986.1	6,986.5	0.4
CV	82,281	124	295	8.8	6,997.4	6,997.4	6,997.4	0.0
CW	82,897	64	237	11.0	7,005.3	7,005.3	7,006.1	0.8
CX	83,517	90	266	9.8	7,013.9	7,013.9	7,013.9	0.0
CY	84,087	70	244	10.7	7,024.3	7,024.3	7,024.3	0.0
CZ	84,473	160	322	8.1	7,040.2	7,040.2	7,040.2	0.0

Revised Data From LOMR Dated Dec. 7, 2005

Revised Data

[1] Feet Above Confluence With Fountain Creek

REVISED TO REFLECT LOMR EFFECTIVE: July 23, 2009

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY
EL PASO COUNTY, CO
AND INCORPORATED AREAS

FLOODWAY DATA

SAND CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY FEET (NGVD)	WITH FLOODWAY FEET (NGVD)	INCREASE
Sand Creek (cont'd)								
DA	85,073	139	456	5.7	7,043.0	7,043.0	7,043.1	0.1
DB	85,483	170	328	7.9	7,053.4	7,053.4	7,053.5	0.1
DC	86,103	100	274	9.5	7,054.4	7,054.4	7,054.4	0.0
DD	86,673	197	434	6.0	7,061.7	7,061.7	7,062.0	0.3
DE	87,073	83	270	9.6	7,068.2	7,068.2	7,068.3	0.1
DF	87,573	98	325	8.0	7,077.7	7,077.7	7,077.9	0.2
DG	88,003	135	304	8.6	7,085.1	7,085.1	7,085.1	0.0
DH	88,738	89	263	9.9	7,096.9	7,096.9	7,096.9	0.0
DI	89,303	74	249	10.4	7,104.1	7,104.1	7,104.3	0.2
DJ	89,663	143	309	8.4	7,123.2	7,123.2	7,123.2	0.0
DK	90,058	140	426	6.1	7,125.1	7,125.1	7,125.2	0.1
DL	90,348	102	276	9.4	7,127.6	7,127.6	7,127.8	0.2
DM	90,698	300	398	6.5	7,141.0	7,141.0	7,141.0	0.0
DN	91,388	120	292	8.9	7,148.5	7,148.5	7,148.6	0.1
DO	91,868	105	313	8.3	7,155.2	7,155.2	7,155.9	0.7
DP	92,748	65	239	10.9	7,173.8	7,173.8	7,173.8	0.0
DQ	93,468	117	288	9.0	7,184.6	7,184.6	7,184.6	0.0
DR	94,448	81	260	10.0	7,204.5	7,204.5	7,204.6	0.1
DS	95,343	100	274	9.5	7,216.8	7,216.8	7,217.2	0.4
DT	95,723	77	252	10.3	7,224.2	7,224.2	7,224.3	0.1
DU	96,333	90	266	9.8	7,232.5	7,232.5	7,233.0	0.5

[1] Feet Above Confluence With Fountain Creek

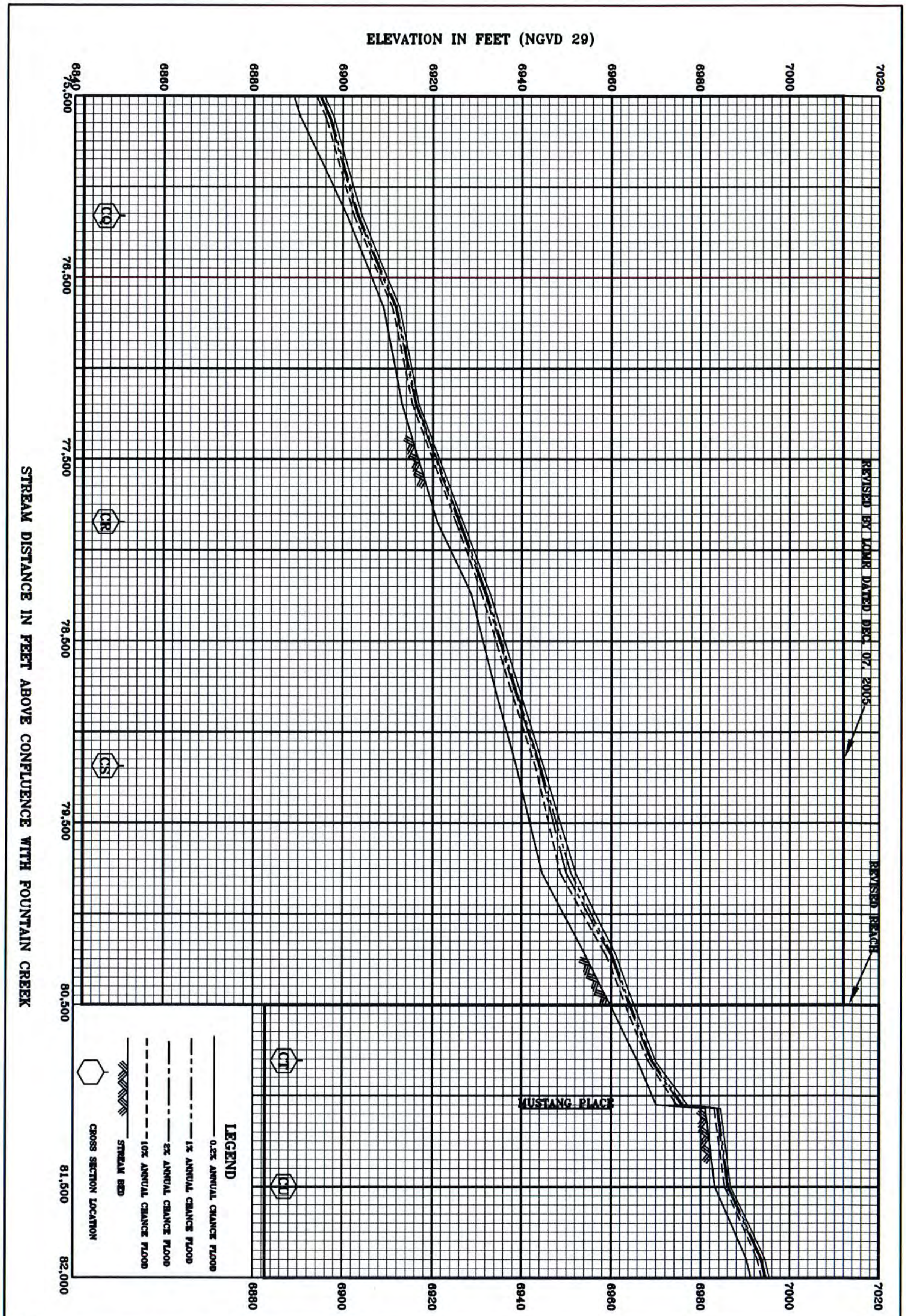
REVISED TO
REFLECT LOMR
EFFECTIVE: July 23, 2009

TABLE 5

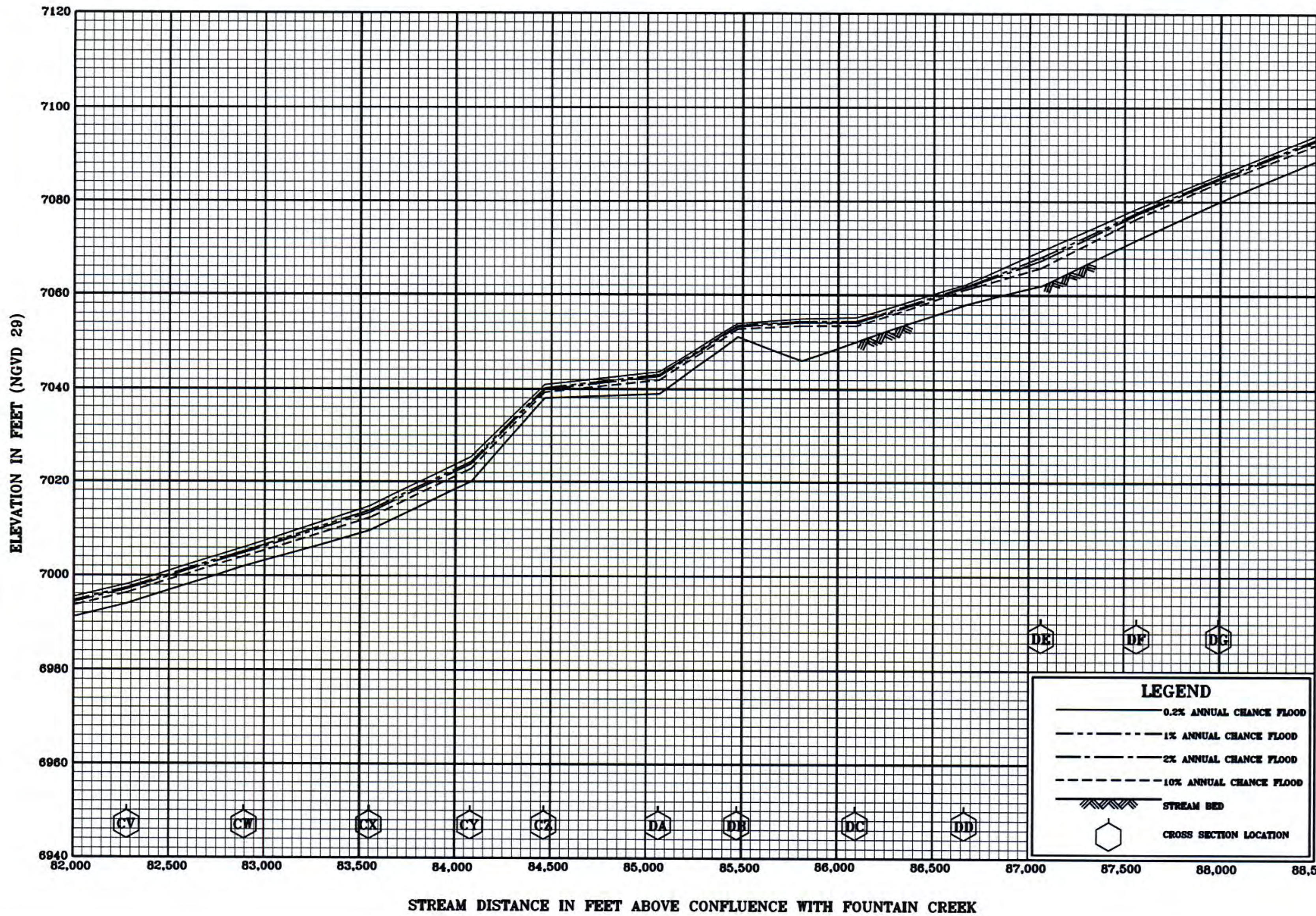
FEDERAL EMERGENCY MANAGEMENT AGENCY
EL PASO COUNTY, CO
AND INCORPORATED AREAS

FLOODWAY DATA

SAND CREEK



204P(a)	FEDERAL EMERGENCY MANAGEMENT AGENCY EL PASO COUNTY, CO AND INCORPORATED AREAS	REVISED TO REFLECT LOMR EFFECTIVE: July 23, 2009 FLOOD PROFILES SAND CREEK



FEDERAL EMERGENCY MANAGEMENT AGENCY

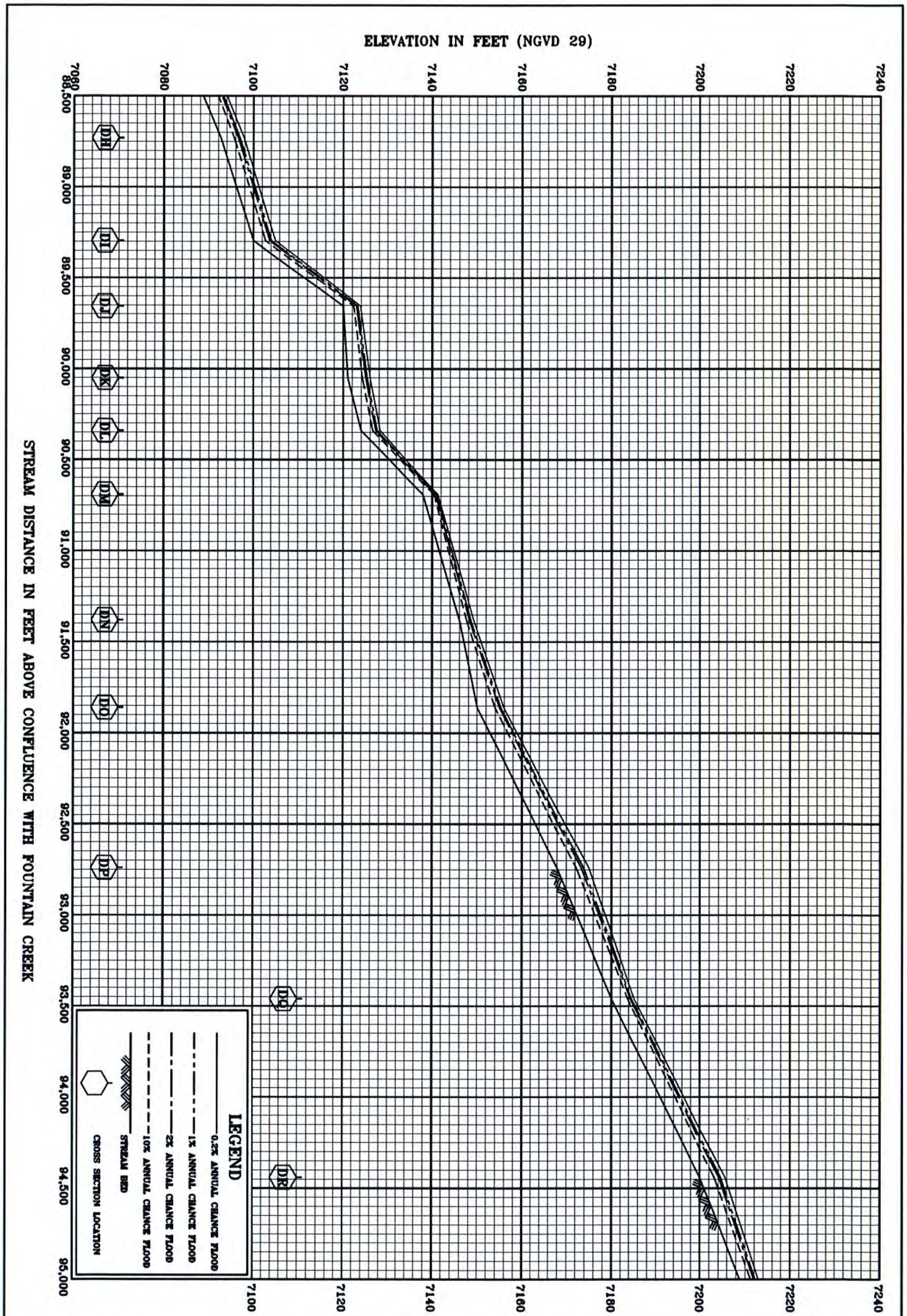
EL PASO COUNTY, CO
AND INCORPORATED AREAS

REVISED TO
REFLECT LOMR
EFFECTIVE: July 23, 2009

FLOOD PROFILES

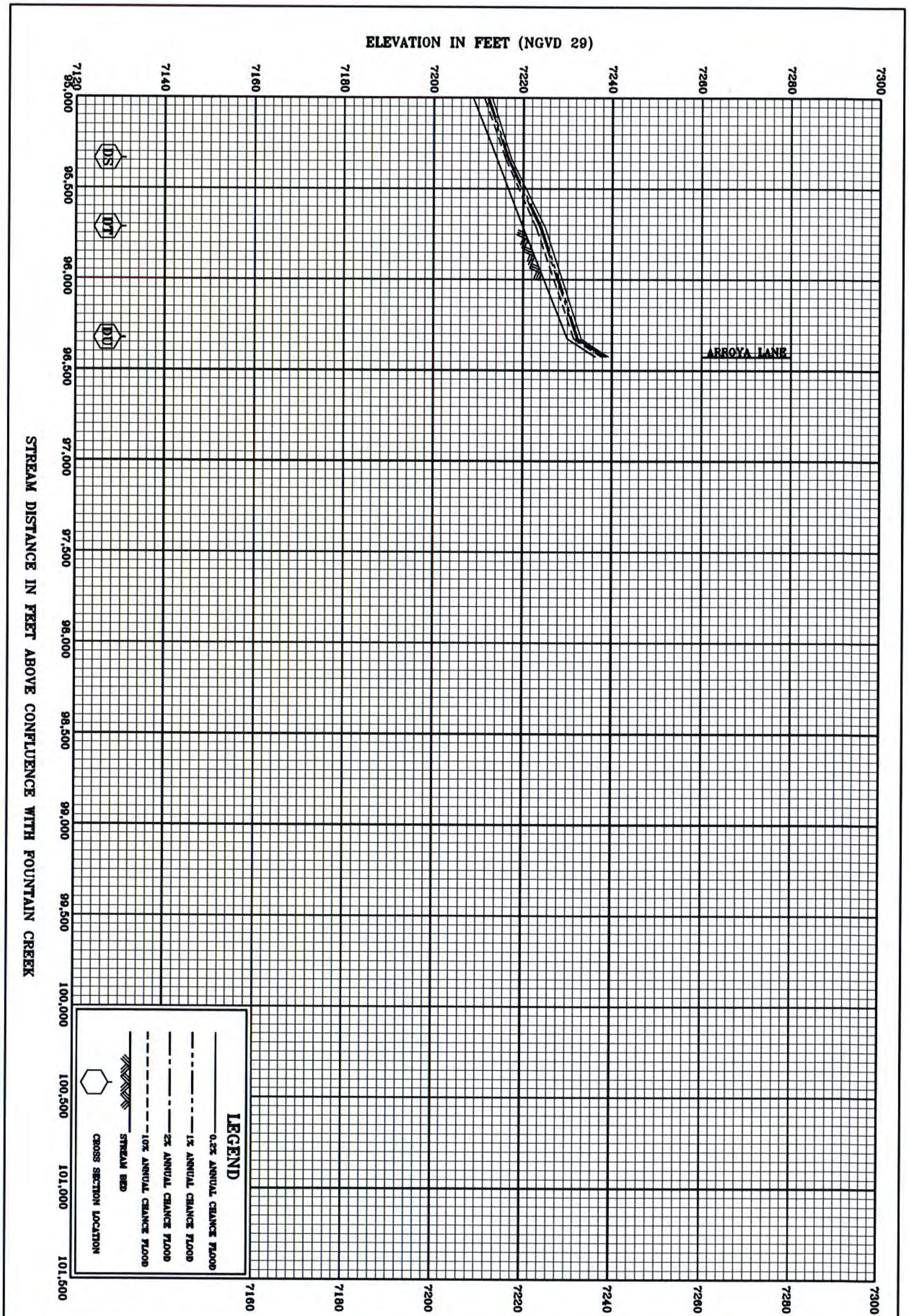
SAND CREEK

204P(b)



FEDERAL EMERGENCY MANAGEMENT AGENCY EL PASO COUNTY, CO AND INCORPORATED AREAS	REVISED TO REFLECT LOMR EFFECTIVE: July 23, 2009	FLOOD PROFILES SAND CREEK

204P(c)



204P(d)

FEDERAL EMERGENCY MANAGEMENT AGENCY

EL PASO COUNTY, CO
AND INCORPORATED AREAS

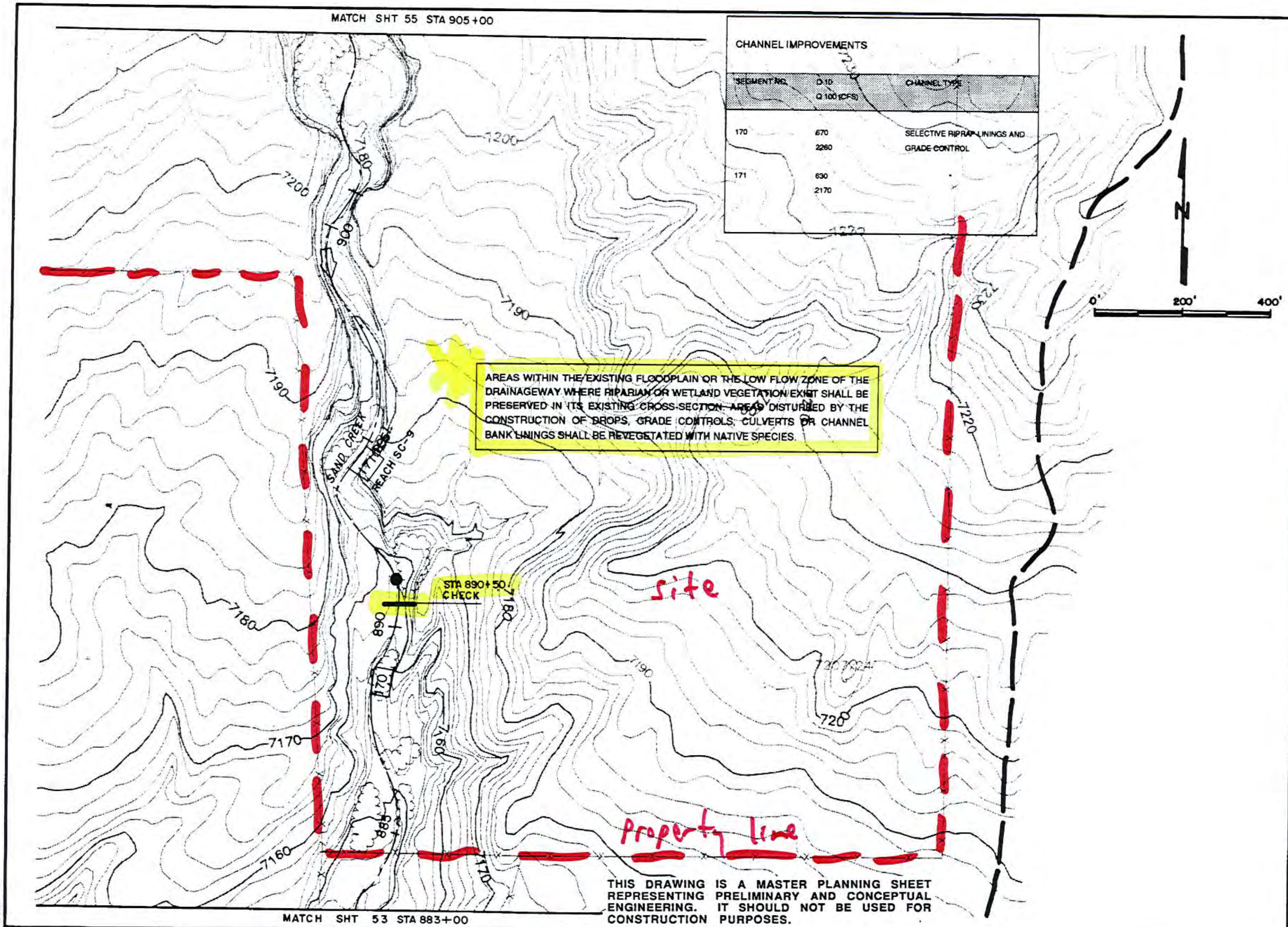
FLOOD PROFILES

REVISED TO
REFLECT LOMR
EFFECTIVE: July 23, 2009

SAND CREEK

RECOMMENDATIONS PER SAND CREEK DBPS

CLASSIC
CONSULTING
ENGINEERS & SURVEYORS

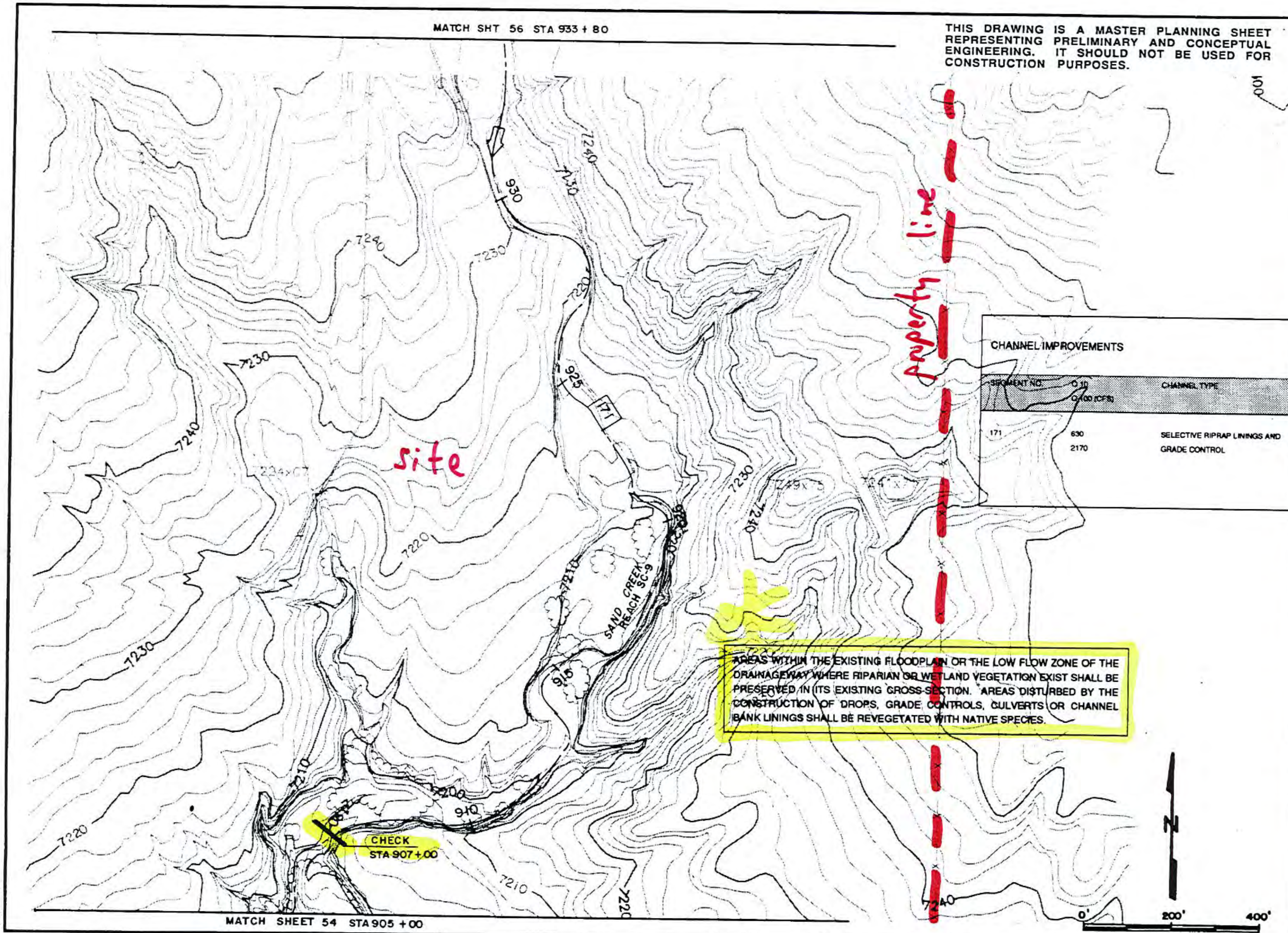


Kiowa Engineering Corporation
419 W. Bijou Street
Colorado Springs, Colorado
80905-1308

SAND CREEK DRAINAGE BASIN PLANNING STUDY
PRELIMINARY DESIGN PLANS

Project No. 90-04-09
Date: 9/92
Design: RNW
Drawn: EAK
Check: RNW
Revisions:

54



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Revisions:	

55

VI. DEVELOPMENT OF ALTERNATIVES AND RECOMMENDED PLAN

The concepts which are available for handling stormwater runoff within the Sand Creek basin have been presented and discussed in detail in the Sand Creek Drainage Basin Planning Study Development of Alternatives Report and the draft East Fork Sand Creek Drainage Basin Planning Study. The process of combining the various channel treatment options, detention schemes and roadway crossing structures into a contiguous plan for all of the reaches is presented in this chapter of the report. As a result of the evaluation of the flood control, environmental, open space, operations and maintenance, and implementation concerns within the Sand Creek basin, the following concepts were identified as having sufficient feasibility to warrant further evaluation and review:

Channel Concepts:	Floodplain Preservation Channelization, 10- or 100-year Selective Improvements
Detention:	Regional detention systems

Channel Concepts: The channel concepts listed above have been evaluated with respect to the parameters listed in the previous chapter. A concept's feasibility depends upon its impact, positive or negative, upon the evaluation parameters. ***The floodplain preservation*** concept has been considered to be the same as the ***"do-nothing"*** alternative. The floodplain preservation concept would involve the regulation of the floodplain limits, generally as depicted on the effective City of Colorado Springs and El Paso County Flood Insurance Rate Maps. Regulation of the floodplain so that future encroachments are minimized and the floodproofing of structures which are currently within the 100-year floodplain would presumably be the methods used to address the flood hazard concerns along Sand Creek. In the upper reaches of Sand Creek, the ownership or easements associated with the 100-year floodplain (or greater limits to allow for an erosion buffer zone) would be a primary issue in regards to implementation of such a concept. Detention in the upper reaches of the basin Sand Creek basin and in the East Fork Sand Creek basin will maintain the 100-year floodplain at existing limits within the lower reaches of Sand Creek. The "do-nothing" concept is feasible wherever the existing drainageway improvements are of adequate capacity to convey flood flows. ***Channelization*** would involve the lining of the Creek into a more confined flow area, and could be done for either the ***100-year or 10-year*** flood discharges. Several typical channel concepts have been presented. The primary bank lining material would probably be riprap. Grade control and/or drop structures would be required in a channelization concept so that the flood velocities could be controlled to a level requiring medium to heavy riprap. Soil cement offers an alternative to riprap and concrete for the construction of drops or grade control structures. Revegetation would occur wherever the native vegetation was disturbed by the channel construction. Willows at the toe of the riprap banks would be a minimum replacement. ***Selective linings*** would involve the construction of grade controls, drop structures, bank linings, storm sewer outlet control structures selectively sited to resist stream erosion or to reduce potential flooding damages. Areas of future concern such as at the outside bends of the creek, or at the outlets of bridges or culverts which will cross the drainageway would be subject to selective improvements.

Detention Concepts: The two general detention concepts evaluated were onsite versus regional detention. During the evaluation process, it was determined that the onsite detention concept has a low feasibility relative to a regional concept. This is because, (1) onsite detention has a unpredictable impact upon lowering peak discharges from urbanized areas to historic conditions (reference, Urbonas and Glidden, "Effect of Detention on Flows in Major Drainageways" ASCE Water Forum '81, 1981), (2) an onsite concept has little impact upon maintaining or enhancing water quality, (3) the number of onsite detention basins, their locations and size cannot be accurately determined in the undeveloped portions of the basin at this time, and (4) onsite detention would present a substantial maintenance responsibility to the jurisdictions involved. For these reasons the onsite detention concept was eliminated and regional detention basin concepts were developed. In the analysis of the channel concepts, regional detention facilities were assumed to be in place.

Channel Alternatives

Presented on Table VI-1 is a matrix of channel alternatives which were evaluated. All reaches of Sand Creek and the East Fork of Sand Creek had at least three alternatives analyzed. Presented on Tables VI-2 through VI-6 are comparative evaluations of the floodplain preservation (do-nothing), channelization and selective lining concepts, for the mainstem Sand Creek basin, by reach. The purpose of the evaluation process was to identify the relative advantages and disadvantages of each concept within each reach.

100-year peak discharge to levels. This will allow for the channel improvements to be constructed within the existing right-of way.

Reaches SC-5 and SC-6: A selective channel improvement concept has been recommended for these reaches. Detention in Reach SC-8 of the basin will maintain flows to historic peak discharge levels, however the low flows will increase in frequency and volume. For this reason it has been recommended to provide riprap channel linings at selective locations to at least the 10-year water surface and install grade controls. This will prevent the long-term degradation of the invert. A residual 100-year floodplain will remain and will offer opportunities for habitat replacement and open space preservation. Land adjacent to the drainageway is currently undeveloped or unplatted at this time which makes the feasibility of implementing this concept greater in comparison to the urbanized reaches of the creek.

Reaches SC-7 and SC-8: A selective improvement concept involving the localized lining of channel banks and grade control construction has been recommended for these reaches. The feasibility of this concept stems from the fact that flows will be reduced because of detention. Numerous individual rural ownerships cross the drainageway, however no habitable structures lie within the 100-year floodplain. Because of this, the economic feasibility of channelization concepts is low. Non-structural measures can be used to limit encroachments into floodprone areas. Additionally, the City of Colorado Springs Comprehensive plan recommends that the floodplains be maintained as open space. Potential habitat disturbances can be avoided with a selective plan, or simply replaced as part of the particular construction activity which caused the disturbance.

Reach SC-9: A floodplain preservation concept has been recommended for this reach. Little increase in urbanization is anticipated in this reach, and for this reason the existing drainageway is expected to remain stable. Localized improvements may be necessary to limit erosion caused by flow concentrations at culverts or storm sewers. Private ownership of the drainageway is anticipated to continue which lower the feasibility of channel concepts which require permanent right-of-ways or easements for construction and maintenance.

Reaches WF-1 through WF-3: A 100-year channel concept has been recommended for these reaches primarily because of the potential for flooding damages. Several roadway crossings are in need of replacement because of the flood hazard the constrictions create. Some open space enhancement potential exists for this concept since these reaches have been degraded visually by debris accumulation, bank sloughing and sedimentation. Little opportunity exists for widening the drainageway because the

Development of the Recommended Plan

Presented on Table VI-7 is a matrix representing the recommended plan for each major drainageway reach. The selection of a recommended channel treatment scheme has been based upon the qualitative and quantitative information presented in the Sand Creek Drainage Basin Planning Study Development of Alternatives report and the draft East Fork Sand Creek Drainage Basin Planning Study. Contained within the Technical Addendum to the Sand Creek Drainage Basin Planning Study Development of Alternatives report, is the alternative hydrologic, hydraulic and conceptual cost data used in the evaluation and comparison of each of the alternatives within the mainstem Sand Creek basin.

Discussion of Recommended Plan

The recommendation of a particular channel treatment or detention scheme has been based upon the qualitative and quantitative data presented. For each reach the flood hazard, environmental, cost, operations and maintenance and open space aspects of the drainageway were weighed for each alternative concept.

Reach SC-1: For this reach a 10-year channel section was recommended for further evaluation. With the implementation of regional detention in the upper basin, the 100-year floodplain will generally be confined within the existing banks, excepting at roadway crossings lacking 100-year capacity. It is recommended that a 10-year low flow channel be constructed within the invert of the existing channel through the construction of benches and sand bars. As urbanization continues towards the full development scenario, the base flow and annual flows will increase in volume and frequency. For this reason, the low flow area must be stabilized to protect the existing channel banks from undermining and subsequent bank sloughing. The benched areas offer an opportunity for habitat replacement and enhancement. At some locations within this reach, a residual 100-year floodplain will remain which will have to be regulated. The residual 100-year floodplain offers some potential for open space preservation and enhancement. This is particularly true in the portion of the reach downstream of Hancock Expressway.

Reaches SC-2 through SC-4: A 100-year channel concept has been recommended primarily because of the potential for flooding damages which exists in these reaches. Habitat disturbed by the construction of channel linings and grade control structures could be replaced along the channel toes and on the overbanks. The replacement of the Waynoka Road crossing will reduce the potential for flood damages in areas adjacent to these roadways. The detention within the upper reaches will limit the

VII. PRELIMINARY DESIGN

The results of the preliminary design analysis are summarized in this section. The alternative improvements have been quantitatively and qualitatively evaluated, and presented to the City of Colorado Springs and other interested agencies and individuals. Field review of specific areas of concern have been conducted in order to refine the channel treatments suggested for use along Sand Creek, East Fork Sand Creek and their major tributaries. The preliminary plan for the recommended alternative is shown on the drawings contained at the rear of this report.

Criteria

The City of Colorado Springs, El Paso County Drainage Criteria Manual was used in the development of the typical sections and plans for the major drainageways within the Basin. The City/County manual was supplemented by various criteria manuals with more specific application. These were:

1. "Design Guidelines and Criteria for Channels and Hydraulic Structures on Sandy Soils," prepared by Simons, Li & Associates, Inc., 1981.
2. Urban Storm Drainage Criteria Manual, Volumes I, II, and III, prepared by the Urban Drainage and Flood Control District.

Various design plans for roadway and channel improvement projects, either proposed or already constructed were reviewed in order to prepare the preliminary design plans. Specifically, the project design plans for the Las Vegas Street and Galley Road bridge replacement projects were reviewed and the improvements incorporated in the preliminary design. The **proposed** Sand Creek Stabilization Project, AT&SF Railroad to Hancock Expressway and the **proposed** Sand Creek Stabilization Project at Fountain Boulevard design plans have been reviewed and incorporated into the preliminary design plan and profiles.

Hydrology

Presented on Table VII-1 is selected hydrologic data to be used for the sizing of major drainageway improvements within the Basin. **Peak flow rates for the 10- and 100-year frequency incorporating and the selected detention alternatives for the Sand Creek and East Fork Sand Creek Basin are summarized for key points along the major drainageways.** Contained within the The technical addenda of this report contains a complete listing of peak discharges for all the sub-basins, stream segments and design points shown on Exhibit 1.

The sizing the drainageway improvements for the tributaries will need to be verified during the final design and layout of the proposed drainageway facilities. Land development activities may alter the location of design points along the tributaries, and therefore slight alteration in a sub-basin's length, slope and area may occur. The methods outlined in the City/County Drainage Criteria Manual should be applied during final design analysis. The rational method should be used to check the peak flow rates for all tributary drainageways and storm sewers draining areas less than 100 acres in size.

Channels

The recommended channel sections for each reach of drainageway has been outlined in Section VI of this report. In general, the banks of Sand Creek channel, from the confluence with Fountain Creek to the proposed Sand Creek Detention Basin No. 2 are to be lined, or in some cases relined, with riprap to either a 10-year or 100-year flow depth, as shown on the preliminary design plans. Above the Sand Creek Detention Basin No. 2, selectively located riprap bank protection such as at outside bends, at bridge or culvert outlets, and at confluences with side tributaries have been recommended. In conjunction with the selective improvement measures, and the 10-year low flow concept, the 100-year floodplain should be preserved and regulated. Wherever existing bank linings were judged to be adequate, no improvements have been recommended at this time.

For the West Fork Sand Creek, 100-year riprap bank linings have been recommended in order to address the 100-year flooding hazard which exists at numerous locations along the West Fork. The final design improvements shown in the Palmer Park Bridge Replacement project drawings have been incorporated into the preliminary design plans. In the uppermost reaches of the West Fork, a short segment of rectangular concrete channel has been recommended because of right-of-way constraints.

For the Center Tributary of Sand Creek, 100-year riprap lined channels have been recommended from the confluence with East Fork to Platte Avenue. Above Platte Avenue, the existing concrete channels have adequate capacity except where the drainageway channel has yet to be improved. The final design plans for the US 24 Bypass Project, Phase II have been incorporated into the plans. As part of the bypass construction, it is proposed to line the Center Tributary using riprap. The location of the proposed roadway, new crossings, drops and channel as shown on the Phase II Bypass plans have been reflected on the preliminary design drawings.

For the East Fork Sand Creek drainageway, riprap lined channel banks have been recommended for the majority of the reaches. This is mainly because of the high level of development predicted for the basin in the area known as the Banning-Lewis Ranch development. Open space to accommodate the 100-year floodplains should be allowed for as the East Fork Sand Creek drainageways develop. This is consistent with the Banning-Lewis Ranch master development plan which was approved at the time of annexation of this property. Above Woodmen Road, selective channel lining improvements and grade control structures have been recommended.

For the most part the side tributaries have been recommended to be lined with riprap, however there are some locations in the upper basin which have been proposed to be grasslined. The location of the side drainageways should be considered approximate and may very likely be modified in the future because of land development.

The primary criteria used when sizing the proposed channel sections has been velocity. For all riprap lined channels, the average design velocity should be no greater than 9 feet per second. This criteria allows for the use of Type H riprap within the main flow area of the drainageway. For the case of a 10-year channel with an overall floodplain section, limiting the main channel velocity to 9 feet per second will result in overbank velocities in the five feet per second range. At this level of overbank velocity, native vegetation will be able to withstand the erosive forces which might result in a 100-year flow event. Velocities approaching 10 feet per second could occur at constrictions such as at roadway crossings and at culvert outlets.

Drop Structures and Check Structures

Drop and check structures have been sited along Sand Creek in order to slow the channel velocity to the recommended 7 feet per second, and to prevent localized and long-term stream degradation from affecting channel linings and overbanks. In the reaches to be selectively lined, drops and check structures will protect the native vegetation from the detrimental effects of stream invert headcutting. Several types of structures could be considered for the Sand Creek Basin. For channel bottom widths in excess of fifty feet, soil cement or sheet piling drops/checks are feasible. For channels narrower than this, reinforced concrete structures are probably the best alternative. **A maximum drop height of three feet is recommended. The methodology recommended for use when designing vertical structures is contained with Volume II of the Urban Storm Drainage Criteria Manual.**

Detention

The recommended plan calls for the construction of six regional detention basins within the Sand Creek basin, and six regional basins within the East Fork Sand Creek basin. The purpose of the Sand Creek detention basins is to limit peak discharges at Powers Boulevard to existing development condition levels. The detention basins in the upper portions of the Sand Creek basin will keep the majority of the existing channel sections and bridges below Powers Boulevard with adequate flow capacity in the future development condition. The detention basins within the East Fork Sand Creek basin have been sized to maintain the flow outfalling from the Banning-Lewis Ranch property at existing levels. This in turn will help to reduce flow to the mainstem of Sand Creek. The detention basins have been designed to accommodate the 100-year future condition volume without overtopping the overflow spillway. Sand Creek Basin Nos. 2 and 6, and East Fork Sand Creek Basin Nos. 1, 2, and 3 will be classified as jurisdictional structures, and their design and operation would be subject to State Engineer's office criteria. Sand Creek basins number 1 and 3 should be designed so as to take advantage of the adjacent roadway embankments, and therefore classifying as incidental storage and not subject State Engineer's regulations.

At Stetson Hills Boulevard, the roadway embankment has created a 2 acre open water wetland which was identified during the environmental review of the basin. It is recommended that this wetland be preserved. Accordingly, an outlet control structure will have to be constructed to pass the 100-year discharge to the downstream channel without overtopping the roadway. No floodwater storage or routing has been accounted for in the hydrology modelling at this roadway for the selected detention plan.

For the East Fork Sand Creek detention basin numbers 2, and 3, the existing embankment and outlet structure act to maintain a permanent pool at this time. It is recommended that the design of these detention basins be directed at maintaining the permanent pool when the flood control storage is to be added. The existence of a permanent pool may enhance the water quality aspects of these basins, and offer the opportunity of open space development conducive with open water.

Water Quality

Improvement of urban stormwater quality has become and important issue in drainage basin planning. Many pollutants are naturally associated with sediments that enter sensitive receiving waters. The pollutants are naturally occurring compounds that are carried to the drainageways in storm runoff. Other pollutants are the result of urbanization such as lawn chemicals, oil and grease, pet feces, lawn clippings and other items. Many pollutants can be limited by programs such as erosion control at construction sites, educational programs to inform the public as to the proper use of lawn chemicals, oil recycling programs and street sweeping programs. Even with these programs in place, erosion along the drainageways can generate large quantities of sediment that can settle out along the downstream channel bottoms.

TABLE VIII-2: SAND CREEK DRAINAGE BASIN PLANNING STUDY
DRAINAGEWAY CONVEYANCE COST ESTIMATE
WITH SELECTED DETENTION ALTERNATIVES

SEGMENT NUMBER	REACH NUMBER	SEGMENT LENGTH (FT)	IMPROVEMENT TYPE	IMP. LENGTH (FT)	UNIT COST ($/LF)	NUMBER OF GRADE CONTROLS	GRADE CONTROL LENGTH (FT)	TOTAL REIMBURSABL COSTS	TOTAL COST
148-2	"	2600	"	2150	127	5	620	$384,650	$384,650
151	SC-8	1700	10-YEAR RIPRAP	500	238	3	250	$164,000	$164,000
160	"	5100	SEL. LININGS (1 SIDE)	4400	127	6	720	$688,400	$688,400
			10-YR RIPRAP	600	238	0	0	$142,800	$142,800
	"								
163	"	6300	SEL. LININGS (1 SIDE)	2600	127	15	1200	$546,200	$546,200
			10-YR RIPRAP	350	238	0	0	$83,300	$83,300
187	"	1200	SEL. LININGS (1 SIDE)	0	0	2	160	$28,800	$28,800
170	SC-9	3200	"	0	0	4	320	$57,600	$57,600
171	"	5000	"	0	0	2	170	$30,600	$30,600
172	"	3650	"	0	0	2	150	$27,000	$27,000
TOTAL SAND CREEK DRAINAGEWAY								$15,560,220	$18,279,420

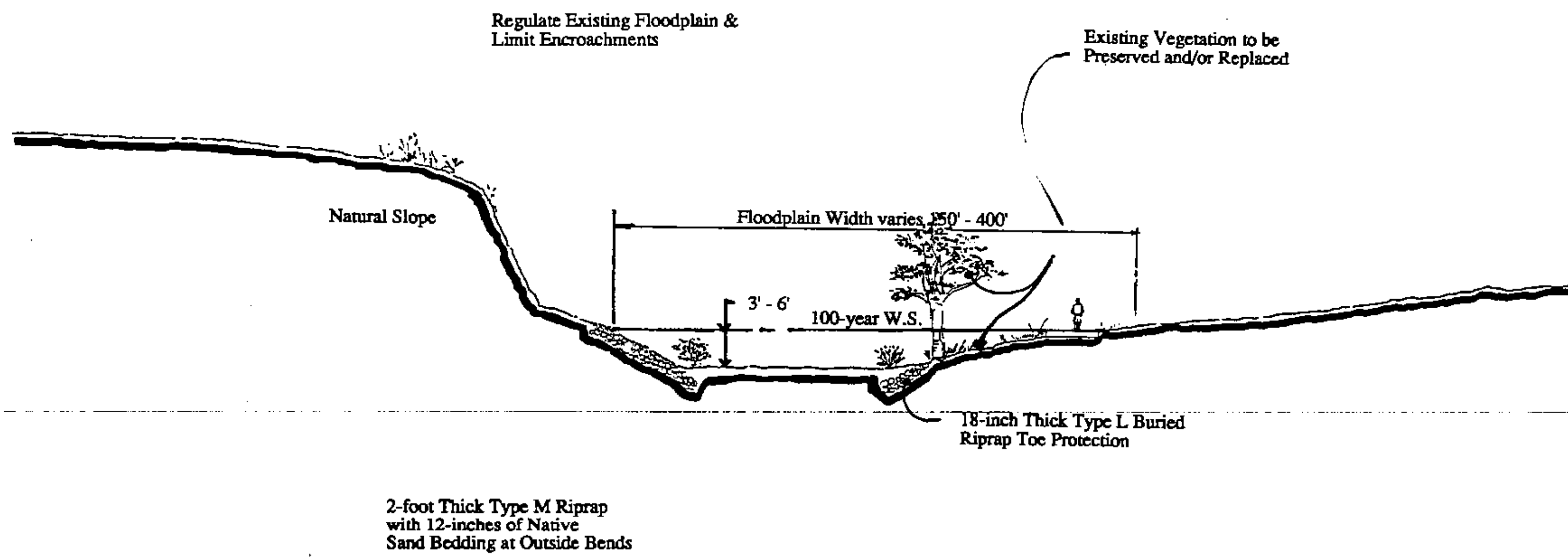
Claimed in Filing 1?

offsite

TABLE VIII-3: SAND CREEK DRAINAGE BASIN PLANNING STUDY
TRIBUTARY DRAINAGEWAY CONVEYANCE COST ESTIMATE
SAND CREEK, CENTER TRIBUTARY AND WEST FORK SAND CREEK

SEGMENT NUMBER	REACH NUMBER	IMPROVEMENT TYPE	IMP. LENGTH (FT)	UNIT COST ($/LF)	NUMBER OF GRADE CONTROLS	LENGTH OF GRADE CONTROL (FT)	TOTAL REIMBURSABLE COSTS	TOTAL COST
147-2	"	"	1150	200	1	30	$235,400	$235,400
153-1	"	"	600	150	0	0	$90,000	$90,000
153-2	"	"	450	150	0	0	$67,500	$67,500
152-1	SC-7	100-YEAR GRASSLINED	1650	150	0	0	$247,500	$247,500
152-2	"	"	800	150	2	100	$138,000	$138,000
150-1	"	100-YEAR STORM SEWER 36" RCP	800	58	0	0	$46,400	$46,400
150-2	"	100-YEAR RIPRAP	2400	200	0	0	$480,000	$480,000
161-1	"	100-YEAR GRASSLINED	550	150	0	0	$82,500	$82,500
154	SC-8	"	2100	200	10	600	$528,000	$528,000
157	"	"	2400	200	13	520	$573,600	$573,600
155-1	"	100-YEAR GRASSLINED	550	175	4	140	$121,450	$121,450
159	"	100-YEAR RIPRAP	3450	200	14	840	$841,200	$841,200
164	"	"	1350	200	5	200	$306,000	$306,000
186	"	"	2250	200	5	200	$486,000	$486,000
169	"	"	650	175	1	40	$120,950	$120,950
173	SC-9	"	950	175	8	320	$223,850	$223,850
WEST FORK SAND CREEK								
154-1	WF-1	100-YEAR RIPRAP	1550	223	2	100	$0	$363,650
161	"	"	600	223	2	80	$0	$148,200
164-2	"	100-YEAR GRASSLINED	500	150	0	0	$0	$75,000
164-4	"	100-YEAR RIPRAP	2500	175	9	280	$0	$487,900
165-1	"	"	1350	175	0	0	$0	$236,250
TOTAL SAND CREEK TRIBUTARY DRAINAGEWAYS							$7,420,650	$12,543,750

offsite



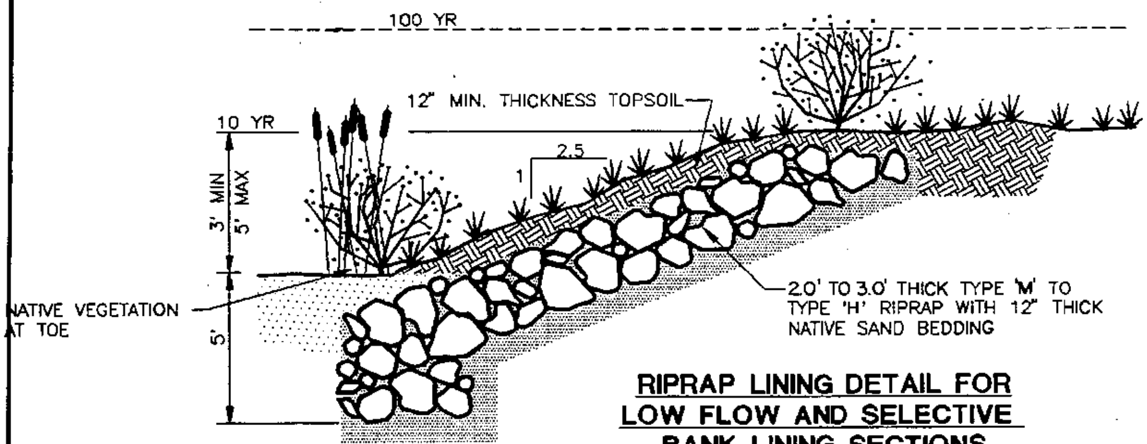
Kiowa Engineering Corporation
419 W. Bijou Street
Colorado Springs, Colorado
80905-1308

SAND CREEK DRAINAGE BASIN PLANNING STUDY

Typical Channel Sections

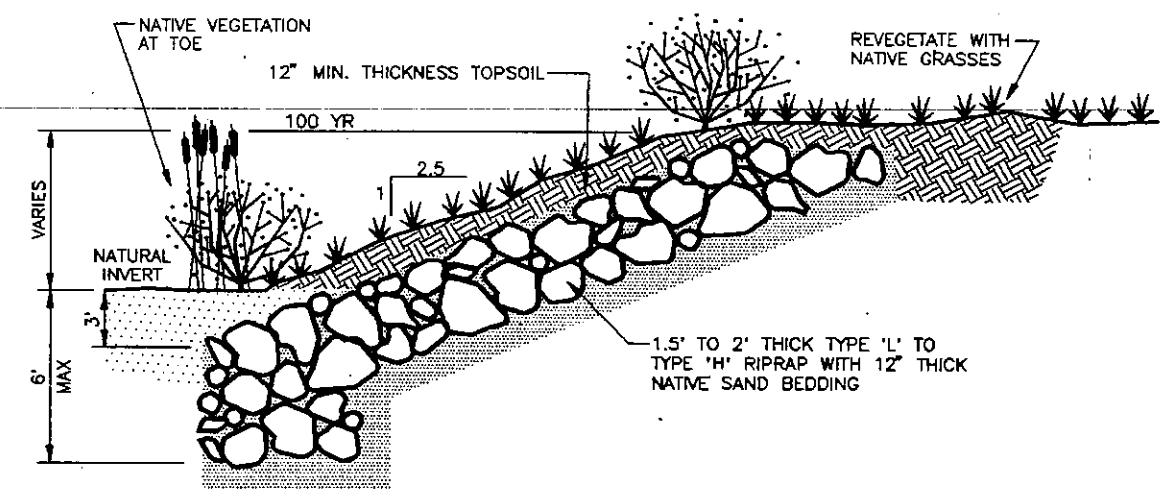
Project No.:
Date:
Design:
Drawn:
Check:
Revisions:

CS-3



RIPRAP LINING DETAIL FOR LOW FLOW AND SELECTIVE BANK LINING SECTIONS

NTS



RIPRAP LINING DETAIL FOR 100 YR CHANNEL SECTIONS

NTS

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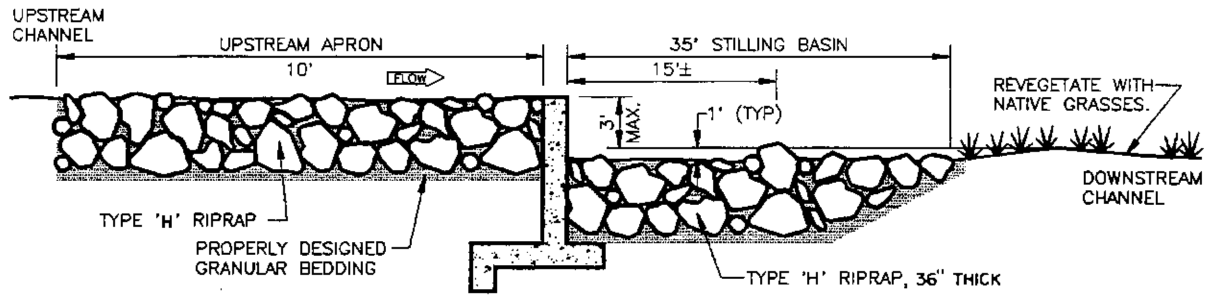
Colorado Springs, Colorado
80905-1308

SAND CREEK DRAINAGE BASIN PLANNING STUDY

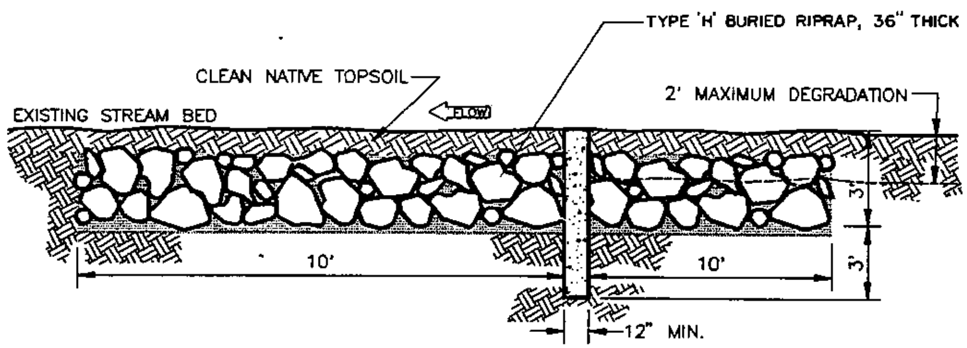
Project No
Date:
Design:
Drawn:
Check.
Revisions:

CS-6



NOTE: DIMENSIONS OF APRON, STILLING BASIN, RIPRAP, AND CHECK STRUCTURE IS TO BE DETERMINED DURING FINAL DESIGN.

TYPICAL DROP STRUCTURE
GENERALIZED PROFILE
NTS



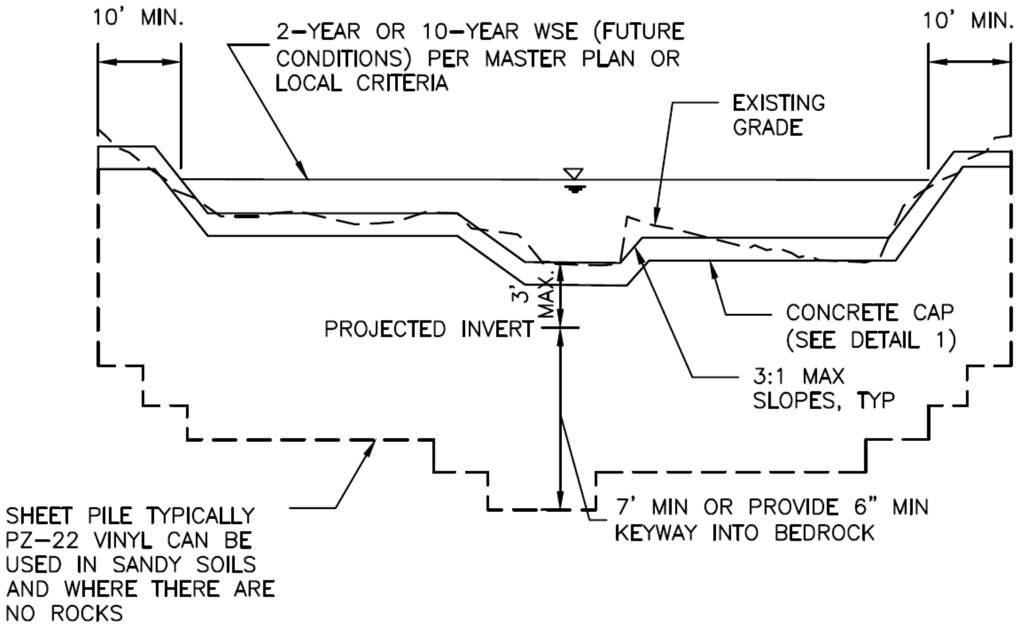
TYPICAL EROSION CONTROL
CHECK PROFILE
NTS

Kiowa Engineering Corporation
419 W. Bijou Street
Colorado Springs, Colorado
80905-1308

SAND CREEK DRAINAGE
BASIN PLANNING STUDY

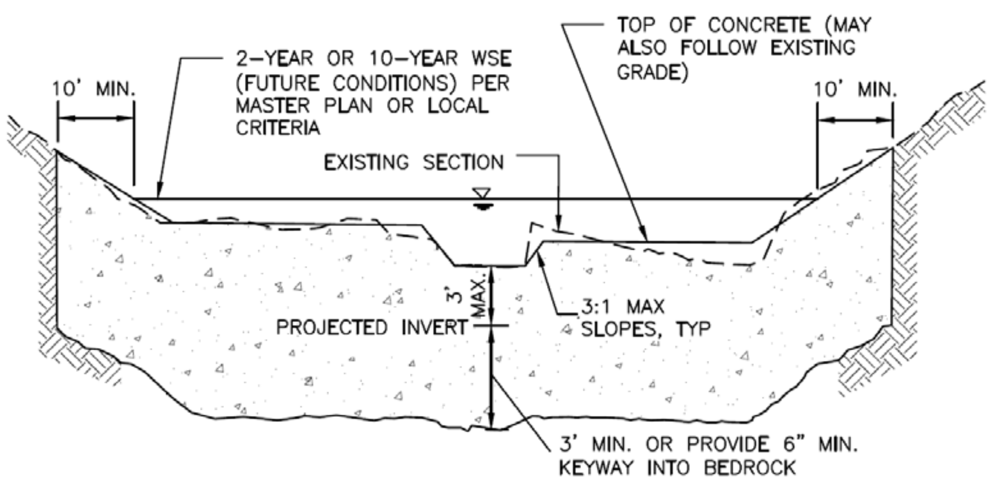
Project No:
Date:
Design:
Drawn:
Check:
Revisions:

CS-7



NOTE: THE STRUCTURE MAY BE COVERED WITH 6" OF SOIL OUTSIDE OF THE LOW FLOW AREA.

SECTION A1
SHEET PILE CHECK



NOTES:
1. TRENCH IN UNDISTURBED SOIL. FORM TOP 6" OF CHECK. DO NOT OVER EXCAVATE TO FORM WALLS OR CONSTRUCT A FOOTING.
2. THE STRUCTURE MAY BE COVERED WITH 6" OF SOIL OUTSIDE OF THE LOW FLOW AREA.
3. VIBRATE CONCRETE INTO TRENCH.

SECTION A2
CONCRETE CHECK

Figure 9-27. Check structure details (Part 2 of 3)

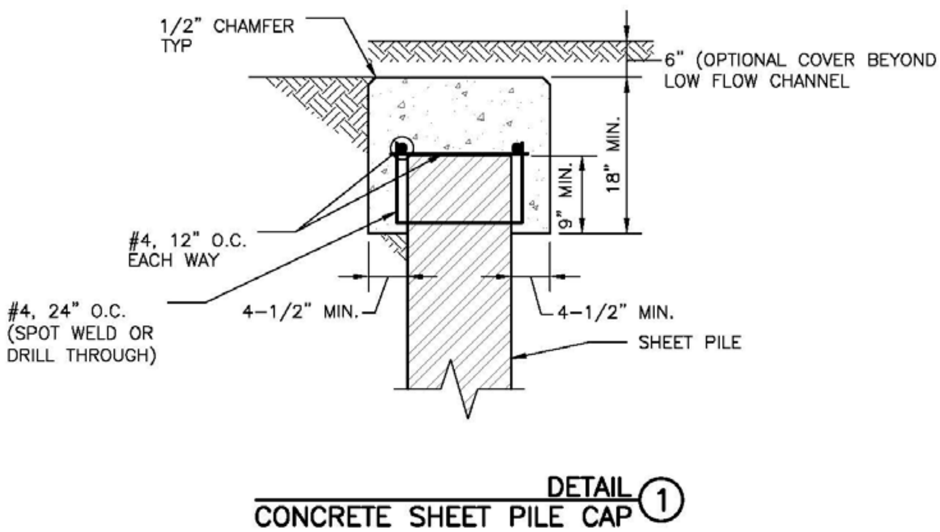


Figure 9-28. Check structure details (Part 3 of 3)

HYDROLOGIC CALCULATIONS

CLASSIC
CONSULTING
ENGINEERS & SURVEYORS

For Colorado Springs and much of the Fountain Creek watershed, the 1-hour depths are fairly uniform and are summarized in Table 6-2. Depending on the location of the project, rainfall depths may be calculated using the described method and the NOAA Atlas maps shown in Figures 6-6 through 6-17.

Table 6-2. Rainfall Depths for Colorado Springs

Return Period	1-Hour Depth	6-Hour Depth	24-Hour Depth
2	1.19	1.70	2.10
5	1.50	2.10	2.70
10	1.75	2.40	3.20
25	2.00	2.90	3.60
50	2.25	3.20	4.20
100	2.52	3.50	4.60

Where Z= 6,840 ft/100

These depths can be applied to the design storms or converted to intensities (inches/hour) for the Rational Method as described below. However, as the basin area increases, it is unlikely that the reported point rainfalls will occur uniformly over the entire basin. To account for this characteristic of rain storms an adjustment factor, the Depth Area Reduction Factor (DARF) is applied. This adjustment to rainfall depth and its effect on design storms is also described below. The UDFCD UD-Rain spreadsheet, available on UDFCD's website, also provides tools to calculate point rainfall depths and Intensity-Duration-Frequency curves[2] and should produce similar depth calculation results.

2.2 Design Storms

Design storms are used as input into rainfall/runoff models and provide a representation of the typical temporal distribution of rainfall events when the creation or routing of runoff hydrographs is required. It has long been observed that rainstorms in the Front Range of Colorado tend to occur as either short-duration, high-intensity, localized, convective thunderstorms (cloud bursts) or longer-duration, lower-intensity, broader, frontal (general) storms. The significance of these two types of events is primarily determined by the size of the drainage basin being studied. Thunderstorms can create high rates of runoff within a relatively small area, quickly, but their influence may not be significant very far downstream. Frontal storms may not create high rates of runoff within smaller drainage basins due to their lower intensity, but tend to produce larger flood flows that can be hazardous over a broader area and extend further downstream.

- **Thunderstorms**: Based on the extensive evaluation of rain storms completed in the Carlton study (Carlton 2011), it was determined that typical thunderstorms have a duration of about 2 hours. The study evaluated over 300,000 storm cells using gage-adjusted NEXRAD data, collected over a 14-year period (1994 to 2008). Storms lasting longer than 3 hours were rarely found. Therefore, the results of the Carlton study have been used to define the shorter duration design storms.

  To determine the temporal distribution of thunderstorms, 22 gage-adjusted NEXRAD storm cells were studied in detail. Through a process described in a technical memorandum prepared by the City of Colorado Springs (City of Colorado Springs 2012), the results of this analysis were interpreted and normalized to the 1-hour rainfall depth to create the distribution shown in Table 6-3 with a 5 minute time interval for drainage basins up to 1 square mile in size. This distribution represents the rainfall

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
Business													
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
Residential													
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
Industrial													
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
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
Undeveloped Areas													
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
Streets													
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
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

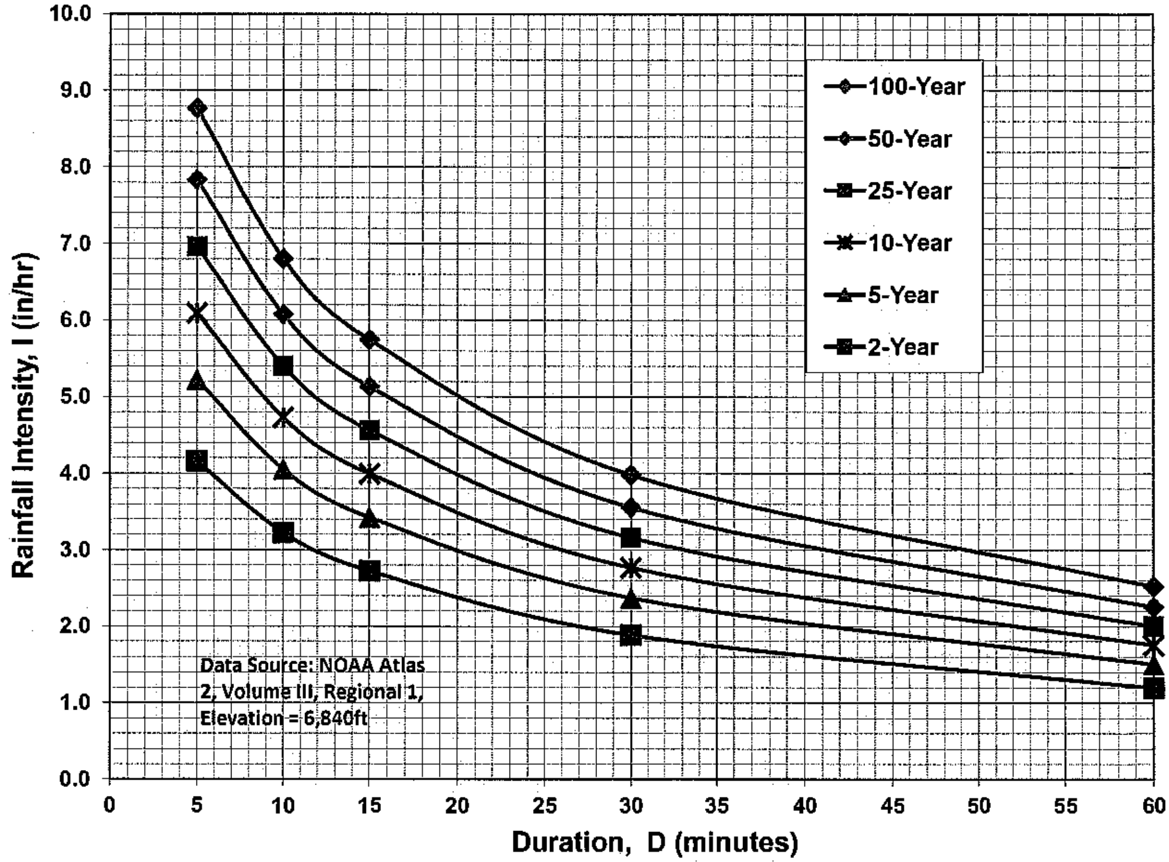
One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the hydraulically most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration 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.

Table 6-10. NRCS Curve Numbers for Frontal Storms & Thunderstorms for Developed Conditions (ARCII)

Fully Developed Urban Areas (vegetation established)[1]	Treatment	Hydrologic Condition	% I	Pre-Development CN			
				HSG A	HSG B	HSG C	HSG D
Open space (lawns, parks, golf courses, cemeteries, etc.):							
Poor condition (grass cover < 50%)	-----	-----	---	68	79	86	89
Fair condition (grass cover 50% to 75%)	-----	-----	---	49	69	79	84
Good condition (grass cover > 75%)	-----	-----	---	39	61	74	80
Impervious areas:							
Paved parking lots, roofs, driveways, etc. (excluding right-of-way	-----	-----	---	98	98	98	98
Streets and roads:							
Paved; curbs and storm sewers (excluding right-of-way)	-----	-----	---	98	98	98	98
Paved; open ditches (including right-of-way)	-----	-----	---	83	89	92	93
Gravel (including right-of-way)	-----	-----	---	76	85	89	91
Dirt (including right-of-way)	-----	-----	---	72	82	87	89
Western desert urban areas:							
Natural desert landscaping (pervious areas only)	-----	-----	---	63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)	-----	-----	---	96	96	96	96
Urban districts:							
Commercial and business	-----	-----	85	89	92	94	95
Industrial	-----	-----	72	81	88	91	93
Residential districts by average lot size:							
1/8 acre or less (town houses)	-----	-----	65	77	85	90	92
1/4 acre	-----	-----	38	61	75	83	87
1/3 acre	-----	-----	30	57	72	81	86
1/2 acre	-----	-----	25	54	70	80	85
1 acre	-----	-----	20	51	68	79	84
2 acres	-----	-----	12	46	65	77	82
Developing Urban Areas[1]	**Treatment[2]**	**Hydrologic Condition[3]**	**% I**	**HSG A**	**HSG B**	**HSG C**	**HSG D**
Newly graded areas (pervious areas only, no vegetation)	-----	-----	---	77	86	91	94
Cultivated Agricultural Lands[1]	**Treatment**	**Hydrologic Condition**	**% I**	**HSG A**	**HSG B**	**HSG C**	**HSG D**
Fallow	Bare soil	-----	---	77	86	91	94
	Crop residue cover (CR)	Poor	---	76	85	90	93
		Good	---	74	83	88	90
Row crops	Straight row (SR)	Poor	---	72	81	88	91
		Good	---	67	78	85	89
	SR + CR	Poor	---	71	80	87	90
		Good	---	64	75	82	85
	Contoured (C)	Poor	---	70	79	84	88
		Good	---	65	75	82	86
	C + CR	Poor	---	69	78	83	87
		Good	---	64	74	81	85
	Contoured & terraced (C&T)	Poor	---	66	74	80	82
		Good	---	62	71	78	81
	C&T+ CR	Poor	---	65	73	79	81
		Good	---	61	70	77	80
Small grain	SR	Poor	---	65	76	84	88
		Good	---	63	75	83	87
	SR + CR	Poor	---	64	75	83	86
		Good	---	60	72	80	84
	C	Poor	---	63	74	82	85
		Good	---	61	73	81	84
	C + CR Poor	Poor	---	62	73	81	84
		Good	---	60	72	80	83
	C&T	Poor	---	61	72	79	82
		Good	---	59	70	78	81
	C&T+ CR	Poor	---	60	71	78	81
		Good	---	58	69	77	80

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.

EFFECTIVE IMPERVIOUSNESS - POND 2

Basin	Acreage	Imp.%
D1 (Fil. 1 Report)	1.1	90%
D2 (Fil. 1 Report)	2.2	60%
H (Fil. 1 Report)	2.0	25%
OS-3 (Fil. 1 Report)	2.5	30%
OS-4 (Fil. 1 Report)	3.1	25%
OS-12 (Fil. 1 Report)	15.0	10%
OS-13 (Fil. 1 Report)	1.4	20%
OS-14 (Fil. 1 Report)	9.1	20%
I (Fil. 1 Report)	3.7	30%
K (Fil. 1 Report)	1.5	30%
L (Fil. 1 Report)	7.3	30%
N (Fil. 1 Report)	2.1	30%
P (Fil. 1 Report)	2.7	30%
Q (Fil. 1 Report)	2.2	10%
OS-4	2.5	2%
OS-5	13.7	2%
OS-6	1.5	2%
OS-8	3.6	30%
J	5.9	30%
N	0.63	30%
O	2.8	30%
P	1.0	30%
Q	1.9	30%
R	2.7	30%
S	6.6	30%
T	1.0	30%
U	1.5	30%
Total	**101.2**	**21.7%**

EFFECTIVE IMPERVIOUSNESS - POND 3

Basin	**Acreage**	**Imp.%**
EX-7	27.6	7.0%
OS-1	3.9	15.1%
OS-2	2.9	24.6%
A	9.5	15.2%
B	6.0	18.9%
C	3.3	23.0%
D	2.3	17.9%
E	8.5	15.6%
Total	**64.0**	**13.0%**

JOB NAME: *RETREAT AT TIMBERRIDGE FILING NO. 2*
JOB NUMBER: *1185.20*
DATE: *03/17/21*
CALCULATED BY: *MAW*

FINAL DRAINAGE REPORT ~ BASIN RUNOFF COEFFICIENT SUMMARY

		IMPERVIOUS AREA / STREETS				LANDSCAPE/DEVELOPED AREAS				WEIGHTED			WEIGHTED CA			
BASIN	TOTAL AREA (AC)	AREA (AC)	C(2)	C(5)	C(100)	AREA (AC)	C(2)	C(5)	C(100)	C(2)	C(5)	C(100)	**CA(2)**	**CA(5)**	**CA(100)**	**EFFECTIVE IMPERVIOUS (%)**
EX-1	12.7	0.00	0.89	0.90	0.96	12.7	0.05	0.12	0.39	0.03	0.09	0.36	**0.38**	**1.14**	**4.57**	2.0%
EX-2	29.4	0.00	0.89	0.90	0.96	29.4	0.05	0.12	0.39	0.03	0.09	0.36	**0.88**	**2.65**	**10.58**	2.0%
EX-3	9.1	0.00	0.89	0.90	0.96	9.1	0.05	0.12	0.39	0.03	0.09	0.36	**0.27**	**0.82**	**3.28**	2.0%
EX-4	84.9	1.50	0.57	0.59	0.70	83.4	0.05	0.12	0.39	0.03	0.09	0.36	**2.55**	**7.64**	**30.56**	3.4%
EX-5	34.2	1.50	0.57	0.59	0.70	32.7	0.05	0.12	0.39	0.03	0.09	0.36	**1.03**	**3.08**	**12.31**	5.4%
EX-7	27.6	0.00	0.89	0.90	0.96	27.6	0.05	0.12	0.39	0.05	0.12	0.39	**1.38**	**3.31**	**10.76**	7.0%
OS-1	3.9	0.20	0.89	0.90	0.96	3.7	0.06	0.14	0.40	0.10	0.18	0.43	**0.40**	**0.70**	**1.67**	15.1%
OS-2	2.9	0.50	0.89	0.90	0.96	2.4	0.06	0.14	0.40	0.20	0.27	0.50	**0.59**	**0.79**	**1.44**	24.6%
OS-3	0.9	0.00	0.89	0.90	0.96	0.9	0.06	0.14	0.40	0.06	0.14	0.40	**0.05**	**0.13**	**0.36**	11.0%
OS-4	2.5	0.00	0.89	0.90	0.96	2.5	0.03	0.09	0.36	0.03	0.09	0.36	**0.08**	**0.23**	**0.90**	2.0%
OS-5	13.7	0.00	0.89	0.90	0.96	13.7	0.03	0.09	0.36	0.03	0.09	0.36	**0.41**	**1.23**	**4.93**	2.0%
OS-6	1.5	0.00	0.89	0.90	0.96	1.5	0.03	0.09	0.36	0.03	0.09	0.36	**0.05**	**0.14**	**0.54**	2.0%
OS-7	2.6	0.00	0.89	0.90	0.96	2.6	0.03	0.09	0.36	0.03	0.09	0.36	**0.08**	**0.23**	**0.94**	2.0%
OS-8	3.6	0.00	0.89	0.90	0.96	3.6	0.18	0.25	0.47	0.18	0.25	0.47	**0.65**	**0.90**	**1.69**	30.0%
OS-9	0.9	0.00	0.89	0.90	0.96	0.9	0.18	0.25	0.47	0.18	0.25	0.47	**0.16**	**0.23**	**0.42**	30.0%
A	9.5	0.50	0.89	0.90	0.96	9.00	0.06	0.14	0.40	0.10	0.18	0.43	**0.99**	**1.71**	**4.08**	15.2%
B	6.0	0.60	0.89	0.90	0.96	5.40	0.06	0.14	0.40	0.14	0.22	0.46	**0.86**	**1.30**	**2.74**	18.9%
C	3.3	0.50	0.89	0.90	0.96	2.80	0.06	0.14	0.40	0.19	0.26	0.48	**0.61**	**0.84**	**1.60**	23.0%
D	2.3	0.20	0.89	0.90	0.96	2.10	0.06	0.14	0.40	0.13	0.21	0.45	**0.30**	**0.47**	**1.03**	17.9%
E	8.5	0.50	0.89	0.90	0.96	8.00	0.06	0.14	0.40	0.11	0.18	0.43	**0.93**	**1.57**	**3.68**	15.6%
F	13.6	0.00	0.89	0.90	0.96	13.60	0.04	0.10	0.38	0.04	0.10	0.38	**0.54**	**1.36**	**5.17**	6.5%
G	1.4	0.60	0.89	0.90	0.96	0.80	0.06	0.14	0.40	0.42	0.47	0.64	**0.58**	**0.65**	**0.90**	55.7%
H1	0.5	0.15	0.89	0.90	0.96	0.37	0.15	0.22	0.46	0.36	0.42	0.60	**0.19**	**0.22**	**0.31**	47.3%
H2	0.5	0.15	0.89	0.90	0.96	0.32	0.15	0.22	0.46	0.39	0.44	0.62	**0.18**	**0.21**	**0.29**	49.1%
I	0.17	0.05	0.89	0.90	0.96	0.12	0.18	0.25	0.47	0.39	0.44	0.61	**0.07**	**0.08**	**0.10**	47.6%
J	5.90	0.70	0.89	0.90	0.96	5.20	0.18	0.25	0.47	0.26	0.33	0.53	**1.56**	**1.93**	**3.12**	37.1%
K	1.50	0.00	0.89	0.90	0.96	1.50	0.18	0.25	0.47	0.18	0.25	0.47	**0.27**	**0.38**	**0.71**	30.0%
L	0.53	0.00	0.89	0.90	0.96	0.53	0.18	0.25	0.47	0.18	0.25	0.47	**0.10**	**0.13**	**0.25**	30.0%
M	0.81	0.20	0.89	0.90	0.96	0.61	0.18	0.25	0.47	0.36	0.41	0.59	**0.29**	**0.33**	**0.48**	44.8%
N	0.63	0.15	0.89	0.90	0.96	0.48	0.18	0.25	0.47	0.35	0.40	0.59	**0.22**	**0.26**	**0.37**	44.3%
O	2.80	0.25	0.89	0.90	0.96	2.55	0.18	0.25	0.47	0.24	0.31	0.51	**0.68**	**0.86**	**1.44**	35.4%
P	1.00	0.25	0.89	0.90	0.96	0.75	0.18	0.25	0.47	0.36	0.41	0.59	**0.36**	**0.41**	**0.59**	45.0%
Q	1.90	0.00	0.89	0.90	0.96	1.90	0.06	0.14	0.40	0.06	0.14	0.40	**0.11**	**0.27**	**0.76**	30.0%
R	2.70	0.60	0.89	0.90	0.96	2.10	0.18	0.25	0.47	0.34	0.39	0.58	**0.91**	**1.07**	**1.56**	43.3%
S	6.60	0.90	0.89	0.90	0.96	5.70	0.18	0.25	0.47	0.28	0.34	0.54	**1.83**	**2.24**	**3.54**	38.2%
T	1.00	0.30	0.89	0.90	0.96	0.70	0.02	0.08	0.35	0.28	0.33	0.53	**0.28**	**0.33**	**0.53**	48.0%
U	1.50	0.00	0.89	0.90	0.96	1.50	0.18	0.25	0.47	0.18	0.25	0.47	**0.27**	**0.38**	**0.71**	30.0%
V	2.10	0.00	0.89	0.90	0.96	2.10	0.18	0.25	0.47	0.18	0.25	0.47	**0.38**	**0.53**	**0.99**	30.0%
W	1.40	0.15	0.89	0.90	0.96	1.25	0.18	0.25	0.47	0.26	0.32	0.52	**0.36**	**0.45**	**0.73**	36.4%

Should this be lower for basin V?

JOB NAME:	*RETREAT AT TIMBERRIDGE FILING NO. 2*
JOB NUMBER:	*1185.20*
DATE:	*03/17/21*
CALC'D BY:	*MAW*

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.

$$t_c = \frac{L}{180} + 10$$

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}}$$

$$V = C_v S_w^{0.5}$$

Tc=L/V

FINAL DRAINAGE REPORT ~ BASIN RUNOFF SUMMARY

	WEIGHTED			OVERLAND				STREET / CHANNEL FLOW				Tc	INTENSITY			TOTAL FLOWS		
BASIN	CA(2)	CA(5)	CA(100)	C(5)	Length (ft)	Height (ft)	Tc (min)	Length (ft)	Slope (%)	Velocity (fps)	Tc (min)	TOTAL (min)	I(2) (in/hr)	I(5) (in/hr)	I(100) (in/hr)	Q(2) (cfs)	Q(5) (cfs)	Q(100) (cfs)
EX-1	0.38	1.14	4.57	0.12	300	10	20.6	1000	2.0%	1.4	11.8	32.4	1.90	2.37	3.97	1	**3**	**18**
EX-2	0.88	2.65	10.58	0.12	300	10	20.6	800	2.0%	1.4	9.4	30.0	1.99	2.48	4.16	2	**7**	**44**
EX-3	0.27	0.82	3.28	0.12	300	9	21.3	200	2.0%	1.4	2.4	23.7	2.27	2.84	4.76	1	**2**	**16**
EX-4	2.55	7.64	30.56	0.12	300	12	19.4	2500	2.0%	1.4	29.5	48.9	1.41	1.75	2.93	4	**13**	**90**
EX-5	1.03	3.08	12.31	0.12	300	12	19.4	1200	3.0%	1.7	11.5	30.9	1.95	2.43	4.09	2	**7**	**50**
EX-7	1.38	3.31	10.76	0.12	300	12	19.4	1500	3.0%	1.7	14.4	33.8	1.84	2.30	3.86	3	**8**	**42**
OS-1	0.40	0.70	1.67	0.14	300	10.5	19.9					19.9	2.48	3.10	5.20	1	**2**	**9**
OS-2	0.59	0.79	1.44	0.14	300	8	21.7	100	2.0%	1.4	1.2	22.9	2.31	2.89	4.84	1	**2**	**7**
OS-3	0.05	0.13	0.36	0.14	300	12	19.0					19.0	2.53	3.17	5.32	0.1	**0.4**	**2**
OS-4	0.08	0.23	0.90	0.09	300	12	20.0					20.0	2.47	3.09	5.19	0.2	**0.7**	**5**
OS-5	0.41	1.23	4.93	0.09	300	12	20.0					20.0	2.47	3.09	5.19	1	**4**	**26**
OS-6	0.05	0.14	0.54	0.09	275	13	18.1					18.1	2.59	3.24	5.44	0.1	**0.4**	**3**
OS-7	0.08	0.23	0.94	0.09	250	16	15.6					15.6	2.76	3.46	5.81	0.2	**0.8**	**5**
OS-8	0.65	0.90	1.69	0.25	100	2	12.2	600	2.0%	2.8	3.5	15.7	2.75	3.45	5.79	2	**3**	**10**

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Paved areas and shallow paved swales	20

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

$$t_c = \frac{L}{180} + 10$$

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}}$$

$$V = C_v S_w^{0.5}$$

Tc=L/V

FINAL DRAINAGE REPORT ~ BASIN RUNOFF SUMMARY

BASIN	WEIGHTED CA(2)	CA(5)	CA(100)	OVERLAND C(5)	Length (ft)	Height (ft)	Tc (min)	STREET / CHANNEL FLOW Length (ft)	Slope (%)	Velocity (fps)	Tc (min)	Tc TOTAL (min)	INTENSITY I(2) (in/hr)	I(5) (in/hr)	I(100) (in/hr)	TOTAL FLOWS Q(2) (cfs)	Q(5) (cfs)	Q(100) (cfs)
OS-9	0.16	0.23	0.42	0.25	50	1	8.6	600	3.0%	3.5	2.9	11.5	3.13	3.92	6.58	0.5	**0.9**	**3**
A	0.99	1.71	4.08	0.14	300	10.5	19.9	375	4.0%	2.0	3.1	23.0	2.30	2.88	4.84	2	**5**	**20**
B	0.86	1.30	2.74	0.14	230	15	14.2	450	2.0%	1.4	5.3	19.5	2.50	3.13	5.25	2	**4**	**14**
C	0.61	0.84	1.60	0.14	300	10	20.2					20.2	2.46	3.08	5.16	2	**3**	**8**
D	0.30	0.47	1.03	0.14	250	10	17.3					17.3	2.64	3.30	5.54	1	**2**	**6**
E	0.93	1.57	3.68	0.14	300	12	19.0	300	2.0%	1.4	3.5	22.5	2.33	2.91	4.88	2	**5**	**18**
F	0.54	1.36	5.17	0.10	300	9	21.8	600	1.5%	1.2	8.2	29.9	1.99	2.48	4.17	1	**3**	**22**
G	0.58	0.65	0.90	0.14	100	2	13.8					13.8	2.91	3.65	6.12	1.7	**2.4**	**5**
H1	0.19	0.22	0.31	0.22	100	4	10.1					10.1	3.29	4.12	6.92	0.6	**0.9**	**2**
H2	0.18	0.21	0.29	0.22	100	4	10.1					10.1	3.29	4.12	6.92	0.6	**0.8**	**2**
I	0.07	0.08	0.10	0.25	100	6	8.5					8.5	3.49	4.37	7.34	0.2	**0.3**	**0.8**
J	1.56	1.93	3.12	0.25	100	2	12.2	600	2.0%	2.8	3.5	15.7	2.75	3.45	5.79	4	**7**	**18**
K	0.27	0.38	0.71	0.25	100	3	10.7					10.7	3.22	4.03	6.77	1	**2**	**5**
L	0.10	0.13	0.25	0.25	100	8	7.7					7.7	3.60	4.52	7.58	0.3	**0.6**	**2**

JOB NAME:	***RETREAT AT TIMBERRIDGE FILING NO. 2***
JOB NUMBER:	***1185.20***
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CALC'D BY:	***MAW***

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
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Paved areas and shallow paved swales	20

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

$$t_c = \frac{L}{180} + 10$$

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}}$$

$$V = C_v S_w^{0.5}$$

Tc=L/V

FINAL DRAINAGE REPORT ~ BASIN RUNOFF SUMMARY

	WEIGHTED			OVERLAND				STREET / CHANNEL FLOW				Tc	INTENSITY			TOTAL FLOWS		
BASIN	CA(2)	CA(5)	CA(100)	C(5)	Length (ft)	Height (ft)	Tc (min)	Length (ft)	Slope (%)	Velocity (fps)	Tc (min)	TOTAL (min)	I(2) (in/hr)	I(5) (in/hr)	I(100) (in/hr)	Q(2) (cfs)	Q(5) (cfs)	Q(100) (cfs)
M	0.29	0.33	0.48	0.25	100	2	12.2	100	2.0%	2.8	0.6	12.8	3.00	3.76	6.31	0.9	**1.2**	**3**
N	0.22	0.26	0.37	0.25	100	2	12.2	80	2.0%	2.8	0.5	12.7	3.01	3.77	6.33	0.7	**1.0**	**2**
O	0.68	0.86	1.44	0.25	100	2	12.2	400	3.0%	3.5	1.9	14.1	2.88	3.61	6.06	2	**3**	**9**
P	0.36	0.41	0.59	0.25	50	1	8.6	400	3.0%	3.5	1.9	10.6	3.23	4.05	6.80	1	**2**	**4**
Q	0.11	0.27	0.76	0.14	80	5	8.5					8.5	3.49	4.38	7.35	0.4	**1.2**	**6**
R	0.91	1.07	1.56	0.25	100	2	12.2	700	3.0%	3.5	3.4	15.6	2.77	3.46	5.82	3	**4**	**9**
S	1.83	2.24	3.54	0.25	50	1	8.6	1100	3.0%	3.5	5.3	13.9	2.90	3.63	6.10	5	**8**	**22**
T	0.28	0.33	0.53	0.08	50	1	10.4	500	3.0%	3.5	2.4	12.8	3.00	3.76	6.32	0.8	**1.2**	**3**
U	0.27	0.38	0.71	0.25	80	5	7.5					7.5	3.64	4.56	7.66	1	**2**	**5**
V	0.38	0.53	0.99	0.25	90	1.8	11.6					11.6	3.12	3.91	6.56	1	**2**	**6**
W	0.36	0.45	0.73	0.25	100	3	10.7					10.7	3.22	4.03	6.77	1	**2**	**5**

JOB NAME: *RETREAT AT TIMBERRIDGE FILING NO. 2*
JOB NUMBER: *1185.20*
DATE: *03/17/21*
CALCULATED BY: *MAW*

FINAL DRAINAGE REPORT ~ SURFACE ROUTING SUMMARY

Design Point(s)	Contributing Basins	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity I(5)	Intensity I(100)	Flow Q(5)	Flow Q(100)	Inlet Size
1	EX-7, OS-1, OS-2, B (40.4 AC.)	6.09	16.61	40.4	2.04	3.41	12	57	EX. DUAL 30" RCP CULVERTS
2	Basin A (9.5 AC.)	1.71	4.08	23.0	2.88	4.84	5	20	24" RCP CULVERT
3	DP-1, Basin D (42.7 ac.)	6.57	17.64	40.9	2.02	3.38	13	60	DUAL 30" RCP CULVERTS
4	Basin C (3.3 AC.)	0.84	1.60	20.2	3.08	5.16	3	8	24" RCP CULVERT
5	**POND 1 TOTAL INFLOW (64.0 AC.)**	**10.69**	**27.00**	**46.4**	**1.83**	**3.07**	**20**	**83**	**POND 1**
6	Basin G, Basin OS-9 (2.3 ac.)	0.88	1.32	13.8	3.65	6.12	3	8	Exist. 10' TYPE R AT GRADE INLET
7	Basin OS-4, J and 70% of Basin OS-5 (18.0 ac.)	3.02	7.47	20.2	3.08	5.16	9	39	15' TYPE R SUMP INLET
8	Basin N and 30% of Basin OS-5 (4.7 ac.)	0.62	1.85	20.2	3.08	5.16	2	10	10' TYPE R SUMP INLET
9	Basin OS-8, Q (5.5 ac.)	1.17	2.45	15.7	3.45	5.79	4	14	Exist. 10' TYPE R SUMP INLET
10	Basin OS-6, O (4.3 ac.)	1.00	1.98	18.1	3.24	5.44	3	11	10' TYPE R SUMP INLET
11	Basin P (1.0 ac.)	0.41	0.59	10.6	4.05	6.80	2	4	5' TYPE R SUMP INLET
12	Basin R (2.7 ac.)	1.07	1.56	15.6	3.46	5.82	4	9	10' TYPE R AT GRADE INLET
13	Basin S and Flow-by from Basin R (9.3 ac.)	2.25	3.93	16.1	3.42	5.74	8	23	15' TYPE R SUMP INLET
14	Basin T (1.0 ac.)	0.33	0.53	12.8	3.76	6.32	1	3	5' TYPE R SUMP INLET
15	Basin V and OS-7 (4.7 ac.)	0.76	1.92	15.6	3.46	5.81	3	11	REAR YARD SWALE

JOB NAME: ***RETREAT AT TIMBERRIDGE FILING NO. 2***
JOB NUMBER: ***1185.20***
DATE: ***03/17/21***
CALCULATED BY: ***MAW***

* PIPES ARE LISTED AT MAXIMUM SIZE REQUIRED TO ACCOMMODATE Q100 FLOWS AT MINIMUM GRADE.
REFER TO INDIVIDUAL PIPE SHEETS FOR HYDRAULIC INFORMATION.

FINAL DRAINAGE REPORT ~ PIPE ROUTING SUMMARY

Pipe Run	Contributing Basins	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity		Flow		
					I(5)	I(100)	Q(5)	Q(100)	Pipe Size*
1	DP-7	3.02	7.47	20.2	3.08	5.16	9	39	30" RCP
2	DP-8	0.62	1.85	20.2	3.08	5.16	2	10	24" RCP
3	PR-1, PR-2	3.64	9.32	20.8	3.03	5.09	11	47	36" RCP
4	DP-10	1.00	1.98	10.6	4.05	6.80	4	13	24" RCP
5	DP-11	0.41	0.59	13.8	3.65	6.12	2	4	18" RCP
6	PR-3, PR-4, PR-5	5.05	11.89	21.8	2.96	4.97	15	59	36" RCP
7	DP-12 Pickup	1.05	1.17	15.6	3.46	5.82	4	7	24" RCP
8	PR-6, PR-7	6.11	13.06	22.2	2.93	4.92	18	64	36" RCP
9	DP-13	2.25	3.93	16.1	3.42	5.74	8	23	30" RCP
10	DP-14	0.33	0.53	16.3	3.40	5.70	1	3	18" RCP
11	PR-9, PR-10	2.57	4.47	16.3	3.40	5.70	9	25	30" RCP
12	**PR-8, PR-11**	**8.68**	**17.53**	**22.7**	**2.90**	**4.87**	**25**	**85**	**42" RCP**

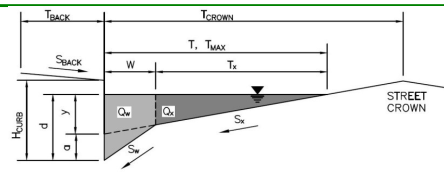
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: **RETREAT AT TIMBERRIDGE FILING NO. 2**

Inlet ID: **DP-7**



Gutter Geometry (Enter data in the blue cells)

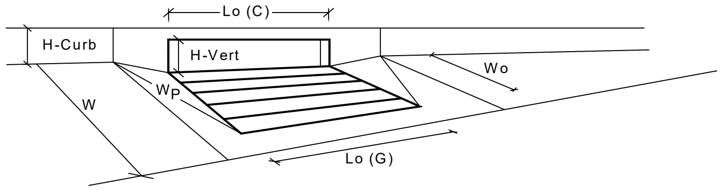
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	17.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	17.0	17.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



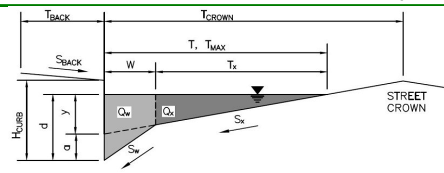
Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	12.0	inches
Grate Information			MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	15.00	15.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)			MINOR	MAJOR	
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.33	0.83	ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.57	1.00	
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	0.79	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A	
			MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)		Q_a =	**9.7**	**39.1**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	9.0	39.0	cfs

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: RETREAT AT TIMBERRIDGE FILING NO. 2

Inlet ID: DP-8



Gutter Geometry (Enter data in the blue cells)

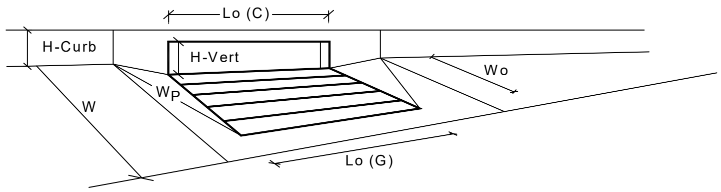
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	17.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	17.0	17.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



		MINOR	MAJOR	
Design Information (Input)				
Type of Inlet — CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	1	1	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	6.0	12.0	inches
Grate Information		MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate	L_o (G) =	N/A	N/A	feet
Width of a Unit Grate	W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	N/A	N/A	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	10.00	10.00	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)	Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.33	0.83	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.57	1.00	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.93	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**8.3**	**25.5**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	2.0	10.0	cfs

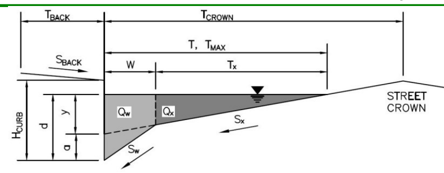
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: RETREAT AT TIMBERRIDGE FILING NO. 2

Inlet ID: DP-9

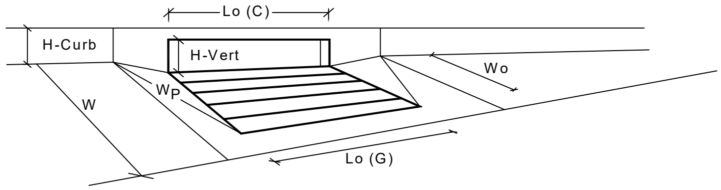


Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00		inches
Distance from Curb Face to Street Crown	T_{CROWN} =	17.0		ft
Gutter Width	W =	2.00		ft
Street Transverse Slope	S_X =	0.020		ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083		ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000		ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016		
		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	17.0	17.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLEET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	12.0	inches
Grate Information			MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	10.00	10.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.33	0.83	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.57	1.00	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.93	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	

		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**8.3**	**25.5**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	4.0	14.0	cfs

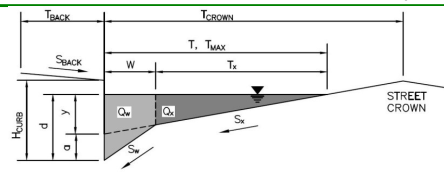
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: RETREAT AT TIMBERRIDGE FILING NO. 2

Inlet ID: DP-10



Gutter Geometry (Enter data in the blue cells)

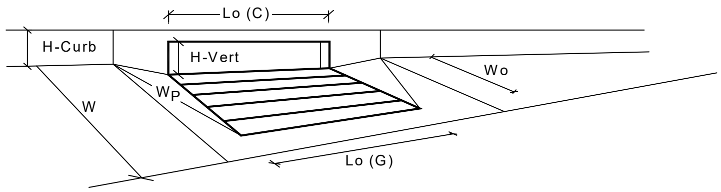
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	17.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	17.0	17.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**SUMP**	**SUMP**	**cfs**

INLEET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	12.0	inches
Grate Information			MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	10.00	10.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.33	0.83	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.57	1.00	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.93	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	

		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**8.3**	**25.5**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	3.0	11.0	cfs

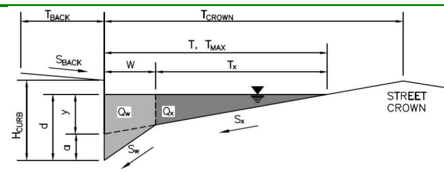
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: RETREAT AT TIMBERRIDGE FILING NO. 2

Inlet ID: DP-11



Gutter Geometry (Enter data in the blue cells)

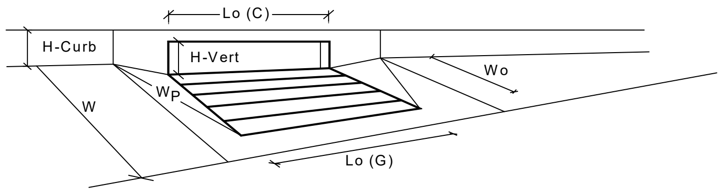
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	17.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	17.0	17.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	12.0	inches
Grate Information			MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.33	0.83	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.77	1.00	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	1.00	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	

		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**5.4**	**12.3**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	2.0	4.0	cfs

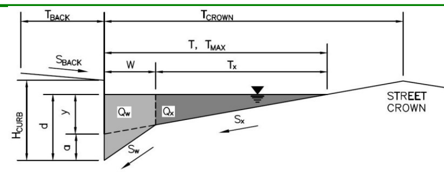
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: RETREAT AT TIMBERRIDGE FILING NO. 2

Inlet ID: DP-12



Gutter Geometry (Enter data in the blue cells)

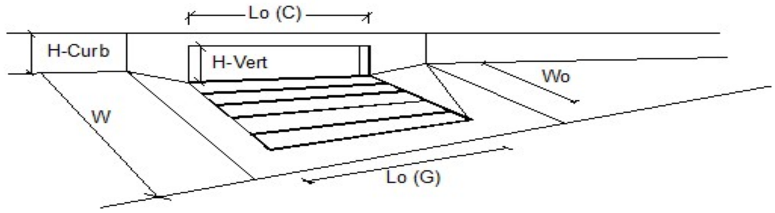
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00		inches
Distance from Curb Face to Street Crown	T_{CROWN} =	17.0		ft
Gutter Width	W =	2.00		ft
Street Transverse Slope	S_X =	0.020		ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083		ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.022		ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016		
		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	17.0	17.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**16.1**	**16.1**	**cfs**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

Version 4.05 Released March 2017



Design Information (Input)			MINOR	MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	10.00	10.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C_f-C =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity'			MINOR	MAJOR	
Total Inlet Interception Capacity		**Q =**	**4.0**	**6.7**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)		**Q_b =**	**0.0**	**2.3**	**cfs**
Capture Percentage = Q_a/Q_o =		**C% =**	**99**	**75**	**%**

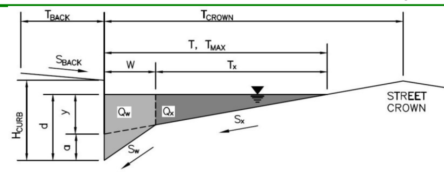
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: RETREAT AT TIMBERRIDGE FILING NO. 2

Inlet ID: DP-13



Gutter Geometry (Enter data in the blue cells)

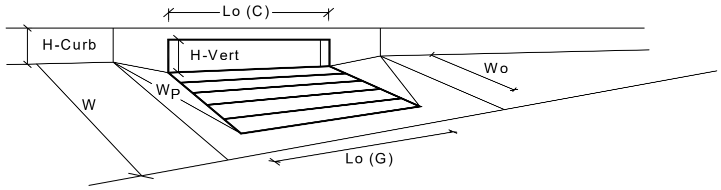
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	17.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	17.0	17.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	12.0	inches
Grate Information			MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	15.00	15.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)			MINOR	MAJOR	
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.33	0.83	ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.57	1.00	
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	0.79	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A	
			MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)		Q_a =	**9.7**	**39.1**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	8.0	24.3	cfs

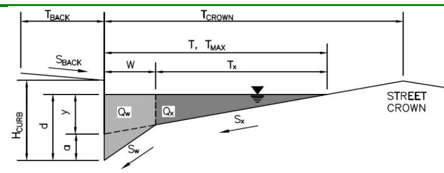
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: RETREAT AT TIMBERRIDGE FILING NO. 2

Inlet ID: DP-14



Gutter Geometry (Enter data in the blue cells)

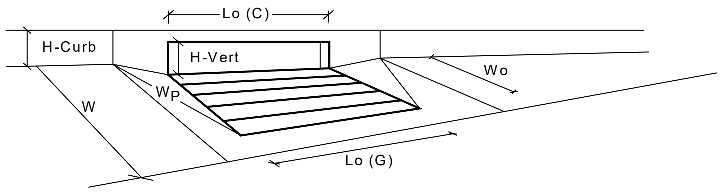
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	17.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	17.0	17.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	12.0	inches
Grate Information			MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.33	0.83	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.77	1.00	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	1.00	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	

		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**5.4**	**12.3**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	1.0	3.0	cfs

Culvert Report

DUAL 30 IN. RCP CULVERTS AT DP 1

Invert Elev Dn (ft)	= 7228.28
Pipe Length (ft)	= 60.68
Slope (%)	= 1.01
Invert Elev Up (ft)	= 7228.89
Rise (in)	= 30.0
Shape	= Circular
Span (in)	= 30.0
No. Barrels	= 2
n-Value	= 0.013
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

Embankment

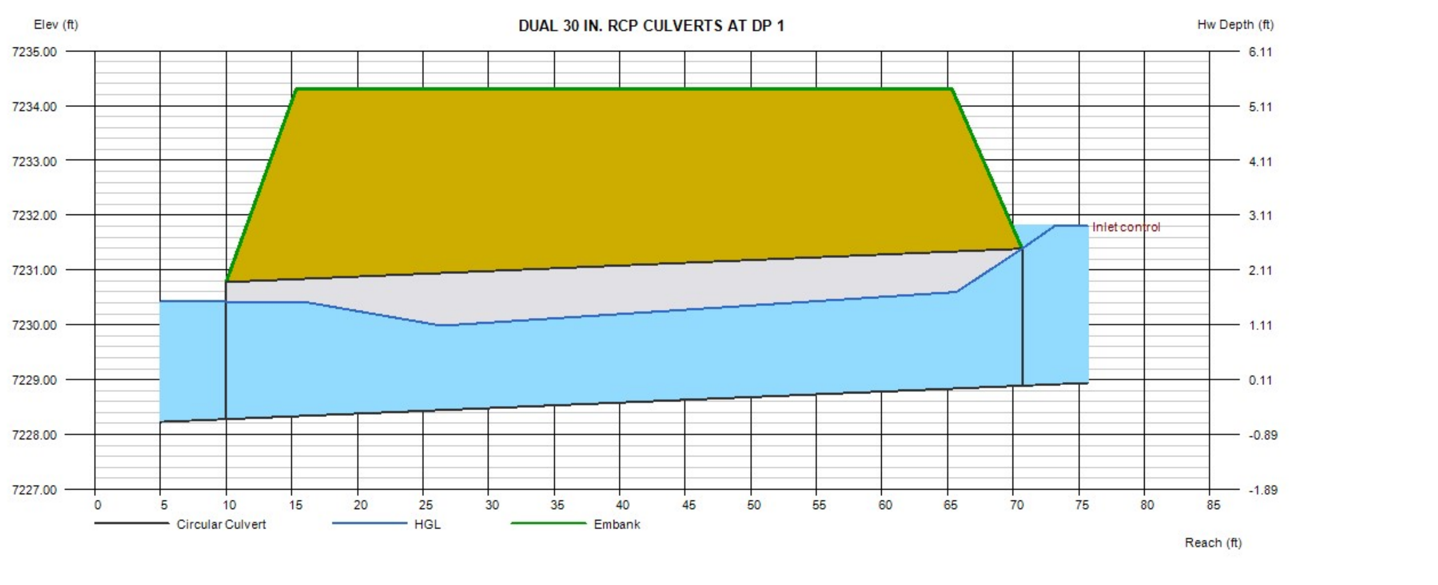
Top Elevation (ft)	= 7234.30
Top Width (ft)	= 50.00
Crest Width (ft)	= 50.00

Calculations

Qmin (cfs)	= 0.00
Qmax (cfs)	= 55.00
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

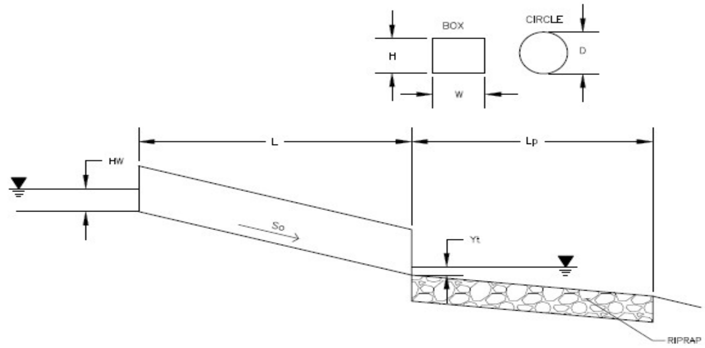
Qtotal (cfs)	= 55.00
Qpipe (cfs)	= 55.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 6.14
Veloc Up (ft/s)	= 7.33
HGL Dn (ft)	= 7230.42
HGL Up (ft)	= 7230.68
Hw Elev (ft)	= 7231.81
Hw/D (ft)	= 1.17
Flow Regime	= Inlet Control



DETERMINATION OF CULVERT HEADWATER AND OUTLET PROTECTION

MHFD-Culvert, Version 4.00 (May 2020)

Project: Retreat at TimberRidge Filing No. 2
ID: DP-2 (24" Culvert)



Soil Type:
Choose One:
(●) Sandy
( ) Non-Sandy

Supercritical Flow! Using Adjusted Diameter to calculate protection type.

Design Information:

Design Discharge	Q =	20	cfs
Circular Culvert:			
Barrel Diameter in Inches	D =	24	inches
Inlet Edge Type (Choose from pull-down list)		Grooved Edge Projecting	
OR:			
Box Culvert:		**OR**	
Barrel Height (Rise) in Feet	H (Rise) =		ft
Barrel Width (Span) in Feet	W (Span) =		ft
Inlet Edge Type (Choose from pull-down list)			
Number of Barrels	# Barrels =	1	
Inlet Elevation	Elev IN =	7230.81	ft
Outlet Elevation **OR** Slope	Elev OUT =	7230	ft
Culvert Length	L =	81	ft
Manning's Roughness	n =	0.013	
Bend Loss Coefficient	k_b =	0	
Exit Loss Coefficient	k_x =	1	
Tailwater Surface Elevation	$Y_{t, Elevation}$ =		ft
Max Allowable Channel Velocity	V =	5	ft/s

Calculated Results:

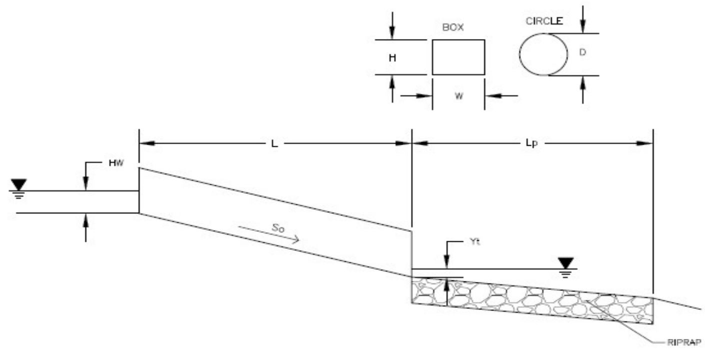
Culvert Cross Sectional Area Available	A =	3.14	ft^2
Culvert Normal Depth	Y_n =	1.46	ft
Culvert Critical Depth	Y_c =	1.61	ft
Froude Number	Fr =	1.22	**Supercritical!**
Entrance Loss Coefficient	k_e =	0.20	
Friction Loss Coefficient	k_f =	1.00	
Sum of All Loss Coefficients	k_s =	2.20	ft
Headwater:			
Inlet Control Headwater	HW_I =	2.65	ft
Outlet Control Headwater	HW_O =	2.38	ft
Design Headwater Elevation	**HW =**	**7233.46**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/D =**	**1.33**	
Outlet Protection:			
Flow/(Diameter^2.5)	Q/D^2.5 =	3.54	$ft^{0.5}/s$
Tailwater Surface Height	Y_t =	0.80	ft
Tailwater/Diameter	Yt/D =	0.40	
Expansion Factor	1/(2*tan(Θ)) =	3.91	
Flow Area at Max Channel Velocity	A_t =	4.00	ft^2
Width of Equivalent Conduit for Multiple Barrels	W_{eq} =	-	ft
Length of Riprap Protection	L_p **=**	**12**	**ft**
Width of Riprap Protection at Downstream End	**T =**	**6**	**ft**
Adjusted Diameter for Supercritical Flow	Da =	1.73	ft
Minimum Theoretical Riprap Size	d_{50} min=	6	in
Nominal Riprap Size	d_{50} nominal=	9	in
MHFD Riprap Type	**Type =**	**L**	

DETERMINATION OF CULVERT HEADWATER AND OUTLET PROTECTION

MHFD-Culvert, Version 4.00 (May 2020)

Project: **Retreat at TimberRidge Filing No. 2**

ID: **DP-3 (Dual 30" Culverts)**



Soil Type:
Choose One:
(●) Sandy
( ) Non-Sandy

Supercritical Flow! Using Adjusted Diameter to calculate protection type.

Design Information:

Design Discharge	Q =	60	cfs
Circular Culvert:			
Barrel Diameter in Inches	D =	30	inches
Inlet Edge Type (Choose from pull-down list)		Grooved Edge Projecting	
OR:			
Box Culvert:		**OR**	
Barrel Height (Rise) in Feet	H (Rise) =		ft
Barrel Width (Span) in Feet	W (Span) =		ft
Inlet Edge Type (Choose from pull-down list)			
Number of Barrels	# Barrels =	2	
Inlet Elevation	Elev IN =	7221	ft
Outlet Elevation **OR** Slope	Elev OUT =	7216.5	ft
Culvert Length	L =	106.06	ft
Manning's Roughness	n =	0.013	
Bend Loss Coefficient	k_b =	0	
Exit Loss Coefficient	k_x =	1	
Tailwater Surface Elevation	$Y_{t,\ Elevation}$ =		ft
Max Allowable Channel Velocity	V =	5	ft/s

Calculated Results:

Culvert Cross Sectional Area Available	A =	4.91	ft^2
Culvert Normal Depth	Y_n =	1.03	ft
Culvert Critical Depth	Y_c =	1.87	ft
Froude Number	Fr =	3.16	**Supercritical!**
Entrance Loss Coefficient	k_e =	0.20	
Friction Loss Coefficient	k_f =	0.97	
Sum of All Loss Coefficients	k_s =	2.17	ft
Headwater:			
Inlet Control Headwater	HW_I =	2.86	ft
Outlet Control Headwater	HW_O =	N/A	ft
Design Headwater Elevation	**HW =**	**7223.86**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/D =**	**1.14**	

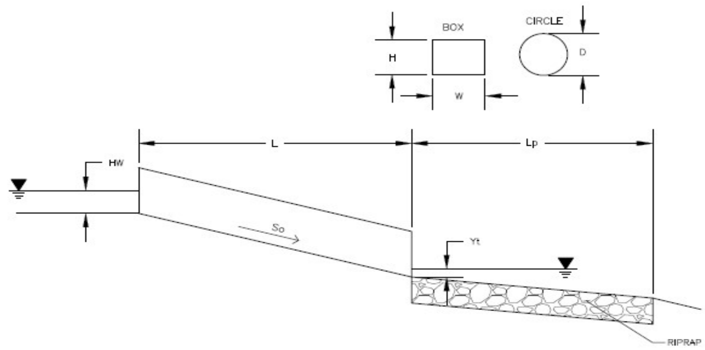
Outlet Control Headwater Approximation Method Inaccurate for Low Flow - Backwater Calculations Required

Outlet Protection:			
Flow/(Diameter^2.5)	Q/D^2.5 =	3.04	$ft^{0.5}/s$
Tailwater Surface Height	Y_t =	1.00	ft
Tailwater/Diameter	Yt/D =	0.40	
Expansion Factor	1/(2*tan(Θ)) =	4.35	
Flow Area at Max Channel Velocity	A_t =	12.00	ft^2
Width of Equivalent Conduit for Multiple Barrels	W_{eq} =	5.00	ft
Length of Riprap Protection	L_p **=**	**25**	**ft**
Width of Riprap Protection at Downstream End	**T =**	**11**	**ft**
Adjusted Diameter for Supercritical Flow	Da =	1.76	ft
Minimum Theoretical Riprap Size	d_{50} min=	7	in
Nominal Riprap Size	d_{50} nominal=	9	in
MHFD Riprap Type	**Type =**	**L**	

DETERMINATION OF CULVERT HEADWATER AND OUTLET PROTECTION

MHFD-Culvert, Version 4.00 (May 2020)

Project: Retreat at TimberRidge Filing No. 2
ID: DP-4 (24" RCP Culvert)



Soil Type:
Choose One:
(●) Sandy
( ) Non-Sandy

Supercritical Flow! Using Adjusted Diameter to calculate protection type.

Design Information:

Design Discharge	Q =	8	cfs
Circular Culvert:			
Barrel Diameter in Inches	D =	24	inches
Inlet Edge Type (Choose from pull-down list)		Grooved Edge Projecting	
OR:			
Box Culvert:		**OR**	
Barrel Height (Rise) in Feet	H (Rise) =		ft
Barrel Width (Span) in Feet	W (Span) =		ft
Inlet Edge Type (Choose from pull-down list)			
Number of Barrels	# Barrels =	1	
Inlet Elevation	Elev IN =	7220.5	ft
Outlet Elevation **OR** Slope	Elev OUT =	7216.34	ft
Culvert Length	L =	86.89	ft
Manning's Roughness	n =	0.013	
Bend Loss Coefficient	k_b =	0	
Exit Loss Coefficient	k_x =	1	
Tailwater Surface Elevation	$Y_{t,\ Elevation}$ =		ft
Max Allowable Channel Velocity	V =	5	ft/s

Calculated Results:

Culvert Cross Sectional Area Available	A =	3.14	ft^2
Culvert Normal Depth	Y_n =	0.54	ft
Culvert Critical Depth	Y_c =	1.01	ft
Froude Number	Fr =	3.28	**Supercritical!**
Entrance Loss Coefficient	k_e =	0.20	
Friction Loss Coefficient	k_f =	1.07	
Sum of All Loss Coefficients	k_s =	2.27	ft
Headwater:			
Inlet Control Headwater	HW_I =	1.39	ft
Outlet Control Headwater	HW_O =	N/A	ft
Design Headwater Elevation	**HW =**	**N/A**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/D =**	**N/A**	

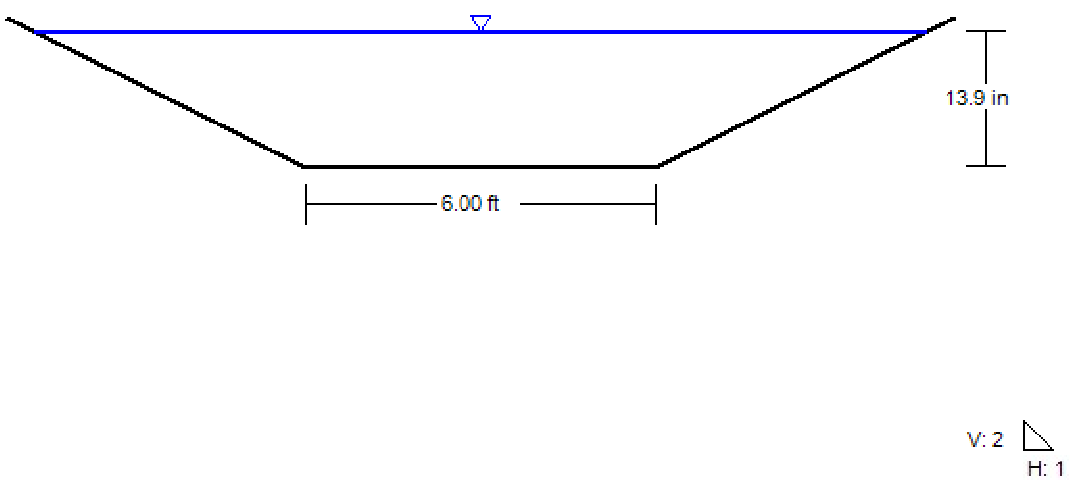
Outlet Control Headwater Approximation Method Inaccurate for Low Flow - Backwater Calculations Required

Outlet Protection:			
Flow/(Diameter^2.5)	Q/D^2.5 =	1.41	$ft^{0.5}/s$
Tailwater Surface Height	Y_t =	0.80	ft
Tailwater/Diameter	Yt/D =	0.40	
Expansion Factor	1/(2*tan(Θ)) =	6.30	
Flow Area at Max Channel Velocity	A_t =	1.60	ft^2
Width of Equivalent Conduit for Multiple Barrels	W_{eq} =	-	ft
Length of Riprap Protection	**L_p =**	**6**	**ft**
Width of Riprap Protection at Downstream End	**T =**	**3**	**ft**
Adjusted Diameter for Supercritical Flow	Da =	1.27	ft
Minimum Theoretical Riprap Size	d_{50} min=	3	in
Nominal Riprap Size	d_{50} nominal=	6	in
MHFD Riprap Type	**Type =**	**VL**	

Cross Section for Channel into Pond 3

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.025 ft/ft
Normal Depth	13.9 in
Left Side Slope	4.000 H:V
Right Side Slope	4.000 H:V
Bottom Width	6.00 ft
Discharge	71.00 cfs



Worksheet for Channel into Pond 3

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.025 ft/ft
Left Side Slope	4.000 H:V
Right Side Slope	4.000 H:V
Bottom Width	6.00 ft
Discharge	71.00 cfs

Results

Normal Depth	13.9 in
Flow Area	12.3 ft²
Wetted Perimeter	15.6 ft
Hydraulic Radius	9.5 in
Top Width	15.28 ft
Critical Depth	14.9 in
Critical Slope	0.019 ft/ft
Velocity	5.75 ft/s
Velocity Head	0.51 ft
Specific Energy	1.67 ft
Froude Number	1.128
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	13.9 in
Critical Depth	14.9 in
Channel Slope	0.025 ft/ft
Critical Slope	0.019 ft/ft

Worksheet for Trickle Channel

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013
Channel Slope	0.010 ft/ft
Normal Depth	4.0 in
Bottom Width	2.00 ft

Results

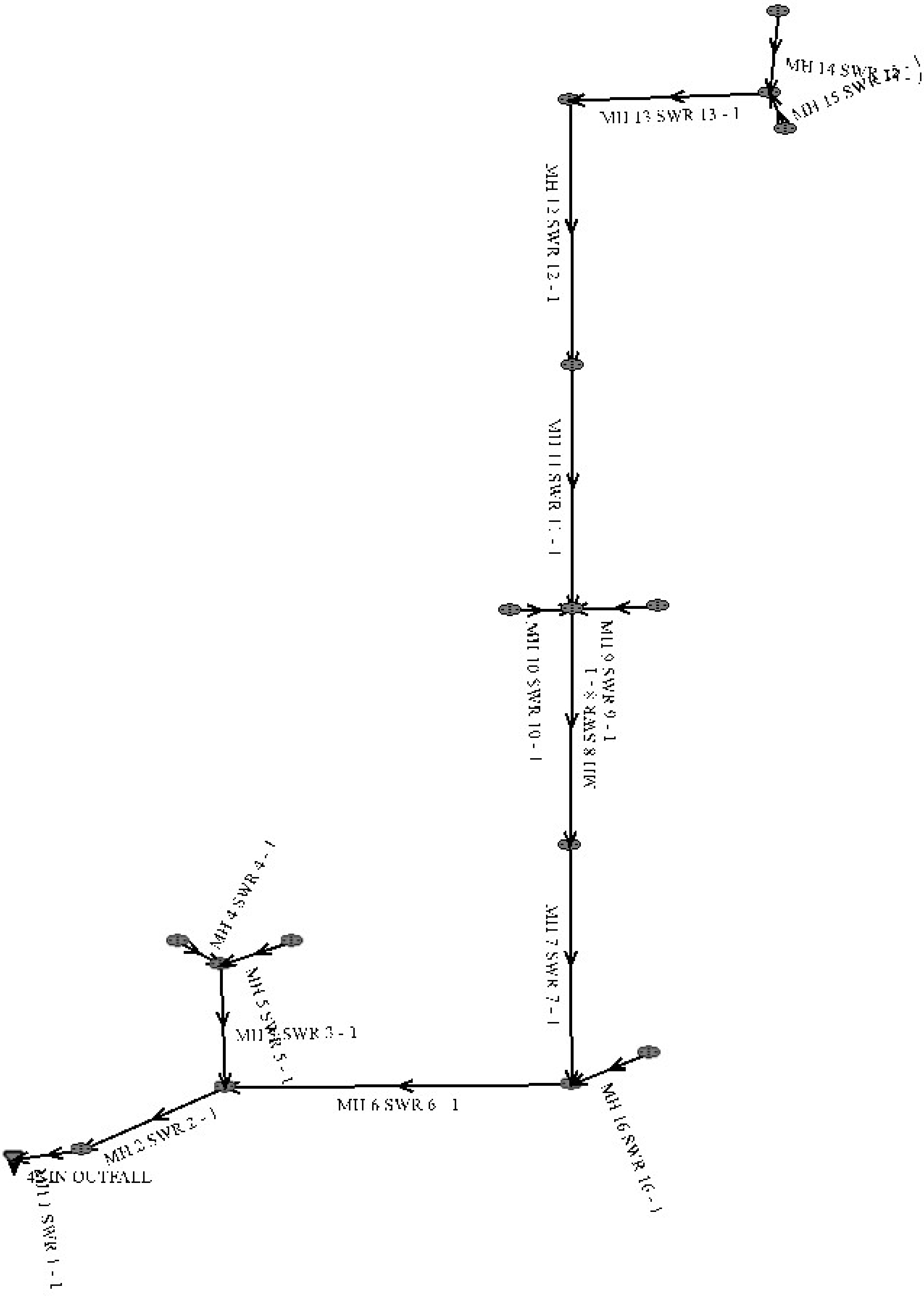
Discharge	3.02 cfs
Flow Area	0.7 ft²
Wetted Perimeter	2.7 ft
Hydraulic Radius	3.0 in
Top Width	2.00 ft
Critical Depth	5.0 in
Critical Slope	0.005 ft/ft
Velocity	4.54 ft/s
Velocity Head	0.32 ft
Specific Energy	0.65 ft
Froude Number	1.385
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	4.0 in
Critical Depth	5.0 in
Channel Slope	0.010 ft/ft
Critical Slope	0.005 ft/ft


MH 13 SWR 13 - 1
MH 12 SWR 12 - 1
MH 11 SWR 11 - 1
MH 10 SWR 10 - 1
MH 9 SWR 9 - 1
MH 8 SWR 8 - 1
MH 7 SWR 7 - 1
MH 16 SWR 16 - 1
MH 6 SWR 6 - 1
MH 4 SWR 4 - 1
MH 5 SWR 5 - 1
MH 3 SWR 3 - 1
MH 2 SWR 2 - 1
IN OUTFALL
MH 1 SWR 1 - 1

42” RCP Storm System HGL Calcs.

System Input Summary

Rainfall Parameters

Rainfall Return Period: 100
Rainfall Calculation Method: Table

Time	Intensity
5	8.68
10	6.93
20	5.19
30	4.16
40	3.44
60	2.42
120	0.67

Rational Method Constraints

Minimum Urban Runoff Coeff.: 0.20
Maximum Rural Overland Len. (ft): 500
Maximum Urban Overland Len. (ft): 300
Used UDFCD Tc. Maximum: Yes

Sizer Constraints

Minimum Sewer Size (in): 18.00
Maximum Depth to Rise Ratio: 0.90
Maximum Flow Velocity (fps): 18.0
Minimum Flow Velocity (fps): 2.0

Backwater Calculations:

Tailwater Elevation (ft): 7168.30

Sewer Flow Summary:

	Full Flow Capacity		Critical Flow		Normal Flow						
Element Name	Flow (cfs)	Velocity (fps)	Depth (in)	Velocity (fps)	Depth (in)	Velocity (fps)	Froude Number	Flow Condition	Flow (cfs)	Surcharged Length (ft)	Comment
MH 1 SWR 1 - 1	142.67	14.83	34.46	10.06	23.35	15.47	2.17	Supercritical Jump	85.00	3.88	
MH 2 SWR 2 - 1	352.36	36.62	34.46	10.06	14.05	30.14	5.75	Supercritical	85.00	0.00	Velocity is Too High
MH 6 SWR 6 - 1	137.06	19.39	30.83	9.93	17.30	19.06	3.17	Supercritical	64.00	0.00	Velocity is Too High
MH 7 SWR 7 - 1	103.61	14.66	29.80	9.43	19.46	15.13	2.34	Supercritical Jump	59.00	64.17	
MH 8 SWR 8 - 1	66.88	9.46	29.80	9.43	26.26	10.68	1.31	Supercritical	59.00	0.00	
MH 11 SWR 11 - 1	99.20	14.03	26.79	8.33	17.44	13.84	2.29	Supercritical	47.00	0.00	
MH 12 SWR 12 - 1	66.88	9.46	26.79	8.33	22.25	10.25	1.44	Supercritical	47.00	0.00	
MH 13 SWR 13 - 1	66.88	9.46	26.79	8.33	22.25	10.25	1.44	Supercritical Jump	47.00	5.06	
MH 14 SWR 14 - 1	41.13	8.38	25.28	8.84	23.30	9.53	1.20	Pressurized	39.00	26.28	
MH 15 SWR 15 - 1	60.44	19.24	13.58	5.46	6.60	14.23	4.00	Supercritical	10.00	0.00	
MH 9 SWR 9 - 1	31.27	9.95	15.56	6.03	10.79	9.49	2.02	Pressurized	13.00	26.17	

MH 10 SWR 10 - 1	38.41	21.74	9.18	4.41	3.92	14.06	5.17	Supercritical	4.00	0.00	
MH 16 SWR 16 - 1	31.27	9.95	11.26	4.83	7.72	8.02	2.07	Supercritical Jump	7.00	29.76	
MH 3 SWR 3 - 1	41.13	8.38	20.44	7.02	16.89	8.78	1.45	Pressurized	25.00	41.27	
MH 5 SWR 5 - 1	63.71	12.98	19.58	6.78	12.46	11.93	2.38	Supercritical Jump	23.00	22.28	
MH 4 SWR 4 - 1	34.61	19.59	7.90	4.02	3.58	12.01	4.63	Supercritical Jump	3.00	5.18	

- A Froude number of 0 indicates that pressured flow occurs (adverse slope or undersized pipe).
- If the sewer is not pressurized, full flow represents the maximum gravity flow in the sewer.
- If the sewer is pressurized, full flow represents the pressurized flow conditions.

Grade Line Summary:

Tailwater Elevation (ft): 7168.30

	Invert Elev.		Downstream Manhole Losses		HGL		EGL		
Element Name	**Downstream (ft)**	**Upstream (ft)**	**Bend Loss (ft)**	**Lateral Loss (ft)**	**Downstream (ft)**	**Upstream (ft)**	**Downstream (ft)**	**Friction Loss (ft)**	**Upstream (ft)**
MH 1 SWR 1 - 1	7164.75	7165.31	0.00	0.00	7168.30	7168.30	7169.51	0.25	7169.76
MH 2 SWR 2 - 1	7165.30	7178.00	0.10	0.00	7168.40	7180.87	7180.58	1.87	7182.44

MH 6 SWR 6 - 1	7178.66	7193.96	0.10	0.00	7180.97	7196.53	7185.74	12.32	7198.06
MH 7 SWR 7 - 1	7194.56	7206.93	1.43	0.19	7198.60	7209.41	7199.68	11.11	7210.79
MH 8 SWR 8 - 1	7207.43	7210.92	0.05	0.00	7209.61	7213.40	7211.38	3.40	7214.78
MH 11 SWR 11 - 1	7211.47	7215.89	0.03	0.40	7213.83	7218.12	7215.90	3.30	7219.20
MH 12 SWR 12 - 1	7216.38	7219.42	0.03	0.00	7218.24	7221.65	7219.87	2.86	7222.73
MH 13 SWR 13 - 1	7219.92	7220.75	0.91	0.00	7222.95	7222.98	7223.64	0.42	7224.06
MH 14 SWR 14 - 1	7221.25	7221.51	1.04	0.00	7224.12	7224.36	7225.10	0.24	7225.34
MH 15 SWR 15 - 1	7221.75	7222.09	0.13	0.00	7223.11	7225.29	7225.44	0.00	7225.44
MH 9 SWR 9 - 1	7212.42	7212.92	0.35	0.00	7214.87	7214.96	7215.14	0.09	7215.22
MH 10 SWR 10 - 1	7212.93	7213.48	0.11	0.00	7213.51	7216.24	7216.32	0.00	7216.32
MH 16 SWR 16 - 1	7195.45	7196.37	0.01	0.00	7197.99	7197.99	7198.07	0.03	7198.10
MH 3 SWR 3 - 1	7179.01	7179.42	0.33	0.00	7182.38	7182.53	7182.78	0.15	7182.93
MH 5 SWR 5 - 1	7179.91	7180.52	0.28	0.00	7182.87	7182.93	7183.21	0.07	7183.28
MH 4 SWR 4 - 1	7180.86	7181.60	0.03	0.00	7182.91	7182.91	7182.96	0.01	7182.97

Description

Photograph SB-1. Sediment basin at the toe of a slope. Photo courtesy of WWE.

A sediment basin is a temporary pond built on a construction site to capture eroded or disturbed soil transported in storm runoff prior to discharge from the site. Sediment basins are designed to capture site runoff and slowly release it to allow time for settling of sediment prior to discharge. Sediment basins are often constructed in locations that will later be modified to serve as post-construction stormwater basins.

Appropriate Uses

Most large construction sites (typically greater than 2 acres) will require one or more sediment basins for effective management of construction site runoff. On linear construction projects, sediment basins may be impractical; instead, sediment traps or other combinations of BMPs may be more appropriate.

Sediment basins should not be used as stand-alone sediment controls. Erosion and other sediment controls should also be implemented upstream.

When feasible, the sediment basin should be installed in the same location where a permanent post-construction detention pond will be located.

Design and Installation

The design procedure for a sediment basin includes these steps:

- **Basin Storage Volume**: Provide a storage volume of at least 3,600 cubic feet per acre of drainage area. To the extent practical, undisturbed and/or off-site areas should be diverted around sediment basins to prevent “clean” runoff from mixing with runoff from disturbed areas. For undisturbed areas (both on-site and off-site) that cannot be diverted around the sediment basin, provide a minimum of 500 ft^3/acre of storage for undeveloped (but stable) off-site areas in addition to the 3,600 ft^3/acre for disturbed areas. For stable, developed areas that cannot be diverted around the sediment basin, storage volume requirements are summarized in Table SB-1.

- **Basin Geometry:** Design basin with a minimum length-to-width ratio of 2:1 (L:W). If this cannot be achieved because of site space constraints, baffling may be required to extend the effective distance between the inflow point(s) and the outlet to minimize short-circuiting.

- **Dam Embankment**: It is recommended that embankment slopes be 4:1 (H:V) or flatter and no steeper than 3:1 (H:V) in any location.

Sediment Basins	
Functions	
Erosion Control	No
Sediment Control	Yes
Site/Material Management	No

- **Inflow Structure**: For concentrated flow entering the basin, provide energy dissipation at the point of inflow.

Table SB-1. Additional Volume Requirements for Undisturbed and Developed Tributary Areas Draining through Sediment Basins

Imperviousness (%)	Additional Storage Volume (ft^3) Per Acre of Tributary Area
Undeveloped	500
10	800
20	1230
30	1600
40	2030
50	2470
60	2980
70	3560
80	4360
90	5300
100	6460

- **Outlet Works**: The outlet pipe shall extend through the embankment at a minimum slope of 0.5 percent. Outlet works can be designed using one of the following approaches:
  - **Riser Pipe (Simplified Detail):** Detail SB-1 provides a simplified design for basins treating no more than 15 acres.
  - **Orifice Plate or Riser Pipe**: Follow the design criteria for Full Spectrum Detention outlets in the EDB Fact Sheet provided in Chapter 4 of this manual for sizing of outlet perforations with an emptying time of approximately 72 hours. In lieu of the trash rack, pack uniformly sized 1½ - to 2-inch gravel in front of the plate or surrounding the riser pipe. This gravel will need to be cleaned out frequently during the construction period as sediment accumulates within it. The gravel pack will need to be removed and disposed of following construction to reclaim the basin for use as a permanent detention facility. If the basin will be used as a permanent extended detention basin for the site, a trash rack will need to be installed once contributing drainage areas have been stabilized and the gravel pack and accumulated sediment have been removed.
  - **Floating Skimmer**: If a floating skimmer is used, install it using manufacturer's recommendations. Illustration SB-1 provides an illustration of a Faircloth Skimmer Floating Outlet™, one of the more commonly used floating skimmer outlets. A skimmer should be designed to release the design volume in no less than 48 hours. The use of a floating skimmer outlet can increase the sediment capture efficiency of a basin significantly. A floating outlet continually decants cleanest water off the surface of the pond and releases cleaner water than would discharge from a perforated riser pipe or plate.

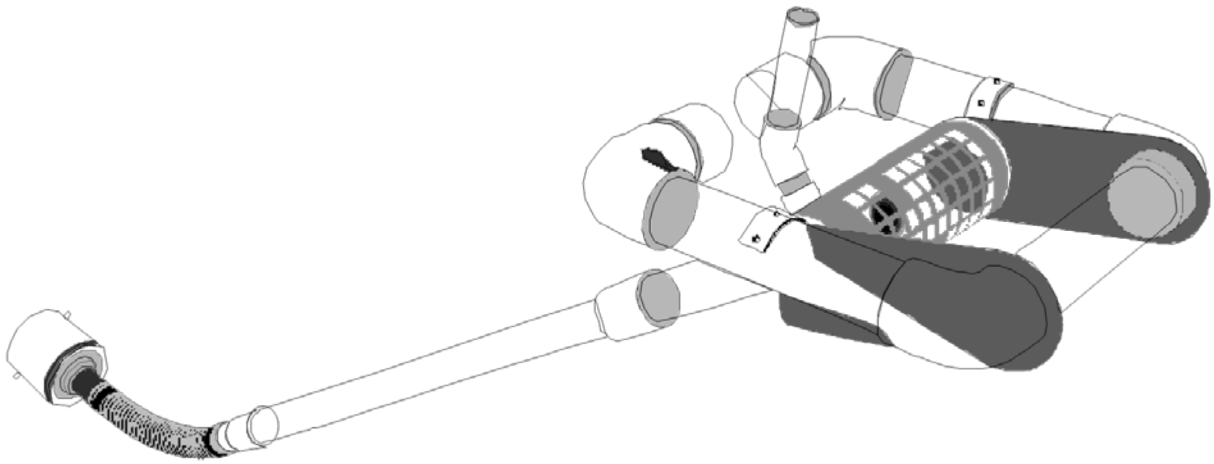


Illustration SB-1. Outlet structure for a temporary sediment basin - Faircloth Skimmer Floating Outlet. Illustration courtesy of J. W. Faircloth & Sons, Inc., FairclothSkimmer.com.

- **Outlet Protection and Spillway:** Consider all flow paths for runoff leaving the basin, including protection at the typical point of discharge as well as overtopping.
  - **Outlet Protection:** Outlet protection should be provided where the velocity of flow will exceed the maximum permissible velocity of the material of the waterway into which discharge occurs. This may require the use of a riprap apron at the outlet location and/or other measures to keep the waterway from eroding.
  - **Emergency Spillway:** Provide a stabilized emergency overflow spillway for rainstorms that exceed the capacity of the sediment basin volume and its outlet. Protect basin embankments from erosion and overtopping. If the sediment basin will be converted to a permanent detention basin, design and construct the emergency spillway(s) as required for the permanent facility. If the sediment basin will not become a permanent detention basin, it may be possible to substitute a heavy polyvinyl membrane or properly bedded rock cover to line the spillway and downstream embankment, depending on the height, slope, and width of the embankments.

Maintenance and Removal

Maintenance activities include the following:

- Dredge sediment from the basin, as needed to maintain BMP effectiveness, typically when the design storage volume is no more than one-third filled with sediment.

- Inspect the sediment basin embankments for stability and seepage.

- Inspect the inlet and outlet of the basin, repair damage, and remove debris. Remove, clean and replace the gravel around the outlet on a regular basis to remove the accumulated sediment within it and keep the outlet functioning.

- Be aware that removal of a sediment basin may require dewatering and associated permit requirements.

- Do not remove a sediment basin until the upstream area has been stabilized with vegetation.

Final disposition of the sediment basin depends on whether the basin will be converted to a permanent post-construction stormwater basin or whether the basin area will be returned to grade. For basins being converted to permanent detention basins, remove accumulated sediment and reconfigure the basin and outlet to meet the requirements of the final design for the detention facility. If the sediment basin is not to be used as a permanent detention facility, fill the excavated area with soil and stabilize with vegetation.

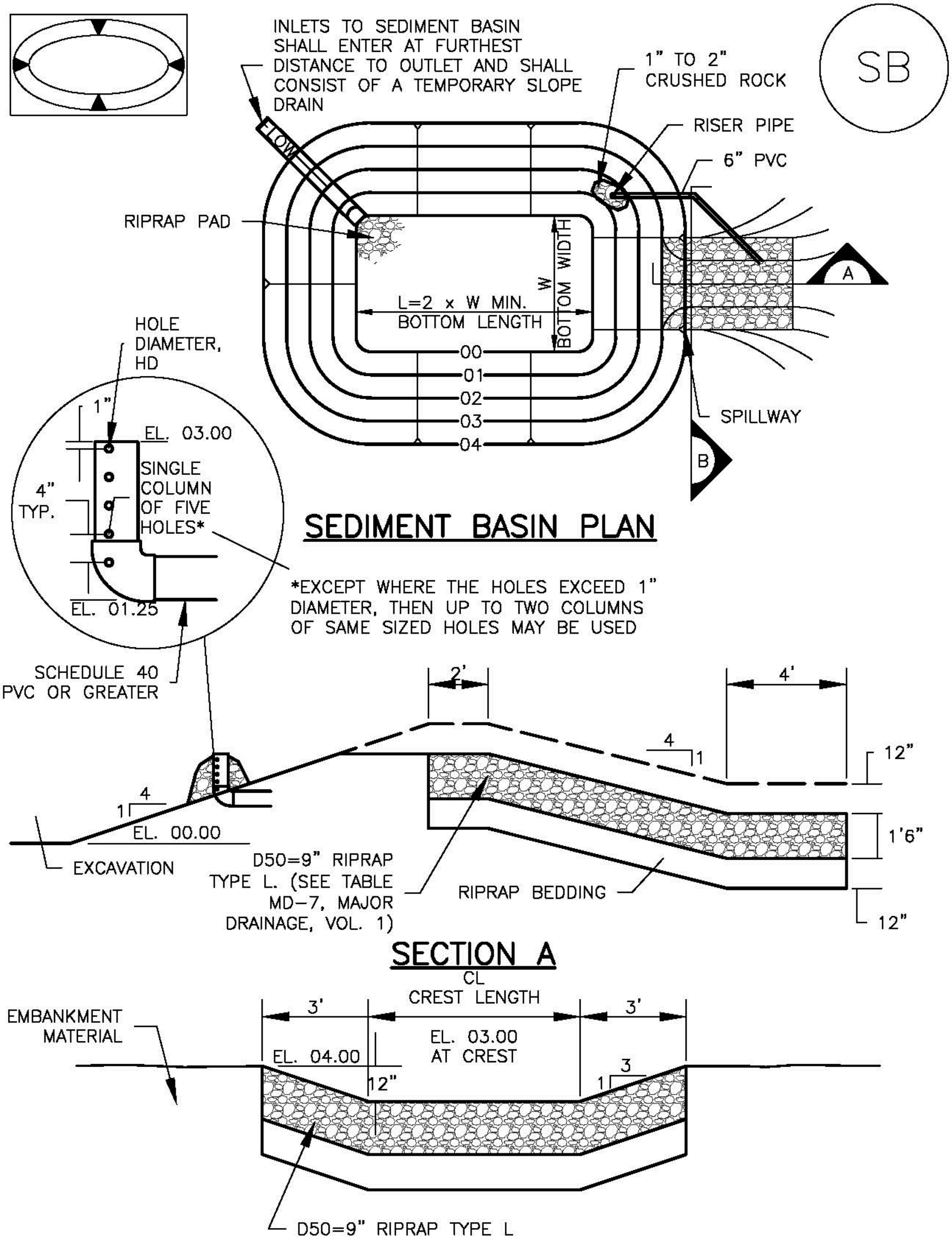

INLETS TO SEDIMENT BASIN SHALL ENTER AT FURTHEST DISTANCE TO OUTLET AND SHALL CONSIST OF A TEMPORARY SLOPE DRAIN
1" TO 2" CRUSHED ROCK
SB
FLOW
RISER PIPE
6" PVC
RIPRAP PAD
W BOTTOM WIDTH
L=2 x W MIN. BOTTOM LENGTH
A
00
01
02
03
04
SPILLWAY
B
HOLE DIAMETER, HD
1"
EL. 03.00
SINGLE COLUMN OF FIVE HOLES*
4" TYP.
EL. 01.25
SEDIMENT BASIN PLAN
*EXCEPT WHERE THE HOLES EXCEED 1" DIAMETER, THEN UP TO TWO COLUMNS OF SAME SIZED HOLES MAY BE USED
SCHEDULE 40 PVC OR GREATER
2'
4'
4
1
12"
1'6"
12"
EL. 00.00
EXCAVATION
D50=9" RIPRAP TYPE L. (SEE TABLE MD-7, MAJOR DRAINAGE, VOL. 1)
RIPRAP BEDDING
SECTION A
CL
CREST LENGTH
3'
3'
EMBANKMENT MATERIAL
EL. 04.00
EL. 03.00 AT CREST
12"
3
1
D50=9" RIPRAP TYPE L

TABLE SB-1. SIZING INFORMATION FOR STANDARD SEDIMENT BASIN			
Upstream Drainage Area (rounded to nearest acre), (ac)	Basin Bottom Width (W), (ft)	Spillway Crest Length (CL), (ft)	Hole Diameter (HD), (in)
1	12 1/2	2	9/32
2	21	3	13/16
3	28	5	1/2
4	33 1/2	6	9/16
5	38 1/2	8	21/32
6	43	9	21/32
7	47 1/4	11	25/32
8	51	12	27/32
9	55	13	7/8
10	58 1/4	15	15/16
11	61	16	31/32
12	64	18	1
13	67 1/2	19	1 1/16
14	70 1/2	21	1 1/8
15	73 1/4	22	1 3/16

SEDIMENT BASIN INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
   - LOCATION OF SEDIMENT BASIN.
   - TYPE OF BASIN (STANDARD BASIN OR NONSTANDARD BASIN).
   - FOR STANDARD BASIN, BOTTOM WIDTH W, CREST LENGTH CL, AND HOLE DIAMETER, HD.
   - FOR NONSTANDARD BASIN, SEE CONSTRUCTION DRAWINGS FOR DESIGN OF BASIN INCLUDING RISER HEIGHT H, NUMBER OF COLUMNS N, HOLE DIAMETER HD AND PIPE DIAMETER D.

2. FOR STANDARD BASIN, BOTTOM DIMENSION MAY BE MODIFIED AS LONG AS BOTTOM AREA IS NOT REDUCED.

3. SEDIMENT BASINS SHALL BE INSTALLED PRIOR TO ANY OTHER LAND-DISTURBING ACTIVITY THAT RELIES ON ON BASINS AS AS A STORMWATER CONTROL.

4. EMBANKMENT MATERIAL SHALL CONSIST OF SOIL FREE OF DEBRIS, ORGANIC MATERIAL, AND ROCKS OR CONCRETE GREATER THAN 3 INCHES AND SHALL HAVE A MINIMUM OF 15 PERCENT BY WEIGHT PASSING THE NO. 200 SIEVE.

5. EMBANKMENT MATERIAL SHALL BE COMPACTED TO AT LEAST 95 PERCENT OF MAXIMUM DENSITY IN ACCORDANCE WITH ASTM D698.

6. PIPE SCH 40 OR GREATER SHALL BE USED.

7. THE DETAILS SHOWN ON THESE SHEETS PERTAIN TO STANDARD SEDIMENT BASIN(S) FOR DRAINAGE AREAS LESS THAN 15 ACRES. SEE CONSTRUCTION DRAWINGS FOR EMBANKMENT, STORAGE VOLUME, SPILLWAY, OUTLET, AND OUTLET PROTECTION DETAILS FOR ANY SEDIMENT BASIN(S) THAT HAVE BEEN INDIVIDUALLY DESIGNED FOR DRAINAGE AREAS LARGER THAN 15 ACRES.

SEDIMENT BASIN MAINTENANCE NOTES

1. INSPECT BMPs EACH WORKDAY, AND MAINTAIN THEM IN EFFECTIVE OPERATING CONDITION. MAINTENANCE OF BMPs SHOULD BE PROACTIVE, NOT REACTIVE. INSPECT BMPs AS SOON AS POSSIBLE (AND ALWAYS WITHIN 24 HOURS) FOLLOWING A STORM THAT CAUSES SURFACE EROSION, AND PERFORM NECESSARY MAINTENANCE.

2. FREQUENT OBSERVATIONS AND MAINTENANCE ARE NECESSARY TO MAINTAIN BMPs IN EFFECTIVE OPERATING CONDITION. INSPECTIONS AND CORRECTIVE MEASURES SHOULD BE DOCUMENTED THOROUGHLY.

3. WHERE BMPs HAVE FAILED, REPAIR OR REPLACEMENT SHOULD BE INITIATED UPON DISCOVERY OF THE FAILURE.

4. SEDIMENT ACCUMULATED IN BASIN SHALL BE REMOVED AS NEEDED TO MAINTAIN BMP EFFECTIVENESS, TYPICALLY WHEN SEDIMENT DEPTH REACHES ONE FOOT (I.E., TWO FEET BELOW THE SPILLWAY CREST).

5. SEDIMENT BASINS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVER IS ACCEPTED BY THE LOCAL JURISDICTION.

6. WHEN SEDIMENT BASINS ARE REMOVED, ALL DISTURBED AREAS SHALL BE COVERED WITH TOPSOIL, SEEDED AND MULCHED OR OTHERWISE STABILIZED AS APPROVED BY LOCAL JURISDICTION.

(DETAILS ADAPTED FROM DOUGLAS COUNTY, COLORADO)

NOTE: MANY JURISDICTIONS HAVE BMP DETAILS THAT VARY FROM UDFCD STANDARD DETAILS. CONSULT WITH LOCAL JURISDICTIONS AS TO WHICH DETAIL SHOULD BE USED WHEN DIFFERENCES ARE NOTED.

STORMWATER QUALITY CALCULATIONS

Design Procedure Form: Extended Detention Basin (EDB)

UD-BMP (Version 3.07, March 2018)

Designer: Marc A. Whorton, P.E.
Company: Classic Consulting
Date: April 1, 2021
Project: Retreat at TimberRidge Filing No. 2
Location: Pond 3

1. Basin Storage Volume

A) Effective Imperviousness of Tributary Area, I_a	I_a =	13.0	%
B) Tributary Area's Imperviousness Ratio ($i = I_a / 100$)	i =	0.130	
C) Contributing Watershed Area	Area =	64.000	ac
D) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm	d_6 =	0.42	in
E) Design Concept (Select EURV when also designing for flood control)	Choose One: ◯ Water Quality Capture Volume (WQCV) ◉ Excess Urban Runoff Volume (EURV)		
F) Design Volume (WQCV) Based on 40-hour Drain Time ($V_{DESIGN} = (1.0 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i) / 12 * Area$)	V_{DESIGN}=		ac-ft
G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume ($V_{WQCV\ OTHER} = (d_6*(V_{DESIGN}/0.43))$)	$V_{DESIGN\ OTHER}$=	0.434	ac-ft
H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired)	$V_{DESIGN\ USER}$=		ac-ft
I) NRCS Hydrologic Soil Groups of Tributary Watershed			
i) Percentage of Watershed consisting of Type A Soils	HSG_A =	0	%
ii) Percentage of Watershed consisting of Type B Soils	HSG_B =	100	%
iii) Percentage of Watershed consisting of Type C/D Soils	$HSG_{C/D}$ =	0	%
J) Excess Urban Runoff Volume (EURV) Design Volume For HSG A: $EURV_A = 1.68 * i^{1.28}$ For HSG B: $EURV_B = 1.36 * i^{1.08}$ For HSG C/D: $EURV_{C/D} = 1.20 * i^{1.08}$	$EURV_{DESIGN}$ =	0.801	ac-f t
K) User Input of Excess Urban Runoff Volume (EURV) Design Volume (Only if a different EURV Design Volume is desired)	$EURV_{DESIGN\ USER}$=		ac-f t

2. Basin Shape: Length to Width Ratio (A basin length to width ratio of at least 2:1 will improve TSS reduction.)

L : W = 2.0 : 1

3. Basin Side Slopes

A) Basin Maximum Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred) — Z = 4.00 ft / ft

4. Inlet

A) Describe means of providing energy dissipation at concentrated inflow locations:

5. Forebay

A) Minimum Forebay Volume (V_{FMIN} = 3% of the WQCV)	V_{FMIN} =	0.013	ac-ft
B) Actual Forebay Volume	V_F =	0.013	ac-ft
C) Forebay Depth (D_F = 18 inch maximum)	D_F =	18.0	in
D) Forebay Discharge			
i) Undetained 100-year Peak Discharge	Q_{100} =	71.00	cfs
ii) Forebay Discharge Design Flow ($Q_F = 0.02 * Q_{100}$)	Q_F =	1.42	cfs
E) Forebay Discharge Design	Choose One: ◯ Berm With Pipe ◉ Wall with Rect. Notch ◯ Wall with V-Notch Weir	Flow too small for berm w/ pipe	
F) Discharge Pipe Size (minimum 8-inches)	Calculated D_P =		in
G) Rectangular Notch Width	Calculated W_N =	6.4	in

Design Procedure Form: Extended Detention Basin (EDB)

Designer: Marc A. Whorton, P.E.
Company: Classic Consulting
Date: April 1, 2021
Project: Retreat at TimberRidge Filing No. 2
Location: Pond 3

6. Trickle Channel	
A) Type of Trickle Channel	Choose One: (●) Concrete ( ) Soft Bottom
F) Slope of Trickle Channel	S = 0.0100 ft / ft
7. Micropool and Outlet Structure	
A) Depth of Micropool (2.5-feet minimum)	D_M = 2.5 ft
B) Surface Area of Micropool (10 ft^2 minimum)	A_M = 115 sq ft
C) Outlet Type	Choose One: (●) Orifice Plate ( ) Other (Describe):
D) Smallest Dimension of Orifice Opening Based on Hydrograph Routing (Use UD-Detention)	$D_{orifice}$ = 1.50 inches
E) Total Outlet Area	A_{ot} = 5.58 square inches
8. Initial Surcharge Volume	
A) Depth of Initial Surcharge Volume (Minimum recommended depth is 4 inches)	D_{IS} = 6 in
B) Minimum Initial Surcharge Volume (Minimum volume of 0.3% of the WQCV)	V_{IS} = 57 cu ft
C) Initial Surcharge Provided Above Micropool	V_s= 57.5 cu ft
9. Trash Rack	
A) Water Quality Screen Open Area: $A_t = A_{ot} * 38.5*(e^{-0.095D})$	A_t = 186 square inches
B) Type of Screen (If specifying an alternative to the materials recommended in the USDCM, indicate "other" and enter the ratio of the total open are to the total screen are for the material specified.) Other (Y/N): N	*Aluminum Amico-Klemp SR Series with Cross Rods 2" O.C.*
C) Ratio of Total Open Area to Total Area (only for type 'Other')	User Ratio =
D) Total Water Quality Screen Area (based on screen type)	A_{total} = 262 sq. in.
E) Depth of Design Volume (EURV or WQCV) (Based on design concept chosen under 1E)	H= 4.5 feet
F) Height of Water Quality Screen (H_{TR})	H_{TR}= 82 inches
G) Width of Water Quality Screen Opening ($W_{opening}$) (Minimum of 12 inches is recommended)	$W_{opening}$ = 12.0 inches **VALUE LESS THAN RECOMMENDED MIN. WIDTH. WIDTH HAS BEEN SET TO 12 INCHES.**

Design Procedure Form: Extended Detention Basin (EDB)

Designer:	**Marc A. Whorton, P.E.**
Company:	**Classic Consulting**
Date:	**April 1, 2021**
Project:	**Retreat at TimberRidge Filing No. 2**
Location:	**Pond 3**

10. Overflow Embankment A) Describe embankment protection for 100-year and greater overtopping: B) Slope of Overflow Embankment (Horizontal distance per unit vertical, 4:1 or flatter preferred)	 Ze = 4.00 ft / ft
11. Vegetation	Choose One ○ Irrigated ◉ Not Irrigated
12. Access A) Describe Sediment Removal Procedures	

Notes:

Design Procedure Form: Extended Detention Basin (EDB)

UD-BMP (Version 3.07, March 2018)

Designer: Marc A. Whorton, P.E.
Company: Classic Consulting
Date: April 1, 2021
Project: Retreat at TimberRidge Filing No. 2
Location: Pond 3 ← Is this duplicate?

1. Basin Storage Volume

A) Effective Imperviousness of Tributary Area, I_a — I_a = 13.0 %

B) Tributary Area's Imperviousness Ratio ($i = I_a / 100$) — i = 0.130

C) Contributing Watershed Area — Area = 64.000 ac

D) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm — d_6 = 0.42 in

E) Design Concept (Select EURV when also designing for flood control)

Choose One
- ◯ Water Quality Capture Volume (WQCV)
- ◉ Excess Urban Runoff Volume (EURV)

F) Design Volume (WQCV) Based on 40-hour Drain Time ($V_{DESIGN} = (1.0 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i) / 12 * Area)$) — V_{DESIGN}= ____ ac-ft

G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume ($V_{WQCV\ OTHER} = (d_6*(V_{DESIGN}/0.43))$) — $V_{DESIGN\ OTHER}$= 0.434 ac-ft

H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired) — $V_{DESIGN\ USER}$= ____ ac-ft

I) NRCS Hydrologic Soil Groups of Tributary Watershed
- i) Percentage of Watershed consisting of Type A Soils — HSG_A = 0 %
- ii) Percentage of Watershed consisting of Type B Soils — HSG_B = 100 %
- iii) Percentage of Watershed consisting of Type C/D Soils — $HSG_{C/D}$ = 0 %

J) Excess Urban Runoff Volume (EURV) Design Volume
- For HSG A: $EURV_A = 1.68 * i^{1.28}$
- For HSG B: $EURV_B = 1.36 * i^{1.08}$
- For HSG C/D: $EURV_{C/D} = 1.20 * i^{1.08}$

$EURV_{DESIGN}$ = 0.801 ac-f t

K) User Input of Excess Urban Runoff Volume (EURV) Design Volume (Only if a different EURV Design Volume is desired) — $EURV_{DESIGN\ USER}$= ____ ac-f t

2. Basin Shape: Length to Width Ratio (A basin length to width ratio of at least 2:1 will improve TSS reduction.) — L : W = 2.0 : 1

3. Basin Side Slopes

A) Basin Maximum Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred) — Z = 4.00 ft / ft

4. Inlet

A) Describe means of providing energy dissipation at concentrated inflow locations:

5. Forebay

A) Minimum Forebay Volume (V_{FMIN} = 3% of the WQCV) — V_{FMIN} = 0.013 ac-ft

B) Actual Forebay Volume — V_F = 0.013 ac-ft

C) Forebay Depth (D_F = 18 inch maximum) — D_F = 18.0 in

D) Forebay Discharge
- i) Undetained 100-year Peak Discharge — Q_{100} = 71.00 cfs
- ii) Forebay Discharge Design Flow ($Q_F = 0.02 * Q_{100}$) — Q_F = 1.42 cfs

E) Forebay Discharge Design

Choose One
- ◯ Berm With Pipe
- ◉ Wall with Rect. Notch
- ◯ Wall with V-Notch Weir

Flow too small for berm w/ pipe

F) Discharge Pipe Size (minimum 8-inches) — Calculated D_P = ____ in

G) Rectangular Notch Width — Calculated W_N = 6.4 in

Design Procedure Form: Extended Detention Basin (EDB)

Designer:	**Marc A. Whorton, P.E.**
Company:	**Classic Consulting**
Date:	**April 1, 2021**
Project:	**Retreat at TimberRidge Filing No. 2**
Location:	**Pond 3**

6. Trickle Channel	
A) Type of Trickle Channel	Choose One: (●) Concrete ( ) Soft Bottom
F) Slope of Trickle Channel	S = 0.0100 ft / ft
7. Micropool and Outlet Structure	
A) Depth of Micropool (2.5-feet minimum)	D_M = 2.5 ft
B) Surface Area of Micropool (10 ft^2 minimum)	A_M = 115 sq ft
C) Outlet Type	Choose One: (●) Orifice Plate ( ) Other (Describe):
D) Smallest Dimension of Orifice Opening Based on Hydrograph Routing (Use UD-Detention)	$D_{orifice}$ = 1.78 inches
E) Total Outlet Area	A_{ot} = 8.18 square inches
8. Initial Surcharge Volume	
A) Depth of Initial Surcharge Volume (Minimum recommended depth is 4 inches)	D_{IS} = 6 in
B) Minimum Initial Surcharge Volume (Minimum volume of 0.3% of the WQCV)	V_{IS} = 57 cu ft
C) Initial Surcharge Provided Above Micropool	V_s= 57.5 cu ft
9. Trash Rack	
A) Water Quality Screen Open Area: $A_t = A_{ot} * 38.5*(e^{-0.095D})$	A_t = 266 square inches
B) Type of Screen (If specifying an alternative to the materials recommended in the USDCM, indicate "other" and enter the ratio of the total open are to the total screen are for the material specified.) Other (Y/N): N	*Aluminum Amico-Klemp SR Series with Cross Rods 2" O.C.*
C) Ratio of Total Open Area to Total Area (only for type 'Other')	User Ratio =
D) Total Water Quality Screen Area (based on screen type)	A_{total} = 375 sq. in.
E) Depth of Design Volume (EURV or WQCV) (Based on design concept chosen under 1E)	H= 3.5 feet
F) Height of Water Quality Screen (H_{TR})	H_{TR}= 70 inches
G) Width of Water Quality Screen Opening ($W_{opening}$) (Minimum of 12 inches is recommended)	$W_{opening}$ = 12.0 inches **VALUE LESS THAN RECOMMENDED MIN. WIDTH. WIDTH HAS BEEN SET TO 12 INCHES.**

Design Procedure Form: Extended Detention Basin (EDB)

Designer: Marc A. Whorton, P.E.
Company: Classic Consulting
Date: April 1, 2021
Project: Retreat at TimberRidge Filing No. 2
Location: Pond 3

10. Overflow Embankment	
A) Describe embankment protection for 100-year and greater overtopping:	
B) Slope of Overflow Embankment (Horizontal distance per unit vertical, 4:1 or flatter preferred)	Ze = 4.00 ft / ft
11. Vegetation	Choose One ○ Irrigated ◉ Not Irrigated
12. Access	
A) Describe Sediment Removal Procedures	

Notes:

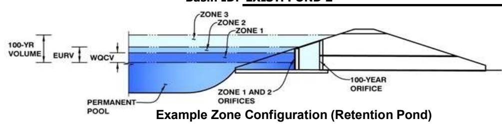
DETENTION POND CALCULATIONS

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.03 (May 2020)

Project: RETREAT AT TIMBERRIDGE FILING NO. 2

Basin ID: EXIST. POND 2



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	**EDB**			
Watershed Area =	101.20	acres		
Watershed Length =	4,000	ft		
Watershed Length to Centroid =	2,000	ft		
Watershed Slope =	0.032	ft/ft		
Watershed Imperviousness =	21.70%	percent		
Percentage Hydrologic Soil Group A =	0.0%	percent		
Percentage Hydrologic Soil Group B =	100.0%	percent		
Percentage Hydrologic Soil Groups C/D =	0.0%	percent		
Target WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	User Input			

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	1.033	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	2.196	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	2.378	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	4.231	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	5.985	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	8.800	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	10.837	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	13.643	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3.85 in.) =	25.127	acre-feet	3.85	inches
Approximate 2-yr Detention Volume =	1.519	acre-feet		
Approximate 5-yr Detention Volume =	2.234	acre-feet		
Approximate 10-yr Detention Volume =	3.529	acre-feet		
Approximate 25-yr Detention Volume =	4.308	acre-feet		
Approximate 50-yr Detention Volume =	4.550	acre-feet		
Approximate 100-yr Detention Volume =	5.553	acre-feet		

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	1.033	acre-feet
Zone 2 Volume (EURV - Zone 1) =	1.163	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	3.357	acre-feet
Total Detention Basin Volume =	5.553	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

Depth Increment = 1.00 ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	277	0.006		
7162	--	2.00	--	--	--	10,268	0.236	10,545	0.242
7264	--	4.00	--	--	--	30,108	0.691	50,921	1.169
7166	--	6.00	--	--	--	38,919	0.893	119,948	2.754
7168	--	8.00	--	--	--	45,498	1.044	204,365	4.692
7170	--	10.00	--	--	--	52,628	1.208	302,491	6.944
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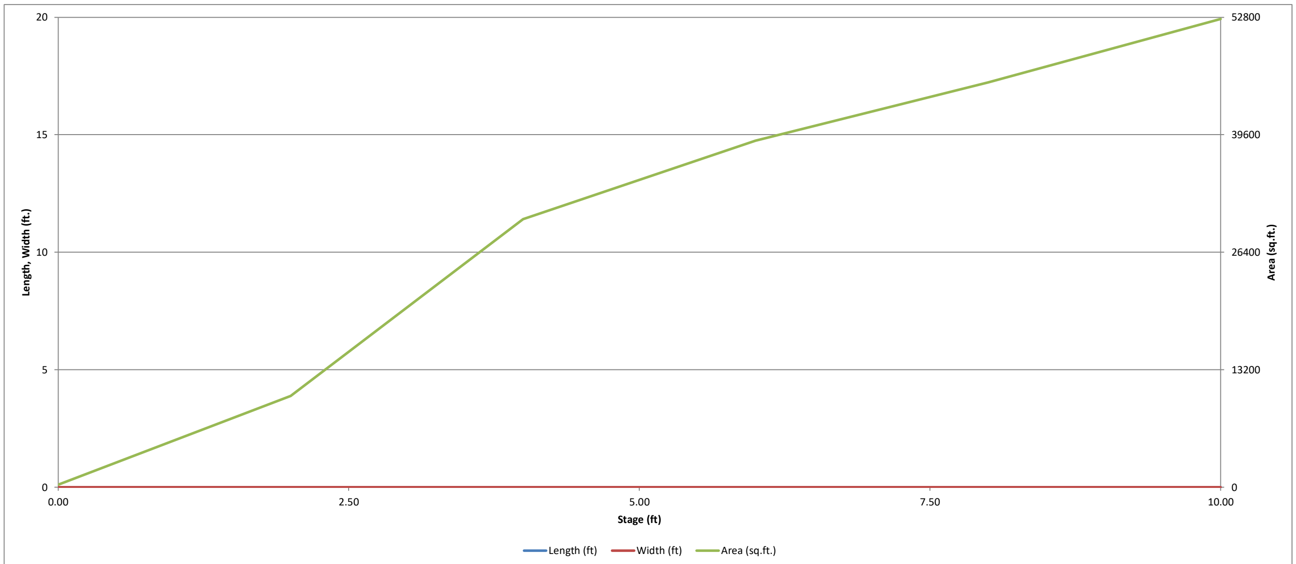
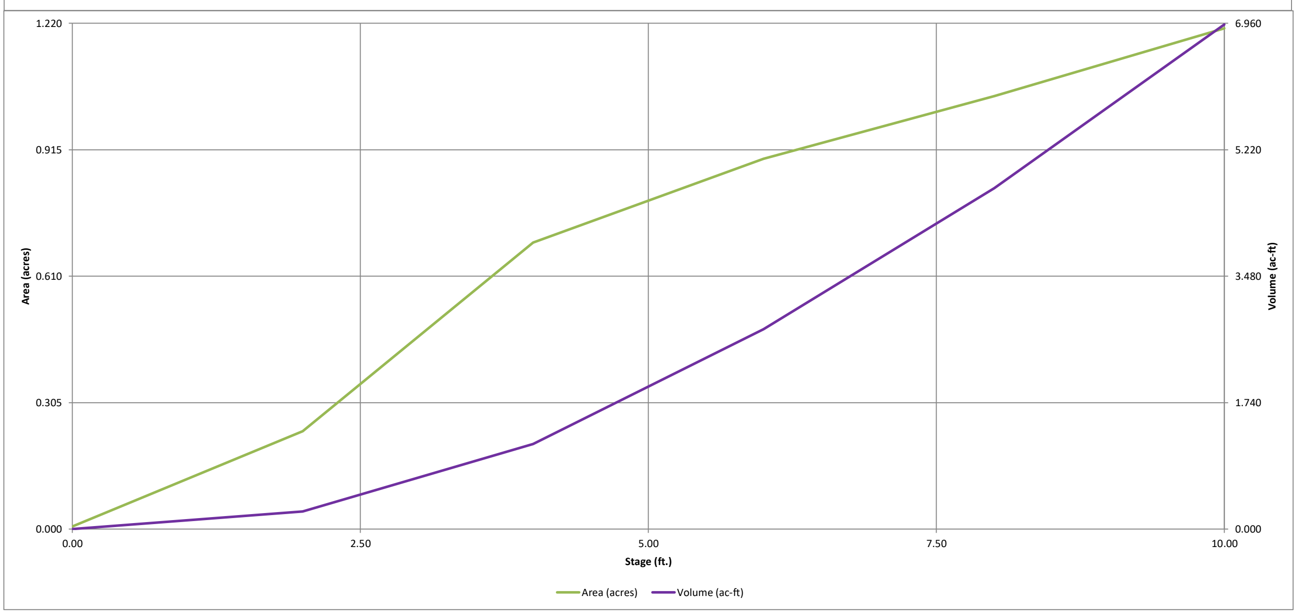
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.03 (May 2020)



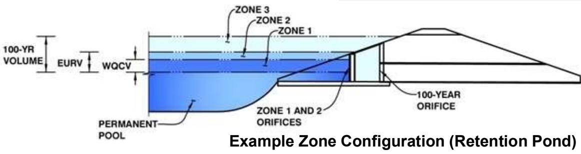


See comment letter regarding location of Pond 3.
Pond 3 details will be reviewed following resolution of the pond location.

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.03 (May 2020)

Project: **RETREAT AT TIMBERRIDGE FILING NO. 2**
Basin ID: **EXIST. POND 2**



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	3.80	1.033	Orifice Plate
Zone 2 (EURV)	5.36	1.163	Orifice Plate
Zone 3 (100-year)	8.80	3.357	Weir&Pipe (Restrict)
Total (all zones)		5.553	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =		ft (distance below the filtration media surface)
Underdrain Orifice Diameter =		inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =		ft^2
Underdrain Orifice Centroid =		feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	5.50	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	16.50	inches
Orifice Plate: Orifice Area per Row =	N/A	inches

Calculated Parameters for Plate

WQ Orifice Area per Row =	N/A	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.40	2.80	4.20				
Orifice Area (sq. inches)	3.00	4.00	4.00	4.00				

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	N/A	N/A	inches

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =	N/A	N/A	ft^2
Vertical Orifice Centroid =	N/A	N/A	feet

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir (and No Outlet Pipe)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	5.50	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	8.00	N/A	feet
Overflow Weir Grate Slope =	4.00	N/A	H:V
Horiz. Length of Weir Sides =	4.00	N/A	feet
Overflow Grate Open Area % =	75%	N/A	%, grate open area/total area
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	6.50	N/A	feet
Overflow Weir Slope Length =	4.12	N/A	feet
Grate Open Area / 100-yr Orifice Area =	2.57	N/A	
Overflow Grate Open Area w/o Debris =	24.74	N/A	ft^2
Overflow Grate Open Area w/ Debris =	12.37	N/A	ft^2

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	1.00	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	42.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	42.00		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	9.62	N/A	ft^2
Outlet Orifice Centroid =	1.75	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	3.14	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	9.00	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	65.00	feet
Spillway End Slopes =	3.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

Spillway Design Flow Depth=	0.77	feet
Stage at Top of Freeboard =	10.77	feet
Basin Area at Top of Freeboard =	1.21	acres
Basin Volume at Top of Freeboard =	6.94	acre-ft

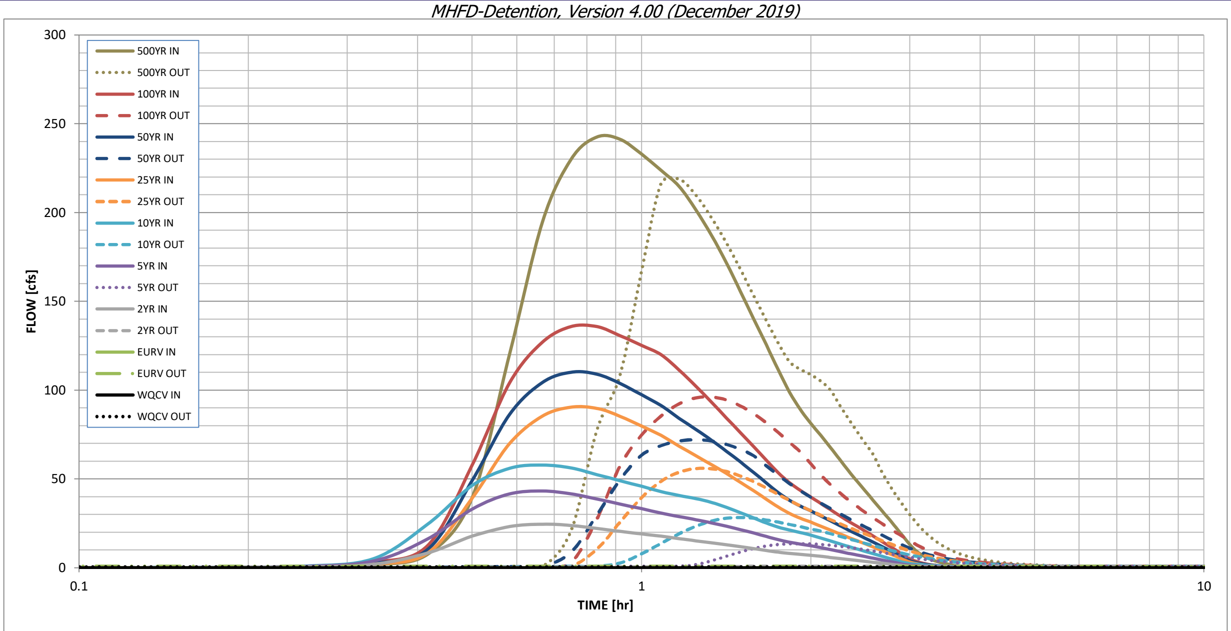
Routed Hydrograph Results

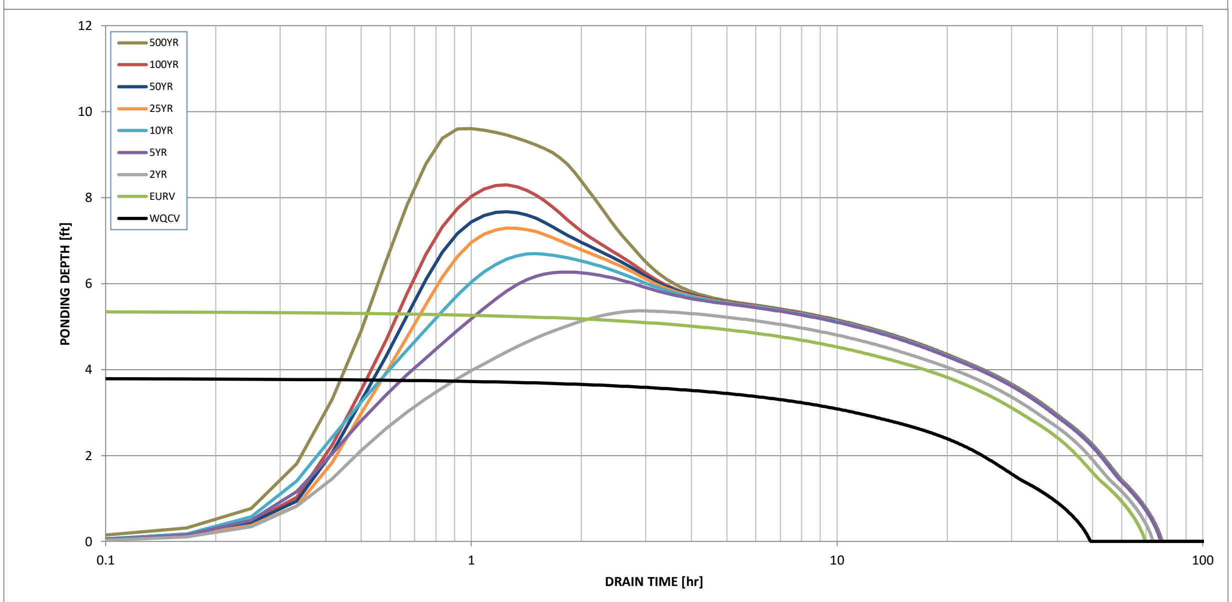
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

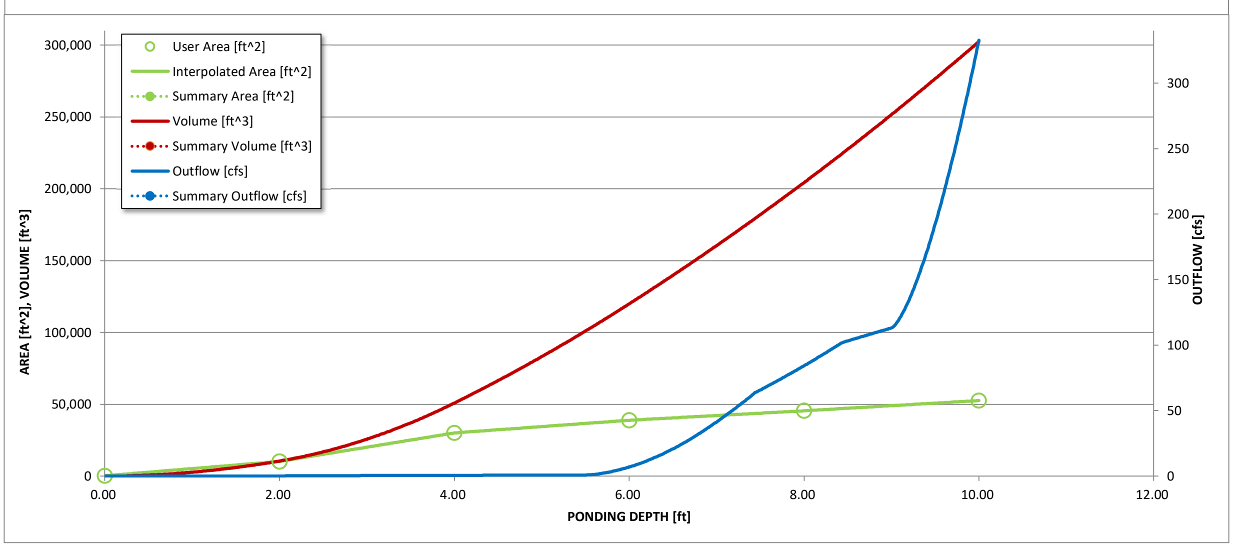
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52	3.85
CUHP Runoff Volume (acre-ft) =	1.033	2.196	2.378	4.231	5.985	8.800	10.837	13.643	25.127
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	2.378	4.231	5.985	8.800	10.837	13.643	25.127
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	9.1	25.4	39.2	71.6	90.0	115.0	215.1
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.09	0.25	0.39	0.71	0.89	1.14	2.13
Peak Inflow Q (cfs) =	N/A	N/A	24.5	43.1	57.8	90.5	110.1	135.8	242.6
Peak Outflow Q (cfs) =	0.5	0.9	0.9	13.5	28.3	55.8	72.1	96.2	218.8
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.5	0.7	0.8	0.8	0.8	1.0
Structure Controlling Flow =	Plate	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	0.5	1.1	2.2	2.9	3.8	5.0
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	43	59	62	59	56	52	49	46	35
Time to Drain 99% of Inflow Volume (hours) =	**46**	65	68	69	67	64	62	59	53
Maximum Ponding Depth (ft) =	3.80	5.36	5.37	6.27	6.70	7.29	7.68	8.30	9.61
Area at Maximum Ponding Depth (acres) =	0.65	0.83	0.83	0.91	0.95	0.99	1.02	1.07	1.18
Maximum Volume Stored (acre-ft) =	1.035	2.203	2.203	2.988	3.388	3.969	4.351	4.998	6.468

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.00 (December 2019)







S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename:

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

Time Interval: 5.00 min

SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.34
0:15:00	0.00	0.00	0.43	0.71	0.88	0.60	0.78	0.73	1.68
0:20:00	0.00	0.00	1.88	3.68	5.01	1.98	2.53	3.03	7.56
0:25:00	0.00	0.00	8.30	16.23	24.40	8.18	10.13	12.46	39.19
0:30:00	0.00	0.00	17.70	32.99	46.22	39.10	48.93	57.61	120.72
0:35:00	0.00	0.00	23.11	41.58	56.04	69.97	86.40	104.22	194.66
0:40:00	0.00	0.00	24.51	43.12	57.85	85.42	104.29	127.00	230.10
0:45:00	0.00	0.00	23.78	41.51	56.11	90.49	110.08	135.80	242.56
0:50:00	0.00	0.00	22.05	38.65	52.45	89.78	109.04	135.78	241.28
0:55:00	0.00	0.00	20.40	35.83	48.94	85.26	103.71	130.68	232.90
1:00:00	0.00	0.00	19.01	33.24	45.82	79.79	97.41	125.23	223.76
1:05:00	0.00	0.00	17.71	30.78	42.88	74.48	91.27	119.94	214.82
1:10:00	0.00	0.00	16.40	28.78	40.68	68.45	84.18	111.34	201.40
1:15:00	0.00	0.00	15.16	27.04	38.95	63.00	77.83	102.14	187.03
1:20:00	0.00	0.00	14.00	25.21	36.76	57.94	71.71	93.19	171.66
1:25:00	0.00	0.00	12.87	23.33	33.96	53.02	65.61	84.35	155.54
1:30:00	0.00	0.00	11.76	21.43	30.96	48.11	59.52	76.03	140.15
1:35:00	0.00	0.00	10.67	19.57	27.97	43.30	53.58	68.17	125.49
1:40:00	0.00	0.00	9.62	17.57	25.12	38.59	47.76	60.57	111.46
1:45:00	0.00	0.00	8.72	15.76	22.84	34.11	42.25	53.46	98.88
1:50:00	0.00	0.00	8.07	14.40	21.20	30.55	37.94	47.84	89.11
1:55:00	0.00	0.00	7.53	13.32	19.79	27.87	34.67	43.49	81.28
2:00:00	0.00	0.00	7.00	12.33	18.34	25.64	31.94	39.78	74.51
2:05:00	0.00	0.00	6.41	11.28	16.74	23.42	29.17	36.17	67.74
2:10:00	0.00	0.00	5.80	10.19	15.09	21.23	26.41	32.66	61.03
2:15:00	0.00	0.00	5.20	9.13	13.49	19.13	23.78	29.34	54.67
2:20:00	0.00	0.00	4.63	8.12	11.96	17.12	21.26	26.22	48.70
2:25:00	0.00	0.00	4.10	7.15	10.52	15.21	18.87	23.33	43.16
2:30:00	0.00	0.00	3.58	6.22	9.15	13.37	16.58	20.55	37.86
2:35:00	0.00	0.00	3.08	5.32	7.85	11.58	14.35	17.82	32.72
2:40:00	0.00	0.00	2.59	4.44	6.60	9.81	12.16	15.12	27.66
2:45:00	0.00	0.00	2.11	3.59	5.38	8.08	10.02	12.46	22.67
2:50:00	0.00	0.00	1.65	2.77	4.20	6.38	7.91	9.82	17.76
2:55:00	0.00	0.00	1.21	2.00	3.10	4.71	5.84	7.24	13.10
3:00:00	0.00	0.00	0.86	1.46	2.36	3.17	3.94	4.90	9.30
3:05:00	0.00	0.00	0.65	1.14	1.90	2.23	2.84	3.46	6.82
3:10:00	0.00	0.00	0.53	0.93	1.56	1.62	2.10	2.51	5.08
3:15:00	0.00	0.00	0.43	0.77	1.29	1.22	1.59	1.81	3.76
3:20:00	0.00	0.00	0.36	0.63	1.06	0.92	1.21	1.30	2.77
3:25:00	0.00	0.00	0.30	0.52	0.87	0.71	0.94	0.92	2.02
3:30:00	0.00	0.00	0.24	0.42	0.69	0.55	0.72	0.64	1.44
3:35:00	0.00	0.00	0.20	0.33	0.54	0.42	0.55	0.46	1.05
3:40:00	0.00	0.00	0.16	0.26	0.42	0.33	0.43	0.37	0.81
3:45:00	0.00	0.00	0.13	0.20	0.32	0.26	0.34	0.29	0.63
3:50:00	0.00	0.00	0.10	0.15	0.25	0.20	0.26	0.23	0.50
3:55:00	0.00	0.00	0.08	0.11	0.19	0.15	0.20	0.18	0.39
4:00:00	0.00	0.00	0.06	0.08	0.14	0.12	0.15	0.14	0.29
4:05:00	0.00	0.00	0.04	0.05	0.09	0.08	0.11	0.10	0.20
4:10:00	0.00	0.00	0.03	0.03	0.06	0.06	0.07	0.06	0.13
4:15:00	0.00	0.00	0.02	0.02	0.03	0.03	0.04	0.04	0.08
4:20:00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.04
4:25:00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.03 (May 2020)

Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

Stage - Storage Description	Stage [ft]	Area [ft ^{2}]	Area [acres]	Volume [ft ^{3}]	Volume [ac-ft]	Total Outflow [cfs]

For best results, include the stages of all grade slope changes (e.g. ISV and Floor) from the S-A-V table on Sheet 'Basin'.

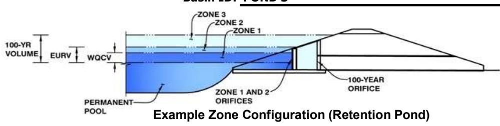
Also include the inverts of all outlets (e.g. vertical orifice, overflow grate, and spillway, where applicable).

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.03 (May 2020)

Project: RETREAT AT TIMBERRIDGE FILING NO. 2

Basin ID: POND 3



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	**EDB**	
Watershed Area =	64.00	acres
Watershed Length =	3,700	ft
Watershed Length to Centroid =	1,500	ft
Watershed Slope =	0.045	ft/ft
Watershed Imperviousness =	13.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	100.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	User Input	

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.444	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.799	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	1.015	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	2.087	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	3.141	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	4.964	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	6.227	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	8.024	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3.85 in.) =	15.211	acre-feet	3.85	inches
Approximate 2-yr Detention Volume =	0.524	acre-feet		
Approximate 5-yr Detention Volume =	0.804	acre-feet		
Approximate 10-yr Detention Volume =	1.500	acre-feet		
Approximate 25-yr Detention Volume =	2.003	acre-feet		
Approximate 50-yr Detention Volume =	2.108	acre-feet		
Approximate 100-yr Detention Volume =	2.680	acre-feet		

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.444	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.354	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	1.881	acre-feet
Total Detention Basin Volume =	2.680	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

Depth Increment = 1.00 ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	115	0.003		
7200	--	0.50	--	--	--	115	0.003	58	0.001
7202	--	2.50	--	--	--	9,962	0.229	10,134	0.233
7204	--	4.50	--	--	--	17,195	0.395	37,291	0.856
7206	--	6.50	--	--	--	24,054	0.552	78,540	1.803
7208	--	8.50	--	--	--	32,500	0.746	135,094	3.101
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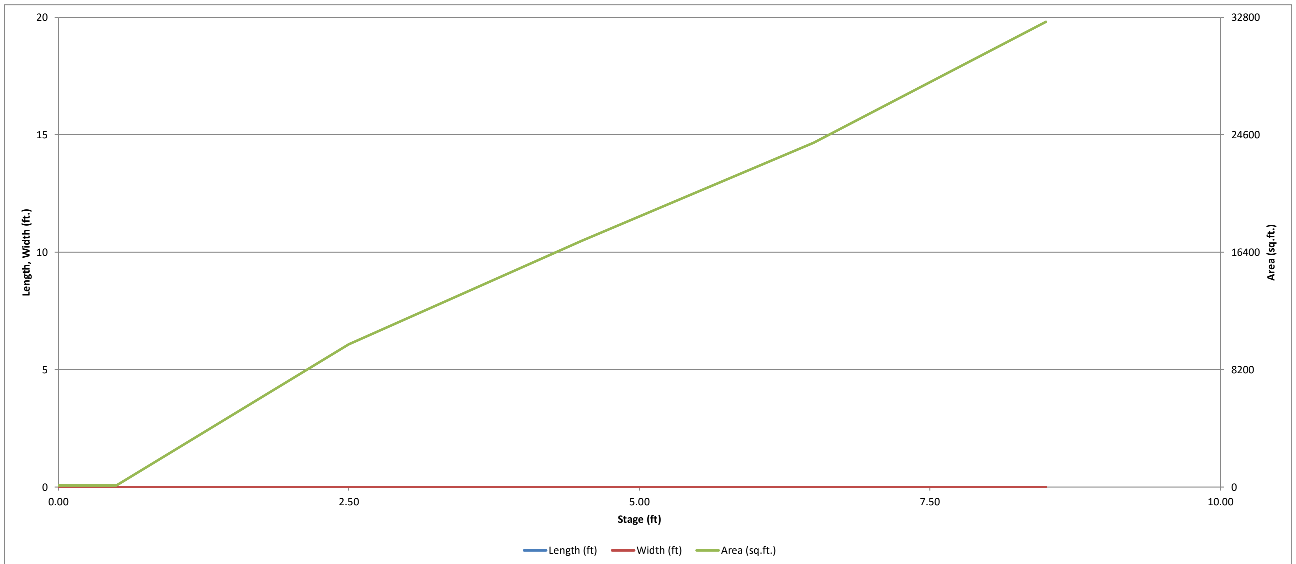
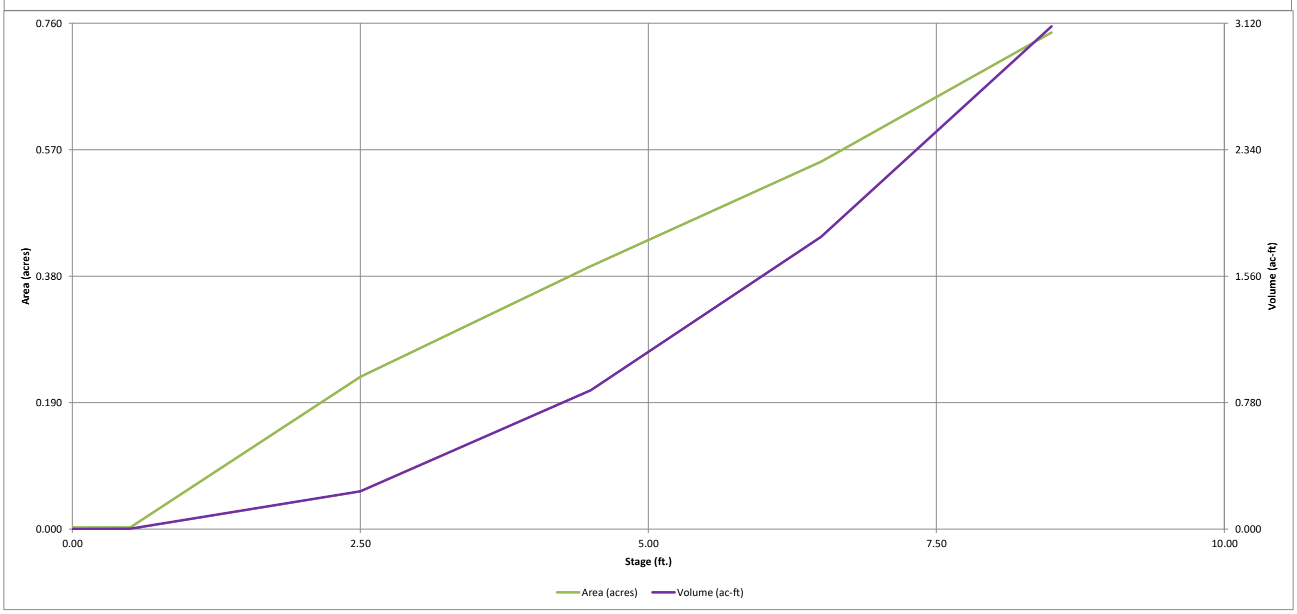
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.03 (May 2020)



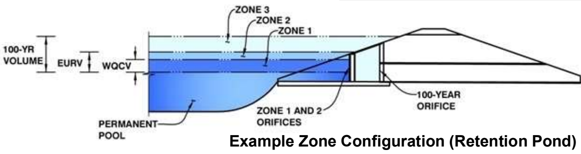


DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.03 (May 2020)

Project: **RETREAT AT TIMBERRIDGE FILING NO. 2**

Basin ID: **POND 3**



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	3.31	0.444	Orifice Plate
Zone 2 (EURV)	4.36	0.354	Orifice Plate
Zone 3 (100-year)	7.92	1.881	Weir&Pipe (Restrict)
Total (all zones)		2.680	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =		ft (distance below the filtration media surface)
Underdrain Orifice Diameter =		inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =		ft^2
Underdrain Orifice Centroid =		feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	4.50	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	18.00	inches
Orifice Plate: Orifice Area per Row =	1.86	sq. inches (diameter = 1-1/2 inches)

Calculated Parameters for Plate

WQ Orifice Area per Row =	1.292E-02	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.50	3.00					
Orifice Area (sq. inches)	1.86	1.86	1.86					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	N/A	N/A	inches

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =	N/A	N/A	ft^2
Vertical Orifice Centroid =	N/A	N/A	feet

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir (and No Outlet Pipe)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	4.50	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	8.00	N/A	feet
Overflow Weir Grate Slope =	4.00	N/A	H:V
Horiz. Length of Weir Sides =	4.00	N/A	feet
Overflow Grate Open Area % =	75%	N/A	%, grate open area/total area
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	5.50	N/A	feet
Overflow Weir Slope Length =	4.12	N/A	feet
Grate Open Area / 100-yr Orifice Area =	5.04	N/A	
Overflow Grate Open Area w/o Debris =	24.74	N/A	ft^2
Overflow Grate Open Area w/ Debris =	12.37	N/A	ft^2

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	2.50	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	30.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	30.00		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	4.91	N/A	ft^2
Outlet Orifice Centroid =	1.25	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	3.14	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	6.75	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	35.00	feet
Spillway End Slopes =	10.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

Spillway Design Flow Depth=	0.72	feet
Stage at Top of Freeboard =	8.47	feet
Basin Area at Top of Freeboard =	0.74	acres
Basin Volume at Top of Freeboard =	3.07	acre-ft

Routed Hydrograph Results

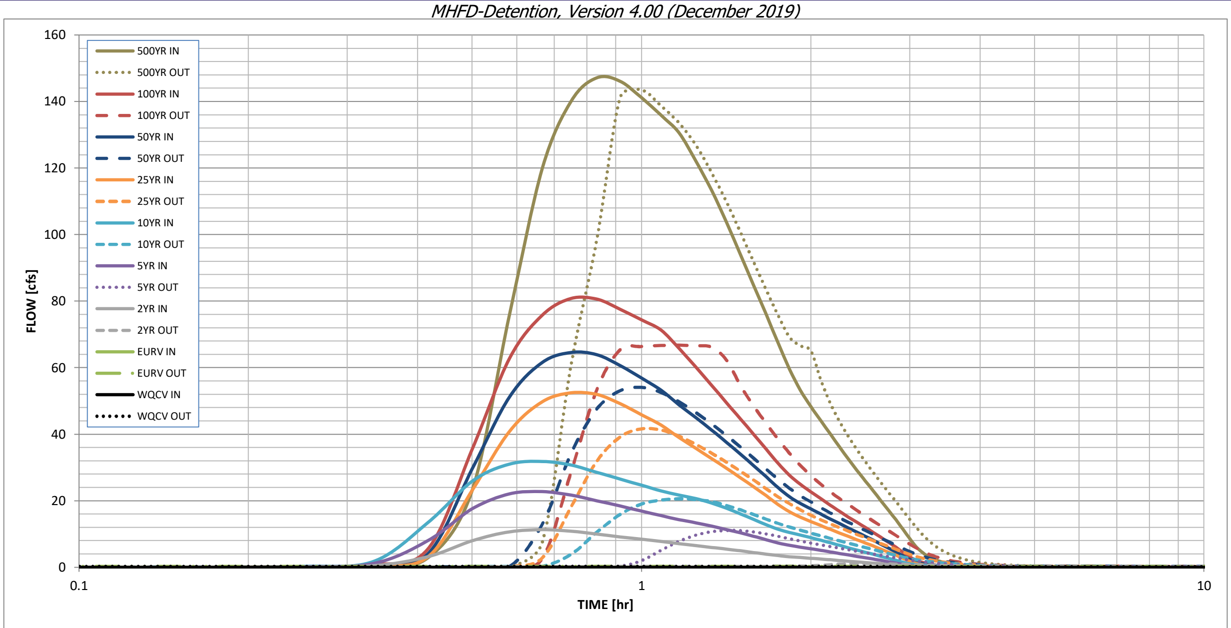
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

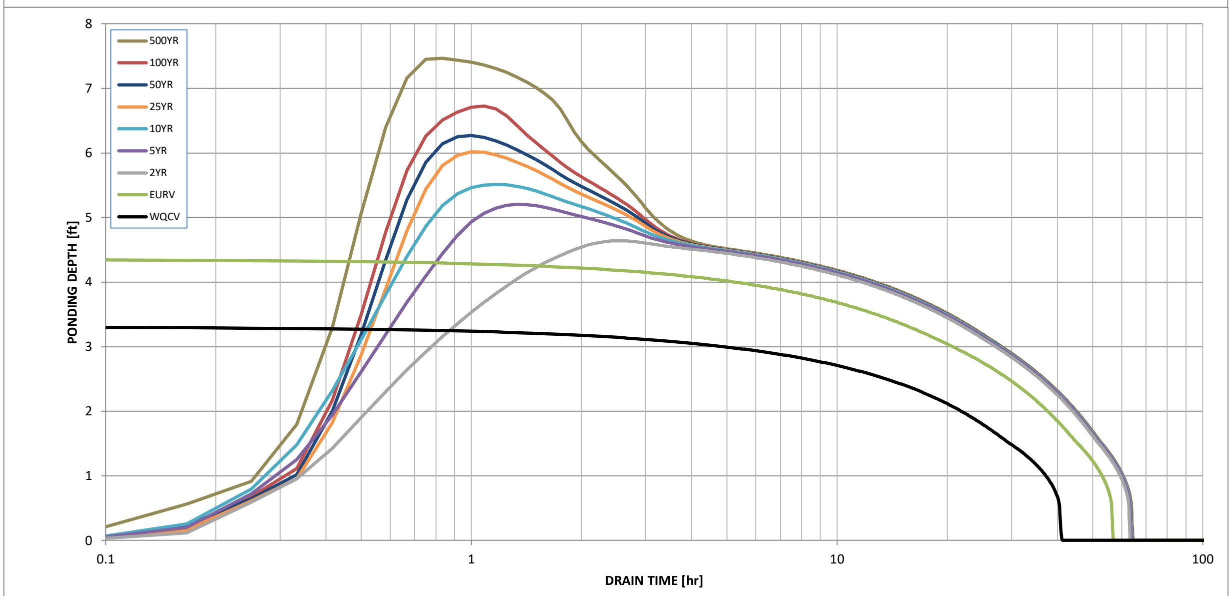
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52	3.85
CUHP Runoff Volume (acre-ft) =	0.444	0.799	1.015	2.087	3.141	4.964	6.227	8.024	15.211
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	1.015	2.087	3.141	4.964	6.227	8.024	15.211
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	6.0	16.9	25.8	46.6	58.4	74.9	139.7
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.09	0.26	0.40	0.73	0.91	1.17	2.18
Peak Inflow Q (cfs) =	N/A	N/A	11.3	22.7	31.8	52.4	64.6	80.8	147.1
Peak Outflow Q (cfs) =	0.2	0.3	1.1	11.1	20.6	41.6	54.1	66.8	143.5
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.7	0.8	0.9	0.9	0.9	1.0
Structure Controlling Flow =	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	0.03	0.4	0.8	1.7	2.2	2.7	2.8
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	38	52	57	52	49	43	40	36	23
Time to Drain 99% of Inflow Volume (hours) =	**40**	55	61	59	58	54	53	50	44
Maximum Ponding Depth (ft) =	3.31	4.36	4.64	5.20	5.51	6.02	6.27	6.73	7.46
Area at Maximum Ponding Depth (acres) =	0.30	0.38	0.41	0.45	0.47	0.51	0.53	0.57	0.65
Maximum Volume Stored (acre-ft) =	0.445	0.802	0.912	1.152	1.295	1.542	1.678	1.927	2.378

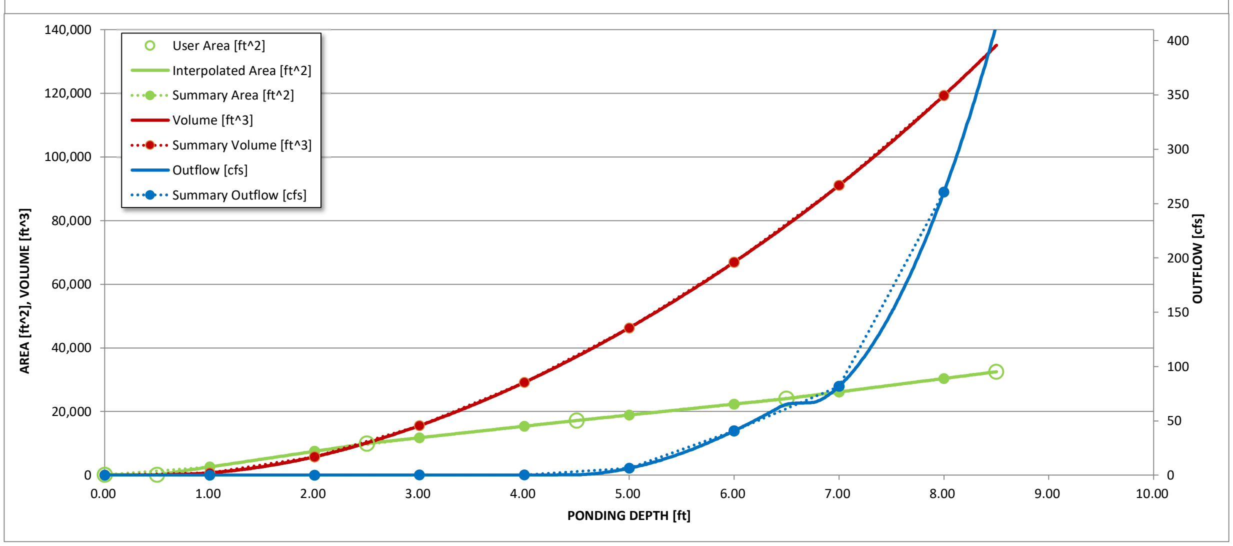
A larger outlet area is recommended for safety.

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.00 (December 2019)







S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename:

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.09
	0:15:00	0.00	0.00	0.11	0.18	0.23	0.15	0.20	0.19	0.41
	0:20:00	0.00	0.00	0.46	1.11	1.71	0.48	0.56	0.76	2.75
	0:25:00	0.00	0.00	3.17	7.93	13.33	3.06	3.88	5.32	22.95
	0:30:00	0.00	0.00	7.98	17.56	25.84	23.03	29.49	35.32	76.33
	0:35:00	0.00	0.00	10.67	22.07	31.01	40.96	51.33	62.94	120.03
	0:40:00	0.00	0.00	11.28	22.71	31.82	49.77	61.55	75.85	140.14
	0:45:00	0.00	0.00	10.84	21.65	30.70	52.41	64.58	80.80	147.10
	0:50:00	0.00	0.00	9.96	20.00	28.54	51.94	63.89	80.58	146.10
	0:55:00	0.00	0.00	9.13	18.38	26.50	49.14	60.60	77.52	141.12
	1:00:00	0.00	0.00	8.43	16.91	24.70	45.87	56.85	74.36	135.83
	1:05:00	0.00	0.00	7.77	15.50	22.96	42.72	53.22	71.27	130.60
	1:10:00	0.00	0.00	7.10	14.34	21.66	39.00	48.82	65.78	122.06
	1:15:00	0.00	0.00	6.52	13.35	20.64	35.69	44.95	60.11	113.25
	1:20:00	0.00	0.00	5.98	12.34	19.32	32.66	41.23	54.70	103.76
	1:25:00	0.00	0.00	5.45	11.33	17.71	29.78	37.60	49.47	93.99
	1:30:00	0.00	0.00	4.94	10.32	16.04	26.93	34.02	44.58	84.72
	1:35:00	0.00	0.00	4.44	9.32	14.38	24.18	30.55	39.95	75.88
	1:40:00	0.00	0.00	3.94	8.26	12.78	21.46	27.15	35.46	67.36
	1:45:00	0.00	0.00	3.50	7.29	11.43	18.84	23.88	31.17	59.55
	1:50:00	0.00	0.00	3.17	6.58	10.47	16.66	21.18	27.63	53.24
	1:55:00	0.00	0.00	2.93	6.04	9.68	15.05	19.19	24.94	48.28
	2:00:00	0.00	0.00	2.71	5.57	8.90	13.74	17.55	22.70	44.08
	2:05:00	0.00	0.00	2.48	5.09	8.11	12.52	16.00	20.60	40.03
	2:10:00	0.00	0.00	2.25	4.61	7.34	11.38	14.52	18.65	36.16
	2:15:00	0.00	0.00	2.03	4.15	6.58	10.30	13.13	16.82	32.53
	2:20:00	0.00	0.00	1.81	3.71	5.86	9.27	11.80	15.11	29.13
	2:25:00	0.00	0.00	1.61	3.27	5.17	8.28	10.53	13.51	25.96
	2:30:00	0.00	0.00	1.41	2.85	4.51	7.32	9.31	11.99	22.95
	2:35:00	0.00	0.00	1.21	2.44	3.88	6.37	8.11	10.47	20.01
	2:40:00	0.00	0.00	1.02	2.04	3.27	5.44	6.93	8.98	17.12
	2:45:00	0.00	0.00	0.82	1.64	2.67	4.51	5.76	7.48	14.25
	2:50:00	0.00	0.00	0.63	1.25	2.08	3.60	4.60	6.00	11.40
	2:55:00	0.00	0.00	0.45	0.88	1.50	2.68	3.45	4.52	8.59
	3:00:00	0.00	0.00	0.29	0.57	1.06	1.80	2.35	3.11	6.06
	3:05:00	0.00	0.00	0.19	0.40	0.80	1.15	1.54	2.06	4.26
	3:10:00	0.00	0.00	0.14	0.31	0.64	0.77	1.06	1.41	3.07
	3:15:00	0.00	0.00	0.11	0.25	0.51	0.53	0.75	0.97	2.22
	3:20:00	0.00	0.00	0.09	0.20	0.41	0.37	0.54	0.65	1.58
	3:25:00	0.00	0.00	0.07	0.16	0.33	0.26	0.39	0.43	1.11
	3:30:00	0.00	0.00	0.06	0.13	0.26	0.19	0.28	0.27	0.75
	3:35:00	0.00	0.00	0.05	0.10	0.20	0.13	0.20	0.17	0.49
	3:40:00	0.00	0.00	0.04	0.07	0.15	0.10	0.15	0.12	0.35
	3:45:00	0.00	0.00	0.03	0.06	0.11	0.07	0.11	0.09	0.26
	3:50:00	0.00	0.00	0.02	0.04	0.08	0.06	0.09	0.07	0.20
	3:55:00	0.00	0.00	0.02	0.03	0.06	0.04	0.07	0.06	0.16
	4:00:00	0.00	0.00	0.01	0.02	0.04	0.03	0.05	0.04	0.12
	4:05:00	0.00	0.00	0.01	0.01	0.03	0.02	0.04	0.03	0.09
	4:10:00	0.00	0.00	0.01	0.01	0.02	0.02	0.03	0.02	0.06
	4:15:00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.04
	4:20:00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.03 (May 2020)

Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

Stage - Storage Description	Stage [ft]	Area [ft^2]	Area [acres]	Volume [ft^3]	Volume [ac-ft]	Total Outflow [cfs]
	0.00	115	0.003	0	0.000	0.00
	1.00	2,577	0.059	730	0.017	0.06
	2.00	7,500	0.172	5,769	0.132	0.13
	3.00	11,770	0.270	15,567	0.357	0.18
	4.00	15,387	0.353	29,146	0.669	0.28
	5.00	18,910	0.434	46,318	1.063	6.38
	6.00	22,339	0.513	66,942	1.537	40.74
	7.00	26,165	0.601	91,095	2.091	81.76
	8.00	30,388	0.698	119,372	2.740	260.55

For best results, include the stages of all grade slope changes (e.g. ISV and Floor) from the S-A-V table on Sheet 'Basin'.

Also include the inverts of all outlets (e.g. vertical orifice, overflow grate, and spillway, where applicable).

HEC-RAS CALCULATIONS

CLASSIC CONSULTING

619 N. Cascade Avenue, Suite 200, Colorado Springs, Colorado 80903 (719)785-0790 (719)785-0799 (Fax)

RETREAT AT TIMBERRIDGE FILING NO. 1
CONSTRUCTION PLANS
HEC-RAS ANALYSIS
CHANNEL STATIONING EXHIBIT

DESIGNED BY MAW	SCALE	DATE	7/22/19
DRAWN BY MAW	(H) 1"= 100'	SHEET 1	OF 1
CHECKED BY	(V) 1"= N/A	JOB NO.	1185.00

RETREAT AT TIMBERRIDGE FILING NO. 2

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 55+32.95)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 51+82.08)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 49+03.69)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 47+12.26)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 44+44.93)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 42+31.86)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 39+15.99)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 37+08.56)

RETREAT AT TIMBERRIDGE FILING NO. 2

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 35+40.59)

TABLE 10-1

COMPOSITE ROUGHNESS COEFFICIENTS FOR UNLINED OPEN CHANNELS
(Reference: Chow, Ven Te, 1959; Open-Channel Hydraulics)

$$n = (n_o + n_1 + n_2 + n_3 + n_4)m \qquad (10-2)$$

	Channel Conditions	Value
Material Type n_o	Earth	0.020
	Fine Gravel	0.024
	Coarse Gravel	0.028
Degree of Irregularity n_1	Smooth	0.000
	Minor	0.005
	Moderate	0.010
	Severe	0.020
Variation of Channel Cross Section n_2	Gradual	0.000
	Alternating Occasionally	0.005
	Alternating Frequently	0.010 - 0.015
Relative Effect of Obstructions n_3	Negligible	0.000
	Minor	0.010 - 0.015
	Appreciable	0.020 - 0.030
	Severe	0.040 - 0.060
Vegetation n_4	Low	0.005 - 0.010
	Medium	0.010 - 0.025
	High	0.025 - 0.050
	Very High	0.050 - 0.100
Degree of Meandering m	Minor	1.000 - 1.200
	Appreciable	1.200 - 1.500
	Severe	1.500

TABLE 10-2 (Continued)

TYPICAL ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS

Type of Channel and Description	Minimum	Normal	Maximum
NATURAL STREAMS			
Minor streams (top width at flood stage 100 ft)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
LINED OR BUILT-UP CHANNELS			
a. Corrugated Metal	0.021	0.025	0.030
b. Concrete			
1. Trowel finish	0.011	0.013	0.015
2. Float finish	0.013	0.015	0.016
3. Finished, with gravel on bottom	0.015	0.017	0.020
4. Unfinished	0.014	0.017	0.020
5. Gunite, good section	0.016	0.019	0.023
6. Gunite, wavy section	0.018	0.022	0.025
7. On good excavated rock	0.017	0.020	
8. On irregular excavated rock	0.022	0.027	

Table 3. Adjustment values for factors that affect roughness of flood plains
[Modified from Aldridge and Garrett, 1973, table 2]

Flood-plain conditions		*n* value adjustment	Example
Degree of irregularity (n_1)	Smooth	0.000	Compares to the smoothest, flattest flood plain attainable in a given bed material.
	Minor	0.001–0.005	Is a flood plain slightly irregular in shape. A few rises and dips or sloughs may be visible on the flood plain.
	Moderate	0.006–0.010	Has more rises and dips. Sloughs and hummocks may occur.
	Severe	0.011–0.020	Flood plain very irregular in shape. Many rises and dips or sloughs are visible. Irregular ground surfaces in pastureland and furrows perpendicular to the flow are also included.
Variation of flood-plain cross section (n_2)		0.0	Not applicable.
Effect of obstructions (n_3)	Negligible	0.000–0.004	Few scattered obstructions, which include debris deposits, stumps, exposed roots, logs, or isolated boulders, occupy less than 5 percent of the cross-sectional area.
	Minor	0.005–0.019	Obstructions occupy less than 15 percent of the cross-sectional area.
	Appreciable	0.020–0.030	Obstructions occupy from 15 to 50 percent of the cross-sectional area.
Amount of vegetation (n_4)	Small	0.001–0.010	Dense growth of flexible turf grass, such as Bermuda, or weeds growing where the average depth of flow is at least two times the height of the vegetation, or supple tree seedlings such as willow, cottonwood, arrowweed, or saltcedar growing where the average depth of flow is at least three times the height of the vegetation.
	Medium	0.011–0.025	Turf grass growing where the average depth of flow is from one to two times the height of the vegetation, or moderately dense stemmy grass, weeds, or tree seedlings growing where the average depth of flow is from two to three times the height of the vegetation; brushy, moderately dense vegetation, similar to 1- to 2-year-old willow trees in the dormant season.
	Large	0.025–0.050	Turf grass growing where the average depth of flow is about equal to the height of the vegetation, or 8- to 10-year-old willow or cottonwood trees intergrown with some weeds and brush (none of the vegetation in foliage) where the hydraulic radius exceeds 2 ft, or mature row crops such as small vegetables, or mature field crops where depth of flow is at least twice the height of the vegetation.
	Very large	0.050–0.100	Turf grass growing where the average depth of flow is less than half the height of the vegetation, or moderate to dense brush, or heavy stand of timber with few down trees and little undergrowth where depth of flow is below branches, or mature field crops where depth of flow is less than the height of the vegetation.
	Extreme	0.100–0.200	Dense bushy willow, mesquite, and saltcedar (all vegetation in full foliage), or heavy stand of timber, few down trees, depth of flow reaching branches.
Degree of meander (m)		1.0	Not applicable.

Chow (1959) presents a table showing minimum, normal, and maximum values of *n* for flood plains covered by pasture and crops. These values are helpful for comparing the roughness values of flood plains having similar vegetation.

Vegetation-Density Method

For a wooded flood plain, the vegetation-density method can be used as an alternative to the previous method for determining *n* values for flood plains. In a wooded flood plain, where the tree diameters can be measured, the vegetation density of the flood plain can be determined.

Determining the vegetation density is an effective way of relating plant height and density characteristics, as a function of depth of flow, to the flow resistance of vegetation. Application of the flow-resistance model presented below requires an estimate of the vegetation density as a function of depth of flow. The procedure requires a direct or indirect determination of vegetation density at a given depth. If the change in *n* value through a range in depth is required, then an estimation of vegetation density through that range is necessary.

Techniques for Determining Vegetation Density

Petryk and Bosmajian (1975) developed a method of analysis of the vegetation density to determine the rough-

Classification of Vegetal Covers

Retardance Class	Cover	Condition
A	Weeping lovegrass	Excellent stand, tall, average 30 in.
	Yellow bluestem Ischaemum	Excellent stand, tall, average 36 in.
B	Bermuda grass	Good stand, tall, average 12 in.
	Native grass mixture (little bluestem, bluestem, blue gamma, and other long and short Midwest grasses	Good stand, unmowed
	Weeping lovegrass	Good stand, tall, average 24 in.
	Lespedeza serica	Good stand, not woody, tall, average 19 in.
	Alfalfa	Good stand uncut, average 11 in.
	Weeping lovegrass	Good stand, unmowed, average 13 in.
	Kudzu	Dense growth, uncut
	Blue gamma	Good stand, uncut, average 13 in.
C	Crabgrass	Fair stand, uncut, avg. 10 in.
	Bermuda grass	Good stand, mowed, average 6 in.
	Common lespedeza	Good stand, uncut, average 11 in.
	Grass-legume mixture - summer (orchard grass, redtop Italian ryegrass, and common lespedeza)	Good stand, uncut, average 6 to 8 in.
	Centipedegrass	Very dense cover, average 6 in.
	Kentucky Bluegrass	Good stand, headed, 6 to 12 in.
D	Bermuda grass	Good stand, cut to 2.5 in. height
	Common lespedeza	Excellent stand, uncut, average 4.5 in.
	Buffalo Grass	Good stand, uncut, 3 t 6 in.
	Grass-legume mixture - fall (orchard grass, redtop Italian ryegrass, and common lespedeza)	Good stand, uncut, 3 to 5 in.
	Lespedeza serica	After cutting to 2 in. height, good stand before cutting
E	Bermuda grass	Good stand, cut to average 1.5 in. height
	Bermuda grass	Burned stubble

Note: Covers classified have been tested in experimental channels. Covers were green and generally uniform.

Source: HEC-15

*

Coefficients for Roughness of Grass-Lined Channels

SCS Retardance Class	C_n
A	0.605
B	0.418
C	0.220
D	0.147
E	0.093
Source: HEC-15	

Composite Roughness

Culverts using different materials for portions of the perimeter such as embedded culverts or culverts with an invert liner should use a composite Manning's n value. A weighted n value based on the materials can be derived using the following equation:

$$n_c = \left[\frac{\Sigma(p_i n_i^{1.5})}{p}\right]^{0.67}$$

Where:
n_c = Composite/weighted Manning's n.
p_i = Wetted perimeter for the material, ft.
n_i = Manning's n value for the material.
p = Total wetted perimeter, ft.

750.1.4.1.2 Hydraulic Radius

The hydraulic radius is a characteristic depth of flow and is defined as the cross-sectional area of flow divided by the wetted perimeter of the channel. The hydraulic radius is computed as follows:

$$R = \frac{A}{P}$$

where:

R = hydraulic radius, ft
A = cross-sectional area of flow, ft^2
P = wetted perimeter of the channel cross section, ft

750.1.4.1.3 Slope

Table 8–8 Characteristics of selected grass species for use in channels and waterways

Grass species	Height at maturity (ft)	Height at maturity (m)
Cool-season grasses		
Creeping foxtail	3–4	0.9–1.2
Crested wheatgrass	2–3	0.6–0.9
Green needlegrass	3–4	0.9–1.2
Russian wild rye	3–4	0.9–1.2
Smooth bromegrass	3–4	0.9–1.2
Tall fescue	3–4	0.9–1.2
Tall wheatgrass		1.2–1.5
Western wheatgrass	2–3	0.6–0.9
Warm-season grasses		
Bermudagrass	3/4–2	0.2–0.6
Big bluestem	4–6	1.2–1.8
Blue grama	1–2	0.3–0.6
Buffalograss	1/3–1	0.1–0.3
Green spangletop	3–4	0.9–1.2
Indiangrass	5–6	1.5–1.8
Klein grass	3–4	0.9–1.2
Little bluestem	3–4	0.9–1.2
Plains bristlegrass	1–2	0.3–0.6
Sand bluestem	5–6	1.5–1.8
Sideoats grama	2–3	0.6–0.9
Switchgrass	4–5	1.2–1.5
Vine mesquitegrass	1–2	0.3–0.6
Weeping lovegrass	3–4	0.9–1.2
Old World bluestems		
Caucasian bluestem	4–5	1.2–1.5
Ganada yellow bluestem	3–4	0.9–1.2

Table 8–9 Retardance curve index by SCS retardance class

SCS retardance class	Retardance curve index
A	10.0
B	7.64
C	5.60
D	4.44
E	2.88

this table were obtained from a review of the available qualitative descriptions and stem counts reported by researchers studying channel resistance and stability.

Since cover conditions vary from year to year and season to season, it is recommended that an upper and lower bound be determined for C_I. The lower bound should be used in stability computations, and the upper bound should be used to determine channel capacity. Some practitioners find that the use of SCS retardance class (table 8–9) is a preferable approach.

The vegetal cover index, C_F, depends primarily on the density and uniformity of density in the immediate vicinity of the soil boundary. Because this parameter is associated with the prevention of local erosion damage which may lead to channel unraveling, the cover factor should represent the weakest area in a reach, rather than the average for the cover species. Recommended values for the cover factor are presented in table 8–10. Values in this table do not account for such considerations as maintenance practices or uniformity of soil fertility or moisture. Therefore, appropriate engineering judgment should be used in its application.

Table 8–10 Properties of grass channel linings values (apply to good uniform stands of each cover)

Cover factor (C_F)	Covers tested	Reference stem density (stems/ft²)	Reference stem density (stems/m²)
0.90	Bermudagrass	500	5,380
	Centipede grass	500	5,380
0.87	Buffalograss	400	4,300
	Kentucky bluegrass	350	3,770
	Blue grama	350	3,770
0.75	Grass mixture	200	2,150
0.50	Weeping lovegrass	350	3,770
	Yellow bluestem	250	2,690
0.50	Alfalfa	500	5,380
	Lespedeza sericea	300	3,280
0.50	Common lespedeza	150	1,610
	Sudangrass	50	538

Multiply the stem densities given by 1/3, 2/3, 1, 4/3, and 5/3 for poor, fair, good, very good, and excellent covers, respectively. Reduce the C_F by 20% for fair stands and 50% for poor stands.

Two soil parameters are required for application of effective stress concepts to the stability design of lined or unlined channels having an erodible soil boundary: soil grain roughness, n_s, and allowable effective stress, τ_a. When the effective stress approach is used, the soil parameters are the same for both lined and unlined channels with negligible bed-material sediment transport.

Soil grain roughness is defined as the roughness associated with particles or aggregates of a size that can be independently moved by the flow at incipient channel failure. For noncohesive soils, the soil grain roughness and effective shear stress are both a function of the D_{75} grain size. When D_{75} is greater than 1.3 millimeter, the soil is considered coarse grained. When D_{75} is less than 1.3 millimeter, the soil is considered fine grained. Fine-grained roughness is considered to have a constant value of 0.0156. Fine-grained effective shear stress is taken to have a constant value of 0.02 pound per square foot. Coarse-grained shear stress and roughness are given in figures 8–21 and 8–22.

A soil grain roughness of 0.0156 is assigned to all cohesive soils. The allowable effective stresses are a function of the unified soil classification system soil type, the plasticity index, and the void ratio. The basic allowable shear stress, τ_{ab}, is determined from the plasticity index and soil classification, and then adjusted by the void ratio correction factor, C_e, using the following equation:

$$\tau_a = \tau_{ab} C_e^2 \qquad \text{(eq. 8–29)}$$

The basic allowable effective stress can be determined from figure 8–23 and the void ratio correction factor from figure 8–24. These two figures were developed directly from the allowable velocity curves in AH 667. Stress partitioning (slope partitioning) is essential to application of figures 8–21 to 8–24, with or without vegetation (Temple et al. 1987).

(e) General design procedure

Use the basic shear stress equation to determine effective shear stress on the soil beneath the vegetation. Use any consistent units of measurement.

$$\tau_e = \gamma d S (1 - C_F)\left(\frac{n_s}{n}\right)^2 \qquad \text{(eq. 8–30)}$$

where:

τ_e = effective shear stress exerted on the soil beneath vegetation (lb/ft² or N/m²)
γ = specific weight of water (lb/ft³ or N/m³)
d = maximum depth of flow in the cross section (ft or m)
S = energy slope, dimensionless
C_F = vegetation cover factor (0 for unlined channel), dimensionless
n_s = grain roughness of underlying soil, typically taken as dimensionless
n = roughness coefficient of vegetation, typically taken as dimensionless

The flow depth is used instead of the hydraulic radius because this will result in the maximum local shear stress, rather than the average shear stress. The cover factor is a function of the grass and stem density. Roughness coefficients are standard Manning's roughness values; n_s can be determined from figure 8–22, n can be determined from the old SCS curves (fig. 8–20) or from the following equation.

$$n_R = \exp\left\{C_I\left[0.0133(\ln R_v)^2 - 0.0954 \ln R_v + 0.297\right] - 4.16\right\} \qquad \text{(eq. 8–31)}$$

where:

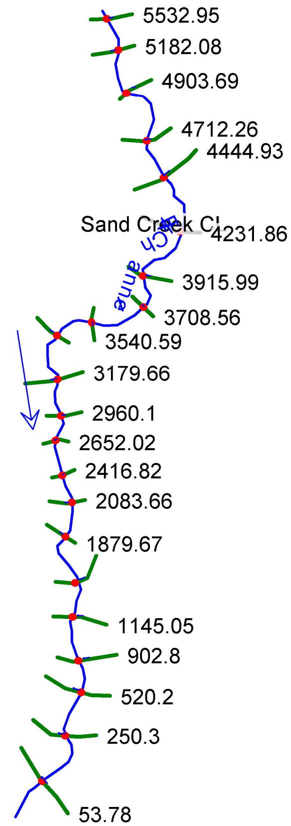
R_v = (VR/v) x 10^{-5} (this dimensionless term reduces to VR for practical application in English units)
V = channel velocity (ft/s or m/s)
R = hydraulic radius (ft or m)
Limited to $0.0025C_I^{2.5} < R_v < 36$

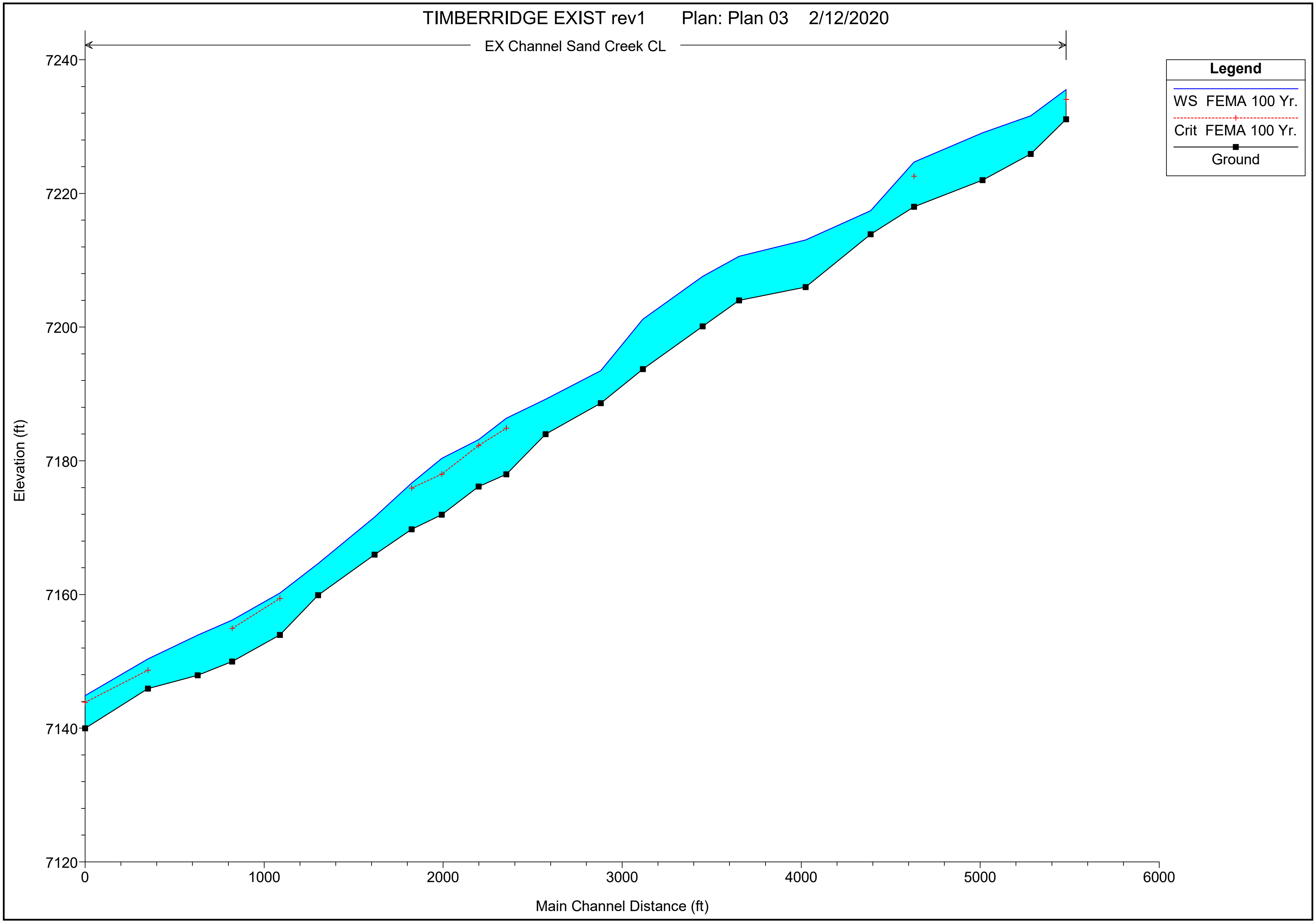
A reference value of Manning's resistance coefficient, n_R, is applicable to vegetation established on relatively smoothly graded fine-grained soil.

If vegetated channel liner mats are used, manufacturer-supplied roughness coefficients for particular mats may be used in the equation.

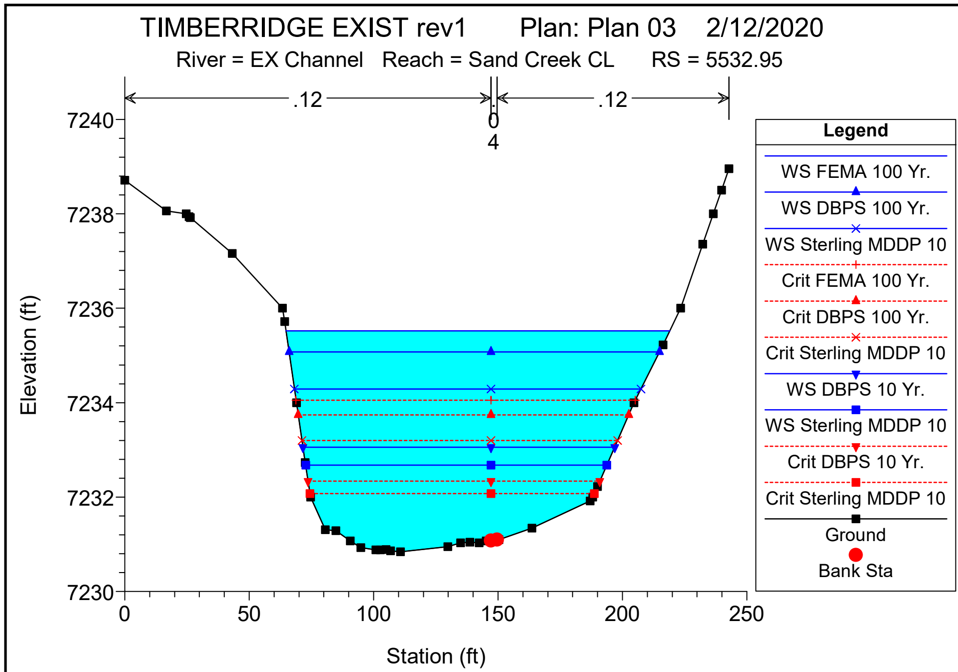
Maximum allowable shear stress, τ_{va}, in pound per square foot is determined as a function of the retardance curve index, C_I. Very little information is available for vegetal performance under very high stresses and this relation is believed to be conservative.

$$\tau_{va} = 0.75 C_I \qquad \text{(eq. 8–32)}$$


5532.95
5182.08
4903.69
4712.26
4444.93
Sand Creek CI
4231.86
3915.99
3708.56
3540.59
3179.66
2960.1
2652.02
2416.82
2083.66
1879.67
1145.05
902.8
520.2
250.3
53.78



TIMBERRIDGE EXIST rev1 Plan: Plan 03 2/12/2020
EX Channel Sand Creek CL
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Elevation (ft)
7240
7220
7200
7180
7160
7140
7120
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (ft)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River = EX Channel Reach = Sand Creek CL RS = 5532.95
.12
.12
Legend
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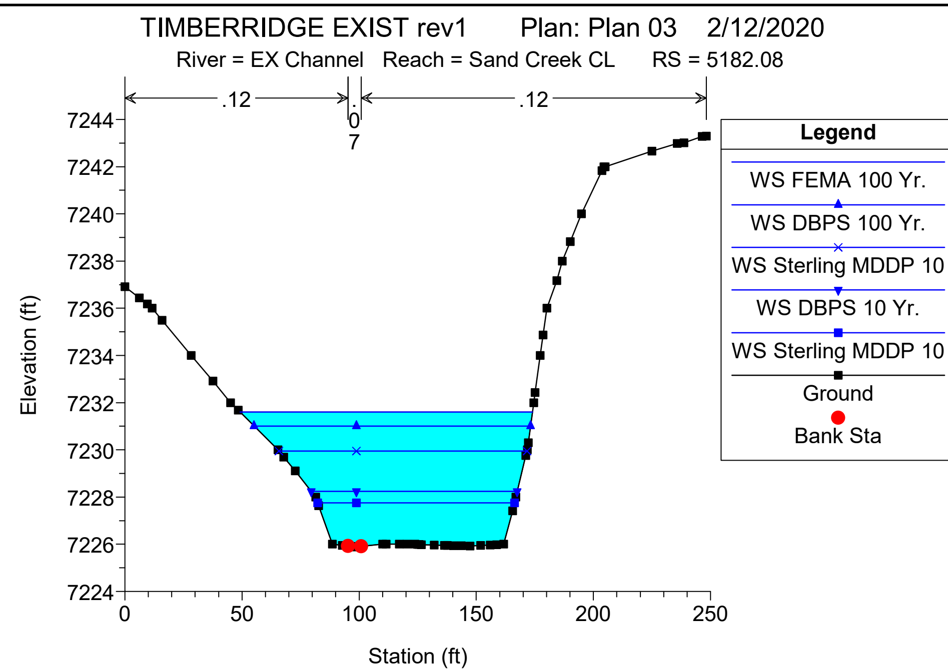
WS DBPS 100 Yr.
WS Sterling MDDP 10
Crit FEMA 100 Yr.
Crit DBPS 100 Yr.
Crit Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Crit DBPS 10 Yr.
Crit Sterling MDDP 10
Ground
Bank Sta
Elevation (ft)
Station (ft)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.12
.12
Legend
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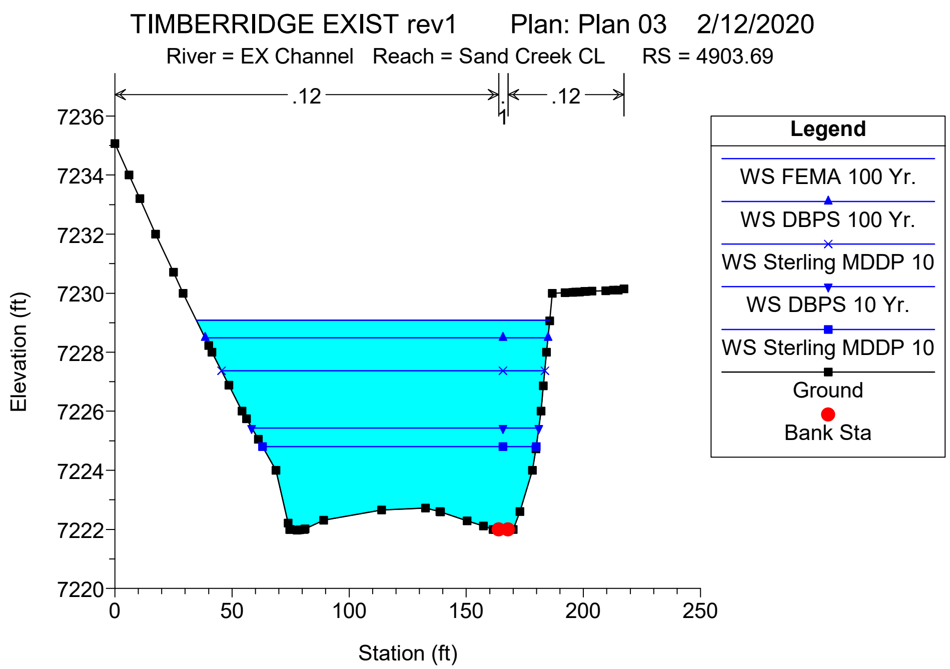
WS DBPS 100 Yr.
WS Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Ground
Bank Sta
Elevation (ft)
Station (ft)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.12
.12
Legend
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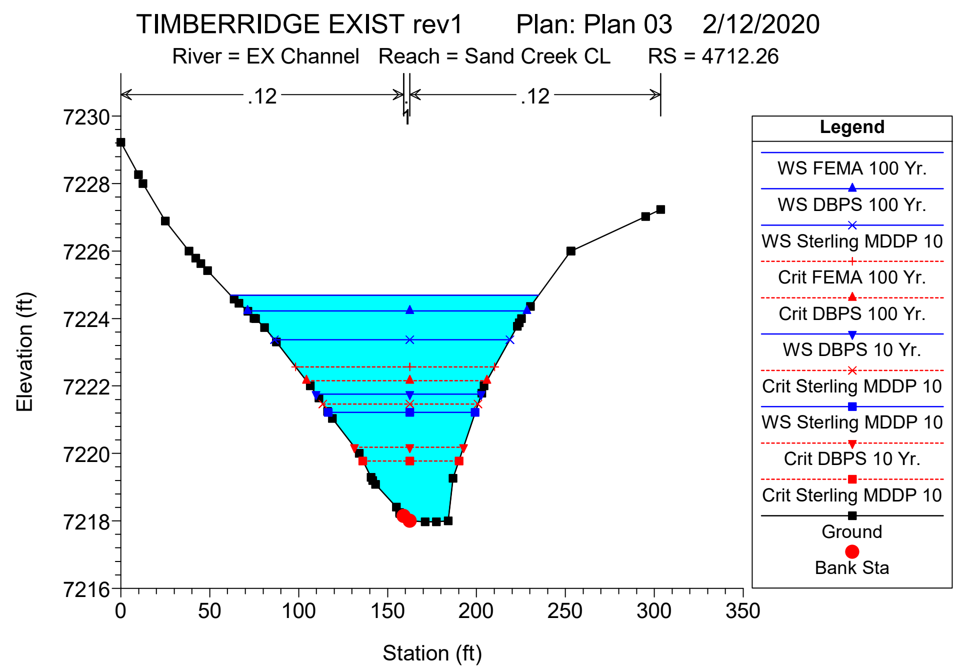
WS DBPS 100 Yr.
WS Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Ground
Bank Sta
Elevation (ft)
Station (ft)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.12
.12
Legend
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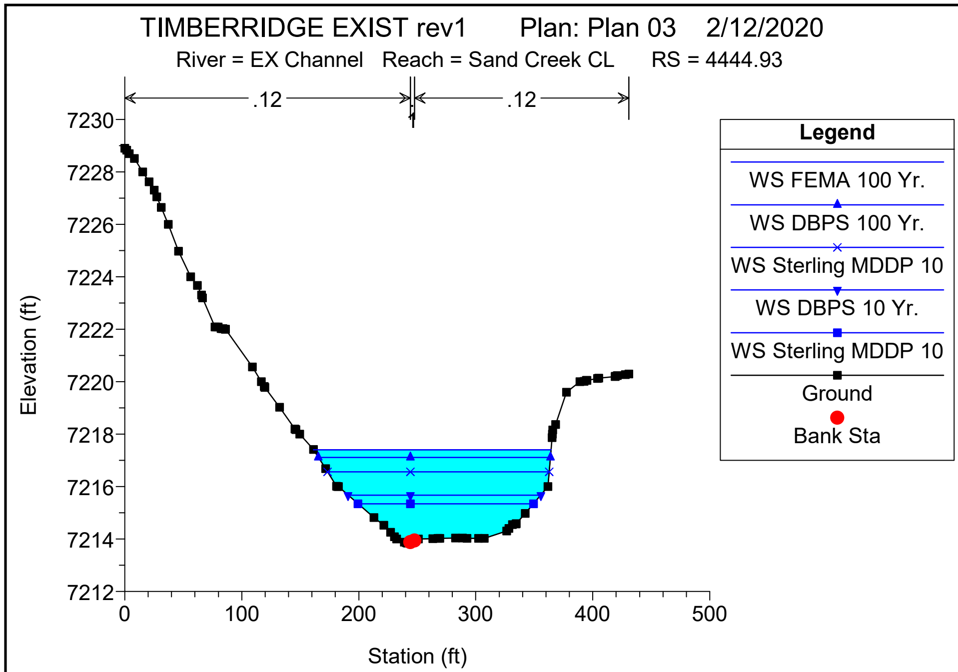
WS DBPS 100 Yr.
WS Sterling MDDP 10
Crit FEMA 100 Yr.
Crit DBPS 100 Yr.
WS DBPS 10 Yr.
Crit Sterling MDDP 10
WS Sterling MDDP 10
Crit DBPS 10 Yr.
Crit Sterling MDDP 10
Ground
Bank Sta
Elevation (ft)
Station (ft)



TIMBERRIDGE EXIST rev1 Plan: Plan 03 2/12/2020
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.12
.12
Elevation (ft)
Station (ft)
Legend
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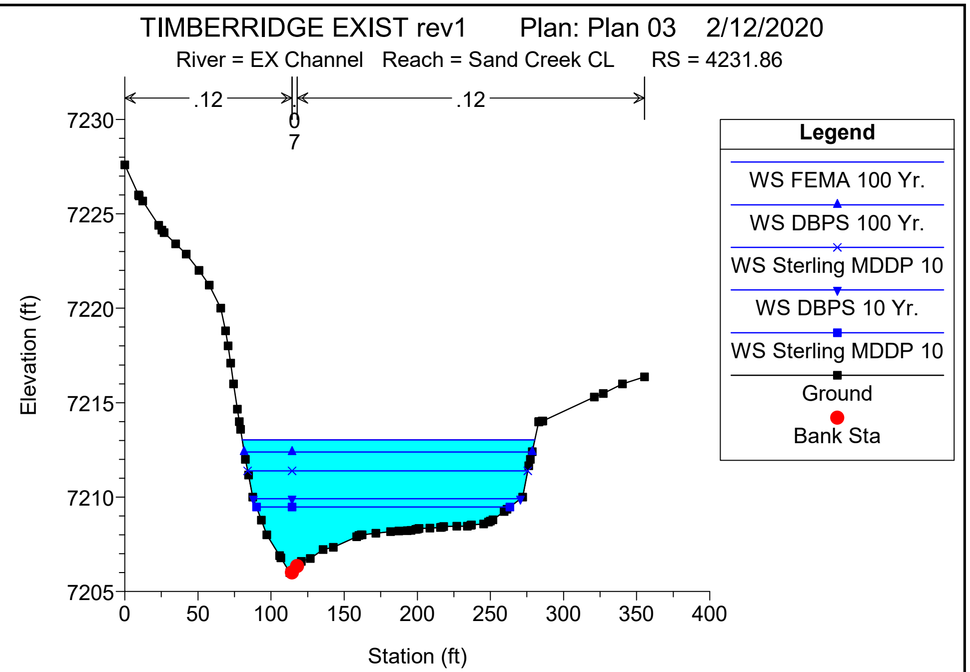
WS DBPS 100 Yr.
WS Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Ground
Bank Sta



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.12
0
7
.12
Elevation (ft)
Station (ft)
Legend
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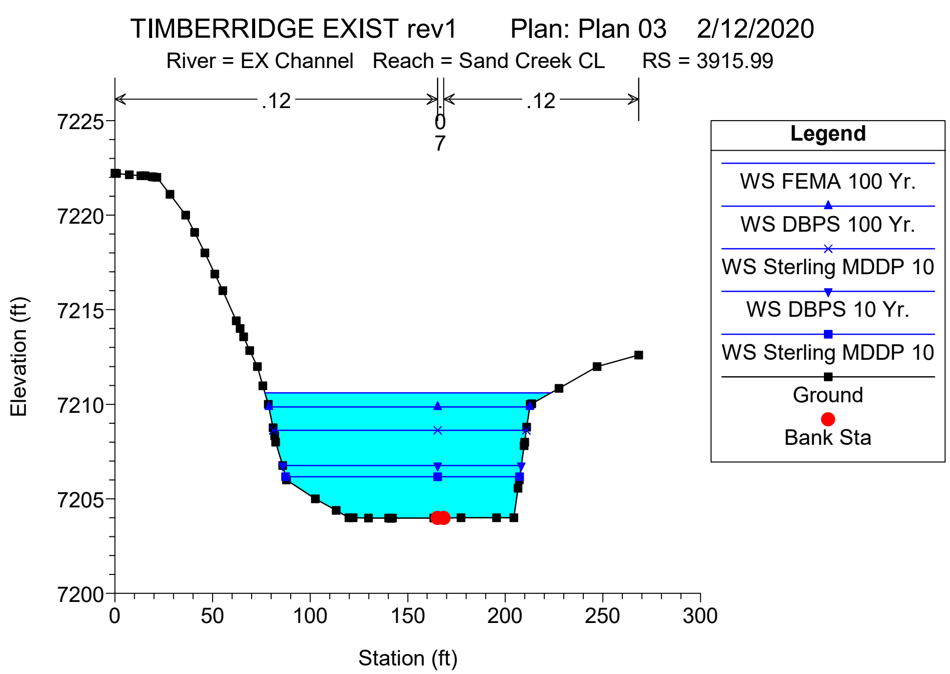
WS DBPS 100 Yr.
WS Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Ground
Bank Sta



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River = EX Channel Reach = Sand Creek CL RS = 3915.99
.12
0
7
.12
Elevation (ft)
Station (ft)
Legend
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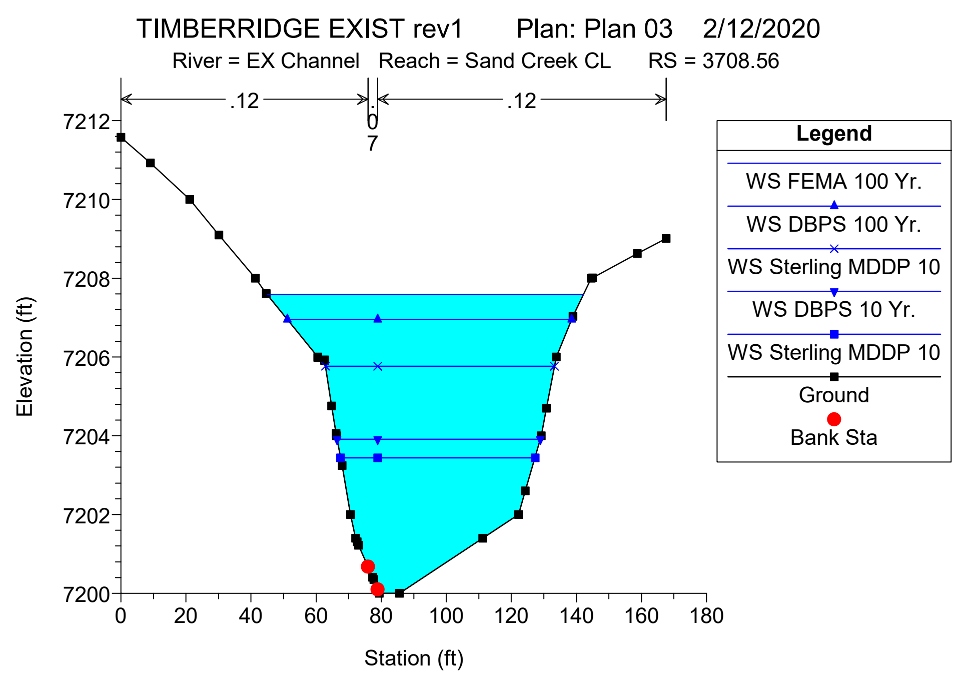
WS DBPS 100 Yr.
WS Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Ground
Bank Sta



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.12
0
7
.12
Elevation (ft)
Station (ft)
Legend
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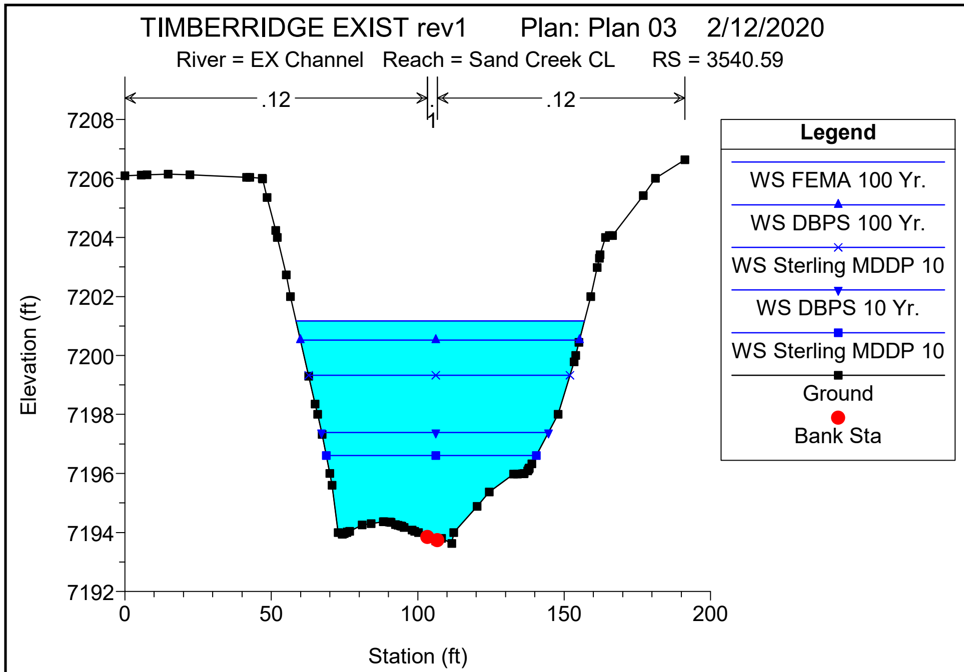
WS DBPS 100 Yr.
WS Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Ground
Bank Sta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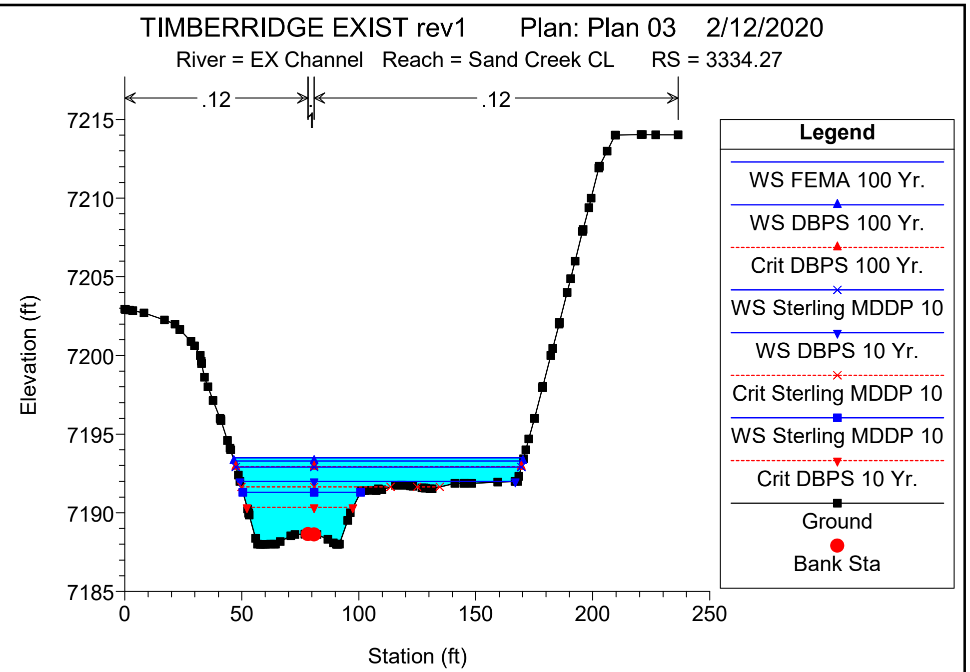
.12
.12
7208
7206
7204
7202
7200
7198
7196
7194
7192
Elevation (ft)
0
50
100
150
200
Station (ft)
Legend
WS FEMA 100 Yr.
WS DBPS 100 Yr.
WS Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Ground
Bank Sta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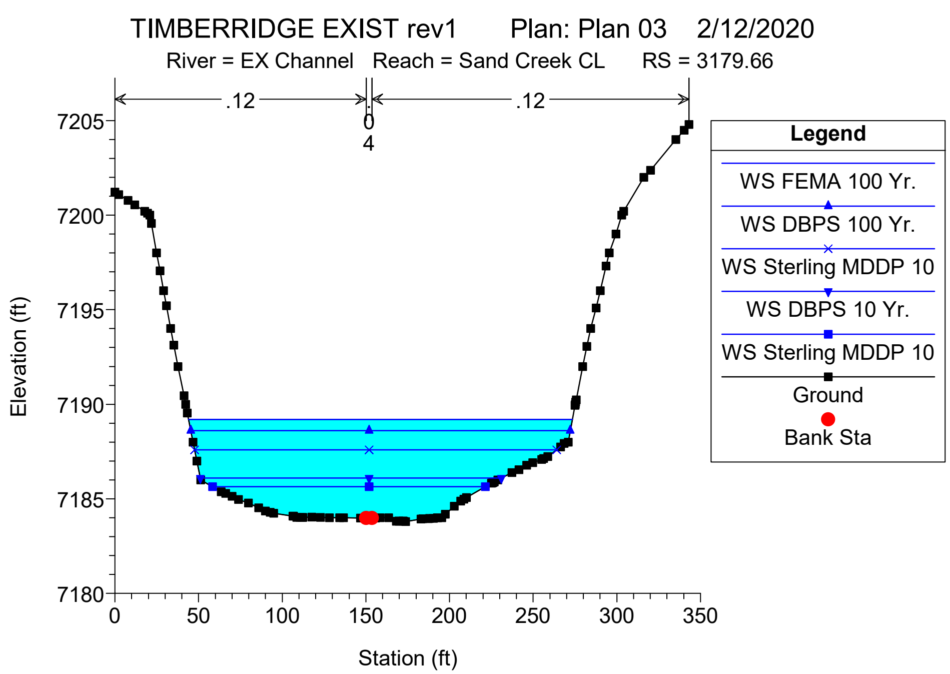
.12
.12
7215
7210
7205
7200
7195
7190
7185
Elevation (ft)
0
50
100
150
200
250
Station (ft)
Legend
WS FEMA 100 Yr.
WS DBPS 100 Yr.
Crit DBPS 100 Yr.
WS Sterling MDDP 10
WS DBPS 10 Yr.
Crit Sterling MDDP 10
WS Sterling MDDP 10
Crit DBPS 10 Yr.
Ground
Bank Sta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.12
0
4
.12
7205
7200
7195
7190
7185
7180
Elevation (ft)
0
50
100
150
200
250
300
350
Station (ft)
Legend
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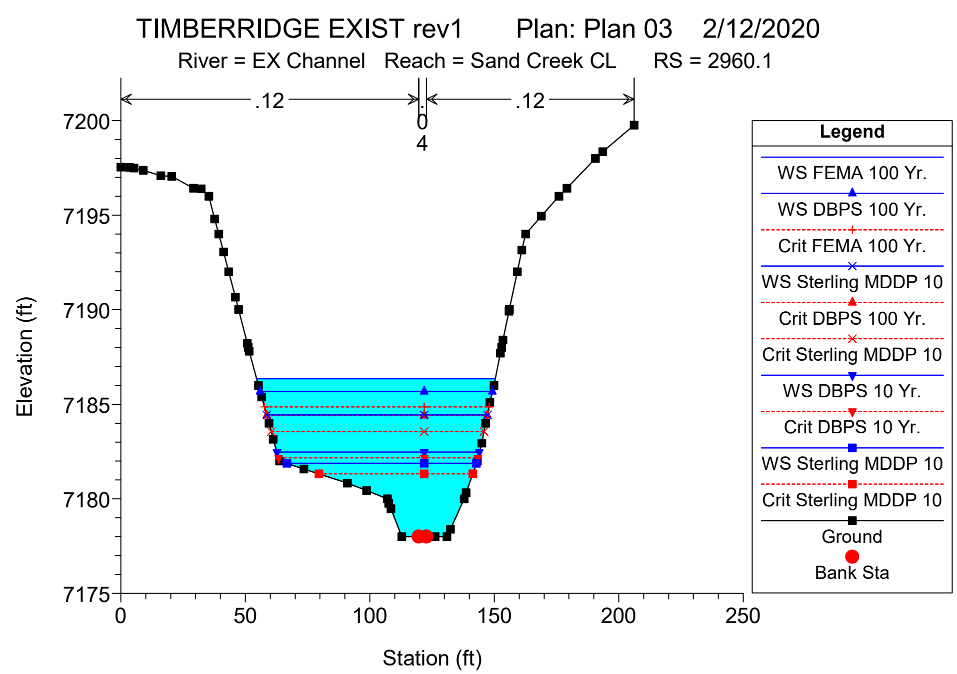
WS DBPS 100 Yr.
WS Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Ground
Bank Sta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0
4
.12
7200
7195
7190
7185
7180
7175
Elevation (ft)
0
50
100
150
200
250
Station (ft)
Legend
WS FEMA 100 Yr.
WS DBPS 100 Yr.
Crit FEMA 100 Yr.
WS Sterling MDDP 10
Crit DBPS 100 Yr.
Crit Sterling MDDP 10
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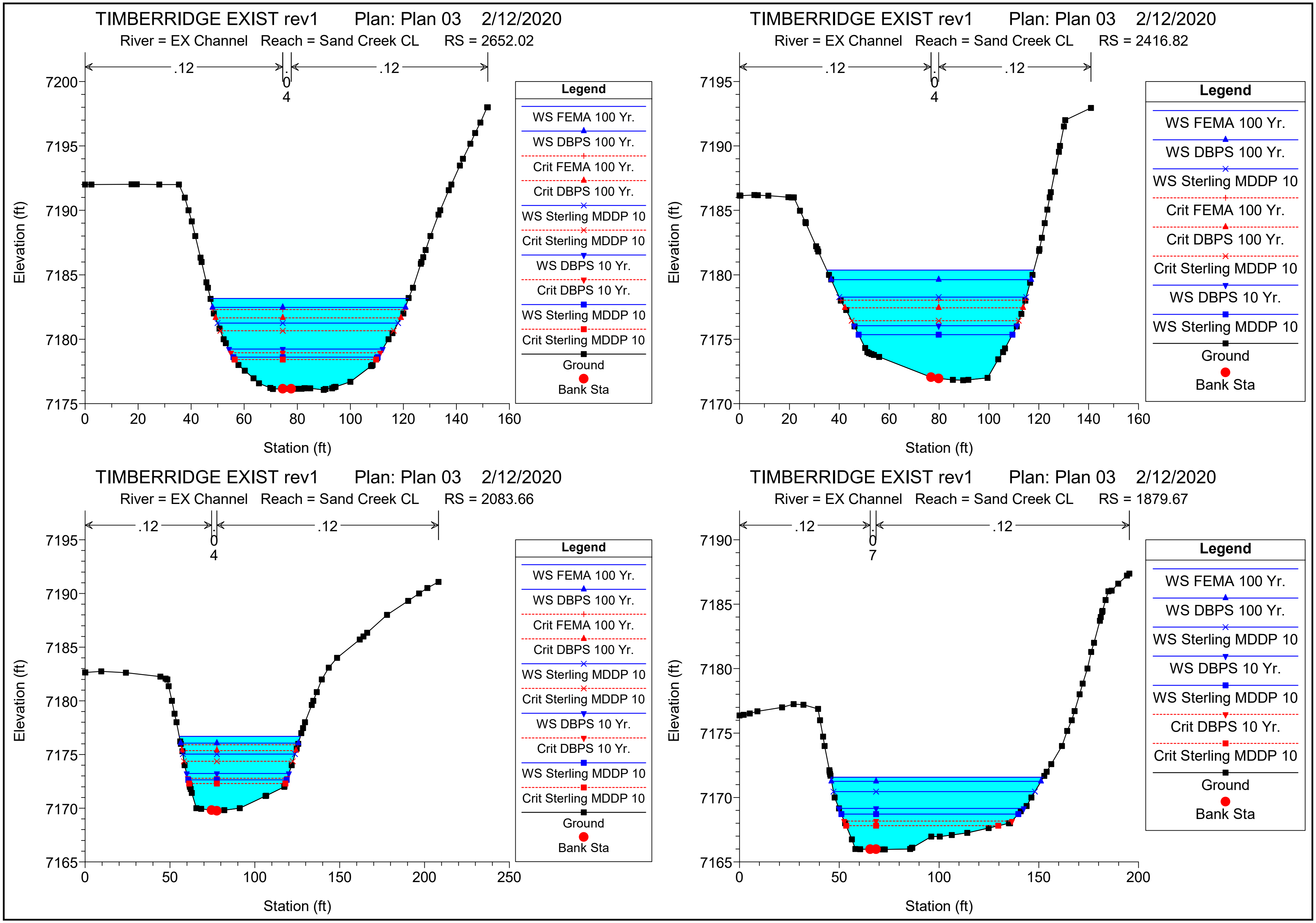
Crit DBPS 10 Yr.
WS Sterling MDDP 10
Crit Sterling MDDP 10
Ground
Bank Sta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.12
0
4
Legend
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WS DBPS 100 Yr.
Crit FEMA 100 Yr.
Crit DBPS 100 Yr.
WS Sterling MDDP 10
Crit Sterling MDDP 10
WS DBPS 10 Yr.
Crit DBPS 10 Yr.
WS Sterling MDDP 10
Crit Sterling MDDP 10
Ground
Bank Sta
Elevation (ft)
Station (ft)
TIMBERRIDGE EXIST rev1 Plan: Plan 03 2/12/2020
River = EX Channel Reach = Sand Creek CL RS = 2416.82
.12
0
4
Legend
WS FEMA 100 Yr.
WS DBPS 100 Yr.
WS Sterling MDDP 10
Crit FEMA 100 Yr.
Crit DBPS 100 Yr.
Crit Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Ground
Bank Sta
Elevation (ft)
Station (ft)
TIMBERRIDGE EXIST rev1 Plan: Plan 03 2/12/2020
River = EX Channel Reach = Sand Creek CL RS = 2083.66
.12
0
4
Legend
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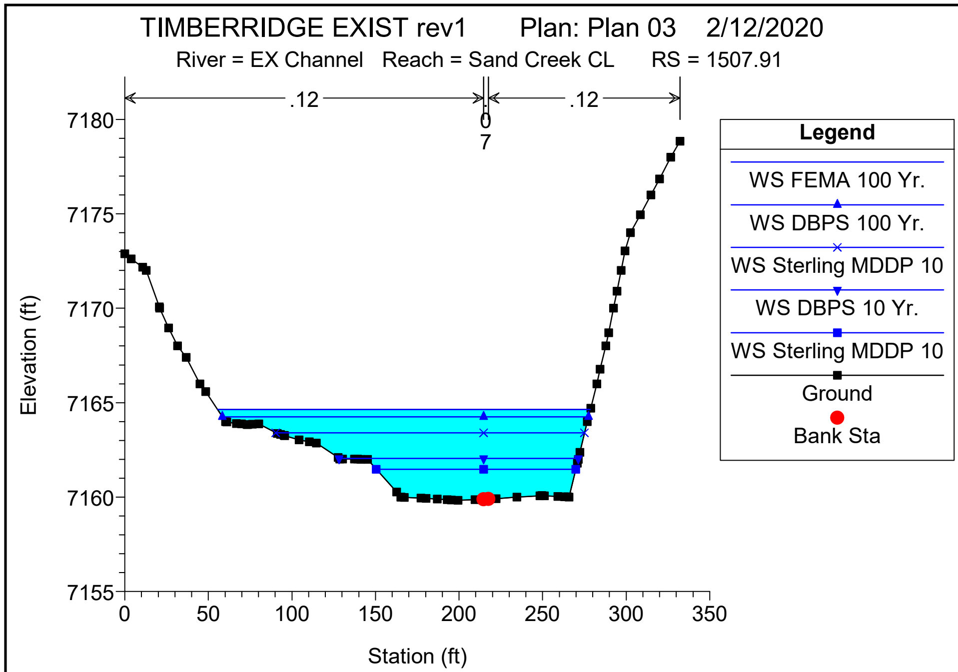
WS DBPS 100 Yr.
Crit FEMA 100 Yr.
Crit DBPS 100 Yr.
WS Sterling MDDP 10
Crit Sterling MDDP 10
WS DBPS 10 Yr.
Crit DBPS 10 Yr.
WS Sterling MDDP 10
Crit Sterling MDDP 10
Ground
Bank Sta
Elevation (ft)
Station (ft)
TIMBERRIDGE EXIST rev1 Plan: Plan 03 2/12/2020
River = EX Channel Reach = Sand Creek CL RS = 1879.67
.12
0
7
Legend
WS FEMA 100 Yr.
WS DBPS 100 Yr.
WS Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Crit DBPS 10 Yr.
Crit Sterling MDDP 10
Ground
Bank Sta
Elevation (ft)
Station (ft)


TIMBERRIDGE EXIST rev1 Plan: Plan 03 2/12/2020
River = EX Channel Reach = Sand Creek CL RS = 1507.91
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.12
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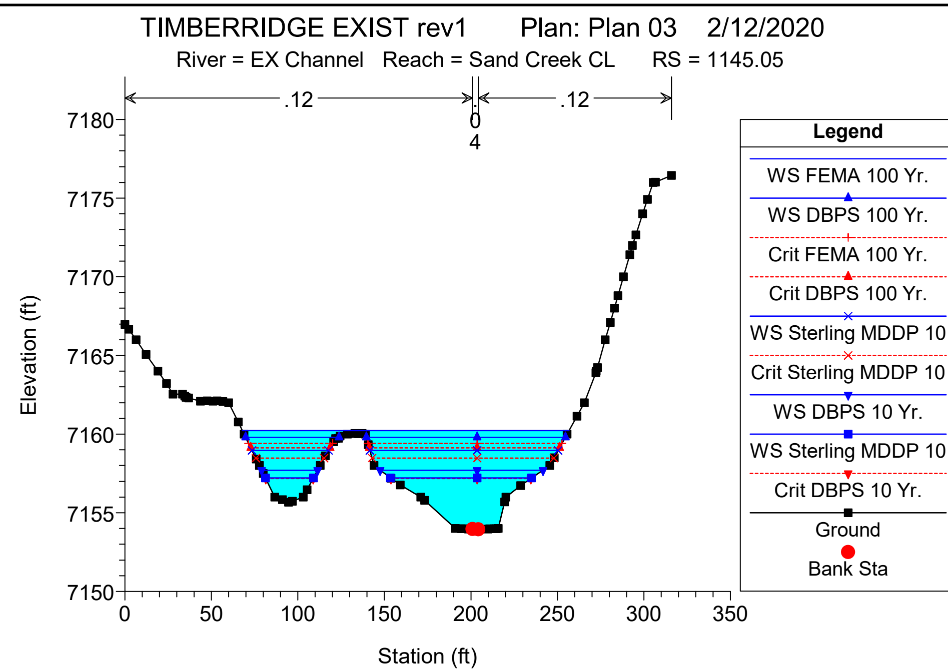
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 Yr.
WS DBPS 100 Yr.
WS Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Ground
Bank Sta


TIMBERRIDGE EXIST rev1 Plan: Plan 03 2/12/2020
River = EX Channel Reach = Sand Creek CL RS = 1145.05
.12
.12
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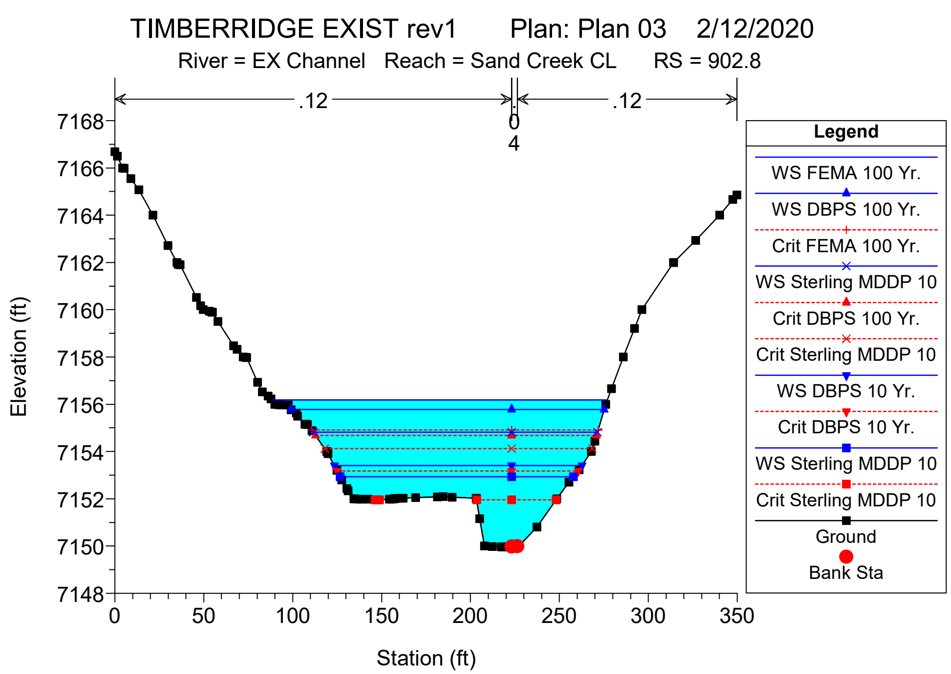
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 Yr.
WS DBPS 100 Yr.
Crit FEMA 100 Yr.
Crit DBPS 100 Yr.
WS Sterling MDDP 10
Crit Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Crit DBPS 10 Yr.
Ground
Bank Sta


TIMBERRIDGE EXIST rev1 Plan: Plan 03 2/12/2020
River = EX Channel Reach = Sand Creek CL RS = 902.8
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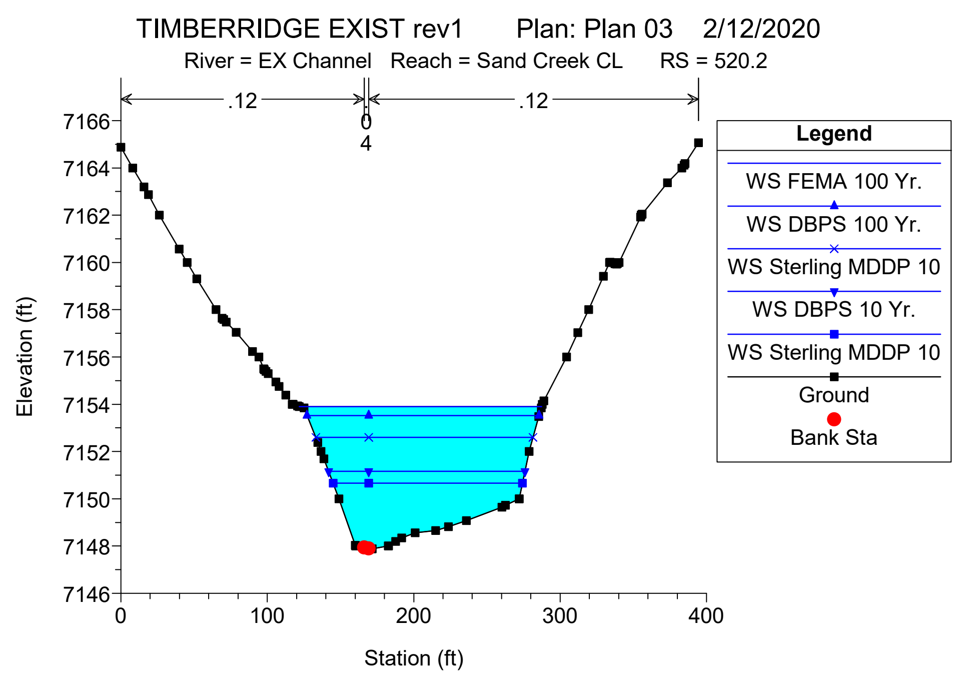
4
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 Yr.
WS DBPS 100 Yr.
Crit FEMA 100 Yr.
WS Sterling MDDP 10
Crit DBPS 100 Yr.
Crit Sterling MDDP 10
WS DBPS 10 Yr.
Crit DBPS 10 Yr.
WS Sterling MDDP 10
Crit Sterling MDDP 10
Ground
Bank Sta


TIMBERRIDGE EXIST rev1 Plan: Plan 03 2/12/2020
River = EX Channel Reach = Sand Creek CL RS = 520.2
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Elevation (ft)
Station (ft)
Legend
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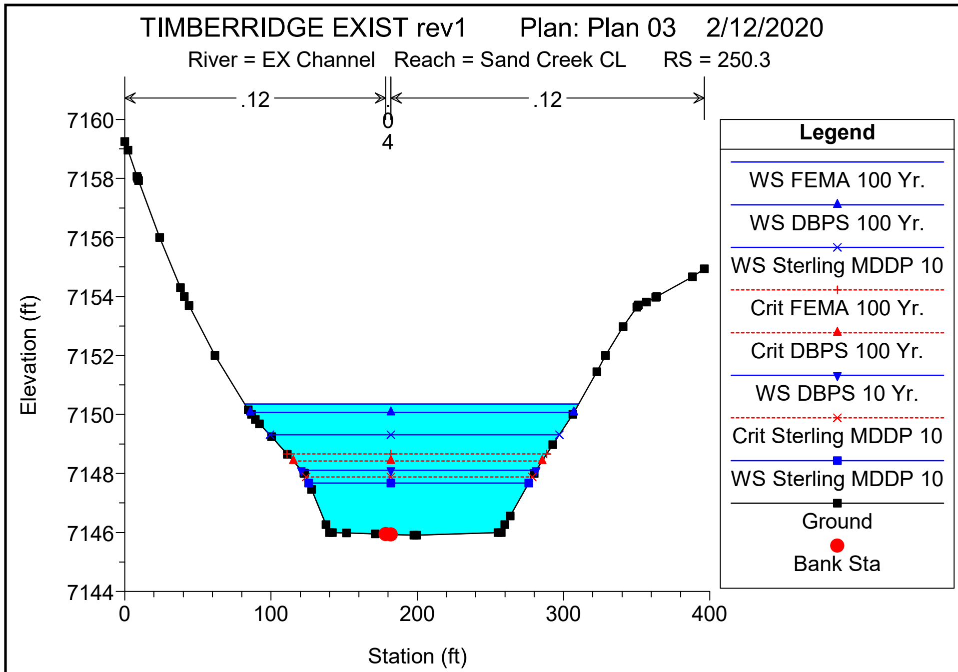
WS DBPS 100 Yr.
WS Sterling MDDP 10
WS DBPS 10 Yr.
WS Sterling MDDP 10
Ground
Bank Sta


TIMBERRIDGE EXIST rev1 Plan: Plan 03 2/12/2020
River = EX Channel Reach = Sand Creek CL RS = 250.3
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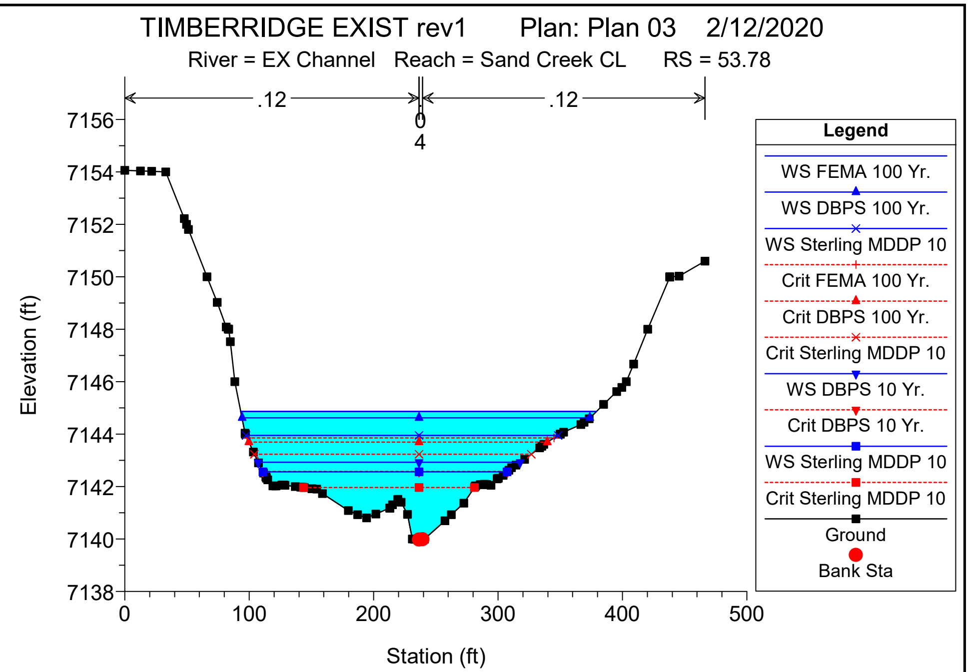
4
.12
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 Yr.
WS DBPS 100 Yr.
WS Sterling MDDP 10
Crit FEMA 100 Yr.
Crit DBPS 100 Yr.
WS DBPS 10 Yr.
Crit Sterling MDDP 10
WS Sterling MDDP 10
Ground
Bank Sta


TIMBERRIDGE EXIST rev1 Plan: Plan 03 2/12/2020
River = EX Channel Reach = Sand Creek CL RS = 53.78
.12
0
4
.12
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 Yr.
WS DBPS 100 Yr.
WS Sterling MDDP 10
Crit FEMA 100 Yr.
Crit DBPS 100 Yr.
Crit Sterling MDDP 10
WS DBPS 10 Yr.
Crit DBPS 10 Yr.
WS Sterling MDDP 10
Crit Sterling MDDP 10
Ground
Bank Sta

HEC-RAS Plan: EX Channel   River: EX Channel   Reach: Sand Creek CL

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Max Chl Dpth	Hydr Radius	E.G. Elev	E.G. Slope	Vel Total	Shear Total	Flow Area	Top Width	Froude # XS
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(lb/sq ft)	(sq ft)	(ft)	
Sand Creek CL	5532.95	FEMA 100 Yr.	2600	7231.08	7235.52	7234.05	4.68	3.62	7236.03	0.022518	4.63	5.09	561.42	154.26	0.53
Sand Creek CL	5532.95	DBPS 100 Yr.	2170	7231.08	7235.07	7233.74	4.23	3.30	7235.53	0.022947	4.40	4.73	493.69	148.91	0.53
Sand Creek CL	5532.95	DBPS 10 Yr.	630	7231.08	7233.06	7232.34	2.22	1.74	7233.25	0.023166	2.89	2.51	217.95	125.24	0.47
Sand Creek CL	5532.95	Sterling MDDP 10	1487	7231.08	7234.29	7233.20	3.45	2.72	7234.65	0.023415	3.91	3.98	380.63	139.25	0.51
Sand Creek CL	5532.95	Sterling MDDP 10	430	7231.08	7232.68	7232.07	1.84	1.41	7232.83	0.022799	2.51	2.01	171.34	121.05	0.46
Sand Creek CL	5182.08	FEMA 100 Yr.	2600	7225.89	7231.60		5.71	4.25	7232.06	0.018385	4.83	4.88	538.23	124.78	0.46
Sand Creek CL	5182.08	DBPS 100 Yr.	2170	7225.89	7231.01		5.12	3.90	7231.43	0.019231	4.65	4.68	466.74	118.05	0.46
Sand Creek CL	5182.08	DBPS 10 Yr.	630	7225.89	7228.24		2.35	2.06	7228.46	0.026081	3.45	3.36	182.78	87.91	0.46
Sand Creek CL	5182.08	Sterling MDDP 10	1487	7225.89	7229.95		4.06	3.25	7230.29	0.021236	4.28	4.30	347.54	105.91	0.46
Sand Creek CL	5182.08	Sterling MDDP 10	430	7225.89	7227.75		1.86	1.66	7227.92	0.027783	3.07	2.88	140.24	84.02	0.45
Sand Creek CL	4903.69	FEMA 100 Yr.	2600	7221.98	7229.08		7.11	5.44	7229.23	0.006455	3.11	2.19	834.70	150.79	0.24
Sand Creek CL	4903.69	DBPS 100 Yr.	2170	7221.98	7228.48		6.51	5.02	7228.62	0.006274	2.91	1.96	746.03	146.41	0.23
Sand Creek CL	4903.69	DBPS 10 Yr.	630	7221.98	7225.44		3.47	2.71	7225.49	0.005936	1.88	1.00	335.16	122.57	0.20
Sand Creek CL	4903.69	Sterling MDDP 10	1487	7221.98	7227.37		5.40	4.20	7227.47	0.006024	2.53	1.58	587.29	138.03	0.22
Sand Creek CL	4903.69	Sterling MDDP 10	430	7221.98	7224.80		2.83	2.20	7224.84	0.006110	1.66	0.84	258.95	116.82	0.20
Sand Creek CL	4712.26	FEMA 100 Yr.	2600	7218.00	7224.69	7222.56	6.72	3.42	7225.02	0.022929	4.37	4.90	595.24	173.14	0.44
Sand Creek CL	4712.26	DBPS 100 Yr.	2170	7218.00	7224.22	7222.15	6.25	3.28	7224.53	0.022188	4.18	4.55	518.63	157.21	0.43
Sand Creek CL	4712.26	DBPS 10 Yr.	630	7218.00	7221.76	7220.18	3.79	2.30	7221.91	0.017028	2.93	2.44	214.93	92.93	0.36
Sand Creek CL	4712.26	Sterling MDDP 10	1487	7218.00	7223.37	7221.47	5.40	2.97	7223.62	0.020309	3.76	3.77	395.96	132.51	0.40
Sand Creek CL	4712.26	Sterling MDDP 10	430	7218.00	7221.22	7219.78	3.25	2.01	7221.33	0.015413	2.57	1.94	167.53	82.63	0.34
Sand Creek CL	4444.93	FEMA 100 Yr.	2600	7213.88	7217.40		3.56	2.63	7217.79	0.040891	4.87	6.70	534.32	202.97	0.54
Sand Creek CL	4444.93	DBPS 100 Yr.	2170	7213.88	7217.11		3.27	2.39	7217.45	0.040693	4.56	6.08	475.64	198.27	0.53
Sand Creek CL	4444.93	DBPS 10 Yr.	630	7213.88	7215.68		1.84	1.27	7215.82	0.041199	3.01	3.27	209.50	164.71	0.48
Sand Creek CL	4444.93	Sterling MDDP 10	1487	7213.88	7216.56		2.72	1.95	7216.83	0.041676	4.02	5.07	369.61	189.52	0.52
Sand Creek CL	4444.93	Sterling MDDP 10	430	7213.88	7215.35		1.50	1.05	7215.47	0.043935	2.73	2.88	157.50	149.90	0.48
Sand Creek CL	4231.86	FEMA 100 Yr.	2600	7206.00	7213.03		7.03	4.68	7213.17	0.006020	2.76	1.76	943.27	200.14	0.24
Sand Creek CL	4231.86	DBPS 100 Yr.	2170	7206.00	7212.39		6.39	4.11	7212.52	0.006641	2.66	1.70	815.20	196.97	0.25
Sand Creek CL	4231.86	DBPS 10 Yr.	630	7206.00	7209.91		3.91	1.87	7209.98	0.008532	1.84	1.00	342.68	182.71	0.29
Sand Creek CL	4231.86	Sterling MDDP 10	1487	7206.00	7211.38		5.38	3.22	7211.49	0.007400	2.40	1.49	619.75	191.59	0.26
Sand Creek CL	4231.86	Sterling MDDP 10	430	7206.00	7209.47		3.47	1.52	7209.54	0.008470	1.63	0.81	264.54	173.30	0.29
Sand Creek CL	3915.99	FEMA 100 Yr.	2600	7203.98	7210.60		6.63	5.34	7210.78	0.007035	3.26	2.35	798.22	146.52	0.26
Sand Creek CL	3915.99	DBPS 100 Yr.	2170	7203.98	7209.86		5.89	5.10	7210.03	0.006918	3.12	2.20	695.96	133.69	0.25
Sand Creek CL	3915.99	DBPS 10 Yr.	630	7203.98	7206.76		2.79	2.41	7206.84	0.008573	2.12	1.29	297.77	122.23	0.25
Sand Creek CL	3915.99	Sterling MDDP 10	1487	7203.98	7208.63		4.66	4.05	7208.76	0.007497	2.79	1.90	533.48	129.49	0.25
Sand Creek CL	3915.99	Sterling MDDP 10	430	7203.98	7206.17		2.20	1.88	7206.23	0.009588	1.90	1.12	226.66	119.89	0.25
Sand Creek CL	3708.56	FEMA 100 Yr.	2600	7200.10	7207.58		7.58	4.46	7208.29	0.025118	5.87	6.99	442.80	97.22	0.56
Sand Creek CL	3708.56	DBPS 100 Yr.	2170	7200.10	7206.95		6.95	4.30	7207.59	0.024758	5.65	6.64	384.15	87.35	0.54
Sand Creek CL	3708.56	DBPS 10 Yr.	630	7200.10	7203.92		3.91	2.65	7204.18	0.022000	3.75	3.63	168.13	62.56	0.45
Sand Creek CL	3708.56	Sterling MDDP 10	1487	7200.10	7205.77		5.77	4.03	7206.26	0.023468	5.11	5.91	291.24	70.38	0.49
Sand Creek CL	3708.56	Sterling MDDP 10	430	7200.10	7203.44		3.44	2.30	7203.63	0.018000	3.09	2.58	139.24	59.81	0.40
Sand Creek CL	3540.59	FEMA 100 Yr.	2600	7193.71	7201.17		7.54	5.28	7201.56	0.016232	4.87	5.35	534.27	98.51	0.38
Sand Creek CL	3540.59	DBPS 100 Yr.	2170	7193.71	7200.52		6.89	4.82	7200.87	0.016396	4.61	4.93	470.91	95.30	0.37
Sand Creek CL	3540.59	DBPS 10 Yr.	630	7193.71	7197.39		3.76	2.52	7197.56	0.017944	3.18	2.82	198.37	77.51	0.36

This is next to Lot 13 - if the channel is anticipated to drop 5' in this location additional protection is needed.

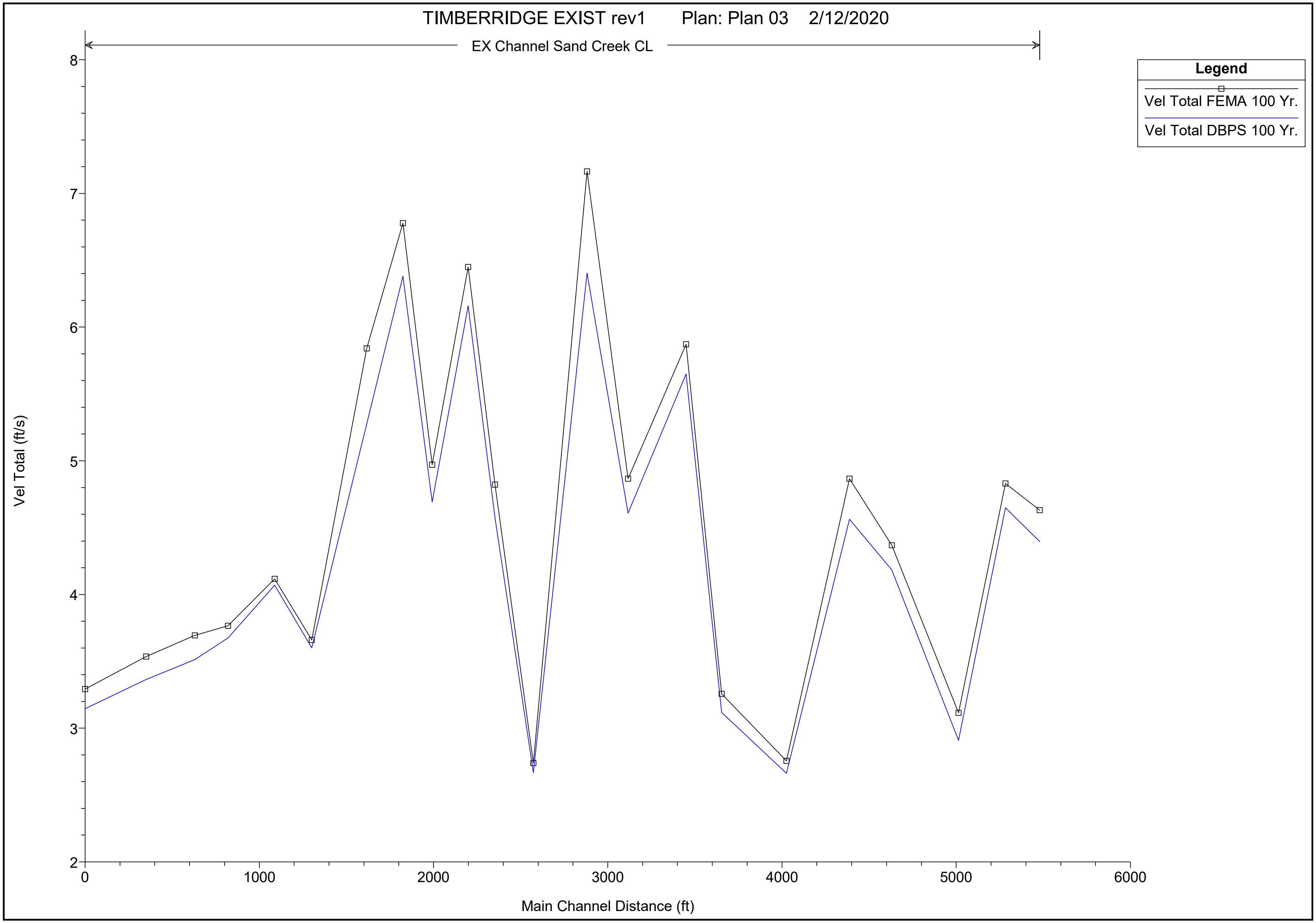
HEC-RAS Plan: EX Channel River: EX Channel Reach: Sand Creek CL (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Max Chl Dpth	Hydr Radius	E.G. Elev	E.G. Slope	Vel Total	Shear Total	Flow Area	Top Width	Froude # XS
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(lb/sq ft)	(sq ft)	(ft)	
Sand Creek CL	3540.59	Sterling MDDP 10	1487	7193.71	7199.33		5.70	3.95	7199.61	0.016974	4.12	4.19	360.69	89.33	0.37
Sand Creek CL	3540.59	Sterling MDDP 10	430	7193.71	7196.61		2.98	1.92	7196.77	0.023749	3.08	2.85	139.68	71.70	0.41
Sand Creek CL	3334.27	FEMA 100 Yr.	2600	7188.62	7193.49		5.51	2.86	7194.42	0.073099	7.17	13.07	362.87	124.31	0.80
Sand Creek CL	3334.27	DBPS 100 Yr.	2170	7188.62	7193.30	7192.93	5.32	2.69	7194.05	0.062288	6.40	10.47	338.85	123.57	0.74
Sand Creek CL	3334.27	DBPS 10 Yr.	630	7188.62	7191.99	7190.34	4.01	1.52	7192.26	0.028882	3.48	2.73	180.90	117.69	0.59
Sand Creek CL	3334.27	Sterling MDDP 10	1487	7188.62	7192.91	7191.64	4.93	2.34	7193.41	0.045393	5.11	6.64	291.05	122.07	0.65
Sand Creek CL	3334.27	Sterling MDDP 10	430	7188.62	7191.30		3.32	2.48	7191.48	0.021255	3.35	3.29	128.21	50.30	0.37
Sand Creek CL	3179.66	FEMA 100 Yr.	2600	7183.98	7189.19		5.39	4.12	7189.37	0.006748	2.74	1.73	948.90	229.38	0.30
Sand Creek CL	3179.66	DBPS 100 Yr.	2170	7183.98	7188.60		4.80	3.57	7188.78	0.007669	2.67	1.71	813.47	226.82	0.32
Sand Creek CL	3179.66	DBPS 10 Yr.	630	7183.98	7186.09		2.29	1.62	7186.22	0.014340	2.17	1.45	290.92	179.91	0.40
Sand Creek CL	3179.66	Sterling MDDP 10	1487	7183.98	7187.59		3.79	2.71	7187.76	0.009833	2.53	1.66	588.17	216.49	0.35
Sand Creek CL	3179.66	Sterling MDDP 10	430	7183.98	7185.63		1.83	1.30	7185.75	0.016735	2.03	1.36	211.87	163.01	0.42
Sand Creek CL	2960.1	FEMA 100 Yr.	2600	7177.99	7186.35	7184.86	8.36	5.44	7187.34	0.012352	4.82	4.20	539.23	95.90	0.59
Sand Creek CL	2960.1	DBPS 100 Yr.	2170	7177.99	7185.67	7184.40	7.68	4.93	7186.58	0.012498	4.57	3.85	474.47	93.36	0.60
Sand Creek CL	2960.1	DBPS 10 Yr.	630	7177.99	7182.47	7182.17	4.48	2.36	7183.11	0.013648	3.23	2.01	195.10	81.29	0.73
Sand Creek CL	2960.1	Sterling MDDP 10	1487	7177.99	7184.43	7183.56	6.44	3.98	7185.23	0.012904	4.11	3.21	362.09	88.65	0.63
Sand Creek CL	2960.1	Sterling MDDP 10	430	7177.99	7181.87	7181.32	3.88	1.91	7182.44	0.013267	2.92	1.58	147.46	76.10	0.77
Sand Creek CL	2652.02	FEMA 100 Yr.	2600	7176.16	7183.16	7182.30	7.09	5.22	7184.74	0.023111	6.45	7.53	403.16	74.63	0.77
Sand Creek CL	2652.02	DBPS 100 Yr.	2170	7176.16	7182.47	7181.65	6.40	4.70	7183.93	0.024025	6.16	7.06	352.38	72.79	0.78
Sand Creek CL	2652.02	DBPS 10 Yr.	630	7176.16	7179.24	7178.95	3.17	2.37	7180.06	0.030771	4.53	4.56	139.00	57.91	0.82
Sand Creek CL	2652.02	Sterling MDDP 10	1487	7176.16	7181.25	7180.65	5.18	3.82	7182.47	0.025760	5.59	6.14	265.78	68.09	0.79
Sand Creek CL	2652.02	Sterling MDDP 10	430	7176.16	7178.61	7178.43	2.54	1.89	7179.31	0.034408	4.16	4.05	103.47	54.37	0.86
Sand Creek CL	2416.82	FEMA 100 Yr.	2600	7171.94	7180.36	7178.02	8.55	6.07	7181.30	0.011436	4.97	4.33	523.13	83.01	0.54
Sand Creek CL	2416.82	DBPS 100 Yr.	2170	7171.94	7179.62	7177.44	7.81	5.57	7180.45	0.011348	4.69	3.95	462.48	80.17	0.54
Sand Creek CL	2416.82	DBPS 10 Yr.	630	7171.94	7176.05		4.24	3.04	7176.43	0.010721	3.12	2.03	201.81	65.32	0.50
Sand Creek CL	2416.82	Sterling MDDP 10	1487	7171.94	7178.26	7176.44	6.45	4.63	7178.92	0.011294	4.17	3.26	356.97	74.99	0.53
Sand Creek CL	2416.82	Sterling MDDP 10	430	7171.94	7175.35		3.54	2.52	7175.65	0.010263	2.73	1.61	157.59	61.66	0.48
Sand Creek CL	2083.66	FEMA 100 Yr.	2600	7169.76	7176.69	7175.91	6.94	5.14	7178.44	0.025935	6.78	8.33	383.61	71.31	0.81
Sand Creek CL	2083.66	DBPS 100 Yr.	2170	7169.76	7176.07	7175.37	6.32	4.71	7177.63	0.025755	6.38	7.57	340.07	69.34	0.80
Sand Creek CL	2083.66	DBPS 10 Yr.	630	7169.76	7173.24	7172.78	3.49	2.55	7173.91	0.022028	4.02	3.51	156.72	60.20	0.72
Sand Creek CL	2083.66	Sterling MDDP 10	1487	7169.76	7175.04	7174.37	5.29	3.95	7176.21	0.023864	5.50	5.89	270.45	66.10	0.76
Sand Creek CL	2083.66	Sterling MDDP 10	430	7169.76	7172.64	7172.30	2.89	2.06	7173.19	0.022350	3.55	2.87	121.00	57.95	0.73
Sand Creek CL	1879.67	FEMA 100 Yr.	2600	7165.97	7171.58		5.62	4.11	7172.20	0.031597	5.84	8.10	445.17	106.68	0.54
Sand Creek CL	1879.67	DBPS 100 Yr.	2170	7165.97	7171.26		5.30	3.86	7171.76	0.027995	5.28	6.74	411.26	105.05	0.51
Sand Creek CL	1879.67	DBPS 10 Yr.	630	7165.97	7169.15	7168.17	3.19	2.16	7169.34	0.020911	3.13	2.82	201.37	92.62	0.42
Sand Creek CL	1879.67	Sterling MDDP 10	1487	7165.97	7170.46		4.50	3.22	7170.84	0.025939	4.52	5.22	329.27	100.99	0.48
Sand Creek CL	1879.67	Sterling MDDP 10	430	7165.97	7168.72	7167.81	2.76	1.82	7168.86	0.018628	2.65	2.11	162.36	88.70	0.39
Sand Creek CL	1507.91	FEMA 100 Yr.	2600	7159.88	7164.63		4.81	3.17	7164.87	0.017371	3.66	3.44	710.48	222.91	0.39
Sand Creek CL	1507.91	DBPS 100 Yr.	2260	7159.88	7164.25		4.43	2.85	7164.49	0.019124	3.60	3.41	627.63	218.99	0.41
Sand Creek CL	1507.91	DBPS 10 Yr.	670	7159.88	7162.05		2.23	1.66	7162.19	0.024465	2.81	2.54	238.69	143.21	0.41
Sand Creek CL	1507.91	Sterling MDDP 10	1520	7159.88	7163.40		3.58	2.46	7163.60	0.020266	3.34	3.11	455.39	184.75	0.40
Sand Creek CL	1507.91	Sterling MDDP 10	450	7159.88	7161.47		1.65	1.40	7161.59	0.028902	2.69	2.52	167.28	119.36	0.42

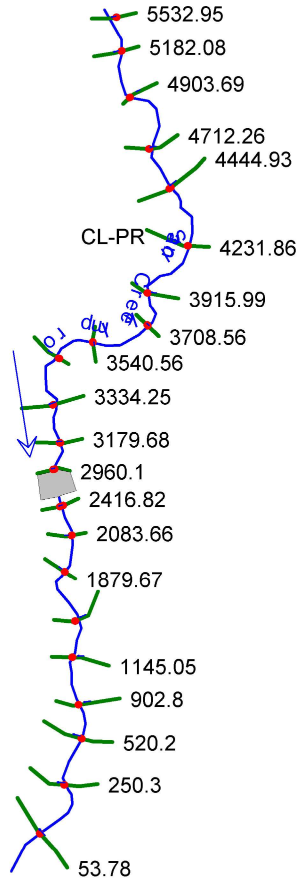
HEC-RAS Plan: EX Channel River: EX Channel Reach: Sand Creek CL (Continued)

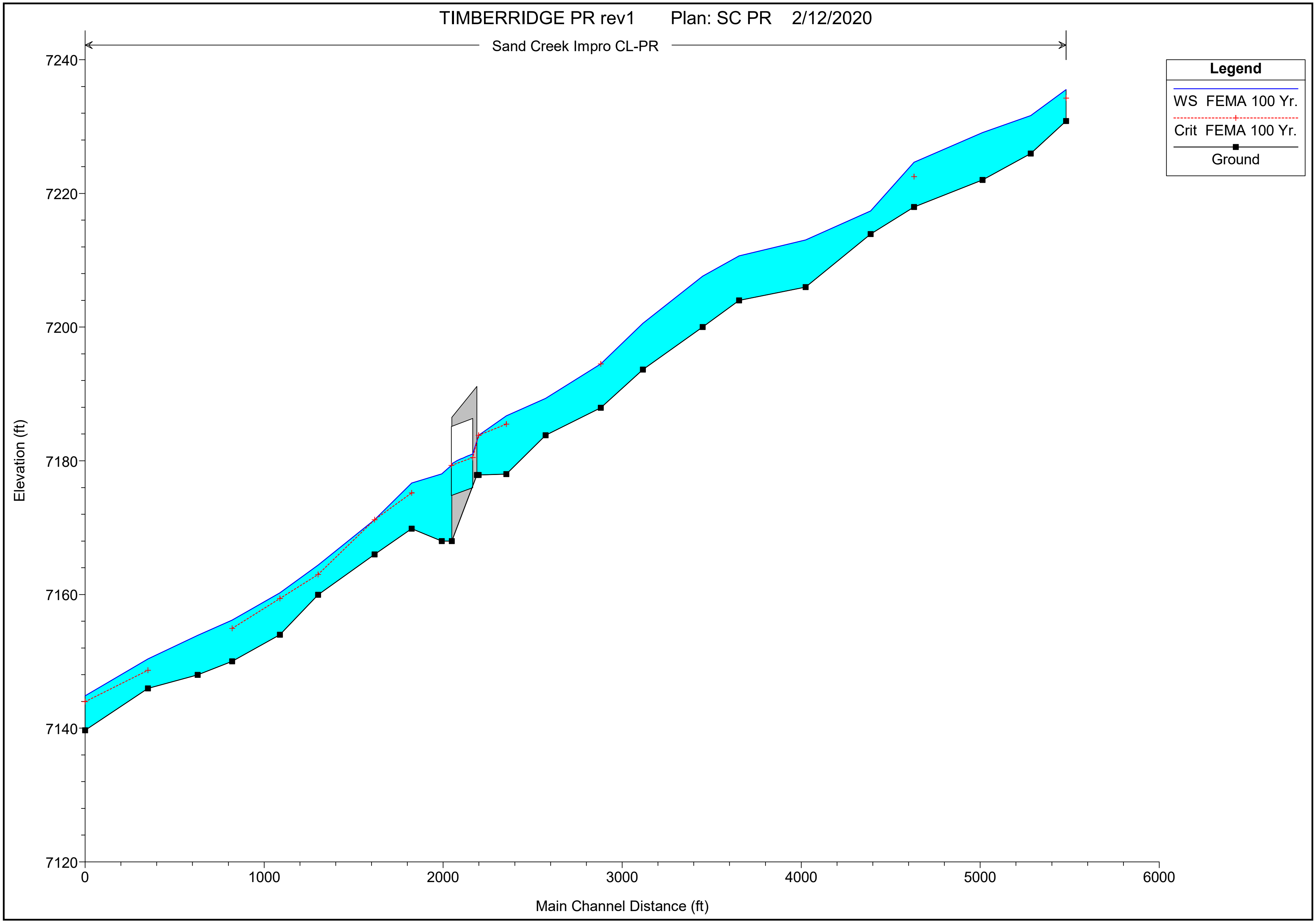
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Max Chl Dpth	Hydr Radius	E.G. Elev	E.G. Slope	Vel Total	Shear Total	Flow Area	Top Width	Froude # XS
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(lb/sq ft)	(sq ft)	(ft)	
Sand Creek CL	1145.05	FEMA 100 Yr.	2600	7153.95	7160.23	7159.42	6.28	3.31	7161.04	0.018058	4.12	3.73	631.41	188.80	0.70
Sand Creek CL	1145.05	DBPS 100 Yr.	2260	7153.95	7159.81	7159.14	5.86	3.24	7160.55	0.017537	4.07	3.55	555.35	169.18	0.67
Sand Creek CL	1145.05	DBPS 10 Yr.	670	7153.95	7157.71	7157.18	3.76	1.90	7158.17	0.014815	2.77	1.76	242.20	126.57	0.69
Sand Creek CL	1145.05	Sterling MDDP 10	1520	7153.95	7158.97	7158.47	5.02	2.72	7159.61	0.017078	3.61	2.90	420.68	153.10	0.68
Sand Creek CL	1145.05	Sterling MDDP 10	450	7153.95	7157.21		3.26	1.66	7157.58	0.013177	2.46	1.37	183.29	109.31	0.66
Sand Creek CL	902.8	FEMA 100 Yr.	2600	7149.98	7156.19	7154.92	6.23	3.64	7156.73	0.014044	3.77	3.19	690.52	188.81	0.55
Sand Creek CL	902.8	DBPS 100 Yr.	2260	7149.98	7155.77	7154.68	5.81	3.47	7156.29	0.014165	3.67	3.07	615.10	176.13	0.54
Sand Creek CL	902.8	DBPS 10 Yr.	670	7149.98	7153.41	7153.18	3.45	1.74	7153.84	0.017688	2.74	1.93	244.11	139.26	0.70
Sand Creek CL	902.8	Sterling MDDP 10	1520	7149.98	7154.82	7154.13	4.86	2.83	7155.28	0.015038	3.34	2.66	454.67	159.84	0.57
Sand Creek CL	902.8	Sterling MDDP 10	450	7149.98	7152.93	7151.96	2.97	1.36	7153.36	0.019136	2.51	1.62	179.05	131.17	0.79
Sand Creek CL	520.2	FEMA 100 Yr.	2600	7147.90	7153.90		6.02	4.22	7154.32	0.011080	3.69	2.92	703.76	165.62	0.44
Sand Creek CL	520.2	DBPS 100 Yr.	2260	7147.90	7153.53		5.65	4.03	7153.90	0.010740	3.51	2.70	643.44	158.55	0.43
Sand Creek CL	520.2	DBPS 10 Yr.	670	7147.90	7151.16		3.28	2.22	7151.34	0.009545	2.25	1.32	298.12	134.11	0.40
Sand Creek CL	520.2	Sterling MDDP 10	1520	7147.90	7152.61		4.73	3.37	7152.89	0.010122	3.03	2.13	502.03	148.42	0.41
Sand Creek CL	520.2	Sterling MDDP 10	450	7147.90	7150.66		2.77	1.79	7150.80	0.009331	1.94	1.04	231.62	129.32	0.40
Sand Creek CL	250.3	FEMA 100 Yr.	2600	7145.93	7150.36	7148.66	4.44	3.22	7150.70	0.015312	3.54	3.07	735.42	228.27	0.46
Sand Creek CL	250.3	DBPS 100 Yr.	2260	7145.93	7150.07	7148.42	4.16	3.03	7150.38	0.014997	3.36	2.84	671.63	221.45	0.45
Sand Creek CL	250.3	DBPS 10 Yr.	670	7145.93	7148.11		2.20	1.84	7148.24	0.013148	2.26	1.51	296.30	160.55	0.38
Sand Creek CL	250.3	Sterling MDDP 10	1520	7145.93	7149.32	7147.88	3.40	2.59	7149.55	0.014349	2.96	2.32	512.69	197.96	0.43
Sand Creek CL	250.3	Sterling MDDP 10	450	7145.93	7147.68		1.76	1.52	7147.77	0.012772	1.96	1.21	229.25	150.37	0.36
Sand Creek CL	53.78	FEMA 100 Yr.	2600	7139.97	7144.87	7143.86	4.90	2.76	7145.22	0.016021	3.29	2.76	789.78	286.02	0.50
Sand Creek CL	53.78	DBPS 100 Yr.	2260	7139.97	7144.62	7143.69	4.65	2.57	7144.95	0.016006	3.15	2.56	718.39	279.57	0.51
Sand Creek CL	53.78	DBPS 10 Yr.	670	7139.97	7142.93	7142.58	2.96	1.45	7143.15	0.016007	2.19	1.45	305.31	210.61	0.56
Sand Creek CL	53.78	Sterling MDDP 10	1520	7139.97	7143.95	7143.24	3.98	2.16	7144.24	0.016020	2.81	2.16	541.68	250.80	0.51
Sand Creek CL	53.78	Sterling MDDP 10	450	7139.97	7142.56	7141.97	2.59	1.18	7142.77	0.016010	1.95	1.18	230.97	196.16	0.60

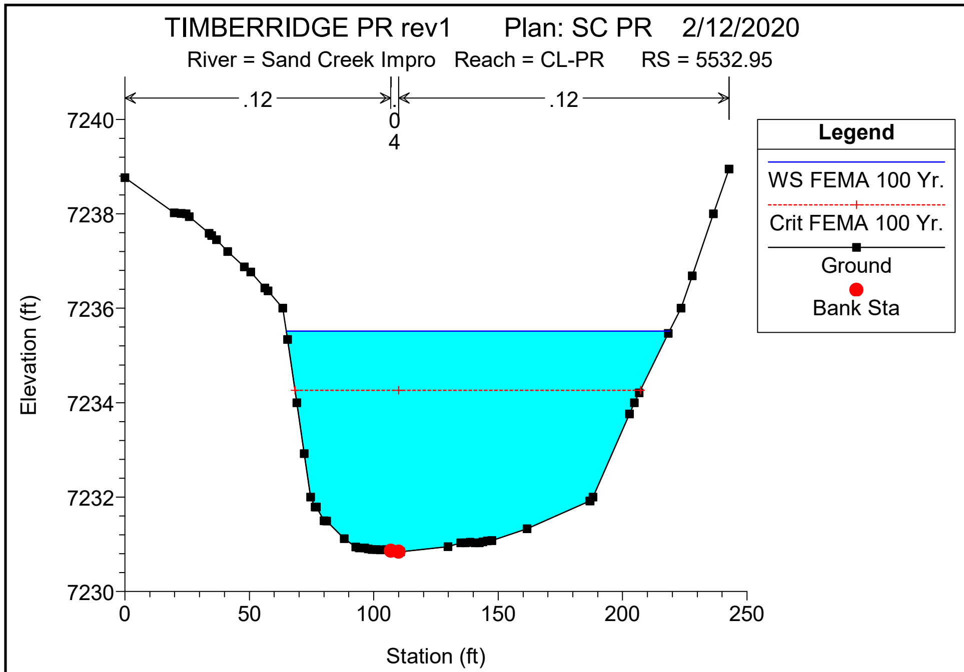
Please highlight the cross-sections within and adjacent to this plat.

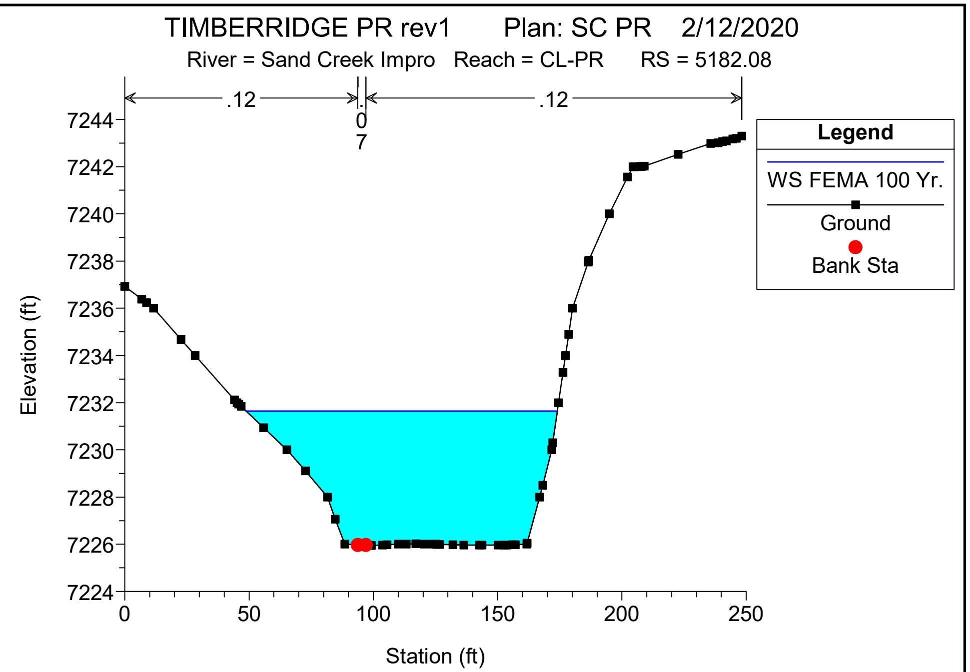


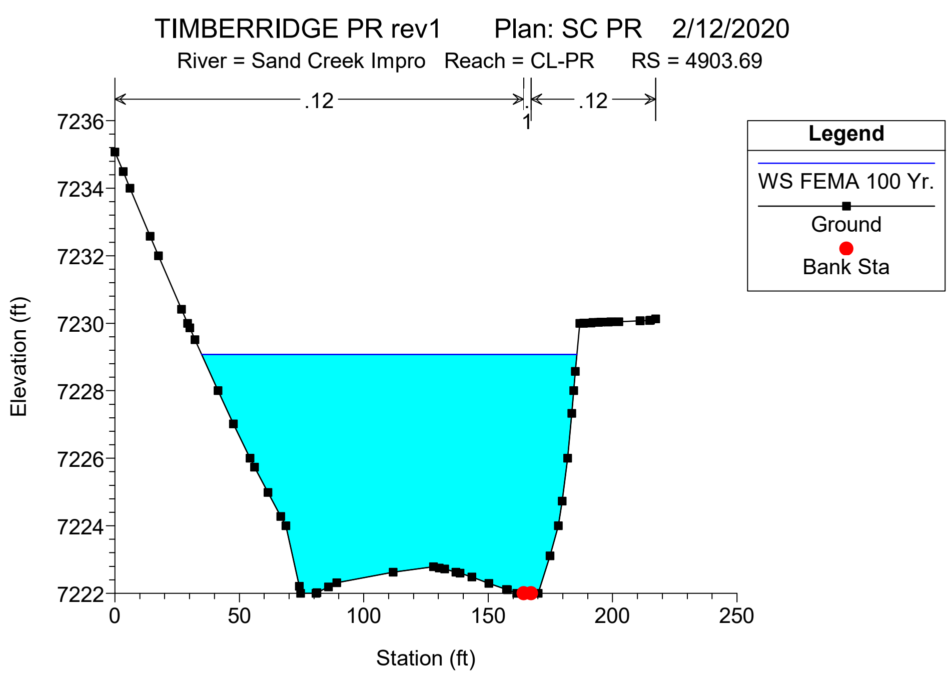
TIMBERRIDGE EXIST rev1 Plan: Plan 03 2/12/2020
EX Channel Sand Creek CL
Legend
Vel Total FEMA 100 Yr.
Vel Total DBPS 100 Yr.
Vel Total (ft/s)
8
7
6
5
4
3
2
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (ft)

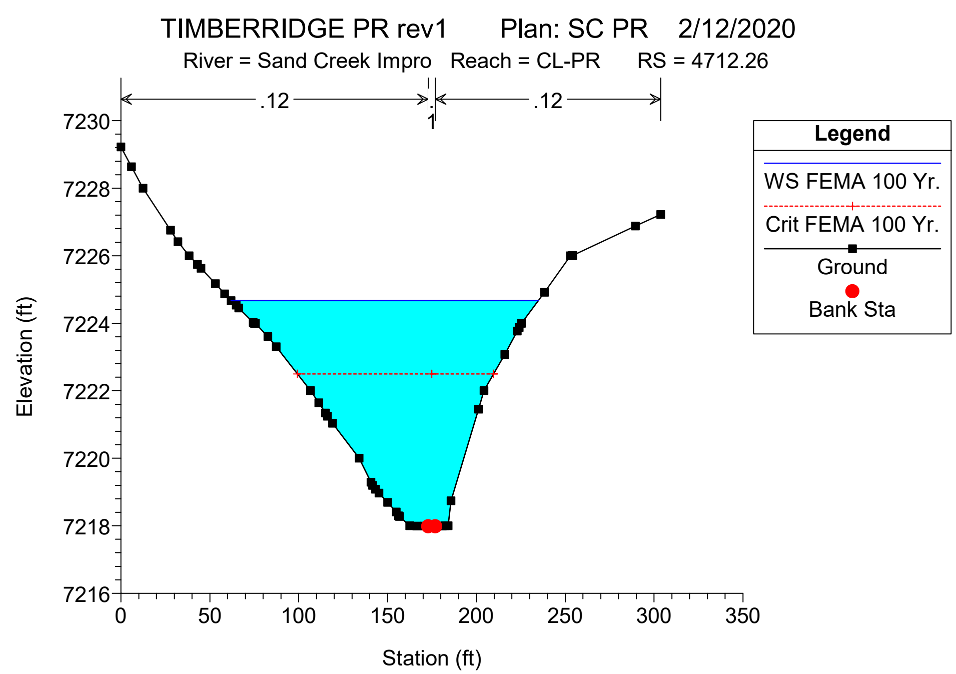

5532.95
5182.08
4903.69
4712.26
4444.93
CL-PR
4231.86
3915.99
3708.56
3540.56
3334.25
3179.68
2960.1
2416.82
2083.66
1879.67
1145.05
902.8
520.2
250.3
53.78

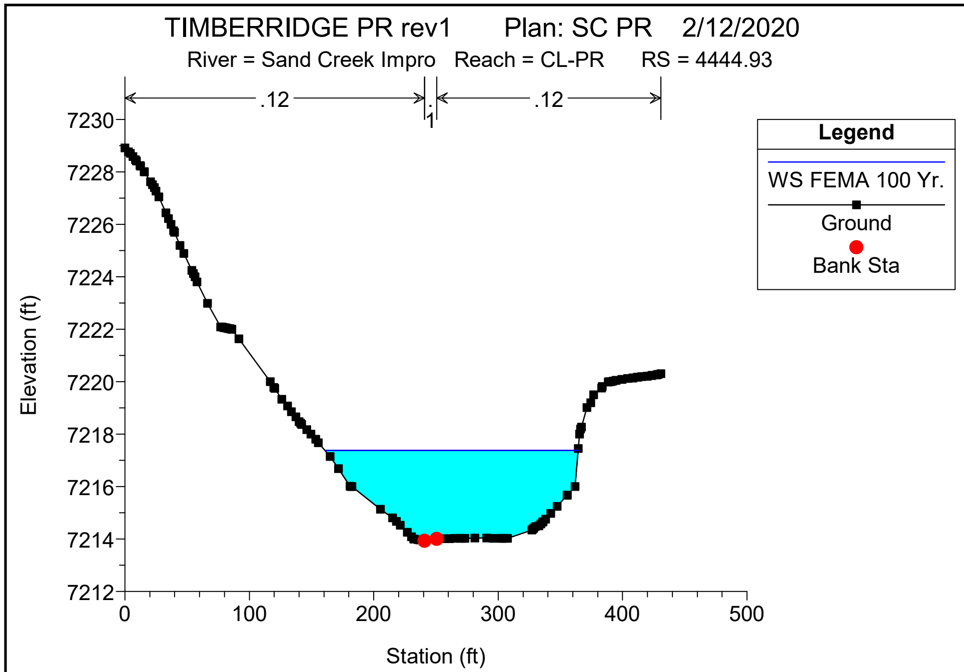

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
Sand Creek Impro CL-PR
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Elevation (ft)
Main Channel Distance (ft)
7240
7220
7200
7180
7160
7140
7120
0
1000
2000
3000
4000
5000
6000

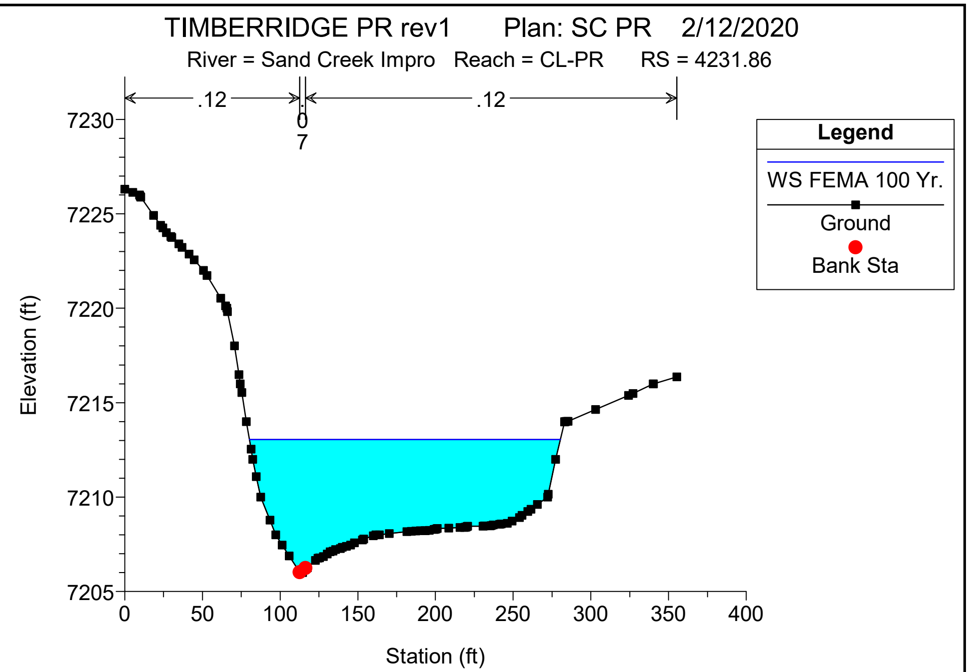

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 5532.95
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

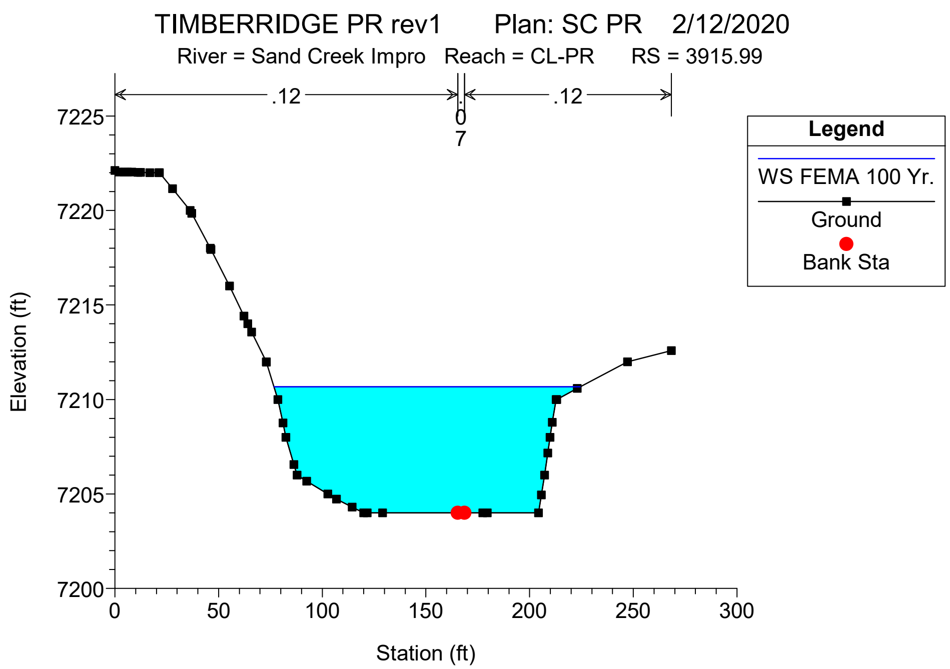

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 5182.08
Legend
WS FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

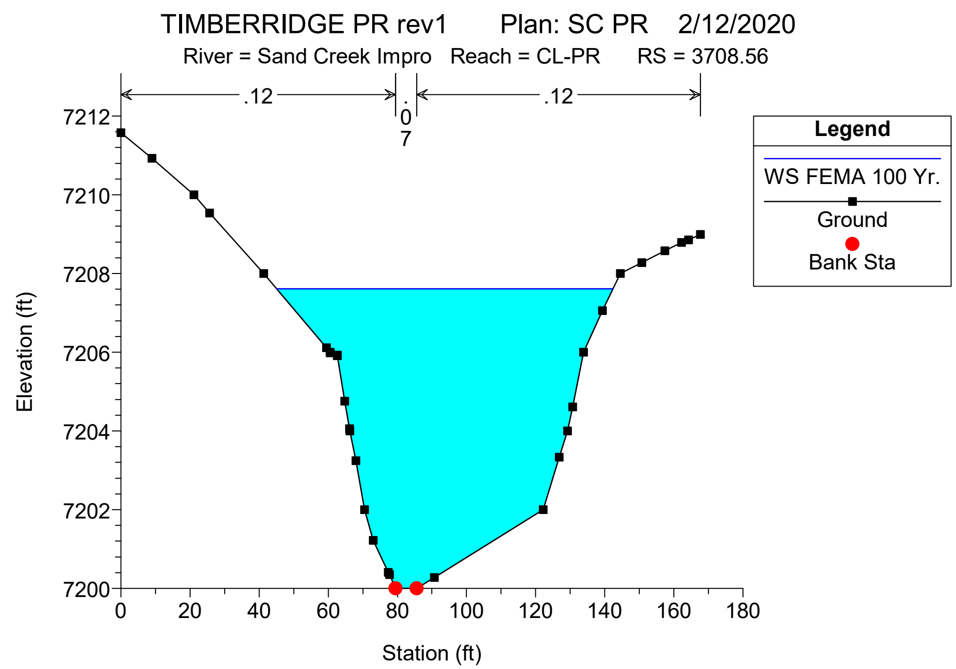

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 4903.69
Legend
WS FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

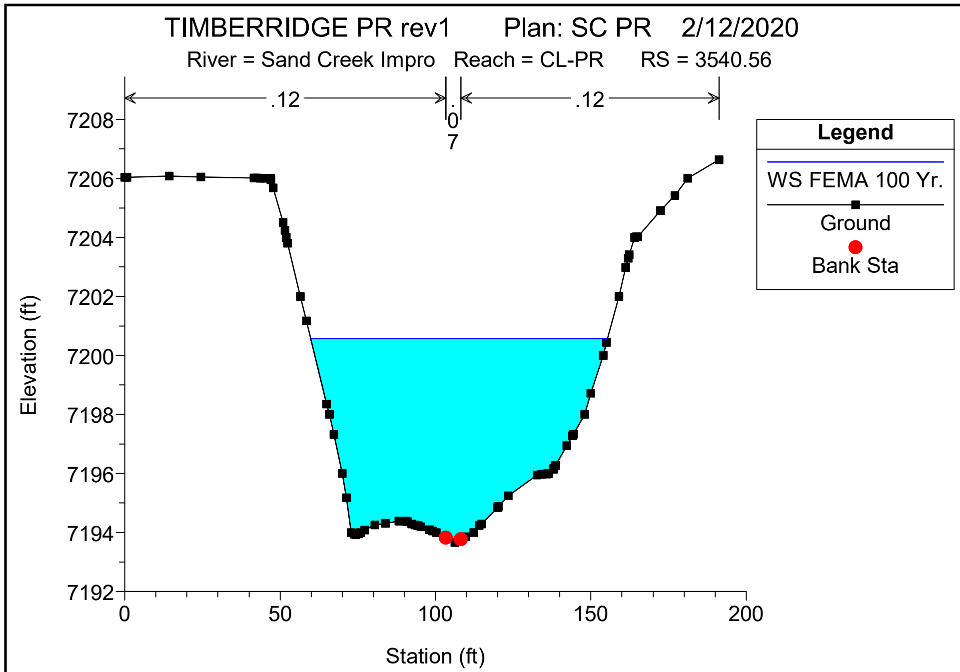

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 4712.26
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

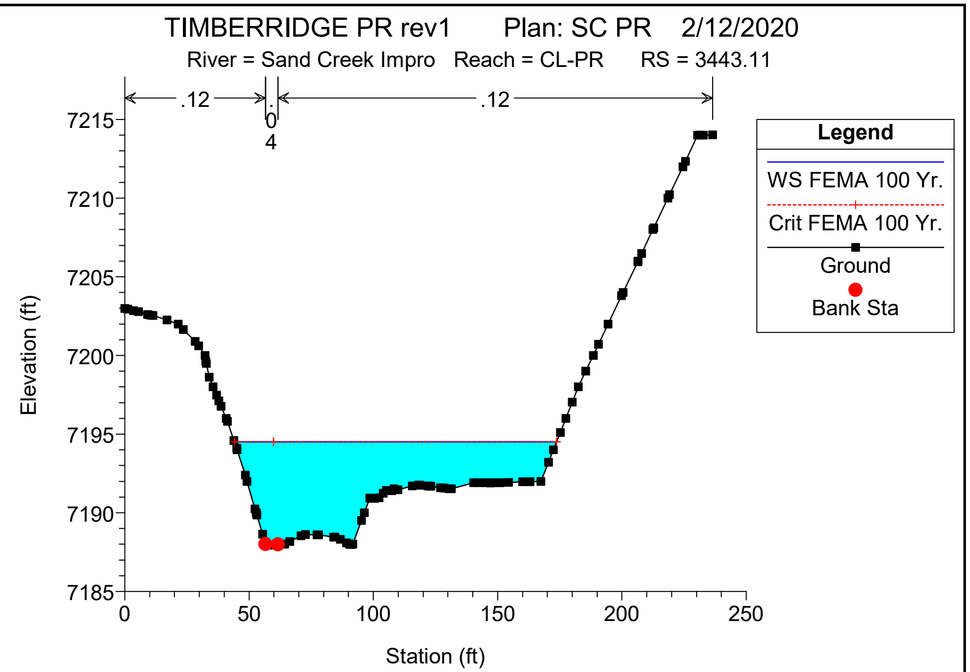

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 4444.93
.12
.12
Legend
WS FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

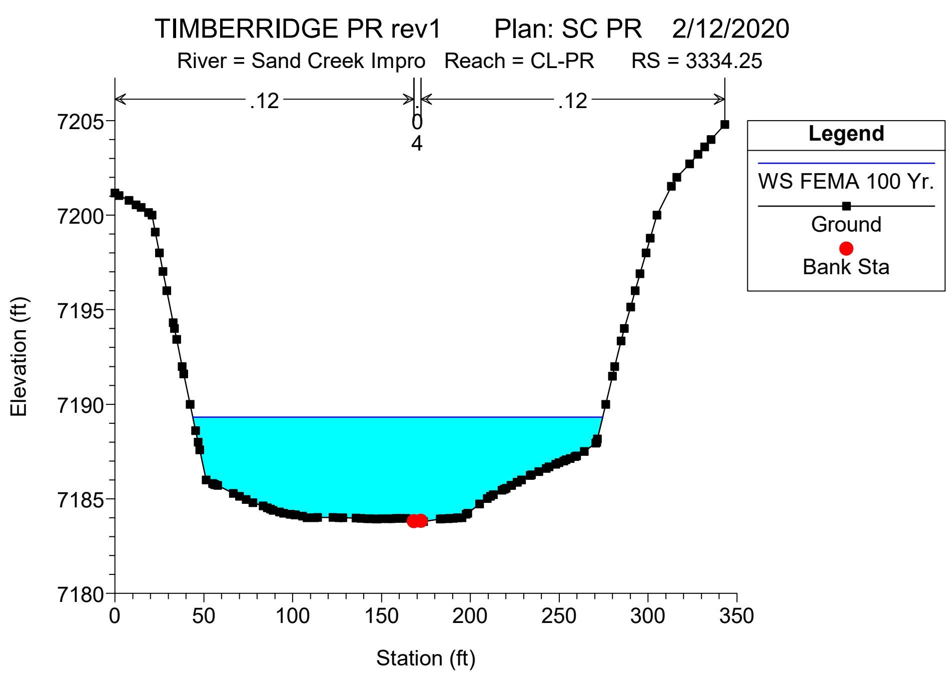

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 4231.86
.12
.12
Legend
WS FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

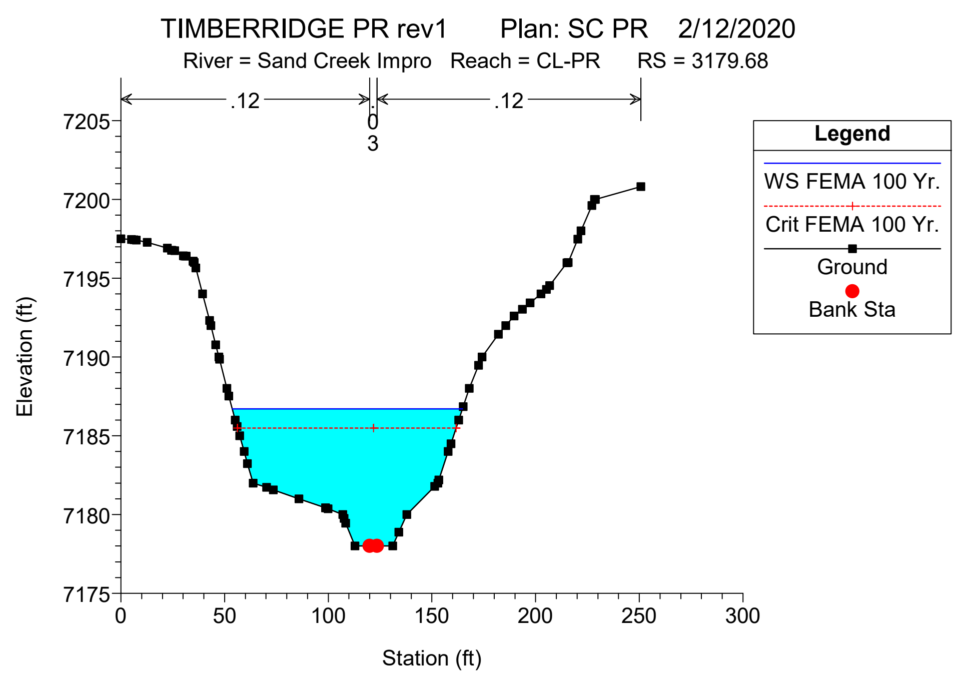

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 3915.99
.12
.12
Legend
WS FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

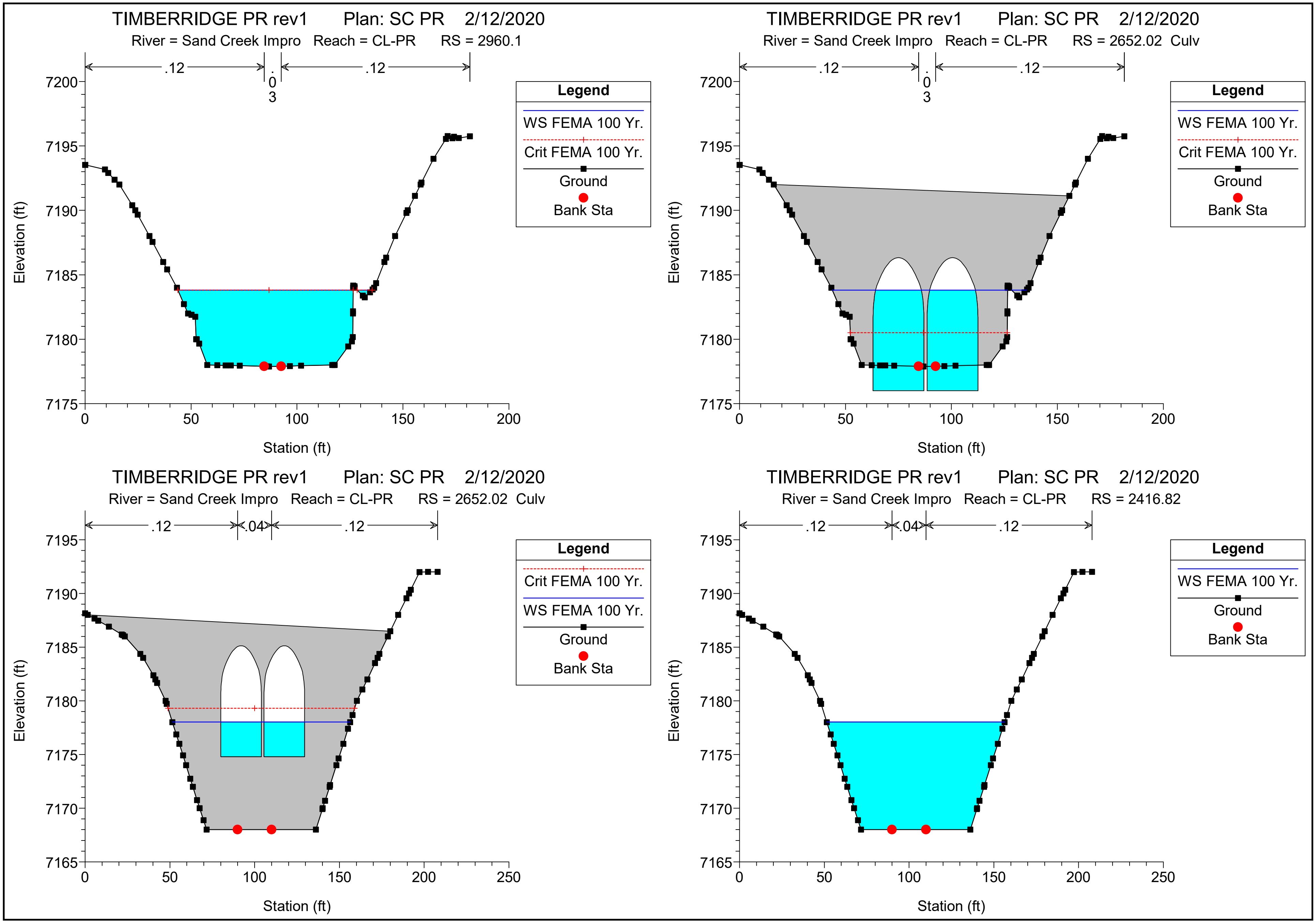

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 3708.56
.12
.12
Legend
WS FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)


TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 3540.56
.12
.07
.12
Legend
WS FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

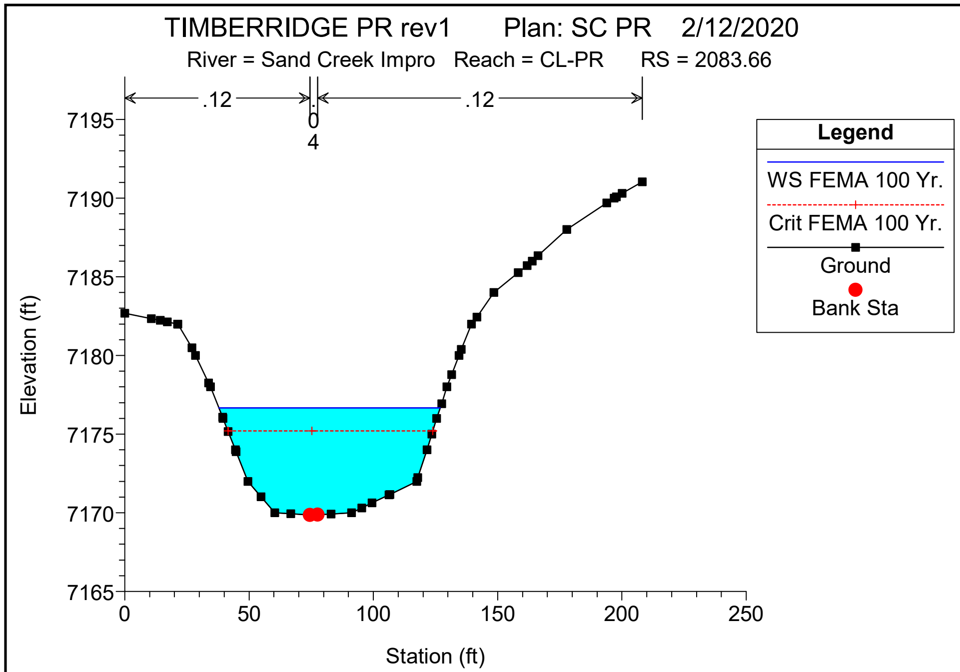

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 3443.11
.12
.04
.12
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

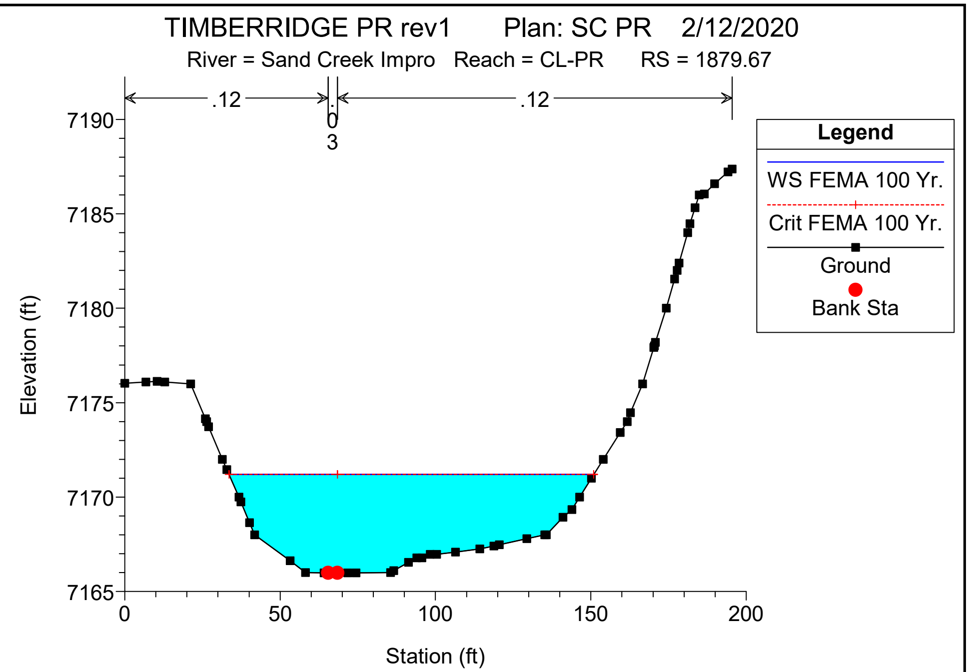

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 3334.25
.12
.04
.12
Legend
WS FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

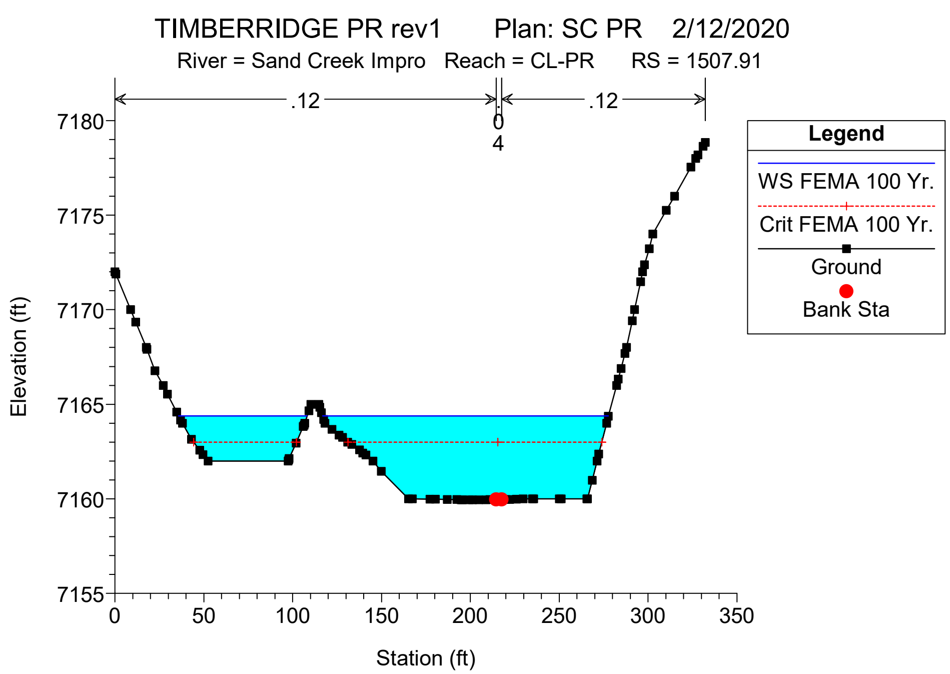

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 3179.68
.12
.03
.12
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

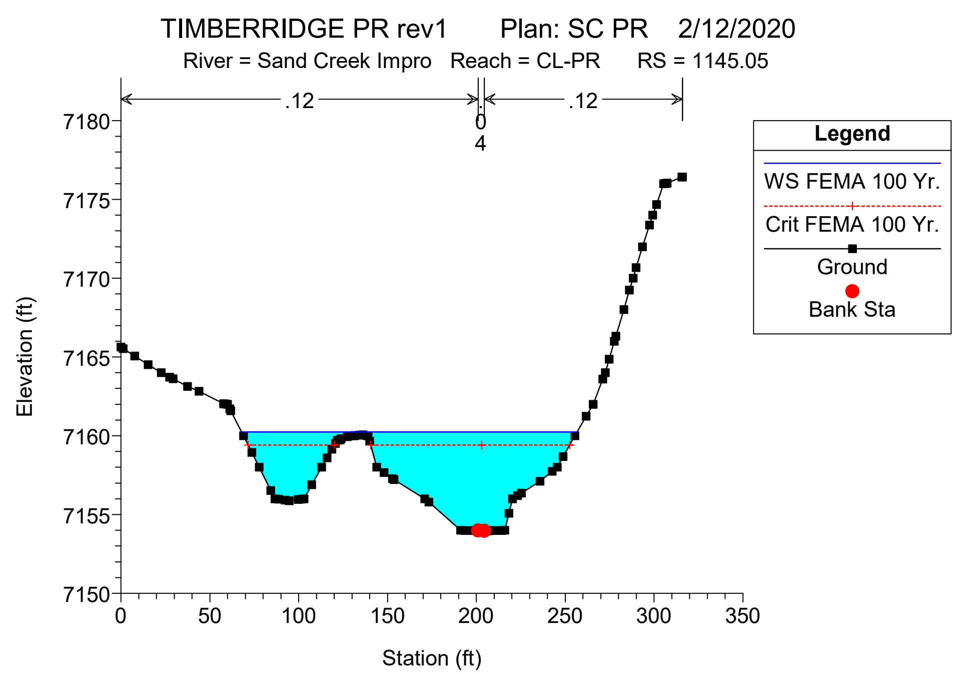


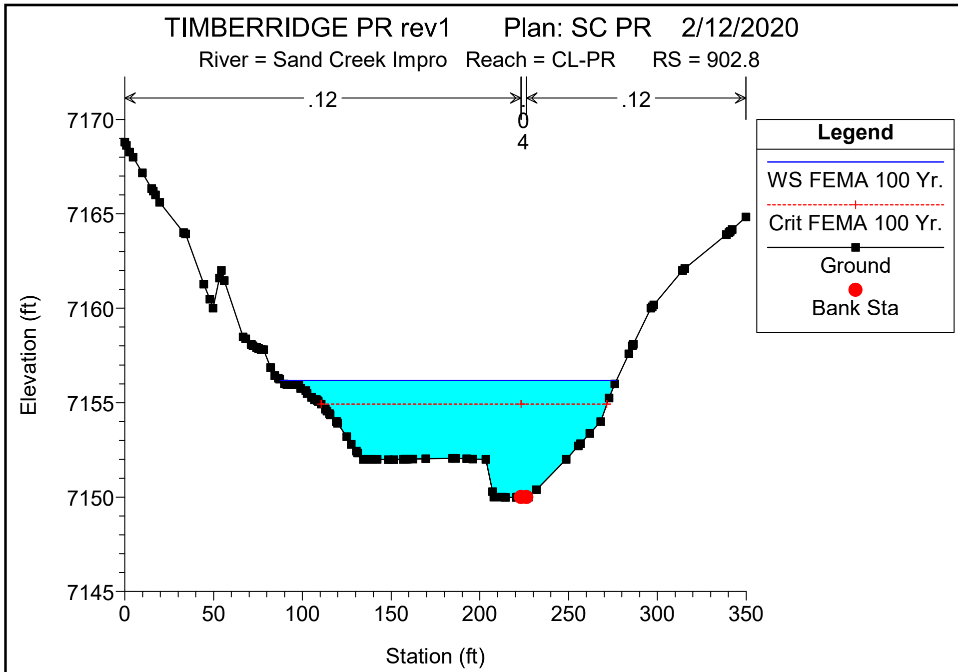
TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 2960.1
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 2652.02 Culv
TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 2652.02 Culv
TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 2416.82

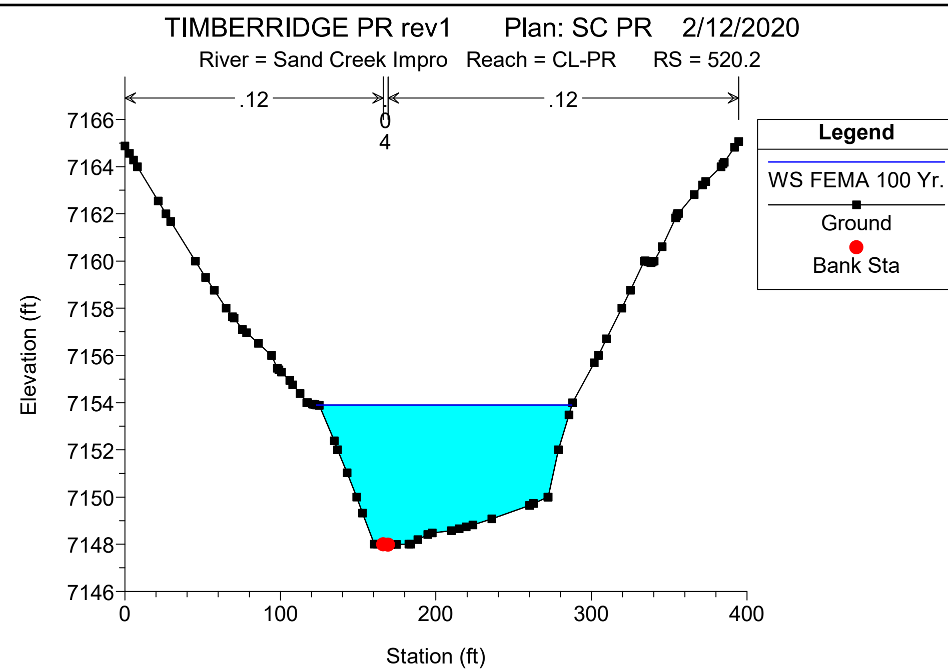

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 2083.66
.12
.12
0
4
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Bank Sta

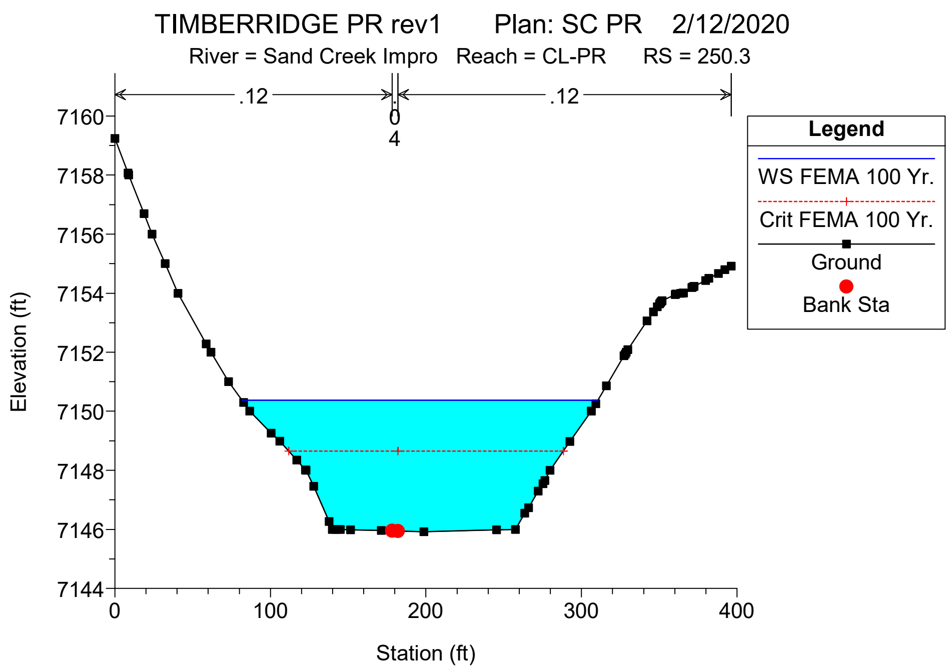

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 1879.67
.12
.12
0
3
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Bank Sta

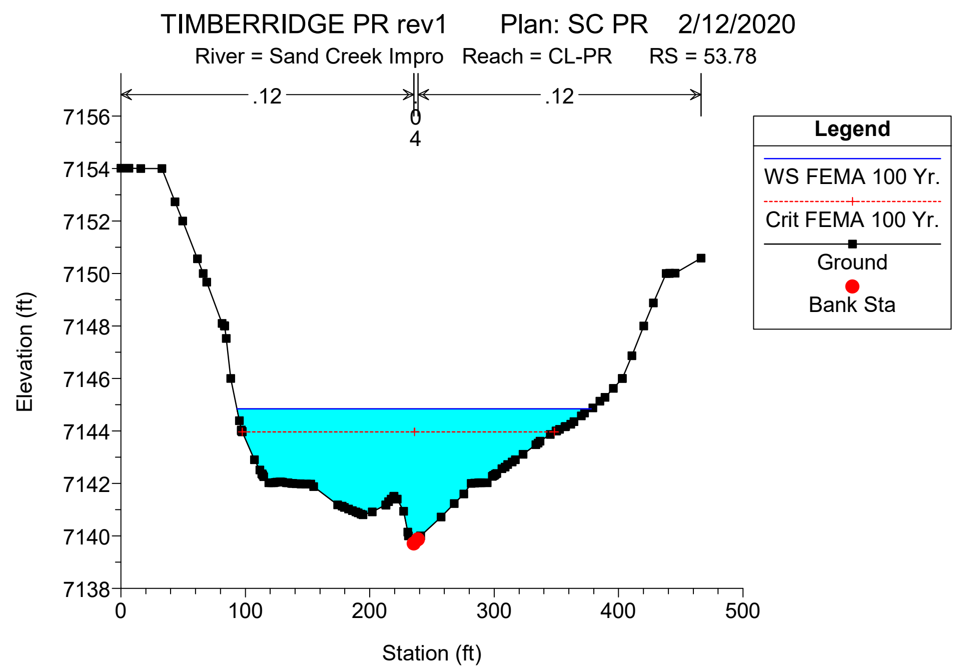

TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 1507.91
.12
.12
0
4
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Bank Sta


TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 1145.05
.12
.12
0
4
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Bank Sta


TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 902.8
.12
0
4
.12
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)


TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 520.2
.12
0
4
.12
Legend
WS FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)


TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 250.3
.12
0
4
.12
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)


TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
River = Sand Creek Impro Reach = CL-PR RS = 53.78
.12
0
4
.12
Legend
WS FEMA 100 Yr.
Crit FEMA 100 Yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

HEC-RAS Plan: SC PR River: Sand Creek Impro Reach: CL-PR

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Max Chl Dpth	Hydr Radius	E.G. Elev	E.G. Slope	Vel Total	Shear Total	Flow Area	Top Width	Froude # XS
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(lb/sq ft)	(sq ft)	(ft)	
CL-PR	5532.95	FEMA 100 Yr.	2600	7230.84	7235.52	7234.26	4.68	3.61	7236.12	0.022532	4.65	5.08	559.31	154.07	0.57
CL-PR	5532.95	DBPS 100 Yr.	2170	7230.84	7235.07	7233.95	4.23	3.29	7235.61	0.022905	4.41	4.71	491.77	148.65	0.57
CL-PR	5532.95	DBPS 10 Yr.	630	7230.84	7233.06	7232.50	2.22	1.73	7233.31	0.023035	2.91	2.48	216.54	125.20	0.54
CL-PR	5532.95	Sterling MDDP 10	1487	7230.84	7234.29	7233.38	3.45	2.71	7234.72	0.023299	3.92	3.95	379.06	139.17	0.56
CL-PR	5532.95	Sterling MDDP 10	430	7230.84	7232.68	7232.24	1.84	1.40	7232.87	0.022857	2.53	2.00	169.66	120.97	0.53
CL-PR	5182.08	FEMA 100 Yr.	2600	7225.96	7231.65		5.70	4.27	7232.07	0.018615	4.79	4.96	542.74	125.32	0.44
CL-PR	5182.08	DBPS 100 Yr.	2170	7225.96	7231.06		5.11	3.92	7231.45	0.019462	4.61	4.76	470.87	118.58	0.44
CL-PR	5182.08	DBPS 10 Yr.	630	7225.96	7228.29		2.34	2.08	7228.49	0.026314	3.41	3.41	185.01	88.36	0.44
CL-PR	5182.08	Sterling MDDP 10	1487	7225.96	7229.99		4.04	3.26	7230.32	0.021471	4.24	4.37	351.05	106.45	0.44
CL-PR	5182.08	Sterling MDDP 10	430	7225.96	7227.79		1.84	1.68	7227.95	0.027798	3.02	2.92	142.22	84.05	0.43
CL-PR	4903.69	FEMA 100 Yr.	2600	7222.00	7229.08		7.08	5.44	7229.24	0.006504	3.12	2.21	834.06	150.85	0.24
CL-PR	4903.69	DBPS 100 Yr.	2170	7222.00	7228.49		6.48	5.01	7228.62	0.006323	2.91	1.98	745.50	146.47	0.23
CL-PR	4903.69	DBPS 10 Yr.	630	7222.00	7225.44		3.44	2.71	7225.50	0.005992	1.88	1.01	334.88	122.66	0.20
CL-PR	4903.69	Sterling MDDP 10	1487	7222.00	7227.37		5.37	4.19	7227.47	0.006083	2.53	1.59	586.67	138.19	0.22
CL-PR	4903.69	Sterling MDDP 10	430	7222.00	7224.81		2.81	2.20	7224.85	0.006187	1.66	0.85	258.54	116.93	0.20
CL-PR	4712.26	FEMA 100 Yr.	2600	7217.98	7224.67	7222.49	6.69	3.43	7225.00	0.022684	4.36	4.86	596.20	172.82	0.44
CL-PR	4712.26	DBPS 100 Yr.	2170	7217.98	7224.21	7222.08	6.23	3.29	7224.51	0.022022	4.17	4.52	520.04	157.47	0.43
CL-PR	4712.26	DBPS 10 Yr.	630	7217.98	7221.75	7220.15	3.76	2.32	7221.89	0.016998	2.91	2.46	216.66	92.87	0.35
CL-PR	4712.26	Sterling MDDP 10	1487	7217.98	7223.35	7221.41	5.37	2.98	7223.60	0.020224	3.75	3.77	396.37	132.21	0.40
CL-PR	4712.26	Sterling MDDP 10	430	7217.98	7221.22	7219.76	3.24	2.03	7221.33	0.015199	2.52	1.93	170.41	83.30	0.33
CL-PR	4444.93	FEMA 100 Yr.	2600	7213.93	7217.38		3.45	2.59	7217.78	0.041470	4.92	6.71	528.48	203.56	0.56
CL-PR	4444.93	DBPS 100 Yr.	2170	7213.93	7217.10		3.17	2.37	7217.45	0.040993	4.61	6.07	470.76	198.02	0.54
CL-PR	4444.93	DBPS 10 Yr.	630	7213.93	7215.68		1.75	1.26	7215.83	0.040995	3.03	3.23	207.63	164.62	0.49
CL-PR	4444.93	Sterling MDDP 10	1487	7213.93	7216.56		2.63	1.93	7216.83	0.041638	4.06	5.02	366.53	189.42	0.53
CL-PR	4444.93	Sterling MDDP 10	430	7213.93	7215.34		1.41	1.04	7215.47	0.044949	2.78	2.90	154.49	149.20	0.50
CL-PR	4231.86	FEMA 100 Yr.	2600	7206.00	7213.05		7.05	4.68	7213.18	0.005951	2.75	1.74	944.92	200.18	0.24
CL-PR	4231.86	DBPS 100 Yr.	2170	7206.00	7212.39		6.39	4.11	7212.52	0.006602	2.66	1.69	815.09	196.97	0.25
CL-PR	4231.86	DBPS 10 Yr.	630	7206.00	7209.91		3.91	1.87	7209.99	0.008531	1.84	0.99	341.65	182.71	0.29
CL-PR	4231.86	Sterling MDDP 10	1487	7206.00	7211.38		5.38	3.21	7211.49	0.007400	2.40	1.48	618.74	191.90	0.26
CL-PR	4231.86	Sterling MDDP 10	430	7206.00	7209.48		3.48	1.52	7209.55	0.008382	1.63	0.80	264.61	173.44	0.30
CL-PR	3915.99	FEMA 100 Yr.	2600	7203.99	7210.67		6.67	5.37	7210.84	0.006819	3.22	2.28	807.78	147.59	0.25
CL-PR	3915.99	DBPS 100 Yr.	2170	7203.99	7209.92		5.93	5.14	7210.08	0.006714	3.09	2.16	702.67	133.86	0.25
CL-PR	3915.99	DBPS 10 Yr.	630	7203.99	7206.76		2.77	2.41	7206.84	0.008606	2.12	1.29	297.60	122.40	0.25
CL-PR	3915.99	Sterling MDDP 10	1487	7203.99	7208.64		4.65	4.07	7208.77	0.007426	2.78	1.88	535.10	129.53	0.25
CL-PR	3915.99	Sterling MDDP 10	430	7203.99	7206.17		2.17	1.87	7206.23	0.009769	1.91	1.14	225.47	119.97	0.26
CL-PR	3708.56	FEMA 100 Yr.	2600	7200.00	7207.61		7.61	4.48	7208.47	0.022675	5.84	6.34	445.42	97.38	0.61
CL-PR	3708.56	DBPS 100 Yr.	2170	7200.00	7207.00		7.00	4.31	7207.76	0.022077	5.59	5.94	388.08	88.02	0.59
CL-PR	3708.56	DBPS 10 Yr.	630	7200.00	7203.76		3.76	2.53	7204.15	0.022567	3.98	3.57	158.43	61.66	0.55
CL-PR	3708.56	Sterling MDDP 10	1487	7200.00	7205.80		5.80	4.06	7206.39	0.020504	5.07	5.19	293.58	70.55	0.53
CL-PR	3708.56	Sterling MDDP 10	430	7200.00	7203.33		3.33	2.21	7203.60	0.017709	3.25	2.44	132.37	59.09	0.49
CL-PR	3540.56	FEMA 100 Yr.	2600	7193.66	7200.57		6.91	4.85	7201.18	0.020761	5.47	6.29	474.94	95.52	0.49
CL-PR	3540.56	DBPS 100 Yr.	2170	7193.66	7199.95		6.29	4.40	7200.51	0.021210	5.21	5.83	416.82	92.51	0.50
CL-PR	3540.56	DBPS 10 Yr.	630	7193.66	7197.31		3.65	2.46	7197.55	0.017340	3.28	2.66	191.88	76.96	0.43
CL-PR	3540.56	Sterling MDDP 10	1487	7193.66	7198.86		5.20	3.61	7199.31	0.021767	4.66	4.91	319.14	86.58	0.50

How did the channel drop 5 feet? If this model is "future, post-erosion, it needs to be labeled as such. Do the check structures allow for 5' of erosion?

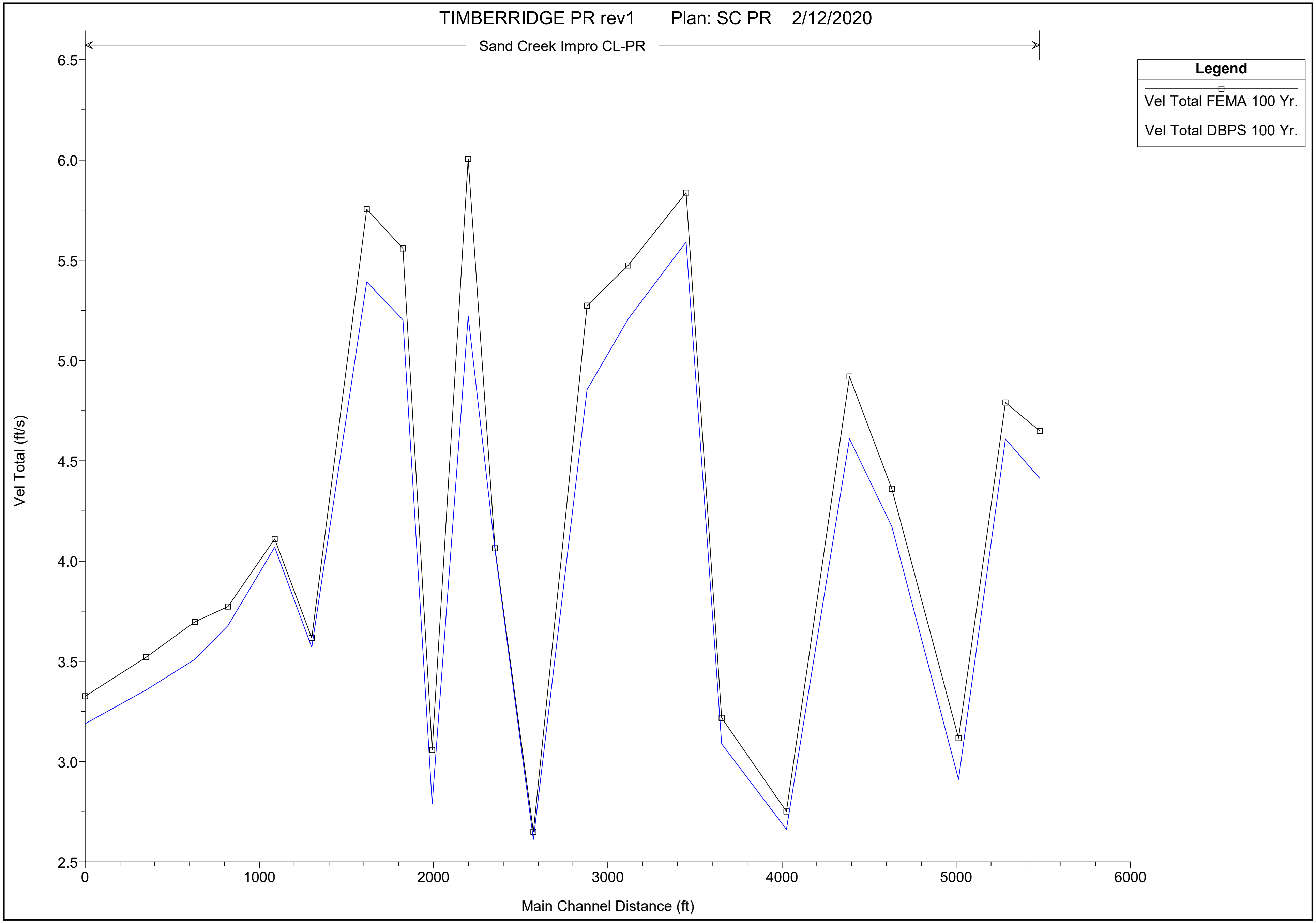
HEC-RAS Plan: SC PR River: Sand Creek Impro Reach: CL-PR (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Max Chl Dpth	Hydr Radius	E.G. Elev	E.G. Slope	Vel Total	Shear Total	Flow Area	Top Width	Froude # XS
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(lb/sq ft)	(sq ft)	(ft)	
CL-PR	3540.56	Sterling MDDP 10	430	7193.66	7196.50		2.84	1.84	7196.75	0.024145	3.26	2.77	131.95	70.93	0.51
CL-PR	3443.11	FEMA 100 Yr.	2600	7187.94	7194.51	7194.51	6.56	3.73	7196.07	0.021671	5.27	5.04	492.98	129.56	0.91
CL-PR	3443.11	DBPS 100 Yr.	2170	7187.94	7194.15	7194.15	6.21	3.42	7195.54	0.020111	4.85	4.30	447.03	127.88	0.89
CL-PR	3443.11	DBPS 10 Yr.	630	7187.94	7191.36	7190.82	3.42	2.37	7192.50	0.025903	4.74	3.84	132.80	54.41	0.96
CL-PR	3443.11	Sterling MDDP 10	1487	7187.94	7193.45	7193.45	5.51	2.83	7194.60	0.017805	4.14	3.14	359.38	124.76	0.89
CL-PR	3443.11	Sterling MDDP 10	430	7187.94	7190.91	7190.56	2.97	2.24	7191.62	0.019329	3.94	2.70	109.12	47.34	0.79
CL-PR	3334.25	FEMA 100 Yr.	2600	7183.81	7189.32		5.52	4.23	7189.51	0.005907	2.65	1.56	981.23	230.65	0.30
CL-PR	3334.25	DBPS 100 Yr.	2170	7183.81	7188.66		4.86	3.64	7188.85	0.006937	2.61	1.58	830.90	227.52	0.32
CL-PR	3334.25	DBPS 10 Yr.	630	7183.81	7186.03		2.23	1.57	7186.19	0.015218	2.24	1.50	280.91	178.27	0.45
CL-PR	3334.25	Sterling MDDP 10	1487	7183.81	7187.56		3.76	2.68	7187.75	0.009702	2.55	1.62	582.77	217.08	0.38
CL-PR	3334.25	Sterling MDDP 10	430	7183.81	7185.57	7185.03	1.77	1.27	7185.72	0.017980	2.12	1.42	202.82	159.92	0.48
CL-PR	3179.68	FEMA 100 Yr.	2600	7178.00	7186.71	7185.49	8.71	5.63	7187.94	0.007518	4.06	2.64	639.85	110.97	0.65
CL-PR	3179.68	DBPS 100 Yr.	2170	7178.00	7185.75	7184.94	7.75	4.91	7187.04	0.008743	4.05	2.68	535.16	106.58	0.72
CL-PR	3179.68	DBPS 10 Yr.	630	7178.00	7182.53	7182.53	4.53	2.33	7183.49	0.009626	2.92	1.40	215.73	91.59	0.91
CL-PR	3179.68	Sterling MDDP 10	1487	7178.00	7184.63	7184.05	6.63	4.06	7185.70	0.008282	3.55	2.10	418.93	101.39	0.72
CL-PR	3179.68	Sterling MDDP 10	430	7178.00	7181.91	7181.80	3.91	1.84	7182.82	0.009671	2.68	1.11	160.58	86.43	0.99
CL-PR	2960.1	FEMA 100 Yr.	2600	7177.88	7183.81	7183.81	5.93	4.52	7186.24	0.015014	6.00	4.24	433.01	89.70	1.00
CL-PR	2960.1	DBPS 100 Yr.	2170	7177.88	7183.62	7183.62	5.74	4.49	7185.43	0.011742	5.22	3.29	415.72	86.85	0.87
CL-PR	2960.1	DBPS 10 Yr.	630	7177.88	7180.25	7180.25	2.37	2.07	7181.27	0.020692	4.06	2.68	155.15	73.90	0.99
CL-PR	2960.1	Sterling MDDP 10	1487	7177.88	7181.69	7181.69	3.81	3.37	7183.66	0.021780	5.67	4.58	262.04	74.31	1.06
CL-PR	2960.1	Sterling MDDP 10	430	7177.88	7179.69	7179.69	1.81	1.59	7180.56	0.024632	3.75	2.45	114.63	71.48	1.04
CL-PR	2652.02		Culvert												
CL-PR	2416.82	FEMA 100 Yr.	2600	7168.00	7178.03		10.03	7.75	7178.46	0.001610	3.06	0.78	850.03	104.94	0.32
CL-PR	2416.82	DBPS 100 Yr.	2170	7168.00	7177.34		9.34	7.31	7177.69	0.001441	2.79	0.66	778.14	102.14	0.30
CL-PR	2416.82	DBPS 10 Yr.	630	7168.00	7173.86		5.86	4.92	7173.94	0.000608	1.41	0.19	447.31	88.13	0.18
CL-PR	2416.82	Sterling MDDP 10	1487	7168.00	7176.06		8.06	6.46	7176.28	0.001131	2.29	0.46	650.59	96.97	0.26
CL-PR	2416.82	Sterling MDDP 10	430	7168.00	7173.14		5.14	4.39	7173.19	0.000445	1.12	0.12	384.42	85.21	0.15
CL-PR	2083.66	FEMA 100 Yr.	2600	7169.86	7176.67	7175.20	6.81	5.12	7177.75	0.018458	5.56	5.90	467.69	89.07	0.64
CL-PR	2083.66	DBPS 100 Yr.	2170	7169.86	7176.09	7174.72	6.23	4.72	7177.04	0.017970	5.20	5.29	417.06	86.40	0.63
CL-PR	2083.66	DBPS 10 Yr.	630	7169.86	7173.17	7172.49	3.31	2.49	7173.62	0.017534	3.42	2.72	183.97	73.27	0.59
CL-PR	2083.66	Sterling MDDP 10	1487	7169.86	7175.02	7173.85	5.16	3.93	7175.75	0.017320	4.55	4.25	327.03	81.60	0.60
CL-PR	2083.66	Sterling MDDP 10	430	7169.86	7172.54	7172.09	2.68	1.96	7172.93	0.019196	3.10	2.35	138.88	70.36	0.62
CL-PR	1879.67	FEMA 100 Yr.	2600	7165.99	7171.19	7171.19	5.21	3.81	7172.98	0.028576	5.75	6.80	451.84	117.40	0.96
CL-PR	1879.67	DBPS 100 Yr.	2170	7165.99	7170.77	7170.77	4.79	3.48	7172.37	0.028116	5.39	6.11	402.44	114.64	0.96
CL-PR	1879.67	DBPS 10 Yr.	630	7165.99	7168.82	7168.76	2.84	1.90	7169.55	0.021750	3.29	2.58	191.77	100.63	0.88
CL-PR	1879.67	Sterling MDDP 10	1487	7165.99	7170.01	7170.01	4.03	2.87	7171.29	0.026838	4.68	4.82	317.64	109.73	0.94
CL-PR	1879.67	Sterling MDDP 10	430	7165.99	7168.47	7168.38	2.49	1.60	7169.02	0.018443	2.74	1.84	156.86	97.71	0.83
CL-PR	1507.91	FEMA 100 Yr.	2600	7159.96	7164.39	7162.99	4.45	3.06	7164.73	0.016308	3.62	3.12	718.84	233.19	0.47
CL-PR	1507.91	DBPS 100 Yr.	2260	7159.96	7164.01	7162.75	4.07	2.77	7164.36	0.017902	3.57	3.09	633.11	227.58	0.50
CL-PR	1507.91	DBPS 10 Yr.	670	7159.96	7161.95	7161.23	2.01	1.78	7162.17	0.024174	2.99	2.68	224.05	125.58	0.50
CL-PR	1507.91	Sterling MDDP 10	1520	7159.96	7163.22	7162.20	3.28	2.22	7163.52	0.019435	3.30	2.69	460.79	206.84	0.51
CL-PR	1507.91	Sterling MDDP 10	450	7159.96	7161.46	7160.95	1.52	1.36	7161.65	0.029371	2.75	2.49	163.35	120.10	0.52

HEC-RAS Plan: SC PR River: Sand Creek Impro Reach: CL-PR (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Max Chl Dpth	Hydr Radius	E.G. Elev	E.G. Slope	Vel Total	Shear Total	Flow Area	Top Width	Froude # XS
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(lb/sq ft)	(sq ft)	(ft)	
CL-PR	1145.05	FEMA 100 Yr.	2600	7153.97	7160.24	7159.42	6.27	3.31	7161.05	0.017947	4.11	3.71	632.55	188.76	0.69
CL-PR	1145.05	DBPS 100 Yr.	2260	7153.97	7159.81	7159.12	5.84	3.25	7160.55	0.017500	4.07	3.55	555.47	169.09	0.67
CL-PR	1145.05	DBPS 10 Yr.	670	7153.97	7157.71	7157.23	3.74	1.89	7158.17	0.014848	2.76	1.75	242.44	127.39	0.69
CL-PR	1145.05	Sterling MDDP 10	1520	7153.97	7158.97	7158.47	5.00	2.72	7159.61	0.017020	3.61	2.89	420.96	153.05	0.68
CL-PR	1145.05	Sterling MDDP 10	450	7153.97	7157.22		3.25	1.64	7157.59	0.013306	2.45	1.36	183.48	111.09	0.67
CL-PR	902.8	FEMA 100 Yr.	2600	7149.99	7156.18	7154.92	6.20	3.63	7156.73	0.014153	3.77	3.20	689.09	188.94	0.55
CL-PR	902.8	DBPS 100 Yr.	2260	7149.99	7155.77	7154.69	5.79	3.47	7156.29	0.014206	3.68	3.08	614.39	175.99	0.54
CL-PR	902.8	DBPS 10 Yr.	670	7149.99	7153.42	7153.18	3.44	1.75	7153.84	0.017659	2.74	1.93	244.17	139.03	0.69
CL-PR	902.8	Sterling MDDP 10	1520	7149.99	7154.82	7154.13	4.84	2.83	7155.28	0.015070	3.35	2.66	454.21	159.68	0.57
CL-PR	902.8	Sterling MDDP 10	450	7149.99	7152.94	7152.85	2.96	1.36	7153.37	0.019105	2.51	1.62	179.34	131.19	0.79
CL-PR	520.2	FEMA 100 Yr.	2600	7147.98	7153.90		5.92	4.25	7154.31	0.011062	3.70	2.94	703.30	164.34	0.44
CL-PR	520.2	DBPS 100 Yr.	2260	7147.98	7153.53		5.55	4.04	7153.90	0.010733	3.51	2.71	643.97	158.44	0.42
CL-PR	520.2	DBPS 10 Yr.	670	7147.98	7151.16		3.18	2.22	7151.33	0.009612	2.25	1.33	297.97	134.05	0.39
CL-PR	520.2	Sterling MDDP 10	1520	7147.98	7152.61		4.63	3.37	7152.89	0.010142	3.03	2.13	502.24	148.41	0.41
CL-PR	520.2	Sterling MDDP 10	450	7147.98	7150.66		2.68	1.79	7150.80	0.009375	1.94	1.05	231.82	129.26	0.39
CL-PR	250.3	FEMA 100 Yr.	2600	7145.95	7150.37	7148.65	4.45	3.22	7150.71	0.015150	3.52	3.05	738.50	228.86	0.46
CL-PR	250.3	DBPS 100 Yr.	2260	7145.95	7150.08	7148.41	4.16	3.03	7150.39	0.014919	3.36	2.82	673.05	221.77	0.45
CL-PR	250.3	DBPS 10 Yr.	670	7145.95	7148.12		2.20	1.85	7148.24	0.012952	2.25	1.50	297.75	160.58	0.37
CL-PR	250.3	Sterling MDDP 10	1520	7145.95	7149.33	7147.88	3.41	2.59	7149.56	0.014206	2.95	2.30	514.46	198.14	0.42
CL-PR	250.3	Sterling MDDP 10	450	7145.95	7147.68		1.76	1.53	7147.78	0.012593	1.95	1.20	230.66	150.96	0.35
CL-PR	53.78	FEMA 100 Yr.	2600	7139.68	7144.84	7143.96	5.16	2.74	7145.25	0.016008	3.33	2.74	781.65	284.79	0.55
CL-PR	53.78	DBPS 100 Yr.	2260	7139.68	7144.58	7143.81	4.90	2.56	7144.97	0.016007	3.19	2.56	708.62	276.00	0.55
CL-PR	53.78	DBPS 10 Yr.	670	7139.68	7142.89	7142.65	3.21	1.43	7143.19	0.016011	2.24	1.42	298.70	209.26	0.64
CL-PR	53.78	Sterling MDDP 10	1520	7139.68	7143.92	7143.35	4.24	2.14	7144.27	0.016001	2.85	2.14	534.10	249.07	0.57
CL-PR	53.78	Sterling MDDP 10	450	7139.68	7142.52	7142.40	2.84	1.15	7142.81	0.016008	2.01	1.15	224.09	193.76	0.70

Please highlight the cross-sections within and adjacent to this plat.


TIMBERRIDGE PR rev1 Plan: SC PR 2/12/2020
Sand Creek Impro CL-PR
Legend
Vel Total FEMA 100 Yr.
Vel Total DBPS 100 Yr.
Vel Total (ft/s)
Main Channel Distance (ft)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
0
1000
2000
3000
4000
5000
6000

DRAINAGE MAPS

Move drainage plans to end of report pdf

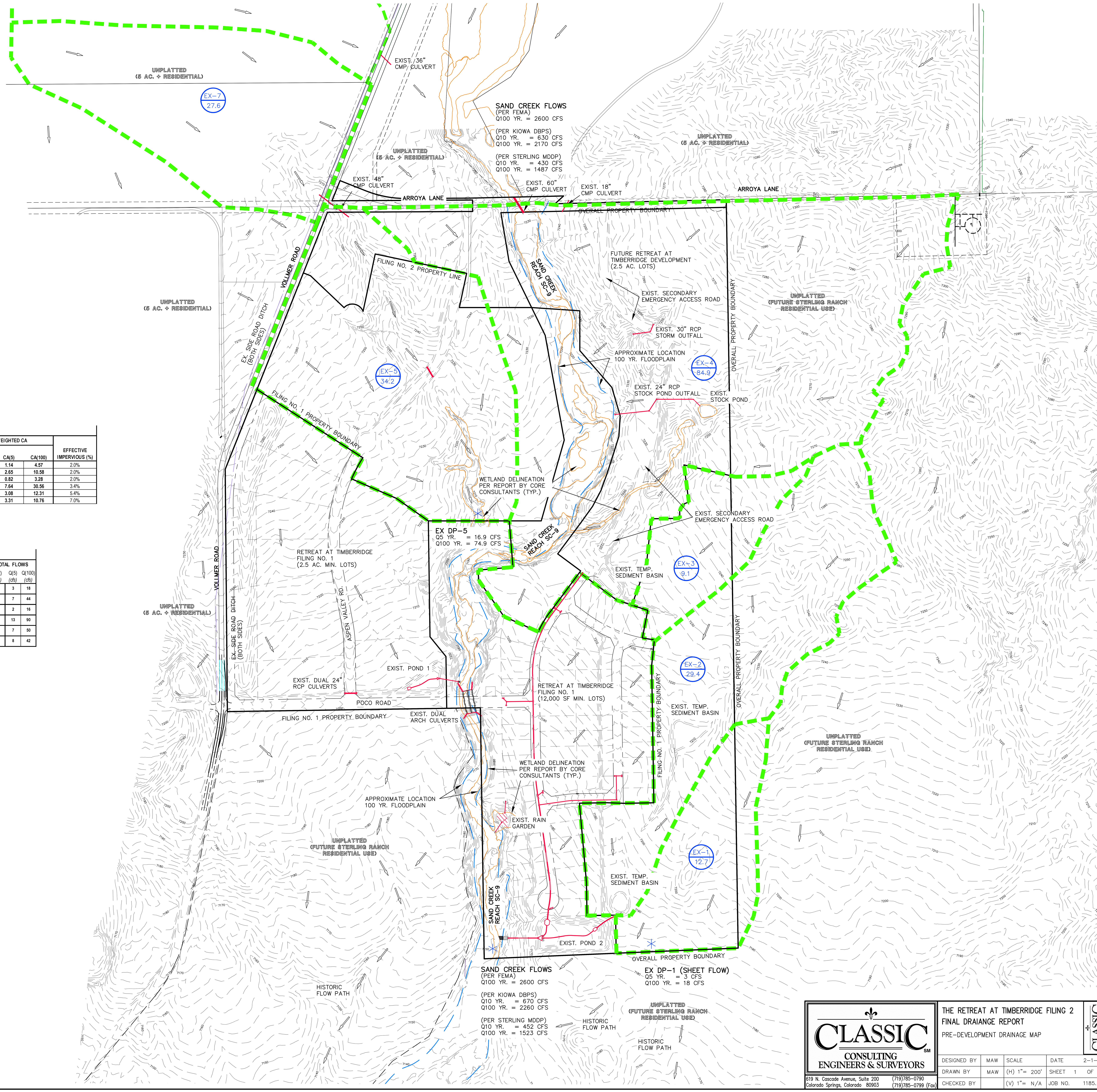
CLASSIC
CONSULTING
ENGINEERS & SURVEYORS

FINAL DRAINAGE REPORT ~ BASIN RUNOFF COEFFICIENT SUMMARY

BASIN	TOTAL AREA (AC)	IMPERVIOUS AREA / STREETS				LANDSCAPE/DEVELOPED AREAS				WEIGHTED			WEIGHTED CA			EFFECTIVE IMPERVIOUS (%)
		AREA (AC)	C(2)	C(5)	C(100)	AREA (AC)	C(2)	C(5)	C(100)	C(2)	C(5)	C(100)	**CA(2)**	**CA(5)**	**CA(100)**	
EX-1	12.7	0.00	0.89	0.90	0.96	12.7	0.05	0.12	0.39	0.03	0.09	0.36	**0.38**	**1.14**	**4.57**	2.0%
EX-2	29.4	0.00	0.89	0.90	0.96	29.4	0.05	0.12	0.39	0.03	0.09	0.36	**0.88**	**2.65**	**10.58**	2.0%
EX-3	9.1	0.00	0.89	0.90	0.96	9.1	0.05	0.12	0.39	0.03	0.09	0.36	**0.27**	**0.82**	**3.28**	2.0%
EX-4	84.9	1.50	0.57	0.59	0.70	83.4	0.05	0.12	0.39	0.03	0.09	0.36	**2.55**	**7.64**	**30.56**	3.4%
EX-5	34.2	1.50	0.57	0.59	0.70	32.7	0.05	0.12	0.39	0.03	0.09	0.36	**1.03**	**3.08**	**12.31**	5.4%
EX-7	27.6	0.00	0.89	0.90	0.96	27.6	0.05	0.12	0.39	0.05	0.12	0.39	**1.38**	**3.31**	**10.76**	7.0%

FINAL DRAINAGE REPORT ~ BASIN RUNOFF SUMMARY

BASIN	WEIGHTED			OVERLAND				STREET / CHANNEL FLOW				Tc	INTENSITY			TOTAL FLOWS		
	CA(2)	CA(5)	CA(100)	C(5)	Length *(ft)*	Height *(ft)*	Tc *(min)*	Length *(ft)*	Slope *(%)*	Velocity *(fps)*	Tc *(min)*	TOTAL *(min)*	I(2) *(in/hr)*	I(5) (in/hr)	I(100) (in/hr)	Q(2) *(cfs)*	Q(5) *(cfs)*	Q(100) *(cfs)*
EX-1	0.38	1.14	4.57	0.12	300	10	20.6	1000	2.0%	1.4	11.8	32.4	1.90	2.37	3.97	1	**3**	**18**
EX-2	0.88	2.65	10.58	0.12	300	10	20.6	800	2.0%	1.4	9.4	30.0	1.99	2.48	4.16	2	**7**	**44**
EX-3	0.27	0.82	3.28	0.12	300	9	21.3	200	2.0%	1.4	2.4	23.7	2.27	2.84	4.76	1	**2**	**16**
EX-4	2.55	7.64	30.56	0.12	300	12	19.4	2500	2.0%	1.4	29.5	48.9	1.41	1.75	2.93	4	**13**	**90**
EX-5	1.03	3.08	12.31	0.12	300	12	19.4	1200	3.0%	1.7	11.5	30.9	1.95	2.43	4.09	2	**7**	**50**
EX-7	1.38	3.31	10.76	0.12	300	12	19.4	1500	3.0%	1.7	14.4	33.8	1.84	2.30	3.86	3	**8**	**42**



LEGEND

DESCRIPTION	SYMBOL
EXISTING GROUND CONTOUR	6910
PROPOSED FINISHED CONTOUR	6910
BASIN BOUNDARY	
DESIGN POINT	
BASIN IDENTIFIER / AREA IN ACRES	BB / 10.0
EXISTING DIRECTION OF FLOW	
EXISTING STORM SEWER	
WETLAND DELINEATION	

200 100 0 200 400

SCALE: 1" = 200'

CLASSIC CONSULTING ENGINEERS & SURVEYORS
619 N. Cascade Avenue, Suite 200
Colorado Springs, Colorado 80903
(719)785-0790
(719)785-0799 (Fax)

THE RETREAT AT TIMBERRIDGE FILING 2
FINAL DRAIANGE REPORT
PRE-DEVELOPMENT DRAINAGE MAP

DESIGNED BY	MAW	SCALE	DATE 2-1-21
DRAWN BY	MAW	(H) 1"= 200'	SHEET 1 OF 3
CHECKED BY		(V) 1"= N/A	JOB NO. 1185.20

LEGEND
DESCRIPTION
SYMBOL
EXISTING GROUND CONTOUR
PROPOSED FINISHED CONTOUR
BASIN BOUNDARY
BASIN IDENTIFIER
AREA IN ACRES
DESIGN POINT
EXISTING DIRECTION OF FLOW
PROPOSED DIRECTION OF FLOW
DRAINAGE IMPROVEMENTS
PIPE RUN
WETLAND DELINEATION
SCALE: 1" = 100'
NOTE:
SEE SHEET 3 FOR ALL BASIN CALCULATIONS.
ANY FUTURE DEVELOPMENT WITHIN BASIN EX-7 WILL REQUIRE DETENTION AND RELEASE TO HISTORIC FLOWS
UNPLATTED (5 AC. ± RESIDENTIAL)
EXIST. 48" CMP CULVERT
ARROYA LANE (EXIST. GRAVEL ROAD)
Label the Sand Creek Flows
EXIST. 60" CMP CULVERT
FUTURE TIMBERRIDGE RURAL LOTS (2.5 AC. MIN.)
FUTURE TIMBERRIDGE RURAL LOT (2.5 AC. MIN.)
18" DRIVEWAY CULVERT REQUIRED
Is stabilization required?
VOLLMER ROAD
TRACT A (40' WIDE ROW DEDICATION)
Address whether future Vollmer Road increased flows will continue along Vollmer and Pond 1 or provide a drainage easement across the lots to the east.
SIDE ROAD DITCH NOT WELL DEFINED IN THIS AREA SO FLOWS FROM VOLLMER RD. ENTER PROPERTY
DRAINAGE ESMT.
FALCON NEST COURT (RURAL LOCAL)
EXIST. DUAL 30" RCP CULVERTS
Label stabilization
FILING NO. 1 BOUNDARY
ASPEN VALLEY ROAD (RURAL LOCAL)
PROP. 24" RCP CULVERT
PROP. DUAL 30" RCP CULVERTS
APPROXIMATE LOCATION 100 YR. FLOODPLAIN (PER LOMR 08-080541P)
APPROXIMATE LOCATION 100 YR. FLOODPLAIN (HEC-RAS CALCULATED)
WETLAND DELINEATION PER REPORT BY CORE CONSULTANTS (TYP.)
Online ponds are typically not allowed. Verify whether USACE approves the use of waters of the state for conveyance and WQ treatment. ECM I.7.1.C.4 and 5 must be met.
SAND CREEK REACH SC-9
PROP. SHEET PILE CHECK STRUCTURE W/ CONC. CAP
EXIST. 30" RCP STORM CONSTRUCTED WITH FILING NO. 1 (TO REMAIN)
EXIST. EMERGENCY FIRE ACCESS ROAD CONSTRUCTED WITH FILING NO. 1 (TO REMAIN)
Show FEMA floodplain elevation lines.
EXIST. 24" RCP OUTFALL CONSTRUCTED WITH FILING NO. 1 FOR STOCK POND RELEASE
EXIST. STOCK POND TO REMAIN
TRACT C
PROP. TRAIL
EXIST. TEMP. SEDIMENT BASIN CONSTRUCTED WITH FILING NO. 1 (TO REMAIN)
FUTURE TIMBERRIDGE RURAL LOTS (1.0 AC. MIN.)
PROPERTY BOUNDARY
UNPLATTED (FUTURE STERLING RANCH RESIDENTIAL USE)
TRACT B
PROPOSED POND 3
PRE-DEVELOPMENT
Q2 YR. = 6.0 CFS
Q5 YR. = 16.9 CFS
Q100 YR. = 74.9 CFS
DEVELOPED RELEASE
Q2 YR. = 1.1 CFS
Q5 YR. = 11.1 CFS
Q100 YR. = 66.8 CFS
PROP. RIP-RAP BANK STABILIZATION (TYP.)
PROP. TRAIL AND ACCESS ROAD
Additional protection needed due to shear stress?
EXIST. SHEET PILE CHECK STRUCTURE W/ CONC. CAP
RETREAT AT TIMBERRIDGE FILING NO. 1 (2.5 AC. MIN.)
EXIST. PERMANENT SEDIMENT BASIN
FUTURE TIMBERRIDGE URBAN LOTS (12,000 SF MIN.)
EXIST. 10' TYPE R AT-GRADE INLET
EXIST. 36" RCP STORM
EXIST. TEMP. SEDIMENT BASIN CONSTRUCTED WITH FILING NO. 1 (TO REMAIN)
TSBs are temporary and can not remain in place. Permanent WQ is required
EXIST. 15' TYPE R AT-GRADE INLET
ELK ANTLER LANE (URBAN LOCAL)
OWL PERCH LOOP (URBAN LOCAL)
PROP. 15' TYPE R SUMP INLET
PROP. 10' TYPE R SUMP INLET
NOTE: FUTURE DEVELOPED FLOW QUANTITIES WITHIN BASINS OS-4, OS-5 & OS-6 EQUAL TO THE PRE-DEVELOPMENT FLOW QUANTITIES WILL BE TREATED AND DETAINED WITHIN EXIST. POND 2.
PROP. TEMP. SEDIMENT BASIN TO REMAIN UNTIL FUTURE STERLING RANCH DEVELOPMENT
NOTE: GRADING AND DRAINAGE ESMTS. TO BE ACQUIRED FROM ADJACENT PROPERTY OWNER PRIOR TO CONST.
Provide easements and swales or storm drain for future offsite flows
EXIST. RIP-RAP BANK STABILIZATION (TYP.)
remove design point number for the filing 2 drainage report
EXIST. DUAL 24" RCP CULVERTS
EXIST. POND 1
EXIST. 10' TYPE R SUMP INLET
RETREAT AT TIMBERRIDGE FILING NO. 1 LOTS (12,000 SF MIN.)
SEE SHEET 3
CLASSIC CONSULTING
619 N. Cascade Avenue, Suite 200 Colorado Springs, Colorado 80903
(719)785-0790 (719)785-0799 (Fax)
THE RETREAT AT TIMBERRIDGE FILING 2
FINAL DRAINAGE REPORT
DEVELOPED DRAINAGE MAP
DESIGNED BY MAW
DRAWN BY MAW
CHECKED BY
SCALE (H) 1"= 100' (V) 1"= N/A
DATE 3-3-21
SHEET 2 OF 3
JOB NO. 1185.20

FINAL DRAINAGE REPORT ~ PIPE ROUTING SUMMARY

Pipe Run	Contributing Basins	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity I(5)	Intensity I(100)	Flow Q(5)	Flow Q(100)	Pipe Size*
1	DP-7	3.02	7.47	20.2	3.08	5.16	9	39	30" RCP
2	DP-8	0.62	1.85	20.2	3.08	5.16	2	10	24" RCP
3	PR-1, PR-2	3.64	9.32	20.8	3.03	5.09	11	47	36" RCP
4	DP-10	1.00	1.98	10.6	4.05	6.80	4	13	24" RCP
5	DP-11	0.41	0.59	13.8	3.65	6.12	2	4	18" RCP
6	PR-3, PR-4, PR-5	5.05	11.89	21.8	2.96	4.97	15	59	36" RCP
7	DP-12 Pickup	1.05	1.17	15.6	3.46	5.82	4	7	24" RCP
8	PR-6, PR-7	6.11	13.06	22.2	2.93	4.92	18	64	36" RCP
9	DP-13	2.25	3.93	16.1	3.42	5.74	8	23	30" RCP
10	DP-14	0.33	0.53	16.3	3.40	5.70	1	3	18" RCP
11	PR-9, PR-10	2.57	4.47	16.3	3.40	5.70	9	25	30" RCP
12	**PR-8, PR-11**	**8.68**	**17.53**	**22.7**	**2.90**	**4.87**	**25**	**85**	**42" RCP**

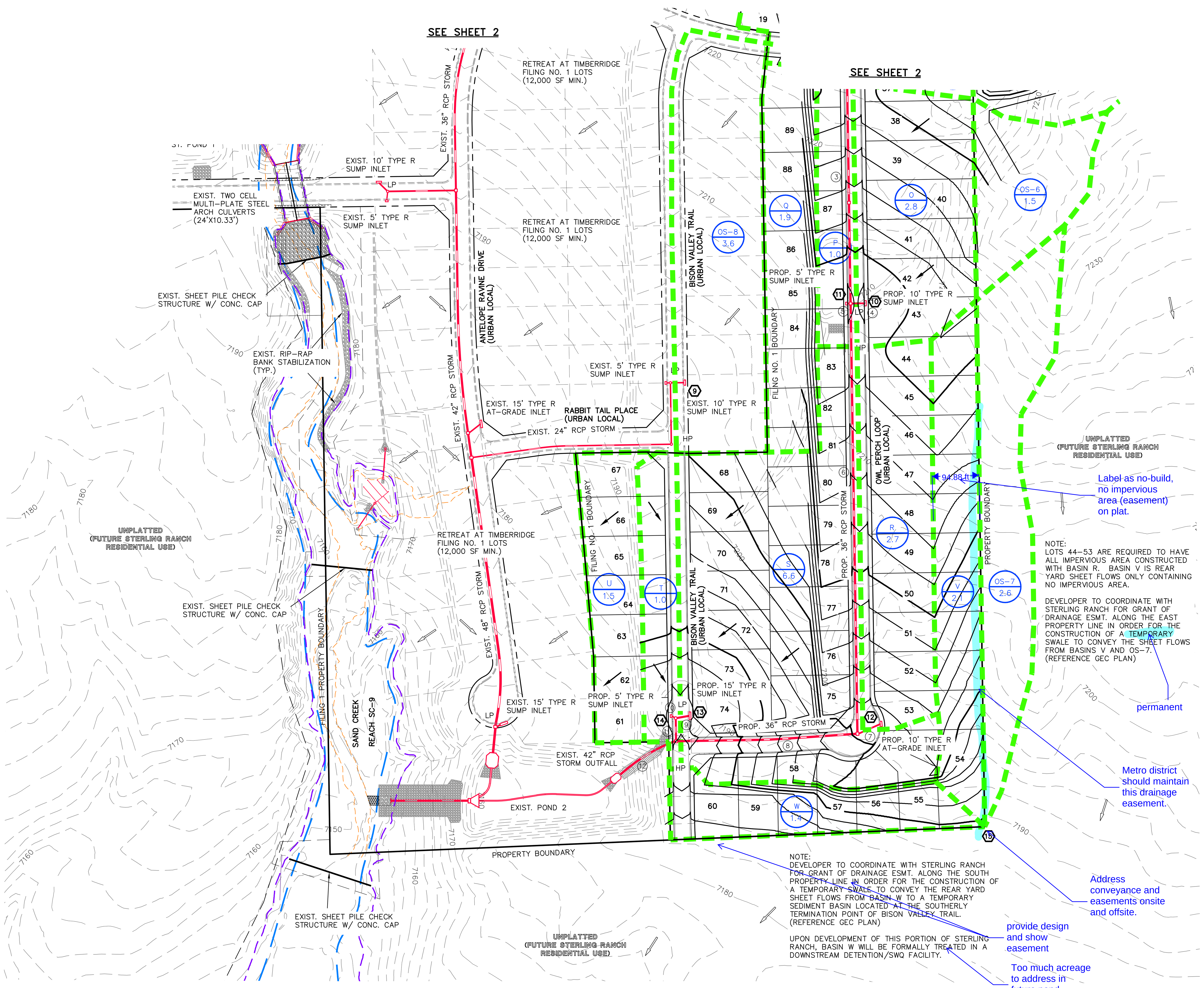
FINAL DRAINAGE REPORT ~ SURFACE ROUTING SUMMARY

Design Point(s)	Contributing Basins	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity I(5)	Intensity I(100)	Flow Q(5)	Flow Q(100)	Inlet Size
1	EX-7, OS-1, OS-2, B (40.4 AC.)	6.09	16.61	40.4	2.04	3.41	12	57	DUAL 30" RCP CULVERTS
2	Basin A (9.5 AC.)	1.71	4.08	23.0	2.88	4.84	5	20	24" RCP CULVERT
3	DP-1, Basin D (42.7 ac.)	6.57	17.64	40.9	2.02	3.38	13	60	DUAL 30" RCP CULVERTS
4	Basin C (3.3 AC.)	0.84	1.60	20.2	3.08	5.16	3	8	24" RCP CULVERT
5	**POND 1 TOTAL INFLOW (64.0 AC.)**	**10.69**	**27.00**	**46.4**	**1.83**	**3.07**	**20**	**83**	**POND 1**
6	Basin G, Basin OS-9 (2.3 ac.)	0.88	1.32	13.8	3.65	6.12	3	8	Exist. 10' TYPE R AT GRADE
7	Basin OS-4, J and 70% of Basin OS-5 (18.0 ac.)	3.02	7.47	20.2	3.08	5.16	9	39	15' TYPE R SUMP INLET
8	Basin N and 30% of Basin OS-5 (4.7 ac.)	0.62	1.85	20.2	3.08	5.16	2	10	10' TYPE R SUMP INLET
9	Basin OS-8, Q (5.5 ac.)	1.17	2.45	15.7	3.45	5.79	4	14	Exist. 10' TYPE R SUMP INLET
10	Basin OS-6, O (4.3 ac.)	1.00	1.98	18.1	3.24	5.44	3	11	10' TYPE R SUMP INLET
11	Basin P (1.0 ac.)	0.41	0.59	10.6	4.05	6.80	2	4	5' TYPE R SUMP INLET
12	Basin R (2.7 ac.)	1.07	1.56	15.6	3.46	5.82	4	9	10' TYPE R AT GRADE INLET
13	Basin S and Flow-by from Basin R (9.3 ac.)	2.25	3.93	16.1	3.42	5.74	8	23	15' TYPE R SUMP INLET
14	Basin T (1.0 ac.)	0.33	0.53	12.8	3.76	6.32	1	3	5' TYPE R SUMP INLET
15	Basin V and OS-7 (4.7 ac.)	0.76	1.92	15.6	3.46	5.81	3	11	REAR YARD SWALE

FINAL DRAINAGE REPORT ~ BASIN RUNOFF SUMMARY

BASIN	WEIGHTED CA(2)	CA(5)	CA(100)	OVERLAND C(5)	Length (ft)	Height (ft)	Tc (min)	STREET / CHANNEL FLOW Length (ft)	Slope (%)	Velocity (fps)	Tc (min)	Tc TOTAL (min)	INTENSITY I(2) (in/hr)	I(5) (in/hr)	I(100) (in/hr)	TOTAL FLOWS Q(2) (cfs)	Q(5) (cfs)	Q(100) (cfs)
OS-1	0.40	0.70	1.67	0.14	300	10.5	19.9					19.9	2.48	3.10	5.20	1	**2**	**9**
OS-2	0.59	0.79	1.44	0.14	300	8	21.7	100	2.0%	1.4	1.2	22.9	2.31	2.89	4.84	1	**2**	**7**
OS-3	0.05	0.13	0.36	0.14	300	12	19.0					19.0	2.53	3.17	5.32	0.1	**0.4**	**2**
OS-4	0.08	0.23	0.90	0.09	300	12	20.0					20.0	2.47	3.09	5.19	0.2	**0.7**	**5**
OS-5	0.41	1.23	4.93	0.09	300	12	20.0					20.0	2.47	3.09	5.19	1	**4**	**26**
OS-6	0.05	0.14	0.54	0.09	275	13	18.1					18.1	2.59	3.24	5.44	0.1	**0.4**	**3**
OS-7	0.08	0.23	0.94	0.09	250	16	15.6					15.6	2.76	3.46	5.81	0.2	**0.8**	**5**
OS-8	0.65	0.90	1.69	0.25	100	2	12.2	600	2.0%	2.8	3.5	15.7	2.75	3.45	5.79	2	**3**	**10**
OS-9	0.16	0.23	0.42	0.25	50	1	8.6	600	3.0%	3.5	2.9	11.5	3.13	3.92	6.58	0.5	**0.9**	**3**
A	0.99	1.71	4.08	0.14	300	10.5	19.9	375	4.0%	2.0	3.1	23.0	2.30	2.88	4.84	2	**5**	**20**
B	0.86	1.30	2.74	0.14	230	15	14.2	450	2.0%	1.4	5.3	19.5	2.50	3.13	5.25	2	**4**	**14**
C	0.61	0.84	1.60	0.14	300	10	20.2					20.2	2.46	3.08	5.16	2	**3**	**8**
D	0.30	0.47	1.03	0.14	250	10	17.3					17.3	2.64	3.30	5.54	1	**2**	**6**
E	0.93	1.57	3.68	0.14	300	12	19.0	300	2.0%	1.4	3.5	22.5	2.33	2.91	4.88	2	**5**	**18**
F	0.54	1.36	5.17	0.10	300	9	21.8	600	1.5%	1.2	8.2	29.9	1.99	2.48	4.17	1	**3**	**22**
G	0.58	0.65	0.90	0.14	100	2	13.8					13.8	2.91	3.65	6.12	1.7	**2.4**	**5**
H1	0.19	0.22	0.31	0.22	100	4	10.1					10.1	3.29	4.12	6.92	0.6	**0.9**	**2**
H2	0.18	0.21	0.29	0.22	100	4	10.1					10.1	3.29	4.12	6.92	0.6	**0.8**	**2**
I	0.07	0.08	0.10	0.25	100	6	8.5					8.5	3.49	4.37	7.34	0.2	**0.3**	**0.8**
J	1.56	1.93	3.12	0.25	100	2	12.2	600	2.0%	2.8	3.5	15.7	2.75	3.45	5.79	4	**7**	**18**
K	0.27	0.38	0.71	0.25	100	3	10.7					10.7	3.22	4.03	6.77	1	**2**	**5**
L	0.10	0.13	0.25	0.25	100	8	7.7					7.7	3.60	4.52	7.58	0.3	**0.6**	**2**
M	0.29	0.33	0.48	0.25	100	2	12.2	100	2.0%	2.8	0.6	12.8	3.00	3.76	6.31	0.9	**1.2**	**3**
N	0.22	0.26	0.37	0.25	100	2	12.2	80	2.0%	2.8	0.5	12.7	3.01	3.77	6.33	0.7	**1.0**	**2**
O	0.68	0.86	1.44	0.25	100	2	12.2	400	3.0%	3.5	1.9	14.1	2.88	3.61	6.06	2	**3**	**9**
P	0.36	0.41	0.59	0.25	50	1	8.6	400	3.0%	3.5	1.9	10.6	3.23	4.05	6.80	1	**2**	**4**
Q	0.11	0.27	0.76	0.14	80	5	8.5					8.5	3.49	4.38	7.35	0.4	**1.2**	**6**
R	0.91	1.07	1.56	0.25	100	2	12.2	700	3.0%	3.5	3.4	15.6	2.77	3.46	5.82	3	**4**	**9**
S	1.83	2.24	3.54	0.25	50	1	8.6	1100	3.0%	3.5	5.3	13.9	2.90	3.63	6.10	5	**8**	**22**
T	0.28	0.33	0.53	0.08	50	1	10.4	500	3.0%	3.5	2.4	12.8	3.00	3.76	6.32	0.8	**1.2**	**3**
U	0.27	0.38	0.71	0.25	80	5	7.5					7.5	3.64	4.56	7.66	1	**2**	**5**
V	0.38	0.53	0.99	0.25	90	1.8	11.6					11.6	3.12	3.91	6.56	1	**2**	**6**
W	0.36	0.45	0.73	0.25	100	3	10.7					10.7	3.22	4.03	6.77	1	**2**	**5**

What are developed flows or are future detained flows to match these flows?



LEGEND

DESCRIPTION	SYMBOL
EXISTING GROUND CONTOUR	6910
PROPOSED FINISHED CONTOUR	6910
BASIN BOUNDARY	
BASIN IDENTIFIER / AREA IN ACRES	BB 10.0
DESIGN POINT	1
EXISTING DIRECTION OF FLOW	
PROPOSED DIRECTION OF FLOW	
DRAINAGE IMPROVEMENTS	

100 50 0 100 200

SCALE: 1" = 100'

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THE RETREAT AT TIMBERRIDGE FILING 2
FINAL DRAINAGE REPORT
DEVELOPED DRAINAGE MAP

DESIGNED BY	MAW	SCALE	DATE 3-3-21
DRAWN BY	MAW	(H) 1"= 100'	SHEET 3 OF 3
CHECKED BY		(V) 1"= N/A	JOB NO. 1185.20

SECTION 404 PERMTTING

WETLAND IMPACT MAP

(CORE CONSULTANTS REPORT)

Update for Filing 2

COMPENSATORY MITIGATION PLAN

The Retreat at Timber Ridge Residential Development – Filing No. 1 El Paso County, CO

PREPARED FOR:

Classic Communities
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Colorado Springs, CO 80919
Phone: 719-785-3270
Contact: Loren Moreland

PREPARED BY:

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Phone: 303-730-5979
Contact: Dan Maynard
CORE Project Number: 19-XXX

July 2019

TABLE OF CONTENTS

TABLES

APPENDICES

1.0 INTRODUCTION

CORE Consultants, Inc. (CORE) was retained by Classic Communities (Applicant) to provide a compensatory mitigation plan for the proposed The Retreat at Timber Ridge Residential Development – Filing No. 1 ("Project"). The Project encompasses approximately 68 acres of largely undisturbed land zoned for a planned unit development (PUD), located southeast of the intersection of Vollmer Road and Arroya Lane on portions of Sections 27 and 28 in Township 12 South, Range 65 West, and can be found on the U.S. Geological Survey (USGS) Falcon Northwest 7.5-minute quadrangle (**Appendix I:** *Site Location Map*). Coordinates of the approximate center of the Project are latitude 38.980576° North and longitude -104. 663569° West.

The Project would consist of 70 single family lots, open space and trails, permanent access roads, utilities, stormwater detention ponds, and channel improvements to prevent long-term stream degradation. Permanent impacts to potentially jurisdictional wetlands totaling 0.44 acre and 691 linear feet would result from the development of the Project. Construction of the southernmost access road and associated culvert construction would result in 0.11 acre and 211 linear feet of permanent impacts to Stream Channel Containing Wetlands (SCCW) 6. Construction of the southernmost detention pond would result in an additional 0.26 acre and 210 linear feet of permanent impacts to SCCW 6 (**Appendix II:** *Compensatory Wetland Mitigation Plan Map*). Construction of the northern access road would result in 0.07 acre and 270 linear feet of permanent impacts to SCCW 4 (**Appendix II**). Temporary impacts to potentially jurisdictional wetlands totaling 0.06 acre and 64 linear feet would result from the development of the four buried sheet pile check structures. This report presents the mitigation plan for the establishment and management of a wetland mitigation area on the Project site which would offset 0.44 acre of permanent loss to Waters of the U.S. (WOTUS) resulting from development of the Project.

2.0 SITE DESCRIPTION

CORE conducted a formal wetland delineation on May 15 and 16, 2017 in accordance with the U.S. Army Corps of Engineers' (USACE) 1987 USACE Wetland Delineation Manual (USACE 1987) and the Western Mountains, Valleys, and Coasts Regional Supplement (Version 2.0) (USACE 2010). The regulatory status of the wetlands and waters considered herein are assumed jurisdictional for the purpose of quantifying impacts to WOTUS.

The main channel of Sand Creek drains the Project in a southerly direction. Two eastern tributaries identified in NHD spatial data, and one unidentified western tributary are located in the proposed Project area (**Appendix II**). The majority of the main channel of Sand Creek and its associated tributaries were characterized as stream channels containing potentially jurisdictional persistent emergent (PEM) wetlands; short stretches of the main channel throughout the Project area were characterized as potentially jurisdictional stream channels lacking wetlands (**Appendix II**). Sand Creek and its tributaries flow to the Fountain Creek watershed approximately 20 miles downstream.

The Environmental Protection Agency (EPA) Section 303(d) list identifies stream segments that do not meet water quality standards. Selenium and *E. coli* are listed as causes for impairment of Sand Creek within the Fountain watershed (EPA 2016). As such, primary needs for the watershed headwaters include mechanisms to reduce waste runoff into watercourses, as well as mechanisms to capture and uptake excess nutrients and waste. The mitigation proposed is anticipated to encourage the removal of excess nutrients and prevent additional nutrient runoff through the creation of wetlands. Creation of wetlands would improve local habitats and water quality. Improved water quality would be expected as a result of locating the mitigation wetlands upslope and upstream of the majority of the areas of wetland impacts within the Project area.

3.0 COMPENSATORY MITIGATION PLAN

This compensatory mitigation plan was prepared to compensate for the loss of 0.44 acre of wetland habitat through the establishment of new emergent wetlands within the Project. Coordinates of the wetland areas to be impacted are shown in Table 3-1 below, and depicted in **Appendix II**.

TABLE 3-1: LOCATIONS OF IMPACTED WETLANDS

WOTUS ID[1]	LATITUDE	LONGITUDE	PERMANENT IMPACTS
SCCW 4	38.979822	-104.660451	0.07 acre; 270 linear feet
SCCW 6	38.976811	-104.663614	0.11 acre; 211 linear feet
SCCW 6	38.975046	-104.662760	0.26 acre; 210 linear feet

[1]Only the USACE can determine jurisdictional status

3.1 Objectives

Mitigation for 0.44 acre of permanent wetland loss would be located adjacent to the main channel of Sand Creek within the Project. Specifically, mitigation would involve the following:

- Creation of 0.44 acre of emergent, palustrine wetland habitat adjacent to and between the main channel of Sand Creek identified as JD Channel A and Isolated Wetland 1 (Proposed Mitigation B; **Attachment II**).
- Creation of stable upland buffers through soil amendments (as necessary), seedbed preparation and decompaction (as necessary), and appropriate native plant selection based on surrounding and existing native vegetation. Noxious weed control and management would be implemented as needed.

A total of 0.44 acre of emergent wetlands would be established within the Project and would offset the 0.44 acre of permanent wetland loss resulting from the construction of the Project.

3.2 Site Selection

Completing the majority of mitigation near the site of impacts would ensure the mitigation directly offsets the on-site Project impacts. Moreover, on-site mitigation ensures that hydrologic and soil conditions are conducive to successful mitigation implementation. Hydrology for the mitigation area would be supplied in part by runoff from the proposed Project, and by contouring adjacent to the existing channel and upland within the proposed mitigation area to ensure sufficient saturation. The NRCS identifies Project area soils as hydric (NRCS 2014). Therefore, retention of on-site soils would further facilitate the establishment and longevity of the proposed mitigation area. Salvaged soils from impacted wetland areas on the Project site would be utilized to prepare the mitigation area.

The Proposed mitigation area would consist of one palustrine, persistent emergent, seasonally flooded wetland and upland buffer located between JD Channel A and Isolated Wetland 1. The proposed location of the mitigation area would serve to connect the existing Isolated Wetland A with the main channel of Sand Creek (JD Channel A), thereby serving to increase filtration of additional stormwater runoff resulting from Project construction.

3.3 Mitigation Area Protection

The mitigation area will be owned by the Applicant and authorized access would require permission from the Applicant. According to the USACE's *Regional Compensatory Mitigation and Monitoring Guidelines for South Pacific Division* (2015), the mitigation area requires protection of the site in the form of a deed restriction, easement or similar legally-binding document. A deed restriction would be prepared to provide for long-term protection of the mitigation area.

3.4 Baseline Information

The Project would result in the permanent loss of 0.44 acre of wetland characterized as palustrine, emergent, persistent, and seasonally flooded (PEM1C). The proposed mitigation area would consist of 0.44 acre of wetland characterized as palustrine, emergent, persistent, and seasonally flooded (PEM1C) since the mitigation area would develop wetlands mirroring the surrounding wetland areas within and adjacent to Sand Creek (**Appendix II**). Wetland vegetation was dominant during the 2017 wetland delineation within the channel where impacts are proposed: vegetation consisted of Arctic rush (*Juncus arcticus* syn. *J. balticus*), Nebraska sedge (*Carex nebrascensis*), clustered field sedge (*Carex praegracilis*), and common spike rush (*Eleocharis palustris*).

3.5 Mitigation Work Plan

The mitigation area would be created immediately adjacent to the main channel of Sand Creek (JD Channel A; **Appendix II**). Contouring of both the upland area associated with the proposed mitigation area and the proposed mitigation area itself would ensure that drainage patterns would direct sufficient hydrology to the mitigation area. Soil preparation and amendments, seeding, and installation of wetland plugs would create 0.44 acre of emergent wetland adjacent to the main channel of Sand Creek (**Appendix II**). Establishment of the wetland would augment water filtration capacity of anticipated runoff resulting from the proposed Project, and would support the Sand Creek watershed priority to reduce selenium and *E. coli* within the watershed.

Native wetland plant communities would be established within the mitigation area through seeding and the installation of wetland plugs. Newly seeded areas and plugs would be protected by erosion control mats. A CORE biologist would determine, upon a site assessment of the mitigation area, if transplanting of neighboring wetland plants would expedite the establishment of the proposed wetland mitigation area. Potential wetland plant populations that would be utilized for transplant include Arctic rush, Nebraska sedge, and clustered field sedge.

3.6 Mitigation Work Plan Schedule

Mitigation work would begin immediately in conjunction with the commencement of construction activities and would be completed within three months of commencement. Project construction is anticipated to begin in fall of 2019. Construction is expected to be completed in summer or fall of 2020; restoration and mitigation installation measures would be completed by fall 2020. Primary mitigation measures and an estimated schedule of activities implementation are outlined below:

- Year 1
    - Grading, clearing, and other site preparation as needed for construction of the wetland mitigation site;

  - Documentation of baseline conditions and seeding of mitigation area and uplands; installation of wetland plugs.

- Year 2
  - Monitoring and management: set up monitoring locations and collect relevant data, control noxious weeds (if needed), and transplant wetland vegetation from existing on-site wetlands (if needed).

- Years 3, 4, and 5
  - Site monitoring to determine whether performance standards are met and request concurrence from USACE;
  - If standards are not met, continue monitoring and management until they are met.

3.7 Operation and Maintenance

The Applicant would be responsible for monitoring the proposed mitigation area throughout the life of the Project. The Applicant, or an authorized representative for the Applicant familiar with wetland ecology would monitor the condition of the mitigation site and would make adjustments on an as-needed basis in accordance with USACE mitigation requirements and permit conditions.

3.8 Performance Standards and Monitoring Requirements

Performance standards would be used to assess the success of mitigation measures implemented at the Project. Performance standards are required and must be met in order for mitigation activities to be approved by the USACE. However, performance standards may change based on the conditions included in the approved Section 404 permit to be issued for the Project. The mitigation area would be monitored for a period of five years, or until performance standards are met. If performance standards are met during the first year of monitoring, additional monitoring would not be required. Performance standards should be met by the end of the five-year monitoring period. If standards are not met within five years, additional monitoring and corrective action may be required at the request of the USACE.

The mitigation plan for The Retreat at Timber Ridge – Filing No. 1 would be determined successful and complete when the following standards of performance are met:

1. Wetland vegetation areas and buffers should have a vegetation cover of at least 85 percent, and the vegetation must be composed of at least 50 percent emergent wetland species (i.e., species rated facultative, facultative wetland, or obligate wetland plant species on the National Wetland Plant List (Lichvar et al. 2016) and at least 50 percent of dominant species shall be newly established. Mitigation areas (wetlands and buffers) will have no more than 20 percent non-native species coverage. Vegetation maintenance activities for locations not meeting these requirements may include transplanting the appropriate wetland species and eradication of non-native species if necessary.

2. Upland buffer establishment will be determined successful when ground cover of native species – species rated upland, facultative upland, or facultative plants on the National Wetland Plant List (Lichvar *et al.* 2016) – is equal to or greater than 85 percent, with less than 1-percent invasive species documented at each monitoring location. Vegetation maintenance activities for sample

locations not meeting ground cover requirements would include re-seeding or planting of the appropriate native species and eradication of invasive species if necessary.

3. Coverage of noxious weed species (**Table 3-2:** *El Paso County Noxious Weeds*) shall be 95 percent eradicated across all mitigation areas (wetlands and upland buffers) and maintained as such in perpetuity.

4. Documentation shall demonstrate consistent wetland hydrology during the growing season. Data shall indicate 14 or more consecutive days of flooding or ponding, or a water table 12 inches or less below the soil surface. Data must demonstrate the presence of wetland hydrology with 50% or higher probability. Documentation of recorded data will be presented with photographs, moisture probe data, and/or the collection of multiple soil pit samples during the growing season.

5. Soil documentation and morphologic description should demonstrate the development of redoximorphic features or other hydric soil indicators over time, and progression toward hydric soil conditions. Documentation would include pre-and post-construction, and during the 3rd, 5th, and final years of wetland establishment and would be collected according to the Western Mountains, Valleys, and Coasts Regional Supplement (Version 2.0) (USACE 2010) to the 1987 USACE Wetland Delineation Manual (USACE 1987).

TABLE 3-2: El PASO COUNTY NOXIOUS WEEDS

COMMON NAME	SCIENTIFIC NAME
Bull Thistle	*Cirsium vulgare*
Canada Thistle	*Cirsium arvense*
Common Mullein	*Verbascum thapsus*
Common Tansy	*Tanacetum vulgare*
Common Teasel	*Dipsacus fullonum*
Cutleaf Teasel	*Dipsacus laciniatus*
Cypress Spurge	*Euphorbia cyparissias*
Dalmation Toadflax	*Linaria dalmatica*
Dalmation Toadflax	*Linaria genistifolia*
Diffuse Knapweed	*Centaurea diffusa*
Field Bindweed	*Convulvulus arvensis*
Hoary Cress	*Cardaria draba*
Houndstongue	*Cynoglossum officinale*
Leafy Spurge	*Euphorbia esula*
Mediterranean Sage	*Salvia aethiopis*
Musk Thistle	*Carduus nutans*
Myrtle Spurge	*Euphorbia myrcinites*
Orange Hawkweed	*Hieracium aurantiacum*
Perennial Pepperweed	*Lepidium latifolium*
Plumeless Thistle	*Carduus acanthoides*
Poison Hemlock	*Conium maculatum*
Puncturevine	*Tribulus terrestris*
Purple Loosestrife	*Lythrum salicaria*
Redstem Filaree	*Erodium cicutarium*
Russian Knapweed	*Acroptilon repens*
Russian Olive	*Elaeagnus angustifolia*
Salt Cedar	*Tamarix chinensis*
Salt Cedar	*Tamarix parviflora*
Salt Cedar	*Tamarix ramosissima*
Scotch Thistle	*Onopordum acanthium*
Spotted Knapwseed	*Centaurea maculosa*
Sulfur Cinquefoil	*Potentilla recta*

Monitoring would be conducted during the growing season by qualified personnel experienced in wetland ecology and mitigation. Monitoring would occur for a minimum of five years post-construction, unless conditions are met in prior years. Results of monitoring visits would be used to assess and modify maintenance and operations plans as appropriate and implement adaptive management strategies as necessary. Monitoring would entail annual site visits to assess progress in meeting performance standards, and to evaluate establishment, development, and maintenance of the mitigation area. The mitigation area would be monitored to ensure the establishment of desirable wetland characteristics. Standardized plots would be established to confirm the dominance of emergent wetland species at the wetland establishment location. A report detailing the results of each monitoring survey would be submitted to the USACE within two months of any site visit. The site would also be monitored incidentally while walking between sampling points. During incidental observations, areas of concern would be noted, including areas of erosion, significant areas of bare ground, and areas where invasive species have become established. Incidental observations would be included in the annual report and would be considered for maintenance and adaptive management.

Photo monitoring points would be established prior to construction to determine baseline conditions. Each monitoring report would include photos depicting baseline conditions, construction, and current state to demonstrate progress toward wetland establishment. A map would document the locations of sampling transects and photo monitoring points.

4.0 LONG TERM MANAGEMENT PLAN

Funding for the management of the mitigation plan would be provided by the Applicant and the Applicant would be responsible for the monitoring and long-term management of the proposed mitigation area. Since the mitigation site would be located on the Applicant's property, access to the site could be controlled to protect the area. Periodic inspections would also be conducted by the Applicant or by the Applicant's authorized personnel to ensure that the desired site characteristics are maintained including maintaining proper hydrology through the mitigation area, controlling invasive plants (if any), and other maintenance as needed. If invasive species are detected during inspections, invasive species control measures would be implemented. Where invasive plants are limited, control methods would consist of removal by hand or mechanical methods. If invasive plants become established beyond a point of mechanical control, chemical control methods would be initiated. Appropriate herbicides would be selected based on target species and would be applied in accordance with manufacturer and invasive species control recommendations. Herbicide application would not occur when rain is forecasted, or during or immediately following precipitation events to prevent herbicides from running into sensitive water features. Invasive species control would be conducted in a manner that minimizes impacts to desirable species to the extent practicable. Where significant invasive species infestations have occurred, the area would be transplanted with local wetland plant sources, or re-seeded with desirable vegetation after control of invasives. Alternative methods of invasive species control would be utilized as appropriate based on target species. For example, prolonged flooding followed by heavy seeding has been documented to control Johnsongrass (*Sorghum halepense*). Wetland and transitional vegetation would be mowed on an as-needed basis. Signage may also be used along the boundaries of the proposed mitigation area identifying the area as such. If control of the development were to transfer from the Applicant to a different entity, that entity would become responsible for the maintenance and upkeep of the mitigation area.

The principal management concerns for the mitigation area are maintaining suitable hydrology to support wetland growth and the maintenance of vegetation, including the control of invasive and weedy species. Operation and maintenance activities would generally ensure compliance with the conditions of the USACE permit. Project area management needs would be assessed during monitoring sessions and on an as-needed basis. Operation and maintenance activities would be modified as appropriate in accordance with principles of adaptive management and based on observations during mitigation monitoring activities.

4.1 Adaptive Management Strategy

Management objectives and techniques may be modified in response to feedback such as monitoring results. Adaptive management is based on the idea that the collective general understanding of natural system is necessarily incomplete, and thus new information should be allowed to influence the potential re-evaluation of strategies for management.

Management techniques would be modified as appropriate to ensure performance standards are met, based on monitoring and incidental observations. Potential management modifications or corrective actions that may be taken to ensure standards are met include: alternative vegetation management, modification of hydrology, alternative control measures for invasive species, re-seeding or planting, stabilization of banks or other areas.

If the mitigation area should fail to meet performance standards, corrective action would be taken. If necessary, corrective action may be taken prior to the end of the five-year monitoring period.

5.0 CONCLUSIONS AND RECOMMENDATIONS

In summary, the proposed Project, consisting of 70 single family lots, open space and trails, permanent access roads, utilities, stormwater detention ponds, and channel improvements to prevent long-term stream degradation, would result in 0.44 acre and 91 linear feet of permanent impacts to the main channel of Sand Creek and its associated tributaries. On-site mitigation is planned that would offset 0.44 acre of wetland loss. Mitigation practices would comply with the 2008 Mitigation Rule (33 CFR 332-Compensatory Mitigation for losses of aquatic resources) as specified by the USACE Albuquerque District Southern Colorado Regulatory Office.

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APPENDIX I

SITE LOCATION MAP

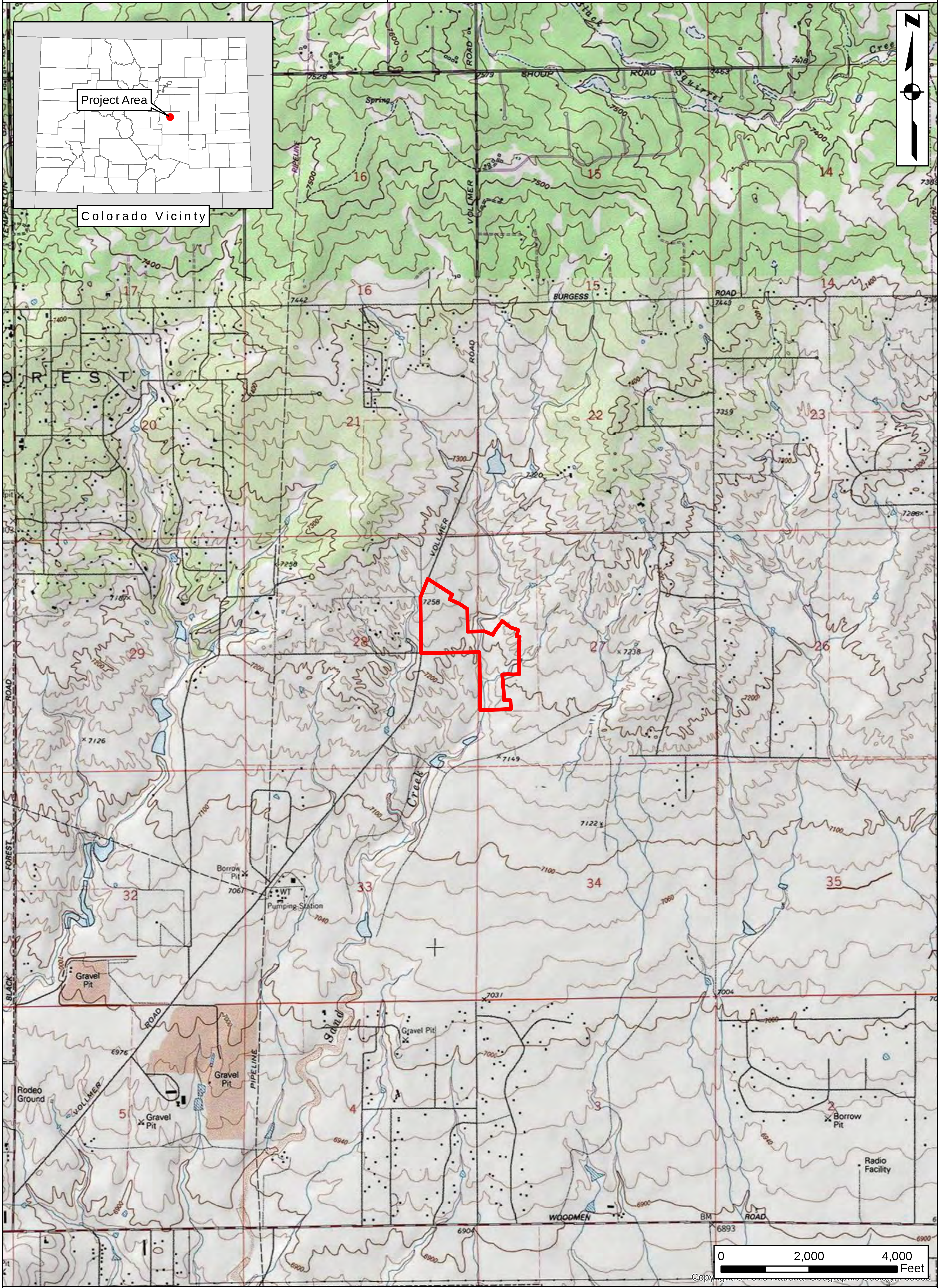
CORE CONSULTANTS

CIVIL ENGINEERING
DEVELOPMENT CONSULTING
NATURAL RESOURCES CONSULTING
LAND SURVEYING
303.703.4444
1950 W. Littleton Blvd., Ste. 109
Littleton, CO 80120

Retreat at Timber Ridge

Site Location Map

El Paso County, Colorado



Filing 1 Boundary

Date: 7/26/2019

CORE Project #: 16-059

APPENDIX II

COMPENSATORY WETLAND MITIGATION PLAN MAP

CORE CONSULTANTS

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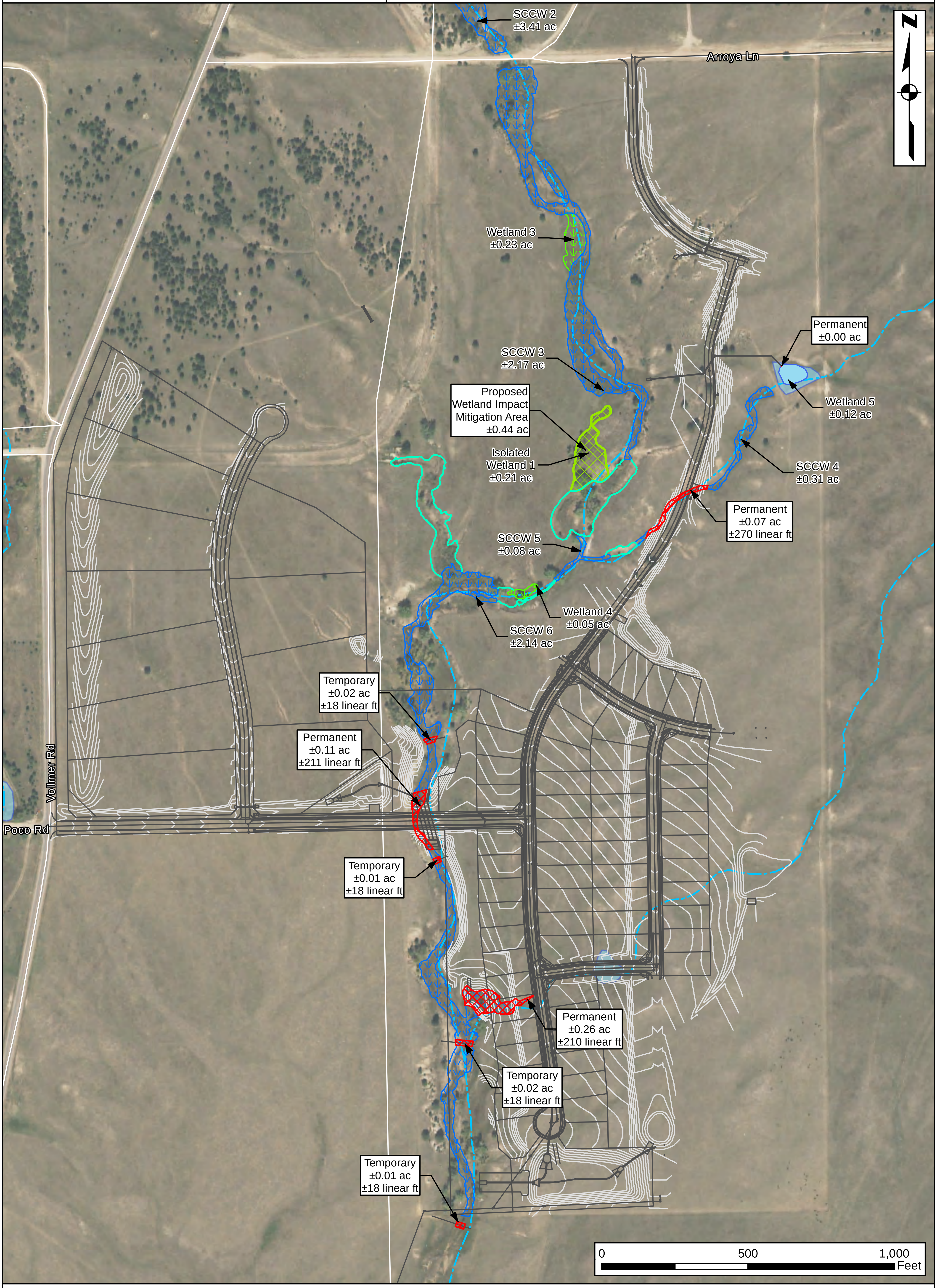
Retreat at Timber Ridge

Compensatory Mitigation Map

El Paso County, Colorado



Filing 1 Layout
NHD Watercourse
NHD Waterbody
JD Channel (OHWM)
Stream Channel Containing Wetlands
Wetland
Pond
Isolated Wetland
Proposed Impacts
Proposed Grading
Mitigated Wetland

Date: 7/25/2019

CORE Project #: 16-059