INNOVATIVE DESIGN. CLASSIC RESULTS.

FINAL DRAINAGE REPORT
FOR
RETREAT AT TIMBERRIDGE
FILING NO. 2

Prepared for:
TIMBERRIDGE DEVELOPMENT GROUP, LLC
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Engineering Review

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See comment letter also

Job No. 1185.20

PCD Project No. SF-21-021

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

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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.

Include flows for Basin EX-5

Existing DP routing needs to be shown in appendix. Flows do not match those shown on drainage map.

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.

culvert material?

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. As reasonably 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:

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.

Reference the water quality plan and state how much area from roads and urban lots is proposed not to be treated.

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.

Include flows and discussion of Basin B

state the entity the drainage easement will be granted to and will maintain these.

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. Permanent rock check dams are planned through this corridor to mitigate erosion and sediment transfer potential.

RR calculations for this culvert are missing from appendix.

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 natural drainage area within the drainage easement on lot 7. (See Appendix for culvert and rip-rap calculations)

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 = 17 cfs, Q_{100} = 74 cfs)** represents this combined flow total where a proposed 42” RCP will collect and convey the developed flows under Falcon Nest Court towards Pond 3. The proposed channel within lot 7 is contained within a drainage esmt. as shown on the drainage map and final plat. It will convey the developed flows from Design Points 1 and 2 towards Design Point 3 and be lined with Turf Reinforcement Matting. (See Appendix for channel calculations)

with culvert ponding area easement

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 will collect and convey these flows to where they combine with the previously mentioned developed flows from Design Point 3.

Basin E1 (Q_2 = 2 cfs Q_5 = 4 cfs, Q_{100} = 15 cfs) represents a portion of the proposed 2.5 ac. rural lots (Lots 10-12) that will continue to sheet flow in a southeasterly direction towards the natural ravine. The majority of the upstream pre-development flows will be collected by the previously described proposed 42" RCP at Design Point 3. Only the developed flows from lots 10-12 will now contribute to this area and thus, the natural ravine will remain native with no further improvements required. This natural drainage corridor will be protected and placed in a drainage esmt. across these lots as shown on the Final Plat. Given the size of these lots, minimal unconnected impervious area introduced and sizeable receiving pervious areas per lot, the WQCV reduction = 100% with 0 untreated WQCV within this basin. (See UD-BMP Runoff Reduction Sheet – Ver. 3.07 in Appendix)

Basin E2 (Q_2 = 0.5 cfs Q_5 = 1.2 cfs, Q_{100} = 6 cfs) represents a portion of lots 9 & 10 that will continue to sheet flow in a southerly direction towards Pond 3. These flows are accounted for in the Design Point 5 and Pond 3 calculations.

Basin OS-3 (Q_2 = 0.1 cfs Q_5 = 0.4 cfs, Q_{100} = 2 cfs) represents a small portion of the extreme rear yard of the proposed lots 11 & 12 that continues to sheet flow towards Sand Creek as originally anticipated.

Design Point 5 (Q_5 = 18 cfs, Q_{100} = 79 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)
0.395 Ac.-ft. WQCV required
0.309 Ac.-ft. EURV required with 4:1 max. slopes
1.700 Ac.-ft. 100-yr. Storage

2.404 Ac.-ft. Total

Total Peak In-flow: **Q_2 = 10.3 cfs, Q_5 = 20.8 cfs, Q_{100} = 74.7 cfs**

Pond Peak Design Release: **Q_2 = 1.0 cfs, Q_5 = 10.1 cfs, Q_{100} = 59.6 cfs**

Pre-development Release: **Q_2 = 5.6 cfs, Q_5 = 15.8 cfs, Q_{100} = 69.2 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 peak release of Q_{100} = 59.6 cfs which is less than the predevelopment flows at this location of Q_{100} = 69.2 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 rear yard developed flows will sheet flow directly off-site and into the open space tract in Filing No. 1. Given the minimal unconnected impervious area introduced and sizeable receiving pervious areas per lot, the WQCV reduction = 100% with 0 untreated WQCV within these basins. (See UD-BMP Runoff Reduction Sheet – Ver. 3.07 in Appendix)

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). In the interim, the pre-development off-site flows from Basin OS-5 will be captured in an off-site temporary sediment basin at the east termination point 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. However, the proposed downstream storm system has been sized and accounts for these anticipated off-site basins. Upon future development within the off-site basins OS-4 and OS-5, developed release must adhere to these anticipated flows described above. Ultimately, the total developed 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 curb and inlet? it appears that a pipe is needed due to the basin elevation.

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). Again, in the interim, the pre-development off-site flows from Basin OS-5 will be captured in the off-site temporary sediment basin at the east termination point of Elk Antler Lane. (See GEC Plan) The proposed downstream storm system has been sized and accounts for this anticipated off-site basin. Ultimately, the total developed flows will combine at Design Point 8 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.

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. Given the minimal unconnected impervious area introduced and sizeable receiving pervious areas per lot, the WQCV reduction = 100% with 0 untreated WQCV within this basin. (See UD-BMP Runoff Reduction Sheet – Ver. 3.07 in Appendix) Basin L (Q_2 = 0.3 cfs Q_5 = 0.6 cfs, Q_{100} = 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. Again, given the minimal unconnected impervious area introduced and sizeable receiving pervious area for this lot, the WQCV reduction = 100% with 0 untreated WQCV within this basin. (See UD-BMP Runoff Reduction Sheet – Ver. 3.07 in Appendix) 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, just south of the intersection of Elk Antler Lane and Antelope Ravine Dr., will continue to adequately collect these flows.

The now permanent sediment basins will need maintenance agreements, O&M, and MS4/SDI sheets

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.

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 to the west towards Design Point 13. (See Appendix for calculations.)

List Basin S flows

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 in Bison Valley Trail.

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. Again, the emergency overflow will be 12" and then southerly over the highpoint in Bison Valley Trail.

Pipe Run 15 (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 44-54. These developed flows will sheet flow in a southeasterly direction and directly into the proposed off-site swale and ultimately into the temporary sediment basin proposed at the southerly termination point of Bison Valley Trail. Based on the extremely large lot depths (215'+), given the minimal unconnected impervious area anticipated at the rear of these lots and the sizeable receiving pervious area per lot, the WQCV reduction = 100% with 0 untreated WQCV within this basin. (See UD-BMP Runoff Reduction Sheet – Ver. 3.07 in Appendix) 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 permanent drainage easements along the eastern property line to facility this 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. Given the minimal unconnected impervious area introduced and sizeable receiving pervious area per lot, the WQCV reduction = 100% with 0 untreated WQCV within this basin. (See UD-BMP Runoff Reduction Sheet – Ver.

Design Point 15?

3.07 in Appendix) Regardless, these rear yard developed flows sheet flow in a southerly direction directly into the off-site swale and ultimately into the temporary sediment basin proposed at the southerly termination point of Bison Valley Trail. At this point, all on-site developed flows will be captured and temporarily treated until future Sterling Ranch development takes place. Coordination with the Sterling Ranch property owner is taking place for the acquisition of appropriate temporary grading and permanent drainage easements along the southern property line to facilitate these facilities. Upon future development of Sterling Ranch in this area, Basins V, W and OS-7 will be further analyzed to determine how to potentially eliminate the swale along the property line.

Missing discussion on Basin F

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.

Describe maintenance access for ponds.

structural improvements

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 velocities do or do not exceed recommended allowable? List the range of velocities.

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 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.

There is still not enough information in this section. Provide the proposed criteria being used in the channel design.

HEC-RAS MODELING

Autodesk River and Flood Analysis Module 2019 and HEC-RAS ver. 5.0.6 were used to perform an updated one-dimensional, steady flow hydraulic model of the upper portion of Reach SC-9 from Arroya Lane down to approximately 500 feet north of the Poco Road culvert crossing constructed with Retreat at TimberRidge Filing No. 1. This AutoCAD River Module 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 utilized within the AutoCAD River Module containing three-dimensional coordinates for the stream centerline, cross-sections, reach stations, overbank stations and reach lengths. Two separate models defining the existing condition and proposed condition were prepared using the same centerline stationing. 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 just south of Arroya Lane, channel station 27+00.00 down to approximately 500 feet north of the Poco Road crossing, channel station 1+00.00 all within the Sand Creek DBPS segment 171. 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)
DBPS Segment 171	
FEMA 100 Yr.	2600
DBPS 100 Yr.	2170
DBPS 10 Yr.	630
Sterling MDDP 100 Yr.	1487
Sterling MDDP 10 Yr.	430

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. As discussed earlier, the FEMA FIS flows appear to be significantly higher than both those presented in the DBPS and the Sterling Ranch MDDP. 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 at Poco Road 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:

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 existing conditions calculations in the Appendix shows that a few stations showed velocity exceeding 7.0 ft./sec. and shear stress exceeding the limit above. (Sta: 6+00 and 7+00) Improvements in this area is being proposed to help reduce both the velocity and shear. These channel improvements within Filing No. 2 consist of widening of the floodplain from stations 6+50 – 10+00, installation of rip-rap stabilization from stations 6+50 – 11+00 and installation of one additional check structure located at station 17+00.

What is the range of shear stress in the channel after improvements?

The DBPS 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.) Between stations 6+50 and 10+00, the north side of the natural channel floodplain is proposed to be widened to help mitigate the existing velocity and sheer in this area. Then both sides of the channel through this stretch will be provided with rip-rap stabilization. The existing channel slope throughout this reach ranges from 0.7% to 2.5%. Per the HEC-RAS model, the proposed channel velocities, after improvements range from 2.6 ft./sec. to 6.3 ft./sec. All stations are within the allowable velocity of 7.0 ft./sec.

Address whether this is valid based on current design practices.

The DBPS does not depict any structures along this stretch of channel. However, an additional one is being planned at station 17+00 to further limit degradation and help control the elevation of the channel invert as well as aide in the adjacent wetland mitigation self-irrigation plan. The check structure is designed to be sheet piling with a concrete cap per Urban Drainage Vol. 2 Figures 9-27 thru 9-28. The intent of this structure is to hold grade so if the stream wants to flatten its equilibrium slope, the incision is limited. Thus, the plan is for this structure to eventually become drop structures as dictated by future channel characteristics.

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.

Per DCM section 10.7, FR No. < 0.90

A public trail along the west side of Sand Creek is planned and will allow to associated channel improvements. (See channel plans for exact ramp locations and details)

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:

7.74 Ac.	Sand Creek Drainage corridor (Tract B)
0.96 Ac.	Detention Facility (Tract A)
34.30 Ac.	2.5 Ac. lots (Rural Lots 1-12 incl. ROW dedication)
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**%**)

7.74 Ac. x 2% = **0.15 Impervious Ac.**

Fees for Detention Facilities & Park

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

0.96 Ac. x 7% = **0.07 Impervious Ac.**

<u>Fees for 2.5 Ac. lots</u>

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

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

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

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

<u>Fees for 1/3 Ac. lots</u> (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: **12.90 Imp. Ac.** (Drainage Fees)

Total Impervious Acreage: **13.84 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 13.84 Impervious Ac. = **<u>$ 115,411.76</u>**

Drainage Fees

$ 20,387.00 x 12.90 Impervious Ac. = **<u>$ 262,992.30</u>**

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, Segment 171 as shown in the DBPS. However, Retreat at TimberRidge Filing No. 1 requested fee reduction based on the channel improvements presented in the DBPS for this portion of Segment 171. These Filing 1 fee offsets need to be vetted and finalized following the process in the DCM (Sections 1.7 and 3.3). Any additional request for fee reduction with Filing 2 must be brought to Drainage Board for approval of fee increase. The following facilities within the Sand Creek Drainage Basin seem to meet the criteria for this reduction:

Verify based on
other comments

Proposed Sand Creek Channel Improvements (Filing 2):

Sheet Pile Check Structure w/ Conc. Cap	$45,000 EA x 1 =	$ 45,000
Selective Bank Stabilization (Buried Rip-Rap)	$100/LF x 800 LF =	$ 80,000
Selective Bank Stabilization (Grading & Reveg.)	=	$120,000
Total	=	**$245,000**

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

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.

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 pre-development 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

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.

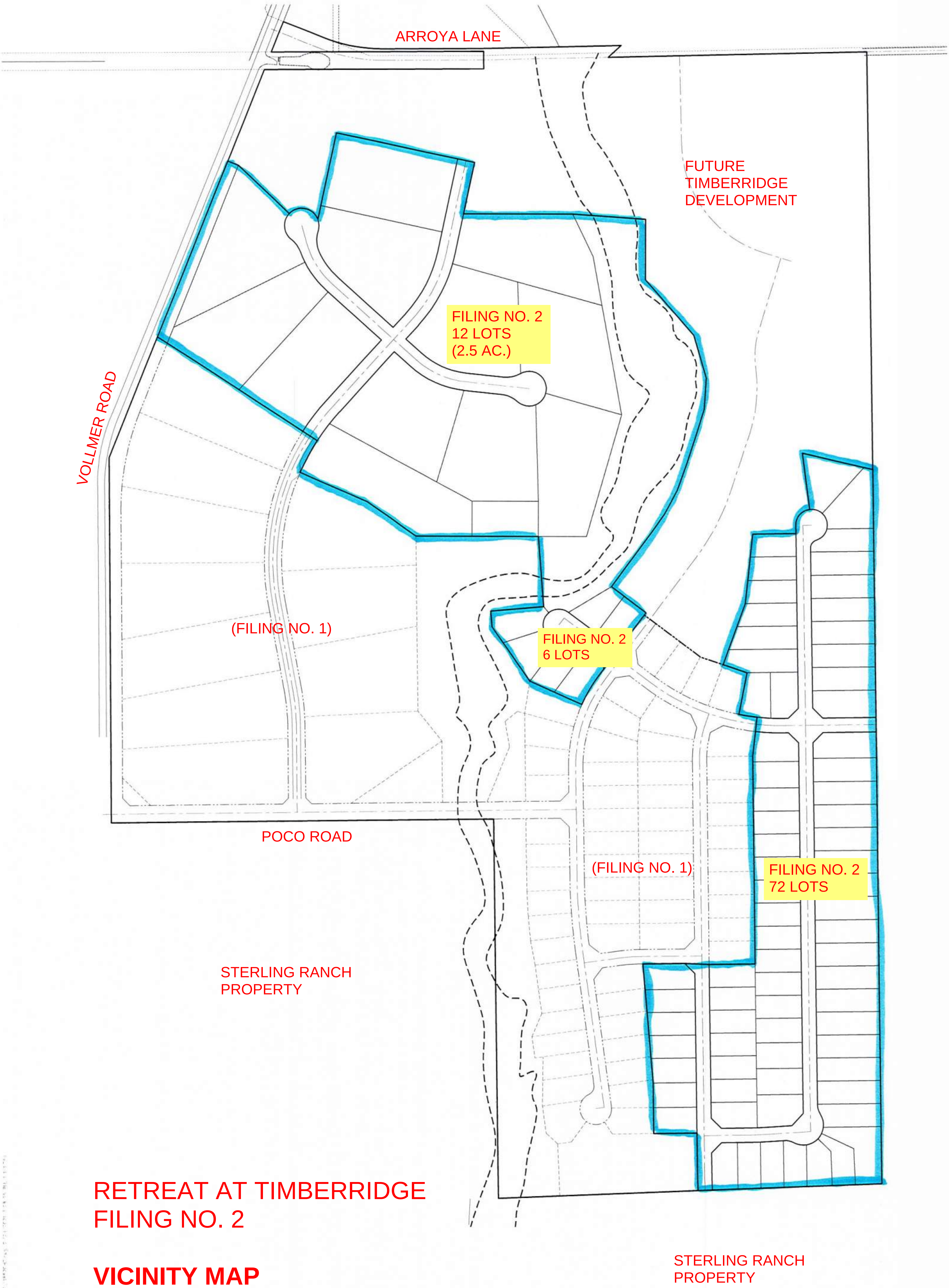
6. "Preliminary Drainage Report for The Retreat at TimberRidge Preliminary Plan – South of Arroya Lane", Classic Consulting, approved October 2018.

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

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

APPENDIX

VICINITY MAP



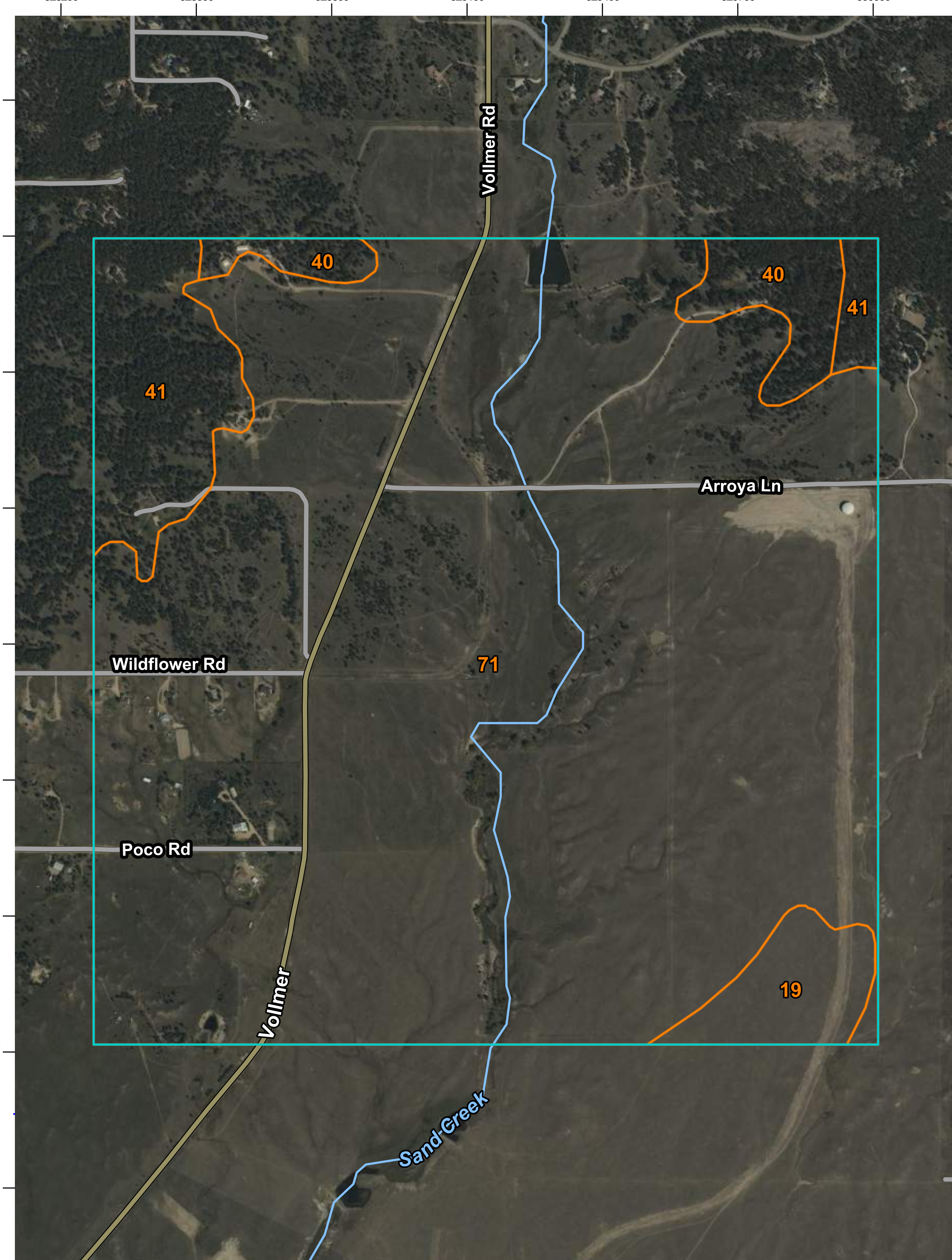
RETREAT AT TIMBERRIDGE
FILING NO. 2

VICINITY MAP

SOILS MAP (S.C.S SURVEY)

CLASSIC
CONSULTING
ENGINEERS & SURVEYORS

Soil Map—El Paso County Area, Colorado



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)

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.

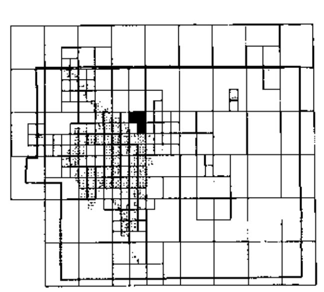
Contact **FEMA Map Service Center** (MSC) via the FEMA Map Information eXchange (FMIX) 1-877-336-2627 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this 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

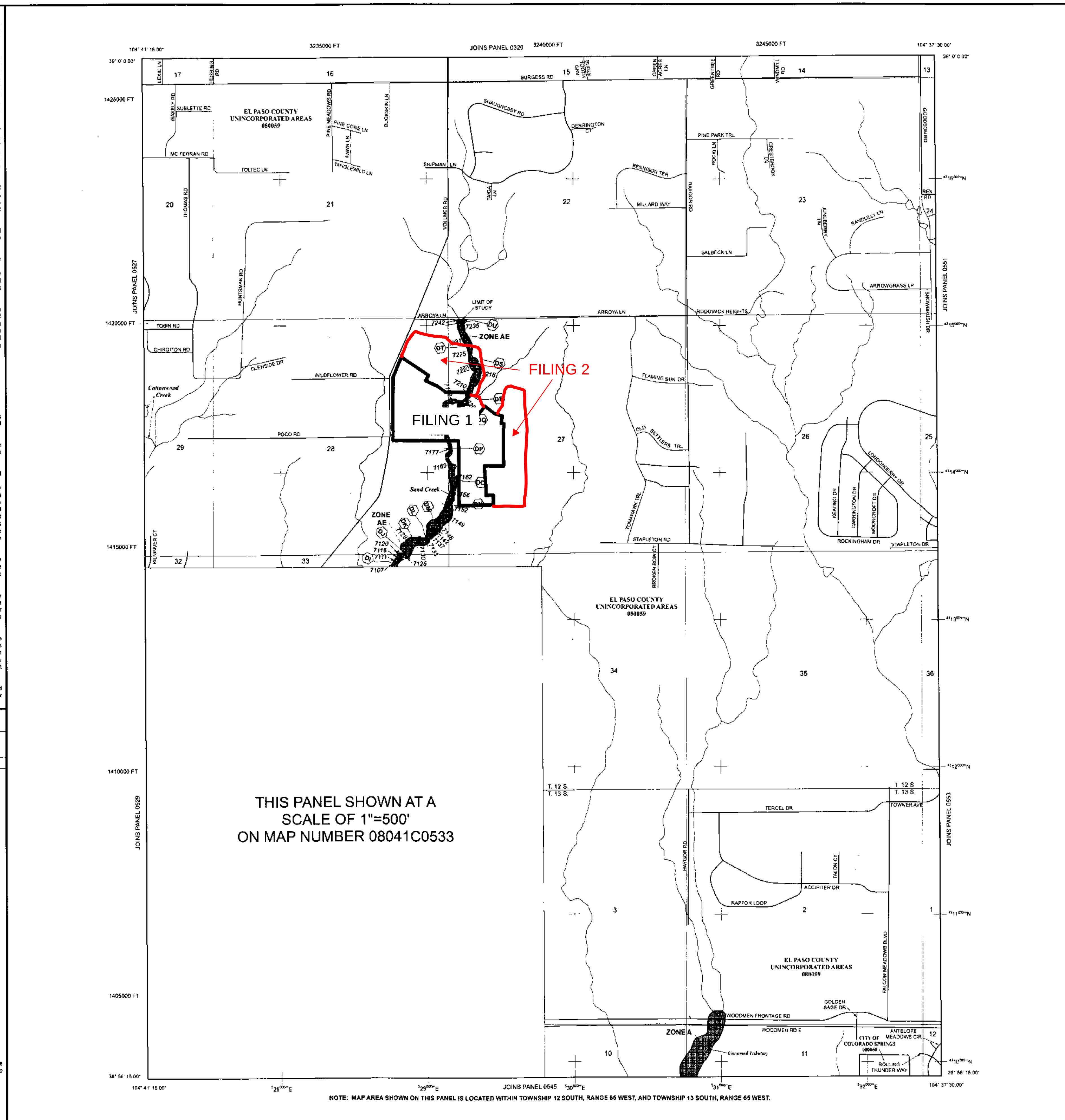
Flooding Source	Vertical Datum Offset (ft)
REFER TO SECTION 3.3 OF THE EL PASO COUNTY FLOOD INSURANCE STUDY FOR STREAM BY STREAM VERTICAL DATUM CONVERSION INFORMATION	

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



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.

(solid line)	Floodplain boundary
(dashed line)	Floodway boundary
(long-dashed line)	Zone D Boundary
(dotted line)	CBRS and OPA boundary
(hatched line)	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

 | Issue Date: March 6, 2009 | Effective Date: July 23, 2009 | Case No.: 08-08-0541P | LOMR-APP

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

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)

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.

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)

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.

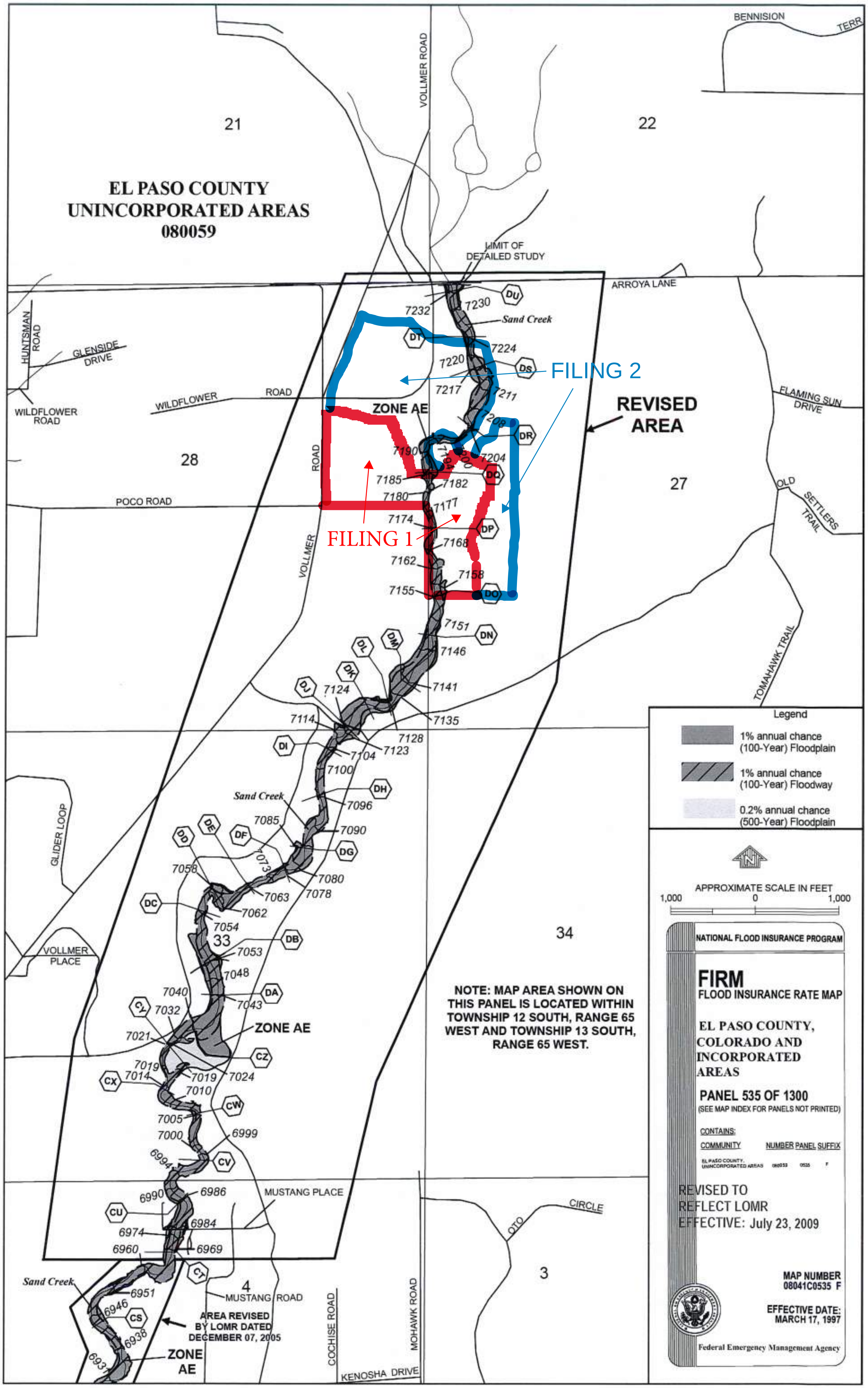
A notice of changes will be published in the *Federal Register*. A short notice also will be published in your local newspaper on or about the dates listed below. Please refer to FEMA's website at https://www.floodmaps.fema.gov/fhm/Scripts/bfe_main.asp for a more detailed description of proposed BFE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

David N. Bascom

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


EL PASO COUNTY
UNINCORPORATED AREAS
080059
21
22
28
27
33
34
4
3
VOLLMER ROAD
BENNISION
TERR
LIMIT OF
DETAILED STUDY
ARROYA LANE
Sand Creek
HUNTSMAN ROAD
GLENSIDE DRIVE
WILDFLOWER ROAD
FILING 2
FILING 1
ZONE AE
REVISED
AREA
FLAMING SUN DRIVE
OLD SETTLERS TRAIL
POCO ROAD
TOMAHAWK TRAIL
GLIDER LOOP
VOLLMER PLACE
MUSTANG PLACE
MUSTANG ROAD
CIRCLE
OTO
COCHISE ROAD
MOHAWK ROAD
KENOSHA DRIVE
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
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

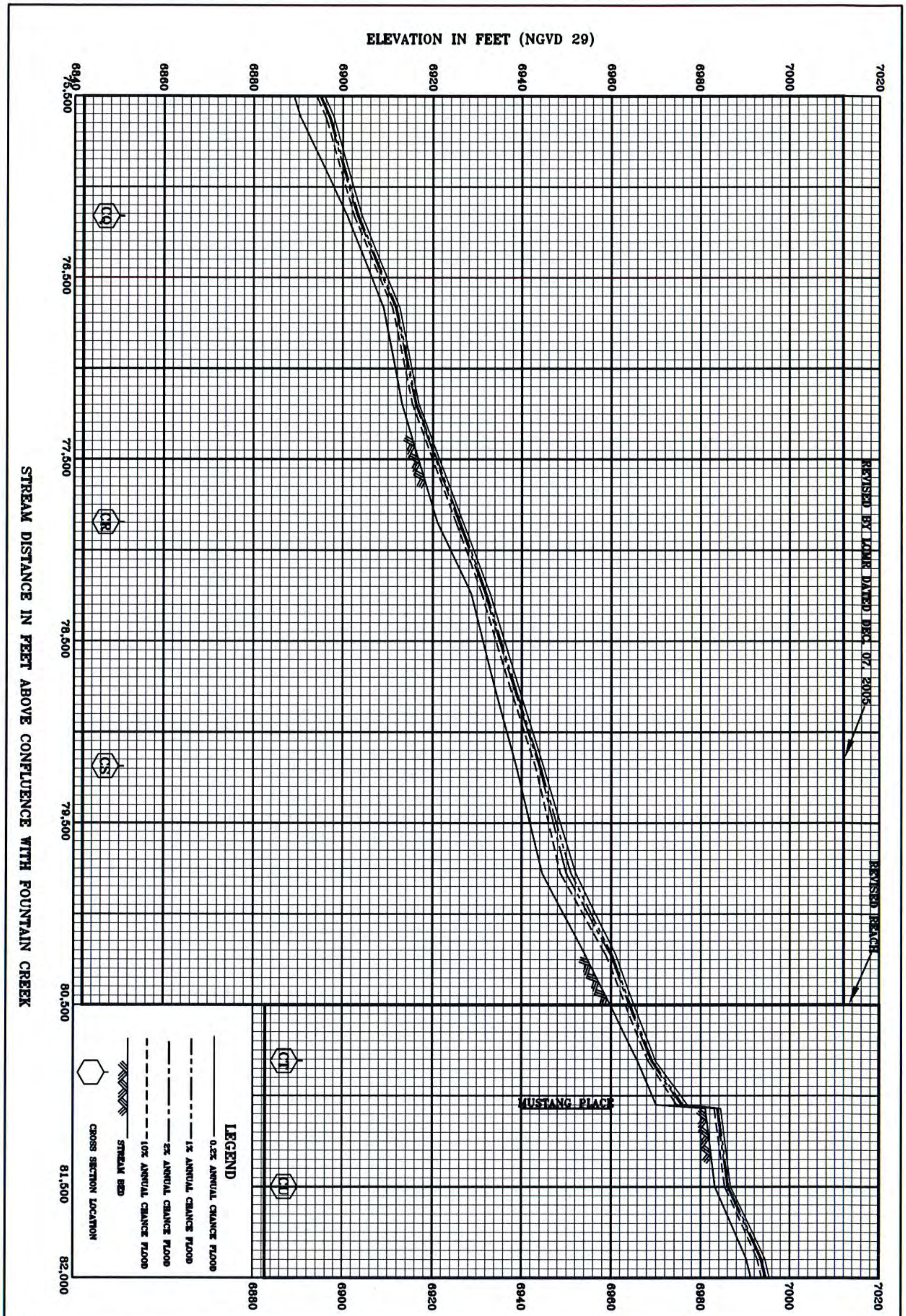
REVISED TO
REFLECT LOMR
EFFECTIVE: July 23, 2009

TABLE 5

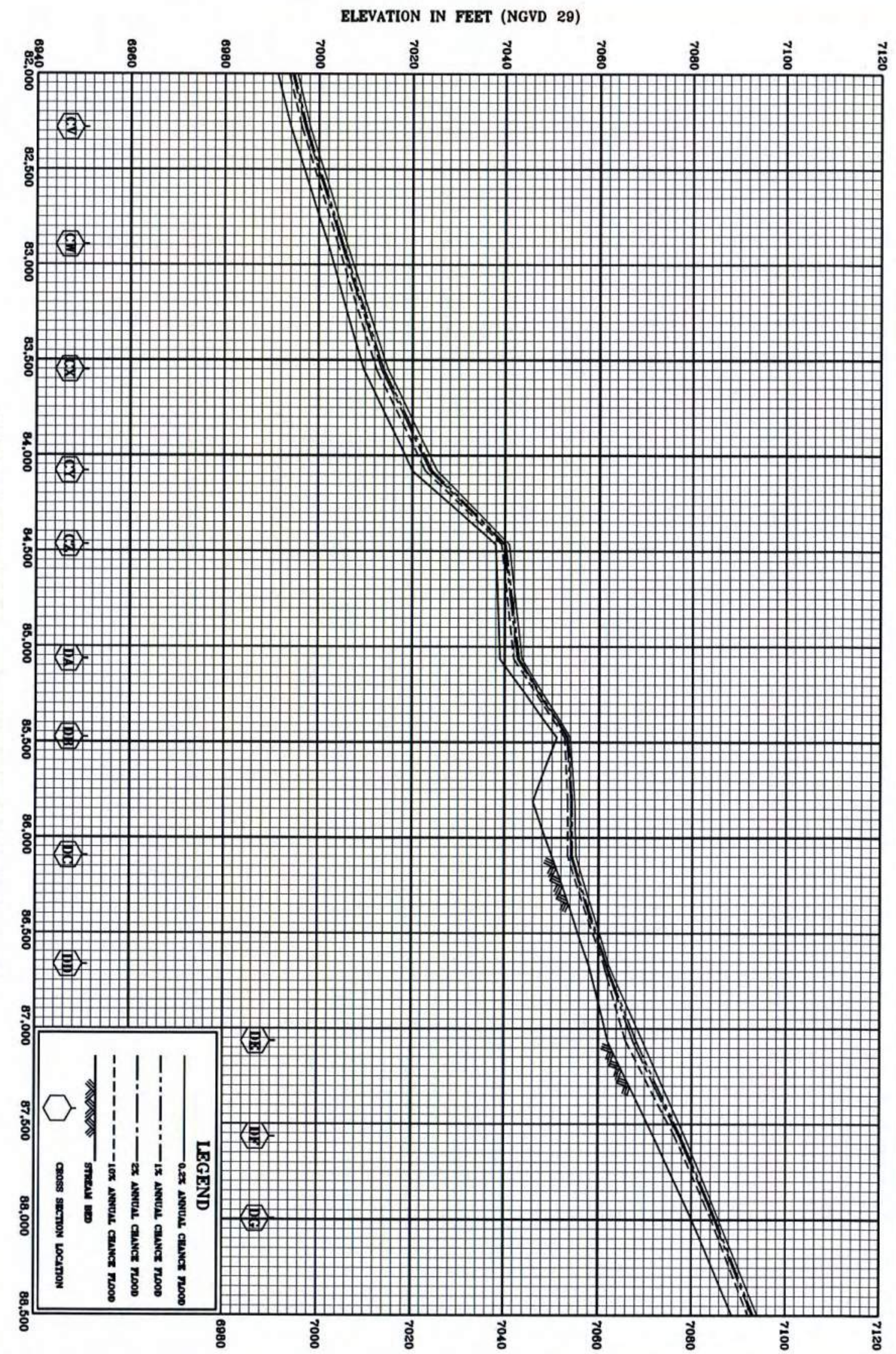
FEDERAL EMERGENCY MANAGEMENT AGENCY
EL PASO COUNTY, CO
AND INCORPORATED AREAS

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



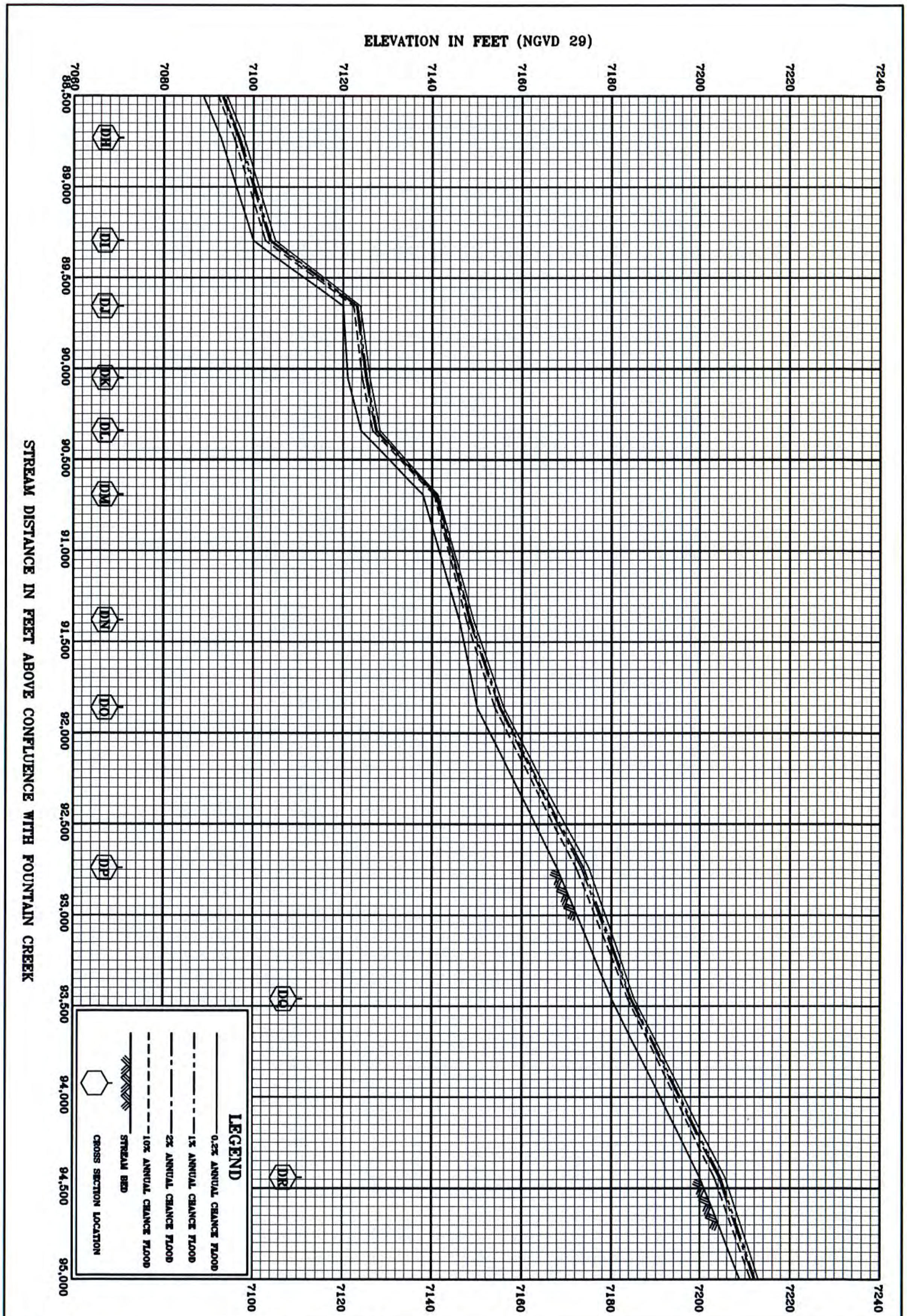
FEDERAL EMERGENCY MANAGEMENT AGENCY

EL PASO COUNTY, CO
AND INCORPORATED AREAS

REVISED TO
REFLECT LOMR
EFFECTIVE: July 23, 2009

FLOOD PROFILES

SAND CREEK



FEDERAL EMERGENCY MANAGEMENT AGENCY

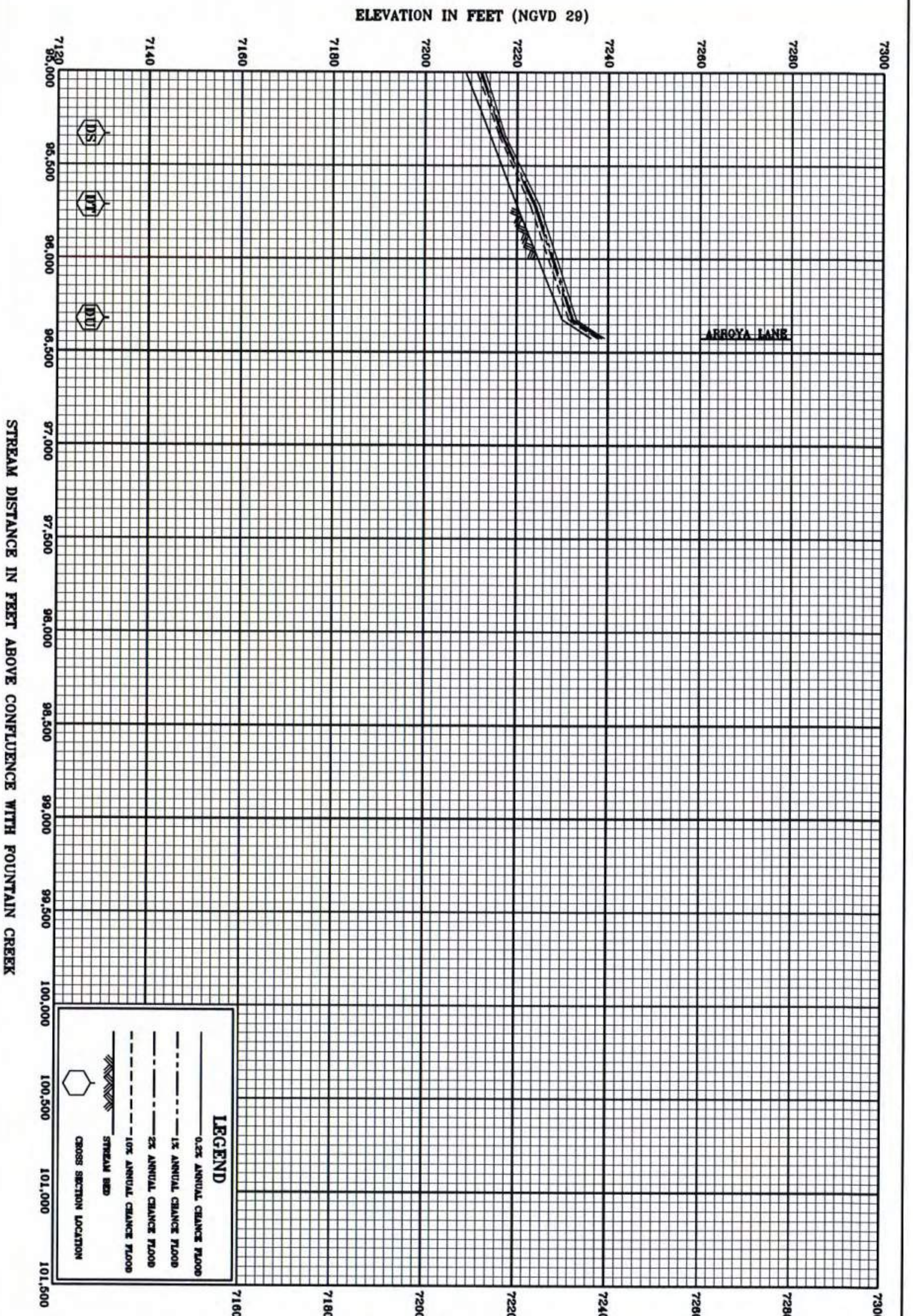
EL PASO COUNTY, CO
AND INCORPORATED AREAS

REVISED TO
REFLECT LOMR
EFFECTIVE: July 23, 2009

FLOOD PROFILES

SAND CREEK

204P(c)



FEDERAL EMERGENCY MANAGEMENT AGENCY

EL PASO COUNTY, CO
AND INCORPORATED AREAS

REVISED TO
REFLECT LOMR
EFFECTIVE: July 23, 2009

FLOOD PROFILES

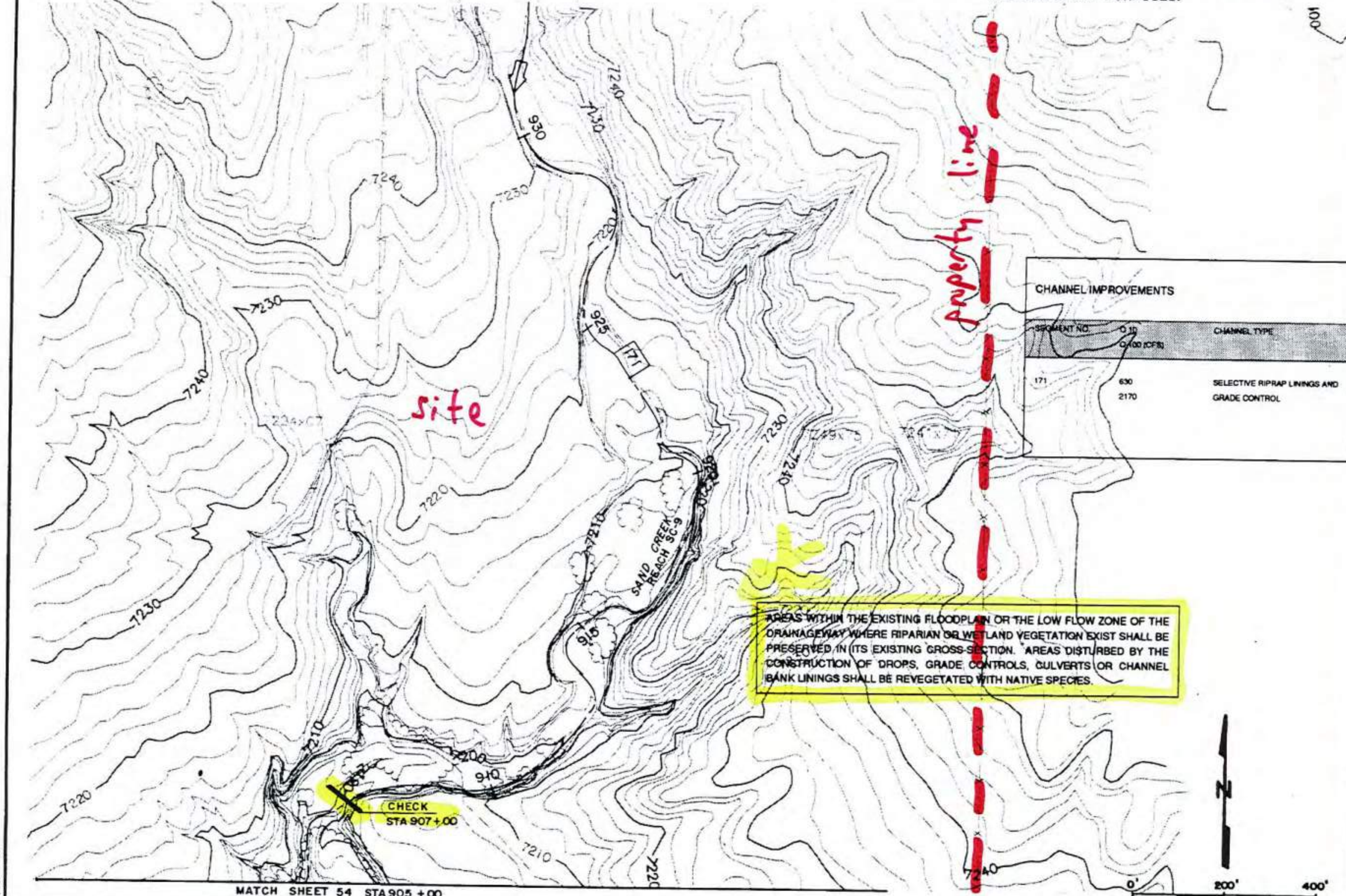
SAND CREEK

RECOMMENDATIONS PER SAND CREEK DBPS

CLASSIC
CONSULTING
ENGINEERS & SURVEYORS

THIS DRAWING IS A MASTER PLANNING SHEET REPRESENTING PRELIMINARY AND CONCEPTUAL ENGINEERING. IT SHOULD NOT BE USED FOR CONSTRUCTION PURPOSES.

MATCH SHT 56 STA 933 + 80



CHANNEL IMPROVEMENTS

SEGMENT NO.	Q 10 / Q 100 (CFS)	CHANNEL TYPE
171	630 / 2170	SELECTIVE RIPRAP LININGS AND GRADE CONTROL

AREAS WITHIN THE EXISTING FLOODPLAIN OR THE LOW FLOW ZONE OF THE DRAINAGEWAY WHERE RIPARIAN OR WETLAND VEGETATION EXIST SHALL BE PRESERVED IN ITS EXISTING CROSS-SECTION. AREAS DISTURBED BY THE CONSTRUCTION OF DROPS, GRADE CONTROLS, CULVERTS OR CHANNEL BANK LININGS SHALL BE REVEGETATED WITH NATIVE SPECIES.

MATCH SHEET 54 STA 905 + 00

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:	

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

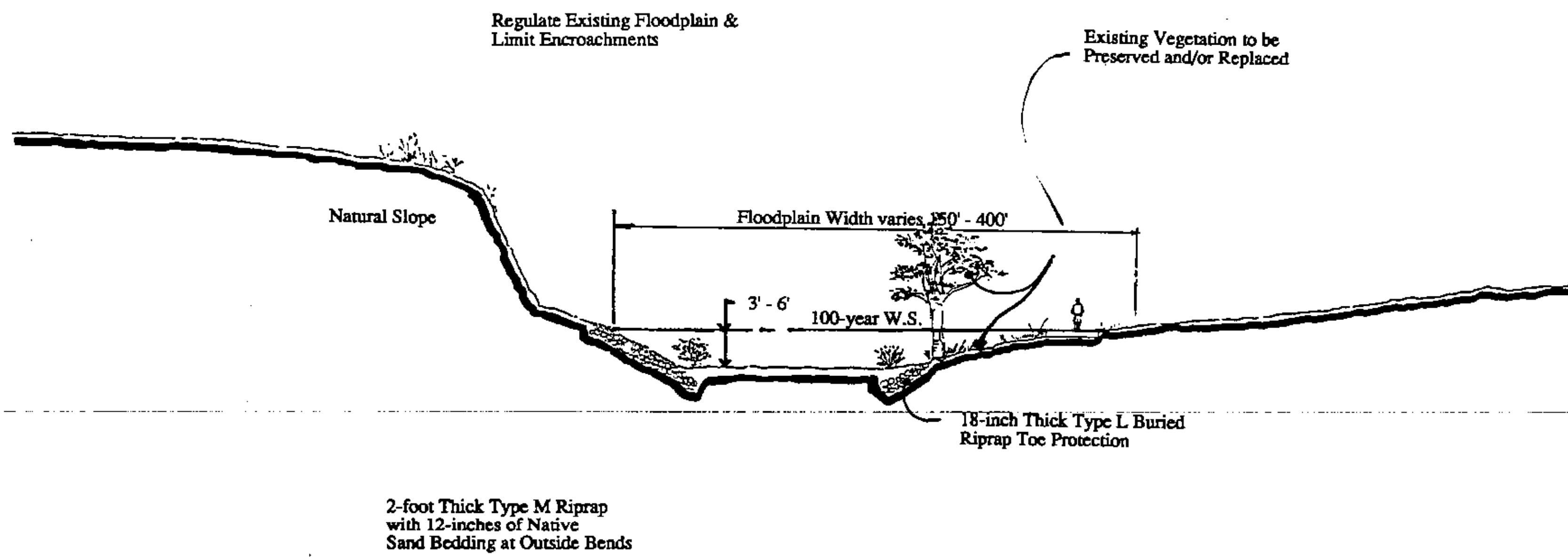
The recommended plan calls for the construction of six regional detention basins within the Sand Creek basin, and six regional basins within the East Fork Sand Creek basin. The purpose of the Sand Creek detention basins is to limit peak discharges at Powers Boulevard to existing development condition 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.



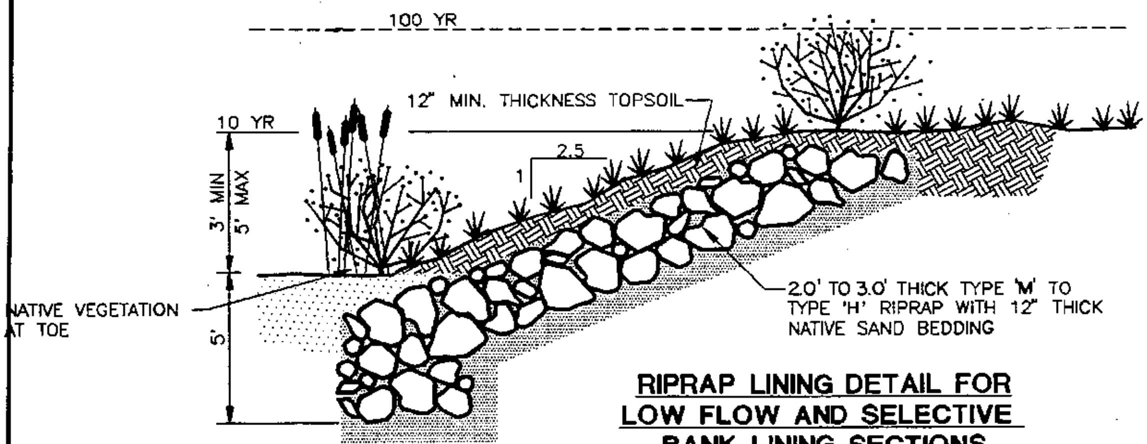
Kiowa Engineering Corporation
419 W. Bijou Street
Colorado Springs, Colorado
80905-1308

SAND CREEK DRAINAGE
BASIN PLANNING STUDY

Typical Channel Sections

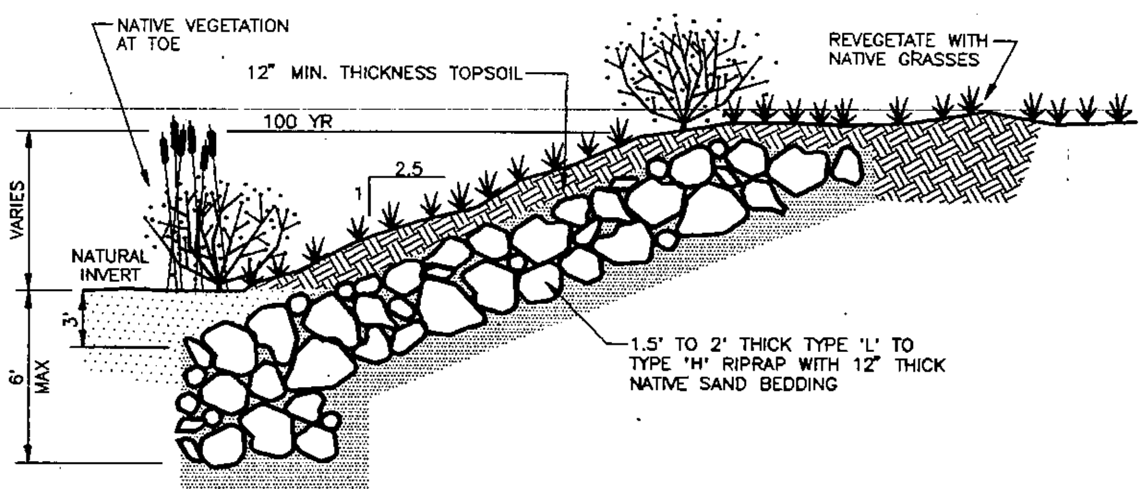
Project No.
Date:
Design:
Drawn:
Check:
Revisions:

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
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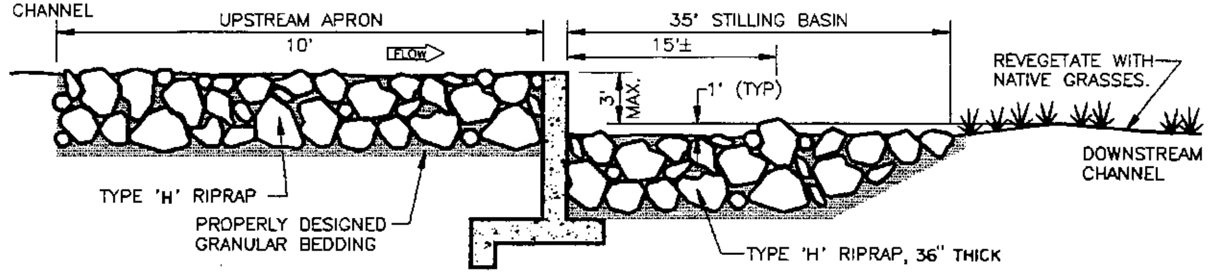
SAND CREEK DRAINAGE BASIN PLANNING STUDY

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

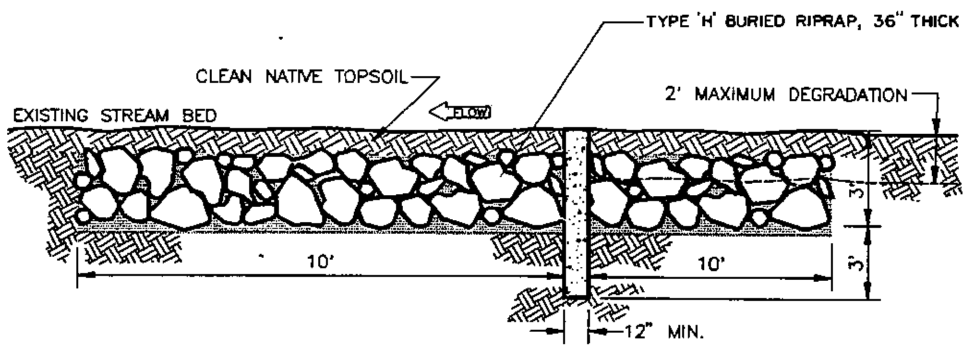
CS-6



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

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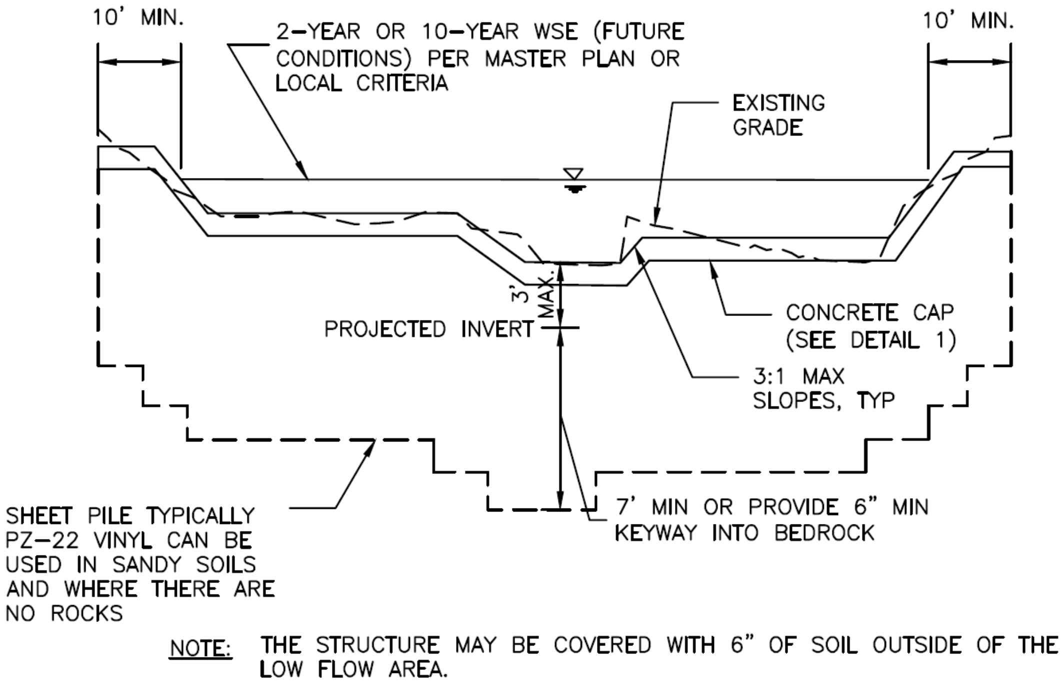
SAND CREEK DRAINAGE BASIN PLANNING STUDY

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

CS-7



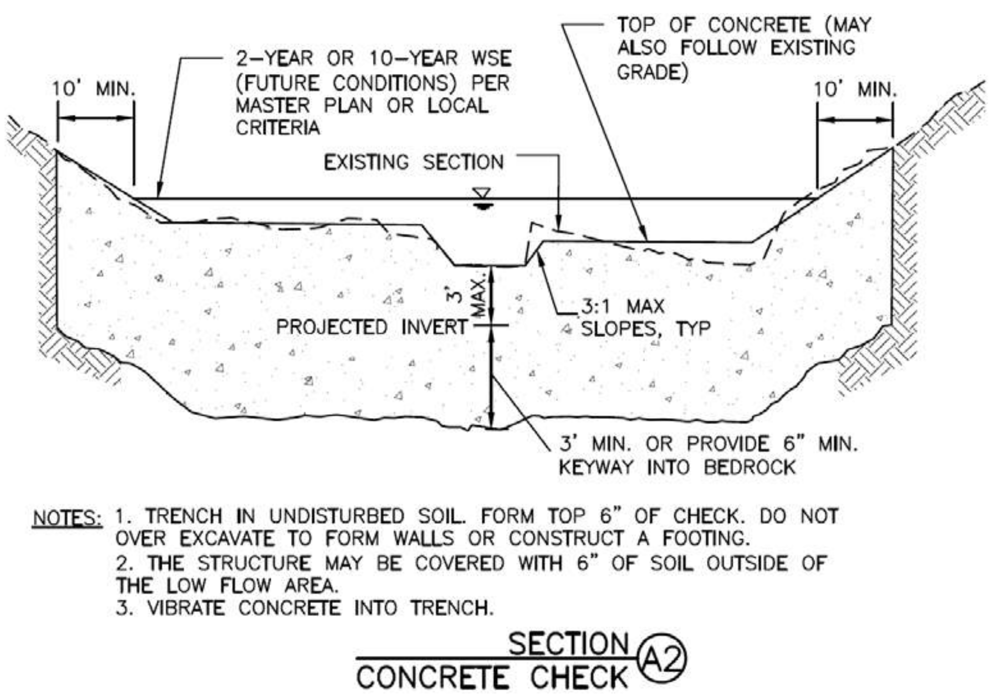


Figure 9-27. Check structure details (Part 2 of 3)

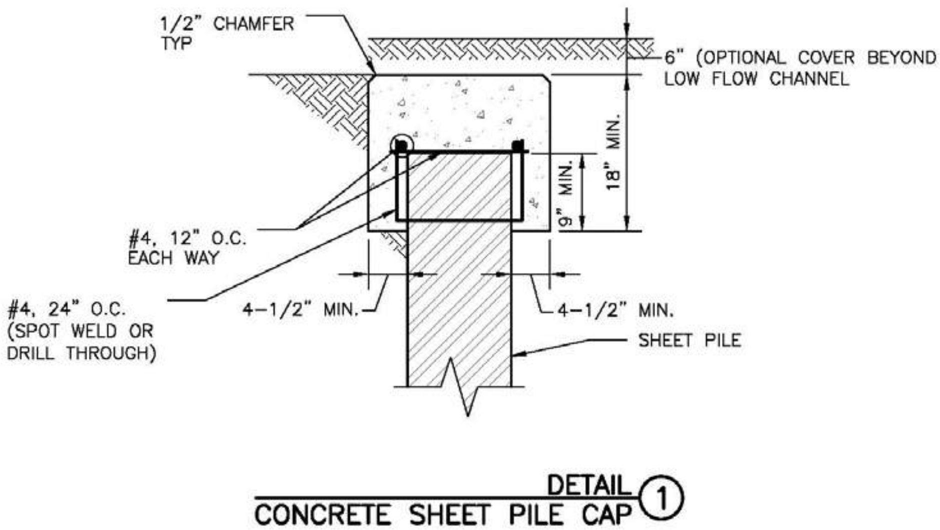


Figure 9-28. Check structure details (Part 3 of 3)

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

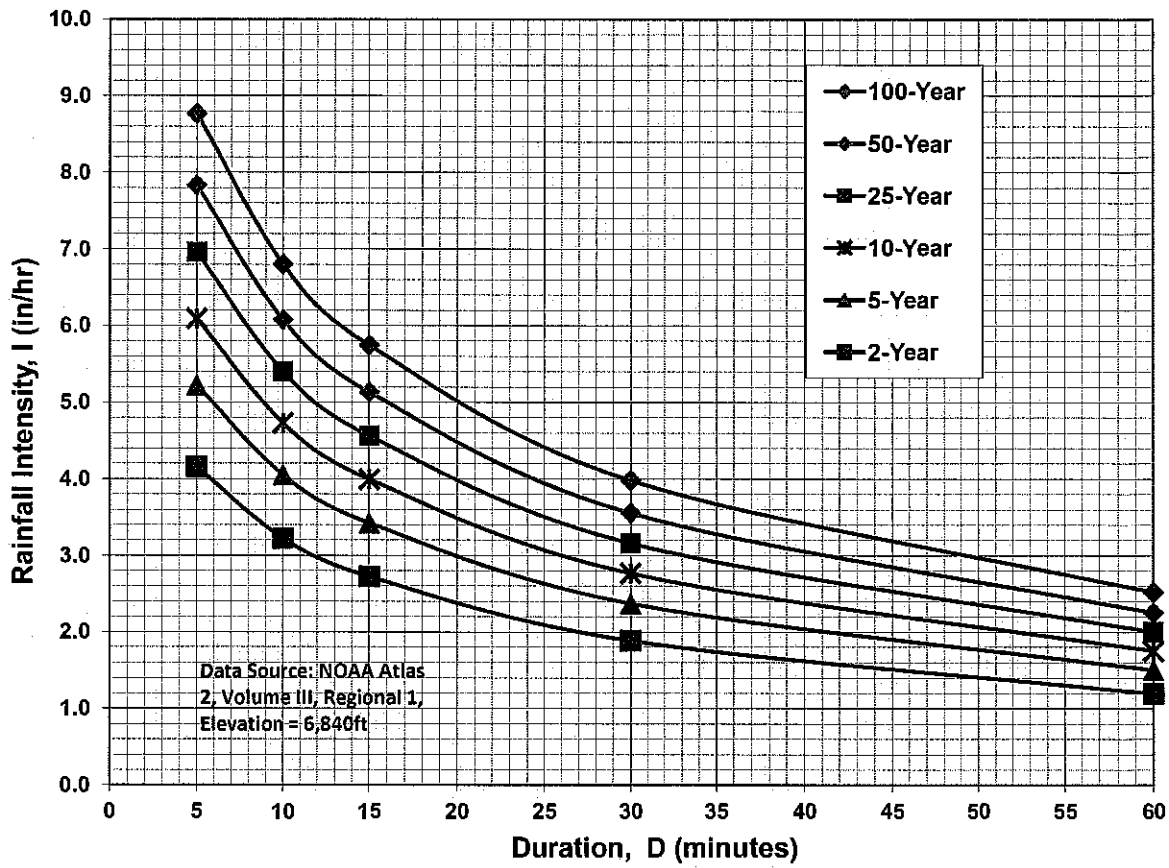
One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the hydraulically most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration 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%
E2	2.8	12.4%
Total	**58.3**	**12.6%**

JOB NAME: *RETREAT AT TIMBERRIDGE FILING NO. 2*
JOB NUMBER: *1185.20*
DATE: *09/17/21*
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%
E1	7.1	0.45	0.89	0.90	0.96	6.65	0.06	0.14	0.40	0.11	0.19	0.44	**0.80**	**1.34**	**3.09**	16.0%
E2	2.8	0.05	0.89	0.90	0.96	2.75	0.06	0.14	0.40	0.07	0.15	0.41	**0.21**	**0.43**	**1.15**	12.4%
F	12.2	0.00	0.89	0.90	0.96	12.20	0.04	0.10	0.38	0.04	0.10	0.38	**0.49**	**1.22**	**4.64**	7.2%
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%

JOB NAME:	***RETREAT AT TIMBERRIDGE FILING NO. 2***
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$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}}$$

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

Tc=L/V

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

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

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

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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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)
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**
E1	0.80	1.34	3.09	0.14	300	12	19.0	300	2.0%	1.4	3.5	22.5	2.33	2.91	4.88	2	**4**	**15**
E2	0.21	0.43	1.15	0.14	300	7	22.7					22.7	2.32	2.90	4.87	0.5	**1.2**	**6**
F	0.49	1.22	4.64	0.10	300	9	21.8	600	1.5%	1.2	8.2	29.9	1.99	2.48	4.17	1	**3**	**19**
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**

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

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

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

Tc=L/V

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
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Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

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

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

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)
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

JOB NAME: *RETREAT AT TIMBERRIDGE FILING NO. 2*
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DATE: *09/17/21*
CALCULATED BY: *MAW*

Include design point surface routing for existing conditions/basins

FINAL DRAINAGE REPORT ~ SURFACE ROUTING SUMMARY

Design Point(s)	Contributing Basins	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity		Flow		Inlet Size
					I(5)	I(100)	Q(5)	Q(100)	
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, DP-2, Basin D (52.2 ac.)	8.28	21.72	40.9	2.02	3.38	17	74	42" RCP CULVERT
4	Basin C (3.3 AC.)	0.84	1.60	20.2	3.08	5.16	3	8	24" RCP CULVERT
5	**POND 3 TOTAL INFLOW DP-3, DP-4, BASIN E2 (58.3 AC.)**	**9.55**	**24.47**	**43.4**	**1.93**	**3.23**	**18**	**79**	**POND 3**
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

JOB NAME: ***RETREAT AT TIMBERRIDGE FILING NO. 2***
JOB NUMBER: ***1185.20***
DATE: ***09/17/21***
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
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, W and OS-7 (6.1 ac.)	1.21	2.65	15.6	3.46	5.81	4	15	TEMP. SEDIMENT BASIN

Include DP discussion in report

JOB NAME: *RETREAT AT TIMBERRIDGE FILING NO. 2*
JOB NUMBER: *1185.20*
DATE: *09/17/21*
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-3	8.28	21.72	40.9	2.02	3.38	17	74	42" RCP
2	DP-4	0.84	1.60	20.2	3.08	5.16	3	8	24" RCP
3	**PR-1, PR-2**	**9.12**	**23.32**	**40.9**	**2.02**	**3.38**	**18**	**79**	**42" RCP**
4	DP-7	3.02	7.47	20.2	3.08	5.16	9	39	30" RCP
5	DP-8	0.62	1.85	20.2	3.08	5.16	2	10	24" RCP
6	PR-1, PR-2	3.64	9.32	20.8	3.03	5.09	11	47	36" RCP
7	DP-10	1.00	1.98	10.6	4.05	6.80	4	13	24" RCP
8	DP-11	0.41	0.59	13.8	3.65	6.12	2	4	18" RCP
9	PR-3, PR-4, PR-5	5.05	11.89	21.8	2.96	4.97	15	59	36" RCP
10	DP-12 Pickup	1.05	1.17	15.6	3.46	5.82	4	7	24" RCP
11	PR-6, PR-7	6.11	13.06	22.2	2.93	4.92	18	64	36" RCP
12	DP-13	2.25	3.93	16.1	3.42	5.74	8	23	30" RCP
13	DP-14	0.33	0.53	16.3	3.40	5.70	1	3	18" RCP
14	PR-9, PR-10	2.57	4.47	16.3	3.40	5.70	9	25	30" RCP
15	**PR-8, PR-11**	**8.68**	**17.53**	**22.7**	**2.90**	**4.87**	**25**	**85**	**42" RCP**

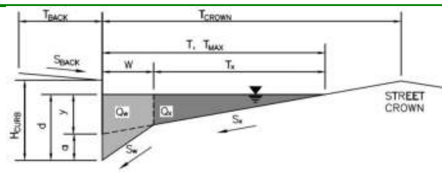
Version 4.05 Released March 2017

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)

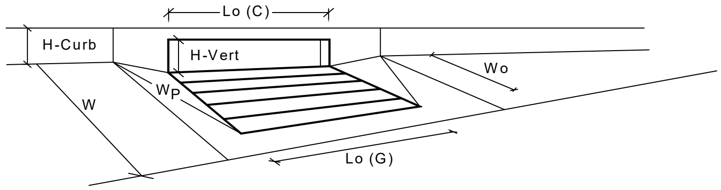
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
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

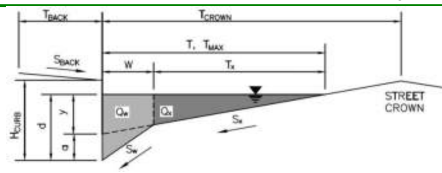
Version 4.05 Released March 2017

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-8**



Gutter Geometry (Enter data in the blue cells)

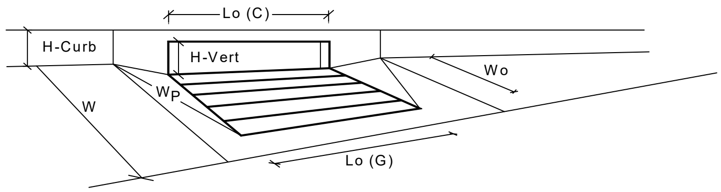
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
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



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)	$Q_{PEAK\ REQUIRED}$ =	2.0	10.0	cfs

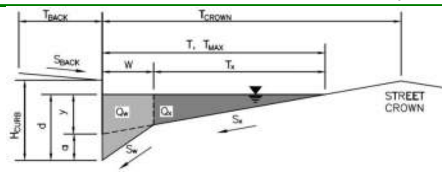
Version 4.05 Released March 2017

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)

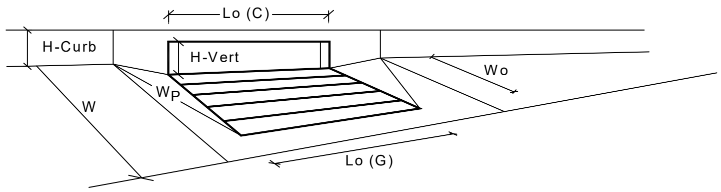
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
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**

INLET IN A SUMP OR SAG LOCATION

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' 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

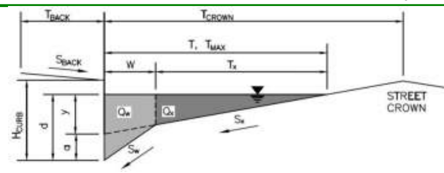
Version 4.05 Released March 2017

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)

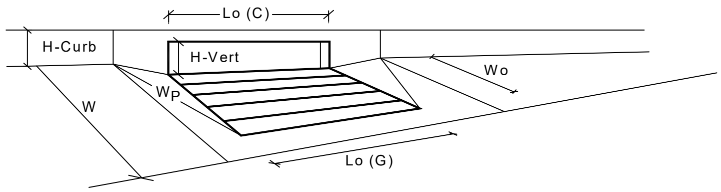
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
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**

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) =	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

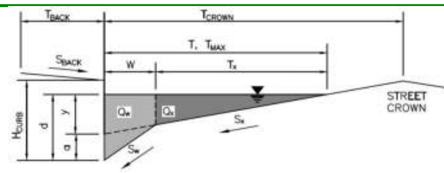
Version 4.05 Released March 2017

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)

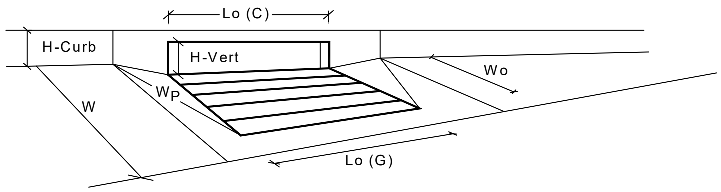
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
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



		MINOR	MAJOR	
Design Information (Input) CDOT Type R Curb Opening				
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

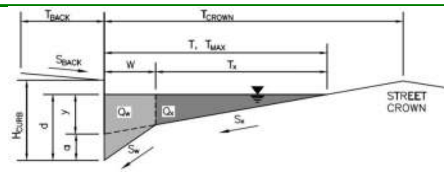
Version 4.05 Released March 2017

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	

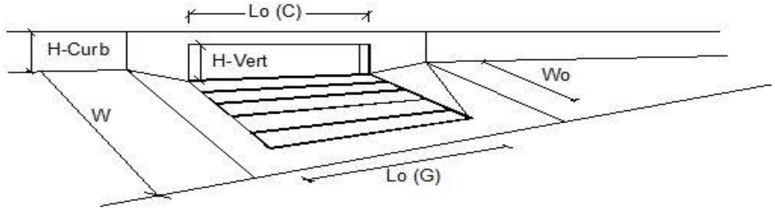
		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	17.0	17.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

		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



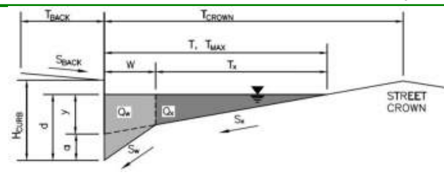
Design Information (Input)			MINOR	MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit 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**	**%**

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)

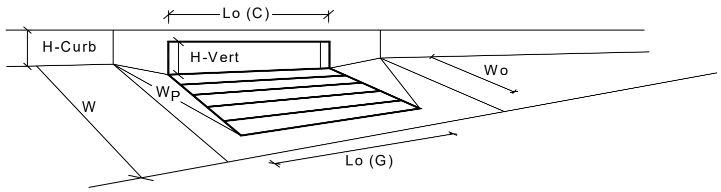
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
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	

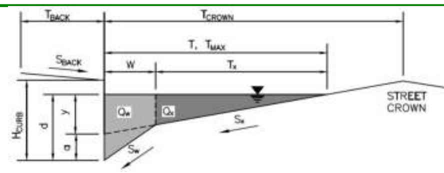
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**9.7**	**39.1**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	8.0	24.3	cfs

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)

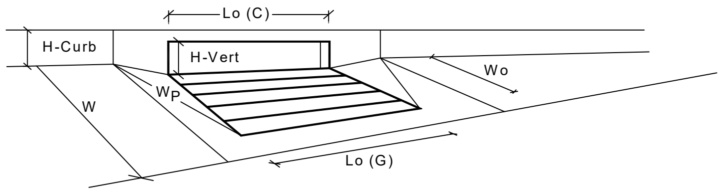
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	12.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
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)		MINOR	MAJOR	
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) =	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

Include analysis of existing inlet at DP 6 to show it still functions appropriately.

Culvert Report

Existing

DUAL 30 IN. RCP CULVERTS AT DP 1

Q100=57 cfs per summary spreadsheet

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

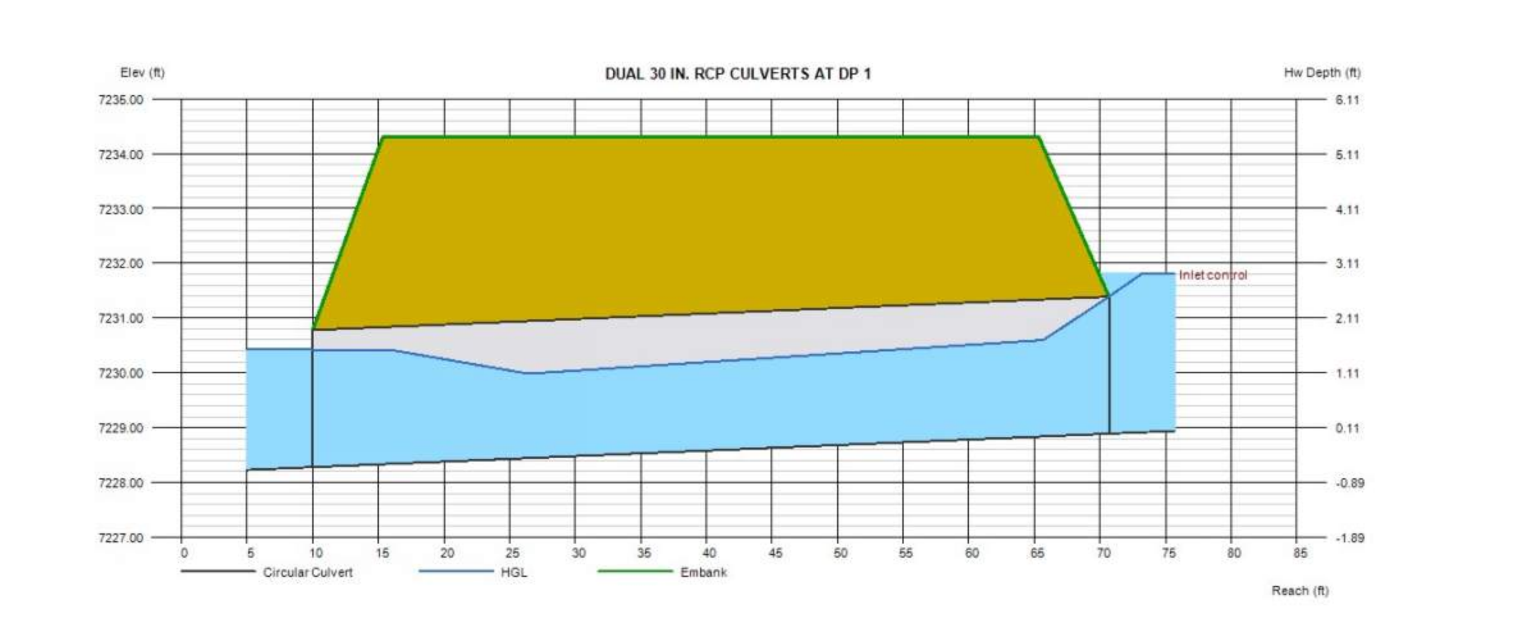
Top Elevation (ft)	= 7234.30
Top Width (ft)	= 50.00
Crest Width (ft)	= 50.00

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



Include calculations for RR outlet protection, unless installed with Filing 1. If so, please note that in report and remove reference to rr calculations in report.

Culvert Report

24 in. RCP Culvert at DP 2

Invert Elev Dn (ft)	=	7229.81
Pipe Length (ft)	=	100.12
Slope (%)	=	1.00
Invert Elev Up (ft)	=	7230.81
Rise (in)	=	24.0
Shape	=	Circular
Span (in)	=	24.0
No. Barrels	=	1
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

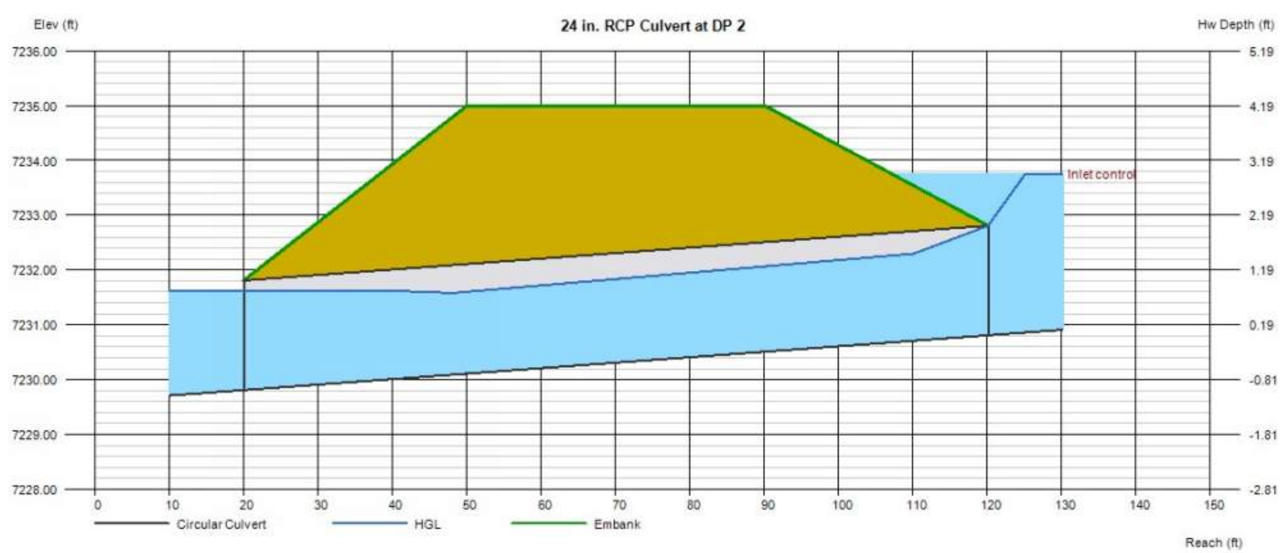
Top Elevation (ft)	=	7235.00
Top Width (ft)	=	40.00
Crest Width (ft)	=	50.00

Calculations

Qmin (cfs)	=	0.00
Qmax (cfs)	=	20.00
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

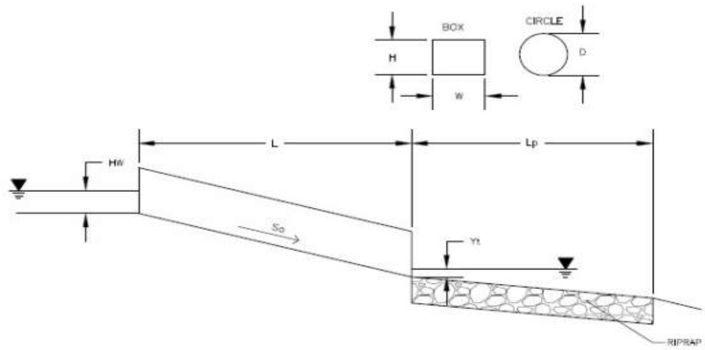
Qtotal (cfs)	=	20.00
Qpipe (cfs)	=	20.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	6.71
Veloc Up (ft/s)	=	7.40
HGL Dn (ft)	=	7231.61
HGL Up (ft)	=	7232.42
Hw Elev (ft)	=	7233.75
Hw/D (ft)	=	1.47
Flow Regime	=	Inlet Control



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.

Update invert & pipe length to match culvert calculations on previous sheet

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**	

Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. | Friday, Sep 17 2021

42 IN. RCP STORM SYSTEM AT DP 3

Invert Elev Dn (ft)	=	7218.85
Pipe Length (ft)	=	39.91
Slope (%)	=	2.88
Invert Elev Up (ft)	=	7220.00
Rise (in)	=	42.0
Shape	=	Circular
Span (in)	=	42.0
No. Barrels	=	1
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

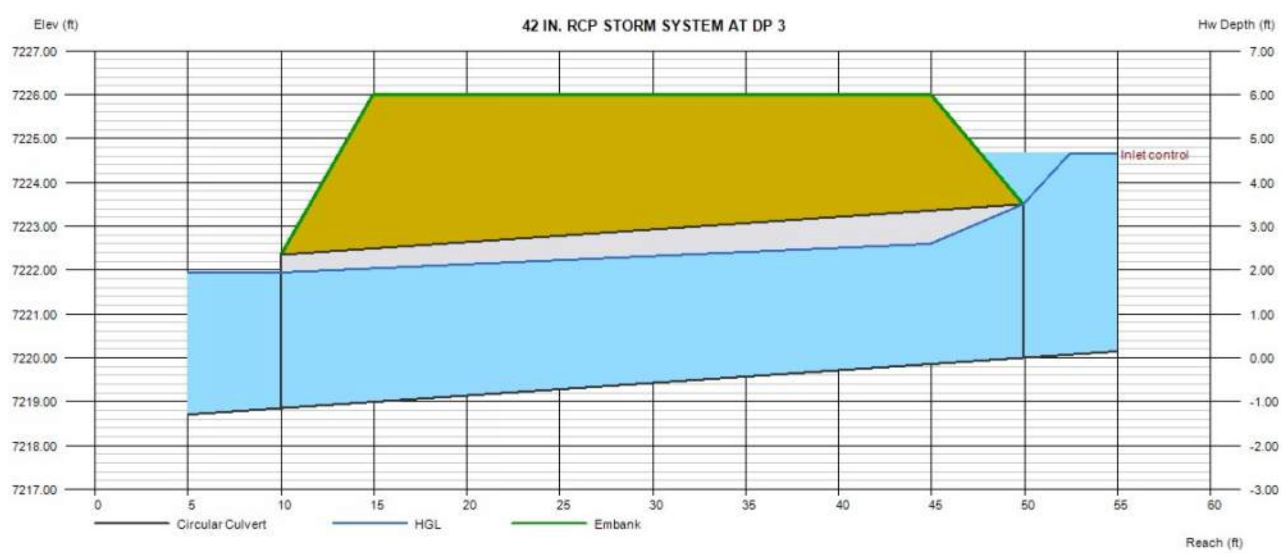
Top Elevation (ft)	=	7226.00
Top Width (ft)	=	30.00
Crest Width (ft)	=	50.00

Calculations

Qmin (cfs)	=	0.00
Qmax (cfs)	=	74.00
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	74.00
Qpipe (cfs)	=	74.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	8.22
Veloc Up (ft/s)	=	9.32
HGL Dn (ft)	=	7221.95
HGL Up (ft)	=	7222.69
Hw Elev (ft)	=	7224.65
Hw/D (ft)	=	1.33
Flow Regime	=	Inlet Control



Culvert Report

24 in. RCP Culvert at DP 4

Invert Elev Dn (ft)	=	7218.67
Pipe Length (ft)	=	8.87
Slope (%)	=	12.18
Invert Elev Up (ft)	=	7219.75
Rise (in)	=	24.0
Shape	=	Circular
Span (in)	=	24.0
No. Barrels	=	1
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

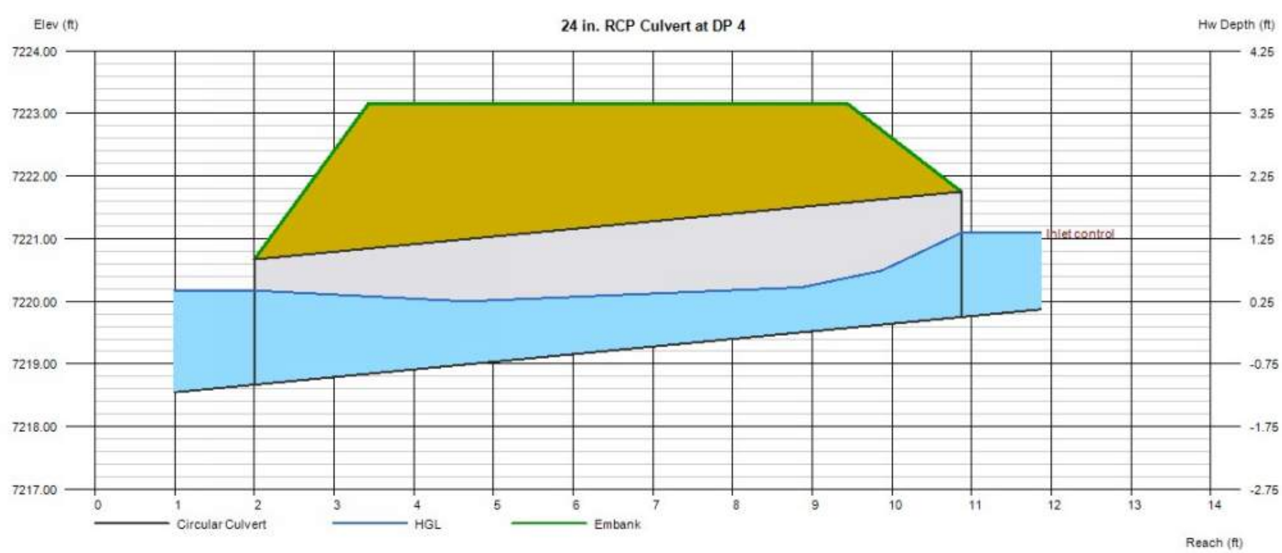
Top Elevation (ft)	=	7223.16
Top Width (ft)	=	6.00
Crest Width (ft)	=	50.00

Calculations

Qmin (cfs)	=	0.00
Qmax (cfs)	=	8.00
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	8.00
Qpipe (cfs)	=	8.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	3.16
Veloc Up (ft/s)	=	5.06
HGL Dn (ft)	=	7220.17
HGL Up (ft)	=	7220.76
Hw Elev (ft)	=	7221.10
Hw/D (ft)	=	0.67
Flow Regime	=	Inlet Control



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Sep 16 2021

Total channel depth needs to be 1.64' min (0.64' +1.0' freeboard). Please increase channel depth by 0.15'

Proposed Channel within Lot 7 - North side of Falcon Nest Ct.

Trapezoidal

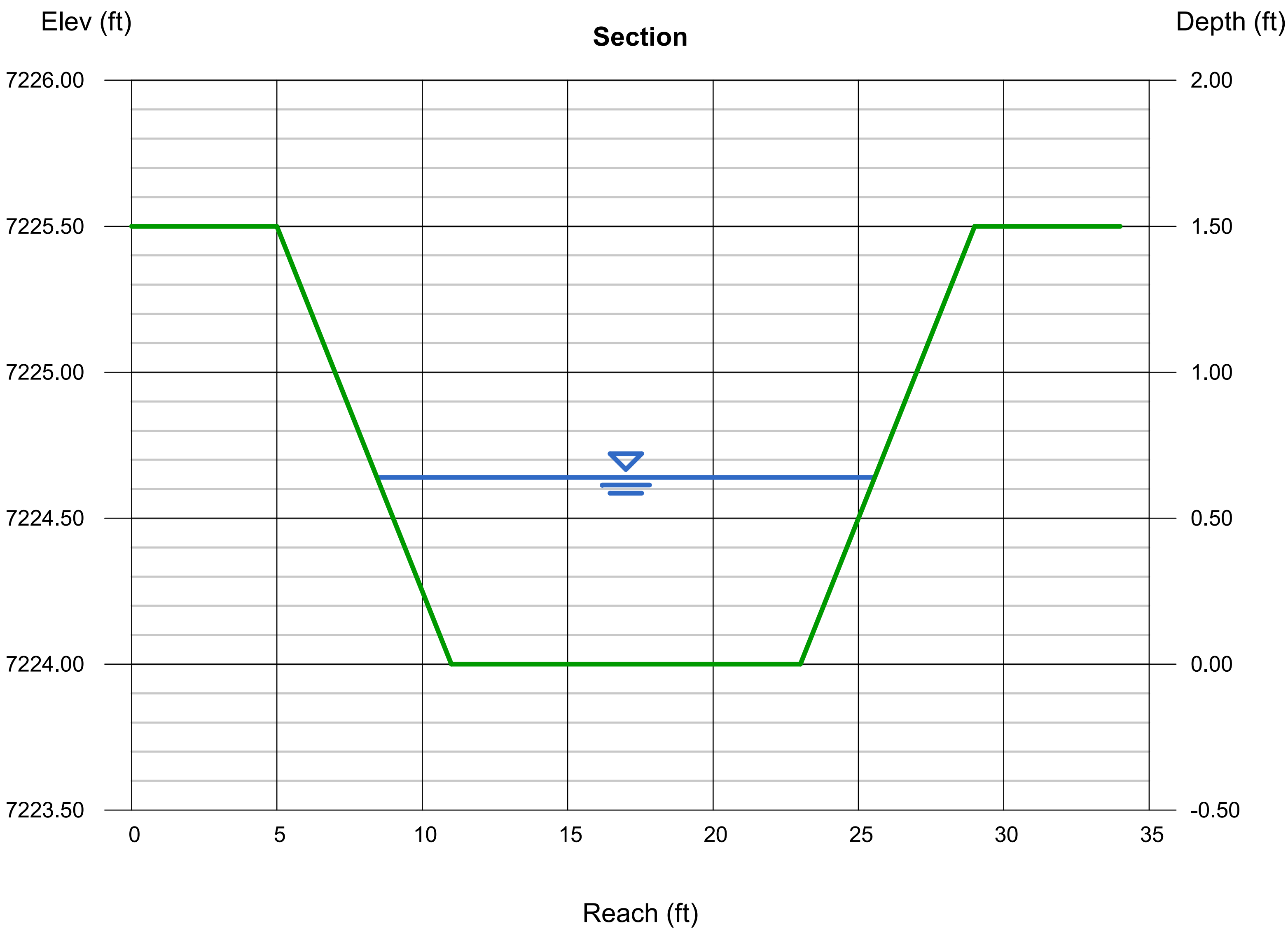
Bottom Width (ft)	=	12.00
Side Slopes (z:1)	=	4.00, 4.00
Total Depth (ft)	=	1.50
Invert Elev (ft)	=	7224.00
Slope (%)	=	6.00
N-Value	=	0.030

Calculations

Compute by:		Known Q
Known Q (cfs)	=	74.00

Highlighted

Depth (ft)	=	0.64
Q (cfs)	=	74.00
Area (sqft)	=	9.32
Velocity (ft/s)	=	7.94
Wetted Perim (ft)	=	17.28
Crit Depth, Yc (ft)	=	0.95
Top Width (ft)	=	17.12
EGL (ft)	=	1.62



DITCH CALCUALTIONS

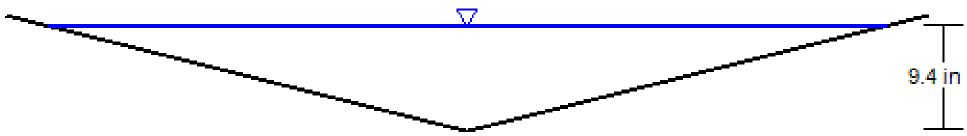
Proposed Channel within Lot 7 - North side of Falcon Nest Ct.

	Erosion Control Blanket (ECB)	**Turf Reinforcement Mat (TRM)**	**Revegetation - Grass lined**
	(North American Green - SC150)	**(North American Green - P300)**	**(Native Seed Mix)**
Given:	**(Temporary - 24 months)**	**(Permanent)**	
Design Flow (cfs)	74.0	74.0	74.0
Permissible Shear (lbs/ft.^{2})	2.0	8.0	0.1
Permissible Velocity (ft./sec.)	8.0	16.0	3.0
Safety Factor	1	1	1
Ditch Slope (Max.)	6.0%	6.0%	6.0%
Channel Section (18 in. depth	Trapezoidal -Ditch	Trapezoidal -Ditch	Trapezoidal -Ditch
12' wide bottom w/ 4:1 sides)			
Flow Area (ft.^{2})	9.32	9.32	9.32
Wetted Perimeter (ft.)	17.28	17.28	17.28
Hydraulic Radius	0.95	0.95	0.95
Mannings n	0.035	0.030	0.030
Depth of Flow (max.)	1.0	1.0	0.5
Calculations:			
Shear Stress (lbs/ft.^{2})	3.7	3.7	1.9
Velocity (ft./sec.)	7.9	7.9	7.9
Allowed Flow (cfs)	93.9	109.6	109.6

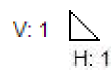
Natural Swale adjacent to Lots 43-54 (24" depth)

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.040 ft/ft
Normal Depth	9.4 in
Left Side Slope	4.000 H:V
Right Side Slope	4.000 H:V
Discharge	11.00 cfs



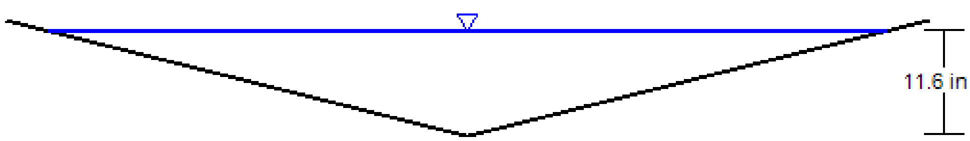
What is velocity in swale? Any lining any needed?



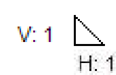
Natural Swale adjacent to Lots 54-60 (24" Depth)

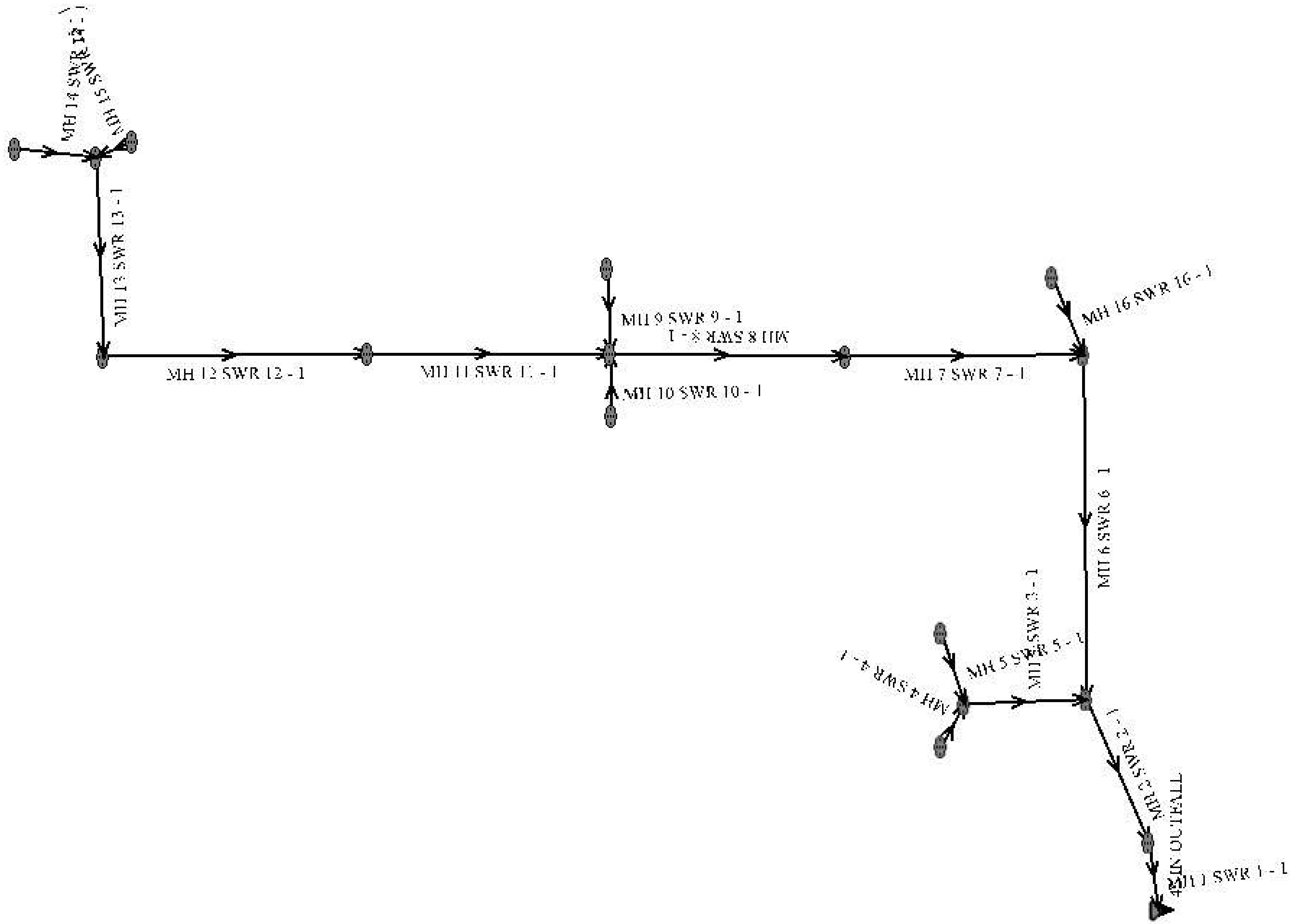
Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.025 ft/ft
Normal Depth	11.6 in
Left Side Slope	4.000 H:V
Right Side Slope	4.000 H:V
Discharge	15.00 cfs



What is velocity in swale? Any lining any needed?




MH 14 SWR
MH 15 SWR 15 - 1
MH 13 SWR 13 - 1
MH 12 SWR 12 - 1
MH 11 SWR 11 - 1
MH 9 SWR 9 - 1
MH 8 SWR 8 - 1
MH 10 SWR 10 - 1
MH 7 SWR 7 - 1
MH 16 SWR 16 - 1
MH 6 SWR 6 - 1
MH 3 SWR 3 - 1
MH 5 SWR 5 - 1
MH 4 SWR 4 - 1
MH 2 SWR 2 - 1
IN OUTFALL
MH 1 SWR 1 - 1

42” RCP Storm System into Exist. Pond 2 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

Manhole Input Summary:

		Given Flow		Sub Basin Information						
Element Name	**Ground Elevation (ft)**	**Total Known Flow (cfs)**	**Local Contribution (cfs)**	**Drainage Area (Ac.)**	**Runoff Coefficient**	**5yr Coefficient**	**Overland Length (ft)**	**Overland Slope (%)**	**Gutter Length (ft)**	**Gutter Velocity (fps)**
42 IN OUTFALL	7166.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 1 SWR 1 - 1	7173.70	85.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 2 SWR 2 - 1	7185.90	85.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 6 SWR 6 - 1	7200.24	64.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 7 SWR 7 - 1	7213.98	59.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 8 SWR 8 - 1	7217.86	59.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 11 SWR 11 - 1	7222.82	47.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 12 SWR 12 - 1	7227.77	47.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 13 SWR 13 - 1	7227.05	47.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 14 SWR 14 - 1	7227.30	39.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 15 SWR 15 - 1	7227.30	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

MH 9 SWR 9 - 1	7218.18	13.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 10 SWR 10 - 1	7218.18	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 16 SWR 16 - 1	7201.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 3 SWR 3 - 1	7185.51	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 5 SWR 5 - 1	7185.81	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 4 SWR 4 - 1	7185.81	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Manhole Output Summary:

	Local Contribution					Total Design Flow				
Element Name	**Overland Time (min)**	**Gutter Time (min)**	**Basin Tc (min)**	**Intensity (in/hr)**	**Local Contrib (cfs)**	**Coeff. Area**	**Intensity (in/hr)**	**Manhole Tc (min)**	**Peak Flow (cfs)**	**Comment**
42 IN OUTFALL	0.00	0.00	0.00	0.00	0.00	926.95	0.09	0.05	85.00	Surface Water Present (Upstream)
MH 1 SWR 1 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85.00	Surface Water Present (Downstream)
MH 2 SWR 2 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85.00	
MH 6 SWR 6 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64.00	
MH 7 SWR 7 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.00	
MH 8 SWR 8 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.00	
MH 11 SWR 11 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.00	

MH 12 SWR 12 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.00	
MH 13 SWR 13 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.00	
MH 14 SWR 14 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	39.00	
MH 15 SWR 15 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	
MH 9 SWR 9 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.00	
MH 10 SWR 10 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	
MH 16 SWR 16 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	
MH 3 SWR 3 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00	
MH 5 SWR 5 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.00	
MH 4 SWR 4 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	

Sewer Input Summary:

		Elevation			Loss Coefficients			Given Dimensions		
Element Name	Sewer Length (ft)	Downstream Invert (ft)	Slope (%)	Upstream Invert (ft)	Mannings n	Bend Loss	Lateral Loss	Cross Section	Rise (ft or in)	Span (ft or in)
MH 1 SWR 1 - 1	28.00	7164.75	2.0	7165.31	0.013	0.03	1.00	CIRCULAR	42.00 in	42.00 in
MH 2 SWR 2 - 1	104.10	7165.30	12.2	7178.00	0.013	0.08	1.00	CIRCULAR	42.00 in	42.00 in
MH 6 SWR 6 - 1	364.39	7178.50	4.1	7193.40	0.013	0.08	1.00	CIRCULAR	36.00 in	36.00 in
MH 7 SWR 7 - 1	515.53	7194.90	2.4	7207.41	0.013	1.32	1.00	CIRCULAR	36.00 in	36.00 in
MH 8 SWR 8 - 1	349.50	7207.91	1.0	7211.40	0.013	0.05	1.00	CIRCULAR	36.00 in	36.00 in
MH 11 SWR 11 - 1	200.72	7211.90	2.0	7215.89	0.013	0.05	1.00	CIRCULAR	36.00 in	36.00 in
MH 12 SWR 12 - 1	303.78	7216.38	1.0	7219.42	0.013	0.05	1.00	CIRCULAR	36.00 in	36.00 in
MH 13 SWR 13 - 1	82.55	7219.92	1.0	7220.75	0.013	1.32	1.00	CIRCULAR	36.00 in	36.00 in
MH 14 SWR 14 - 1	26.28	7221.25	1.0	7221.51	0.013	1.06	0.00	CIRCULAR	30.00 in	30.00 in
MH 15 SWR 15 - 1	4.82	7221.75	7.1	7222.09	0.013	0.83	0.00	CIRCULAR	24.00 in	24.00 in
MH 9 SWR 9 - 1	26.17	7212.42	1.9	7212.92	0.013	1.32	0.00	CIRCULAR	24.00 in	24.00 in
MH 10 SWR 10 - 1	4.17	7212.93	13.3	7213.48	0.013	1.32	0.00	CIRCULAR	18.00 in	18.00 in
MH 16 SWR 16 - 1	48.28	7195.90	1.0	7196.37	0.013	0.08	0.00	CIRCULAR	24.00 in	24.00 in
MH 3 SWR 3 - 1	41.27	7179.01	1.0	7179.42	0.013	0.83	0.00	CIRCULAR	30.00 in	30.00 in
MH 5 SWR 5 - 1	25.52	7179.91	2.4	7180.52	0.013	0.83	0.00	CIRCULAR	30.00 in	30.00 in
MH 4 SWR 4 - 1	6.86	7180.86	10.8	7181.60	0.013	0.63	0.00	CIRCULAR	18.00 in	18.00 in

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	135.24	19.13	30.83	9.93	17.43	18.87	3.13	Supercritical	64.00	0.00	Velocity is Too High
MH 7 SWR 7 - 1	104.18	14.74	29.80	9.43	19.39	15.20	2.35	Supercritical	59.00	0.00	
MH 8 SWR 8 - 1	66.83	9.45	29.80	9.43	26.28	10.67	1.31	Supercritical	59.00	0.00	
MH 11 SWR 11 - 1	94.29	13.34	26.79	8.33	17.97	13.33	2.17	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	

-Velocities are higher than the allowed 18 fps.

-Pressure pipe-look at upsizing pipe size

-Pressure pipe-look at upsizing pipe size

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	22.39	7.13	12.08	5.05	9.91	6.53	1.46	Supercritical	8.00	0.00	
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.

Sewer Sizing Summary:

			Existing		Calculated		Used			
Element Name	**Peak Flow (cfs)**	**Cross Section**	**Rise**	**Span**	**Rise**	**Span**	**Rise**	**Span**	**Area (ft^2)**	**Comment**
MH 1 SWR 1 - 1	85.00	CIRCULAR	42.00 in	42.00 in	36.00 in	36.00 in	42.00 in	42.00 in	9.62	
MH 2 SWR 2 - 1	85.00	CIRCULAR	42.00 in	42.00 in	27.00 in	27.00 in	42.00 in	42.00 in	9.62	
MH 6 SWR 6 - 1	64.00	CIRCULAR	36.00 in	36.00 in	30.00 in	30.00 in	36.00 in	36.00 in	7.07	

MH 7 SWR 7 - 1	59.00	CIRCULAR	36.00 in	36.00 in	30.00 in	30.00 in	36.00 in	36.00 in	7.07	
MH 8 SWR 8 - 1	59.00	CIRCULAR	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	7.07	
MH 11 SWR 11 - 1	47.00	CIRCULAR	36.00 in	36.00 in	30.00 in	30.00 in	36.00 in	36.00 in	7.07	
MH 12 SWR 12 - 1	47.00	CIRCULAR	36.00 in	36.00 in	33.00 in	33.00 in	36.00 in	36.00 in	7.07	
MH 13 SWR 13 - 1	47.00	CIRCULAR	36.00 in	36.00 in	33.00 in	33.00 in	36.00 in	36.00 in	7.07	
MH 14 SWR 14 - 1	39.00	CIRCULAR	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	4.91	
MH 15 SWR 15 - 1	10.00	CIRCULAR	24.00 in	24.00 in	18.00 in	18.00 in	24.00 in	24.00 in	3.14	
MH 9 SWR 9 - 1	13.00	CIRCULAR	24.00 in	24.00 in	18.00 in	18.00 in	24.00 in	24.00 in	3.14	
MH 10 SWR 10 - 1	4.00	CIRCULAR	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	1.77	
MH 16 SWR 16 - 1	8.00	CIRCULAR	24.00 in	24.00 in	18.00 in	18.00 in	24.00 in	24.00 in	3.14	
MH 3 SWR 3 - 1	25.00	CIRCULAR	30.00 in	30.00 in	27.00 in	27.00 in	30.00 in	30.00 in	4.91	
MH 5 SWR 5 - 1	23.00	CIRCULAR	30.00 in	30.00 in	21.00 in	21.00 in	30.00 in	30.00 in	4.91	
MH 4 SWR 4 - 1	3.00	CIRCULAR	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	1.77	

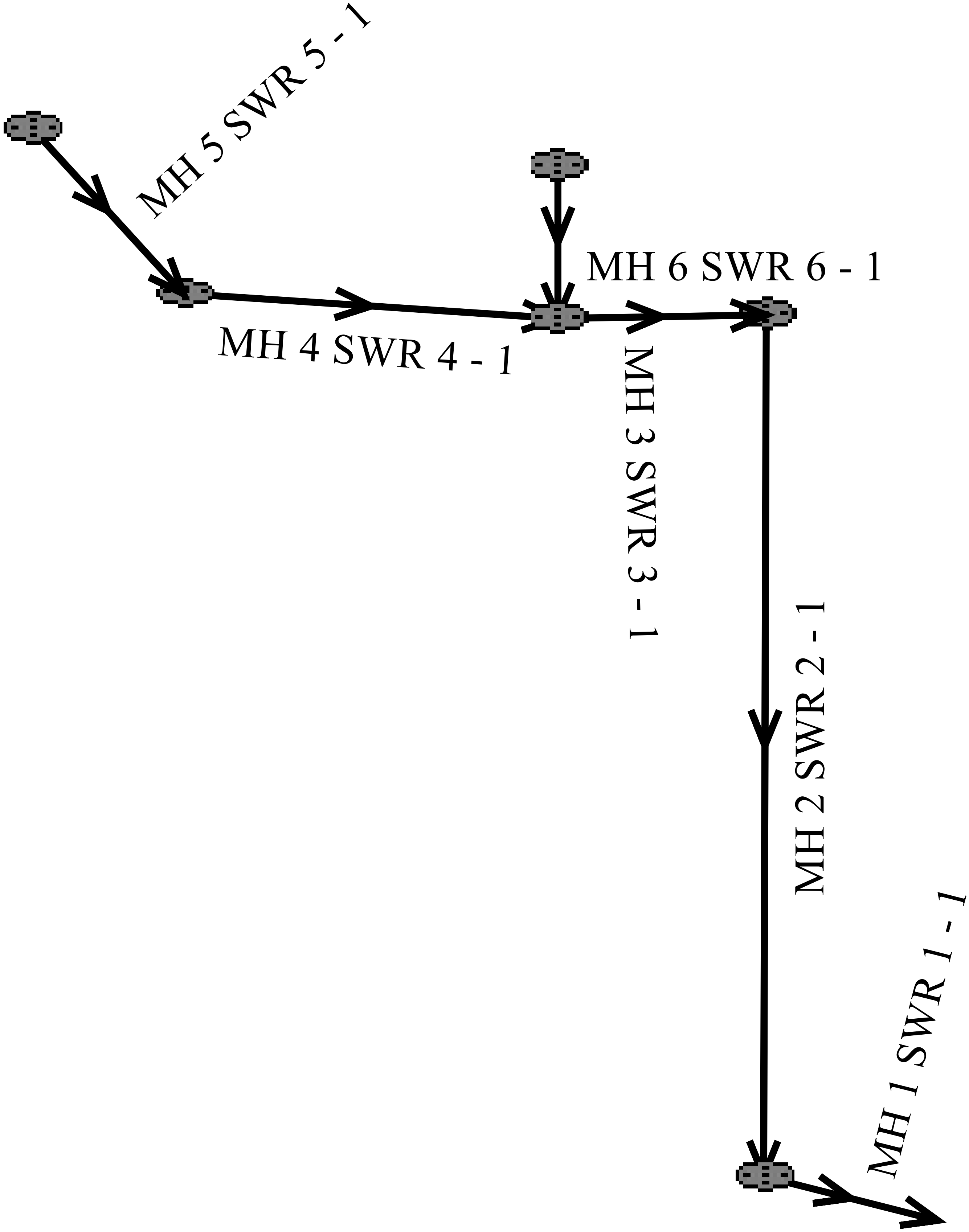
- Calculated diameter was determined by sewer hydraulic capacity rounded up to the nearest commercially available size.
- Sewer sizes should not decrease downstream.
- All hydraulics where calculated using the 'Used' parameters.

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	7178.50	7193.40	0.10	0.00	7180.97	7195.97	7185.48	12.02	7197.50
MH 7 SWR 7 - 1	7194.90	7207.41	1.43	0.19	7197.59	7209.89	7200.10	11.17	7211.27
MH 8 SWR 8 - 1	7207.91	7211.40	0.05	0.00	7210.10	7213.88	7211.87	3.40	7215.26
MH 11 SWR 11 - 1	7211.90	7215.89	0.03	0.40	7214.31	7218.12	7216.16	3.04	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	7215.35	7215.44	7215.62	0.09	7215.70
MH 10 SWR 10 - 1	7212.93	7213.48	0.11	0.00	7213.99	7216.24	7216.32	0.00	7216.32
MH 16 SWR 16 - 1	7195.90	7196.37	0.01	0.00	7196.65	7197.38	7197.51	0.26	7197.77
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

- Bend and Lateral losses only apply when there is an outgoing sewer. The system outfall, sewer #0, is not considered a sewer.
- Bend loss = Bend K * V_fi ^ 2/(2*g)
- Lateral loss = V_fo ^ 2/(2*g)- Junction Loss K * V_fi ^ 2/(2*g).
- Friction loss is always Upstream EGL - Downstream EGL.


MH 5 SWR 5 - 1
MH 6 SWR 6 - 1
MH 4 SWR 4 - 1
MH 3 SWR 3 - 1
MH 2 SWR 2 - 1
MH 1 SWR 1 - 1

42” Storm System Outfall to Pond 3 – 100 yr. HGL

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): 7206.60

Manhole Input Summary:

		Given Flow		Sub Basin Information						
Element Name	**Ground Elevation (ft)**	**Total Known Flow (cfs)**	**Local Contribution (cfs)**	**Drainage Area (Ac.)**	**Runoff Coefficient**	**5yr Coefficient**	**Overland Length (ft)**	**Overland Slope (%)**	**Gutter Length (ft)**	**Gutter Velocity (fps)**
42 IN OUTFALL TO POND 3	7166.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 1 SWR 1 - 1	7210.13	79.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 2 SWR 2 - 1	7216.19	79.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 3 SWR 3 - 1	7223.16	79.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 6 SWR 6 - 1	7223.16	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 4 SWR 4 - 1	7226.04	74.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 5 SWR 5 - 1	7224.50	74.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Manhole Output Summary:

	Local Contribution					Total Design Flow				
Element Name	**Overland Time (min)**	**Gutter Time (min)**	**Basin Tc (min)**	**Intensity (in/hr)**	**Local Contrib (cfs)**	**Coeff. Area**	**Intensity (in/hr)**	**Manhole Tc (min)**	**Peak Flow (cfs)**	**Comment**
42 IN OUTFALL TO POND 3	0.00	0.00	0.00	0.00	0.00	813.49	0.10	0.06	79.00	Surface Water Present (Upstream)
MH 1 SWR 1 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	79.00	Surface Water Present (Downstream)
MH 2 SWR 2 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	79.00	Surface Water Present (Upstream)
MH 3 SWR 3 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	79.00	Surface Water Present (Downstream)
MH 6 SWR 6 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	
MH 4 SWR 4 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	74.00	
MH 5 SWR 5 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	74.00	

Sewer Input Summary:

		Elevation			Loss Coefficients			Given Dimensions		
Element Name	**Sewer Length (ft)**	**Downstream Invert (ft)**	**Slope (%)**	**Upstream Invert (ft)**	**Mannings n**	**Bend Loss**	**Lateral Loss**	**Cross Section**	**Rise (ft or in)**	**Span (ft or in)**
MH 1 SWR 1 - 1	27.56	7203.00	1.0	7203.28	0.013	0.03	1.00	CIRCULAR	42.00 in	42.00 in
MH 2 SWR 2 - 1	444.75	7203.78	2.4	7214.52	0.013	0.73	1.00	CIRCULAR	42.00 in	42.00 in

MH 3 SWR 3 - 1	165.46	7215.02	1.0	7216.67	0.013	1.32	1.00	CIRCULAR	42.00 in	42.00 in
MH 6 SWR 6 - 1	8.87	7218.67	12.2	7219.75	0.013	1.32	0.00	CIRCULAR	24.00 in	24.00 in
MH 4 SWR 4 - 1	117.35	7217.17	1.0	7218.35	0.013	0.63	1.00	CIRCULAR	42.00 in	42.00 in
MH 5 SWR 5 - 1	39.91	7218.85	2.9	7220.00	0.013	0.05	1.00	CIRCULAR	42.00 in	42.00 in

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	100.88	10.49	33.33	9.65	27.98	11.60	1.42	Supercritical Jump	79.00	24.72	
MH 2 SWR 2 - 1	156.77	16.29	33.33	9.65	21.10	16.33	2.45	Supercritical Jump	79.00	13.10	
MH 3 SWR 3 - 1	100.88	10.49	33.33	9.65	27.98	11.60	1.42	Supercritical Jump	79.00	145.49	
MH 6 SWR 6 - 1	79.15	25.20	12.08	5.05	5.15	16.16	5.19	Supercritical	8.00	0.00	
MH 4 SWR 4 - 1	101.17	10.52	32.32	9.31	26.67	11.48	1.46	Supercritical Jump	74.00	29.05	
MH 5 SWR 5 - 1	171.24	17.80	32.32	9.31	19.30	17.15	2.72	Supercritical	74.00	0.00	

- 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.

Sewer Sizing Summary:

			Existing		Calculated		Used			
Element Name	Peak Flow (cfs)	Cross Section	Rise	Span	Rise	Span	Rise	Span	Area (ft^2)	Comment
MH 1 SWR 1 - 1	79.00	CIRCULAR	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	9.62	
MH 2 SWR 2 - 1	79.00	CIRCULAR	42.00 in	42.00 in	33.00 in	33.00 in	42.00 in	42.00 in	9.62	
MH 3 SWR 3 - 1	79.00	CIRCULAR	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	9.62	
MH 6 SWR 6 - 1	8.00	CIRCULAR	24.00 in	24.00 in	18.00 in	18.00 in	24.00 in	24.00 in	3.14	
MH 4 SWR 4 - 1	74.00	CIRCULAR	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	9.62	
MH 5 SWR 5 - 1	74.00	CIRCULAR	42.00 in	42.00 in	33.00 in	33.00 in	42.00 in	42.00 in	9.62	

- Calculated diameter was determined by sewer hydraulic capacity rounded up to the nearest commercially available size.
- Sewer sizes should not decrease downstream.
- All hydraulics where calculated using the 'Used' parameters.

Grade Line Summary:

Tailwater Elevation (ft): 7206.60

	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	7203.00	7203.28	0.00	0.00	7206.60	7206.75	7207.65	0.15	7207.80
MH 2 SWR 2 - 1	7203.78	7214.52	0.76	0.00	7207.52	7217.30	7208.56	10.18	7218.74
MH 3 SWR 3 - 1	7215.02	7216.67	1.38	0.00	7219.08	7219.88	7220.12	0.89	7221.02
MH 6 SWR 6 - 1	7218.67	7219.75	0.13	0.00	7220.02	7223.05	7223.15	0.00	7223.15
MH 4 SWR 4 - 1	7217.17	7218.35	0.58	0.13	7220.81	7221.04	7221.72	0.67	7222.39
MH 5 SWR 5 - 1	7218.85	7220.00	0.05	0.00	7221.09	7224.11	7225.03	0.00	7225.03

- Bend and Lateral losses only apply when there is an outgoing sewer. The system outfall, sewer #0, is not considered a sewer.
- Bend loss = Bend K * V_fi ^ 2/(2*g)
- Lateral loss = V_fo ^ 2/(2*g)- Junction Loss K * V_fi ^ 2/(2*g).
- Friction loss is always Upstream EGL - Downstream EGL.

Description

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.

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

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.

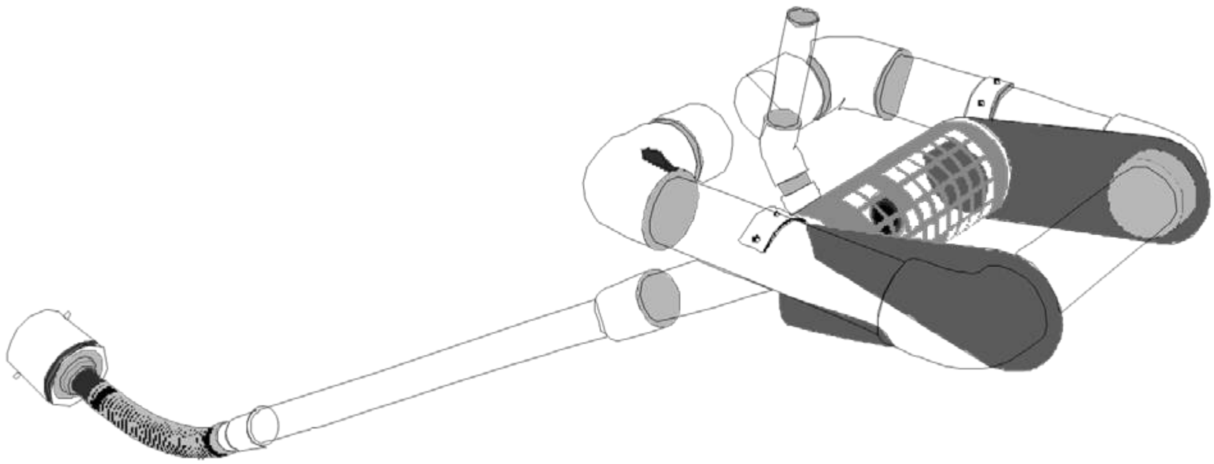


Illustration SB-1. Outlet structure for a temporary sediment basin - Faircloth Skimmer Floating Outlet. Illustration courtesy of J. W. Faircloth & Sons, Inc., FairclothSkimmer.com.

- **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.

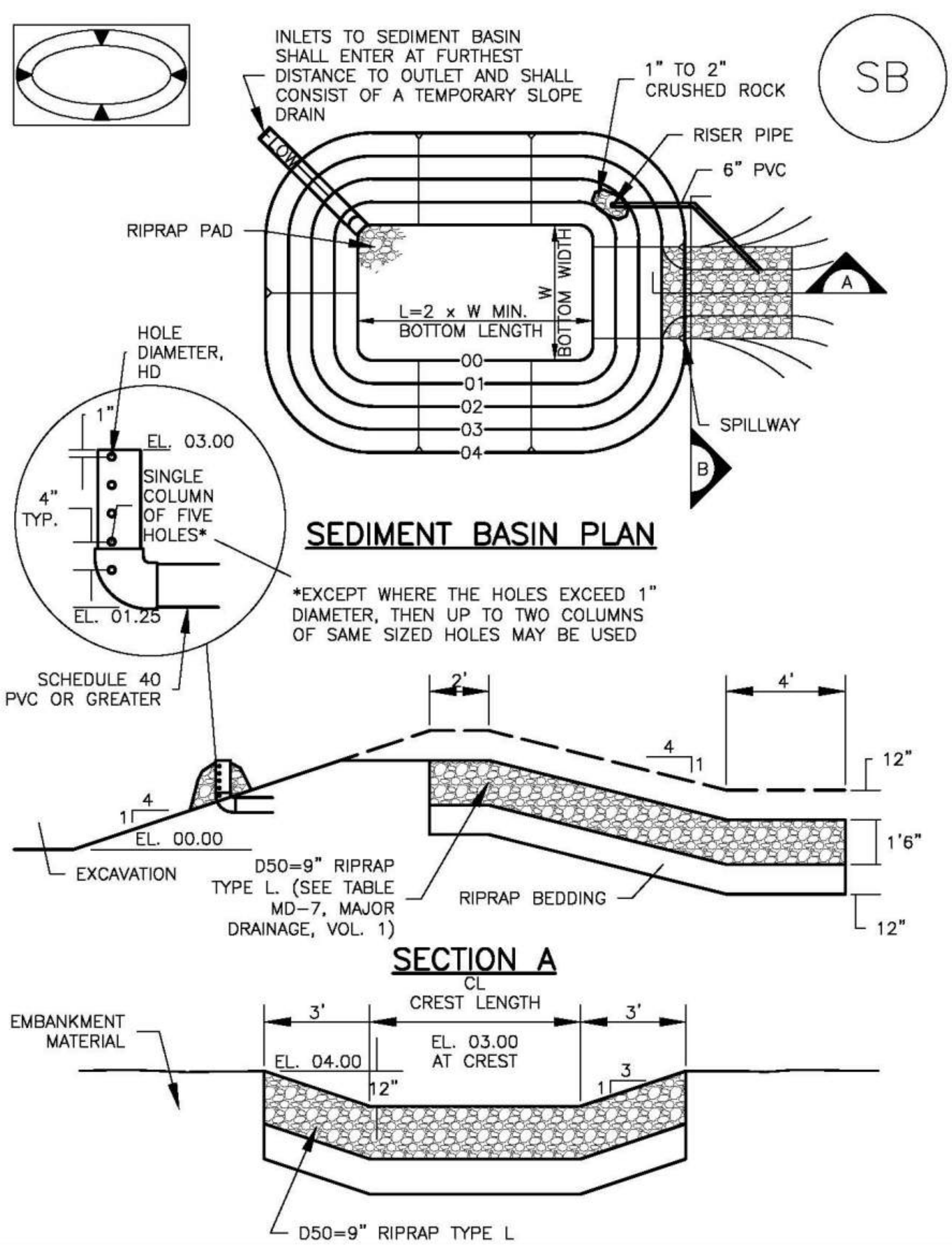

INLETS TO SEDIMENT BASIN SHALL ENTER AT FURTHEST DISTANCE TO OUTLET AND SHALL CONSIST OF A TEMPORARY SLOPE DRAIN
1" TO 2" CRUSHED ROCK
SB
RISER PIPE
6" PVC
FLOW
RIPRAP PAD
BOTTOM WIDTH
W
L=2 x W MIN.
BOTTOM LENGTH
A
00
01
02
03
04
SPILLWAY
B
HOLE DIAMETER, HD
1"
EL. 03.00
SINGLE COLUMN OF FIVE HOLES*
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"
1
4
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

CLASSIC
CONSULTING
ENGINEERS & SURVEYORS

Design Procedure Form: Extended Detention Basin (EDB)

UD-BMP (Version 3.07, March 2018)

Designer: Marc A. Whorton, P.E.
Company: Classic Consulting
Date: September 14, 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 = 12.6 %
B) Tributary Area's Imperviousness Ratio ($i = I_a / 100$)	i = 0.126
C) Contributing Watershed Area	Area = 58.300 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 ($V_{WQCV\ OTHER} = (d_6*(V_{DESIGN}/0.43))$)	$V_{DESIGN\ OTHER}$= 0.385 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: $EURV_{C/D} = 1.20 * i^{1.08}$	$EURV_{DESIGN}$ = 0.705 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} = 0.012 ac-ft
B) Actual Forebay Volume	V_F = 0.012 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} = 79.00 cfs
ii) Forebay Discharge Design Flow ($Q_F = 0.02 * Q_{100}$)	Q_F = 1.58 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 = 6.7 in

Design Procedure Form: Extended Detention Basin (EDB)

Designer: Marc A. Whorton, P.E.
Company: Classic Consulting
Date: September 14, 2021
Project: Retreat at TimberRidge Filing No. 2
Location: Pond 3

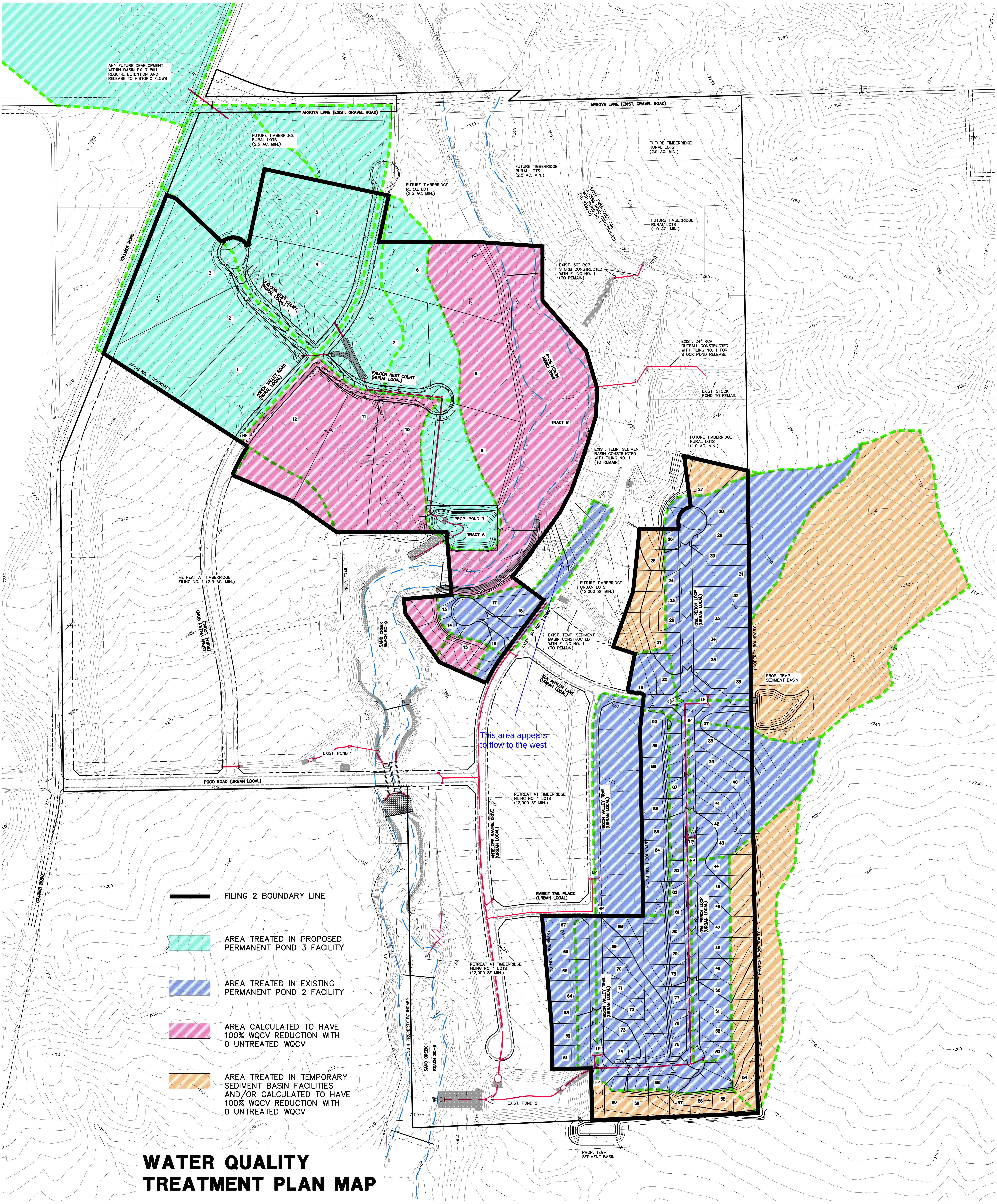
6. Trickle Channel	
A) Type of Trickle Channel	Choose One: (●) Concrete ( ) Soft Bottom
F) Slope of Trickle Channel	S = 0.0100 ft / ft
7. Micropool and Outlet Structure	
A) Depth of Micropool (2.5-feet minimum)	D_M = 2.5 ft
B) Surface Area of Micropool (10 ft^2 minimum)	A_M = 115 sq ft
C) Outlet Type	Choose One: (●) Orifice Plate ( ) Other (Describe):
D) Smallest Dimension of Orifice Opening Based on Hydrograph Routing (Use UD-Detention)	$D_{orifice}$ = 1.24 inches
E) Total Outlet Area	A_{ot} = 3.94 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} = 50 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 = 135 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	*S.S. Well Screen with 60% Open Area*
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} = 225 sq. in.
E) Depth of Design Volume (EURV or WQCV) (Based on design concept chosen under 1E)	H= 4.8 feet
F) Height of Water Quality Screen (H_{TR})	H_{TR}= 85.6 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:	**September 14, 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:



WATER QUALITY TREATMENT PLAN MAP

provide a figure showing all proposed UIA and RPA areas to be utilized for runoff reduction. All RPA areas will need to be within a no build/drainage easement and discussed in the maintenance agreement and O&M Manual.

Design Procedure Form: Runoff Reduction

UD-BMP (Version 3.07, March 2018)

Designer: Marc A. Whorton, P.E.
Company: Classic Consulting
Date: September 16, 2021
Project: Retreat at TimberRidge Filing No. 2
Location: BASIN E1

SITE INFORMATION (User Input in Blue Cells)

WQCV Rainfall Depth: 0.53 inches

Depth of Average Runoff Producing Storm, d_6 = 0.42 inches (for Watersheds Outside of the Denver Region, Figure 3-1 in USDCM Vol. 3)

Area Type	UIA:RPA	UIA:RPA	SPA
Area ID	ROADWAY	HOUSES	YARDS
Downstream Design Point ID	SC	SC	SC
Downstream BMP Type	None	None	None
DCIA (ft^2)	--	--	--
UIA (ft^2)	17,135	11,800	--
RPA (ft^2)	34,000	38,000	--
SPA (ft^2)	--	--	208,341
HSG A (%)	0%	0%	0%
HSG B (%)	100%	100%	100%
HSG C/D (%)	0%	0%	0%
Average Slope of RPA (ft/ft)	0.030	0.060	--
UIA:RPA Interface Width (ft)	60.00	70.00	--

CALCULATED RUNOFF RESULTS

Area ID	ROADWAY	HOUSES	YARDS
UIA:RPA Area (ft^2)	51,135	49,800	--
L / W Ratio	14.20	10.16	--
UIA / Area	0.3351	0.2369	--
Runoff (in)	0.00	0.00	0.00
Runoff (ft^3)	0	0	0
Runoff Reduction (ft^3)	614	423	9202

CALCULATED WQCV RESULTS

Area ID	ROADWAY	HOUSES	YARDS
WQCV (ft^3)	697	480	0
WQCV Reduction (ft^3)	697	480	0
WQCV Reduction (%)	100%	100%	0%
Untreated WQCV (ft^3)	0	0	0

CALCULATED DESIGN POINT RESULTS (sums results from all columns with the same Downstream Design Point ID)

Downstream Design Point ID	SC
DCIA (ft^2)	0
UIA (ft^2)	28,935
RPA (ft^2)	72,000
SPA (ft^2)	208,341
Total Area (ft^2)	309,276
Total Impervious Area (ft^2)	28,935
WQCV (ft^3)	1,178
WQCV Reduction (ft^3)	1,178
WQCV Reduction (%)	100%
Untreated WQCV (ft^3)	0

CALCULATED SITE RESULTS (sums results from all columns in worksheet)

Total Area (ft^2)	309,276
Total Impervious Area (ft^2)	28,935
WQCV (ft^3)	1,178
WQCV Reduction (ft^3)	1,178
WQCV Reduction (%)	100%
Untreated WQCV (ft^3)	0

Design Procedure Form: Runoff Reduction

UD-BMP (Version 3.07, March 2018)

Designer: Marc A. Whorton, P.E.
Company: Classic Consulting
Date: September 16, 2021
Project: Retreat at TimberRidge Filing No. 2
Location: BASIN F (Lots 8 & 9)

SITE INFORMATION (User Input in Blue Cells)

WQCV Rainfall Depth: 0.53 inches

Depth of Average Runoff Producing Storm, d_6 = 0.42 inches (for Watersheds Outside of the Denver Region, Figure 3-1 in USDCM Vol. 3)

Area Type	UIA:RPA	SPA									
Area ID	HOUSES	YARDS									
Downstream Design Point ID	SC	SC									
Downstream BMP Type	None	None									
DCIA (ft^2)	--	--									
UIA (ft^2)	4,750	--									
RPA (ft^2)	28,000	--									
SPA (ft^2)	--	498,682									
HSG A (%)	0%	0%									
HSG B (%)	100%	100%									
HSG C/D (%)	0%	0%									
Average Slope of RPA (ft/ft)	0.030	--									
UIA:RPA Interface Width (ft)	70.00	--									

CALCULATED RUNOFF RESULTS

Area ID	HOUSES	YARDS									
UIA:RPA Area (ft^2)	32,750	--									
L / W Ratio	6.68	--									
UIA / Area	0.1450	--									
Runoff (in)	0.00	0.00									
Runoff (ft^3)	0	0									
Runoff Reduction (ft^3)	170	22025									

CALCULATED WQCV RESULTS

Area ID	HOUSES	YARDS									
WQCV (ft^3)	193	0									
WQCV Reduction (ft^3)	193	0									
WQCV Reduction (%)	100%	0%									
Untreated WQCV (ft^3)	0	0									

CALCULATED DESIGN POINT RESULTS (sums results from all columns with the same Downstream Design Point ID)

Downstream Design Point ID	SC										
DCIA (ft^2)	0										
UIA (ft^2)	4,750										
RPA (ft^2)	28,000										
SPA (ft^2)	498,682										
Total Area (ft^2)	531,432										
Total Impervious Area (ft^2)	4,750										
WQCV (ft^3)	193										
WQCV Reduction (ft^3)	193										
WQCV Reduction (%)	100%										
Untreated WQCV (ft^3)	0										

CALCULATED SITE RESULTS (sums results from all columns in worksheet)

Total Area (ft^2)	531,432
Total Impervious Area (ft^2)	4,750
WQCV (ft^3)	193
WQCV Reduction (ft^3)	193
WQCV Reduction (%)	100%
Untreated WQCV (ft^3)	0

Design Procedure Form: Runoff Reduction

UD-BMP (Version 3.07, March 2018)

Designer: Marc A. Whorton, P.E.
Company: Classic Consulting
Date: September 16, 2021
Project: Retreat at TimberRidge Filing No. 2
Location: BASIN K (Lots 21-26 rear yards)

SITE INFORMATION (User Input in Blue Cells)

WQCV Rainfall Depth: 0.53 inches

Depth of Average Runoff Producing Storm, d_6 = 0.42 inches (for Watersheds Outside of the Denver Region, Figure 3-1 in USDCM Vol. 3)

Area Type	UIA:RPA
Area ID	K
Downstream Design Point ID	Sed. Basin
Downstream BMP Type	None
DCIA (ft^2)	--
UIA (ft^2)	12,600
RPA (ft^2)	45,000
SPA (ft^2)	--
HSG A (%)	0%
HSG B (%)	100%
HSG C/D (%)	0%
Average Slope of RPA (ft/ft)	0.040
UIA:RPA Interface Width (ft)	70.00

CALCULATED RUNOFF RESULTS

Area ID	K
UIA:RPA Area (ft^2)	57,600
L / W Ratio	11.76
UIA / Area	0.2188
Runoff (in)	0.00
Runoff (ft^3)	0
Runoff Reduction (ft^3)	452

CALCULATED WQCV RESULTS

Area ID	K
WQCV (ft^3)	513
WQCV Reduction (ft^3)	513
WQCV Reduction (%)	100%
Untreated WQCV (ft^3)	0

CALCULATED DESIGN POINT RESULTS (sums results from all columns with the same Downstream Design Point ID)

Downstream Design Point ID	Sed. Basin
DCIA (ft^2)	0
UIA (ft^2)	12,600
RPA (ft^2)	45,000
SPA (ft^2)	0
Total Area (ft^2)	57,600
Total Impervious Area (ft^2)	12,600
WQCV (ft^3)	513
WQCV Reduction (ft^3)	513
WQCV Reduction (%)	100%
Untreated WQCV (ft^3)	0

CALCULATED SITE RESULTS (sums results from all columns in worksheet)

Total Area (ft^2)	57,600
Total Impervious Area (ft^2)	12,600
WQCV (ft^3)	513
WQCV Reduction (ft^3)	513
WQCV Reduction (%)	100%
Untreated WQCV (ft^3)	0

Design Procedure Form: Runoff Reduction

UD-BMP (Version 3.07, March 2018)

Designer:	**Marc A. Whorton, P.E.**
Company:	**Classic Consulting**
Date:	**September 16, 2021**
Project:	**Retreat at TimberRidge Filing No. 2**
Location:	**BASINS H1, H2, I (Lots 13-16 rear yards)**

SITE INFORMATION (User Input in Blue Cells)

WQCV Rainfall Depth: 0.53 inches

Depth of Average Runoff Producing Storm, d_6 = 0.42 inches (for Watersheds Outside of the Denver Region, Figure 3-1 in USDCM Vol. 3)

Area Type	UIA:RPA	UIA:RPA	UIA:RPA
Area ID	H1	H2	I
Downstream Design Point ID	SC	SC	SC
Downstream BMP Type	None	None	None
DCIA (ft^2)	--	--	--
UIA (ft^2)	4,000	3,000	2,500
RPA (ft^2)	13,000	12,000	10,000
SPA (ft^2)	--	--	--
HSG A (%)	0%	0%	0%
HSG B (%)	100%	100%	100%
HSG C/D (%)	0%	0%	0%
Average Slope of RPA (ft/ft)	0.040	0.040	0.060
UIA:RPA Interface Width (ft)	180.00	90.00	50.00

CALCULATED RUNOFF RESULTS

Area ID	H1	H2	I
UIA:RPA Area (ft^2)	17,000	15,000	12,500
L / W Ratio	0.52	1.85	5.00
UIA / Area	0.2353	0.2000	0.2000
Runoff (in)	0.00	0.00	0.00
Runoff (ft^3)	0	0	0
Runoff Reduction (ft^3)	143	108	90

CALCULATED WQCV RESULTS

Area ID	H1	H2	I
WQCV (ft^3)	163	122	102
WQCV Reduction (ft^3)	163	122	102
WQCV Reduction (%)	100%	100%	100%
Untreated WQCV (ft^3)	0	0	0

CALCULATED DESIGN POINT RESULTS (sums results from all columns with the same Downstream Design Point ID)

Downstream Design Point ID	SC
DCIA (ft^2)	0
UIA (ft^2)	9,500
RPA (ft^2)	35,000
SPA (ft^2)	0
Total Area (ft^2)	44,500
Total Impervious Area (ft^2)	9,500
WQCV (ft^3)	387
WQCV Reduction (ft^3)	387
WQCV Reduction (%)	100%
Untreated WQCV (ft^3)	0

CALCULATED SITE RESULTS (sums results from all columns in worksheet)

Total Area (ft^2)	44,500
Total Impervious Area (ft^2)	9,500
WQCV (ft^3)	387
WQCV Reduction (ft^3)	387
WQCV Reduction (%)	100%
Untreated WQCV (ft^3)	0

Design Procedure Form: Runoff Reduction

UD-BMP (Version 3.07, March 2018)

Designer: Marc A. Whorton, P.E.
Company: Classic Consulting
Date: September 16, 2021
Project: Retreat at TimberRidge Filing No. 2
Location: BASINS V, W & OS-7 (Lots 43-60 rear yards)

SITE INFORMATION (User Input in Blue Cells)

WQCV Rainfall Depth: 0.53 inches

Depth of Average Runoff Producing Storm, d_6 = 0.42 inches (for Watersheds Outside of the Denver Region, Figure 3-1 in USDCM Vol. 3)

Area Type	UIA:RPA	SPA	UIA:RPA								
Area ID	V	OS-7	W								
Downstream Design Point ID	DP-15	DP-15	DP-15								
Downstream BMP Type	None	None	None								
DCIA (ft^2)	--	--	--								
UIA (ft^2)	7,200	--	12,600								
RPA (ft^2)	40,000	--	38,500								
SPA (ft^2)	--	113,256	--								
HSG A (%)	0%	0%	0%								
HSG B (%)	100%	100%	100%								
HSG C/D (%)	0%	0%	0%								
Average Slope of RPA (ft/ft)	0.060	--	0.060								
UIA:RPA Interface Width (ft)	60.00	--	70.00								

CALCULATED RUNOFF RESULTS

Area ID	V	OS-7	W								
UIA:RPA Area (ft^2)	47,200	--	51,100								
L / W Ratio	13.11	--	10.43								
UIA / Area	0.1525	--	0.2466								
Runoff (in)	0.00	0.00	0.00								
Runoff (ft^3)	0	0	0								
Runoff Reduction (ft^3)	258	5002	452								

CALCULATED WQCV RESULTS

Area ID	V	OS-7	W								
WQCV (ft^3)	293	0	513								
WQCV Reduction (ft^3)	293	0	513								
WQCV Reduction (%)	100%	0%	100%								
Untreated WQCV (ft^3)	0	0	0								

CALCULATED DESIGN POINT RESULTS (sums results from all columns with the same Downstream Design Point ID)

Downstream Design Point ID	DP-15										
DCIA (ft^2)	0										
UIA (ft^2)	19,800										
RPA (ft^2)	78,500										
SPA (ft^2)	113,256										
Total Area (ft^2)	211,556										
Total Impervious Area (ft^2)	19,800										
WQCV (ft^3)	806										
WQCV Reduction (ft^3)	806										
WQCV Reduction (%)	100%										
Untreated WQCV (ft^3)	0										

CALCULATED SITE RESULTS (sums results from all columns in worksheet)

Total Area (ft^2)	211,556
Total Impervious Area (ft^2)	19,800
WQCV (ft^3)	806
WQCV Reduction (ft^3)	806
WQCV Reduction (%)	100%
Untreated WQCV (ft^3)	0

DETENTION POND CALCULATIONS

Include calculation for sizing of riprap on emergency spillway

Include calculation for sizing of plunge pool at end of pond outlet culvert

Include culvert analysis for 30" pond outlet culvert

CLASSIC
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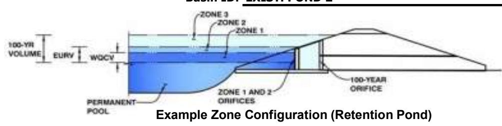
ENGINEERS & SURVEYORS

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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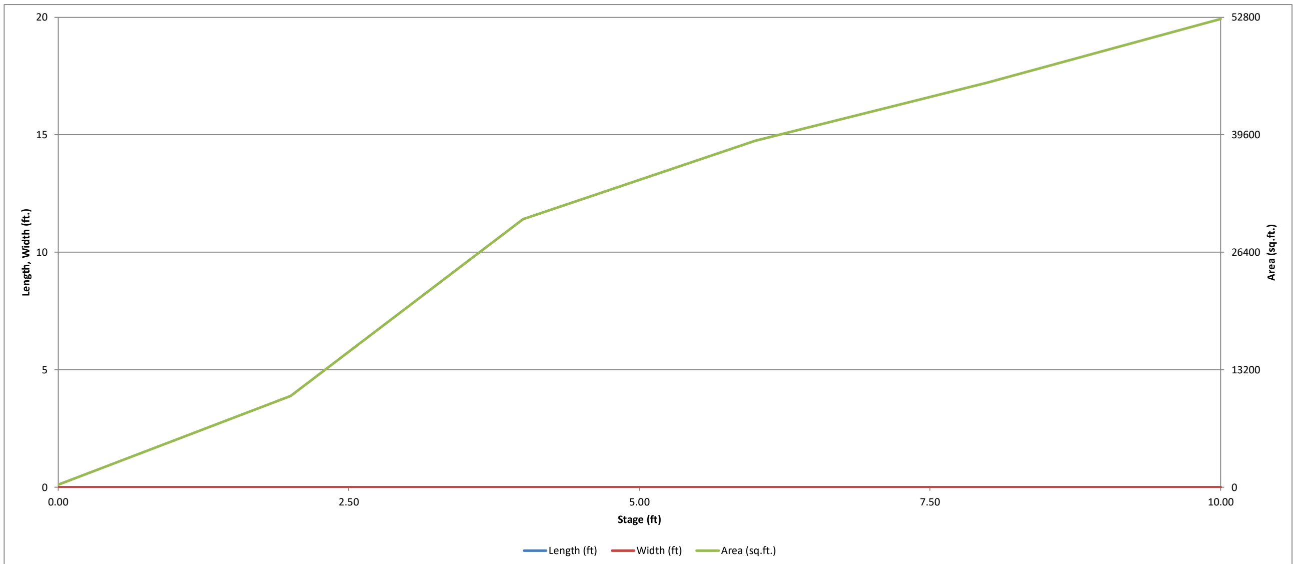
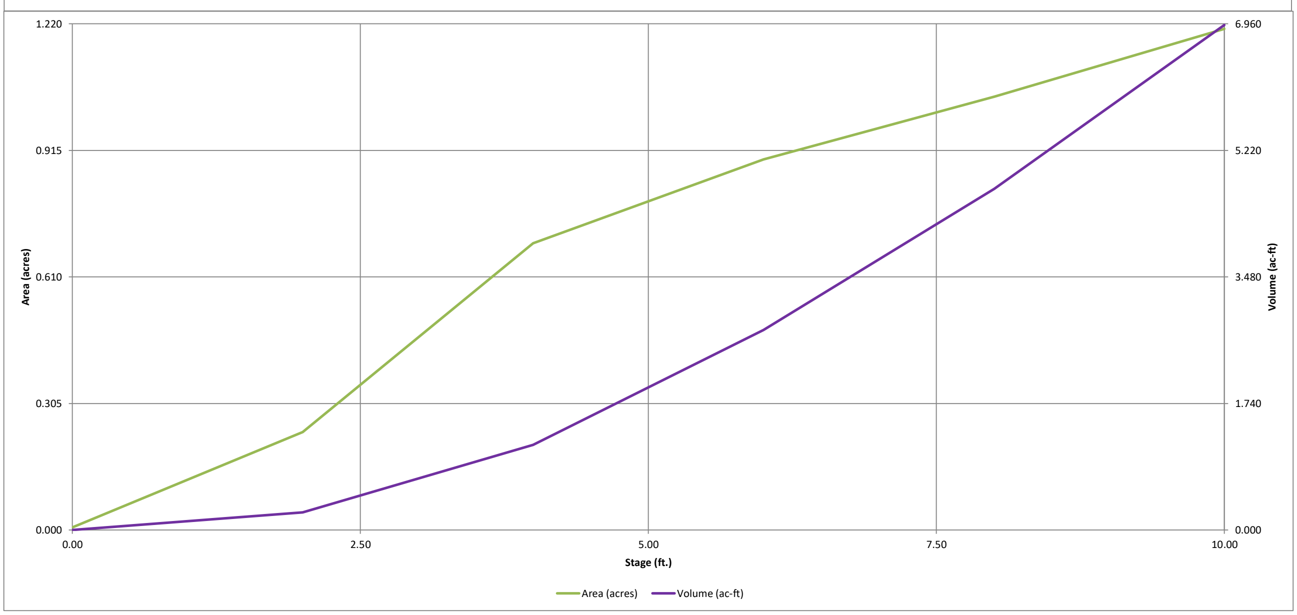
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.03 (May 2020)



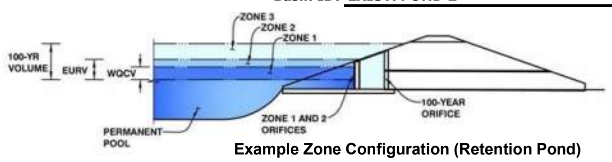


DETENTION BASIN OUTLET STRUCTURE DESIGN

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)

				Calculated Parameters for Underdrain		
Underdrain Orifice Invert Depth =		ft (distance below the filtration media surface)		Underdrain Orifice Area =		ft^2
Underdrain Orifice Diameter =		inches		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)

			Calculated Parameters for Plate		
Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	N/A	ft^2
Depth at top of Zone using Orifice Plate =	5.50	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	16.50	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	N/A	inches	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		Calculated Parameters for Vertical Orifice	Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A	feet
Vertical Orifice Diameter =	N/A	N/A	inches				

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		Calculated Parameters for Overflow Weir	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	5.50	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	6.50	N/A	feet
Overflow Weir Front Edge Length =	8.00	N/A	feet	Overflow Weir Slope Length =	4.12	N/A	feet
Overflow Weir Grate Slope =	4.00	N/A	H:V	Grate Open Area / 100-yr Orifice Area =	2.57	N/A	
Horiz. Length of Weir Sides =	4.00	N/A	feet	Overflow Grate Open Area w/o Debris =	24.74	N/A	ft^2
Overflow Grate Open Area % =	75%	N/A	%, grate open area/total area	Overflow Grate Open Area w/ Debris =	12.37	N/A	ft^2
Debris Clogging % =	50%	N/A	%				

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

	Zone 3 Restrictor	Not Selected		Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate	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 Orifice Area =	9.62	N/A	ft^2
Outlet Pipe Diameter =	42.00	N/A	inches	Outlet Orifice Centroid =	1.75	N/A	feet
Restrictor Plate Height Above Pipe Invert =	42.00		inches	Half-Central Angle of Restrictor Plate on Pipe =	3.14	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

			Calculated Parameters for Spillway		
Spillway Invert Stage=	9.00	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.77	feet
Spillway Crest Length =	65.00	feet	Stage at Top of Freeboard =	10.77	feet
Spillway End Slopes =	3.00	H:V	Basin Area at Top of Freeboard =	1.21	acres
Freeboard above Max Water Surface =	1.00	feet	Basin Volume at Top of Freeboard =	6.94	acre-ft

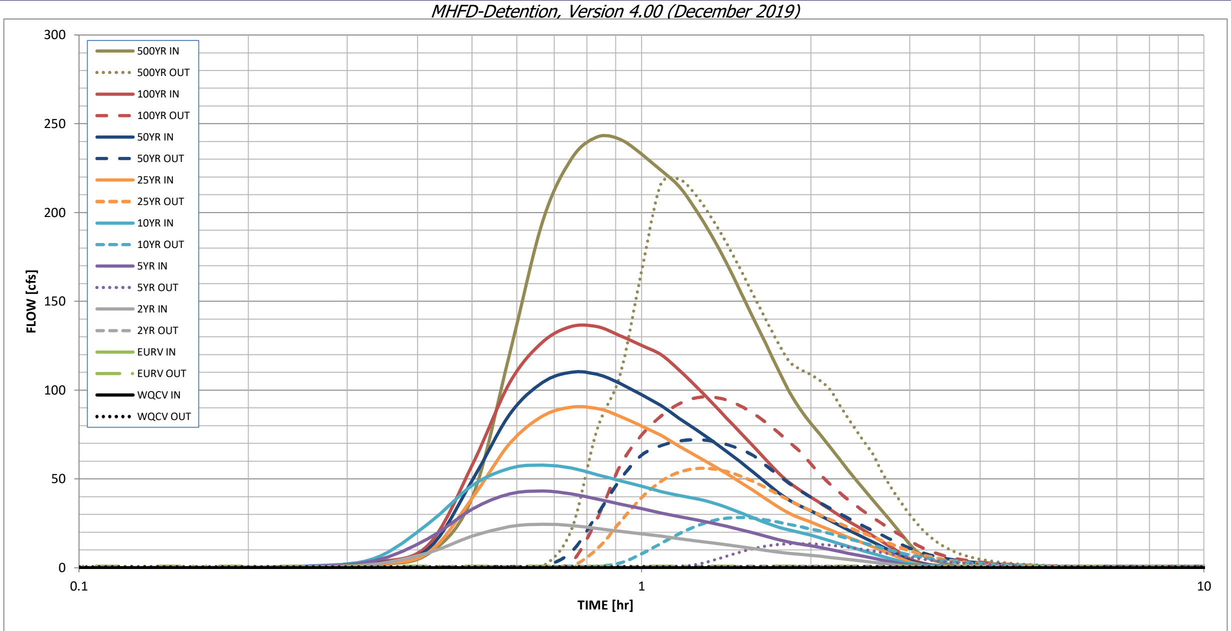
Routed Hydrograph Results

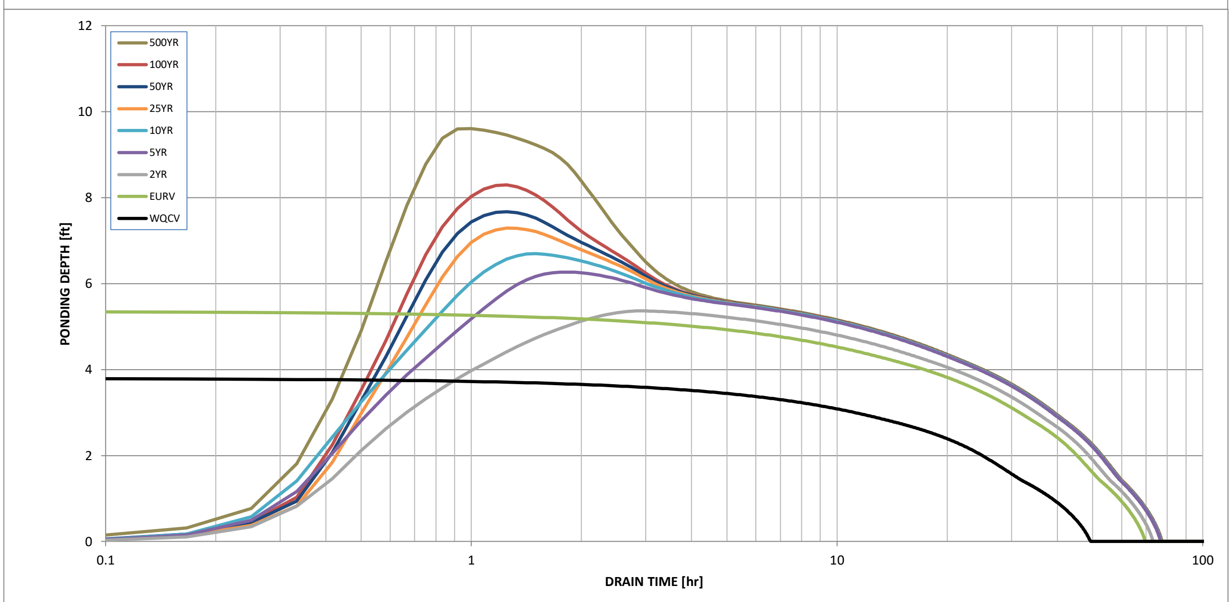
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

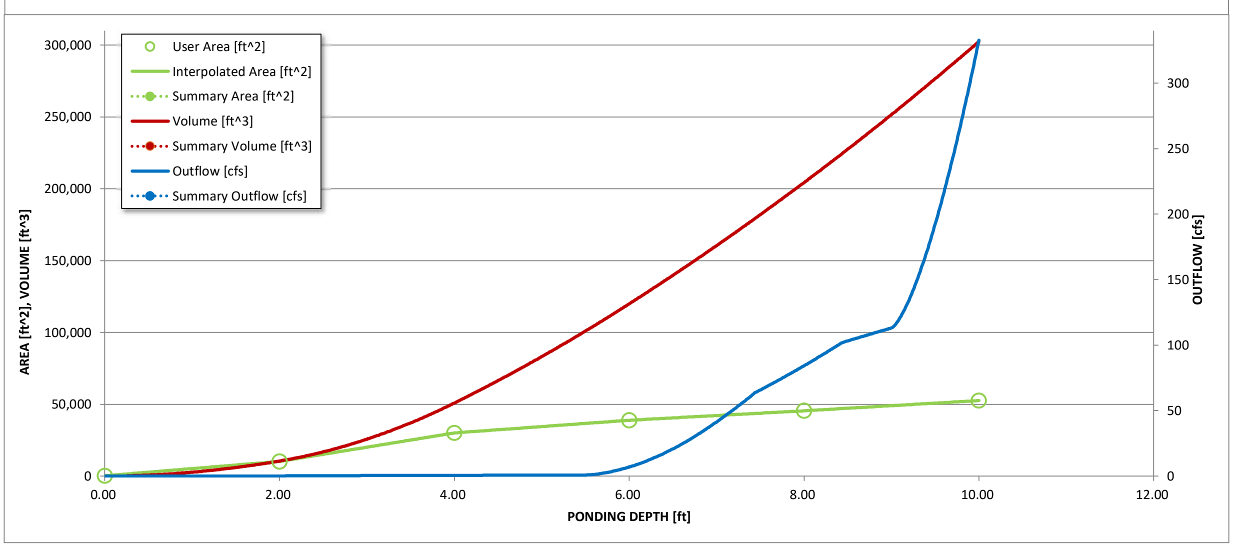
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52	3.85
CUHP Runoff Volume (acre-ft) =	1.033	2.196	2.378	4.231	5.985	8.800	10.837	13.643	25.127
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	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.

	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	0.05	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'.

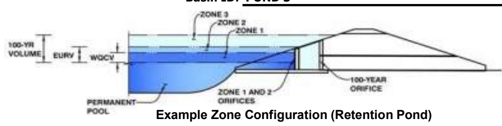
Also include the inverts of all outlets (e.g. vertical orifice, overflow grate, and spillway, where applicable).

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 =	58.30	acres
Watershed Length =	3,400	ft
Watershed Length to Centroid =	1,500	ft
Watershed Slope =	0.050	ft/ft
Watershed Imperviousness =	12.60%	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) =	0.395	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.703	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	0.904	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	1.876	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	2.832	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	4.494	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	5.642	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	7.279	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3.85 in.) =	13.819	acre-feet	3.85	inches
Approximate 2-yr Detention Volume =	0.460	acre-feet		
Approximate 5-yr Detention Volume =	0.708	acre-feet		
Approximate 10-yr Detention Volume =	1.336	acre-feet		
Approximate 25-yr Detention Volume =	1.794	acre-feet		
Approximate 50-yr Detention Volume =	1.887	acre-feet		
Approximate 100-yr Detention Volume =	2.404	acre-feet		

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.395	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.309	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	1.700	acre-feet
Total Detention Basin Volume =	2.404	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	--	--	--	3,459	0.079	3,631	0.083
7204	--	4.50	--	--	--	17,521	0.402	24,611	0.565
7206	--	6.50	--	--	--	22,243	0.511	64,375	1.478
7208	--	8.50	--	--	--	27,439	0.630	114,057	2.618
7209	--	9.50	--	--	--	30,197	0.693	142,875	3.280
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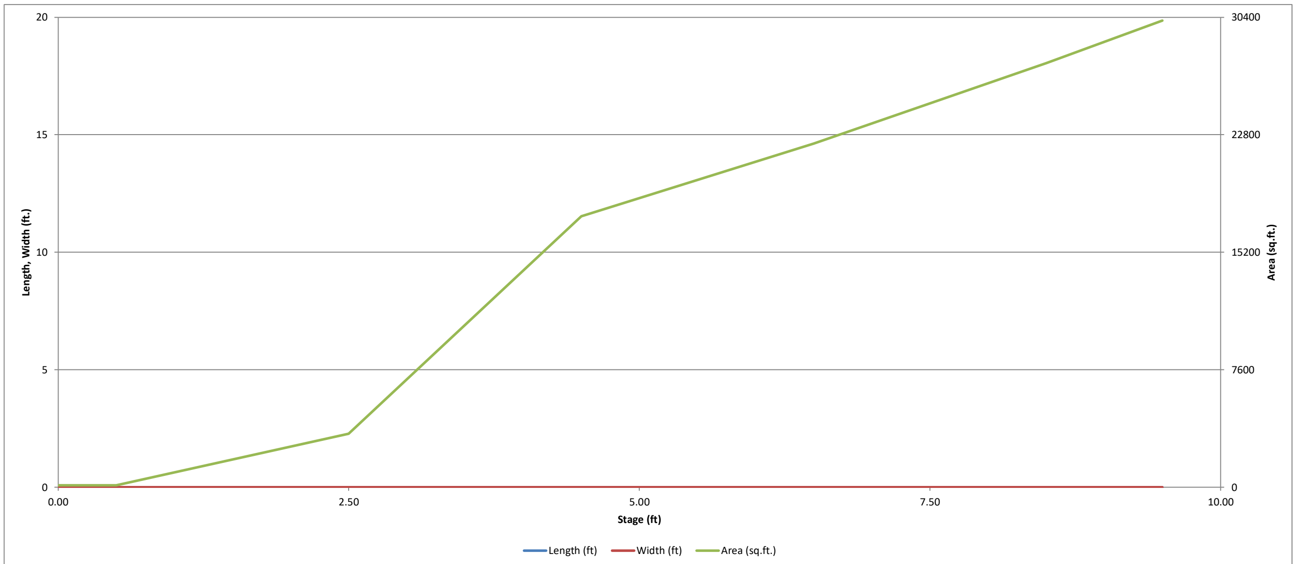
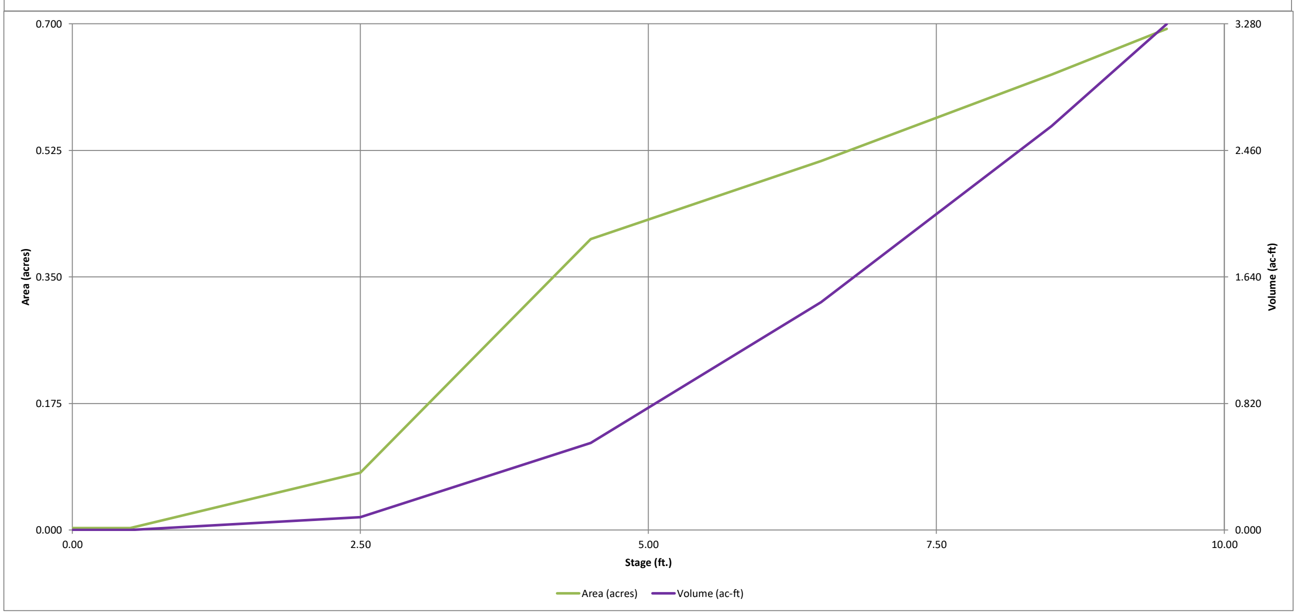

Length, Width (ft.)
Area (sq.ft.)
Stage (ft)
Length (ft)
Width (ft)
Area (sq.ft.)

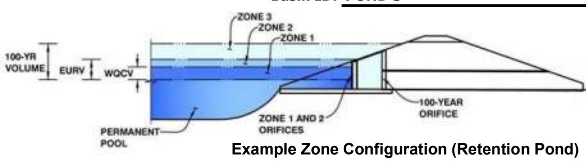

Area (acres)
Volume (ac-ft)
Stage (ft.)
Area (acres)
Volume (ac-ft)

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)	4.04	0.395	Orifice Plate
Zone 2 (EURV)	4.84	0.309	Orifice Plate
Zone 3 (100-year)	8.16	1.700	Weir&Pipe (Restrict)
Total (all zones)		2.404	

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

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)	Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

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)	WQ Orifice Area per Row =	N/A	ft^2
Depth at top of Zone using Orifice Plate =	5.00	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	20.00	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	N/A	inches	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

1.23 sq. in. based on orifice diameter shown on plans

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	1.70	3.40					
Orifice Area (sq. inches)	1.20	1.29	1.29					

	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 =	5.00	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	10.00	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 =	6.00	N/A	feet
Overflow Weir Slope Length =	4.12	N/A	feet
Grate Open Area / 100-yr Orifice Area =	6.30	N/A	
Overflow Grate Open Area w/o Debris =	30.92	N/A	ft^2
Overflow Grate Open Area w/ Debris =	15.46	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 =	0.50	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=	7.50	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.76	feet
Spillway Crest Length =	35.00	feet	Stage at Top of Freeboard =	9.26	feet
Spillway End Slopes =	4.00	H:V	Basin Area at Top of Freeboard =	0.68	acres
Freeboard above Max Water Surface =	1.00	feet	Basin Volume at Top of Freeboard =	3.12	acre-ft

Calculated Parameters for Spillway

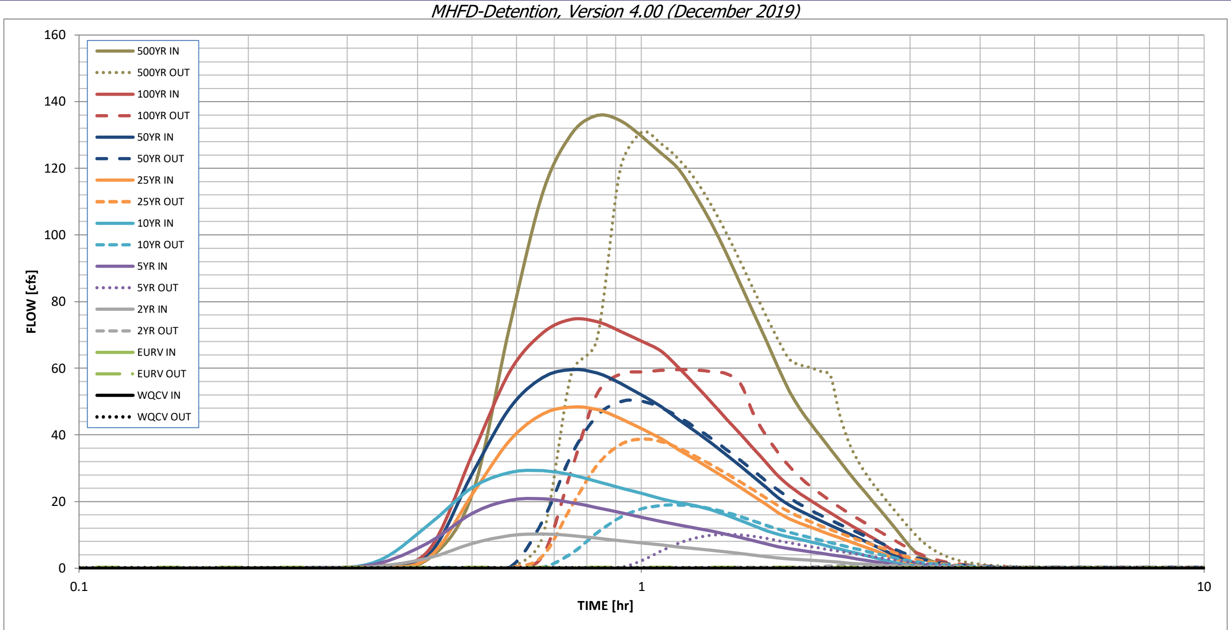
Routed Hydrograph Results

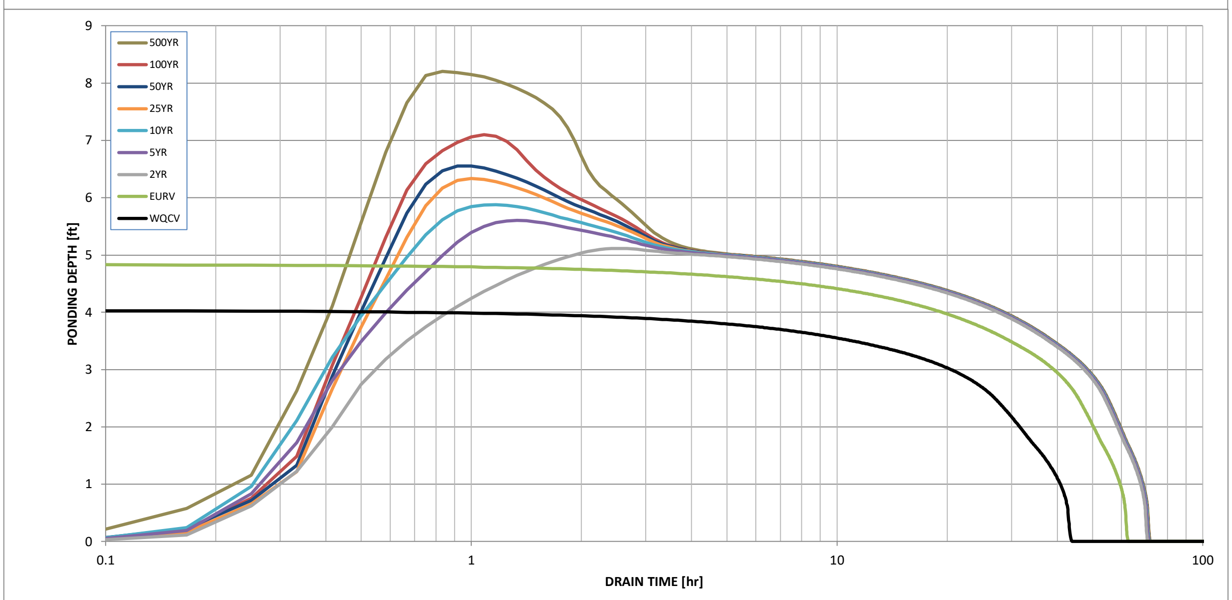
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

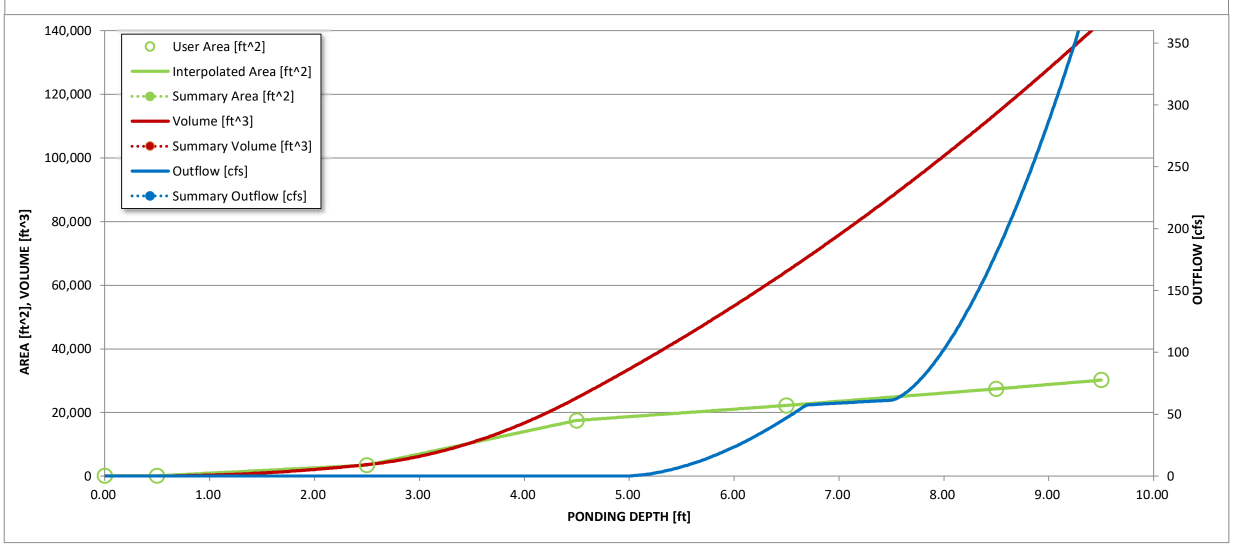
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52	3.85
CUHP Runoff Volume (acre-ft) =	0.395	0.703	0.904	1.876	2.832	4.494	5.642	7.279	13.819
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.904	1.876	2.832	4.494	5.642	7.279	13.819
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	5.6	15.8	24.0	43.0	54.0	69.2	129.0
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.10	0.27	0.41	0.74	0.93	1.19	2.21
Peak Inflow Q (cfs) =	N/A	N/A	10.3	20.8	29.3	48.3	59.6	74.7	135.8
Peak Outflow Q (cfs) =	0.2	0.2	1.0	10.1	19.0	38.7	50.1	59.6	130.8
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.6	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	0.02	0.3	0.6	1.3	1.6	1.9	2.1
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) =	40	56	63	58	54	49	46	41	27
Time to Drain 99% of Inflow Volume (hours) =	**42**	60	67	65	63	60	58	56	49
Maximum Ponding Depth (ft) =	4.04	4.84	5.12	5.60	5.88	6.34	6.56	7.10	8.21
Area at Maximum Ponding Depth (acres) =	0.33	0.42	0.44	0.46	0.48	0.50	0.51	0.55	0.61
Maximum Volume Stored (acre-ft) =	0.397	0.705	0.820	1.040	1.167	1.392	1.503	1.790	2.432

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	0.01	0.00	0.08
0:15:00	0.00	0.00	0.10	0.17	0.21	0.14	0.18	0.17	0.37
0:20:00	0.00	0.00	0.41	1.01	1.58	0.43	0.50	0.67	2.55
0:25:00	0.00	0.00	2.95	7.51	12.72	2.84	3.62	4.99	21.98
0:30:00	0.00	0.00	7.42	16.44	24.17	22.06	28.28	33.86	72.66
0:35:00	0.00	0.00	9.78	20.38	28.68	38.31	48.01	58.97	112.34
0:40:00	0.00	0.00	10.28	20.85	29.25	46.22	57.17	70.48	130.16
0:45:00	0.00	0.00	9.81	19.73	28.04	48.33	59.58	74.66	135.85
0:50:00	0.00	0.00	8.97	18.17	26.01	47.63	58.62	74.00	134.31
0:55:00	0.00	0.00	8.21	16.68	24.13	44.98	55.52	71.13	129.59
1:00:00	0.00	0.00	7.56	15.30	22.42	41.90	51.98	68.13	124.56
1:05:00	0.00	0.00	6.95	14.00	20.83	38.93	48.54	65.17	119.60
1:10:00	0.00	0.00	6.35	12.93	19.65	35.47	44.47	60.02	111.61
1:15:00	0.00	0.00	5.82	12.02	18.70	32.44	40.91	54.77	103.41
1:20:00	0.00	0.00	5.32	11.08	17.43	29.61	37.42	49.70	94.43
1:25:00	0.00	0.00	4.83	10.12	15.90	26.90	34.01	44.80	85.24
1:30:00	0.00	0.00	4.35	9.17	14.33	24.23	30.65	40.22	76.53
1:35:00	0.00	0.00	3.88	8.23	12.76	21.63	27.37	35.86	68.18
1:40:00	0.00	0.00	3.42	7.24	11.26	19.07	24.16	31.62	60.17
1:45:00	0.00	0.00	3.04	6.41	10.14	16.62	21.10	27.63	53.05
1:50:00	0.00	0.00	2.79	5.83	9.33	14.81	18.88	24.65	47.66
1:55:00	0.00	0.00	2.57	5.36	8.62	13.41	17.14	22.30	43.29
2:00:00	0.00	0.00	2.38	4.92	7.90	12.24	15.67	20.27	39.46
2:05:00	0.00	0.00	2.17	4.48	7.18	11.13	14.24	18.36	35.73
2:10:00	0.00	0.00	1.96	4.04	6.46	10.09	12.89	16.56	32.17
2:15:00	0.00	0.00	1.75	3.62	5.76	9.09	11.60	14.88	28.81
2:20:00	0.00	0.00	1.56	3.20	5.09	8.13	10.36	13.29	25.66
2:25:00	0.00	0.00	1.37	2.80	4.46	7.21	9.19	11.83	22.74
2:30:00	0.00	0.00	1.18	2.41	3.84	6.31	8.04	10.39	19.91
2:35:00	0.00	0.00	1.00	2.03	3.26	5.42	6.92	8.96	17.16
2:40:00	0.00	0.00	0.82	1.66	2.69	4.54	5.81	7.55	14.42
2:45:00	0.00	0.00	0.64	1.29	2.13	3.67	4.71	6.14	11.71
2:50:00	0.00	0.00	0.47	0.93	1.58	2.81	3.61	4.74	9.03
2:55:00	0.00	0.00	0.30	0.60	1.09	1.96	2.54	3.36	6.50
3:00:00	0.00	0.00	0.19	0.40	0.80	1.23	1.63	2.20	4.51
3:05:00	0.00	0.00	0.14	0.30	0.63	0.81	1.12	1.49	3.23
3:10:00	0.00	0.00	0.11	0.24	0.51	0.55	0.78	1.03	2.34
3:15:00	0.00	0.00	0.09	0.20	0.41	0.38	0.56	0.69	1.67
3:20:00	0.00	0.00	0.07	0.16	0.33	0.26	0.40	0.46	1.17
3:25:00	0.00	0.00	0.06	0.12	0.26	0.19	0.29	0.29	0.80
3:30:00	0.00	0.00	0.04	0.10	0.20	0.13	0.21	0.18	0.53
3:35:00	0.00	0.00	0.04	0.07	0.15	0.10	0.15	0.11	0.36
3:40:00	0.00	0.00	0.03	0.06	0.11	0.07	0.11	0.09	0.26
3:45:00	0.00	0.00	0.02	0.04	0.08	0.05	0.08	0.07	0.20
3:50:00	0.00	0.00	0.02	0.03	0.06	0.04	0.07	0.05	0.16
3:55:00	0.00	0.00	0.01	0.02	0.04	0.03	0.05	0.04	0.12
4:00:00	0.00	0.00	0.01	0.01	0.03	0.02	0.04	0.03	0.09
4:05:00	0.00	0.00	0.01	0.01	0.02	0.02	0.03	0.02	0.06
4:10:00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.04
4:15:00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02
4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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).

HEC-RAS CALCULATIONS

Include design for check structure and calculation for sizing of riprap for bank protection

Include design for secondary bypass channel for wetlands and discuss in report

CLASSIC CONSULTING ENGINEERS & SURVEYORS

SEE RETREAT AT TIMBERRIDGE FILING NO. 2 GRADING AND EROSION CONTROL PLAN FOR EROSION CONTROL DETAILS.

48 HOURS BEFORE YOU DIG, CALL UTILITY LOCATORS
811
UTILITY NOTIFICATION CENTER OF COLORADO
IT'S THE LAW

THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES ARE SHOWN IN AN APPROXIMATE WAY ONLY. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK. THE CONTRACTOR SHALL BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MIGHT BE CAUSED BY HIS FAILURE TO EXACTLY LOCATE AND PRESERVE ANY AND ALL UNDERGROUND UTILITIES.

NO.	REVISION	DATE

REVIEW:

PREPARED UNDER MY DIRECT SUPERVISION FOR AND ON BEHALF OF CLASSIC CONSULTING ENGINEERS AND SURVEYORS, LLC

MARC A. WHORTON, COLORADO P.E. #37155 DATE

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

RETREAT AT TIMBERRIDGE FILING NO. 2
CONSTRUCTION PLANS
HEC-RAS ANALYSIS
CHANNEL STATIONING EXHIBIT

DESIGNED BY	MAW	SCALE	DATE 10-25-21
DRAWN BY	MAW	(H) 1"= 50'	SHEET 1 OF 1
CHECKED BY		(V) 1"= N/A	JOB NO. 1185.20

RETREAT AT TIMBERRIDGE FILING NO. 2

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (AT ARROYA LN.)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (SOUTH OF ARROYA LN.)

Pictures taken May/July 2019

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 25+00)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 21+25)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 19+00)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 15+75)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 12+00)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 10+00)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 6+75)

SAND CREEK REACH 9 - LOOKING DOWNSTREAM (HEC-RAS STA: 4+00)

TABLE 10-1

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

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

	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.

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

where:

τ_e = effective shear stress exerted on the soil beneath vegetation (lb/ft^2 or N/m^2)
γ = specific weight of water (lb/ft^3 or N/m^3)
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.

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

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)

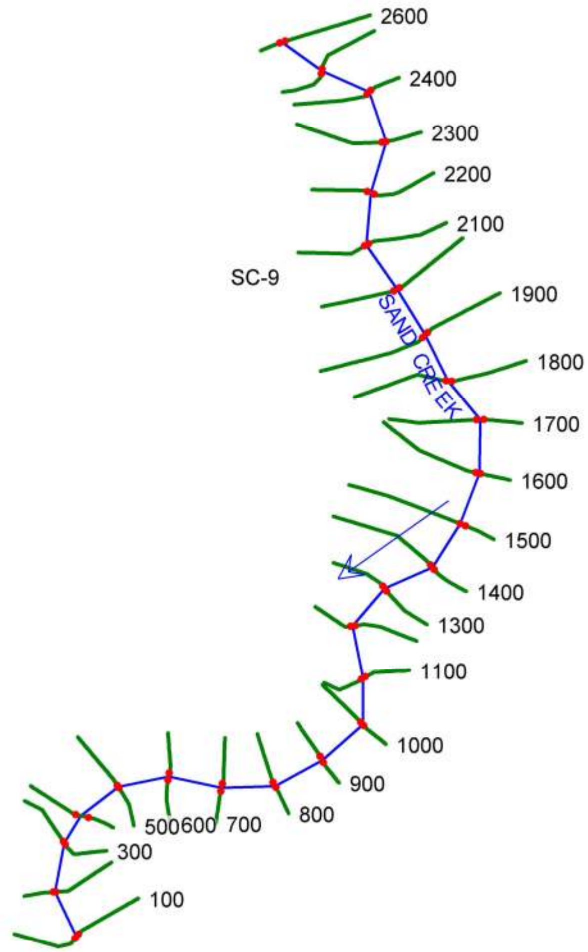
Limited to $0.0025 C_I^{2.5} < R_v < 36$

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

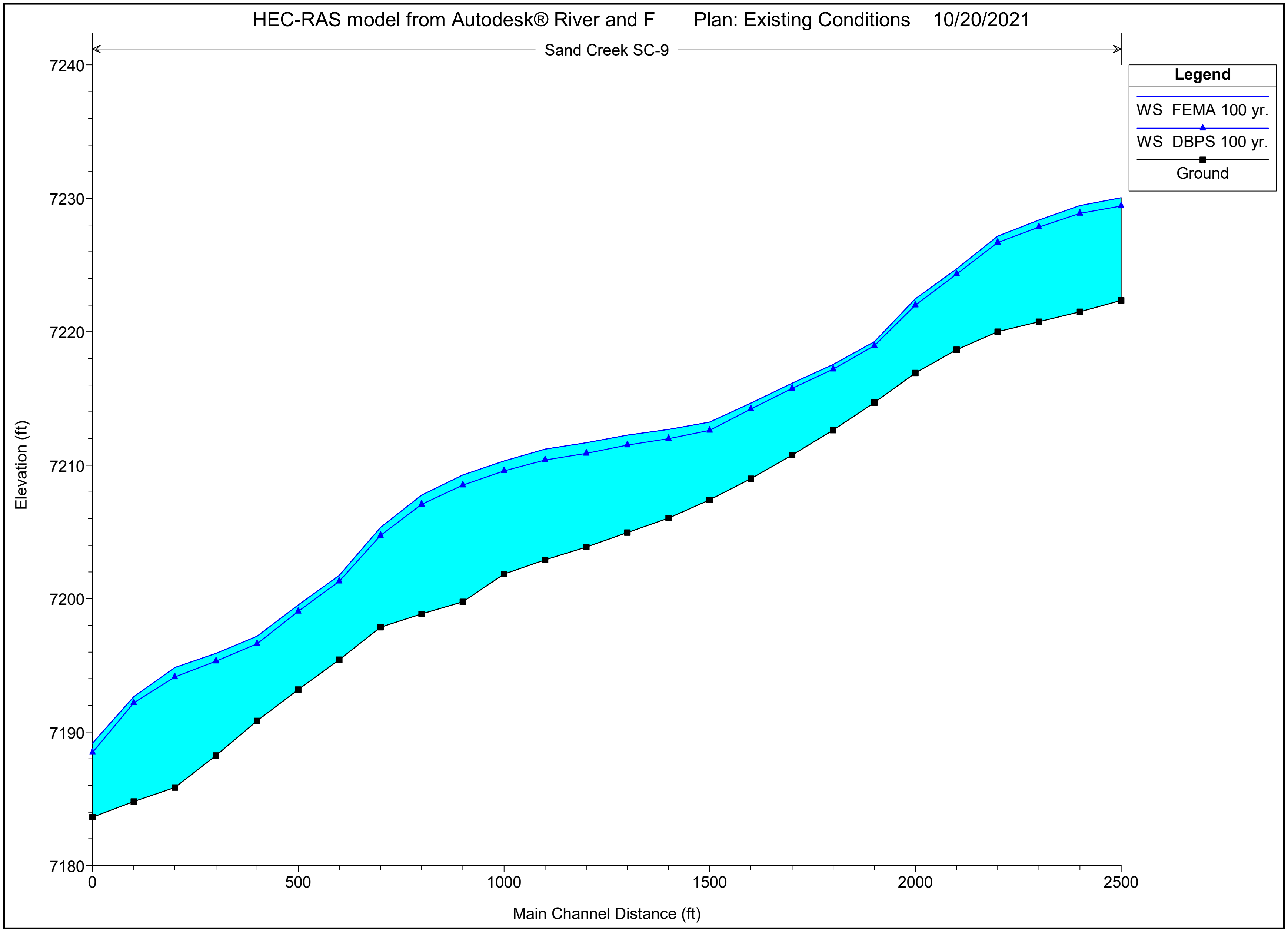
If vegetated channel liner mats are used, manufacturer-supplied roughness coefficients for particular mats may be used in the equation.

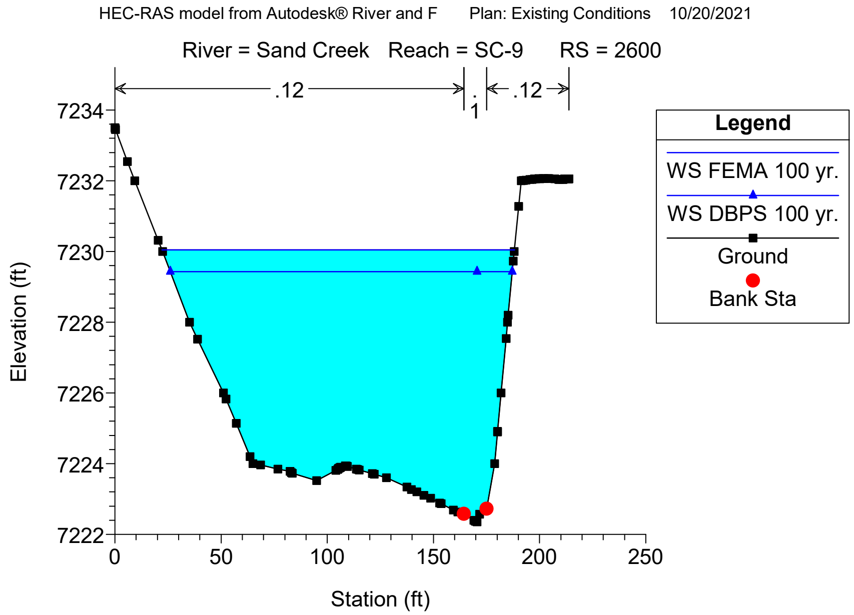
Maximum allowable shear stress, τ_{va}, in pound per square foot is determined as a function of the retardance curve index, C_I. Very little information is available for vegetal performance under very high stresses and this relation is believed to be conservative.

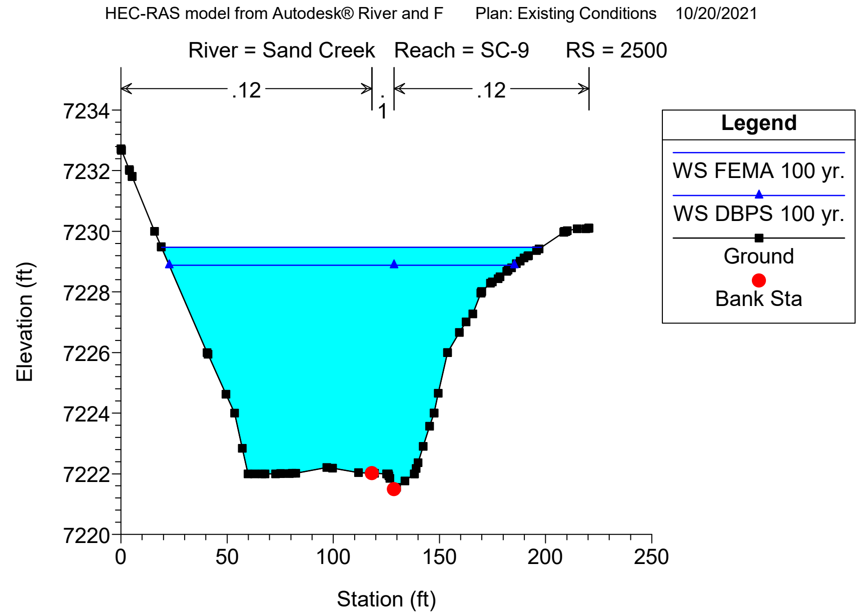
$$\tau_{va} = 0.75 C_I \qquad \text{(eq. 8–32)}$$

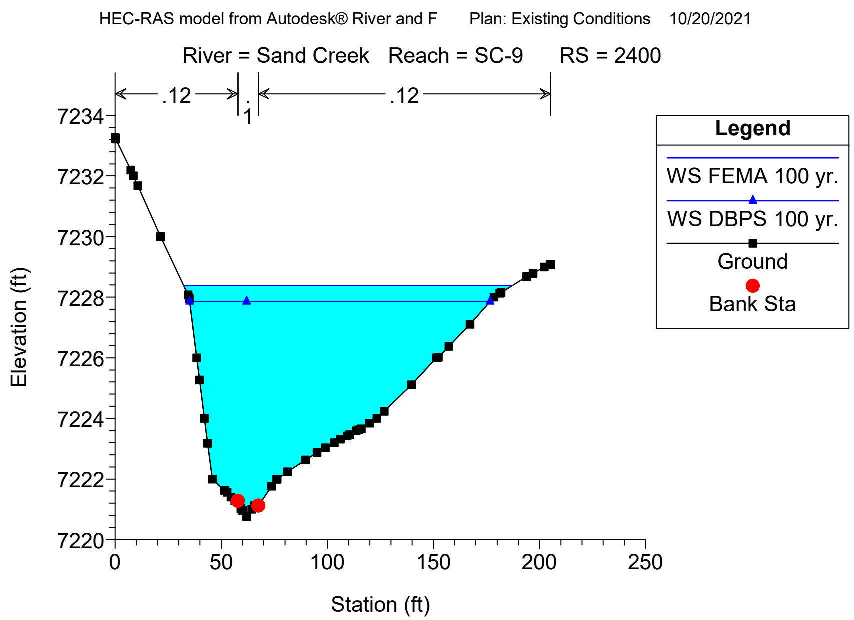


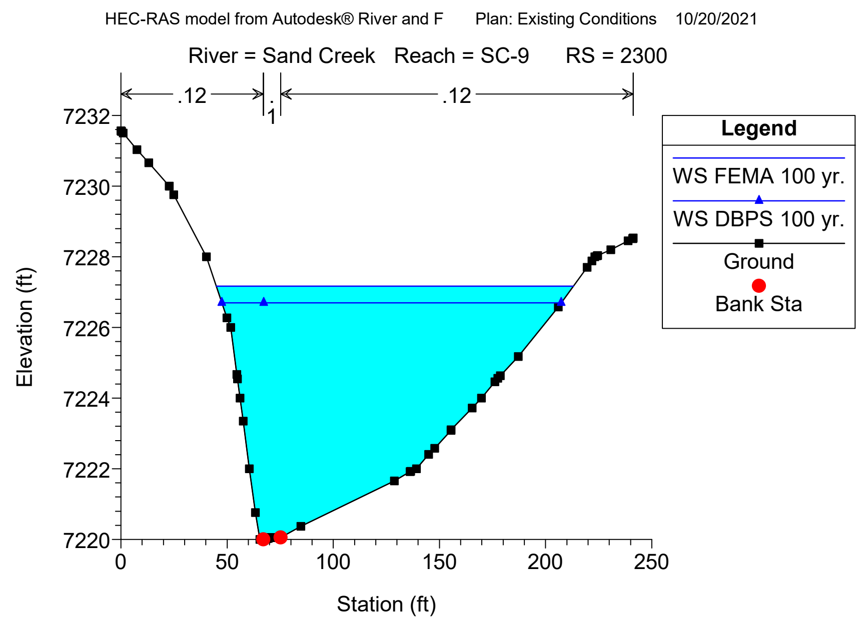
2600
2400
2300
2200
2100
SC-9
1900
SAND CREEK
1800
1700
1600
1500
1400
1300
1100
1000
900
800
500600 700
300
100

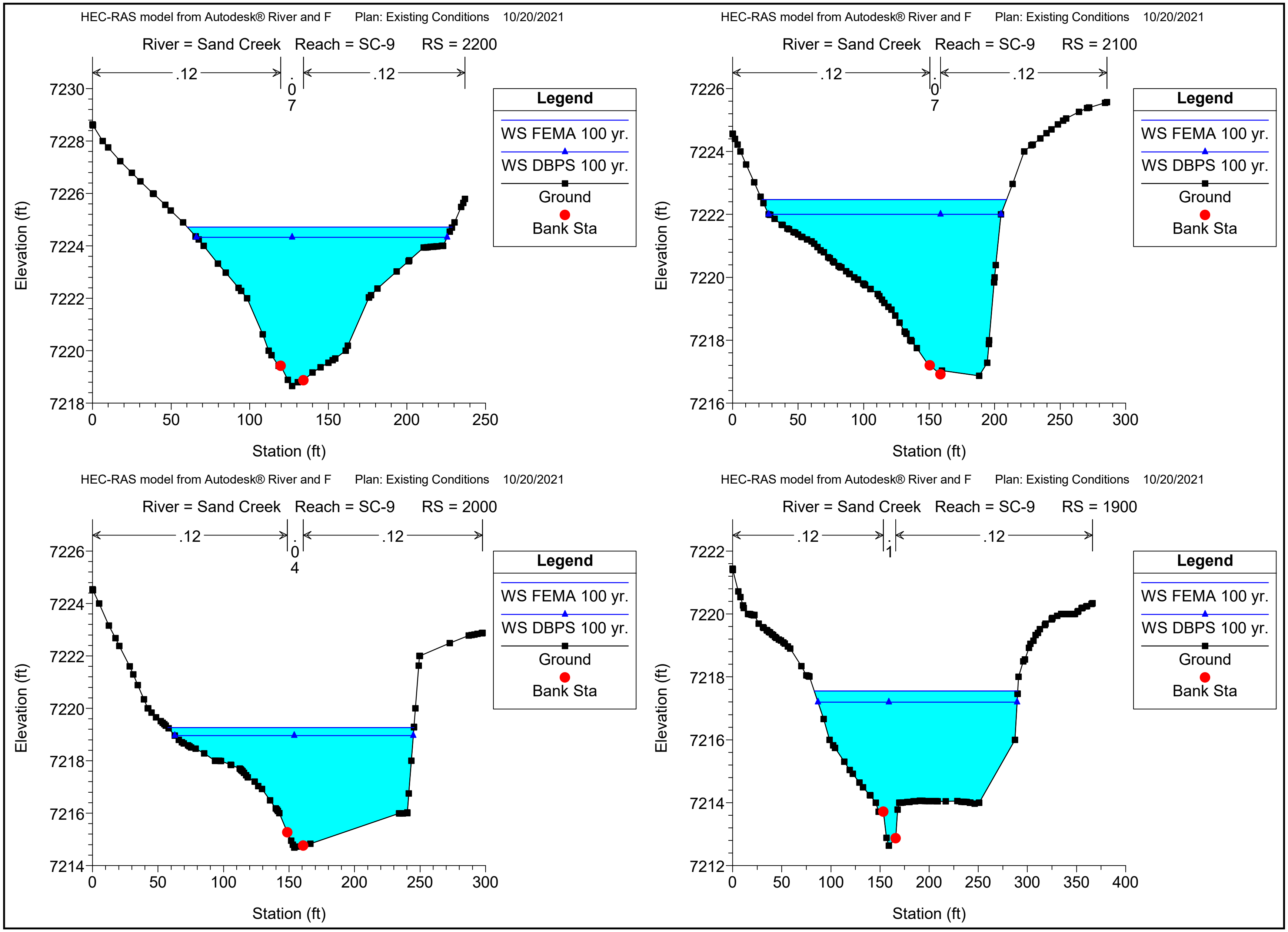

HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
Sand Creek SC-9
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Elevation (ft)
7180
7190
7200
7210
7220
7230
7240
0
500
1000
1500
2000
2500
Main Channel Distance (ft)


HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 2600
.12
.1
.12
Elevation (ft)
7234
7232
7230
7228
7226
7224
7222
0
50
100
150
200
250
Station (ft)
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta

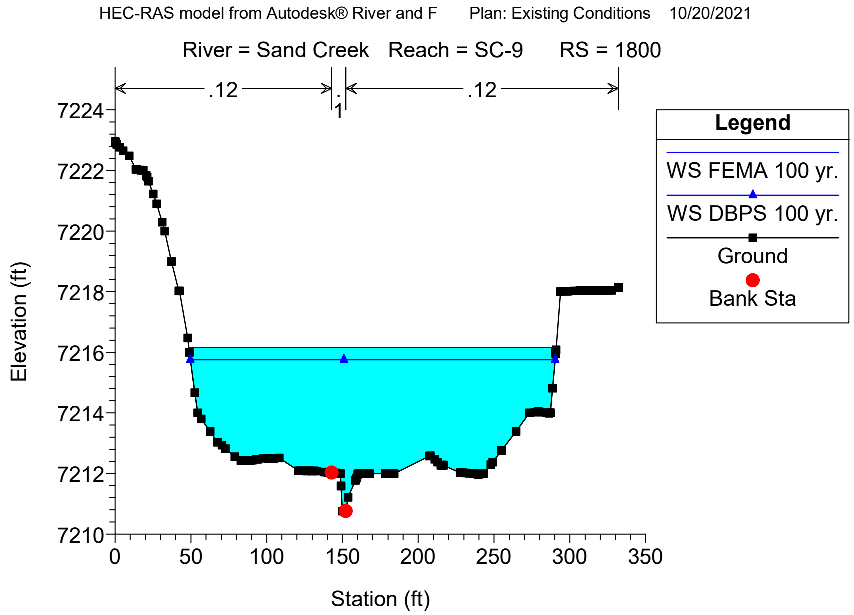

HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 2500
.12
.1
.12
Elevation (ft)
7234
7232
7230
7228
7226
7224
7222
7220
0
50
100
150
200
250
Station (ft)
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta

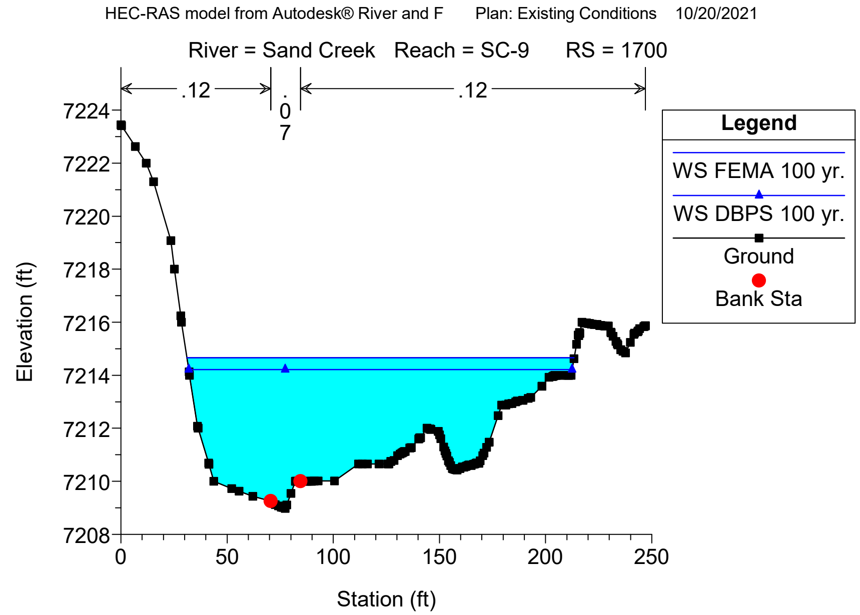

HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 2400
.12
.1
.12
Elevation (ft)
7234
7232
7230
7228
7226
7224
7222
7220
0
50
100
150
200
250
Station (ft)
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta

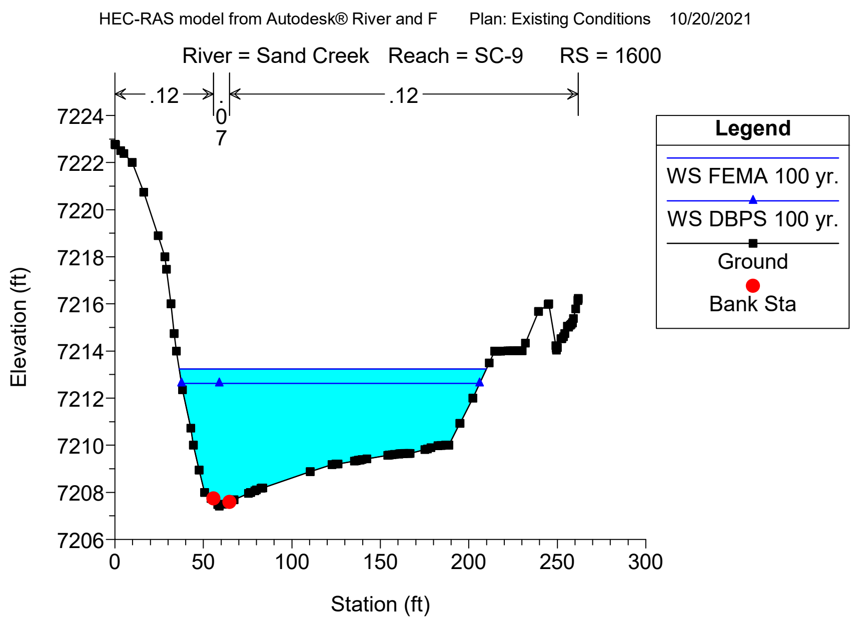

HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 2300
.12
.1
.12
Elevation (ft)
7232
7230
7228
7226
7224
7222
7220
0
50
100
150
200
250
Station (ft)
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta

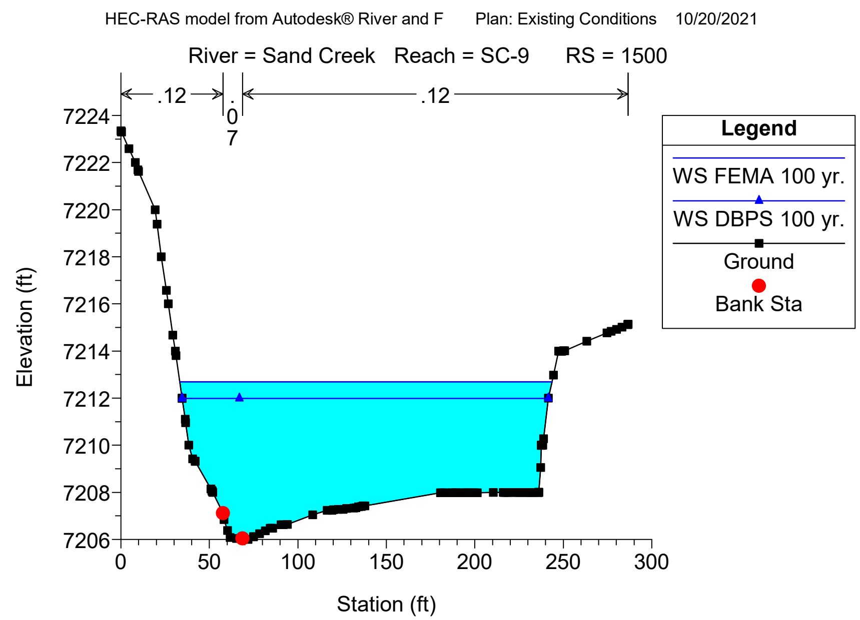


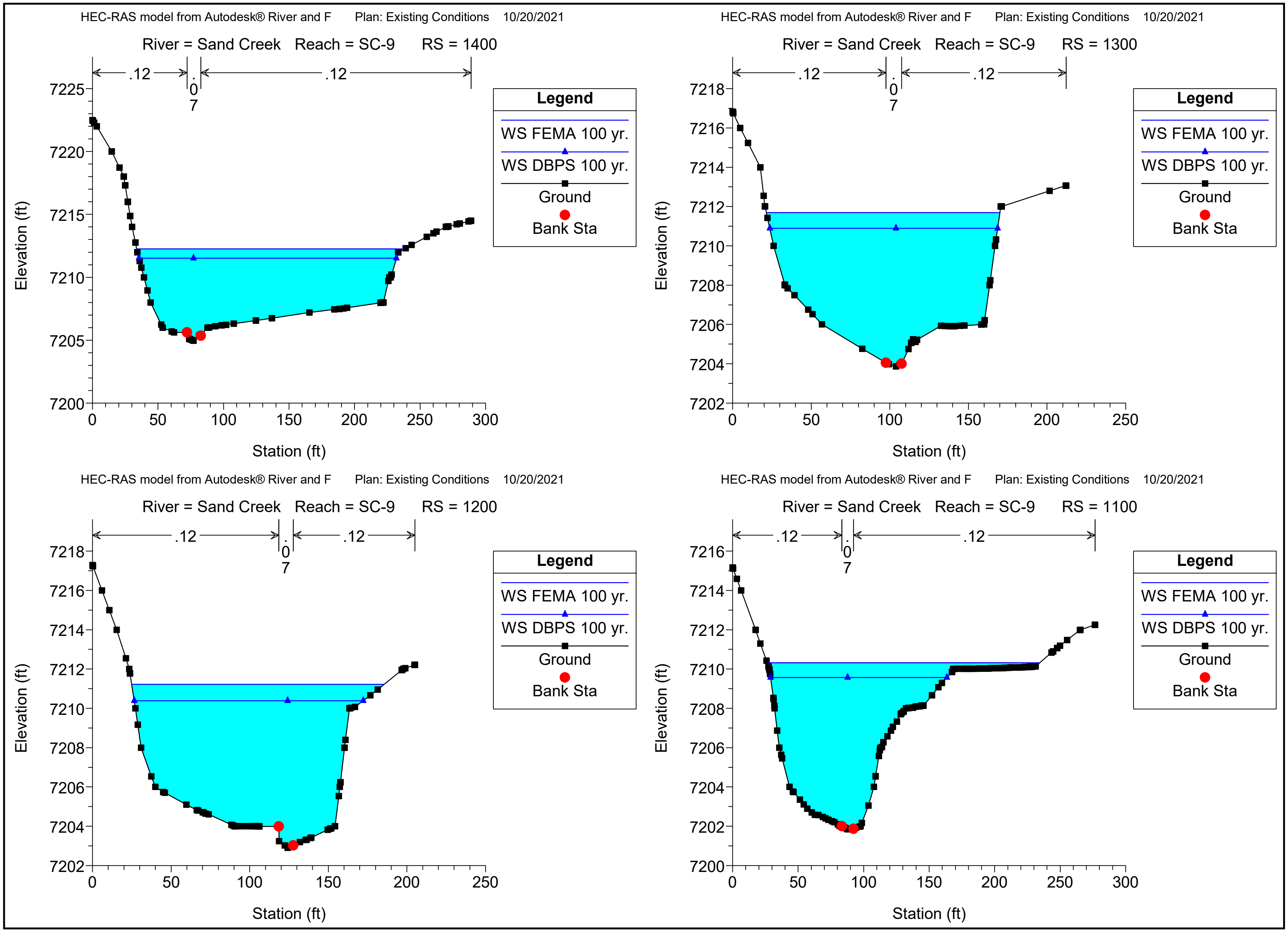
HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 2200
.12
0
7
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7218
7220
7222
7224
7226
7228
7230
0
50
100
150
200
250
HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 2100
.12
0
7
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7216
7218
7220
7222
7224
7226
0
50
100
150
200
250
300
HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 2000
.12
0
4
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7214
7216
7218
7220
7222
7224
7226
0
50
100
150
200
250
300
HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 1900
.12
.1
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7212
7214
7216
7218
7220
7222
0
50
100
150
200
250
300
350
400

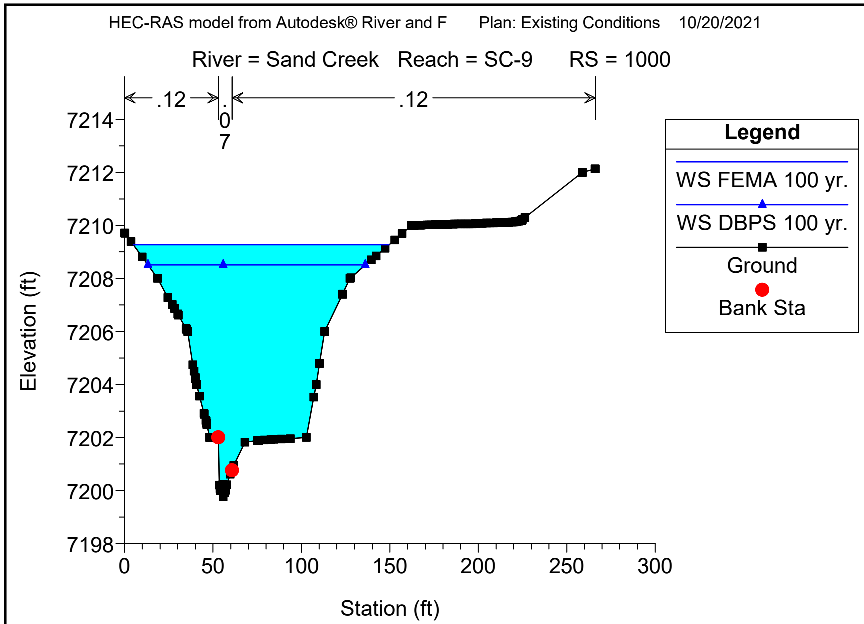

HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 1800
.12
.1
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

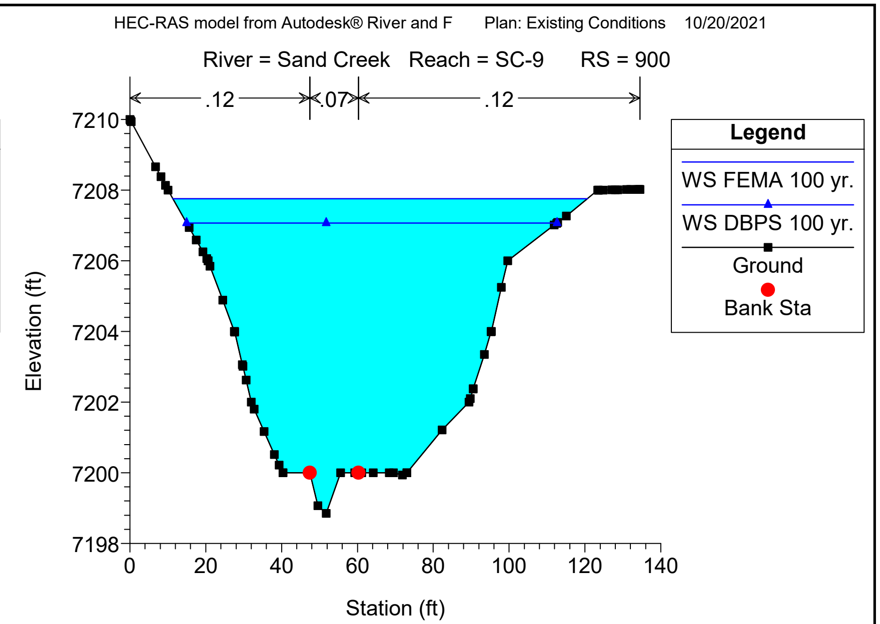

HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 1700
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

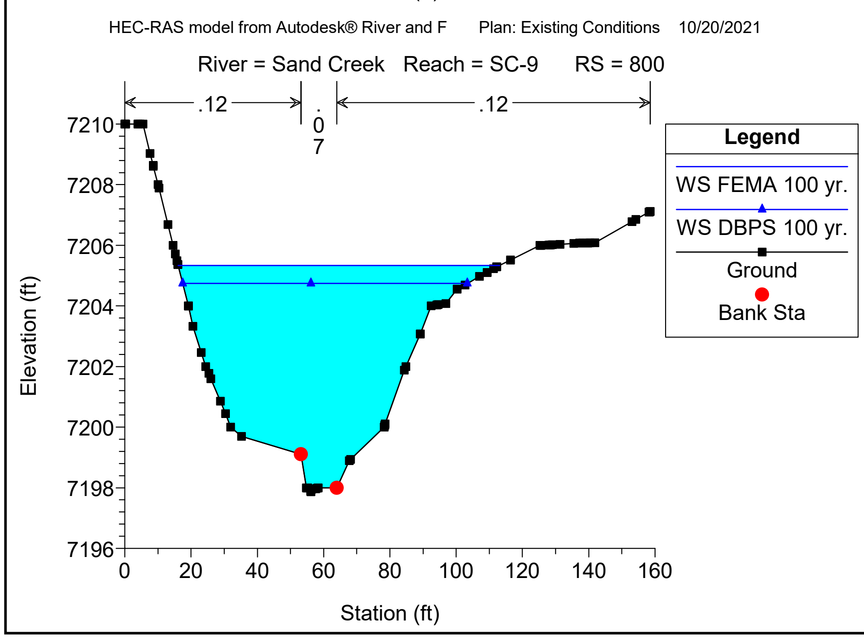

HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 1600
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

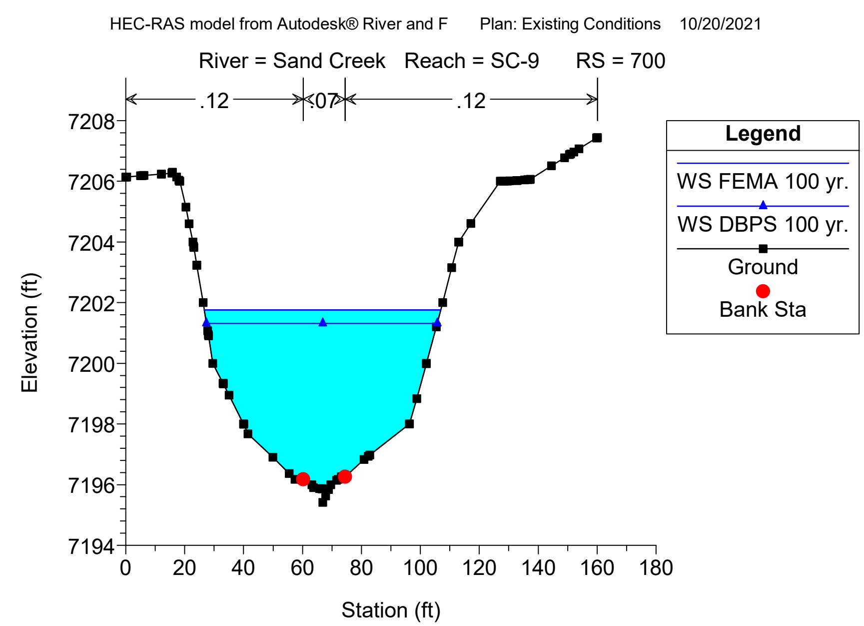

HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 1500
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

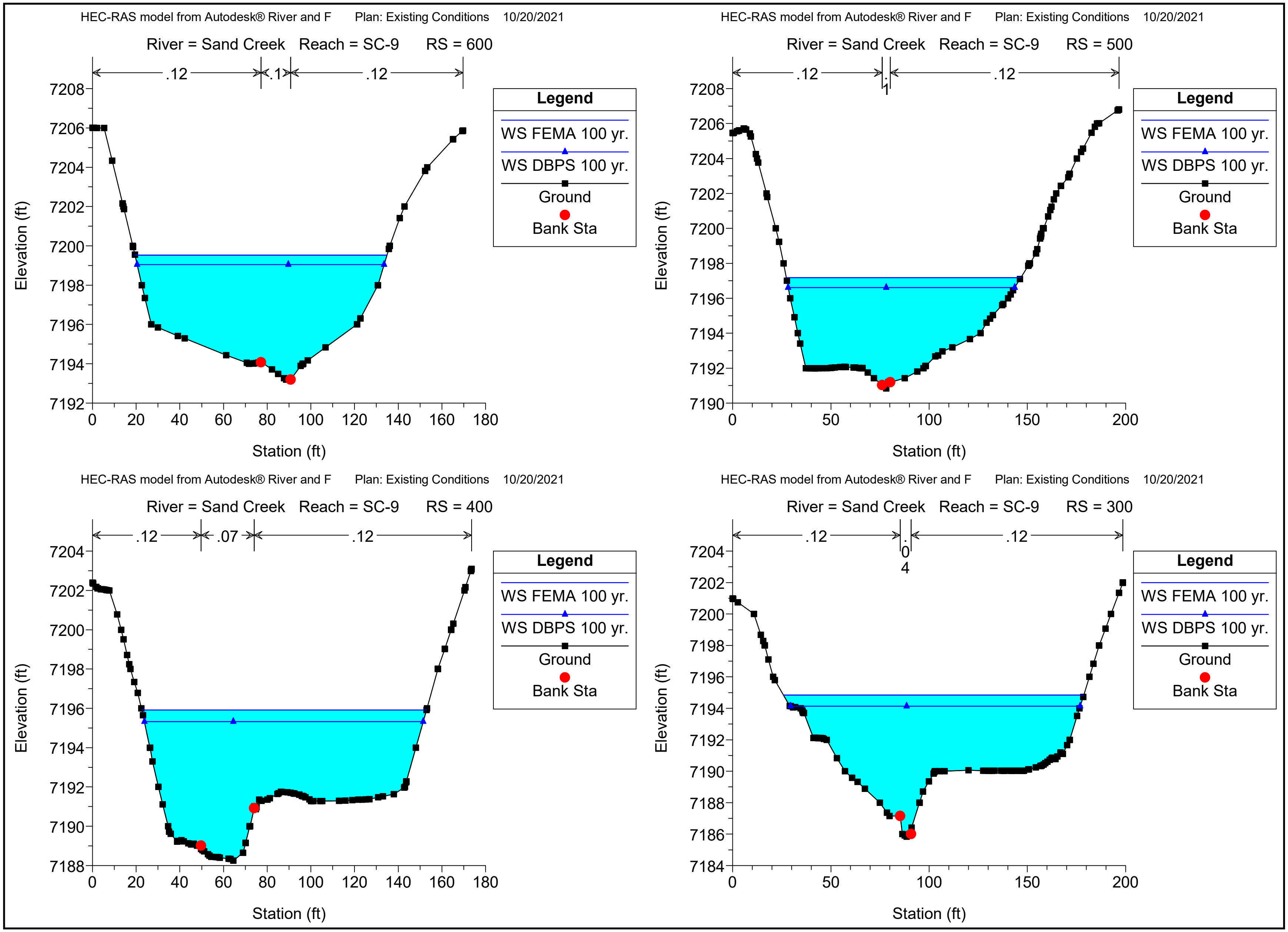

HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 1400
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7200
7205
7210
7215
7220
7225
0
50
100
150
200
250
300
HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 1300
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7202
7204
7206
7208
7210
7212
7214
7216
7218
0
50
100
150
200
250
HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 1200
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7202
7204
7206
7208
7210
7212
7214
7216
7218
0
50
100
150
200
250
HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 1100
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7200
7202
7204
7206
7208
7210
7212
7214
7216
0
50
100
150
200
250
300

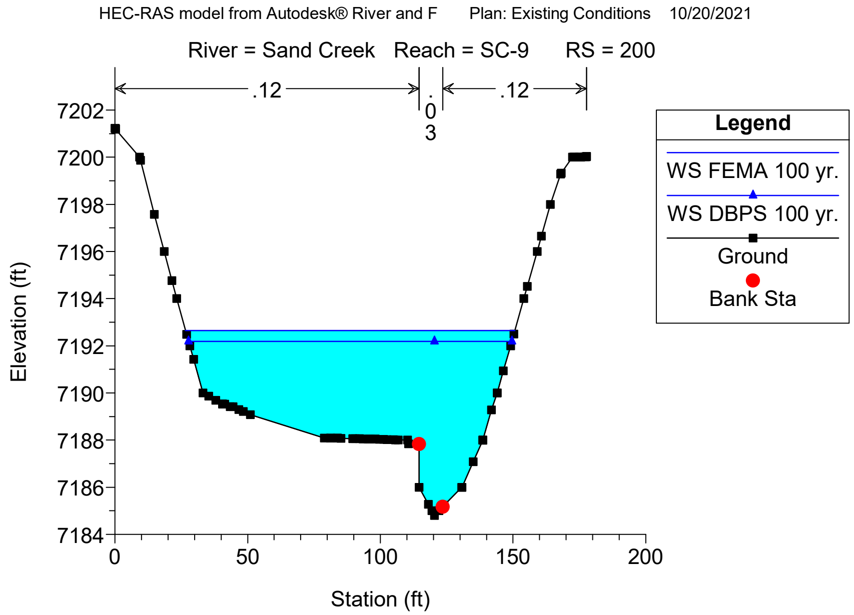

HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 1000
.12
.12
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta

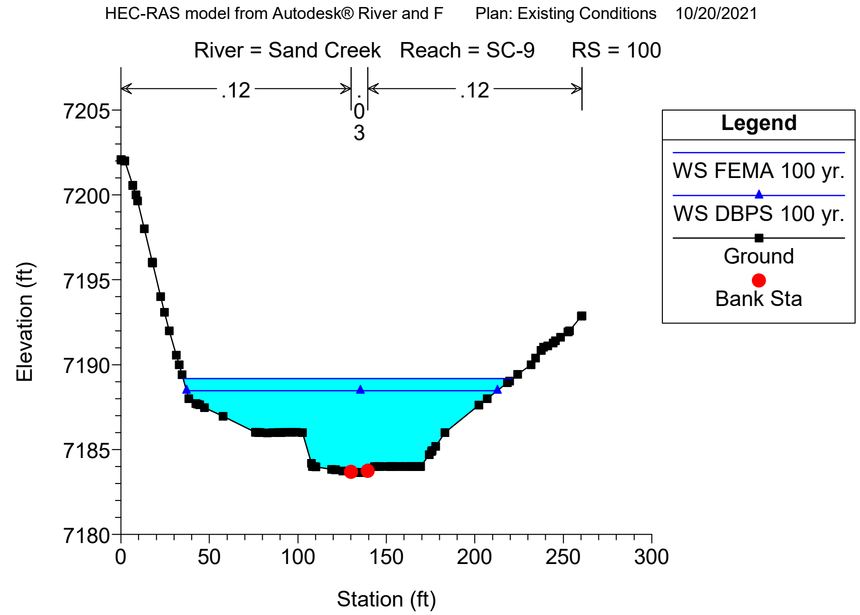

HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 900
.12
.07
.12
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta


HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 800
.12
.12
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta


HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 700
.12
.07
.12
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta


HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 600
.12
.1
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 500
.12
.1
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 400
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 300
.12
.04
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)


HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 200
.12
.03
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7202
7200
7198
7196
7194
7192
7190
7188
7186
7184
0
50
100
150
200

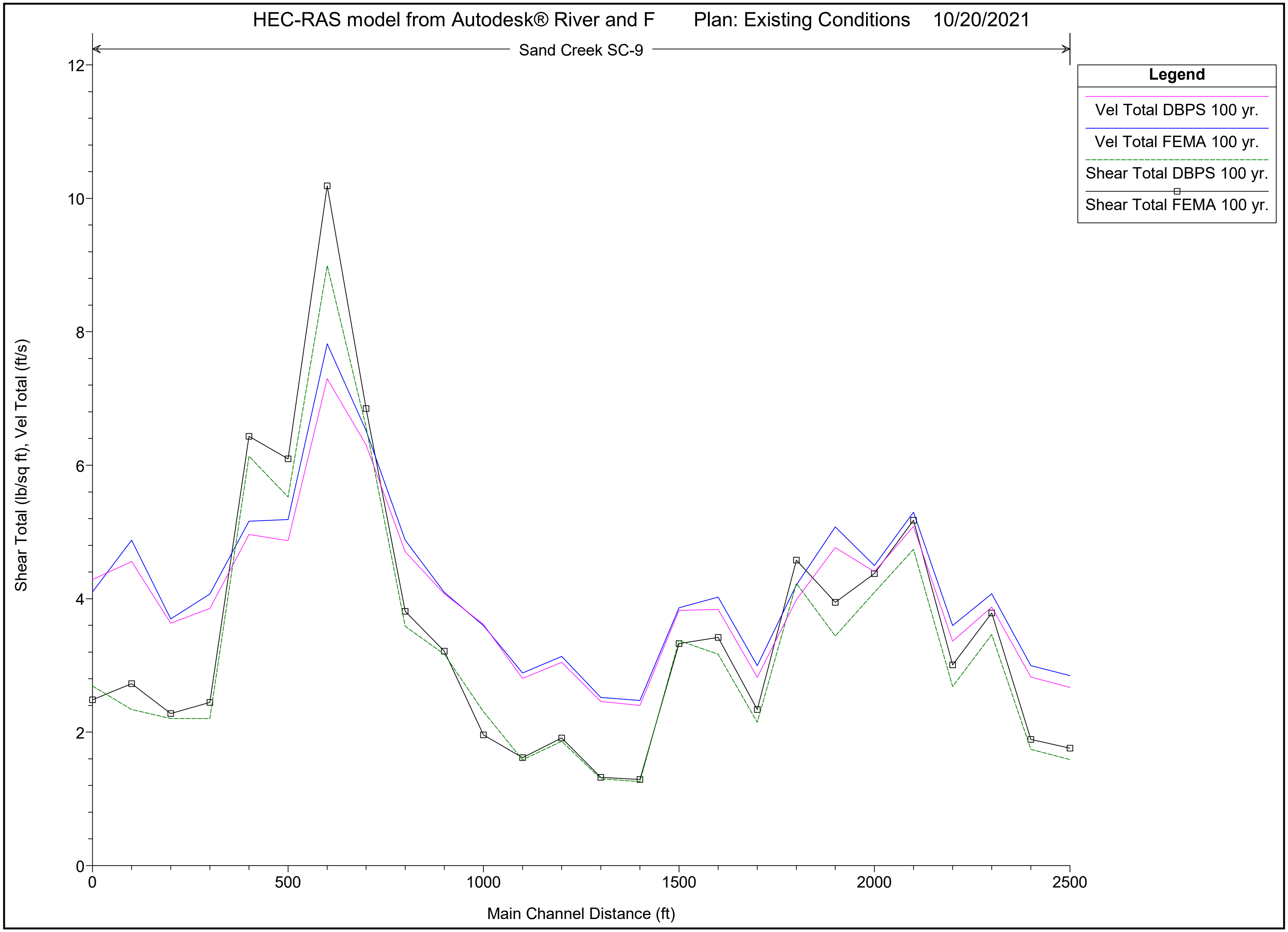

HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
River = Sand Creek Reach = SC-9 RS = 100
.12
.03
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7205
7200
7195
7190
7185
7180
0
50
100
150
200
250
300

HEC-RAS Plan: Ex. Cond. River: Sand Creek Reach: SC-9

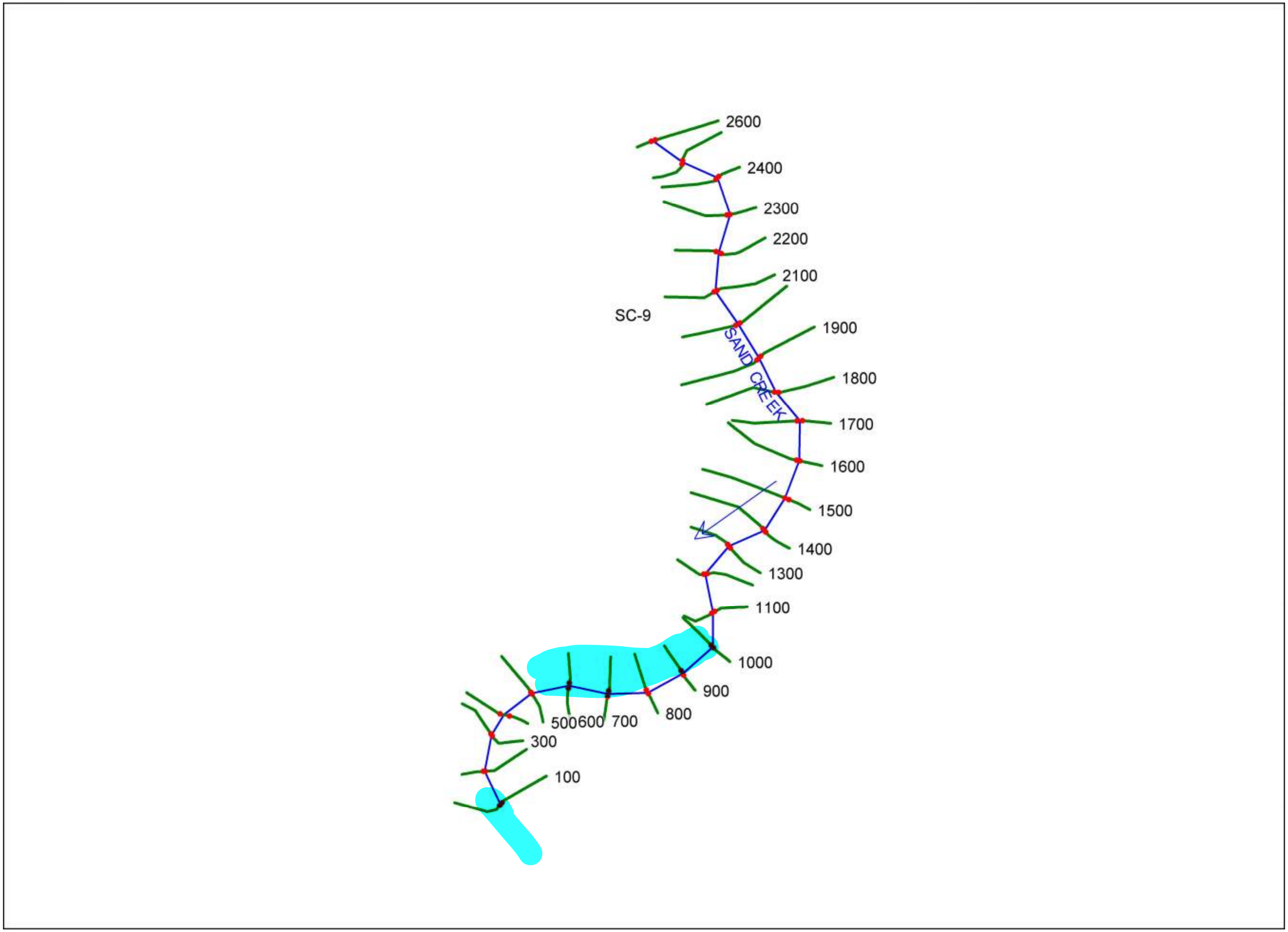
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Max Chl Dpth	Hydr Radius	E.G. Elev	E.G. Slope	Vel Total	Shear Total	Flow Area	Top Width	Froude # XS
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(lb/sq ft)	(sq ft)	(ft)	
SC-9	2600	FEMA 100 yr.	2600.00	7222.35	7230.04		7.69	5.42	7230.18	0.005197	2.85	1.76	913.30	165.94	0.22
SC-9	2600	DBPS 100 yr.	2170.00	7222.35	7229.43		7.08	4.98	7229.55	0.005114	2.67	1.59	813.19	161.08	0.22
SC-9	2500	FEMA 100 yr.	2600.00	7221.49	7229.47		7.98	4.81	7229.63	0.006294	3.00	1.89	867.87	178.83	0.26
SC-9	2500	DBPS 100 yr.	2170.00	7221.49	7228.88		7.39	4.68	7229.02	0.005957	2.83	1.74	767.52	162.56	0.24
SC-9	2400	FEMA 100 yr.	2600.00	7220.76	7228.38		7.62	4.07	7228.69	0.014896	4.07	3.79	638.08	154.82	0.39
SC-9	2400	DBPS 100 yr.	2170.00	7220.76	7227.85		7.09	3.91	7228.13	0.014193	3.87	3.46	560.02	141.56	0.38
SC-9	2300	FEMA 100 yr.	2600.00	7220.00	7227.17		7.17	4.26	7227.40	0.011310	3.60	3.01	722.83	168.17	0.33
SC-9	2300	DBPS 100 yr.	2170.00	7220.00	7226.70		6.70	4.00	7226.90	0.010742	3.36	2.68	645.48	159.81	0.31
SC-9	2200	FEMA 100 yr.	2600.00	7218.65	7224.71		6.06	2.91	7225.65	0.028534	5.30	5.18	490.82	168.37	0.80
SC-9	2200	DBPS 100 yr.	2170.00	7218.65	7224.32		5.67	2.67	7225.21	0.028458	5.08	4.74	426.97	159.51	0.81
SC-9	2100	FEMA 100 yr.	2600.00	7216.91	7222.47		5.60	3.08	7222.96	0.022789	4.50	4.38	578.16	186.77	0.56
SC-9	2100	DBPS 100 yr.	2170.00	7216.91	7222.00		5.13	2.76	7222.49	0.023773	4.41	4.10	492.54	177.30	0.59
SC-9	2000	FEMA 100 yr.	2600.00	7214.69	7219.27	7219.25	4.58	2.71	7220.59	0.023302	5.07	3.95	512.34	187.76	0.98
SC-9	2000	DBPS 100 yr.	2170.00	7214.69	7218.96	7218.91	4.27	2.49	7220.13	0.022155	4.77	3.44	455.40	181.96	0.97
SC-9	1900	FEMA 100 yr.	2600.00	7212.63	7217.55		4.92	2.97	7217.86	0.024680	4.21	4.58	618.13	207.11	0.46
SC-9	1900	DBPS 100 yr.	2170.00	7212.63	7217.20		4.57	2.68	7217.48	0.025323	3.98	4.23	544.59	202.67	0.46
SC-9	1800	FEMA 100 yr.	2600.00	7210.76	7216.16		5.40	3.55	7216.30	0.010533	3.00	2.34	867.60	242.34	0.28
SC-9	1800	DBPS 100 yr.	2170.00	7210.76	7215.75		4.99	3.18	7215.88	0.010824	2.82	2.15	769.37	240.62	0.28
SC-9	1700	FEMA 100 yr.	2600.00	7208.98	7214.66		5.68	3.51	7215.03	0.015604	4.02	3.42	646.19	182.35	0.46
SC-9	1700	DBPS 100 yr.	2170.00	7208.98	7214.21		5.23	3.10	7214.57	0.016339	3.84	3.17	565.04	180.53	0.48
SC-9	1600	FEMA 100 yr.	2600.00	7207.41	7213.24		5.83	3.85	7213.56	0.013840	3.86	3.33	673.00	173.53	0.41
SC-9	1600	DBPS 100 yr.	2170.00	7207.41	7212.62		5.21	3.35	7212.94	0.016136	3.82	3.37	567.56	168.40	0.44
SC-9	1500	FEMA 100 yr.	2600.00	7206.04	7212.69		6.69	4.93	7212.81	0.004188	2.47	1.29	1051.22	210.36	0.22
SC-9	1500	DBPS 100 yr.	2170.00	7206.04	7211.98		5.98	4.32	7212.10	0.004673	2.40	1.26	904.60	206.98	0.23
SC-9	1400	FEMA 100 yr.	2600.00	7204.96	7212.26		7.30	5.00	7212.39	0.004241	2.52	1.32	1031.11	204.28	0.23
SC-9	1400	DBPS 100 yr.	2170.00	7204.96	7211.51		6.55	4.45	7211.64	0.004685	2.46	1.30	882.00	196.51	0.24
SC-9	1300	FEMA 100 yr.	2600.00	7203.87	7211.69		7.82	5.49	7211.90	0.005574	3.14	1.91	829.19	148.59	0.27
SC-9	1300	DBPS 100 yr.	2170.00	7203.87	7210.89		7.02	4.85	7211.10	0.006154	3.05	1.86	712.30	144.96	0.29
SC-9	1200	FEMA 100 yr.	2600.00	7202.91	7211.21		8.30	5.49	7211.39	0.004722	2.89	1.62	900.68	160.49	0.25
SC-9	1200	DBPS 100 yr.	2170.00	7202.91	7210.39		7.48	5.19	7210.55	0.004885	2.80	1.58	774.19	145.69	0.24
SC-9	1100	FEMA 100 yr.	2600.00	7201.85	7210.32		8.47	3.44	7210.73	0.009117	3.60	1.96	722.95	208.12	0.48
SC-9	1100	DBPS 100 yr.	2170.00	7201.85	7209.57		7.72	4.40	7209.91	0.008409	3.62	2.31	600.24	134.55	0.39
SC-9	1000	FEMA 100 yr.	2600.00	7199.76	7209.27		9.51	4.28	7209.70	0.012015	4.09	3.21	635.18	144.59	0.44
SC-9	1000	DBPS 100 yr.	2170.00	7199.76	7208.51		8.75	4.21	7208.91	0.012048	4.07	3.17	532.92	122.92	0.43

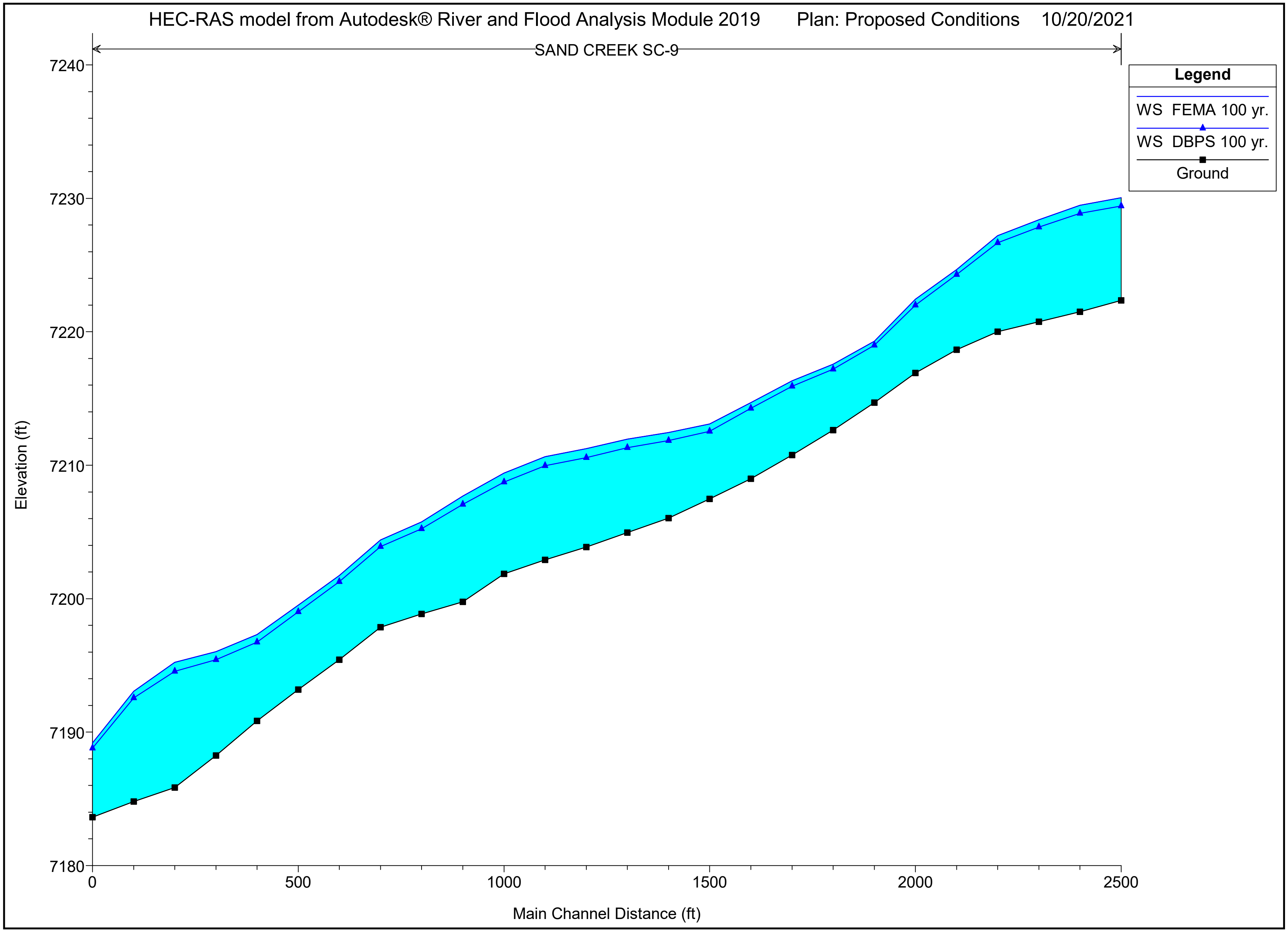
HEC-RAS Plan: Ex. Cond. River: Sand Creek Reach: SC-9 (Continued)

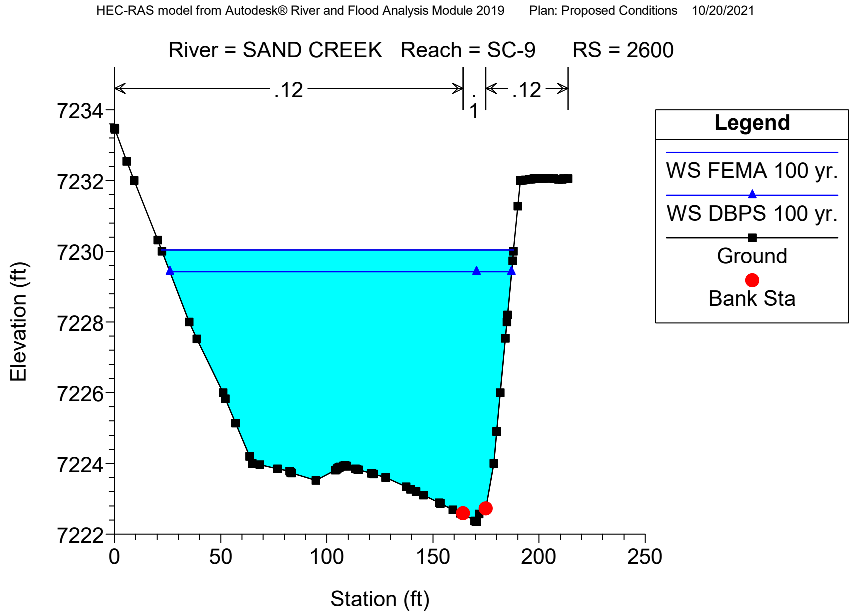
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Max Chl Dpth	Hydr Radius	E.G. Elev	E.G. Slope	Vel Total	Shear Total	Flow Area	Top Width	Froude # XS
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(lb/sq ft)	(sq ft)	(ft)	
SC-9	900	FEMA 100 yr.	2600.00	7198.85	7207.76		8.91	4.77	7208.44	0.012804	4.88	3.81	533.05	109.31	0.53
SC-9	900	DBPS 100 yr.	2170.00	7198.85	7207.07		8.22	4.61	7207.67	0.012460	4.70	3.59	461.30	97.66	0.51
SC-9	800	FEMA 100 yr.	2600.00	7197.87	7205.34		7.47	4.02	7206.59	0.027271	6.52	6.85	398.94	97.06	0.78
SC-9	800	DBPS 100 yr.	2170.00	7197.87	7204.74		6.87	3.92	7205.86	0.026867	6.31	6.57	344.05	85.87	0.75
SC-9	700	FEMA 100 yr.	2600.00	7195.42	7201.76	7201.35	6.34	4.05	7203.28	0.040315	7.82	10.19	332.43	80.30	0.86
SC-9	700	DBPS 100 yr.	2170.00	7195.42	7201.31	7200.92	5.89	3.72	7202.65	0.038748	7.30	8.99	297.30	78.33	0.84
SC-9	600	FEMA 100 yr.	2600.00	7193.19	7199.53		6.34	4.29	7200.00	0.022766	5.18	6.09	501.48	115.45	0.46
SC-9	600	DBPS 100 yr.	2170.00	7193.19	7199.04		5.85	3.89	7199.46	0.022724	4.87	5.53	445.57	113.11	0.46
SC-9	500	FEMA 100 yr.	2600.00	7190.84	7197.18		6.34	4.16	7197.62	0.024773	5.16	6.43	503.76	119.34	0.46
SC-9	500	DBPS 100 yr.	2170.00	7190.84	7196.62		5.78	3.75	7197.03	0.026244	4.96	6.14	437.44	115.25	0.46
SC-9	400	FEMA 100 yr.	2600.00	7188.25	7195.91		7.66	4.78	7196.34	0.008189	4.07	2.45	638.96	130.44	0.42
SC-9	400	DBPS 100 yr.	2170.00	7188.25	7195.32		7.07	4.31	7195.72	0.008180	3.85	2.20	563.27	127.72	0.42
SC-9	300	FEMA 100 yr.	2600.00	7185.84	7194.84		9.00	4.52	7195.64	0.008073	3.70	2.28	703.58	152.77	0.59
SC-9	300	DBPS 100 yr.	2170.00	7185.84	7194.14		8.30	3.98	7194.97	0.008869	3.63	2.20	597.14	147.37	0.64
SC-9	200	FEMA 100 yr.	2600.00	7184.80	7192.65	7192.65	7.85	4.17	7194.62	0.010470	4.88	2.73	533.11	124.10	0.96
SC-9	200	DBPS 100 yr.	2170.00	7184.80	7192.19	7192.19	7.39	3.80	7193.95	0.009869	4.56	2.34	476.02	121.78	0.95
SC-9	100	FEMA 100 yr.	2600.00	7183.63	7189.18	7189.18	5.55	3.39	7190.74	0.011738	4.10	2.48	634.04	186.15	0.96
SC-9	100	DBPS 100 yr.	2170.00	7183.63	7188.47	7185.99	4.84	2.87	7190.25	0.015020	4.29	2.69	506.39	175.71	1.11

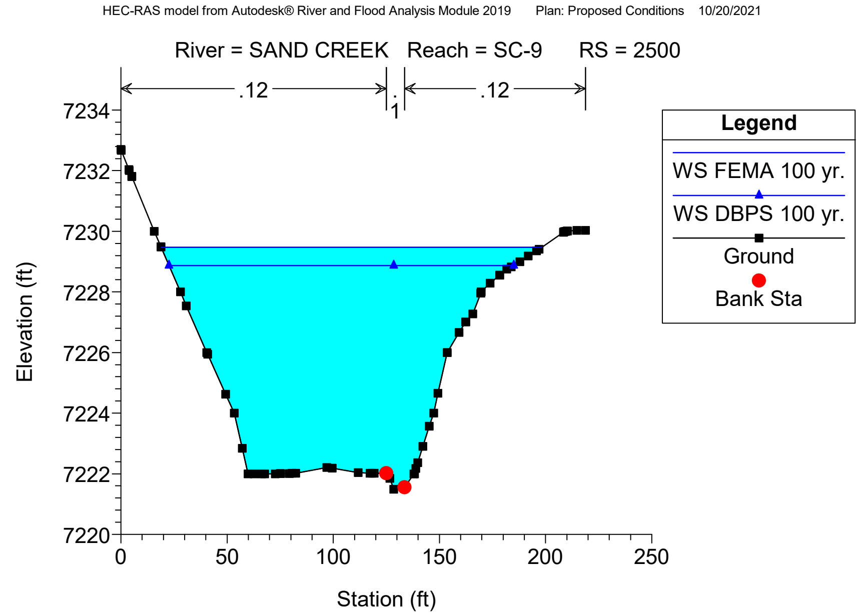


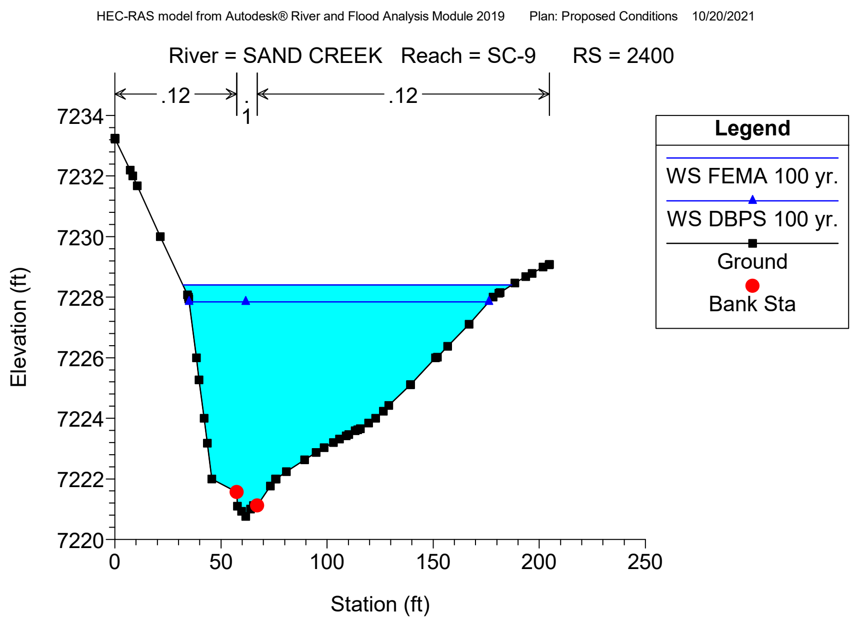
HEC-RAS model from Autodesk® River and F Plan: Existing Conditions 10/20/2021
Sand Creek SC-9
Legend
Vel Total DBPS 100 yr.
Vel Total FEMA 100 yr.
Shear Total DBPS 100 yr.
Shear Total FEMA 100 yr.
Shear Total (lb/sq ft), Vel Total (ft/s)
0
2
4
6
8
10
12
0
500
1000
1500
2000
2500
Main Channel Distance (ft)

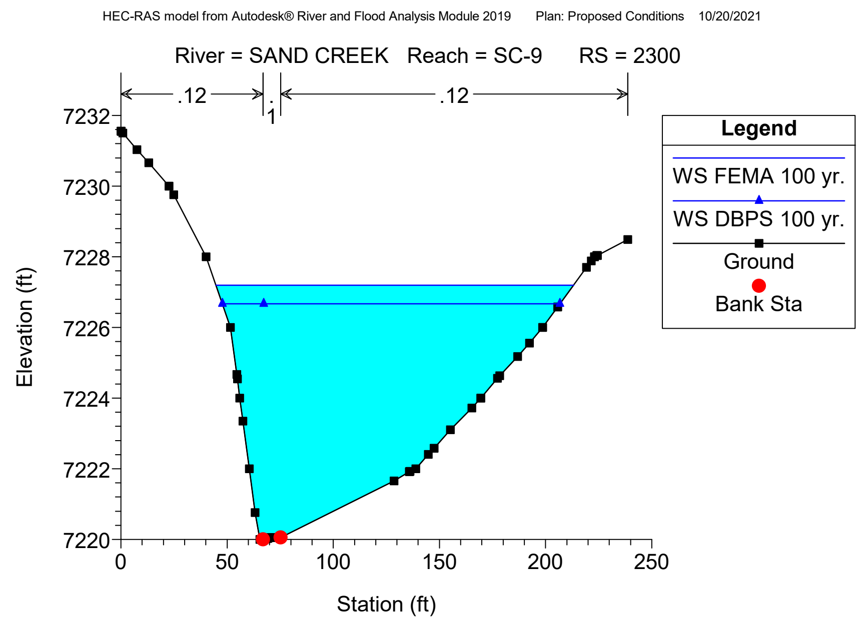

2600
2400
2300
2200
2100
SC-9
SAND CREEK
1900
1800
1700
1600
1500
1400
1300
1100
1000
900
800
700
500600
300
100

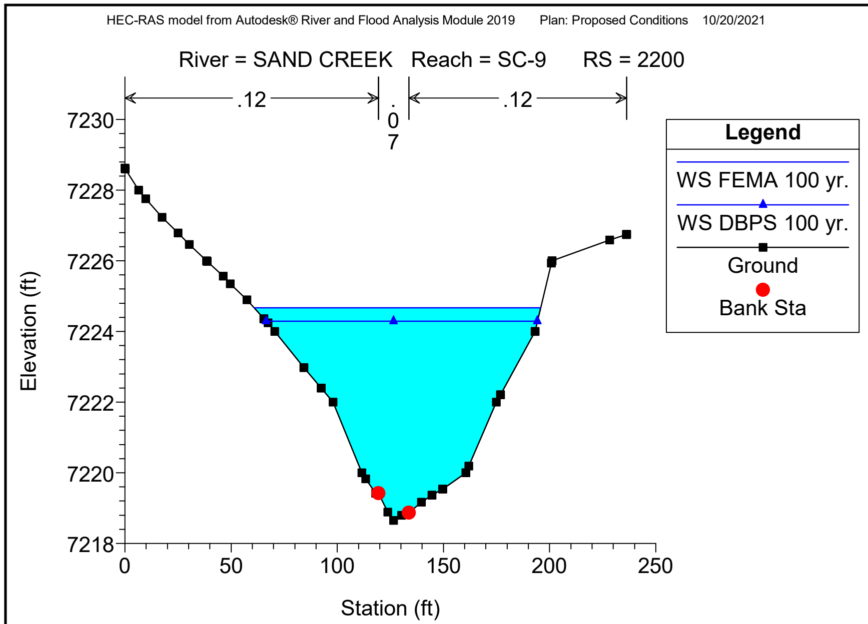

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
SAND CREEK SC-9
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Elevation (ft)
Main Channel Distance (ft)
7240
7230
7220
7210
7200
7190
7180
0
500
1000
1500
2000
2500

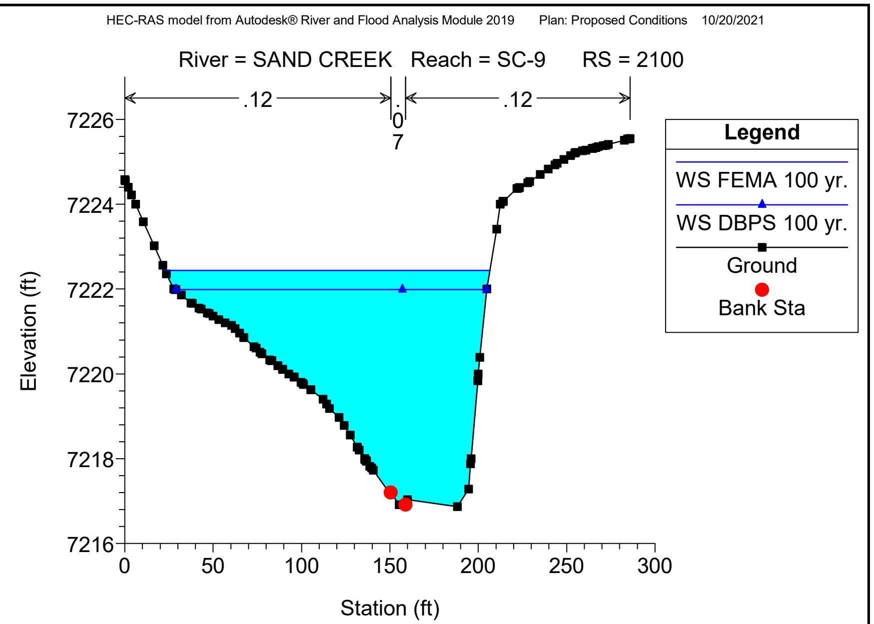

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 2600
.12
.1
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

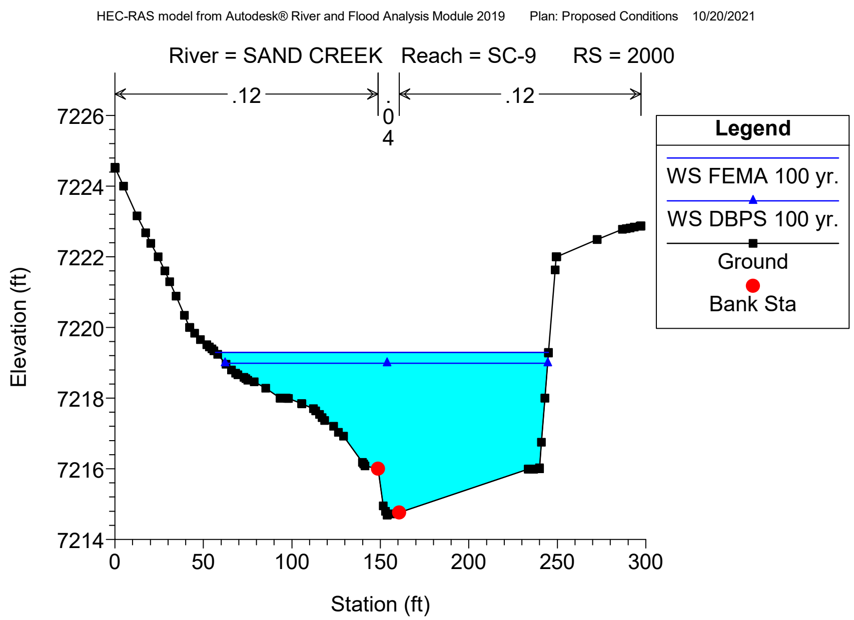

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 2500
.12
.1
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

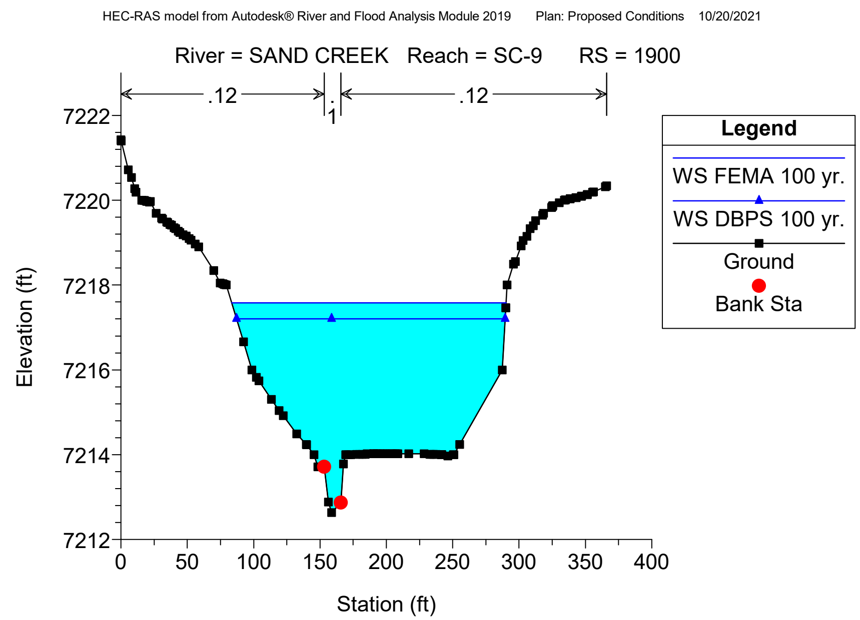

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 2400
.12
.1
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

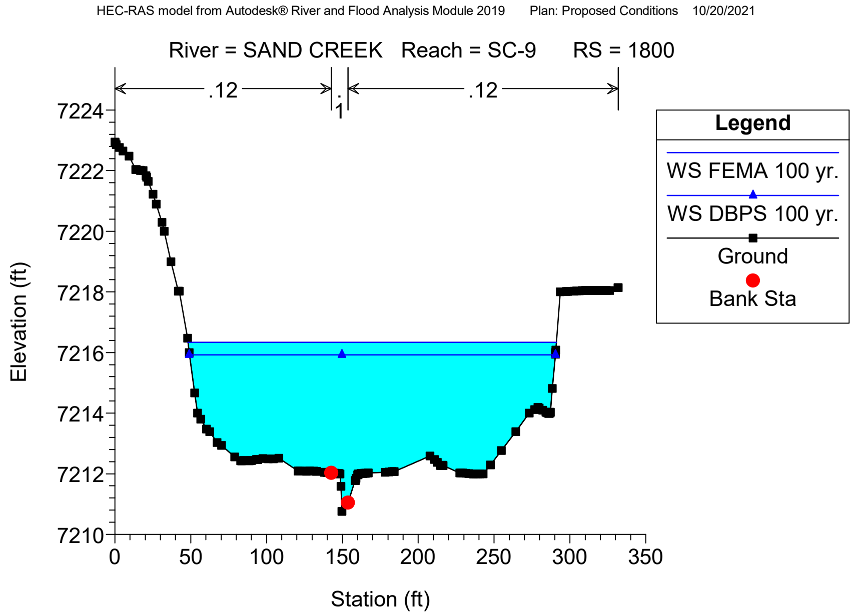

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 2300
.12
.1
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

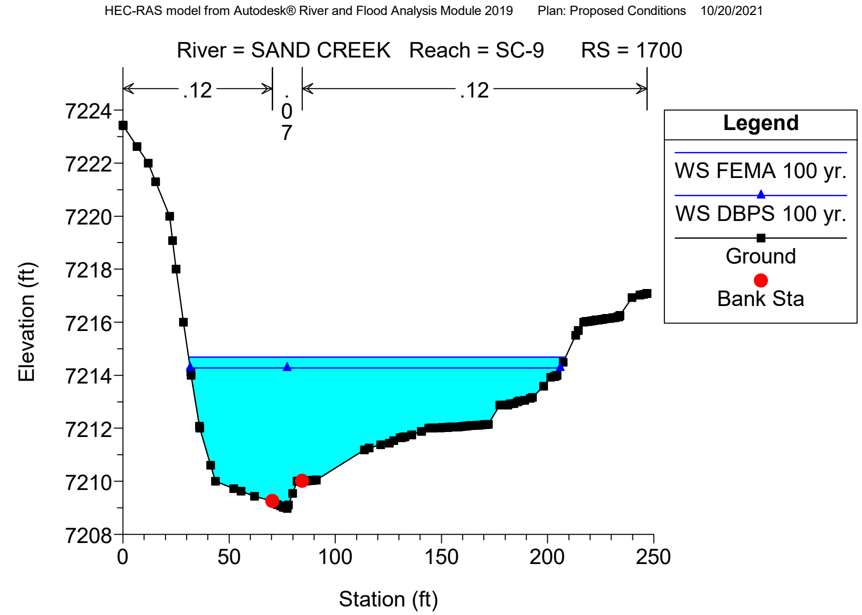

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 2200
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

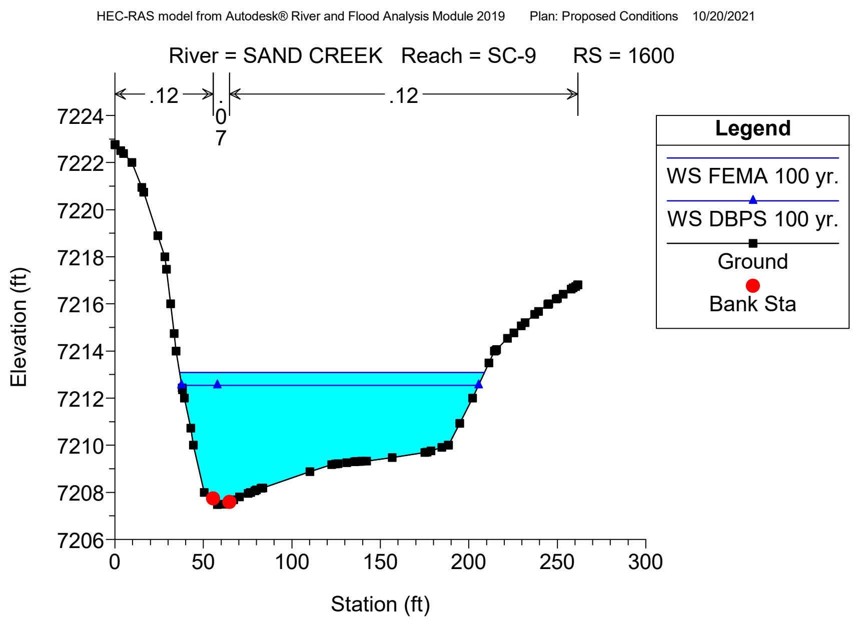

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 2100
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

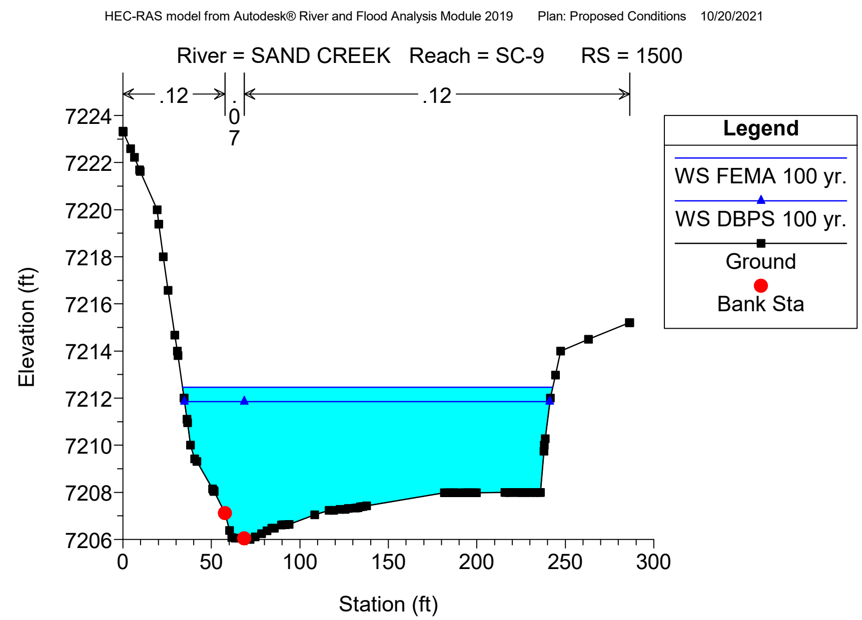

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 2000
.12
.04
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

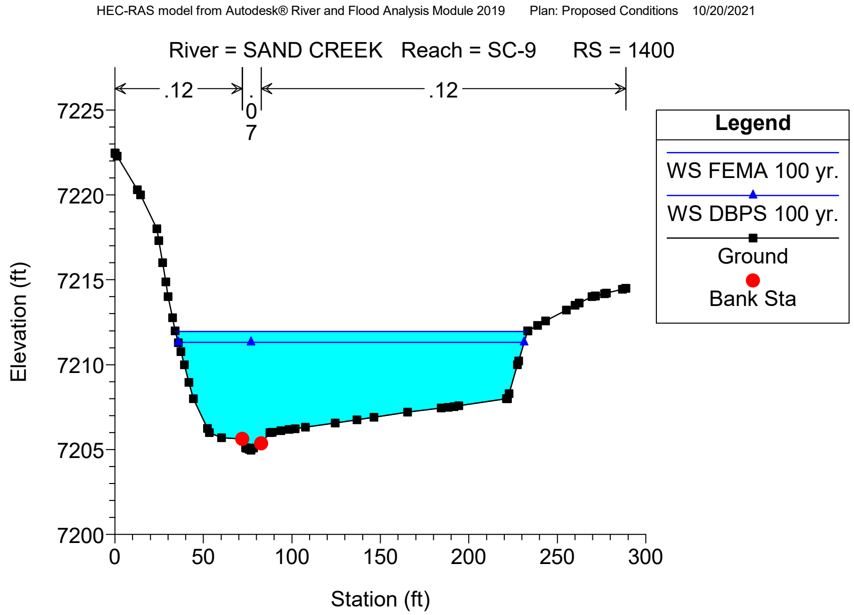

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 1900
.12
.1
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

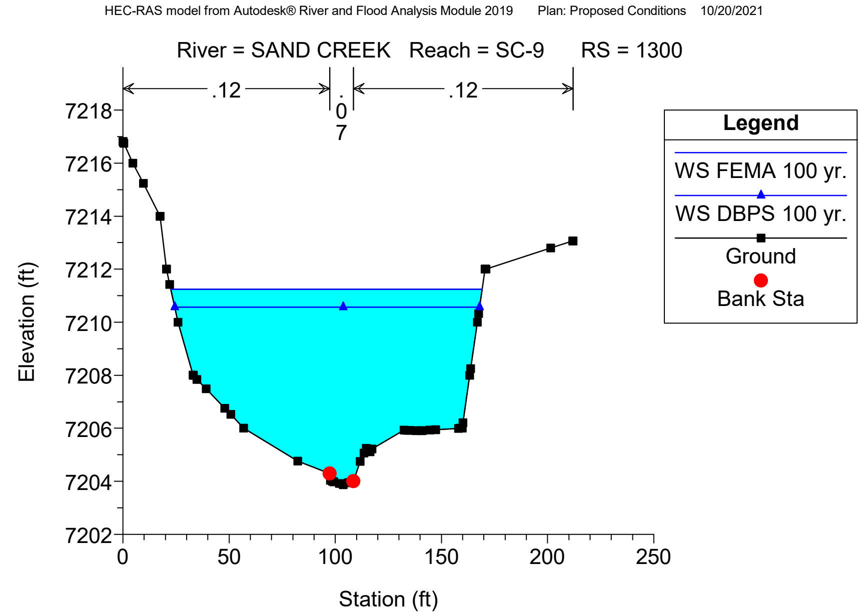

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 1800
.12
.1
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7210
7212
7214
7216
7218
7220
7222
7224
0
50
100
150
200
250
300
350

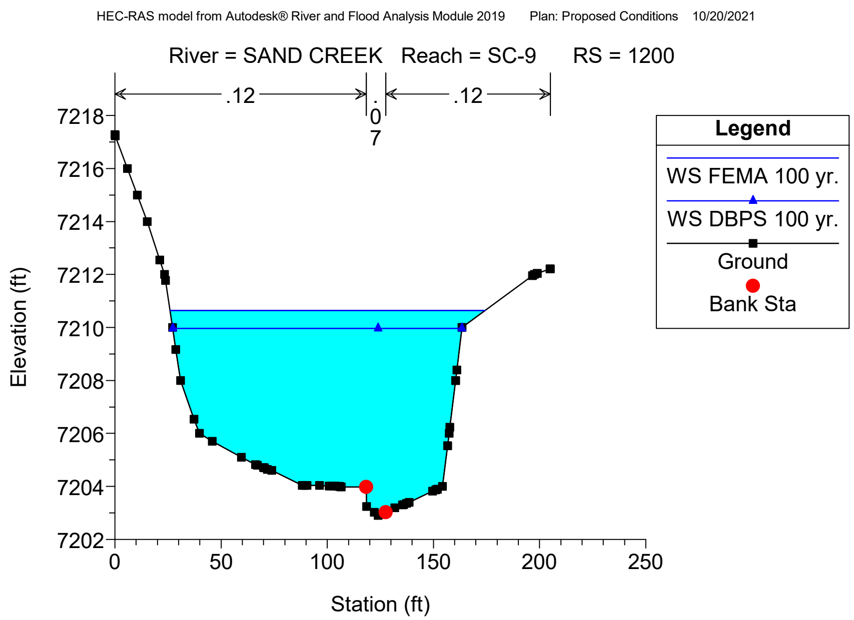

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 1700
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7208
7210
7212
7214
7216
7218
7220
7222
7224
0
50
100
150
200
250

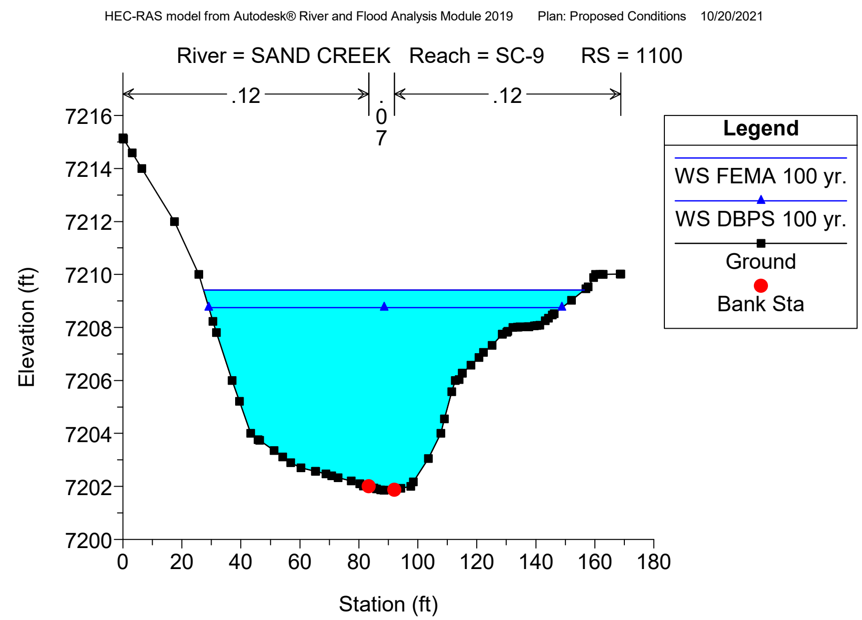

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 1600
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7206
7208
7210
7212
7214
7216
7218
7220
7222
7224
0
50
100
150
200
250
300

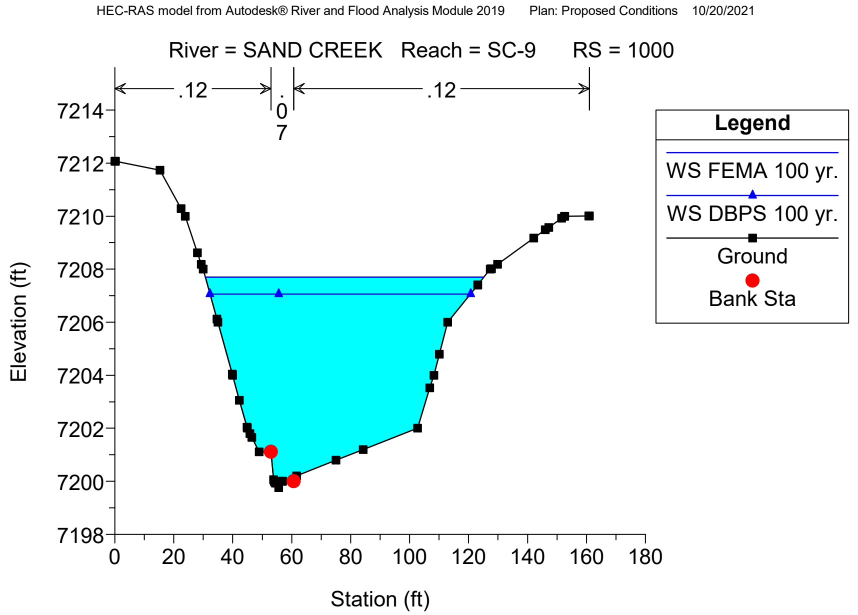

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 1500
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)
7206
7208
7210
7212
7214
7216
7218
7220
7222
7224
0
50
100
150
200
250
300

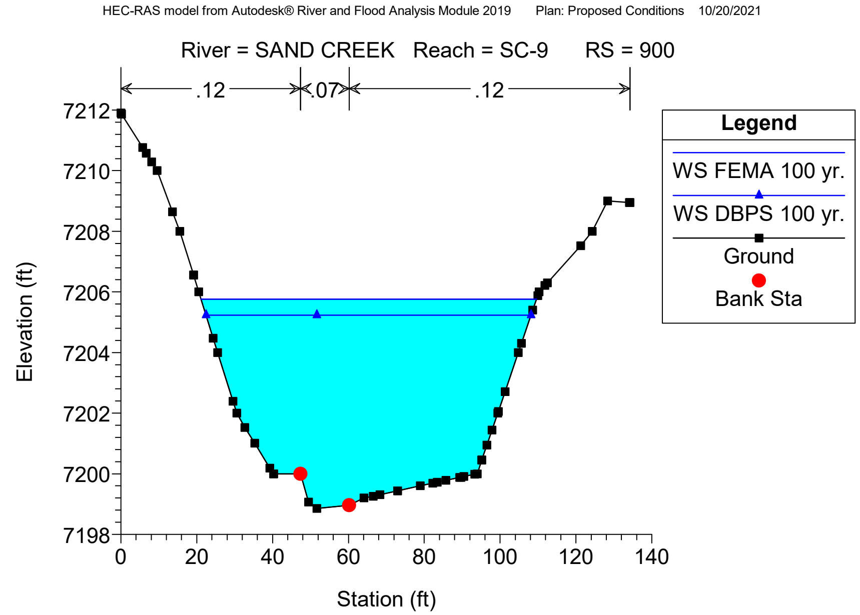

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 1400
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

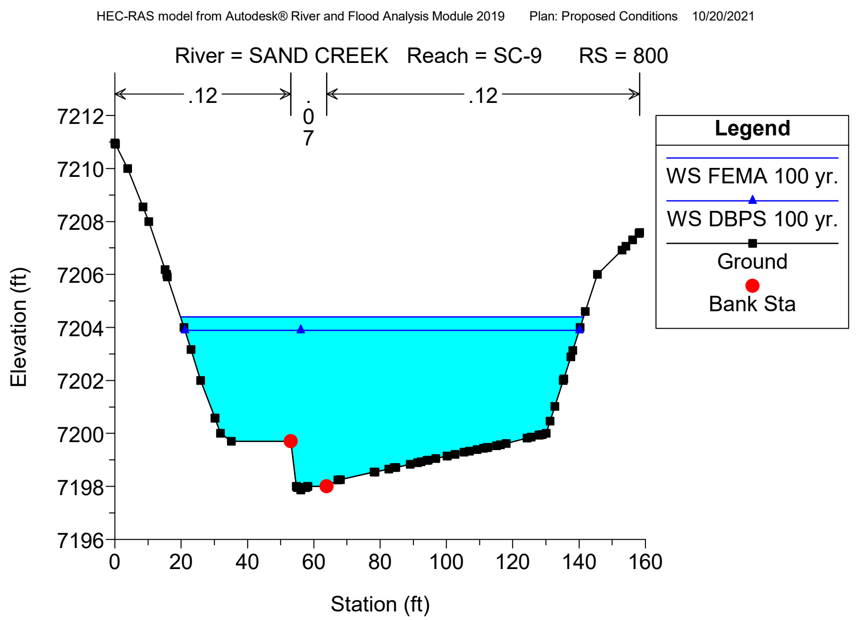

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 1300
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

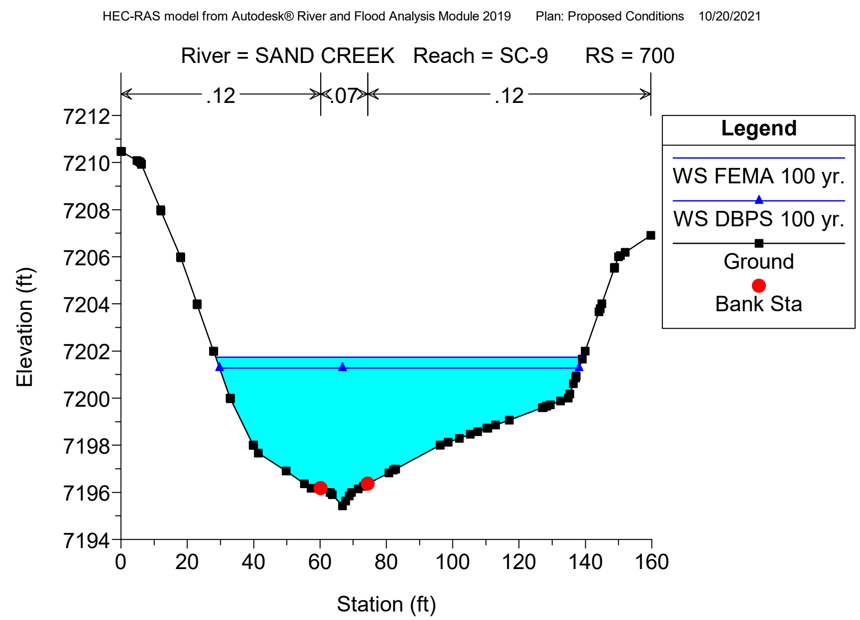

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 1200
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

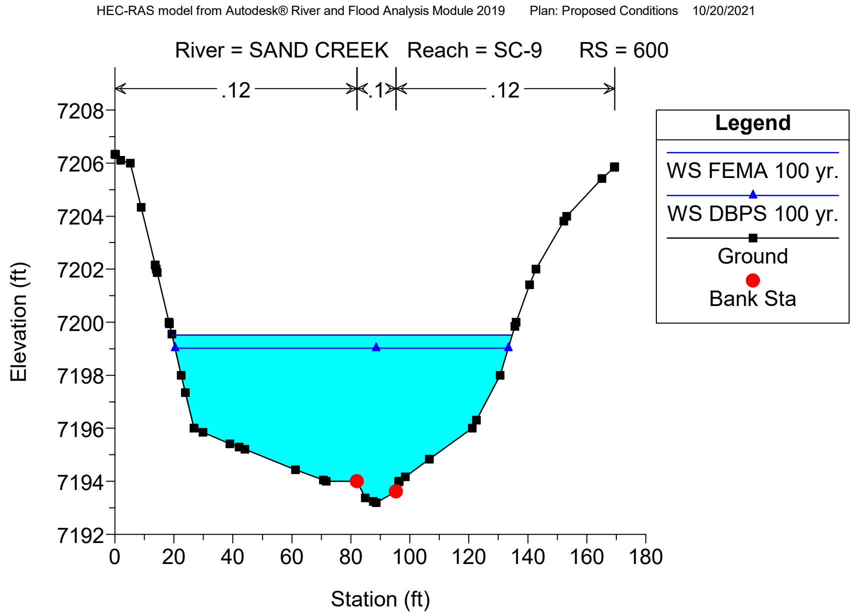

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 1100
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

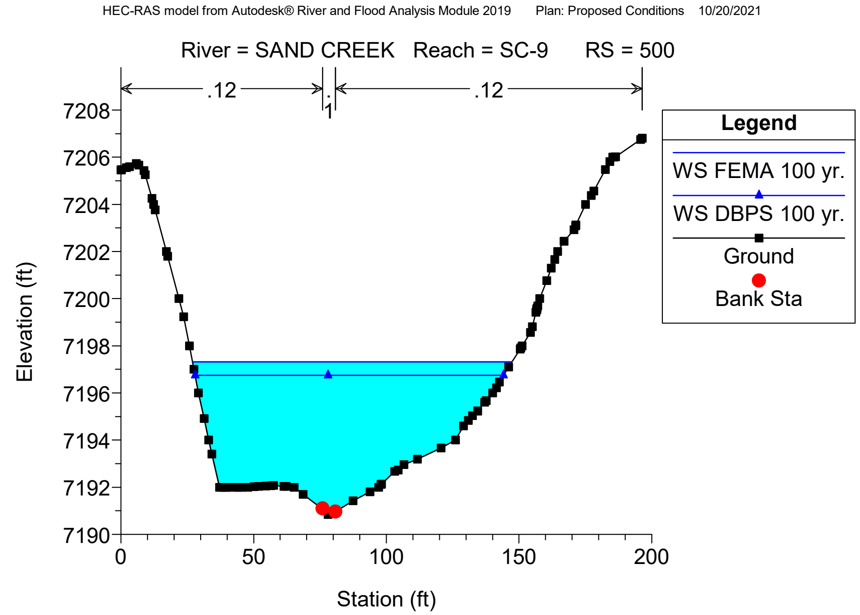

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 1000
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

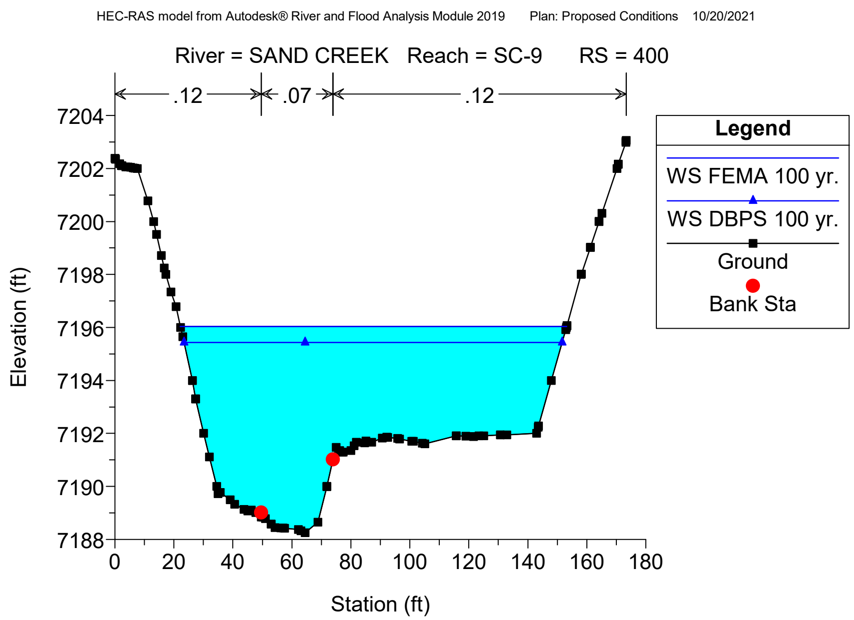

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 900
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

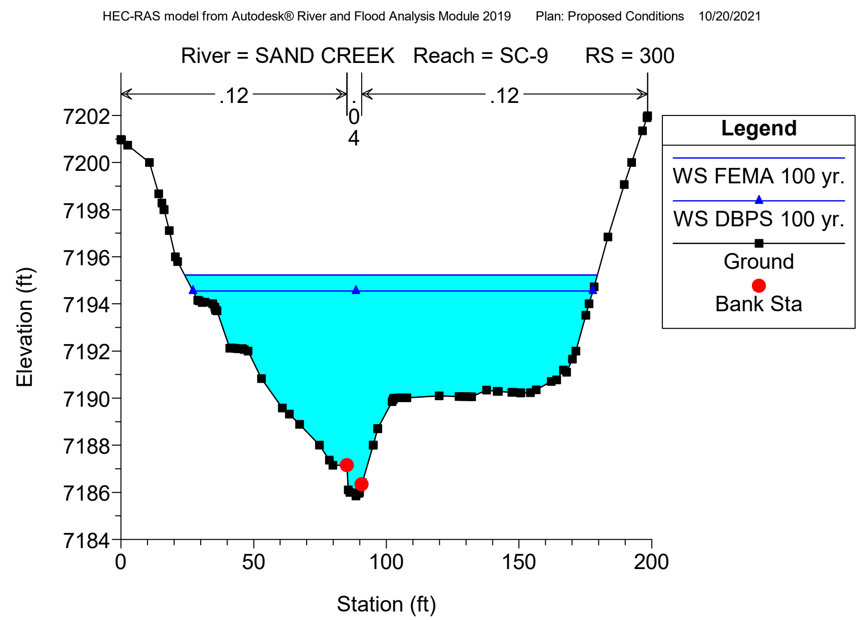

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 800
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

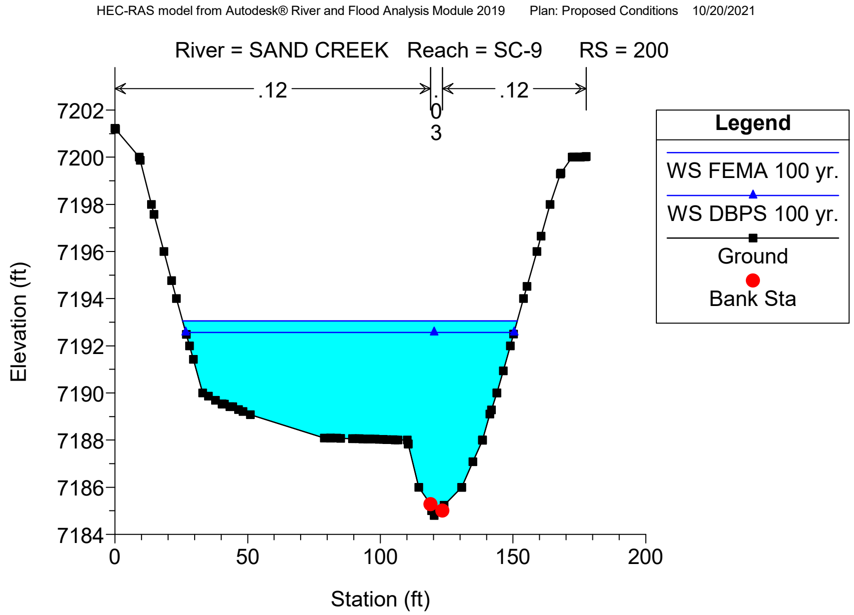

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 700
.12
.07
.12
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)


HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 600
.12
.1
.12
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta

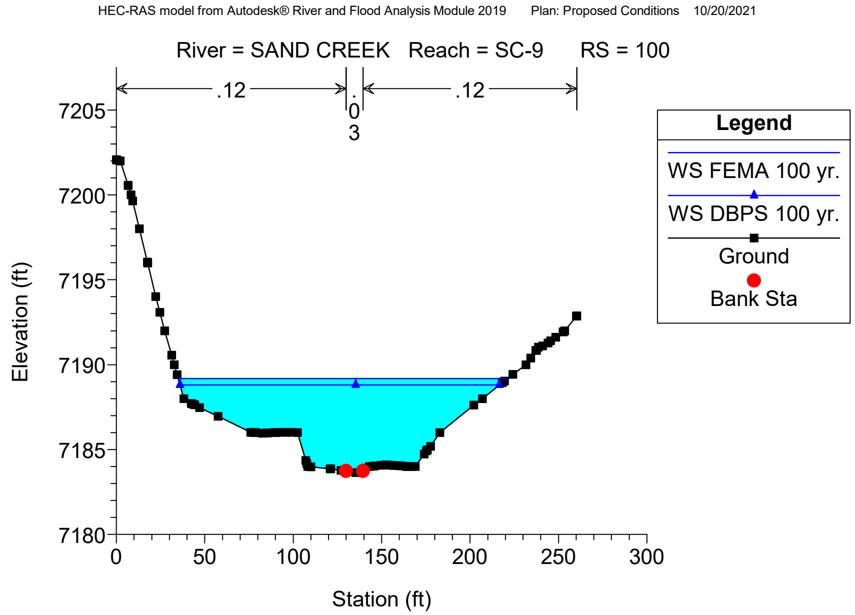

HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 500
.12
.1
.12
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta


HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 400
.12
.07
.12
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta


HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 300
.12
.04
.12
Elevation (ft)
Station (ft)
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta



HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 200
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)



HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
River = SAND CREEK Reach = SC-9 RS = 100
Legend
WS FEMA 100 yr.
WS DBPS 100 yr.
Ground
Bank Sta
Elevation (ft)
Station (ft)

HEC-RAS Plan: Pr. Cond.   River: SAND CREEK   Reach: SC-9

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)	
SC-9	2600	FEMA 100 yr.	2600.00	7222.35	7230.04		7.69	5.42	7230.18	0.005201	2.85	1.76	913.08	165.93	0.22
SC-9	2600	DBPS 100 yr.	2170.00	7222.35	7229.42		7.07	4.97	7229.54	0.005136	2.67	1.59	812.03	161.02	0.22
SC-9	2500	FEMA 100 yr.	2600.00	7221.49	7229.47		7.98	4.81	7229.63	0.006123	2.99	1.84	869.91	179.19	0.26
SC-9	2500	DBPS 100 yr.	2170.00	7221.49	7228.87		7.38	4.69	7229.01	0.005836	2.83	1.71	767.71	162.31	0.24
SC-9	2400	FEMA 100 yr.	2600.00	7220.76	7228.40		7.64	4.06	7228.71	0.015076	4.08	3.82	637.27	154.93	0.39
SC-9	2400	DBPS 100 yr.	2170.00	7220.76	7227.85		7.09	3.88	7228.13	0.014604	3.90	3.54	555.93	141.24	0.38
SC-9	2300	FEMA 100 yr.	2600.00	7220.00	7227.20		7.20	4.28	7227.42	0.011077	3.57	2.96	727.85	168.43	0.32
SC-9	2300	DBPS 100 yr.	2170.00	7220.00	7226.67		6.67	4.00	7226.87	0.010907	3.38	2.72	641.35	159.01	0.32
SC-9	2200	FEMA 100 yr.	2600.00	7218.65	7224.67		6.02	3.28	7225.67	0.029316	5.84	6.01	445.02	134.89	0.78
SC-9	2200	DBPS 100 yr.	2170.00	7218.65	7224.29		5.64	3.08	7225.18	0.027866	5.50	5.35	394.81	127.69	0.76
SC-9	2100	FEMA 100 yr.	2600.00	7216.91	7222.44		5.57	3.10	7222.95	0.022595	4.53	4.37	573.36	183.88	0.57
SC-9	2100	DBPS 100 yr.	2170.00	7216.91	7221.99		5.12	2.78	7222.48	0.023701	4.42	4.11	491.47	175.94	0.59
SC-9	2000	FEMA 100 yr.	2600.00	7214.69	7219.30	7219.22	4.61	2.70	7220.57	0.023635	5.07	3.99	512.53	188.20	0.97
SC-9	2000	DBPS 100 yr.	2170.00	7214.69	7218.99	7218.90	4.30	2.48	7220.12	0.022439	4.76	3.48	455.93	182.34	0.95
SC-9	1900	FEMA 100 yr.	2600.00	7212.63	7217.58		4.95	3.01	7217.88	0.023883	4.17	4.48	624.00	206.62	0.45
SC-9	1900	DBPS 100 yr.	2170.00	7212.63	7217.20		4.57	2.69	7217.48	0.024873	3.96	4.18	547.32	202.29	0.45
SC-9	1800	FEMA 100 yr.	2600.00	7210.76	7216.34		5.58	3.71	7216.47	0.009037	2.86	2.09	908.07	242.90	0.26
SC-9	1800	DBPS 100 yr.	2170.00	7210.76	7215.93		5.17	3.33	7216.04	0.009143	2.68	1.90	809.11	241.33	0.26
SC-9	1700	FEMA 100 yr.	2600.00	7208.98	7214.69		5.70	3.29	7215.18	0.019487	4.43	4.00	587.37	177.51	0.55
SC-9	1700	DBPS 100 yr.	2170.00	7208.98	7214.27		5.29	2.93	7214.73	0.019950	4.22	3.65	514.36	174.34	0.56
SC-9	1600	FEMA 100 yr.	2600.00	7207.48	7213.09		5.61	3.76	7213.43	0.015166	3.98	3.56	652.87	172.32	0.42
SC-9	1600	DBPS 100 yr.	2170.00	7207.48	7212.54		5.06	3.32	7212.87	0.016828	3.88	3.48	559.79	167.77	0.44
SC-9	1500	FEMA 100 yr.	2600.00	7206.04	7212.46		6.46	4.74	7212.59	0.004839	2.59	1.43	1003.36	209.23	0.23
SC-9	1500	DBPS 100 yr.	2170.00	7206.04	7211.85		5.84	4.20	7211.96	0.005161	2.48	1.35	876.34	206.45	0.24
SC-9	1400	FEMA 100 yr.	2600.00	7204.96	7211.96		7.00	4.84	7212.10	0.004995	2.68	1.51	970.56	198.91	0.24
SC-9	1400	DBPS 100 yr.	2170.00	7204.96	7211.31		6.35	4.28	7211.45	0.005385	2.57	1.44	842.81	195.41	0.25
SC-9	1300	FEMA 100 yr.	2600.00	7203.87	7211.25		7.38	5.12	7211.50	0.007051	3.41	2.26	762.54	146.58	0.31
SC-9	1300	DBPS 100 yr.	2170.00	7203.87	7210.57		6.70	4.56	7210.81	0.007475	3.27	2.13	663.82	143.48	0.32
SC-9	1200	FEMA 100 yr.	2600.00	7202.91	7210.64		7.73	5.34	7210.85	0.006155	3.21	2.05	810.67	148.37	0.28
SC-9	1200	DBPS 100 yr.	2170.00	7202.91	7209.96		7.05	5.13	7210.14	0.005859	3.04	1.88	714.85	136.18	0.26
SC-9	1100	FEMA 100 yr.	2600.00	7201.86	7209.41		7.55	4.39	7209.94	0.013490	4.53	3.69	573.82	129.11	0.49
SC-9	1100	DBPS 100 yr.	2170.00	7201.86	7208.75		6.89	4.05	7209.25	0.014115	4.42	3.57	490.79	119.66	0.50
SC-9	1000	FEMA 100 yr.	2600.00	7199.76	7207.70		7.94	4.92	7208.39	0.018081	5.44	5.55	477.86	94.50	0.52
SC-9	1000	DBPS 100 yr.	2170.00	7199.76	7207.07		7.31	4.62	7207.68	0.017602	5.17	5.08	420.10	88.44	0.51

These (and 2 above) are still very high

HEC-RAS Plan: Pr. Cond. River: SAND CREEK Reach: SC-9 (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)	
SC-9	900	FEMA 100 yr.	2600.00	7198.85	7205.76		6.91	4.92	7206.55	0.018791	5.83	5.78	446.23	88.45	0.56
SC-9	900	DBPS 100 yr.	2170.00	7198.85	7205.23		6.38	4.57	7205.92	0.017833	5.42	5.08	400.56	85.73	0.54
SC-9	800	FEMA 100 yr.	2600.00	7197.87	7204.40		6.53	4.62	7204.83	0.014136	4.54	4.08	573.01	121.52	0.43
SC-9	800	DBPS 100 yr.	2170.00	7197.87	7203.90		6.03	4.23	7204.27	0.013742	4.23	3.63	512.78	118.93	0.42
SC-9	700	FEMA 100 yr.	2600.00	7195.42	7201.74		6.32	3.69	7202.80	0.030615	6.30	7.05	412.73	110.63	0.76
SC-9	700	DBPS 100 yr.	2170.00	7195.42	7201.28		5.86	3.31	7202.27	0.030978	5.99	6.40	362.43	108.33	0.77
SC-9	600	FEMA 100 yr.	2600.00	7193.19	7199.52		6.33	4.27	7199.99	0.022882	5.21	6.10	499.50	115.40	0.47
SC-9	600	DBPS 100 yr.	2170.00	7193.19	7199.02		5.83	3.87	7199.44	0.022993	4.90	5.56	442.67	113.02	0.47
SC-9	500	FEMA 100 yr.	2600.00	7190.84	7197.32		6.48	4.27	7197.73	0.022127	4.98	5.90	521.78	120.35	0.44
SC-9	500	DBPS 100 yr.	2170.00	7190.84	7196.74		5.90	3.85	7197.13	0.023317	4.78	5.61	453.66	116.16	0.44
SC-9	400	FEMA 100 yr.	2600.00	7188.25	7196.04		7.79	4.71	7196.49	0.008322	4.12	2.45	631.75	131.06	0.43
SC-9	400	DBPS 100 yr.	2170.00	7188.25	7195.43		7.18	4.22	7195.85	0.008447	3.93	2.22	552.76	128.22	0.44
SC-9	300	FEMA 100 yr.	2600.00	7185.84	7195.23		9.39	4.78	7195.87	0.006622	3.43	1.98	757.36	155.51	0.51
SC-9	300	DBPS 100 yr.	2170.00	7185.84	7194.55		8.71	4.26	7195.19	0.006960	3.32	1.85	653.98	150.67	0.54
SC-9	200	FEMA 100 yr.	2600.00	7184.80	7193.06	7193.06	8.26	4.57	7194.94	0.010234	4.43	2.92	587.44	126.11	0.90
SC-9	200	DBPS 100 yr.	2170.00	7184.80	7192.56	7192.56	7.76	4.17	7194.28	0.009715	4.13	2.53	525.79	123.67	0.90
SC-9	100	FEMA 100 yr.	2600.00	7183.63	7189.19	7189.19	5.56	3.39	7190.75	0.011746	4.10	2.48	634.41	186.38	0.96
SC-9	100	DBPS 100 yr.	2170.00	7183.63	7188.80	7188.80	5.17	3.10	7190.21	0.011294	3.85	2.19	563.36	180.62	0.95

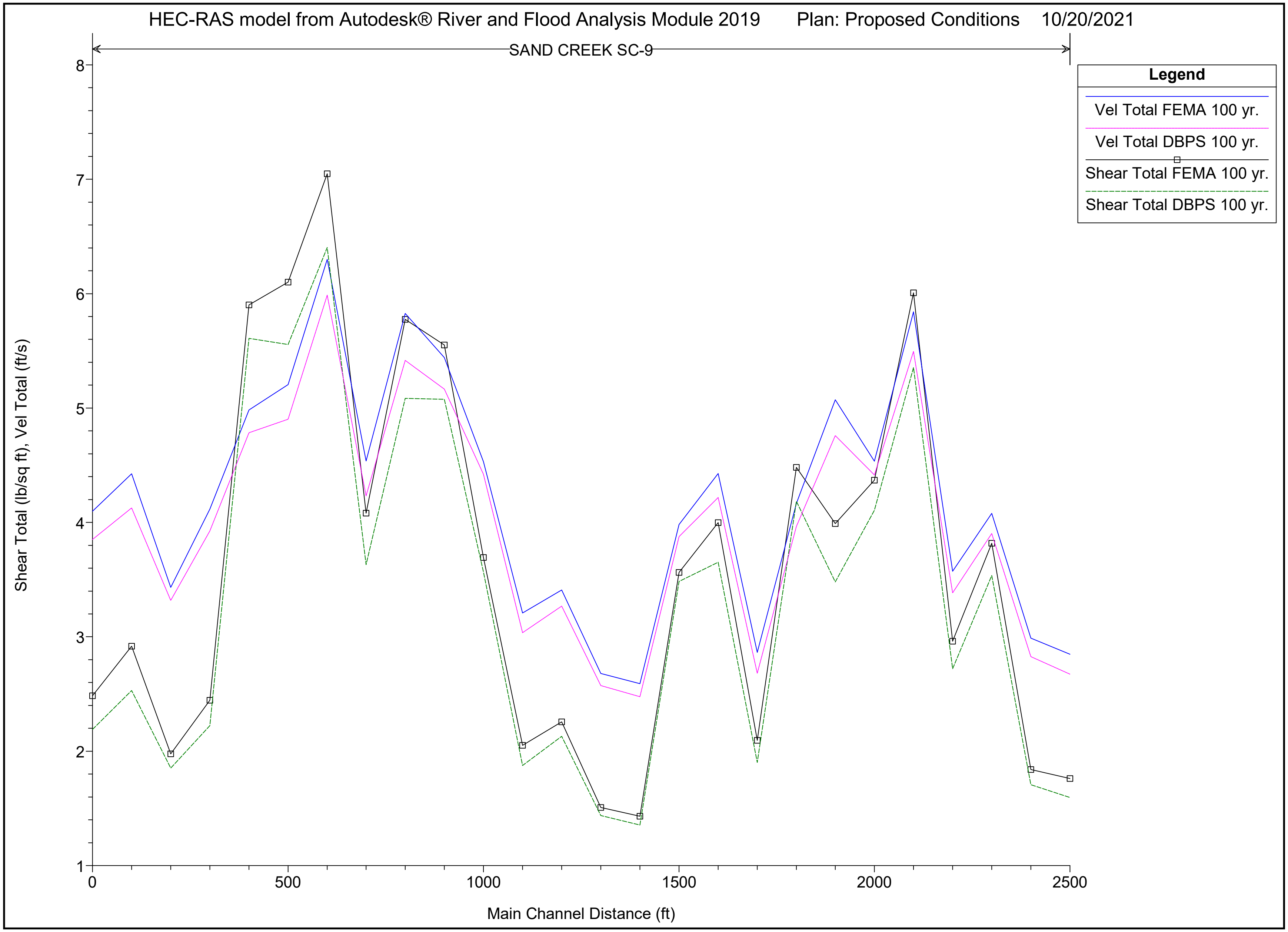
Grade control required?

Table 8-3. Design parameters for naturalized channels

Design Parameter	Design Value
Maximum 100-year depth outside of bankfull channel	5 ft
Roughness values	Per Table 8-5
Maximum 5-year velocity, main channel (within bankfull channel width) (ft/s)	5 ft/s
Maximum 100-year velocity, main channel (within bankfull channel width) (ft/s)	7 ft/s
Froude No., 5-year, main channel (within bankfull channel width)	0.7
Froude No., 100-year, main channel (within bankfull channel width)	0.8
Maximum shear stress, 100-year, main channel (within bankfull channel width)	1.2 lb/sf
Minimum bankfull capacity of bankfull channel (based on future development conditions)	70% of 2-year discharge or 10% of 100-yr discharge, whichever is greater[1]
Minimum bankfull channel geometry	Per Table 8-2
Minimum bankfull channel width/depth ratio (Equation 8-3)	9
Minimum entrenchment ratio (Equation 8-4)	3
Maximum longitudinal slope of low flow channel (assuming unlined, unvegetated low flow channel)	0.2 percent
Bankfull channel sinuosity (Equation 8-5)	1.1 to 1.3[2]
Maximum overbank side slope	4(H):1(V)
Maximum bankfull side slope	2.5(H):1(V)
Minimum radius of curvature	2.5 times top width

[1]Roughly equivalent to a 1.5-year event based on extrapolation of regional data.

MHFD has acceptable criteria; address channel design and stability.


HEC-RAS model from Autodesk® River and Flood Analysis Module 2019 Plan: Proposed Conditions 10/20/2021
SAND CREEK SC-9
Legend
Vel Total FEMA 100 yr.
Vel Total DBPS 100 yr.
Shear Total FEMA 100 yr.
Shear Total DBPS 100 yr.
Shear Total (lb/sq ft), Vel Total (ft/s)
1
2
3
4
5
6
7
8
0
500
1000
1500
2000
2500
Main Channel Distance (ft)

SECTION 404 PERMTTING

WETLAND IMPACT MAP

(CORE CONSULTANTS REPORT)

CLASSIC
CONSULTING
ENGINEERS & SURVEYORS

CORE

September 22, 2021

Loren Moreland
Classic Homes
2138 Flying Horse Club Dr.
Colorado Springs, CO 80921

RE: Filing 2- Retreat at Timber Ridge- Anticipated Wetland and Stream Mitigation

Dear Mr. Moreland:

At your request, CORE Consultants, Inc. (CORE) evaluated the proposed temporary and permanent impacts to Sand Creek and its' associated tributaries and wetland features for the Retreat at Timber Ridge- Filing 2 project. Based on the Filing 2 design files Classic Consulting (Classic) provided CORE on September 9, 2021 and follow up discussions with Marc Whorton (Classic) regarding the nature of the proposed impacts, CORE determined that 0.049 acres of permanent wetland impacts and 0.040 acres of temporary wetland impacts are proposed. Additionally, construction of Filing 2 will require 0.073 acres of permanent stream channel impacts and 0.009 acres of temporary stream channel impacts.

General Condition 23 of the 2021 Nationwide Permits issued by the United States Army Corps of Engineers (USACE) identifies the appropriate and practicable mitigation necessary to ensure that the individual and cumulative adverse environmental effects are no more than minimal. Per General Condition 23(c), compensatory mitigation at a minimum one-for-one ratio will be required for all wetland losses that exceed 1/10-acre (0.1 acres). Because Filing 2 of this project proposes less than 0.1 acres of permanent wetland impacts (wetland losses), we do not anticipate that the USACE will require compensatory mitigation for wetlands. Per General Condition 23(d), compensatory mitigation at a minimum one-for-one ratio will be required for all losses of stream bed that exceed 3/100-acre (0.03 acres) and require pre-construction notification. Because Filing 2 of this project proposes 0.073 acres of permanent stream impacts, we anticipate that the USACE will require compensatory mitigation for streams.

For stream mitigation, the USACE now requires applicants complete a Stream Quantification Tool to determine the amount of mitigation required based on the pre-construction functionality of the stream (reach hydrology and hydraulics, geomorphology, physicochemical, and biology). CORE is working with the USACE as well as WaterVation, PLLC to determine the mitigation required and develop a mitigation approach that satisfies the USACE's requirements for stream rehabilitation, enhancement, and/or preservation as deemed appropriate for this project area.

Sincerely,
CORE Consultants, Inc.

Natalie Graves

Natalie Graves
Natural Resources Project Manager

Attachments- Filing 2- Proposed Impacts Map

CORE LAND DEVELOPMENT ENERGY PUBLIC INFRASTRUCTURE | 3473 S. BROADWAY ENGLEWOOD, CO 80113 303.703.4444

Retreat at Timber Ridge

Filing 2 Wetland Impact Map

El Paso County, Colorado

NHD Watercourse
NHD Waterbody
Filing 2 Boundary
JD Channel (OHWM)
Stream Channel Containing Wetlands
Wetland
Pond
Isolated Wetland

Filing 2 Impacts

Permanent, Stream
Permanent, Wetland
Temporary, Stream
Temporary, Wetland

Date: 9/14/2021
CORE Project #: 16-059

DRAINAGE MAPS

CLASSIC
CONSULTING
ENGINEERS & SURVEYORS

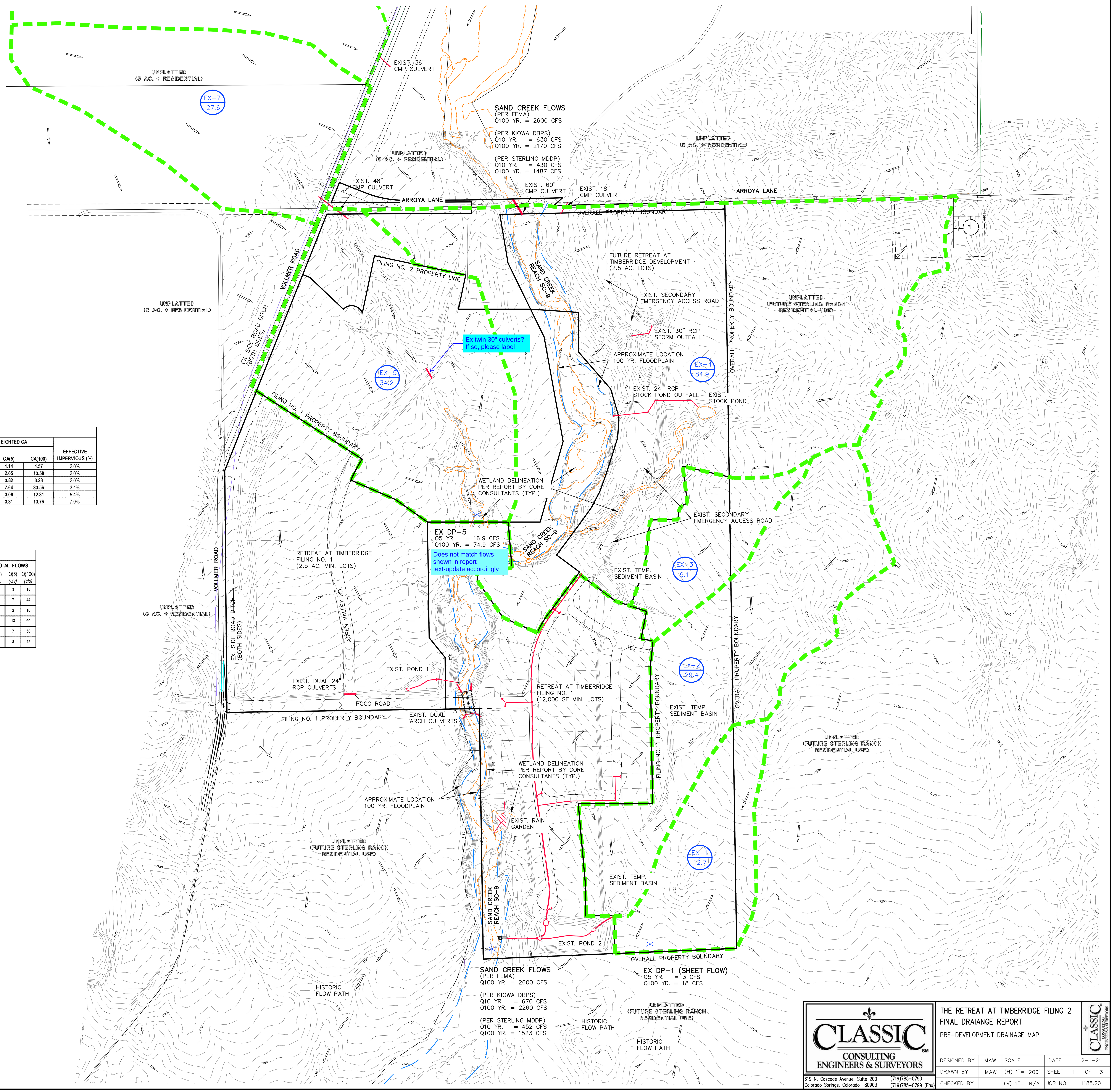
FINAL DRAINAGE REPORT ~ BASIN RUNOFF COEFFICIENT SUMMARY

BASIN	TOTAL AREA (AC)	IMPERVIOUS AREA / STREETS AREA (AC)	C(2)	C(5)	C(100)	LANDSCAPE/DEVELOPED AREAS AREA (AC)	C(2)	C(5)	C(100)	WEIGHTED C(2)	C(5)	C(100)	WEIGHTED CA 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%

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)
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**

Include design point summary table.



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


Indicate whether all proposed storm facilities are private or public
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
Include on legend on next page
SCALE: 1" = 100'
NOTE: SEE SHEET 3 FOR ALL BASIN CALCULATIONS.
SAND CREEK FLOWS
(PER FEMA)
Q100 YR. = 2600 CFS
(PER KIOWA DBPS)
Q10 YR. = 630 CFS
Q100 YR. = 2170 CFS
(PER STERLING MDDP)
Q10 YR. = 430 CFS
Q100 YR. = 1487 CFS
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)
EXIST. 60" CMP CULVERT
FUTURE TIMBERRIDGE RURAL LOTS (2.5 AC. MIN.)
FUTURE TIMBERRIDGE RURAL LOT (2.5 AC. MIN.)
FUTURE TIMBERRIDGE RURAL LOTS (1.0 AC. MIN.)
NOTE: UPON FUTURE UPGRADE FOR VOLLMER ROAD TO A COUNTY STD. TWO-LANE RURAL ARTERIAL, DRAINAGE FROM ROADWAY WILL BE ROUTED TO THE SOUTH VIA SIDEROAD DITCH.
INSTALL PERMANENT ROCK CHECK DAMS EVERY 75'-80' (SEE DETAIL EC-12)
18" DRIVEWAY CULVERT REQUIRED
INSTALL EROSION CONTROL BLANKET (NORTH AMERICAN GREEN – SC150 OR EQUIV.) WITHIN ASPEN VALLEY. ROADSIDE DITCH ADJACENT TO LOTS 4-7
PROP. MAINTENANCE ACCESS RAMP
APPROXIMATE LOCATION 100 YR. FLOODPLAIN (PER LOMR 08-080541P)
APPROXIMATE LOCATION 100 YR. FLOODPLAIN (HEC-RAS CALCULATED)
EXIST. EMERGENCY FIRE ACCESS ROAD CONSTRUCTED WITH FILING NO. 1 (TO REMAIN)
EXIST. 30" RCP STORM CONSTRUCTED WITH FILING NO. 1 (TO REMAIN)
Show FEMA floodplain elevation lines.
PROPERTY BOUNDARY
UNPLATTED (FUTURE STERLING RANCH RESIDENTIAL USE)
VOLLMER ROAD
40' WIDE ROW DEDICATION
SIDE ROAD DITCH NOT WELL DEFINED IN THIS AREA SO FLOWS FROM EXISTING VOLLMER RD. ENTER PROPERTY
DRAINAGE ESMT.
FALCON NEST COURT (RURAL LOCAL)
18" DRIVEWAY CULVERTS REQUIRED FOR LOTS 1-3
INSTALL EROSION CONTROL BLANKET (NORTH AMERICAN GREEN – SC150 OR EQUIV.) WITHIN FALCON NEST CT. ROADSIDE DITCH ADJACENT TO LOTS 1-3
PROP. 24" RCP CULVERT
EXIST. DUAL 30" RCP CULVERTS
Label RR protection
and rock check dams?
WETLAND DELINEATION PER REPORT BY CORE CONSULTANTS (TYP.)
INSTALL TURF REINFORCEMENT MAT (TRM) – P300 OR EQUIV. WITHIN PROPOSED CHANNEL IN LOT 7.
SAND CREEK REACH SC-9
APPROXIMATE LOCATION 100 YR. FLOODPLAIN (HEC-RAS CALCULATED)
EXIST. 24" RCP OUTFALL CONSTRUCTED WITH FILING NO. 1 FOR STOCK POND RELEASE
FILING NO. 1 BOUNDARY
ASPEN VALLEY ROAD (RURAL LOCAL)
PROP. 24" RCP
PROP. TRAIL/ MAINTENANCE ACCESS
EXIST. STOCK POND TO REMAIN
PROP. 42" RCP
REFERENCE APPENDIX FOR RUNOFF REDUCTION FORM FOR BASIN F – LOTS 8&9 (100% WQCV REDUCTION W/ 0% UNTREATED WQCV)
TRACT B
PROP. SHEET PILE CHECK STRUCTURE W/ CONC. CAP
See comment letter
INSTALL EROSION CONTROL BLANKET (NORTH AMERICAN GREEN – SC150 OR EQUIV.) WITHIN FALCON NEST CT. ROADSIDE DITCH ADJACENT TO LOTS 11-12
REFERENCE APPENDIX FOR RUNOFF REDUCTION FORM FOR BASIN E – LOTS 10-12 (100% WQCV REDUCTION W/ 0% UNTREATED WQCV)
Basin E1
APPROXIMATE LOCATION 100 YR. FLOODPLAIN (PER LOMR 08-080541P)
EXIST. TEMP. SEDIMENT BASIN CONSTRUCTED WITH FILING NO. 1 (TO REMAIN)
FUTURE TIMBERRIDGE RURAL LOTS (1.0 AC. MIN.)
REFERENCE APPENDIX FOR RUNOFF REDUCTION FORM FOR BASIN L – LOT 27 (100% WQCV REDUCTION W/ 0% UNTREATED WQCV)
PROPOSED POND 3
PRE-DEVELOPMENT
Q2 YR. = 5.6 CFS
Q5 YR. = 15.8 CFS
Q100 YR. = 69.2 CFS
DEVELOPED RELEASE
Q2 YR. = 1.0 CFS
Q5 YR. = 10.1 CFS
Q100 YR. = 59.6 CFS
PROP. MAINTENANCE ACCESS RAMP
DRAINAGE ESMT. to metro District
Label emergency spillway
Label proposed storm pipe size & material
TRACT A
PROP. RIP-RAP BANK STABILIZATION (TYP.)
EXIST. SHEET PILE CHECK STRUCTURE W/ CONC. CAP
Additional protection needed due to shear stress?
RETREAT AT TIMBERRIDGE FILING NO. 1 (2.5 AC. MIN.)
PROP. TRAIL
EXIST. EMERGENCY FIRE ACCESS ROAD CONSTRUCTED WITH FILING NO. 1 (TO REMAIN)
FUTURE TIMBERRIDGE URBAN LOTS (12,000 SF MIN.)
REFERENCE APPENDIX FOR RUNOFF REDUCTION FORM FOR BASIN K – LOTS 21-26 (100% WQCV REDUCTION W/ 0% UNTREATED WQCV)
OWL PERCH LOOP (URBAN LOCAL)
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.
EXIST. 10' TYPE R AT-GRADE INLET
EXIST. 36" RCP STORM
EXIST. TEMP. SEDIMENT BASIN CONSTRUCTED WITH FILING NO. 1 (TO REMAIN)
EXIST. PERMANENT SEDIMENT BASIN
ASPEN VALLEY ROAD (RURAL LOCAL)
EXIST. RIP-RAP BANK STABILIZATION (TYP.)
REFERENCE APPENDIX FOR RUNOFF REDUCTION FORM FOR BASINS H1, H2, I – LOTS 13-16 (100% WQCV REDUCTION W/ 0% UNTREATED WQCV)
EXIST. 15' TYPE R AT-GRADE INLET
ELK ANTLER LANE (URBAN LOCAL)
PROP. 15' TYPE R SUMP INLET
PROP. TEMP. SEDIMENT BASIN TO REMAIN UNTIL FUTURE STERLING RANCH DEVELOPMENT.
MAINTENANCE BY THE RETREAT AT TIMBERRIDGE METRO. DISTRICT.
PROPOSED DRAINAGE ESMT.
EXIST. SHEET PILE CHECK STRUCTURE W/ CONC. CAP
RETREAT AT TIMBERRIDGE FILING NO. 1 LOTS (12,000 SF MIN.)
PROP. 10' TYPE R SUMP INLET
Label proposed storm pipe size & material
EXIST. DUAL 24" RCP CULVERTS
EXIST. POND 1
EXIST. 36" RCP STORM
EXIST. 10' TYPE R SUMP INLET
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 ~ BASIN RUNOFF COEFFICIENT SUMMARY

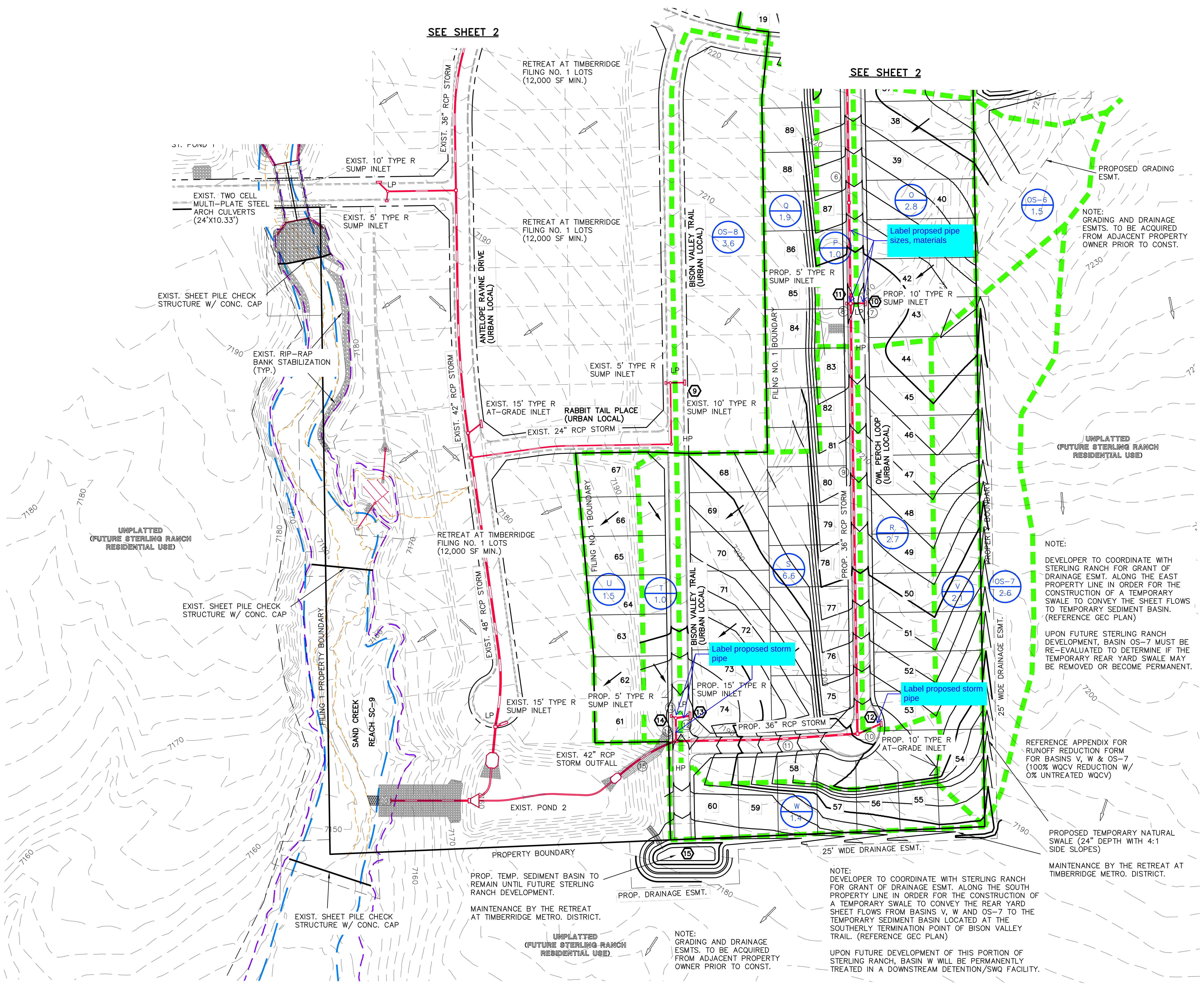
BASIN	TOTAL AREA (AC)	IMPERVIOUS AREA / STREETS AREA (AC)	C(2)	C(5)	C(100)	LANDSCAPE/DEVELOPED AREAS AREA (AC)	C(2)	C(5)	C(100)	WEIGHTED C(2)	C(5)	C(100)	WEIGHTED CA CA(2)	CA(5)	CA(100)	EFFECTIVE IMPERVIOUS (%)
OS-1	3.9	0.20	0.89	0.90	0.96	3.7	0.06	0.14	0.40	0.10	0.18	0.43	**0.40**	**0.70**	**1.67**	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%
E1	7.1	0.45	0.89	0.90	0.96	6.65	0.06	0.14	0.40	0.11	0.19	0.44	**0.80**	**1.34**	**3.09**	16.0%
E2	2.8	0.05	0.89	0.90	0.96	2.75	0.06	0.14	0.40	0.07	0.15	0.41	**0.21**	**0.43**	**1.15**	12.4%
F	12.2	0.00	0.89	0.90	0.96	12.20	0.04	0.10	0.38	0.04	0.10	0.38	**0.49**	**1.22**	**4.64**	7.2%
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%

FINAL DRAINAGE REPORT ~ SURFACE ROUTING SUMMARY

Design Point(s)	Contributing Basins	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity I(5)	I(100)	Flow Q(5)	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, DP-2, Basin D (52.2 ac.)	8.28	21.72	40.9	2.02	3.38	17	74	42" RCP CULVERT
4	Basin C (3.3 AC.)	0.84	1.60	20.2	3.08	5.16	3	8	24" RCP CULVERT
5	**POND 3 TOTAL INFLOW DP-3, DP-4, BASIN E2 (58.3 AC.)**	**9.55**	**24.47**	**43.4**	**1.93**	**3.23**	**18**	**79**	**POND 3**
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, W and OS-7 (6.1 ac.)	1.21	2.65	15.6	3.46	5.81	4	15	TEMP. SEDIMENT BASIN

FINAL DRAINAGE REPORT ~ PIPE ROUTING SUMMARY

Pipe Run	Contributing Basins	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity I(5)	I(100)	Flow Q(5)	Q(100)	Pipe Size*
1	DP-3	8.28	21.72	40.9	2.02	3.38	17	74	42" RCP
2	DP-4	0.84	1.60	20.2	3.08	5.16	3	8	24" RCP
3	**PR-1, PR-2**	**9.12**	**23.32**	**40.9**	**2.02**	**3.38**	**18**	**79**	**42" RCP**
4	DP-7	3.02	7.47	20.2	3.08	5.16	9	39	30" RCP
5	DP-8	0.62	1.85	20.2	3.08	5.16	2	10	24" RCP
6	PR-1, PR-2	3.64	9.32	20.8	3.03	5.09	11	47	36" RCP
7	DP-10	1.00	1.98	10.6	4.05	6.80	4	13	24" RCP
8	DP-11	0.41	0.59	13.8	3.65	6.12	2	4	18" RCP
9	PR-3, PR-4, PR-5	5.05	11.89	21.8	2.96	4.97	15	59	36" RCP
10	DP-12 Pickup	1.05	1.17	15.6	3.46	5.82	4	7	24" RCP
11	PR-6, PR-7	6.11	13.06	22.2	2.93	4.92	18	64	36" RCP
12	DP-13	2.25	3.93	16.1	3.42	5.74	8	23	30" RCP
13	DP-14	0.33	0.53	16.3	3.40	5.70	1	3	18" RCP
14	PR-9, PR-10	2.57	4.47	16.3	3.40	5.70	9	25	30" RCP
15	**PR-8, PR-11**	**8.68**	**17.53**	**22.7**	**2.90**	**4.87**	**25**	**85**	**42" RCP**



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**
E1	0.80	1.34	3.09	0.14	300	12	19.0	300	2.0%	1.4	3.5	22.5	2.33	2.91	4.88	2	**4**	**15**
E2	0.21	0.43	1.15	0.14	300	7	22.7					22.7	2.32	2.90	4.87	0.5	**1.2**	**6**
F	0.49	1.22	4.64	0.10	300	9	21.8	600	1.5%	1.2	8.2	29.9	1.99	2.48	4.17	1	**3**	**19**
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**

100 50 0 100 200

SCALE: 1" = 100'

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	

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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