FINAL DRAINAGE REPORT FOR STERLING RANCH FILING NO. 2

EL PASO COUNTY, COLORADO

This is not for the preliminary plan. Phase II

MARCH 2018

Prepared for:

SR Land, LLC
20 Boulder Crescent, Suite 210
Colorado Springs, CO 80903

Prepared by:

CIVIL CONSULTANTS, INC.
20 Boulder Crescent, Suite 110
Colorado Springs, CO 80903
(719) 955-5485

Project #09-002
DSD Project # SP-19-001

See comment letter.

FINAL DRAINAGE REPORT FOR
STERLING RANCH FILING NO. 2

DRAINAGE PLAN STATEMENTS

ENGINEERS STATEMENT

The attached drainage plan and report was 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 master plan of the drainage basin.

____
Virgil A. Sanchez, P.E. #37160
For and on Behalf of M&S Civil Consultants, Inc

DEVELOPER'S STATEMENT

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

BY:___________________________________
James F Morley

TITLE:__________________________
DATE:__________________________

ADDRESS: SR Land, LLC
20 Boulder Crescent, Suite 210
Colorado Springs, CO 80903

EL PASO COUNTY'S STATEMENT

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

BY:______________________________ DATE:___________________
Jennifer Irvine, P.E.
County Engineer / ECM Administrator

FINAL DRAINAGE REPORT FOR
STERLING RANCH FILING NO. 2

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FINAL DRAINAGE REPORT FOR STERLING RANCH FILING NO. 2

PURPOSE

This document is the Final Drainage Report for Sterling Ranch Filing No.2. This report was previously discussed, as a preliminary drainage report, in the "Master Development Drainage Report for Sterling Ranch Filing Nos. 1&2, and Final Drainage Report for Sterling Ranch Filing No.1" prepared by MS Civil Consultants, dated April 2017. The purpose of this document is to identify and analyze the on and offsite drainage patterns and to ensure that post development runoff is routed through the site safely and in a manner that satisfies the requirements set forth by the El Paso County Drainage Criteria Manual. The principal use for this Final Drainage Report and Final Plat, is only for the major roadways, 49 lot single family residential lots, zero lot single family residential and tracts. The defined tracts are for the development of; landscape areas, and future single family lots. The tracts proposed for future single family development will be replatted into lots, except for those shown on this drainage report, and will have a separate final drainage report. The following report is an analysis of the drainage for the entire development, single family lots, onsite and offsite drainage.

GENERAL LOCATION AND DESCRIPTION

Sterling Ranch Filing No. 2 is located in Section 32, Township 12 South, Range 65 West of the 6th Principal Meridian, Section 33, Township 12 South, Range 65 West of the 6th Principal Meridian and Section 4, Township 13 South, Range 65 West of the 6th Principal Meridian within unincorporated El Paso County, Colorado. The site is bound on the west by existing Vollmer Road. The site is bound on the north by the Barbarick Subdivision and Sterling Ranch Filing No. 1. The property is bound to the east by Sand Creek. The site is bound on the south by properties owned by FM Partners LLC and 8335 Vollmer Road LLC c/o Pioneer Sand Co. Sterling Ranch lies within the Sand Creek Drainage Basin. Flows from this site are tributary to Sand Creek.

Sterling Ranch Filing No. 2 consists of 144.778 acres and is presently undeveloped. Vegetation is sparse, consisting of native grasses. Existing site terrain generally slopes from north to south at grade rates that vary between 2% and 8%.

Sterling Ranch Filing No. 2 is currently zoned "RS-5000" for residential single family development, and "CS" for Commercial development. Improvements proposed for the site include paved, streets, trails, utilities, and storm drainage improvements, as normally constructed for a residential and commercial development. Full spectrum detention facilities are proposed to be constructed along the length of the site, off line of Sand Creek, to provide water quality treatment and detain stormwater for the development.

SOILS

Soils for this project are delineated by the map in the appendix as Blakeland Loamy Sand (8), Flakeland-Fluvaquentic Haplaquolis (9) and Columbine Gravelly Sandy Loam (19) are characterized as Hydrologic Soil Types "A". Pring Coarse Sandy Loam (71) is characterized as Hydrologic Soil Types "B". Soils in the study area are shown as mapped by S.C.S. in the "Soils Survey of El Paso County Area". Vegetation is sparse, consisting of native grasses and weeds.

HYDROLOGIC CALCULATIONS

Hydrologic calculations were performed using the El Paso County and City of Colorado Springs Storm Drainage Design Criteria manual and where applicable the Urban Storm Drainage Criteria Manual. The Rational Method was used to estimate stormwater runoff anticipated from design storms with 5-year and 100-year recurrence intervals.

The historic and developed drainage conditions in this report were calculated using the Soil Conservation Service (SCS) Hydrograph procedure per the El Paso County Drainage Criteria Manual. Since the majority of the existing drainage basins in this report exceed 100 acres in size, this method was selected for an "MDDP" level of detail. However, in future phases of drainage analysis for Sterling Ranch, the Rational Method will be used to analyze smaller drainage basin areas. Normally, the Rational Method is a bit more conservative, but is better used to analyze smaller basins and smaller "local" drainage facilities. The SCS procedure will be used for regional and larger drainage facilities, such as, detention ponds, channel improvements and culverts.

HYDRAULIC CALCULATIONS

Hydraulic calculations were estimated using the Manning's Formula and the methods described in the El Paso County and City of Colorado Springs Storm Drainage Design Criteria manual. The relevant data sheets are included in the appendix of this report.

FLOODPLAIN STATEMENT

A portion of this site is within a designated F.E.M.A. floodplain as determined by the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) Panel No. 08041C0535 F, effective date March 17, 1997 and revised to reflect LOMR, 08-08-O541P, dated July 23, 2009. An annotated FIRM Panel is included in the Appendix. The only development within the floodplain will be outfall pipes and minor bank stabilization. A "No Rise Permit" will be performed with the proposed improvements to Sand Creek.

DRAINAGE CRITERIA

This drainage analysis has been prepared in accordance with the current City of Colorado Springs/El Paso County Drainage Criteria Manual, Volumes I & II, dated November 1991, including subsequent updates. El Paso County has also adopted Chapter 6 and Section 3.2.1 of Chapter 13 in the City of Colorado Springs & El Paso County Drainage Criteria Manual Volumes I and II, dated May 2014. (Appendix I of the El Paso County's Engineering Criteria Manual (ECM), 2008). In addition to the ECM, the Urban Storm Drainage Criteria Manuals, Volumes 1-3, published by the Urban Drainage and Flood Control District (Volumes 1 & 2 dated January 2016, Volume 3 dated November 2010 and updates. Calculations were performed to determine runoff quantities for the 5-year and 100-year frequency storms for developed conditions using the Rational Method. The site is in excess of 100 acres, which according to the above referenced criteria triggers the use of the Soil Conservation Service (SCS) Method for peak runoff determination. To be conservative, the rational method is used to ensure downstream structures are of adequate size to accept anticipated peak flows, and to be consistent with future Final Drainage Reports within Sterling Ranch. However, the SCS method, Full Spectrum Detention was used to size the detention ponds for the development. The SCS method is less conservative and more accurately sizes the storm events to model the detention ponds, and Sand Creek channel conveyance.

Address Phase II specifically

WETLANDS

Sterling Ranch was authorized under Section 404 of the Clean Water Act to discharge dredged and fill materials into waters of the United States to conduct work associated with construction of Sterling Ranch Residential Development in accordance with Action Number SPA-2015-00428-SCO. A copy of the permit is within the Appendix of this report. For the construction of Sterling Ranch Filing No. 1, ~2950 square feet of wetlands will be displaced and mitigated. The disturbance areas are located within the general area of Pond BB, Pond 4 and Pond 8 which outfall into the Sand Creek Channel. A mitigation area is designated on the construction drawings. Coordination with the wetlands consultant and the Army Corp of Engineers will be in conformance with the wetland permit. No other construction associated with Sterling Ranch Filing No. 1 will disturb the existing wetlands. Sterling Ranch Filing No. 2 will have significant wetland disturbance. The area(s) of mitigation will be shown on the construction drawings and Final Drainage report associated with Filing No. 2. Included in this report (in the appendix) are the memo and map from Core Consultants showing intent to have wetlands delineated in the Filing No. 2 areas of wetland disturbance and mitigation.

EXISTING DRAINAGE CONDITIONS

The Sterling Ranch Filing No. 2 site consists of 49.643 acres and is situated west of the Sand Creek Watershed. This area was previously studied in the "Sand Creek Drainage Basin Planning Study" (DBPS) prepared by Kiowa Corporation, revised March 1996. More recently the area was studied in the "Preliminary Drainage Report for Sterling Ranch-Phase 1", dated May 2015, by M&S Civil Consultants, Inc. (henceforth referred to as "PDR"). A "Master Development Drainage Plan For Sterling Ranch", prepared by M&S Civil Consultants, Inc., dated July 2010 and "Technical Memorandum Sand Creek Channel Study (North of Woodmen Road) Hydrologic Analysis" (TM-SCCS) prepared by M&S Civil Consultants, Inc., dated July 2016, was submitted and under review but not approved. And finally this report was studied in the “Master Development Drainage Report for Sterling Ranch Filing Nos. 1&2, and Final Drainage Report for Sterling Ranch Filing No.1” prepared by MS Civil Consultants, dated April 2017.

The Sand Creek DBPS assumed the Sterling Ranch property to have a "large lot residential" use for the majority of the site. However, the proposed master plan is a mix of; school, multi-family, single-family, and commercial land uses, resulting in higher runoff. The site generally drains from north to south consisting of rolling hills. Currently, the site is used as pasture land for cattle. Sand Creek is located east of the site running north to south. This reach of drainage conveyance is not currently improved. There are a few stock ponds within the creek channel used for cattle watering. Barbed wire fences bound the entire ~1440 acres of Sterling Ranch.

Offsite flows enter Sterling Ranch from the east, west and north , described as follows;

To the west, the existing subdivision west of Vollmer Road historically drains south to the west side of Vollmer Road. A roadside ditch carries the flow southwesterly and is intercepted by the Pond 6 storm infrastructure. Flows will ultimately be released into Sand Creek. See the Historic Basin Descriptions section of this report.

To the east; Sand Creek conveys flows from north to south. Flows from Sand Creek will continue to be conveyed through Sterling Ranch. (DBPS SEG: 170, 187, 163)

To the north; Sterling Ranch Filing No. 1 flows are captured via detention ponds Pond 4 and Pond 8 and are released into Sand Creek. Flows from the Barbarick Subdivision are collected by detention ponds and water quality ponds and are released at the northend of the proposed Sterling Ranch Filing No. 2 site. See "Final Drainage Report for Barbarick Subdivision, Portions of Lots 1, 2 and Lots 3 & 4, by Matrix Design Group, June 2016". (DBPS SEG: 164, 159)

To the south of Sterling Ranch Filing No.2 lie properties owned by FM Partners LLC (undeveloped) and 8335 Vollmer Road LLC c/o Pioneer Sand Co., (zoned I-3 heavy industrial). The undeveloped runoff from these areas is conveyed from north to south, via historic drainage patterns, and do not impact any Sterling Ranch property.

The following "Proposed Drainage Characteristics" will address how developed and historic flows will be routed through Sterling Ranch to Sand Creek. If future offsite development occurs upstream of Sterling Ranch from the west or north, the propertie(s) will be required to detain to historic/ existing conditions per the County / City drainage criteria.

Refer to the Sterling Ranch Historic Drainage Map and Sterling Ranch Filing No.1&2 MDDP-Proposed Drainage Map (in the appendix) for off-site basin information. Descriptions of off-site basins are discussed below.

The following drainage basin narratives are based on information derived from field visits, USGS topographic mapping, aerial topography, field surveys and information provided by others familiar with the site. A "sheet flow" verses "concentrated ditch flow" designation was determined as best as possible from the available source topography, actual conditions may vary. Ownership was determined by the use of the El Paso County Assessor's web site as of the date of this report. A summary of peak runoff for the basins and designated design points are depicted on the Sterling Ranch Historic Drainage Map and Existing Conditions Drainage Map in the appendix.

Historic Basin Descriptions

Basin EX-1 (Q5 = 3 cfs, Q100 = 40 cfs) is a 24 acre area of land located in the southwestern portion of the site, southeast of Vollmer Road. This area of land, as well as the balance of Sterling Ranch is undeveloped and is used for pasture. Runoff from the basin generally travels as sheet flow from north to south until it reaches the northern boundary of an existing gravel pit.

Basin EX-2 (Q5 = 3 cfs, Q100 = 45 cfs) is a 31 acre area of land located in the southwest portion of the site, southeast of Vollmer Road. Runoff from the basin generally travels as sheet flow and concentrated ditch flow from north to south until it reaches the northern boundary of an existing gravel pit.

Basin EX-3 (Q5 = 49 cfs, Q100 = 341 cfs) is a 311 acre area of land located in the western portion of the site. A portion of the basin extends off-site to the northwest side of Vollmer Road, and is undeveloped (See Proposed Drainage Map, Sub-basin EX3~W-2, OS1A, OS1B, OS1C, OS1D~ Q5=21.0 cfs and Q100=154.2 cfs). A southern portion of the basin (adjacent to Vollmer Road) is currently developed as commercial/industrial ground outside of the Sterling Ranch boundary, (Barbarick Subdivision). The remaining southern portion of the ground is within Sterling Ranch. Runoff from the basin generally travels from north to south until it reaches the southern boundary of Sterling Ranch and flows into a tributary of Sand Creek (See Sand Creek Drainage Basin Planning Study, Segment 159, page 47-48, anticipated flows=950 cfs). Per the approved Preliminary/Final Drainage Report for the Barbarick Subdivision, detention ponds are proposed to detain flows discharging to the south into Sterling Ranch. At the time of this report, the detention ponds have not been constructed. (See Proposed Map for location and flows).

Basin EX-4 (Q5 = 71 cfs, Q100 = 352 cfs) is a 330 acre area of land located on the western portion of the site, including the Sand Creek channel. A portion of this basin extends off-site to the northwest of Vollmer Road, and is currently undeveloped property. Runoff from the basin generally travels from north to south until it reaches the northern boundary of the site, being conveyed in the Sand Creek channel (See Proposed Drainage Map, Sub-Basin EX4A,EX4B, EX4C~Q5=28.2 cfs and Q100=208.4 cfs). (See SCDBPS, Segment 163, pages 49-51)

Basin EX-5 (Q5 = 14 cfs, Q100 = 209 cfs) is a 152 acre area of land located on the northwestern portion of the site, including the Sand Creek channel. A portion of this basin extends off-site to the north of the site boundary. Runoff from the basin generally travels from northwest to southeast until it reaches the Sand Creek Channel, then being conveyed through Sterling Ranch. (See SCDBPS, Segments, 170,& 187, pages 51-54).

Basin EX-6 (Q5 = 118 cfs, Q100 = 2168 cfs) is a 1,692 acre area of land located north of Sterling Ranch, tributary to the Sand Creek channel. Some of the basin developed as low density residential , or is vacant and used for pasture. Runoff from the basin generally travels from north to south until it reaches the Sand Creek Channel, then being conveyed through Sterling Ranch. (See SCDBPS, Segments, 170,& 171, pages 54-55. The anticipated SCDBPS flow at the north boundary of Sterling Ranch is Q10 = 670cfs, Q100 = 2260cfs)

Basins EX 7 – 13 exist on the east side of Sand Creek and do not effect Sterling Ranch Filing No. 1 & 2. (Per Historic Drainage Map in the Appendix)

<u>Basins OS 20-23 and Off-Site Conveyance</u>
The existing drainage patterns on the west side of Vollmer Road are not intended to be significantly altered by the development of Sterling Ranch. The construction of Vollmer Road will address the ditch flows along the west side and will install drainage culverts were necessary per this report. The majority of the flows from the west side of Vollmer Road are to be routed in the historical direction to the southwest along the roadway to a proposed Pond W-2 and Pond W-4. At the north end of the Barbarick subdivision, west side of Vollmer Road, a new 48” RCP is proposed to convey the flows from the full spectrum detention pond W-2 and across Sterling Ranch development to Sand Creek. The proposed 48” RCP replaces an undersized existing 24” CMP that historically conveyed a portion of the runoff from the upstream watershed, but at a different location. The purpose of this relocation is to conveniently route the flows across Sterling Ranch in a logical path to Sand Creek as in the historical condition. Runoff produced from the remaining off-site watershed located along the west edge of the development will be routed along the west side of Vollmer Road to the southwest corner of the development and a proposed Pond W-4. At the northwest corner of Tahiti Drive and Vollmer Road a 66” RCP will be installed to collect and convey runoff under proposed Marksheffel Road before ultimately discharging into Sand Creek. Runoff reaching the development along the south boundary line of the Barbarick Subdivision will be conveyed through the proposed site by portions of the existing western tributary channel, proposed temporary swales and proposed storm sewer until it ultimately reaches Pond W-5. Additional internal collection and conveyance storm sewer systems will be constructed with future development parcels within Sterling Ranch. Runoff reaching the northern boundary of Phase I at proposed Briargate Parkway will be redirected around the site via a temporary swale to Sand Creek. BMP’s will be installed to prevent erosion of the temporary swale.

The intention of the drainage design for Sterling Ranch is to not adversely affect any adjacent property within the developed flows from Sterling Ranch. As previously mentioned, on the south end of the site, the developed flows are to be re-directed and collected in local storm sewer facilities onsite to Sterling Ranch. Only very minor amount of storm water shall be conveyed from small landscaped areas, or tracts onto the adjacent lands. This amount of discharge is far less than the historic runoff onto these properties. (East side of Barbarick Subdivision). No downstream retention ponds exist that would be sacrificed by this redirection of flow.

To the east of the proposed Sterling Ranch – Phase I, the property is not planned for development at this time. Therefore, the adjacent properties to the east and south will not see any change in the upstream historical conveyance of flows. The majority of all major flows exiting the Sterling Ranch – Phase I development will be detained and treated in onsite full spectrum detention ponds, prior to discharging into the Sand Creek channel. The option to construct larger online regional facilities to aid in the treatment and detention of runoff produced from planned and future development will continue to be re-evaluated.

Existing Utilities – High Pressure Gas Pipelines

At the southwest corner of Sterling Ranch exists three high pressure gas/petroleum pipelines. There are two 20-inch diameter and one 6-inch diameter pipelines. Special care in design and coordination with the appropriate utility agency shall be made to ensure of safety. Also, at the southwest portion of the site exists a Colorado Springs Utilities gas distribution line that serves the Barbarick Subdivision. This gas line will likely be relocated in the proposed right-of-way of the southern proposed Filing No. 2 subdivision. However, it should be noted that the gas pipelines existed pre-development. Additional utilities (including MVEA, Century link, CIG,...,) are present adjacent to the Vollmer right-of-way, and will be relocated where necessary with the Vollmer Road improvements.

PROPOSED DRAINAGE CHARACTERISTICS

General Concept Drainage Discussion

The following is a description of the offsite and onsite basins, offsite bypass flows and the overall future drainage characteristics for the development of Sterling Ranch Filing No. 2. The initial development of Filing No. 2 consists only of the roadway and storm sewer infrastructure for; Marksheffel Road (4 lane urban principal arterial), Vollmer Road (modified Urban Minor Arterial) and Sterling Ranch Road (urban non-residential collector). Calculations have been provided to show the proposed development will adequately convey flows for the adjacent tracts to be developed.

Let it be noted that, the areas to be platted in Sterling Ranch Filing No. 2 are as follows:
-Vollmer Road additional ROW dedication and adjacent Tracts D and F
-Marksheffel Road and adjacent Tracts D and C
-Sterling Ranch Road and adjacent Tracts B, D, J, K and A
-Tract E zero lot line single family residential and
-49 single family residential lots and Tracts G, H and I.
These platted areas will be addressed in this report as the Final Drainage Report for Sterling Ranch Filing No. 2. The areas proposed for future single family development, future commercial parcels and future school site will be replatted and will have a separate final drainage reports.

The following DPs and Basins were determined using the Rational Method since this method offers a more conservative approach to sizing swales and storm drain. It should be noted that all calculations and drainage basins have been revised to reflect the new criteria updates by the El Paso County/City of Colorado Springs Drainage Criteria Manual. See appendix for minor and major street capacity rating table sheets for street sections, sump inlet capacity rating table and design peak flow sheets for at-grade inlets. Surface flow is designated as Design Points (DP) and storm sewer routing as Pipe Run (PR).

Detailed Drainage Discussion

Design Points Tributary to Detention Pond W-5 (Proposed Drainage Map)–Filing No. 2

DP28, 33.3 acres, consists of Basin OS3 off-site Barbarick Subdivision with runoff coefficients of 0.36 for the 5-year and 0.55 for the 100-year and Basin YY future Sterling Ranch residential lots with runoff coefficients of 0.22 for the 5-year and 0.46 for the 100-year. Developed runoff of Q5=25.8 cfs and Q100=60.2 cfs has been calculated for DP28. Per the "Final Drainage Report for Barbarick Subdivision Protions of Lots 1, 2 and Lots 3, 4", prepared by Matirx Design Group, dated June 6, 2016, a combined onsite flow of Q5=11.4 cfs and Q100=85.4 cfs was calculated up to the detention pond on the south boundary line of the Barbarick Subdivision. The reduction of flow, form previous reports is attributed to a reduction of Sterling Ranch Subdivision flow contributing to the OS3 basin. The release rate from the detention pond combined with Basin YY are Q5=25.8 cfs and Q100=60.2 cfs The surface runoff shall be collected by a temporary sediment basin and 36" FES and routed south via 36" RCP (PR32) to PR34. Historic flows produced by Basin OS3 will be accounted for in the calculations for detention/water quality for Pond W5. The drainage report was prepared by Matrix Design Group, 2016 for the Barbarick Subdivision and has been attached at the end of the reference section of this report. The Final Drainage Report for Filing No. 2 will address the revisions from the previous report to the new Matrix report.

In the interim, a temporary diversion swale will be constructed and will replace the construction of PR32. The diversion swale will route flows from DP28 to DP29 (Q5=41.4 cfs and Q100=97.8 cfs). Figure CU-9 Inlet Control Nomograph INT DP29 INT is provided and swale grading complies with required headwater depth. Upon development of Tract I the diversion swale will be removed and PR32 will be installed.

DP29, 12.58 acres, consists of Basin XX future residential lots and streets with runoff coefficients of 0.22 for the 5-year and 0.46 for the 100-year and Basin JP-1 future school site with runoff coefficients of 0.39 for the 5-year and 0.55 for the 100-year. Developed runoff of Q5=17.3 cfs and Q100=41.7 cfs has been calculated for DP29. The surface runoff will be routed via overlot grading and curb and gutter to a temporary sediment basin at DP29 which will be collected by a 36" FES. The flow will be routed west via a 36" RCP (PR33)and will combine with flow from PR32. The combined flows in PR34 (Q5=41.4 cfs and Q100=97.8 cfs) will be routed south and west via a 48" RCP to PR35.

DP30, 2.46 acres, consists of Basin III future open space area with runoff coefficients of 0.08 for the 5-year and 0.35 for the 100-year and Basin JP-7A (Sterling Ranch Road) with runoff coefficients of 0.90 for the 5-year and 0.96 for the 100-year. Developed runoff of Q5=6.5 cfs and Q100=13.0 cfs has been calculated for DP30. The surface runoff is routed via overlot grading and curb and gutter to DP30 which will be collected by a 15' CDOT type R at-grade inlet. The intercepted flow (Q5=6.5 cfs and Q100=11.1 cfs) will routed south via a 24" RCP (PR34A) and will combine with flows from PR34 and PR34B. The combined flows (Q5=53.1 cfs and Q100=117.8 cfs) will be routed west via a 48" RCP (PR35) to PR39.

DP31, 4.64 acres, consists of Basin JJJ future residential lots with runoff coefficients of 0.22 for the 5-year and 0.46 for the 100-year and Basin JP-7B (Sterling Ranch Road) with runoff coefficients of 0.90 for the 5-year and 0.96 for the 100-year. Developed runoff of Q5=8.4 cfs and Q100=19.8 cfs has been calculated for DP31. The surface runoff is routed via overlot grading and curb and gutter to DP31 which will be collected by a 15' CDOT type R at-grade inlet. The intercepted flow (Q5=8.2 cfs and Q100=14.2 cfs) will routed south via a 24" RCP (PR34B) and will combine with flows from PR34 and PR34A. The combined flows (PR35, Q5=53.1 cfs and Q100=117.8 cfs) will be routed west via a 48" RCP to PR39.

DP32, 17.0 acres, consists of Basin OS2 off-site Barbarick Subdivision with runoff coefficients of 0.55 for the 5-year and 0.87 for the 100-year. Developed runoff of Q5=30.4 cfs and Q100=80.8 cfs has been calculated for DP32 Per the "Final Drainage Report for Barbarick Subdivision Protions of Lots 1, 2 and Lots 3, 4", prepared by Matirx Design Group, dated June 6, 2016, a combined onsite flow of Q5=3.13 cfs and Q100=11.6 cfs was calculated up to the sand filter pond on the south boundary line of the Barbarick Subdivision. The release rate from the sand filter pond combined with Lots 1 and 2 west of the sand filter pond are Q5=30.4 cfs and Q100=80.8 cfs The surface runoff shall be collected by a temporary sediment basin and 42" FES. The flow will be routed south via 42" RCP (PR36) to PR38. Upon future development of this basin, full spectrum detention shall be required and will release to historic release rates of Q5=30.4 cfs and Q100=80.8 cfs. Historic flows produced by Basin OS2 will be accounted for in the calculations for detention/water quality for Pond W-5. The Final Drainage Report for Filing No. 2, will address the revisions from the previous report to the new Matrix report.

In the interim, a temporary diversion swale will be constructed and will replace the construction of PR36. The diversion swale will route flows from DP32 to DP33 (Q5=45.9 cfs and Q100=115.2 cfs). Figure CU-9 Inlet Control Nomograph INT DP33 is provided and swale grading complies with required headwater depth. Upon development of Tract H the diversion swale will be removed and PR36 will be installed.

DP33, 9.68 acres, consists of Basin AAA future residential lots and streets with runoff coefficients of 0.49 for the 5-year and 0.65 for the 100-year. Developed runoff of Q5=17.3 cfs and Q100=38.5 cfs has been calculated for DP33. The surface runoff will be routed via overlot grading and curb and gutter to a temporary sediment basin at DP33 which will be collected by a 30" FES. The flow will be routed west via a 30" RCP (PR37) and will combine with flows from PR36. The combined flows (PR38, Q5=45.9 cfs and Q100=115.2 cfs) will be routed south via a 48" RCP to PR39. The combined flows in PR39 (Q5=98.5 cfs and Q100=232.0 cfs) will be routed south via a 66" RCP to PR57.

DP39, 2.74 acres, consists of Basin BBB proposed residential lots and streets with runoff coefficients of 0.45 for the 5-year and 0.59 for the 100-year. Developed runoff of Q5=4.8 cfs and Q100=10.6 cfs has been calculated for DP39. The surface runoff is routed via overlot grading and curb and gutter to dual 10' CDOT type R at-grade inlets. The intercepted flow (Q5=4.8 cfs and Q100=10.14 cfs) will be routed south via an 18" RCP (PR40A, PR40B) to PR40 (18" RCP). The flows from PR40 will be routed south to PR41 (24" RCP).

DP39A, 8.47 acres, consists of Basin BBB proposed residential lots and streets with runoff coefficients of 0.45 for the 5-year and 0.59 for the 100-year. Developed runoff of Q5=12.4 cfs and Q100=27.3 cfs has been calculated for DP39A. The surface runoff is routed via overlot grading and curb and gutter to dual 10' CDOT type R at-grade inlets. The intercepted flow (Q5=11.36 cfs and Q100=17.86 cfs) will be routed east via an 18" RCP (PR41A) and a 24" RCP (PR41B). The combined flows from PR41B and PR40 (Q5=15.5 cfs and Q100=26.9 cfs) will be routed south via a 24" RCP to PR41.

DP44, 3.59 acres, consists of Basin HHH undisturbed gas line easements and minimal rear residential lots with runoff coefficients of 0.08 for the 5-year and 0.35 for the 100-year. Developed runoff of Q5=1.0 cfs and Q100=7.7 cfs has been calculated for DP44. The surface runoff is routed via historic drainage patterns and overlot grading to a temporary sediment basin at DP44 which will be collected by an 18" FES. The flow will be routed west via an 18" RCP (PR47) and will combine with flows at DP40 and PR42 (24" RCP).

DP40, 3.12 acres, consists of Basin CCC proposed residential lots and streets with runoff coefficients of 0.49 for the 5-year and 0.62 for the 100-year and flowby from DP39 and DP39A. Developed runoff of Q5=6.0 cfs and Q100=20.2 cfs has been calculated for DP40. The surface runoff is routed via overlot grading and curb and gutter to dual 15' CDOT type R at-grade inlets at DP40. The flow will be routed west via a 24" RCP (PR42) and will combine with flow from PR47. The combined flows in PR42 (Q5=4.8 cfs and Q100=15.8 cfs) will be routed south to PR48 (36" RCP). The combined flows from PR42 and PR41 will be routed south and west via a 36" RCP (PR48, Q5=23.0 cfs and Q100=52.3 cfs). These flows are then routed to DP45.

DP43A, 19.14 acres, consists of Basin FFF proposed residential lots and streets with runoff coefficients of 0.49 for the 5-year and 0.62 for the 100-year. Developed runoff of Q5=35.0 cfs and Q100=74.3 cfs has been calculated for DP43A. The surface runoff is routed via overlot grading to a temporary sediment basin at DP43A which will be collected by a 42" FES. The flow will be routed south via a 42" RCP (PR50) and will combine with flow from PR48. The combined flows PR50A (Q5=54.2 cfs and Q100=118.6 cfs) will be routed south via a 48" RCP to PR52. Figure CU-9 Inlet Control Nomograph DP43A is provided and swale grading complies with required headwater depth

DP45, 2.7 acres total, consists of Basin JP-7C (Sterling Ranch Road) with runoff coefficients of 0.90 for the 5-year and 0.96 for the 100-year, Basin FFF1 proposed residential backyard lots with runoff coefficients of 0.22 for the 5-year and 0.46 for the 100-year, Basin GGG proposed residential lots and streets with runoff coefficients of 0.49 for the 5-year and 0.62 for the 100-year and flowby from DP30 and DP40. Developed runoff of Q5=4.4 cfs and Q100=13.3 cfs has been calculated for DP45. The surface runoff is routed via curb and gutter to DP45 which will be collected by a 15' CDOT type R at-grade inlet. The intercepted flow (Q5=4.4 cfs and Q100=11.25 cfs) will be routed south via an 18" RCP (PR51) to PR52. The combined flows PR52 (Q5=58.2 cfs and Q100=128.8 cfs) will be routed south via a 48" RCP to PR56.

DP46, 0.61 acres, consists of Basin JP-7D (Sterling Ranch Road) with runoff coefficients of 0.90 for the 5-year and 0.96 for the 100-year and flowby from DP-31. Developed runoff of Q5=2.4 cfs and Q100=9.7 cfs has been calculated for DP46. The surface runoff is routed via curb and gutter to DP46 which will be collected by a 15' CDOT type R at-grade inlet. The intercepted flow (Q5=4.4 cfs and Q100=9.1 cfs) will be routed south via an 18" RCP (PR53) to PR56. The combined flows PR56 (Q5=60.2 cfs and Q100=136.2 cfs) will be routed south via a 48" RCP to PR56A.

DP51, 1.76 acres, consists of Basin RP-7B (Marksheffel Road) with runoff coefficients of 0.90 for the 5-year and 0.96 for the 100-year. Developed runoff of Q5=5.8 cfs and Q100=10.5 cfs has been calculated for DP51. The surface runoff is routed via curb and gutter to DP51 which will be collected by a 15' CDOT type R at-grade inlet. The intercepted flow (Q5=5.8 cfs and Q100=9.7 cfs) will routed east via an 18" RCP (PR54) to PR55. Surface flow-by (Q5=0.0 cfs and Q100=0.9 cfs) from the inlet will be released at the end of the curb section and will be routed via overlot grading to a temporary sediment basin (TSB) as shown on the "Sterling Ranch-Phase 1 Offsite Grading, Early Grading & Erosion Control Plans", prepared by M&S Civil Consultants, Inc., dated November 2015. Flows released from the TSB will be routed via historic drainage patterns to Sand Creek. Erosion control has been provided per the offsite grading plan.

DP52, 1.93 acres, consists of Basin RP-7A (Marksheffel Road) with runoff coefficients of 0.90 for the 5-year and 0.96 for the 100-year and flowby from DP45 and DP46. Developed runoff of Q5=6.4 cfs and Q100=13.9 cfs has been calculated for DP52. The surface runoff is routed via curb and gutter to DP52 which will be collected by a 15' CDOT type R at-grade inlet. The intercepted flow (Q5=6.4 cfs and Q100=11.56 cfs) will combine with flows from PR54 (PR55, Q5=12.2 cfs and Q100=21.2 cfs) and be routed east via a 30" RCP to PR56A. The combined flows from PR55 and PR56 (PR56A, Q5=71.1 cfs and Q100=155.2 cfs) will be routed south via a 54" RCP to PR56B. The flows in PR56B (Q5=71.1 cfs and Q100=155.2 cfs) will be routed east via a 2-42” RCP and combine with flows from PR39 to PR57. The combined flows in PR57 (Q5=168.1 cfs and Q100=383.8 cfs) will be routed south via a 78" RCP to PR58. Surface flow-by (Q5=0.0 cfs and Q100=2.3 cfs) from the inlet will be released at the end of the curb section and will be routed via overlot grading to a TSB as shown on the "Sterling Ranch-Phase 1 Offsite Grading, Early Grading & Erosion Control Plans", prepared by M&S Civil Consultants, Inc., dated November 2015. Flows released from the TSB will be routed via historic drainage patterns to Sand Creek. Erosion control has been provided per the offsite grading plan.

DP38, 25.89 acres, consists of Basin OOO future residential lots and streets with runoff coefficients of 0.45 for the 5-year and 0.59 for the 100-year. Developed runoff of Q5=37.2 cfs and Q100=81.9 cfs has been calculated for DP38. The surface runoff is routed via overlot grading and curb and gutter to a temporary sediment basin at DP38 which will be collected by a 42" FES. The flow will be routed south via a 42" RCP (PR44) and will combine with flows from PR57 and PR57A. The combined flows in PR58

(Q5=208.9 cfs and Q100=481.1 cfs) will be routed south via an 84" RCP to Detention Pond W-5 (DP57). Flows will outfall into a concrete lined forebay. Figure CU-9 Inlet Control Nomograph DP43A is provided and swale grading complies with required headwater depth

DP56, 8.17 acres total, consists of Basin RRR future commercial site with runoff coefficients of 0.81 for the 5-year and 0.88 for the 100-year, Basin PPP1 future residential lots with runoff coefficients of 0.22 for the 5-year and 0.46 for the 100-year and Basin QQQ undisturbed gas line easements with runoff coefficients of 0.08 for the 5-year and 0.35 for the 100-year. Developed runoff of Q5=5.7 cfs and Q100=20.5 cfs has been calculated for DP56. The surface runoff is routed via historic drainage patterns and overlot grading to DP56 which will be collected by a 24" FES. The flow will be routed south via a 24" RCP (PR57A) and will combine with flows from PR57 and PR44. The combined flows in PR58 (Q5=209.5 cfs and Q100=483.5 cfs) will be routed south via an 84" RCP to Detention Pond W-5 (DP57). Flows will outfall into a concrete lined forebay. Figure CU-9 Inlet Control Nomograph DP43A is provided and swale grading complies with required headwater depth

DP57, 7.95 acres, consists of Basin UUU (**Detention Pond W-5**) with runoff coefficients of 0.08 for the 5-year and 0.35 for the 100-year. Contributing surface runoff to detention pond W-5 include Basin PPP2 0.75 acres, future residential lots with runoff coefficients of 0.22 for the 5-year and 0.46 for the 100-year, Basin TTT 1.38 acres, future open space with runoff coefficients of 0.08 for the 5-year and 0.35 for the 100-year and Basin OS4 5.13 acres, existing residential lots with runoff coefficients of 0.20 for the 5-year and 0.44 for the 100-year The combined upstream developed runoff of Q5=217.4 cfs and Q100=517.9 cfs has been calculated for DP57. The proposed Detention Pond functions to provide full spectrum detention and water quality for runoff calculated onsite. The pond is designed to treat approx 175.6 acres, and provide 2.97 ac-ft of water quality storage and 17.37 ac-ft of 100-year storage. The forebay, trickle channel micropool, outlet structure and pipe have been designed per the UDFCD manual and per the Detention Design-UD-Detention v3.07 workbook. The detention pond will be private and shall be maintained by the Sterling Ranch Metropolitan District. Access shall be granted to the owner and El Paso County for access and maintenance of the private detention pond. A private maintenance agreement document shall accompany the submittal. In the event of clogging or total inlet failure, flows at DP57 will over top the emergency spillway and outfall into Sand Creek. A rip rap apron will be constructed to dissipate energy and prevent local scour at the outlet. The peak release rate from pond W-5 (PR71, Q5=2.5 cfs and Q100=149.7 cfs) will outfall, via a 48" RCP into Sand Creek. The summed flows (PR71 & PR67, Q5=42.2 cfs and Q100=472.4 cfs) will routed via a 84" RCP (PR74) to DP68 and outfall into Sand Creek. Impacts from the outfall into Sand Creek will be addressed in the revised TM-SCCS.

The water quality volume and 100-year volume required for the site has been determined using the guidelines set forth in the City of Colorado Springs/El Paso County Drainage Criteria Manual Chapter 6-Volume II. Refer to the Detention Basin Design sheets located within the appendix of this report.

Design Points Tributary to Sand Creek Filing No. 2

DP47A, 3.12 acres, consists of Basin RP-3B (Vollmer Road) with runoff coefficients of 0.90 for the 5-year and 0.96 for the 100-year and flowby from DP16 (in the future developed condition). Developed runoff of Q5=11.1 cfs and Q100=24.4 cfs has been calculated for DP47A. In the interim the surface runoff is routed to a road side swale to DP47A which will be collected by a 2.91' x 5.67' CDOT Type D inlet. In the interim a riprap apron will be constructed to dissipate energy and prevent local scour at the outlet.

In the future, upon full build out of Vollmer Road, the surface runoff will be routed via curb and gutter to DP47A which will be collected by a 15' CDOT type R at-grade inlet. The intercepted flow (PR68, Q5=10.0 cfs and Q100=15.8 cfs) will be routed north via a 30" RCP to DP60.

DP48A, 4.12 acres, consists of Basin RP-3A (Vollmer Road) with runoff coefficients of 0.90 for the 5-year and 0.96 for the 100-year and flowby from DP17 (in the future developed condition). Developed runoff of Q5=13.5 cfs and Q100=26.6 cfs has been calculated for DP48A. In the interim the surface runoff will sheet flow and be routed to a roadside swale and ultimately to DP60.

In the future, upon full build out of Vollmer Road, the surface runoff will be routed via curb and gutter to DP48A which will be collected by a 15' CDOT type R at-grade inlet. The intercepted flow (Q5=11.4 cfs and Q100=16.5 cfs) will combine with flows from PR68 and be routed west via a 30" RCP (PR69). The cumulative flows in PR69 (Q5=21.2 cfs and Q100=31.9 cfs) will outfall into a proposed road side swale and be routed to DP60. Upon full build out a riprap apron will be constructed to dissipate energy and prevent local scour at the outlet.

DP69, 15.73 acres, consists of Sub-Basin OS20A partially developed low density residential with runoff coefficients of 0.10 for the 5-year and 0.36 for the 100-year. Calculated runoff of Q5=4.5 cfs and Q100=27.4 cfs has been calculated for DP69. The flow will be routed south via a 24" RCP (PR73) under Glider Loop. The surface runoff is routed via historic drainage patterns and a 4' wide road side swale to DP60. A riprap apron will be constructed to dissipate energy and prevent local scour at the outlet. (See swale and riprap calculations and specification sheet for fabric in appendix). DP69 calculations are for sizing the culvert under Glider Loop. The acreage and flows for DP69 is included in the final DP60.

DP70, 36.32 acres, consists of Sub-Basin OS20B partially developed low density residential with runoff coefficients of 0.10 for the 5-year and 0.36 for the 100-year and flows from DP69. Calculated runoff of Q5=15.0 cfs and Q100=90.7 cfs has been calculated for DP70. The flow will be routed south via an existing 24" CMP under Glider Loop. The surface runoff is routed via historic drainage patterns swale to DP60. The existing roadside swale will provide adequate drainage, assuming the swale has been maintained. The acreage and flows for DP70 is included in the final DP60.

DP71, 106.79 acres, consists of Sub-Basin OS20C partially developed low density residential with runoff coefficients of 0.10 for the 5-year and 0.36 for the 100-year and flows from DP70. Calculated runoff of Q5=25.6 cfs and Q100=154.4 cfs has been calculated for DP70. The flow will be routed south via an existing 24" CMP under the entrance to an existing Gas substation. The surface runoff is routed via historic drainage patterns swale to DP60. The existing roadside swale will provide adequate drainage, assuming the swale has been maintained. The acreage and flows for DP71 is included in the final DP60.

DP60, 308 acres, consists of Basin OS20 (off-site basin) partially developed low density residential with runoff coefficients of 0.10 for the 5-year and 0.36 for the 100-year and flow from PR69. Calculated runoff of Q5=59.7 cfs and Q100=316.2 cfs has been calculated for DP60. The existing roadside swale will provide adequate drainage, assuming the swale has been maintained. Flows in the swale will be routed through an existing 3.5’ X5.5’ HECMP to DP 49 (Pond W-4). A rip rap apron will be constructed to dissipate energy and prevent local scour at the outlet.

DP47 & DP47-1, 2.05 acres, consists of Basin RP-4B (Vollmer Road) with runoff coefficients of 0.90 for the 5-year and 0.96 for the 100-year and flowby from DP47A (in the future condition). Developed runoff of Q5=7.7 cfs and Q100=20.4 cfs has been calculated for DP47. In the interim the surface runoff is routed to a road side swale to DP47A which will be collected by a 2.91' x 5.67' CDOT Type D inlet. In the interim a riprap apron will be constructed to dissipate energy and prevent local scour at the outlet.

In the future, upon full build out of Vollmer Road, the surface runoff is routed via curb and gutter to DP47 & DP47-1 which will be collected by a 2-10' CDOT type R at-grade inlets. The captured flow (Q5=7.7 cfs and Q100=17.6 cfs) will be routed west via a 30" RCP (PR61) to PR62.

DP48 & DP48-1, 1.94 acres, consists of Basin RP-4A (Vollmer Road) with runoff coefficients of 0.90 for the 5-year and 0.96 for the 100-year and flowby from DP48A(in the future condition). Developed runoff of Q5=8.2 cfs and Q100=21.0 cfs has been calculated for DP48. In the interim the surface runoff will sheet flow into and be routed to a roadside swale and ultimately to DP49.

In the future, upon full build out of Vollmer Road, the surface runoff is routed via curb and gutter to DP48 & DP48-1 which will be collected by a 2-10' CDOT type R at-grade inlets. The flow will combine with flows from PR61 and be routed west to via a 30" RCP (PR62) to a riprap forebay. The cumulative flows in PR62 (Q5=15.8 cfs and Q100=38.2 cfs) will outfall into a proposed roadside swale, see appendix for open channel calculator sheet. The vegetated grass swale will facilitate sedimentation and filtering while limiting erosion. A riprap apron will be constructed to dissipate energy and prevent local scour at the outlet. Flows in the swale will be routed to DP 49 (Pond W-4).

DP72, 8.87 acres, consists of Sub-Basin OS21A partially developed low density residential with runoff coefficients of 0.11 for the 5-year and 0.37 for the 100-year and flows from DP60. Calculated runoff of Q5=71.9 cfs and Q100=345.9 cfs has been calculated for DP72. The flow will be routed south via a proposed 15' swale to DP49. The acreage and flows for DP72 is included in the final DP49.

DP73, 8.76 acres, consists of Sub-Basin OS21C partially developed low density residential with runoff coefficients of 0.11 for the 5-year and 0.37 for the 100-year and flows from DP72. Calculated runoff of Q5=3.2 cfs and Q100=18.1 cfs has been calculated for DP73. In the interim the surface runoff is routed to via a road side swale to DP73 which will be collected by a 2.91' x 5.67' CDOT Type D inlet. In the interim a 24" RCP pipe (PR76) will route flows to a concrete forebay in Pond W-4. The acreage and flows for DP73 is included in the final DP49.

DP49, 33.0 acres, consists of Basin OS21 (**Interim Detention Pond W-4**) with runoff coefficients of 0.11 for the 5-year and 0.37 for the 100-year, flow from DP60 and PR62. The combined upstream developed runoff of Q5=72.9 cfs and Q100=367.1 cfs has been calculated for DP49. The proposed interim Detention Pond functions to provide full spectrum detention and water quality for runoff calculated onsite. The pond is designed to treat approx 352.2 acres, and provide 1.75 ac-ft of water quality storage and 7.67 ac-ft of 100-year storage. The forebay, trickle channel micropool, outlet structure and pipe have been designed per the UDFCD manual and per the Detention Design-UD-Detention v3.06 workbook. The detention pond will be private and shall be maintained by the Sterling Ranch Metropolitan District. Access shall be granted to the owner and El Paso County for access and maintenance of the private detention pond. A private maintenance agreement document shall accompany the submittal. In the event of clogging or total inlet failure, flows at DP49 will over top the emergency spillway and outfall into the existing roadside swale parallel to Vollmer Road. A rip rap apron will be constructed to dissipate energy and prevent local scour at the outlet. The peak release rate from pond W-4 (PR63, Q5=15.4 cfs and Q100=289.4 cfs) will be routed south, via a 66" RCP to PR65.

A preliminary design of detention pond W-4 has been used to calculate potential volume. Upon future upstream development, expansion of Pond W-4 will need to be finalized. Per the "Technical Memorandum Sand Creek Channel Study (North of Woodmen Road) Hydrologic Analysis" prepared by MS Civil Consultants, Inc., dated October 2016 (see appendix for Map), the fully developed runoff of Q5=112.8 cfs and Q100=429.4 cfs has been calculated for DP49. The potential ultimate Detention Pond functions to provide full spectrum detention and water quality for runoff calculated onsite. The pond is designed to treat approx 352.2 acres, and provide 2.06 ac-ft of water quality storage and 11.12 ac-ft of 100-year storage. Volumes were designed per the UDFCD manual and per the Detention Design-UD-Detention v3.06 workbook. The peak release rate from pond W-4 (PR63, Q5=20.8 cfs and Q100=289.4 cfs) will be routed south, via a 66" RCP to PR65. Minor modifications will be required to outlet structure and spillway to comply with Detention Design-UD-Detention v3.06 workbook. Again, the ultimate design and analysis will need to be finalized upon upstream development and location of Marksheffel Road.

The water quality volume and 100-year volume required for the site has been determined using the guidelines set forth in the City of Colorado Springs/El Paso County Drainage Criteria Manual Chapter 6-Volume II. Refer to the Detention Basin Design sheets located within the appendix of this report.

DP50, 8.56 acres, consists of Basin JP-11 a future commercial parcel with runoff coefficients of 0.81 for the 5-year and 0.88 for the 100-year. Developed runoff of Q5=29.4 cfs and Q100=53.7 cfs has been calculated for DP50. In the undeveloped condition, runoff of Q5=2.0 cfs and Q100=15.0 cfs are routed via historic drainage patterns and proposed swales to DP50. The surface runoff will be collected by a 36" FES. The flows will routed south via a 36" RCP (PR64) to PR65. The accumulated flow in PR65 (Q5=32.0 cfs and Q100=309.9 cfs) will be routed south to PR67. Upon future development of this basin, full spectrum detention shall be required and will release to historic release rates of Q5=2.0 cfs and Q100=15.0 cfs.

DP53, 5.37 acres, consists of Basin JP-12 a future commercial parcel with runoff coefficients of 0.81 for the 5-year and 0.88 for the 100-year. Developed runoff of Q5=19.8 cfs and Q100=36.1 cfs has been calculated for DP53. In the undeveloped condition, runoff of Q5=1.4 cfs and Q100=10.0 cfs are routed via historic drainage patterns and proposed swales to DP53. The surface runoff will be collected by a 30" FES. The flows will routed south via a 30" RCP (PR66) to PR67. The accumulated flow in PR67 (Q5=39.1 cfs and Q100=322.7 cfs) will be routed via a 72" RCP south to Sand Creek (DP68). Upon future development of this basin, full spectrum detention shall be required and will release to historic release rates of Q5=1.4 cfs and Q100=10.0 cfs. The summed flows at DP68 (PR74, Q5=42.2 cfs and Q100=472.4 cfs) will outfall into Sand Creek. Impacts from the outfall into Sand Creek will be addressed in the revised TM-SCCS. A riprap apron will be constructed to dissipate energy and prevent local scour at the outlet.

DP54, 1.21 acres, consists of Basin RP-7D (Marksheffel Road) with runoff coefficients of 0.08 for the 5-year and 0.35 for the 100-year and DP51 flowby. Undeveloped runoff of Q5=0.4 cfs and Q100=3.5 cfs has been calculated for DP54. Undeveloped flows will be routed to a temporary sediment basin via overlot grading as shown on the "Sterling Ranch-Phase 1 Offsite Grading, Early Grading & Erosion Control Plans", prepared by M&S Civil Consultants, Inc., dated November 2015, which will route flows via historic drainage patterns to Sand Creek. Erosion control will be provided.

DP55, 1.28 acres, consists of Basin RP-7C (Marksheffel Road) with runoff coefficients of 0.08 for the 5-year and 0.35 for the 100-year and DP51 flowby. Undeveloped runoff of Q5=0.4 cfs and Q100=4.9 cfs has been calculated for DP55. Undeveloped flows will be routed to a temporary sediment basin via overlot grading as shown on the "Sterling Ranch-Phase 1 Offsite Grading, Early Grading & Erosion Control Plans", prepared by M&S Civil Consultants, Inc., dated November 2015, which will route flows via historic drainage patterns to Sand Creek. Erosion control will be provided.

Basin SSS, 1.21 acres, consists of the backyards of future residential lots with runoff coefficients of 0.22 for the 5-year and 0.46 for the 100-year. Developed runoff of Q5=1.1 cfs and Q100=3.8 cfs has been calculated for this basin. Developed flows will be sheet flow into Sand Creek. Erosion control will be provided.

There will be bank stabilization improvements to the Sand Creek Drainage Channel with the development of the STERLING RANCH FILING NOS. 2 site to maintain the integrity of pond W-5. However, channel improvements for Sand Creek (checks, drops, etc…) will be installed in accordance with the Subdivision Improvement Agreement.

DETENTION PONDS

Detention Pond W-5, has combined upstream developed runoff of Q5=217.4 cfs and Q100=517.9 cfs. The proposed Detention Pond functions to provide full spectrum detention and water quality for runoff calculated onsite. The pond is designed to treat approx 175.6 acres, and provide 2.97 ac-ft of water quality storage and 17.37 ac-ft of 100-year storage. The forebay, trickle channel micropool, outlet structure and pipe have been designed per the UDFCD manual and per the Detention Design-UD-Detention v3.05 workbook. See Sand Creek Channel Study-Future Hydrologic Conditions Map in the appendix. Impacts from the outfall into Sand Creek will be addressed in the revised TM-SCCS.

Detention Pond W-4, has combined upstream developed runoff of Q5=72.9 cfs and Q100=367.1 cfs. The proposed Detention Pond functions to provide full spectrum detention and water quality for runoff calculated onsite. The pond is designed to treat approx 352.2 acres, and provide 1.75 ac-ft of water quality storage and 7.67 ac-ft of 100-year storage. The forebay, trickle channel micropool, outlet structure and pipe have been designed per the UDFCD manual and per the Detention Design-UD-Detention v3.05 workbook. See Sand Creek Channel Study-Future Hydrologic Conditions Map in the appendix. Impacts from the outfall into Sand Creek will be addressed in the revised TM-SCCS.

The detention ponds will be private and shall be maintained by the Sterling Ranch Metropolitan District. Access shall be granted to the owner and El Paso County for access and maintenance of the private detention pond. A private maintenance agreement document shall accompany the submittal. In the event of clogging or total inlet failure, flows will over top the emergency spillway and outfall into Sand Creek. A rip rap apron will be constructed to dissipate energy and prevent local scour at the outlet.

The water quality volume and 100-year volume required for the site has been determined using the guidelines set forth in the City of Colorado Springs/El Paso County Drainage Criteria Manual Chapter 6 - Volume II. Refer to the Detention Basin Design sheets located within the appendix of this report.

EROSION CONTROL

It is the policy of the El Paso County that a grading and erosion control plan be submitted with the drainage report. EPC approved "Early Grading Plan for Sterling Ranch Phase I Onsite Grading & Erosion Control", November 18, 2015. And "Early Grading Plan for Sterling Ranch Phase I Offsite Grading & Erosion Control", December 3, 2015. Grading and Erosion control operations are currently underway (August 2016). Grading and Erosion Control will cease with the final development of the site in the next 12-36 months.

CHANNEL IMPROVEMENTS

Per the Sand Creek DBPS, Sand Creek and connected tributaries in the area of the site will require improvements. The east tributary reaches within the site boundary (DBPS SEG: 169, 186, 164, 159) will not require improvements because they will no longer be present, as development in the areas will eliminate them, and replace them with, a storm sewer system to discharge into Sand Creek. Sand Creek itself will continue to be routed through the development. Per the DBPS, selective rip rap linings, grade control check structures, and drop structure improvements are required to stabilize the channel to prevent further degradation, scour and meandering. Full Spectrum Detention will also be used on its benefits to the integrity of the Sand Creek Channel. A separate document with detailed alternative sections, HEC-RAS analyses, etc. will be submitted with for the applicable and adjoining areas of development, in accordance with SIA requirements.

Downstream channel improvements are proposed to be similar to what was anticipated in the SCDBPS. Check structures and rip-rap lining in some locations shall be installed to handle the volume of flows from the full spectrum detention ponds. In the final design stage of the applicable and adjoining development, the channels will be analyzed to verify the amount of improvements necessary.

The approved Subdivision Improvements Agreement for Sterling Ranch Filing No. 2 address the timing and funding for channel improvements.

<u>Channel Improvements and Wetland Mitigation</u>
Areas with the existing floodplain or the low flow zone of the drainageways where riparian or wetland vegetation exists 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. Coordination with a wetland consultant will take place for mitigation of the disturbed wetlands. Included in this report (in the appendix) are the memo and map from Core Consultants showing intent to have wetlands delineated in the Filing No. 2 areas of wetland disturbance.

CONSTRUCTION COST OPINION – FILING NO. 2
Drainage Facilities:

Item	Description	Quantity	Unit Cost			Cost
1	18”RCP	595	$40	/LF	$	23,800.00
2	24" RCP	591	$50	/LF	$	29,550.00
3	30" RCP	382	$65	/LF	$	24,830.00
4	36" RCP	1375	$75	/LF	$	103,125.00
5	42" RCP	1238	$85	/LF	$	105,230.00
6	48" RCP	1158	$150	/LF	$	173,700.00
7	54" RCP	344	$200	/LF	$	68,800.00
8	66" RCP	1863	$300	/LF	$	558,900.00
9	72" RCP	2562	$350	/LF	$	896,700.00
10	78” RCP	240	$400	/LF	$	96,000.00
11	84" RCP	299	$450	/LF	$	134,550.00
12	24" FES	2	$335	/EA	$	670.00
13	30" FES	3	$475	/EA	$	1,425.00
14	36" FES	2	$775	/EA	$	1,550.00
15	42" FES	3	$895	/EA	$	2,685.00
16	48” FES	1	$1096	/EA	$	1,096.00
17	84" Headwall	2	$10000	/EA	$	20,000.00
18	15' CDOT Type R At-Grade	8	$6000	/EA	$	48,000.00
19	10' CDOT Type R At-Grade	4	$5000	/EA	$	20,000.00
20	2.9’x5.5’ CDOT TYPE D	3	$3500	/EA	$	10,500.00
21	Storm Sewer MH, box base < 15 feet	15	$10000	/EA	$	150,000.00
22	Storm Sewer MH, box base ~ 15 feet-20 feet	4	$15000	/EA	$	60,000.00
23	Storm Sewer MH, box base > 20 feet	1	$20000	/EA	$	20,000.00
24	*Detention Pond W-5	1	$200000	/EA	$	200,000.00
25	*Detention Pond W-4	1	$200000	/EA	$	200,000.00
26	Mod CDOT Outlet Structure	2	$15000	/EA	$	30,000.00
			Total		**$**	**2,981,111.00**

M & S Civil Consultants, Inc. (M & S) cannot and does not guarantee the construction cost will not vary from these opinions of probable costs. These opinions represent our best judgment as design professionals familiar with the construction industry and this development in particular. The above is only an estimate of the facility cost and drainage basin fee amounts in 2017.

DRAINAGE & BRIDGE FEES – FILING NO. 2

This site is within the Sand Creek Drainage Basin. The 2017 Drainage and Bridge Fees per El Paso County for the STERLING RANCH FILING NO. 1 site are as follows: **(see next sheet for itemized statement)**

Per Sterling Ranch Filing No.2 Plat – **Total Area** **49.643 Acres**

FILING NO. 2 FEES:

Drainage Fees:	**(See attached Spreadsheet)**	**$**	**583,073.57**
Bridge Fees:	**(See attached Spreadsheet)**	**$**	**176,647.86**

<u>STERLING RANCH TOTAL:</u>

Sand Creek Channel Improvements (DBPS Estimate – 2017 dollars) **$8,237,679.00**

Sand Creek Bridge Improvements (DBPS Estimate – 2017 dollars) **$1,904,456.00**

DRAINAGE & BRIDGE FEES - FILING NO. 2 - CONTNUED

An Intergovernmental Agreement for the Establishment of The Sterling Ranch Storm-Water Escrow Fund and the Subdivision Improvements Agreement Sterling Ranch Filing No. 2, address the timing of drainage improvement and fees. The above cost estimate is for informational purposes only. Final drainage improvement costs will be determined post construction.

SUMMARY

Development of this site will not adversely affect the surrounding development per this final drainage report with no negative impact of the neighboring developments. The proposed drainage facilities will adequately convey, detain and route runoff from the tributary and onsite flows to the Sand Creek Drainage channel. Full Spectrum Detention and Water Quality Ponds will be used to discharge developed flows into Sand Creek per the Urban Drainage criteria flow rates, which are at or less than the historic flow. Care will be taken during construction to accommodate overland flow routes onsite and temporary drainage conditions. The development of the STERLING RANCH FILING NO. 2 project(s) shall not adversely affect adjacent or downstream property.

STERLING RANCH FILING NO. 2 - TRACTS AND RIGHT-OF-WAY - DRAINAGE & BRIDGE FEES (2018)

TRACT/ROW	SIZE/ACRE	USE	MAINTENANCE	OWNERSHIP	% Impervious	DRAINAGE FEE	FEE	BRIDGE FEE	FEE
A	0.391	LANDSCAPE/PUBLIC IMPROVEMENTS/PUBLIC UTILITY	SRMD #1	SRMD #1	29.0%	$ 17,197	$ 1,949.97	$ 5,210	$ 590.76
B	0.658	LANDSCAPE/PUBLIC IMPROVEMENTS/PUBLIC UTILITY	SRMD #1	SRMD #1	29.0%	$ 17,197	$ 3,281.53	$ 5,210	$ 994.17
C	0.845	LANDSCAPE/PUBLIC IMPROVEMENTS/PUBLIC UTILITY	SRMD #1	SRMD #1	24.0%	$ 17,197	$ 3,487.55	$ 5,210	$ 1,056.59
D	2.159	LANDSCAPE/PUBLIC IMPROVEMENTS/PUBLIC UTILITY	SRMD #1	SRMD #1	13.0%	$ 17,197	$ 4,826.68	$ 5,210	$ 1,462.29
E	19.674	ZERO LOT LINE FUTURE SINGLE FAMILY RESIDENTIAL LOTS	SR LAND, LLC	SR LAND, LLC	70.0%	$ 17,197	$ 236,833.64	$ 5,210	$ 71,751.08
F	1.231	LANDSCAPE/PUBLIC IMPROVEMENTS/PUBLIC UTILITY	SRMD #1	SRMD #1	4.0%	$ 17,197	$ 846.78	$ 5,210	$ 256.54
G	0.249	LANDSCAPE/PUBLIC IMPROVEMENTS/PUBLIC UTILITY	SRMD #1	SRMD #1	2.0%	$ 17,197	$ 85.64	$ 5,210	$ 25.95
H	0.062	LANDSCAPE/PUBLIC IMPROVEMENTS/PUBLIC UTILITY	SRMD #1	SRMD #1	2.0%	$ 17,197	$ 21.32	$ 5,210	$ 6.46
I	0.5	LANDSCAPE/PUBLIC IMPROVEMENTS/PUBLIC UTILITY/MAIL KIOSK	SRMD #1	SRMD #1	15.0%	$ 17,197	$ 1,289.78	$ 5,210	$ 390.75
J	0.379	LANDSCAPE/PUBLIC IMPROVEMENTS/PUBLIC UTILITY	SRMD #1	SRMD #1	30.0%	$ 17,197	$ 1,955.30	$ 5,210	$ 592.38
K	0.387	LANDSCAPE/PUBLIC IMPROVEMENTS/PUBLIC UTILITY	SRMD #1	SRMD #1	30.0%	$ 17,197	$ 1,996.57	$ 5,210	$ 604.88
49 LOTS	11.871	SINGLE FAMILY RESIDENTIAL LOTS	SRMD #1	SRMD #1	70.0%	$ 17,197	$ 142,901.91	$ 5,210	$ 43,293.54
ROW	4.734	ROAD RIGHTS OF WAY (STERLING RANCH ROAD)	EPC	EPC	95.0%	$ 17,197	$ 77,340.07	$ 5,210	$ 23,430.93
ROW	3.525	ROAD RIGHTS OF WAY (MARKSHEFFEL ROAD)	EPC	EPC	95.0%	$ 17,197	$ 57,588.45	$ 5,210	$ 17,446.99
ROW	2.979	ROAD RIGHTS OF WAY (VOLLMER ROAD, ULTIMATE)	EPC	EPC	95.0%	$ 17,197	$ 48,668.37	$ 5,210	$ 14,744.56
							DRAINAGE FEE		**BRIDGE FEE**
	49.644	**TOTAL AREA**				**TOTAL FEES**	**$ 583,073.57**		**$ 176,647.86**

*SRMD#1 = STERLING RANCH METROPOLITAN DISTRICT NO. 1

REFERENCES

1.) "El Paso County and City of Colorado Springs Drainage Criteria Manual, Vol I & II".

2.) "Urban Storm Drainage Criteria Manuals, Volumes 1-3"

3.) NRSC Web Soil Survey Map for El Paso County. http://websoilsurvey.nrcs.usda.gov

4.) Flood Insurance Rate Map (FIRM), Federal Emergency Management Agency, Effective date March 17, 1997.

5.) "Sand Creek Drainage Basin Planning Study" (DBPS) prepared by Kiowa Corporation, revised March 1996

6.) "Preliminary Drainage Report for Sterling Ranch-Phase 1", dated May 2015, by M&S Civil Consultants, Inc.

7.) "Sterling Ranch-Phase 1 Offsite Grading, Early Grading & Erosion Control Plans", prepared by M&S Civil Consultants, Inc., dated November 2015

8.) "Sterling Ranch-Phase 1 Onsite Grading, Early Grading & Erosion Control Plans", prepared by M&S Civil Consultants, Inc., dated November 2015

9.) "Final Drainage Report for Barbarick Subdivision, Portions of Lots 1, 2 and Lots 3 & 4, by Matrix Design Group, dated June 2016.

10.) "Preliminary and Final Drainage Report, Barbarick Subdivision, A Replat of Lot "D", McClintock Subdivision", El Paso County, Revised August 15, 2007, prepared by Oliver E. Watts, Consulting Engineer, Inc.

11.) "Master Development Drainage Plan For Sterling Ranch", prepared by M&S Civil Consultants, Inc., dated July 2010 (Draft not approved)

12.) "Technical Memorandum Sand Creek Channel Study (North of Woodmen Road) Hydrologic Analysis" (TM-SCCS) prepared by M&S Civil Consultants, Inc., dated July 2016

13.) "Master Development Drainage Report for Sterling Ranch Filing Nos. 1&2 and Final Drainage Report for Sterling Ranch Filing No. 1", prepared by M&S Civil Consultants, Inc., dated April 2017

APPENDIX

NEW DOC

FINAL DRAINAGE REPORT
For

BARBARICK SUBDIVISION, PORTIONS OF LOTS 1, 2 and LOTS 3 & 4
El Paso County, Colorado

Sand Creek Drainage Basin

Prepared for:
El Paso County Development Services
Engineering Division

On Behalf of:
Wykota Construction
430 Beacon Light Road, Suite 130
Monument, CO 80132

Prepared by:

Matrix
DESIGN GROUP
2435 Research Parkway, Suite 300
Colorado Springs, CO 80920
(719) 575-0100
Fax (719) 572-0208

June 6, 2016

15.789.001

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 master plan of the drainage basin.

SEAL

Gregory G. Shaner
Registered Professional Engineer
State of Colorado No. 36307

Developer's Statement:

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

Wykota Construction
Business Name

By: Justin Ballard

Title: President

Address: 430 Beacon Light Road, Suite 130
Monument, CO 80132

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.

9 JUNE 2016

Print Name — JENNIFER IRVINE Date
County Engineer / ECM Administrator

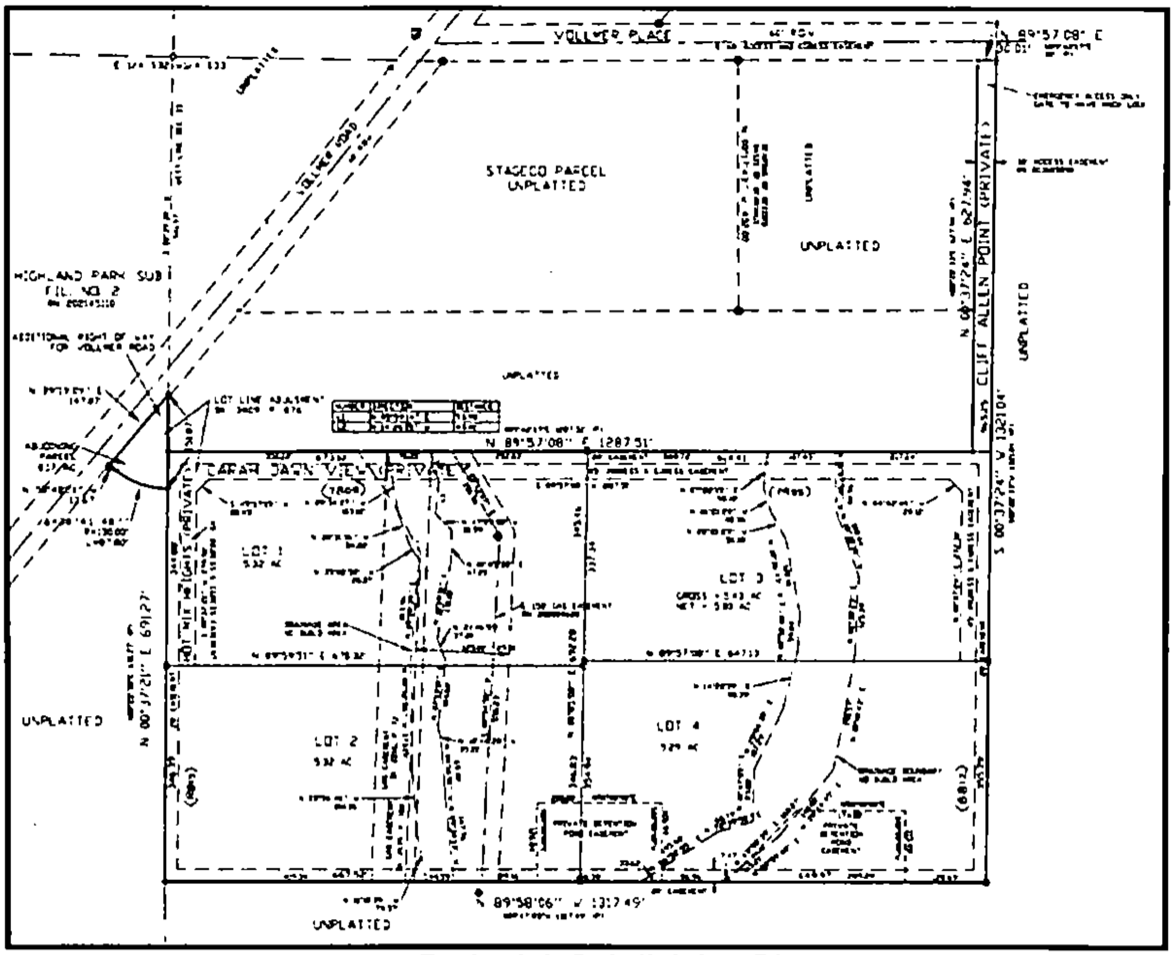
TABLE of CONTENTS

<u>Surrounding Developments.</u> The following are the existing or planned general land uses adjacent to the property.

<u>North:</u> Un-platted parcels that contain commercial/industrial uses. Carah Dawn View is on the north side of the property.

<u>East and South:</u> Although this adjacent area is currently undeveloped, the Sterling Ranch Master Planned area is in the process of developing this area (future single family development).

<u>West:</u> This is an undeveloped, un-platted lot. Across Vollmer Road is a low density single family development (Highland Park, Fil 2).



Barbarick Subdivision Plat

Property Description

1. Major Drainage Way: The entire site is located within the Sand Creek Drainage Basin. The Main Fork of Sand Creek is located about 1500 feet to the east. The site currently drains to the south into natural drainage ways that direct runoff to Sand Creek. The Sand Creek Drainage Basin is located in the northeastern portion of the City of Colorado Springs and El Paso County. The general drainage pattern of this larger basin flows to the southwest and ultimately feeds into Fountain Creek.

2. Project Site Area: This site is approximately 21.37 acres in area.

3. Ground Cover: This site is covered with native grasses.

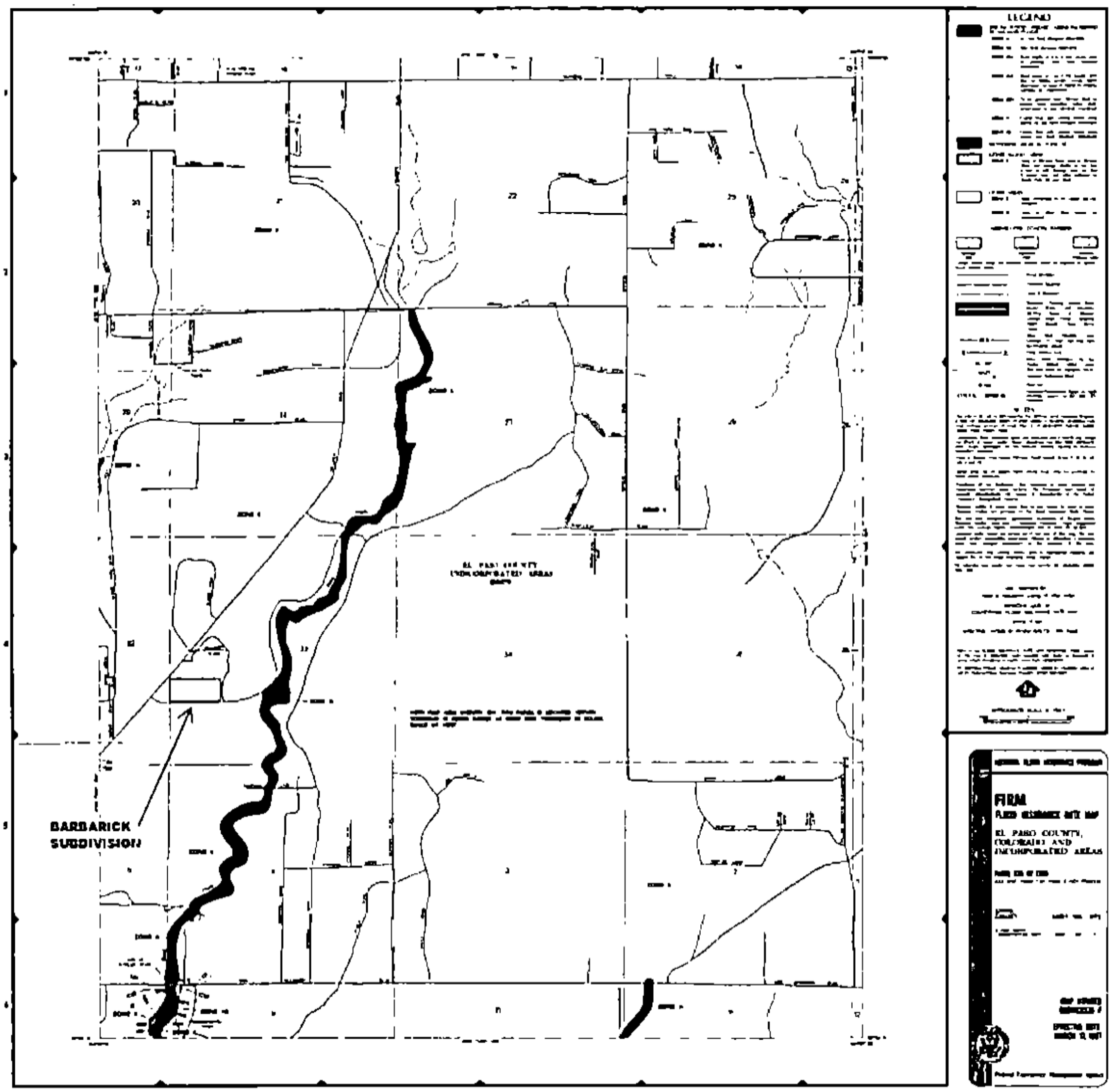
4. General Topography: The site drains from north to the south with average grades ranging from 1% to 5%. There are two natural drainage ways that drain through these lots.

5. Irrigation Facilities: No known functioning irrigation facilities are located on the site. A small detention pond does exist to the northeast of the property; however, the outfall of this pond will be re-routed in order to direct runoff around the perimeter of the proposed development.

6. Utilities: Utilities in the project area include; but are not limited to, telephone, high pressure gas/petroleum and electrical lines. Water & wastewater service is provided through wells & individual septic systems. These utilities will be examined on a case-by-case basis and avoided where feasible, or they will be relocated. Any relocation of these utilities will be coordinated with the respective utility contact. Utility services will be extended into the site as necessary. There are large gas easements that run north-south through these lots. These easements contain one 6 inch and two 20 inch high pressure gas/petroleum pipelines. These Utility Easements will be no-build zones and grading will be fill only.

7. On-Site Drainage Ways: The plat shows two "Drainage Boundary – No Build Area(s)" draining through the subdivision. These are not regulated FEMA floodplains. The site development will include the installation of pass through culverts for offsite flows, and regraded. An amended plat has been completed for the removal of the no build areas, identification of new drainage easements, and relocation of water quality ponds.

8. <u>Floodplain Statement:</u> Review of the Flood Insurance Rate Map (FIRM) 535 (08041CO535 F), effective date March 17, 1997, published by the Federal Emergency Management Agency (FEMA) reveals that no portion of Barbaric Subdivision lie within any designated 100-year floodplain.



FEMA - Flood Insurance Rate Map (FIRM)

HYDROLOGIC AND HYDRAULIC ANALYSIS

Basin Description

The Barbarick Subdivision is located within the Sand Creek Drainage Basin. The tributary area that drains through the Barbarick Subdivision is developed, which includes large lot single-family parcels and some commercial/industrial land uses. Sub-basins were delineated using surveyed information, proposed contours and field observations. See the Drainage Basin Maps in the Appendix.

This study is in conformance with the following two approved Drainage Reports:

1. ***Preliminary Drainage Report for Sterling Ranch-Phase 1, Sand Creek Drainage Basin***, M & S Civil Consultants, Inc., May 2015 **AKA: "SR-PDR"**

2. ***Woodmen Storage Final Drainage Report, El Paso County,*** Calibre Engineering, Inc., July 2004; Revised February, 2010; Revised May, 2010; Revised July, 2010 **AKA: "WS-FDR"**

This study is *not* in conformance with the following approved Drainage Report due to changes from the approved recent reports cited above that supercede the original report:

1. ***Preliminary and Final Drainage Plan and Report, Barbarick Subdivision a Replat of Lot "D", McClintock Subdivision, El Paso County,*** Oliver E. Watts, Consulting Engineer, Inc., August 15, 2007 **AKA: "BS-FDR"**

Design Criteria

This report has been prepared in accordance to the criteria set forth in the ***City of Colorado Springs & El Paso County Drainage Criteria Manual, Volumes I and II***, dated November 1991 including subsequent updates. El Paso County has also adopted Chapter 6 and Section 3.2.1 of Chapter 13 in the ***City of Colorado Springs & El Paso County Drainage Criteria Manual, Volumes I and II***, dated May 2014 (Appendix I of the El Paso County's Engineering Criteria Manual (ECM), 2008). In addition to the ECM, the ***Urban Storm Drainage Criteria Manuals, Volumes 1-3***, published by the Urban Drainage and Flood Control District, (Volumes 1 & 2 dated January 2016, Volume 3 dated November 2010 with some sections update November 2015), has also been used to supplement the ECM.

Hydrologic Criteria

Hydrologic analyses for the site have been completed using the Rational Method for on-site basins. The SCS Method was used in the referenced studies for the larger off-site basins (greater than 100 acres). The design storms for each method are:

Initial Storm = 5-Year Storm
Major Storm = 100-Year Storm

Rational Method: The Rational Method will be utilized to evaluate smaller basins (under 100 acres). This methodology is used for the design of localized facilities such as inlets, storm drain, drainage swales and detention:

Rational Method peak flow rate equation (cfs): Q=C*I*A

Where: Q = Maximum runoff rate in cubic feet per second (cfs)
C = Runoff coefficient
I = Average rainfall intensity in inches per hour
A = Area of drainage sub-basin in acres

Runoff Coefficient

Rational Method coefficients are derived from UDFCD Vol 1 (Chapter 6 – Runoff, 2016-01 Rev) for the various land uses, including parking areas, drives, walks, roofs, lawns and open space areas. The Runoff Coefficients associated with these land uses also have a corresponding impervious value that is used in the detention calculations. The Rational Method Coefficients used in this study include:

Land Use or Surface Type	% Impervious	Runoff Coefficient (B Soils)	
		(5-Year)	(100-Year)
Greenbelts/Agricultural	2%	.03	.46
Gravel (packed)	40%	.37	.65
Drives & Walks	90%	.84	.90

Table 6-3. Recommended percentage imperviousness values

Land Use or Surface Characteristics	Percentage Imperviousness (%)
Business:	
Downtown Areas	95
Suburban Areas	75
Residential:	
Single-family	
2.5 acres or larger	12
0.75 – 2.5 acres	20
0.25 – 0.75 acres	30
0.25 acres or less	45
Apartments	75
Industrial:	
Light areas	80
Heavy areas	90
Parks, cemeteries	10
Playgrounds	25
Schools	55
Railroad yard areas	50
Undeveloped Areas:	
Historic flow analysis	2
Greenbelts, agricultural	2
Off-site flow analysis (when land use not defined)	45
Streets:	
Paved	100
Gravel (packed)	40
Drive and walks	90
Roofs	90
Lawns, sandy soil	2
Lawns, clayey soil	2

Table 6-5. Runoff coefficients, c

Total or Effective % Imperviousness	NRCS Hydrologic Soil Group A					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
2%	0.02	0.02	0.02	0.02	0.02	0.17
5%	0.04	0.05	0.05	0.05	0.05	0.19
10%	0.09	0.09	0.09	0.09	0.1	0.23
15%	0.13	0.14	0.14	0.14	0.14	0.28
20%	0.18	0.19	0.19	0.19	0.19	0.32
25%	0.22	0.23	0.24	0.24	0.24	0.36
30%	0.27	0.28	0.28	0.28	0.29	0.4
35%	0.31	0.33	0.33	0.33	0.33	0.44
40%	0.36	0.37	0.38	0.38	0.38	0.48
45%	0.4	0.42	0.42	0.42	0.43	0.52
50%	0.45	0.47	0.47	0.47	0.48	0.56
55%	0.49	0.51	0.52	0.52	0.52	0.6
60%	0.53	0.56	0.56	0.57	0.57	0.64
65%	0.58	0.6	0.61	0.61	0.62	0.68
70%	0.62	0.65	0.66	0.66	0.67	0.72
75%	0.67	0.7	0.71	0.71	0.71	0.76
80%	0.71	0.74	0.75	0.76	0.76	0.8
85%	0.76	0.79	0.8	0.8	0.81	0.84
90%	0.8	0.84	0.85	0.85	0.86	0.88
95%	0.85	0.88	0.89	0.9	0.9	0.92
100%	0.89	0.93	0.94	0.94	0.95	0.96
Total or Effective % Imperviousness	**NRCS Hydrologic Soil Group B**					
2%	0.02	0.02	0.14	0.24	0.38	0.46
5%	0.04	0.05	0.17	0.27	0.39	0.48
10%	0.09	0.09	0.21	0.3	0.42	0.5
15%	0.13	0.14	0.25	0.34	0.45	0.53
20%	0.18	0.19	0.29	0.37	0.48	0.55
25%	0.22	0.23	0.33	0.41	0.51	0.58
30%	0.27	0.28	0.37	0.44	0.54	0.6
35%	0.31	0.33	0.41	0.48	0.57	0.63
40%	0.36	0.37	0.45	0.51	0.6	0.65
45%	0.4	0.42	0.49	0.55	0.63	0.67
50%	0.45	0.47	0.53	0.58	0.66	0.7
55%	0.49	0.51	0.57	0.62	0.69	0.72
60%	0.53	0.56	0.61	0.65	0.72	0.75
65%	0.58	0.6	0.65	0.69	0.75	0.77
70%	0.62	0.65	0.69	0.72	0.78	0.8
75%	0.67	0.7	0.73	0.76	0.81	0.82
80%	0.71	0.74	0.77	0.79	0.84	0.85
85%	0.76	0.79	0.81	0.83	0.87	0.87
90%	0.8	0.84	0.85	0.86	0.89	0.9
95%	0.85	0.88	0.89	0.9	0.92	0.92
100%	0.89	0.93	0.94	0.94	0.95	0.94

Time of Concentration

The time of concentration (T_c) for the Rational Method was calculated by methods derived from the UDFCD. The time of concentration 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 initial time or overland flow time (t_i)

plus the time of travel (t_t) in concentrated form, such as a swale or drainageway. A minimum T_c of 5 minutes and 10 minutes were used for the final calculations in developed and undeveloped conditions, respectively.

Storm Drain Systems

All proposed storm drain infrastructure will be located within private property and will be owned and maintained by the property owner.

The storm drain hydraulics is analyzed using *Bentley's* FlowMaster, CulvertMaster & StormCAD design software. Colorado Department of Transportation (CDOT) type inlets will be used where necessary.

The designated outfall locations for the proposed on-site storm drains are the natural drainage ways at the south end of the property. The proposed storm drain infrastructure will be discussed in more detail below.

EXISTING DRAINAGE REPORT DISCUSSION

The approved Barbarick Subdivision Final Drainage Report (BS-FDR) and the approved Woodmen Storage Final Drainage Report (WS-FDR) both apply to the existing general drainage conditions for this site. The off-site basins and general flow patterns in the BS-FDR and WS-FDR still apply. Excerpts from these reports are provided below for reference.

On-site and Off-Site Basin Descriptions from the BS-FDR and WS-FDR:

The following summary is taken from the Barbarick Subdivision Final Drainage Report (BS-FDR):

Off-site:

Off-site Basin O3 This basin encompasses approximately 7.03 acres and represents the area north and northwest of Lot 1. This basin drains into Lot 1 through a series of (2) 24" CMP pipes which control the flow of 14/36 cfs in the 5/100 year storm events.

Lots 1 & 2 – these lots are considered fully developed lots and drain north to south collecting at the existing concrete settling pond on Lot 2. This developed flow (20.8 cfs /57.2 cfs) combines with Off-site Basin O3 to total 30.5 cfs / 80.8 cfs in the greenbelt offsite south of Lot 2. At the time of development permit for these developed lots, a detention pond for water quality will be required, probably in the area of the existing concrete settling pond, that will accommodate Lots 1 and 2 west of the gas easement and flood plain area.

On-site:

On-site Basins A1 and B1 (for portions of Lots 1 and 2, and Lots 3 & 4)
These basins encompass approximately 5.3 & 3.8 acres and represent the buildable portions of the property as described in the BS-FDR (see Basin Map from BS-FDR below). These basins were slated (in the BS-FDR) to drain into small detention ponds that would release to historic rates. These discharge rates were calculated to be 2.9/7.3 and 2.2/5.4 cfs (5/100 year). The BS-FDR does not include the drainage ways in any hydrology calculations due to the fact that this no-build drainage area was not planed on being developed. This drainage way allowed off-site flows from O1+O2 to pass-through Lots 3 & 4. The drainage way to the west of A1 passes through flows from offsite O3. Since the approval of this report, offsite tributary basins O1+O2 have been changed, and the development of the property encompasses the whole property, including the previously determined no-build area.

The following summary is taken from the Woodmen Storage Final Drainage Report (WS-FDR):

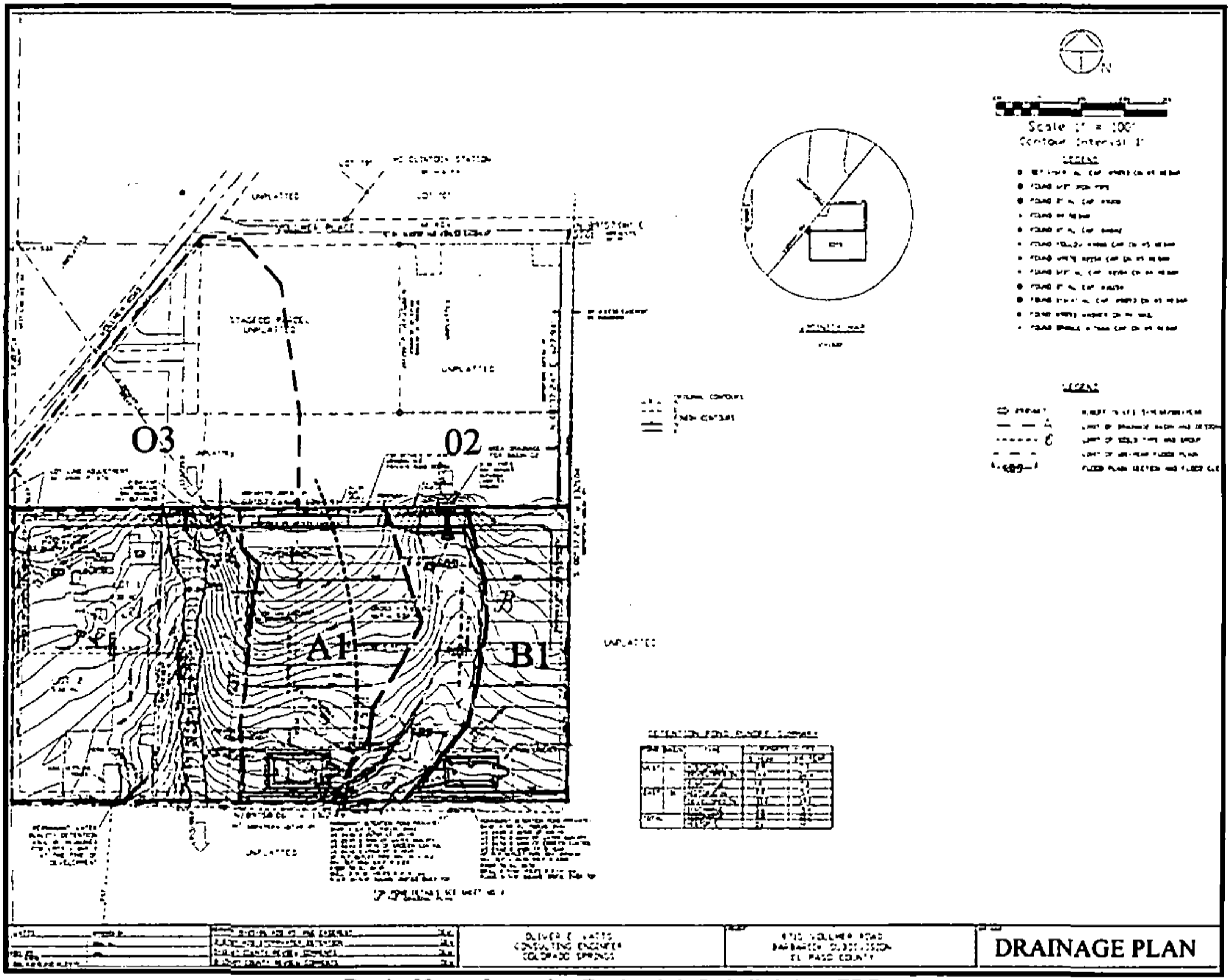
Off-site:

Design Point 5 - This design point encompasses approximately 19.69 acres and represents the tributary area north of the project site. This basin drains into a proposed detention pond near the northeast corner of the property and generates 57.4/92.7 cfs in the 10/100 year storm events, historic flows are 16.7/30.3 cfs. The releases rates from this pond are lower than historic 16.1 cfs/29.4 cfs in the 10/100-year storm events. These flows are conveyed along the east property line of the site and into the eastern natural drainage way that leaves the property to the south.

Review of the Sterling Ranch Preliminary Drainage Report (SR-PDR):

The Barbarick Subdivision is surrounded on three sides by the planned Sterling Ranch Development. The approved Sterling Ranch PDR was prepared by M&S Civil Consultants in May of 2015. This Sterling Ranch PDR re-analyzes runoff from Barbarick Subdivision and plans for storm drain improvements to convey this runoff to a full spectrum detention and water quality pond to be located down stream of Barbarick Subdivision as part of Sterling Ranch Phase One.

In summary; the Sterling Ranch PDR is planning on receiving 73.3/139.2 cfs (5/100 year) from Basin OS3. A 54" RCP is planned to convey this flow through Sterling Ranch. The Sterling Ranch PDR is planning on receiving 45/86 cfs (5/100 year) from OS2, encompasses Lots 1 & 2 and OS3 encompasses Lots 3 & 4 and the Basin north of Lot 3. A 48" RCP is planned to convey this flow through Sterling Ranch. The cumulative runoff from the northerly property and Lots 1 through 4 does not exceed the anticipated rates in the SR-PDR.



Basin Map - from the Barbarick Subdivision FDR

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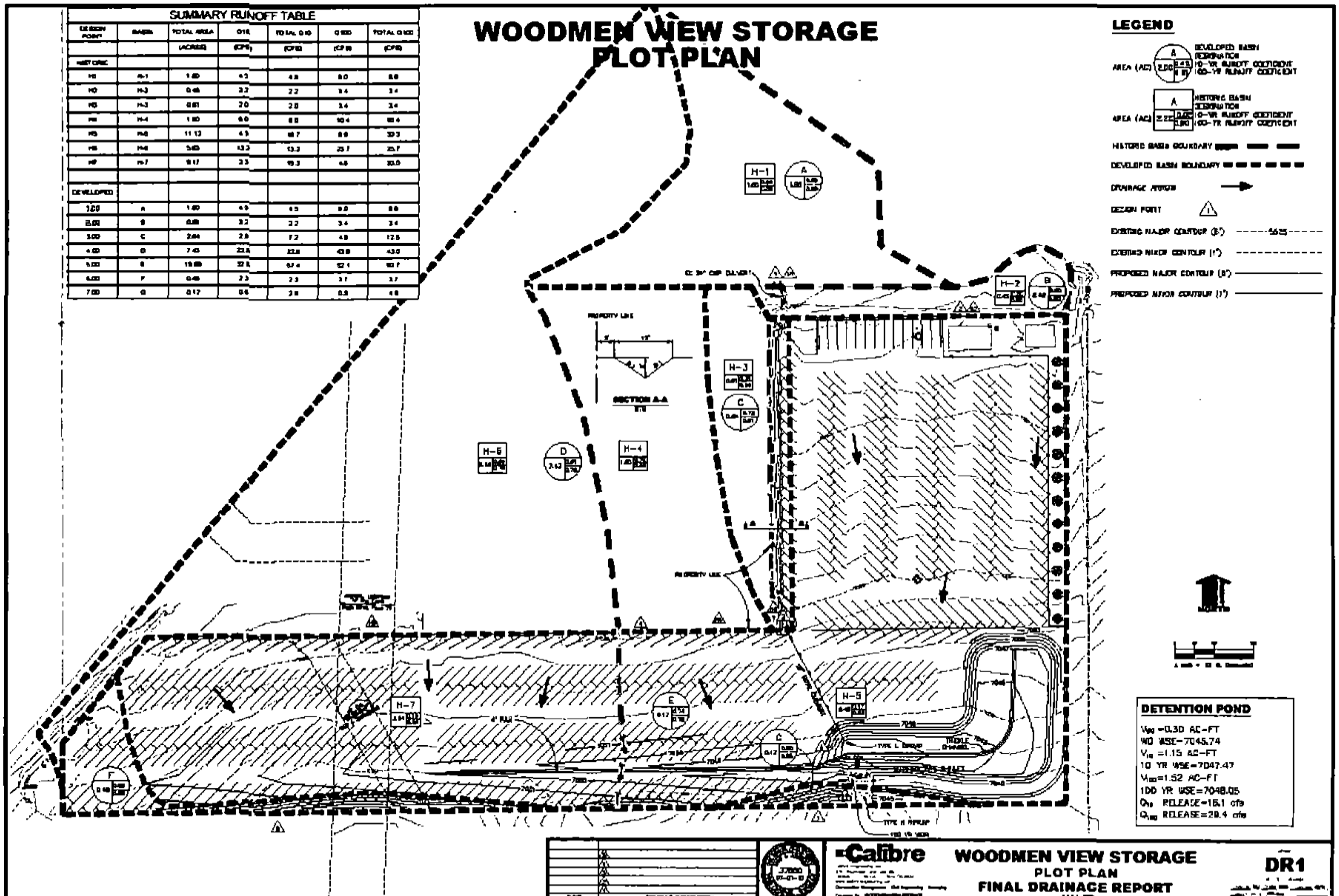

Basin Map - from the FDR

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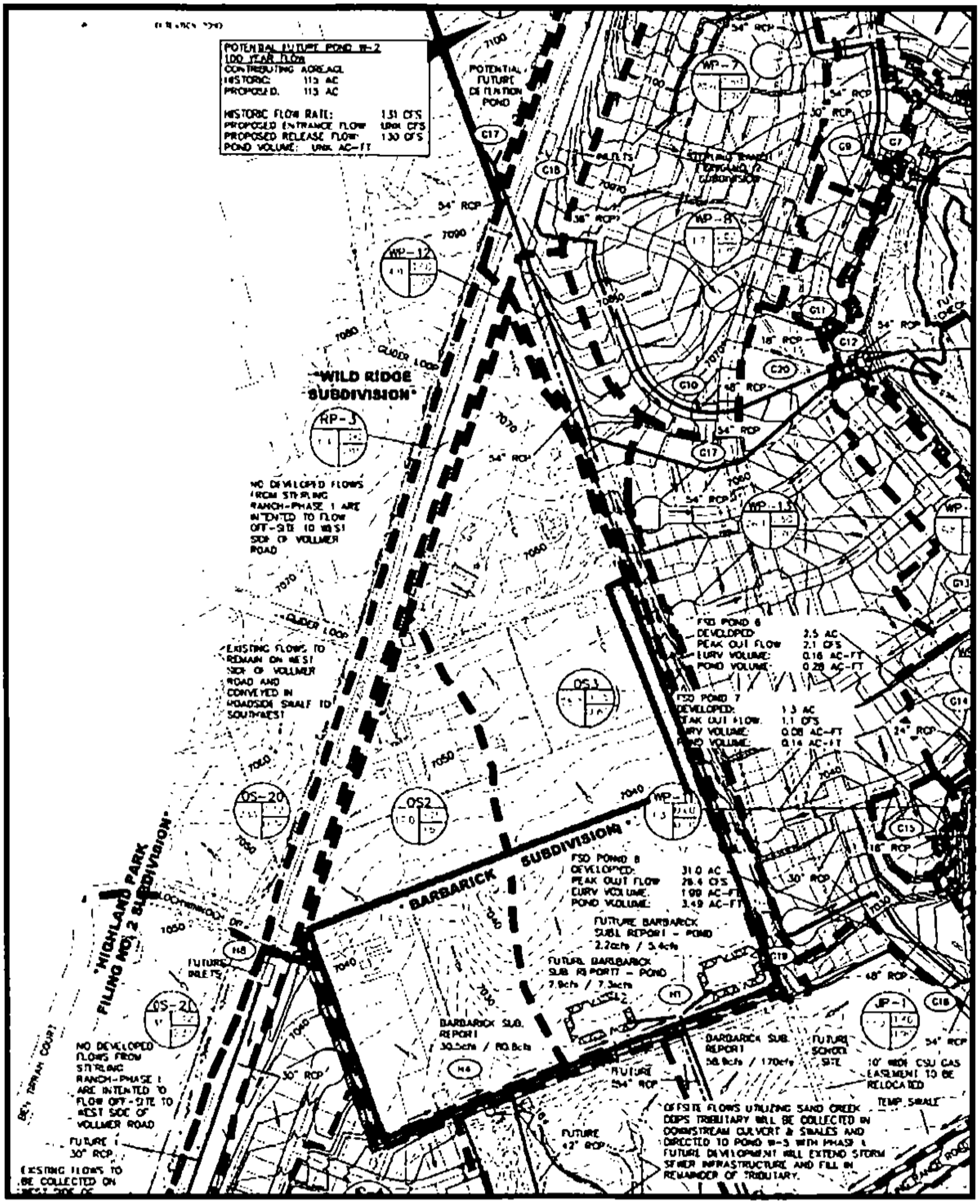
CIVIL CONSULTANTS, INC.
102 E. PIKES PEAK AVE. STE 306
COLORADO SPRINGS, CO 80903
(719) 955-5485, FAX (719) 448-8427

STERLING RANCH PHASE 1

PROPOSED – DRAINAGE MAP (OVERALL)

PROJECT NO. 09-001		SCALE	DATE: 5/08/15	
DESIGNED BY:	DLM	HORIZ: 1"=200'		
DRAWN BY:	DLM	VERT: N/A	SHEET 1 OF 1	D2
CHECKED BY:	VAS			

Basin Map from the Sterling Ranch PDR



STORM SEWER ROUTING SUMMARY		
DESIGN POINT	Q_5 (cfs)	Q_{100} (cfs)
G4A	640	1584
G5	78	146
G6	32	66
G7	82	157
G8	20	42
G9	14	29
G10	47	97
G11	4	9
G12	72	144
G13	12	25
G14	7	14
G15	3	7
G16	60	125
G17	80	130
G18	29	54
G19	11	23
G20	69	138
G21	1044	1767
G22	5	10
G23	64	133
G25	1056	1795
H1	73	139
H2	46	92
H3	103	200
H4	45	86
H5	30	61
H6	68	134
H8	16	29
H11	22	45
H12	31	62
H13	57	118
H14	196	382
H16	31	65
H17	26	54
H18	224	441

BASIN SUMMARY			
BASIN	AREA (acres)	Q_5 (cfs)	Q_{100} (cfs)
OS1	110.1	68	167
OS2	17.0	45	86
OS3	28.7	73	139
OS4	5.0	5	11

Flow Summary from the Sterling Ranch PDR

EXISTING SITE DRAINAGE DISCUSSION:

On-Site (Existing Conditions):

On-site Basin H1 This basin covers approximately 10.7 acres and represents the majority of Lots 3 & 4. This basin is modeled as good condition undeveloped rangeland. This drains to the south and generates 2.6/23.7 cfs in the 5/100 year storm events.

On-site Basin H2 This existing basin covers approximately 3.70 acres and represents the eastern half of Lots 1 & 2.This basin is modeled as good condition rangeland and generates 0.9/8.2 cfs in the 5/100 year storm events.

On-site Basin H3 This existing basin covers 1.1 acres and represents the a small portion of lots 3 & 4 that drains south easterly. This basin is modeled as good condition rangeland and generates 0.3/2.7 cfs in the 5/100 year storm events. This basin sheet flows offsite where it is captured in a small swale between the site and existing roadway and conveyed westerly to the low point south of the outfall of Basin H1.

These existing basins encompass the previously unmodelled drainage area from the BS-FDR. The total historic flow from the site is 3.8/34.6 cfs in the 5/100 year storm events. The following design point table is for combined allowable discharge rates from the property at respective locations including historic flows from the tributary upstream basins:

Design Point	5/100 Release	Comments
DP H1	16.7*/30.3 cfs	DP H5 WS-FDR - * is 10year
DP H2	13.7/35.5 cfs	O3 BS-FDR
DP H3	56.7 cfs	DPH1+H1+H3 (100-year)
DP H4	14.6/43.7 cfs	DPH2 + H2

Design Point H3 will release a flow lower than previously anticipated within the BS-FDR (52.9/170 cfs). It is the introduction of development within the Sterling Ranch site that has eliminated offsite flows from BS-FDR Basin O1 that significantly changed the drainage pattern. The historic release is now contained solely to the historic flows from WS-FDR design point H5 and the proposed onsite historic flows.

Design Point H4 will combine with the western half of Lots 1&2. Per the BS-FDR the combined portions of Lots 1&2 and O3 to release a combined flow of 30.5/80.8 cfs downstream. The flow anticipated in the BS-FDR appears consistent with the smaller basin analysis of this report and should be used for downstream analysis.

PROPOSED DRAINAGE DISCUSSION

Introduction

The proposed site will be developed differently than anticipated in the previous BS-FDR. The previous plan for this site maintained the existing native drainage way down the middle of Lots 1 & 2 and 3 & 4, thereby splitting the buildable area into the outer thirds of these lots. The native drainage way and "Drainage Boundary – No Build Area" (as shown on the Plat & FDR) will be eliminated with the proposed development. The proposed site and proposed drainage improvements will allow this native drainage way to be eliminated while maintaining the pass through of major flows. These modifications to the site and to the drainage patterns will allow a larger buildable area.

The existing retention pond, located just north of Lot 3, will be modified by others to become a water quality/detention pond pursuant to the WS-FDR. A new outlet works and a storm drain pipe will convey runoff from this detention pond (16.1/29.4 cfs in the 10/100 year storm events) discharging at the property line. This development is proposing a CDOT Type D inlet to capture the discharged flow and pipe it downstream along the east side of Lots 3 & 4 to discharge into the proposed Full Spectrum Extended

Detention Basin (EDB) in Lot 4. The EDB is designed to pass through, and not treat or detain, these offsite flows.

A new EDB will be provided in Lot 4. This detention basin will provide water quality treatment for portions of Lots 1 & 2, and Lots 3 & 4. In the approved Barbarick FDR there were to be two separate ponds. The new site development has been planned for a single pond to treat the developed flows. Tributary water sheet flow across the site to shallow swales that will direct runoff to the proposed EDB. The EDB will have a forebay at the confluence of the two pipe outfalls, a concrete trickle channel that terminates at a micropool structure, and is designed to treat the WQCV, EURV and 100-year detention.

A second SFB water quality with detention catchment basin will be provided at the south east/downstream end of Lot 2. This SFB will not have an outlet structure to release flows due to requirements from the gas main utility ownership of no structure to be built within the existing easements. There will be a small spillway to allow the release of large storm events. Runoff will be directed to the proposed SFB where possible.

Flow from the area north of Lot 1 (Basin O3) will pass through the site via two 24" culverts and will be discharged at the southern boundary of Lot 2, as historically done. An earthen channel will run north-south along the east side of the existing Lot 1 and Lot 2 developments. The channel is approximately 1-ft deep with 4:1 side slopes and will capture and convey any westerly flowing nuisance runoff from the proposed improvements to the sand filter detention pond as discussed in the original Barbarick Subdivision FDR, instead of the existing Lot 1 and 2 improved areas.

Runoff from the property is at historic flows and will not exceed the anticipated runoff as determined in the Sterling Ranch PDR. This is described in more detail below. The Sterling Ranch PDR includes an analysis of future drainage conditions and includes recommended infrastructure to convey this runoff. Since the Sterling Ranch surrounds the Barbarick Subdivision, it is appropriate to include the recommendations from the SR-PDR in this Proposed Drainage Discussion.

Proposed On-Site Basin Descriptions: (See Basin Map in the pocket)

On-site Basin D1 (D for Developed condition) - This developed basin encompasses approximately 11.4 acres - the majority of Lots 3 & 4 and small portions of Lots 1 & 2. This basin generates 19.7/56.0 cfs in the 5/100 year storm events and sheet flows into shallow swales that direct the runoff into the proposed EDB to be located in Lot 4. Lot 3 is based on Owner provided information for a gravel parking/vehicle storage area, and Lot 4 has been based on proposed building site improvements as identified in the rezoning application. Any changes to the land use will require an update to the Final Drainage Report; much like the original Barbarick Subdivision Final Drainage Report is being updated with the grading and Lot 4 development application.

On-site Basin D2 This undeveloped basin encompasses 1.2 acres and represents the south portion of Lot 4, below and south of the two detention ponds. This basin is historic in nature and generates 0.8/3.0 cfs and drains directly into a road side ditch within the Sterling Ranch development.

On-site Basin D3 This developed basin encompasses approximately 3.13 acres - the remaining proposed infill portions of Lots 1 and 2 (east of the currently built out Lots 1&2). As discussed in the original Barbarick Subdivision FDR, development of these areas will require a detention water quality pond. This basin generates 4.1/11.6 cfs in the 5/100 year storm events and sheet flows southerly to the proposed SFB located at the southern-most portion of Lot 2.

The following design point table is for combined allowable discharge rates from the property at respective locations including historic flows from the tributary upstream basins:

Design Point	5/100 Year	Comments
DP D1	85.4 cfs (100)	D1+O2 Pass Through
DP D2	48.9 cfs (100)	Pond Release+D2
DP D3	4.1/11.6 cfs	D3
DP D4	13.8/39.1 cfs	Pond Release +03 Pass Through

All release flows downstream are at or below historic levels.

RECOMMENDED DESIGN

Off-site Detention Facility:

This shallow pond will be modified for the proposed development to the north as part of the WS-FDR. This will eliminate the retention properties in this pond, will provide detention for off-site flows, will provide a suitable outlet structure, and will remove accumulated sediment. The modified pond will store up to 1.52 acft (66,211 cuft) to the principal spillway (elevation = 7048.05). A summary of flows into and out of this pond:

Off-site Pond Flow Summary (cfs)	5 year	100 year
Proposed Flow into offsite pond (Basin G/DP 5)	**57.4**	**92.7**
Increase in peak flow due to development	46.2	51.3
Proposed flow out of modified pond	**16.1**	**29.4**
Reduction in peak flow	41.3	63.3

For complete pond design, refer to the WS-FDR.

Proposed 30" HDPE Storm Drain from Modified Off-site Detention Pond:

This storm drain will capture flows from the discharged offsite pond and route them along the perimeter of the property daylighting into the EDB in Lot 4. 4' precast concrete manholes will be used for maintenance access at all bends and grade breaks. A grouted riprap forebay will help dissipate energy at the outlet of the pipe, and allow for settling prior to entering the pond. See the Appendix for the hydraulic analysis of this storm drain (StormCAD).

In the event of an emergency and the offsite pond fails, developed flow (Q100=93.0 cfs) will overtop the pond and be collected between the proposed roadway and pond berm.. Flow not captured by the proposed inlet will bypass easterly to the proposed offsite swale between this property and the Sterling Ranch property and conveyed southerly.

Proposed 18" HDPE Storm Drain Culvert:

A 18" HDPE culvert will convey collected runoff from Lot 3 (Developed Q100 = 15.90cfs) through Lot 4 to the FSD Pond and join sheet flow from Lot 4 and the 30" piped bypass flow from basin O2. This culvert will be privately owned and maintained by the property owners. See the Appendix for open channel calculations.

On-site FSD - EDB Pond in Lot 4 (Basin D1):

This On-site Full Spectrum Extended Detention Basin Pond provides water quality, EURV and 100-year detention. Onsite flows will combine with the 30-inch bypass flows from the north and pass through the EDB. The pond has been sized for the release of historic flows from Basin D1, as well as provides capacity for pass through conveyance of historic flows from the north.

The following table outlines the onsite existing and developed flow, required detention, and modifications to required detention utilizing the upstream over detention.

On-site Basin Flow Summary (cfs)	5 year	100 year
Existing On-site Flow at Pond	2.2	16.5
Developed On-site Flow (Basin D1)	19.7	56.0
Increase in peak flow due to development	17.5	39.5
Proposed Pass Through Flow from Off-Site Pond	16.1*	29.4
Proposed total flow out of EDB pond	0.3	45.9**

*Includes 10 year from WS-FDR
**Includes Pass Through flow of 29.4 cfs

Water Quality Benefits:
Stormwater from Lots 3 & 4, and portions of 1 &2 will drain directly to the proposed Full Spectrum Extended Detention Pond. This pond will be privately maintained and provide water quality treatment to approximately 11.4 acres of developed land.

The proposed Water Quality facility is sized using the methods derived from the UDFCD Stormwater FSD Design Workbook (UD-FSD 1.11) (see Appendix). The Water Quality Capture Volume (WQCV) will be provided in this EDB, where the "initial flush" of storm water will be drained over a 40-hour time period.

The impervious area ratio is used in the UDFCD workbook to calculate the WQCV. An adjusted impervious ratio of 57% to correlate with the land use charts and Runoff Coefficients (provided above) is being utilized for the sizing of the facility.

The EDB Pond will have a a forebay, concrete trickle channel and micro-pool within the outlet structure (per UDFCD). This outlet structure will have a bar screen and an orifice plate containing 3 rows outlets (1.55 sq in orifices for the first two, and 3.8 sq in for the last row). The EURV has been designed to an elevation of 7021.50. The top of the inlet will have a grate to allow flows that exceed the WQCV and EURV to drain through the outlet works without overtopping the spillway, with an internal orifice plate of 2.37-ft diameter constricting flows to historic release rates ($Q100_{Onsite}$ = 16.5 cfs + $Q100_{bypass}$ = 29.4 Total Release = 45.9 cfs) .

The EDB pond can store up to 64,904 cuft (1.49 acft) to the principal spillway (7023.20). The pond bottom elevation will be at 7018.50 and the top of the embankment will be at elevation 7025.10. Should the outlet works become fully blocked; the 36' spillway will have the capacity to pass the combined 100 year peak developed runoff and northerly bypass with a flow depth = 0.90' (55.0 + 29.4 = 84.4 cfs) maintaining 1-ft of freeboard. .

Summary results include:

- WQCV Volume = 0.203 ac-ft depth 1.53-ft (40 hour release)
- EURV Volume Stored = 0.677 ac-ft at depth 2.98 ft (72 hour release)
- 5 Year Volume Stored = 0.673 ac-ft at depth 2.98 ft (72 hour release)
- 100 Year Volume Stored = 1.261 ac-ft depth 4.26-ft (77 hour release)
- Emergency Spilllway Volume at Crest = 1.49 ac-ft at depth 4.7ft.

A 30" HDPE pipe will drain this outlet structure. A Low-Tailwater basin will be provided at the outlet for energy dissipation. This storm drain will daylight into the open channel just south of Lot 4 near the entrance of an existing 12" CMP. This existing 12" CMP drains under a dirt road. This dirt road will be eliminated upon development of the Sterling Ranch. Due to the limited capacity of this existing 12" CMP, runoff in excess of 5.7 cfs will overtop this dirt road, creating tail water to 7018.0. See the Appendix for the calculation results (CulvertMaster).

On-site Sand Filter Basin w/ Detention in Lot 2 (Basin D3):

A sand filter basin detention pond is being proposed to treat runoff from the proposed gravel parking portions of Lots 1 and 2 prior to discharging from the site. Due to the high pressure gas mains within this basin, grading is limited to fill only and no structures are allowed within the gas easement, so this pond will have underdrain design with partial infiltration and a controlled overflow design for the 100-year event.

The following table outlines the onsite existing and developed flow, required detention, and modifications to required detention utilizing the upstream over detention.

On-site Basin Flow Summary (cfs)	5 year	100 year
Existing On-site Flow at Pond	0.5	4.2
Developed On-site Flow (Basin D3)	4.1	11.6
Increase in peak flow due to development	3.6	7.4
Proposed total flow out of Sand Filter pond	0.1	3.6

Water Quality Benefits:
Stormwater from portions of 1 &2 will drain directly to the proposed Sand Filter Pond. This pond will be privately maintained and provide water quality treatment to approximately 3.13 acres of developed land.

The proposed Water Quality facility is sized using the methods derived from the UDFCD Stormwater Detention Design Workbook (UD-Detention 3.04) (see Appendix). The Water Quality Capture Volume (WQCV) will be provided in this SFB, where the "initial flush" of storm water will be drained over a 12-hour time period.

The impervious area ratio is used in the UDFCD workbook to calculate the WQCV. An adjusted impervious ratio of 57% to correlate with the land use charts and Runoff Coefficients (provided above) is being utilized for the sizing of the facility.

The sand filter will contain a 4" underdrain beneath 18" of CDOT Class C material. The underdrain will contain a 1.27" diameter orifice to control the outflow time in accordance with UDFCD.

The SFB pond can store up to 16,247 cu ft (0.373 acft) to the principal spillway (7025.50). The pond bottom elevation will be at 7023.00 and the top of the embankment will be at elevation 7027.37. Because the spillway acts as the 100-year control structure and notched weir design is proposed. The spillway is 5-ft wide for a depth of 10-inches for the release of the 100-year flow (3.6 cfs which is less than the 4.2 historic) then the spillway widens to 10ft for a depth of 18-inches which will have the capacity to pass the combined 100 year peak developed runoff (11.6cfs) with a flow depth = 0.5' maintaining 1-ft of freeboard.

Summary results include:

- WQCV Volume =0.039 ac-ft depth 0.37-ft (12 hour release)
- EURV Volume Stored = 0.181 ac-ft at depth 1.52 ft (42 hour release)
- 5 Year Volume Stored = 0.181 ac-ft at depth 1.52 ft (42 hour release)
- 100 Year Volume Stored = 0.394 ac-ft depth 2.83-ft (68 hour release)

Proposed (2) 24" HDPE Storm Drain Culvert:

Two 24" pipes will convey offsite flows through Lots 1 and 2 discharging to the south. The culverts will connect to a pair of existing 24" culverts entering the property and will discharge to a riprap settling basing prior to the released downstream. These culverts will be privately owned and maintained by the property owners. See the Appendix for the hydraulic analysis of this storm drain (CulvertMaster). Flow from these pipes will join the flow from the Sand Filter and discharge at Design Point 4 (combined 39.4 cfs in the 100-year event). Per the BS-FDR this flow combines with the westerly portions of Lots 1 & 2 offsite for a total release of 30.5/80.8 cfs in the 5/100 year events.

As stated above in the summary from the Sterling Ranch PDR, the anticipated runoff from this proposed discharge point (aka: SR-PDR Basin H4) is 30.5/80.8 cfs (5/100 year) due to the large pass through flow. A 42" RCP is planned to convey this flow through Sterling Ranch.

DRAINAGE, BRIDGE, AND POND FEES

This subdivision has already been platted. No additional Drainage, Bridge or Pond fees are required.

MAINTENANCE

All proposed storm drain infrastructure will be located within private property and will be owned and maintained by the property owner. The detention pond will be owned and maintained by the property owner and will require maintenance consisting of routine inspections, removal of debris from the detention area, and bi-annual inspections for hydraulic performance of the basin. Refer to the DCM for exact maintenance criteria and for other Best Management Practices (BMP).

EROSION CONTROL

Best Management Practices (BMPs) will be utilized to minimize erosion during construction and will be shown on the construction drawings. These will be in accordance with will be utilized as deemed necessary by the contractor and/or engineer. The contractor shall minimize the amount of area disturbed during all construction activities.

In general, the following shall be applied in developing the sequence of major activities;

1. Install down slope and side slope perimeter BMPs before the land disturbing activity occurs.
2. Do not disturb area until it is necessary for the construction activity to proceed.
3. Cover or stabilize exposed areas as soon as possible.
4. Time the construction activities to reduce the impacts from seasonal climatic changes or weather events.
5. The construction of permanent filtration BMPs should wait until the end of the construction project when drainage areas have been stabilized.
6. Do not remove the temporary erosion controls until after all areas are stabilized.

Slopes

Erosion control soil retention blankets shall be installed where noted on slopes 3:1 or steeper. At a minimum, coconut/straw blend fiber material blankets should be used. The silt fence or erosion logs shall be installed at the toe of fill slopes where noted on a level contour. Erosion logs shall also be installed on slopes greater than ten feet in height where noted to reduce runoff length. The erosion logs shall be installed on a level contour. Disturbed surfaces shall be left in a roughened condition at all times when horizontal depressions approximately 2" to 4" deep, spaced 4" to 6" apart. Silt fence and erosion logs shall remain in place until all construction is complete and/or "finally stabilized", after which the silt fence and erosion logs shall be removed from the slopes. All material shall be installed per manufacturer's installation instructions.

Stockpiles/Mobilization/Winter Shutdown

Soils stockpiled for more than 30 days shall be mulched with mulch tackifier and native seeding within 14 days of stockpile construction. After mobilization and prior to winter shutdown, all disturbed slopes not completed shall be mulched with mulch tackifier and native seeding.

Inlet and Outlet Protection

Storm Drain Inlet Protection shall be provided at all storm inlets. Outlet protection shall be provided at all pipe outlet and runoff / rundown treatment locations. All materials shall be installed per manufacturer's installation instructions.

Concrete Washout

Concrete washout structures shall be installed for cleaning concrete trucks. The concrete washout structure shall be constructed such that water can only evaporate or infiltrate from the structure . Residue and concrete from the washout structure shall be periodically cleaned out and properly disposed.

Erosion Control Supervisor and Maintenance

The erosion control supervisor shall be a person other than the superintendent. The erosion control supervisor shall inspect at least every 14 days and after any precipitation or snowmelt event that causes surface erosion. At sites where construction has been completed but a vegetative cover has not been established, these inspections must occur at least once per month.

All erosion control measures shall remain in place until all construction is complete and final stabilization has been achieved. "Final stabilization" is where all disturbed areas have been built on, paved, or germinated with a uniform vegetative cover with a density of at least 70% of pre-disturbance levels. Equivalent permanent, physical erosion reduction methods may also be employed. Any areas not meeting this standard shall be repaired according to the BMP guidelines. Accumulated sediment and debris shall be removed when the sediment level reaches one half the height of the BMP or when the sediment/debris adversely impacts the functionality of the BMP. The Contractor shall remove all sediment, mud, and construction debris that may accumulate in public right of ways not designated before-hand as a result of this construction project. All repairs, removals, and replacements stated above shall be conducted in a timely manner.

Cost Estimate

The proposed drainage system to be constructed will be privately owned and maintained. The developer will be responsible for constructing the proposed improvements.

An engineer's estimate of probable construction costs has been provided for the proposed improvements. The storm sewer systems will be located in the Sand Creek Drainage Basin. The construction cost for the improvements are not eligible for reimbursement.

Engineer's Estimate of Probable Construction Costs
Tri-Lakes Construction - Sand Creek Drainage Basin
Non-Reimbursable Private Improvements

Item	Unit	Quantity	Unit Cost	Total Cost
Precast Manhole	EA	4	$2,500	$10,000
18" HDPE Pipe	LF	231	$45	$10,395
24" HDPE Pipe	LF	1212	$60	$72,720
30" HDPE Pipe	LF	1128	$72	$81,216
18" Flared End	EA	2	$225	$450
24" Flared End	EA	2	$250	$500
24" CMP-HDPE	EA	2	$200	$400
30" Flared End	EA	1	$350	$350
CDOT Type D Inlet	EA	1	$4,000	$4,000
EDB Pond Outlet	EA	1	$35,000	$35,000
			SubTotal	$215,031.00
			15% Contingency	$32,254.65
			Total Estimate	**$247,285.65**

REFERENCES

1. ***City of Colorado Springs & El Paso County Drainage Criteria Manual, Volumes I and II***, dated May 2014 including subsequent updates

2. ***City of Colorado Springs & El Paso County Drainage Criteria Manual, Volumes I and II***, dated November 1991 including subsequent updates

3. **Appendix I of the El Paso County's Engineering Criteria Manual** (ECM), 2008).

4. ***Urban Storm Drainage Criteria Manuals, Volumes 1-3***, published by the Urban Drainage and Flood Control District, (Volumes 1 & 2 dated 2016, Volume 3 dated 2015)

5. ***Preliminary Drainage Report for Sterling Ranch-Phase 1, Sand Creek Drainage Basin***, M & S Civil Consultants, Inc., May 2015

6. ***Woodmen Storage Final Drainage Report, El Paso County,*** Calibre Engineering, Inc., July 2004; Revised February, 2010; Revised May, 2010; Revised July, 2010

7. ***Preliminary and Final Drainage Plan and Report for Barbarick Subdivision, El Paso County***, Oliver E. Watts Consulting Engineer Inc., January 2005; Revised October 2005; Revised December 2006; Revised May 2007; Revised August 15, 2007

8. ***NOAA Atlas 14, Volume 8 Version 2*** U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Hydrometeorological Design Studies Center.

9. FEMA Map Service Center: http://msc.fema.gov

10. NRCS Web Soil Survey. http://websoilsurvey.nrcs.usda.gov

APPENDIX A

HYDROLOGIC AND HYDRAULIC CALCULATIONS

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Barbarick Subdivision
Catchment ID: H-1 5 Year

I. Catchment Hydrologic Data

Catchment ID = H1
Area = 10.70 Acres
Percent Imperviousness = 2.00 %
NRCS Soil Type = B A, B, C, or D

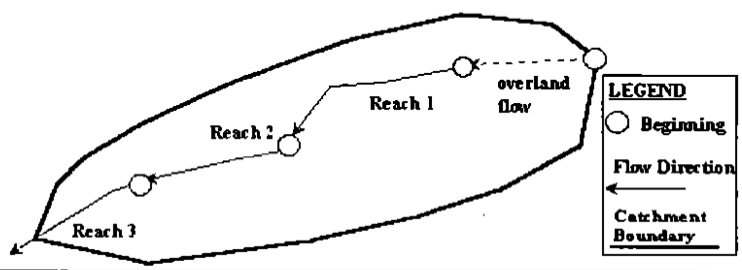
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 5 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 1.23 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.08
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.08
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0300	300	0.08	N/A	0.23	22.16
1	0.0300	338		10.00	1.73	3.25
2						
3						
4						
5						
Sum		638			Computed Tc =	25.42
					Regional Tc =	13.54
					User-Entered Tc =	13.54

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I = 2.12 inch/hr — Peak Flowrate, Qp = 1.85 cfs
Rainfall Intensity at Regional Tc, I = 2.93 inch/hr — Peak Flowrate, Qp = 2.56 cfs
Rainfall Intensity at User-Defined Tc, I = 2.93 inch/hr — Peak Flowrate, Qp = 2.56 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Barbarick Subdivision
Catchment ID: H-1 100 Year

I. Catchment Hydrologic Data

Catchment ID = H1
Area = 10.70 Acres
Percent Imperviousness = 2.00 %
NRCS Soil Type = B A, B, C, or D

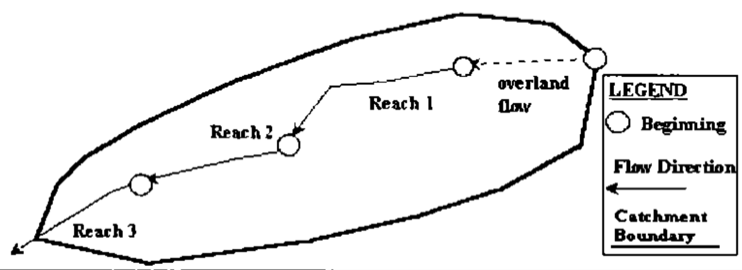
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr =	100	years	(input return period for design storm)
C1 =	28.50		(input the value of C1)
C2=	10.00		(input the value of C2)
C3=	0.786		(input the value of C3)
P1=	2.57	inches	(input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.36
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.08
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0300	300	0.08	N/A	0.23	22.16
1	0.0300	338		10.00	1.73	3.25
2						
3						
4						
5						
Sum		638			Computed Tc =	25.42
					Regional Tc =	13.54
					User-Entered Tc =	13.54

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I =	4.44 inch/hr	Peak Flowrate, Qp =	17.20 cfs
Rainfall Intensity at Regional Tc, I =	6.12 inch/hr	Peak Flowrate, Qp =	23.71 cfs
Rainfall Intensity at User-Defined Tc, I =	6.12 inch/hr	Peak Flowrate, Qp =	23.71 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Barbarick Subdivision
Catchment ID: H-2 5 Year

I. Catchment Hydrologic Data

Catchment ID = H2
Area = 3.70 Acres
Percent Imperviousness = 2.00 %
NRCS Soil Type = B A, B, C, or D

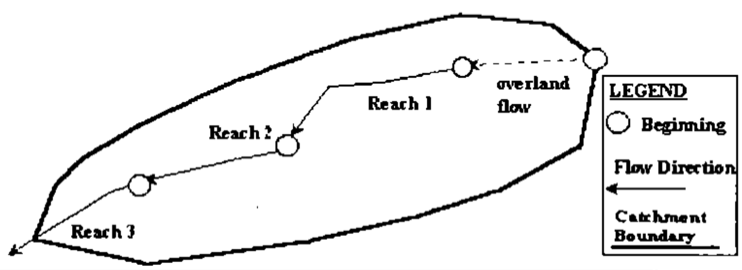
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 5 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 1.23 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.08
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.08
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0380	155	0.08	N/A	0.18	14.74
1	0.0350	515		10.00	1.87	4.59
2						
3						
4						
5						
	Sum	670			Computed Tc =	19.32
					Regional Tc =	13.72
					User-Entered Tc =	13.72

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I = 2.46 inch/hr — Peak Flowrate, Qp = 0.74 cfs
Rainfall Intensity at Regional Tc, I = 2.91 inch/hr — Peak Flowrate, Qp = 0.88 cfs
Rainfall Intensity at User-Defined Tc, I = 2.91 inch/hr — Peak Flowrate, Qp = 0.88 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: **Barbarick Subdivision**
Catchment ID: **H-2 100 Year**

I. Catchment Hydrologic Data

Catchment ID = H2
Area = 3.70 Acres
Percent Imperviousness = 2.00 %
NRCS Soil Type = B A, B, C, or D

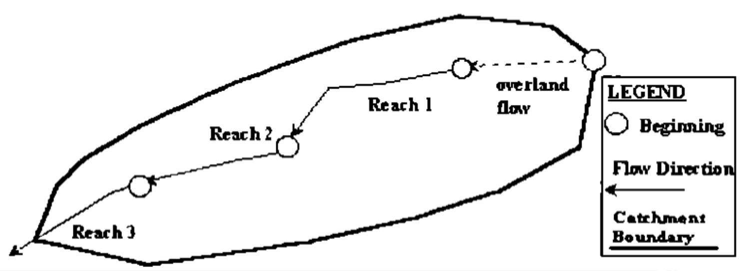
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.36
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.08
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0380	155	0.08	N/A	0.18	14.74
1	0.0350	515		10.00	1.87	4.59
2						
3						
4						
5						
	Sum	670			Computed Tc =	19.32
					Regional Tc =	13.72
					User-Entered Tc =	13.72

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I = 5.15 inch/hr — Peak Flowrate, Qp = 6.90 cfs
Rainfall Intensity at Regional Tc, I = 6.08 inch/hr — Peak Flowrate, Qp = 8.15 cfs
Rainfall Intensity at User-Defined Tc, I = 6.08 inch/hr — Peak Flowrate, Qp = 8.15 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: **Barbarick Subdivision**
Catchment ID: **H-3 5 year**

I. Catchment Hydrologic Data

Catchment ID = H3
Area = 1.11 Acres
Percent Imperviousness = 2.00 %
NRCS Soil Type = B A, B, C, or D

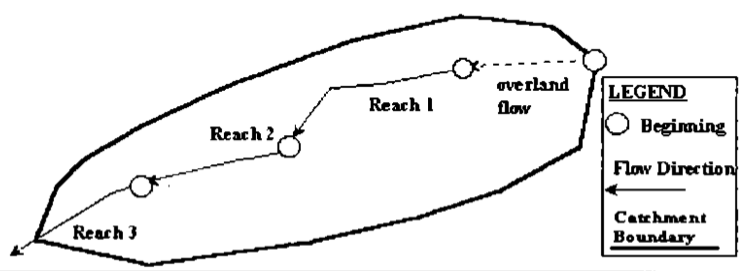
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr =	5 years	(input return period for design storm)
C1 =	28.50	(input the value of C1)
C2=	10.00	(input the value of C2)
C3=	0.786	(input the value of C3)
P1=	1.23 inches	(input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.08
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.08
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0250	338	0.08	N/A	0.23	24.98
1						
2						
3						
4						
5						
Sum		338				

Computed Tc =	24.98
Regional Tc =	11.88
User-Entered Tc =	11.88

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I =	2.14 inch/hr	Peak Flowrate, Qp =	0.19 cfs
Rainfall Intensity at Regional Tc, I =	3.10 inch/hr	Peak Flowrate, Qp =	0.28 cfs
Rainfall Intensity at User-Defined Tc, I =	3.10 inch/hr	Peak Flowrate, Qp =	0.28 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: **Barbarick Subdivision**
Catchment ID: **H-3 100 year**

I. Catchment Hydrologic Data

Catchment ID = H3
Area = 1.11 Acres
Percent Imperviousness = 2.00 %
NRCS Soil Type = B A, B, C, or D

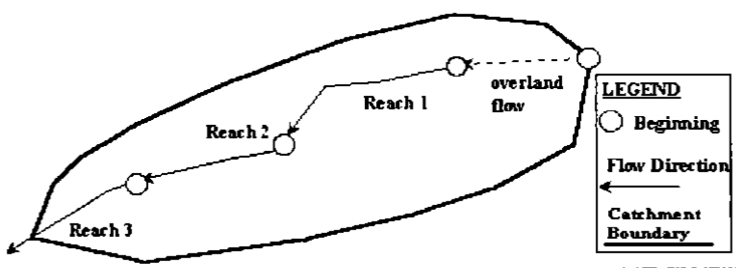
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.67 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.36
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.08
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Conveyance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0250	338	0.08	N/A	0.23	24.98
1						
2						
3						
4						
5						
Sum		338				

Computed Tc = 24.98
Regional Tc = 11.88
User-Entered Tc = 11.88

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I = 4.65 inch/hr		Peak Flowrate, Qp = 1.87 cfs
Rainfall Intensity at Regional Tc, I = 6.73 inch/hr		Peak Flowrate, Qp = 2.71 cfs
Rainfall Intensity at User-Defined Tc, I = 6.73 inch/hr		Peak Flowrate, Qp = 2.71 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: **Barbarick Subdivision**
Catchment ID: **D-2 5 Year**

I. Catchment Hydrologic Data

Catchment ID = D2
Area = 1.20 Acres
Percent Imperviousness = 2.00 %
NRCS Soil Type = B A, B, C, or D

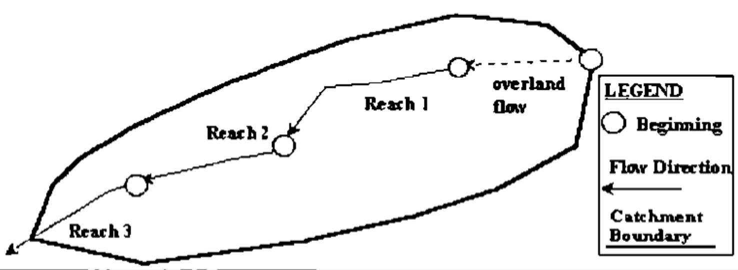
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 5 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 1.23 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.08
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.08
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0200	155	0.08	N/A	0.14	18.21
1						
2						
3						
4						
5						
Sum		155			Computed Tc =	18.21
					Regional Tc =	10.86
					User-Entered Tc =	10.86

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I = 2.54 inch/hr   Peak Flowrate, Qp = 0.25 cfs
Rainfall Intensity at Regional Tc, I = 3.22 inch/hr   Peak Flowrate, Qp = 0.32 cfs
Rainfall Intensity at User-Defined Tc, I = 3.22 inch/hr   Peak Flowrate, Qp = 0.32 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Barbarick Subdivision
Catchment ID: D2 - 100yr

I. Catchment Hydrologic Data

Catchment ID = D2
Area = 1.20 Acres
Percent Imperviousness = 2.00 %
NRCS Soil Type = B A, B, C, or D

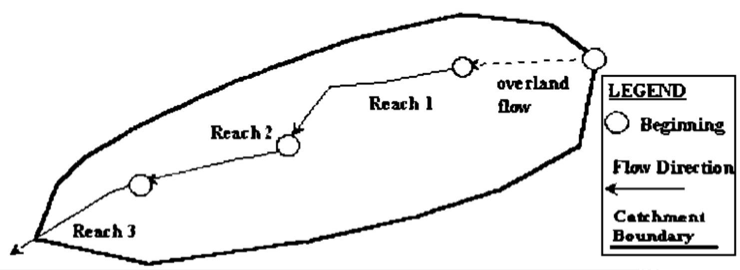
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr =	100 years	(input return period for design storm)
C1 =	28.50	(input the value of C1)
C2=	10.00	(input the value of C2)
C3=	0.786	(input the value of C3)
P1=	2.57 inches	(input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.36
Overide Runoff Coefficient, C = ____ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.08
Overide 5-yr. Runoff Coefficient, C = ____ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0200	85	0.08	N/A	0.11	13.49
1						
2						
3						
4						
5						
Sum		85				

Computed Tc = 13.49
Regional Tc = 10.47
User-Entered Tc = 10.47

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I =	6.13 inch/hr	Peak Flowrate, Qp =	2.66 cfs
Rainfall Intensity at Regional Tc, I =	6.83 inch/hr	Peak Flowrate, Qp =	2.97 cfs
Rainfall Intensity at User-Defined Tc, I =	6.83 inch/hr	Peak Flowrate, Qp =	2.97 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: **Barbarick Subdivision**
Catchment ID: **Lot3-Culvert 100yr**

I. Catchment Hydrologic Data

Catchment ID = Lot 3
Area = 4.86 Acres
Percent Imperviousness = 57.00 %
NRCS Soil Type = B A, B, C, or D

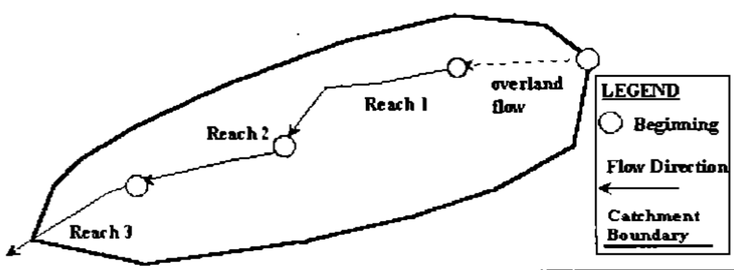
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.55
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.39
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0300	300	0.39	N/A	0.32	15.41
1	0.0100	500		10.00	1.00	8.33
2						
3						
4						
5						
	Sum	800				

Computed Tc = 23.74
Regional Tc = 14.44
User-Entered Tc = 14.44

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I = 4.61 inch/hr — Peak Flowrate, Qp = 12.34 cfs
Rainfall Intensity at Regional Tc, I = 5.94 inch/hr — Peak Flowrate, Qp = 15.90 cfs
Rainfall Intensity at User-Defined Tc, I = 5.94 inch/hr — Peak Flowrate, Qp = 15.90 cfs

Matrix DESIGN GROUP

Final Design for Full Spectrum Detention Basins

Project: Barbarick Subdivision

Basin ID: Lot 3 FSD Pond

See Outlet Structure Figure on Initial Design Worksheet

User Input: Watershed Parameters

Watershed Area =	11 40	acres
Watershed Length =	668	ft
Watershed Slope =	0.020	ft/ft
Watershed Imperviousness =	57.0%	percent
Percentage Hydrologic Soil Group A =	5%	percent
Percentage Hydrologic Soil Group B =	95%	percent
Percentage Hydrologic Soil Groups C/D =	0%	percent
Location for 1-hr Rainfall Depths =	User Input	

User Input: Detention Basin Parameters

Depth of Initial Surcharge Volume =	0.33	ft
Depth of Trickle Channel =	0.50	ft
Trickle Channel Slope =	0 005	ft/ft
Available EURV Ponding Depth =	3 00	ft (2.99 ft recommended)
Desired WQCV Drain Time =	40	hours

User Input: Outlet Structure Parameters

Overflow Weir Front Edge Height, H_o =	3.3	ft (relative to lowest WQ orifice)
Overflow Weir Front Edge Length =	6.0	ft
Overflow Weir Slope =	0	H:V (enter zero for flat grate)
Horizontal Length of the Overflow Weir Sides =	3.5	ft
Overflow Grate Open Area % =	70%	%, grate open area / total area
Debris Clogging % =	50%	%

Calculated Outlet Discharge Parameters

Height of Grate Upper Edge H_t =	3.3	ft
Over Flow Weir Slope Length =	3 5	ft
Grate Open Area /100-yr Orifice Area =	9.3	should be ≥ 4
Overflow Grate Area w/o Debris =	14 7	ft^2

User Input: Water Quality Orifices (numbered from lowest to highest)

	Row 1	Row 2	Row 3	Row 4	Row 5
Area (sq inch)	1.55	1 55	3 80		
Stage (ft)	0.00	1 00	2 00		

	Row 6	Row 7	Row 8	Row 9	Row 10
Area (sq inch)					
Stage (ft)					

User Input: 100-Year Orifice Parameters

100-yr Restrictor Plate Type =	Circular Orifice	
100-Year Orifice Invert Depth =	1.2	ft (below the lowest WQ orifice)
100-Year Orifice Diameter =	17.0	in

Calculated 100-yr Orifice Parameters

100-Year Orifice Area =	1.6	ft^2
100-Year Orifice Centroid =	0.71	ft
Half-Central Angle of Plate on Pipe =		radians

User Input: Emergency Spillway Parameters

Spillway Invert Stage=	4.7	ft (relative to lowest WQ orifice)
Spillway Crest Length =	23	ft
Spillway End Slopes =	4.0	H:V
Freeboard above Spillway =	1.0	ft

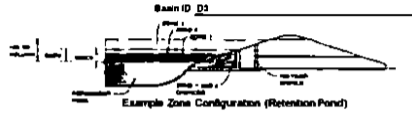
Calculated Spillway Parameters

Spillway Design Flow Depth=	0 8	ft
Stage at Top of Freeboard =	6 5	ft
Basin Area at Top of Freeboard =	0.63	acres

User Defined Stage (ft)	User Defined Area (ft^2)	User Defined Volume (ac-ft)
0.00	1,250	0 00
0 50	4,076	0 03
1.50	10,413	0.19
2.50	15,584	0 49
3 00	17,528	0 68
3.50	19,472	0 89
4 50	23,488	1.38
4.70	24,472	1 49
5.50	27,426	1.97
6.50	31,603	2 64

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

Project: Barbarick 1-4
Basin ID: D3



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	SF			
Watershed Area =	3.13	acres		
Watershed Length =	648	ft		
Watershed Slope =	0.030	ft/ft		
Watershed Imperviousness =	57.00%	percent		
Percentage Hydrologic Soil Group A =	5.0%	percent		
Percentage Hydrologic Soil Group B =	95.0%	percent		
Percentage Hydrologic Soil Groups C/D =	0.0%	percent		
Desired WQCV Drain Time =	12.0	hours		
Location for 1-hr Rainfall Depths =	User Input			
Water Quality Capture Volume (WQCV) =	0.047	acre-feet	Optional User Input 1-hr Precipitation	
Excess Urban Runoff Volume (EURV) =	0.194	acre-feet		
2-yr Runoff Volume (P1 = 0.95 in.) =	0.128	acre-feet	0.95	inches
5-yr Runoff Volume (P1 = 1.23 in.) =	0.194	acre-feet	1.23	inches
10-yr Runoff Volume (P1 = 1.48 in.) =	0.253	acre-feet	1.48	inches
25-yr Runoff Volume (P1 = 1.88 in.) =	0.363	acre-feet	1.88	inches
50-yr Runoff Volume (P1 = 2.21 in.) =	0.452	acre-feet	2.21	inches
100-yr Runoff Volume (P1 = 2.57 in.) =	0.554	acre-feet	2.57	inches
500-yr Runoff Volume (P1 = 0 in.) =	0.000	acre-feet		inches
Approximate 2-yr Detention Volume =	0.122	acre-feet		
Approximate 5-yr Detention Volume =	0.179	acre-feet		
Approximate 10-yr Detention Volume =	0.204	acre-feet		
Approximate 25-yr Detention Volume =	0.237	acre-feet		
Approximate 50-yr Detention Volume =	0.273	acre-feet		
Approximate 100-yr Detention Volume =	0.336	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.047	acre-feet
Zone 2 Volume (100-year - Zone 1) =	0.289	acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =	0.336	acre-feet
Initial Surcharge Volume (ISV) =	N/A	ft^3
Initial Surcharge Depth (ISD) =	N/A	ft
Total Available Detention Depth (H_{total}) =	2.50	ft
Depth of Trickle Channel (H_{TC}) =	N/A	ft
Slope of Trickle Channel (S_{TC}) =	N/A	ft/ft
Slopes of Main Basin Sides (S_{main}) =	4	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	1.5	
Initial Surcharge Area (A_{ISV}) =	0	ft^2
Surcharge Volume Length (L_{ISV}) =	0.0	ft
Surcharge Volume Width (W_{ISV}) =	0.0	ft
Depth of Basin Floor (H_{FLOOR}) =	0.00	ft
Length of Basin Floor (L_{FLOOR}) =	81.0	ft
Width of Basin Floor (W_{FLOOR}) =	54.0	ft
Area of Basin Floor (A_{FLOOR}) =	4,370	ft^2
Volume of Basin Floor (V_{FLOOR}) =	0	ft^3
Depth of Main Basin (H_{MAIN}) =	2.50	ft
Length of Main Basin (L_{MAIN}) =	101.0	ft
Width of Main Basin (W_{MAIN}) =	74.0	ft
Area of Main Basin (A_{MAIN}) =	7,469	ft^2
Volume of Main Basin (V_{MAIN}) =	14,626	ft^3
Calculated Total Basin Volume (V_{total}) =	0.336	acre-feet

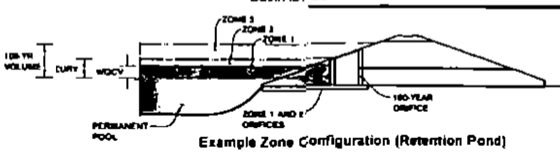
Depth Increment = 0.1 ft

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)
Media Surface	0.00		81.0	54.0	4,370		0.100		
	0.10		81.8	54.8	4,478		0.103	442	0.010
	0.20		82.5	55.5	4,577		0.105	850	0.020
	0.30		83.3	56.3	4,688		0.108	1,313	0.030
	0.40		84.1	57.1	4,801		0.110	1,788	0.041
Zone 1 (WQCV)	0.45		84.6	57.6	4,869		0.112	2,078	0.048
	0.50		84.9	57.9	4,914		0.113	2,273	0.052
	0.60		85.7	58.7	5,029		0.115	2,770	0.064
	0.70		86.5	59.5	5,145		0.118	3,279	0.075
	0.80		87.3	60.3	5,263		0.121	3,800	0.087
	0.90		88.1	61.1	5,381		0.124	4,332	0.099
	1.00		88.9	61.9	5,501		0.126	4,876	0.112
	1.10		89.7	62.7	5,627		0.129	5,437	0.125
	1.20		90.5	63.5	5,745		0.132	6,000	0.138
	1.30		91.3	64.3	5,869		0.135	6,581	0.151
	1.40		92.1	65.1	5,994		0.138	7,174	0.165
	1.50		92.9	65.9	6,120		0.141	7,780	0.179
	1.60		93.7	66.7	6,248		0.143	8,398	0.193
	1.70		94.5	67.5	6,377		0.146	9,030	0.207
	1.80		95.3	68.3	6,507		0.149	9,674	0.222
	1.90		96.1	69.1	6,639		0.152	10,331	0.237
	2.00		96.9	69.9	6,771		0.155	11,001	0.253
	2.10		97.8	70.8	6,919		0.159	11,754	0.270
	2.20		98.6	71.6	7,054		0.162	12,453	0.286
	2.30		99.4	72.4	7,191		0.165	13,165	0.302
	2.40		100.2	73.2	7,329		0.168	13,891	0.319
Zone 2 (100-year)	2.50		101.0	74.0	7,469		0.171	14,631	0.336
	2.60		101.8	74.8	7,609		0.175	15,385	0.353
	2.70		102.6	75.6	7,751		0.178	16,153	0.371
	2.80		103.4	76.4	7,894		0.181	16,935	0.389
	2.90		104.2	77.2	8,039		0.185	17,732	0.407
	3.00		105.0	78.0	8,184		0.188	18,543	0.426
	3.10		105.8	78.8	8,331		0.191	19,369	0.445
	3.20		106.6	79.6	8,480		0.195	20,209	0.464
	3.30		107.4	80.4	8,629		0.198	21,065	0.484
	3.40		108.2	81.2	8,780		0.202	21,935	0.504
	3.50		109.0	82.0	8,932		0.205	22,821	0.524
	3.60		109.8	82.6	9,085		0.209	23,722	0.545
	3.70		110.6	83.6	9,240		0.212	24,638	0.566
	3.80		111.4	84.4	9,396		0.216	25,570	0.587
	3.90		112.2	85.2	9,553		0.219	26,517	0.609
	4.00		113.0	86.0	9,712		0.223	27,480	0.631
	4.10		113.8	86.8	9,872		0.227	28,460	0.653
	4.20		114.6	87.6	10,033		0.230	29,455	0.676
	4.30		115.4	88.4	10,195		0.234	30,466	0.699
	4.40		116.2	89.7	10,359		0.238	31,494	0.723
	4.50		117.0	90.0	10,523		0.242	32,538	0.747
	4.60		117.8	90.8	10,690		0.245	33,599	0.771
	4.70		118.6	91.6	10,857		0.249	34,676	0.796
	4.80		119.4	92.4	11,026		0.253	35,770	0.821
	4.90		120.2	93.2	11,196		0.257	36,881	0.847
	5.00		121.0	94.0	11,367		0.261	38,009	0.873
	5.10		121.8	94.6	11,540		0.265	39,155	0.899
	5.20		122.6	95.6	11,714		0.269	40,317	0.926
	5.30		123.4	96.4	11,889		0.273	41,497	0.953
	5.40		124.2	97.2	12,066		0.277	42,695	0.980
	5.50		125.0	98.0	12,243		0.281	43,911	1.008
	5.60		125.8	98.8	12,422		0.285	45,144	1.036
	5.70		126.6	99.6	12,602		0.289	46,395	1.065
	5.80		127.4	100.4	12,784		0.293	47,664	1.094
	5.90		128.2	101.2	12,967		0.298	48,952	1.124
	6.00		129.0	102.0	13,151		0.302	50,258	1.154
	6.10		129.8	102.8	13,336		0.306	51,582	1.184
	6.20		130.6	103.6	13,523		0.310	52,925	1.215
	6.30		131.4	104.4	13,711		0.315	54,287	1.246
	6.40		132.2	105.2	13,900		0.319	55,667	1.278
	6.50		133.0	106.0	14,090		0.323	57,067	1.310
	6.60		133.8	106.8	14,282		0.328	58,485	1.343
	6.70		134.6	107.6	14,475		0.332	59,923	1.376
	6.80		135.4	108.4	14,670		0.337	61,380	1.409
	6.90		136.2	109.2	14,865		0.341	62,857	1.443
	7.00		137.0	110.0	15,062		0.346	64,353	1.477
	7.10		137.8	110.8	15,260		0.350	65,870	1.512
	7.20		138.6	111.6	15,460		0.355	67,406	1.547
	7.30		139.4	112.4	15,661		0.360	68,962	1.583
	7.40		140.2	113.2	15,863		0.364	70,538	1.619
	7.50		141.0	114.0	16,066		0.369	72,134	1.656
	7.60		141.8	114.8	16,271		0.374	73,751	1.693
	7.70		142.6	115.6	16,476		0.378	75,388	1.731
	7.80		143.4	116.4	16,684		0.383	77,046	1.769
	7.90		144.2	117.2	16,892		0.388	78,725	1.807
	8.00		145.0	118.0	17,102		0.393	80,425	1.846
	8.10		145.8	118.8	17,313		0.397	82,145	1.886
	8.20		146.6	119.6	17,525		0.402	83,887	1.926
	8.30		147.4	120.4	17,738		0.407	85,650	1.966
	8.40		148.2	121.2	17,953		0.412	87,435	2.007
	8.50		149.0	122.0	18,169		0.417	89,241	2.049
	8.60		149.8	122.8	18,387		0.422	91,069	2.091
	8.70		150.6	123.6	18,605		0.427	92,919	2.133
	8.80		151.4	124.4	18,825		0.432	94,790	2.176
	8.90		152.2	125.2	19,047		0.437	96,684	2.220
	9.00		153.0	126.0	19,269		0.442	98,560	2.264
	9.10		153.8	126.8	19,493		0.447	100,538	2.308
	9.20		154.6	127.6	19,718		0.453	102,498	2.353
	9.30		155.4	128.4	19,944		0.458	104,481	2.399
	9.40		156.2	129.2	20,172		0.463	106,487	2.445
	9.50		157.0	130.0	20,401		0.468	108,516	2.491
	9.60		157.8	130.8	20,631		0.474	110,567	2.538
	9.70		158.6	131.6	20,863		0.479	112,642	2.586

Detention Basin Outlet Structure Design

Project: Barbarick Subdivision

Basin ID: D3



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	0.45	0.047	Filtration Media
Zone 2 (100-year)	2.50	0.289	Not Utilized
Zone 3			
		0.336	Total

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

Underdrain Orifice Invert Depth =	1.00	ft (distance below the filtration media surface)
Underdrain Orifice Diameter =	1.27	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	0.0	ft^2
Underdrain Orifice Centroid =	0.05	feet

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

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

Calculated Parameters for Plate

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

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

	Row 1 (optional)	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)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Orifice Area (sq. inches)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	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)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Orifice Area (sq. inches)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

User Input: Vertical Orifice (Circular or Rectangular)

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

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =			ft^2
Vertical Orifice Centroid =			feet

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Not Selected	Not Selected	
Overflow Weir Front Edge Height, Ho =			ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =			feet
Overflow Weir Slope =			H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =			feet
Overflow Grate Open Area % =			%, grate open area/total area
Debris Clogging % =			%

Calculated Parameters for Overflow Weir

	Not Selected	Not Selected	
Height of Grate Upper Edge, H_t =			feet
Over Flow Weir Slope Length =			feet
Grate Open Area / 100-yr Orifice Area =			should be ≥ 4
Overflow Grate Open Area w/o Debris =			ft^2
Overflow Grate Open Area w/ Debris =			ft^2

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

	Not Selected	Not Selected	
Depth to Invert of Outlet Pipe =			ft (distance below basin bottom at Stage = 0 ft)
Circular Orifice Diameter =			inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

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

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	2.50	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	5.00	feet
Spillway End Slopes =	4.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

Spillway Design Flow Depth=	0.66	feet
Stage at Top of Freeboard =	4.16	feet
Basin Area at Top of Freeboard =	0.23	acres

Routed Hydrograph Results

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) =	0.53	1.07	0.95	1.23	1.48	1.88	2.21	2.57	0.00
Calculated Runoff Volume (acre-ft) =	0.047	0.194	0.128	0.194	0.253	0.363	0.452	0.554	0.000
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.047	0.194	0.127	0.194	0.253	0.363	0.451	0.553	#N/A
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.17	0.34	0.80	1.04	1.33	1.89
Predevelopment Peak Q (cfs) =	0.0	0.0	0.0	0.5	1.1	2.5	3.2	4.2	5.9
Peak Inflow Q (cfs) =	1.0	4.1	2.7	4.1	5.3	7.6	9.4	11.6	#N/A
Peak Outflow Q (cfs) =	0.0	0.1	0.1	0.1	0.1	0.2	1.7	3.6	#N/A
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.1	0.1	0.1	0.5	0.9	#N/A
Structure Controlling Flow =	Filtration Media	Filtration Media	Filtration Media	Filtration Media	Filtration Media	Spillway	Spillway	Spillway	#N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	#N/A
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) =	12	41	29	41	51	66	65	65	#N/A
Time to Drain 99% of Inflow Volume (hours) =	13	42	30	42	52	68	68	68	#N/A
Maximum Ponding Depth (ft) =	0.37	1.52	1.04	1.52	1.91	2.55	2.71	2.83	#N/A
Area at Maximum Ponding Depth (acres) =	0.11	0.14	0.13	0.14	0.15	0.17	0.18	0.18	#N/A
Maximum Volume Stored (acre-ft) =	0.039	0.181	0.117	0.181	0.240	0.343	0.371	0.394	#N/A

APPENDIX B

STORMCAD INFORMATION

Culvert Calculator Report
Twin 24" Culvert

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	2.00 ft	Headwater Depth/Height	1.32
Computed Headwater Elev:	7,038.15 ft	Discharge	35.50 cfs
Inlet Control HW Elev.	7,038.10 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	7,038.15 ft	Control Type	Entrance Control

Grades			
Upstream Invert	7,035.51 ft	Downstream Invert	7,020.00 ft
Length	606.00 ft	Constructed Slope	0.025594 ft/ft

Hydraulic Profile			
Profile	S2	Depth, Downstream	0.94 ft
Slope Type	Steep	Normal Depth	0.94 ft
Flow Regime	Supercritical	Critical Depth	1.52 ft
Velocity Downstream	12.17 ft/s	Critical Slope	0.006140 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.012
Section Material	Concrete	Span	2.00 ft
Section Size	24 inch	Rise	2.00 ft
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	7,038.15 ft	Upstream Velocity Head	0.75 ft
Ke	0.50	Entrance Loss	0.37 ft

Inlet Control Properties			
Inlet Control HW Elev.	7,038.10 ft	Flow Control	Transition
Inlet Type	Square edge w/headwall	Area Full	6.3 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

Culvert Calculator Report
Outlet Pipe

Solve For: Discharge

Culvert Summary			
Allowable HW Elevation	7,023.10 ft	Headwater Depth/Height	2.07
Computed Headwater Elev:	7,023.10 ft	Discharge	55.60 cfs
Inlet Control HW Elev.	7,023.10 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	7,022.97 ft	Control Type	Inlet Control

Grades			
Upstream Invert	7,017.92 ft	Downstream Invert	7,017.52 ft
Length	40.00 ft	Constructed Slope	0.010000 ft/ft

Hydraulic Profile			
Profile	CompositeM2PressureProfile	Depth, Downstream	2.36 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	2.36 ft
Velocity Downstream	11.58 ft/s	Critical Slope	0.013538 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.012
Section Material	Concrete	Span	2.50 ft
Section Size	30 inch	Rise	2.50 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	7,022.97 ft	Upstream Velocity Head	1.99 ft
Ke	0.20	Entrance Loss	0.40 ft

Inlet Control Properties			
Inlet Control HW Elev.	7,023.10 ft	Flow Control	Submerged
Inlet Type	Beveled ring, 33.7° bevels	Area Full	4.9 ft²
K	0.00180	HDS 5 Chart	3
M	2.50000	HDS 5 Scale	B
C	0.02430	Equation Form	1
Y	0.83000		

02-Overflow Channel

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.050	
Channel Slope	0.02000	ft/ft
Normal Depth	2.00	ft
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	4.00	ft

Results

Discharge	94.99	ft^3/s
Flow Area	20.00	ft^2
Wetted Perimeter	16.65	ft
Hydraulic Radius	1.20	ft
Top Width	16.00	ft
Critical Depth	1.73	ft
Critical Slope	0.03707	ft/ft
Velocity	4.75	ft/s
Velocity Head	0.35	ft
Specific Energy	2.35	ft
Froude Number	0.75	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.00	ft
Critical Depth	1.73	ft
Channel Slope	0.02000	ft/ft

O2-Overflow Channel

GVF Output Data

Critical Slope	0.03707	ft/ft

Worksheet for Open Channel Culvert Lot 3

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.03000	ft/ft
Diameter	1.50	ft
Discharge	15.90	ft³/s

Results

Normal Depth	1.02	ft
Flow Area	1.28	ft²
Wetted Perimeter	2.91	ft
Hydraulic Radius	0.44	ft
Top Width	1.40	ft
Critical Depth	1.42	ft
Percent Full	68.1	%
Critical Slope	0.01690	ft/ft
Velocity	12.41	ft/s
Velocity Head	2.39	ft
Specific Energy	3.41	ft
Froude Number	2.29	
Maximum Discharge	21.20	ft³/s
Discharge Full	19.71	ft³/s
Slope Full	0.01952	ft/ft
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	68.08	%
Downstream Velocity	Infinity	ft/s

Worksheet for Open Channel Culvert Lot 3

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.02	ft
Critical Depth	1.42	ft
Channel Slope	0.03000	ft/ft
Critical Slope	0.01690	ft/ft

Worksheet for Outlet with Passthrough-Weir

Project Description

Solve For	Discharge		

Input Data

Headwater Elevation		1.40	ft
Crest Elevation		0.00	ft
Tailwater Elevation		0.00	ft
Weir Coefficient		3.00	US
Crest Length		32.00	ft
Number Of Contractions	0		

Results

Discharge	159.02	ft^3/s
Headwater Height Above Crest	1.40	ft
Tailwater Height Above Crest	0.00	ft
Flow Area	44.80	ft^2
Velocity	3.55	ft/s
Wetted Perimeter	34.80	ft
Top Width	32.00	ft

Weir is more restrictive than Orifice
159.02 cfs
70% Gate Opening
50% Clogging

= 55.66 cfs > 45.9 tributary
→ Install orifice Restrictor on outlet pipe.

Worksheet for Outlet wPass - Orifice

Project Description

Solve For	Discharge	

Input Data

Headwater Elevation	1.40	ft
Centroid Elevation	0.00	ft
Tailwater Elevation	0.00	ft
Discharge Coefficient	0.60	
Opening Width	4.00	ft
Opening Height	12.00	ft

Results

Discharge	273.35	ft³/s
Headwater Height Above Centroid	1.40	ft
Tailwater Height Above Centroid	0.00	ft
Flow Area	48.00	ft²
Velocity	5.69	ft/s

Top Box Weir is more Restrictive
USE Weir Calculations.

Worksheet for FSD Outlet Orifice Plate

Project Description

Solve For	Diameter

Input Data

Discharge	45.90	ft³/s (16.5 Hrs + 29.4 Res)
Headwater Elevation	4.70	ft
Centroid Elevation	0.00	ft
Tailwater Elevation	0.00	ft
Discharge Coefficient	0.60	

Results

Diameter	2.37	ft
Headwater Height Above Centroid	4.70	ft
Tailwater Height Above Centroid	0.00	ft
Flow Area	4.40	ft²
Velocity	10.43	ft/s

Worksheet for FSD Overflow - Pass

Project Description

Solve For	Discharge		

Input Data

Headwater Elevation		0.90	ft
Crest Elevation		0.00	ft
Tailwater Elevation		0.00	ft
Crest Surface Type	Gravel		
Crest Breadth		12.00	ft
Crest Length		36.00	ft

Results

Discharge	86.22	ft³/s	(55 bwl + 29.4 pass = 84.4 cfs)
Headwater Height Above Crest	0.90	ft	
Tailwater Height Above Crest	0.00	ft	
Weir Coefficient	2.80	US	
Submergence Factor	1.00		
Adjusted Weir Coefficient	2.80	US	
Flow Area	32.40	ft²	
Velocity	2.66	ft/s	
Wetted Perimeter	37.80	ft	
Top Width	36.00	ft	

Worksheet for SFB Overflow Developed

Project Description

Solve For	Discharge		

Input Data

Headwater Elevation		0.45	ft
Crest Elevation		0.00	ft
Tailwater Elevation		0.00	ft
Crest Surface Type	Gravel		
Crest Breadth		6.00	ft
Crest Length		10.00	ft

Results

Discharge	8.08	ft³/s
Headwater Height Above Crest	0.45	ft
Tailwater Height Above Crest	0.00	ft
Weir Coefficient	2.68	US
Submergence Factor	1.00	
Adjusted Weir Coefficient	2.68	US
Flow Area	4.50	ft²
Velocity	1.80	ft/s
Wetted Perimeter	10.90	ft
Top Width	10.00	ft

Worksheet for Type D Inlet - Weir

Project Description

Solve For	Discharge

Input Data

Headwater Elevation	1.50	ft
Crest Elevation	0.00	ft
Weir Coefficient	3.00	US
Crest Length	17.17	ft

Results

Discharge	94.61	ft^3/s
Headwater Height Above Crest	1.50	ft
Flow Area	25.75	ft^2
Velocity	3.67	ft/s
Wetted Perimeter	20.17	ft
Top Width	17.17	ft

Type D Weir is most restictive
94.61 cfs
70% Grate Opening
50% Clogging

= 33.11 cfs > 29.4 cfs tributary

Worksheet for Type D Inlet - Orifice

Project Description

Solve For	Discharge

Input Data

Headwater Elevation	1.50	ft
Centroid Elevation	0.00	ft
Tailwater Elevation	0.00	ft
Discharge Coefficient	0.60	
Opening Width	2.92	ft
Opening Height	5.67	ft

Results

Discharge	97.50	ft^3/s
Headwater Height Above Centroid	1.50	ft
Tailwater Height Above Centroid	0.00	ft
Flow Area	16.54	ft^2
Velocity	5.89	ft/s

Type D Weir is more restrictive
→ Use Weir Calculations

Worksheet for Western Channel Capacity

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.02000	ft/ft
Normal Depth	1.00	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)

Results

Discharge	17.30	ft³/s
Flow Area	4.00	ft²
Wetted Perimeter	8.25	ft
Hydraulic Radius	0.49	ft
Top Width	8.00	ft
Critical Depth	1.03	ft
Critical Slope	0.01703	ft/ft
Velocity	4.32	ft/s
Velocity Head	0.29	ft
Specific Energy	1.29	ft
Froude Number	1.08	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.00	ft
Critical Depth	1.03	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.01703	ft/ft

Label	Start Node	Stop Node	Branch ID	Branch Element ID	Length (Unified) (ft)	Upstream Inlet C	Upstream Intensity (in/h)	Upstream Inlet Area (acres)	System Intensity (in/h)
CO-1	CB-1	MH-1	1	1	255.4	(N/A)	8	(N/A)	8
CO-2	MH-1	MH-2	1	2	295.1	(N/A)	8	(N/A)	8
CO-3	MH-2	MH-3	1	3	295.1	(N/A)	8	(N/A)	8
CO-4	MH-3	MH-4	1	4	44.9	(N/A)	8	(N/A)	8
CO-5	MH-4	OF-1	1	5	198.3	(N/A)	8	(N/A)	8

	System Rational Flow (ft^3/s)	Total Flow (ft^3/s)	Rise (Unified) (in)	Capacity (Full Flow) (ft^3/s)	Velocity (Average) (ft/s)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Slope (ft/ft)
CO-1	0	29.4	30	44.49	9.68	7032.21	7029.65	0.01
CO-2	0	29.4	30	44.43	9.67	7029.35	7026.4	0.01
CO-3	0	29.4	30	38.97	8.72	7026.2	7023.93	0.008
CO-4	0	29.4	30	57.43	11.77	7023.63	7022.88	0.017
CO-5	0	29.4	30	44.4	9.67	7022.88	7020.9	0.01

APPENDIX C

STANDARD DESIGN CHARTS AND TABLES

NOAA Atlas 14, Volume 8, Version 2
Location name: Colorado Springs, Colorado, US*
Latitude: 38.9514°, Longitude: -104.6905°
Elevation: 6984 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Penca, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

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

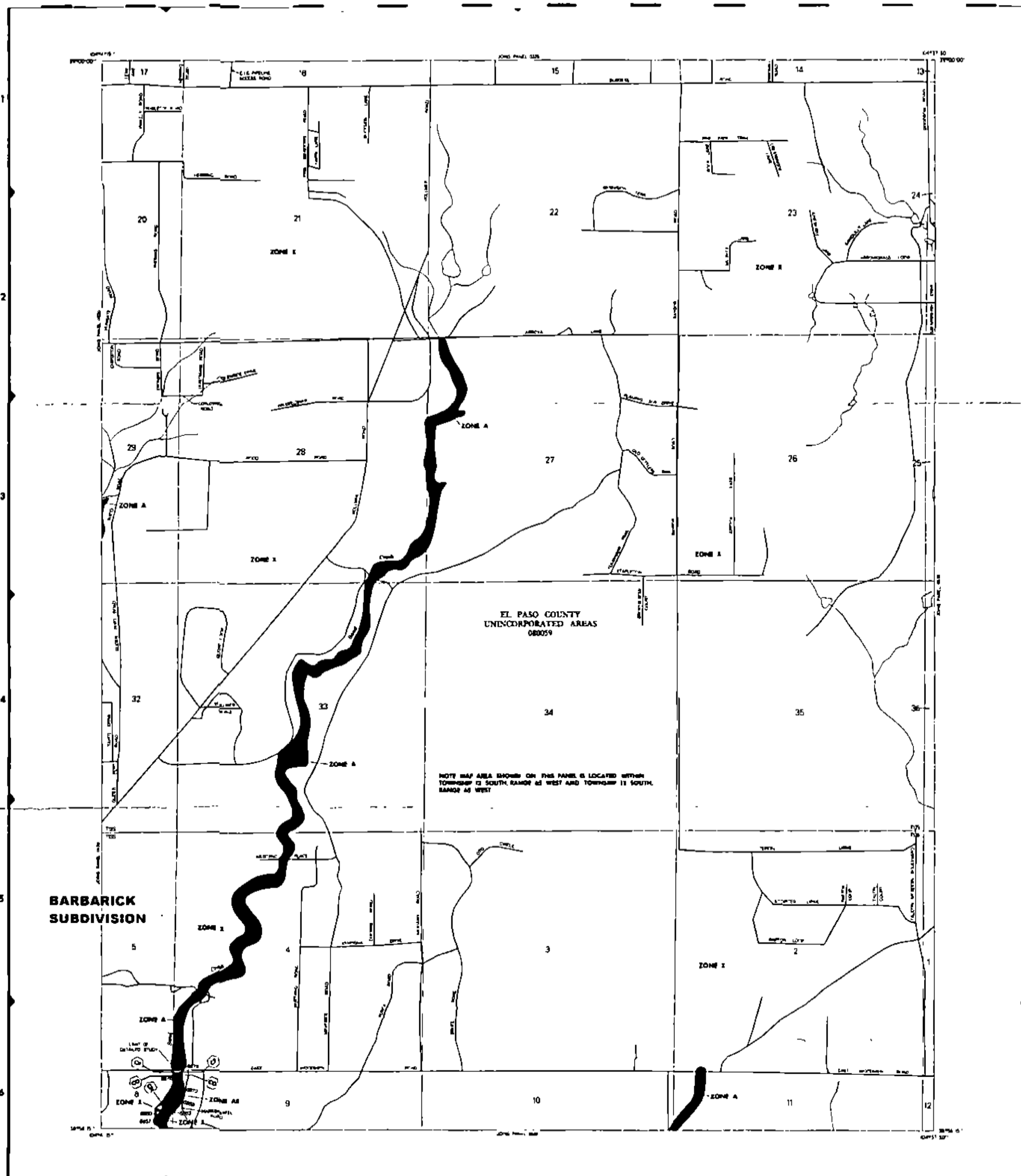
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.237 (0.195-0.290)	0.289 (0.238-0.355)	0.380 (0.311-0.467)	0.460 (0.374-0.568)	0.577 (0.456-0.746)	0.674 (0.517-0.880)	0.775 (0.573-1.04)	0.883 (0.625-1.21)	1.03 (0.701-1.46)	1.15 (0.759-1.65)
10-min	0.347 (0.285-0.425)	0.424 (0.348-0.520)	0.556 (0.455-0.684)	0.673 (0.548-0.832)	0.846 (0.667-1.09)	0.987 (0.757-1.29)	1.14 (0.839-1.52)	1.29 (0.914-1.78)	1.51 (1.03-2.14)	1.69 (1.11-2.41)
15-min	0.423 (0.348-0.519)	0.516 (0.424-0.634)	0.678 (0.555-0.834)	0.821 (0.668-1.01)	1.03 (0.814-1.33)	1.20 (0.924-1.57)	1.38 (1.02-1.85)	1.58 (1.11-2.17)	1.84 (1.25-2.61)	2.06 (1.35-2.94)
30-min	0.613 (0.504-0.751)	0.747 (0.614-0.917)	0.980 (0.802-1.21)	1.19 (0.965-1.47)	1.49 (1.17-1.92)	1.74 (1.33-2.27)	2.00 (1.48-2.67)	2.27 (1.61-3.13)	2.66 (1.80-3.76)	2.97 (1.95-4.24)
60-min	0.795 (0.654-0.974)	0.948 (0.779-1.16)	1.23 (1.00-1.51)	1.48 (1.21-1.83)	1.88 (1.49-2.44)	2.21 (1.70-2.90)	2.57 (1.91-3.46)	2.96 (2.10-4.09)	3.52 (2.39-4.99)	3.97 (2.61-5.67)
2-hr	0.977 (0.809-1.19)	1.15 (0.951-1.40)	1.47 (1.22-1.80)	1.78 (1.46-2.19)	2.27 (1.82-2.94)	2.68 (2.09-3.51)	3.14 (2.35-4.21)	3.65 (2.61-5.02)	4.38 (3.00-6.18)	4.98 (3.30-7.06)
3-hr	1.08 (0.897-1.31)	1.25 (1.04-1.51)	1.58 (1.31-1.93)	1.92 (1.57-2.34)	2.45 (1.98-3.19)	2.92 (2.29-3.83)	3.45 (2.60-4.62)	4.04 (2.91-5.55)	4.90 (3.39-6.92)	5.62 (3.75-7.95)
6-hr	1.26 (1.05-1.51)	1.44 (1.20-1.73)	1.81 (1.51-2.18)	2.19 (1.81-2.65)	2.81 (2.30-3.64)	3.37 (2.66-4.39)	4.00 (3.04-5.34)	4.71 (3.43-6.45)	5.77 (4.02-8.09)	6.65 (4.46-9.33)
12-hr	1.45 (1.23-1.74)	1.68 (1.41-2.00)	2.12 (1.78-2.54)	2.55 (2.13-3.07)	3.26 (2.68-4.19)	3.89 (3.10-5.03)	4.59 (3.52-6.08)	5.38 (3.94-7.31)	6.54 (4.59-9.11)	7.51 (5.08-10.5)
24-hr	1.68 (1.43-1.99)	1.97 (1.67-2.33)	2.50 (2.12-2.98)	3.01 (2.53-3.60)	3.80 (3.13-4.80)	4.48 (3.58-5.72)	5.23 (4.02-6.83)	6.04 (4.45-8.11)	7.23 (5.09-9.96)	8.20 (5.58-11.4)
2-day	1.95 (1.67-2.29)	2.31 (1.97-2.72)	2.95 (2.51-3.48)	3.53 (2.99-4.18)	4.39 (3.62-5.46)	5.11 (4.10-6.44)	5.88 (4.55-7.59)	6.71 (4.96-8.91)	7.89 (5.59-10.8)	8.83 (6.07-12.2)
3-day	2.15 (1.85-2.51)	2.54 (2.16-2.97)	3.22 (2.75-3.78)	3.83 (3.26-4.52)	4.74 (3.92-5.87)	5.50 (4.42-6.88)	6.30 (4.89-8.09)	7.16 (5.31-9.45)	8.37 (5.96-11.4)	9.34 (6.45-12.8)
4-day	2.31 (2.00-2.70)	2.72 (2.34-3.17)	3.42 (2.94-4.01)	4.06 (3.46-4.78)	5.00 (4.15-6.16)	5.78 (4.67-7.21)	6.61 (5.14-8.46)	7.50 (5.58-9.87)	8.75 (6.25-11.8)	9.76 (6.75-13.3)
7-day	2.74 (2.38-3.18)	3.17 (2.75-3.68)	3.92 (3.39-4.57)	4.60 (3.95-5.38)	5.60 (4.67-6.86)	6.43 (5.23-7.97)	7.32 (5.73-9.30)	8.27 (6.19-10.8)	9.60 (6.90-12.9)	10.7 (7.44-14.5)
10-day	3.11 (2.71-3.60)	3.58 (3.11-4.14)	4.39 (3.80-5.09)	5.11 (4.40-5.95)	6.17 (5.17-7.51)	7.05 (5.75-8.69)	7.98 (6.27-10.1)	8.97 (6.75-11.7)	10.4 (7.47-13.9)	11.5 (8.03-15.5)
20-day	4.18 (3.67-4.79)	4.79 (4.20-5.50)	5.83 (5.09-6.71)	6.72 (5.84-7.77)	7.99 (6.71-9.59)	9.01 (7.38-11.0)	10.0 (7.94-12.6)	11.1 (8.42-14.3)	12.6 (9.17-16.7)	13.8 (9.73-18.6)
30-day	5.05 (4.46-5.77)	5.80 (5.11-6.63)	7.04 (6.18-8.07)	8.08 (7.05-9.30)	9.51 (8.01-11.3)	10.6 (8.73-12.8)	11.8 (9.32-14.6)	12.9 (9.79-16.5)	14.4 (10.5-19.0)	15.6 (11.1-20.9)
45-day	6.14 (5.44-6.98)	7.06 (6.25-8.03)	8.54 (7.53-9.74)	9.75 (8.55-11.2)	11.4 (9.60-13.4)	12.6 (10.4-15.1)	13.8 (11.0-17.0)	15.0 (11.4-19.1)	16.6 (12.1-21.7)	17.7 (12.6-23.7)
60-day	7.05 (6.27-7.99)	8.12 (7.20-9.20)	9.80 (8.66-11.1)	11.1 (9.80-12.7)	12.9 (10.9-15.2)	14.2 (11.8-17.0)	15.5 (12.4-19.0)	16.7 (12.8-21.1)	18.3 (13.4-23.8)	19.4 (13.9-25.8)

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

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

Please refer to NOAA Atlas 14 document for more information.

Back to Top



LEGEND

SPECIAL FLOOD HAZARD AREAS INUNDATED BY 100-YEAR FLOOD

FLOODWAY AREAS IN ZONE AE

OTHER FLOOD AREAS

OTHER AREAS

UNDEVELOPED COASTAL BARRIERS

NOTES

MAP REPOSITORY

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP

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

APPROXIMATE SCALE IN FEET

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)

MAP NUMBER 08041C0535 F

EFFECTIVE DATE: MARCH 17, 1997

Federal Emergency Management Agency

Map Unit Legend

El Paso County Area, Colorado (CO625)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
9	Blakeland-Fluvaquentic Haplaquolls	12.5	76.4%
71	Pring coarse sandy loam, 3 to 8 percent slopes	3.9	23.6%
Totals for Area of Interest		**16.4**	**100.0%**

El Paso County Area, Colorado

9—Blakeland-Fluvaquentic Haplaquolls

Map Unit Setting

National map unit symbol: 36b6
Elevation: 3,500 to 5,800 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 46 to 55 degrees F
Frost-free period: 110 to 165 days
Farmland classification: Not prime farmland

Map Unit Composition

Blakeland and similar soils: 60 percent
Fluvaquentic haplaquolls and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Blakeland

Setting

Landform: Flats, hills
Landform position (three-dimensional): Side slope, talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy alluvium derived from arkose and/or eolian deposits derived from arkose

Typical profile

A - 0 to 11 inches: loamy sand
AC - 11 to 27 inches: loamy sand
C - 27 to 60 inches: sand

Properties and qualities

Slope: 1 to 9 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Available water storage in profile: Low (about 4.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: Sandy Foothill (R049BY210CO)

Description of Fluvaquentic Haplaquolls

Setting

Landform: Swales
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 12 inches: variable

Properties and qualities

Slope: 1 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 6.00 in/hr)
Depth to water table: About 0 to 24 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)

Interpretive groups

Land capability classification (irrigated): 6w
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: D

Minor Components

Other soils

Percent of map unit:

Pleasant

Percent of map unit:
Landform: Depressions

Data Source Information

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 13, Sep 22, 2015

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
Natural 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 storage in profile: Low (about 6.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Loamy Park (R048AY222CO)

Minor Components

Other soils

Percent of map unit:

Pleasant

Percent of map unit:

Landform: Depressions

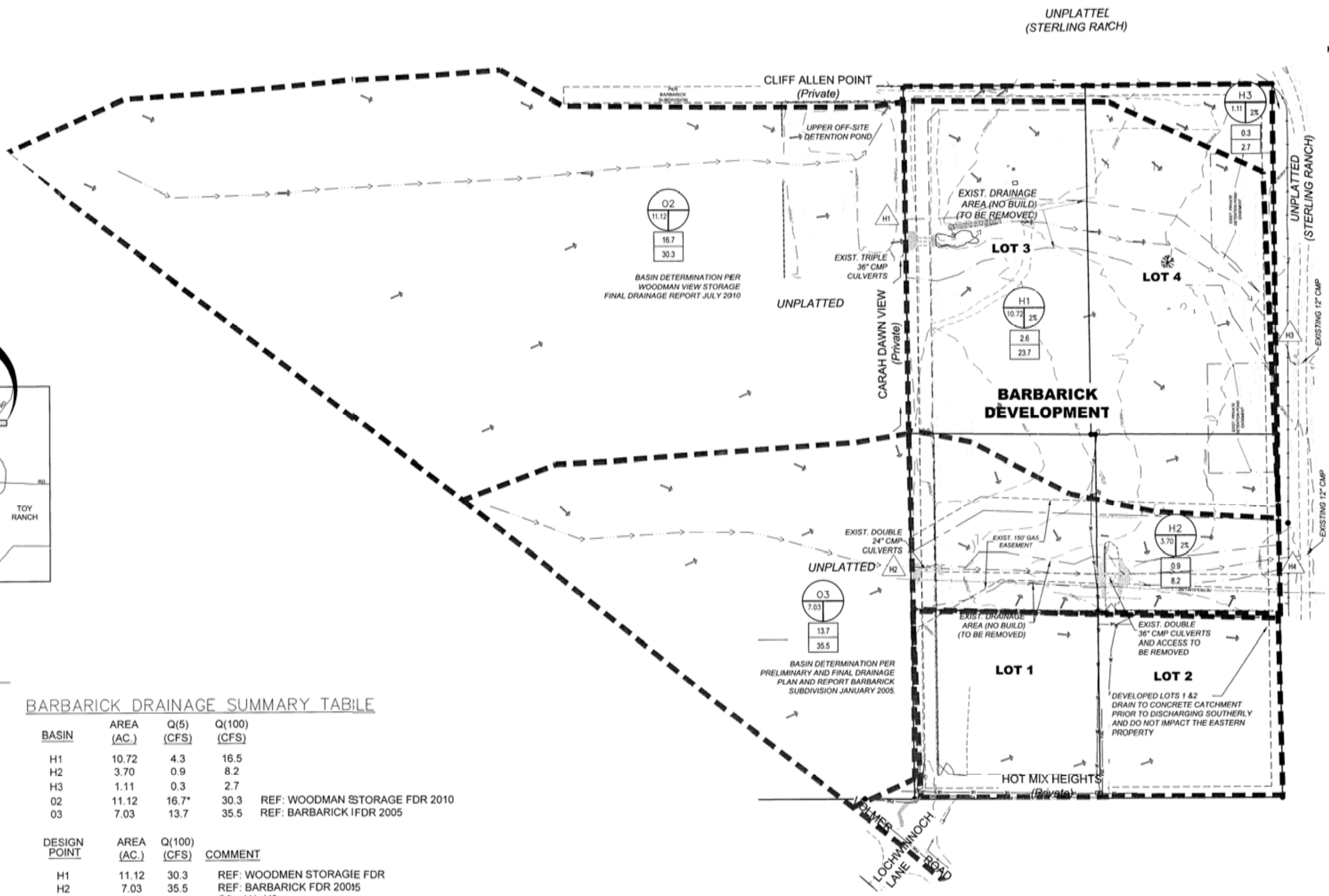
Data Source Information

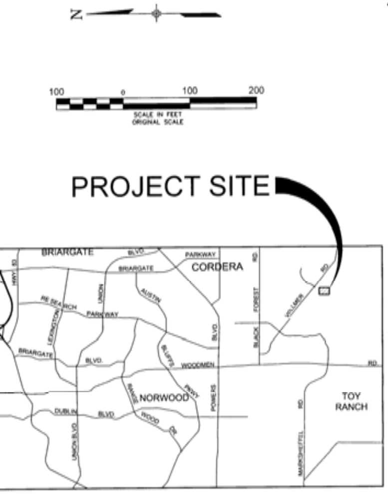
Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 13, Sep 22, 2015

APPENDIX D

MAPS

Know what's below. Call before you dig. 811





VICINITY MAP

N.T.S.

LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CONTOUR
- PHASE 3A FILING LIMITS
- TEMPORARY DIVERSION SWALE
- LOT LINE
- X — DESIGN POINT
- XX — SUB BASIN DESIGNATION
- 99.9 — SUB BASIN PERCENT IMPERVIOUS
- 0.99 — SUB BASIN AREA (AC.)
- 0.0 — 5 -YEAR STORM EVENT PEAK FLOW (CFS)
- 0.0 — 100-YEAR STORM EVENT PEAK FLOW (CFS)
- PROPOSED FLOW DIRECTION
- EXISTING FLOW DIRECTION

BARBARICK DRAINAGE SUMMARY TABLE

BASIN	AREA (AC.)	Q(5) (CFS)	Q(100) (CFS)	
H1	10.72	4.3	16.5	
H2	3.70	0.9	8.2	
H3	1.11	0.3	2.7	
O2	11.12	16.7*	30.3	REF: WOODMAN STORAGE FDR 2010
O3	7.03	13.7	35.5	REF: BARBARICK IFDR 2005

DESIGN POINT	AREA (AC.)	Q(100) (CFS)	COMMENT
H1	11.12	30.3	REF: WOODMEN STORAGE FDR
H2	7.03	35.5	REF: BARBARICK FDR 2005
H3	22.95	56.7	O2 + H1+H3
H4	10.73	43.7	O3 + H2

NO.	DATE	DESCRIPTION	BY
		REVISIONS	

BENCHMARK DATA(ELEV.) ______
(DATUM) ______
(DESCRIPTION/LOCATION) ______

NAME: S:\15.789.001 Tri Lakes\Dwg\CD\Drainage\20160605-DP01.dwg
PCP: Matrix.ctb
PLOT DATE: Tue Jun 07, 2016 12:49pm

VERTICAL BENCHMARK:

THE VERTICAL INFORMATION ON THIS MAP IS BASED ON THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 AND THE 1960 SUPPLEMENTARY ADJUSTMENT BEING A FOUND 3.25" ALUMINUM CAP IN A ROAD BOX DESIGNATED AS FACILITIES INFORMATION MANAGEMENT SYSTEM (FIMS) MONUMENT "F_E69" AND HAVING PUBLISHED ELEVATION OF 6975.62 FEET WAS USED TO REFERENCE THIS VERTICAL DATUM. THE BENCHMARK IS LOCATED ON THE WEST SIDE OF BLACK FOREST ROAD, ABOUT 1.95 MILES SOUTH OF OLD RANCH ROAD, JUST SOUTH OF THE SCHMIDT CONSTRUCTION COMPANY DRIVEWAY. A CORNER FENCE POST IS 28.1 FEET TO THE SOUTHWEST, AND THE MOST SOUTHERLY GUARD RAIL POST IS 25.7 FEET TO THE NORTH.

BASIS OF BEARING:

THE BASIS OF BEARINGS FOR THIS MAP IS THE NORTH LINE OF BARBARICK SUBDIVISION ACCORDING TO THE OFFICIAL MAP THEREOF RECORDED FEBRUARY 12, 2008 IN THE OFFICE OF THE EL PASO COUNTY CLERK AND RECORDER UNDER RECEPTION NUMBER 208712754, SAID LINE MONUMENTED ON THE WEST END BY A FOUND 5/8" REBAR AND ON THE EAST BY A FOUND 4/8" REBAR WITH 1" ALUMINUM CAP STAMPED "LS 2154" BEING A POINT ON THE NORTH LINE BEARING NORTH 89°12'41 EAST 12287.35 FEET FROM THE WEST END THEREOF

PREPARED UNDER MY DIRECT SUPERVISION, FOR AND ON BEHALF OF MATRIX DESIGN GROUP, INC.

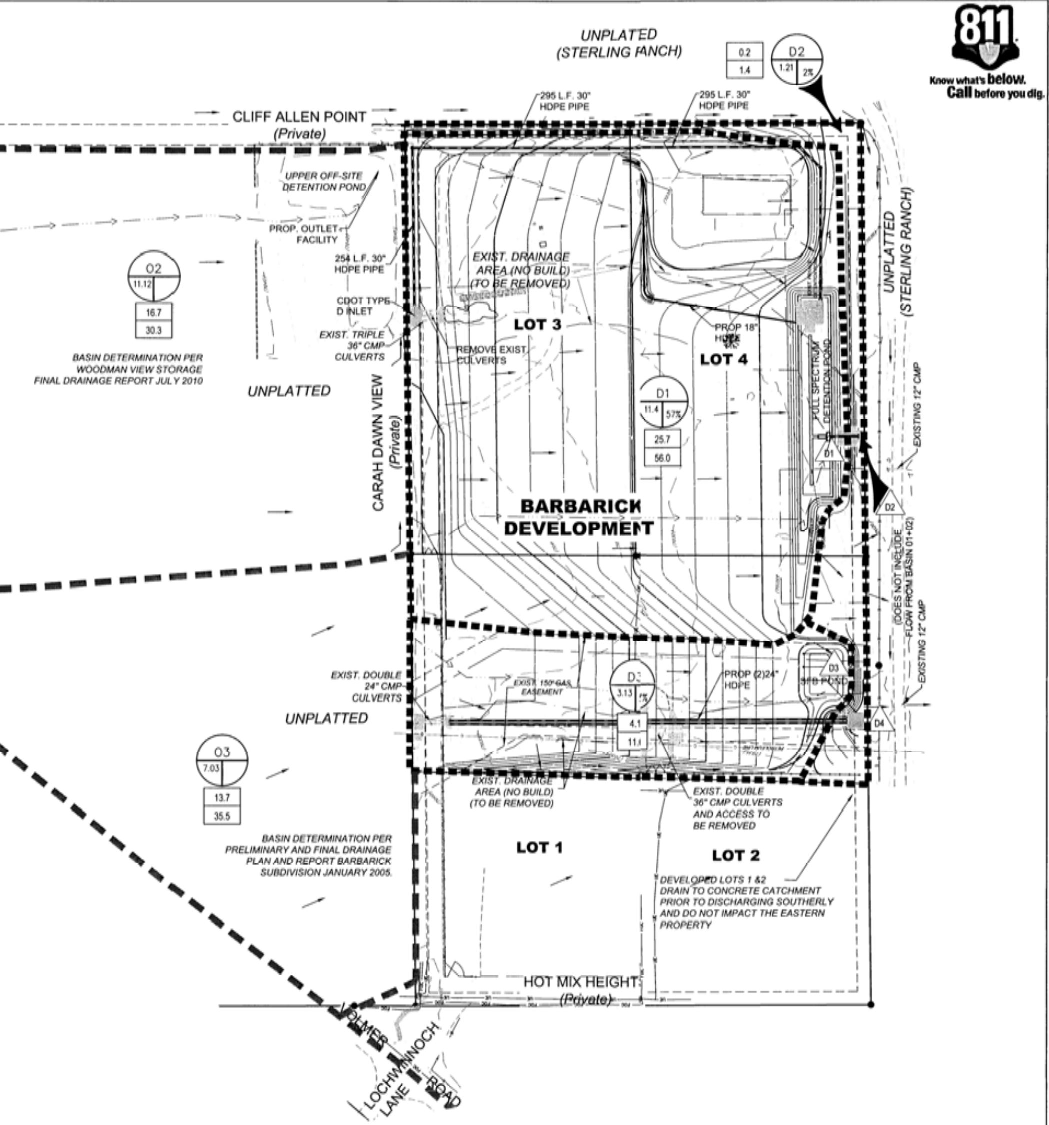
Matrix DESIGN GROUP

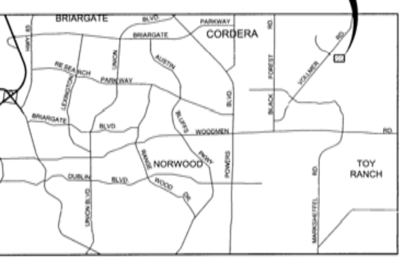
2435 Research Parkway, Suite 300 Colorado Springs, CO 80920
Phone 719-575-0100
Fax 719-575-0208

BARBARICK SUBDIVISION LOTS 1-4

EXISTING CONDITIONS DRAINAGE PLAN

DESIGNED BY:	BJH	SCALE		DATE ISSUED:	April 2016	DP01
DRAWN BY:	BJH	HORIZ:	1"=50'			
CHECKED BY:	ES	VERT:	N/A	SHEET NO. 1 OF 2 SHEETS		





VICINITY MAP
N.T.S.

SAND FILTER POND

V_{WQ} = 0.039 AC-FT
WQ WSE = 23.37
EURV WC = 0.181
EURV ELEV = 24.52
100-YR WSE = 0.394 AC-FT
100-YR ELEV = 25.83
Q_5 RELEASE = 0.1 CFS
Q_{100} RELEASE = 3.6 CFS

FSD POND

V_{WQ} = 0.203 AC-FT
WQ WSE = 20.03
V_5 = 0.673 AC-FT
5-YR WSE = 21.50
V_{100} = 1.261 AC-FT
100-YR WSE = 22.76
Q_{100} RELEASE = 45.9 CFS
EURV = 0.677 AC-FT
EURV ELEV = 21.50

BARBARICK DRAINAGE SUMMARY TABLE

BASIN	AREA (AC.)	Q(5 (CFS)	Q(100) (CFS)	% IMP.	COMMENT
D1	11.40	25.7	56.0	57%	
D2	1.21	0.8	3.0	2%	HISTORIC
D3	3.13	4.1	11.6	57%	
02	11.12	16.7	30.3		REFF: WOODMAN STORAGE FDR 2010
03	7.03	13.7	35.5		REFF: BARBARICK FDR 2005

DESIGN POINT	AREA (AC.)	Q(100) (CFS)	COMMENT
D1	11.40	85.4	D1 BASIN TO FSD +02 PASS THROUGH
D2	22.52	48.9	POND RELEASE + D2
D3	3.13	11.6	D3 BASIN TO SFB
D4	10.16	39.1	POND RELEASE + O3 PIPE PASS THROUGH

LEGEND

SUB-BASIN BOUNDARY
EXISTING CONTOUR
PHASE 3A FILING LIMITS
TEMPORARY DIVERSION SWALE
LOT LINE
DESIGN POINT
SUB BASIN DESIGNATION
SUB BASIN PERCENT IMPERVIOUS
SUB BASIN AREA (AC.)
5 -YEAR STORM EVENT PEAK FLOW (CFS)
100-YEAR STORM EVENT PEAK FLOW (CFS)
PROPOSED FLOW DIRECTION
EXISTING FLOW DIRECTION

RENCE
WINGS
BDRY
RES
nage)

NO.	DATE	DESCRIPTION	BY

REVISIONS

BENCHMARK DATA(ELEV.) ______
(DATUM) ______
(DESCRIPTION/LOCATION) ______

NAME: S:\15.789.001 Tri Lakes\Dwg\CD\Drainage\20160605-DP01.dwg
PCP: Matrix.ctb
PLOT DATE: Tue Jun 07, 2016 12:49pm

VERTICAL BENCHMARK:

THE VERTICAL INFORMATION ON THIS MAP IS BASED ON THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 AND THE 1960 SUPPLEMENTARY ADJUSTMENT BEING A FOUND 3.25" ALUMINUM CAP IN A ROAD BOX DESIGNATED AS FACILITIES INFORMATION MANAGEMENT SYSTEM (FIMS) MONUMENT "F_69" AND HAVING PUBLISHED ELEVATION OF 6975.62 FEET WAS USED TO REFERENCE THIS VERTICAL DATUM. THE BENCHMARK IS LOCATED ON THE WEST SIDE OF BLACK FOREST ROAD, ABOUT 1.95 MILES SOUTH OF OLD RANCH ROAD, JUST SOUTH OF THE SCHMIDT CONSTRUCTION COMPANY DRIVEWAY. A CORNER FENCE POST IS 28.1 FEET TO THE SOUTHWEST, AND THE MOST SOUTHERLY GUARD RAIL POST IS 25.7 FEET TO THE NORTH.

BASIS OF BEARING:

THE BASIS OF BEARINGS FOR THIS MAP IS THE NORTH LINE OF BARBARICK SUBDIVISION ACCORDING TO THE OFFICIAL MAP THEREOF RECORDED FEBRUARY 12, 2008 IN THE OFFICE OF THE EL PASO COUNTY CLERK AND RECORDER UNDER RECEPTION NUMBER 208712754, SAID LINE MONUMENTED ON THE WEST END BY A FOUND 5/8" REBAR AND ON THE EAST BY A FOUND 4/8" REBAR WITH 1" ALUMINUM CAP STAMPED "LS 2154" BEING A POINT ON THE NORTH LINE BEARING NORTH 89°12'41 EAST 1287.35 FEET FROM THE WEST END THEREOF

PREPARED UNDER MY DIRECT SUPERVISION, FOR AND ON BEHALF OF MATRIX DESIGN GROUP, INC.

Matrix DESIGN GROUP
2435 Research Parkway, Suite 300 Colorado Springs, CO 80920
Phone 719-575-0100
Fax 719-575-0208

BARBARICK SUBDIVISION LOTS 1-4

PROPOSED DRAINAGE PLAN

DESIGNED BY	BJH	SCALE		DATE ISSUED:	April 2016	DP02
DRAWN BY:	BJH	HORIZ:	1"=100'	SHEET NO. 1 OF 2 SHEETS		
CHECKED BY	ES	VERT:	N/A			

SAND CREEK DBPS COST OPINION & MAPS

SAND CREEK DRAINAGE BASIN PLANNING STUDY - COSTS FOR STERLING RANCH

CONSTRUCTION COST OPINION PER DBPS

SAND CREEK Drainageway Conveyance Cost Estimate (pg. 64 DBPS)

	DBPS SEG/DESCRIPTION	UNIT	QUANTITY	UNIT COST	GRADE CONTROLS	LENGTH	DBPS REIMBURSABLE COST
1	163 Sel. Linings (1 side)	LF	2600	$127	15	1200	$546,200
2	187 Sel. Linings (1 side)	LF	0	$0	2	160	$28,800
3	170 Sel. Linings (1 side)	LF	0	$0	3	240	$43,200
	SUB-TOTAL (DBPS Dollars)						**$618,200**
	***(2017 Dollars)**	*(2017 Dollars) - Drainage Fee Multiplier - 3.32					***$2,054,773***

Existing Pond Outlet Structures and Embankment Repairs (pg. 50, 52, 53)

	DBPS SEG/DESCRIPTION	UNIT	QUANTITY	UNIT COST		PROPOSED REIMBURSABLE COST
1	SEG 170 - Pond Outlet	1	1	$20,000	*10	$20,000
	Embankment	1	1	$35,000	*10	$35,000
2	SEG 170 - Pond Outlet	1	1	$20,000	*10	$20,000
	Embankment	1	1	$35,000	*10	$35,000
3	SEG 163 - Pond Outlet	1	1	$20,000	*10	$20,000
	Embankment	1	1	$35,000	*10	$35,000
	SUB-TOTAL (DBPS Dollars)					**$165,000**
	***(2017 Dollars)**	*(2017 Dollars - Proposed Costs - Not included in DBPS)				***$165,000***

SAND CREEK DRAINAGE BASIN PLANNING STUDY - COSTS FOR STERLING RANCH

CONSTRUCTION COST OPINION PER DBPS

Sand Creek BRIDGE Crossing Cost Estimate (pg. 83 DBPS)

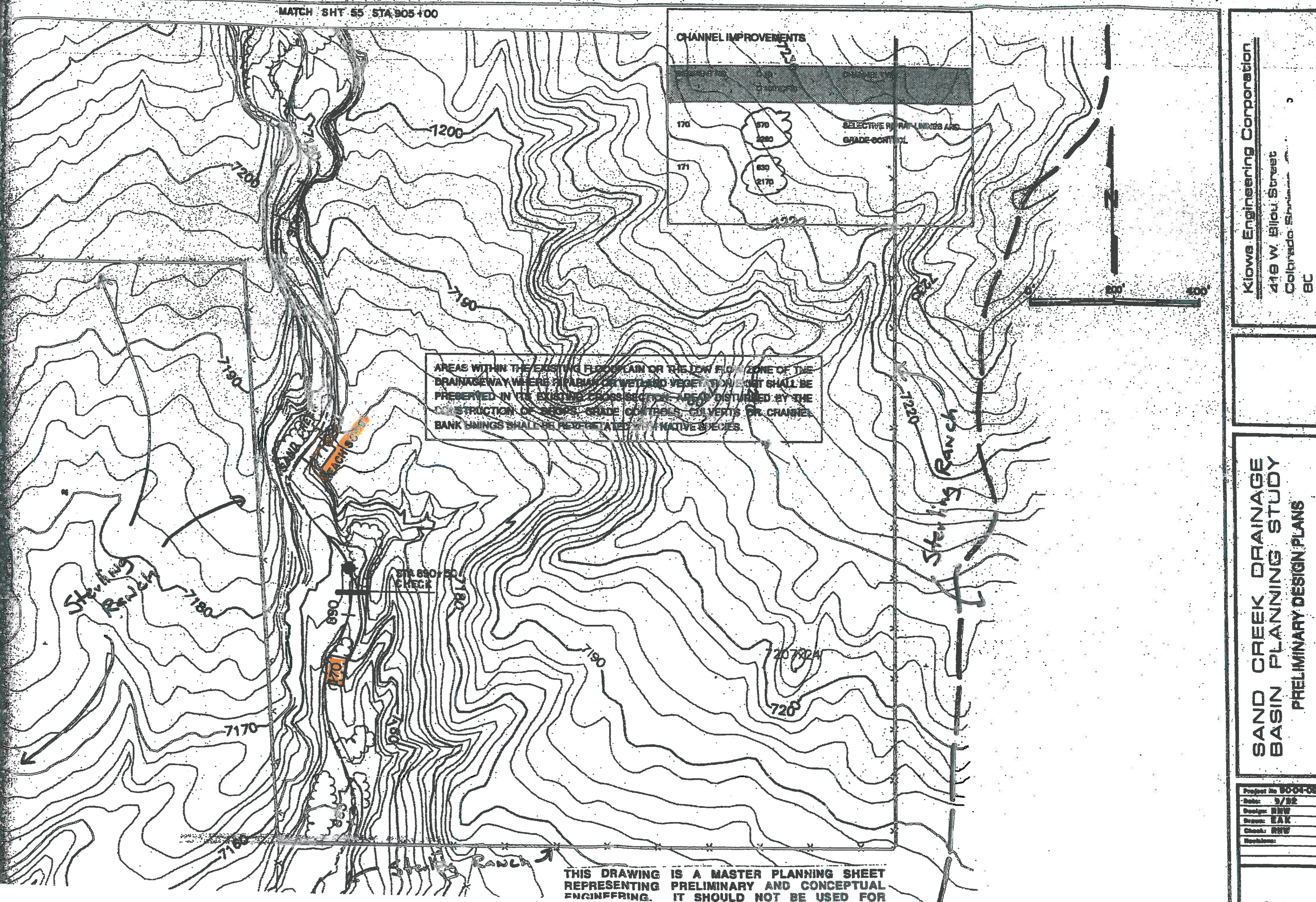
	DBPS SEG/DESCRIPTION	UNIT	QUANTITY	UNIT COST		DBPS REIMBURSABLE COST
1	Resarch Pkwy 6'H x 8'W CBC	LF	80	$1,560	*10	$124,800
	SUB-TOTAL (DBPS Dollars)					$124,800
	***(2017 Dollars)**	*(2017 Dollars) - Bridge Fee Multiplier - See previous sheet - 15.26				*$1,904,456*

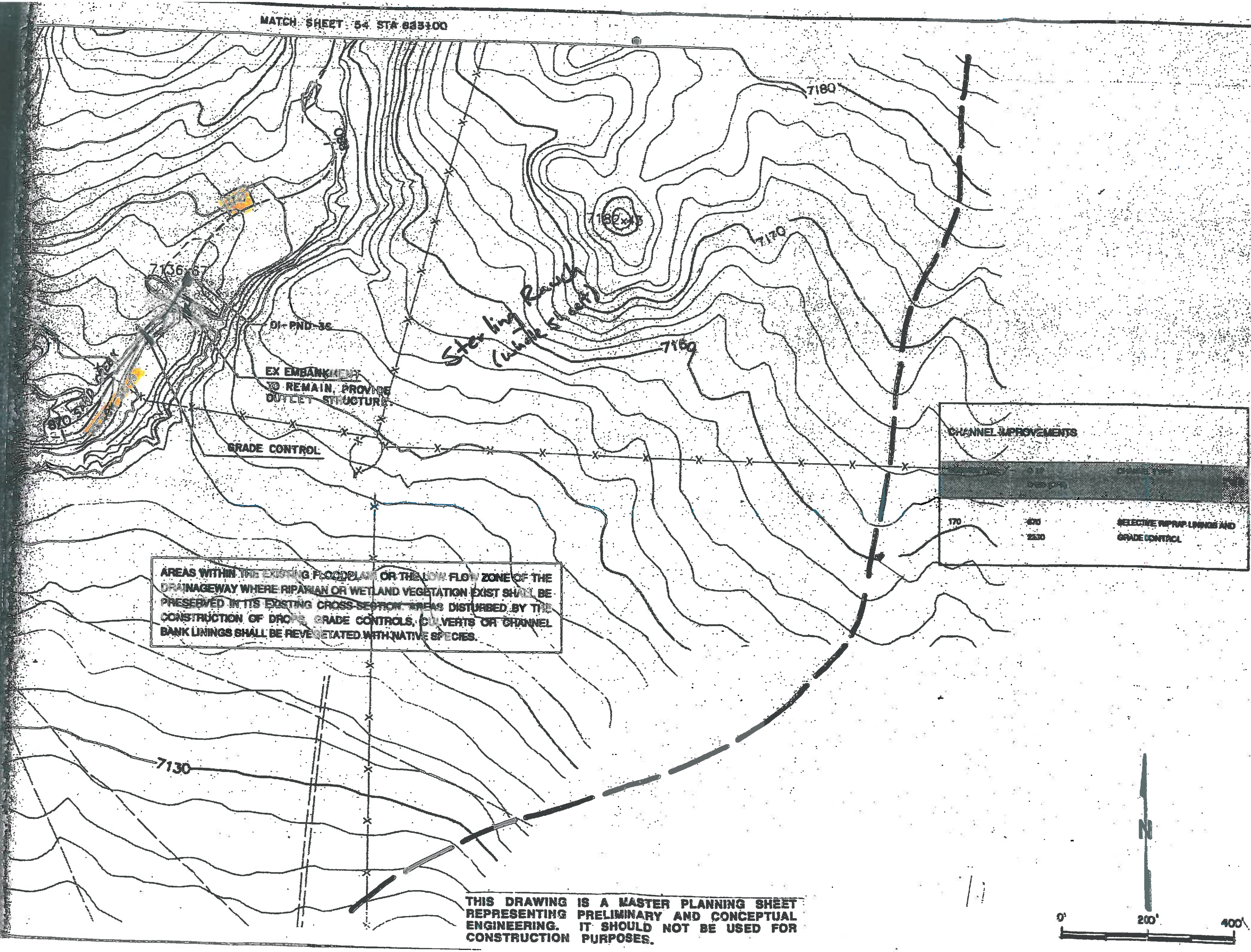
TOTAL REIMBURSABLE DRAINAGE COST PER DBPS (2017 DOLLARS) - Per Proposed Amendment ***$8,237,679***

TOTAL REIMBURSABLE BRIDGE COST PER DBPS (2017 DOLLARS) - Per Proposed Amendment ***$1,904,456***

*Cost Difference Summary

1. The Sand Creek DBPS assumed a lower density of development for the proposed Sterling Ranch area.
2. Vollmer Road culverts are propsed as CMP in the SCDBPS, However RCP is the standard and therefore should be reimbursable.
3. No Costs for existing pond outlet structures or embankment repairs were given in the SCDBPS
4. The Sand Creek bridge estimate is only 80 LF, however the ROW is 160' in width and with the embankment considered the actual lengths will exceed 200 LF.
5. The Sand Creek roadway culvert estimate assumes CMP pipe, however RCP pipe is now the standard.
6. The Sand Creek drainageway estimate assumes grade control structures only, however drop structures will replace some of the check structures.
7. The Sand Creek drainageway assumes design for some 10-yr facilities, however 100-yr facilities will be constructed throughout the development.
8. The Sand Creek DBPS does not consider Vollmer Road as an improved arterial road, however Vollmer Road drainage improvements will be necessary.
9. The Sand Creek DBPS (page 50) 100-yr outlet control structure for the existing pond was not included in the cost estimate for the Sand Creek improvements, however for the existing embankment to remain, a structure will be necessary.
10. Not included in Sand Creek DBPS cost Estimate
11. Actuall costs will far exceed Sand Creek DBPS budget


MATCH SHT 55 STA 905+00
CHANNEL IMPROVEMENTS
170
171
SELECTIVE RIPRAP LININGS AND GRADE CONTROL
7200
7190
7180
7170
7160
7220
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.
STA 890+50 CHECK
890
Sterling Ranch
Sterling Ranch
Sterling Ranch
Sterling Ranch
0'
200'
400'
THIS DRAWING IS A MASTER PLANNING SHEET REPRESENTING PRELIMINARY AND CONCEPTUAL ENGINEERING. IT SHOULD NOT BE USED FOR
Kiowa Engineering Corporation
419 W. Bijou Street
BC
SAND CREEK DRAINAGE BASIN PLANNING STUDY
PRELIMINARY DESIGN PLANS
Date: 3/92
Design: RNW
Drawn: EAK
Check: RNW
Revisions:

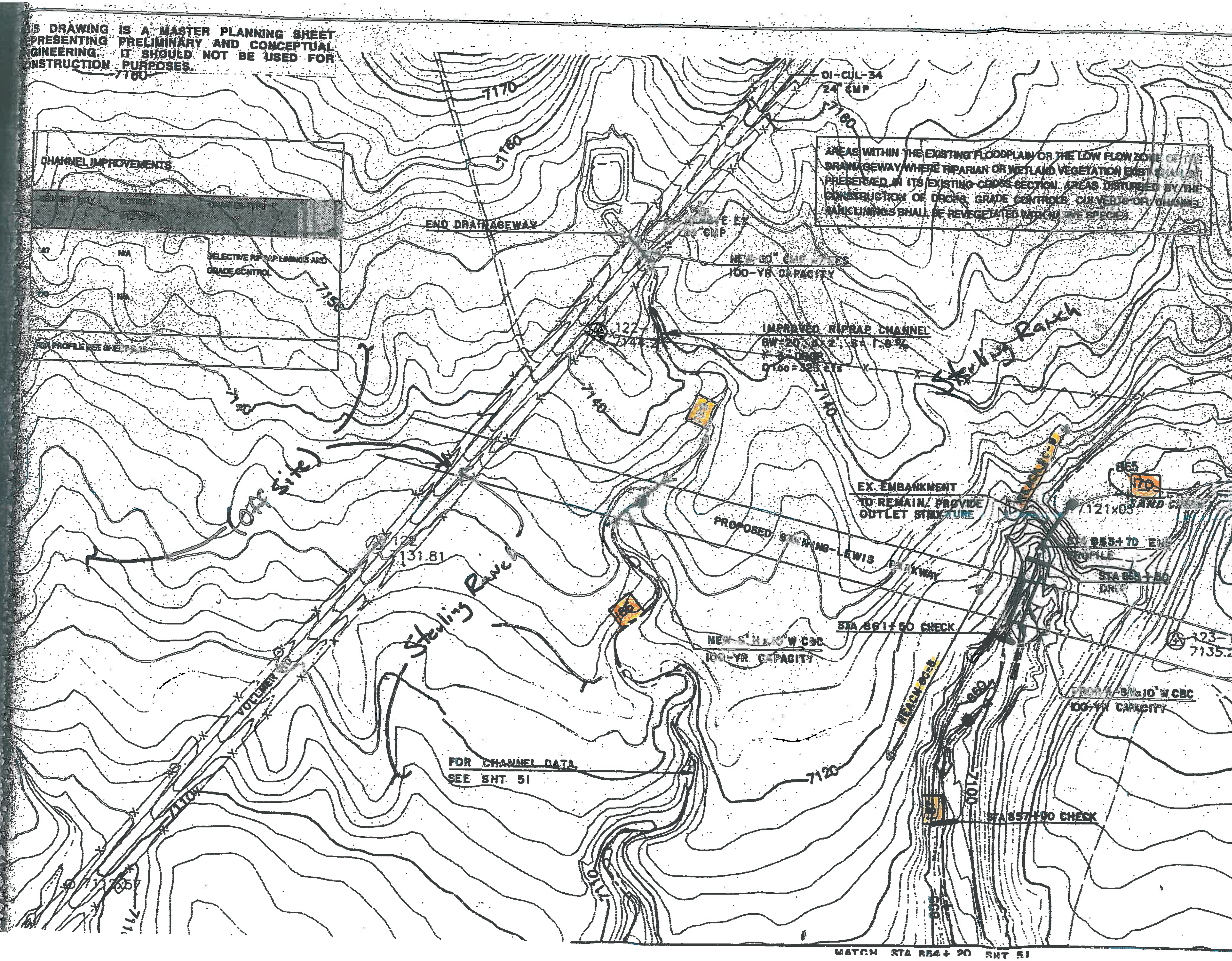


Kiowa Engineering Corporation
419 W. Bijou Street
Colorado Springs, Colorado
80905-1308

SAND CREEK DRAINAGE
BASIN PLANNING STUDY

PRELIMINARY DESIGN PLANS

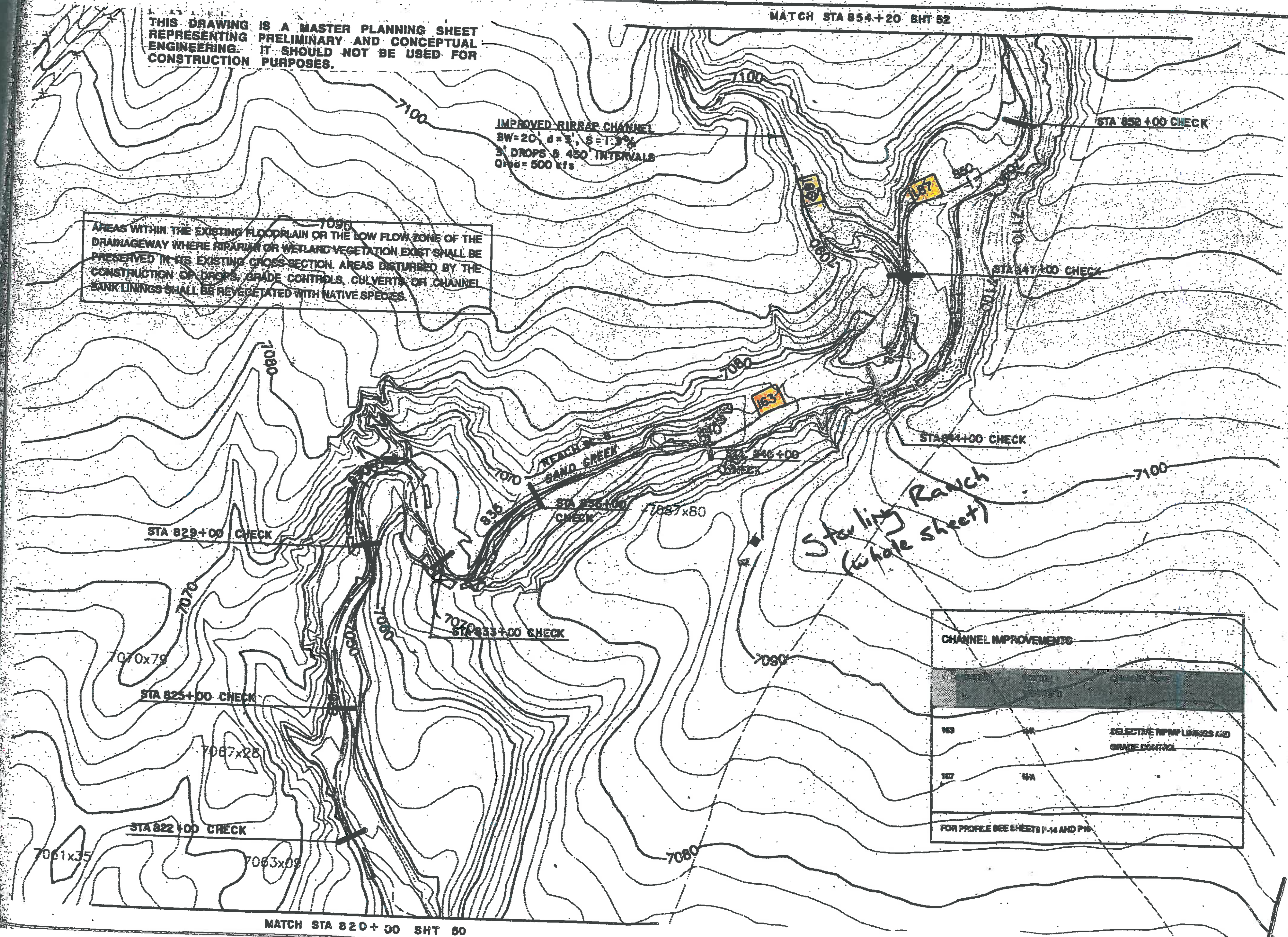
Project No: 90-04-09
Date: 9-92
Design: RNW
Drawn: EAK
Check: RNW
Revisions:



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:	11/92
Design:	RNW
Drawn:	EAK
Check:	RNW
Revisions:	

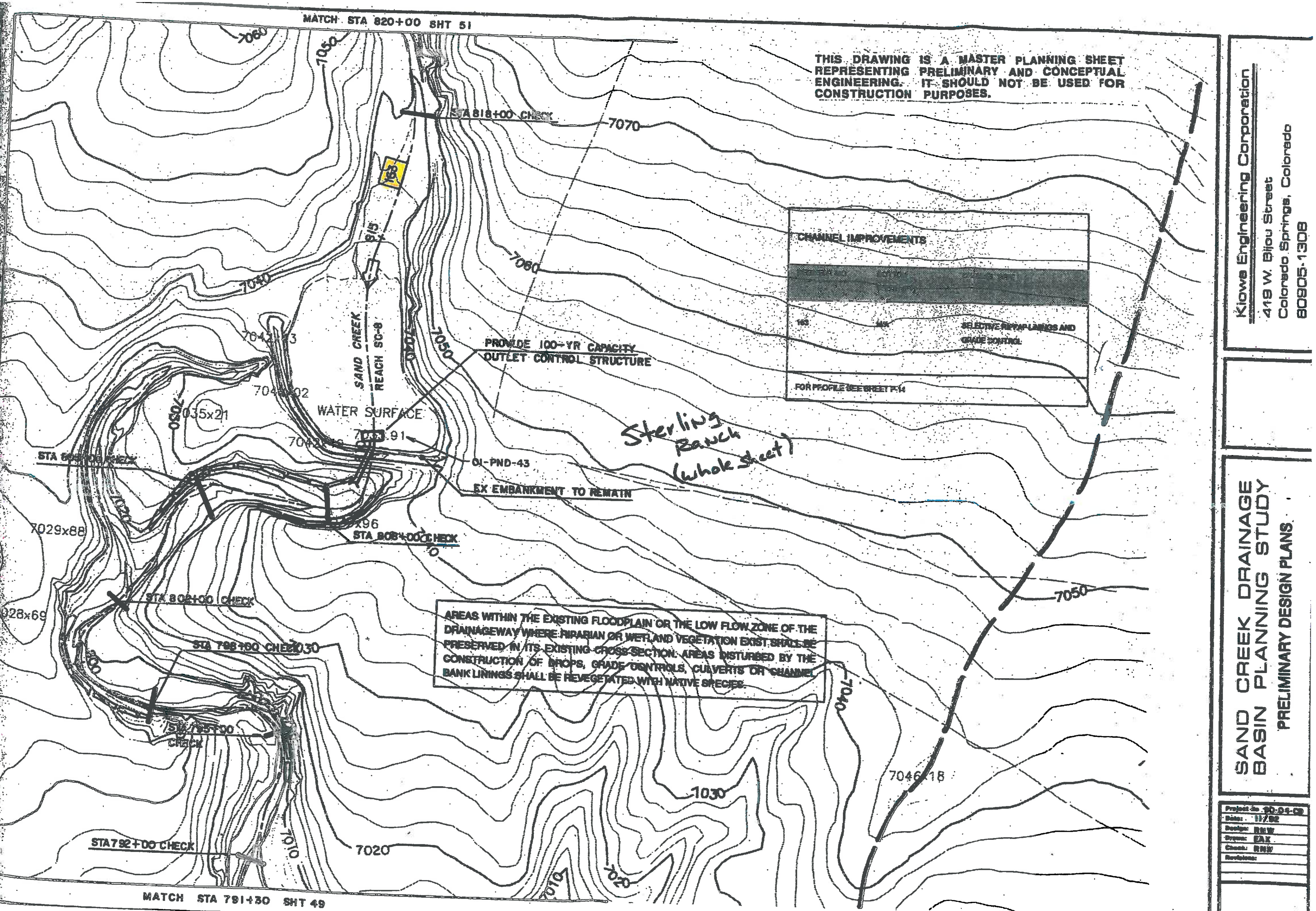


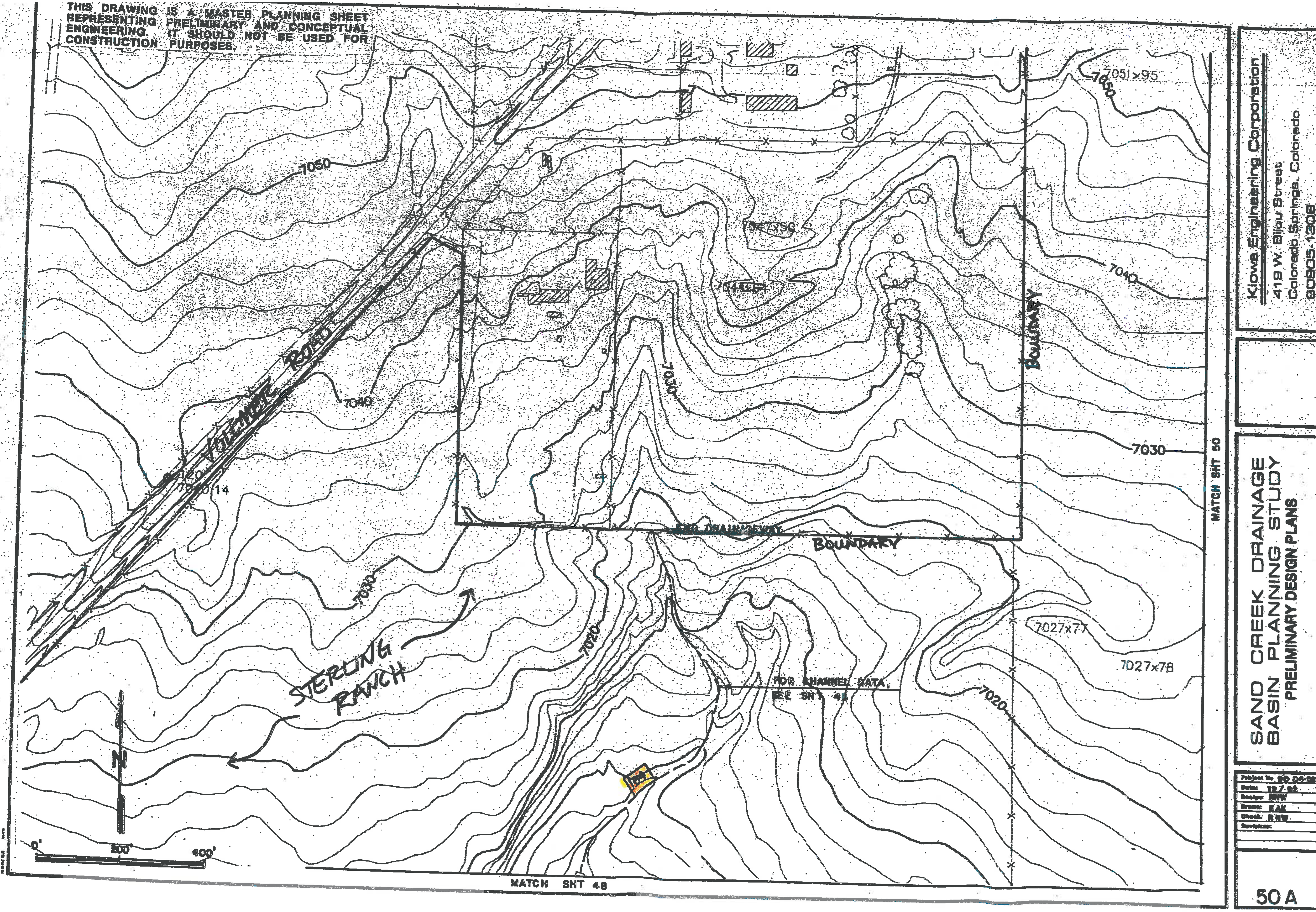
Kiowa Engineering Corporation
419 W. Bijou Street
Colorado Springs, Colorado
80905-1308

SAND CREEK DRAINAGE BASIN PLANNING STUDY

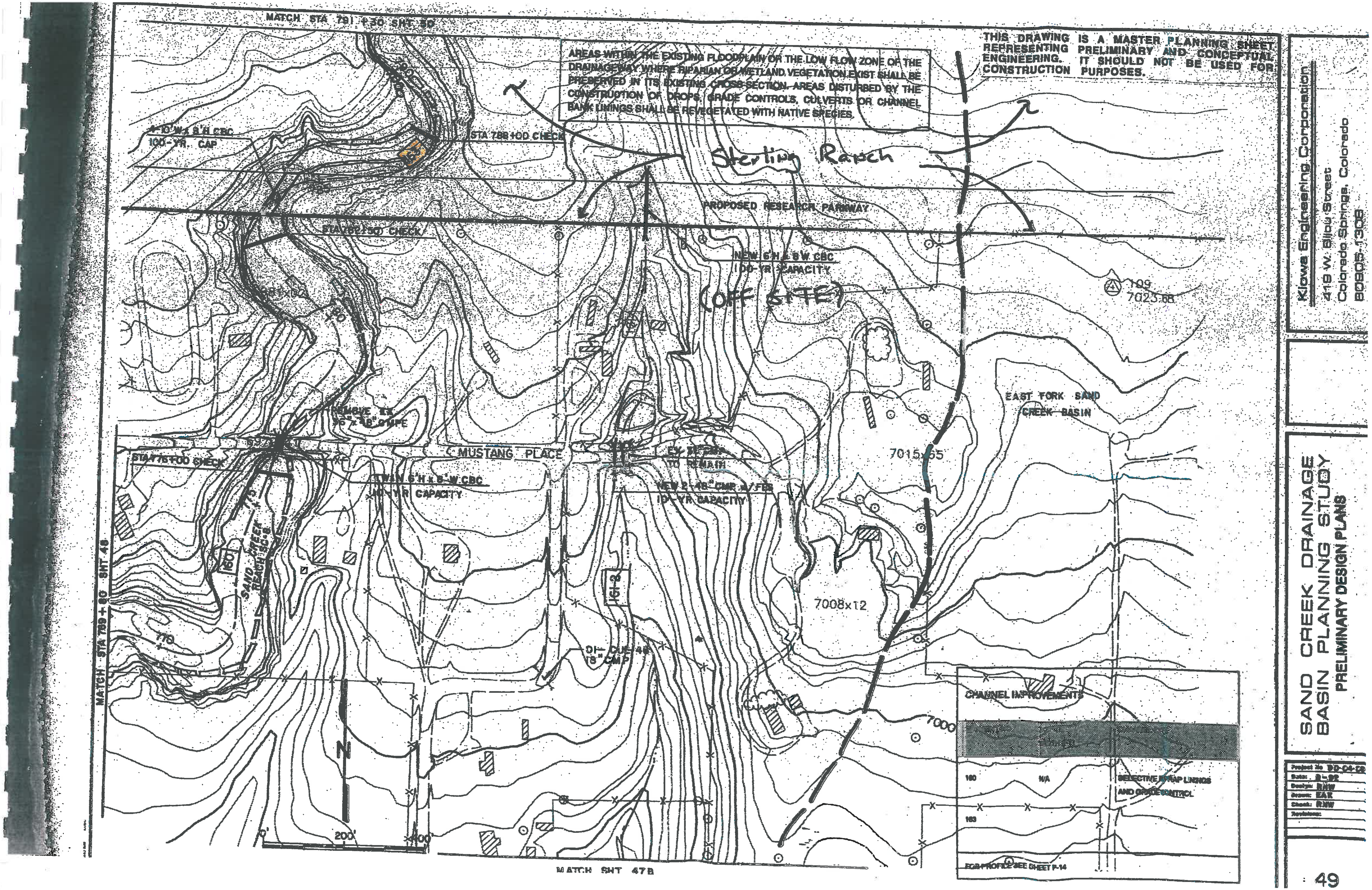
PRELIMINARY DESIGN PLANS

Project No	90-04-09
Date:	11/92
Design:	RRW
Drawn:	EAK
Check:	RRW
Revisions:	

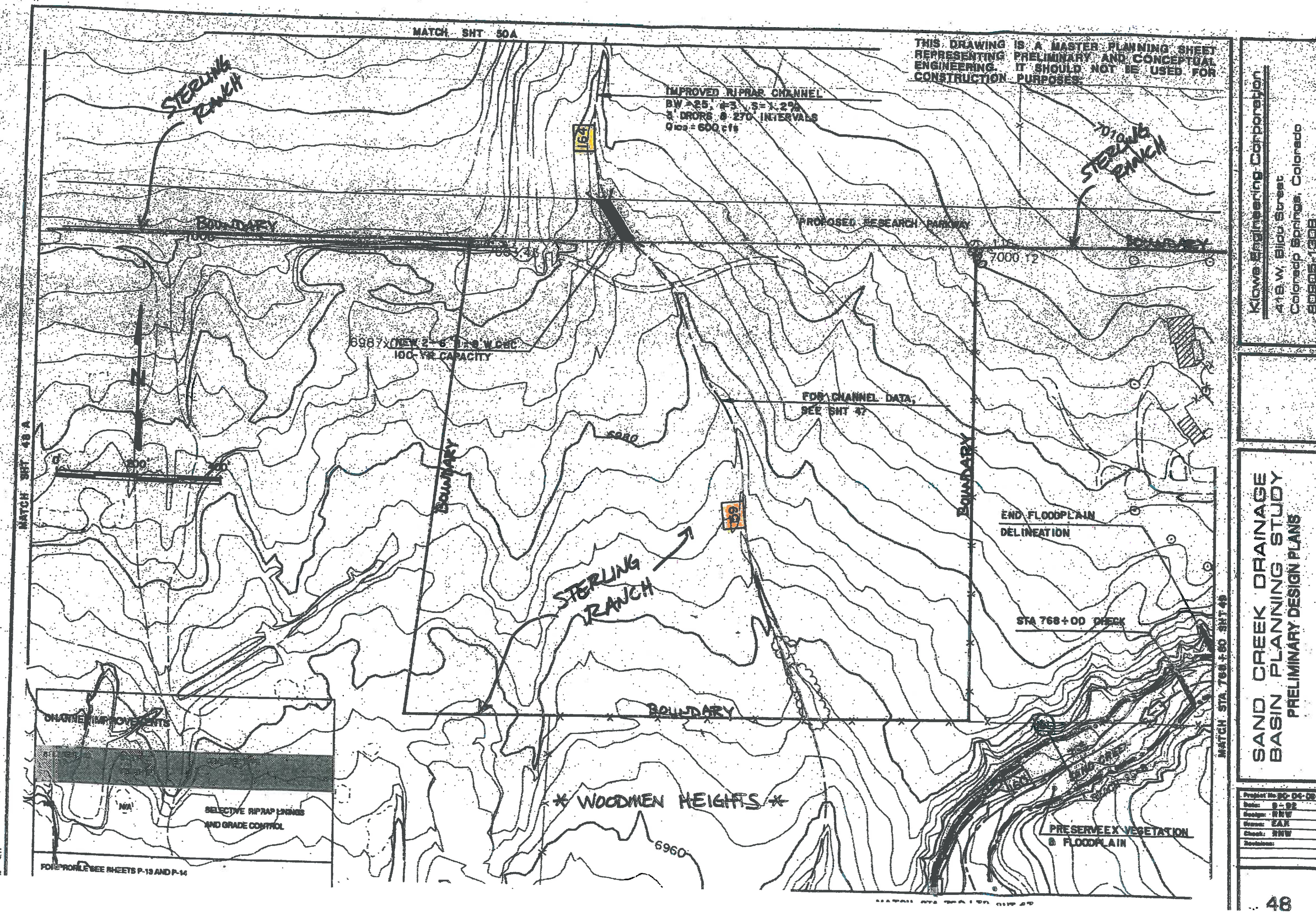

MATCH STA 820+00 SHT 51
THIS DRAWING IS A MASTER PLANNING SHEET REPRESENTING PRELIMINARY AND CONCEPTUAL ENGINEERING. IT SHOULD NOT BE USED FOR CONSTRUCTION PURPOSES.
STA 818+00 CHECK
7070
7060
7050
7040
7030
7020
7010
7000
165
815
SAND CREEK REACH SC-8
CHANNEL IMPROVEMENTS
165
SELECTIVE RIPRAP LININGS AND GRADE CONTROL
FOR PROFILE SEE SHEET P-14
PROVIDE 100-YR CAPACITY OUTLET CONTROL STRUCTURE
WATER SURFACE
01-PND-43
EX EMBANKMENT TO REMAIN
STA 805+00 CHECK
STA 808+00 CHECK
STA 802+00 CHECK
STA 798+00 CHECK
STA 795+00 CHECK
STA 792+00 CHECK
7042x43
7042x02
7035x21
7029x88
7028x69
7046x18
Sterling Ranch (whole sheet)
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 STA 791+30 SHT 49
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: 11/92
Design: RNW
Drawn: EAX
Check: RNW
Revisions:



THIS DRAWING IS A MASTER PLANNING SHEET REPRESENTING PRELIMINARY AND CONCEPTUAL ENGINEERING. IT SHOULD NOT BE USED FOR CONSTRUCTION PURPOSES.
7050
7051x95
7050
7040
7040
7030
7030
7030
7020
7020
7027x77
7027x78
VOLLMER ROAD
BOUNDARY
BOUNDARY
STERLING RANCH
FOR CHANNEL DATA, SEE SHT 48
N
0'
200'
400'
MATCH SHT 48
MATCH SHT 50
Kiowa Engineering Corporation
419 W. Bijou Street
Colorado Springs, Colorado
80905-1308
SAND CREEK DRAINAGE
BASIN PLANNING STUDY
PRELIMINARY DESIGN PLANS
50 A



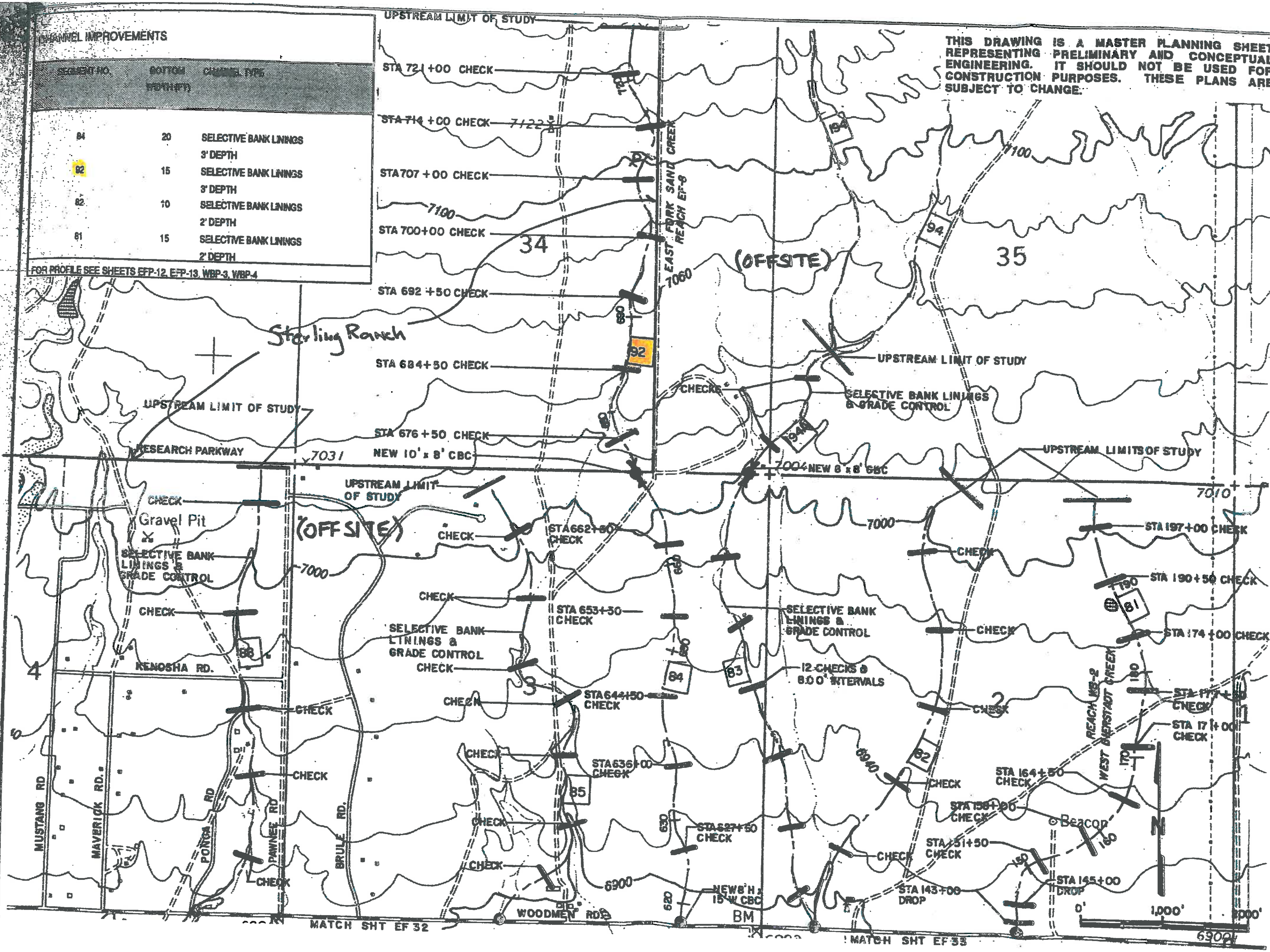
MATCH STA 791+30 SHT 50
AREAS WITHIN THE EXISTING FLOODPLAIN OR THE LOW FLOW ZONE OF THE DRAINAGEWAY WHERE RIPARIAN OR WETLAND VEGETATION EXIST SHALL BE PRESERVED IN ITS EXISTING CROSS-SECTION. AREAS DISTURBED BY THE CONSTRUCTION OF DROPS, GRADE CONTROLS, CULVERTS OR CHANNEL BANK LININGS SHALL BE REVEGETATED WITH NATIVE SPECIES.
THIS DRAWING IS A MASTER PLANNING SHEET REPRESENTING PRELIMINARY AND CONCEPTUAL ENGINEERING. IT SHOULD NOT BE USED FOR CONSTRUCTION PURPOSES.
Sterling Ranch
STA 788+00 CHECK
100-YR. CAP
PROPOSED RESEARCH PARKWAY
STA 782+50 CHECK
NEW 6'H x 8'W CBC
100-YR CAPACITY
(OFF SITE)
7023.68
REMOVE EX. 36" x 48" CMPE
MUSTANG PLACE
STA 775+00 CHECK
TWIN 6'H x 8'W CBC
100-YR CAPACITY
TO REMAIN
NEW 2-48" CMP W/FES
100-YR CAPACITY
EAST FORK SAND CREEK BASIN
7015x65
SAND CREEK REACH SC-6
7008x12
770
7000
MATCH STA 769+60 SHT 46
200'
400'
CHANNEL IMPROVEMENTS
N/A
SELECTIVE RIPRAP LININGS AND GRADE CONTROL
FOR PROFILE SEE SHEET P-14
MATCH SHT 47B
Kiowa Engineering Corporation
419 W. Bijou Street
Colorado Springs, Colorado
80905-1308
SAND CREEK DRAINAGE BASIN PLANNING STUDY
PRELIMINARY DESIGN PLANS
Project No. 90-04-05
Designer: RHW
Drawn: EAK
Check: RHW
49


MATCH SHT 50A
THIS DRAWING IS A MASTER PLANNING SHEET REPRESENTING PRELIMINARY AND CONCEPTUAL ENGINEERING. IT SHOULD NOT BE USED FOR CONSTRUCTION PURPOSES.
IMPROVED RIPRAP CHANNEL
STERLING RANCH
BOUNDARY
PROPOSED RESEARCH PARKWAY
7000
7010
6987X NEW 2-6 D+8 W CBC
100-YR CAPACITY
N
0' 200'
MATCH SHT 48 A
FOR CHANNEL DATA, SEE SHT 47
6980
END FLOODPLAIN DELINEATION
STA 768+00 CHECK
CHANNEL IMPROVEMENTS
N/A
SELECTIVE RIPRAP LININGS AND GRADE CONTROL
WOODMEN HEIGHTS
6960
PRESERVE EX VEGETATION & FLOODPLAIN
Kiowa Engineering Corporation
419 W. Bijou Street
Colorado Springs, Colorado
80905-1308
SAND CREEK DRAINAGE BASIN PLANNING STUDY
PRELIMINARY DESIGN PLANS
48

CHANNEL IMPROVEMENTS

SEGMENT NO.	BOTTOM WIDTH (FT)	CHANNEL TYPE
84	20	SELECTIVE BANK LININGS 3' DEPTH
92	15	SELECTIVE BANK LININGS 3' DEPTH
82	10	SELECTIVE BANK LININGS 2' DEPTH
81	15	SELECTIVE BANK LININGS 2' DEPTH

FOR PROFILE SEE SHEETS EFP-12, EFP-13, WBP-3, WBP-4



THIS DRAWING IS A MASTER PLANNING SHEET REPRESENTING PRELIMINARY AND CONCEPTUAL ENGINEERING. IT SHOULD NOT BE USED FOR CONSTRUCTION PURPOSES. THESE PLANS ARE SUBJECT TO CHANGE.

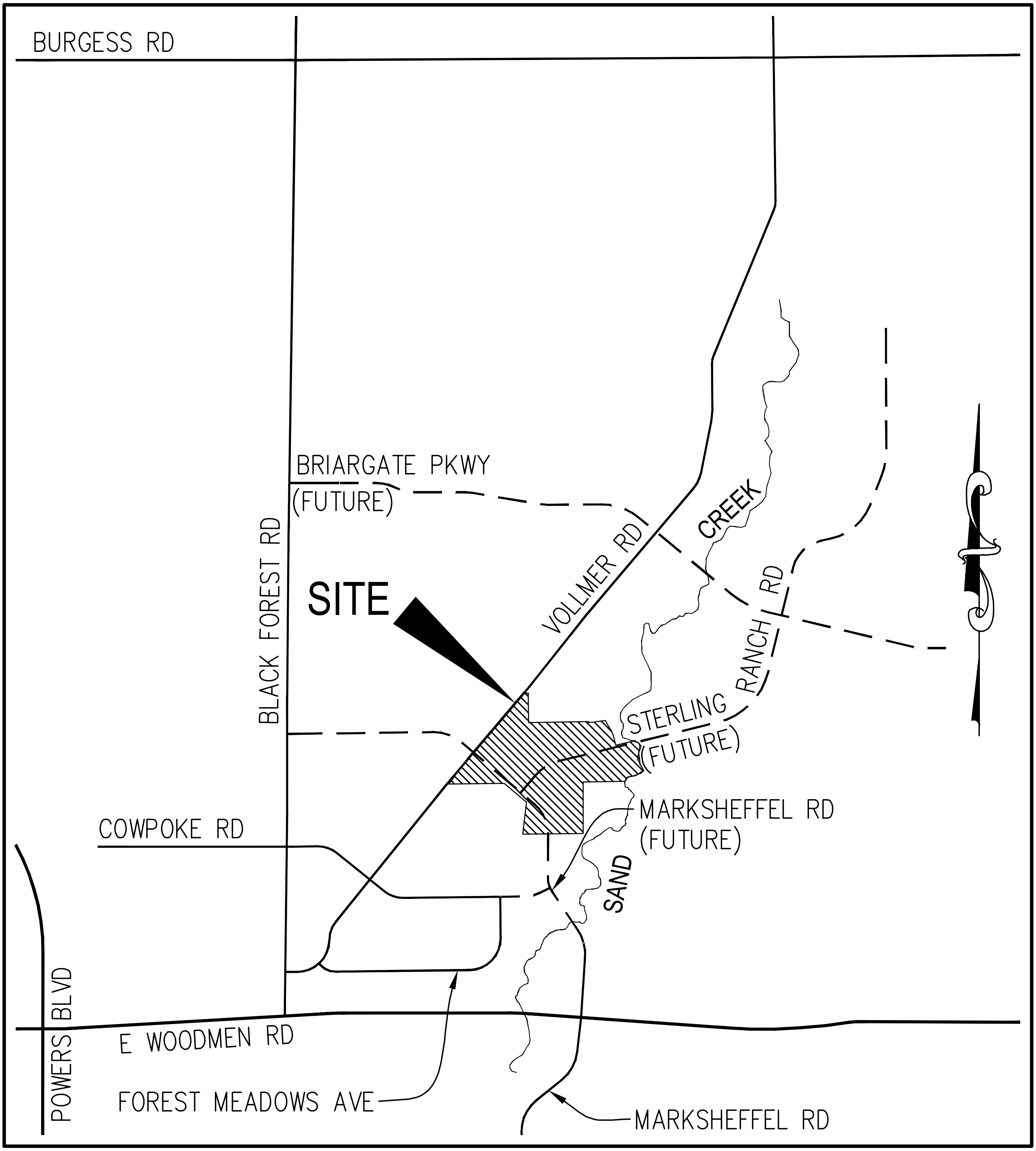
Kiowa Engineering Corporation
419 W. Bijou Street
Colorado Springs, Colorado
80905-1308

SAND CREEK DRAINAGE BASIN PLANNING STUDY
PRELIMINARY DESIGN PLANS

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

EF-34

VICINITY MAP



VICINITY MAP

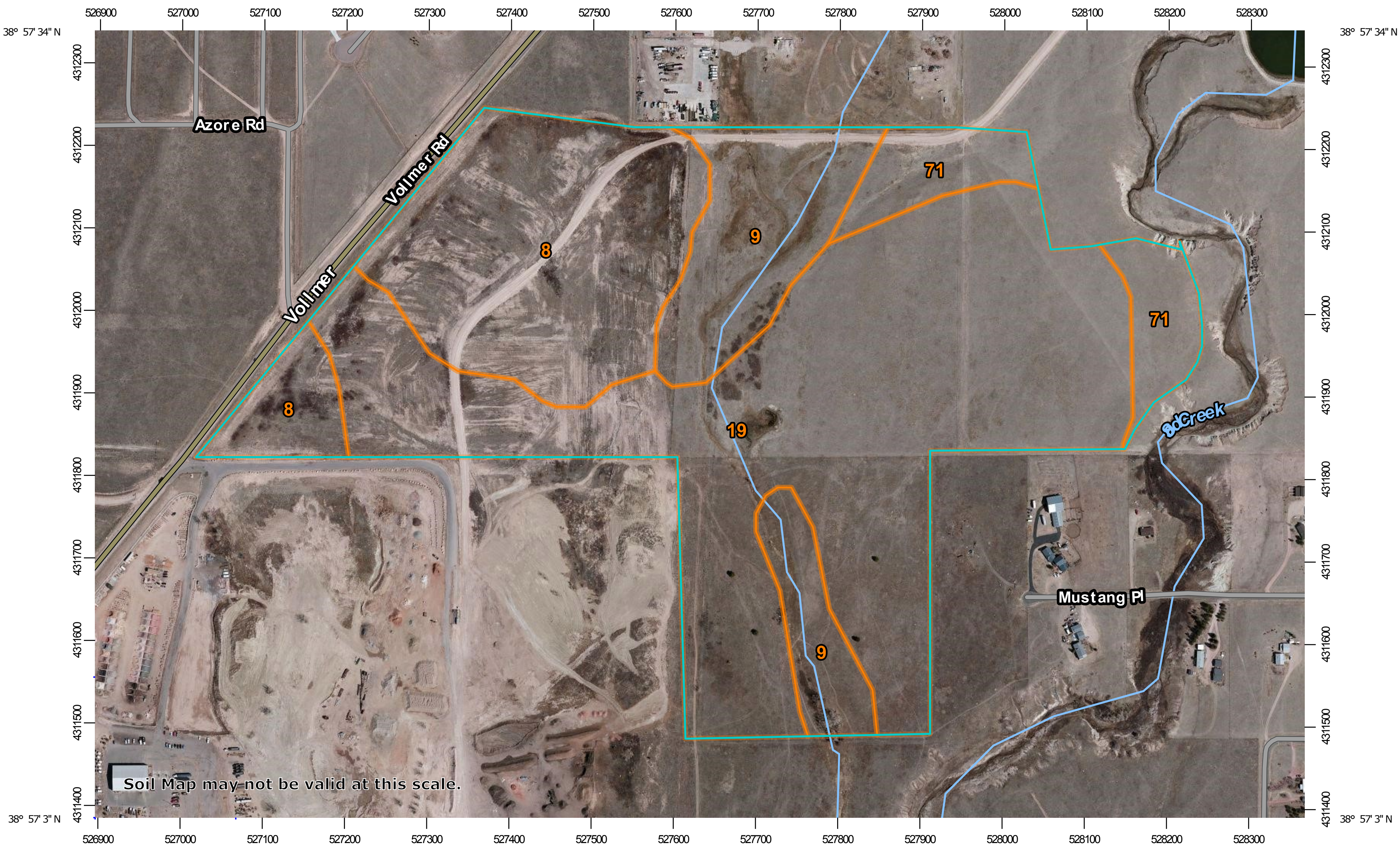
N.T.S.

SOILS MAP

Soil Map—El Paso County Area, Colorado
(Sterling Ranch Filing No. 2)

104° 41' 22" W

104° 40' 21" W



104° 41' 22" W

104° 40' 21" W

Map Scale: 1:6,730 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 50, 100, 200, 300

Feet: 0, 300, 600, 1200, 1800

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.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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 14, Sep 23, 2016

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

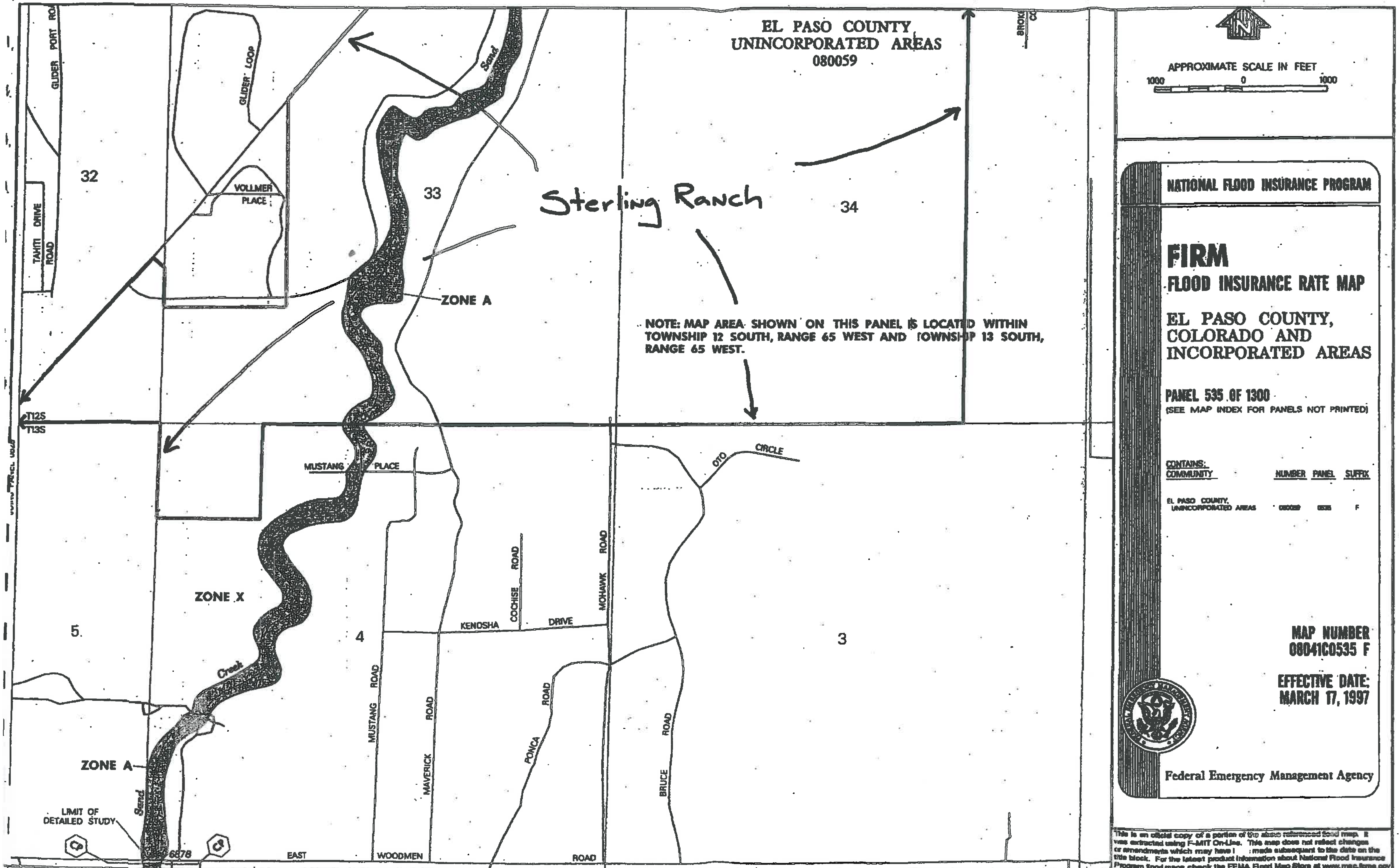
Date(s) aerial images were photographed: Apr 15, 2011—Sep 22, 2011

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.

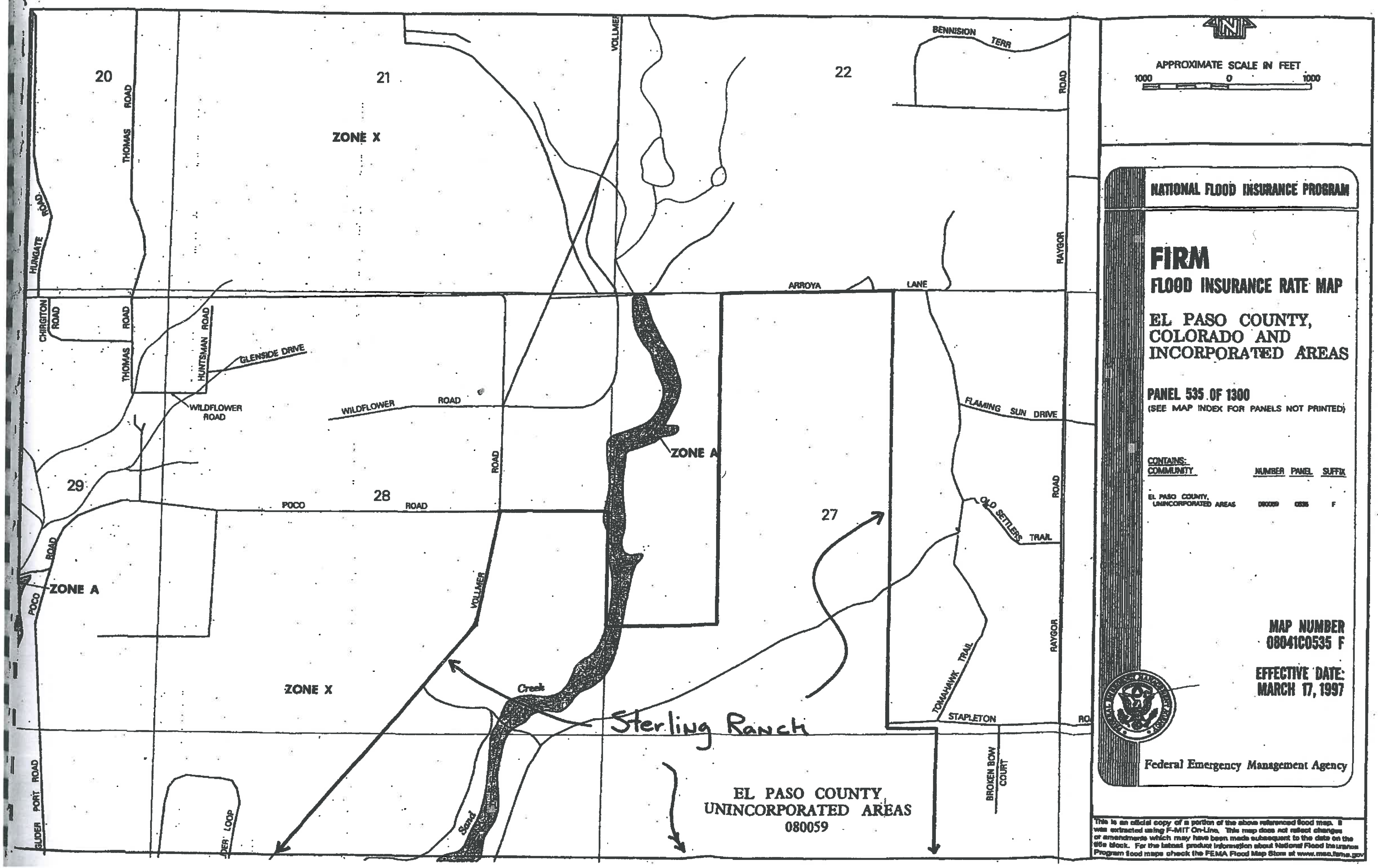
Map Unit Legend

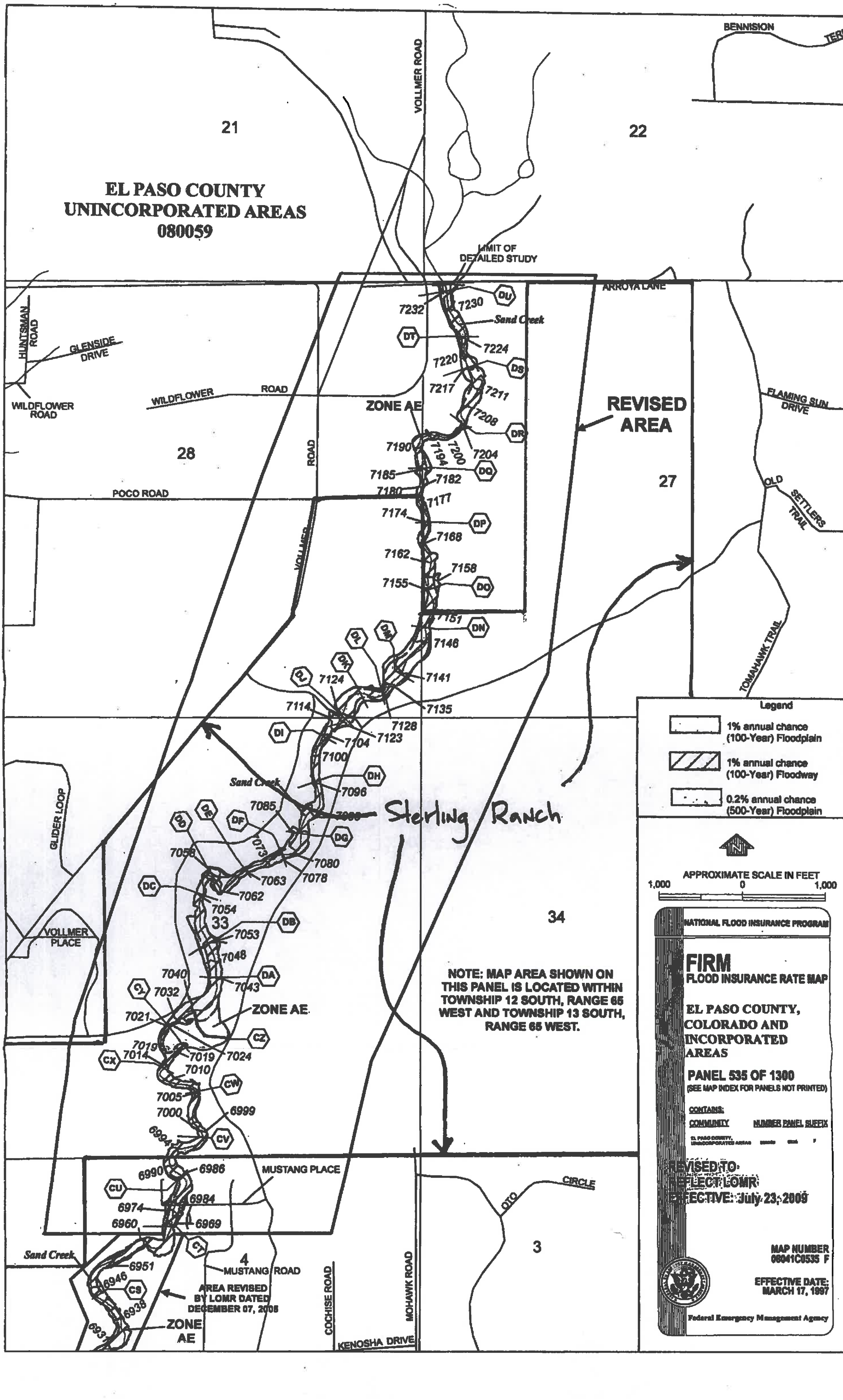
El Paso County Area, Colorado (CO625)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
8 Type A	Blakeland loamy sand, 1 to 9 percent slopes	30.5	25.1%
9 Type A	Blakeland-Fluvaquentic Haplaquolls	17.2	14.1%
19 Type A	Columbine gravelly sandy loam, 0 to 3 percent slopes	65.4	53.8%
71 Type B	Pring coarse sandy loam, 3 to 8 percent slopes	8.4	7.0%
Totals for Area of Interest		**121.5**	**100.0%**

FIRM PANEL W/ REVISED LOMR



EL PASO COUNTY
UNINCORPORATED AREAS
080059
APPROXIMATE SCALE IN FEET
1000 0 1000
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
EL PASO COUNTY, COLORADO AND INCORPORATED AREAS
PANEL 535 OF 1300
(SEE MAP INDEX FOR PANELS NOT PRINTED)
CONTAINS:
COMMUNITY NUMBER PANEL SUFFIX
EL PASO COUNTY, UNINCORPORATED AREAS F
MAP NUMBER
08041C0535 F
EFFECTIVE DATE:
MARCH 17, 1997
Federal Emergency Management Agency
This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov
Sterling Ranch
NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 12 SOUTH, RANGE 65 WEST AND TOWNSHIP 13 SOUTH, RANGE 65 WEST.
GLIDER PORT ROAD
GLIDER LOOP
VOLLMER PLACE
TAHITI DRIVE ROAD
32
33
34
5
4
3
ZONE A
ZONE X
T12S
T13S
MUSTANG PLACE
OTO CIRCLE
COCHISE ROAD
MOHAWK ROAD
KENOSHA DRIVE
MUSTANG ROAD
MAVERICK ROAD
PONCA ROAD
BRUCE ROAD
Sand Creek
LIMIT OF DETAILED STUDY
6878
EAST WOODMEN ROAD


20
21
22
ZONE X
BENNISION TERR
VOLLMER
THOMAS ROAD
HUNGATE ROAD
CHIRGTON ROAD
HUNTSMAN ROAD
GLENSIDE DRIVE
WILDFLOWER ROAD
ARROYA LANE
RAYGOR ROAD
FLAMING SUN DRIVE
ZONE A
29
28
27
POCO ROAD
OLD SETTLERS TRAIL
TOMAHAWK TRAIL
STAPLETON
Creek
Sand
Sterling Ranch
ZONE X
EL PASO COUNTY
UNINCORPORATED AREAS
080059
BROKEN BOW COURT
GLIDER PORT ROAD
APPROXIMATE SCALE IN FEET
1000 0 1000
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
EL PASO COUNTY, COLORADO AND INCORPORATED AREAS
PANEL 535 OF 1300
(SEE MAP INDEX FOR PANELS NOT PRINTED)
CONTAINS:
COMMUNITY NUMBER PANEL SUFFIX
EL PASO COUNTY, UNINCORPORATED AREAS F
MAP NUMBER 08041C0535 F
EFFECTIVE DATE: MARCH 17, 1997
Federal Emergency Management Agency
This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov


EL PASO COUNTY
UNINCORPORATED AREAS
080059
21
22
27
28
33
34
3
4
VOLLMER ROAD
BENNISION TERR
LIMIT OF DETAILED STUDY
ARROYA LANE
HUNTSMAN ROAD
GLENSIDE DRIVE
WILDFLOWER ROAD
POCO ROAD
FLAMING SUN DRIVE
OLD SETTLERS TRAIL
TOMAHAWK TRAIL
REVISED AREA
ZONE AE
Sand Creek
Sterling Ranch
GLIDER LOOP
VOLLMER PLACE
MUSTANG PLACE
MUSTANG ROAD
CIRCLE
OTO
COCHISE ROAD
MOHAWK ROAD
KENOSHA DRIVE
AREA REVISED BY LOMR DATED DECEMBER 07, 2006
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

WETLAND PERMIT

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
200 SOUTH SANTA FE AVENUE, SUITE 301
PUEBLO, COLORADO 81003-4270

SIGNED

REPLY TO
ATTENTION OF

February 29, 2016

Regulatory Division

SUBJECT: Action No. SPA-2015-00428-SCO, Sterling Ranch Residential Development Project, El Paso County, Colorado

Jim Morley
SR Land, LLC
20 Boulder Crescent Suite 201
Colorado Springs, CO 80903

Mr. Morley:

You are hereby authorized under Section 404 of the Clean Water Act to discharge dredged and fill material into waters of the United States to conduct work in associated with construction of the Sterling Ranch Residential Development in accordance with Action Number SPA-2015-00428-SCO. A copy of the permit is enclosed.

To use this permit, you must ensure that the work is conducted in accordance with the terms and conditions of the permit. You must submit revised drawings to us for approval prior to construction should any changes be found necessary in either the location or plans for the work. Approval of revised plans may be granted if they are found not contrary to the public interest.

This permit is not an approval of the project design features, nor does it imply that the construction is adequate for its intended purpose. This permit does not authorize any injury to property or invasion of rights or any infringement of Federal, state or local laws or regulations. You must possess the authority, including property rights, to undertake the proposed work.

Enclosed is a compliance certification form. Upon completion of the project, please sign and date the form and return it to this office.

If you have any questions concerning our regulatory program, please contact me at 719-543-6915 or by e-mail at van.a.truan@usace.army.mil. At your convenience, please complete a Customer Service Survey at http://per2.nwp.usace.army.mil/survey.html.

Sincerely,

Van Truan
Chief, Southern Colorado
Regulatory Branch

Enclosure(s)

September 23, 2016

Mr. Virgil Sanchez
MS Civil Consultants, Inc.
20 Boulder Crescent, Suite 110
Colorado Springs, CO 80903

RE: Sand Creek Wetland Memo
Sterling Ranch Residential Development Project
El Paso County, Colorado

Dear Mr. Sanchez:

CORE Consultants, Inc. (CORE) was retained by MS Civil Consultants, Inc. to complete a wetland delineation for portions of the proposed Sterling Ranch Residential Development Project ("Project"). The Project is located on approximately 1,500 acres in unincorporated El Paso County (County), Colorado, and encompasses a portion of the perennial stream Sand Creek, its western tributaries, and adjacent uplands. CORE submitted a formal wetland delineation report to the U.S. Army Corps of Engineers (USACE) as a component of a Section 404 permit application for the Project (Permit Number SPA-2015-00428-SCO), which was approved by the USACE in February, 2016.

At the time of 404 permit issuance, CORE had performed wetland surveys in all areas of the Project covered by the permit. However, at the time of this writing, wetland surveys covering future phases of development have not been performed. Prior to development of future phases not covered under SPA-2015-00428-SCO, a formal wetland delineation will be performed in those areas, and any necessary 404 permitting will be obtained. Based on CORE's findings throughout Sand Creek in the current permit area, CORE expects that wetlands may occur throughout the floodplain in portions of Sand Creek in future development areas further downstream (**Attachment 1:** *Wetland Location Map*).

If you should have any questions, concerns, or require additional information, please feel free to contact our office directly at 303.703.4444.

Sincerely,
CORE Consultants, Inc.

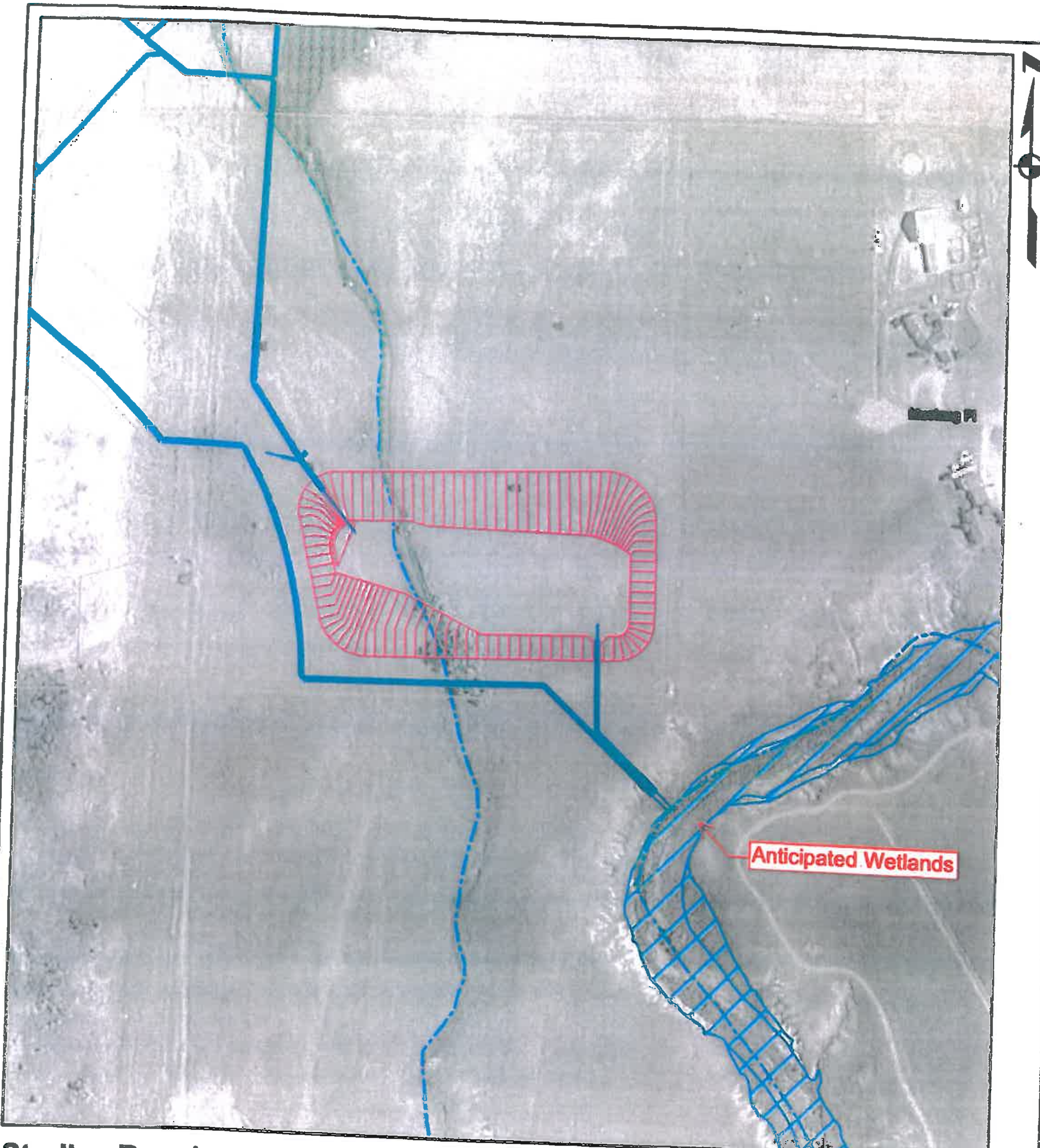
Daniel Maynard

Daniel Maynard
Senior Ecologist

CORE CONSULTANTS

ATTACHMENT I

WETLAND LOCATION MAP



Sterling Ranch

Wetland Location Map

El Paso County, Colorado

0 250 500

Feet

1 inch = 250 feet

Proposed Storm Pipe

Proposed Detention Pond

Wetland

NHD Watercourse

100-year Floodplain

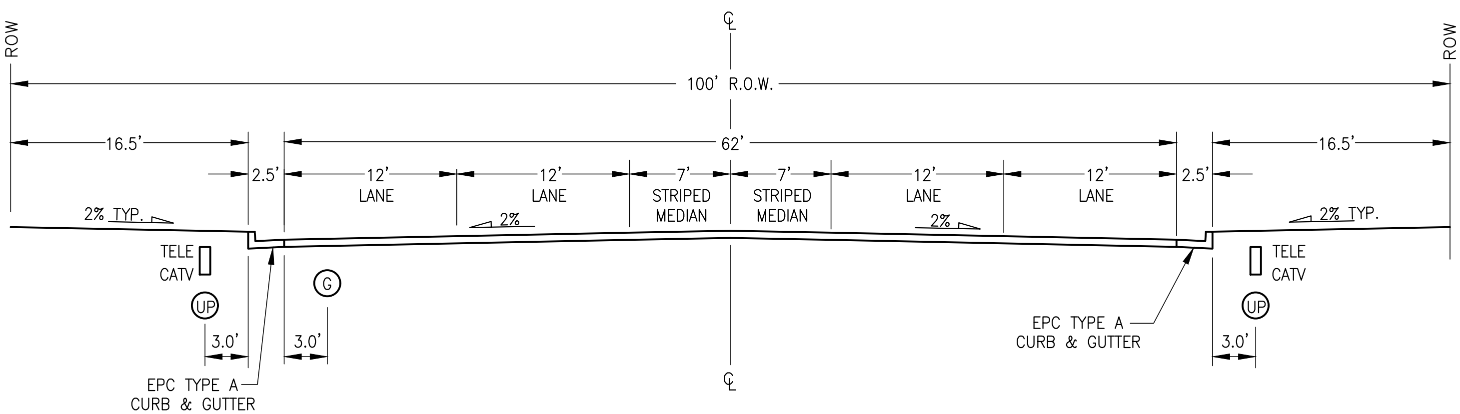
Date: 9/23/2016

Project #: 15-001

CORE CONSULTANTS

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

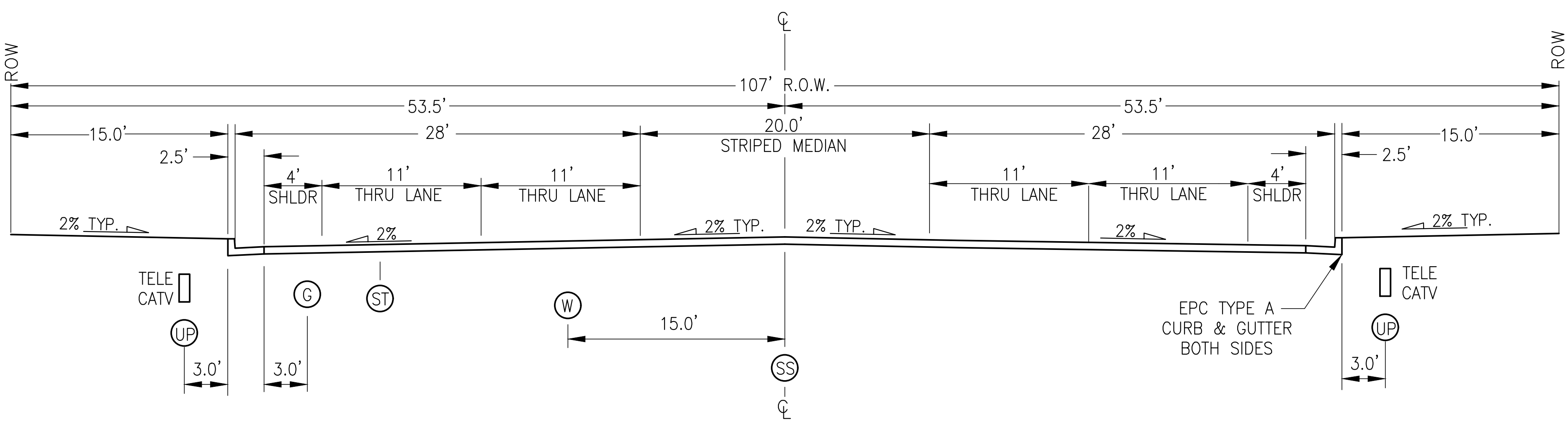
STREET SECTIONS



VOLLMER ROAD

(MODIFIED) URBAN MINOR ARTERIAL CROSS SECTION

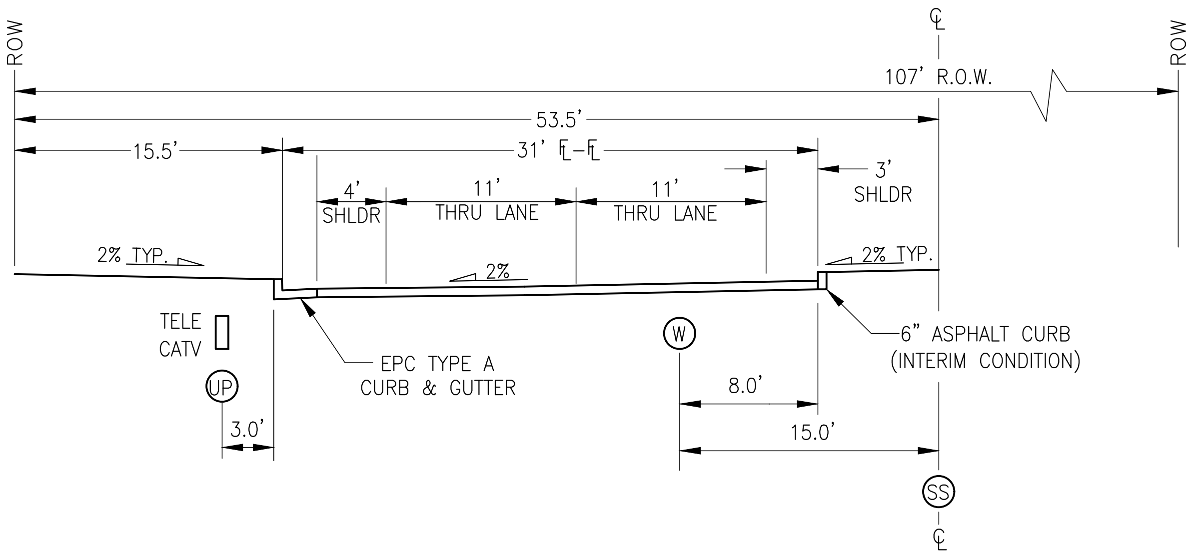
SCALE: NTS



"ULTIMATE" MARKSHEFFEL ROAD

(MODIFIED) 4 LANE URBAN PRINCIPAL ARTERIAL CROSS SECTION

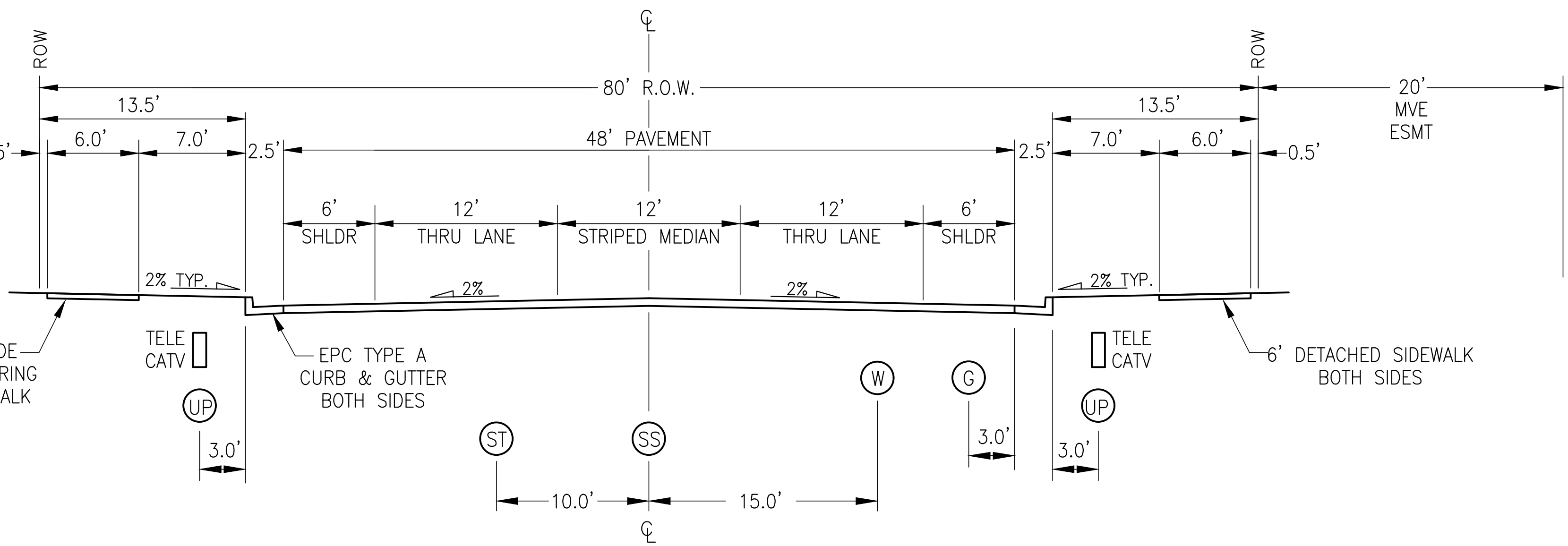
SCALE: NTS



"INTERIM" MARKSHEFFEL ROAD

(MODIFIED) 4 LANE URBAN PRINCIPAL ARTERIAL CROSS SECTION

SCALE: NTS



STERLING RANCH ROAD
URBAN NON-RESIDENTIAL COLLECTOR

SCALE: NTS

HYDROLOGIC CALCULATIONS

STERLING RANCH FILING NO. 2
PRELIMINARY DRAINAGE REPORT
(Area Drainage Summary)

From Area Runoff Coefficient Summary				OVERLAND				STREET / CHANNEL FLOW				Time of Travel (T_t)		INTENSITY *		TOTAL FLOWS	
BASIN	AREA TOTAL (Acres)	C_5	C_{100} (From DCM Table 5-1)	C_5	Length (ft)	Height (ft)	T_C (min)	Length (ft)	Slope (%)	Velocity (fps)	T_t (min)	TOTAL (min)	CHECK (min)	I_5 (in/hr)	I_{100} (in/hr)	Q_5 (c.f.s.)	Q_{100} (c.f.s.)
Proposed Area Drainage Summary																	
XX	0.39	0.22	0.46	0.22	85	4	8.8	0	2.0%	3.0	0.0	8.8	10.5	4.3	7.3	0.4	1.3
YY	4.56	0.22	0.46	0.22	75	1.5	10.9	818	2.9%	2.3	6.0	16.9	15.0	3.5	5.9	3.5	12.4
AAA	9.68	0.49	0.65	0.49	100	2	8.8	924	1.5%	3.0	5.1	13.8	15.7	3.6	6.1	17.3	38.5
BBB	2.74	0.45	0.59	0.45	100	2	9.3	412	2.1%	3.0	2.3	11.6	12.8	3.9	6.6	4.8	10.6
BBB1	8.47	0.45	0.59	0.45	100	1.2	11.1	1240	2.5%	3.0	6.8	17.9	17.4	3.3	5.5	12.4	27.3
FFF1	1.04	0.22	0.46	0.22	204	4.08	18.1	444	1.3%	2.3	3.3	21.3	13.6	3.7	6.2	0.8	2.9
GGG	0.63	0.49	0.62	0.49	80	1.6	7.8	264	2.9%	3.0	1.5	9.3	11.9	4.2	7.1	1.3	2.8
FFF	19.14	0.49	0.62	0.49	100	2	8.8	781	1.8%	3.0	4.3	13.1	14.9	3.7	6.3	35.0	74.3
CCC	3.12	0.49	0.62	0.49	100	2	8.8	641	3.6%	3.0	3.5	16.6	14.1	3.6	6.1	5.5	11.7
HHH	3.59	0.08	0.35	0.08	100	2	14.7	590	2.4%	3.0	3.2	17.9	13.8	3.6	6.1	1.0	7.7
HHH1	0.69	0.08	0.35	0.08	100	2	14.7	172	1.5%	2.3	1.3	15.9	11.5	3.9	6.6	0.2	1.6
III	0.76	0.08	0.35	0.08	50	1	10.4	0	2.4%	3.0	0.0	10.4	10.3	4.1	6.9	0.2	1.8
JJJ	3.11	0.22	0.46	0.22	82	1.64	11.4	0	2.4%	3.0	0.0	11.4	10.5	4.1	6.8	2.8	9.8
OOO	25.89	0.45	0.59	0.45	62	1.24	7.4	2058	2.0%	3.0	11.3	18.7	21.8	3.2	5.4	37.2	81.9
PPP1	1.23	0.22	0.46	0.22	65	1.3	10.2	0	2.0%	2.3	0.0	10.2	10.4	4.1	6.9	1.1	3.9
PPP2	0.75	0.22	0.46	0.22	65	1.3	10.2	0	2.0%	2.3	0.0	10.2	10.4	4.1	6.9	0.7	2.4
QQQ	5.76	0.08	0.35	0.08	100	2	14.7	1080	2.0%	2.3	7.9	22.6	16.6	3.4	5.7	1.6	11.4
RRR	1.18	0.81	0.88	0.81	100	2	4.2	220	2.0%	2.3	1.6	5.8	11.8	3.9	6.5	3.7	6.8
SSS	1.21	0.22	0.46	0.22	60	1.2	9.8	0	2.0%	2.3	0.0	9.8	10.3	4.1	6.8	1.1	3.8
TTT	1.38	0.08	0.35	0.08	100	3	12.8	167	2.4%	2.3	1.2	14.0	11.5	3.9	6.6	0.4	3.2
UUU	7.95	0.08	0.35	0.08	40	10	4.0	386	0.5%	2.3	2.8	6.9	12.4	4.7	7.9	3.0	21.9
JP-1	12.19	0.39	0.55	0.39	100	2	10.2	763	1.3%	3.0	4.2	14.4	14.8	3.6	6.0	17.0	40.6
JP-7A	1.7	0.90	0.96	0.90	25	0.5	1.4	1624	1.7%	3.0	8.9	10.4	19.2	4.1	6.8	6.2	11.2
JP-7B	1.53	0.90	0.96	0.90	25	0.5	1.4	1624	1.7%	3.0	8.9	10.4	19.2	4.1	6.8	5.6	10.1
JP-7C	0.66	0.90	0.96	0.90	100	2	2.9	722	0.8%	3.0	4.0	6.8	14.6	4.7	7.9	2.8	5.0
JP-7D	0.61	0.90	0.96	0.90	25	0.5	1.4	722	0.8%	3.0	4.0	5.4	14.2	5.1	8.5	2.8	5.0
JP-11	8.56	0.81	0.88	0.81	100	2	4.2	928	1.3%	3.0	5.1	9.3	15.7	4.2	7.1	29.4	53.7
JP-11 UNDEV	8.56	0.08	0.35	0.08	100	2	14.7	928	1.3%	2.3	6.8	21.4	15.7	3.0	5.0	2.0	15.0
JP-12	5.37	0.81	0.88	0.81	100	2	4.2	612	1.3%	3.0	3.4	7.5	14.0	4.6	7.6	19.8	36.1
JP-12 UNDEV	5.37	0.08	0.35	0.08	100	2	14.7	612	1.3%	2.3	4.5	19.1	14.0	3.2	5.3	1.4	10.0
OS2	17	0.55	0.87	0.56	300	9	12.0	1125	3.5%	2.3	8.2	20.2	17.9	3.3	5.5	30.4	80.8
OS3	28.7	0.36	0.55	0.36	300	9	16.1	1185	3.0%	2.3	8.7	24.8	18.3	3.2	5.4	33.3	85.5
OS4	5.13	0.20	0.44	0.20	300	9	19.6	700	7.0%	2.3	5.1	24.7	15.6	3.5	5.8	3.6	13.1
OS20	308	0.10	0.36	0.10	500	9.3	32.9	7282	1.9%	2.3	53.4	86.2	53.2	1.6	2.7	49.9	301.5
OS20A	15.73	0.10	0.36	0.10	300	6	24.9	2031	2.5%	2.3	14.9	39.8	23.0	2.9	4.8	4.5	27.4
OS20B	36.32	0.10	0.36	0.10	300	6	24.9	1712	2.5%	2.3	12.5	37.4	21.2	3.0	5.0	10.9	65.9
OS20C	106.79	0.10	0.36	0.10	300	6	24.9	7551	2.5%	2.3	55.3	80.2	53.6	1.6	2.7	17.2	103.8
OS20D	149.16	0.10	0.36	0.10	300	6	24.9	6901	2.5%	2.3	50.6	75.4	50.0	1.7	2.9	25.6	154.5
OS21	33	0.11	0.37	0.11	300	2	35.4	2673	2.0%	2.3	19.6	55.0	26.5	2.7	4.5	9.7	54.6
OS21A	8.87	0.11	0.37	0.11	100	2	14.2	1837	2.0%	2.3	13.5	27.7	20.8	3.0	5.1	3.0	16.7
OS21B	15.37	0.11	0.37	0.11	100	2	14.2	1784	2.0%	2.3	13.1	27.3	20.5	3.1	5.1	5.2	29.2
OS21C	8.76	0.11	0.37	0.11	100	2	14.2	1167	2.0%	3.0	6.4	20.6	17.0	3.3	5.6	3.2	18.1
RP-3A	4.12	0.90	0.96	0.90	45	0.9	1.9	2273	1.8%	3.0	12.5	14.4	22.9	3.6	6.0	12.5	22.4
RP-3B	3.12	0.90	0.96	0.90	45	0.9	1.9	2273	1.8%	3.0	12.5	14.4	22.9	3.6	6.0	9.6	17.2
RP-4A	1.94	0.90	0.96	0.90	45	0.9	1.9	1735	1.5%	3.0	9.5	11.5	19.9	3.9	6.6	6.9	12.3
RP-4B	2.05	0.90	0.96	0.90	45	0.9	1.9	1735	1.5%	3.0	9.5	11.5	19.9	3.9	6.6	7.2	13.0
RP-7A	1.93	0.90	0.96	0.90	52	1.04	2.1	2083	2.2%	3.0	11.4	13.5	21.9	3.7	6.2	6.4	11.4
RP-7B	1.76	0.90	0.96	0.90	46	0.92	1.9	2083	2.2%	3.0	11.4	13.4	21.8	3.7	6.2	5.8	10.5
RP-7C UNDEV	1.28	0.08	0.35	0.08	52	1.04	10.6	248	2.3%	2.3	1.8	12.4	11.7	3.8	6.4	0.4	2.9
RP-7D UNDEV	1.21	0.08	0.35	0.08	46	0.92	9.9	248	2.3%	2.3	1.8	11.8	11.6	3.9	6.5	0.4	2.8

* Intensity equations assume a minimum travel time of 5 minutes.

Calculated by: ET
Date: 5/3/2017
Checked by: VAS

#REF! CA_5	Basin	#REF! CA_{100}
0.09	XX	0.18
1.00	YY	2.10
4.74	AAA	6.29
1.23	BBB	1.62
3.81	BBB1	5.00
0.23	FFF1	0.48
0.31	GGG	0.39
9.38	FFF	11.87
1.53	CCC	1.93
0.29	HHH	1.26
0.06	HHH1	0.24
0.06	III	0.27
0.68	JJJ	1.43
11.65	OOO	15.28
0.27	PPP1	0.57
0.17	PPP2	0.35
0.46	QQQ	2.02
0.96	RRR	1.04
0.27	SSS	0.56
0.11	TTT	0.48
0.64	UUU	2.78
4.75	JP-1	6.75
1.53	JP-7A	1.63
1.38	JP-7B	1.47
0.59	JP-7C	0.63
0.55	JP-7D	0.59
6.93	JP-11	7.53
0.68	JP-11 UNDEV	3.00
4.35	JP-12	4.73
0.43	JP-12 UNDEV	1.88
9.35	OS2	14.79
10.33	OS3	15.79
1.03	OS4	2.26
30.80	OS20	110.88
1.57	OS20A	5.66
3.63	OS20B	13.08
10.68	OS20C	38.44
14.92	OS20D	53.70
3.63	OS21	12.21
0.98	OS21A	3.28
1.69	OS21B	5.69
0.96	OS21C	3.24
3.71	RP-3A	3.96
2.81	RP-3B	3.00
1.75	RP-4A	1.86
1.85	RP-4B	1.97
1.74	RP-7A	1.85
1.58	RP-7B	1.69
0.10	RP-7C UNDEV	0.45
0.10	RP-7D UNDEV	0.42

STERLING RANCH FILING NO. 2
PRELIMINARY DRAINAGE REPORT
(Basin Routing Summary)

DESIGN POINT	CONTRIBUTING BASINS	CA_5	CA_{100}	C_5	Length (ft)	Height (ft)	T_C (min)	Length (ft)	Slope (%)	Velocity (fps)	T_t (min)	TOTAL (min)	I_5 (in/hr)	I_{100} (in/hr)	Q_5 (c.f.s.)	Q_{100} (c.f.s.)	COMMENTS
	From Area Runoff Coefficient Summary			OVERLAND				PIPE / CHANNEL FLOW				Time of Travel (T_t)	INTENSITY *		TOTAL FLOWS		
	PROPOSED DRAINAGE BASIN ROUTING SUMMARY																
16	RP-2B, T FILING NO. 1 FDR	3.00	3.43									13.4	3.7	6.2	*11.1*	*21.3*	INTERIM CDOT TYPE D 2.91'x5.67' FUTURE 15' AT-GRADE INLET
17	RP-2A FILING NO. 1 FDR	2.36	2.52									15.2	3.5	5.9	*8.3*	*14.8*	FUTURE 15' AT-GRADE INLET
28	OS3, YY	7.99	11.12									18.3	3.2	5.4	*25.8*	*60.2*	36" FES/TSB BARBARICK SUBDIVISION
29	JP-1, XX	4.34	6.93									14.4	3.6	6.0	*17.3*	*41.7*	36" FES/TSB
30	JP-7A, III	1.59	1.90									10.4	4.1	6.8	*6.5*	*13.0*	15' AT-GRADE INLET
31	JP-7B, JJJ	2.06	2.90									10.5	4.1	6.8	*8.4*	*19.8*	15' AT-GRADE INLET
32	OS2	9.35	14.79									17.9	3.3	5.5	*30.4*	*80.8*	42"FES/TSB BARBARICK SUBDIVISION
33	AAA	4.74	6.29									13.8	3.6	6.1	*17.3*	*38.5*	30" FES/TSB
38	OOO	11.65	15.28									18.7	3.2	5.4	*37.2*	*81.9*	42" FES/TSB
39	BBB	1.23	1.62									11.6	3.9	6.6	*4.8*	*10.6*	10' AT-GRADE INLET FLOW SPLIT
39A	BBB1	3.81	5.00									17.4	3.3	5.5	*12.4*	*27.3*	10' AT-GRADE INLET FLOW SPLIT
40	CCC, FLOWBY DP39, FLOWBY DP39A	1.84	3.69									17.4	3.3	5.5	*6.0*	*20.2*	15' AT-GRADE INLET FLOW SPLIT
43A	FFF	9.38	11.87									13.1	3.7	6.3	*35.0*	*74.3*	42"FES/TSB
44	HHH	0.29	1.26									13.8	3.6	6.1	*1.0*	*7.7*	18" FES/TSB
45	JP-7C, FFF1, GGG, HHH1, FLOWBY DP30, FLOWBY DP40	1.19	2.15									13.6	3.7	6.2	*4.4*	*13.3*	15' AT-GRADE INLET
46	JP-7D FLOWBY DP31	0.59	1.42									10.5	4.1	6.8	*2.4*	*9.7*	15' AT-GRADE INLET
47A	RP-3B, FLOWBY DP16	3.10	4.05									14.4	3.6	6.0	*11.1*	*24.4*	INTERIM AREA INLET 2.9'x5.7' TYPE D CDOT INLET FUTURE 15' AT-GRADE INLET
48A	RP-3A, FLOWBY DP17	3.76	4.43									14.4	3.6	6.0	*13.5*	*26.6*	INTERIM SHEET FLOW OFF SHOULDER INTO ROADSIDE DITCH FUTURE 15' AT-GRADE INLET
47-1	RP-4B, FLOWBY DP47A	2.16	3.40									14.4	3.6	6.0	*7.7*	*20.4*	INTERIM AREA INLET 2.9'x5.7' TYPE D CDOT INLET FUTURE 10' AT-GRADE INLET
47	FLOWBY DP47-1	0.41	1.68									14.4	3.6	6.0	*1.5*	*10.1*	FUTURE 10' AT-GRADE INLET
48-1	RP-4A, FLOWBY DP48A	2.35	3.58									15.2	3.5	5.9	*8.2*	*21.0*	INTERIM SHEET FLOW OFF SHOULDER INTO ROADSIDE DITCH FUTURE 10' AT-GRADE INLET
48	FLOWBY DP48-1	0.48	1.80									15.2	3.5	5.9	*1.7*	*10.6*	FUTURE 10' AT-GRADE INLET

	From Area Runoff Coefficient Summary			OVERLAND				PIPE / CHANNEL FLOW				Time of Travel (T_t)	INTENSITY *		TOTAL FLOWS		
DESIGN POINT	CONTRIBUTING BASINS	CA_5	CA_{100}	C_5	Length (ft)	Height (ft)	T_C (min)	Length (ft)	Slope (%)	Velocity (fps)	T_t (min)	TOTAL (min)	I_5 (in/hr)	I_{100} (in/hr)	Q_5 (c.f.s.)	Q_{100} (c.f.s.)	COMMENTS
49	OS21, DP60, PR62	44.98	135.03									53.2	1.6	2.7	72.9	367.1	W-4 DETENTION POND
49	RELEASE POND W-4	12.82	106.38									53.2	1.6	2.7	20.8	289.4	PEAK OUTFLOW FROM POND W-4--UD-Det v3.06
50	JP-11	6.93	7.53									9.3	4.2	7.1	29.4	53.7	36" FES
51	RP-7B	1.58	1.69									13.4	3.7	6.2	5.8	10.5	15' AT-GRADE INLET
52	RP-7A, FLOWBY DP45 FLOWBY DP46	1.74	2.26									13.6	3.7	6.2	6.4	13.9	15' AT-GRADE INLET
53	JP-12	4.35	4.73									7.5	4.6	7.6	19.8	36.1	30" FES
54	RP-7D UNDEVELOPED, FLOWBY DP51	0.10	0.57									13.4	3.7	6.2	0.4	3.5	TSB
55	RP7C UNDEVELOPED, FLOWBY DP52	0.10	0.80									13.6	3.7	6.2	0.4	4.9	TSB
56	QQQ, PPP1, RRR	1.69	3.62									16.6	3.4	5.7	5.7	20.5	24" FES
57	UUU, PPP2, PR58, OS4, TTT	67.36	95.62									18.7	3.2	5.4	217.4	517.9	CUMM. DETENTION POND 28'x5' inlet INTO SAND CREEK
57	RELEASE POND W-5	0.97	27.92									18.7	3.2	5.4	3.1	149.7	PEAK OUTFLOW FROM POND W-5--UD-Det v3.06
60	OS20	36.85	116.31									53.2	1.6	2.7	59.7	316.2	3.5'x5.5' HECMP/ EX SWALE
68	PR67, PR71														42.2	472.4	84" RCP PEAK OUTFLOW INTO SAND CREEK
69	OS20A Sub-basin Cummulative Flow	1.57	5.66									23.0	2.9	4.8	4.5	27.4	24" RCP/ EX SWALE
70	OS20B, DP69 Sub-basin Cummulative Flow	5.21	18.74									23.0	2.9	4.8	15.0	90.7	EX 24" CMP/ EX SWALE
71	OS20C, DP70 Sub-basin Cummulative Flow	15.88	57.18									53.6	1.6	2.7	25.6	154.4	EX 24" CMP/ EX SWALE
72	OS21A, DP 60 Sub-basin Cummulative Flow	44.68	128.07									53.6	1.6	2.7	71.9	345.9	EX SWALE
73	OS21C Sub-basin Cummulative Flow	0.96	3.24									17.0	3.3	5.6	3.2	18.1	24" RCP

* Intensity equations assume a minimum travel time of 5 minutes.

Calculated by: ET
Date: 5/3/2017
Checked by: VAS

Minor Storm Capacity Rating Table for Collector Section

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.02000	ft/ft
Normal Depth	0.49	ft
Section Definitions		

Station (ft)	Elevation (ft)
0+00	0.70
0+10	0.50
0+10	0.50
0+10	0.00
0+12	0.13
0+30	0.49
0+46	0.13
0+50	0.00
0+50	0.50
0+51	0.50
0+60	0.70

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 0.70)	(0+10, 0.50)	0.020
(0+10, 0.50)	(0+51, 0.50)	0.016
(0+51, 0.50)	(0+60, 0.70)	0.020

Channel Slope (ft/ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.00000			8.12	41.00	40.00

Minor Storm Capacity Rating Table for Collector Section

Input Data

Channel Slope (ft/ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.00250	11.32	1.39	8.12	41.00	40.00
0.00500	16.01	1.97	8.12	41.00	40.00
0.00750	19.60	2.41	8.12	41.00	40.00
0.01000	22.64	2.79	8.12	41.00	40.00
0.01250	25.31	3.12	8.12	41.00	40.00
0.01500	27.72	3.41	8.12	41.00	40.00
0.01750	29.95	3.69	8.12	41.00	40.00
0.02000	32.01	3.94	8.12	41.00	40.00
0.02250	33.96	4.18	8.12	41.00	40.00
0.02500	35.79	4.41	8.12	41.00	40.00
0.02750	37.54	4.62	8.12	41.00	40.00
0.03000	39.21	4.83	8.12	41.00	40.00
0.03250	40.81	5.03	8.12	41.00	40.00
0.03500	42.35	5.22	8.12	41.00	40.00
0.03750	43.84	5.40	8.12	41.00	40.00
0.04000	45.27	5.58	8.12	41.00	40.00
0.04250	46.67	5.75	8.12	41.00	40.00
0.04500	48.02	5.91	8.12	41.00	40.00
0.04750	49.34	6.08	8.12	41.00	40.00
0.05000	50.62	6.23	8.12	41.00	40.00

Major Storm Capacity Rating Table for Collector Section

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.02000	ft/ft
Normal Depth	0.70	ft
Section Definitions		

Station (ft)	Elevation (ft)
0+00	0.70
0+10	0.50
0+10	0.50
0+10	0.00
0+12	0.13
0+30	0.49
0+48	0.13
0+50	0.00
0+50	0.50
0+51	0.50
0+60	0.70

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 0.70)	(0+10, 0.50)	0.020
(0+10, 0.50)	(0+51, 0.50)	0.016
(0+51, 0.50)	(0+60, 0.70)	0.020

Channel Slope (ft/ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.00000			18.62	61.02	60.00

Major Storm Capacity Rating Table for Collector Section

Input Data

Channel Slope (ft/ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.00250	36.15	1.94	18.62	61.02	60.00
0.00500	51.12	2.75	18.62	61.02	60.00
0.00750	62.61	3.36	18.62	61.02	60.00
0.01000	72.30	3.88	18.62	61.02	60.00
0.01250	80.83	4.34	18.62	61.02	60.00
0.01500	88.55	4.76	18.62	61.02	60.00
0.01750	95.64	5.14	18.62	61.02	60.00
0.02000	102.25	5.49	18.62	61.02	60.00
0.02250	108.45	5.82	18.62	61.02	60.00
0.02500	114.32	6.14	18.62	61.02	60.00
0.02750	119.90	6.44	18.62	61.02	60.00
0.03000	125.23	6.73	18.62	61.02	60.00
0.03250	130.34	7.00	18.62	61.02	60.00
0.03500	135.26	7.26	18.62	61.02	60.00
0.03750	140.01	7.52	18.62	61.02	60.00
0.04000	144.60	7.77	18.62	61.02	60.00
0.04250	149.05	8.00	18.62	61.02	60.00
0.04500	153.37	8.24	18.62	61.02	60.00
0.04750	157.57	8.46	18.62	61.02	60.00
0.05000	161.67	8.68	18.62	61.02	60.00

HYDRAULIC CALCULATIONS / EDB WQCV CALCULATIONS

STERLING RANCH FILING NO. 2
CONCEPT DRAINAGE CALCULATIONS
(Storm Sewer Routing Summary)

PIPE RUN	Contributing Pipes/Design Points	Equivalent CA_5	Equivalent CA_{100}	Maximum T_C	Intensity*		Flow		PIPE SIZE
					I_5	I_{100}	Q_5	Q_{100}	
16	DP16 FILING NO. 1 FDR	2.70	2.37	13.4	3.7	6.2	10.0	14.7	24" RCP
17	DP17, PR16 FILING NO. 1 FDR	5.01	4.42	15.2	3.5	5.9	17.5	26.0	24" RCP
32	DP28	7.99	11.12	18.3	3.2	5.4	25.8	60.2	36" RCP
33	DP29	4.84	6.93	14.4	3.6	6.0	17.3	41.7	36" RCP
34	PR32, PR33	12.83	18.05	18.3	3.2	5.4	41.4	97.8	48" RCP
34A	DP30	1.60	1.62	10.4	4.1	6.8	6.5	11.1	24" RCP
34B	DP31	2.02	2.08	10.5	4.1	6.8	8.2	14.2	24" RCP
35	PR34, PR34A, PR34B	16.45	21.76	18.3	3.2	5.4	53.1	117.8	48" RCP
36	DP32	9.35	14.79	17.9	3.3	5.5	30.4	80.8	42" RCP
37	DP33	4.74	6.29	13.8	3.6	6.1	17.3	38.5	30" RCP
38	PR36, PR37	14.09	21.08	17.9	3.3	5.5	45.9	115.2	48" RCP
39	PR35, PR38	30.54	42.84	18.3	3.2	5.4	98.5	232.0	66" RCP
44	DP38	11.65	15.28	18.7	3.2	5.4	37.2	81.9	42" RCP
40A	1/2 DP39	0.62	0.81	11.6	3.9	6.6	2.4	5.3	18" RCP
40B	1/2 DP39	0.62	0.81	11.6	3.9	6.6	2.4	5.3	18" RCP
40	DP39	1.24	1.62	11.6	3.9	6.6	4.8	10.6	18" RCP
41A	1/2 DP39A	1.73	1.62	17.4	3.3	5.5	5.7	9.0	18" RCP
41B	DP39A	3.47	3.25	17.4	3.3	5.5	11.4	17.9	24" RCP
41	PR40, PR41B	4.70	4.86	17.4	3.3	5.5	15.5	26.9	24" RCP
42	1/2 DP40, PR47	1.45	2.85	17.4	3.3	5.5	4.8	15.8	24" RCP
47	DP44	0.29	1.26	13.8	3.6	6.1	1.0	7.7	18" RCP
48	1/2 DP40, PR41, PR42	7.07	9.56	17.4	3.3	5.5	23.0	52.3	36" RCP
50	DP43A	9.38	11.87	13.1	3.7	6.3	35.0	74.3	42" RCP
50A	PR48, PR50	16.45	21.43	17.4	3.3	5.5	54.2	118.6	48" RCP
51	DP45	1.20	1.84	13.6	3.7	6.2	4.4	11.3	18" RCP
52	PR50A, PR51	17.64	23.27	17.4	3.3	5.5	58.2	128.8	48" RCP
53	DP46	0.59	1.33	10.5	4.1	6.8	2.4	9.1	18" RCP
54	DP51	1.58	1.56	13.4	3.7	6.2	5.8	9.7	18" RCP
55	DP52, PR54	3.31	3.42	13.4	3.7	6.2	12.2	21.2	30" RCP
56	PR52, PR53	18.24	24.60	17.4	3.3	5.5	60.2	136.2	48" RCP
56A	PR55, PR56	21.55	28.02	17.4	3.3	5.5	71.1	155.2	54" RCP
56B	PR56A	21.55	28.02	17.4	3.3	5.5	71.1	155.2	2-42" RCP
57	PR39, PR56B	52.09	70.86	18.3	3.2	5.4	168.1	383.8	78" RCP
57A	DP56	1.69	3.62	16.6	3.4	5.7	5.7	20.5	24" RCP
58	PR44, PR57, PR57A	65.43	89.76	18.7	3.2	5.4	208.9	481.1	84" RCP
68	DP47A 15' AT-GRADE INLET	2.79	2.63	14.4	3.6	6.0	10.0	15.8	30" RCP
68 INT	DP47A AREA INLET	3.10	4.05	14.4	3.6	6.0	11.1	24.4	30" RCP
69	DP48A 15' AT-GRADE INLET, PR68	6.05	5.43	15.2	3.5	5.9	21.2	31.9	30" RCP
61 INT	DP47 AREA INLET	2.16	3.40	14.4	3.6	6.0	7.7	20.4	30" RCP
61-0	DP47 10' AT-GRADE INLET	1.73	1.71	14.4	3.6	6.0	6.2	10.3	18" RCP
61	DP47 FLOWYBY, PR61-0 10' AT-GRADE INLET	2.15	2.93	14.4	3.6	6.0	7.7	17.6	30" RCP
62-0	DP48 10' AT-GRADE INLET	1.73	1.71	14.4	3.6	6.0	6.2	10.3	18" RCP
62	DP48 FLOWBY, PR62-0, PR61 10' AT-GRADE INLET	4.50	6.51	15.2	3.5	5.9	15.8	38.2	30" RCP
63	DP49	12.82	106.38	53.2	1.6	2.7	20.8	289.4	66" RCP
64	DP50	6.93	7.53	9.3	4.2	7.1	29.4	53.7	36" RCP
65	PR63, PR64	19.75	113.91	53.2	1.6	2.7	32.0	309.9	72" RCP
66	DP53	4.35	4.73	7.5	4.6	7.6	19.8	36.1	30" RCP
67	PR65, PR66	24.10	118.63	53.2	1.6	2.7	39.1	322.7	72" RCP
71	Peak outflow from Pond W-5~UD-Det v3.04						3.1	149.7	48" RCP
73	DP69	1.57	5.66	23.0	2.9	4.8	4.5	27.4	24" RCP
74	PR67, PR71 Summed flows						42.2	472.4	84" RCP
75	DP60	36.85	116.31	53.2	1.6	2.7	59.7	316.2	72" RCP
76	DP 73	0.96	3.24	17.0	3.3	5.6	3.2	18.1	24" RCP

* Intensity equations assume a minimum travel time of 5 minutes.

DP - Design Point
EX - Existing Design Point

FB- Flow By from Design Point
INT- Intercepted Flow from Design Point

Calculated by: ET
Date: 5/3/2017
Checked by: VAS

ENGINEERS EDGE
Solutions By Design

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	84	in
Depth of flow, y =	81	in

(must have $y \geq D/2$)

Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.003	ft/ft

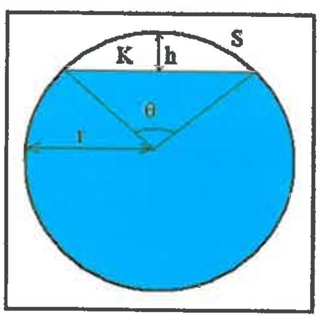
Calculations

n/n_{full} =	1.017857
Partially Full Manning roughness, n =	0.013

Calculations

Pipe Diameter, D =	7	ft
Pipe Radius, r =	3.5	ft
Circ. Segment Height, h =	0.250	ft
Central Angle, q =	0.76	radians
Cross-Sect. Area, A =	38.05	ft^2
Wetted Perimeter, P =	19.3	ft
Hydraulic Radius, R =	1.97	ft
Discharge, Q =	368.58	cfs
Ave. Velocity, V =	9.69	ft/sec

pipe % full [(A/A_{full})*100%] = 98.9%



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A

P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 23 - 84" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

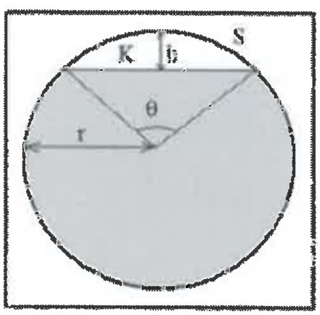
Pipe Diameter, D =	72	in
Depth of flow, y =	72	in
(must have $y \geq D/2$)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.003	ft/ft

Calculations

n/n_{full} =	1
Partially Full Manning roughness, n =	0.013

Calculations

Pipe Diameter, D =	6	ft
Pipe Radius, r =	3	ft
Circ. Segment Height, h =	0.000	ft
Central Angle, q =	0.00	radians
Cross-Sect. Area, A =	28.27	ft^2
Wetted Perimeter, P =	18.8	ft
Hydraulic Radius, R =	1.50	ft
Discharge, Q =	232.59	cfs
Ave. Velocity, V =	8.23	ft/sec
pipe % full $[(A/A_{full})*100\%]$ =	100.0%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 23 - 72" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	30	in
Depth of flow, y =	13	in

(must have y ≥ D/2)

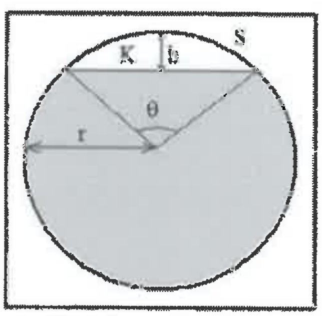
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0847	ft/ft

Calculations

n/n_{full} =	1.2833333
Partially Full Manning roughness, n =	0.017

Calculations

Pipe Diameter, D =	2.5	ft
Pipe Radius, r =	1.25	ft
Circ. Segment Height, h =	1.417	ft
Central Angle, q =	3.41	radians
Cross-Sect. Area, A =	2.04	ft²
Wetted Perimeter, P =	3.6	ft
Hydraulic Radius, R =	0.57	ft
Discharge, Q =	36.33	cfs
Ave. Velocity, V =	17.82	ft/sec
pipe % full [(A/A_{full})*100%] =	41.5%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: **n/n_{full} = 1.25 - (y/D - 0.5)*0.5** (for 0.5 ≤ y/D ≤ 1)

STORM 25 - 30" RCP
PP53

ANSI Screw Slide Chart Selector

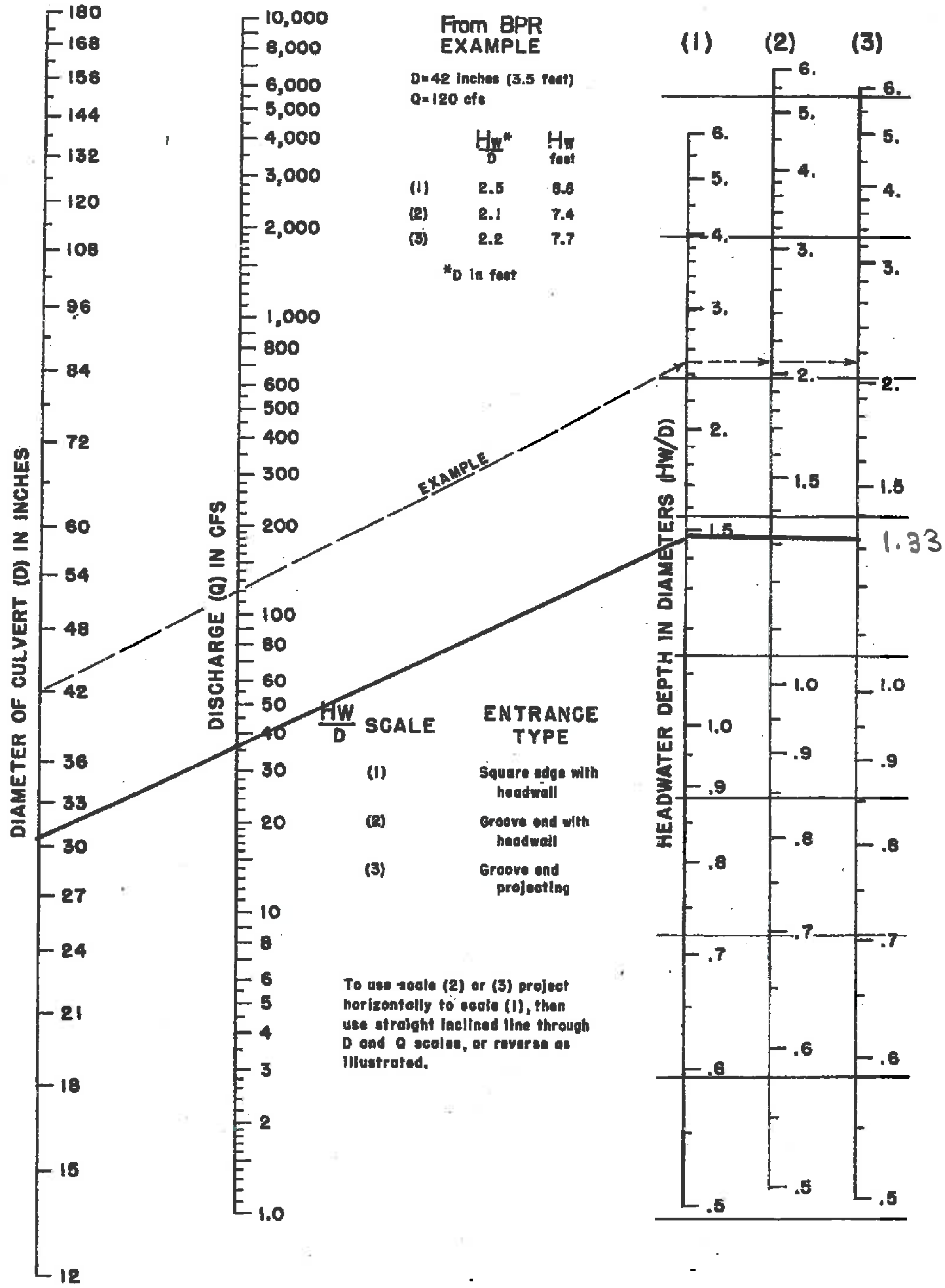
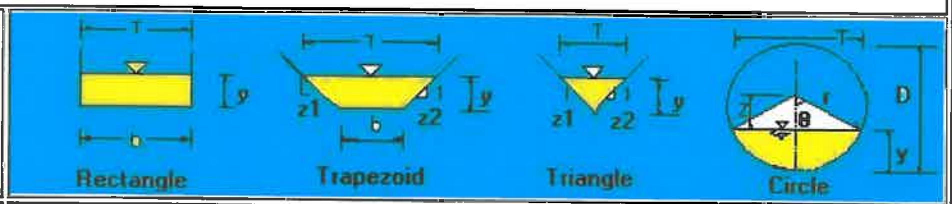


Figure CU-9—Inlet Control Nomograph—Example

DP 53 - Q100 = 36 cfs

The open channel flow calculator

Select Channel Type: Trapezoid



Velocity(V)&Discharge(Q) | Select unit system: Feet(ft)

Channel slope: .109 ft/ft	Water depth(y): 0.7 ft	Bottom width(b) 4 ft
Flow velocity 8.909 ft/s	LeftSlope (Z1): 3 to 1 (H:	RightSlope (Z2): 3 to 1 (H:V
Flow discharge 38.0413 ft^3/s	Input n value 0.035 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 8.43 ft	Flow area 4.27 ft^2	Top width(T) 8.2 ft
Specific energy 1.93 ft	Froude number 2.18	Flow status Supercritical flow
Critical depth 1.08 ft	Critical slope 0.0204 ft/ft	Velocity head 1.23 ft

SR FILZ
TRACT P

DP 53 Q_{100} = 36 cfs

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	72	in
Depth of flow, y =	60	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0063	ft/ft

Calculations

n/n_{full} =	1.0833333	
Partially Full Manning roughness, n =	0.014	

Calculations

Pipe Diameter, D =	6	ft
Pipe Radius, r =	3	ft
Circ. Segment Height, h =	1.000	ft
Central Angle, q =	1.68	radians
Cross-Sect. Area, A =	25.18	ft^2
Wetted Perimeter, P =	13.8	ft
Hydraulic Radius, R =	1.82	ft
Discharge, Q =	315.62	cfs
Ave. Velocity, V =	12.54	ft/sec
pipe % full $[(A/A_{full})*100\%]$ =	89.0%	

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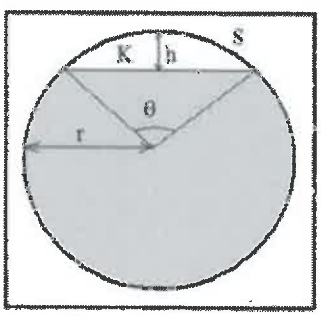


Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2 \arccos\left(\frac{r - h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r * \theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 23 - 72" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

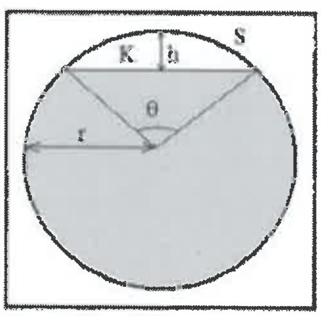
This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs			**Calculations**		
Pipe Diameter, D =	72	in	Pipe Diameter, D =	6	ft
Depth of flow, y =	39	in	Pipe Radius, r =	3	ft
(must have y ≥ D/2)					
			Circ. Segment Height, h =	2.750	ft
Full Pipe Manning roughness, n_{full} =	0.013		Central Angle, q =	2.97	radians
Channel bottom slope, S =	0.0254	ft/ft	Cross-Sect. Area, A =	15.64	ft^2
			Wetted Perimeter, P =	9.9	ft
Calculations			Hydraulic Radius, R =	1.58	ft
n/n_{full} =	1.2291666		Discharge, Q =	314.58	cfs
Partially Full Manning roughness, n =	0.016		Ave. Velocity, V =	20.12	ft/sec
			pipe % full [(A/A_{full})*100%] =	55.3%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\cdot\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 23 - 72" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

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This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

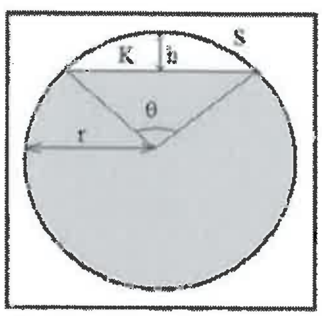
Pipe Diameter, D =	72	in
Depth of flow, y =	38	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0282	ft/ft

Calculations

n/n_{full} =	1.2361111
Partially Full Manning roughness, n =	0.016

Calculations

Pipe Diameter, D =	6	ft
Pipe Radius, r =	3	ft
Circ. Segment Height, h =	2.833	ft
Central Angle, q =	3.03	radians
Cross-Sect. Area, A =	15.14	ft^2
Wetted Perimeter, P =	9.8	ft
Hydraulic Radius, R =	1.55	ft
Discharge, Q =	315.82	cfs
Ave. Velocity, V =	20.86	ft/sec
pipe % full [(A/A_{full})*100%] =	53.5%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$

P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\cdot\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 23 - 72" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

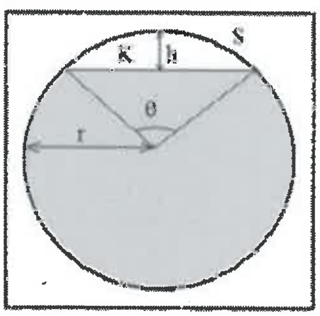
Input	Value	Unit
Pipe Diameter, D =	66	in
Depth of flow, y =	51	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0104	ft/ft

Calculations

n/n_{full} =	1.1136363	
Partially Full Manning roughness, n =	0.014	

Calculations

Quantity	Value	Unit
Pipe Diameter, D =	5.5	ft
Pipe Radius, r =	2.75	ft
Circ. Segment Height, h =	1.250	ft
Central Angle, q =	1.99	radians
Cross-Sect. Area, A =	19.70	ft²
Wetted Perimeter, P =	11.8	ft
Hydraulic Radius, R =	1.67	ft
Discharge, Q =	290.77	cfs
Ave. Velocity, V =	14.76	ft/sec
pipe % full [(A/A_{full})*100%] =	82.9%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\,\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 23 – 66" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D = 66 in
Depth of flow, y = 36 in
(must have y ≥ D/2)

Full Pipe Manning roughness, n_{full} = 0.013
Channel bottom slope, S = 0.0347 ft/ft

Calculations

n/n_{full} = 1.2272727
Partially Full Manning roughness, n = 0.016

Calculations

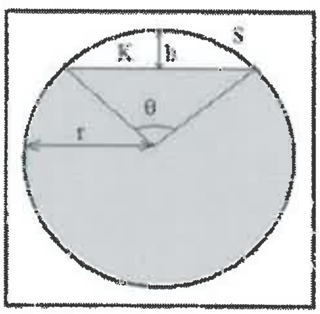
Pipe Diameter, D = 5.5 ft
Pipe Radius, r = 2.75 ft

Circ. Segment Height, h = 2.500 ft

Central Angle, q = 2.96 radians
Cross-Sect. Area, A = 13.25 ft²

Wetted Perimeter, P = 9.1 ft
Hydraulic Radius, R = 1.45 ft
Discharge, Q = 295.34 cfs
Ave. Velocity, V = 22.29 ft/sec

pipe % full [(A/A_{full})*100%] = 55.8%



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A

P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 23 - 66" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

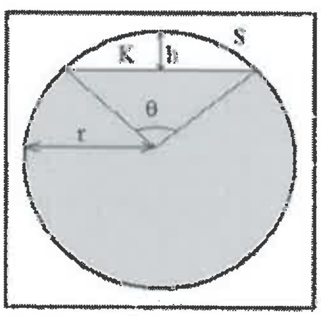
Pipe Diameter, D =	66	in
Depth of flow, y =	44	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0165	ft/ft

Calculations

n/n_{full} =	1.1666666
Partially Full Manning roughness, n =	0.015

Calculations

Pipe Diameter, D =	5.5	ft
Pipe Radius, r =	2.75	ft
Circ. Segment Height, h =	1.833	ft
Central Angle, q =	2.46	radians
Cross-Sect. Area, A =	16.83	ft²
Wetted Perimeter, P =	10.5	ft
Hydraulic Radius, R =	1.60	ft
Discharge, Q =	290.61	cfs
Ave. Velocity, V =	17.27	ft/sec
pipe % full [(A/A_{full})*100%] =	70.8%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$ P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 23 - 66" RCP
OUTLET STRUCTURE W-4

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	48	in
Depth of flow, y =	19	in

(must have $y \geq D/2$)

Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.1958	ft/ft

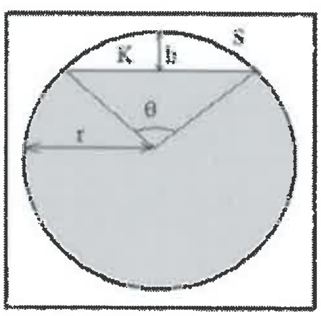
Calculations

n/n_{full} =	1.3020833
Partially Full Manning roughness, n =	0.017

Calculations

Pipe Diameter, D =	4	ft
Pipe Radius, r =	2	ft
Circ. Segment Height, h =	2.417	ft
Central Angle, q =	3.56	radians
Cross-Sect. Area, A =	4.63	ft^2
Wetted Perimeter, P =	5.4	ft
Hydraulic Radius, R =	0.85	ft
Discharge, Q =	161.81	cfs
Ave. Velocity, V =	34.96	ft/sec

pipe % full [(A/A_{full})*100%] = 36.9%



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$ P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r^*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)^*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 20 - 48" RCP
OUTLET STRUCTURE W-5

ENGINEERS EDGE
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Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
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Casting Microfinish Comparator 20 to 900 microinch

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

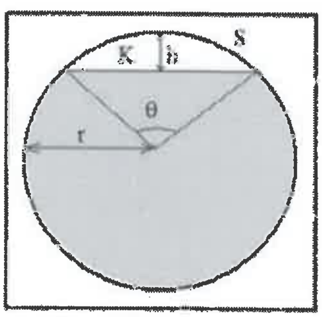
Pipe Diameter, D =	36	in
Depth of flow, y =	22	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0216	ft/ft

Calculations

n/n_{full} =	1.1944444
Partially Full Manning roughness, n =	0.016

Calculations

Pipe Diameter, D =	3	ft
Pipe Radius, r =	1.5	ft
Circ. Segment Height, h =	1.167	ft
Central Angle, q =	2.69	radians
Cross-Sect. Area, A =	4.53	ft^2
Wetted Perimeter, P =	5.4	ft
Hydraulic Radius, R =	0.84	ft
Discharge, Q =	57.11	cfs
Ave. Velocity, V =	12.62	ft/sec
pipe % full [(A/A_{full})*100%] =	64.0%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A   P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 24- 36" RCP

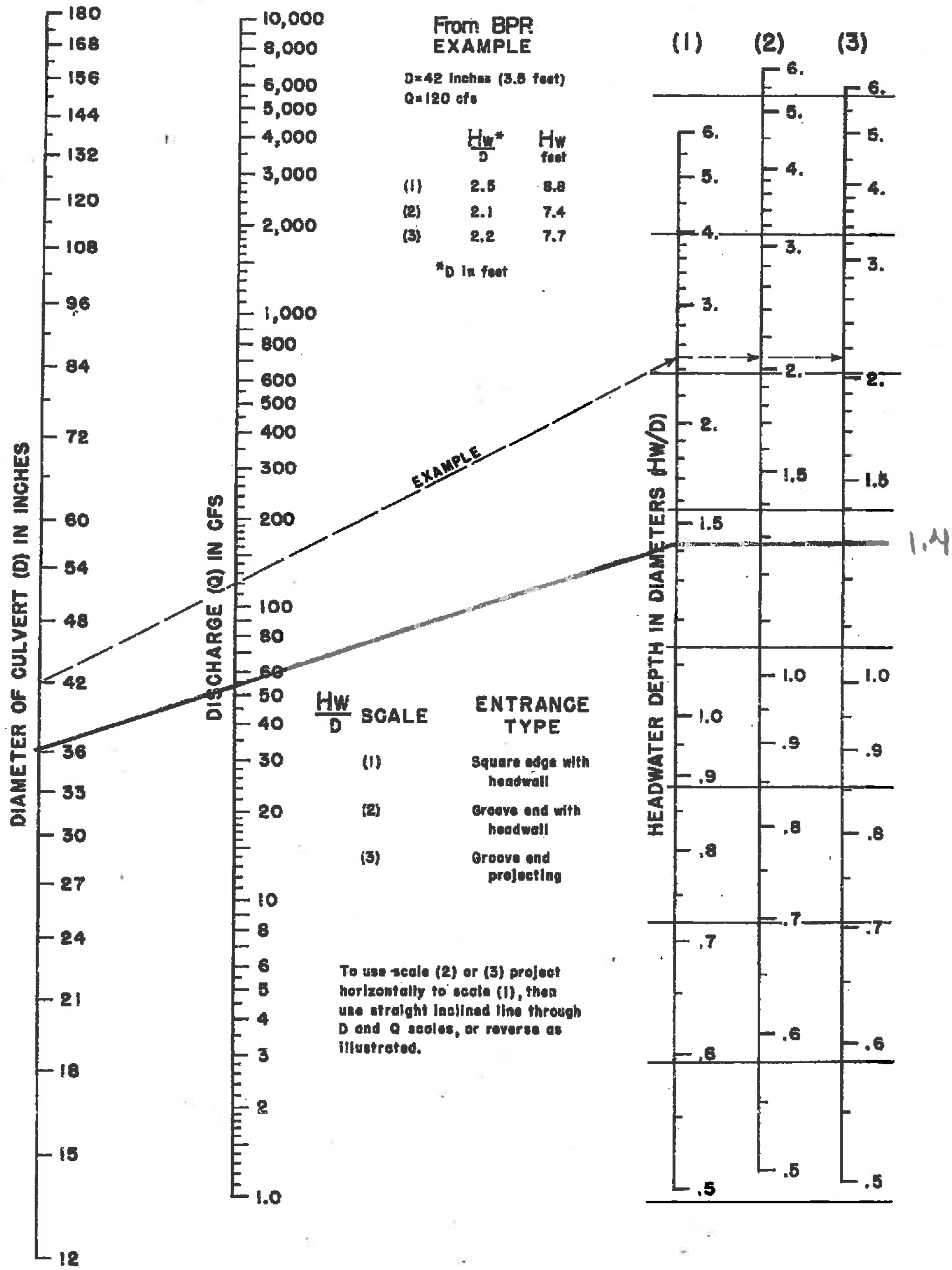
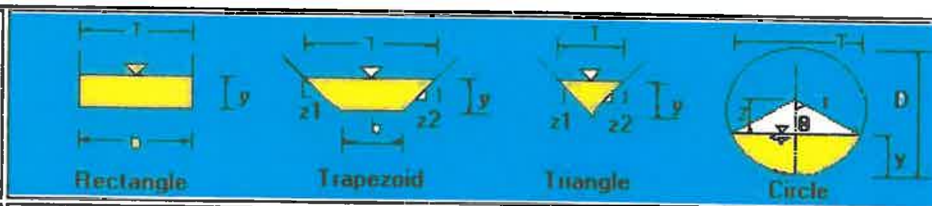


Figure CU-9—Inlet Control Nomograph—Example

DP-50 Q_{100}=53.7 cfs

The open channel flow calculator

Select Channel Type:
Trapezoid

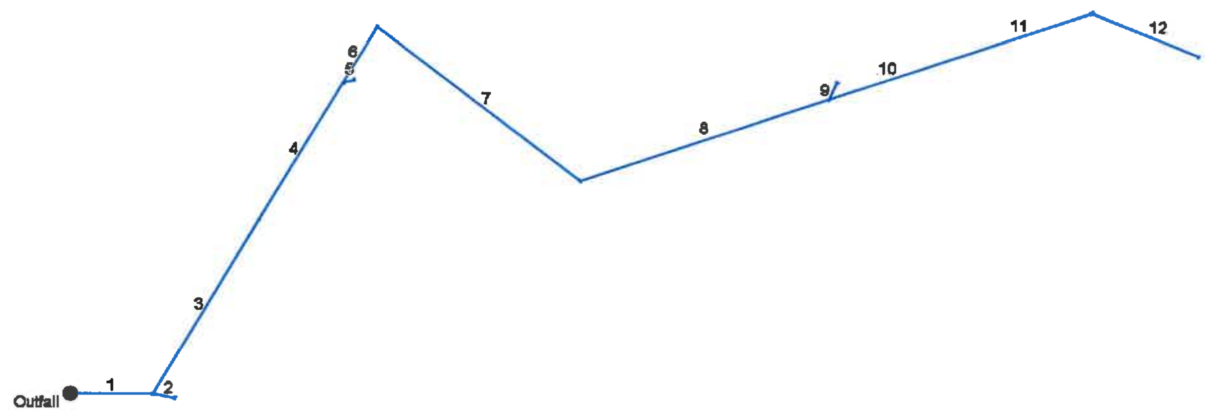


Velocity(V)&Discharge(Q) | Select unit system: Feet(ft)

Channel slope: .005 ft/ft	Water depth(y): 1.7 ft	Bottom width(b) 4 ft
Flow velocity 3.04 ft/s	LeftSlope (Z1): 4 to 1 (H:'	RightSlope (Z2): 4 to 1 (H:V
Flow discharge 55.814 ft^3/s	Input n value 0.035 or select r	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 18.02 ft	Flow area 18.36 ft^2	Top width(T) 17.6 ft
Specific energy 1.84 ft	Froude number 0.52	Flow status Subcritical flow
Critical depth 1.23 ft	Critical slope 0.0198 ft/ft	Velocity head 0.14 ft

SR FIL 2
TRACT A
DP 50 Q_{100}= 54 cfs

09-002 Fil 2_Storm 23



Project File: Storm 20, 23, 24, 25.stm	Number of lines: 12	Date: 5/4/2017

Storm Sewers v10.50

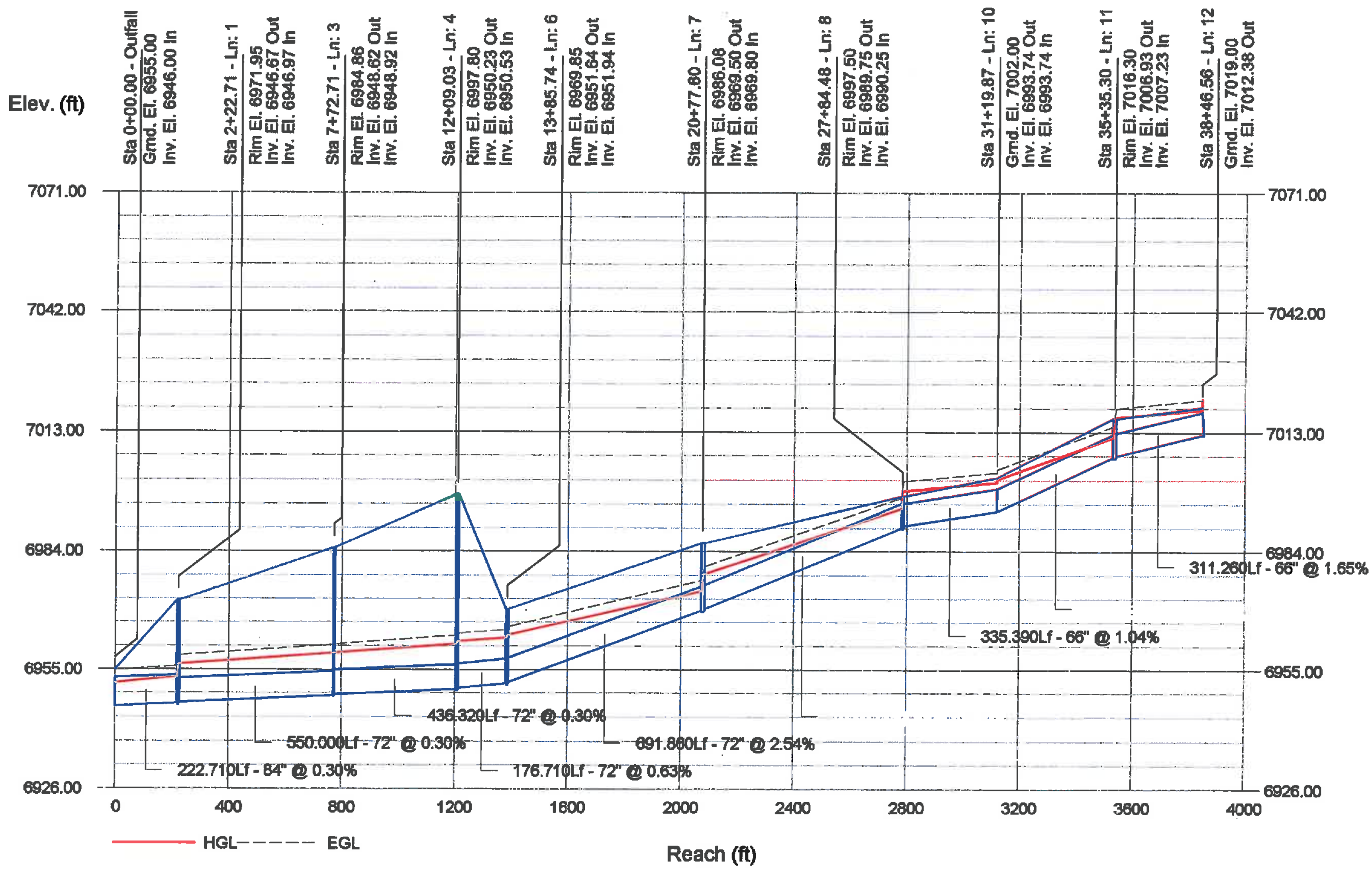
Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	PR 74, Storm 23	472.4	84	Cir	222.710	6946.00	6946.67	0.301	6951.69	6953.32	n/a	6956.32 i	End	Manhole
2	PR 71, Storm 20	149.7	48	Cir	58.550	6949.17	6960.68	19.659	6956.32	6964.27	n/a	6968.89 i	1	OpenHeadwall
3	PR 67.1, Storm 23	322.7	72	Cir	550.000	6946.97	6948.62	0.300	6956.32*	6959.04*	0.10	6959.14	1	Manhole
4	PR 67.2, Storm 23	322.7	72	Cir	436.320	6948.92	6950.23	0.300	6959.14*	6961.30*	0.51	6961.81	3	Manhole
5	PR 66, Storm 25	36.10	30	Cir	30.220	6954.03	6956.59	8.471	6962.99*	6963.19*	0.25	6963.45	4	OpenHeadwall
6	PR 65.1, Storm 23	309.9	72	Cir	176.710	6950.53	6951.64	0.628	6961.97*	6962.77*	0.75	6963.52	4	Manhole
7	PR 65.2, Storm 23	309.9	72	Cir	691.860	6951.94	6969.50	2.538	6963.52	6974.30	n/a	6978.50 i	6	Manhole
8	PR 65.3, Storm 23	309.9	72	Cir	706.880	6969.80	6989.75	2.822	6978.50	6994.55	n/a	6998.75 i	7	Manhole
9	PR 64, Storm 24	53.70	36	Cir	51.220	6992.55	6993.84	2.519	6998.75*	6999.04*	0.27	6999.31	8	OpenHeadwall
10	PR 63.1, Storm 23	289.4	66	Cir	335.390	6990.25	6993.74	1.041	6998.75*	7000.88*	0.69	7001.57	8	None
11	PR 63.2, Storm 23	289.4	66	Cir	415.430	6993.74	7006.93	3.175	7001.57	7011.63	n/a	7016.54 i	10	Manhole
12	PR 63.3, Storm23	289.4	66	Cir	311.260	7007.23	7012.38	1.655	7016.54*	7018.51*	n/a	7021.13 i	11	OpenHeadwall

09-002 Fil 2_Storm 23	Number of lines: 12	Run Date: 5/4/2017

NOTES: Return period = 100 Yrs. ; *Surcharged (HGL above crown). ; i - Inlet control.

Storm Sewer Profile



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Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
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This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	42	in
Depth of flow, y =	40	in

(must have $y \geq D/2$)

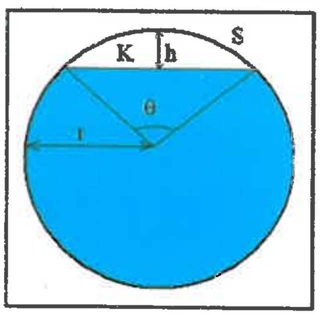
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0057	ft/ft

Calculations

n/n_{full} =	1.0238095
Partially Full Manning roughness, n =	0.013

Calculations

Pipe Diameter, D =	3.5	ft
Pipe Radius, r =	1.75	ft
Circ. Segment Height, h =	0.167	ft
Central Angle, q =	0.88	radians
Cross-Sect. Area, A =	9.45	ft^2
Wetted Perimeter, P =	9.5	ft
Hydraulic Radius, R =	1.00	ft
Discharge, Q =	79.89	cfs
Ave. Velocity, V =	8.45	ft/sec
pipe % full [(A/A_{full})*100%] =	98.3%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$ P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 16 2~42"RCP

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Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

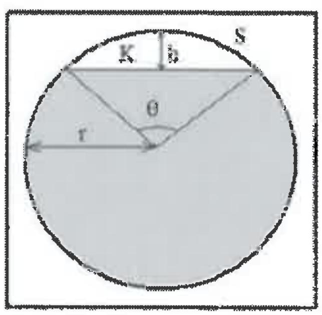
Pipe Diameter, D =	54	in
Depth of flow, y =	34	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0215	ft/ft

Calculations

n/n_{full} =	1.1851851
Partially Full Manning roughness, n =	0.015

Calculations

Pipe Diameter, D =	4.5	ft
Pipe Radius, r =	2.25	ft
Circ. Segment Height, h =	1.667	ft
Central Angle, q =	2.62	radians
Cross-Sect. Area, A =	10.55	ft²
Wetted Perimeter, P =	8.2	ft
Hydraulic Radius, R =	1.28	ft
Discharge, Q =	176.20	cfs
Ave. Velocity, V =	16.71	ft/sec
pipe % full [(A/A_{full})*100%] =	66.3%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\cdot\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 16 - 54" RCP

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Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
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This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	48	in
Depth of flow, y =	34	in

(must have y ≥ D/2)

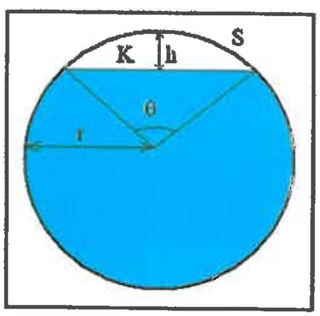
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0228	ft/ft

Calculations

n/n_{full} =	1.145833
Partially Full Manning roughness, n =	0.015

Calculations

Pipe Diameter, D =	4	ft
Pipe Radius, r =	2	ft
Circ. Segment Height, h =	1.167	ft
Central Angle, q =	2.28	radians
Cross-Sect. Area, A =	9.52	ft^2
Wetted Perimeter, P =	8.0	ft
Hydraulic Radius, R =	1.19	ft
Discharge, Q =	161.36	cfs
Ave. Velocity, V =	16.95	ft/sec
pipe % full [(A/A_{full})*100%] =	75.7%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A

P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r^*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 16 48" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	18	in
Depth of flow, y =	6	in

(must have y ≥ D/2)

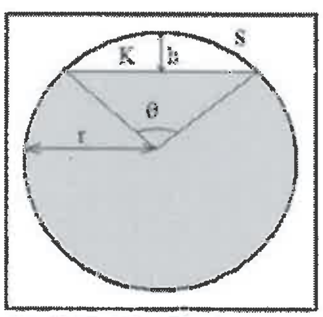
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.256	ft/ft

Calculations

n/n_{full} =	1.3333333
Partially Full Manning roughness, n =	0.017

Calculations

Pipe Diameter, D =	1.5	ft
Pipe Radius, r =	0.75	ft
Circ. Segment Height, h =	1.000	ft
Central Angle, q =	3.82	radians
Cross-Sect. Area, A =	0.52	ft²
Wetted Perimeter, P =	1.8	ft
Hydraulic Radius, R =	0.28	ft
Discharge, Q =	9.58	cfs
Ave. Velocity, V =	18.58	ft/sec
pipe % full [(A/A_{full})*100%] =	29.2%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

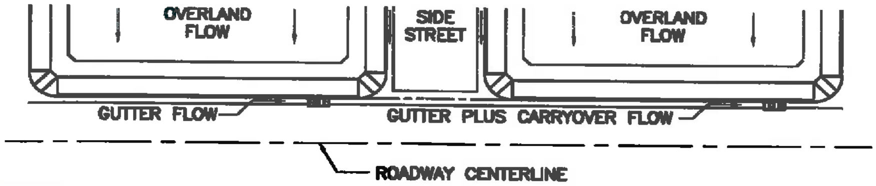
$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 16 LAT 1 -18" RCP
DP 46

DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP46



Show Details

Design Flow: ONLY if already determined through other methods:

(local peak flow for 1/2 of street OR grass-lined channel):

	Minor Storm	Major Storm	
*Q_{Known} =	2.4	9.7	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

<--- FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW. <---

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- Site is Urban
- Site is Non-Urban

Flows Developed For:
- Street Inlets
- Area Inlets in a Median

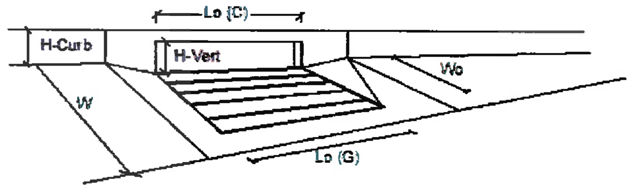
	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c) ^ C_3$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	2.4	9.7	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP46



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	3	3	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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 < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	2.40	9.12	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.0	0.6	cfs
Capture Percentage = Q_a/Q_o =	C% =	100	94	%

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, **D** =	30	in
Depth of flow, **y** =	7	in

(must have $y \geq D/2$)

Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, **S** =	0.2685	ft/ft

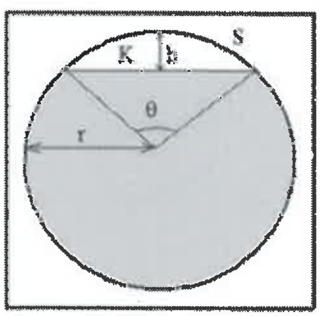
Calculations

n/n_{full} =	1.3833333
Partially Full Manning roughness, **n** =	0.018

Calculations

Pipe Diameter, **D** =	2.5	ft
Pipe Radius, **r** =	1.25	ft
Circ. Segment Height, **h** =	1.917	ft
Central Angle, **q** =	4.27	radians
Cross-Sect. Area, **A** =	0.87	ft^2
Wetted Perimeter, **P** =	2.5	ft
Hydraulic Radius, **R** =	0.35	ft
Discharge, **Q** =	18.40	cfs
Ave. Velocity, **V** =	21.13	ft/sec

pipe % full $[(A/A_{full})*100\%]$ = 17.7%



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$ P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r^*\theta$$

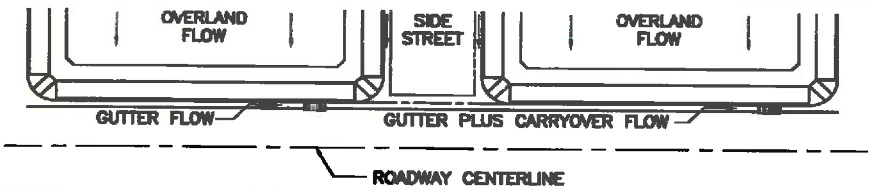
Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 18- 30" RCP
DP52

Worksheet Protected

DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP52



Show Details

Design Flow: ONLY if already determined through other methods:
(local peak flow for 1/2 of street OR grass-lined channel):

	Minor Storm	Major Storm	
$^*Q_{Known}$ =	6.4	13.9	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

<-- FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW. <--

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- ○ Site is Urban
- ○ Site is Non-Urban

Flows Developed For:
- ○ Street Inlets
- ○ Area Inlets in a Median

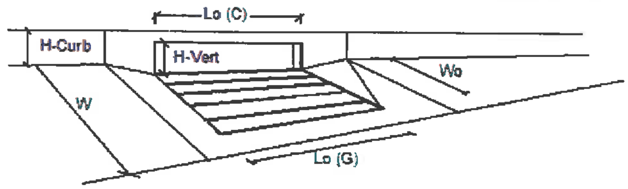
	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c)^{C_3}$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	6.4	13.9	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP52



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	3	3	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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 < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	6.40	11.56	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.0	2.3	cfs
Capture Percentage = Q_a/Q_o =	C% =	100	83	%

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

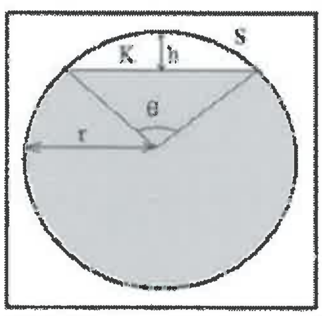
Pipe Diameter, D =	18	in
Depth of flow, y =	12	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.025	ft/ft

Calculations

n/n_{full} =	1.1666666	
Partially Full Manning roughness, n =	0.015	

Calculations

Pipe Diameter, D =	1.5	ft
Pipe Radius, r =	0.75	ft
Circ. Segment Height, h =	0.500	ft
Central Angle, q =	2.46	radians
Cross-Sect. Area, A =	1.25	ft^2
Wetted Perimeter, P =	2.9	ft
Hydraulic Radius, R =	0.44	ft
Discharge, Q =	11.19	cfs
Ave. Velocity, V =	8.94	ft/sec
pipe % full [(A/A_{full})*100%] =	70.8%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A

P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

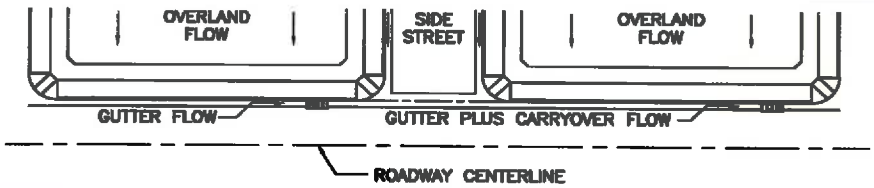
STORM 18- 18" RCP
OP 51

Worksheet Protected

DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP51



Show Details

Design Flow: ONLY if already determined through other methods:

		Minor Storm	Major Storm	
(local peak flow for 1/2 of street OR grass-lined channel):	$*Q_{Known}$ =	5.8	10.5	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

← FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW. ←

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- ○ Site is Urban
- ○ Site is Non-Urban

Flows Developed For:
- ○ Street Inlets
- ○ Area Inlets in a Median

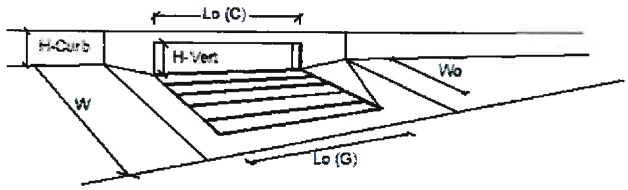
	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c)$ ^ C_3

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	5.8	10.5	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP51



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	3	3	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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 < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	5.80	9.65	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.0	0.9	cfs
Capture Percentage = Q_a/Q_o =	C% =	100	92	%

ENGINEERS EDGE
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Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

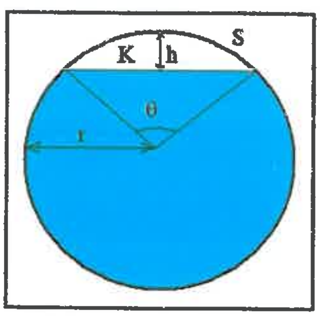
Pipe Diameter, D =	48	in
Depth of flow, y =	48	in
(must have $y \geq D/2$)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.005	ft/ft

Calculations

n/n_{full} =	1
Partially Full Manning roughness, n =	0.013

Calculations

Pipe Diameter, D =	4	ft
Pipe Radius, r =	2	ft
Circ. Segment Height, h =	0.000	ft
Central Angle, q =	0.00	radians
Cross-Sect. Area, A =	12.57	ft^2
Wetted Perimeter, P =	12.6	ft
Hydraulic Radius, R =	1.00	ft
Discharge, Q =	101.84	cfs
Ave. Velocity, V =	8.10	ft/sec
pipe % full [$(A/A_{full})*100\%$] =	100.0%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 21 48" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	42	in
Depth of flow, y =	27	in

(must have y ≥ D/2)

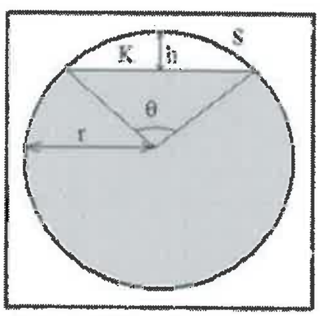
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0145	ft/ft

Calculations

n/n_{full} =	1.1785714
Partially Full Manning roughness, n =	0.015

Calculations

Pipe Diameter, D =	3.5	ft
Pipe Radius, r =	1.75	ft
Circ. Segment Height, h =	1.250	ft
Central Angle, q =	2.56	radians
Cross-Sect. Area, A =	6.54	ft²
Wetted Perimeter, P =	6.5	ft
Hydraulic Radius, R =	1.00	ft
Discharge, Q =	76.74	cfs
Ave. Velocity, V =	11.74	ft/sec
pipe % full [(A/A_{full})*100%] =	67.9%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 21 - 42" RCP
DP43A

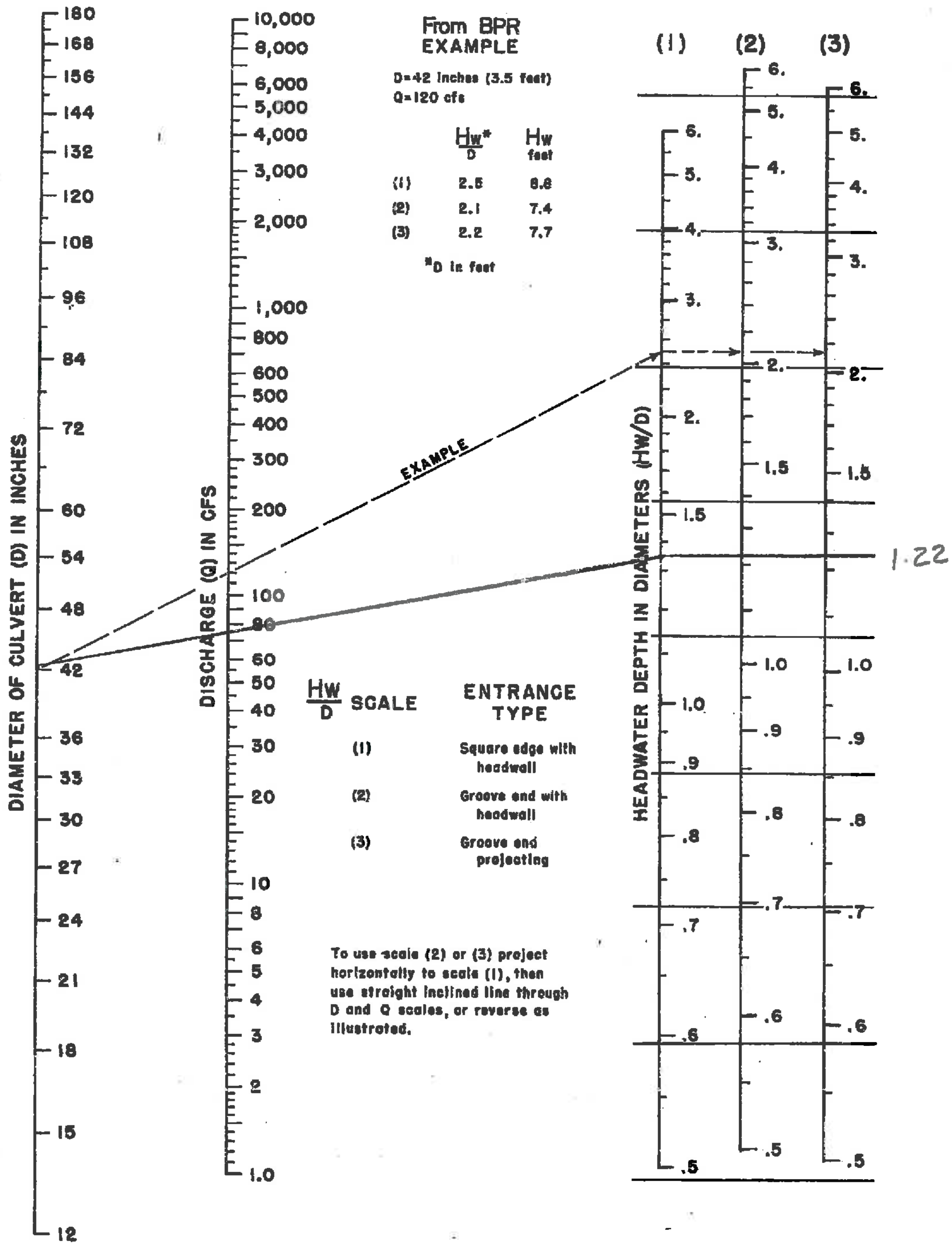
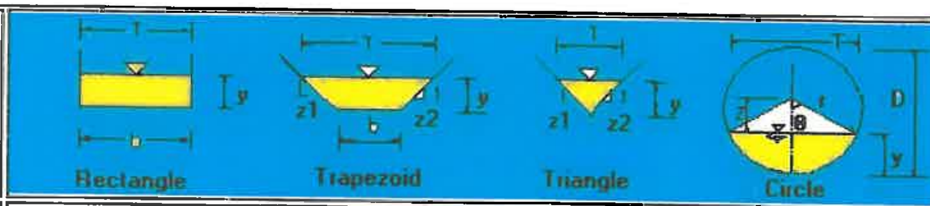


Figure CU-9—Inlet Control Nomograph—Example

DP43A $Q_{100} = 74.3$ cfs

The open channel flow calculator

Select Channel Type: Trapezoid



Velocity(V)&Discharge(Q) | Select unit system: Feet(ft)

Channel slope: .0641 ft/ft	Water depth(y): 1.1 ft	Bottom width(b) 4 ft
Flow velocity 8.5302 ft/s	LeftSlope (Z1): 4 to 1 (H:	RightSlope (Z2): 4 to 1 (H:V
Flow discharge 78.819 ft^3/s	Input n value 0.035 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 13.07 ft	Flow area 9.24 ft^2	Top width(T) 12.8 ft
Specific energy 2.23 ft	Froude number 1.77	Flow status Supercritical flow
Critical depth 1.47 ft	Critical slope 0.0188 ft/ft	Velocity head 1.13 ft

SR FIL 2

TRACT D

DP 43A Q_{100}= 74cfs

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

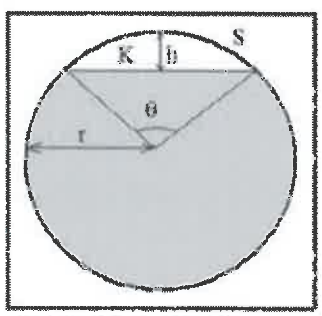
Pipe Diameter, D =	18	in
Depth of flow, y =	7	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.1654	ft/ft

Calculations

n/n_{full} =	1.3055555
Partially Full Manning roughness, n =	0.017

Calculations

Pipe Diameter, D =	1.5	ft
Pipe Radius, r =	0.75	ft
Circ. Segment Height, h =	0.917	ft
Central Angle, q =	3.59	radians
Cross-Sect. Area, A =	0.64	ft²
Wetted Perimeter, P =	2.0	ft
Hydraulic Radius, R =	0.31	ft
Discharge, Q =	11.06	cfs
Ave. Velocity, V =	17.39	ft/sec
pipe % full [(A/A_{full})*100%] =	36.0%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

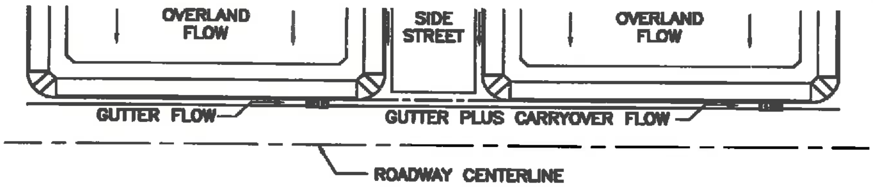
STORM 21 LAT 1 – 18" RCP
DP 45

Worksheet Protected

DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP45



Show Details

Design Flow: ONLY if already determined through other methods:

		Minor Storm	Major Storm	
(local peak flow for 1/2 of street OR grass-lined channel):	*Q_{Known} =	4.4	13.3	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

<--- FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW. <---

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- Site is Urban
- Site is Non-Urban

Flows Developed For:
- Street Inlets
- Area Inlets in a Median

	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

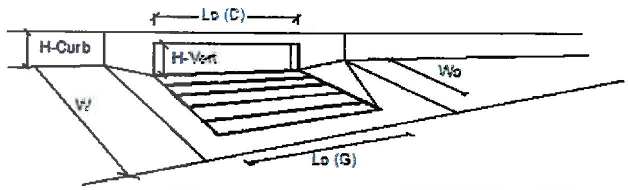
Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c) ^{C_3}$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	4.4	13.3	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP45



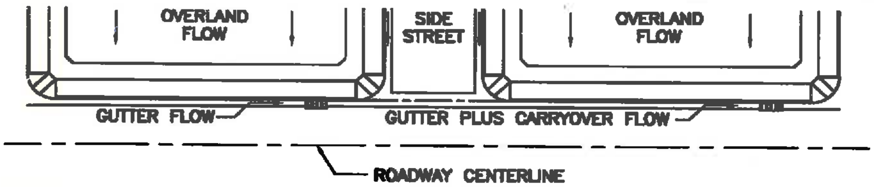
Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	3	3	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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 < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	4.40	11.25	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.0	2.0	cfs
Capture Percentage = Q_a/Q_o =	C% =	100	85	%

Worksheet Protected

DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP45



Show Details

Design Flow: ONLY if already determined through other methods:

		Minor Storm	Major Storm	
(local peak flow for 1/2 of street OR grass-lined channel):	*Q_{Known} =	4.8	12.4	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

← FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW. ←

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- Site is Urban
- Site is Non-Urban

Flows Developed For:
- Street Inlets
- Area Inlets in a Median

	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

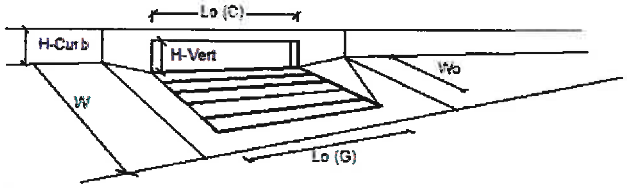
Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c)^{C_3}$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	4.8	12.4	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP45



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	3	3	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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 < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	**4.80**	**10.77**	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	**0.0**	**1.6**	cfs
Capture Percentage = Q_a/Q_o =	C% =	**100**	**87**	%

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V

for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	36	in
Depth of flow, y =	26	in

(must have $y \geq D/2$)

Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0111	ft/ft

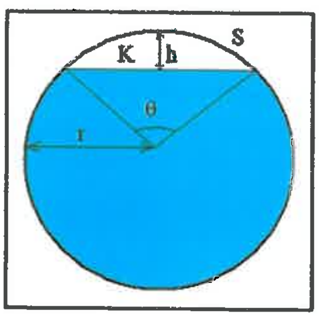
Calculations

n/n_{full} =	1.1388888
Partially Full Manning roughness, n =	0.015

Calculations

Pipe Diameter, D =	3	ft
Pipe Radius, r =	1.5	ft
Circ. Segment Height, h =	0.833	ft
Central Angle, q =	2.22	radians
Cross-Sect. Area, A =	5.47	ft^2
Wetted Perimeter, P =	6.1	ft
Hydraulic Radius, R =	0.90	ft
Discharge, Q =	53.91	cfs
Ave. Velocity, V =	9.86	ft/sec

pipe % full $[(A/A_{full})*100\%]$ = 77.3%



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$ P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 19 36" RCP

ENGINEERS EDGE
Solutions By Design

Partially Full Pipe Flow Calculator and Equations

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

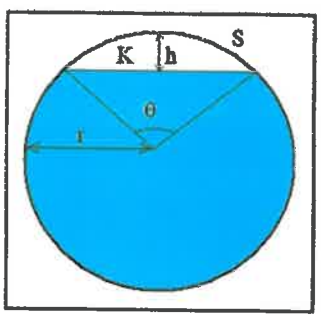
Pipe Diameter, D =	36	in
Depth of flow, y =	20	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0269	ft/ft

Calculations

n/n_{full} =	1.222222	
Partially Full Manning roughness, n =	0.016	

Calculations

Pipe Diameter, D =	3	ft
Pipe Radius, r =	1.5	ft
Circ. Segment Height, h =	1.333	ft
Central Angle, q =	2.92	radians
Cross-Sect. Area, A =	4.03	ft^2
Wetted Perimeter, P =	5.0	ft
Hydraulic Radius, R =	0.80	ft
Discharge, Q =	53.42	cfs
Ave. Velocity, V =	13.25	ft/sec
pipe % full [(A/A_{full})*100%] =	57.1%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A

P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 19 36" RCP

Solutions By Design

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

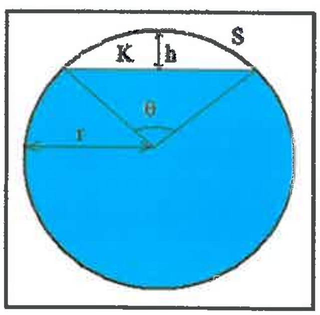
Pipe Diameter, D =	24	in
Depth of flow, y =	17	in
(must have $y \geq D/2$)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.01	ft/ft

Calculations

n/n_{full} =	1.145833	
Partially Full Manning roughness, n =	0.015	

Calculations

Pipe Diameter, D =	2	ft
Pipe Radius, r =	1	ft
Circ. Segment Height, h =	0.583	ft
Central Angle, q =	2.28	radians
Cross-Sect. Area, A =	2.38	ft^2
Wetted Perimeter, P =	4.0	ft
Hydraulic Radius, R =	0.59	ft
Discharge, Q =	16.83	cfs
Ave. Velocity, V =	7.07	ft/sec
pipe % full $[(A/A_{full})*100\%]$ =	75.7%	



Partially Full Pipe Flow Parameters (More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$

P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r^*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 19 LAT-1 24" RCP

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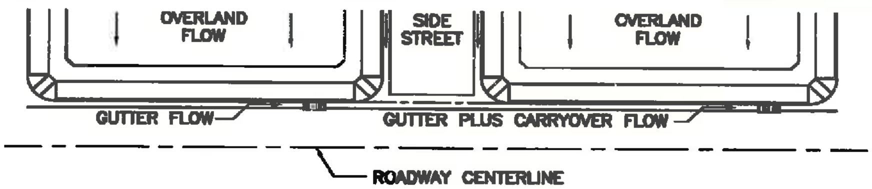
DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP40



Show Details

Design Flow: ONLY if already determined through other methods:
(local peak flow for 1/2 of street OR grass-lined channel):

	Minor Storm	Major Storm	
*Q_{Known} =	3.0	10.1	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

<-- FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW. <--

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- O Site is Urban
- O Site is Non-Urban

Flows Developed For:
- O Street Inlets
- O Area Inlets in a Mediar

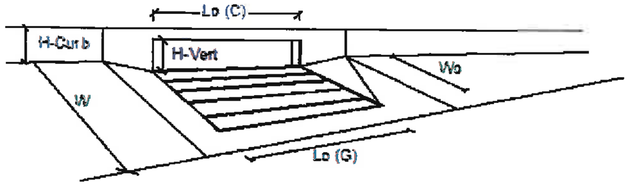
	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

Rainfall Information: Intensity I (inch/hr) = C_1 * P_1 / (C_2 + T_c) ^ C_3

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	3.0	10.1	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP40



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	3	3	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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 < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	3.00	9.67	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.0	0.4	cfs
Capture Percentage = Q_a/Q_o =	C% =	100	96	%

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	18	in
Depth of flow, y =	13	in

(must have y ≥ D/2)

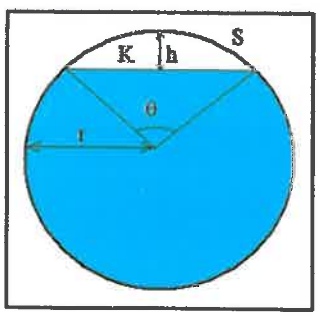
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0109	ft/ft

Calculations

n/n_{full} =	1.138888
Partially Full Manning roughness, n =	0.015

Calculations

Pipe Diameter, D =	1.5	ft
Pipe Radius, r =	0.75	ft
Circ. Segment Height, h =	0.417	ft
Central Angle, q =	2.22	radians
Cross-Sect. Area, A =	1.37	ft^2
Wetted Perimeter, P =	3.0	ft
Hydraulic Radius, R =	0.45	ft
Discharge, Q =	8.41	cfs
Ave. Velocity, V =	6.16	ft/sec
pipe % full [(A/A_{full})*100%] =	77.3%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r^*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 19 LAT-1 18" RCP

ENGINEERS EDGE
Solutions By Design

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

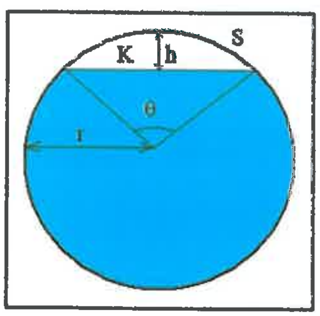
Pipe Diameter, D =	24	in
Depth of flow, y =	16	in
(must have $y \geq D/2$)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0325	ft/ft

Calculations

n/n_{full} =	1.1666666	
Partially Full Manning roughness, n =	0.015	

Calculations

Pipe Diameter, D =	2	ft
Pipe Radius, r =	1	ft
Circ. Segment Height, h =	0.667	ft
Central Angle, q =	2.46	radians
Cross-Sect. Area, A =	2.22	ft^2
Wetted Perimeter, P =	3.8	ft
Hydraulic Radius, R =	0.58	ft
Discharge, Q =	27.48	cfs
Ave. Velocity, V =	12.35	ft/sec
pipe % full [(A/A_{full})*100%] =	70.8%	



Partially Full Pipe Flow Parameters (More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 19 24" RCP

ENGINEERS EDGE
Solutions By Design

Partially Full Pipe Flow Calculator and Equations

[Fluid Flow Table of Contents] | [Hydraulic and Pneumatic Knowledge]
[Fluid Power Equipment]

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	24	in
Depth of flow, y =	14	in

(must have $y \geq D/2$)

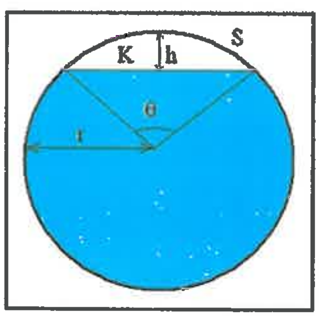
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0235	ft/ft

Calculations

n/n_{full} =	1.208333
Partially Full Manning roughness, n =	0.016

Calculations

Pipe Diameter, D =	2	ft
Pipe Radius, r =	1	ft
Circ. Segment Height, h =	0.833	ft
Central Angle, q =	2.81	radians
Cross-Sect. Area, A =	1.90	ft^2
Wetted Perimeter, P =	3.5	ft
Hydraulic Radius, R =	0.55	ft
Discharge, Q =	18.51	cfs
Ave. Velocity, V =	9.73	ft/sec
pipe % full $[(A/A_{full})*100\%]$ =	60.6%	



Partially Full Pipe Flow Parameters (More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A

P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

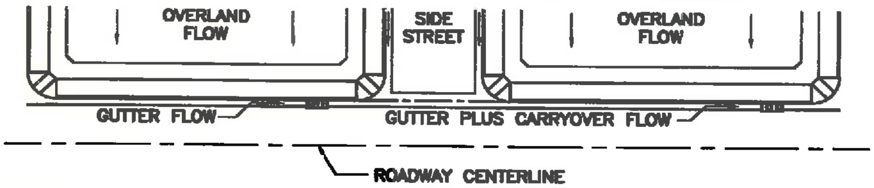
STORM 19 LAT 2 24" RCP

Worksheet Protected

DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP39A



Show Details

Design Flow: ONLY if already determined through other methods:

		Minor Storm	Major Storm	
(local peak flow for 1/2 of street OR grass-lined channel):	$^*Q_{Known}$ =	6.2	13.7	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

<-- FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW. <--

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- ○ Site is Urban
- ○ Site is Non-Urban

Flows Developed For:
- ○ Street Inlets
- ○ Area Inlets in a Median

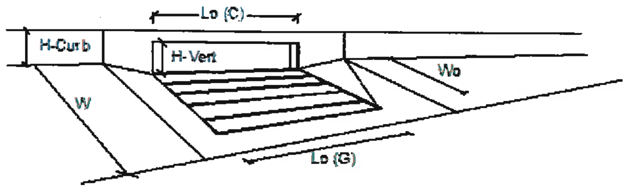
	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c) ^ C_3$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	6.2	13.7	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP39A



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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 < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	5.68	8.93	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.5	4.7	cfs
Capture Percentage = Q_a/Q_o =	C% =	92	65	%

ENGINEERS EDGE
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Partially Full Pipe Flow Calculator and Equations

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V

for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

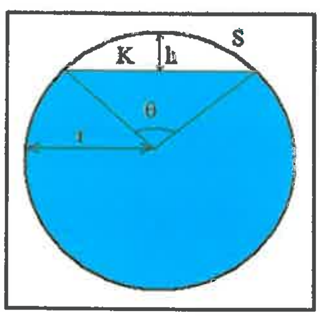
Pipe Diameter, D =	18	in
Depth of flow, y =	13	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.014	ft/ft

Calculations

n/n_{full} =	1.138888(	
Partially Full Manning roughness, n =	0.015	

Calculations

Pipe Diameter, D =	1.5	ft
Pipe Radius, r =	0.75	ft
Circ. Segment Height, h =	0.417	ft
Central Angle, q =	2.22	radians
Cross-Sect. Area, A =	1.37	ft^2
Wetted Perimeter, P =	3.0	ft
Hydraulic Radius, R =	0.45	ft
Discharge, Q =	9.53	cfs
Ave. Velocity, V =	6.98	ft/sec
pipe % full [(A/A_{full})*100%] =	77.3%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 19 LAT-2 18" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

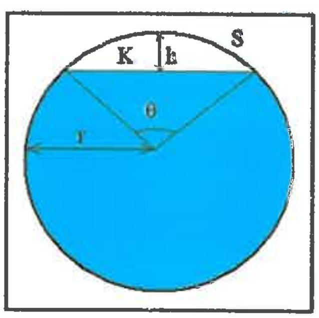
Pipe Diameter, D =	18	in
Depth of flow, y =	11	in
(must have $y \geq D/2$)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0325	ft/ft

Calculations

n/n_{full} =	1.194444
Partially Full Manning roughness, n =	0.016

Calculations

Pipe Diameter, D =	1.5	ft
Pipe Radius, r =	0.75	ft
Circ. Segment Height, h =	0.583	ft
Central Angle, q =	2.69	radians
Cross-Sect. Area, A =	1.13	ft^2
Wetted Perimeter, P =	2.7	ft
Hydraulic Radius, R =	0.42	ft
Discharge, Q =	10.98	cfs
Ave. Velocity, V =	9.71	ft/sec
pipe % full [(A/A_{full})*100%] =	64.0%	



Partially Full Pipe Flow Parameters (More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$ P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 19 18" RCP

ENGINEERS EDGE
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Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	18	in
Depth of flow, y =	9	in

(must have $y \geq D/2$)

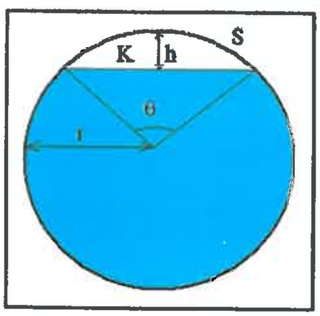
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0241	ft/ft

Calculations

n/n_{full} =	1.25
Partially Full Manning roughness, n =	0.016

Calculations

Pipe Diameter, D =	1.5	ft
Pipe Radius, r =	0.75	ft
Circ. Segment Height, h =	0.750	ft
Central Angle, q =	3.14	radians
Cross-Sect. Area, A =	0.88	ft^2
Wetted Perimeter, P =	2.4	ft
Hydraulic Radius, R =	0.38	ft
Discharge, Q =	6.54	cfs
Ave. Velocity, V =	7.40	ft/sec
pipe % full $[(A/A_{full})*100\%]$ =	50.0%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$ P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

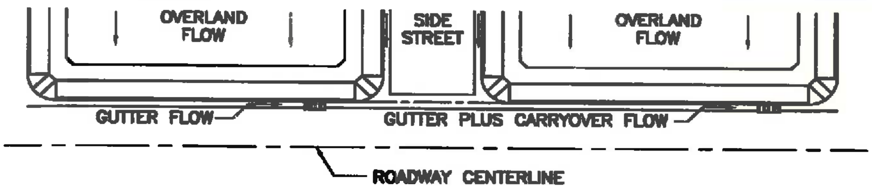
Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 19 LAT 3 18" RCP

Worksheet Protected

DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP39



Show Details

Design Flow: ONLY if already determined through other methods:

		Minor Storm	Major Storm	
(local peak flow for 1/2 of street OR grass-lined channel):	$^*Q_{Known}$ =	2.4	5.3	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

<--- FILL IN THIS SECTION OR...

Geographic Information: (Enter data in the blue cells):

FILL IN THE SECTIONS BELOW. <---

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- ○ Site is Urban
- ○ Site is Non-Urban

Flows Developed For:
- ○ Street Inlets
- ○ Area Inlets in a Median

	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

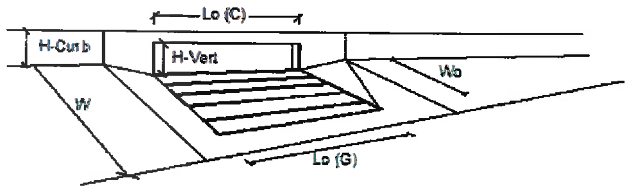
Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c)^{C_3}$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	2.4	5.3	cfs

INLET ON A CONTINUOUS GRADE

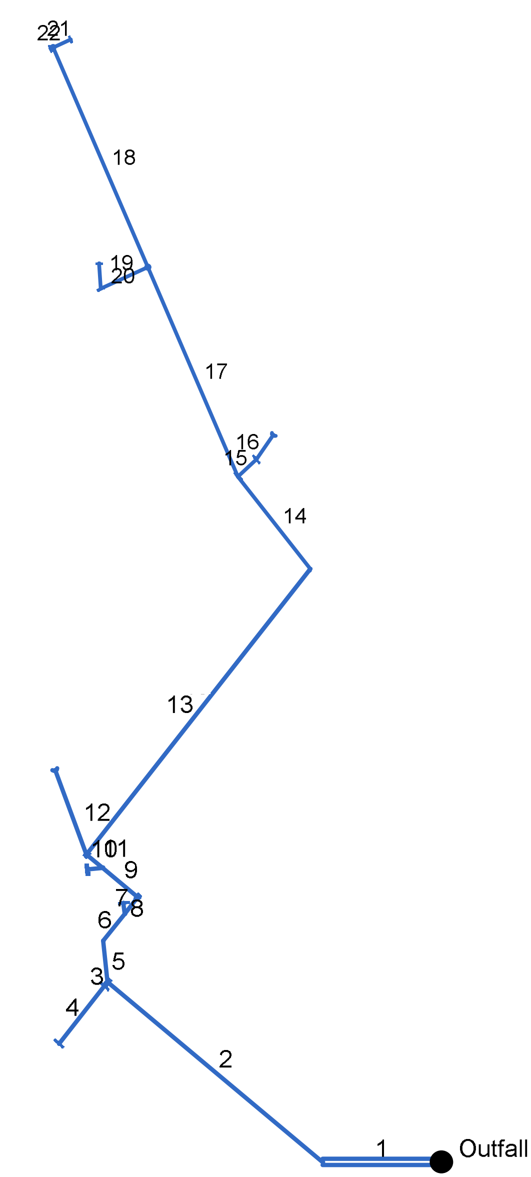
Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP39



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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 < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	2.40	5.07	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.0	0.2	cfs
Capture Percentage = Q_a/Q_o =	C% =	100	96	%

Storm 16, 18, 19, 21



Project File: Storm 16, 18, 19, 21.stm	Number of lines: 13	Date: 11/22/2017

Storm Sewers v10.50

Storm Sewer Summary Report Storm 16, 18, 19, 21

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	Storm 16	155.0	42	Cir(2b)	149.820	6967.50	6968.35	0.567	6977.99*	6978.75*	0.20	6978.95	End	Manhole
2	Storm 16	155.0	54	Cir	349.420	6968.95	6976.45	2.146	6978.95	6980.54	n/a	6982.71 i	1	Manhole
3	Storm 18	21.00	30	Cir	6.610	6978.75	6980.52	26.778	6982.71	6982.67	0.02	6982.69	2	Curb-Horiz
4	Storm 18	10.00	18	Cir	90.330	6981.52	6983.78	2.502	6982.69	6985.00	n/a	6986.10 i	3	Curb-Horiz
5	Storm 16	136.0	48	Cir	50.670	6976.95	6978.10	2.269	6982.71*	6983.10*	0.64	6983.74	2	None
6	Storm 16	136.0	48	Cir	42.500	6978.10	6979.07	2.282	6983.74*	6984.06*	0.55	6984.61	5	None
7	Storm 16	129.0	48	Cir	26.250	6979.07	6979.67	2.286	6984.79*	6984.97*	n/a	6985.93 i	6	Manhole
8	Storm 16_Lat 1	9.00	18	Cir	13.200	6980.32	6983.66	25.306	6986.03*	6986.11*	0.50	6986.61	6	Curb-Horiz
9	Storm 21	129.0	48	Cir	57.000	6980.17	6980.46	0.509	6985.93*	6986.33*	0.49	6986.82	7	None
10	Storm 21_LAt 1	11.00	18	Cir	19.330	6981.71	6985.25	18.314	6987.85*	6988.03*	0.75	6988.79	9	Curb-Horiz
11	Storm 21	119.0	48	Cir	26.000	6980.46	6980.59	0.500	6987.06*	6987.21*	0.56	6987.77	9	Manhole
12	Storm 21	74.00	42	Cir	110.170	6981.09	6982.68	1.444	6988.24*	6988.75*	0.28	6989.03	11	OpenHeadwall
13	Storm 19	52.00	36	Cir	446.950	6982.08	6987.05	1.112	6988.32*	6990.64*	n/a	6990.74 i	11	Manhole
14	Storm 19	52.00	36	Cir	165.240	6987.35	6991.79	2.687	6990.74	6994.13	n/a	6996.08 i	13	Generic
15	Storm 19_Lat 1	15.80	24	Cir	35.380	6992.49	6992.85	1.017	6996.08*	6996.23*	0.02	6996.25	14	Generic
16	Storm 19_Lat 1	7.70	18	Cir	41.630	6993.35	6993.80	1.080	6996.34*	6996.54*	0.09	6996.62	15	OpenHeadwall
17	Storm 19	26.90	24	Cir	319.040	6992.79	7003.16	3.250	6996.08	7004.97	n/a	7007.35 i	14	Manhole
18	Storm 19	10.60	18	Cir	334.890	7003.66	7014.88	3.350	7007.35	7016.13	n/a	7017.34 i	17	Manhole
19	Storm 19_Lat 2	17.90	24	Cir	74.130	7003.46	7005.21	2.361	7007.35*	7007.75*	0.23	7007.97	17	Generic
20	Storm 19_Lat 2	9.00	18	Cir	35.340	7005.71	7006.20	1.387	7008.07*	7008.30*	0.50	7008.80	19	Generic
21	Storm 19_Lat 3	5.30	18	Cir	27.320	7015.18	7015.84	2.415	7017.34*	7017.40*	0.17	7017.58	18	Generic
22	Storm 19_Lat 3	5.30	18	Cir	4.010	7015.18	7015.96	19.446	7017.34	7017.34	0.19	7017.53	18	Generic

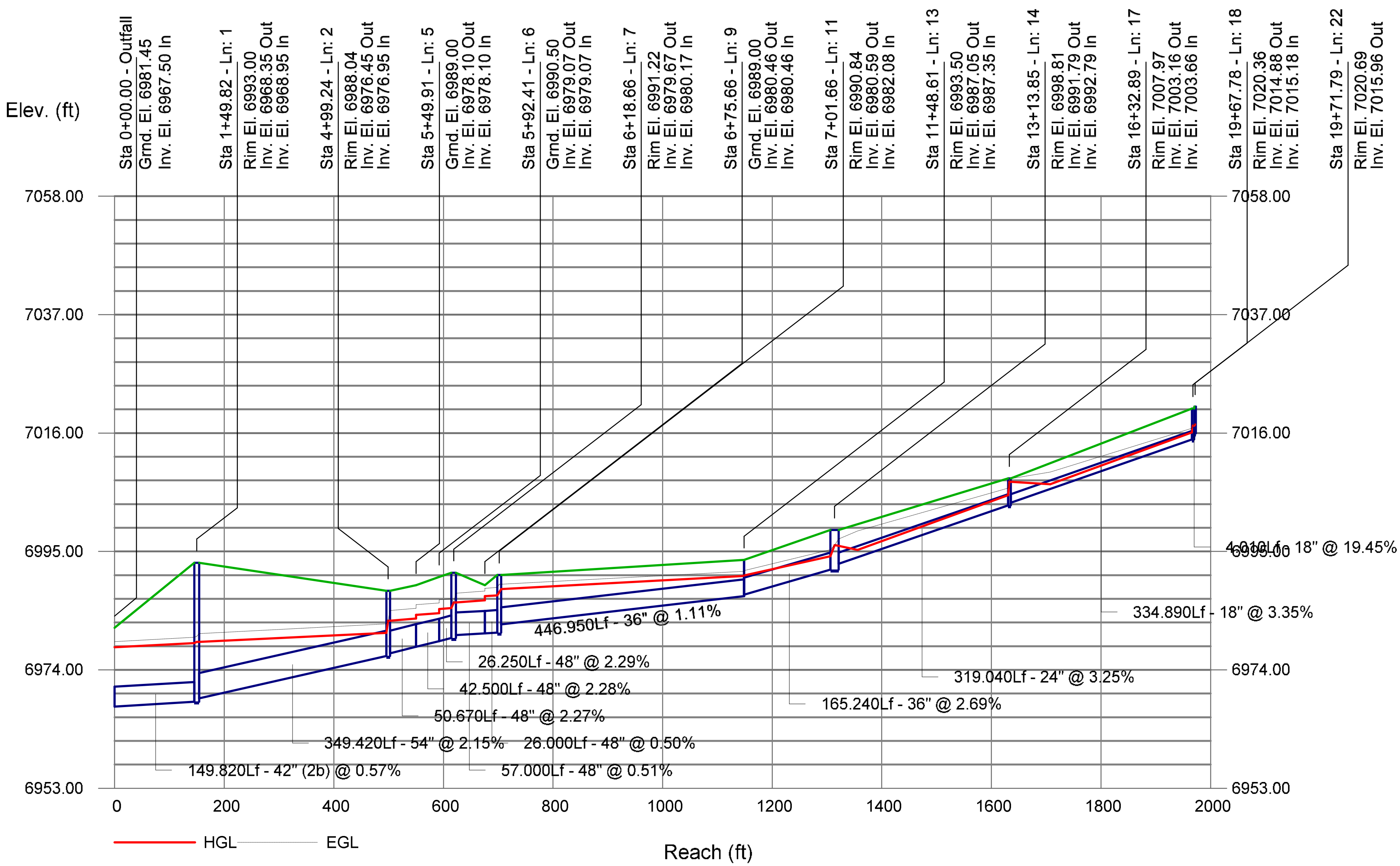
Storm 16, 18, 19, 21 | Number of lines: 22 | Run Date: 11/21/2017

NOTES: Return period = 100 Yrs. ; *Surcharged (HGL above crown). ; i - Inlet control.

Storm Sewer Profile

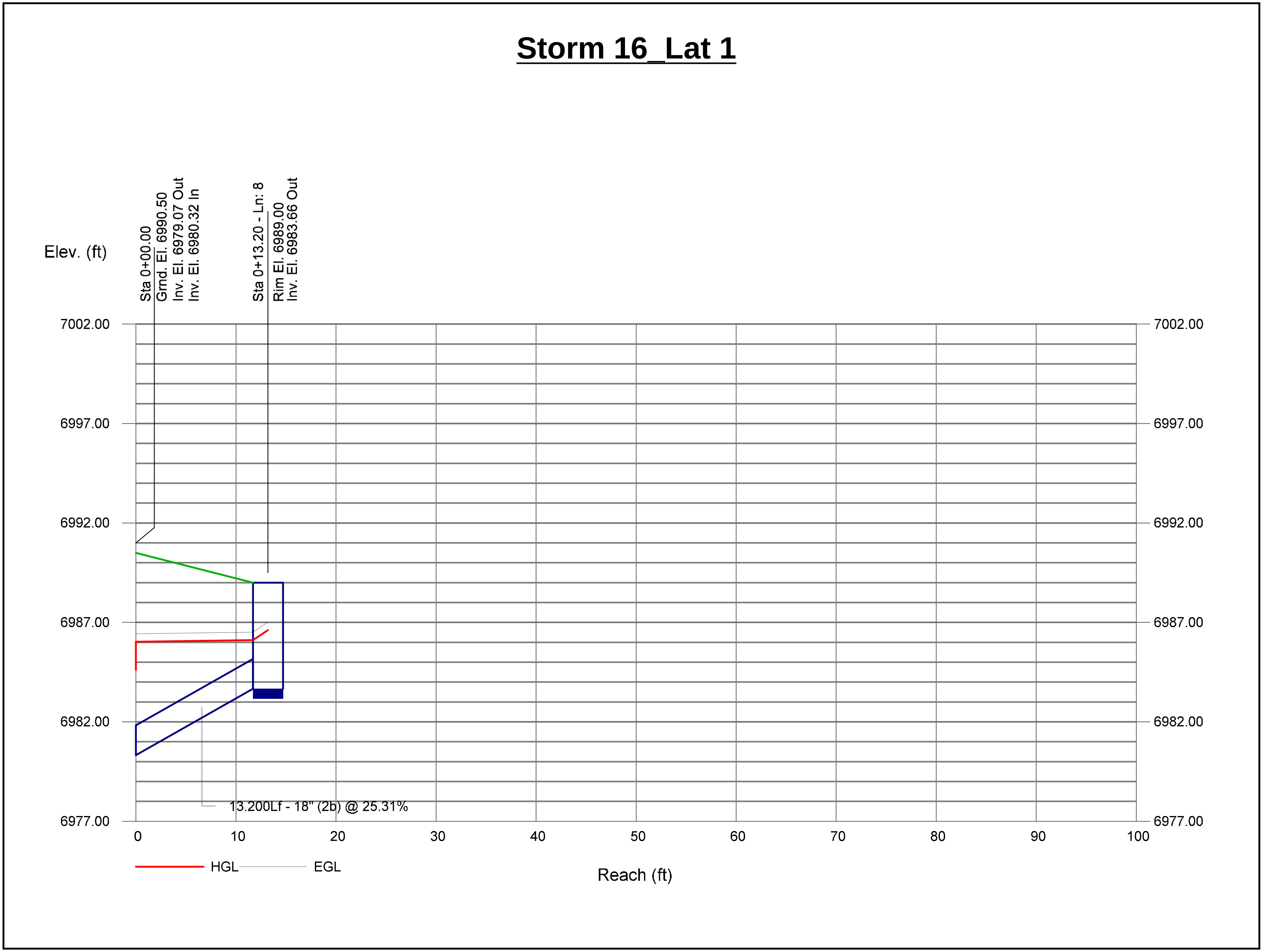
Proj. file: Storm 16, 18, 19, 21.stm

Storm 16, 19, 21



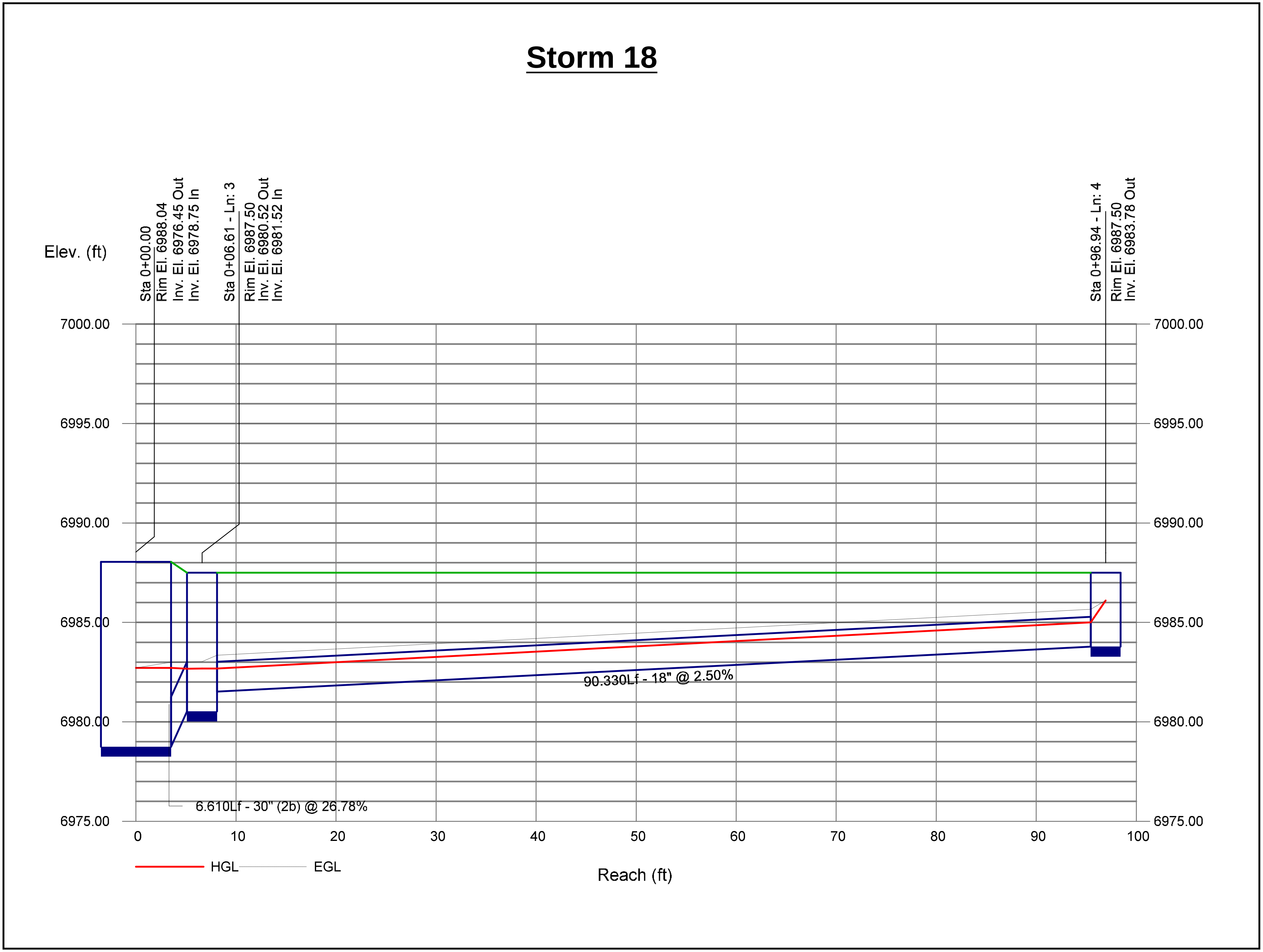
Storm Sewers

Storm Sewer Profile



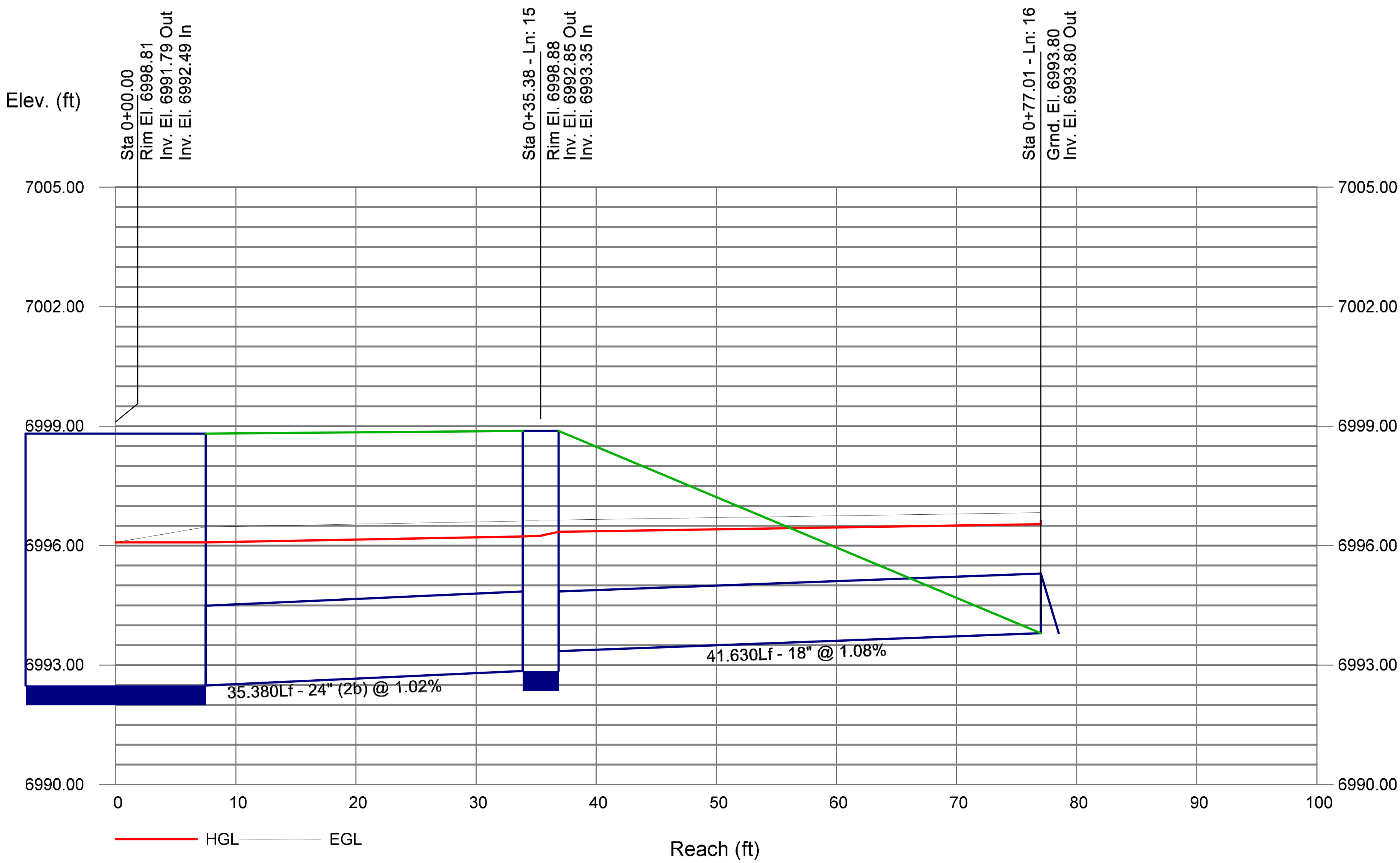
Storm Sewer Profile

Proj. file: Storm 16, 18, 19, 21.stm

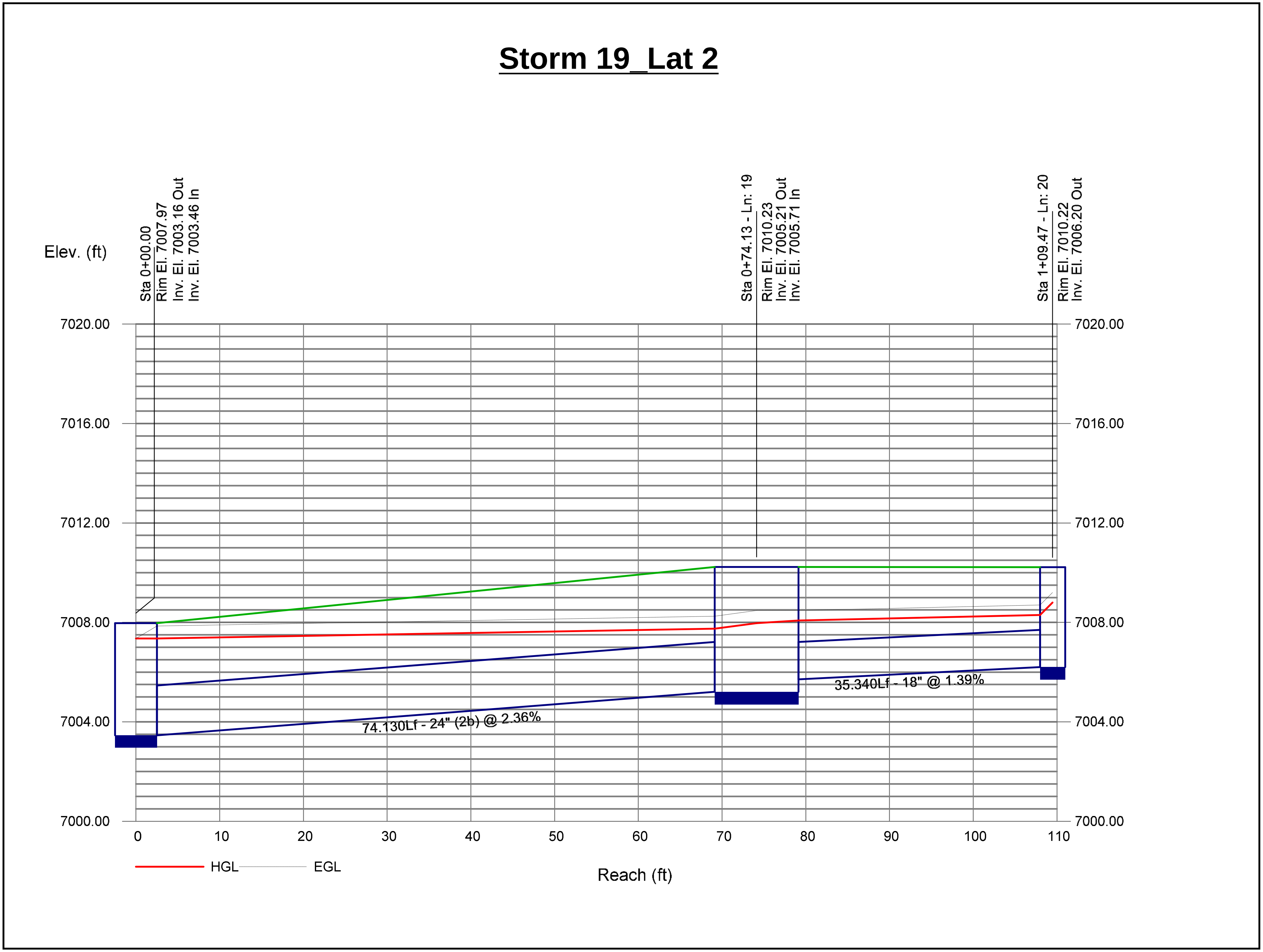


Storm Sewer Profile

Storm 19_Lat 1



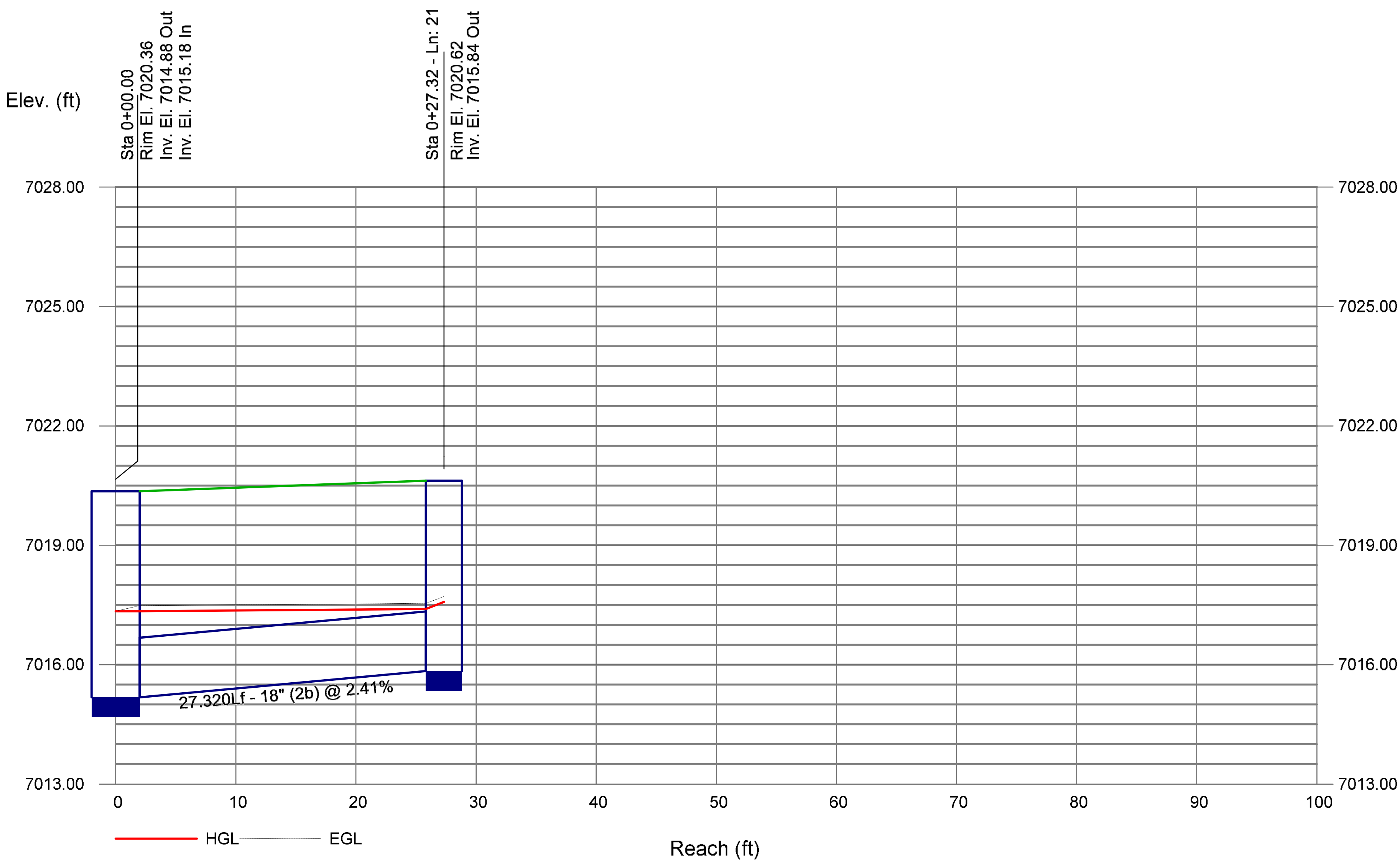
Storm Sewer Profile



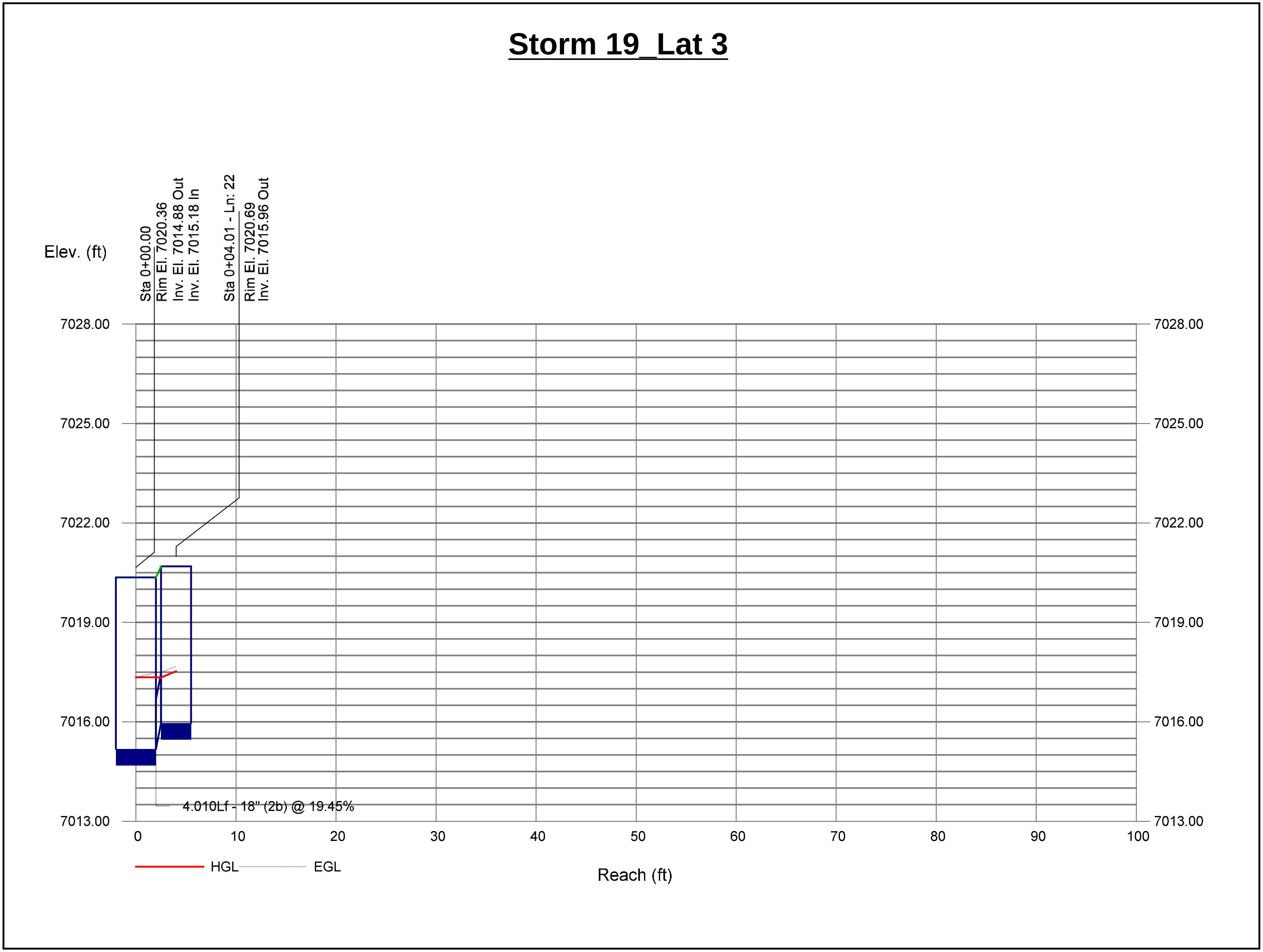
Storm Sewer Profile

Proj. file: Storm 16, 18, 19, 21.stm

Storm 19_Lat 3

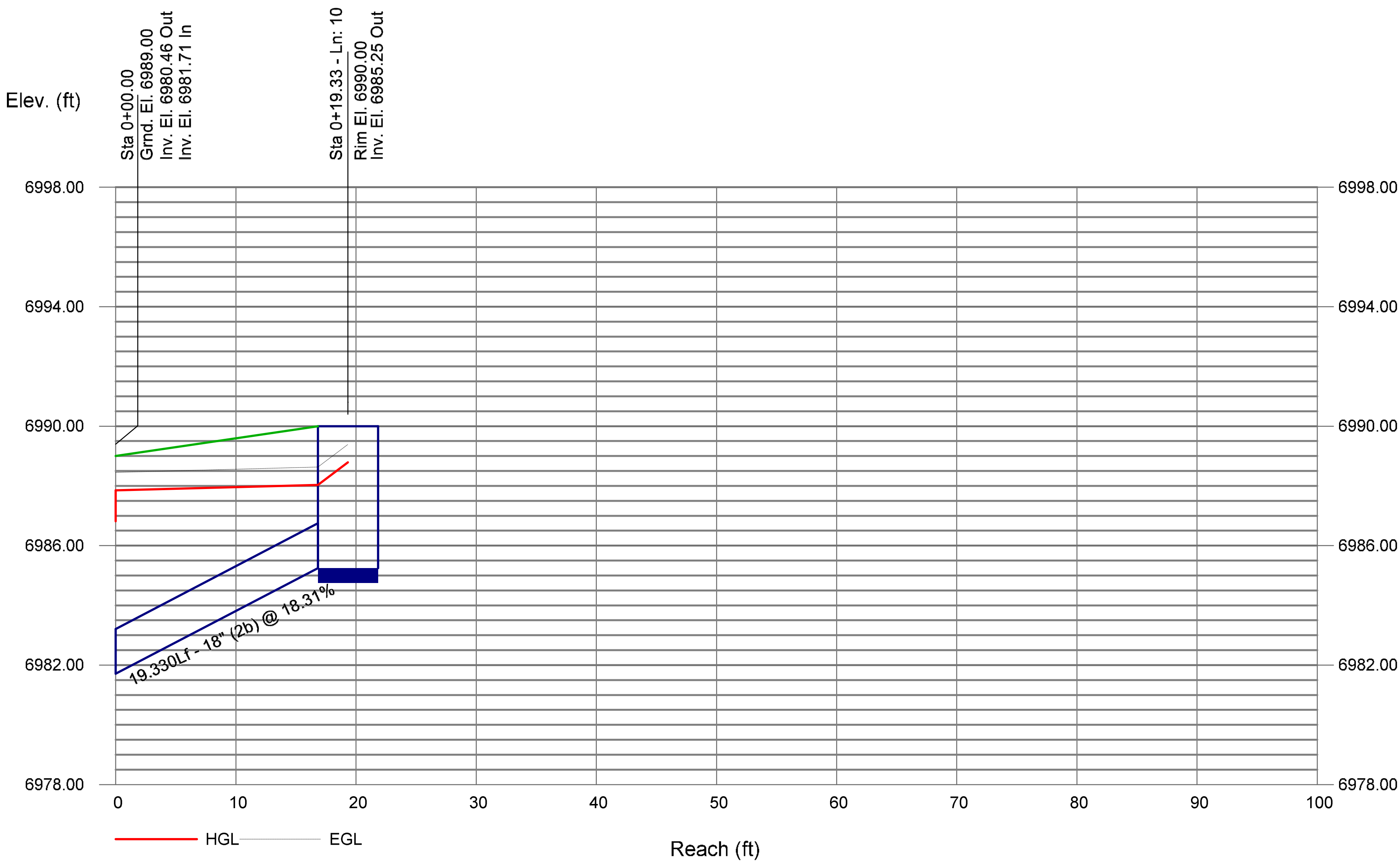


Storm Sewer Profile



Storm Sewer Profile

Storm 21_Lat 1



Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	84	in
Depth of flow, y =	63	in

(must have $y \geq D/2$)

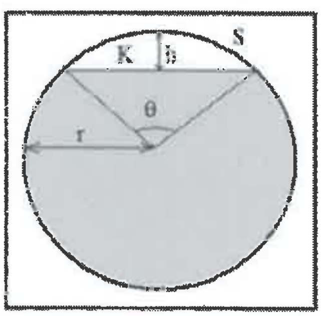
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.009	ft/ft

Calculations

n/n_{full} =	1.125
Partially Full Manning roughness, n =	0.015

Calculations

Pipe Diameter, D =	7	ft
Pipe Radius, r =	3.5	ft
Circ. Segment Height, h =	1.750	ft
Central Angle, q =	2.09	radians
Cross-Sect. Area, A =	30.96	ft^2
Wetted Perimeter, P =	14.7	ft
Hydraulic Radius, R =	2.11	ft
Discharge, Q =	492.56	cfs
Ave. Velocity, V =	15.91	ft/sec
pipe % full [(A/A_{full})*100%] =	80.4%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$ P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r^*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)^*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 14- 84" RCP

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Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	78	in
Depth of flow, y =	73	in

(must have $y \geq D/2$)

Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.005	ft/ft

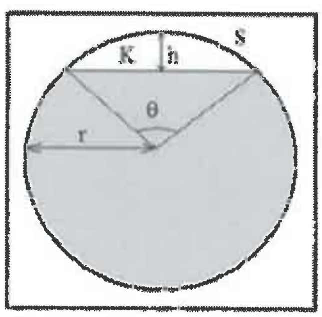
Calculations

n/n_{full} =	1.0320512
Partially Full Manning roughness, n =	0.013

Calculations

Pipe Diameter, D =	6.5	ft
Pipe Radius, r =	3.25	ft
Circ. Segment Height, h =	0.417	ft
Central Angle, q =	1.02	radians
Cross-Sect. Area, A =	32.29	ft^2
Wetted Perimeter, P =	17.1	ft
Hydraulic Radius, R =	1.89	ft
Discharge, Q =	387.43	cfs
Ave. Velocity, V =	12.00	ft/sec

pipe % full $[(A/A_{full})*100\%]$ = 97.3%



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$ P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\,\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 14 – 78" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	66	in
Depth of flow, y =	45	in

(must have y ≥ D/2)

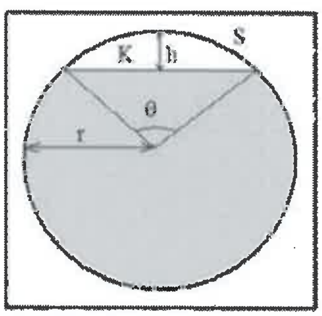
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.01	ft/ft

Calculations

n/n_{full} =	1.1590909
Partially Full Manning roughness, n =	0.015

Calculations

Pipe Diameter, D =	5.5	ft
Pipe Radius, r =	2.75	ft
Circ. Segment Height, h =	1.750	ft
Central Angle, q =	2.40	radians
Cross-Sect. Area, A =	17.26	ft^2
Wetted Perimeter, P =	10.7	ft
Hydraulic Radius, R =	1.61	ft
Discharge, Q =	234.85	cfs
Ave. Velocity, V =	13.61	ft/sec
pipe % full [(A/A_{full})*100%] =	72.6%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$ P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 14 - 66" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	66	in
Depth of flow, y =	31	in

(must have y ≥ D/2)

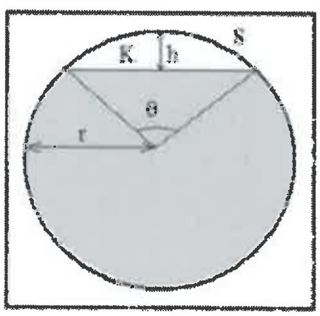
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0381	ft/ft

Calculations

n/n_{full} =	1.2651515
Partially Full Manning roughness, n =	0.016

Calculations

Pipe Diameter, D =	5.5	ft
Pipe Radius, r =	2.75	ft
Circ. Segment Height, h =	2.917	ft
Central Angle, q =	3.26	radians
Cross-Sect. Area, A =	10.96	ft^2
Wetted Perimeter, P =	9.3	ft
Hydraulic Radius, R =	1.32	ft
Discharge, Q =	233.27	cfs
Ave. Velocity, V =	21.28	ft/sec
pipe % full [(A/A_{full})*100%] =	46.1%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 14 – 66" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

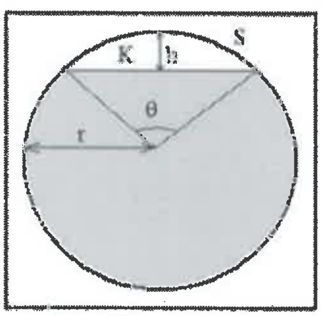
Pipe Diameter, D =	48	in
Depth of flow, y =	33	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.014	ft/ft

Calculations

n/n_{full} =	1.15625
Partially Full Manning roughness, n =	0.015

Calculations

Pipe Diameter, D =	4	ft
Pipe Radius, r =	2	ft
Circ. Segment Height, h =	1.250	ft
Central Angle, q =	2.37	radians
Cross-Sect. Area, A =	9.21	ft^2
Wetted Perimeter, P =	7.8	ft
Hydraulic Radius, R =	1.18	ft
Discharge, Q =	120.49	cfs
Ave. Velocity, V =	13.08	ft/sec
pipe % full [(A/A_{full})*100%] =	73.3%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A

P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 14 - 48" RCP
DP33

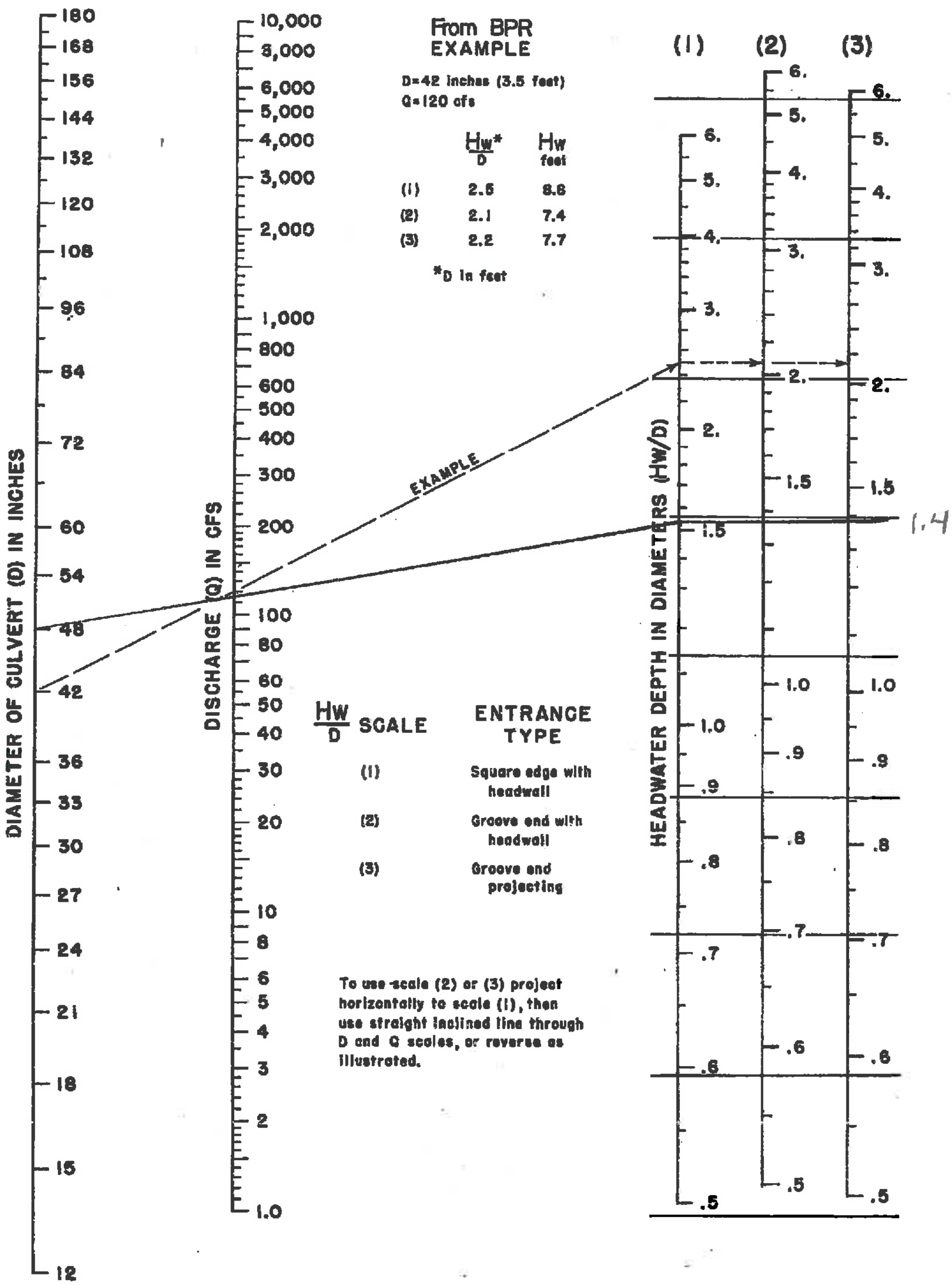
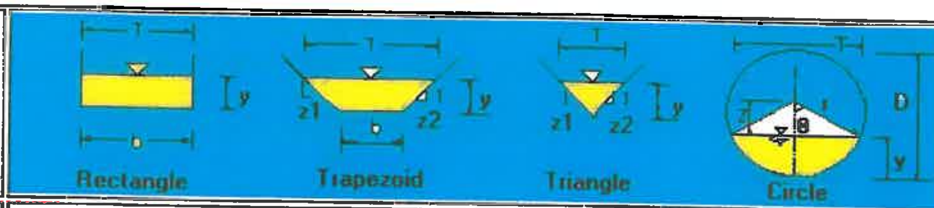


Figure CU-9—Inlet Control Nomograph—Example

INT DP33 Q_{100} = 115.2 cfs

The open channel flow calculator

Select Channel Type: Trapezoid



Velocity(V)&Discharge(Q) | Select unit system: Feet(ft)

Channel slope: .042 ft/ft	Water depth(y): 1.5 ft	Bottom width(b) 4 ft
Flow velocity 8.2089 ft/s	LeftSlope (Z1): 4 to 1 (H:	RightSlope (Z2): 4 to 1 (H:V
Flow discharge 123.1328 ft^3/s	Input n value 0.035 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 16.37 ft	Flow area 15 ft^2	Top width(T) 16 ft
Specific energy 2.55 ft	Froude number 1.49	Flow status Supercritical flow
Critical depth 1.83 ft	Critical slope 0.0177 ft/ft	Velocity head 1.05 ft

SR FIL 2
TRACT H
DP 33 Q_{100} = 115 cfs

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

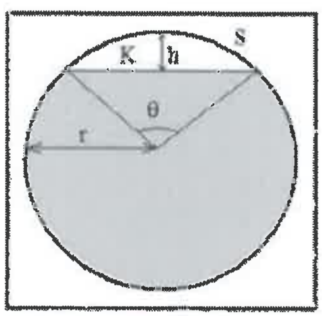
Pipe Diameter, D =	24	in
Depth of flow, y =	10	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.1612	ft/ft

Calculations

n/n_{full} =	1.2916666
Partially Full Manning roughness, n =	0.017

Calculations

Pipe Diameter, D =	2	ft
Pipe Radius, r =	1	ft
Circ. Segment Height, h =	1.167	ft
Central Angle, q =	3.48	radians
Cross-Sect. Area, A =	1.24	ft²
Wetted Perimeter, P =	2.8	ft
Hydraulic Radius, R =	0.44	ft
Discharge, Q =	25.59	cfs
Ave. Velocity, V =	20.66	ft/sec
pipe % full [(A/A_{full})*100%] =	39.4%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 15 - 24" RCP
DP56

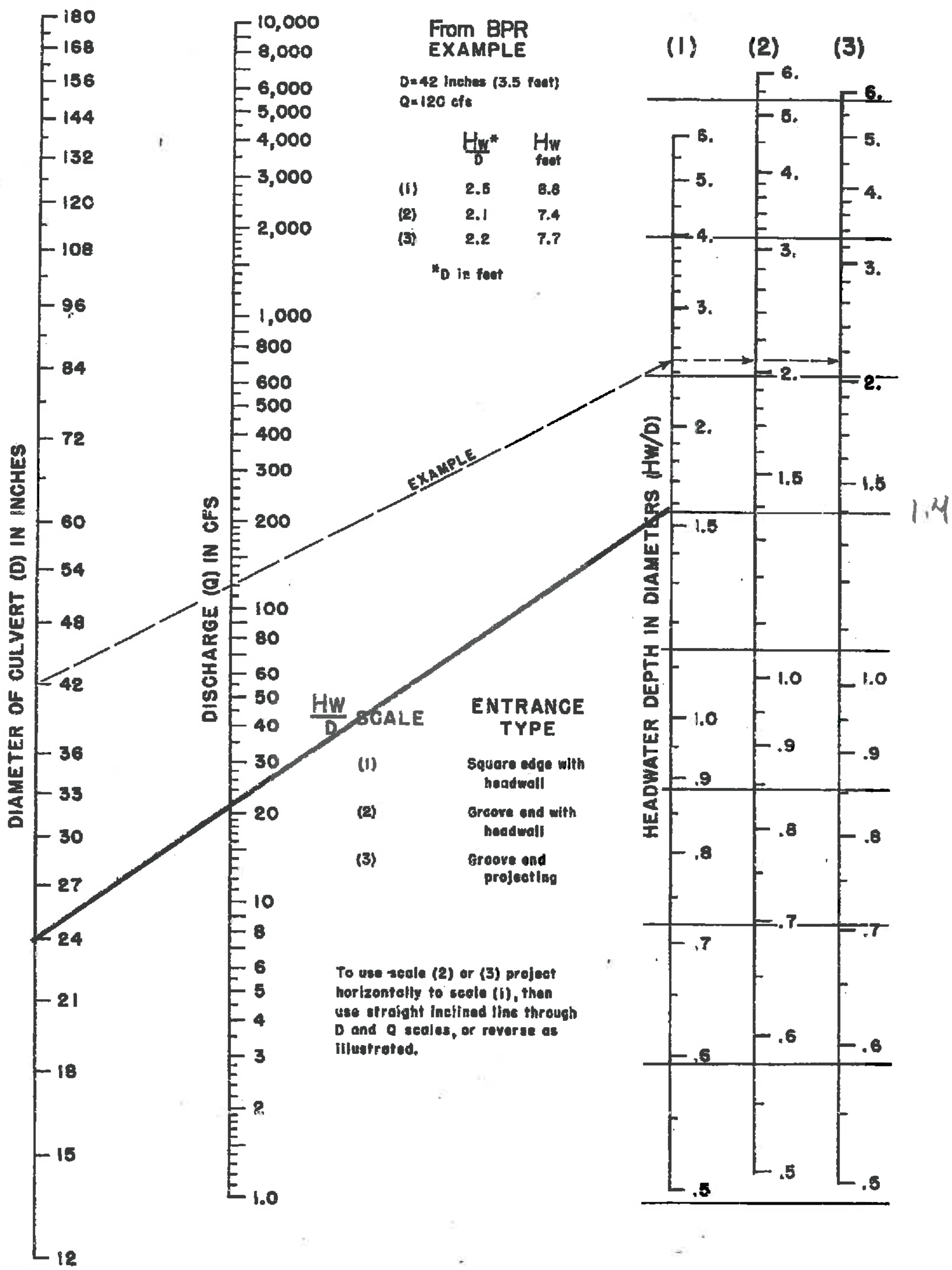
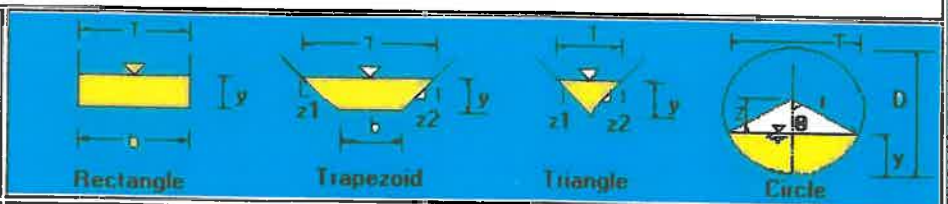


Figure CU-9—Inlet Control Nomograph—Example

DP56 Q_{100}= 205 cfs

The open channel flow calculator

Select Channel Type: Trapezoid



Velocity(V)&Discharge(Q) | Select unit system: Feet(ft)

Channel slope: .01 ft/ft	Water depth(y): 1 ft	Bottom width(b) 4 ft
Flow velocity 3.1965 ft/s	LeftSlope (Z1): 4 to 1 (H:	RightSlope (Z2): 4 to 1 (H:V
Flow discharge 25.5721 ft^3/s	Input n value 0.035 or select r	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 12.25 ft	Flow area 8 ft^2	Top width(T) 12 ft
Specific energy 1.16 ft	Froude number 0.69	Flow status Subcritical flow
Critical depth 0.82 ft	Critical slope 0.022 ft/ft	Velocity head 0.16 ft

SR FIL 2
TRACT M

DP 56 Q_{100}= 21cfs

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

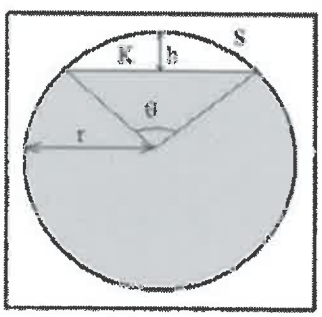
Pipe Diameter, D =	42	in
Depth of flow, y =	32	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.01	ft/ft

Calculations

n/n_{full} =	1.1190476
Partially Full Manning roughness, n =	0.015

Calculations

Pipe Diameter, D =	3.5	ft
Pipe Radius, r =	1.75	ft
Circ. Segment Height, h =	0.833	ft
Central Angle, q =	2.04	radians
Cross-Sect. Area, A =	7.87	ft^2
Wetted Perimeter, P =	7.4	ft
Hydraulic Radius, R =	1.06	ft
Discharge, Q =	83.70	cfs
Ave. Velocity, V =	10.64	ft/sec
pipe % full $[(A/A_{full})*100\%]$ =	81.8%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 15 - 42" RCP
DP38

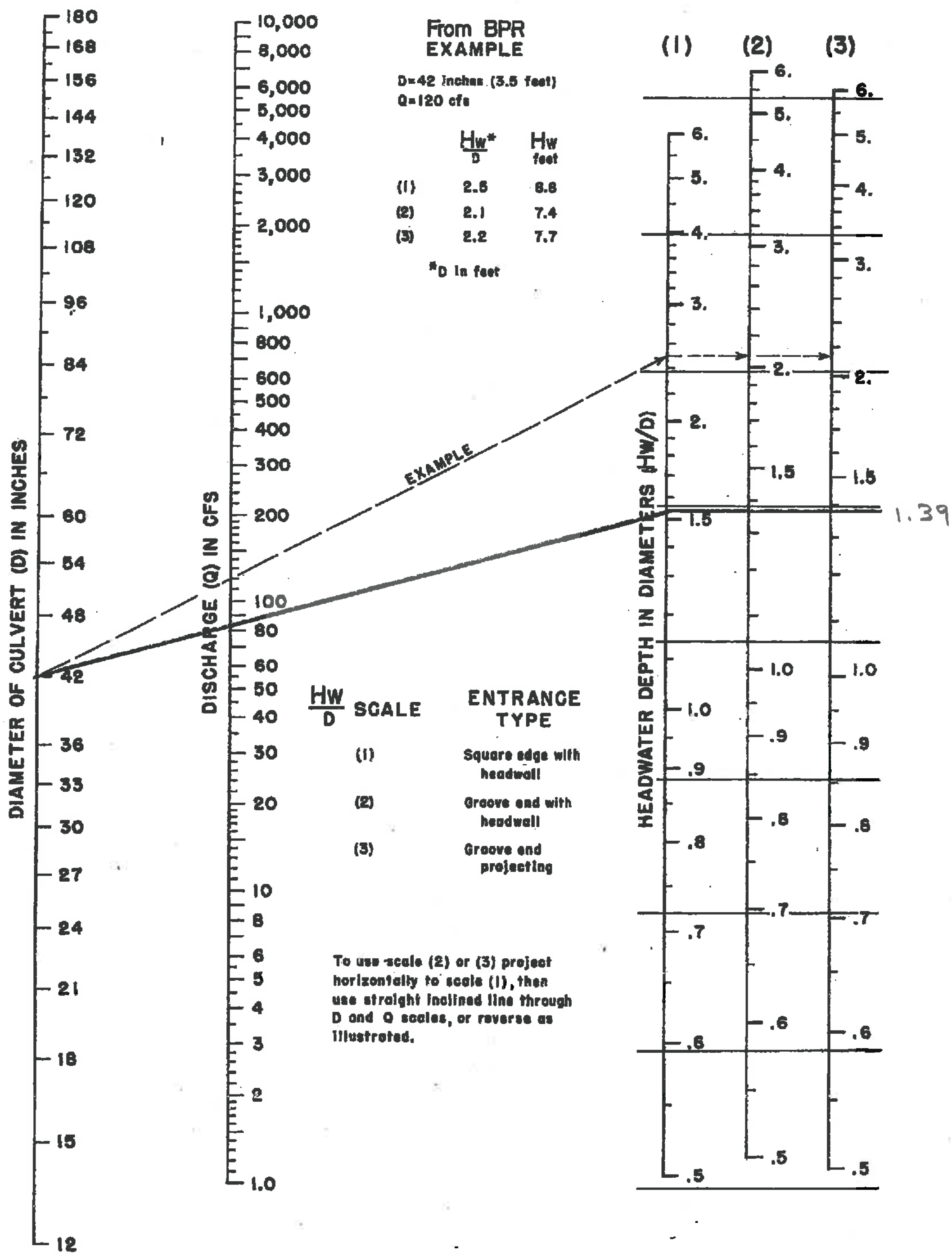
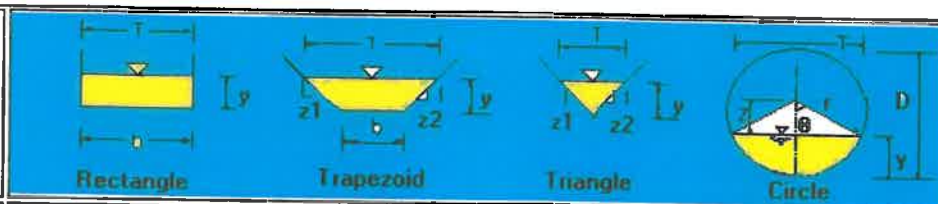


Figure CU-9—Inlet Control Nomograph—Example

DP38 Q_{100} = 81.9 cfs

The open channel flow calculator

Select Channel Type: Trapezoid



Velocity(V)&Discharge(Q) | Select unit system: Feet(ft)

Channel slope: .04 ft/ft	Water depth(y): 1.3 ft	Bottom width(b) 4 ft
Flow velocity 7.3937 ft/s	LeftSlope (Z1): 4 to 1 (H:'	RightSlope (Z2): 4 to 1 (H:V
Flow discharge 88.4286 ft^3/s	Input n value 0.035 or select r	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 14.72 ft	Flow area 11.96 ft^2	Top width(T) 14.4 ft
Specific energy 2.15 ft	Froude number 1.43	Flow status Supercritical flow
Critical depth 1.55 ft	Critical slope 0.0186 ft/ft	Velocity head 0.85 ft

SR FIL 2
TRACT L

DP38 Q_{100} = 82 cfs

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

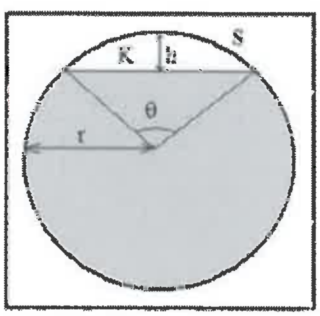
Pipe Diameter, D =	48	in
Depth of flow, y =	48	in
(must have $y \geq D/2$)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.006	ft/ft

Calculations

n/n_{full} =	1
Partially Full Manning roughness, n =	0.013

Calculations

Pipe Diameter, D =	4	ft
Pipe Radius, r =	2	ft
Circ. Segment Height, h =	0.000	ft
Central Angle, q =	0.00	radians
Cross-Sect. Area, A =	12.57	ft^2
Wetted Perimeter, P =	12.6	ft
Hydraulic Radius, R =	1.00	ft
Discharge, Q =	111.57	cfs
Ave. Velocity, V =	8.88	ft/sec
pipe % full $[(A/A_{full})*100\%]$ =	100.0%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$

P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 17 - 48" RCP

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

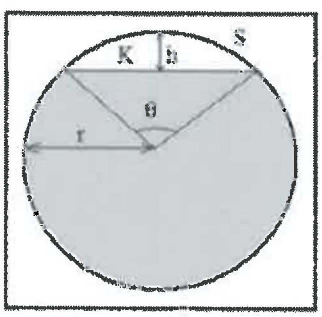
Pipe Diameter, D =	48	in
Depth of flow, y =	27	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0187	ft/ft

Calculations

n/n_{full} =	1.21875	
Partially Full Manning roughness, n =	0.016	

Calculations

Pipe Diameter, D =	4	ft
Pipe Radius, r =	2	ft
Circ. Segment Height, h =	1.750	ft
Central Angle, q =	2.89	radians
Cross-Sect. Area, A =	7.28	ft^2
Wetted Perimeter, P =	6.8	ft
Hydraulic Radius, R =	1.07	ft
Discharge, Q =	98.14	cfs
Ave. Velocity, V =	13.48	ft/sec
pipe % full [(A/A_{full})*100%] =	57.9%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r \cdot \theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 17 – 48" RCP

Partially Full Pipe Flow Calculator and Equations

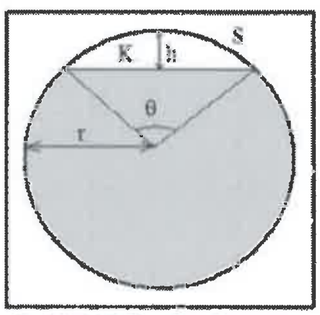
This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs			**Calculations**		
Pipe Diameter, D =	48	in	Pipe Diameter, D =	4	ft
Depth of flow, y =	26	in	Pipe Radius, r =	2	ft
(must have $y \geq D/2$)					
			Circ. Segment Height, h =	1.833	ft
Full Pipe Manning roughness, n_{full} =	0.013		Central Angle, q =	2.97	radians
Channel bottom slope, S =	0.0236	ft/ft	Cross-Sect. Area, A =	6.95	ft^2
			Wetted Perimeter, P =	6.6	ft
Calculations			Hydraulic Radius, R =	1.05	ft
n/n_{full} =	1.2291666		Discharge, Q =	103.28	cfs
Partially Full Manning roughness, n =	0.016		Ave. Velocity, V =	14.86	ft/sec
			pipe % full [(A/A$_{full}$)*100%] =	55.3%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$ P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r{*}\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 17 - 48" RCP

ENGINEERS EDGE
Solutions By Design

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

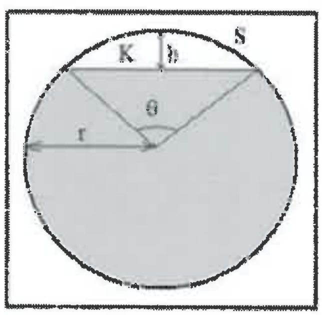
Pipe Diameter, D =	36	in
Depth of flow, y =	30	in
(must have $y \geq D/2$)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.01	ft/ft

Calculations

n/n_{full} =	1.0833333
Partially Full Manning roughness, n =	0.014

Calculations

Pipe Diameter, D =	3	ft
Pipe Radius, r =	1.5	ft
Circ. Segment Height, h =	0.500	ft
Central Angle, q =	1.68	radians
Cross-Sect. Area, A =	6.29	ft^2
Wetted Perimeter, P =	6.9	ft
Hydraulic Radius, R =	0.91	ft
Discharge, Q =	62.63	cfs
Ave. Velocity, V =	9.95	ft/sec
pipe % full [$(A/A_{full})*100\%$] =	89.0%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$ P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\ast\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \leq y/D \leq 1$)

STORM 17 - 36" RCP

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Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	36	in
Depth of flow, y =	24	in

(must have y ≥ D/2)

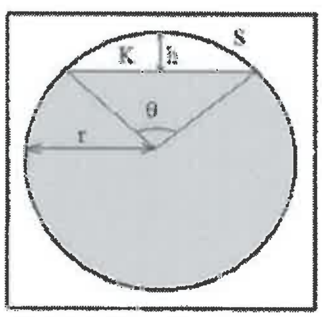
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.01	ft/ft

Calculations

n/n_{full} =	1.1666666
Partially Full Manning roughness, n =	0.015

Calculations

Pipe Diameter, D =	3	ft
Pipe Radius, r =	1.5	ft
Circ. Segment Height, h =	1.000	ft
Central Angle, q =	2.46	radians
Cross-Sect. Area, A =	5.01	ft^2
Wetted Perimeter, P =	5.7	ft
Hydraulic Radius, R =	0.87	ft
Discharge, Q =	44.94	cfs
Ave. Velocity, V =	8.98	ft/sec
pipe % full [(A/A_{full})*100%] =	70.8%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A

P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\theta$$

Equation used for n/n_{full}: n/n_{full} = 1.25 - (y/D -0.5)*0.5 (for 0.5 ≤ y/D ≤ 1)

STORM 17 LAT 2 - 36" RCP
DP29

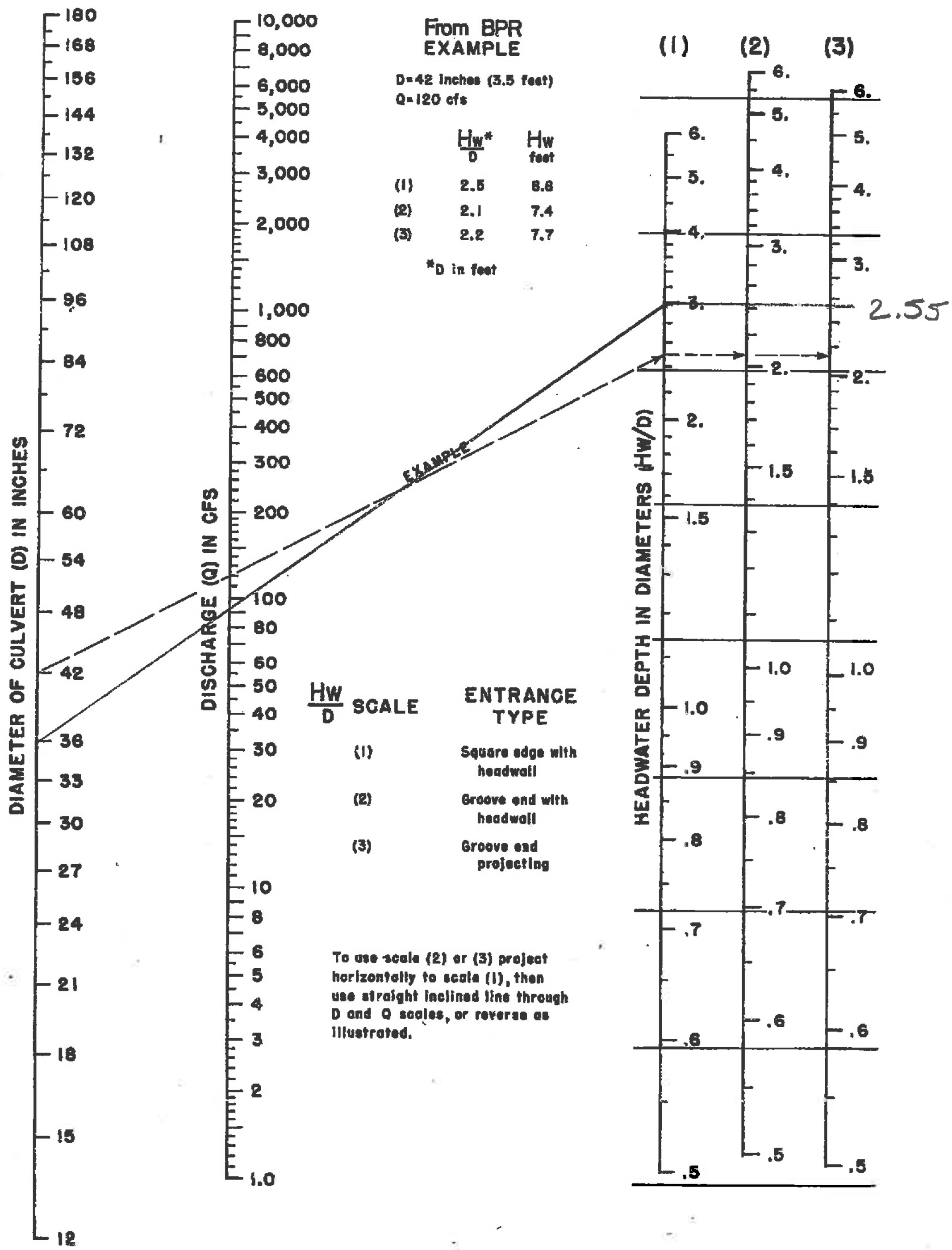
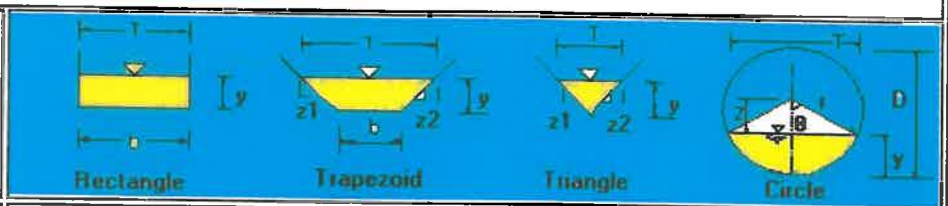


Figure CU-9—Inlet Control Nomograph—Example

INT DP29 Q_{100} = 97.8cfs

The open channel flow calculator

Select Channel Type: Trapezoid



Velocity(V)&Discharge(Q) | Select unit system: Feet(ft)

Channel slope: .0632 ft/ft	Water depth(y): 1.25 ft	Bottom width(b) 4 ft
Flow velocity 9.0928 ft/s	LeftSlope (Z1): 4 to 1 (H:	RightSlope (Z2): 4 to 1 (H:V
Flow discharge 102.2937 ft^3/s	Input n value 0.035 or select r	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 14.31 ft	Flow area 11.25 ft^2	Top width(T) 14 ft
Specific energy 2.53 ft	Froude number 1.79	Flow status Supercritical flow
Critical depth 1.67 ft	Critical slope 0.0181 ft/ft	Velocity head 1.28 ft

SR FIL 2
TRACT I
DP 29 Q_{100} = 98 cfs

ROLLMAX™
ROLLED EROSION CONTROL

Specification Sheet – EroNet™ SC150® Erosion Control Blanket

DESCRIPTION

The extended-term double net erosion control blanket shall be a machine-produced mat of 70% agricultural straw and 30% coconut fiber with a functional longevity of up to 24 months. (NOTE: functional longevity may vary depending upon climatic conditions, soil, geographical location, and elevation). The blanket shall be of consistent thickness with the straw and coconut evenly distributed over the entire area of the mat. The blanket shall be covered on the top side with a heavyweight photodegradable polypropylene netting having ultraviolet additives to delay breakdown and an approximate 0.63 x 0.63 in (1.59 x 1.59 cm) mesh, and on the bottom side with a lightweight photodegradable polypropylene netting with an approximate 0.50 x 0.50 (1.27 x 1.27 cm) mesh. The blanket shall be sewn together on 1.50 inch (3.81 cm) centers with degradable thread. The blanket shall be manufactured with a colored thread stitched along both outer edges (approximately 2-5 inches [5-12.5 cm] from the edge) as an overlap guide for adjacent mats.

The SC150 shall meet Type 3.B specification requirements established by the Erosion Control Technology Council (ECTC) and Federal Highway Administration's (FHWA) FP-03 Section 713.17

Material Content

Matrix	70% Straw Fiber 30% Coconut Fiber	0.35 lbs/sq yd (0.19 kg/sm) 0.15 lbs/sq yd (0.08 kg/sm)
Netting	Top: Heavyweight photodegradable with UV additives	3 lbs/1000 sq ft (1.47 kg/100 sm)
	Bottom: lighweight photodegradable	1.5 lb/1000 sq ft (0.73 kg/100 sm)
Thread	Degradable	

Standard Roll Sizes

Width	6.67 ft (2.03 m)	8 ft (2.4 m)	16.0 ft (4.87 m)
Length	108 ft (32.92 m)	112 ft (34.14 m)	108 ft (32.92 m)
Weight ± 10%	44 lbs (19.95 kg)	55 lbs (24.95 kg)	105.6 lbs (47.9 kg)
Area	80 sq yd (66.9 sm)	100 sq yd (83.61 sm)	192 sq yd (165.6 sm)

Index Property	Test Method	Typical
Thickness	ASTM D6525	0.35 in. (8.89 mm)
Resiliency	ECTC Guidelines	75%
Water Absorbency	ASTM D1117	342%
Mass/Unit Area	ASTM D6475	7.87 oz/sy (267.6 g/sm)
Swell	ECTC Guidelines	30%
Smolder Resistance	ECTC Guidelines	Yes
Stiffness	ASTM D1388	1.11 oz-in
Light Penetration	ASTM D6567	6.2%
Tensile Strength - MD	ASTM D6818	362.4 lbs/ft (5.37 kN/m)
Elongation - MD	ASTM D6818	29.4%
Tensile Strength - TD	ASTM D6818	136.8 lbs/ft (2.03 kN/m)
Elongation - TD	ASTM D6818	27.6%
Biomass Improvement	ASTM D7322	481%

Design Permissible Shear Stress

Unvegetated Shear Stress	2.00 psf (96 Pa)
Unvegetated Velocity	8.0 fps (2.44 m/s)

Slope Design Data: C Factors

	Slope Gradients (S)		
Slope Length (L)	≤ 3:1	3:1 – 2:1	≥ 2:1
≤ 20 ft (6 m)	0.001	0.048	0.100
20-50 ft	0.051	0.079	0.145
≥ 50 ft (15.2 m)	0.10	0.110	0.190

NTPEP Large-Scale Slope
ASTM D6459 - C-factor = 0.031

Roughness Coefficients - Unveg.

Flow Depth	Manning's n
≤ 0.50 ft (0.15 m)	0.050
0.50 – 2.0 ft	0.050-0.018
≥ 2.0 ft (0.60 m)	0.018

Tensar
NORTH AMERICAN GREEN®

Tensar International Corporation
2500 Northwinds Parkway
Suite 500
Alpharetta, GA 30009
800-TENSAR-1
tensarcorp.com

Tensar International Corporation warrants that at the time of delivery the product furnished hereunder shall conform to the specification stated herein. Any other warranty including merchantability and fitness for a particular purpose, are hereby executed. If the product does not meet specifications on this page and Tensar is notified prior to installation, Tensar will replace the product at no cost to the customer. **This product specification supersedes all prior specifications for the product described above and is not applicable to any products shipped prior to January 1, 2012.**

ROLLMAX™
ROLLED EROSION CONTROL

Specification Sheet – VMax® SC250® Turf Reinforcement Mat

DESCRIPTION

The composite turf reinforcement mat (C-TRM) shall be a machine-produced mat of 70% straw and 30% coconut fiber matrix incorporated into permanent three-dimensional turf reinforcement matting. The matrix shall be evenly distributed across the entire width of the matting and stitch bonded between a heavy duty UV stabilized nettings with 0.50 x 0.50 inch (1.27 x 1.27 cm) openings, an ultra heavy UV stabilized, dramatically corrugated (crimped) intermediate netting with 0.5 x 0.5 inch (1.27 x 1.27 cm) openings, and covered by an heavy duty UV stabilized nettings with 0.50 x 0.50 inch (1.27 x 1.27 cm) openings. The middle corrugated netting shall form prominent closely spaced ridges across the entire width of the mat. The three nettings shall be stitched together on 1.50 inch (3.81cm) centers with UV stabilized polypropylene thread to form permanent three-dimensional turf reinforcement matting. All mats shall be manufactured with a colored thread stitched along both outer edges as an overlap guide for adjacent mats.

The SC250 shall meet Type 5A, 5B, and 5C specification requirements established by the Erosion Control Technology Council (ECTC) and Federal Highway Administration's (FHWA) FP-03 Section 713.18

Material Content		
Matrix	70% Straw Fiber	0.35 lb/sq yd (0.19 kg/sm)
	30% Coconut Fiber	0.15 lbs/sq yd (0.08 kg/sm)
Netting	Top and Bottom, UV-Stabilized Polypropylene	5 lb/1000 sq ft (2.44 kg/100 sm)
	Middle, Corrugated UV-Stabilized Polypropylene	24 lb/1000 sf (11.7 kg/100 sm)
Thread	Polypropylene, UV Stable	

Standard Roll Sizes	
Width	6.5 ft (2.0 m)
Length	55.5 ft (16.9 m)
Weight ± 10%	34 lbs (15.42 kg)
Area	40 sq yd (33.4 sm)

Index Property	Test Method	Typical
Thickness	ASTM D6525	0.62 in. (15.75 mm)
Resiliency	ASTM 6524	95.2%
Density	ASTM D792	0.891 g/cm³
Mass/Unit Area	ASTM 6566	16.13 oz/sy (548 g/sm)
UV Stability	ASTM D4355/ 1000 HR	100%
Porosity	ECTC Guidelines	99%
Stiffness	ASTM D1388	222.65 oz-in.
Light Penetration	ASTM D6567	4.1%
Tensile Strength – MD	ASTM D6818	709 lbs/ft (10.51 kN/m)
Elongation – MD	ASTM D6818	23.9%
Tensile Strength – TD	ASTM D6818	712 lbs/ft (10.56 kN/m)
Elongation – TD	ASTM D6818	36.9%
Biomass Improvement	ASTM D7322	441%

Design Permissible Shear Stress	Short Duration	Long Duration
Phase 1: Unvegetated	3.0 psf (144 Pa)	2.5 psf (120 Pa)
Phase 2: Partially Veg.	8.0 psf (383 Pa)	8.0 psf (383 Pa)
Phase 3: Fully Veg.	10.0 psf (480 Pa)	8.0 psf (383 Pa)
Unvegetated Velocity	9.5 fps (2.9 m/s)	
Vegetated Velocity	15 fps (4.6 m/s)	

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

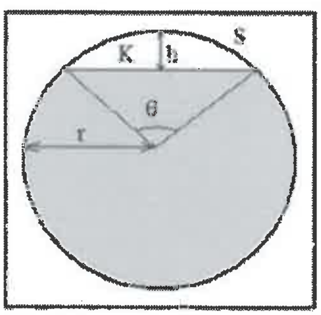
Pipe Diameter, D =	24	in
Depth of flow, y =	13	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0135	ft/ft

Calculations

n/n_{full} =	1.2291666	
Partially Full Manning roughness, n =	0.016	

Calculations

Pipe Diameter, D =	2	ft
Pipe Radius, r =	1	ft
Circ. Segment Height, h =	0.917	ft
Central Angle, q =	2.97	radians
Cross-Sect. Area, A =	1.74	ft^2
Wetted Perimeter, P =	3.3	ft
Hydraulic Radius, R =	0.53	ft
Discharge, Q =	12.25	cfs
Ave. Velocity, V =	7.05	ft/sec
pipe % full $[(A/A_{full})*100\%]$ =	55.3%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

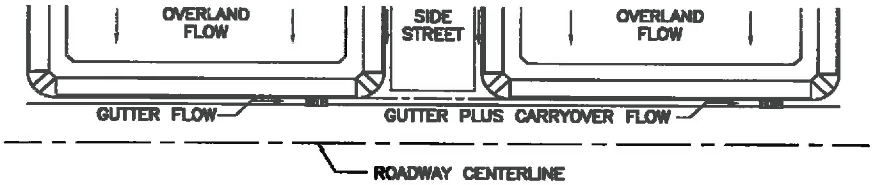
STORM 17 LAT 1 - 24" RCP
DP30

Worksheet Protected

DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP30



Show Details

Design Flow: ONLY if already determined through other methods:

	Minor Storm	Major Storm	
(local peak flow for 1/2 of street OR grass-lined channel): $^*Q_{Known}$ =	6.5	13.0	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

<-- FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW. <--

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- O Site is Urban
- O Site is Non-Urban

Flows Developed For:
- O Street Inlets
- O Area Inlets in a Median

	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

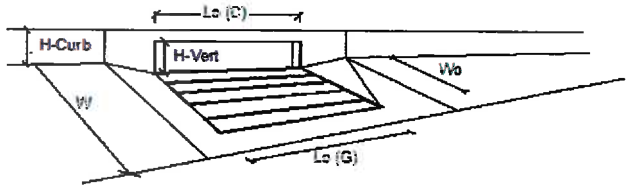
Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c) ^ {C_3}$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	6.5	13.0	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP30



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	3	3	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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 < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	6.50	11.10	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.0	1.9	cfs
Capture Percentage = Q_a/Q_o =	C% =	100	85	%

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Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

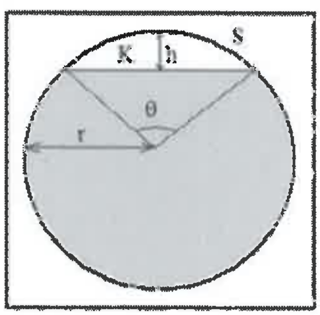
This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs			Calculations		
Pipe Diameter, D =	24	in	Pipe Diameter, D =	2	ft
Depth of flow, y =	11	in	Pipe Radius, r =	1	ft
(must have y ≥ D/2)					
			Circ. Segment Height, h =	1.083	ft
Full Pipe Manning roughness, n_{full} =	0.013		Central Angle, q =	3.31	radians
Channel bottom slope, S =	0.041	ft/ft	Cross-Sect. Area, A =	1.40	ft^2
			Wetted Perimeter, P =	3.0	ft
Calculations			Hydraulic Radius, R =	0.47	ft
n/n_{full} =	1.2708333		Discharge, Q =	15.55	cfs
Partially Full Manning roughness, n =	0.017		Ave. Velocity, V =	11.07	ft/sec
			pipe % full [(A/A_{full})*100%] =	44.7%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\,\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 17 - LAT 1 — 24" RCP
DP 31

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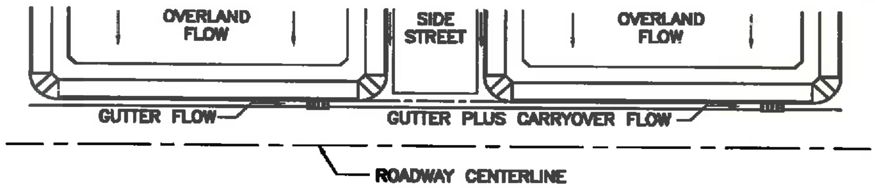
DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP31



Show Details

Design Flow: ONLY if already determined through other methods:

		Minor Storm	Major Storm	
(local peak flow for 1/2 of street OR grass-lined channel):	$*Q_{Known}$ =	8.4	19.8	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

<--- FILL IN THIS SECTION OR...

Geographic Information: (Enter data in the blue cells):

FILL IN THE SECTIONS BELOW. <---

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- ○ Site is Urban
- ○ Site is Non-Urban

Flows Developed For:
- ○ Street Inlets
- ○ Area Inlets in a Median

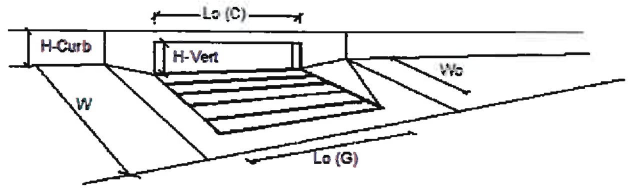
	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c) ^ C_3$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	8.4	19.8	cfs

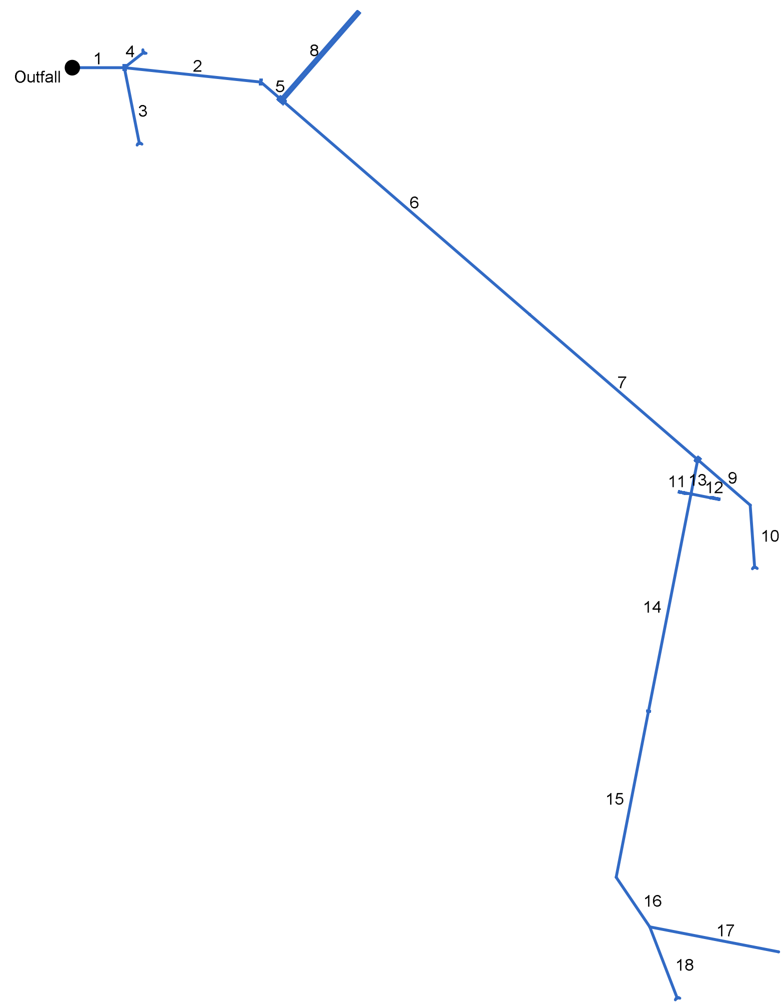
INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP31



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	3	3	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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 < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	8.18	14.15	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.2	5.7	cfs
Capture Percentage = Q_a/Q_o =	C% =	97	71	%

Storm 14, 15



Project File: Storm 14, 15, 16, 17.stm	Number of lines: 18	Date: 11/21/2017

Storm Sewers v10.50

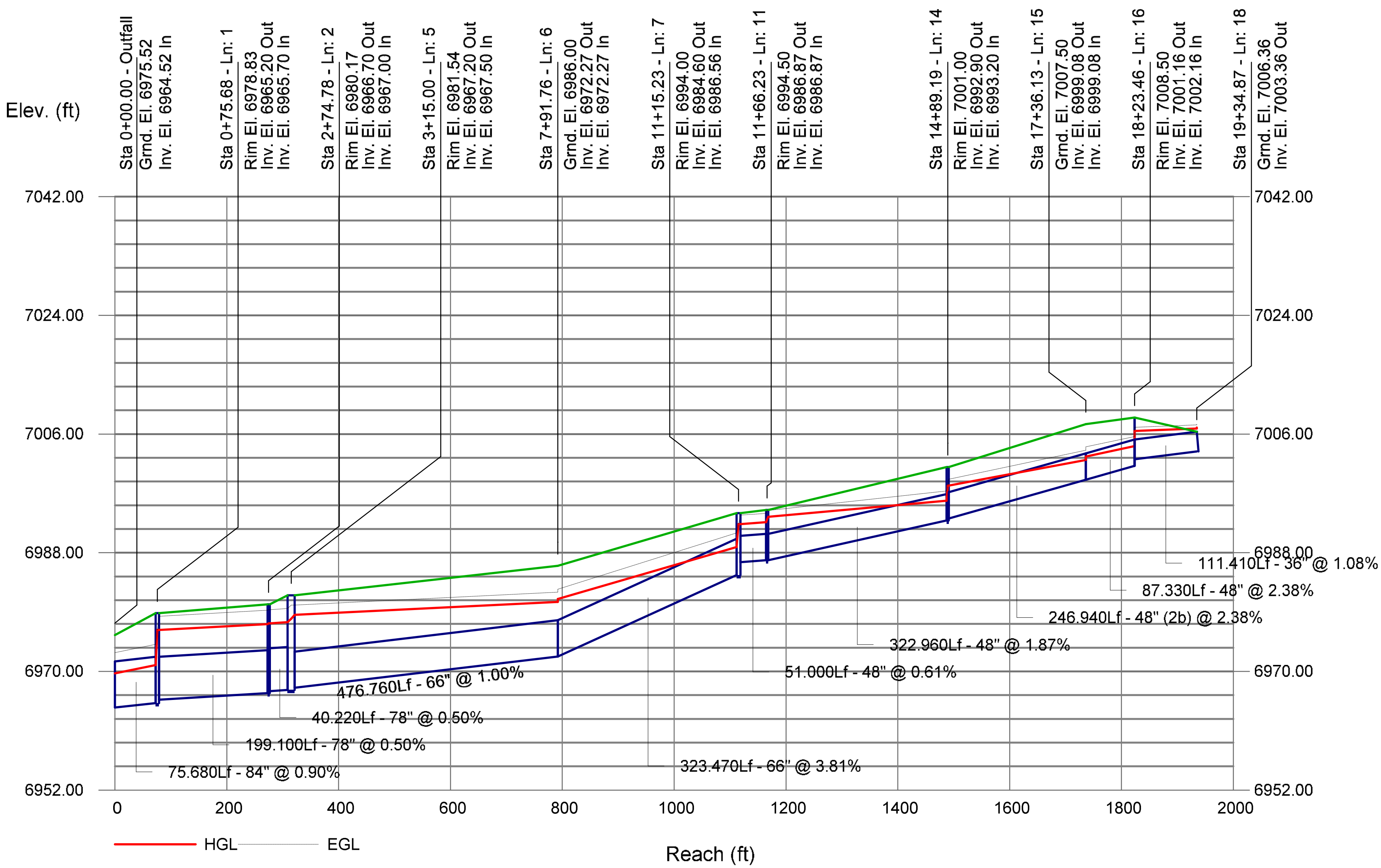
Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	PR 58, Strom 14	481.0	84	Cir	75.680	6964.52	6965.20	0.899	6969.70	6970.94	n/a	6976.27 i	End	Manhole
2	PR 57.1, Storm 14	384.0	78	Cir	199.100	6965.70	6966.70	0.502	6976.27*	6977.18*	0.10	6977.29	1	Manhole
3	PR 44, Storm 15	81.90	42	Cir	112.780	6968.70	6969.87	1.037	6976.27*	6976.91*	0.00	6976.91	1	OpenHeadwall
4	PR 57A, Storm 15	20.50	24	Cir	36.000	6970.20	6975.01	13.360	6976.27	6976.63	n/a	6978.10 i	1	OpenHeadwall
5	PR 57.2, Storm 14	384.0	78	Cir	40.220	6967.00	6967.20	0.498	6977.29*	6977.47*	0.52	6977.99	2	Manhole
6	PR 39.1, Strom 14	232.0	66	Cir	476.760	6967.50	6972.27	1.001	6978.59*	6980.53*	0.44	6980.98	5	None
7	PR 39.2, Storm 14	232.0	66	Cir	323.470	6972.27	6984.60	3.812	6980.98	6988.86	n/a	6992.32 i	6	Manhole
8	PR 56B, Storm 16	175.3	42	Cir(2b)	169.770	6967.50	6968.35	0.501	6978.78*	6979.88*	0.26	6980.14	5	Manhole
9	PR38.1, Storm 14	115.2	48	Cir	101.190	6986.10	6987.52	1.403	6992.32*	6992.88*	0.39	6993.27	7	None
10	PR38.2, Storm 14	115.2	48	Cir	91.270	6987.52	6988.80	1.402	6993.27*	6993.77*	n/a	6994.20 i	9	OpenHeadwall
11	PR 35, Storm 17	117.8	48	Cir	51.000	6986.56	6986.87	0.608	6992.32*	6992.62*	0.41	6993.03	7	Manhole
12	PR 34A, Storm 17 LAT_1	11.10	24	Cir	35.380	6989.37	6989.84	1.328	6994.20*	6994.27*	0.24	6994.51	11	Curb-Horiz
13	PR 34B, Storm 17 LAT_1	14.20	24	Cir	11.450	6989.37	6989.84	4.102	6994.08*	6994.11*	0.40	6994.51	11	Curb-Horiz
14	PR 34.1, Storm 17	97.80	48	Cir	322.960	6986.87	6992.90	1.867	6993.45	6995.90	n/a	6998.20 i	11	Manhole
15	PR 34.2, Storm 17	97.80	48	Cir	246.940	6993.20	6999.08	2.381	6998.20	7002.08	0.51	7002.08	14	None
16	PR 34.3, Storm 17	97.80	48	Cir	87.330	6999.08	7001.16	2.382	7002.59	7004.16	n/a	7006.46 i	15	Manhole
17	PR32, Storm 17	60.00	36	Cir	190.580	7002.16	7004.06	0.997	7006.46*	7007.77*	0.00	7007.77	16	None
18	PR 33, Storm 17 LAT_2	42.00	36	Cir	111.410	7002.16	7003.36	1.077	7006.46*	7006.83*	0.16	7007.00	16	OpenHeadwall

Storm 14, 15 | Number of lines: 18 | Run Date: 11/21/2017

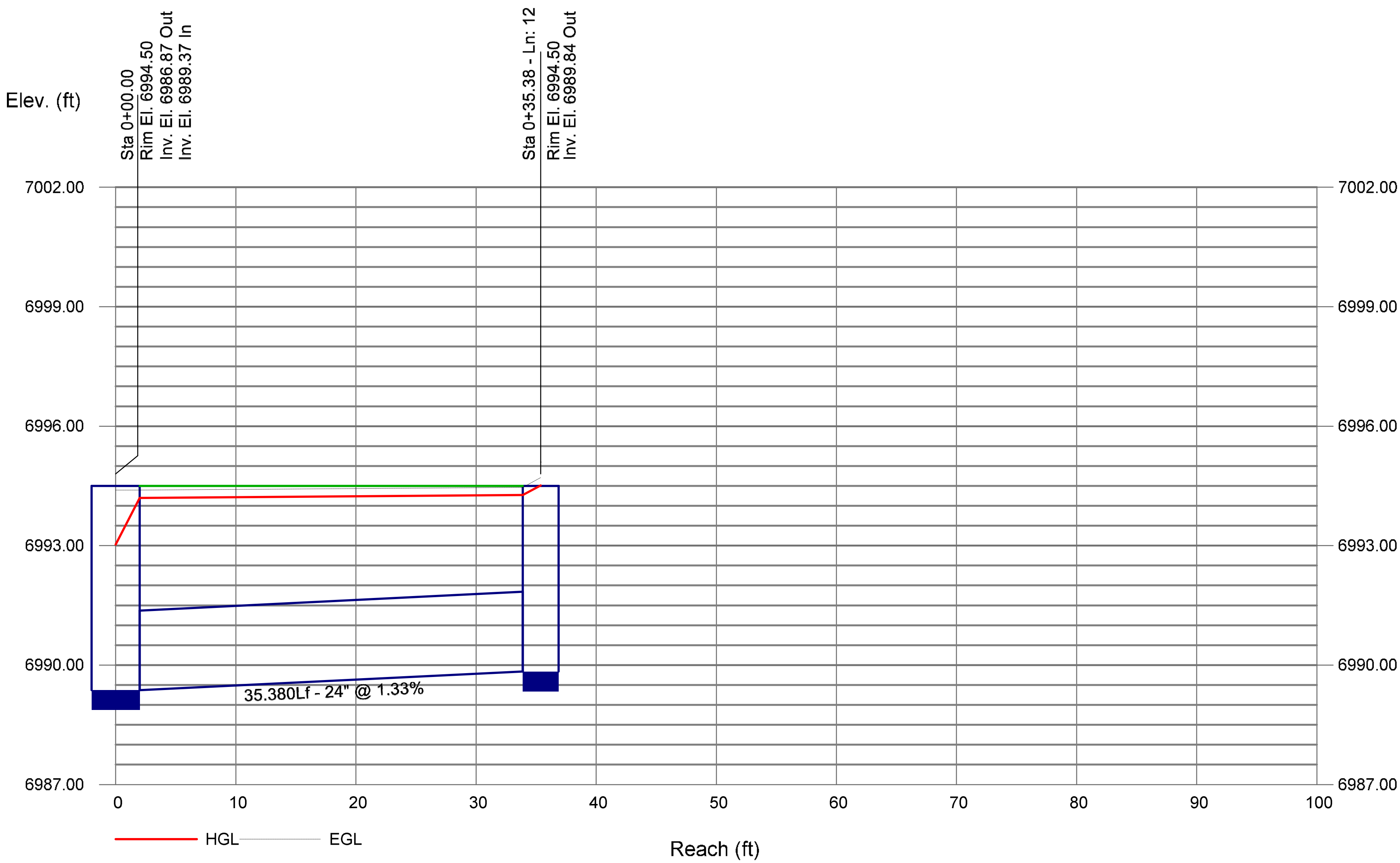
NOTES: Return period = 100 Yrs. ; *Surcharged (HGL above crown). ; i - Inlet control.

Storm 14, 17


Elev. (ft)
Sta 0+00.00 - Outfall
Grnd. El. 6975.52
Inv. El. 6964.52 In
Sta 0+75.68 - Ln: 1
Rim El. 6978.83
Inv. El. 6965.20 Out
Inv. El. 6965.70 In
Sta 2+74.78 - Ln: 2
Rim El. 6980.17
Inv. El. 6966.70 Out
Inv. El. 6967.00 In
Sta 3+15.00 - Ln: 5
Rim El. 6981.54
Inv. El. 6967.20 Out
Inv. El. 6967.50 In
Sta 7+91.76 - Ln: 6
Grnd. El. 6986.00
Inv. El. 6972.27 Out
Inv. El. 6972.27 In
Sta 11+15.23 - Ln: 7
Rim El. 6994.00
Inv. El. 6984.60 Out
Inv. El. 6986.56 In
Sta 11+66.23 - Ln: 11
Rim El. 6994.50
Inv. El. 6986.87 Out
Inv. El. 6986.87 In
Sta 14+89.19 - Ln: 14
Rim El. 7001.00
Inv. El. 6992.90 Out
Inv. El. 6993.20 In
Sta 17+36.13 - Ln: 15
Grnd. El. 7007.50
Inv. El. 6999.08 Out
Inv. El. 6999.08 In
Sta 18+23.46 - Ln: 16
Rim El. 7008.50
Inv. El. 7001.16 Out
Inv. El. 7002.16 In
Sta 19+34.87 - Ln: 18
Grnd. El. 7006.36
Inv. El. 7003.36 Out
7042.00
7024.00
7006.00
6988.00
6970.00
6952.00
111.410Lf - 36" @ 1.08%
87.330Lf - 48" @ 2.38%
246.940Lf - 48" (2b) @ 2.38%
322.960Lf - 48" @ 1.87%
51.000Lf - 48" @ 0.61%
476.760Lf - 66" @ 1.00%
40.220Lf - 78" @ 0.50%
199.100Lf - 78" @ 0.50%
323.470Lf - 66" @ 3.81%
75.680Lf - 84" @ 0.90%
0
200
400
600
800
1000
1200
1400
1600
1800
2000
HGL
EGL
Reach (ft)

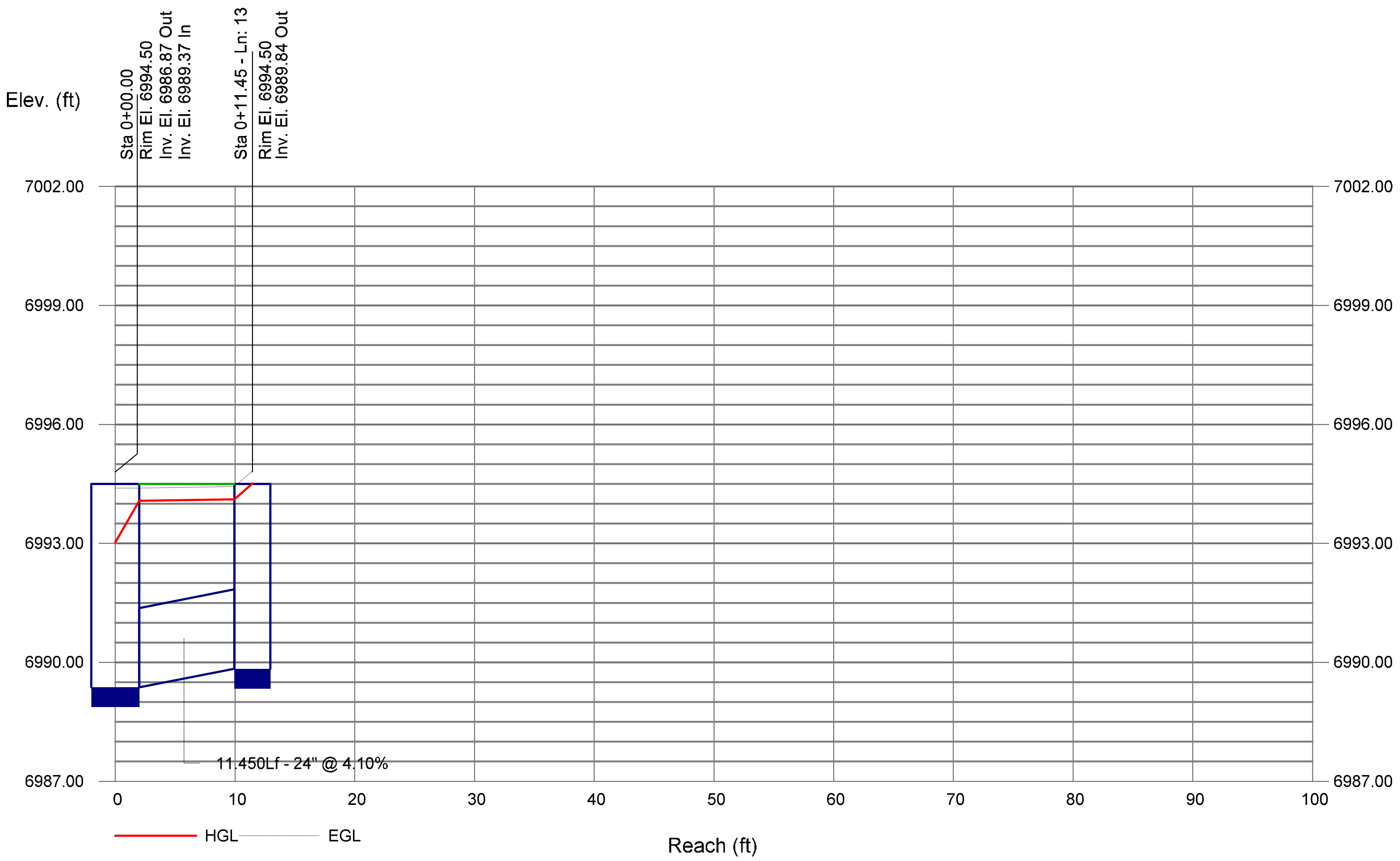
Storm Sewer Profile

Storm 17_Lat 1



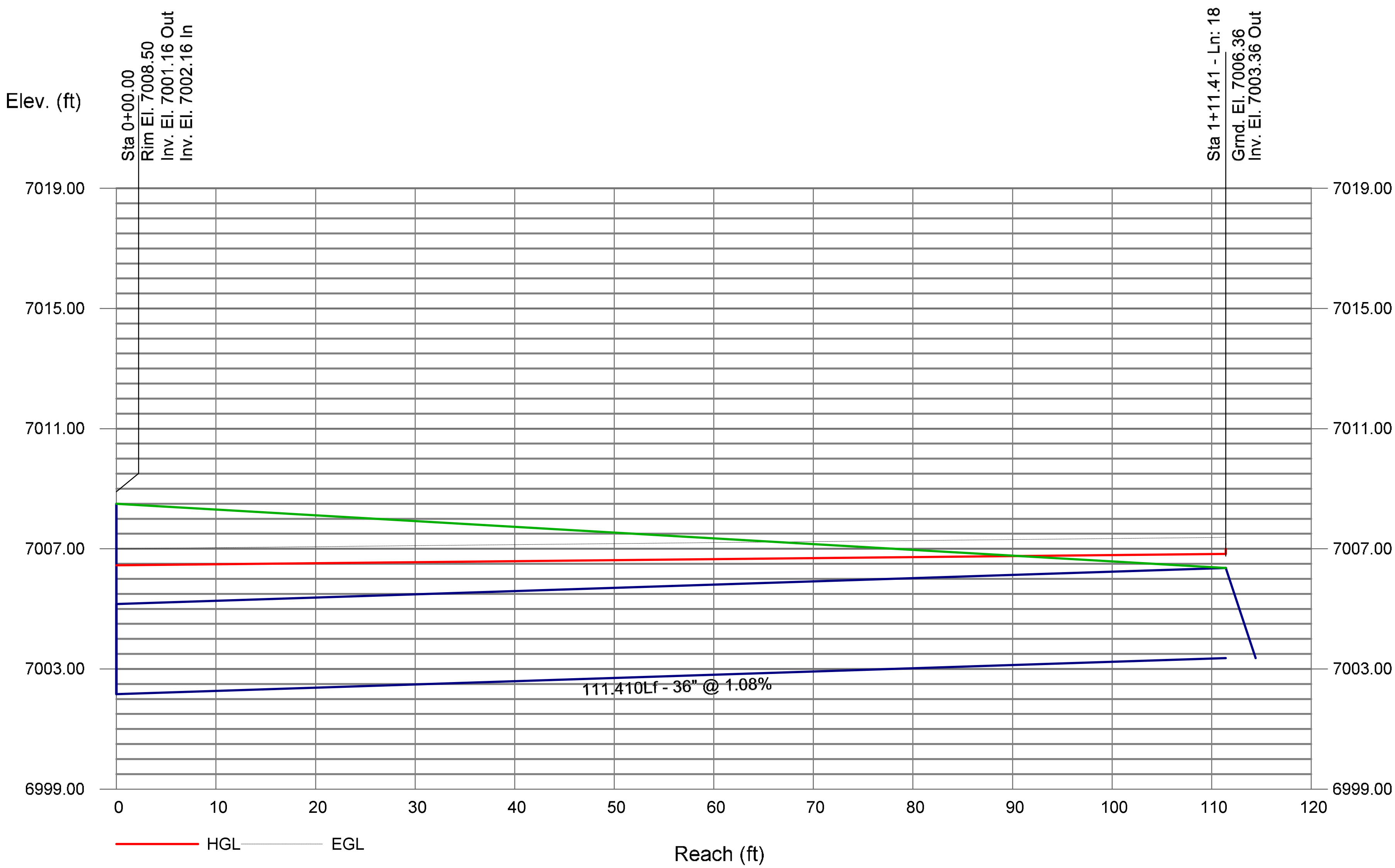
Storm Sewer Profile

Storm 17_Lat 1



Storm Sewer Profile

Storm 17_Lat 2



ENGINEERS EDGE
Solutions By Design

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D = 24 in
Depth of flow, y = 9 in
(must have y ≥ D/2)

Full Pipe Manning roughness, n_{full} = 0.013
Channel bottom slope, S = 0.129 ft/ft

Calculations

n/n_{full} = 1.3125
Partially Full Manning roughness, n = 0.017

Calculations

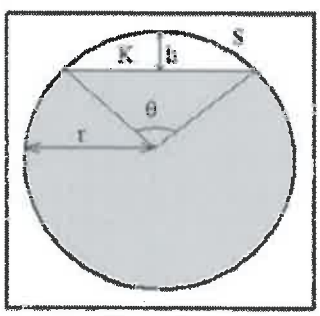
Pipe Diameter, D = 2 ft
Pipe Radius, r = 1 ft

Circ. Segment Height, h = 1.250 ft

Central Angle, q = 3.65 radians
Cross-Sect. Area, A = 1.08 ft^2

Wetted Perimeter, P = 2.6 ft
Hydraulic Radius, R = 0.41 ft
Discharge, Q = 18.57 cfs
Ave. Velocity, V = 17.26 ft/sec

pipe % full $[(A/A_{full})*100\%]$ = 34.3%



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 26 – 24" RCP
DP73

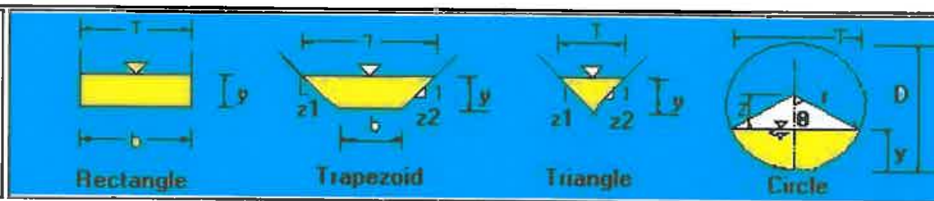
DP 73

2.9' x 5.7' TYPE D CDOT AREA INLET

width	2.91	area	16.4997	open area x 70%		
length	5.67	blockage	0.5			
perimeter	17.16	blockage	4	avail perm.		
				Orifice	**Weir**	
29.5	0			0	0	
29.625	0.125			9.8309	1.802946	
29.75	0.25			13.90299	5.0995	
29.875	0.375			17.02762	9.36838	
30	0.5			19.6618	14.42356	Q100 =
30.125	0.625			21.98256	20.15754	← 18 cfs
30.25	0.75			24.08069	26.49778	
30.375	0.875			26.01012	33.39102	
30.5	1			27.80598	40.796	
30.625	1.125			29.4927	48.67953	
30.75	1.25			31.08804	57.01414	
30.875	1.375			32.60541	65.77663	
31	1.5			34.05524	74.94704	
31.125	1.625			35.44581	84.50796	
31.25	1.75			36.78386	94.44406	
31.375	1.875			38.07491	104.7417	
31.5	2			39.3236	115.3885	
31.625	2.125			40.53384	126.3735	
31.75	2.25			41.70898	137.6865	
31.875	2.375			42.8519	149.3183	
32	2.5			43.96512	161.2603	
32.125	2.625			45.05084	173.5048	
32.25	2.75			46.11101	186.0444	
32.375	2.875			47.14734	198.8723	
32.5	3			48.16138	211.9822	

The open channel flow calculator

Select Channel Type: Triangle



Velocity(V)&Discharge(Q)

Select unit system: Feet(ft)

Channel slope: 0.04 ft/ft	Water depth(y): 1.1 ft	Bottom W(b) 0 ft
Flow velocity 5.5035 ft/s	LeftSlope (Z1): 3 to 1 (H:	RightSlope (Z2): 3 to 1 (H:V
Flow discharge 19.9776 ft^3/s	Input n value 0.035 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 6.96 ft	Flow area 3.63 ft^2	Top width(T) 6.6 ft
Specific energy 1.57 ft	Froude number 1.31	Flow status Supercritical flow
Critical depth 1.22 ft	Critical slope 0.0225 ft/ft	Velocity head 0.47 ft

SR FIL 2
SWALE / AREA INLET
WEST OF VOLLMER/MARKSHEFFEL
INTERSECTION

DP 73 Q_{100} = 18cfs

Storm 26

Project File: Storm 26.stm	Number of lines: 1	Date: 5/4/2017

Storm Sewers v10.50

Storm Sewer Summary Report

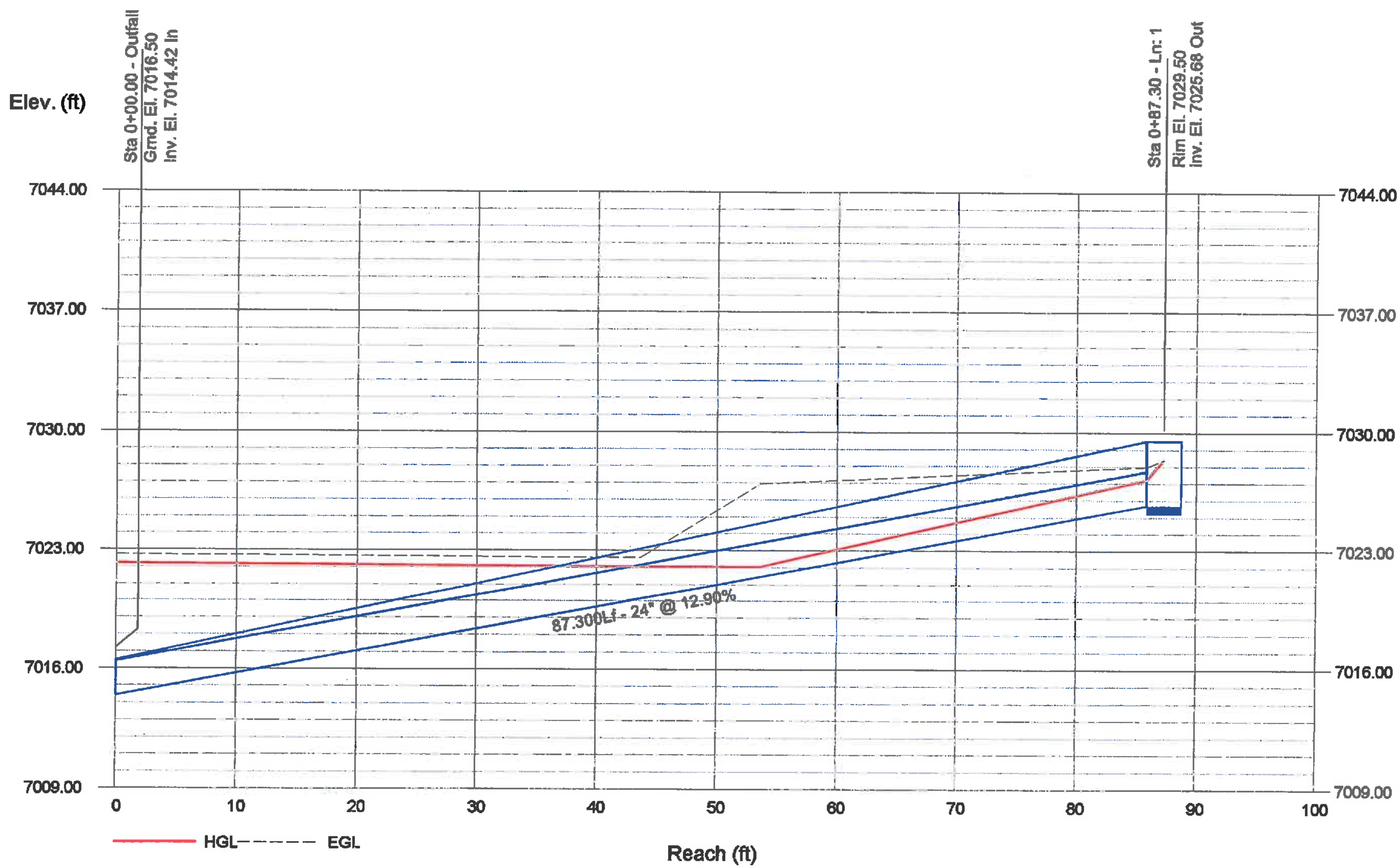
Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	PR 76.1, Storm 26	18.00	24	Cir	87.300	7014.42	7025.68	12.898	7022.21	7027.21	n/a	7028.42 i	End	DropGrate

Storm 22 | Number of lines: 1 | Run Date: 5/4/2017

NOTES: Return period = 100 Yrs. ; i - Inlet control.

Storm Sewer Profile

Proj. file: Storm 26.stm



Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

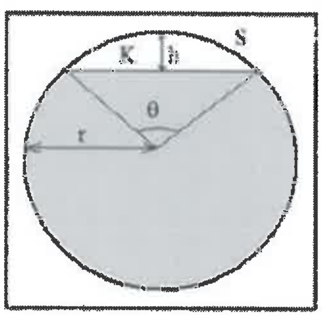
Pipe Diameter, D =	30	in
Depth of flow, y =	16	in
(must have y ≥ D/2)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.01	ft/ft

Calculations

n/n_{full} =	1.2333333	
Partially Full Manning roughness, n =	0.016	

Calculations

Pipe Diameter, D =	2.5	ft
Pipe Radius, r =	1.25	ft
Circ. Segment Height, h =	1.167	ft
Central Angle, q =	3.01	radians
Cross-Sect. Area, A =	2.66	ft^2
Wetted Perimeter, P =	4.1	ft
Hydraulic Radius, R =	0.65	ft
Discharge, Q =	18.57	cfs
Ave. Velocity, V =	6.98	ft/sec
pipe % full [(A/A_{full})*100%] =	54.2%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r \cdot \theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

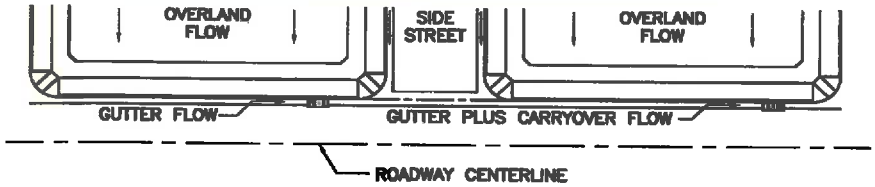
STORM 22- 30" RCP
DP48

Worksheet Protected

DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP48-1



Show Details

Design Flow: ONLY if already determined through other methods:

	Minor Storm	Major Storm	
(local peak flow for 1/2 of street OR grass-lined channel): *Q_{Known} =	8.2	21.0	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

<--- FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW. <---

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- O Site is Urban
- O Site is Non-Urban

Flows Developed For:
- O Street Inlets
- O Area Inlets in a Median

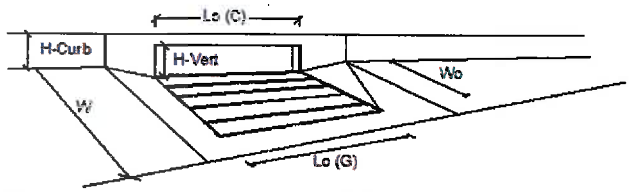
	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c)^{C_3}$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	8.2	21.0	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP48-1



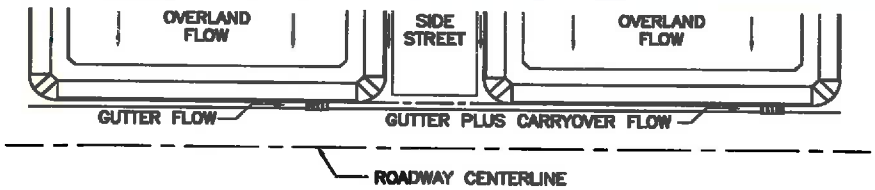
Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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: WARNING: Q > ALLOWABLE Q FOR MAJOR STORM		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	6.47	10.42	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	1.7	10.6	cfs
Capture Percentage = Q_a/Q_o =	C% =	79	50	%

Worksheet Protected

DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP48-2



Show Details

Design Flow: ONLY if already determined through other methods:

		Minor Storm	Major Storm	
(local peak flow for 1/2 of street OR grass-lined channel):	$*Q_{Known}$ =	1.7	10.6	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

← FILL IN THIS SECTION OR...

Geographic Information: (Enter data in the blue cells):

FILL IN THE SECTIONS BELOW. ←

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- Site is Urban
- Site is Non-Urban

Flows Developed For:
- Street Inlets
- Area Inlets in a Median

	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

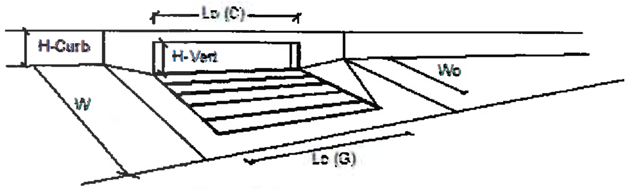
Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c)^{C_3}$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	1.7	10.6	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP48-2



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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 < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	1.70	7.45	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.0	3.2	cfs
Capture Percentage = Q_a/Q_o =	C% =	100	70	%

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, D =	30	in
Depth of flow, y =	15	in

(must have y ≥ D/2)

Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.0612	ft/ft

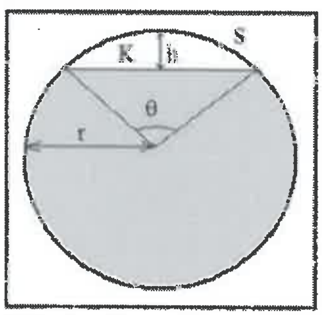
Calculations

n/n_{full} =	1.25
Partially Full Manning roughness, n =	0.016

Calculations

Pipe Diameter, D =	2.5	ft
Pipe Radius, r =	1.25	ft
Circ. Segment Height, h =	1.250	ft
Central Angle, q =	3.14	radians
Cross-Sect. Area, A =	2.45	ft^2
Wetted Perimeter, P =	3.9	ft
Hydraulic Radius, R =	0.63	ft
Discharge, Q =	40.70	cfs
Ave. Velocity, V =	16.58	ft/sec

pipe % full [(A/A_{full})*100%] = 50.0%



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)*0.5$ (for $0.5 \le y/D \le 1$)

STORM 22- 30" RCP
DP 47

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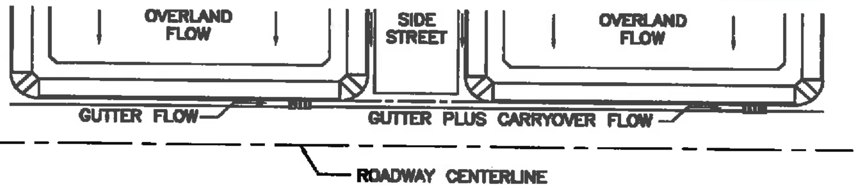
DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP47-1



Show Details

Design Flow: ONLY if already determined through other methods:

		Minor Storm	Major Storm	
(local peak flow for 1/2 of street OR grass-lined channel):	$^*Q_{Known}$ =	7.7	20.4	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

<--- FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW. <---

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- ○ Site is Urban
- ○ Site is Non-Urban

Flows Developed For:
- ○ Street Inlets
- ○ Area Inlets in a Median

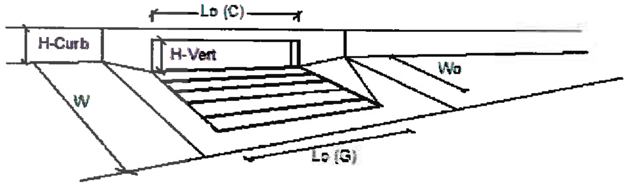
	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c) ^ C_3$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	7.7	20.4	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP47-1

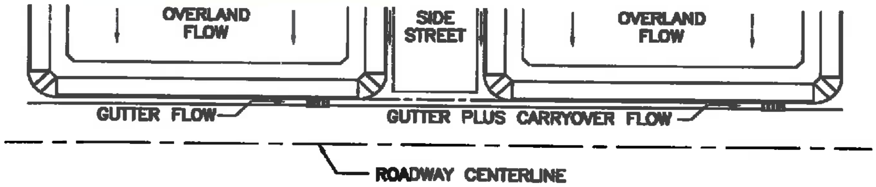


Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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: WARNING: Q > ALLOWABLE Q FOR MAJOR STORM		**MINOR**	**MAJOR**	
Total Inlet Interception Capacity	**Q =**	**6.24**	**10.28**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**1.5**	**10.1**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**81**	**50**	**%**

Worksheet Protected

DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP47-2



Show Details

Design Flow: ONLY if already determined through other methods:

		Minor Storm	Major Storm	
(local peak flow for 1/2 of street OR grass-lined channel):	$^*Q_{Known}$ =	1.5	10.1	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

<--- FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW. <---

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- ○ Site is Urban
- ○ Site is Non-Urban

Flows Developed For:
- ○ Street Inlets
- ○ Area Inlets in a Median

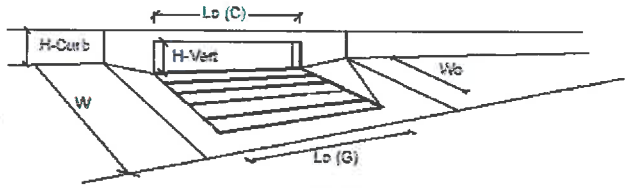
	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c)^{\wedge} C_3$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	1.5	10.1	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP47-2



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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 < maximum allowable from sheet 'Q-Allow'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	1.50	7.26	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.0	2.8	cfs
Capture Percentage = Q_a/Q_o =	C% =	100	72	%

DP 47

width	2.91	area	16.4997	open area x 70%	5.774895
length	5.67	blockage	0.5		
perimeter	17.16	blockage	4	avail perm.	13.16

		Orifice	Weir
23	0	0	0
23.125	0.125	9.8309	1.802946
23.25	0.25	13.90299	5.0995
23.375	0.375	17.02762	9.36838
23.5	0.5	19.6618	14.42356
23.625	0.625	21.98256	20.15754
23.75	0.75	24.08069	26.49778
23.875	0.875	26.01012	33.39102
24	1	27.80598	40.796
24.125	1.125	29.4927	48.67953
24.25	1.25	31.08804	57.01414
24.375	1.375	32.60541	65.77663
24.5	1.5	34.05524	74.94704
24.625	1.625	35.44581	84.50796
24.75	1.75	36.78386	94.44406
24.875	1.875	38.07491	104.7417
25	2	39.3236	115.3885
25.125	2.125	40.53384	126.3735
25.25	2.25	41.70898	137.6865
25.375	2.375	42.8519	149.3183
25.5	2.5	43.96512	161.2603
25.625	2.625	45.05084	173.5048
25.75	2.75	46.11101	186.0444
25.875	2.875	47.14734	198.8723
26	3	48.16138	211.9822

Q_{100} = 20.4 cfs

Storm 22

Project File: Storm 22.stm	Number of lines: 2	Date: 5/4/2017

Storm Sewers v10.50

Storm Sewer Summary Report

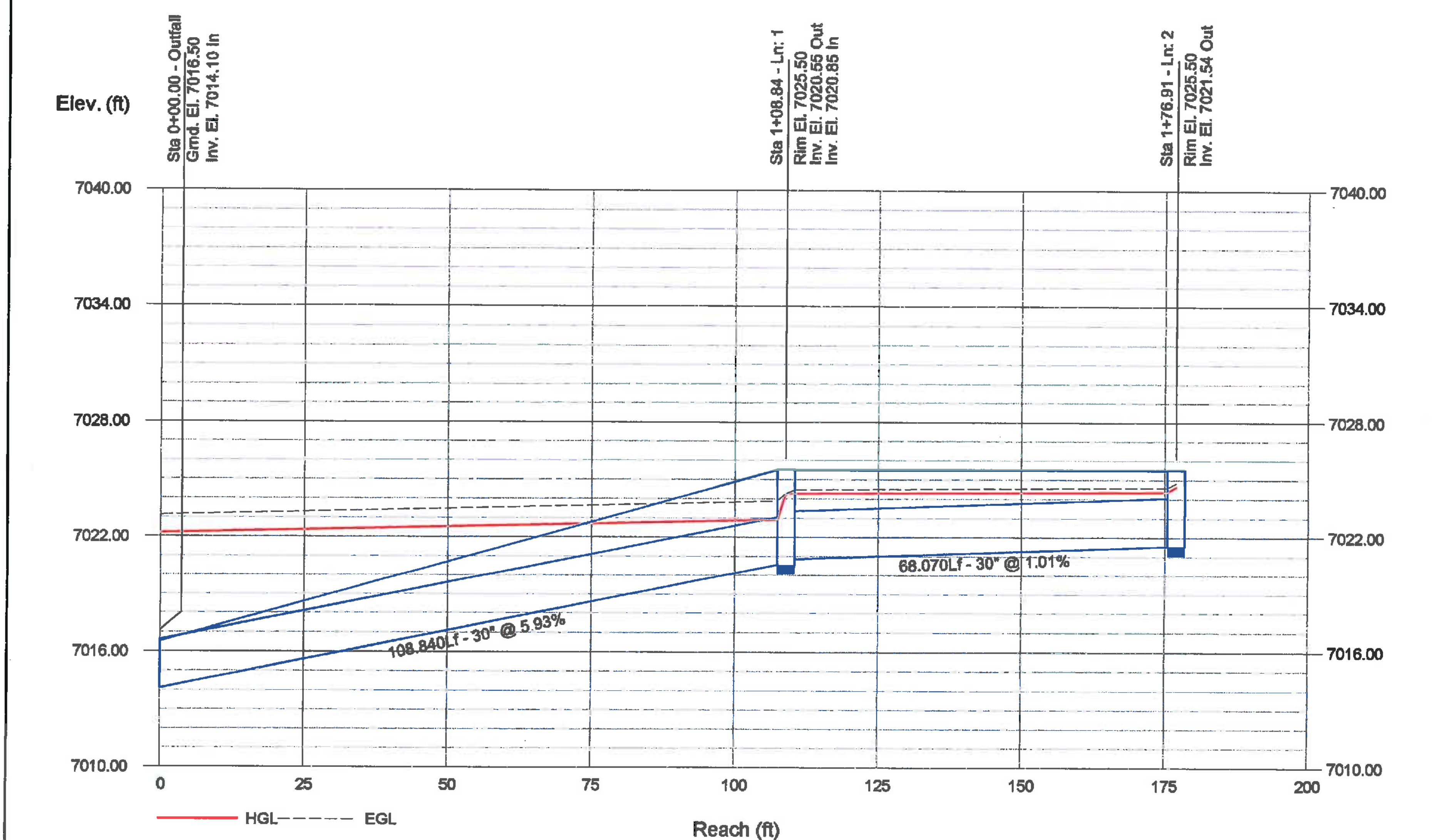
Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	PR 62.1, Storm 22	38.00	30	Cir	108.840	7014.10	7020.55	5.926	7022.21	7022.91	n/a	7024.26 i	End	Curb-Horiz
2	PR 62.2, Storm 22	18.00	30	Cir	68.070	7020.85	7021.54	1.014	7024.26*	7024.38*	0.26	7024.64	1	Curb-Horiz

Storm 22 | Number of lines: 2 | Run Date: 5/4/2017

NOTES: Return period = 100 Yrs. ; *Surcharged (HGL above crown). ; i - Inlet control.

Storm Sewer Profile

Proj. file: Storm 22.stm



Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

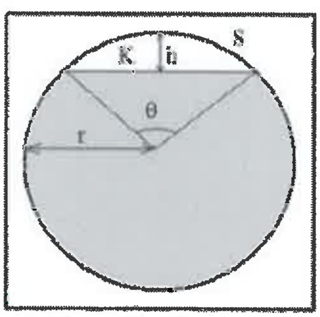
This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs			**Calculations**		
Pipe Diameter, D =	30	in	Pipe Diameter, D =	2.5	ft
Depth of flow, y =	30	in	Pipe Radius, r =	1.25	ft
(must have y ≥ D/2)					
			Circ. Segment Height, h =	0.000	ft
Full Pipe Manning roughness, n_{full} =	0.013		Central Angle, q =	0.00	radians
Channel bottom slope, S =	0.005	ft/ft	Cross-Sect. Area, A =	4.91	ft^2
			Wetted Perimeter, P =	7.9	ft
Calculations			Hydraulic Radius, R =	0.63	ft
n/n_{full} =	1		Discharge, Q =	29.08	cfs
Partially Full Manning roughness, n =	0.013		Ave. Velocity, V =	5.92	ft/sec
			pipe % full [(A/A_{full})*100%] =	100.0%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A P

$$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: n/n_{full} = 1.25 - (y/D - 0.5)*0.5 (for 0.5 ≤ y/D ≤ 1)

STORM VT-Z — 30" RCP
DP48A

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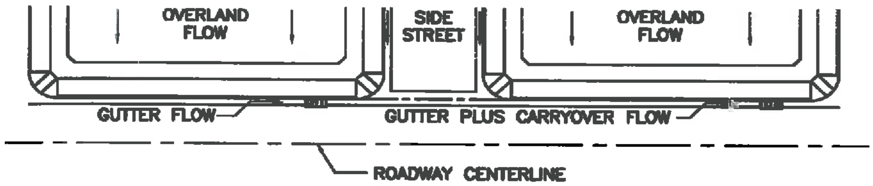
DESIGN PEAK FLOW FOR ONE-HALF OF STREET
OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP48A



Show Details

Design Flow: ONLY if already determined through other methods:
(local peak flow for 1/2 of street OR grass-lined channel):

	Minor Storm	Major Storm	
*Q_{Known} =	13.5	26.6	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

<--- FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW. <---

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- ○ Site is Urban
- ○ Site is Non-Urban

Flows Developed For:
- ○ Street Inlets
- ○ Area Inlets in a Median

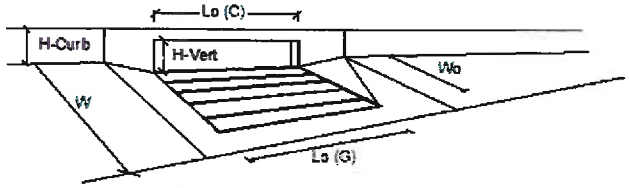
	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c) ^ C_3$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	13.5	26.6	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP48A



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	3	3	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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: WARNING: Q > ALLOWABLE Q FOR MAJOR STORM		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	11.36	16.49	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	2.1	10.1	cfs
Capture Percentage = Q_a/Q_o =	C% =	84	62	%

ENGINEERS EDGE
Solutions By Design

Partially Full Pipe Flow Calculator and Equations

Fluid Flow Table of Contents | Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe using the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

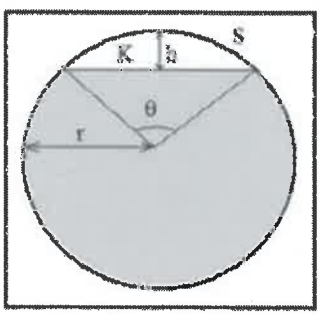
Pipe Diameter, D =	30	in
Depth of flow, y =	18	in
(must have $y \geq D/2$)		
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, S =	0.005	ft/ft

Calculations

n/n_{full} =	1.2	
Partially Full Manning roughness, n =	0.016	

Calculations

Pipe Diameter, D =	2.5	ft
Pipe Radius, r =	1.25	ft
Circ. Segment Height, h =	1.000	ft
Central Angle, q =	2.74	radians
Cross-Sect. Area, A =	3.08	ft^2
Wetted Perimeter, P =	4.4	ft
Hydraulic Radius, R =	0.69	ft
Discharge, Q =	16.28	cfs
Ave. Velocity, V =	5.29	ft/sec
pipe % full $[(A/A_{full})*100\%]$ =	62.6%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

$r = D/2$

$h = 2r - y$

(hydraulic radius)

$R = A/P$

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

$V = Q/A$

P

$$\theta = 2 \arccos\left(\frac{r - h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r^*\theta$$

Equation used for n/n_{full}: $n/n_{full} = 1.25 - (y/D - 0.5)^*0.5$ (for $0.5 \leq y/D \leq 1$)

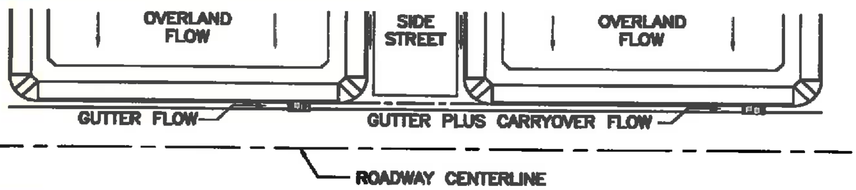
STORM VT-2 -30" RCP
DP47A

Worksheet Protected

DESIGN PEAK FLOW FOR ONE-HALF OF STREET OR GRASS-LINED CHANNEL BY THE RATIONAL METHOD

Project: STERLING RANCH FILING No. 2

Inlet ID: AT-GRADE INLET DP47A



Show Details

Design Flow: ONLY if already determined through other methods:

		Minor Storm	Major Storm	
(local peak flow for 1/2 of street OR grass-lined channel):	$^*Q_{Known}$ =	11.1	24.4	cfs

* If you enter values in Row 14, skip the rest of this sheet and proceed to sheet Q-Allow or Area Inlet.

FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW.

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- Site is Urban
- Site is Non-Urban

Flows Developed For:
- Street Inlets
- Area Inlets in a Median

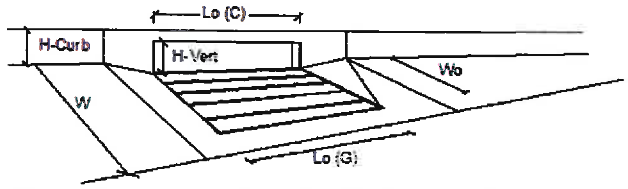
	Slope (ft/ft)	Length (ft)
Overland Flow =		
Channel Flow =		

Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c) ^ C_3$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	0.0	0.0	cfs
Total Design Peak Flow, Q =	**11.1**	**24.4**	cfs

INLET ON A CONTINUOUS GRADE

Project: STERLING RANCH FILING No. 2
Inlet ID: AT-GRADE INLET DP47A



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	3	3	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W from Q-Allow)	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: WARNING: Q > ALLOWABLE Q FOR MAJOR STORM		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	**10.02**	**15.78**	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	**1.1**	**8.6**	cfs
Capture Percentage = Q_a/Q_o =	C% =	**90**	**65**	%

DP 47A

2.9' x 5.7' TYPE D CDOT AREA INLET

width	2.91	area	16.4997	open area x 70%	5.774895
length	5.67	blockage	0.5		
perimeter	17.16	blockage	4	avail perm.	13.16

		Orifice	Weir
92	0	0	0
92.125	0.125	9.8309	1.802946
92.25	0.25	13.90299	5.0995
92.375	0.375	17.02762	9.36838
92.5	0.5	19.6618	14.42356
92.625	0.625	21.98256	20.15754
92.75	0.75	24.08069	26.49778 ← Q_{100} = 24.4 cfs
92.875	0.875	26.01012	33.39102
93	1	27.80598	40.796
93.125	1.125	29.4927	48.67953
93.25	1.25	31.08804	57.01414
93.375	1.375	32.60541	65.77663
93.5	1.5	34.05524	74.94704
93.625	1.625	35.44581	84.50796
93.75	1.75	36.78386	94.44406
93.875	1.875	38.07491	104.7417
94	2	39.3236	115.3885
94.125	2.125	40.53384	126.3735
94.25	2.25	41.70898	137.6865
94.375	2.375	42.8519	149.3183
94.5	2.5	43.96512	161.2603
94.625	2.625	45.05084	173.5048
94.75	2.75	46.11101	186.0444
94.875	2.875	47.14734	198.8723
95	3	48.16138	211.9822

Storm VT-2

Project File: STORM VT2.stm	Number of lines: 2	Date: 5/4/2017

Storm Sewers v10.50

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	PR 69, Storm VT2	32.00	30	Cir	36.700	7042.56	7042.77	0.572	7044.49	7044.73	n/a	7046.18 i	End	Curb-Horiz
2	PR 68, Storm VT2	16.00	30	Cir	90.230	7042.77	7043.23	0.510	7046.18*	7046.30*	0.21	7046.50	1	Curb-Horiz

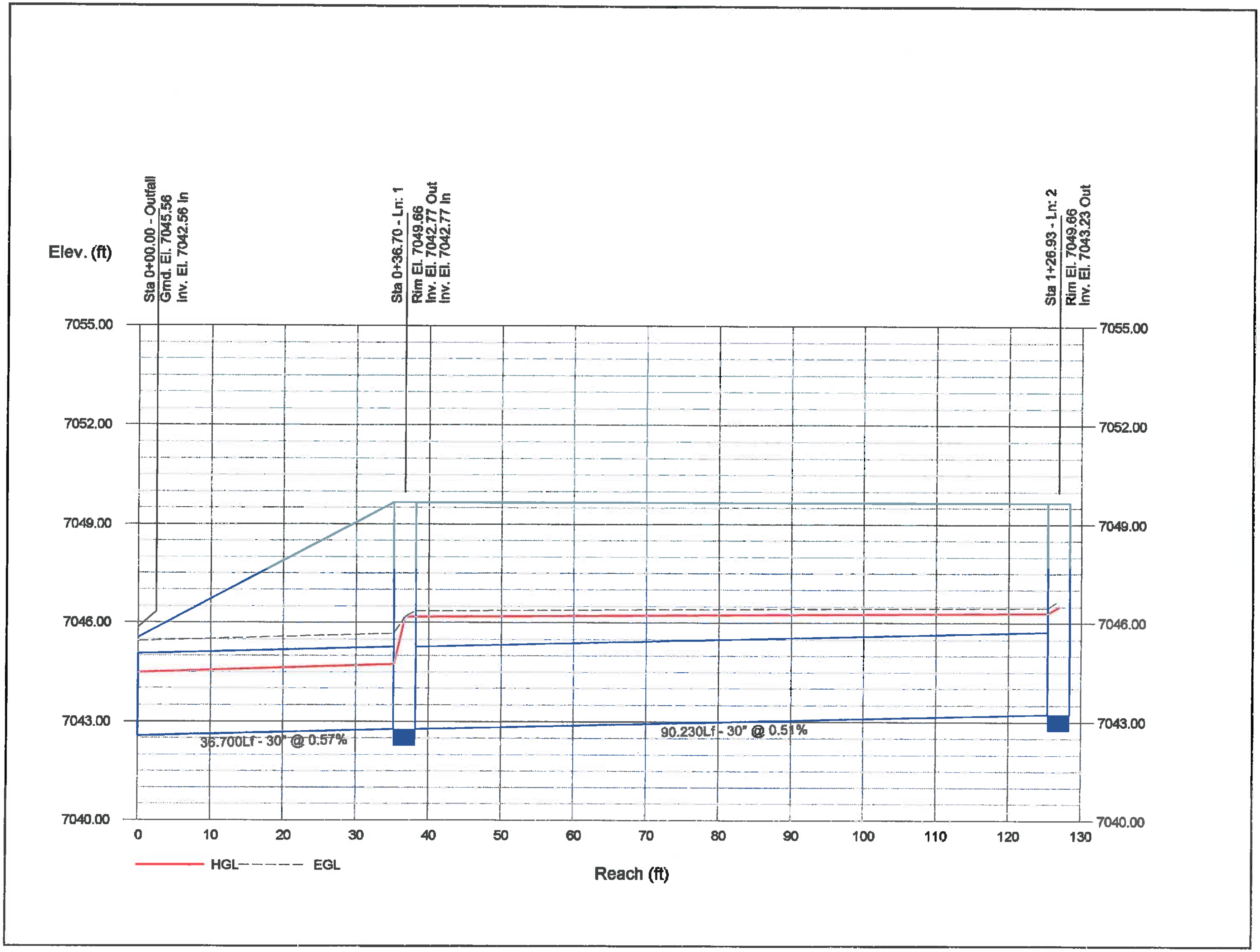
Storm 22	Number of lines: 2	Run Date: 5/4/2017

NOTES: Return period = 100 Yrs. ; *Surcharged (HGL above crown). ; i - Inlet control.

Storm Sewers v10.50

Storm Sewer Profile

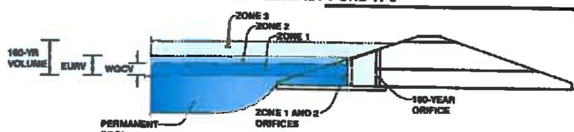
Proj. file: STORM VT2.stm



Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: STERLING RANCH FILING NO. 2
Basin ID: POND W-5



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	3.99	3.141	Orifice Plate
Zone 2 (EURV)	6.46	7.356	Orifice Plate
Zone 3 (100-year)	8.13	6.610	Weir&Pipe (Restrict)
		17.107	Total

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 Diameter =	N/A	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	feet

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

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	6.46	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	25.10	inches
Orifice Plate: Orifice Area per Row =	12.55	sq. inches (use rectangular openings)

Calculated Parameters for Plate

WQ Orifice Area per Row =	8.715E-02	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	2.15	4.31					
Orifice Area (sq. inches)	12.55	12.55	12.55					

	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) and Grate (Flat or Sloped)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	6.46	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	20.00	N/A	feet
Overflow Weir Slope =	0.00	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	6.00	N/A	feet
Overflow Grate Open Area % =	70%	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 =	6.46	N/A	feet
Over Flow Weir Slope Length =	6.00	N/A	feet
Grate Open Area / 100-yr Orifice Area =	7.23	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	84.00	N/A	ft^2
Overflow Grate Open Area w/ Debris =	42.00	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 =	0.83	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	48.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	41.80		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	11.62	N/A	ft^2
Outlet Orifice Centroid =	1.86	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	2.41	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	8.20	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	48.00	feet
Spillway End Slopes =	10.00	H:V
Freeboard above Max Water Surface =	2.00	feet

Calculated Parameters for Spillway

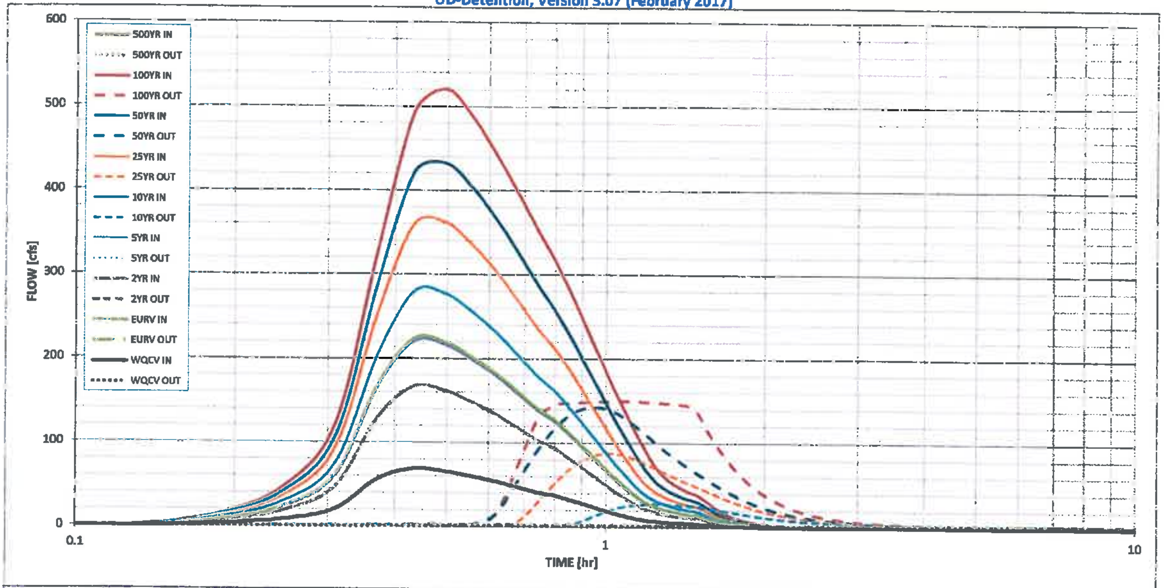
Spillway Design Flow Depth=	1.95	feet
Stage at Top of Freeboard =	12.15	feet
Basin Area at Top of Freeboard =	5.00	acres

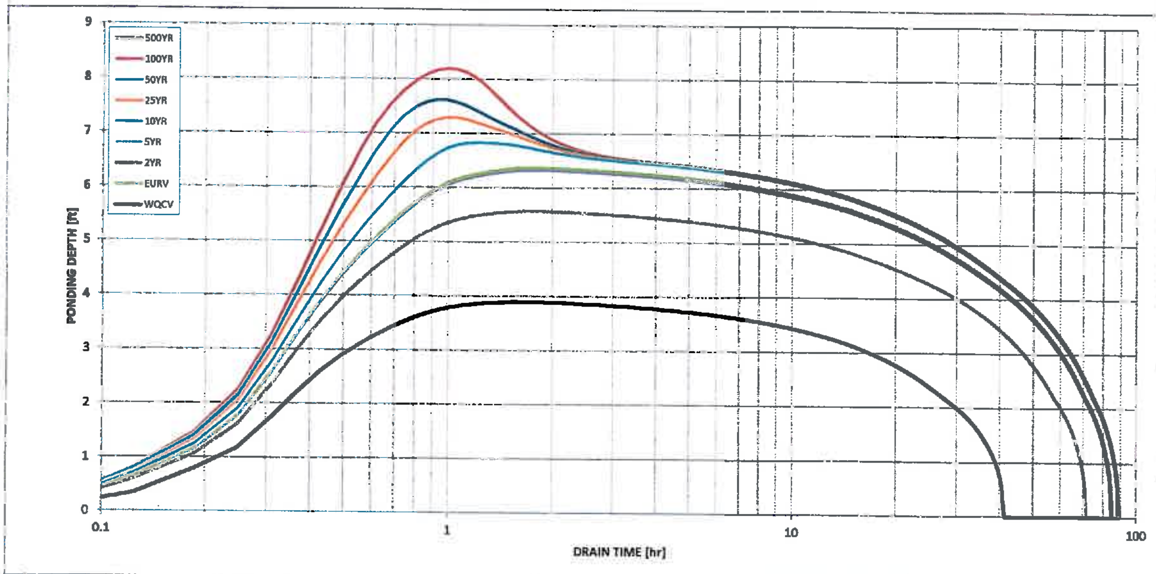
Routed Hydrograph Results

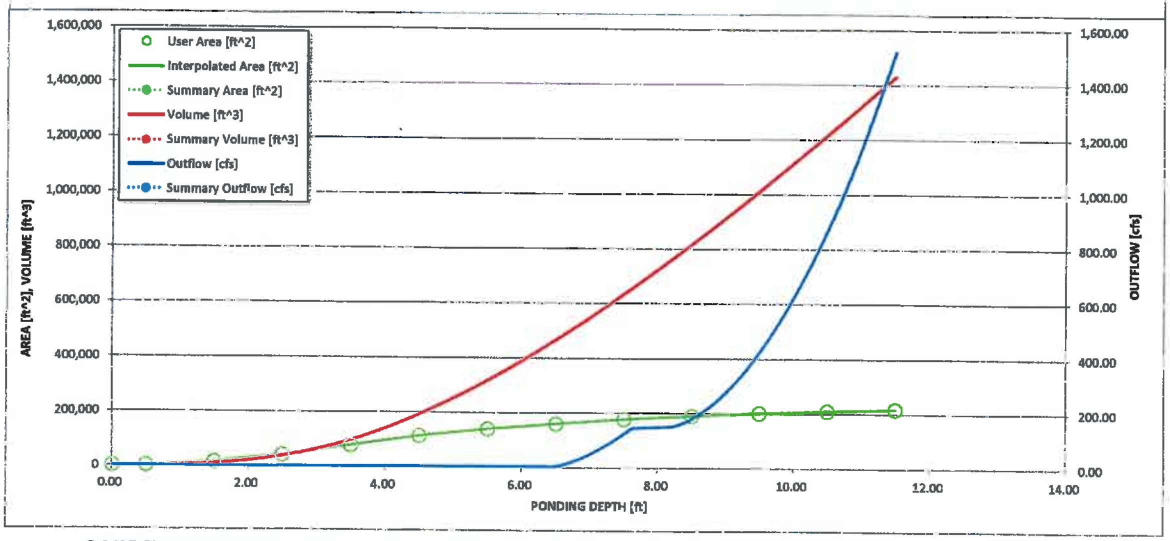
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	0.00
Calculated Runoff Volume (acre-ft) =	3.141	10.497	7.750	10.345	13.246	17.269	20.902	25.403	0.000
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	3.141	10.497	7.750	10.338	13.238	17.265	20.898	25.397	#N/A
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.02	0.14	0.43	0.71	1.11	0.00
Predevelopment Peak Q (cfs) =	0.0	0.0	1.4	3.0	24.4	74.7	124.9	195.0	0.0
Peak Inflow Q (cfs) =	68.7	223.2	166.3	219.9	279.1	362.1	432.3	520.3	#N/A
Peak Outflow Q (cfs) =	1.4	2.5	2.2	2.5	27.5	87.4	142.2	149.7	#N/A
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.8	1.1	1.2	1.1	0.8	#N/A
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	Outlet Plate 1	#N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.3	1.0	1.7	1.7	#N/A
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	#N/A
Time to Drain 97% of Inflow Volume (hours) =	38	77	65	76	78	76	74	73	#N/A
Time to Drain 99% of Inflow Volume (hours) =	40	82	69	81	84	84	83	82	#N/A
Maximum Ponding Depth (ft) =	3.90	6.37	5.57	6.32	6.83	7.29	7.62	8.19	#N/A
Area at Maximum Ponding Depth (acres) =	2.09	3.57	3.22	3.56	3.77	3.96	4.08	4.25	#N/A
Maximum Volume Stored (acre-ft) =	2.970	10.164	7.449	10.021	11.853	13.630	14.958	17.374	#N/A

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







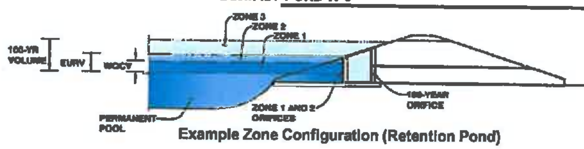
S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: STERLING RANCH FILING NO. 2

Basin ID: POND W-5



Example Zone Configuration (Retention Pond)

Note: L / W Ratio < 1

L / W Ratio = 0.8

Required Volume Calculation

Selected BMP Type =	EDB	
Watershed Area =	175.63	acres
Watershed Length =	2,549	ft
Watershed Slope =	0.026	ft/ft
Watershed Imperviousness =	53.00%	percent
Percentage Hydrologic Soil Group A =	54.8%	percent
Percentage Hydrologic Soil Group B =	45.2%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Desired WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	User Input	
Water Quality Capture Volume (WQCV) =	3.141	acre-feet
Excess Urban Runoff Volume (EURV) =	10.497	acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	7.750	acre-feet
5-yr Runoff Volume (P1 = 1.5 in.) =	10.345	acre-feet
10-yr Runoff Volume (P1 = 1.75 in.) =	13.246	acre-feet
25-yr Runoff Volume (P1 = 2 in.) =	17.269	acre-feet
50-yr Runoff Volume (P1 = 2.25 in.) =	20.902	acre-feet
100-yr Runoff Volume (P1 = 2.52 in.) =	25.403	acre-feet
500-yr Runoff Volume (P1 = 0 in.) =	0.000	acre-feet
Approximate 2-yr Detention Volume =	7.285	acre-feet
Approximate 5-yr Detention Volume =	9.745	acre-feet
Approximate 10-yr Detention Volume =	12.307	acre-feet
Approximate 25-yr Detention Volume =	14.208	acre-feet
Approximate 50-yr Detention Volume =	15.352	acre-feet
Approximate 100-yr Detention Volume =	17.107	acre-feet

Optional User Override
1-hr Precipitation

1.19	inches
1.50	inches
1.75	inches
2.00	inches
2.25	inches
2.52	inches
	inches

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	3.141	acre-feet
Zone 2 Volume (EURV - Zone 1) =	7.356	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	6.610	acre-feet
Total Detention Basin Volume =	17.107	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	

Depth Increment = 0.1 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	--	--	--	632	0.015		
	--	0.50	--	--	--	1,289	0.030	467	0.011
	--	1.50	--	--	--	15,375	0.353	8,659	0.199
	--	2.50	--	--	--	40,729	0.935	36,864	0.846
	--	3.50	--	--	--	76,997	1.768	95,727	2.198
	--	4.50	--	--	--	112,420	2.581	190,435	4.372
	--	5.50	--	--	--	138,892	3.189	316,091	7.256
	--	6.50	--	--	--	158,382	3.636	464,728	10.669
	--	7.50	--	--	--	176,379	4.049	632,109	14.511
	--	8.50	--	--	--	188,901	4.337	814,749	18.704
	--	9.50	--	--	--	202,723	4.654	1,010,561	23.199
	--	10.50	--	--	--	210,154	4.824	1,216,999	27.938
	--	11.50	--	--	--	217,594	4.995	1,430,873	32.848
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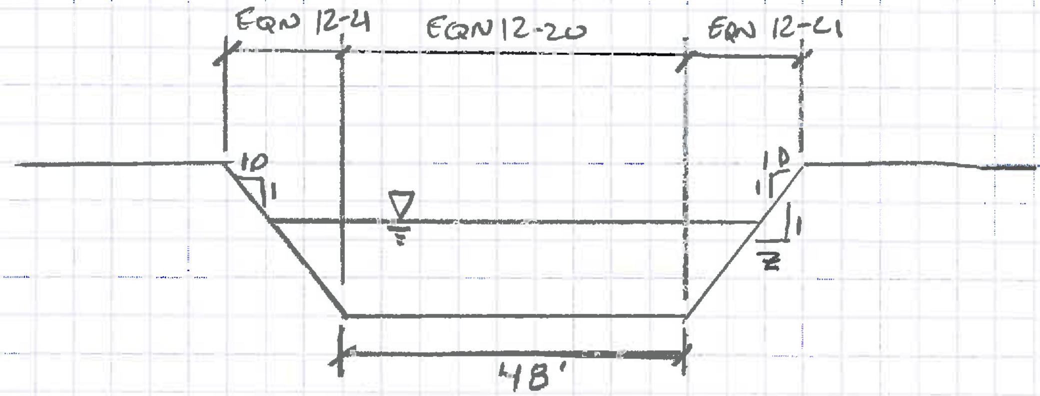
MS CIVIL CONSULTANTS, INC.
20 BOULDER CRESCENT, STE 110
COLORADO SPRINGS, CO 80903
(719) 955-5485

PROJECT: STERLING RANCH FIL No. 2

DATE: 2-17-17 W-5 SPILLWAY

POND W-5 SPILLWAY LENGTH



FROM UDFCD 12-33 STORAGE

Q_{100} 520.3 cfs   C = 3.0

EQN 12-20 $Q = CLH^{1.5}$

EQN 12-21 $Q = \frac{2}{5} C Z H^{2.5}$ PER SIDE

EQN 12-20 $Q = 3.0(48')(2)^{1.5} = 407.29$ cfs

EQN 12-21 $Q = \frac{2}{5}(3.0)(10)(2.0)^{2.5} = 67.88$ cfs $\times 2 = 135.76$ cfs

$Q_{TOTAL} = 407.29$ cfs $+ 135.76$ cfs $=$ $\boxed{543 \text{ cfs} > 520.3 \text{ cfs OK}}$

SPILLWAY RUNDOWN PROTECTION

RIPRAP SIZING (UDFCD 12-34)

FIGURE 12-21

BASED ON SLOPE & UNIT DISCHARGE

Q_{100} = 520.3 cfs

UNIT DISCHARGE = 520.3 / 48 = 10.84 cfs/ft

SLOPE = 10%

FROM FIGURE 12-21 USE TYPE H D_{50} = 18"

SOIL RIPRAP DEPTH $2 \times D_{50} = 2 \times 18" =$ $\boxed{36" = 3'}$

MS CIVIL CONSULTANTS, INC.

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COLORADO SPRINGS, CO 80903
(719) 955-5485

PROJECT: STERLING RANCH FILING No 2

DATE: 2-18-17 SIZE FOREBAY

FOREBAY VOLUME FOR POND W-5

SIZE OF CONTRIBUTING AREA = 175.63 AC ≅ 176 AC

FOREBAY MIN VOL = 3% OF WQCV (UDFCD T-5, TABLE EDB-4)

W-5 WQCV = 2.970 AC FT

FOREBAY MIN VOL REQ = 3% x 2.970 AC-FT x $\frac{43560 \text{ CF}}{1 \text{ AC-FT}}$ = $\boxed{3881 \text{ CF}}$

@ MAX DEPTH OF 30" PER TABLE EDB-4

FROM POND & FOREBAY SPREAD SHEET MIN VOL PROVIDED = $\boxed{3988 \text{ CF} > 3881 \text{ CF}}$ OK

SIZE NOTCH

2% OF 100YR INFLOW Q_{100} = 520.3 cfs

2% x 520.3 cfs = 10.406 cfs ≅ 11 cfs

WEIR EQN $Q = CLH^{1.5}$ C = 3.3 L = 1.0'

$Q = 3.3\ (1.0)\ (2.5)^{1.5}$ = $\boxed{13 \text{ cfs} > 11 \text{ cfs}}$ OK

POND SURCHARGE

DEPTH ≥ 4 in VOLUME ≥ 0.3% WQCV PER TABLE EDB-4

WQCV VOLUME = 2.970 Ac-ft x $\frac{43560 \text{ CF}}{1 \text{ AC-FT}}$ x 0.3% = 388 CF

FROM POND & FOREBAY VOLUME SPREADSHEET MIN SURCHARGE VOLUME PROVIDED

AREA OF MICROPOOL = 672 SQ ft x 7 in $\left(\frac{1 \text{ ft}}{12 \text{ in}}\right)$ = 392 cf

$\boxed{= 392 \text{ cf} \geq 388 \text{ CF}}$ OK

MS CIVIL CONSULTANTS, INC.
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COLORADO SPRINGS, CO 80903
(719) 955-5485

PROJECT: STERLING RANCH FILING No. 2

DATE: 8-21-17

RIP RAP BASIN FOR POND W-5 OUTLET

DESIGN PER UDFCD PER FIGURE 9-37

Q_{100} = 472.4 cfs 84" RCP

DEPTH = 3' W = 9' L = 32'

OVERALL DIMENSION'S PLAN VIEW $\boxed{32' L \times 24' W}$

RIPRAP SIZING FIGURE UDFCD VOL 2 VALID FOR $Q/D^{2.5} < 6.0$

$Q/D^{2.5}$ = 472.4/7^2.5 = 3.6 < 6.0 OK

y_t/D = ASSUMED 0.4

$Q/D^{1.5}$ = 472.4/7^1.5 = 25.51 ≅ 26

FROM FIGURE 9-38 TYPE VH D_{50} = 24"

EQN 9-15 DEPTH = 2 (D_{50}) = 2(24") = 48" ≅ 4'

LOW TAILWATER RIPRAP BASIN = $\boxed{32' L \times 24' W \times 48" D}$

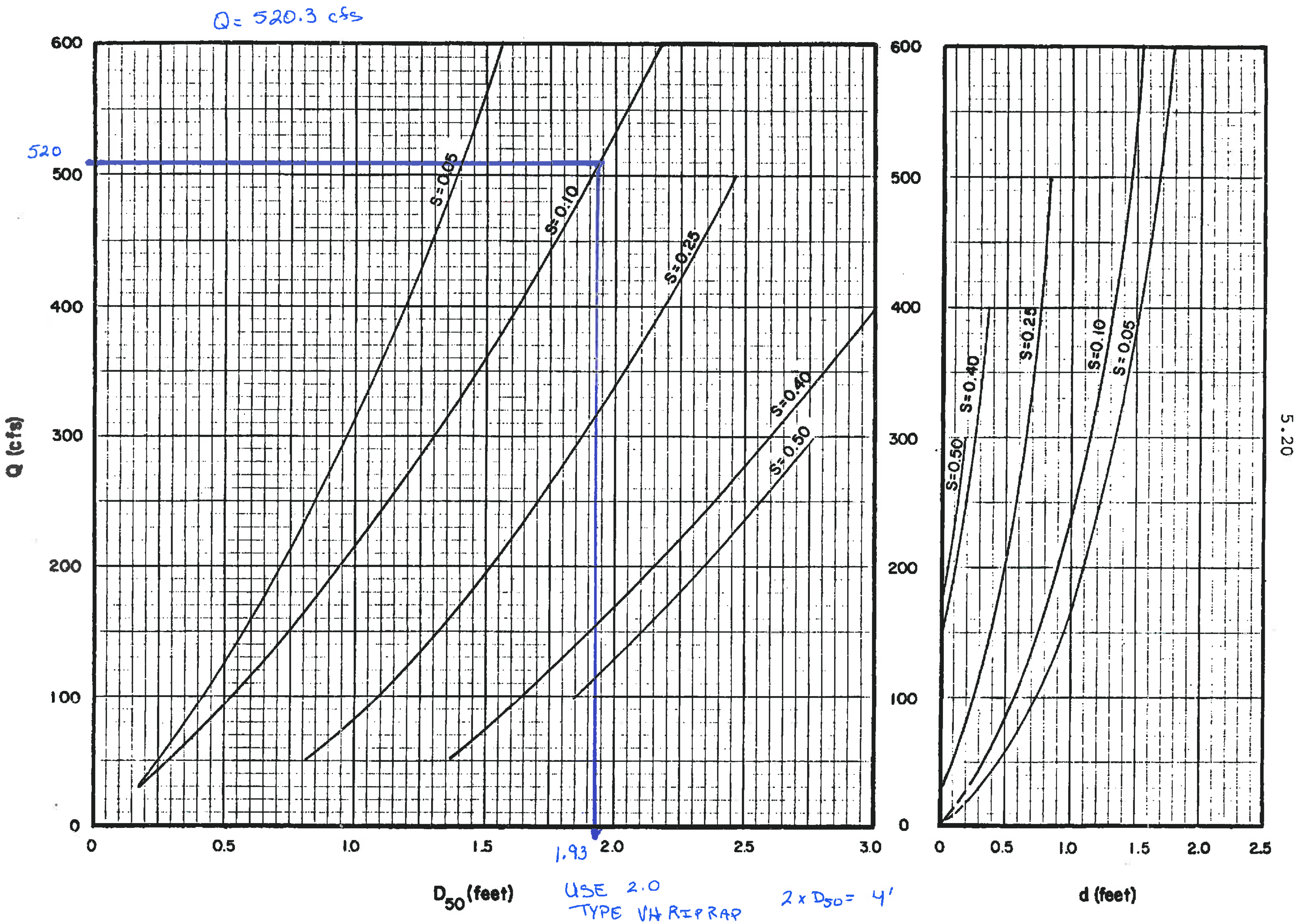
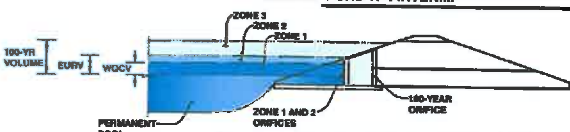


Figure 5.7. Steep slope riprap design, trapezoidal channels, 2:1 sideslopes, 20 ft base width.

POND W-5 SPILLWAY RUNDOWN

Detention Basin Outlet Structure Design

Project: STERLING RANCH FILING NO. 2
Basin ID: POND W-4 INTERIM



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	3.93	1.967	Orifice Plate
Zone 2 (EURV)	4.99	0.953	Orifice Plate
Zone 3 (100-year)	12.40	9.315	Weir&Pipe (Restrict)
		12.235	Total

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 Diameter =	N/A	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	feet

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

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	4.99	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	22.30	inches
Orifice Plate: Orifice Area per Row =	6.80	sq. inches (use rectangular openings)

Calculated Parameters for Plate

WQ Orifice Area per Row =	4.722E-02	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.66	3.33					
Orifice Area (sq. inches)	6.80	6.80	6.80					

	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) and Grate (Flat or Sloped)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	4.99	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	20.00	N/A	feet
Overflow Weir Slope =	4.00	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	5.00	N/A	feet
Overflow Grate Open Area % =	70%	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 =	6.49	N/A	feet
Over Flow Weir Slope Length =	6.18	N/A	feet
Grate Open Area / 100-yr Orifice Area =	3.87	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	86.59	N/A	ft^2
Overflow Grate Open Area w/ Debris =	43.29	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 =	0.58	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	55.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	58.80		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	22.35	N/A	ft^2
Outlet Orifice Centroid =	2.60	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	2.47	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	12.40	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	74.00	feet
Spillway End Slopes =	4.00	H:V
Freeboard above Max Water Surface =	1.50	feet

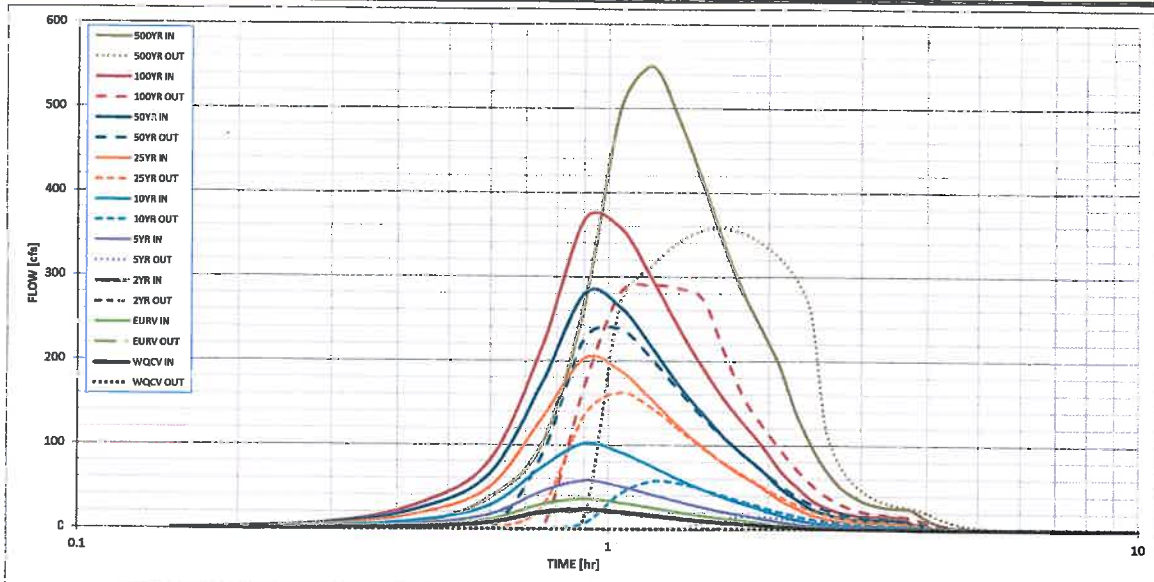
Calculated Parameters for Spillway

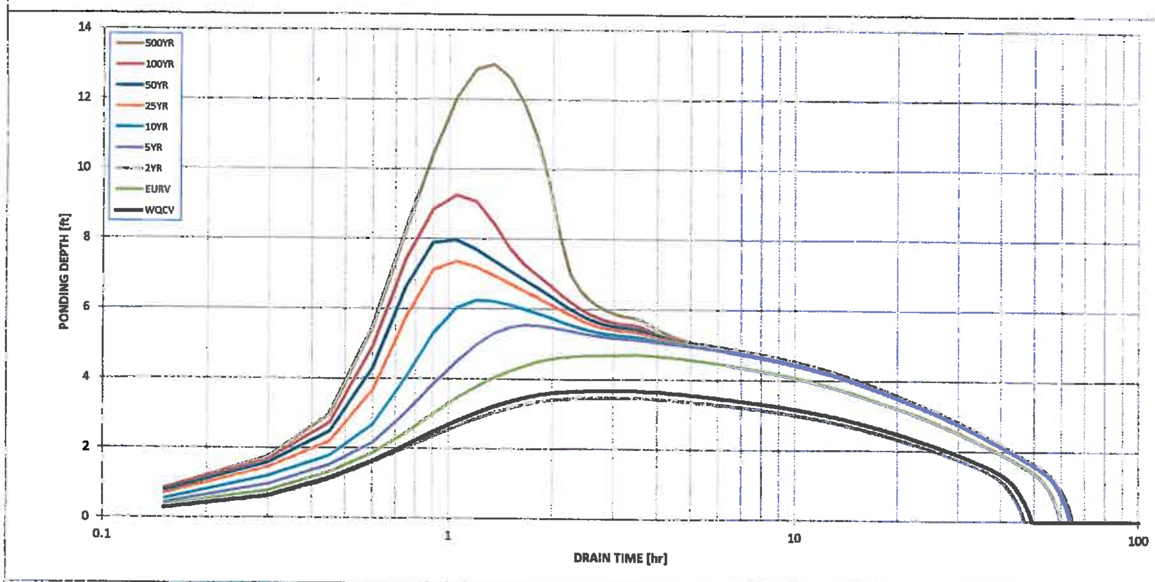
Spillway Design Flow Depth=	1.36	feet
Stage at Top of Freeboard =	15.26	feet
Basin Area at Top of Freeboard =	1.66	acres

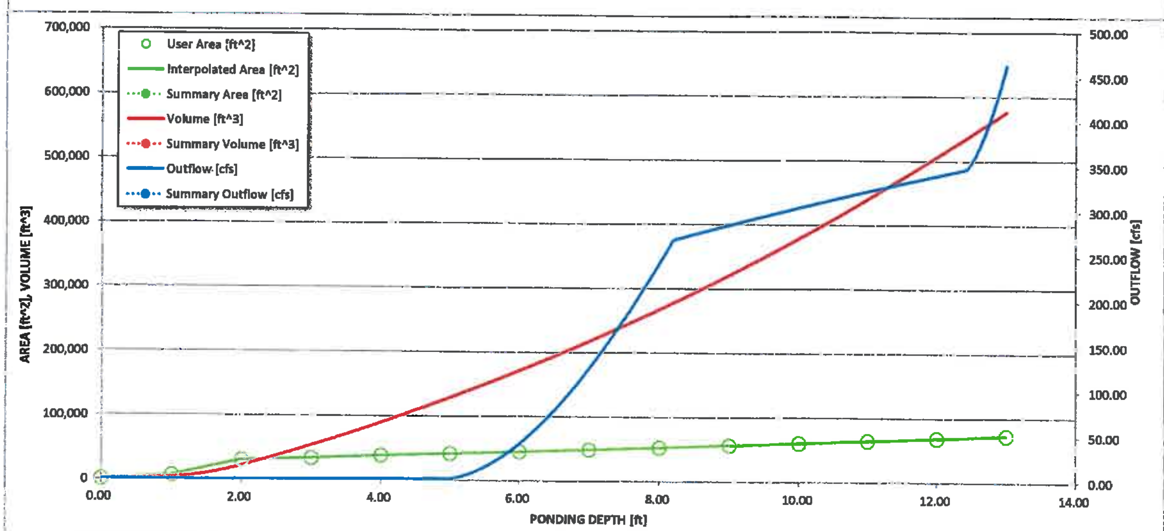
Routed Hydrograph Results

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) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.53	3.29
Calculated Runoff Volume (acre-ft) =	1.967	2.920	1.778	4.643	8.198	16.469	22.829	30.940	49.821
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	1.966	2.919	1.777	4.642	8.194	16.455	22.814	30.925	49.804
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.07	0.15	0.41	0.60	0.84	1.31
Predevelopment Peak Q (cfs) =	0.0	0.0	1.8	26.0	52.1	145.5	212.0	295.1	462.9
Peak Inflow Q (cfs) =	24.1	36.0	21.8	57.5	101.6	202.9	279.6	368.4	549.8
Peak Outflow Q (cfs) =	0.9	1.2	0.8	15.4	56.8	162.6	237.7	289.4	357.4
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.6	1.1	1.1	1.1	1.0	0.8
Structure Controlling Flow =	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	0.2	0.6	1.9	2.7	3.3	4.1
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) =	45	54	43	55	51	43	38	33	23
Time to Drain 99% of Inflow Volume (hours) =	47	57	45	60	58	54	52	49	43
Maximum Ponding Depth (ft) =	3.68	4.69	3.47	5.53	6.24	7.35	7.97	9.25	13.00
Area at Maximum Ponding Depth (acres) =	0.83	0.91	0.81	0.98	1.04	1.14	1.19	1.31	1.66
Maximum Volume Stored (acre-ft) =	1.752	2.645	1.580	3.430	4.145	5.362	6.082	7.666	13.226

Detention Basin Outlet Structure Design





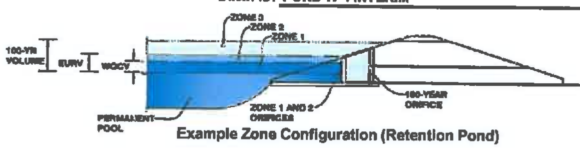


S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

Project: STERLING RANCH FILING NO. 2

Basin ID: POND W-4 INTERIM



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB	
Watershed Area =	352.23	acres
Watershed Length =	16,051	ft
Watershed Slope =	0.022	ft/ft
Watershed Imperviousness =	10.00%	percent
Percentage Hydrologic Soil Group A =	54.0%	percent
Percentage Hydrologic Soil Group B =	46.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Desired WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	UDFCD Default	
Water Quality Capture Volume (WQCV) =	1.967	acre-feet
Excess Urban Runoff Volume (EURV) =	2.920	acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	1.778	acre-feet
5-yr Runoff Volume (P1 = 1.5 in.) =	4.643	acre-feet
10-yr Runoff Volume (P1 = 1.75 in.) =	8.198	acre-feet
25-yr Runoff Volume (P1 = 2 in.) =	16.469	acre-feet
50-yr Runoff Volume (P1 = 2.25 in.) =	22.829	acre-feet
100-yr Runoff Volume (P1 = 2.53 in.) =	30.940	acre-feet
500-yr Runoff Volume (P1 = 3.29 in.) =	49.821	acre-feet
Approximate 2-yr Detention Volume =	1.651	acre-feet
Approximate 5-yr Detention Volume =	3.803	acre-feet
Approximate 10-yr Detention Volume =	4.947	acre-feet
Approximate 25-yr Detention Volume =	6.210	acre-feet
Approximate 50-yr Detention Volume =	8.156	acre-feet
Approximate 100-yr Detention Volume =	12.235	acre-feet

Note: L / W Ratio > 8
L / W Ratio = 16.8

Optional User Override 1-hr Precipitation

1.19	inches
1.50	inches
1.75	inches
2.00	inches
2.25	inches
2.53	inches
	inches

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	1.967	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.953	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	9.315	acre-feet
Total Detention Basin Volume =	12.235	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	

Depth Increment = 0.1 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)
Micropool	--	0.00	--	--	--	208	0.005		
	--	1.00	--	--	--	5,106	0.140	3,098	0.071
	--	2.00	--	--	--	30,155	0.692	20,987	0.482
	--	3.00	--	--	--	33,323	0.765	53,026	1.217
	--	4.00	--	--	--	37,601	0.863	88,488	2.031
	--	5.00	--	--	--	40,867	0.938	127,722	2.932
	--	6.00	--	--	--	44,238	1.016	170,275	3.909
	--	7.00	--	--	--	48,178	1.106	216,483	4.970
	--	8.00	--	--	--	51,797	1.189	266,470	6.117
	--	9.00	--	--	--	55,999	1.286	320,368	7.355
	--	10.00	--	--	--	59,878	1.375	378,307	8.685
	--	11.00	--	--	--	33,864	1.468	440,178	10.105
	--	12.00	--	--	--	67,956	1.560	506,088	11.618
	--	13.00	--	--	--	72,155	1.656	576,143	13.226
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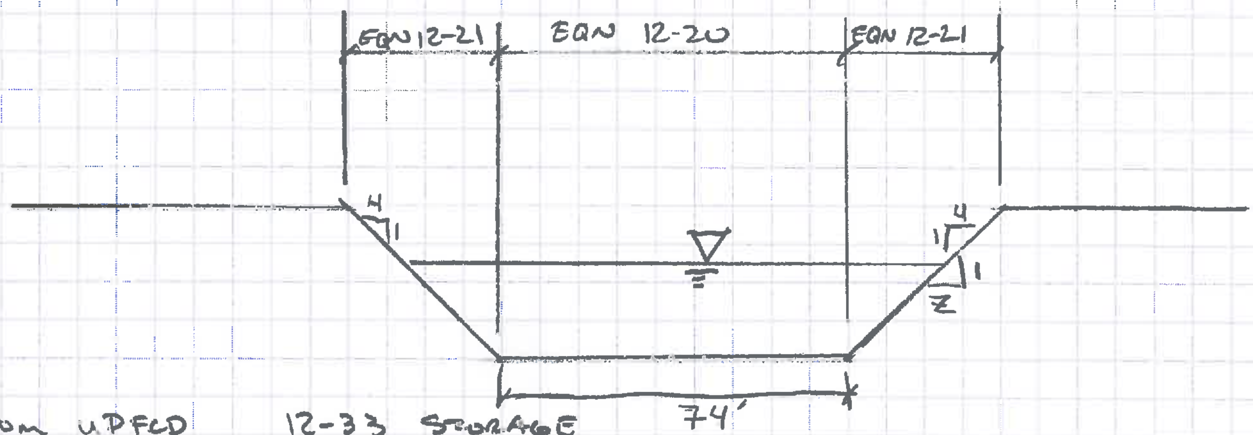
MS CIVIL CONSULTANTS, INC.
20 BOULDER CRESCENT, STE 110
COLORADO SPRINGS, CO 80903
(719) 955-5485

PROJECT: STERLING RANCH FIL. NO. 2

DATE: 1-16-17 W-4 SPILLWAY

POND W-4 SPILLWAY LENGTH



FROM UDFCD 12-33 STORAGE

Q_{100} 429.4 cfs   C = 3.0

EQN 12-20 $Q = CLH^{1.5}$

EQN 12-21 $Q = \frac{2}{5} C Z H^{2.5}$ PER SIDE

EQN 12-20 $Q = 3.0\ (74)\ 1.5^{1.5} = \underline{407.84}$

EQN 12-21 $Q = \frac{2}{5}\ (3.0)(4)(1.5)^{2.5} = 13.23 \times 2$ (SIDES) = $\underline{26.45}$

TOTAL = 407.84 + 26.45 = $\boxed{434.29 > 429.4 \text{ OK}}$

SPILLWAY RUNDOWN PROTECTION

RIPRAP SIZING (UDFCD 12-34)

FIGURE 12-21

BASED ON SLOPE & UNIT DISCHARGE

Q_{100} = 429.4 cfs

UNIT DISCHARGE = 429.4/74' = 5.80

SLOPE = 1.8%

FIGURE 12-21 USE TYPE L D_{50} = 9"

SOIL RIPRAP DEPTH $2 \times D_{50} = 2 \times 9" = \underline{18"}$

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PROJECT: STERLING RANCH FILING No 2

DATE: 2-13-17 SIZE FOREBAY

FOREBAY VOLUME FOR POND W-4

SIZE OF CONTRIBUTING AREA. 352 AC.

NORTH FOREBAY VOLUME 95% OF TOTAL WQCV
WEST FOREBAY VOLUME 5% OF TOTAL WQCV

NORTH MIN FOREBAY VOL = 3% OF WQCV (UDFCD T-5, TABLE EDB-4)
W-4 WQCV = 1.725 AC-FT
NORTH FOREBAY VOL REQ. = 3.0% x (1.725 AC-FT x 95%) x $\frac{43560 \text{ cu ft}}{1 \text{ AC FT}}$ = $\boxed{2142 \text{ CU FT}}$

@ MAXIMUM DEPTH OF 30" PER TABLE EDB-4
FROM POND & FOREBAY VOLUME SPREADSHEET MIN NORTH VOL PROVIDED = $\boxed{2{,}211 \text{ CF} > 2142 \text{ CF OK}}$

SIZE PIPES

2% OF 100 YR INFLOW Q_{100} = 368.4 x 95% = 349.98 cfs ≐ 350 cfs

2% x 350 cfs = 7.0 cfs FROM FLOW CALCULATOR SPREADSHEET
12" PVC ≐ 2.53 cfs x 3 = $\boxed{7.59 \text{ cfs} > 7.0 \text{ cfs}}$ OK

WEST MIN FOREBAY VOL = 3% OF WQCV (UDFCD T-5, TABLE EDB-4)
W-4 WQCV = 1.725 AC-FT
NORTH FOREBAY VOL REQ = 3.0% x (1.725 AC-FT x 5%) x $\frac{43560 \text{ cu ft}}{1 \text{ AC-FT}}$ = $\boxed{113 \text{ cu ft}}$

@ MINIMUM DEPTH OF 8" ≐ 0.67'
FROM POND & FOREBAY VOLUME SPREADSHEET MIN WEST VOL PROVIDED = $\boxed{129 \text{ CF} > 113 \text{ CF}}$

SIZE NOTCH

2% OF 100YR INFLOW Q_{100} = 368.4 x 5% = 18.42 cfs ≐ 19 cfs

2% x 19 cfs = 0.37 cfs ≐ 0.4 cfs WEIR EQN. $Q = CLH^{3/2}$ C = 3.3
$Q = 3.3\,(0.25')\,(0.67')^{3/2}$ = $\boxed{0.452 \text{ cfs} > 0.4 \text{ cfs}}$

POND SURCHARGE

DEPTH ≥ 4 in VOLUME ≥ 0.3% WQCV PER TABLE EDB-4

WQCV VOL = 1.725 AC-FT x $\frac{43560 \text{ cu ft}}{1 \text{ AC-FT}}$ x 0.3% = 23 CF
FROM POND & FOREBAY VOLUME SPREADSHEET MIN SURCHARGE VOL PROVIDED

AREA OF MICROPOOL = 342 sq ft x 4 in $\left(\frac{1 \text{ ft}}{12 \text{ in}}\right)$ = $\boxed{114 \text{ CF} > 23 \text{ CF}}$

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PROJECT: STERLING RANCH FILING No 2

DATE:

SLOPING RIPRAP DROP STRUCTURE INTO POND W-4

$Q_{100} = 368.4$ cfs

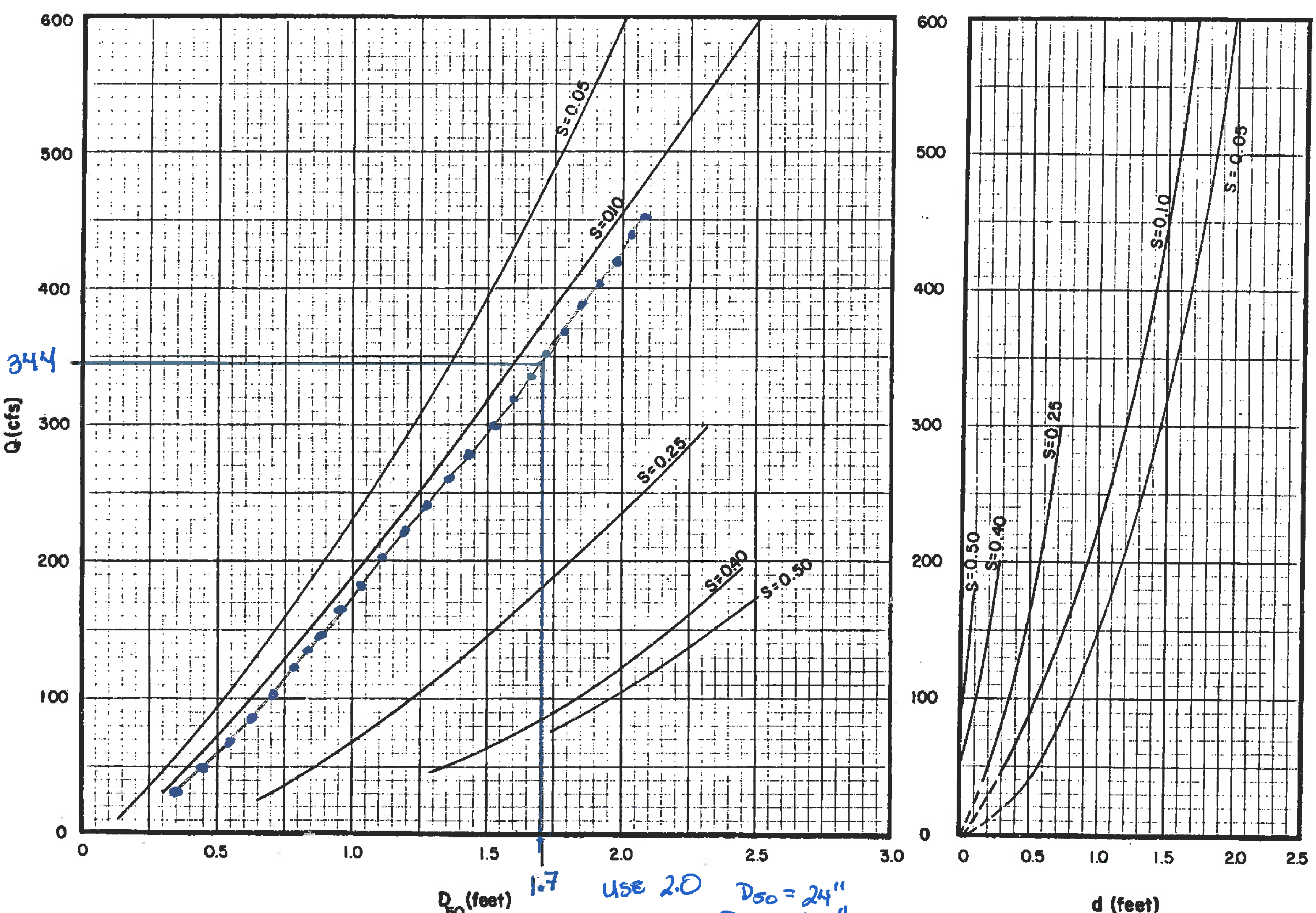
UPSTREAM PARAMETERS

CHANNEL BOTTOM WIDTH = 15'
SIDE SLOPES = 4:1
SLOPE = 0.0213 ft/ft
y_n = 2.01
y_c = 2.18
V_n = 8.0

DROP STRUCTURE PARAMETERS

DROP REQ. = 7022 - 7016 = 6' DROP STRUCTURE SLOPE = 11.5%
DETERMINE UNIT DISCHARGE
368.4 ÷ 15 = 24.56 = q
FOR FIGURE 5.6 14' TRAPEZOIDAL CHANNEL
q = 24.56 × 14 = 343.84 ≅ 344 = Q

FROM FIG. 5.6 D_{50} = 2.0' TYPE "VH" 4' THICK



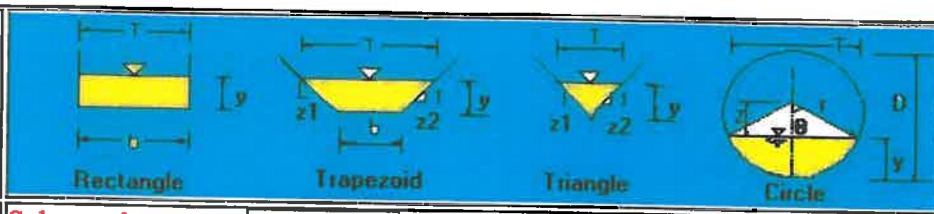
D_{50} = 24"
DEEP = 48"

Figure 5.6. Steep slope riprap design, trapezoidal channels, ~~2:1~~ 4:1 sideslopes, 14 ft 15 ft base width.

15' BOTTOM CHANNEL ALONG WESTSIDE VOLLMER ROAD

The open channel flow calculator

Select Channel Type: Trapezoid



Velocity(V)&Discharge(Q) | Select unit system: Feet(ft)

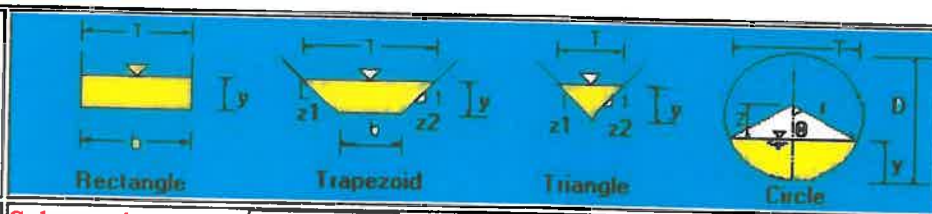
Channel slope: .0167 ft/ft	Water depth(y): 2.1 ft	Bottom width(b) 15 ft
Flow velocity 7.2551 ft/s	LeftSlope (Z1): 4 to 1 (H:	RightSlope (Z2): 4 to 1 (H:V
Flow discharge 356.5167 ft^3/s	Input n value 0.035 or select r	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 32.32 ft	Flow area 49.14 ft^2	Top width(T) 31.8 ft
Specific energy 2.92 ft	Froude number 1.03	Flow status Supercritical flow
Critical depth 2.14 ft	Critical slope 0.0156 ft/ft	Velocity head 0.82 ft

SR FIL. 2

UPPER ROADSIDE DITCH NORTH
OF VOLLMER/MARKSHEFFEL INTERSECTION
DP 72 Q_{100} = 346 cfs

The open channel flow calculator

Select Channel Type: Trapezoid



Velocity(V)&Discharge(Q)

Select unit system: Feet(ft)

Channel slope: .0222 ft/ft	Water depth(y): 1.99 ft	Bottom width(b) 15 ft
Flow velocity 8.1214 ft/s	LeftSlope (Z1): 4 to 1 (H:	RightSlope (Z2): 4 to 1 (H:V
Flow discharge 371.0712 ft^3/s	Input n value 0.035 or select r	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 31.41 ft	Flow area 45.69 ft^2	Top width(T) 30.92 ft
Specific energy 3.01 ft	Froude number 1.18	Flow status Supercritical flow
Critical depth 2.19 ft	Critical slope 0.0155 ft/ft	Velocity head 1.02 ft

SR FIL 2

- LOWER ROADSIDE DITCH - NORTH OF VOLLMER / MARKSHEFFEL INTERSECTION

DP 49 Q_{100} = 368 cfs

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(719) 955-5485

PROJECT: STERLING RANCH FILING No. 2

DATE: 2-21-17

RIPRAP DESIGN FOR 3.5x5.5 HECMP - FIL #2 OUTFALL ROADSIDE SWALE

Q_{100} = 199.14 CFS EX. 3.5 x 5.5 HECMP EQUIV
EX 3.5 x 5.5 HECMP EQUIVALENT ROUND PIPE ≅ 54" DIA

LOW TAILWATER DESIGN OUTLET IN VOLLMER ROAD SWALE

EQN. 9-11 (UDFCD VOL 2 9-68)

$$L_p = \left(\frac{1}{2\tan\theta}\right)\left(\frac{A_t}{y_t} - W\right)$$

EQN 9-12 $A_t = Q/V$ (V = ASSUME 5 ft/s) = 199.14 cfs / 5 ft/s = 39.82 ft² ≅ 40 ft²

$y_t = 0.4(D)$ (0.4 ASSUMED) $y_t = 0.4(4.5) = 1.8$ D = W = 4.5'

$Q/D^{2.5}$ = 199.14 / $4.5^{2.5}$ = 4.64 < 6.0 OK

EQN 9-13 $\theta = \tan^{-1}\left(\frac{1}{2(EF)}\right)$ EF EXPANSION FACTOR FROM FIG. 9-35 = 2.8

$\theta = \tan^{-1}\left(\frac{1}{2(2.8)}\right) = 10.12$

EQN 9-11 $L_p = \left(\frac{1}{2\tan 10.12}\right)\left(\frac{40}{1.8} - 4.5\right) = 49.65 \cong 50'$

CHECK 3(D)min = 3(4.5) = 13.5' < 50' $\boxed{\text{USE } 50'}$

EQN 9-14 $T = 2(L_p \tan\theta) + W$

$T = 2(50 \tan 10.12) + 4.5 = 22.34 \cong 23'$

CHECK 3(D)min = 3(4.5) = 13.5' < 23' $\boxed{\text{USE } 23'}$

RIPRAP SIZING

FIG 9-38 (UDFCD VOL 2) VALID FOR $Q/D^{2.5} \leq 6$

$Q/D^{1.5}$ = 199.14 / $4.5^{1.5}$ = 20.86 $y_t/D = 0.4$ ASSUMED

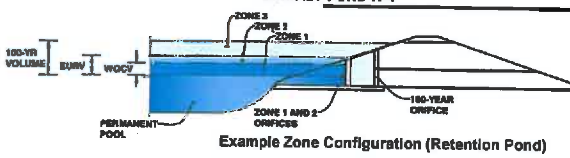
FROM FIG 9-38 ⟹ TYPE H

D_{50} = 18" EQN 9-15 DEPTH $2D_{50} = 2(18") = 36"$

$\boxed{\text{RIPRAP PAD = 50' L x 23' W x 36" DEEP}}$

Detention Basin Outlet Structure Design

Project: STERLING RANCH FILING NO. 2
Basin ID: POND W-4



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	3.77	2.291	Orifice Plate
Zone 2 (EURV)	4.75	1.329	Orifice Plate
Zone 3 (100-year)	9.72	9.719	Weir&Pipe (Restrict)
		13.338	Total

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 Diameter =	N/A	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	feet

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

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	4.99	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	18.10	inches
Orifice Plate: Orifice Area per Row =	8.51	sq. inches (use rectangular openings)

Calculated Parameters for Plate

WQ Orifice Area per Row =	5.910E-02	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.66	3.33					
Orifice Area (sq. inches)	8.51	8.51	8.51					

	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) and Grate (Flat or Sloped)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	4.99	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	20.00	N/A	feet
Overflow Weir Slope =	4.00	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	6.00	N/A	feet
Overflow Grate Open Area % =	70%	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 =	6.49	N/A	feet
Over Flow Weir Slope Length =	6.18	N/A	feet
Grate Open Area / 100-yr Orifice Area =	3.69	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	86.59	N/A	ft^2
Overflow Grate Open Area w/ Debris =	43.29	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 =	0.58	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	66.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	53.40		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	23.45	N/A	ft^2
Outlet Orifice Centroid =	2.72	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	2.74	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	9.80	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	74.00	feet
Spillway End Slopes =	4.00	H:V
Freeboard above Max Water Surface =	1.50	feet

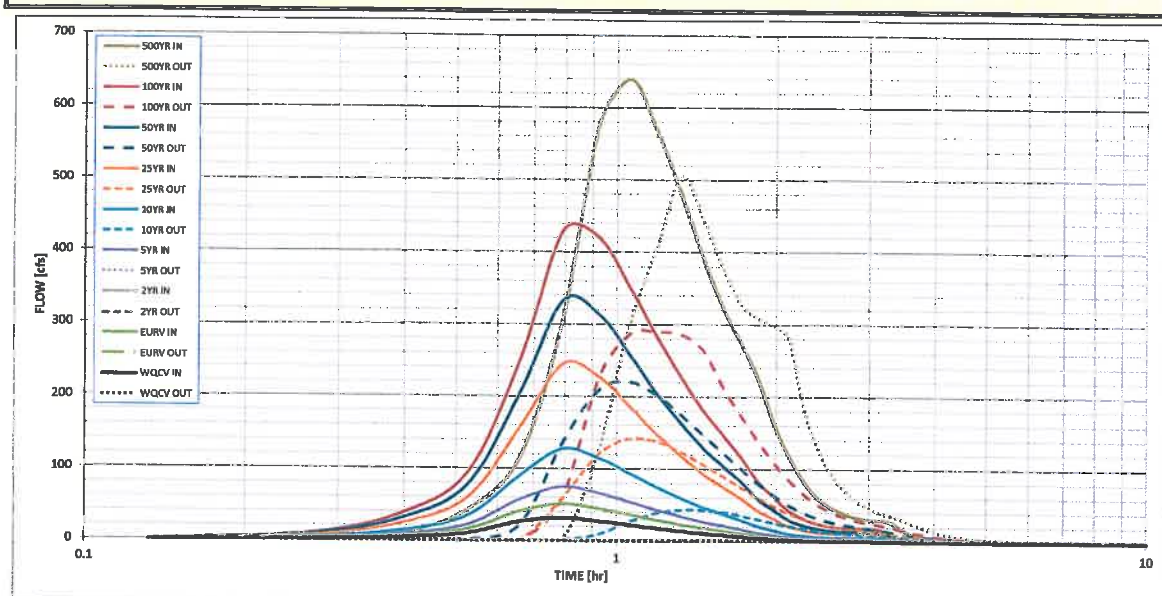
Calculated Parameters for Spillway

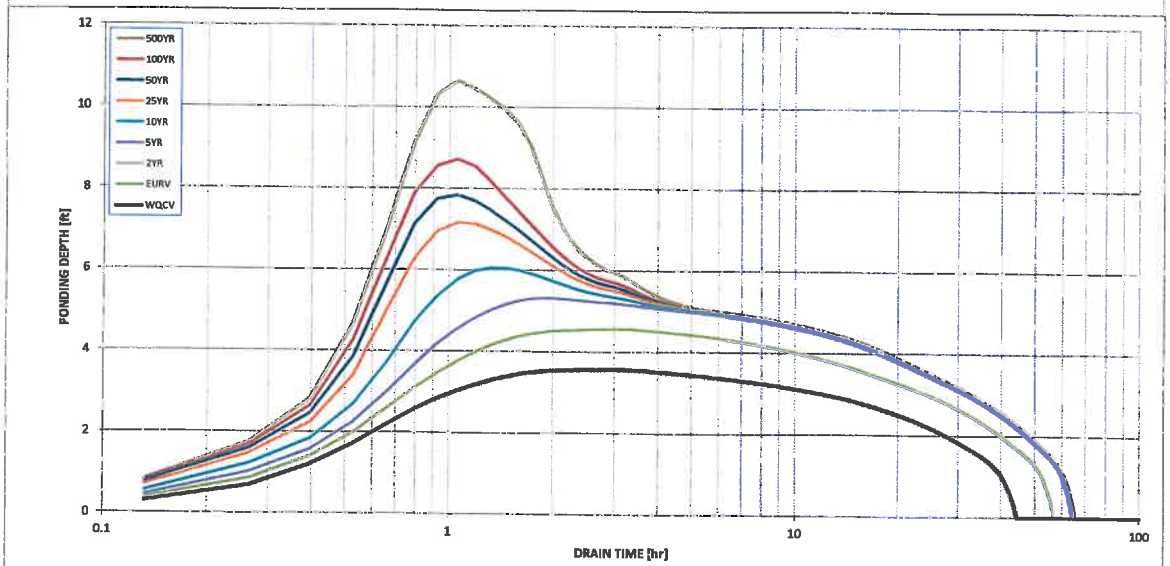
Spillway Design Flow Depth=	1.48	feet
Stage at Top of Freeboard =	12.78	feet
Basin Area at Top of Freeboard =	2.39	acres

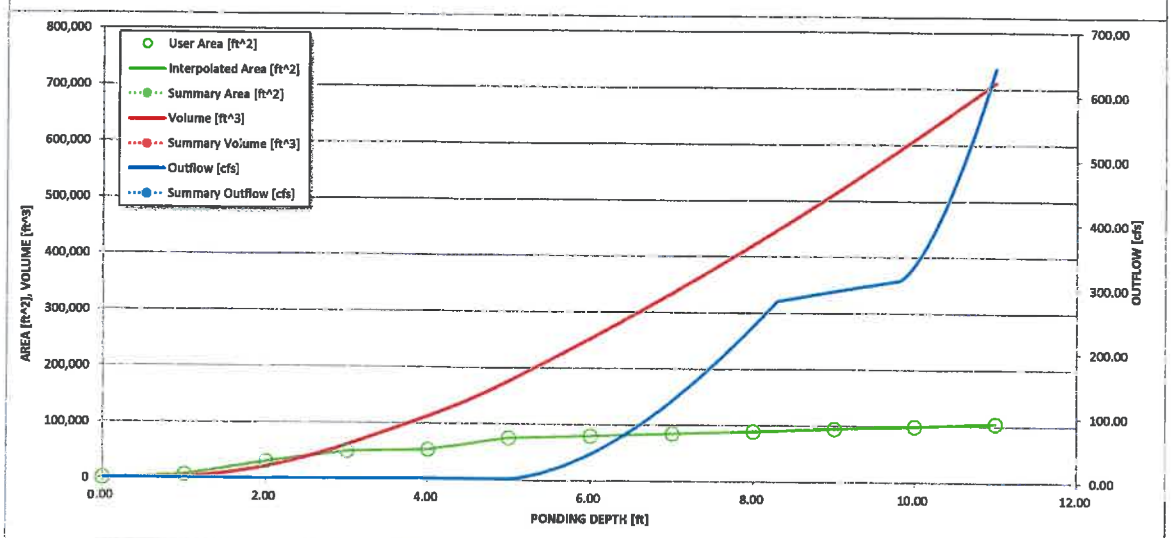
Routed Hydrograph Results

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) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.53	3.29
Calculated Runoff Volume (acre-ft) =	2.291	3.619	2.244	5.316	9.014	17.449	23.854	31.996	51.006
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	2.291	3.620	2.245	5.312	9.015	17.453	23.856	32.004	51.024
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.07	0.15	0.41	0.60	0.84	1.31
Predevelopment Peak Q (cfs) =	0.0	0.0	1.8	26.0	52.1	145.5	212.0	295.1	462.9
Peak Inflow Q (cfs) =	32.0	50.9	31.4	74.9	127.1	244.6	332.3	429.4	639.1
Peak Outflow Q (cfs) =	1.1	1.4	1.1	7.7	43.3	141.1	219.9	289.4	504.4
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.3	0.8	1.0	1.0	1.0	1.1
Structure Controlling Flow =	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	0.1	0.5	1.6	2.5	3.3	3.8
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	41	51	40	56	53	47	44	40	31
Time to Drain 99% of Inflow Volume (hours) =	43	54	42	61	60	57	55	52	48
Maximum Ponding Depth (ft) =	3.58	4.55	3.54	5.30	6.04	7.15	7.83	8.71	10.63
Area at Maximum Ponding Depth (acres) =	1.18	1.49	1.17	1.74	1.82	1.95	2.02	2.13	2.35
Maximum Volume Stored (acre-ft) =	2.058	3.314	2.023	4.551	5.851	7.961	9.291	11.116	15.438

Detention Basin Outlet Structure Design





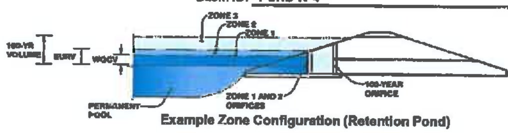


S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

Project: STERLING RANCH FILING NO. 2

Basin ID: POND W-4



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB	
Watershed Area =	352.23	acres
Watershed Length =	12,777	ft
Watershed Slope =	0.022	ft/ft
Watershed Imperviousness =	12.00%	percent
Percentage Hydrologic Soil Group A =	54.0%	percent
Percentage Hydrologic Soil Group B =	46.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Desired WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	UDFCD Default	
Water Quality Capture Volume (WQCV) =	2.291	acre-feet
Excess Urban Runoff Volume (EURV) =	3.619	acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	2.244	acre-feet
5-yr Runoff Volume (P1 = 1.5 in.) =	5.316	acre-feet
10-yr Runoff Volume (P1 = 1.75 in.) =	8.014	acre-feet
25-yr Runoff Volume (P1 = 2 in.) =	17.449	acre-feet
50-yr Runoff Volume (P1 = 2.25 in.) =	23,854	acre-feet
100-yr Runoff Volume (P1 = 2.53 in.) =	31.998	acre-feet
500-yr Runoff Volume (P1 = 3.28 in.) =	51.006	acre-feet
Approximate 2-yr Detention Volume =	2.089	acre-feet
Approximate 5-yr Detention Volume =	4.430	acre-feet
Approximate 10-yr Detention Volume =	5.715	acre-feet
Approximate 25-yr Detention Volume =	7.074	acre-feet
Approximate 50-yr Detention Volume =	9.104	acre-feet
Approximate 100-yr Detention Volume =	13.338	acre-feet

Note: L / W Ratio > 8

L / W Ratio = 10.6

Optional User Override 1-hr Precipitation

1.19	inches
1.50	inches
1.75	inches
2.00	inches
2.25	inches
2.53	inches
	inches

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	2.291	acre-feet
Zone 2 Volume (EURV - Zone 1) =	1.329	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	9.719	acre-feet
Total Detention Basin Volume =	13.338	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	

Depth Increment = 0.1 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)
Micropool	--	0.00	--	--	--	208	0.005		
	--	1.00	--	--	--	6,105	0.140	3,096	0.071
	--	2.00	--	--	--	30,115	0.691	20,967	0.481
	--	3.00	--	--	--	49,313	1.132	60,981	1.400
	--	4.00	--	--	--	52,765	1.211	112,020	2.572
	--	5.00	--	--	--	74,559	1.712	175,682	4.033
	--	6.00	--	--	--	79,051	1.815	252,487	5.796
	--	7.00	--	--	--	84,185	1.933	334,105	7.670
	--	8.00	--	--	--	88,917	2.041	420,656	9.657
	--	9.00	--	--	--	94,245	2.164	512,237	11.759
	--	10.00	--	--	--	99,228	2.278	608,974	13.980
	--	11.00	--	--	--	104,316	2.395	710,747	16.316
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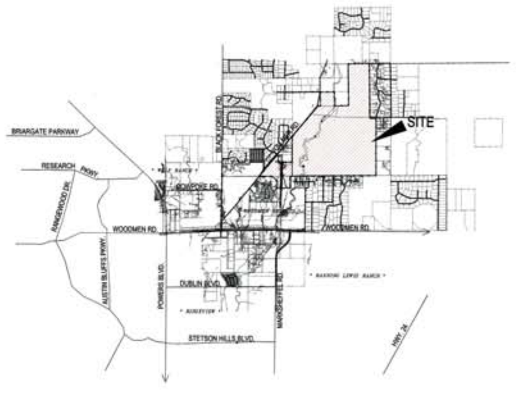
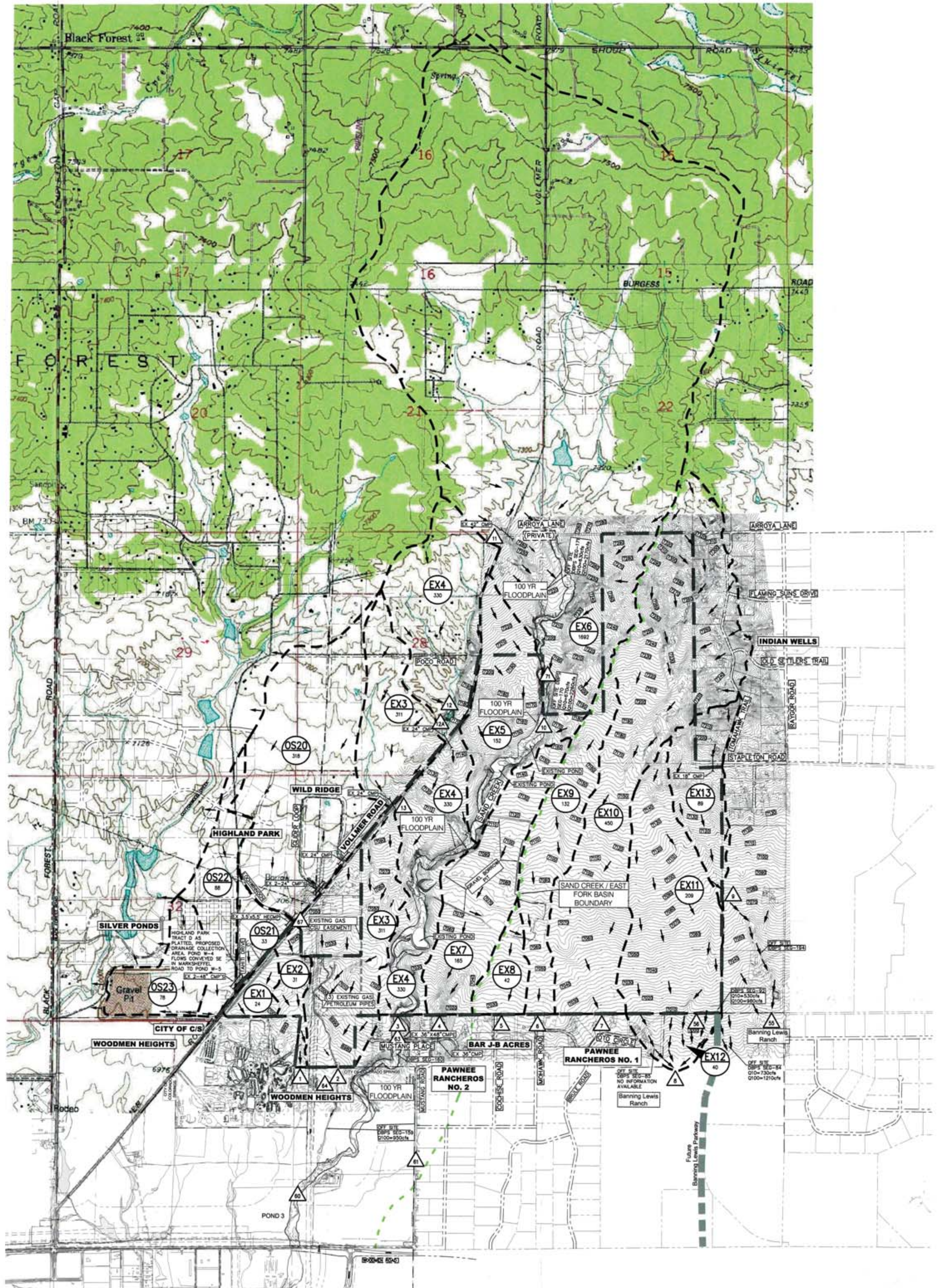
DRAINAGE MAPS



STERLING RANCH
N.T.S.



HISTORIC CONDITION

BASIN SUMMARY			
BASIN	AREA (ACRES)	Q_5 (CFS)	Q_{100} (CFS)
EX-1	24	3	40
EX-2	31	3	45
EX-3	311	49	341
EX-4	330	71	353
EX-5	152	14	209
EX-6	1692	118	2168
EX-7	165	12	197
EX-8	42	4	64
EX-9	132	11	149
EX-10	450	48	474
EX-11	209	17	261
EX-12	40	5	65
EX-13	89	6	114
OS-20	318	61	310
OS-21	33	8	38
OS-22	88	18	91
OS-23	78	34	84

* NOTE: BASINS OS-22 & OS-23 NOT PART OF THIS REPORT. FLOWS FOLLOW HISTORIC PATTERNS ON THE WESTSIDE OF VOLLMER ROAD.

HISTORIC CONDITION

DESIGN POINTS						
DESIGN POINT	SQ. MI.	Q_5 (CFS)	Q_{100} (CFS)	SQ. MI.	DBPS Q_{100}	DBPS DP/ID
1	0.09	5	84			
2	0.49	55	465	0.74	465	64
3	0.52	139	2610	4.33	2552	63
4	0.26	12	197			
5	0.07	4	64			
6	0.21	11	149			
7	0.70	48	474			
8	0.39	18	305			
9	0.14	6	114			
10	2.64	122	2245	3.27	2245	71
11	0.09	5	83			
12A	0.01	3	16			
12	0.27	10	200			
13	0.17	6	126			
				0.48	#	55
				0.53	1210	56
				5.38	2629	60
				0.38	76	61
				0.49	115	67

* NOTE: SQ. MI. ARE NOT CONSISTANT AT EACH DESIGN POINT DP-DBPS

* NOTE: DBPS FLOWS ARE FOR THE EXISTING CONDITION

\# NO DATA GIVEN IN DBPS

1" = 1000'

0 250 500 1000 2000
Scale in Feet

LEGEND

EX1 23.2 — EXISTING MDDP BASIN ACREAGE

E1 — EXISTING FLOW RELEASE POINT

FLOW DIRECTION

BASIN BOUNDARY

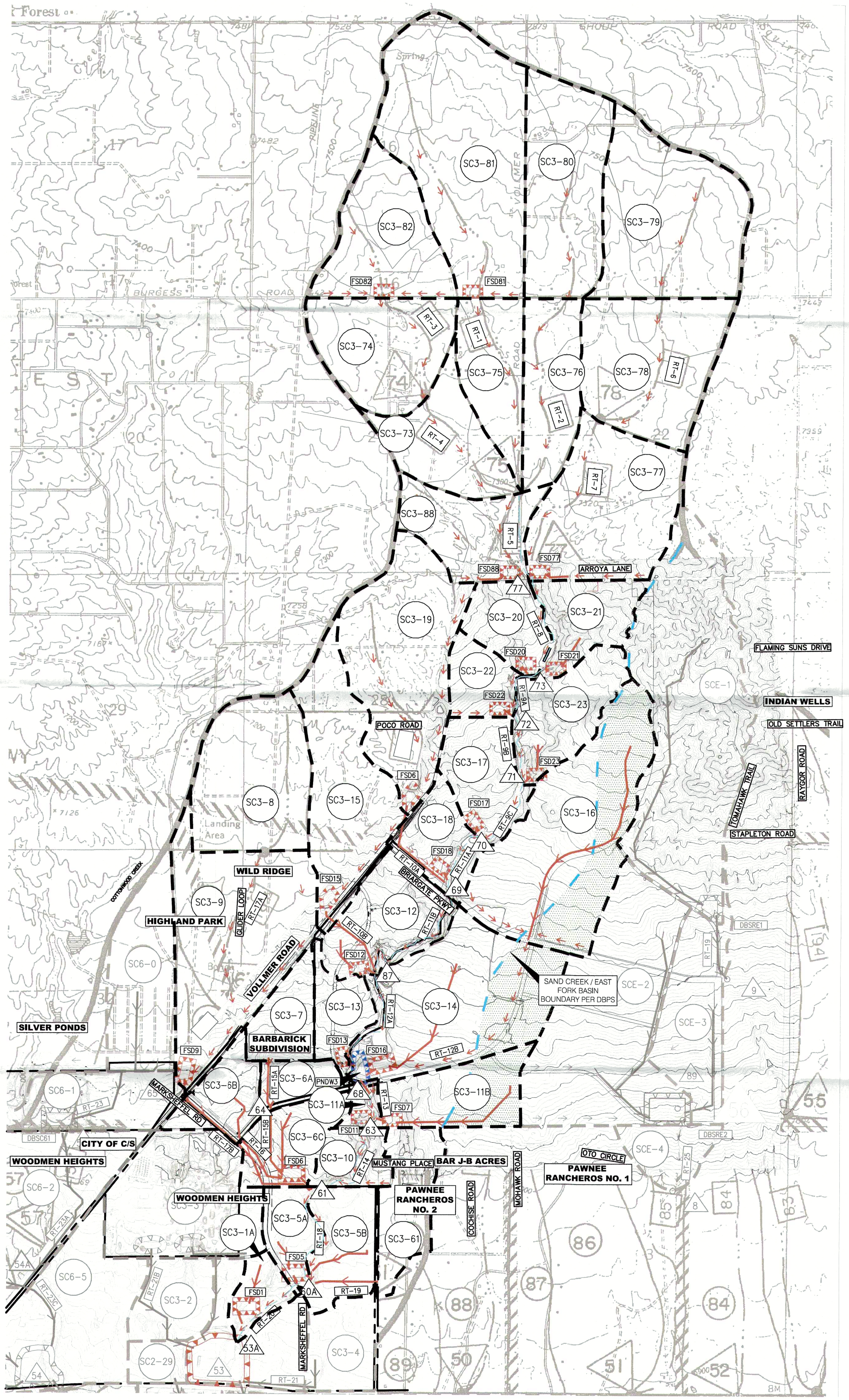
PROPERTY BOUNDARY

6920 — EXISTING CONTOUR

CULVERT PIPE

M&S CIVIL CONSULTANTS, INC.
102 E. PIKES PEAK AVE. STE 306
COLORADO SPRINGS, CO 80903
(719) 955-5485, FAX (719) 444-8427

STERLING RANCH MDDP			
HISTORIC – DRAINAGE MAP			
PROJECT NO. 09-001	FILE: *\dwg\Dev Plan\09001-MDDP HISTORIC		
DESIGNED BY: VAS	SCALE	DATE: 03/16/15	
DRAWN BY: VAS	HORIZ: 1"=500'	SHEET 1 OF 1	D1
CHECKED BY: VAS	VERT: N/A		



0 600 1200 2400
Scale in Feet

LEGEND

- BASIN ID (SC3-77)
- DESIGN POINT (87)
- REACH IDENTIFIER (RT-17A)
- BASIN BOUNDARY
- FLOW DIRECTION
- STORM SEWER
- FULL SPECTRUM DETENTION POND (FSD16)
- DETENTION POND (PNDW3)
- SAND CREEK/EAST FORK BASIN PER DBPS
- INTERBASIN TRANSFER FROM EAST FORK TO SAND CREEK PER DBPS (158.52 AC)

FOR LOCATING & MARKING GAS, ELECTRIC, WATER & TELEPHONE LINES

FOR BURIED UTILITY INFORMATION
48 HRS BEFORE YOU DIG
CALL 1-800-922-1987

File: O:\08035A\Sand Creek Study\dwg\Eng Exhibits\Proposed Conditions Watershed Work Map.dwg Plotstamp: 10/21/2016 2:49 PM

BASIN SUMMARY

BASIN	CN	AREA (ACRES)	AREA (SQ MI)	Q_2 (CFS)	Q_5 (CFS)	Q_{10} (CFS)	Q_{25} (CFS)	Q_{50} (CFS)	Q_{50} (CFS)
SC3-1A	73	27.8	0.085	31.4	45.0	63.8	88.5	110.3	133.1
SC3-5A	84	39.1	0.061	40.6	53.7	71.0	92.4	110.6	129.1
SC3-5B	81	63.0	0.098	53.8	73.0	98.5	130.8	158.6	187.0
SC3-6A	88	49.3	0.077	61.4	79.3	102.2	130.1	153.6	177.1
SC3-6B	85	30.9	0.048	32.9	43.4	57.0	73.9	88.2	102.7
SC3-6C	82	58.0	0.091	53.9	72.5	97.1	128.0	154.5	181.5
SC3-7	88	45.7	0.071	54.0	69.9	90.3	115.2	136.2	157.2
SC3-8	63	143.4	0.224	28.0	45.5	71.1	106.4	138.9	173.8
SC3-9	66	217.4	0.340	49.2	76.2	115.0	168.1	217.1	269.5
SC3-10	63	36.0	0.056	7.6	12.3	19.4	29.1	38.0	47.7
SC3-11A	70	10.7	0.017	5.3	7.8	11.3	15.9	20.0	24.3
SC3-11B	80	76.6	0.120	59.4	81.3	110.8	148.1	180.5	213.7
SC3-12	81	88.2	0.138	77.8	105.6	142.5	189.1	229.1	270.0
SC3-13	85	41.0	0.064	43.9	57.8	76.0	98.5	117.6	136.9
SC3-14	80	199.4	0.311	162.1	221.4	300.7	401.5	488.6	577.7
SC3-15	65	147.6	0.231	32.8	51.8	79.4	117.0	151.5	188.3
SC3-16	79	224.1	0.350	150.7	208.5	286.6	386.6	473.7	563.4
SC3-17	71	70.6	0.110	37.2	53.9	77.7	109.9	138.8	169.2
SC3-18	81	53.7	0.084	49.3	67.1	91.0	121.2	147.3	174.0
SC3-19	63	191.5	0.299	37.2	60.5	94.6	141.6	184.9	231.4
SC3-20	63	50.3	0.079	12.2	19.6	30.4	45.2	58.9	73.5
SC3-21	63	62.6	0.098	14.3	23.1	36.1	53.9	70.3	87.9
SC3-22	63	40.6	0.063	9.2	14.9	23.2	34.6	45.2	56.5
SC3-23	64	81.3	0.127	19.5	31.2	48.2	71.6	93.0	116.0
SC3-61	63	65.5	0.102	13.7	22.0	34.4	51.6	67.6	84.8
SC3-73	63	90.0	0.141	16.4	26.4	41.3	62.1	81.3	102.0
SC3-74	63	119.7	0.187	22.3	36.5	57.3	85.9	112.3	140.7
SC3-75	63	79.3	0.124	13.6	22.1	34.6	51.9	67.8	84.9
SC3-76	63	86.4	0.135	14.2	23.1	36.4	54.6	71.4	89.6
SC3-77	63	163.8	0.256	33.0	53.4	83.2	124.1	161.9	202.4
SC3-78	63	155.6	0.243	28.1	45.3	70.6	106.2	139.1	174.5
SC3-79	63	189.0	0.295	34.9	57.0	89.5	134.3	175.6	220.1
SC3-80	63	147.7	0.231	27.3	44.3	69.6	104.5	136.8	171.4
SC3-81	63	262.9	0.411	48.3	78.3	123.1	184.9	242.0	303.4
SC3-82	63	117.8	0.184	25.0	40.6	63.7	95.5	125.0	156.6
SC3-88	63	87.2	0.136	18.3	29.4	46.2	69.4	90.9	113.9

DESIGN POINT SUMMARY

DESIGN POINT	AREA (SQ MI)	Q_2 (CFS)	Q_5 (CFS)	Q_{10} (CFS)	Q_{25} (CFS)	Q_{50} (CFS)	Q_{100} (CFS)	LOCATION
DP-74	0.371	22.3	36.5	61.8	136.5	192.8	249.7	
DP-75	1.413	82.4	139.5	230.2	521.6	724.3	928.7	
DP-77	2.343	139.3	231.4	430.3	793.5	1118.3	1486.8	ARROYA LANE X-ING
DP-78	0.538	59.7	98.4	154.0	232.6	306.2	385.3	
DP-73	2.520	137.4	236.9	446.0	806.4	1145.0	1521.9	
DP-72	2.583	134.9	236.2	443.8	793.7	1156.5	1501.6	POCO ROAD X-ING
DP-71	2.710	135.1	242.0	452.4	803.1	1154.4	1523.3	STERLING RANCH NORTHERN BNDRY
DP-70	2.820	134.4	246.1	462.4	808.9	1177.6	1543.2	
DP-69	3.203	134.3	256.6	499.1	864.2	1262.7	1673.2	BRIARGATE PARKWAY X-ING
DP-87	3.572	133.9	255.6	541.2	922.7	1371.3	1836.4	
DP-68	4.297	105.0	202.9	462.9	914.3	1302.7	1653.2	STERILNG RANCH ROAD X-ING
DP-64	0.148	114.5	148.0	191.1	243.7	288.0	332.4	
DP-63	4.434	105.1	203.2	471.7	932.6	1327.0	1693.4	STERLING RANCH SOUTHERN BNDRY
DP-61	5.341	106.6	206.3	531.1	1051.2	1523.3	1955.5	COLORADO SPRINGS/EL PASO BNDRY
DP-60A	5.602	111.0	212.4	543.2	1073.9	1558.5	2001.4	MARKSHEFFEL X-ING
DP-53A	5.687	110.4	212.3	546.2	1078.2	1567.6	2017.3	SAND CREEK AND POND 3

WATER QUALITY & DETENTION POND SUMMARY

FSD1

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	31.4	45.0	63.8	88.5	110.3	133.1
ALLOWABLE RELEASE (CFS)	0.1	1.7	3.3	10.9	17.5	25.5
MODELED RELEASE (CFS)	0.2	1.7	3.3	10.9	17.5	25.5
STORED VOLUME (AC-FT)	2.4	2.6	3.0	3.6	4.2	4.9

FSD5

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	40.6	53.7	71.0	92.4	110.6	129.1
ALLOWABLE RELEASE (CFS)	0.1	1.4	2.6	11.3	19.8	30.2
MODELED RELEASE (CFS)	0.1	1.4	2.6	11.2	19.7	30.1
STORED VOLUME (AC-FT)	3.0	3.2	3.8	4.1	4.7	5.2

FSD6

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	196.6	258.6	339.2	438.9	523.4	608.8
ALLOWABLE RELEASE (CFS)	0.6	8.3	15.9	60.5	101.7	151.7
MODELED RELEASE (CFS)	0.6	8.3	15.9	60.4	101.4	151.6
STORED VOLUME (AC-FT)	15.4	16.1	18.3	20.6	23.2	26.2

FSD9

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	67.9	112.8	174.2	259.1	342.0	429.4
ALLOWABLE RELEASE (CFS)	1.7	24.9	49.8	141.1	207.2	290.0
MODELED RELEASE (CFS)	1.7	20.8	49.4	141.2	206.9	289.4
STORED VOLUME (AC-FT)	9.0	9.0	10.0	11.3	13.0	14.5

FSD11A

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	5.3	7.8	11.3	15.9	20.0	24.3
ALLOWABLE RELEASE (CFS)	0.1	1.6	3.2	7.5	9.7	12.4
MODELED RELEASE (CFS)	0.2	0.9	3.0	7.6	9.6	12.2
STORED VOLUME (AC-FT)	0.3	0.3	0.4	0.4	0.5	0.6

FSD11B

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	59.4	81.3	110.8	148.1	180.5	213.7
ALLOWABLE RELEASE (CFS)	0.3	4.5	8.7	29.6	47.7	69.6
MODELED RELEASE (CFS)	0.3	4.5	8.6	29.5	47.7	69.0
STORED VOLUME (AC-FT)	4.8	4.9	5.5	6.4	7.3	8.2

FSD12

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	77.8	105.6	142.5	189.1	229.1	270.0
ALLOWABLE RELEASE (CFS)	0.9	13.2	26.7	62.0	80.2	103.2
MODELED RELEASE (CFS)	0.9	9.0	26.7	61.9	80.1	103.1
STORED VOLUME (AC-FT)	5.2	5.5	5.8	6.7	7.8	8.9

WATER QUALITY & DETENTION POND SUMMARY

FSD13

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	43.9	57.8	76.0	98.5	117.6	136.9
ALLOWABLE RELEASE (CFS)	0.4	6.1	12.3	28.6	37.0	47.6
MODELED RELEASE (CFS)	0.4	4.2	12.3	28.6	36.9	47.2
STORED VOLUME (AC-FT)	3.1	3.1	3.3	3.8	4.4	5.0

FSD15

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	32.8	51.8	79.4	117.0	151.5	188.3
ALLOWABLE RELEASE (CFS)	1.2	17.5	35.7	85.4	111.7	145.8
MODELED RELEASE (CFS)	1.2	13.1	35.7	85.4	111.7	145.7
STORED VOLUME (AC-FT)	3.3	3.3	3.6	4.0	4.5	5.0

FSD16

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	248.6	362.6	503.9	692.0	852.3	1016.5
ALLOWABLE RELEASE (CFS)	1.5	21.5	41.9	143.4	231.0	338.7
MODELED RELEASE (CFS)	1.5	21.5	41.8	143.2	230.8	338.7
STORED VOLUME (AC-FT)	25.5	26.0	29.7	34.2	39.0	43.9

FSD17

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	37.2	53.9	77.7	109.9	138.8	169.2
ALLOWABLE RELEASE (CFS)	0.7	11.1	22.5	52.0	67.2	86.3
MODELED RELEASE (CFS)	0.7	7.3	22.4	52.0	67.3	86.3
STORED VOLUME (AC-FT)	2.3	2.3	2.5	3.0	3.6	4.2

FSD18

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	49.3	67.1	91.0	121.2	147.3	174.0
ALLOWABLE RELEASE (CFS)	0.6	9.2	18.4	42.2	54.6	69.9
MODELED RELEASE (CFS)	0.6	6.6	18.4	42.2	54.6	69.6
STORED VOLUME (AC-FT)	3.2	3.2	3.4	4.0	4.7	5.3

FSD19

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	37.2	60.5	94.6	141.6	184.9	231.4
ALLOWABLE RELEASE (CFS)	1.7	24.6	50.3	118.4	153.3	198.4
MODELED RELEASE (CFS)	1.7	18.6	50.3	118.1	153.2	198.2
STORED VOLUME (AC-FT)	3.4	3.4	3.7	4.1	4.5	5.1

FSD20

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	12.2	19.6	30.4	45.2	58.9	73.5
ALLOWABLE RELEASE (CFS)	0.6	8.4	16.8	38.8	50.1	64.2
MODELED RELEASE (CFS)	0.6	8.4	16.6	38.8	50.0	63.8
STORED VOLUME (AC-FT)	0.8	0.8	0.9	1.0	1.1	1.3

FSD21

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	14.3	23.1	36.1	53.9	70.3	87.9
ALLOWABLE RELEASE (CFS)	0.7	10.1	20.3	47.0	60.7	77.9
MODELED RELEASE (CFS)	0.7	8.8	20.3	46.9	60.6	77.5
STORED VOLUME (AC-FT)	1.0	1.0	1.1	1.2	1.4	1.5

FSD22

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	9.2	14.9	23.2	34.6	45.2	56.5
ALLOWABLE RELEASE (CFS)	0.4	6.6	13.2	30.5	39.4	50.5
MODELED RELEASE (CFS)	0.4	2.1	13.3	29.9	39.3	49.9
STORED VOLUME (AC-FT)	0.7	0.8	0.8	0.9	0.9	1.0

FSD23

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	19.5	31.2	48.2	71.6	93.0	116.0
ALLOWABLE RELEASE (CFS)	0.9	13.0	26.2	60.6	78.4	100.6
MODELED RELEASE (CFS)	0.9	13.1	26.0	60.4	78.3	100.1
STORED VOLUME (AC-FT)	1.4	1.5	1.6	1.7	1.9	2.1

FSD77

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	33.0	53.4	83.2	124.1	161.9	202.4
ALLOWABLE RELEASE (CFS)	1.6	23.7	48.1	112.2	145.1	186.9
MODELED RELEASE (CFS)	1.6	23.5	48.0	110.0	144.9	186.7
STORED VOLUME (AC-FT)	2.8	2.8	3.0	3.3	3.6	3.9

FSD81

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	48.3	78.3	123.1	184.9	242.0	303.4
ALLOWABLE RELEASE (CFS)	2.4	36.7	74.5	174.3	225.5	290.9
MODELED RELEASE (CFS)	2.4	36.0	74.5	174.3	225.3	290.9
STORED VOLUME (AC-FT)	4.6	4.7	4.9	5.2	5.5	5.9

FSD82

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	25.0	40.6	63.7	95.5	125.0	156.6
ALLOWABLE RELEASE (CFS)	1.1	16.4	33.4	78.1	101.1	130.4
MODELED RELEASE (CFS)	1.1	13.2	33.3	78.2	101.2	130.2
STORED VOLUME (AC-FT)	2.1	2.1	2.3	2.5	2.8	3.2

FSD88

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	18.3	29.4	46.2	69.4	90.9	113.9
ALLOWABLE RELEASE (CFS)	0.8	12.6	25.6	59.7	77.3	99.5
MODELED RELEASE (CFS)	0.8	9.2	25.2	59.6	77.2	99.3
STORED VOLUME (AC-FT)	1.5	1.5	1.7	1.8	2.0	2.2

PNDW3

STORM EVENT (YR)	2	5	10	25	50	100
PEAK INFLOW (CFS)	131.6	254.8	579.5	1064.4	1597.5	2152.4
MODELED RELEASE (CFS)	105.0	202.9	462.9	914.3	1302.7	1653.2
STORED VOLUME (AC-FT)	1.3	3.2	9.1	19.6	30.5	43.9

20 BOULDER CRESCENT, SUITE 110
COLORADO SPRINGS, CO 80903
PHONE: 719.955.5485

M&S CIVIL CONSULTANTS, INC.

SAND CREEK CHANNEL STUDY

FUTURE HYDROLOGIC CONDITIONS MAP

PROJECT NO. 08-035 | FILE: \dwg\Eng Exhibits\Proposed Conditions Watershed Work Map.dwg

DESIGNED BY: DLM
DRAWN BY: DLM
CHECKED BY: VAS

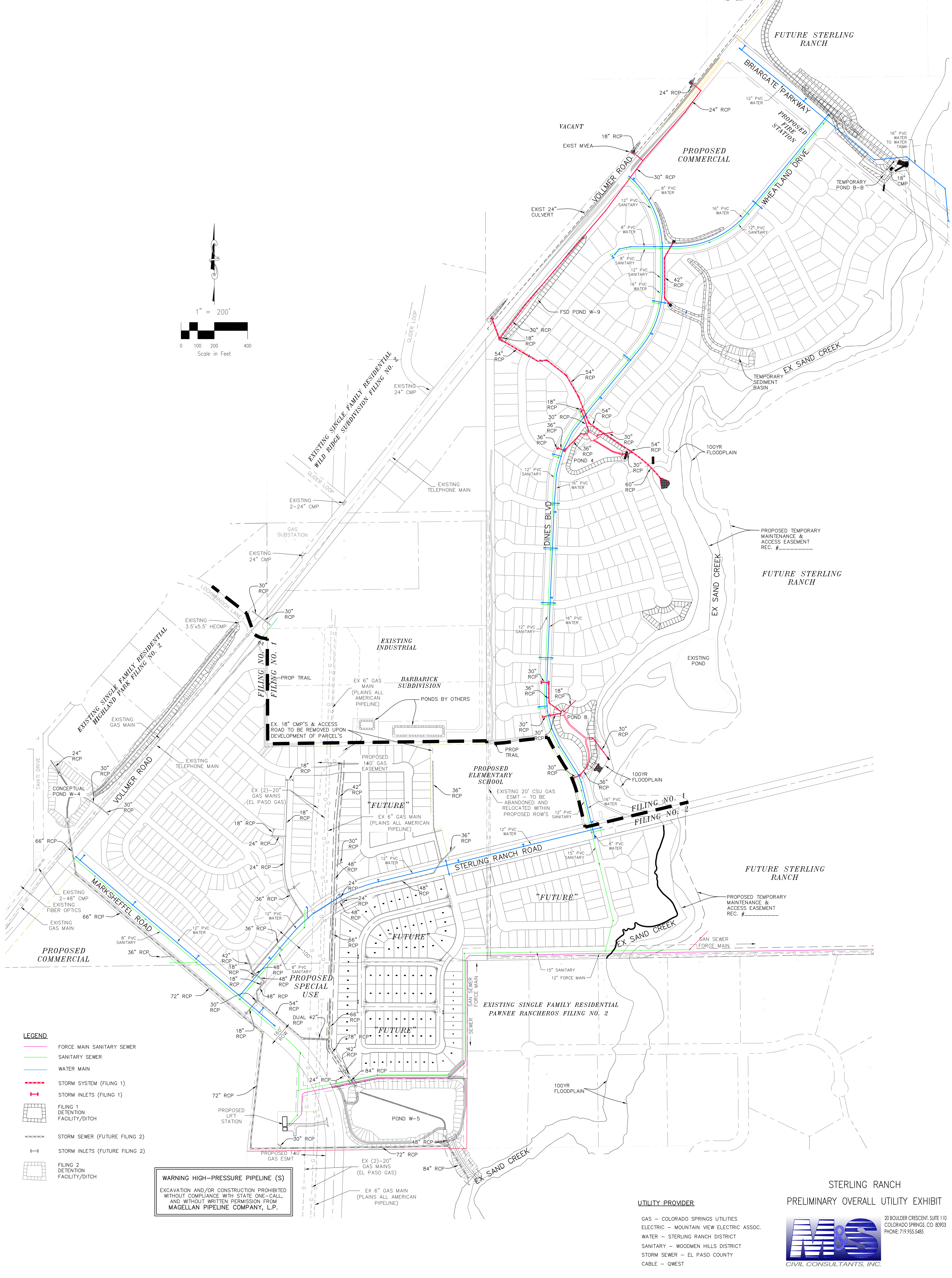
SCALE
HORIZ: NTS
VERT: NTS

DATE: 10-21-16

DM2

STERLING RANCH

PRELIMINARY OVERALL UTILITY EXHIBIT



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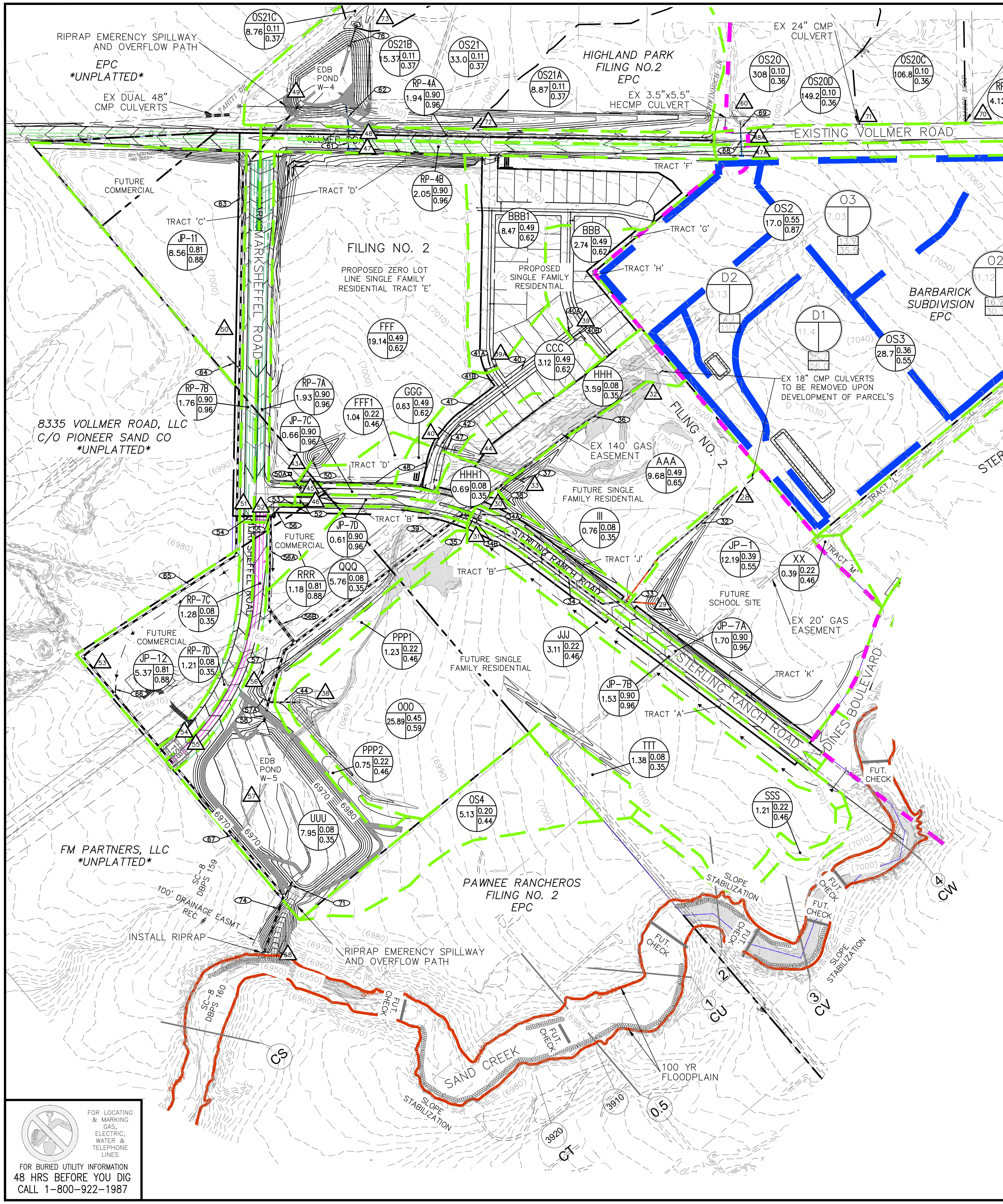
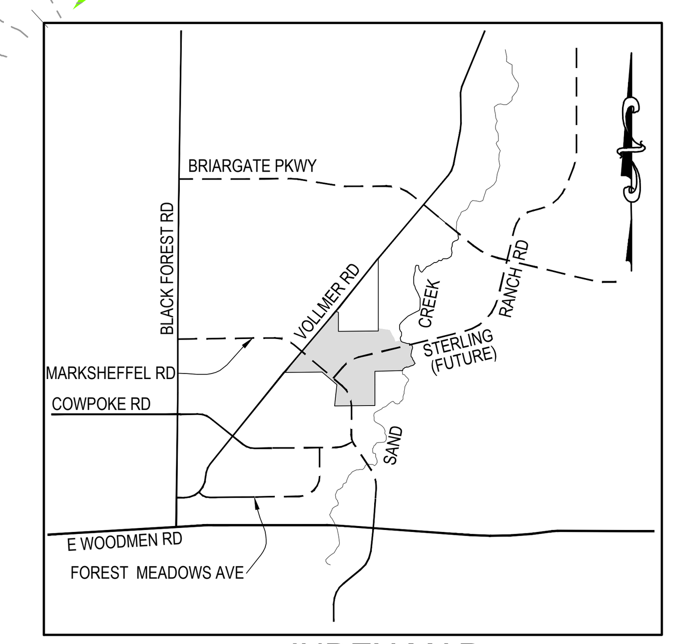


1" = 200'

0 100 200 400 Scale in Feet

LEGEND

BASIN DESIGNATION
ACRES
C5
C100
PIPE RUN REFERENCE LABEL
SURFACE DESIGN POINT
BASIN BOUNDARY
EXISTING CONTOUR
PROP CONTOUR
STORM SEWER PIPE
CROSSPAN
INLET
EXISTING FLOW DIRECTION ARROW
EMERGENCY OVERFLOW DIRECTION
FLOW DIRECTION
FLARED END SECTION
FILING LINE
DIVERSION SWALE
STERLING RANCH FILING NO.1 & NO.2 DIVISION LINE



INDEX MAP
N.T.S.

NOTE:
GRADE CONTROL STRUCTURES IN SAND CREEK TO BE DESIGNED AND CONSTRUCTED BY DEVELOPER/METRO DISTRICT PRIOR TO DEVELOPMENT EAST OF SAND CREEK.

DESIGN POINT SUMMARY

DESIGN POINT	Q_5	Q_{100}	BASIN	STRUCTURE
28	25.8	60.2	OS3,YY	36" FES/TSB BARBARICK SUBDIVISION
29	17.3	41.7	JP-1,XX	36" FES/TSB
30	6.5	13.0	JP-7A,III	15" AT-GRADE INLET
31	8.4	19.8	JP-7B,JJJ	15' AT-GRADE INLET
32	30.4	80.8	OS2	42" FES/TSB BARBARICK SUBDIVISION
33	17.3	38.5	AAA	30" FES/TSB
38	37.2	81.9	OOO	42" FES/TSB
39	4.8	10.6	BBB	2-10' AT-GRADE INLET
39A	12.4	27.3	BBB1	2-10' AT-GRADE INLET
40	6.0	20.2	CCC,FLOWBY DP39, FLOWBY DP39A	2-15' AT-GRADE INELT
43A	35.0	74.3	FFF	42" FES/TSB
44	1.0	7.7	HHH	18" FES/TSB
45	4.4	13.3	JP-7C,FFF1,GGG, HHH1,FLOWBY DP30, FLOWBY DP40	15' AT-GRADE INLET
46	2.4	9.7	JP-7D, FLOWBY DP31	15' AT-GRADE INLET
47A	11.1	24.4	RP-3B,FLOWBY DP16	INTERIM AREA INLET 2.9'x5.7' TYPE D CDOT INLET FUTURE 15' AT-GRADE INLET
48A	13.5	26.6	RP-3A,FLOWBY DP17	INTERIM SHEET FLOW OFF SHOULDER INTO ROADSIDE DITCH FUTURE 15' AT-GRADE INLET
47-1	7.7	20.4	RP-4B, FLOWBY DP47A	INTERIM SHEET FLOW OFF SHOULDER INTO ROAD SIDE DITCH FUTURE 10' AT-GRADE INLET
47	1.5	10.1	FLOWBY DP47-1	FUTURE 10' AT-GRADE INLET
48-1	8.2	21.0	RP-4A,FLOWBY DP48A	INTERIM SHEET FLOW OFF SHOULDER INTO ROAD SIDE DITCH FUTURE 10' AT-GRADE INLET
48	1.7	10.6	FLOWBY DP 48-1	FUTURE 10' AT-GRADE INLET
49	72.9	367.1	OS21,DP60,PR62	W-4 DETENTION POND
49	20.8	289.4	RELEASE FROM POND W-4	PEAK OUTFLOW FROM POND W-4 UD DET v3.06
50	29.4	53.7	JP-11	36" FES
51	5.8	10.5	RP-7B	15' AT-GRADE INLET
52	6.4	13.9	RP-7A,FLOWBY DP45, FLOWBY DP46	15' AT-GRADE INLET
53	19.8	36.1	JP-12	30" FES
54	0.4	3.5	RP-7D UNDEVELOPED, FLOWBY DP51	TSB
55	0.4	4.9	RP-7C UNDEVELOPED, FLOWBY DP52	TSB
56	5.7	20.5	QQQ,PPP1,RRR	24" FES
57	217.4	517.9	UUU,PPP2,PR58,OS4,TTT	CUMM. DETENTION POND 28'x5' INLET INTO INTO SAND CREEK
57	3.1	149.7	RELEASE POND W-5	PEAK OUTFLOW FROM POND W-5 UD Det. v3.06
60	59.7	316.2	OS20	3.5'x5.5' HECMP/EX SWALE
68	42.2	472.4	PR67, PR71	84" RCP PEAK OUTFLOW INTO SAND CREEK
69	4.5	27.4	OS20A SUB-BASIN CUMMULAIVE FLOW	24" RCP/EX SWALE
70	15.0	90.7	OS20B, DP69 SUB-BASIN CUMMULATIVE FLOW	24" CMP/EX SWALE
71	25.6	154.4	OS20C, DP70 SUB-BASIN CUMMULATIVE FLOW	24" CMP/EX SWALE
72	71.9	345.9	OS21A, DP60, SUB-BASIN CUMMULATIVE FLOW	EX SWALE
73	3.2	18.1	OS21C	24" RCP

STORM SEWER SUMMARY

PIPE RUN	Q_5	Q_{100}	PIPE SIZE	CONTRIBUTING PIPES
32	25.8	60.2	36" RCP	DP28
33	17.3	41.7	36" RCP	DP29
34	41.4	97.8	48" RCP	PR32,PR33
34A	6.5	11.1	24" RCP	DP30
34B	8.2	14.2	24" RCP	DP31
35	53.1	117.8	48" RCP	PR34,PR34A,PR34B
36	30.4	80.8	42" RCP	DP32
37	17.3	38.5	30" RCP	DP33
38	45.9	115.2	48" RCP	PR36,PR37
39	98.5	232.0	66" RCP	PR35,PR38
44	37.2	81.9	42" RCP	DP38
40A	2.4	5.3	18" RCP	1/2 DP39
40B	2.4	5.3	18" RCP	1/2 DP39
40	4.8	10.6	18" RCP	DP39
41A	5.7	9.0	18" RCP	1/2 DP39A
41B	11.4	17.9	24" RCP	DP39A
41	15.5	26.9	24" RCP	PR40,PR41B
42	4.8	15.8	24" RCP	1/2 DP40,PR47
47	1.0	7.7	18" RCP	DP44
48	23.0	52.3	36" RCP	1/2 DP40,PR41,PR42
50	35.0	74.3	42" RCP	DP43A
50A	54.2	118.6	48" RCP	PR48,PR50
51	4.4	11.3	18" RCP	DP45
52	58.2	128.8	48" RCP	PR50A,PR51
53	2.4	9.1	18" RCP	DP46
54	5.8	9.7	18" RCP	DP51
55	12.2	21.2	30" RCP	DP52,PR54
56	60.2	136.2	48" RCP	PR52,PR53
56A	71.1	155.2	54" RCP	PR55,PR56
56B	71.1	155.2	2-42" RCP	PR56A
57	168.1	383.8	78" RCP	PR39,PR56B
57A	5.7	20.5	24" RCP	DP56
58	208.9	481.1	84" RCP	PR44,PR57,PR57A
68 INT	11.1	24.4	30" RCP	DP47A INTERIM AREA INLET
68	10.0	15.8	30" RCP	DP47A
69	21.2	31.9	30" RCP	DP48A, PR68
61 INT	7.7	20.4	30" RCP	DP47 AREA INLET
61-0	6.2	10.3	18" RCP	DP47
61	7.7	17.6	30" RCP	DP47 FLOWBY, PR 61-0
62-0	6.2	10.3	18" RCP	DP48
62	15.8	38.2	30" RCP	DP48 FLOWBY, PR61, PR61
63	20.8	289.4	66" RCP	DP49
64	29.4	53.7	36" RCP	DP50
65	32.0	309.9	72" RCP	PR63, PR64
66	19.8	36.1	30" RCP	DP53
67	39.1	322.7	72" RCP	PR65, PR66
71	3.1	149.7	48" RCP	PEAK OUTFLOW FROM POND W-5-UD-Det v3.04
73	4.5	27.4	24" RCP	DP69
74	42.2	472.4	84" RCP	PR67, PR71 SUMMED
75	59.7	316.2	72" RCP	DP60
76	3.2	18.1	24" RCP	DP73

BASIN SUMMARY

BASIN	AREA (ACRES)	Q_5	Q_{100}
XX	0.39	0.4	1.3
YY	4.56	3.5	12.4
AAA	9.68	17.3	38.5
BBB	2.74	4.8	10.6
BBB1	8.47	12.4	27.3
CCC	3.12	5.5	11.7
FFF	19.14	35.0	74.3
FFF1	1.04	0.8	2.9
GGG	0.63	1.3	2.8
HHH	3.59	1.0	7.7
HHH1	0.69	0.2	1.6
III	0.76	0.2	1.8
JJJ	3.11	2.8	9.8
OOO	25.89	37.2	81.9
PPP1	1.23	1.1	3.9
PPP2	0.75	0.7	2.4
QQQ	5.76	1.6	11.4
RRR	1.18	3.7	6.8
SSS	1.21	1.1	3.8
TTT	1.38	0.4	3.2
UUU	7.95	3.0	21.9
JP-1	12.19	17.0	40.6
JP-7A	1.70	6.2	11.2
JP-7B	1.53	5.6	10.1
JP-7C	0.66	2.8	5.0
JP-7D	0.61	2.8	5.0
JP-11	8.56	29.4	53.7
JP-11 UNDEV	8.56	2.0	15.0
JP-12	5.37	19.8	36.1
JP-12 UNDEV	5.37	1.4	10.0
OS2	17.00	30.4	80.8
OS3	28.70	33.3	85.5
OS4	5.13	3.6	13.1
OS20	308.00	49.9	301.5
OS20A	15.73	4.5	27.4
OS20B	36.32	10.9	65.9
OS20C	106.79	17.2	103.8
OS20D	149.16	25.6	154.5
OS21	33.00	9.7	54.6
OS21A	8.87	3.0	16.7
OS21B	15.37	5.2	29.2
OS21C	8.76	3.2	18.1
RP-3A	4.12	12.5	22.4
RP-3B	3.12	9.6	17.2
RP-4A	1.94	6.9	12.3
RP-4B	2.05	7.2	13.0
RP-7A	1.93	6.4	11.4
RP-7B	1.76	5.8	10.5
RP-7C UNDEV	1.28	0.4	2.9
RP-7D UNDEV	1.21	0.4	2.8

STERLING RANCH FILING NO. 2
PROPOSED DRAINAGE MAP

DATE: 12/20/2017
SHEET 1 OF 1
SHEET 1

SCALE: HORIZONTAL: 1"=200' VERTICAL: N/A

PROJECT NO. 09-002
DESIGNED BY: GT
DRAWN BY: BB
CHECKED BY: GT

M&S CIVIL CONSULTANTS, INC.
20 BOULDER CRESCENT, SUITE 110
COLORADO SPRINGS, CO 80903
PHONE: 719.955.5485

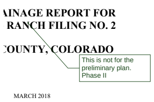
VIRGIL A. SANCHEZ, COLORADO P.E. NO. 37160
FOR AND ON BEHALF OF M&S CIVIL CONSULTANTS, INC.

REVISIONS: NO.	DATE:	BY:	DESCRIPTION:	APPR'D. BY:	DATE:

File: O:\09002A\Sterling Ranch District - Filing 2\dwg\Eng Exhibits\FDP\SR Filing 2-Proposed Drainage Map Filing 2.dwg Plotstamp: 3/7/2018 1:38 PM

Markup Summary

2/5/2019 2:33:04 PM (1)



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Author: dsdparsons
Date: 2/5/2019 2:33:04 PM
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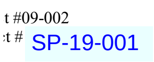
This is not for the preliminary plan. Phase II

3/6/2019 9:18:14 AM (1)



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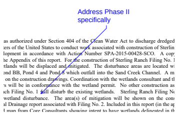
Author: dsdrice
Date: 3/6/2019 9:18:14 AM
Color:

SP-19-001

3/7/2019 3:45:14 PM (1)



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Author: dsdrice
Date: 3/7/2019 3:45:14 PM
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Address Phase II specifically

3/7/2019 3:45:58 PM (1)

Subject: Text Box
Page Label: 1
Author: dsdrice
Date: 3/7/2019 3:45:58 PM
Color:

See comment letter.