Preliminary and Final Drainage Report
Meadowbrook Crossing
El Paso County, Colorado

Prepared for:
Meadowbrook Crossing LLC
90 South Cascade Ave, Suite 1500
Colorado Springs, Colorado 80903

Prepared by:

Kiowa
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Kiowa Project No. 16039

May 2, 2017

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STATEMENTS AND APPROVALS

ENGINEER'S STATEMENT:

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

Kiowa Engineering Corporation, 1604 South 21st Street, Colorado Springs, Colorado 80904

________________________________ ________________

Matthew W. Erichsen, P.E. (PE #36713) Date

For and on Behalf of Kiowa Engineering Corporation

DEVELOPER'S STATEMENT:

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

By: ________________________________ ________________

Date

Meadowbrook Crossing LLC

Print Name: __________________________

Address: Meadowbrook Crossing LLC
90 South Cascade Avenue, Suite 1500
Colorado Springs, Colorado 80903

EL PASO COUNTY:

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

________________________________ ________________

Jennifer Irvine, P.E. Date

El Paso County Engineer/ECM Administrator

I. GENERAL LOCATION AND DESCRIPTION

The Meadowbrook Crossing subdivision will be developed as a single-family residential subdivision located in El Paso County. The subject property is located to the northwest of Meadowbrook Parkway and US Highway 24, east of Peterson Road. The site is located in the south half of Section 8, Township 14 South, Range 65 West of the 6th Principal Meridian, in El Paso County, Colorado. The site is bounded to the west by the East Fork Sand Creek, Cimarron Southeast Filing No. 1 (undeveloped), to the south and east by Meadowbrook Parkway and 24/94 Business Park Filing No. 1 (undeveloped) and to the north by Claremont Business Park Filing No. 2 (commercial property) and Cimarron Hills Filing No. 4 (residential property). The East Fork Sand Creek crosses through the northwest portion of the site from northeast to southwest. The property covers approximately 32.89 acres and is currently undeveloped. A vicinity map of the site is shown on Figure 1 included in the Appendix.

The existing vegetative cover within the development is in fair condition with grasses throughout the site. The existing ground slopes within the property range from 1 to 6 percent typical with areas of vertical slopes along the edge of the drainageway. Soils within the subject site are classified to be within Hydrologic Soils Group A and B as shown in the El Paso County Soils Survey, see Appendix for the Soil Map. Specifically the site includes Blakeland loamy sand (Soil Group A), Blendon sandy loam (Soil Group B) and Ellicott loamy coarse sand (Soil Group A) which is mainly located along the existing drainageway. For the purposes of computing the existing and proposed hydrology for the site, Hydrologic Soil Group B was used.

There are no active irrigation ditches or facilities within or adjacent to the site.

II. MAJOR DRAINAGE BASINS AND SUBBASINS

The site lies within the East Fork Sand Creek drainage basin. The majority of the site drains by sheet flow west/northwest into the East Fork Sand Creek. The Meadows Crossing area was studied as a part of the *Sand Creek Drainage Basin Planning Study (DBPS).* The DBPS shows drainageway improvements adjacent to the site for East Fork Sand Creek. Those improvements include channelizing the existing creek into a trapezoidal channel section with an 80-ft bottom width, 100 year riprap bank lining on both sides of the creek to a depth of 5-feet (depth to be determined by 100 year water surface elevation) and two drop structures. In the existing condition, a concrete vertical check structure is located upstream of the site and grouted sloping boulder drops are used further upstream to provide grade control of the creek. The vertical check structure is exposed to a depth greater than the design likely intended. The proposed drainageway improvements will raise the channel bottom to decrease the exposed height of this check structure to a more manageable height along with flattening the downstream slope to minimize the chance of this check being further exposed in the future. The proposed improvements include construction of a trapezoidal channel section with soil riprap bank lining on both sides and installation of two grouted sloping boulder drops to provide grade control and flatten the longitudinal slope of the creek. The DBPS shows a longitudinal slope of 1.0%, the proposed design will result in a slope of roughly 0.5% to reduce the chance of future erosion. Refer to the East Fork Sand Creek Improvements section for additional information.

The subject property is located within a Zone AE FEMA regulated floodplain based on Flood Insurance Rate Map 08041C0752F, effective dated March 17, 1997. A copy of the FIRM panel is provided in the Appendix. The planned improvements to East Fork Sand Creek will modify the existing floodplain. A Conditional Letter of Map Revision (CLOMR) has been submitted to FEMA for approval of the floodplain modifications. The proposed 100 year floodplain will be contained within the proposed channel section and will not extend into the proposed lots.

In the existing condition, the majority of the site drains by sheet flow to the East Fork Sand Creek, refer to the Existing Conditions Drainage Plan. Basin EX-A: The basin is located along the north and northwest sides of the property including the East Fork Sand Creek. The runoff from this basin will sheet flow to the East Fork Sand Creek. Basin EX-B: The basin is located along the southeast and south sides of the property. The runoff sheet flows west-southwest towards the southwest corner of the property, leaving the site before draining into the creek.

Following is a description of the off-site drainage basins in the existing condition, refer to the Drainage Facility Design section for the proposed condition basin descriptions. Refer to the Proposed Condition Drainage Plan for the basin locations. Basin OS-A: The basin is located along the east side of the development and includes half of existing Meadowbrook Parkway. The gutter of Meadowbrook Parkway carries off site flows from the north to southwest. These off-site flows enter the property at the west end of Meadowbrook Parkway where the street ends. The FDR for 24/94 Business Park shows a proposed 10-ft Type R on the east corner of the intersection (by Others), however not on the north corner within Basin OS-A. Basin OS-B: The basin is located along the south side of the development, west of the Meadowbrook Parkway intersection in proposed Tract H which is the future ROW for the Meadowbrook Parkway extension. In the existing condition, this basin is part of Basin EX-B and runoff sheet flows west to the East Fork Sand Creek. Basin OS-C: The basin is located along the northeast half of Meadowbrook Parkway between Highway 24 and the intersection of Meadowbrook Parkway. The runoff from the basin will sheet flow to the gutter which directs the flows northwest to the existing drain pan at Meadowbrook Parkway which conveys the flows southwest into Basin OS-D. Basin OS-D: The basin is located along the southwest half of Meadowbrook Parkway between Highway 24 and the intersection of Meadowbrook Parkway. The runoff from the basin will sheet flow to the gutter which directs the flows northwest and around the curb return into Basin OS-E. Basin OS-E: The basin is located to the south of the site and will include the south half of the future Meadowbrook Parkway extension west of Newt Drive. In the existing condition, the runoff sheet flows west to East Fork Sand Creek.

An existing 18-inch storm sewer outfalls into the site near the intersection of Meadowbrook Parkway. This pipe carries flows from the east side of Meadowbrook Parkway (24/94 Business Park Filing No. 1). In the proposed condition, this pipe will be abandoned in place and capped (see below for description of proposed 42-inch storm sewer-by others). Off site flows also drain onto the subject site by sheet flow from a landscaped area to the north of the property (Claremont Business Park). This area is small with a minimal amount of runoff. In the proposed condition, the lots are planned to have swales along the lot lines to capture and convey flows from the back of the lots to the front. These swales will be used to convey off site flows.

24/94 Business Park FDR and 42-inch storm sewer by Others: The 24/94 Business Park FDR shows future curb inlets along the future Meadowbrook Parkway extension on the south and west corners of the intersection to capture runoff from Basins OS-A, OS-C and OS-D (The inlet on the west corner will be shifted to the north corner to capture flows before the intersection and to be located over the 42-inch storm sewer). These inlets will connect to the 42-inch RCP storm sewer (described below) from the 24/94 Business Park Filing No. 1 property and be constructed when the street is extended.

The development of the 24/94 Business Park to the south of the site will include the installation of a 42-inch RCP storm sewer system which will cross through the Meadowbrook Crossing site, outfalling into the East Fork Sand Creek. The proposed and future inlets along Meadowbrook Parkway at Newt Drive will be connected to this storm sewer. The portion of pipe crossing under Meadowbrook Parkway was installed when the street was constructed. This storm sewer will be separate from the drainage improvements on the subject site. No on-site stormwater connections are planned into this storm sewer from Meadowbrook Crossing. The construction of this storm sewer will be performed by others. In the event, the development of the 24/94 Business Park does not occur prior to construction of Meadowbrook Crossing, the 42-inch storm sewer will be constructed through the Meadowbrook Crossing for future connection and conveyance of stormwater from that site.

III. DRAINAGE DESIGN CRITERIA

Hydrologic and hydraulic calculations for the site were performed using the methods outlined in the *El Paso County Drainage Criteria Manual*. Topography for the site is presented on the Drainage Plan. The hydrologic calculations were made for the existing and proposed site conditions. The Drainage Plan presents the drainage patterns for the site, including the sub-basins. The peak flow rates for the sub-basins were estimated using the Rational Method. The 5-year (Minor Storm) and 100-year (Major Storm) recurrence intervals were determined. The one-hour rainfall depth was determined from Table 6-2 of the *Drainage Criteria Manual*. These depths are shown in the runoff calculations spreadsheet. The peak flow data generated using the rational method was used to verify street capacities and to size inlets and storm sewers within the subdivision. The drainage basin area, time of concentration, and rainfall intensity were determined for each of the sub-basins within the property. The onsite soils were assumed to be Hydrologic Soil Group B, based on the *Soil Survey*.

The onsite hydraulic structures were sized using the methods outlined in the *El Paso County Drainage Criteria Manual*. The hydraulic capacities of the streets and curb inlets were determined using the UD-Inlet spreadsheet developed by the UDFCD, considering the County criteria for the Minor (5-year) and Major (100-year) storms. Colorado Department of Transportation (CDOT) Type R curb inlets will be used within the site. Ramp curbs will be used throughout the development, except along Newt Drive and between curb returns and at curb inlets, where a 6-inch vertical curb will be used. Storm sewer pipes were initially sized based on their full-flow capacity using the Manning's equation. The UDSewer program was then used to verify storm sewer pipe sizes and perform hydraulic grade line (HGL) and energy grade line (EGL) calculations for the 5-year and 100-year storm events. Hydraulic calculations are provided in the Appendix for the proposed street, inlet and pipe capacities, pipe outlet erosion protection and open channel.

Stormwater detention will not be required on the site, due to the close proximity of the site to a major drainageway, refer to the Stormwater Quality Design section. Stormwater quality improvements will be required and will be provided in a modified Extended Detention Basin at the downstream end of the site. The UD-FSD spreadsheets created by UDFCD were used to size and design the water quality area and outlet structure. The supporting calculations are included in the Appendix of this report.

IV. DRAINAGE FACILITY DESIGN

The drainage of the site will be accomplished through a combination of sheet flow, gutter flow and storm sewer flow. Curb inlets will be placed along the street at locations where needed to decrease the amount of gutter flow for the minor and major storms and at the low point in the street to capture the developed runoff. The captured runoff will be conveyed to the proposed water quality basin for water quality treatment before being discharged to the East Fork Sand Creek. The primary stormwater conveyance facility will be a storm sewer system ranging in size from an 18-inch diameter reinforced concrete pipe (RCP) to a 36-inch RCP conveying the on-site runoff to the water quality basin. The proposed drainage patterns for the site are shown on the Drainage Plan (Exhibit A) provided in the map pocket at the end of this report. The hydrologic and hydraulic calculations are provided in the Appendix.

The County requires a Four Step Process "for receiving water protection that focuses on reducing runoff volumes, treating the water quality capture volume (WQCV), stabilizing drainageways and implementing long-term source controls". In this development following are the steps taken to meet this process. Step 1-Employ Runoff Reduction Practices: The building roof downspouts will typically be directed to the landscaped areas, swales between lots or grassed areas to both convey flows and allow infiltration. Step 2-Implement BMPs that Provide a WQCV with Slow Release: An extended detention basin will be used to provide water quality treatment for most of the runoff from the site. The extended detention basin will release the WQCV over 40 hours. The runoff from the back half of the lots adjacent to the creek will sheet flow over the grass (grass buffer water quality treatment) before reaching the creek. Step 3-Stabilize Drainageways: The proposed development includes stabilizing the existing creek with grade control structures and soil riprap bank lining. Step 4-Implement Site Specific and Other Source Control BMPs: The potential pollutant sources for a residential development like this one include parked vehicles, deicing chemicals, waste storage/disposal practices, landscapes (fertilizers, herbicides, pesticides, excessive irrigation) and pets. Since this is a residential development with public streets, most of the source control BMPs are not easily controlled. No vehicle maintenance is allowed on the streets. No deicers are planned for the sidewalks and streets, however the street deicing will be dependent on the public plowing.

Following is a description of the on-site storm sewer system:

The system will begin with two 10-ft curb inlets at the southwest side of the intersection of Boreal Drive and Newt Drive. An 18-inch storm sewer will connect the two inlets (Inlets C and D) and a 24-inch storm sewer will continue out from the second inlet northwest along Newt Drive. The storm sewer will continue to the intersection of Newt Drive and Preble Drive where two more 10-ft curb inlets will be located on the downstream side of the intersection. Those inlets will connect to this storm sewer. The storm sewer size will increase to 30-inch RCP downstream of the inlets and continue southwest along Preble Drive and south along Boreal Drive to the low point in the southwest corner of the site. Two 20-ft curb inlets will be installed at the low point to capture the developed runoff and transfer the flows into the storm sewer. At the inlets and low point the storm sewer will exit the street section and into a drainage easement between the lots, heading southwest. The storm sewer will outfall into a presedimentation basin within the proposed water quality basin. The runoff will be routed through the water quality basin to the outlet structure. A pipe will outlet from the outlet structure into the creek. Riprap outlet protection will be placed at the end of the water quality basin outlet pipe to reduce erosion. Refer to the Stormwater Quality Design section for a description of the water quality area design.

Following is a description of the proposed condition off-site drainage sub-basins, refer to the Major Drainage Basins and Subbasins section for the existing condition description:

<u>Basin OS-A</u>: Two proposed street connections to Meadowbrook Parkway are located within the basin. Cross pans will be installed along with a high point west of the intersections to minimize the chance of off-site flows entering the site. A proposed 10-ft Type R curb inlet will be installed upstream of the intersection with Newt Drive along the 42-inch storm sewer (by Others) to capture a majority of the gutter flows. The 24/94 Business Park FDR shows this inlet on the west corner of the intersection, however it will be shifted to the north corner to capture flows prior to the intersection and to be located over the proposed 42-inch storm sewer. Flows in excess of the capacity of the inlet will continue along the future layout of Meadowbrook Parkway to East Fork Sand Creek. When Meadowbrook Parkway is extended, the flows bypassing the inlet on the north corner of the intersection will continue in the gutter into Basin OS-B.

<u>Basin OS-B:</u> The basin includes the northern half of the future Meadowbrook Parkway extensions. Runoff from this basin will sheet flow onto the gutter which will convey the flows to the west. A curb inlet will capture the gutter flows and a storm sewer will convey those flows to the Meadowbrook Crossing Water Quality Area. The Water Quality Area has been designed to treat the flows from Basin OS-B. The pipe will be required to outlet into a forebay, either enlarge the existing forebay or construct a forebay for this pipe within the water quality area

Basin OS-C and OS-D: The drainage patterns for these two basins will be similar in the existing and proposed conditions. In the future condition, when Meadowbrook Parkway is extended a curb inlet will be installed at the south corner of the intersection to capture flows from the two basins.

Basin OS-E: The drainage patterns for the basin will be similar in the existing and proposed conditions. In the future condition, when Meadowbrook Parkway is extended, the runoff from the basin will sheet flow to the south gutter of Meadowbrook which will convey the flows west to the property line. This basin is not designed to drain into the Meadowbrook Crossing water quality area.

Following is a description of the on-site drainage sub-basins:

Sub-basin A: The sub-basin is located along the north and northwest side of Preble Drive, including half of Preble Drive and residential lots. The northern lots (where the back of the lots abut adjacent property) have been graded for runoff to sheet flow from the back of the lots to the street section. The northwestern lots that abut the open space will include a high point in the center of the lots to drain half of the lots to the street by sheet flow. The runoff from this basin that sheet flows to the street will flow to the gutter which will convey the flows west/southwest to the on grade 10-ft curb inlet (Inlet A) downstream of the intersection of Newt Drive and Preble Drive. Flows in excess of the inlet capacity will continue southwest along Preble Drive into Basin E. Minor amounts of off-site flow will enter the site from the north (Claremont Business Park) via sheet flow. The Claremont Business Park FDR shows the area to the north of the site and Basin A to drain west into the existing 30-inch storm sewer which outfalls into the creek. Individual lots will include drainage swales along the lot lines between lots to convey the on-site and off-site runoff to the street.

Sub-basin B: The sub-basin is located along the south and southeast side of Preble Drive, between Boreal Drive and Newt Drive. The basin includes residential lots and half the street section. The runoff from this basin will sheet flow to the street gutter which will convey the flows southwest to the on grade 10-ft curb inlet (Inlet B) downstream of the intersection of Newt Drive and Preble Drive. Flows in excess of the inlet capacity will continue southwest along Preble Drive into Basin F.

Sub-basin C: The sub-basin is located along the north/northwest side of Boreal Drive, between Preble Drive and Newt Drive. The basin includes residential lots and half the street section. The runoff from this basin will sheet flow to the street gutter which will convey the flows southwest to the on grade 10-ft curb inlet (Inlet C) downstream of the intersection of Newt Drive and Boreal Drive. Flows in excess of the inlet capacity will continue southwest along Boreal Drive into Basin G.

Sub-basin D: The sub-basin is located along the south/southeast side of Boreal Drive, between Preble Drive and Newt Drive and to the northwest of Meadowbrook Parkway. The basin includes residential lots and half the street section. The lots in this area have been graded to drain to the front of the lot by sheet flow to the street gutter. The gutter will convey the flows southwest to the on grade 10-ft curb inlet (Inlet D) downstream of the intersection of Newt Drive and Boreal Drive. Flows in excess of the inlet capacity will continue southwest along Boreal Drive into Basin H. At the two interior street connections to Meadowbrook Parkway, a crosspan will installed along with a high point along the interior drive to minimize the chance of off-site gutter flows entering the site.

Sub-basin E: The sub-basin is located along the north side of Preble Drive and west side of Boreal Drive, including half of the street section and residential lots. The lots will include a high point in the center of the lots to drain half of the lots to the street by sheet flow. The back of the lots will drain to Basin J. The runoff from sub-basin E will sheet flow to the street gutter which will convey the flows west/south to the sump 20-ft curb inlet (Inlet 1) at the low point in the site along Boreal Drive. The inlets at the low point have been sized to capture the 100 year developed flow and convey into Storm 1. If the inlets become clogged or a flow in excess of the 100 year event occurs, the runoff will overtop the curb and drain between the lots in a swale (Section A-A) to the water quality area. The entire street section will convey the major storm event to the proposed inlets at the low point. For that reason, the total flow was split between the two inlets to determine curb inlet capacity.

Sub-basin F: The sub-basin is located along the south side of Preble Drive and east side of Boreal Drive, including half of the street section and residential lots. The lots will be graded to drain from the back of the lot to the front by sheet flow to the street gutter. The street gutter will convey the runoff west/south to the sump 20-ft curb inlet (Inlet 2) at the low point in the site along Boreal Drive. The inlets at the low point have been sized to capture the 100 year developed flow and convey it into Storm 1. If the inlet becomes clogged or a flow in excess of the 100 year event occurs, the runoff will overtop the street centerline and flow to Inlet 1, refer to the Sub-basin E description. The entire street section will convey the major storm event to the proposed inlets at the low point. For that reason, the total flow was split between the two inlets to determine curb inlet capacity.

Sub-basin G: The sub-basin is located along the north side of Boreal Drive, including half of the street section and residential lots. The lots will be graded to drain from the back of the lot to the front by sheet flow to the street gutter. The street gutter will convey the runoff west to the sump 20-ft curb inlet (Inlet 2) at the low point in the site along Boreal Drive. The inlets at the low point have been sized to capture the 100 year developed flow and convey it into Storm 1. Refer to the Sub-basin F description.

Sub-basin H: The sub-basin is located along the south side of Boreal Drive, between Preble Drive and the low point in Boreal Drive; to the northwest of future Meadowbrook Parkway. The basin includes residential lots and half the street section. The lots in this area have been graded to drain to the front of the lot by sheet flow to the street gutter. The gutter will convey the flows west to the sump condition 20-ft curb inlet (Inlet 1) at the low point in the site along Boreal Drive. Refer to the Sub-basin E description for additional information on the inlet and overflow.

Sub-basin I: The sub-basin is located along the back of the lots on the west side of Boreal Drive and the proposed water quality area. The lots will include a high point in the center of the lots to drain half of the lots to the water quality area by sheet flow. Refer to the Stormwater Quality Design section for a description of the water quality area.

Sub-basin J: The sub-basin is located along the northwest side of the site including the East Fork Sand Creek, the back half of the lots along Preble Drive and the open space to the north of the creek. These areas will sheet flow to the creek which will convey the flows from the northeast corner of the site to the south/southwest. Drainageway improvements are planned for the East Fork Sand Creek within the development that will impact the FEMA regulated 100 year floodplain. Refer to East Fork Sand Creek section for a detailed description of the improvements. The owner is considering making the overbank section on the north side of the creek a dog park. Any impacts associated with the dog park will be limited by management of the area by the HOA including limiting the loss of vegetation within the area.

A. STORMWATER QUALITY DESIGN

Storm water quality measures are required by the County as part of the development of the property, however no stormwater detention is required due to the proximity of the site to a major drainageway. The proposed outfall for the site is well downstream of the centroid of the East Fork Sand Creek basin, so the peak flow from the site will flow into the creek well ahead of the peak for the basin. In addition, stormwater detention has not been required or included in any of the existing adjacent developments. The water quality measures to be instituted for the development will include:

1. Construction of an extended detention basin at the downstream end of the property for site runoff to drain through. The water quality enhancements to be included in the water

quality basin are a presedimentation forebay on-site storm sewer outlet into the water quality area, minimal sloped low flow channel, outlet structure with an internal micropool, water quality orifice plate to reduce the release rate to a drain time of nearly 40 hours for the Water Quality Capture Volume (WQCV) and a well screen across the orifice plate to minimize the chance of debris blocking the orifice plate.

The water quality basin has been sized based on the required water quality capture volume (WQCV) and a 40-hour maximum drain time. The outlet structure will include an overflow grate for flows in excess of the WQCV. The grate has capacity up to roughly the 5-year storm event before the flows will overtop the spillway crest and flow down the spillway into the creek. The water quality area will be a private facility and will be maintained by the Homeowner's Association.

B. EAST FORK SAND CREEK IMPROVEMENTS

The East Fork Sand Creek courses through the site from the northeast to southwest. The existing channel exhibits a moderate amount of degradation and erosion of the main channel and side slopes adjacent to the site. This degradation is most apparent at the existing check structure upstream of the site which is exposed to a depth of roughly 5-ft and the vertical banks in areas along the creek. The proposed improvements will include stabilization of the existing degraded channel by constructing two grouted sloping boulder drops to provide grade control and to lessen the longitudinal slope of the channel to a more stable slope. The creek will be channelized and soil riprap bank lining will be installed on both sides of the creek to minimize the chance of further erosion and creek migration. The design is based on the channel and drop criteria described in the Urban Drainage and Flood Control District's Urban Storm Drainage Criteria Manual (USDCM).

The existing check structure upstream of the site will set the invert elevation at the upstream end. A portion (approximately 2-ft vertical) of the check will be filled in naturally to re-establish the invert that has degraded, leaving the top approximately 3-ft vertical of the check exposed. The sill of the downstream drop structure will set the downstream channel invert and a sustainable longitudinal slope. The channel section will be a trapezoidal section constructed of a soil riprap (65% riprap/ 35% topsoil by volume) mixture along both side slopes. This soil riprap mixture will be buried with topsoil to promote vegetation. The soil riprap will be constructed on 4:1 typical side slopes extending 5-ft below the channel invert to provide toe protection and 1.0-foot minimum above the 100-year floodplain to provide freeboard. The riprap was sized using the criteria contained in the USDCM. The riprap size will vary along the channel reach depending on the flow velocities. The soil riprap will be placed directly on the subgrade without bedding material or geotextile fabric (USDCM Figure 8-34). Granular bedding will only be used if a section of riprap does not include soil mixed into the voids. The typical channel bottom will consist of a native sand and cobble mixture.

The proposed channel alignment/centerline includes two large radius bends. The channel hydraulics at these bends were reviewed to determine the potential for erosion. In both cases, the centerline radii will be greater than 2.0 times the top width, however erosion protection will be installed up to the superelevated 100-year water surface elevation plus 0.5-ft of freeboard at a minimum, along the outside bends. Storm sewer pipe outfalls into the channel will be at least 1-foot (preferably 2-feet) above the channel invert. A concrete cut off wall and riprap pad will be constructed at the pipe outlets.

Based upon the hydraulic analysis discussed above, the project design criteria is as follows:

- Q_{100} = 5,330 cfs

- Typical channel longitudinal slope: 0.3% - 0.5%
- Channel section type: Trapezoidal section with natural bottom and soil riprap bank lining with toe protection
- Channel centerline radius: 300-ft and 500-ft (minimum is 2x channel top width)
- Typical 100-year water surface depth: 4.7-feet
- Soil riprap thickness to be 2xD_{50} of riprap minimum and buried with 4-6 inch thick topsoil in areas outside of channel bottom.
- Bottom width: 120-ft typical. Downstream of the lower drop structure the bottom width will gradually transition to approximately 300-ft to match existing grades.
- Side Slopes: 4:1 typical

Grouted Sloping Boulder Drop Design

The Grouted Sloping Boulder Drop (GSBD) design follows the criteria included in UDFCD's USDCM. Two GSBD's between 2.4 to 3.6-feet high are planned for this section of East Fork Sand Creek. The location of the proposed drops is based on the preferred longitudinal slope of the channel and protecting the proposed development. As recommended by the USDCM, the drops will not be located on a curve.

The longitudinal slope of the drop face is designed at 6:1 (USDCM Criteria 4:1 maximum). Calculations were performed to determine the boulder size within the grouted sloping boulder drops. The minimum boulder size for the drop structures will be 30-inches. These boulders must be carefully placed to create a stepped appearance which helps to increase roughness. The boulders will be placed on undisturbed soil or compacted subgrade. Full penetration of grout around the lower one-half of the rock is essential for successful grouted boulder performance. The grout should be injected to a depth equal to one-half of the boulders being used and keep the upper one-half ungrouted and clean. Typically, the grout will not extend to the top of the boulders.

A vertical cutoff will be located at the upstream face of the crest to minimize seepage from occurring under the structure and possible uplift forces. The cutoff wall will be installed to the specified depth below the proposed channel invert. The vertical cutoff wall will be constructed of sheet pile. A grouted boulder sill will be installed at the downstream end of the drops. The upstream drop will not include a downstream cut off wall, the downstream drop will include a downstream cut off wall to protect against further erosion of the channel downstream of the site. A 0.5% slope was extended from a point downstream of the site near Peterson Road to determine the depth of this downstream cutoff wall. This estimated longitudinal slope represents the maximum downstream channel degradation assuming no future channel stabilization improvements will be constructed between the proposed lower drop structure and Peterson Road. Weep drains will be installed in the drops to release hydrostatic pressure from under the drops and reduce the uplift forces on the grouted channel lining.

HEC-RAS and specific force calculations were used to determine the hydraulic jump location along the drops, the stilling basin length and depth. Riprap will be placed downstream of the sill for a distance of 10-feet to minimize erosion that may occur due to secondary currents.

Based upon the hydraulic calculations and USDCM, the following design criteria have been established for the grouted sloping boulder drops.

- Drop height (H_d)(elevation difference between crest and top of sill): One 2.4-ft and one 3.6-ft

- Typical trapezoidal channel section to continue through drop. Grouted boulders to extend to 1.0-ft vertically above the 100-year water surface elevation.
- Drop face slope: 6:1
- Boulder size: 30-inch minimum, with randomly placed 30-inch to 48-inch feature boulders/boulder islands to help split low flows and dissipate energy. 36-inch minimum for sill.
- Grouted boulder bedding: Undisturbed soil or compacted subgrade.
- Approach length: 10-ft grouted boulders followed by 10-ft type M soil riprap (2.0-ft thick), not buried along the channel bottom.
- Upstream cutoff wall depth: 6.5-ft to 8.5-ft. Cut off material to be steel PZ-22 sheet Pile with a steel reinforced concrete cap.
- Downstream cutoff wall depth: Downstream drop only. 9.0-ft steel PZ-22 sheet pile with a steel reinforced concrete cap.
- Weep drain system: Yes
- Stilling basin depth: 1.5-ft
- Stilling basin length: 20-ft
- Downstream length of riprap protection: 10-ft type M soil riprap (2.0-ft thick), not buried along channel bottom.

Refer to Appendix for Channel design and Grouted Sloping Boulder Drop Design Calculations and additional design information.

The proposed improvements to the East Fork Sand Creek will result in a modification to the existing floodplain. A Conditional Letter of Map Revision has been submitted to FEMA for the floodplain impacts associated with the drainageway improvements. Refer to the CLOMR for detailed information and calculations related to the floodplain modification.

C. COST OF PROPOSED DRAINAGE FACILITIES

Table 2 presents a cost estimate for the construction of drainage improvements (public and private) for development. The public drainageway improvements have been separated since the cost of these improvements will be credited toward the Drainage Fees.

D. DRAINAGE AND BRIDGE FEES

The site lies within the Sand Creek Drainage Basin. The current drainage basin fee is $15,720 per impervious acre and the current bridge fee is $4,762 per impervious acre. The Meadowbrook Crossing subdivision encompasses 32.89 acres. Table 1 details the fees due as part of this development. The public drainageway improvement expenses will be credited toward the Drainage Fees. Table 1 includes a calculation of the Reimbursable Drainage Expenses, based on the Table 2 cost estimate and the DBPS cost estimate for this section of East Fork Sand Creek. The developer will follow the procedures for drainage improvement credits and reimbursements as outlined in EPC DCM Chapter 3, Section 3.3 to determine the final reimbursement. Refer to the Appendix for Section 3.3 of the EPC DCM.

V. CONCLUSIONS

Meadowbrook Crossing will be a single-lot family residential subdivision covering approximately 32.89 acres. On-site drainage will include the use of curb inlets and storm sewers to route the runoff from the site to the water quality basin at the downstream end of the site. No stormwater detention improvements will be required of this development. The treated runoff from the site will be conveyed from the water quality basin to the East Fork Sand Creek. Improvements will be constructed along the East Fork Sand Creek including channelization of the creek with soil riprap bank protection and grade control of the creek invert with two grouted sloping boulder drop structures. A Conditional Letter of Map Revision has been submitted to FEMA for the floodplain impacts associated with the drainageway improvements. The development of the Meadowbrook Crossing property will not adversely impact or deteriorate improvements or natural drainageways downstream of the property.

VI. REFERENCES

1) Meadowbrook Crossing Conditional Letter of Map Revision, prepared by Kiowa Engineering Corporation, dated December 13, 2016.

2) Central Marksheffel Metropolitan District, FEMA Floodplain Letter of Map Revision, prepared by Matrix Design Group, Inc., dated January 2006.

3) Sand Creek Drainage Basin Planning Study, Preliminary Design Report, prepared by Kiowa Engineering Corporation, dated January 1993 (Revised March 1996).

4) Final Drainage Report, Lot 1 24/94 Business Park Filing No. 1, prepared by Core Engineering Group, dated July 14, 2016.

5) Final Drainage Report, Claremont Business Park Filing No. 2, prepared by Matrix Design Group, dated November 2006.

6) City of Colorado Springs and El Paso County Flood Insurance Study, prepared by the Federal Emergency Management Agency, dated March 1997.

7) El Paso County Drainage Criteria Manual (Volumes 1 and 2) and Engineering Criteria Manual, current editions.

8) Urban Storm Drainage Criteria Manual (USDCM) Volumes 1, 2 and 3, Urban Drainage and Flood Control District, Current Editions

9) Soil Survey of El Paso County Area, Colorado, prepared by United States Department of Agriculture Soil Conservation Service.

APPENDIX TABLE OF CONTENTS

APPENDIX

Figure 1: Vicinity Map

Soils Map

FEMA Flood Insurance Rate Map

Table 1: Impervious Area and Drainage Basin & Bridge Fee Calc

Table 2: Opinion of Cost – Drainage Facilities

EPC DCM Section 3.3: Procedures for Drainage Improvement Credits…

Table VIII-8: Sand Creek DBPS Drainage Basin Fee Estimation

Table VIII-2: Sand Creek DBPS Drainageway Conveyance Cost Estimate

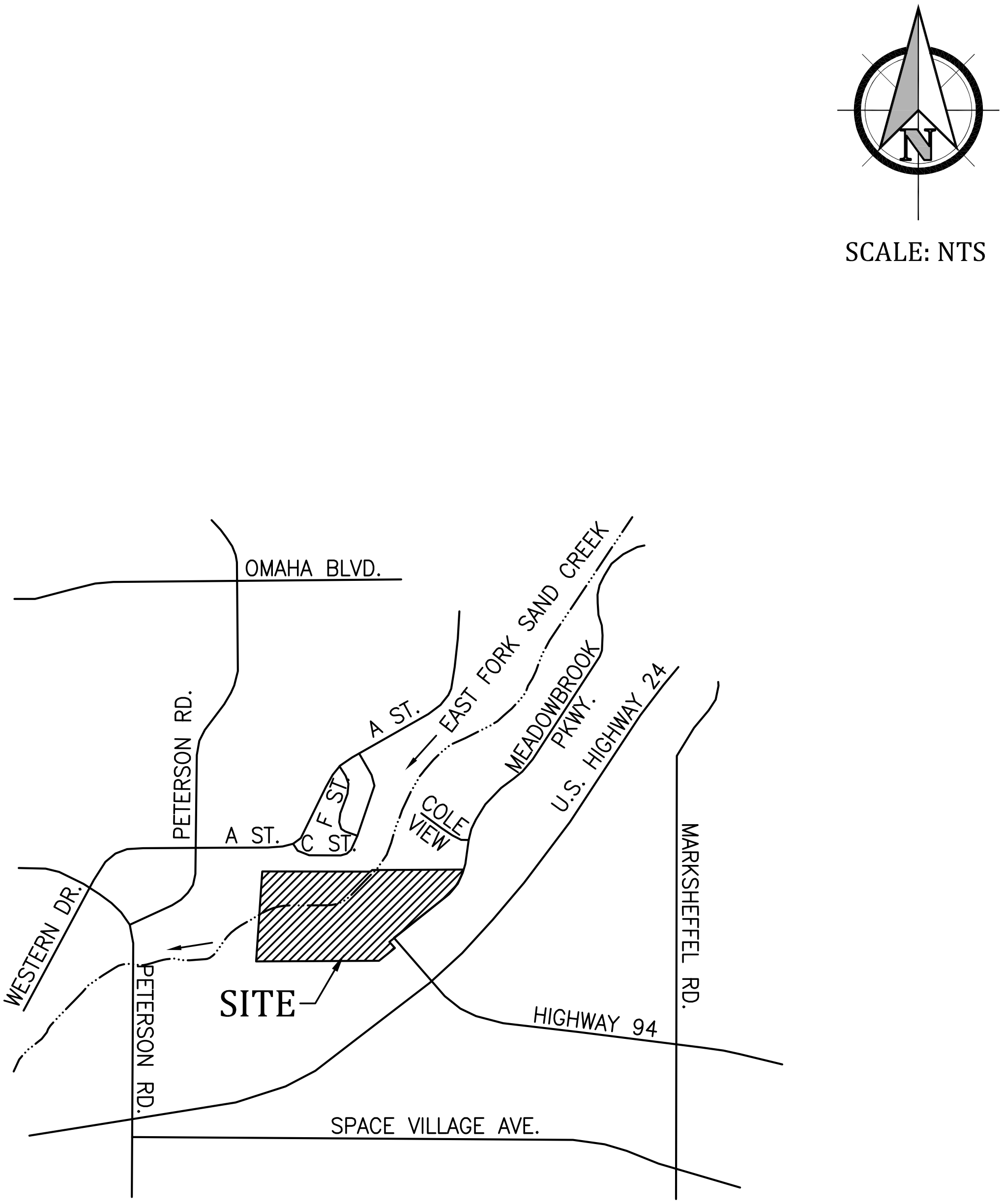
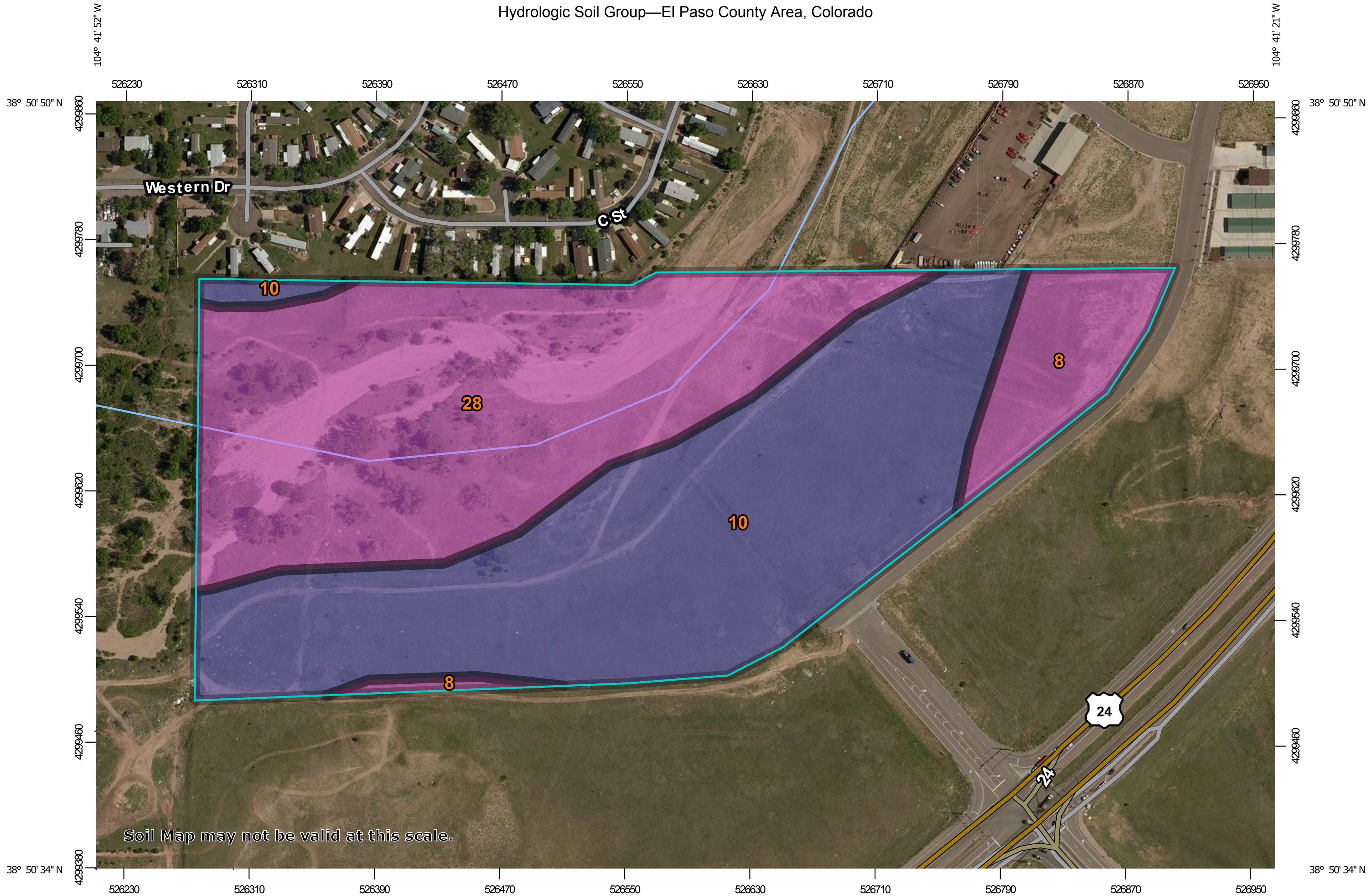


FIGURE 1
VICINITY MAP
MEADOWBROOK CROSSING

16039 Base – Drainage Plan.dwg/Jan 10, 2017



Map Scale: 1:3,440 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 150, 300, 600, 900

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

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

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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: Jun 3, 2014—Jun 17, 2014

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.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — El Paso County Area, Colorado (CO625)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
8	Blakeland loamy sand, 1 to 9 percent slopes	A	2.7	8.3%
10	Blendon sandy loam, 0 to 3 percent slopes	B	15.8	48.2%
28	Ellicott loamy coarse sand, 0 to 5 percent slopes	A	14.3	43.5%
Totals for Area of Interest			**32.8**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

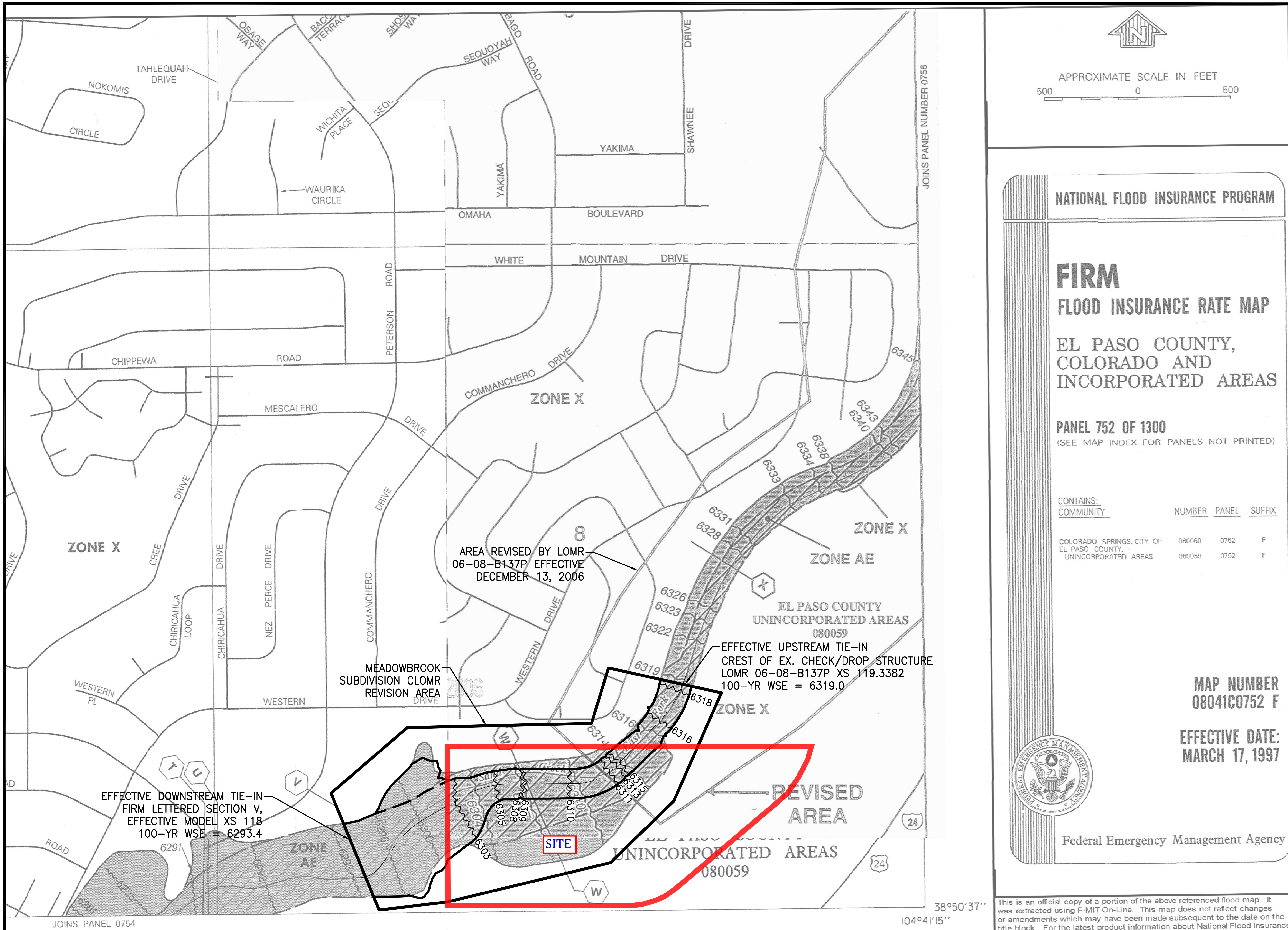
Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

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

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.



MEADOWBROOK SUBDIVISION CLOMR ANNOTATED FIRM

16039 Base - Drainageway.dwg/Dec 13, 2016

Table 1: Impervious Area and Drainage Basin & Bridge Fee Calculation

Meadowbrook Crossing

Total Site/Platted Area =	32.885 ac	
Tract H Area =	1.241 ac	Future Meadowbrook Pkwy
Developed Area =	20.358 ac	Residential lots and streets
Total Undeveloped Area =	11.286 ac	Undeveloped Tract Area
Developed Area =	20.358 ac	
Total Lots =	114 lots	
Lots/Acre =	5.60 lots/ac	
Developed Area: % Impervious =	50.00 %	
Tract H Area =	1.241 ac	
Tract H Area: % Impervious =	82.17 %	
Total Undeveloped Area =	11.286 ac	
Undeveloped Area: % Impervious =	0.00 %	
Total Site/Platted Area =	**32.885 ac**	
Effective % Impervious =	**34.05 %**	

Table 6-6: Drainage Criteria Manual	
8 lots/ac	65%
4 lots/ac	40%
5.60 lots/ac	**50.00%**

These two are dif
1999 (resolution 9
"per acre" while c
impervious acre".

You will have to c
"per impervious a
1996 to 1999 or c
index between 19

Revise calculation

Sand Creek Drainage Basin: Drainage Basin Fee and Bridge Fee Calculations			
Drainage Basin Fee =	$15,720 / ac	**Drainage Basin Fee =**	**$ 176,036.90**
Bridge Fee =	$4,762 / ac	**Bridge Fee =**	**$ 53,326.19**

Current Drainage Basin Fee (2017) =	$15,720 / ac	
DBPS Drainage Basin Fee (Original 1996) =	$6,115 / ac	Table VIII-8: Sand Creek Drainage Basin Planning Study
Percent increase =	257.07%	
Drainageway Conveyance Cost Estimate based on DBPS Table VIII-2 (Original 1996) =	$ 320,976	1,082lf channel improve at $268/lf + 200lf grade control at $155/lf (Table VIII-2 Sand Crk DBPS: Segment 4 East Fork Sand Creek)
Cost Percent Increase (1996 DBPS to 2017) =	257.07%	
Drainageway Conveyance Cost Estimate (DBPS) updated to 2017 prices =	$ 825,142	

Reimbursable Drainage Expenses associated with drainageway improvements (refer to Table 2) =	**$ 935,956.25**
Updated DBPS Drainage Fee (subject section East Fork Sand Crk) (see calculation above) =	**$ 825,141.90**

Reimbursable Drainage Expenses (Smaller of Table 2 and Updated DBPS Drainage Fee) =	**$ 825,141.90**
Drainage Basin Fee =	$ 176,036.90
Remaining Reimbursable Drainageway Expenses =	**$649,105.00**

Total Fees Due	
Drainage Basin Fee =	**$ 0.00**
Bridge Fee =	**$ 53,326.19**

*Reimbursable Expenses applied to drainage fees due

Meadowbrook Crossing
Table 2: Opinion of Cost

Table 2a: Opinion of Cost - On Site Public Drainage Facilities

Item	Quantity	Unit	Unit Cost	**Item Total**
18" Reinforced Concrete Pipe	80	LF	$ 69	$ 5,520.00
24" Reinforced Concrete Pipe	256	LF	$ 84	$ 21,504.00
30" Reinforced Concrete Pipe	1,038	LF	$ 94	$ 97,572.00
36" Reinforced Concrete Pipe	188	LF	$ 124	$ 23,312.00
36" Flared End Section (FES) CSP	1	EA	$ 1,100	$ 1,100.00
End Treatment - Cutoff Wall	1	EA	$ 500	$ 500.00
Curb Inlet (Type R) L =10', Depth < 5 feet	2	EA	$ 5,528	$ 11,056.00
Curb Inlet (Type R) L =10' , 5'-10' Depth	2	EA	$ 6,694	$ 13,388.00
Curb Inlet (Type R) L =20' , 5'-10' Depth	2	EA	$ 8,830	$ 17,660.00
			Estimated Storm Drainage Facilities Cost	**$ 191,612.00**
			Engineering 10%	$ 19,161.20
			Contingency 5%	$ 9,580.60
			Total Estimated Cost	**$ 220,353.80**

Table 2b: Opinion of Cost - Public Drainageway Improvements - Reimbursable

Item	Quantity	Unit	Unit Cost	**Item Total**
30" (B30) Grouted Boulders	1,448	CY	$ 155	$ 224,440.00
36" (B36) Grouted Boulders	117	CY	$ 165	$ 19,305.00
30" to 48" (B30 to B48) Grouted Feature Boulders	128	CY	$ 190	$ 24,320.00
30" to 48" (B30 to B48) Ungrouted Feature Boulders	85	CY	$ 130	$ 11,050.00
Type L Soil Riprap (d50 = 9")	2,142	CY	$ 60	$ 128,520.00
Type M Soil Riprap (d50 = 12")	2,039	CY	$ 70	$ 142,730.00
Type H Soil Riprap (d50 = 18")	2,032	CY	$ 80	$ 162,560.00
Steel Sheetpile Cutoff (PZ 22)	3,626	SF	$ 25	$ 90,650.00
Sheetpile Concrete Cap	515	LF	$ 20	$ 10,300.00
			Estimated Storm Drainage Facilities Cost	**$ 813,875.00**
			Engineering 10%	$ 81,387.50
			Contingency 5%	$ 40,693.75
			Total Estimated Cost	**$ 935,956.25**

Table 2c: Opinion of Cost - On Site Private Drainage Facilities

Item	Quantity	Unit	Unit Cost	**Item Total**
Channel Lining, Concrete (Low Flow Channel)	10	CY	$ 450	$ 4,500.00
Presedimentation Forebay	1	EA	$ 5,500	$ 5,500.00
Water Quality Outlet Structure	1	EA	$ 8,000	$ 8,000.00
Emergency Spillway (Cutoff Wall)	3	CY	$ 450	$ 1,350.00
Gravel Maintenance Access Trail	243	SY	$ 20	$ 4,860.00
Type II Bedding (Low Flow Channel)	15	CY	$ 35	$ 525.00
24" Reinforced Concrete Pipe	40	LF	$ 84	$ 3,360.00
24" Flared End Section (FES) RCP	1	EA	$ 900	$ 900.00
			Estimated Storm Drainage Facilities Cost	**$ 28,995.00**
			Engineering 10%	$ 2,899.50
			Contingency 5%	$ 1,449.75
			Total Estimated Cost	**$ 33,344.25**

Table VIII-8: Sand Creek Drainage Basin Planning Study
Drainage Basin Fee Estimation

Reimbursable Drainageway Improvements		Construction Costs
Lower and Upper Sand Creek		$15,560,220
Center Tributary Sand Creek		$984,500
West Fork Sand Creek		$1,004,400
East Fork Sand Creek		$15,674,470
East Fork Sub-Tributary		$6,227,600
East and West Bierstadt Creeks		$6,688,270
Toy Ranch Tributary		$4,398,550
Tributary Drainageways	Sand Creek	$7,420,650
Tributary Drainageways	East Fork Sand Creek	$16,917,940
Roadway Culverts	Sand Creek	$1,111,000
Roadway Culverts	East Fork Sand Creek	$2,201,500
Habitat Mitigation	Sand Creek	$263,200
Miscellaneous Improvements		$65,000
Total Reimbursable Improvements		$78,517,300
10% Engineering		$7,851,730
5% Contingency		$3,925,865
Total Drainageway Costs		$90,294,895
Study Costs		$139,000
Existing basin outstanding claims (city)		$1,392,635
Existing basin outstanding claims (county)		$376,913
Total		$92,203,443
Unplatted Acreage	City of CS	11312
Unplatted Acreage	El Paso County	7497
City drainage fee		$4,902
County drainage fee with detention facilities		$6,115

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

SEGMENT NUMBER	REACH NUMBER	SEGMENT LENGTH (FT)	IMPROVEMENT TYPE	IMP. LENGTH (FT)	UNIT COST ($/LF)	NUMBER OF GRADE CONTROLS	GRADE CONTROL LENGTH (FT)	TOTAL REIMBURSABL COSTS	TOTAL COST
EAST FORK SAND CREEK									
122	EF-1	4650	100-YR RIPRAP	4650	268	10	1200	0	$1,432,200
1	EF-2	6750	"	5950	268	12	1440	$1,817,800	$1,817,800
2	"	3400	"	3400	268	7	2000	$1,221,200	$1,221,200
3	"	2350	"	2350	268	1	100	$645,300	$645,300
4	"	3350	10-YEAR RIPRAP	3350	268	4	400	$959,800	$959,800
5	"	4270	"	4270	268	3	270	$1,186,210	$1,186,210
14	"	3250	"	3250	268	5	450	$940,750	$940,750
116	EF-3	2000	"	2000	268	5	450	$605,750	$605,750
18	EF-4	3900	"	2250	185	5	450	$486,000	$486,000
24	"	2250	"	2250	185	2	140	$437,950	$437,950
25	"	2530	"	2230	185	7	700	$521,050	$521,050
26	"	1520	"	1020	185	2	160	$213,500	$213,500

Channel Improvements: $268/lf
Grade Control: $155/lf

2. All petitioners for Drainage Board items will be notified by the staff prior to the meeting. They will be informed of the staff's recommendation concerning their item(s) and whether their item is included on that particular agenda.

3. All petitioners will be provided with the Board's decision concerning their agenda item and advised of their appeal right following each Board meeting.

4. All administrative items shall be directed to the staff prior to scheduling for the Board.

3.3 Procedures for Drainage Improvement Credits and Reimbursements

In order for a developer to obtain reimbursement or credit for drainage costs, certain procedures must be followed. Prior to construction, the developer must:

1. Obtain through the subdivision process, an approved drainage report showing the facilities required and the estimated cost of those facilities, and indicate the drainage basin and fee for the acreage shown on the drainage plan. (Copies of the current per-acre fee can be obtained from the Public Works Department.) All drainage basins are identified and fees established each year. Letters of credit are to be posted with the City/County in accordance with the Subdivision Ordinance or Regulations.

2. Obtain three (3) sealed bids for constructing the facilities. If the lowest bid exceeds the Engineer's estimated costs as indicated in the drainage report, the City Engineer must review and give approval (or disapproval) before proceeding.

3. If it is not possible to receive three bids, the developer must obtain the City/County Engineer's approval before proceeding with construction, and the cost and credits shall be determined at that time.

4. The developer proceeds with construction according to the approved plans and any changes during construction shall be discussed with the City/County Engineer.

5. Upon completion of the construction of facilities, the developer shall obtain a certification from a Colorado Registered Professional Engineer that the facilities inspected are constructed in accordance with the approved plans. A written request for the City/County inspection of facilities must be submitted to the City/County Engineer. The assurance for facilities may be released after inspection by the City/County.

6. The developer then submits this certification along with records of the cost of construction, i.e., a copy of the three bids (including the low bid), as-paid bills, a copy of the City/County's inspection and cover letter of request for cash reimbursement or credits. This request must be submitted by the third Thursday of the month to be considered at the next month's Drainage Board Meeting.

7. The City/County Engineer will review the request, and after verification of the costs, will place the request on the Drainage Board Agenda for formal review.

8. The Drainage Board meets on the third Thursday of each month and reviews the requests for reimbursement after hearing from both the City/County and the Developer.

9. If the request is approved, the item is then forwarded to City Council/County Commissioners for final approval of reimbursement after hearing from the City/County and the developer.

10. If the request is not approved, the Drainage Board will set the amount of reimbursement and the developer has the right to appeal to City Council or the County Commissioners.

11. Reimbursements are made twice a year: on the first of June and the first of December. Items to be heard for June disbursement must be approved by the Drainage Board by April 1. Items to be heard for December disbursement must be approved by the Drainage Board no later than October 1.

12. If the Drainage Basin account has insufficient funds for reimbursement, the developer is placed on a priority list and is paid when revenue within the fund is sufficient. Partial reimbursements are made until the developer is fully reimbursed.

13. If the proposed estimated facilities are less than the fees, the difference will be a cash payment by the developer if he has no available credits in the basin. The assurances will not be released until the final paid bills have been submitted to Land Development to verify costs. If any additional fees are due, they will be payable prior to release of assurances.

14. If an overpayment of fees has occurred, the request for cash reimbursement must be submitted to the City/County Engineering Division for approval. Upon approval, the request shall be placed on first priority for immediate refund dependent upon funds available in the Basin Account.

15. If the proposed estimated facilities <u>are equal to the fees</u>, assurances will not be released until the final paid bills have been submitted to verify costs. If any fees are due, they will be payable prior to release of assurances.

16. Basin funds are not transferable among basins.

17. Any dispute over bidding or fees may be heard by the Drainage Board and City Council or County Commissioners.

18. The developer should be aware that all drainage basin fees are finally computed to the time that bids are taken and not at the time of platting.

19. Fees on all basins are adjusted by City/County each year at their first meeting of the year and at other intervals as needed.

For the purpose of arterial bridge reimbursement from the City Bridge Fund (City Code 15-3-1003), the bridge width shall be measured perpendicular to the ROW and the bridge width will be limited to the ROW dimension. (See definition Section 2.3.1) Box culverts, arch pipe culverts, and similar structures will be considered drainage facilities and included in the drainage basin fee computation.

3.4 Drainage Basin Layout

<u>County Basin Code</u>

A basin numbering system has been implemented to provide an orderly system of identifying and indexing County basins. Each basin number is an eight digit alpha-numeric identifier composed of four designators as shown below:

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
00	-00	-00	-00

<u>Designator A</u> - The first two digits signify the major basin designation. El Paso County has thirteen major basins, each tributary to either the South Platte (on the north) or the Arkansas (on the south) Rivers in the State of Colorado. Figure No. 3-1 shows the major basins and the major streams in the County. Thirteen major basins and their two digit codes are listed below:

1. Beaver Creek (BE)
2. Big Sandy Creek (BG)
3. Bijou Creek (BI)
4. Chico Creek (CH)

APPENDIX A

Hydrologic Calculations

Runoff Coef, Time of Concentration and Runoff Calcs

Meadowbrook Crossing
Runoff Coeficient and Percent Impervious Calculation

Basin / DP	Basin or DP Area (DP contributing basins)		Soil Type	LA	Area 1 Land Use			US1	Area 2 Land Use			PV	Area 3 Land Use			DR	Area 4 Land Use			HI	Area 5 Land Use			Basin % Imperv	Basin Runoff Coefficient	
				% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp		C_5	C_{100}
EX-A	773,660 sf	17.76ac	B	0%		0%	0%	50%		0%	0%	100%		0%	0%	90%		0%	0%	2%	17.76ac	100%	2%	**2.0%**	**0.08**	**0.36**
EX-B	632,160 sf	14.51ac	B	0%		0%	0%	50%		0%	0%	100%		0%	0%	90%		0%	0%	2%	14.51ac	100%	2%	**2.0%**	**0.08**	**0.36**
OS-A	56,070 sf	1.29ac	B	0%	0.23ac	18%	0%	50%		0%	0%	100%	1.06ac	82%	82%	90%		0%	0%	2%		0%	0%	**82.2%**	**0.62**	**0.72**
OS-B	67,370 sf	1.55ac	B	0%	0.28ac	18%	0%	50%		0%	0%	100%	1.27ac	82%	82%	90%		0%	0%	2%		0%	0%	**82.2%**	**0.62**	**0.72**
OS-C	35,300 sf	0.81ac	B	0%		0%	0%	50%		0%	0%	100%	0.81ac	100%	100%	90%		0%	0%	2%		0%	0%	**100%**	**0.90**	**0.96**
OS-D	24,100 sf	0.55ac	B	0%	0.09ac	17%	0%	50%		0%	0%	100%	0.46ac	83%	83%	90%		0%	0%	2%		0%	0%	**83.4%**	**0.64**	**0.73**
OS-E	53,800 sf	1.24ac	B	0%	0.32ac	26%	0%	50%		0%	0%	100%	0.91ac	74%	74%	90%		0%	0%	2%		0%	0%	**74.0%**	**0.53**	**0.65**
A	122,179 sf	2.80ac	B	0%	0.00ac	0%	0%	50%	2.80ac	100%	50%	100%		0%	0%	90%		0%	0%	2%		0%	0%	**50.0%**	**0.35**	**0.52**
B	71,386 sf	1.64ac	B	0%	0.00ac	0%	0%	50%	1.64ac	100%	50%	100%		0%	0%	90%		0%	0%	2%		0%	0%	**50.0%**	**0.35**	**0.52**
C	58,008 sf	1.33ac	B	0%	0.00ac	0%	0%	50%	1.33ac	100%	50%	100%		0%	0%	90%		0%	0%	2%		0%	0%	**50.0%**	**0.35**	**0.52**
D	108,668 sf	2.49ac	B	0%	0.00ac	0%	0%	50%	2.49ac	100%	50%	100%		0%	0%	90%		0%	0%	2%		0%	0%	**50.0%**	**0.35**	**0.52**
E	78,540 sf	1.80ac	B	0%	0.00ac	0%	0%	50%	1.80ac	100%	50%	100%		0%	0%	90%		0%	0%	2%		0%	0%	**50.0%**	**0.35**	**0.52**
F	105,199 sf	2.42ac	B	0%	0.00ac	0%	0%	50%	2.42ac	100%	50%	100%		0%	0%	90%		0%	0%	2%		0%	0%	**50.0%**	**0.35**	**0.52**
G	110,318 sf	2.53ac	B	0%	0.00ac	0%	0%	50%	2.53ac	100%	50%	100%		0%	0%	90%		0%	0%	2%		0%	0%	**50.0%**	**0.35**	**0.52**
H	134,423 sf	3.09ac	B	0%	0.00ac	0%	0%	50%	3.09ac	100%	50%	100%		0%	0%	90%		0%	0%	2%		0%	0%	**50.0%**	**0.35**	**0.52**
I	45,746 sf	1.05ac	B	0%	0.67ac	64%	0%	50%	0.35ac	34%	17%	100%		0%	0%	90%	0.02ac	2%	2%	2%		0%	0%	**18.8%**	**0.19**	**0.44**
J	485,500 sf	11.15ac	B	0%	9.59ac	86%	0%	50%	1.55ac	14%	7%	100%		0%	0%	90%		0%	0%	2%		0%	0%	**7.0%**	**0.12**	**0.39**
DP1	F,G	4.95ac	B	0%	0.00ac	0%	0%	50%	4.95ac	100%	50%	100%		0%	0%	90%		0%	0%	2%		0%	0%	**50.0%**	**0.35**	**0.52**
DP2	E,H	4.89ac	B	0%	0.00ac	0%	0%	50%	4.89ac	100%	50%	100%		0%	0%	90%		0%	0%	2%		0%	0%	**50.0%**	**0.35**	**0.52**
DP3	A to H	18.11ac	B	0%	0.00ac	0%	0%	50%	18.11ac	100%	50%	100%		0%	0%	90%		0%	0%	2%		0%	0%	**50.0%**	**0.35**	**0.52**
DP4	A to I	19.16ac	B	0%	0.67ac	4%	0%	50%	18.46ac	96%	48%	100%		0%	0%	90%	0.02ac	0%	0%	2%		0%	0%	**48.3%**	**0.34**	**0.52**
DP4A	A to I, OS-B	20.70ac	B	0%	0.95ac	5%	0%	50%	18.46ac	89%	45%	100%	1.27ac	6%	6%	90%	0.02ac	0%	0%	2%		0%	0%	**50.8%**	**0.35**	**0.53**
DP5	A to J, OS-B	31.85ac	B	0%	10.54ac	33%	0%	50%	20.01ac	63%	31%	100%	1.27ac	4%	4%	90%	0.02ac	0%	0%	2%	0.00ac	0%	0%	**35.5%**	**0.28**	**0.48**
DP10	OS-C, OS-D	1.36ac	B	0%	0.09ac	7%	0%	50%	0.00ac	0%	0%	100%	1.27ac	93%	93%	90%	0.00ac	0%	0%	2%	0.00ac	0%	0%	**93.3%**	**0.78**	**0.85**

Meadowbrook Crossing

Runoff Coeficient and Percent Impervious Calculation

Basin Runoff Coefficient is based on UDFCD % Imperviousness Calculation									
Runoff Coefficients and Percents Impervious									
Hydrologic Soil Type:	**B**	**Runoff Coef Calc Method**							%Imp
Land Use	Abb	%	C_2	C_5	C_{10}	C_{25}	C_{50}	C_{100}	
Commercial Area	CO	95%	0.79	0.81	0.83	0.85	0.87	0.88	
Drives and Walks	DR	90%	0.71	0.73	0.75	0.78	0.80	0.81	
Streets - Gravel (Packed)	GR	40%	0.23	0.30	0.36	0.42	0.46	0.50	
Historic Flow Analysis	HI	2%	0.03	0.08	0.17	0.26	0.31	0.36	
Lawns	LA	0%	0.02	0.08	0.15	0.25	0.30	0.35	
Off-site flow-Undeveloped	OF	45%	0.26	0.32	0.38	0.44	0.48	0.51	
Park	PA	7%	0.05	0.12	0.20	0.29	0.34	0.39	
Streets - Paved	PV	100%	0.89	0.90	0.92	0.94	0.95	0.96	
Roofs	RO	90%	0.71	0.73	0.75	0.78	0.80	0.81	
Residential: 5.6 Lots/Acre	US1	50%	0.29	0.35	0.40	0.46	0.50	0.52	
Residential: 8 Lots/Acre	US2	65%	0.41	0.45	0.49	0.54	0.57	0.59	
Residential: 4 Lots/Acre	US3	40%	0.23	0.30	0.36	0.42	0.46	0.50	

Weighted
%Imp
A
B
C
D

Equations (% Impervious Calculation):

$C_A = K_A + (1.31\, i^3 - 1.44\, i^2 + 1.135\, i - 0.12)$ [Eqn RO-6]

$C_{CD} = K_{CD} + (0.858\, i^3 - 0.786\, i^2 + 0.774\, i + 0.04)$ [Eqn RO-7]

$C_B = (C_A + C_{CD}) / 2$

I = % imperviousness/100 as a decimal (See Table RO-3)

C_A = Runoff coefficient for NRCS Type A Soils

C_B = Runoff coefficient for NRCS Type B Soils

C_{CD} = Runoff coefficient for NRCS Type C and D Soils

K_A = Correction Factor for NRCS Type A Soils - Table RO-4

K_A (2-yr)= 0
K_A (5-yr)= -0.08i + 0.09
K_A (10-yr)= -0.14i + 0.17
K_A (25-yr)= -0.19i + 0.24
K_A (50-yr)= -0.22i + 0.28
K_A (100-yr)= -0.25i + 0.32

K_{CD}=Correct Factor for NRCS Type C & D Soils-Table RO-4

K_{CD} (2-yr)= 0
K_{CD} (5-yr)= -0.10i + 0.11
K_{CD} (10-yr)= -0.18i + 0.21
K_{CD} (25-yr)= -0.28i + 0.33
K_{CD} (50-yr)= -0.33i + 0.40
K_{CD} (100-yr)= -0.39i + 0.46

Residential Percent Impervious Calculcation				
Total Lot and Street Area:	20.358-ac	8 lots/ac	65%	
Total Lots:	114 lots	4 lots/ac	40%	
Lots/Acre:	5.60 lots/ac	Actual: 5.60 lots/ac	**50.00%**	**Use 50%**
Acre/Lot:	0.179-ac/lot			

Meadowbrook Crossing
Time of Concentration Calculation

Sub-Basin Data				Time of Concentration Estimate										Min. Tc in Urban		Final t_c
				Initial/Overland Time (t_i)			Travel Time (t_t)						Comp.	Tc Check (urban)		
Basin / Design Point	Contributing Basins	Area	C_5	Length	Slope	t_i	Length	Slope	Land Type	Cv	Velocity	t_t	t_c	Total Length	t_c Check	
EX-A		17.76ac	0.08	300lf	3.3%	21.7 min.	1900lf	1.3%	SP	7	0.8 ft/sec	39.7 min.	61.4 min.			**61.4 min.**
EX-B		14.51ac	0.08	300lf	2.3%	24.5 min.	1600lf	1.6%	GW	15	1.9 ft/sec	14.1 min.	38.5 min.			**38.5 min.**
OS-A		1.29ac	0.62	40lf	2.0%	4.4 min.	1310lf	1.9%	PV	20	2.8 ft/sec	7.9 min.	12.3 min.	1350lf	17.5 min.	**12.3 min.**
OS-B		1.55ac	0.62	35lf	2.0%	4.1 min.	1270lf	1.3%	PV	20	2.3 ft/sec	9.3 min.	13.4 min.	1305lf	17.3 min.	**13.4 min.**
OS-C		0.81ac	0.90	10lf	2.0%	0.9 min.	570lf	2.5%	PV	20	3.2 ft/sec	3.0 min.	5.0 min.	580lf	13.2 min.	**5.0 min.**
OS-D		0.55ac	0.64	20lf	2.0%	3.0 min.	470lf	2.5%	PV	20	3.2 ft/sec	2.5 min.	5.5 min.	490lf	12.7 min.	**5.5 min.**
OS-E		1.24ac	0.53	20lf	2.0%	3.7 min.	1380lf	1.5%	PV	20	2.4 ft/sec	9.4 min.	13.1 min.	1400lf	17.8 min.	**13.1 min.**
A		2.80ac	0.35	100lf	2.5%	10.1 min.	970lf	2.2%	PV	20	3.0 ft/sec	5.4 min.	15.6 min.	1070lf	15.9 min.	**15.6 min.**
B		1.64ac	0.35	100lf	2.0%	10.9 min.	580lf	1.0%	PV	20	2.0 ft/sec	4.8 min.	15.7 min.	680lf	13.8 min.	**13.8 min.**
C		1.33ac	0.35	100lf	2.0%	10.9 min.	390lf	0.9%	PV	20	1.9 ft/sec	3.4 min.	14.3 min.	490lf	12.7 min.	**12.7 min.**
D		2.49ac	0.35	100lf	2.0%	10.9 min.	660lf	0.9%	PV	20	1.9 ft/sec	5.8 min.	16.7 min.	760lf	14.2 min.	**14.2 min.**
E		1.80ac	0.35	70lf	2.0%	9.1 min.	1020lf	0.6%	PV	20	1.5 ft/sec	11.0 min.	20.1 min.	1090lf	16.1 min.	**16.1 min.**
F		2.42ac	0.35	100lf	2.0%	10.9 min.	960lf	0.6%	PV	20	1.5 ft/sec	10.3 min.	21.2 min.	1060lf	15.9 min.	**15.9 min.**
G		2.53ac	0.35	100lf	2.0%	10.9 min.	930lf	0.7%	PV	20	1.7 ft/sec	9.3 min.	20.2 min.	1030lf	15.7 min.	**15.7 min.**
H		3.09ac	0.35	100lf	2.0%	10.9 min.	990lf	0.7%	PV	20	1.7 ft/sec	9.9 min.	20.8 min.	1090lf	16.1 min.	**16.1 min.**
I		1.05ac	0.19	60lf	1.5%	11.3 min.	30lf	1.0%	PV	20	2.0 ft/sec	0.3 min.	11.5 min.	90lf	10.5 min.	**10.5 min.**
J		11.15ac	0.12	100lf	2.0%	14.3 min.	1400lf	0.8%	GW	15	1.3 ft/sec	17.4 min.	31.7 min.	1500lf	18.3 min.	**18.3 min.**
DP1	F,G	4.95ac	0.35	100lf	2.5%	10.1 min.	960lf	0.8%	PV	20	1.8 ft/sec	9.1 min.	19.2 min.	1060lf	15.9 min.	**15.9 min.**
DP2	E,H	4.89ac	0.35	100lf	1.5%	12.0 min.	1030lf	0.8%	PV	20	1.8 ft/sec	9.6 min.	21.6 min.	1130lf	16.3 min.	**16.3 min.**
DP3	A to H	18.11ac	0.35	100lf	3.0%	9.5 min.	1830lf	0.9%	PV	20	1.9 ft/sec	16.1 min.	25.6 min.	1930lf	20.7 min.	**20.7 min.**
DP4	A to I	19.16ac	0.34	100lf	3.0%	9.7 min.	1900lf	0.9%	PV	20	1.9 ft/sec	16.7 min.	26.3 min.	2000lf	21.1 min.	**21.1 min.**
DP4A	A to I, OS-B	20.70ac	0.35	100lf	3.0%	9.5 min.	1900lf	0.9%	PV	20	1.9 ft/sec	16.7 min.	26.2 min.	2000lf	21.1 min.	**21.1 min.**
DP5	A to J, OS-B	31.85ac	0.28	100lf	3.0%	10.5 min.	1900lf	0.9%	PV	20	1.9 ft/sec	16.7 min.	27.2 min.	2000lf	21.1 min.	**21.1 min.**
DP10	OS-C, OS-D	1.36ac	0.78	20lf	2.0%	2.1 min.	470lf	2.5%	PV	20	3.2 ft/sec	2.5 min.	5.0 min.	490lf	12.7 min.	**5.0 min.**

Equations:

t_i (Overland) = $0.395(1.1-C_5)L^{0.5} S^{-0.333}$

C_5 = Runoff coefficient for 5-year

L = Length of overland flow (ft)

S = Slope of flow path (ft/ft)

tc Check = (L/180)+10 (Developed Cond. Only)

L = Overall Length

Velocity (Travel Time) = $CvS^{0.5}$

Cv = Conveyance Coef (see Table RO-2)

S = Watercourse slope (ft/ft)

Table RO-2

Type of Land Surface	Land Type	Cv
Grassed Waterway	GW	15
Heavy Meadow	HM	2.5
Nearly Bare Ground	NBG	10
Paved Area	PV	20
Riprap (Not Buried)	RR	6.5
Short Pasture/Lawns	SP	7
Tillage/Fields	TF	5

Meadowbrook Crossing
Runoff Calculation

Basin / DP	Contributing Basins	Drainage Area	C_5	C_{100}	Time of Concentration	i_5	i_{100}	**Q_5**	**Q_{100}**	**Basin / DP**
EX-A		17.76 ac	0.08	0.36	61.4 min.	1.4 in/hr	2.4 in/hr	**2.0 cfs**	**15.2 cfs**	EX-A
EX-B		14.51 ac	0.08	0.36	38.5 min.	2.1 in/hr	3.5 in/hr	**2.5 cfs**	**18.6 cfs**	EX-B
OS-A		1.29 ac	0.62	0.72	12.3 min.	3.8 in/hr	6.4 in/hr	**3.0 cfs**	**5.9 cfs**	OS-A
OS-B		1.55 ac	0.62	0.72	13.4 min.	3.7 in/hr	6.2 in/hr	**3.5 cfs**	**6.9 cfs**	OS-B
OS-C		0.81 ac	0.90	0.96	5.0 min.	5.2 in/hr	8.7 in/hr	**3.8 cfs**	**6.7 cfs**	OS-C
OS-D		0.55 ac	0.64	0.73	5.5 min.	5.0 in/hr	8.4 in/hr	**1.8 cfs**	**3.4 cfs**	OS-D
OS-E		1.24 ac	0.53	0.65	13.1 min.	3.7 in/hr	6.3 in/hr	**2.4 cfs**	**5.0 cfs**	OS-E
A		2.80 ac	0.35	0.52	15.6 min.	3.5 in/hr	5.8 in/hr	**3.4 cfs**	**8.6 cfs**	A
B		1.64 ac	0.35	0.52	13.8 min.	3.6 in/hr	6.1 in/hr	**2.1 cfs**	**5.3 cfs**	B
C		1.33 ac	0.35	0.52	12.7 min.	3.8 in/hr	6.3 in/hr	**1.8 cfs**	**4.4 cfs**	C
D		2.49 ac	0.35	0.52	14.2 min.	3.6 in/hr	6.0 in/hr	**3.1 cfs**	**7.9 cfs**	D
E		1.80 ac	0.35	0.52	16.1 min.	3.4 in/hr	5.7 in/hr	**2.2 cfs**	**5.4 cfs**	E
F		2.42 ac	0.35	0.52	15.9 min.	3.4 in/hr	5.8 in/hr	**2.9 cfs**	**7.3 cfs**	F
G		2.53 ac	0.35	0.52	15.7 min.	3.5 in/hr	5.8 in/hr	**3.1 cfs**	**7.7 cfs**	G
H		3.09 ac	0.35	0.52	16.1 min.	3.4 in/hr	5.7 in/hr	**3.7 cfs**	**9.3 cfs**	H
I		1.05 ac	0.19	0.44	10.5 min.	4.1 in/hr	6.8 in/hr	**0.8 cfs**	**3.1 cfs**	I
J		11.15 ac	0.12	0.39	18.3 min.	3.2 in/hr	5.4 in/hr	**4.1 cfs**	**23.4 cfs**	J
DP1	F,G	4.95 ac	0.35	0.52	15.9 min.	3.4 in/hr	5.8 in/hr	**5.9 cfs**	**15.0 cfs**	DP1
DP2	E,H	4.89 ac	0.35	0.52	16.3 min.	3.4 in/hr	5.7 in/hr	**5.8 cfs**	**14.6 cfs**	DP2
DP3	A to H	18.11 ac	0.35	0.52	20.7 min.	3.0 in/hr	5.1 in/hr	**19.2 cfs**	**48.4 cfs**	DP3
DP4	A to I	19.16 ac	0.34	0.52	21.1 min.	3.0 in/hr	5.0 in/hr	**19.6 cfs**	**50.2 cfs**	DP4
DP4A	A to I, OS-B	20.70 ac	0.35	0.53	21.1 min.	3.0 in/hr	5.0 in/hr	**22.1 cfs**	**55.1 cfs**	DP4A
DP5	A to J, OS-B	31.85 ac	0.28	0.48	21.1 min.	3.0 in/hr	5.0 in/hr	**26.3 cfs**	**77.7 cfs**	DP5
DP10	OS-C, OS-D	1.36 ac	0.78	0.85	5.0 min.	5.2 in/hr	8.7 in/hr	**5.5 cfs**	**10.1 cfs**	DP10

Equations (taken from Fig 6-5, City of Colorado Springs DCM):

i_2=-1.19 ln(T_c) + 6.035
i_5=-1.50 ln(T_c) + 7.583
i_{10}=-1.75 ln(T_c) + 8.847
i_{25}=-2.00 ln(T_c) + 10.111
i_{50}=-2.25 ln(T_c) + 11.375
i_{100}=-2.52 ln(T_c) + 12.735

Q = CiA
Q = Peak Runoff Rate (cubic feet/second)
C = Runoff coef representing a ration of peak runoff rate to ave rainfall intensity for a duration equal to the runoff time of concentration.
i = average rainfall intensity in inches per hour
A = Drainage area in acres

P1	Inches
WQCV	0.60 in
2 yr	1.19 in
5 yr	1.50 in
10 yr	1.75 in
25 yr	2.00 in
50 yr	2.25 in
100 yr	2.52 in

APPENDIX A.1

Supporting Tables and Figures

Table 6-6. Runoff Coefficients for Rational Method

(Source: UDFCD 2001)

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

3.2 Time of Concentration

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

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

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

Table 6-2. Rainfall Depths for Colorado Springs

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

Where Z= 6,840 ft/100

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

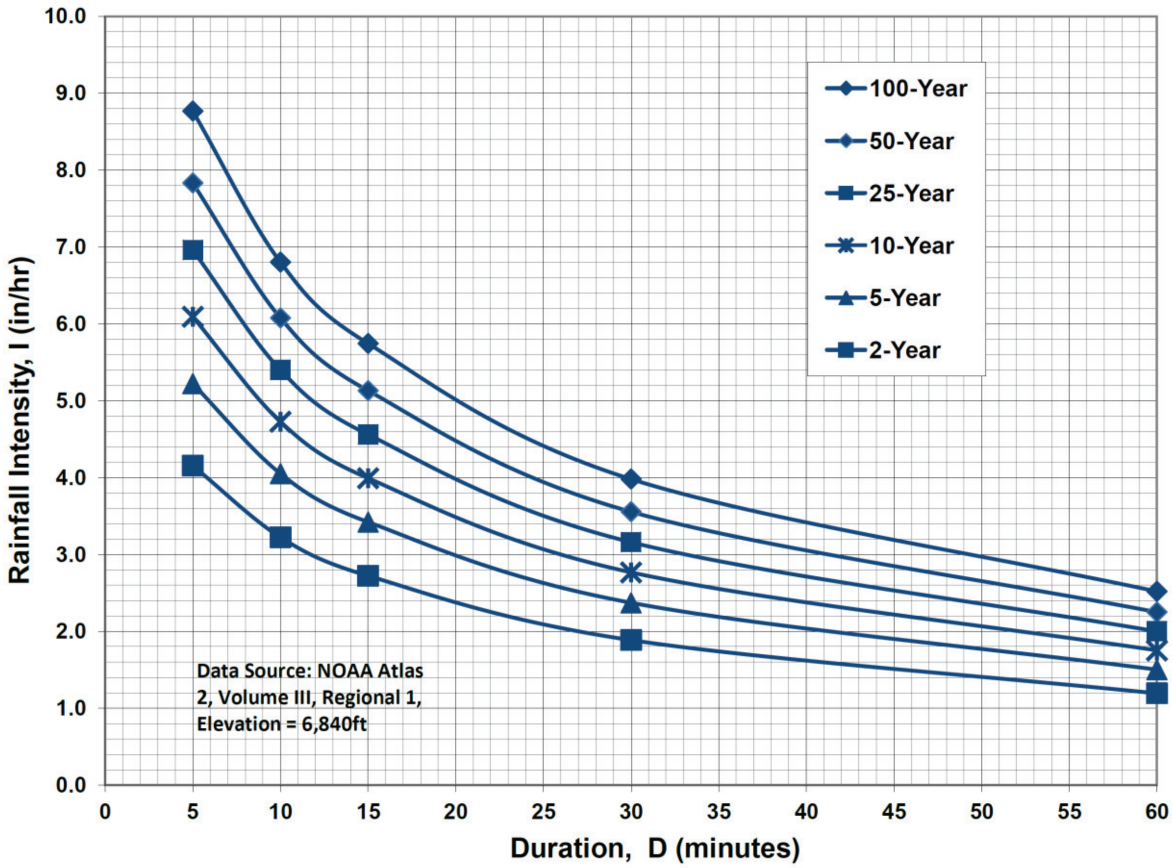
2.2 Design Storms

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

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

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

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

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

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

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

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

$$I_{5} = -1.50 \ln(D) + 7.583$$

$$I_{2} = -1.19 \ln(D) + 6.035$$

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

APPENDIX B

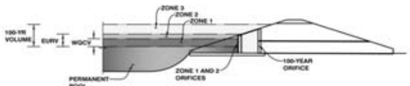
Water Quality Area Calculations

Water Quality Area Sizing
Outlet Structure Calculations
Forebay, Low Flow Channel and Spillway Calculations

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

Project: Meadowbrook Crossing

Basin ID: Water Quality Area (DP 4A)



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	**EDB**			
Watershed Area =	20.70	acres		
Watershed Length =	1,750	ft		
Watershed Slope =	0.015	ft/ft		
Watershed Imperviousness =	50.80%	percent		
Percentage Hydrologic Soil Group A =	0.0%	percent		
Percentage Hydrologic Soil Group B =	100.0%	percent		
Percentage Hydrologic Soil Groups C/D =	0.0%	percent		
Desired WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	User Input			
Water Quality Capture Volume (WQCV) =	0.360	acre-feet	Optional User Input 1-hr Precipitation	
Excess Urban Runoff Volume (EURV) =	1.126	acre-feet		
2-yr Runoff Volume (P1 = 1.19 in.) =	0.935	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	1.432	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	1.849	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	2.440	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	2.929	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	3.487	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3.29 in.) =	4.855	acre-feet	3.29	inches
Approximate 2-yr Detention Volume =	0.884	acre-feet		
Approximate 5-yr Detention Volume =	1.310	acre-feet		
Approximate 10-yr Detention Volume =	1.434	acre-feet		
Approximate 25-yr Detention Volume =	1.502	acre-feet		
Approximate 50-yr Detention Volume =	1.680	acre-feet		
Approximate 100-yr Detention Volume =	2.030	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.360	acre-feet	
Zone 2 Volume (User Defined - Zone 1) =	0.255	acre-feet	**Total detention volume is less than 100-year volume.**
Select Zone 3 Storage Volume (Optional) =		acre-feet	
Total Detention Basin Volume =	0.615	acre-feet	
Initial Surcharge Volume (ISV) =	user	ft^3	
Initial Surcharge Depth (ISD) =	user	ft	
Total Available Detention Depth (H_{total}) =	user	ft	
Depth of Trickle Channel (H_{TC}) =	user	ft	
Slope of Trickle Channel (S_{TC}) =	user	ft/ft	
Slopes of Main Basin Sides (S_{main}) =	user	H:V	
Basin Length-to-Width Ratio ($R_{L/W}$) =	user		
Initial Surcharge Area (A_{ISV}) =	user	ft^2	
Surcharge Volume Length (L_{ISV}) =	user	ft	
Surcharge Volume Width (W_{ISV}) =	user	ft	
Depth of Basin Floor (H_{FLOOR}) =	user	ft	
Length of Basin Floor (L_{FLOOR}) =	user	ft	
Width of Basin Floor (W_{FLOOR}) =	user	ft	
Area of Basin Floor (A_{FLOOR}) =	user	ft^2	
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3	
Depth of Main Basin (H_{MAIN}) =	user	ft	
Length of Main Basin (L_{MAIN}) =	user	ft	
Width of Main Basin (W_{MAIN}) =	user	ft	
Area of Main Basin (A_{MAIN}) =	user	ft^2	
Volume of Main Basin (V_{MAIN}) =	user	ft^3	
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet	

Depth Increment = 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	--	--	--	0	0.000		
0.68	--	0.68	--	--	--	140	0.003	48	0.001
1.68	--	1.68	--	--	--	3,700	0.085	1,968	0.045
2.68	--	2.68	--	--	--	10,300	0.236	8,968	0.206
3.68	--	3.68	--	--	--	12,200	0.280	20,218	0.464
4.68	--	4.68	--	--	--	14,100	0.324	33,368	0.766
5.68	--	5.68	--	--	--	16,100	0.370	48,468	1.113
6.18	--	6.18	--	--	--	17,200	0.395	56,793	1.304
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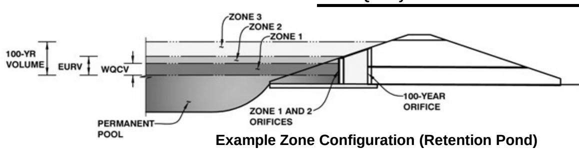
Detention Basin Outlet Structure Design

Project: Meadowbrook Crossing
Basin ID: Water Quality Area



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	3.30	0.360	Orifice Plate
Zone 2 (User)	4.20	0.255	Weir&Pipe (Circular)
Zone 3			
		0.615	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 =	3.25	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	N/A	inches
Orifice Plate: Orifice Area per Row =	1.04	sq. inches (diameter = 1-1/8 inches)

Calculated Parameters for Plate

WQ Orifice Area per Row =	7.222E-03	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	1.00	2.00					
Orifice Area (sq. inches)	1.04	1.04	1.04					

	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 2 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.33	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	4.00	N/A	feet
Overflow Weir Slope =	4.00	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	4.00	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 2 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	4.33	N/A	feet
Over Flow Weir Slope Length =	4.12	N/A	feet
Grate Open Area / 100-yr Orifice Area =	3.67	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	11.54	N/A	ft^2
Overflow Grate Open Area w/ Debris =	5.77	N/A	ft^2

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

	Zone 2 Circular	Not Selected	
Depth to Invert of Outlet Pipe =	0.33	N/A	ft (distance below basin bottom at Stage = 0 ft)
Circular Orifice Diameter =	24.00	N/A	inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 2 Circular	Not Selected	
Outlet Orifice Area =	3.14	N/A	ft^2
Outlet Orifice Centroid =	1.00	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	N/A	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	4.68	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	22.00	feet
Spillway End Slopes =	4.00	H:V
Freeboard above Max Water Surface =	0.50	feet

Calculated Parameters for Spillway

Spillway Design Flow Depth=	0.89	feet
Stage at Top of Freeboard =	6.07	feet
Basin Area at Top of Freeboard =	0.39	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	2.52	3.29
Calculated Runoff Volume (acre-ft) =	0.360	1.126	0.935	1.432	1.849	2.440	2.929	3.487	4.855
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.359	1.124	0.934	1.431	1.848	2.438	2.927	3.484	4.852
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.15	0.30	0.70	0.91	1.17	1.66
Predevelopment Peak Q (cfs) =	0.0	0.0	0.2	3.1	6.3	14.6	18.9	24.3	34.4
Peak Inflow Q (cfs) =	6.6	20.6	17.2	26.2	33.8	44.7	53.8	64.2	89.6
Peak Outflow Q (cfs) =	0.2	9.7	6.7	14.8	21.4	35.0	45.0	60.3	86.0
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	4.8	3.4	2.4	2.4	2.5	2.5
Structure Controlling Flow =	Plate	Overflow Grate 1	Overflow Grate 1	Overflow Grate 1	Spillway	Spillway	Spillway	Spillway	Spillway
Max Velocity through Grate 1 (fps) =	N/A	0.83	0.57	1.3	1.8	2.3	2.5	2.8	2.9
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) =	39	39	40	38	36	33	31	29	25
Time to Drain 99% of Inflow Volume (hours) =	**41**	44	44	43	42	41	40	39	37
Maximum Ponding Depth (ft) =	3.19	4.22	4.06	4.45	4.69	4.92	5.05	5.22	5.48
Area at Maximum Ponding Depth (acres) =	0.26	0.30	0.30	0.31	0.32	0.33	0.34	0.35	0.36
Maximum Volume Stored (acre-ft) =	0.332	0.619	0.571	0.690	0.766	0.845	0.886	0.944	1.040

Meadowbrook Crossing

Water Quality Area Calculations

Presedementation / Forebay Sizing

Forebay	100 Yr Flow	Detention WQCV	Total Req'd Forebay Vol 3.0% WQCV	Tributary Area	% Total Trib Area	Required Forebay Volume	Forebay Design			Discharge Design Flow 2.0% 100yr	Calc'd Open Width (1" min)	**Design Width**
							Area	Depth	Volume			
1	48.4cfs	14,022cf	421cf	19.16ac	100.0%	421cf	290sf	1.50-ft	435 cf	0.97 cfs	5.7-inch	**6.0-inch**
2					0.0%	---			---	---	---	
Totals		14,022cf	421cf	19.16ac	100.0%							

Opening Width Equation for Rectangular Opening

$L = Q / (CH^{1.5}) \times 12 + 0.2 \times H \times 12$ (UD-BMP Spreadsheet -- EDB tab)

C = 3.0

Forebay Overflow Calculation

Forebay	Water Surf Elev	Crest Elev	Crest Length	Flow Depth	**Calc'd Flow**
1	6,303.31	6,302.81	8.0 ft	0.50 ft	8.5 cfs

Weir Equation:

$Q = CLH^{1.5}$

C = 3.0

C = Weir coefficient (dimensionless), C = 3.0 (most cases)

L = Length of weir at Crest, in ft. Not including sideslopes.

Low Flow Channel Calculation

Location	100yr Flow	Req'd Flow 2.0% 100yr	Bottom Width	Flow Depth	Side Slope	Slope	Manning 'n'	Top Width	Flow Area	Wetted Perimeter	Hydraulic Radius	Flow Velocity	**Capacity**
WQ Area	50.2cfs	1.0cfs	2.0 ft	0.50 ft	0.0:1	0.5%	0.013	2.0 ft	1.00 sf	3.0 ft	0.33 ft	3.9 ft/sec	**3.9 cfs**

Equations:

Area (A) = $b(d)+zd^2$

b = width

d = depth

Perimeter (P) = $b+2d*(1+z^2)^{0.5}$

z = side slope

Hydraulic Radius = A/P

Velocity = $(1.49/n)R_n^{2/3} S^{1/2}$

S = Slope of the channel

n = Manning's number

R_n = Hydraulic Radius (Reynold's Number)

Flow = $(1.49/n)AR_n^{2/3} S^{1/2}$

Spillway Calculation

Detention Area	100-yr Flow	120% 100yr Flow	Water Surf Elev	Crest Elev	Crest Length	Z	C	Flow Depth (H)	**Calc'd Flow**
WQ Area	55.1 cfs	66.1 cfs	6,305.9	6,305.0	22 ft	4:1	3.0	0.92 ft	66 cfs

Broad Crested Weir Equation (USDCM Eqn 12-20 and 12-21):

$Q = CLH^{1.5} + 2x((2/5)CZH^{5/2})$

C = Weir coefficient, C = 3.0 (most cases)

L = Length of weir at Crest, in ft. Not including sideslopes.

H = Head above weir crest, in ft

Z = Side slope (horizontal:vertical)

APPENDIX B.1

Supporting Tables and Figures

Table EDB-4. EDB component criteria

	On-Site EDBs for Watersheds up to 1 Impervious Acre[1]	**EDBs with Watersheds between 1 and 2 Impervious Acres[1]**	**EDBs with Watersheds up to 5 Impervious Acres**	**EDBs with Watersheds over 5 Impervious Acres**	**EDBs with Watersheds over 20 Impervious Acres**
Forebay Release and Configuration	EDBs should not be used for watersheds with less than 1 impervious acre.	Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration	Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration	Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration	Release 2% of the undetained 100-year peak discharge by way of a wall/notch or berm/pipe[2] configuration
Minimum Forebay Volume		1% of the WQCV	2% of the WQCV	3% of the WQCV	3% of the WQCV
Maximum Forebay Depth		12 inches	18 inches	18 inches	30 inches
Trickle Channel Capacity		≥ the maximum possible forebay outlet capacity	≥ the maximum possible forebay outlet capacity	≥ the maximum possible forebay outlet capacity	≥ the maximum possible forebay outlet capacity
Micropool		Area ≥ 10 ft^2	Area ≥ 10 ft^2	Area ≥ 10 ft^2	Area ≥ 10 ft^2
Initial Surcharge Volume		Depth ≥ 4 inches	Depth ≥ 4 inches	Depth ≥ 4 in. Volume ≥ 0.3% WQCV	Depth ≥ 4 in. Volume ≥ 0.3% WQCV

[1] EDBs are not recommended for sites with less than 2 impervious acres. Consider a sand filter or rain garden.

[2] Round up to the first standard pipe size (minimum 8 inches).

APPENDIX C

Hydraulic Calculations

Inlet Summary – UD-Inlet
Inlet Capacity Calculations – UD-Inlet
Pipe Sizing Calculations
UDSewer Plan Schematic
UDSewer Input and Output Tables: 5-year and 100-year Storm Events
Swale Calculations

Inlet Management

Worksheet Protected

INLET NAME	A	B	C	D
Site Type (Urban or Rural)	URBAN	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	STREET	STREET	STREET	STREET
Hydraulic Condition	On Grade	On Grade	On Grade	On Grade
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	3.4	2.1	1.8	3.1
Major Q_{Known} (cfs)	7.0	7.0	6.15	6.15

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)				
Percent Impervious				
NRCS Soil Type				

Watershed Profile

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

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)				
One-Hour Precipitation, P_1 (inches)				

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)				
One-Hour Precipitation, P_1 (inches)				

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	**3.4**	**2.1**	**1.8**	**3.1**
Major Total Design Peak Flow, Q (cfs)	**7.0**	**7.0**	**6.15**	**6.15**
Minor Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0	0.0
Major Flow Bypassed Downstream, Q_b (cfs)	1.0	1.1	0.6	0.7

Inlet Management

Worksheet Protected

INLET NAME	E	F	G	H
Site Type (Urban or Rural)	URBAN	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	STREET	STREET	STREET	STREET
Hydraulic Condition	On Grade	On Grade	On Grade	On Grade
Inlet Type				

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	2.2	2.9	3.1	3.7
Major Q_{Known} (cfs)	5.4	7.3	7.7	9.3

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	A	B	C	D
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	1.0	1.1	0.6	0.7

Watershed Characteristics

Subcatchment Area (acres)				
Percent Impervious				
NRCS Soil Type				

Watershed Profile

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

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)				
One-Hour Precipitation, P_1 (inches)				

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)				
One-Hour Precipitation, P_1 (inches)				

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	**2.2**	**2.9**	**3.1**	**3.7**
Major Total Design Peak Flow, Q (cfs)	**6.4**	**8.4**	**8.3**	**10.0**
Minor Flow Bypassed Downstream, Q_b (cfs)				
Major Flow Bypassed Downstream, Q_b (cfs)				

Inlet Management

Worksheet Protected

INLET NAME	DP1	DP2	Inlet 53
Site Type (Urban or Rural)	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	STREET	STREET	STREET
Hydraulic Condition	In Sump	In Sump	On Grade
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	5.9	5.8	3.0
Major Q_{Known} (cfs)	15.0	14.6	5.9

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	User-Defined	User-Defined	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	1.7	1.7	0.0

Watershed Characteristics

Subcatchment Area (acres)			
Percent Impervious			
NRCS Soil Type			

Watershed Profile

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

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	**5.9**	**5.8**	**3.0**
Major Total Design Peak Flow, Q (cfs)	**16.7**	**16.3**	**5.9**
Minor Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A	0.0
Major Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A	0.7

Inlet Management

Worksheet Protected

INLET NAME	Inlet 52	Inlet 61
Site Type (Urban or Rural)		
Inlet Application (Street or Area)	STREET	STREET
Hydraulic Condition	On Grade	On Grade
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	5.5	3.5
Major Q_{Known} (cfs)	10.1	6.9

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.7

Watershed Characteristics

Subcatchment Area (acres)		
Percent Impervious		
NRCS Soil Type		

Watershed Profile

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

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)		
One-Hour Precipitation, P_1 (inches)		

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)		
One-Hour Precipitation, P_1 (inches)		

CALCULATED OUTPUT

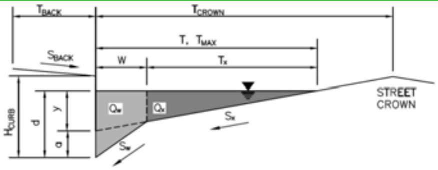
Minor Total Design Peak Flow, Q (cfs)	**5.5**	**3.5**
Major Total Design Peak Flow, Q (cfs)	**10.1**	**7.6**
Minor Flow Bypassed Downstream, Q_b (cfs)	0.3	0.0
Major Flow Bypassed Downstream, Q_b (cfs)	2.6	1.3

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

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

Project: **Meadowbrook Crossing**

Inlet ID: **A**



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	7.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	16.2	ft
Gutter Width	W =	1.17	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.143	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.010	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	16.2	16.2	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	4.9	8.5	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes

Maximum Capacity for 1/2 Street based On Allowable Spread		Minor Storm	Major Storm	
Water Depth without Gutter Depression (Eq. ST-2)	y =	3.89	3.89	inches
Vertical Depth between Gutter Lip and Gutter Flowline (usually 2")	d_C =	2.0	2.0	inches
Gutter Depression (d_C - (W * S_x * 12))	a =	1.73	1.73	inches
Water Depth at Gutter Flowline	d =	5.61	5.61	inches
Allowable Spread for Discharge outside the Gutter Section W (T - W)	T_X =	15.0	15.0	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.240	0.240	
Discharge outside the Gutter Section W, carried in Section T_X	Q_X =	7.1	7.1	cfs
Discharge within the Gutter Section W (Q_T - Q_X)	Q_W =	2.2	2.2	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Maximum Flow Based On Allowable Spread	**Q_T =**	**9.3**	**9.3**	**cfs**
Flow Velocity within the Gutter Section	V =	1.7	1.7	fps
V*d Product: Flow Velocity times Gutter Flowline Depth	V*d =	0.8	0.8	

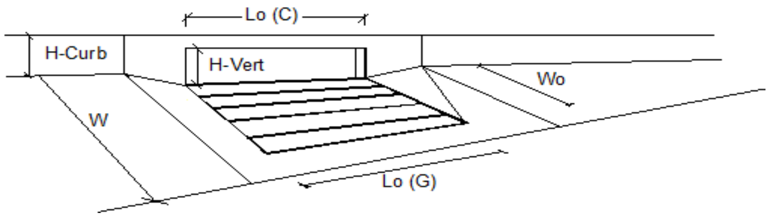
Maximum Capacity for 1/2 Street based on Allowable Depth		Minor Storm	Major Storm	
Theoretical Water Spread	T_{TH} =	13.3	28.3	ft
Theoretical Spread for Discharge outside the Gutter Section W (T - W)	$T_{X\ TH}$ =	12.1	27.1	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.299	0.128	
Theoretical Discharge outside the Gutter Section W, carried in Section $T_{X\ TH}$	$Q_{X\ TH}$ =	4.0	34.3	cfs
Actual Discharge outside the Gutter Section W, (limited by distance T_{CROWN})	Q_X =	4.0	30.3	cfs
Discharge within the Gutter Section W (Q_d - Q_X)	Q_W =	1.7	5.0	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	2.1	cfs
Total Discharge for Major & Minor Storm (Pre-Safety Factor)	Q =	5.7	37.4	cfs
Average Flow Velocity Within the Gutter Section	V =	1.5	2.3	fps
V*d Product: Flow Velocity Times Gutter Flowline Depth	V*d =	0.6	1.7	
Slope-Based Depth Safety Reduction Factor for Major & Minor ($d \geq 6"$) Storm	R =	1.00	1.00	
Max Flow Based on Allowable Depth (Safety Factor Applied)	**Q_d =**	**5.7**	**37.4**	**cfs**
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)	d =	4.92	8.52	inches
Resultant Flow Depth at Street Crown (Safety Factor Applied)	d_{CROWN} =	0.00	2.91	inches

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**5.7**	**37.4**	**cfs**

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

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

INLET ON A CONTINUOUS GRADE



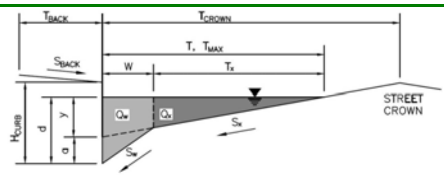
Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	10.00	10.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C_f-C =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity'			MINOR	MAJOR	
Design Discharge for Half of Street (from Sheet *Inlet Management*)		**Q_o =**	**3.4**	**7.0**	cfs
Water Spread Width		T =	10.7	14.4	ft
Water Depth at Flowline (outside of local depression)		d =	4.3	5.2	inches
Water Depth at Street Crown (or at T_{MAX})		d_{CROWN} =	0.0	0.0	inches
Ratio of Gutter Flow to Design Flow		E_o =	0.379	0.274	
Discharge outside the Gutter Section W, carried in Section T_x		Q_x =	2.1	5.0	cfs
Discharge within the Gutter Section W		Q_w =	1.3	1.9	cfs
Discharge Behind the Curb Face		Q_{BACK} =	0.0	0.0	cfs
Flow Area within the Gutter Section W		A_W =	0.32	0.41	sq ft
Velocity within the Gutter Section W		V_W =	4.0	4.7	fps
Water Depth for Design Condition		d_{LOCAL} =	7.3	8.2	inches
Grate Analysis (Calculated)			MINOR	MAJOR	
Total Length of Inlet Grate Opening		L =	N/A	N/A	ft
Ratio of Grate Flow to Design Flow		$E_{o\text{-}GRATE}$ =	N/A	N/A	
Under No-Clogging Condition			MINOR	MAJOR	
Minimum Velocity Where Grate Splash-Over Begins		V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow		R_f =	N/A	N/A	
Interception Rate of Side Flow		R_x =	N/A	N/A	
Interception Capacity		Q_i =	N/A	N/A	cfs
Under Clogging Condition			MINOR	MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet		GrateCoef =	N/A	N/A	
Clogging Factor for Multiple-unit Grate Inlet		GrateClog =	N/A	N/A	
Effective (unclogged) Length of Multiple-unit Grate Inlet		L_e =	N/A	N/A	ft
Minimum Velocity Where Grate Splash-Over Begins		V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow		R_f =	N/A	N/A	
Interception Rate of Side Flow		R_x =	N/A	N/A	
Actual Interception Capacity		**Q_a =**	**N/A**	**N/A**	cfs
Carry-Over Flow = Q_o-Q_a (to be applied to curb opening or next d/s inlet)		**Q_b =**	**N/A**	**N/A**	cfs
Curb or Slotted Inlet Opening Analysis (Calculated)			MINOR	MAJOR	
Equivalent Slope S_e (based on grate carry-over)		S_e =	0.147	0.112	ft/ft
Required Length L_T to Have 100% Interception		L_T =	8.78	14.34	ft
Under No-Clogging Condition			MINOR	MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L, L_T)		L =	8.78	10.00	ft
Interception Capacity		Q_i =	3.4	6.1	cfs
Under Clogging Condition			MINOR	MAJOR	
Clogging Coefficient		CurbCoef =	1.25	1.25	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet		CurbClog =	0.06	0.06	
Effective (Unclogged) Length		L_e =	8.75	8.75	ft
Actual Interception Capacity		**Q_a =**	**3.4**	**6.0**	cfs
Carry-Over Flow = $Q_{b(GRATE)}$-Q_a		**Q_b =**	**0.0**	**1.0**	cfs
Summary			MINOR	MAJOR	
Total Inlet Interception Capacity		**Q =**	**3.4**	**6.0**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)		**Q_b =**	**0.0**	**1.0**	**cfs**
Capture Percentage = Q_a/Q_o =		**C% =**	**100**	**86**	**%**

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

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

Project: **Meadowbrook Crossing**

Inlet ID: **B**



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	7.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	16.2	ft
Gutter Width	W =	1.17	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.143	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.010	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	16.2	16.2	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	4.9	8.5	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes

Maximum Capacity for 1/2 Street based On Allowable Spread		Minor Storm	Major Storm	
Water Depth without Gutter Depression (Eq. ST-2)	y =	3.89	3.89	inches
Vertical Depth between Gutter Lip and Gutter Flowline (usually 2")	d_C =	2.0	2.0	inches
Gutter Depression (d_C - (W * S_x * 12))	a =	1.73	1.73	inches
Water Depth at Gutter Flowline	d =	5.61	5.61	inches
Allowable Spread for Discharge outside the Gutter Section W (T - W)	T_X =	15.0	15.0	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.240	0.240	
Discharge outside the Gutter Section W, carried in Section T_X	Q_X =	7.1	7.1	cfs
Discharge within the Gutter Section W (Q_T - Q_X)	Q_W =	2.2	2.2	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Maximum Flow Based On Allowable Spread	**Q_T =**	**9.3**	**9.3**	**cfs**
Flow Velocity within the Gutter Section	V =	1.7	1.7	fps
V*d Product: Flow Velocity times Gutter Flowline Depth	V*d =	0.8	0.8	

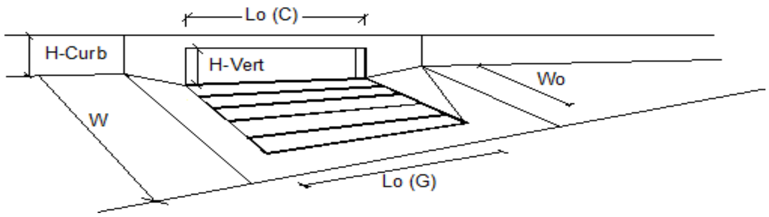
Maximum Capacity for 1/2 Street based on Allowable Depth		Minor Storm	Major Storm	
Theoretical Water Spread	T_{TH} =	13.3	28.3	ft
Theoretical Spread for Discharge outside the Gutter Section W (T - W)	$T_{X\,TH}$ =	12.1	27.1	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.299	0.128	
Theoretical Discharge outside the Gutter Section W, carried in Section $T_{X\,TH}$	$Q_{X\,TH}$ =	4.0	34.3	cfs
Actual Discharge outside the Gutter Section W, (limited by distance T_{CROWN})	Q_X =	4.0	30.3	cfs
Discharge within the Gutter Section W (Q_d - Q_X)	Q_W =	1.7	5.0	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	2.1	cfs
Total Discharge for Major & Minor Storm (Pre-Safety Factor)	Q =	5.7	37.4	cfs
Average Flow Velocity Within the Gutter Section	V =	1.5	2.3	fps
V*d Product: Flow Velocity Times Gutter Flowline Depth	V*d =	0.6	1.7	
Slope-Based Depth Safety Reduction Factor for Major & Minor (d $\geq$ 6") Storm	R =	1.00	1.00	
Max Flow Based on Allowable Depth (Safety Factor Applied)	**Q_d =**	**5.7**	**37.4**	**cfs**
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)	d =	4.92	8.52	inches
Resultant Flow Depth at Street Crown (Safety Factor Applied)	d_{CROWN} =	0.00	2.91	inches

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**5.7**	**37.4**	**cfs**

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

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

INLET ON A CONTINUOUS GRADE



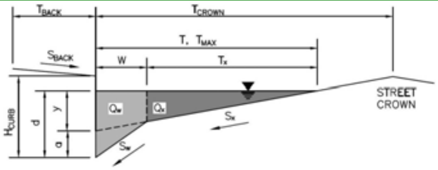
Design Information (Input)		MINOR	MAJOR	
Type of Inlet (CDOT Type R Curb Opening)	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	10.00	10.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Design Discharge for Half of Street (from Sheet *Inlet Management*)	**Q_o =**	**2.1**	**7.0**	cfs
Water Spread Width	T =	8.7	14.4	ft
Water Depth at Flowline (outside of local depression)	d =	3.8	5.2	inches
Water Depth at Street Crown (or at T_{MAX})	d_{CROWN} =	0.0	0.0	inches
Ratio of Gutter Flow to Design Flow	E_o =	0.472	0.274	
Discharge outside the Gutter Section W, carried in Section T_x	Q_x =	1.1	5.0	cfs
Discharge within the Gutter Section W	Q_w =	1.0	1.9	cfs
Discharge Behind the Curb Face	Q_{BACK} =	0.0	0.0	cfs
Flow Area within the Gutter Section W	A_W =	0.27	0.41	sq ft
Velocity within the Gutter Section W	V_W =	3.6	4.7	fps
Water Depth for Design Condition	d_{LOCAL} =	6.8	8.2	inches
Grate Analysis (Calculated)		MINOR	MAJOR	
Total Length of Inlet Grate Opening	L =	N/A	N/A	ft
Ratio of Grate Flow to Design Flow	$E_{o\text{-}GRATE}$ =	N/A	N/A	
Under No-Clogging Condition		MINOR	MAJOR	
Minimum Velocity Where Grate Splash-Over Begins	V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow	R_f =	N/A	N/A	
Interception Rate of Side Flow	R_x =	N/A	N/A	
Interception Capacity	Q_i =	N/A	N/A	cfs
Under Clogging Condition		MINOR	MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet	GrateCoef =	N/A	N/A	
Clogging Factor for Multiple-unit Grate Inlet	GrateClog =	N/A	N/A	
Effective (unclogged) Length of Multiple-unit Grate Inlet	L_e =	N/A	N/A	ft
Minimum Velocity Where Grate Splash-Over Begins	V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow	R_f =	N/A	N/A	
Interception Rate of Side Flow	R_x =	N/A	N/A	
Actual Interception Capacity	**Q_a =**	**N/A**	**N/A**	cfs
Carry-Over Flow = Q_o-Q_a (to be applied to curb opening or next d/s inlet)	**Q_b =**	**N/A**	**N/A**	cfs
Curb or Slotted Inlet Opening Analysis (Calculated)		MINOR	MAJOR	
Equivalent Slope S_e (based on grate carry-over)	S_e =	0.179	0.112	ft/ft
Required Length L_T to Have 100% Interception	L_T =	6.28	14.34	ft
Under No-Clogging Condition		MINOR	MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L, L_T)	L =	6.28	10.00	ft
Interception Capacity	Q_i =	2.1	6.1	cfs
Under Clogging Condition		MINOR	MAJOR	
Clogging Coefficient	CurbCoef =	1.25	1.25	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet	CurbClog =	0.06	0.06	
Effective (Unclogged) Length	L_e =	8.75	8.75	ft
Actual Interception Capacity	**Q_a =**	**2.1**	**6.0**	cfs
Carry-Over Flow = $Q_{b(GRATE)}$-Q_a	**Q_b =**	**0.0**	**1.0**	cfs
Summary		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**2.1**	**6.0**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**1.0**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**86**	**%**

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

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

Project: **Meadowbrook Crossing**

Inlet ID: **C**



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	7.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	16.2	ft
Gutter Width	W =	1.17	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.143	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.009	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	16.2	16.2	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	4.9	8.5	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes

Maximum Capacity for 1/2 Street based On Allowable Spread		Minor Storm	Major Storm	
Water Depth without Gutter Depression (Eq. ST-2)	y =	3.89	3.89	inches
Vertical Depth between Gutter Lip and Gutter Flowline (usually 2")	d_C =	2.0	2.0	inches
Gutter Depression (d_C - (W * S_x * 12))	a =	1.73	1.73	inches
Water Depth at Gutter Flowline	d =	5.61	5.61	inches
Allowable Spread for Discharge outside the Gutter Section W (T - W)	T_X =	15.0	15.0	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.240	0.240	
Discharge outside the Gutter Section W, carried in Section T_X	Q_X =	6.7	6.7	cfs
Discharge within the Gutter Section W (Q_T - Q_X)	Q_W =	2.1	2.1	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Maximum Flow Based On Allowable Spread	**Q_T =**	**8.9**	**8.9**	**cfs**
Flow Velocity within the Gutter Section	V =	1.6	1.6	fps
V*d Product: Flow Velocity times Gutter Flowline Depth	V*d =	0.8	0.8	

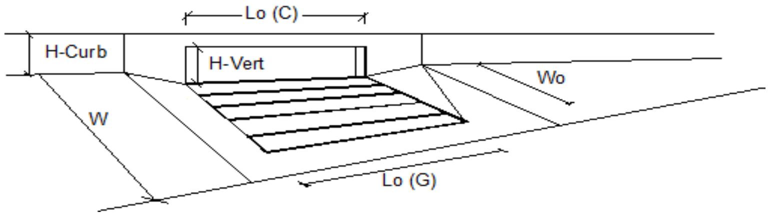
Maximum Capacity for 1/2 Street based on Allowable Depth		Minor Storm	Major Storm	
Theoretical Water Spread	T_{TH} =	13.3	28.3	ft
Theoretical Spread for Discharge outside the Gutter Section W (T - W)	$T_{X\,TH}$ =	12.1	27.1	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.299	0.128	
Theoretical Discharge outside the Gutter Section W, carried in Section $T_{X\,TH}$	$Q_{X\,TH}$ =	3.8	32.5	cfs
Actual Discharge outside the Gutter Section W, (limited by distance T_{CROWN})	Q_X =	3.8	28.8	cfs
Discharge within the Gutter Section W (Q_d - Q_X)	Q_W =	1.6	4.8	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	2.0	cfs
Total Discharge for Major & Minor Storm (Pre-Safety Factor)	Q =	5.4	35.5	cfs
Average Flow Velocity Within the Gutter Section	V =	1.5	2.2	fps
V*d Product: Flow Velocity Times Gutter Flowline Depth	V*d =	0.6	1.6	
Slope-Based Depth Safety Reduction Factor for Major & Minor ($d \geq 6"$) Storm	R =	1.00	1.00	
Max Flow Based on Allowable Depth (Safety Factor Applied)	**Q_d =**	**5.4**	**35.5**	**cfs**
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)	d =	4.92	8.52	inches
Resultant Flow Depth at Street Crown (Safety Factor Applied)	d_{CROWN} =	0.00	2.91	inches

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**5.4**	**35.5**	**cfs**

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

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

INLET ON A CONTINUOUS GRADE

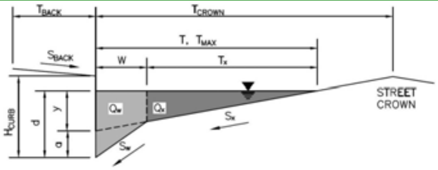


Design Information (Input)		MINOR	MAJOR	
Type of Inlet — CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	10.00	10.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Design Discharge for Half of Street (from Sheet *Inlet Management*)	**Q_o =**	**1.8**	**6.2**	cfs
Water Spread Width	T =	8.3	14.0	ft
Water Depth at Flowline (outside of local depression)	d =	3.7	5.1	inches
Water Depth at Street Crown (or at T_{MAX})	d_{CROWN} =	0.0	0.0	inches
Ratio of Gutter Flow to Design Flow	E_o =	0.494	0.282	
Discharge outside the Gutter Section W, carried in Section T_x	Q_x =	0.9	4.4	cfs
Discharge within the Gutter Section W	Q_w =	0.9	1.7	cfs
Discharge Behind the Curb Face	Q_{BACK} =	0.0	0.0	cfs
Flow Area within the Gutter Section W	A_W =	0.26	0.40	sq ft
Velocity within the Gutter Section W	V_W =	3.4	4.4	fps
Water Depth for Design Condition	d_{LOCAL} =	6.7	8.1	inches
Grate Analysis (Calculated)		MINOR	MAJOR	
Total Length of Inlet Grate Opening	L =	N/A	N/A	ft
Ratio of Grate Flow to Design Flow	$E_{o\text{-}GRATE}$ =	N/A	N/A	
Under No-Clogging Condition		MINOR	MAJOR	
Minimum Velocity Where Grate Splash-Over Begins	V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow	R_f =	N/A	N/A	
Interception Rate of Side Flow	R_x =	N/A	N/A	
Interception Capacity	Q_i =	N/A	N/A	cfs
Under Clogging Condition		MINOR	MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet	GrateCoef =	N/A	N/A	
Clogging Factor for Multiple-unit Grate Inlet	GrateClog =	N/A	N/A	
Effective (unclogged) Length of Multiple-unit Grate Inlet	L_e =	N/A	N/A	ft
Minimum Velocity Where Grate Splash-Over Begins	V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow	R_f =	N/A	N/A	
Interception Rate of Side Flow	R_x =	N/A	N/A	
Actual Interception Capacity	**Q_a =**	**N/A**	**N/A**	cfs
Carry-Over Flow = Q_o-Q_a (to be applied to curb opening or next d/s inlet)	**Q_b =**	**N/A**	**N/A**	cfs
Curb or Slotted Inlet Opening Analysis (Calculated)		MINOR	MAJOR	
Equivalent Slope S_e (based on grate carry-over)	S_e =	0.186	0.115	ft/ft
Required Length L_T to Have 100% Interception	L_T =	5.67	13.23	ft
Under No-Clogging Condition		MINOR	MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L, L_T)	L =	5.67	10.00	ft
Interception Capacity	Q_i =	1.8	5.7	cfs
Under Clogging Condition		MINOR	MAJOR	
Clogging Coefficient	CurbCoef =	1.25	1.25	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet	CurbClog =	0.06	0.06	
Effective (Unclogged) Length	L_e =	8.75	8.75	ft
Actual Interception Capacity	**Q_a =**	**1.8**	**5.5**	cfs
Carry-Over Flow = $Q_{b(GRATE)}$-Q_a	**Q_b =**	**0.0**	**0.6**	cfs
Summary		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**1.8**	**5.5**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**0.6**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**90**	**%**

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

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

Project: Meadowbrook Crossing
Inlet ID: D



Gutter Geometry (Enter data in the blue cells)			
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	7.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	16.2	ft
Gutter Width	W =	1.17	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.143	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.009	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	16.2	16.2	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	4.9	8.5	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes

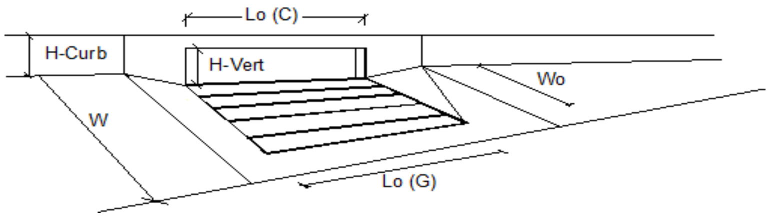
Maximum Capacity for 1/2 Street based On Allowable Spread		Minor Storm	Major Storm	
Water Depth without Gutter Depression (Eq. ST-2)	y =	3.89	3.89	inches
Vertical Depth between Gutter Lip and Gutter Flowline (usually 2")	d_C =	2.0	2.0	inches
Gutter Depression (d_C - (W * S_x * 12))	a =	1.73	1.73	inches
Water Depth at Gutter Flowline	d =	5.61	5.61	inches
Allowable Spread for Discharge outside the Gutter Section W (T - W)	T_X =	15.0	15.0	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.240	0.240	
Discharge outside the Gutter Section W, carried in Section T_X	Q_X =	6.7	6.7	cfs
Discharge within the Gutter Section W (Q_T - Q_X)	Q_W =	2.1	2.1	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Maximum Flow Based On Allowable Spread	**Q_T =**	**8.9**	**8.9**	**cfs**
Flow Velocity within the Gutter Section	V =	1.6	1.6	fps
V*d Product: Flow Velocity times Gutter Flowline Depth	V*d =	0.8	0.8	

Maximum Capacity for 1/2 Street based on Allowable Depth		Minor Storm	Major Storm	
Theoretical Water Spread	T_{TH} =	13.3	28.3	ft
Theoretical Spread for Discharge outside the Gutter Section W (T - W)	$T_{X\ TH}$ =	12.1	27.1	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.299	0.128	
Theoretical Discharge outside the Gutter Section W, carried in Section $T_{X\ TH}$	$Q_{X\ TH}$ =	3.8	32.5	cfs
Actual Discharge outside the Gutter Section W, (limited by distance T_{CROWN})	Q_X =	3.8	28.8	cfs
Discharge within the Gutter Section W (Q_d - Q_X)	Q_W =	1.6	4.8	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	2.0	cfs
Total Discharge for Major & Minor Storm (Pre-Safety Factor)	Q =	5.4	35.5	cfs
Average Flow Velocity Within the Gutter Section	V =	1.5	2.2	fps
V*d Product: Flow Velocity Times Gutter Flowline Depth	V*d =	0.6	1.6	
Slope-Based Depth Safety Reduction Factor for Major & Minor (d $\geq$ 6") Storm	R =	1.00	1.00	
Max Flow Based on Allowable Depth (Safety Factor Applied)	**Q_d =**	**5.4**	**35.5**	**cfs**
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)	d =	4.92	8.52	inches
Resultant Flow Depth at Street Crown (Safety Factor Applied)	d_{CROWN} =	0.00	2.91	inches

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**5.4**	**35.5**	**cfs**

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

INLET ON A CONTINUOUS GRADE



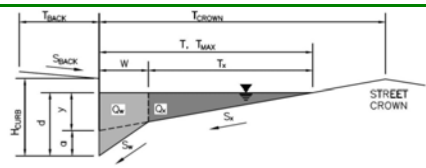
Design Information (Input)	CDOT Type R Curb Opening	MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	10.00	10.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Design Discharge for Half of Street (from Sheet *Inlet Management*)	**Q_o =**	**3.1**	**6.2**	cfs
Water Spread Width	T =	10.6	14.0	ft
Water Depth at Flowline (outside of local depression)	d =	4.3	5.1	inches
Water Depth at Street Crown (or at T_{MAX})	d_{CROWN} =	0.0	0.0	inches
Ratio of Gutter Flow to Design Flow	E_o =	0.386	0.282	
Discharge outside the Gutter Section W, carried in Section T_x	Q_x =	1.9	4.4	cfs
Discharge within the Gutter Section W	Q_w =	1.2	1.7	cfs
Discharge Behind the Curb Face	Q_{BACK} =	0.0	0.0	cfs
Flow Area within the Gutter Section W	A_W =	0.32	0.40	sq ft
Velocity within the Gutter Section W	V_W =	3.8	4.4	fps
Water Depth for Design Condition	d_{LOCAL} =	7.3	8.1	inches
Grate Analysis (Calculated)		MINOR	MAJOR	
Total Length of Inlet Grate Opening	L =	N/A	N/A	ft
Ratio of Grate Flow to Design Flow	$E_{o\text{-}GRATE}$ =	N/A	N/A	
Under No-Clogging Condition		MINOR	MAJOR	
Minimum Velocity Where Grate Splash-Over Begins	V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow	R_f =	N/A	N/A	
Interception Rate of Side Flow	R_x =	N/A	N/A	
Interception Capacity	Q_i =	N/A	N/A	cfs
Under Clogging Condition		MINOR	MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet	GrateCoef =	N/A	N/A	
Clogging Factor for Multiple-unit Grate Inlet	GrateClog =	N/A	N/A	
Effective (unclogged) Length of Multiple-unit Grate Inlet	L_e =	N/A	N/A	ft
Minimum Velocity Where Grate Splash-Over Begins	V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow	R_f =	N/A	N/A	
Interception Rate of Side Flow	R_x =	N/A	N/A	
Actual Interception Capacity	**Q_a =**	**N/A**	**N/A**	cfs
Carry-Over Flow = Q_o-Q_a (to be applied to curb opening or next d/s inlet)	**Q_b =**	**N/A**	**N/A**	cfs
Curb or Slotted Inlet Opening Analysis (Calculated)		MINOR	MAJOR	
Equivalent Slope S_e (based on grate carry-over)	S_e =	0.150	0.115	ft/ft
Required Length L_T to Have 100% Interception	L_T =	8.26	13.23	ft
Under No-Clogging Condition		MINOR	MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L, L_T)	L =	8.26	10.00	ft
Interception Capacity	Q_i =	3.1	5.7	cfs
Under Clogging Condition		MINOR	MAJOR	
Clogging Coefficient	CurbCoef =	1.25	1.25	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet	CurbClog =	0.06	0.06	
Effective (Unclogged) Length	L_e =	8.75	8.75	ft
Actual Interception Capacity	**Q_a =**	**3.1**	**5.5**	cfs
Carry-Over Flow = $Q_{b(GRATE)}$-Q_a	**Q_b =**	**0.0**	**0.6**	cfs
Summary		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**3.1**	**5.5**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**0.6**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**90**	**%**

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

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

Project: Meadowbrook Crossing

Inlet ID: DP1



Gutter Geometry (Enter data in the blue cells)			
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	7.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	16.2	ft
Gutter Width	W =	1.17	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.143	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

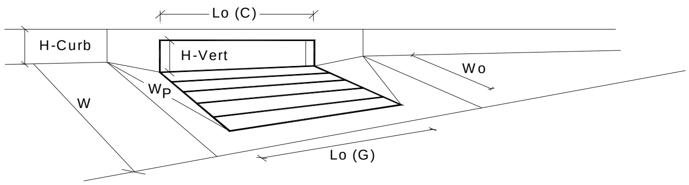
		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	16.2	16.2	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	4.9	8.5	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes

Maximum Capacity for 1/2 Street based On Allowable Spread		Minor Storm	Major Storm	
Water Depth without Gutter Depression (Eq. ST-2)	y =	3.89	3.89	inches
Vertical Depth between Gutter Lip and Gutter Flowline (usually 2")	d_C =	2.0	2.0	inches
Gutter Depression (d_C - (W * S_x * 12))	a =	1.73	1.73	inches
Water Depth at Gutter Flowline	d =	5.61	5.61	inches
Allowable Spread for Discharge outside the Gutter Section W (T - W)	T_X =	15.0	15.0	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.240	0.240	
Discharge outside the Gutter Section W, carried in Section T_X	Q_X =	0.0	0.0	cfs
Discharge within the Gutter Section W (Q_T - Q_X)	Q_W =	0.0	0.0	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Maximum Flow Based On Allowable Spread	**Q_T =**	**SUMP**	**SUMP**	**cfs**
Flow Velocity within the Gutter Section	V =	0.0	0.0	fps
V*d Product: Flow Velocity times Gutter Flowline Depth	V*d =	0.0	0.0	

Maximum Capacity for 1/2 Street based on Allowable Depth		Minor Storm	Major Storm	
Theoretical Water Spread	T_{TH} =	13.3	28.3	ft
Theoretical Spread for Discharge outside the Gutter Section W (T - W)	$T_{X\,TH}$ =	12.1	27.1	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.299	0.128	
Theoretical Discharge outside the Gutter Section W, carried in Section $T_{X\,TH}$	$Q_{X\,TH}$ =	0.0	0.0	cfs
Actual Discharge outside the Gutter Section W, (limited by distance T_{CROWN})	Q_X =	0.0	0.0	cfs
Discharge within the Gutter Section W (Q_d - Q_X)	Q_W =	0.0	0.0	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Total Discharge for Major & Minor Storm (Pre-Safety Factor)	Q =	0.0	0.0	cfs
Average Flow Velocity Within the Gutter Section	V =	0.0	0.0	fps
V*d Product: Flow Velocity Times Gutter Flowline Depth	V*d =	0.0	0.0	
Slope-Based Depth Safety Reduction Factor for Major & Minor (d $\geq$ 6") Storm	R =	SUMP	SUMP	
Max Flow Based on Allowable Depth (Safety Factor Applied)	**Q_d =**	**SUMP**	**SUMP**	**cfs**
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)	d =			inches
Resultant Flow Depth at Street Crown (Safety Factor Applied)	d_{CROWN} =			inches

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

INLET IN A SUMP OR SAG LOCATION



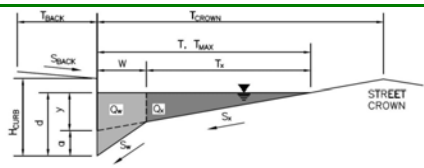
		MINOR	MAJOR	
Design Information (Input) — CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	1	1	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	4.9	7.0	inches
Grate Information		MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate	L_o (G) =	N/A	N/A	feet
Width of a Unit Grate	W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	N/A	N/A	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	20.00	20.00	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)	Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	1.17	1.17	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	0.67	0.67	
Grate Flow Analysis (Calculated)		MINOR	MAJOR	
Clogging Coefficient for Multiple Units	Coef =	N/A	N/A	
Clogging Factor for Multiple Units	Clog =	N/A	N/A	
Grate Capacity as a Weir (based on Modified HEC22 Method)		MINOR	MAJOR	
Interception without Clogging	Q_{wi} =	N/A	N/A	cfs
Interception with Clogging	Q_{wa} =	N/A	N/A	cfs
Grate Capacity as a Orifice (based on Modified HEC22 Method)		MINOR	MAJOR	
Interception without Clogging	Q_{oi} =	N/A	N/A	cfs
Interception with Clogging	Q_{oa} =	N/A	N/A	cfs
Grate Capacity as Mixed Flow		MINOR	MAJOR	
Interception without Clogging	Q_{mi} =	N/A	N/A	cfs
Interception with Clogging	Q_{ma} =	N/A	N/A	cfs
Resulting Grate Capacity (assumes clogged condition)	Q_{Grate} =	**N/A**	**N/A**	**cfs**
Curb Opening Flow Analysis (Calculated)		MINOR	MAJOR	
Clogging Coefficient for Multiple Units	Coef =	1.33	1.33	
Clogging Factor for Multiple Units	Clog =	0.03	0.03	
Curb Opening as a Weir (based on Modified HEC22 Method)		MINOR	MAJOR	
Interception without Clogging	Q_{wi} =	6.8	18.0	cfs
Interception with Clogging	Q_{wa} =	6.6	17.4	cfs
Curb Opening as an Orifice (based on Modified HEC22 Method)		MINOR	MAJOR	
Interception without Clogging	Q_{oi} =	35.5	42.0	cfs
Interception with Clogging	Q_{oa} =	34.3	40.6	cfs
Curb Opening Capacity as Mixed Flow		MINOR	MAJOR	
Interception without Clogging	Q_{mi} =	14.4	25.6	cfs
Interception with Clogging	Q_{ma} =	14.0	24.7	cfs
Resulting Curb Opening Capacity (assumes clogged condition)	Q_{Curb} =	**6.6**	**17.4**	**cfs**
Resultant Street Conditions		MINOR	MAJOR	
Total Inlet Length	L =	20.00	20.00	feet
Resultant Street Flow Spread (based on sheet *Q-Allow* geometry)	T =	13.3	22.0	ft.>T-Crown
Resultant Flow Depth at Street Crown	d_{CROWN} =	0.0	1.4	inches
Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.24	0.42	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.46	0.66	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.71	0.84	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**6.6**	**17.4**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	5.9	16.6	cfs

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

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

Project: Meadowbrook Crossing

Inlet ID: DP2



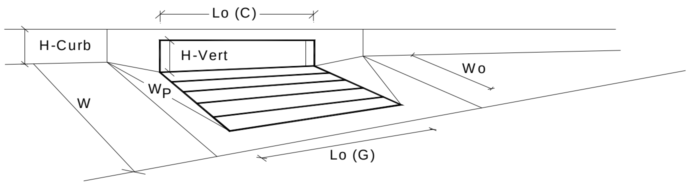
Gutter Geometry (Enter data in the blue cells)				
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	7.5		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00		inches
Distance from Curb Face to Street Crown	T_{CROWN} =	16.2		ft
Gutter Width	W =	1.17		ft
Street Transverse Slope	S_X =	0.020		ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.143		ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000		ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016		
		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	16.2	16.2	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	4.9	8.5	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes

Maximum Capacity for 1/2 Street based On Allowable Spread		Minor Storm	Major Storm	
Water Depth without Gutter Depression (Eq. ST-2)	y =	3.89	3.89	inches
Vertical Depth between Gutter Lip and Gutter Flowline (usually 2")	d_C =	2.0	2.0	inches
Gutter Depression (d_C - (W * S_x * 12))	a =	1.73	1.73	inches
Water Depth at Gutter Flowline	d =	5.61	5.61	inches
Allowable Spread for Discharge outside the Gutter Section W (T - W)	T_X =	15.0	15.0	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.240	0.240	
Discharge outside the Gutter Section W, carried in Section T_X	Q_X =	0.0	0.0	cfs
Discharge within the Gutter Section W (Q_T - Q_X)	Q_W =	0.0	0.0	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Maximum Flow Based On Allowable Spread	**Q_T =**	**SUMP**	**SUMP**	**cfs**
Flow Velocity within the Gutter Section	V =	0.0	0.0	fps
V*d Product: Flow Velocity times Gutter Flowline Depth	V*d =	0.0	0.0	

Maximum Capacity for 1/2 Street based on Allowable Depth		Minor Storm	Major Storm	
Theoretical Water Spread	T_{TH} =	13.3	28.3	ft
Theoretical Spread for Discharge outside the Gutter Section W (T - W)	$T_{X\ TH}$ =	12.1	27.1	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.299	0.128	
Theoretical Discharge outside the Gutter Section W, carried in Section $T_{X\ TH}$	$Q_{X\ TH}$ =	0.0	0.0	cfs
Actual Discharge outside the Gutter Section W, (limited by distance T_{CROWN})	Q_X =	0.0	0.0	cfs
Discharge within the Gutter Section W (Q_d - Q_X)	Q_W =	0.0	0.0	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Total Discharge for Major & Minor Storm (Pre-Safety Factor)	Q =	0.0	0.0	cfs
Average Flow Velocity Within the Gutter Section	V =	0.0	0.0	fps
V*d Product: Flow Velocity Times Gutter Flowline Depth	V*d =	0.0	0.0	
Slope-Based Depth Safety Reduction Factor for Major & Minor (d $\geq$ 6") Storm	R =	SUMP	SUMP	
Max Flow Based on Allowable Depth (Safety Factor Applied)	**Q_d =**	**SUMP**	**SUMP**	**cfs**
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)	d =			inches
Resultant Flow Depth at Street Crown (Safety Factor Applied)	d_{CROWN} =			inches

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

INLET IN A SUMP OR SAG LOCATION



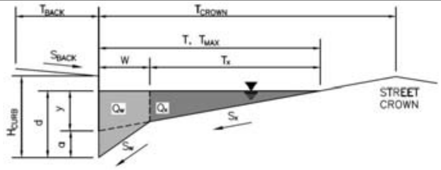
		MINOR	MAJOR	
Design Information (Input) CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from 'Q-Allow')	a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	1	1	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	4.9	7.0	inches
Grate Information		MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate	L_o (G) =	N/A	N/A	feet
Width of a Unit Grate	W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	N/A	N/A	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	20.00	20.00	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)	Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	1.17	1.17	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	0.67	0.67	
Grate Flow Analysis (Calculated)		MINOR	MAJOR	
Clogging Coefficient for Multiple Units	Coef =	N/A	N/A	
Clogging Factor for Multiple Units	Clog =	N/A	N/A	
Grate Capacity as a Weir (based on Modified HEC22 Method)		MINOR	MAJOR	
Interception without Clogging	Q_{wi} =	N/A	N/A	cfs
Interception with Clogging	Q_{wa} =	N/A	N/A	cfs
Grate Capacity as a Orifice (based on Modified HEC22 Method)		MINOR	MAJOR	
Interception without Clogging	Q_{oi} =	N/A	N/A	cfs
Interception with Clogging	Q_{oa} =	N/A	N/A	cfs
Grate Capacity as Mixed Flow		MINOR	MAJOR	
Interception without Clogging	Q_{mi} =	N/A	N/A	cfs
Interception with Clogging	Q_{ma} =	N/A	N/A	cfs
Resulting Grate Capacity (assumes clogged condition)	Q_{Grate} =	**N/A**	**N/A**	**cfs**
Curb Opening Flow Analysis (Calculated)		MINOR	MAJOR	
Clogging Coefficient for Multiple Units	Coef =	1.33	1.33	
Clogging Factor for Multiple Units	Clog =	0.03	0.03	
Curb Opening as a Weir (based on Modified HEC22 Method)		MINOR	MAJOR	
Interception without Clogging	Q_{wi} =	6.8	18.0	cfs
Interception with Clogging	Q_{wa} =	6.6	17.4	cfs
Curb Opening as an Orifice (based on Modified HEC22 Method)		MINOR	MAJOR	
Interception without Clogging	Q_{oi} =	35.5	42.0	cfs
Interception with Clogging	Q_{oa} =	34.3	40.6	cfs
Curb Opening Capacity as Mixed Flow		MINOR	MAJOR	
Interception without Clogging	Q_{mi} =	14.4	25.6	cfs
Interception with Clogging	Q_{ma} =	14.0	24.7	cfs
Resulting Curb Opening Capacity (assumes clogged condition)	Q_{Curb} =	**6.6**	**17.4**	**cfs**
Resultant Street Conditions		MINOR	MAJOR	
Total Inlet Length	L =	20.00	20.00	feet
Resultant Street Flow Spread (based on sheet *Q-Allow* geometry)	T =	13.3	22.0	ft.>T-Crown
Resultant Flow Depth at Street Crown	d_{CROWN} =	0.0	1.4	inches
Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.24	0.42	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.46	0.66	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.71	0.84	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**6.6**	**17.4**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	5.8	16.2	cfs

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

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

Project: Meadowbrook Crossing

Inlet ID: Inlet 52



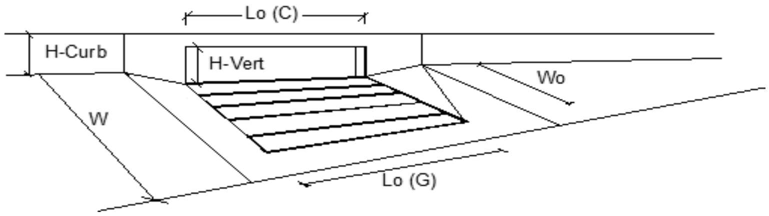
Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	14.0		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00		inches
Distance from Curb Face to Street Crown	T_{CROWN} =	26.0		ft
Gutter Width	W =	2.00		ft
Street Transverse Slope	S_X =	0.020		ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083		ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.012		ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.020		
		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	20.0	26.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	9.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**12.1**	**28.9**	**cfs**

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

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

INLET ON A CONTINUOUS GRADE



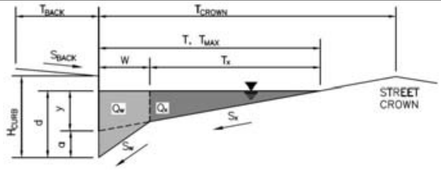
Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	10.00	10.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C_f-C =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity'			MINOR	MAJOR	
Total Inlet Interception Capacity		**Q =**	**5.2**	**7.5**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)		**Q_b =**	**0.3**	**2.6**	**cfs**
Capture Percentage = Q_a/Q_o =		**C% =**	**94**	**74**	**%**

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

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

Project: Meadowbrook Crossing

Inlet ID: Inlet 53



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	14.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	26.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.010	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

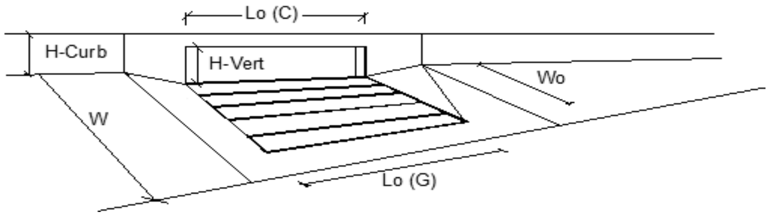
		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	20.0	26.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	Q_{allow} =	**13.8**	**32.7**	**cfs**

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

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

INLET ON A CONTINUOUS GRADE



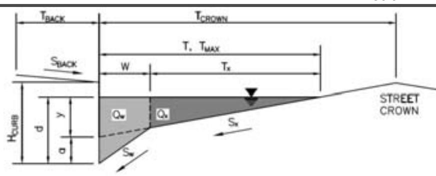
Design Information (Input)		MINOR	MAJOR	
Type of Inlet (CDOT Type R Curb Opening)	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	10.00	10.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**3.0**	**5.2**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**0.7**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**88**	**%**

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

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

Project: Meadowbrook Crossing

Inlet ID: Inlet 61



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	26.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	26.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.010	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.020	

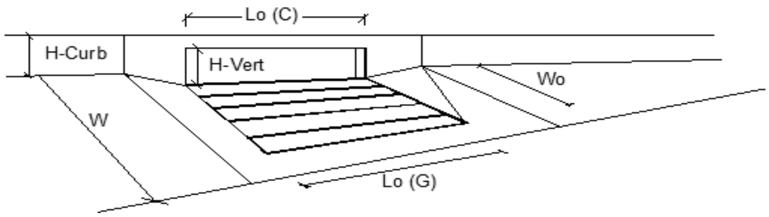
		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	20.0	26.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**11.0**	**26.4**	**cfs**

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

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

INLET ON A CONTINUOUS GRADE



Design Information (Input)		MINOR	MAJOR	
Type of Inlet (CDOT Type R Curb Opening)	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	10.00	10.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**3.5**	**6.3**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**1.3**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**83**	**%**

Meadowbrook Crossing

Pipe Diameter Calculations

Pipe #	5yr Flow	100yr or Design Flow	Contributing Flows	Manning 'n'	Pipe Slope	Calculated Pipe Diameter	**Pipe Diameter**	Minimum Slope of Pipe	Full Pipe Flow Velocity	Head above Pipe Flowline	H	Pipe Inlet Control Capacity	**Mannings Pipe Capacity**	Capacity Check
S10	3.1 cfs	5.5 cfs	Inlet D (Basin D)	0.013	**0.50%**	16-inch	**18-inch**	0.27%	4.2 ft/sec		----	----	**7.4 cfs**	OK
S11	4.9 cfs	11.0 cfs	Inlets C, D	0.013	**0.50%**	21-inch	**24-inch**	0.24%	5.1 ft/sec		----	----	**16.0 cfs**	OK
S12	10.4 cfs	23.0 cfs	Inlets A,B,C,D	0.013	**0.50%**	28-inch	**30-inch**	0.31%	5.9 ft/sec		----	----	**29.1 cfs**	OK
S13	16.3 cfs	39.7 cfs	Inlets A,B,C,D,1	0.013	**0.50%**	34-inch	**36-inch**	0.35%	6.7 ft/sec		----	----	**47.3 cfs**	OK
S14	19.2 cfs	48.4 cfs	DP 3	0.013	**0.60%**	35-inch	**36-inch**	0.53%	7.3 ft/sec		----	----	**51.8 cfs**	OK
S15	19.6 cfs	16.0 cfs	WQ Outlet & DP 4	0.013	**0.50%**	24-inch	**24-inch**	0.50%	5.1 ft/sec	5.26 ft	4.3 ft	33.8 cfs	**16.0 cfs**	OK
S20	3.4 cfs	6.0 cfs	Inlet A (Basin A)	0.013	**0.50%**	17-inch	**18-inch**	0.33%	4.2 ft/sec	5.77 ft	5.0 ft	20.7 cfs	**7.4 cfs**	OK
S30	5.9 cfs	16.7 cfs	Inlet 1 (DP 1)+Carry Ov	0.013	**0.50%**	24-inch	**30-inch**	0.17%	5.9 ft/sec	5.34 ft	4.1 ft	51.8 cfs	**29.1 cfs**	OK
S52	5.5 cfs	10.1 cfs	Inlet 52 (DP 10)	0.013	**0.50%**	20-inch	**24-inch**	0.20%	5.1 ft/sec		----	----	**16.0 cfs**	OK
S61	3.5 cfs	6.9 cfs	Inlet 61 (OS-B)	0.013	**1.00%**	15-inch	**18-inch**	0.43%	6.0 ft/sec		----	----	**10.5 cfs**	OK

Equations:

Pipe Dia=$((2.16Qn)/(S^{0.5}))^{0.375}$

Q = Discharge in cubic feet per second

n = Manning's roughness coefficient

RCP=0.013, CMP=0.024, HDPE (smooth)=0.012

S = Slope of the pipe

R_h = Hydraulic Radius

Flow Velocity = $(1.49/n)R_h^{2/3} S^{1/2}$

Pipe Capacity = $(1.49/n)AR_h^{2/3} S^{1/2}$

A = Cross-sectional area of pipe

$A=p (D^2/4)$

D = Inside Diameter of Pipe

$R_h = A_w/W_p$

$A_w = p(d^2/4)$

A_w = Water Cross Sectional Area

d = Water (Flow) Depth Within Pipe

W_p = pd (For Capacity Calculation)

W_p=Wetted Perimeter of Pipe

Orifice Equation:

$Q = CA(2gH)^{0.5}$

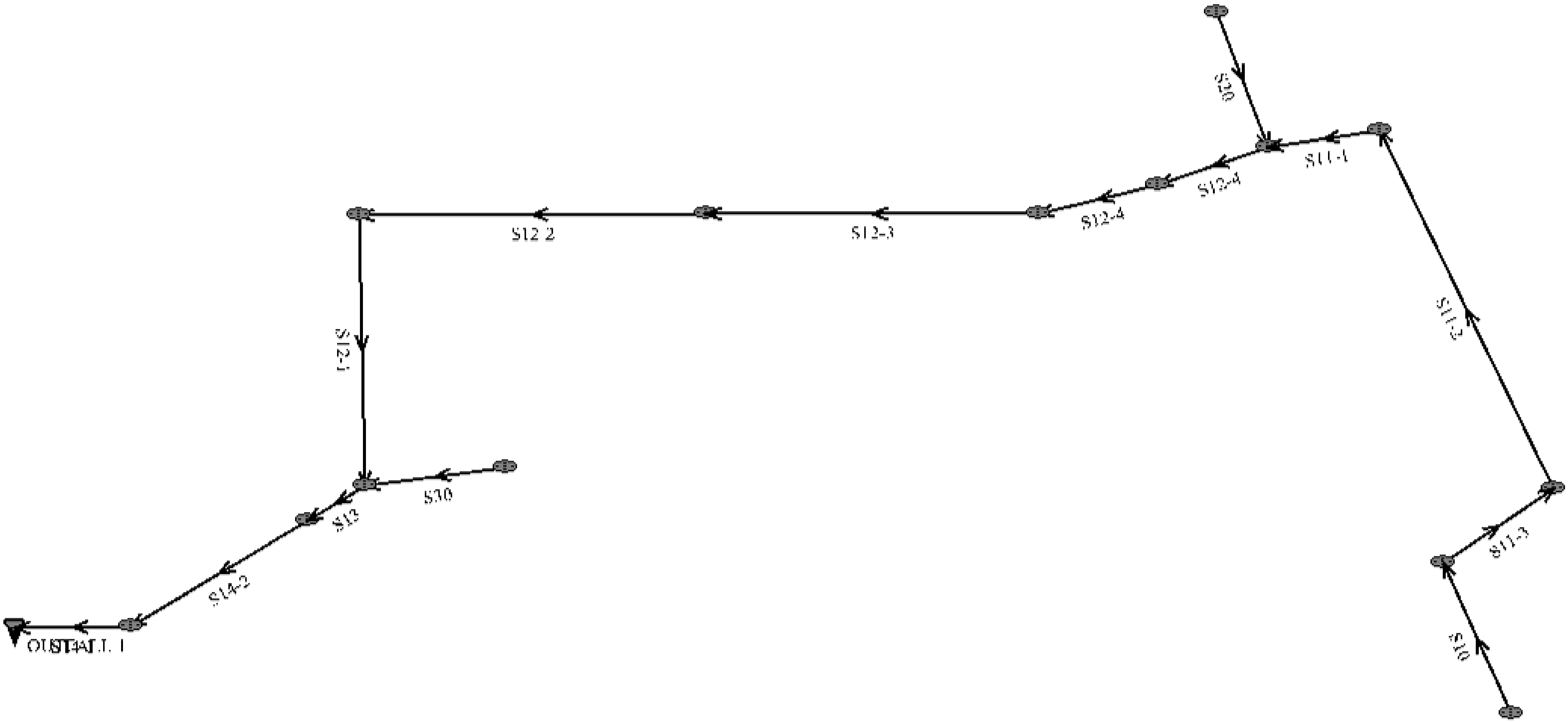
C = Orifice coefficient (dimensionless)

C = 0.65

A = Cross-sectional area of opening, in sf

g = Gravitational accel constant, 32.2 ft/sec^2

H = Head above centerline of pipe, ft



S20
S11-1
S12-4
S12-4
S12 2
S12-3
S12-1
S11-2
S30
S13
S11-3
S14-2
S10

Program: UDSEWER Math Model Interface 2.2.1.2 **Run Date:** 5/2/2017 3:14:06 PM	# UDSewer Results Summary **Project Title:** Meadowbrook Crossing **Project Description:** 5 yr Storm Event

System Input Summary

Rainfall Parameters

Rainfall Return Period: 5
Rainfall Calculation Method: Formula

One Hour Depth (in):
Rainfall Constant "A": 28.5
Rainfall Constant "B": 10
Rainfall Constant "C": 0.786

Rational Method Constraints

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

Sizer Constraints

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

Backwater Calculations:

Tailwater Elevation (ft): 6303.50

Manhole Input Summary:

		Given Flow		Sub Basin Information						
Element Name	Ground Elevation (ft)	Total Known Flow (cfs)	Local Contribution (cfs)	Drainage Area (Ac.)	Runoff Coefficient	5yr Coefficient	Overland Length (ft)	Overland Slope (%)	Gutter Length (ft)	Gutter Velocity (fps)
OUTFALL 1	6305.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S14-1	6307.80	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

S14-2	6308.78	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S13	6308.83	16.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S30	6309.15	5.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S12-1	6310.05	10.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S12-2	6312.37	10.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S12-3	6314.24	10.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S12-4	6314.53	10.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S12-4	6315.79	10.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S20	6315.79	3.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S11-1	6315.86	4.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S11-2	6315.92	4.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S11-3	6315.96	4.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S10	6315.96	3.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Manhole Output Summary:

	Local Contribution					Total Design Flow				
Element Name	**Overland Time (min)**	**Gutter Time (min)**	**Basin Tc (min)**	**Intensity (in/hr)**	**Local Contrib (cfs)**	**Coeff. Area**	**Intensity (in/hr)**	**Manhole Tc (min)**	**Peak Flow (cfs)**	**Comment**
OUTFALL 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
S14-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.20	
S14-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.20	
S13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.30	
S30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.90	
S12-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.40	
S12-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.40	
S12-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.40	
S12-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.40	
S12-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.40	
S20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.40	
S11-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.90	
S11-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.90	
S11-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.90	
S10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.10	

Sewer Input Summary:

		Elevation			Loss Coefficients			Given Dimensions		
Element Name	**Sewer Length (ft)**	**Downstream Invert (ft)**	**Slope (%)**	**Upstream Invert (ft)**	**Mannings n**	**Bend Loss**	**Lateral Loss**	**Cross Section**	**Rise (ft or in)**	**Span (ft or in)**
S14-1	51.11	6301.75	0.60	6302.06	0.013	0.03	0.00	CIRCULAR	36.00 in	36.00 in
S14-2	125.28	6302.26	0.60	6303.01	0.013	0.14	0.00	CIRCULAR	36.00 in	36.00 in

S13	24.42	6303.04	0.50	6303.16	0.013	0.13	0.00	CIRCULAR	36.00 in	36.00 in
S30	29.47	6303.66	0.50	6303.81	0.013	0.05	0.42	CIRCULAR	30.00 in	30.00 in
S12-1	210.90	6303.66	0.50	6304.71	0.013	0.20	0.00	CIRCULAR	30.00 in	30.00 in
S12-2	317.04	6305.01	0.50	6306.60	0.013	1.00	0.00	CIRCULAR	30.00 in	30.00 in
S12-3	317.04	6306.69	0.50	6308.28	0.013	0.05	0.00	CIRCULAR	30.00 in	30.00 in
S12-4	50.11	6308.48	0.50	6308.73	0.013	0.06	0.00	CIRCULAR	30.00 in	30.00 in
S12-4	104.14	6308.93	0.50	6309.45	0.013	0.07	0.00	CIRCULAR	30.00 in	30.00 in
S20	29.34	6310.45	0.50	6310.60	0.013	0.05	0.25	CIRCULAR	18.00 in	18.00 in
S11-1	25.56	6309.95	0.50	6310.08	0.013	0.05	0.00	CIRCULAR	24.00 in	24.00 in
S11-2	209.01	6310.38	0.50	6311.43	0.013	0.84	0.00	CIRCULAR	24.00 in	24.00 in
S11-3	25.33	6311.72	0.50	6311.85	0.013	0.80	0.00	CIRCULAR	24.00 in	24.00 in
S10	29.34	6312.35	0.50	6312.50	0.013	0.82	0.00	CIRCULAR	18.00 in	18.00 in

Sewer Flow Summary:

	Full Flow Capacity		**Critical Flow**		**Normal Flow**						
Element Name	**Flow (cfs)**	**Velocity (fps)**	**Depth (in)**	**Velocity (fps)**	**Depth (in)**	**Velocity (fps)**	**Froude Number**	**Flow Condition**	**Flow (cfs)**	**Surcharged Length (ft)**	**Comment**
S14-1	51.80	7.33	16.86	5.91	15.17	6.78	1.22	Supercritical	19.20	0.00	
S14-2	51.80	7.33	16.86	5.91	15.17	6.78	1.22	Supercritical	19.20	0.00	
S13	47.29	6.69	15.47	5.61	14.58	6.07	1.12	Supercritical	16.30	0.00	
S30	29.08	5.92	9.64	4.33	9.17	4.64	1.10	Supercritical	5.90	0.00	
S12-1	29.08	5.92	12.94	5.13	12.40	5.43	1.09	Supercritical	10.40	0.00	
S12-2	29.08	5.92	12.94	5.13	12.40	5.43	1.09	Supercritical	10.40	0.00	
S12-3	29.08	5.92	12.94	5.13	12.40	5.43	1.09	Supercritical	10.40	0.00	
S12-4	29.08	5.92	12.94	5.13	12.40	5.43	1.09	Supercritical	10.40	0.00	
S12-4	29.08	5.92	12.94	5.13	12.40	5.43	1.09	Supercritical	10.40	0.00	
S20	7.45	4.21	8.44	4.18	8.54	4.12	0.98	Subcritical	3.40	0.00	
S11-1	16.04	5.11	9.35	4.32	9.10	4.49	1.05	Supercritical	4.90	0.00	
S11-2	16.04	5.11	9.35	4.32	9.10	4.49	1.05	Supercritical	4.90	0.00	
S11-3	16.04	5.11	9.35	4.32	9.10	4.49	1.05	Supercritical	4.90	0.00	
S10	7.45	4.21	8.04	4.06	8.10	4.02	0.99	Subcritical	3.10	0.00	

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

Sewer Sizing Summary:

			Existing		**Calculated**		**Used**			
Element Name	**Peak Flow (cfs)**	**Cross Section**	**Rise**	**Span**	**Rise**	**Span**	**Rise**	**Span**	**Area (ft^2)**	**Comment**
S14-1	19.20	CIRCULAR	36.00 in	36.00 in	27.00 in	27.00 in	36.00 in	36.00 in	7.07	

S14-2	19.20	CIRCULAR	36.00 in	36.00 in	27.00 in	27.00 in	36.00 in	36.00 in	7.07	
S13	16.30	CIRCULAR	36.00 in	36.00 in	27.00 in	27.00 in	36.00 in	36.00 in	7.07	
S30	5.90	CIRCULAR	30.00 in	30.00 in	18.00 in	18.00 in	30.00 in	30.00 in	4.91	
S12-1	10.40	CIRCULAR	30.00 in	30.00 in	21.00 in	21.00 in	30.00 in	30.00 in	4.91	
S12-2	10.40	CIRCULAR	30.00 in	30.00 in	21.00 in	21.00 in	30.00 in	30.00 in	4.91	
S12-3	10.40	CIRCULAR	30.00 in	30.00 in	21.00 in	21.00 in	30.00 in	30.00 in	4.91	
S12-4	10.40	CIRCULAR	30.00 in	30.00 in	21.00 in	21.00 in	30.00 in	30.00 in	4.91	
S12-4	10.40	CIRCULAR	30.00 in	30.00 in	21.00 in	21.00 in	30.00 in	30.00 in	4.91	
S20	3.40	CIRCULAR	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	1.77	
S11-1	4.90	CIRCULAR	24.00 in	24.00 in	18.00 in	18.00 in	24.00 in	24.00 in	3.14	
S11-2	4.90	CIRCULAR	24.00 in	24.00 in	18.00 in	18.00 in	24.00 in	24.00 in	3.14	
S11-3	4.90	CIRCULAR	24.00 in	24.00 in	18.00 in	18.00 in	24.00 in	24.00 in	3.14	
S10	3.10	CIRCULAR	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	1.77	

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

Grade Line Summary:

Tailwater Elevation (ft): 6303.50

	Invert Elev.		Downstream Manhole Losses		HGL		EGL		
Element Name	**Downstream (ft)**	**Upstream (ft)**	**Bend Loss (ft)**	**Lateral Loss (ft)**	**Downstream (ft)**	**Upstream (ft)**	**Downstream (ft)**	**Friction Loss (ft)**	**Upstream (ft)**
S14-1	6301.75	6302.06	0.00	0.00	6303.50	6303.50	6303.73	0.28	6304.01
S14-2	6302.26	6303.01	0.02	0.00	6303.52	6304.41	6304.24	0.72	6304.96
S13	6303.04	6303.16	0.01	0.00	6304.72	6304.72	6304.97	0.05	6305.02
S30	6303.66	6303.81	0.00	0.07	6305.02	6305.02	6305.09	0.02	6305.12
S12-1	6303.66	6304.71	0.01	0.00	6304.73	6305.79	6305.15	1.05	6306.20
S12-2	6305.01	6306.60	0.07	0.00	6306.05	6307.68	6306.51	1.58	6308.09
S12-3	6306.69	6308.28	0.00	0.00	6307.73	6309.36	6308.19	1.58	6309.77
S12-4	6308.48	6308.73	0.00	0.00	6309.51	6309.81	6309.97	0.25	6310.22
S12-4	6308.93	6309.45	0.00	0.00	6309.96	6310.53	6310.42	0.52	6310.94
S20	6310.45	6310.60	0.00	0.06	6311.16	6311.32	6311.43	0.15	6311.58
S11-1	6309.95	6310.08	0.00	0.00	6310.71	6310.86	6311.02	0.13	6311.15
S11-2	6310.38	6311.43	0.03	0.00	6311.14	6312.21	6311.46	1.04	6312.50
S11-3	6311.72	6311.85	0.03	0.00	6312.48	6312.63	6312.79	0.13	6312.92
S10	6312.35	6312.50	0.04	0.00	6313.02	6313.18	6313.28	0.15	6313.43

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

- Lateral loss = V_fo ^ 2/(2*g)- Junction Loss K * V_fi ^ 2/(2*g).
- Friction loss is always Upstream EGL - Downstream EGL.

Excavation Estimate:

The trench side slope is 1.0 ft/ft
The minimum trench width is 2.00 ft

					Downstream			Upstream				
Element Name	Length (ft)	Wall (in)	Bedding (in)	Bottom Width (ft)	Top Width (ft)	Trench Depth (ft)	Cover (ft)	Top Width (ft)	Trench Depth (ft)	Cover (ft)	Volume (cu. yd)	Comment
S14-1	51.11	4.00	6.00	6.67	0.00	4.45	0.28	9.48	6.57	2.41	69.64	Sewer Too Shallow
S14-2	125.28	4.00	6.00	6.67	9.08	6.38	2.21	9.54	6.60	2.44	208.91	
S13	24.42	4.00	6.00	6.67	9.48	6.58	2.41	9.34	6.50	2.34	41.14	
S30	29.47	3.50	6.00	6.08	8.83	5.96	2.38	9.18	6.13	2.55	42.48	
S12-1	210.90	3.50	6.00	6.08	8.85	5.97	2.38	9.18	6.13	2.55	304.26	
S12-2	317.04	3.50	6.00	6.08	8.57	5.83	2.24	10.04	6.56	2.98	474.53	
S12-3	317.04	3.50	6.00	6.08	9.85	6.47	2.88	10.42	6.75	3.17	520.55	
S12-4	50.11	3.50	6.00	6.08	10.02	6.55	2.97	10.10	6.59	3.01	81.54	
S12-4	104.14	3.50	6.00	6.08	9.70	6.39	2.81	11.18	7.13	3.55	177.50	
S20	29.34	2.50	4.00	4.92	10.17	5.88	3.63	9.88	5.73	3.48	38.11	
S11-1	25.56	3.00	4.00	5.50	10.68	6.42	3.59	10.56	6.36	3.53	39.48	
S11-2	209.01	3.00	4.00	5.50	9.95	6.06	3.23	7.98	5.07	2.24	262.09	
S11-3	25.33	3.00	4.00	5.50	7.39	4.78	1.95	7.22	4.69	1.86	25.21	Sewer Too Shallow
S10	29.34	2.50	4.00	4.92	6.71	4.15	1.90	6.42	4.00	1.75	22.52	Sewer Too Shallow

Total earth volume for sewer trenches = 2308 cubic yards.

- The trench was estimated to have a bottom width equal to the outer pipe diameter plus 36 inches.
- If the calculated width of the trench bottom is less than the minimum acceptable width, the minimum acceptable width was used.
- The sewer wall thickness is equal to: (equivalent diameter in inches/12)+1 inches
- The sewer bedding thickness is equal to:
  - Four inches for pipes less than 33 inches.
  - Six inches for pipes less than 60 inches.
  - Eight inches for all larger sizes.

Program: UDSEWER Math Model Interface 2.2.1.2 **Run Date:** 5/1/2017 6:05:35 PM	# UDSewer Results Summary **Project Title:** Meadowbrook Crossing **Project Description:** 100 year Storm Event

System Input Summary

Rainfall Parameters

Rainfall Return Period: 100
Rainfall Calculation Method: Formula

One Hour Depth (in):
Rainfall Constant "A": 28.5
Rainfall Constant "B": 10
Rainfall Constant "C": 0.786

Rational Method Constraints

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

Sizer Constraints

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

Backwater Calculations:

Tailwater Elevation (ft): 6303.50

Manhole Input Summary:

		Given Flow		Sub Basin Information						
Element Name	Ground Elevation (ft)	Total Known Flow (cfs)	Local Contribution (cfs)	Drainage Area (Ac.)	Runoff Coefficient	5yr Coefficient	Overland Length (ft)	Overland Slope (%)	Gutter Length (ft)	Gutter Velocity (fps)
OUTFALL 1	6305.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S14-1	6307.80	48.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

S14-2	6308.78	48.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S13	6308.83	39.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S30	6309.15	16.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S12-1	6310.05	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S12-2	6312.37	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S12-3	6314.24	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S12-4	6314.53	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S12-5	6315.79	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S20	6315.79	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S11-1	6315.86	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S11-2	6315.92	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S11-3	6315.96	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S10	6315.96	5.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Manhole Output Summary:

	Local Contribution					Total Design Flow				
Element Name	**Overland Time (min)**	**Gutter Time (min)**	**Basin Tc (min)**	**Intensity (in/hr)**	**Local Contrib (cfs)**	**Coeff. Area**	**Intensity (in/hr)**	**Manhole Tc (min)**	**Peak Flow (cfs)**	**Comment**
OUTFALL 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
S14-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.40	
S14-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.40	
S13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	39.70	
S30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.70	
S12-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.00	
S12-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.00	
S12-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.00	
S12-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.00	
S12-5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.00	
S20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	
S11-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.00	
S11-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.00	
S11-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.00	
S10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.50	

Sewer Input Summary:

		Elevation			Loss Coefficients			Given Dimensions		
Element Name	**Sewer Length (ft)**	**Downstream Invert (ft)**	**Slope (%)**	**Upstream Invert (ft)**	**Mannings n**	**Bend Loss**	**Lateral Loss**	**Cross Section**	**Rise (ft or in)**	**Span (ft or in)**
S14-1	51.11	6301.75	0.60	6302.06	0.013	0.03	0.00	CIRCULAR	36.00 in	36.00 in
S14-2	125.28	6302.26	0.60	6303.01	0.013	0.14	0.00	CIRCULAR	36.00 in	36.00 in

S13	24.42	6303.04	0.50	6303.16	0.013	0.13	0.00	CIRCULAR	36.00 in	36.00 in
S30	29.47	6303.66	0.50	6303.81	0.013	0.05	0.42	CIRCULAR	30.00 in	30.00 in
S12-1	210.90	6303.66	0.50	6304.71	0.013	0.20	0.00	CIRCULAR	30.00 in	30.00 in
S12-2	317.04	6305.01	0.50	6306.60	0.013	1.00	0.00	CIRCULAR	30.00 in	30.00 in
S12-3	317.04	6306.69	0.50	6308.28	0.013	0.05	0.00	CIRCULAR	30.00 in	30.00 in
S12-4	50.11	6308.48	0.50	6308.73	0.013	0.06	0.00	CIRCULAR	30.00 in	30.00 in
S12-5	104.14	6308.93	0.50	6309.45	0.013	0.07	0.00	CIRCULAR	30.00 in	30.00 in
S20	29.34	6310.45	0.50	6310.60	0.013	0.05	0.25	CIRCULAR	18.00 in	18.00 in
S11-1	25.56	6309.95	0.50	6310.08	0.013	0.05	0.00	CIRCULAR	24.00 in	24.00 in
S11-2	209.01	6310.38	0.50	6311.43	0.013	0.84	0.00	CIRCULAR	24.00 in	24.00 in
S11-3	25.33	6311.72	0.50	6311.85	0.013	0.80	0.00	CIRCULAR	24.00 in	24.00 in
S10	29.34	6312.35	0.50	6312.50	0.013	0.82	0.00	CIRCULAR	18.00 in	18.00 in

Sewer Flow Summary:

	Full Flow Capacity		Critical Flow		Normal Flow						
Element Name	**Flow (cfs)**	**Velocity (fps)**	**Depth (in)**	**Velocity (fps)**	**Depth (in)**	**Velocity (fps)**	**Froude Number**	**Flow Condition**	**Flow (cfs)**	**Surcharged Length (ft)**	**Comment**
S14-1	51.80	7.33	27.18	8.45	27.58	8.33	0.97	Subcritical	48.40	0.00	
S14-2	51.80	7.33	27.18	8.45	27.58	8.33	0.97	Subcritical	48.40	0.00	
S13	47.29	6.69	24.61	7.71	25.25	7.49	0.95	Subcritical	39.70	0.00	
S30	29.08	5.92	16.58	6.00	16.30	6.13	1.03	Pressurized	16.70	29.47	
S12-1	29.08	5.92	19.58	6.78	20.13	6.57	0.95	Subcritical Surcharged	23.00	52.66	
S12-2	29.08	5.92	19.58	6.78	20.13	6.57	0.95	Subcritical	23.00	0.00	
S12-3	29.08	5.92	19.58	6.78	20.13	6.57	0.95	Subcritical	23.00	0.00	
S12-4	29.08	5.92	19.58	6.78	20.13	6.57	0.95	Subcritical	23.00	0.00	
S12-5	29.08	5.92	19.58	6.78	20.13	6.57	0.95	Subcritical	23.00	0.00	
S20	7.45	4.21	11.35	5.11	12.24	4.69	0.86	Subcritical	6.00	0.00	
S11-1	16.04	5.11	14.27	5.65	14.60	5.50	0.96	Subcritical	11.00	0.00	
S11-2	16.04	5.11	14.27	5.65	14.60	5.50	0.96	Subcritical	11.00	0.00	
S11-3	16.04	5.11	14.27	5.65	14.60	5.50	0.96	Subcritical	11.00	0.00	
S10	7.45	4.21	10.85	4.94	11.51	4.61	0.89	Subcritical	5.50	0.00	

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

Sewer Sizing Summary:

			Existing		Calculated		Used			
Element Name	**Peak Flow (cfs)**	**Cross Section**	**Rise**	**Span**	**Rise**	**Span**	**Rise**	**Span**	**Area (ft^2)**	**Comment**

S14-1	48.40	CIRCULAR	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	7.07	
S14-2	48.40	CIRCULAR	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	7.07	
S13	39.70	CIRCULAR	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	7.07	
S30	16.70	CIRCULAR	30.00 in	30.00 in	27.00 in	27.00 in	30.00 in	30.00 in	4.91	
S12-1	23.00	CIRCULAR	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	4.91	
S12-2	23.00	CIRCULAR	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	4.91	
S12-3	23.00	CIRCULAR	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	4.91	
S12-4	23.00	CIRCULAR	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	4.91	
S12-5	23.00	CIRCULAR	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	4.91	
S20	6.00	CIRCULAR	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	1.77	
S11-1	11.00	CIRCULAR	24.00 in	24.00 in	21.00 in	21.00 in	24.00 in	24.00 in	3.14	
S11-2	11.00	CIRCULAR	24.00 in	24.00 in	21.00 in	21.00 in	24.00 in	24.00 in	3.14	
S11-3	11.00	CIRCULAR	24.00 in	24.00 in	21.00 in	21.00 in	24.00 in	24.00 in	3.14	
S10	5.50	CIRCULAR	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	1.77	

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

Grade Line Summary:

Tailwater Elevation (ft): 6303.50

	Invert Elev.		Downstream Manhole Losses		HGL		EGL		
Element Name	**Downstream (ft)**	**Upstream (ft)**	**Bend Loss (ft)**	**Lateral Loss (ft)**	**Downstream (ft)**	**Upstream (ft)**	**Downstream (ft)**	**Friction Loss (ft)**	**Upstream (ft)**
S14-1	6301.75	6302.06	0.00	0.00	6304.02	6304.38	6305.13	0.31	6305.44
S14-2	6302.26	6303.01	0.10	0.00	6304.52	6305.34	6305.63	0.75	6306.39
S13	6303.04	6303.16	0.06	0.00	6305.95	6306.02	6306.45	0.08	6306.53
S30	6303.66	6303.81	0.01	0.41	6306.77	6306.82	6306.95	0.05	6307.00
S12-1	6303.66	6304.71	0.07	0.00	6306.25	6306.82	6306.59	0.65	6307.24
S12-2	6305.01	6306.60	0.34	0.00	6307.18	6308.23	6307.58	1.36	6308.94
S12-3	6306.69	6308.28	0.02	0.00	6308.33	6310.00	6309.04	1.59	6310.63
S12-4	6308.48	6308.73	0.02	0.00	6310.11	6310.43	6310.82	0.26	6311.08
S12-5	6308.93	6309.45	0.02	0.00	6310.56	6311.16	6311.27	0.53	6311.80
S20	6310.45	6310.60	0.01	0.30	6311.93	6312.00	6312.11	0.08	6312.19
S11-1	6309.95	6310.08	0.01	0.00	6311.55	6311.59	6311.81	0.07	6311.88
S11-2	6310.38	6311.43	0.16	0.00	6311.75	6312.62	6312.07	1.05	6313.11
S11-3	6311.72	6311.85	0.15	0.00	6312.91	6313.08	6313.41	0.13	6313.54
S10	6312.35	6312.50	0.12	0.00	6313.37	6313.47	6313.66	0.13	6313.79

- Bend and Lateral losses only apply when there is an outgoing sewer. The system outfall, sewer #0, is not considered a sewer.

- Bend loss = Bend K * V_fi ^ 2/(2*g)
- Lateral loss = V_fo ^ 2/(2*g)- Junction Loss K * V_fi ^ 2/(2*g).
- Friction loss is always Upstream EGL - Downstream EGL.

Excavation Estimate:

The trench side slope is 1.0 ft/ft
The minimum trench width is 2.00 ft

					Downstream			Upstream				
Element Name	Length (ft)	Wall (in)	Bedding (in)	Bottom Width (ft)	Top Width (ft)	Trench Depth (ft)	Cover (ft)	Top Width (ft)	Trench Depth (ft)	Cover (ft)	Volume (cu. yd)	Comment
S14-1	51.11	4.00	6.00	6.67	0.00	4.45	0.28	9.48	6.57	2.41	69.64	Sewer Too Shallow
S14-2	125.28	4.00	6.00	6.67	9.08	6.38	2.21	9.54	6.60	2.44	208.91	
S13	24.42	4.00	6.00	6.67	9.48	6.58	2.41	9.34	6.50	2.34	41.14	
S30	29.47	3.50	6.00	6.08	8.83	5.96	2.38	9.18	6.13	2.55	42.48	
S12-1	210.90	3.50	6.00	6.08	8.85	5.97	2.38	9.18	6.13	2.55	304.26	
S12-2	317.04	3.50	6.00	6.08	8.57	5.83	2.24	10.04	6.56	2.98	474.53	
S12-3	317.04	3.50	6.00	6.08	9.85	6.47	2.88	10.42	6.75	3.17	520.55	
S12-4	50.11	3.50	6.00	6.08	10.02	6.55	2.97	10.10	6.59	3.01	81.54	
S12-5	104.14	3.50	6.00	6.08	9.70	6.39	2.81	11.18	7.13	3.55	177.50	
S20	29.34	2.50	4.00	4.92	10.17	5.88	3.63	9.88	5.73	3.48	38.11	
S11-1	25.56	3.00	4.00	5.50	10.68	6.42	3.59	10.56	6.36	3.53	39.48	
S11-2	209.01	3.00	4.00	5.50	9.95	6.06	3.23	7.98	5.07	2.24	262.09	
S11-3	25.33	3.00	4.00	5.50	7.39	4.78	1.95	7.22	4.69	1.86	25.21	Sewer Too Shallow
S10	29.34	2.50	4.00	4.92	6.71	4.15	1.90	6.42	4.00	1.75	22.52	Sewer Too Shallow

Total earth volume for sewer trenches = 2308 cubic yards.

- The trench was estimated to have a bottom width equal to the outer pipe diameter plus 36 inches.
- If the calculated width of the trench bottom is less than the minimum acceptable width, the minimum acceptable width was used.
- The sewer wall thickness is equal to: (equivalent diameter in inches/12)+1 inches
- The sewer bedding thickness is equal to:
  - Four inches for pipes less than 33 inches.
  - Six inches for pipes less than 60 inches.
  - Eight inches for all larger sizes.

Meadowbrook Crossing
Swale and Channel Capacity Calculations

Description	Design Flow	Bottom Width	Channel Side Slope Left	Channel Side Slope Right	Flow Depth	Channel Slope	Manning "n"	Top Width	Channel Area	Wetted Perimeter	Rn	Flow Velocity	Channel Flow Capacity
Section A-A	48.4 cfs	10.0 ft	4:1	4:1	1.00 ft	1.0%	0.035	18.0 ft	14.00 sf	18.2 ft	0.77 ft	3.6 ft/sec	**50.0 cfs**

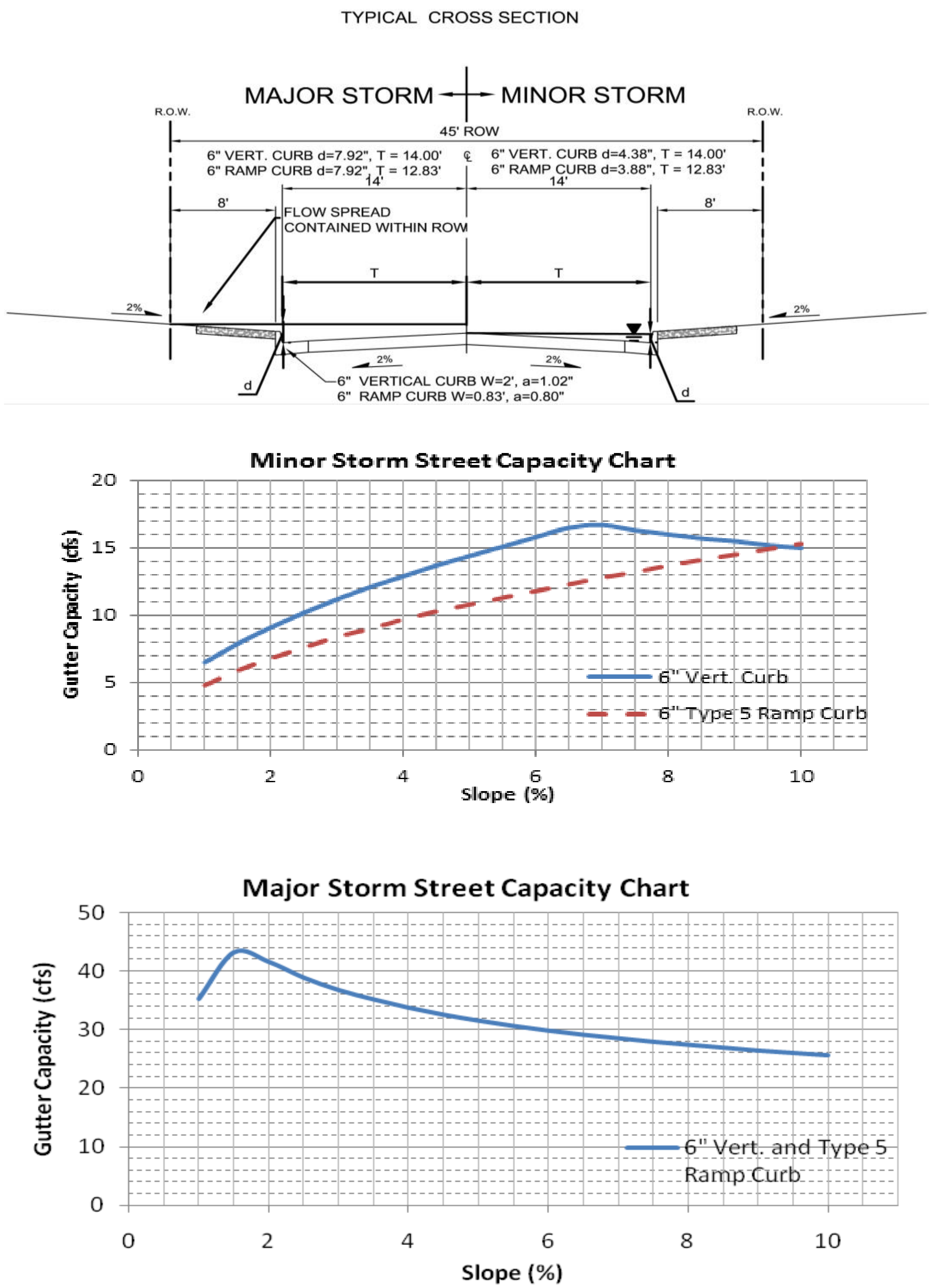
Equations:

Area (A) = $b(d)+zd^2$
b = width
d = depth

Perimeter (P) = $b+2d*(1+z^2)^{0.5}$
z = side slope
Hydraulic Radius = A/P

Velocity = $(1.49/n)R_n^{2/3} S^{1/2}$
S = Slope of the channel
n = Manning's number
R_n = Hydraulic Radius (Reynold's Number)
Flow = $(1.49/n)AR_n^{2/3} S^{1/2}$

Figure 7-9. Street Capacity Charts Minor Residential (Attached Sidewalk)



These charts shall only be used for the standard street sections as shown. The capacity shown is based on ½ the street section as calculated by the UD-Inlet spreadsheets. Minor storm capacities are based on no crown overtopping, curb height or maximum allowable spread widths. Major storm capacities are based on flow being containing within the public right-of-way, including conveyance capacity behind the curb. The UDFCD Safety Reduction Factor was applied. An 'n_{STREET}' of 0.016 and 'n_{BACK}' of 0.020 was used. Calculations were done using UD-Inlet 3.00.xls, March, 2011.

APPENDIX D

Drainageway Calculations

Riprap and Boulder Sizing Calculations
Hydraulic Jump and Basin Length Calculations
Seepage Calculations
Supporting Figures

CLOMR Appendix D: Proposed Conditions HEC-RAS Model

Pages from Sand Creek DBPS

Meadowbrook Subdivision

Riprap and Boulder Design Calculation

Station	Description	Riprap or Boulder	Straight or Curved Section	Flow Velocity	Channel Slope	For Curved Sections rc	T	V_a	Velocity for Calc	Super-elevation dY	Rock Sizing Parameter	Calculated Riprap Type	Calculated Boulder Size	**Riprap or Boulder Classification**	**Note**
22+03	Toe Protection	Riprap	Curve	10.2ft/sec	0.50%	600ft	149ft	16.2ft/sec	16.2ft/sec	0.40ft	4.9	H	---	**H**	
19+83	Upstream of Drop Crest	Riprap	Straight	8.2ft/sec	0.50%				8.2ft/sec		2.5	VL	---	**M**	1
19+10	Downstream of Drop Sill	Riprap	Straight	7.8ft/sec	0.40%				7.8ft/sec		2.3	VL	---	**M**	2
18+35	Toe Protection, Outside Bend	Riprap	Curve	8.2ft/sec	0.40%	300ft	158ft	15.5ft/sec	15.5ft/sec	0.55ft	4.6	M	---	**M**	
18+35	Toe Protection	Riprap	Straight	8.2ft/sec	0.40%				8.2ft/sec		2.4	VL	---	**L**	3
14+45	Upstream of Drop Crest	Riprap	Straight	8.1ft/sec	0.40%				8.1ft/sec		2.4	VL	---	**M**	1
13+79	Downstream of Drop Sill	Riprap	Straight	7.3ft/sec	0.30%				7.3ft/sec		2.0	VL	---	**M**	2
13+25	Toe Protection, Outside Bend	Riprap	Curve	10.3ft/sec	0.30%	500ft	158ft	17.6ft/sec	17.6ft/sec	0.52ft	4.9	H	---	**H**	
13+25	Toe Protection	Riprap	Straight	10.3ft/sec	0.30%				10.3ft/sec		2.9	VL	---	**L**	3
19+73	Upper Drop Structure	Boulder	Straight	10.5ft/sec	16.67%				10.5ft/sec		5.8	---	B30	**B30**	
14+35	Lower Drop Structure	Boulder	Straight	10.5ft/sec	16.67%				10.5ft/sec		5.8	---	B30	**B30**	

Equations:

Rock Sizing Parameter = $VS^{0.17}/(G_s-1)^{0.66}$

V = Mean channel flow velocity for Riprap Sizing

V = Critical Velocity for Grouted Boulder Sizing

S = Longitudinal channel slope

G_s = Specific Gravity of stone (minimum G_s = 2.50)

G_s = 2.55 (UDFCD Recommended)

G_s = 2.55

Straight	Boulder
Curve	Riprap

Equations taken from *UDFCD USDCM (Eqn MD-13 & HS-9)* and *City of Colorado Springs & El Paso County Drainage Criteria Manual*

$v_a = (-0.147\ r_c/T + 2.176)V$ (Eqn UDFCD MD-10)

V_a = Adjusted channel velocity for riprap sizing along outside of channel bends

r_c = channel centerline radius

T = Top width of water during the major design flood

Superelevation (dY) = $V^2T/2gr_c$ (Eqn UDFCD MD-9)

V = Mean channel flow velocity

T = Top Width of the channel under design flow conditions

g = Gravitational constant = 32.2 ft/sec^2

r_c = channel centerline radius

Rock Sizing Parameter		Riprap Type	D50	
0.00	3.29	VL	6 inches	VL
3.30	3.99	L	9 inches	L
4.00	4.59	M	12 inches	M
4.60	5.59	H	18 inches	H
5.60	6.40	VH	24 inches	VH

Rock Sizing Parameter		Grouted Boulder Classification	Grouted Boulder Min. Dimension	
				B18
				B24
0.00	4.49	B18	18 inches	B30
4.50	4.99	B18	18 inches	B36
5.00	5.59	B24	24 inches	B42
5.60	6.39	B30	30 inches	B48
6.40	6.99	B36	36 inches	
7.00	7.49	B42	42 inches	
7.50	8.00	B48	48 inches	

<u>Notes:</u>
1. Type M Riprap is minimum size recommended for areas immediately upstream of drop structures (water surface drawdown area).
2. Type M Riprap is minimum size recommended for areas immediately downstream of drop structures (hydraulic jump area).
3. Type L Riprap is minimum size recommended for bank lining/toe protection.

Meadowbrook Subdivision

Hydraulic Jump and Basin Length Calculations

Upper Drop Structure (Crest Station 19+73)

Hec Ras Mixed Flow Analysis (100-year)

				Supercritical Analysis						Subcritical Analysis					
	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Vel Chnl	Froude # Chl	Max Chl Dpth	Specif Force	W.S. Elev	Crit W.S.	Vel Chnl	Froude # Chl	Max Chl Dpth	Specif Force
		(cfs)	(ft)	(ft)	(ft)	(ft/s)		(ft)	(cu ft)	(ft)	(ft)	(ft/s)		(ft)	(cu ft)
Drop Crest	1973	5330	6309.73	6313.50	6313.50	10.48	1.00	3.77	2656.70	6313.50	6313.50	10.48	1.00	3.76	2656.70
	1971.09	5330	6309.41	6312.72	6313.17	12.09	1.23	3.31	2706.63	6313.18	6313.18	10.47	1.00	3.77	2656.70
	1969.18	5330	6309.08	6312.52	6312.84	11.57	1.15	3.44	2681.33	6312.85	6312.85	10.48	1.00	3.76	2656.70
	1967.27	5330	6308.76	6312.22	6312.52	11.50	1.14	3.46	2678.22	6312.53	6312.53	10.47	1.00	3.77	2656.70
	1965.36	5330	6308.44	6312.13	6312.20	10.73	1.04	3.69	2658.32	6312.21	6312.21	10.48	1.00	3.76	2656.70
	1963.45	5330	6308.11	6311.87	6311.87	10.49	1.00	3.76	2656.71	6311.88	6311.88	10.47	1.00	3.77	2656.70
	1961.54	5330	6307.79	6311.10	6311.55	12.10	1.23	3.31	2706.74	6311.56	6311.56	10.48	1.00	3.76	2656.70
	1959.63	5330	6307.46	6310.88	6311.22	11.65	1.17	3.42	2684.58	6311.23	6311.23	10.47	1.00	3.77	2656.70
Jump Begins	1958.68	5330	6307.30	6311.07	6311.07	10.47	1.00	3.77	2656.70	6311.32	6311.06	9.74	0.91	4.02	2669.18
	1956.77	5330	6306.98	6310.29	6310.75	12.09	1.23	3.31	2706.52	6311.45	6310.74	8.64	0.77	4.47	2749.99
	1954.86	5330	6306.66	6310.10	6310.43	11.60	1.16	3.43	2682.55	6311.54	6310.42	7.83	0.67	4.88	2879.22
	1952.95	5330	6306.33	6310.00	6310.10	10.79	1.05	3.67	2659.12	6311.60	6310.09	7.16	0.59	5.27	3050.32
	1951	5330	6306.00	6309.76	6309.78	10.61	1.02	3.76	2664.71	6311.65	6309.79	6.68	0.53	5.65	3238.94
	1949	5330	6305.67	6309.51	6309.51	10.57	1.00	3.84	2679.66	6311.68	6309.51	6.33	0.49	6.01	3431.43
	1947	5330	6305.34	6309.23	6309.23	10.62	1.00	3.89	2695.30	6311.70	6309.23	6.04	0.46	6.36	3636.49
	1945	5330	6305.00	6308.95	6308.95	10.68	1.00	3.95	2711.62	6311.72	6308.95	5.77	0.43	6.72	3859.51
Drop Toe	1943	5330	6304.67	6308.27	6308.67	12.09	1.19	3.60	2763.68	6311.74	6308.67	5.54	0.40	7.07	4085.22
	1941	5330	6304.67	6308.27	6308.67	12.11	1.19	3.59	2764.70	6311.73	6308.67	5.54	0.40	7.06	4081.18

Jump begins at Sta. 19+58.68 which is on the drop face, 16' upstream of the drop toe (Sta. 19+43). Calculate minimum drop basin length starting from drop toe:

Hydraulic Jump Length, Figure 15-4 (Chow)

F_1 =	1.17	L/Y_2 =	3.3
Y_2 (ft)=	7.07	L (ft)=	23.33
		60%L (ft)=	14.00

(Minimum required length from toe for protection, minimum Basin Length) = **14.0'**	**use 20'**

(blue)	Froude No. at beginning of hydraulic jump
(orange)	Specific Force (cu ft) at beginning of hydraulic jump (at location where Specific Force (subcritical) > Specific Force (supercritical))
(green)	Maximum Channel Depth (ft) at approximate downstream end of hydraulic jump

Meadowbrook Subdivision

Hydraulic Jump and Basin Length Calculations

Lower Drop Structure (Crest Station 14+35)

Hec Ras Mixed Flow Analysis (100-year)

				Supercritical Analysis						Subcritical Analysis					
	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Vel Chnl	Froude # Chl	Max Chl Dpth	Specif Force	W.S. Elev	Crit W.S.	Vel Chnl	Froude # Chl	Max Chl Dpth	Specif Force
		(cfs)	(ft)	(ft)	(ft)	(ft/s)		(ft)	(cu ft)	(ft)	(ft)	(ft/s)		(ft)	(cu ft)
Drop Crest	1435	5330	6304.22	6307.98	6307.98	10.49	1.00	3.76	2656.71	6307.99	6307.99	10.47	1.00	3.77	2656.69
	1433.13	5330	6303.90	6307.21	6307.66	12.10	1.23	3.31	2707.18	6307.67	6307.67	10.48	1.00	3.76	2656.70
	1431.26	5330	6303.59	6307.03	6307.35	11.57	1.15	3.44	2681.33	6307.36	6307.36	10.47	1.00	3.77	2656.69
	1429.4	5330	6303.27	6306.73	6307.03	11.50	1.14	3.46	2678.43	6307.10	6307.03	10.28	0.98	3.83	2657.42
	1428.46	5330	6303.11	6306.42	6306.88	12.10	1.23	3.31	2707.29	6307.20	6306.87	9.57	0.88	4.09	2676.28
Jump Begins	1427.53	5330	6302.95	6306.64	6306.71	10.74	1.04	3.68	2658.40	6307.26	6306.71	9.00	0.81	4.31	2713.68
	1425.66	5330	6302.63	6306.39	6306.39	10.49	1.00	3.76	2656.71	6307.37	6306.39	8.10	0.70	4.73	2827.78
	1423.8	5330	6302.32	6306.08	6306.08	10.49	1.00	3.76	2656.71	6307.43	6306.08	7.42	0.62	5.11	2975.69
	1421.93	5330	6302.00	6305.31	6305.76	12.10	1.23	3.31	2707.07	6307.49	6305.77	6.84	0.55	5.49	3159.08
	1420	5330	6301.67	6305.16	6305.46	11.52	1.14	3.49	2685.72	6307.52	6305.46	6.41	0.50	5.85	3360.75
	1418	5330	6301.34	6304.94	6305.18	11.36	1.11	3.60	2693.36	6307.55	6305.18	6.09	0.47	6.21	3563.99
	1416	5330	6301.00	6304.82	6304.89	10.86	1.04	3.82	2697.28	6307.57	6304.89	5.81	0.44	6.57	3784.75
	1414	5330	6300.67	6304.60	6304.62	10.73	1.01	3.93	2711.50	6307.59	6304.62	5.57	0.41	6.92	4011.21
Drop Toe	1412	5330	6300.33	6304.34	6304.34	10.73	1.00	4.01	2728.19	6307.60	6304.34	5.35	0.38	7.27	4253.02
	1410	5330	6300.33	6304.33	6304.33	10.74	1.01	4.00	2728.17	6307.60	6304.33	5.35	0.39	7.27	4248.55

Jump begins at Sta. 14+27.53 which is on the drop face, 15.5' upstream of the drop toe (Sta. 14+12). Calculate minimum drop basin length starting from drop toe:

Hydraulic Jump Length, Figure 15-4 (Chow)

F_1 =	1.23	L/Y_2 =	3.3
Y_2 (ft)=	7.27	L (ft)=	23.99
		60%L (ft)=	14.39

(Minimum required length from toe for protection, minimum Basin Length) = **14.4'**	**use 20'**

(blue)	Froude No. at beginning of hydraulic jump
(orange)	Specific Force (cu ft) at beginning of hydraulic jump (at location where Specific Force (subcritical) > Specific Force (supercritical))
(green)	Maximum Channel Depth (ft) at approximate downstream end of hydraulic jump

Hydraulic jump locations were calculated using criteria from the Urban Storm Drainage Criteria Manual Vol. II, Hydraulic Structures section 2.3.4
Hydraulic jump lengths were calculated using criteria from the Urban Storm Drainage Criteria Manual Vol. II, Hydraulic Structures section 2.3.5
and from Open Channel Hydraulics by Ven Te Chow
HEC-RAS was used for the frontwater (supercirtical profile analysis) and for the backwater (subcritical profile analysis)

To determine the location of the hydraulic jump, a tailwater elevation has to be established by water surface profile analysis that starts from a downstream control point and works upstream to the drop basin. This backwater analysis is based upon entire cross sections for the downstream waterway. The hydraulic jump, in either the low-flow, trickle channel, or the main drop, will begin to form where the unit specific force of the downstream tailwater is greater than the specific force of the supercritical flow below the drop. Special consideration must be given to submerged hydraulic jumps because it is here that reverse rollers are most common. For submerged jumps, the resulting downstream hydraulics should be evaluated (Cotton 1995).

The determination of the jump location is usually accomplished through the comparison of specific force between supercritical inflow and the downstream subcritical flow (i.e., tailwater) conditions:

$$F = \left(\frac{q^2}{gy}\right) + \left(\frac{y^2}{2}\right) \qquad \text{(HS-6)}$$

in which:

F = specific force (ft^2)

q = unit discharge (determined at crest, for low-flow, trickle, and main channel zones) (cfs/ft)

y = depth at analysis point (ft)

g = acceleration of gravity = 32.2 ft/sec^2

The depth, y, for downstream specific energy determination is the tailwater water surface elevation minus the ground elevation at the point of interest, which is typically the main basin elevation or the trickle channel invert (if the jump is to occur in the basin). The depth, for the upstream specific energy (supercritical flow), is the supercritical flow depth at the point in question.

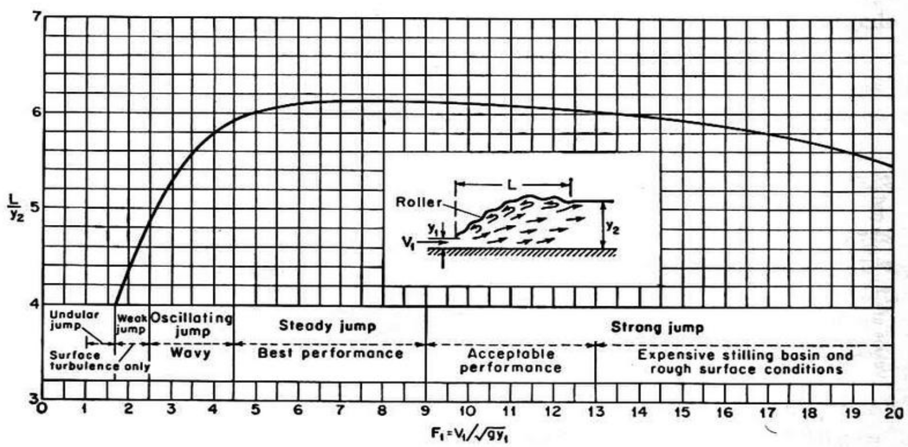


FIG. 15-4. Length in terms of sequent depth y_2 of jumps in horizontal channels. *(Based on data and recommendations of U.S. Bureau of Reclamation* [34].)

Figure 15-4 (Chow), Used to determine the length of the hydraulic jump

KIOWA ENGINEERING CORPORATION

JOB 16039 – MEADOWBROOK SUBDIV.
SHEET NO. 1 OF 2
CALCULATED BY CJC DATE 11/07/16
CHECKED BY ______ DATE ______
SCALE ______

DETERMINE BASIN LENGTH FOR EA. DROP STRUCTURE – FROM HEC-RAS

UPPER DROP (CREST STA. 19+73):

APPROX. 2-YR. FLOW ($\frac{1}{2}$ OF 10 YR. OF 1,940 CFS = 970 CFS) –

JUMP OCCURS AT STA. 19+52 (ON FACE, 21' D/S OF CREST, 9' U/S OF TOE)

CREST STA. ≐ 19+73

TOE STA. = 19 + 43

$F_{r_1} = 2.30$

$Y_2 = 3.62$ FT.

$\frac{L}{Y_2} \simeq 4.7$ (FIG. 15-4, CHOW - HYD. JUMP LENGTH)

$L = 4.7(3.62 \text{ FT.}) = 17.0$ FT.

BASIN LENGTH = 60% L = 0.6 L = 0.6 (17.0) = **10.2 FT.**

10-YR. FLOW (Q = 1,940 CFS) –

JUMP STA. = 19+51 (ON FACE, 22' D/S OF CREST, 8' U/S OF TOE)

CREST STA. = 19+73

TOE STA. = 19+43

$F_{r_1} = 2.28$

$Y_2 = 4.64$ FT.

$\frac{L}{Y_2} \simeq 4.7$

$L = 4.7(4.64 \text{ FT.}) = 21.8$ FT.

BASIN LENGTH = 60% L = 0.6L = 0.6 (21.8 FT.) = **13.1 FT.**

* 100-YR. FLOW (Q = 5,330 CFS) –

JUMP STA. = 19+59 (ON FACE, 14' D/S OF CREST, 16' U/S OF TOE)

$F_{r_1} = 1.17$

$Y_2 = 7.07$ FT.

$\frac{L}{Y_2} \simeq 3.3$

$L = 3.3(7.07 \text{ FT.}) = 23.3$ FT.

BASIN LENGTH = 60% L = 0.6 (23.3 FT.) = **14.0 FT.**

USE 20.0'

KIOWA ENGINEERING CORPORATION

JOB 16039 – MEADOWBROOK SUBDIV.
SHEET NO. 2 OF 2
CALCULATED BY CJC DATE 11/07/16
CHECKED BY DATE
SCALE

LOWER DROP (CREST STA. 14+35):

APPROX. 2-YR. FLOW ($Q = 970$ CFS) –

JUMP STA. = 14+23 (ON FACE, 12' D/S OF CREST, 11' U/S OF TOE)

CREST STA. = 14+35

TOE STA. = 14+12

$F_{r_1} = 2.13$

$Y_2 = 3.83$ FT.

$\frac{L}{Y_2} \simeq 4.5$

$L = 4.5(3.83 \text{ FT.}) = 17.2$ FT.

BASIN LENGTH = 60% L = 0.6 (17.2) = **10.3 FT.**

10-YR. FLOW ($Q = 1,940$ CFS) –

JUMP STA. = 14+22 (ON FACE, 13' D/S OF CREST, 10' U/S OF TOE)

$F_{r_1} = 2.06$

$Y_2 = 4.83$ FT.

$\frac{L}{Y_2} \simeq 4.5$

$L = 4.5(4.83 \text{ FT.}) = 21.7$ FT.

BASIN LENGTH = 0.6 (21.7) = **13.0 FT.**

* 100-YR. FLOW ($Q = 5,330$ CFS) –

JUMP STA. = 14+27.5 (ON FACE, 7.5' D/S OF CREST, 15.5' U/S OF TOE)

$F_{r_1} = 1.23$

$Y_2 = 7.27$ FT.

$\frac{L}{Y_2} \simeq 3.3$

$L = 3.3(7.27 \text{ FT.}) = 24.0$ FT.

BASIN LENGTH = 0.6 (24.0) = **14.4 FT.**

USE 20.0'

D PRODUCT 207

Seepage Analysis (Lane's Weighted Creep Method Calculation)

Location	C_w	Weep Drain System	**C_w**	**H_s**	Drop Height	L_a	L_f	L_s	**L_H**	Required $L_{v\text{-calc}}$	**$L_{V\text{-Struct}}$**	L_v Difference $L_{v\text{-calc}}$ and $L_{v\text{-Struct}}$	Additional Calculated Cut off Wall Depth	**Additional Cutoff Wall Depth[1]**
Sta. 19+73.04	7.0	No	**7.0**	**5.6 ft**	3.6 ft	10.0ft	30.4ft	23.0ft	**63.4 ft**	18.1 ft	**6.5 ft**	11.6 ft	5.8 ft	**6 ft**
Sta. 14+35	7.0	No	**7.0**	**3.5 ft**	2.4 ft	10.0ft	23.3ft	23.0ft	**56.3 ft**	5.7 ft	**6.5 ft**	0.0 ft	0.0 ft	**4 ft**

Equations:

$C_w = [(L_H/3)+L_v] / H_s$ (USDCM Eqn 9-5)

C_w = Lane's Weighted Creep Ratio

Table 9-3: Lane's Weighted Creep Recommended Ratios (USDCM)

- C_w = 8.5 Very fine sand or silt
- C_w = 7.0 Fine Sand
- C_w = 6.0 Medium Sand
- C_w = 5.0 Coarse Sand
- C_w = 4.0 Fine Gravel
- C_w = 3.0 Coarse gravel including cobbles or Soft Clay
- C_w = 2.0 Medium Clay

Weep Drain System: 10% Reduction is C_w if weep drain system is used

H_s = Head Differential between analysis points -- Taken from HEC-Ras

Yes
No

Drop Height = Difference between Crest and Sill

L_H = Sum of the Horizontal Creep Distances (Less than 45 degrees)

$L_H = L_a + L_f$

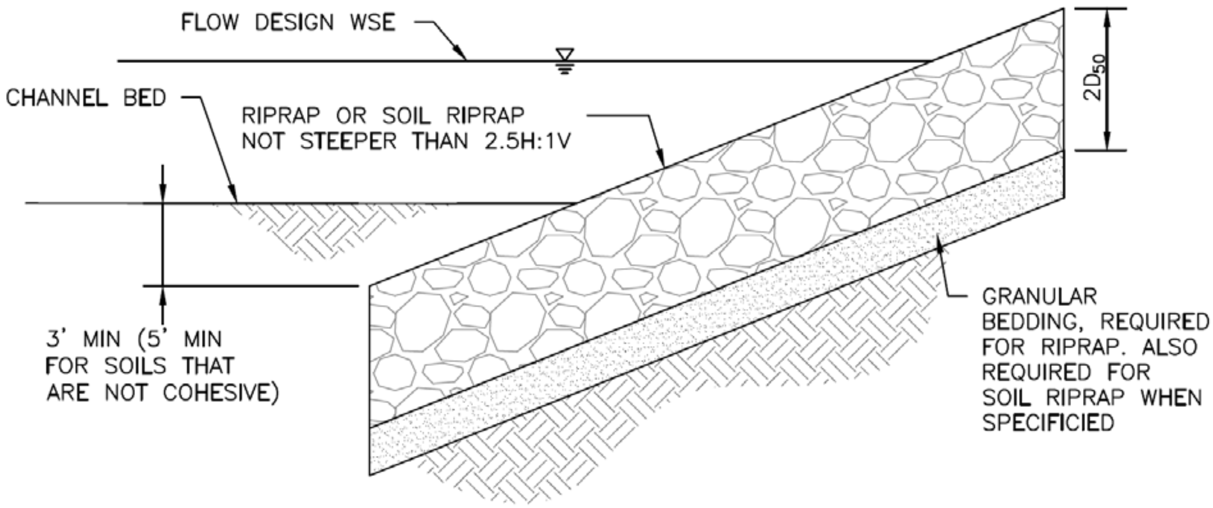
- L_a = Approach Length
- L_s = Length of stilling basin (Toe to Sill)
- L_f = Drop Face Length (Crest to Toe)

L_v = Sum of the Vertical Creep Distances (Steeper than 45 degrees)

$L_{v\text{-Struct}}$ = Vertical creep distances of structure w/o cut off wall

Additional Calculated Cutoff Wall Depth = Half of L_v Difference if Sheet Pile

[1] 4.0 ft minimum recommended for Additional Cutoff Wall Depth.



RIPRAP DESIGNATION	% SMALLER THAN GIVEN SIZE BY WEIGHT	INTERMEDIATE ROCK DIMENSION (INCHES)	D_{50}* (INCHES)
TYPE VL	70 – 100 50 – 70 35 – 50 2 – 10	12 9 6 2	6
TYPE L	70 – 100 50 – 70 35 – 50 2 – 10	15 12 9 3	9
TYPE M	70 – 100 50 – 70 35 – 50 2 – 10	21 18 12 4	12
TYPE H	70 – 100 50 – 70 35 – 50 2 – 10	30 24 18 6	18
*D_{50} = MEAN ROCK SIZE			

Figure 8-34. Riprap and soil riprap placement and gradation (part 1 of 3)

APPENDIX D

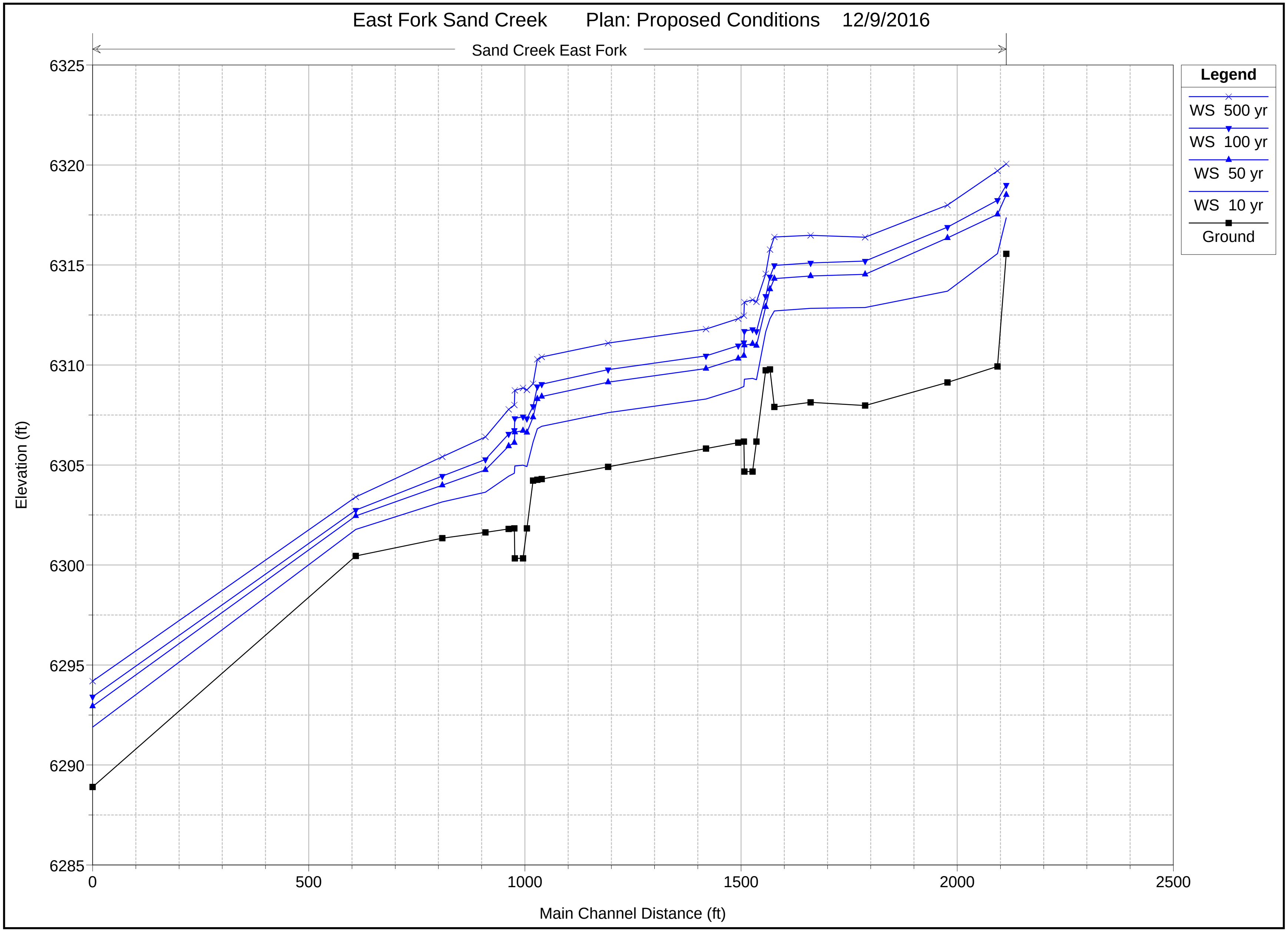
PROPOSED CONDITIONS HEC-RAS MODEL
SAND CREEK EAST FORK

HEC-RAS Plan: Proposed River: Sand Creek Reach: East Fork

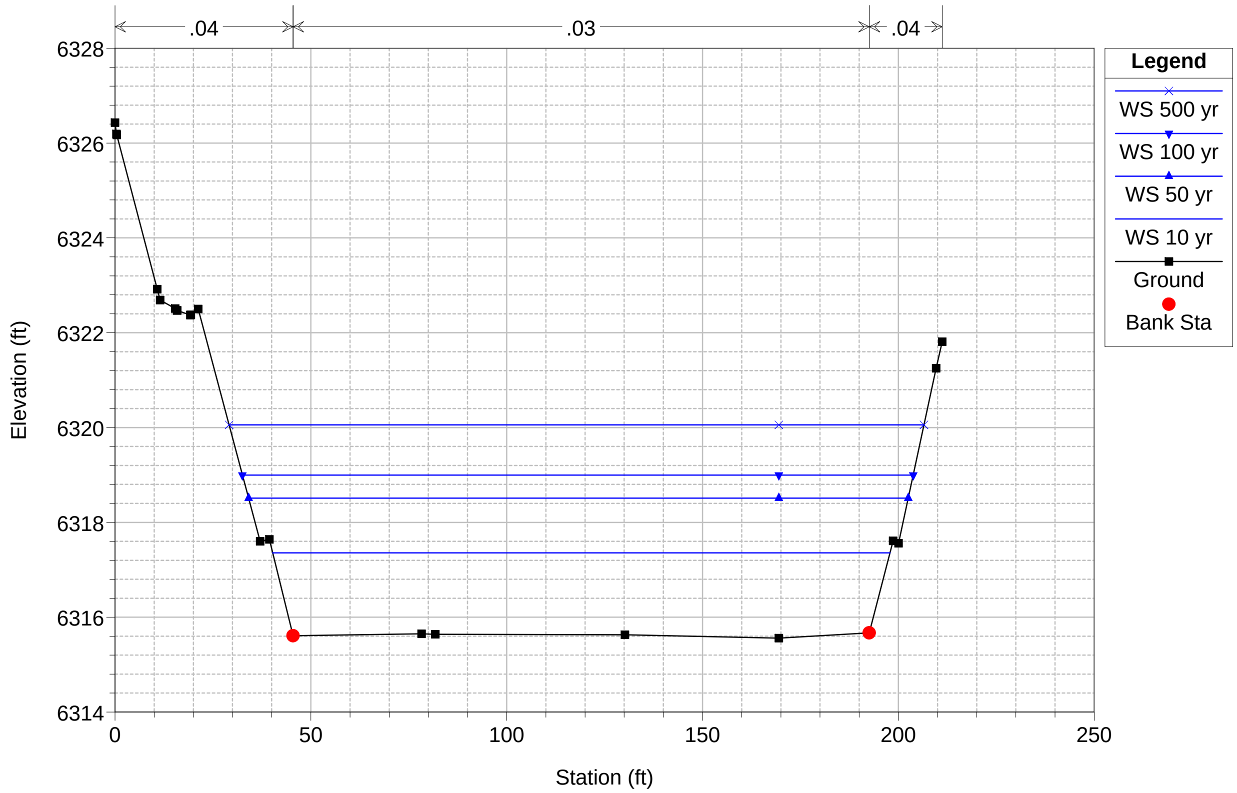
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
East Fork	2529	10 yr	1940.00	6315.56	6317.36	6317.36	6318.21	0.010874	7.47	264.75	157.62	1.00
East Fork	2529	50 yr	4180.00	6315.56	6318.51	6318.51	6319.89	0.009018	9.55	454.04	168.43	0.99
East Fork	2529	100 yr	5330.00	6315.56	6319.00	6319.00	6320.62	0.008627	10.35	536.56	171.26	0.99
East Fork	2529	500 yr	8120.00	6315.56	6320.06	6320.06	6322.16	0.007871	11.86	721.20	177.43	0.99
East Fork	2509	10 yr	1940.00	6309.93	6315.57	6312.08	6315.67	0.000299	2.62	774.85	155.71	0.20
East Fork	2509	50 yr	4180.00	6309.93	6317.53	6313.30	6317.78	0.000477	4.07	1089.67	164.92	0.27
East Fork	2509	100 yr	5330.00	6309.93	6318.24	6313.83	6318.57	0.000566	4.71	1207.04	168.24	0.29
East Fork	2509	500 yr	8120.00	6309.93	6319.71	6314.99	6320.24	0.000734	6.01	1459.63	175.59	0.34
East Fork	2394	10 yr	1940.00	6309.13	6313.69	6313.69	6315.41	0.009070	10.78	190.40	57.12	1.01
East Fork	2394	50 yr	4180.00	6309.13	6316.35	6316.06	6317.54	0.007487	8.93	481.81	158.55	0.90
East Fork	2394	100 yr	5330.00	6309.13	6316.89	6316.57	6318.30	0.007151	9.73	568.07	161.19	0.91
East Fork	2394	500 yr	8120.00	6309.13	6318.00	6317.67	6319.91	0.006831	11.38	749.42	166.62	0.93
East Fork	2203	10 yr	1940.00	6307.97	6312.87	6312.08	6313.76	0.005206	7.55	257.12	73.25	0.71
East Fork	2203	50 yr	4180.00	6307.97	6314.53	6314.53	6316.14	0.006806	10.38	436.36	145.48	0.84
East Fork	2203	100 yr	5330.00	6307.97	6315.20	6315.20	6316.95	0.006750	11.01	534.57	149.92	0.84
East Fork	2203	500 yr	8120.00	6307.97	6316.39	6316.39	6318.56	0.007154	12.47	717.43	156.67	0.88
East Fork	2077	10 yr	1940.00	6308.13	6312.83	6311.37	6313.19	0.002246	4.80	403.95	132.73	0.49
East Fork	2077	50 yr	4180.00	6308.13	6314.45	6312.92	6315.13	0.002661	6.63	632.51	148.04	0.56
East Fork	2077	100 yr	5330.00	6308.13	6315.10	6313.51	6315.94	0.002788	7.34	731.09	153.31	0.58
East Fork	2077	500 yr	8120.00	6308.13	6316.48	6314.69	6317.65	0.002964	8.67	950.49	164.18	0.62
East Fork	1993	10 yr	1940.00	6307.90	6312.71	6310.98	6312.95	0.002596	4.00	485.61	146.24	0.39
East Fork	1993	50 yr	4180.00	6307.90	6314.32	6312.27	6314.82	0.003453	5.70	732.70	159.90	0.47
East Fork	1993	100 yr	5330.00	6307.90	6314.98	6312.83	6315.61	0.003726	6.34	840.34	165.50	0.50
East Fork	1993	500 yr	8120.00	6307.90	6316.40	6314.00	6317.27	0.004027	7.49	1090.46	193.44	0.53
East Fork	1983	10 yr	1940.00	6309.78	6312.32	6311.71	6312.83	0.008467	5.74	337.88	143.65	0.66
East Fork	1983	50 yr	4180.00	6309.78	6313.79	6312.96	6314.66	0.008216	7.48	558.82	155.91	0.70
East Fork	1983	100 yr	5330.00	6309.78	6314.41	6313.48	6315.43	0.008167	8.12	656.31	161.02	0.71
East Fork	1983	500 yr	8120.00	6309.78	6315.77	6314.63	6317.08	0.007592	9.19	886.72	198.29	0.71
East Fork	1973	10 yr	1940.00	6309.73	6311.66	6311.66	6312.58	0.021384	7.69	252.16	138.59	1.01
East Fork	1973	50 yr	4180.00	6309.73	6312.91	6312.91	6314.37	0.018303	9.69	431.30	148.93	1.00
East Fork	1973	100 yr	5330.00	6309.73	6313.44	6313.44	6315.12	0.017513	10.42	511.74	153.35	1.00
East Fork	1973	500 yr	8120.00	6309.73	6314.56	6314.56	6316.72	0.016341	11.80	688.20	164.27	1.01
East Fork	1952	10 yr	1940.00	6306.17	6309.26	6308.10	6309.60	0.004332	4.64	417.75	147.56	0.49
East Fork	1952	50 yr	4180.00	6306.17	6310.97	6309.35	6311.56	0.004440	6.13	681.68	161.32	0.53
East Fork	1952	100 yr	5330.00	6306.17	6311.68	6309.89	6312.37	0.004469	6.68	798.49	167.05	0.54
East Fork	1952	500 yr	8120.00	6306.17	6313.16	6311.03	6314.08	0.004456	7.70	1058.17	206.27	0.56
East Fork	1943	10 yr	1940.00	6304.67	6309.33	6306.73	6309.49	0.001287	3.22	601.93	147.64	0.28
East Fork	1943	50 yr	4180.00	6304.67	6311.06	6308.04	6311.42	0.001985	4.81	869.52	161.72	0.37
East Fork	1943	100 yr	5330.00	6304.67	6311.77	6308.61	6312.23	0.002217	5.40	987.37	167.54	0.39
East Fork	1943	500 yr	8120.00	6304.67	6313.26	6309.81	6313.92	0.002545	6.52	1251.83	216.83	0.43
East Fork	1924	10 yr	1940.00	6304.67	6309.29	6306.76	6309.46	0.001389	3.32	583.68	144.69	0.29
East Fork	1924	50 yr	4180.00	6304.67	6310.99	6308.10	6311.37	0.002159	4.97	840.79	158.28	0.38
East Fork	1924	100 yr	5330.00	6304.67	6311.69	6308.68	6312.17	0.002416	5.59	953.90	163.89	0.41
East Fork	1924	500 yr	8120.00	6304.67	6313.14	6309.89	6313.85	0.002807	6.77	1203.63	201.13	0.45
East Fork	1923	10 yr	1940.00	6306.17	6308.93	6308.14	6309.38	0.006665	5.37	361.53	142.09	0.59
East Fork	1923	50 yr	4180.00	6306.17	6310.47	6309.39	6311.25	0.006794	7.09	589.47	154.40	0.64
East Fork	1923	100 yr	5330.00	6306.17	6311.12	6309.93	6312.04	0.006786	7.71	691.59	159.61	0.65
East Fork	1923	500 yr	8120.00	6306.17	6312.47	6311.08	6313.69	0.006776	8.87	914.96	170.45	0.68
East Fork	1910	10 yr	1940.00	6306.12	6308.80	6308.09	6309.28	0.007354	5.54	350.37	141.45	0.62
East Fork	1910	50 yr	4180.00	6306.12	6310.32	6309.34	6311.14	0.007331	7.27	574.99	153.63	0.66
East Fork	1910	100 yr	5330.00	6306.12	6310.97	6309.88	6311.93	0.007285	7.89	675.60	158.79	0.67
East Fork	1910	500 yr	8120.00	6306.12	6312.32	6311.03	6313.59	0.007190	9.05	896.94	169.58	0.69
East Fork	1835	10 yr	1940.00	6305.82	6308.30	6307.79	6308.86	0.003848	6.03	321.73	139.83	0.70
East Fork	1835	50 yr	4180.00	6305.82	6309.82	6309.04	6310.74	0.003674	7.68	543.97	152.01	0.72
East Fork	1835	100 yr	5330.00	6305.82	6310.46	6309.58	6311.53	0.003654	8.29	642.83	157.12	0.72
East Fork	1835	500 yr	8120.00	6305.82	6311.79	6310.73	6313.18	0.003649	9.44	859.87	167.80	0.74
East Fork	1609	10 yr	1940.00	6304.91	6307.62	6306.87	6308.08	0.002874	5.48	354.14	141.73	0.61
East Fork	1609	50 yr	4180.00	6304.91	6309.14	6308.13	6309.95	0.003060	7.22	578.98	153.93	0.66
East Fork	1609	100 yr	5330.00	6304.91	6309.77	6308.68	6310.73	0.003135	7.86	677.77	158.99	0.67
East Fork	1609	500 yr	8120.00	6304.91	6311.10	6309.82	6312.37	0.003223	9.06	897.12	183.30	0.69
East Fork	1455	10 yr	1940.00	6304.30	6306.94	6306.23	6307.41	0.007459	5.52	351.55	144.22	0.62
East Fork	1455	50 yr	4180.00	6304.30	6308.43	6307.47	6309.25	0.007493	7.26	575.41	156.51	0.67
East Fork	1455	100 yr	5330.00	6304.30	6309.04	6308.01	6310.01	0.007533	7.91	673.43	161.60	0.68
East Fork	1455	500 yr	8120.00	6304.30	6310.40	6309.15	6311.66	0.007162	8.99	914.58	228.27	0.69

HEC-RAS Plan: Proposed River: Sand Creek Reach: East Fork (Continued)

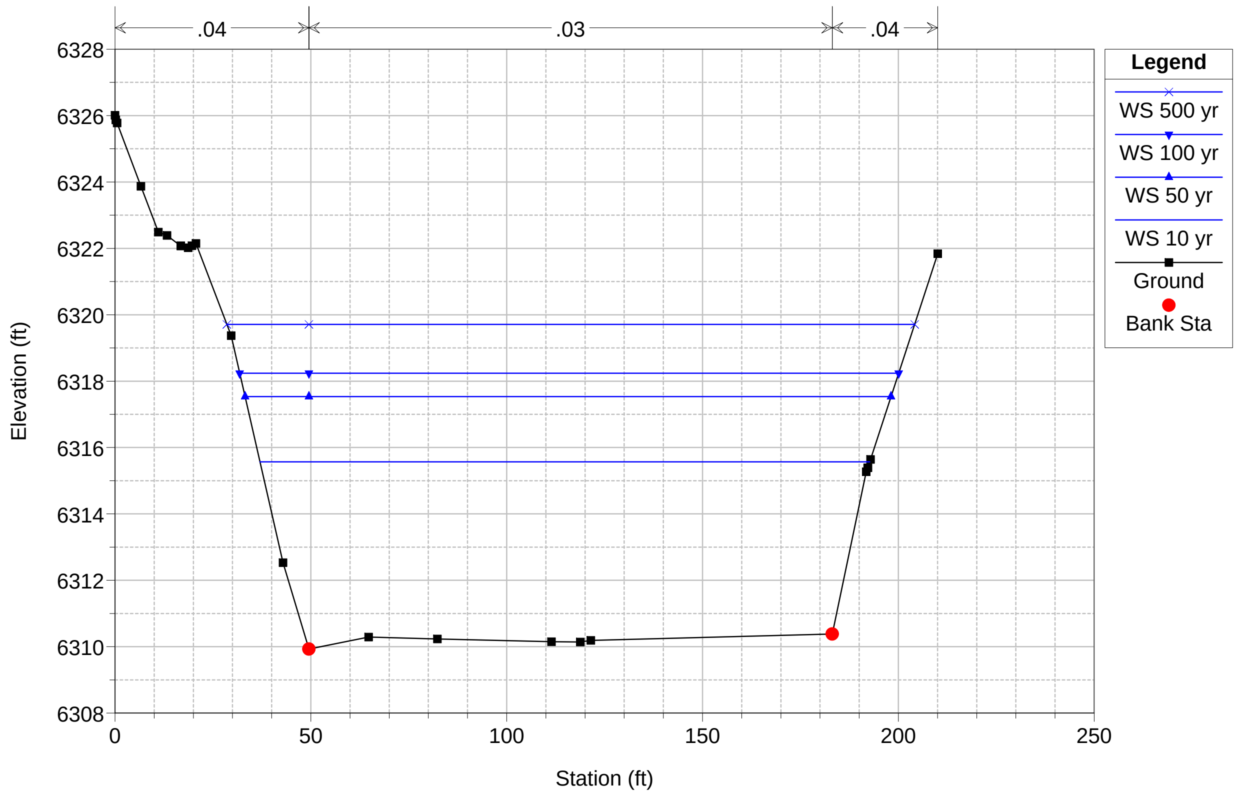
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
East Fork	1445	10 yr	1940.00	6304.26	6306.81	6306.19	6307.32	0.008325	5.71	339.56	143.59	0.65
East Fork	1445	50 yr	4180.00	6304.26	6308.30	6307.43	6309.16	0.008029	7.43	562.75	155.94	0.69
East Fork	1445	100 yr	5330.00	6304.26	6308.92	6307.97	6309.93	0.008001	8.07	660.42	161.05	0.70
East Fork	1445	500 yr	8120.00	6304.26	6310.29	6309.10	6311.58	0.007418	9.12	901.10	235.71	0.70
East Fork	1435	10 yr	1940.00	6304.22	6306.15	6306.15	6307.07	0.021555	7.72	251.43	138.42	1.01
East Fork	1435	50 yr	4180.00	6304.22	6307.39	6307.39	6308.86	0.018407	9.71	430.34	148.74	1.01
East Fork	1435	100 yr	5330.00	6304.22	6307.93	6307.93	6309.62	0.017525	10.42	511.43	153.19	1.01
East Fork	1435	500 yr	8120.00	6304.22	6309.06	6309.06	6311.21	0.016192	11.77	689.92	163.68	1.01
East Fork	1421	10 yr	1940.00	6301.83	6304.92	6303.76	6305.26	0.004333	4.64	418.39	148.20	0.49
East Fork	1421	50 yr	4180.00	6301.83	6306.63	6305.01	6307.21	0.004448	6.12	683.03	162.39	0.53
East Fork	1421	100 yr	5330.00	6301.83	6307.32	6305.54	6308.01	0.004518	6.68	797.87	168.18	0.54
East Fork	1421	500 yr	8120.00	6301.83	6308.75	6306.68	6309.69	0.004602	7.75	1048.00	186.19	0.56
East Fork	1412	10 yr	1940.00	6300.33	6304.99	6302.40	6305.15	0.001294	3.22	602.72	148.79	0.28
East Fork	1412	50 yr	4180.00	6300.33	6306.71	6303.72	6307.07	0.001991	4.80	871.74	163.19	0.37
East Fork	1412	100 yr	5330.00	6300.33	6307.41	6304.28	6307.87	0.002237	5.39	988.05	169.04	0.39
East Fork	1412	500 yr	8120.00	6300.33	6308.86	6305.48	6309.52	0.002625	6.54	1242.82	195.93	0.44
East Fork	1393	10 yr	1940.00	6300.33	6304.95	6302.42	6305.12	0.001388	3.32	584.54	145.15	0.29
East Fork	1393	50 yr	4180.00	6300.33	6306.64	6303.76	6307.02	0.002161	4.97	841.51	158.80	0.38
East Fork	1393	100 yr	5330.00	6300.33	6307.33	6304.34	6307.81	0.002441	5.60	951.95	164.32	0.41
East Fork	1393	500 yr	8120.00	6300.33	6308.73	6305.55	6309.45	0.002915	6.82	1191.57	183.06	0.46
East Fork	1392	10 yr	1940.00	6301.83	6304.59	6303.79	6305.04	0.006645	5.36	362.06	142.30	0.59
East Fork	1392	50 yr	4180.00	6301.83	6306.12	6305.05	6306.90	0.006843	7.10	588.50	154.60	0.64
East Fork	1392	100 yr	5330.00	6301.83	6306.73	6305.59	6307.67	0.006983	7.77	685.61	159.58	0.66
East Fork	1392	500 yr	8120.00	6301.83	6308.00	6306.74	6309.28	0.007273	9.08	894.28	169.80	0.70
East Fork	1379	10 yr	1940.00	6301.80	6304.44	6303.76	6304.93	0.007737	5.62	345.18	141.59	0.63
East Fork	1379	50 yr	4180.00	6301.80	6305.95	6305.03	6306.79	0.007664	7.36	567.74	153.91	0.68
East Fork	1379	100 yr	5330.00	6301.80	6306.55	6305.56	6307.56	0.007789	8.05	662.19	158.85	0.69
East Fork	1379	500 yr	8120.00	6301.80	6307.78	6306.71	6309.15	0.008082	9.39	864.58	168.94	0.73
East Fork	1325	10 yr	1940.00	6301.63	6303.64	6303.53	6304.44	0.006933	7.19	269.84	142.64	0.92
East Fork	1325	50 yr	4180.00	6301.63	6304.75	6304.75	6306.20	0.007524	9.64	433.51	151.65	1.01
East Fork	1325	100 yr	5330.00	6301.63	6305.27	6305.27	6306.95	0.007352	10.38	513.55	155.88	1.01
East Fork	1325	500 yr	8120.00	6301.63	6306.40	6306.40	6308.52	0.006972	11.68	694.93	165.06	1.00
East Fork	1225	10 yr	1940.00	6301.34	6303.15	6302.94	6303.76	0.005726	6.22	311.90	180.24	0.83
East Fork	1225	50 yr	4180.00	6301.34	6303.99	6303.99	6305.24	0.007609	8.97	466.06	187.93	1.00
East Fork	1225	100 yr	5330.00	6301.34	6304.45	6304.45	6305.89	0.007360	9.65	552.17	192.16	1.00
East Fork	1225	500 yr	8120.00	6301.34	6305.41	6305.41	6307.27	0.006995	10.94	742.46	201.32	1.00
East Fork	1025	10 yr	1940.00	6300.45	6301.78	6301.78	6302.29	0.009390	5.71	339.84	340.55	1.01
East Fork	1025	50 yr	4180.00	6300.45	6302.46	6302.46	6303.28	0.008056	7.27	574.82	355.38	1.01
East Fork	1025	100 yr	5330.00	6300.45	6302.75	6302.75	6303.70	0.007725	7.85	678.82	361.75	1.01
East Fork	1025	500 yr	8120.00	6300.45	6303.40	6303.40	6304.60	0.007073	8.80	922.65	386.42	1.00
East Fork	416	10 yr	1940.00	6288.90	6291.89	6290.55	6291.98	0.000608	2.41	803.56	379.37	0.29
East Fork	416	50 yr	4180.00	6288.90	6292.94	6291.28	6293.13	0.000741	3.46	1216.45	406.98	0.34
East Fork	416	100 yr	5330.00	6288.90	6293.41	6291.57	6293.64	0.000755	3.82	1410.69	419.23	0.36
East Fork	416	500 yr	8120.00	6288.90	6294.19	6292.19	6294.54	0.000905	4.75	1745.52	439.53	0.40

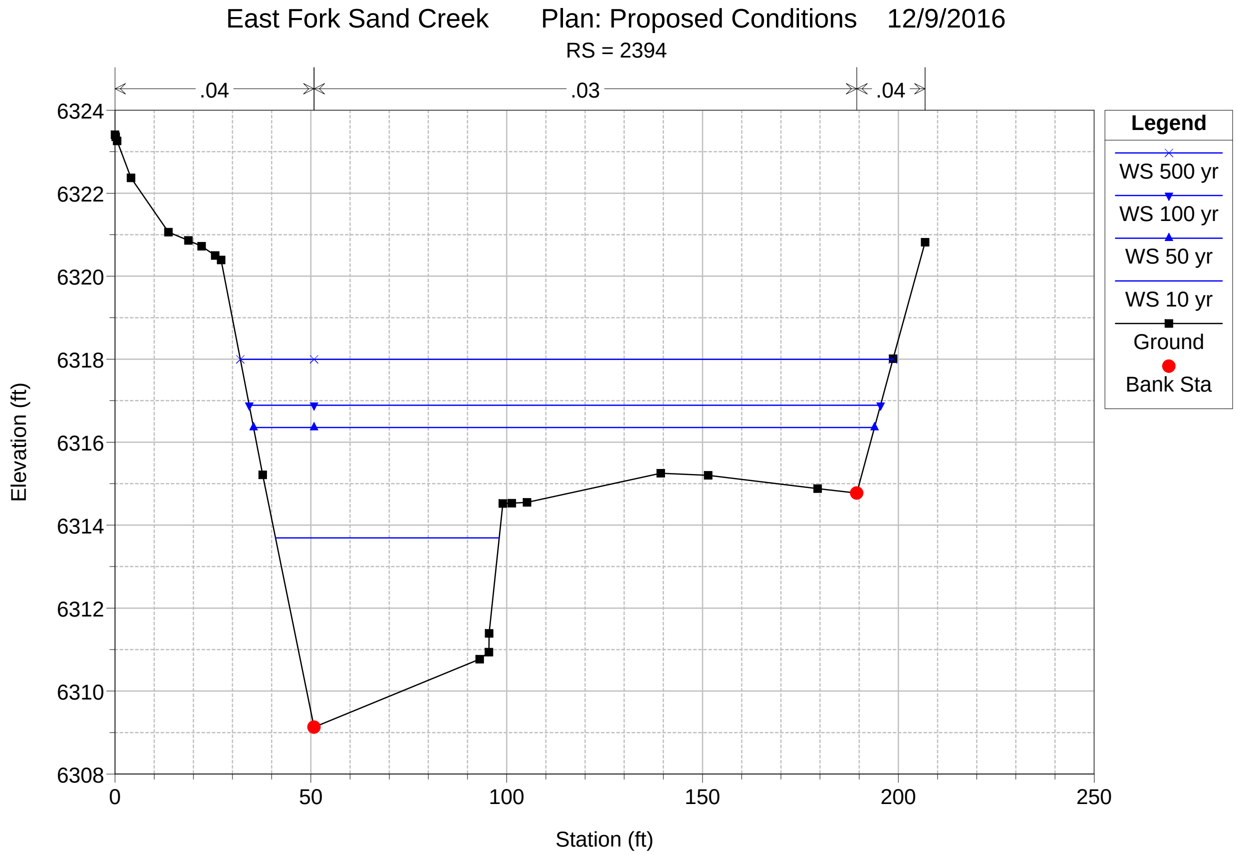

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
Sand Creek East Fork
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Elevation (ft)
6325
6320
6315
6310
6305
6300
6295
6290
6285
0
500
1000
1500
2000
2500
Main Channel Distance (ft)

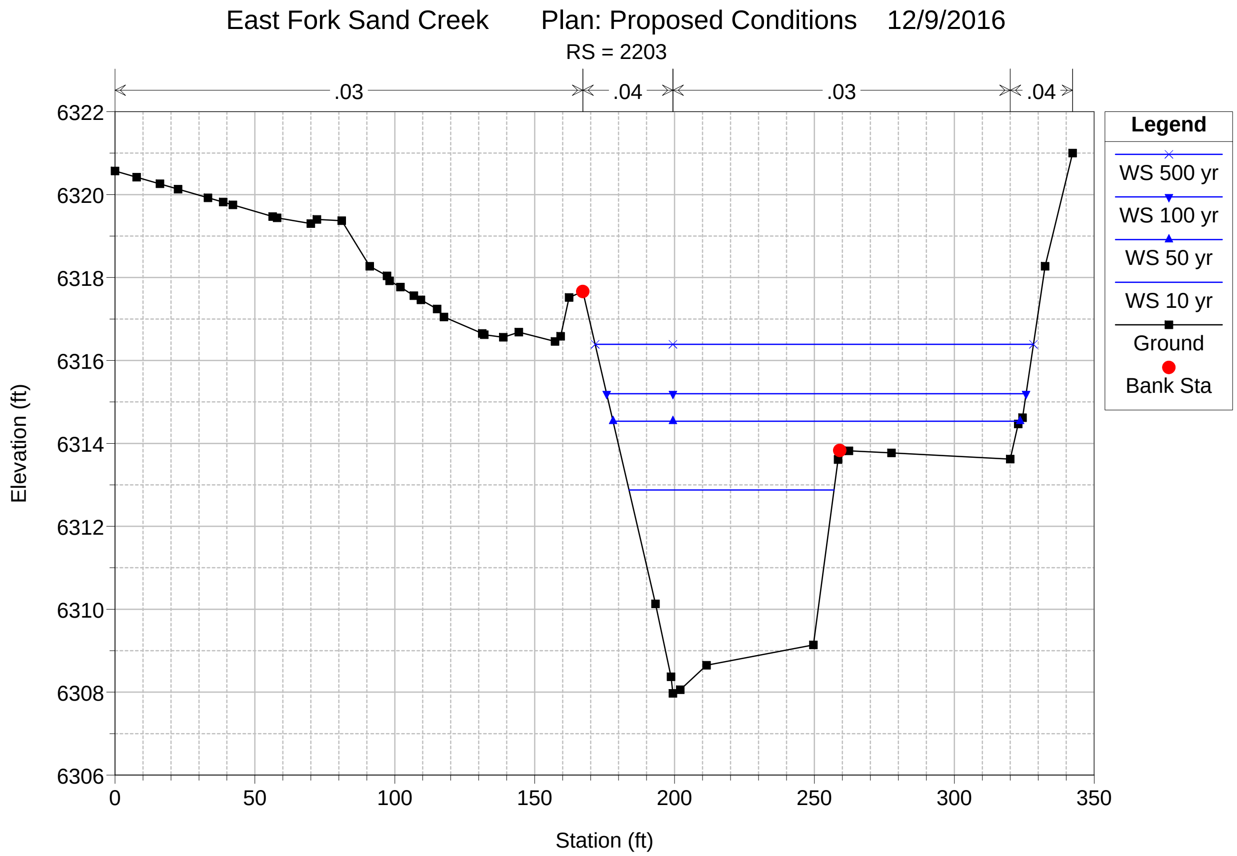
East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 2529 Located at LOMR 06-08-B137P, XS 119.3382

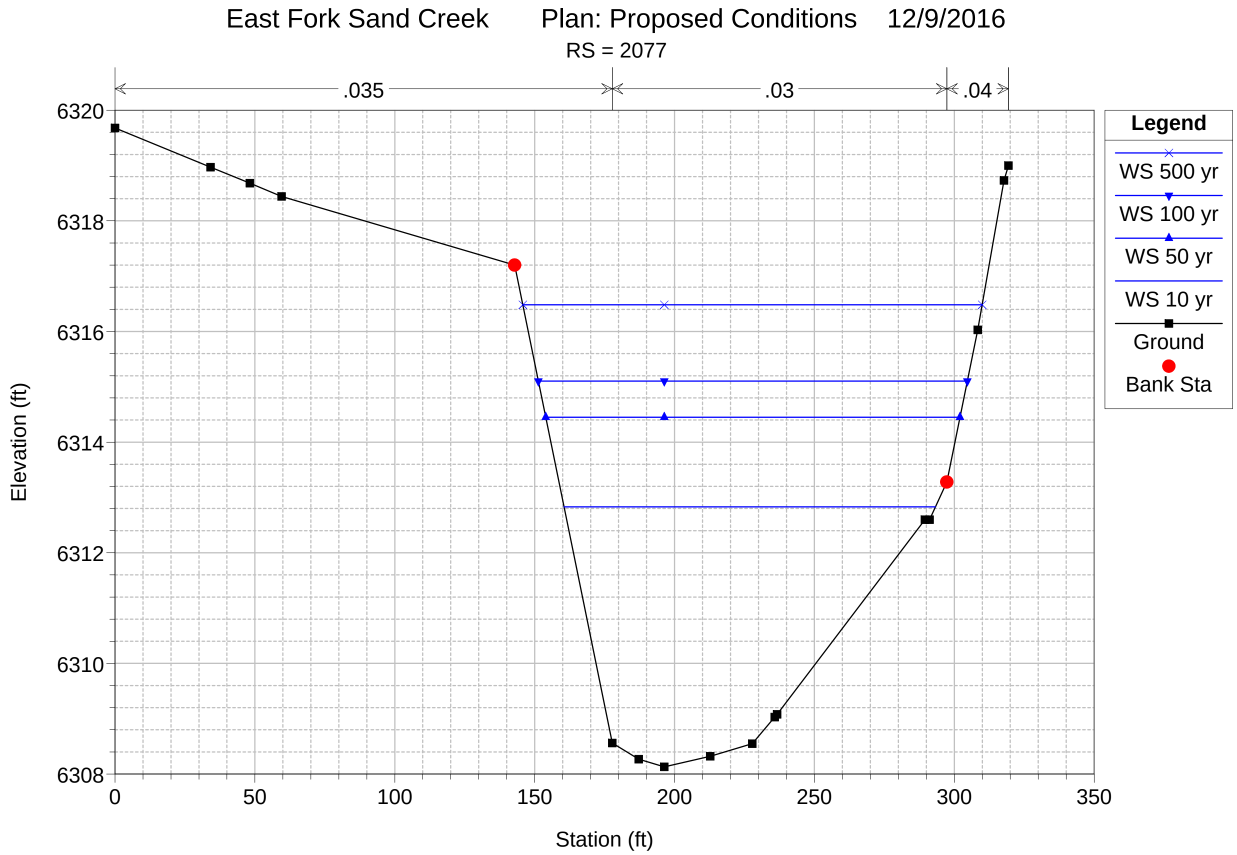


East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 2509

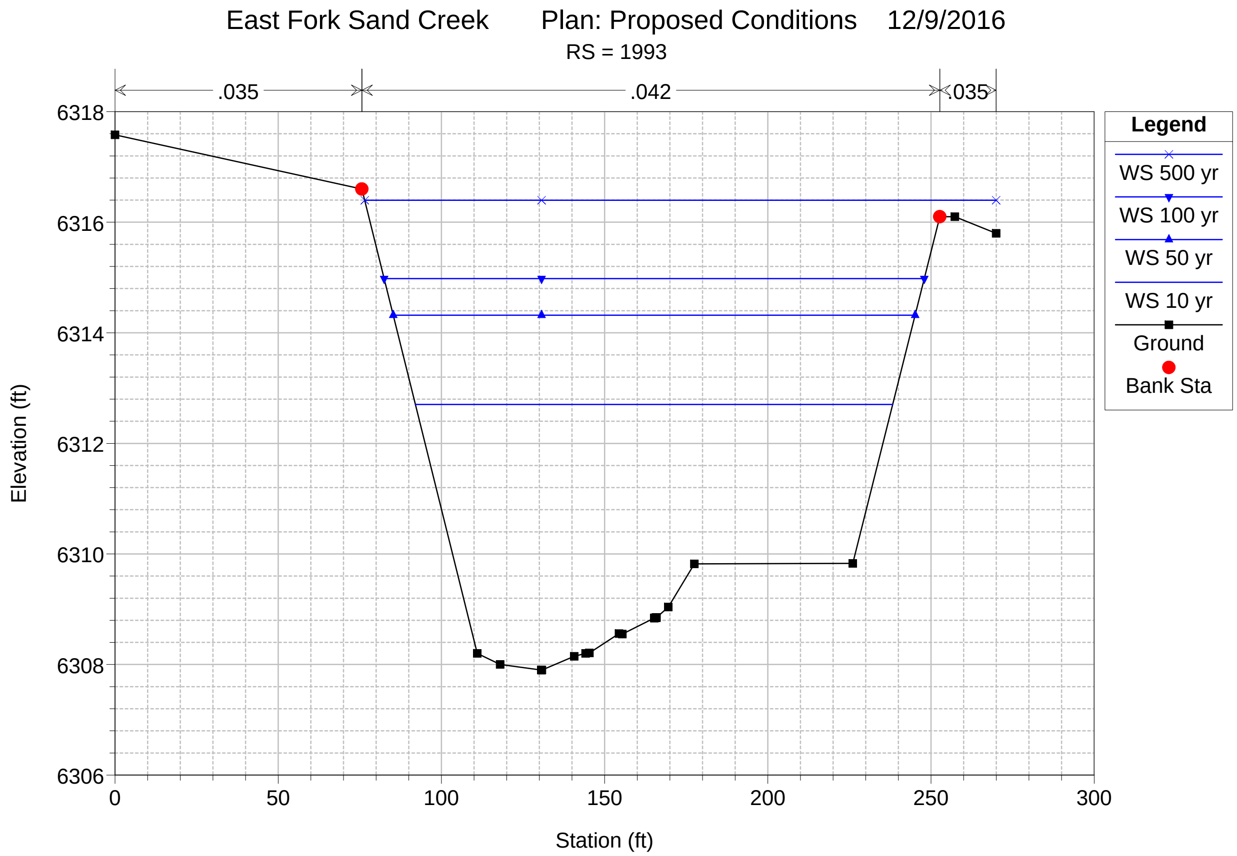



East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 2394
.04
.03
.04
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
6324
6322
6320
6318
6316
6314
6312
6310
6308
0
50
100
150
200
250

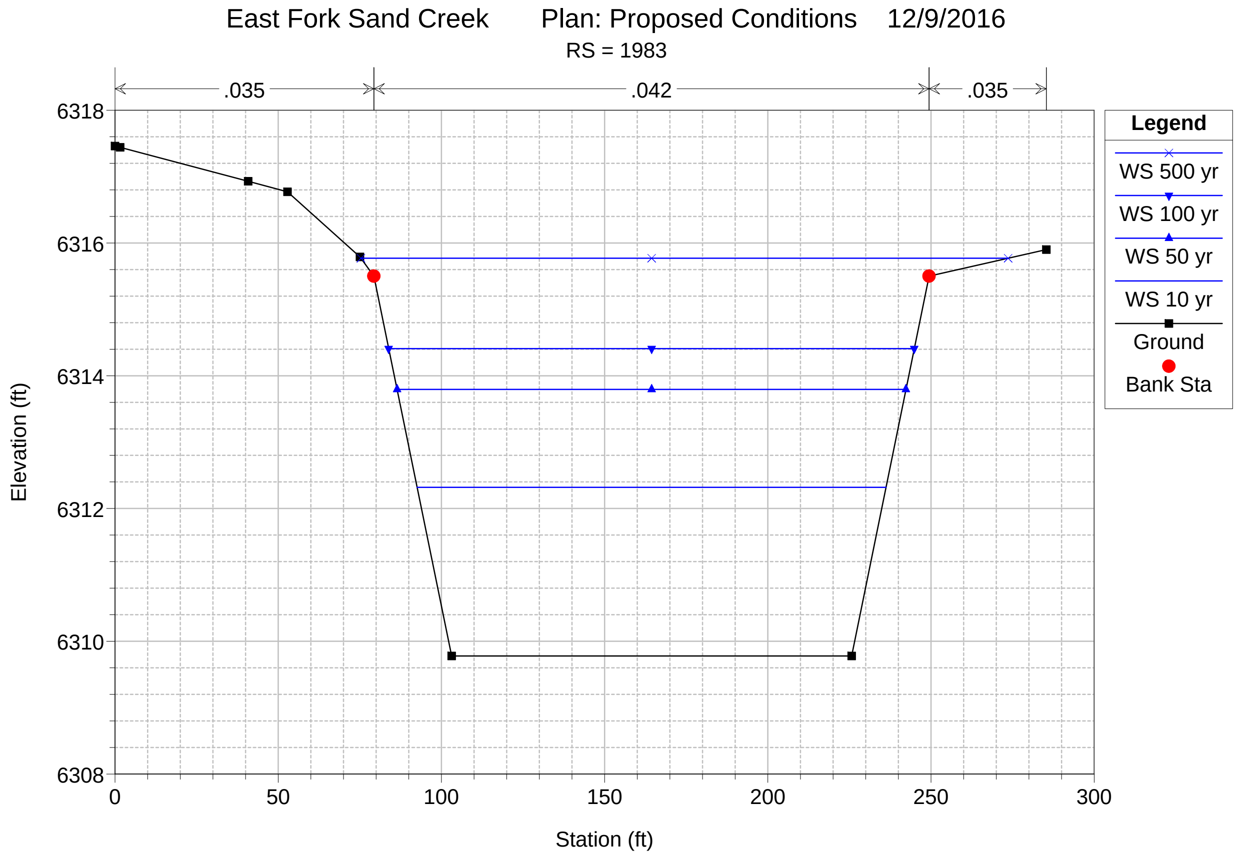

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 2203
.03
.04
.03
.04
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
6322
6320
6318
6316
6314
6312
6310
6308
6306
0
50
100
150
200
250
300
350

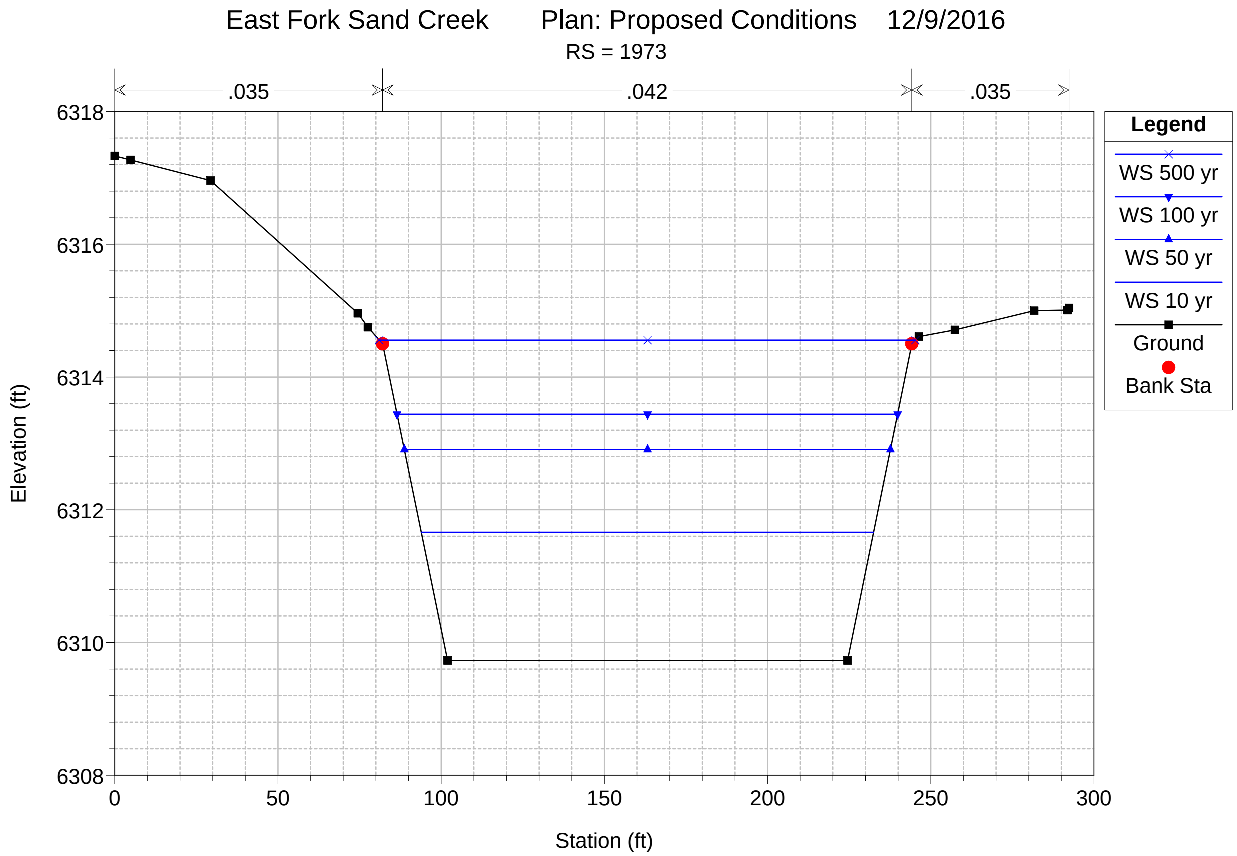


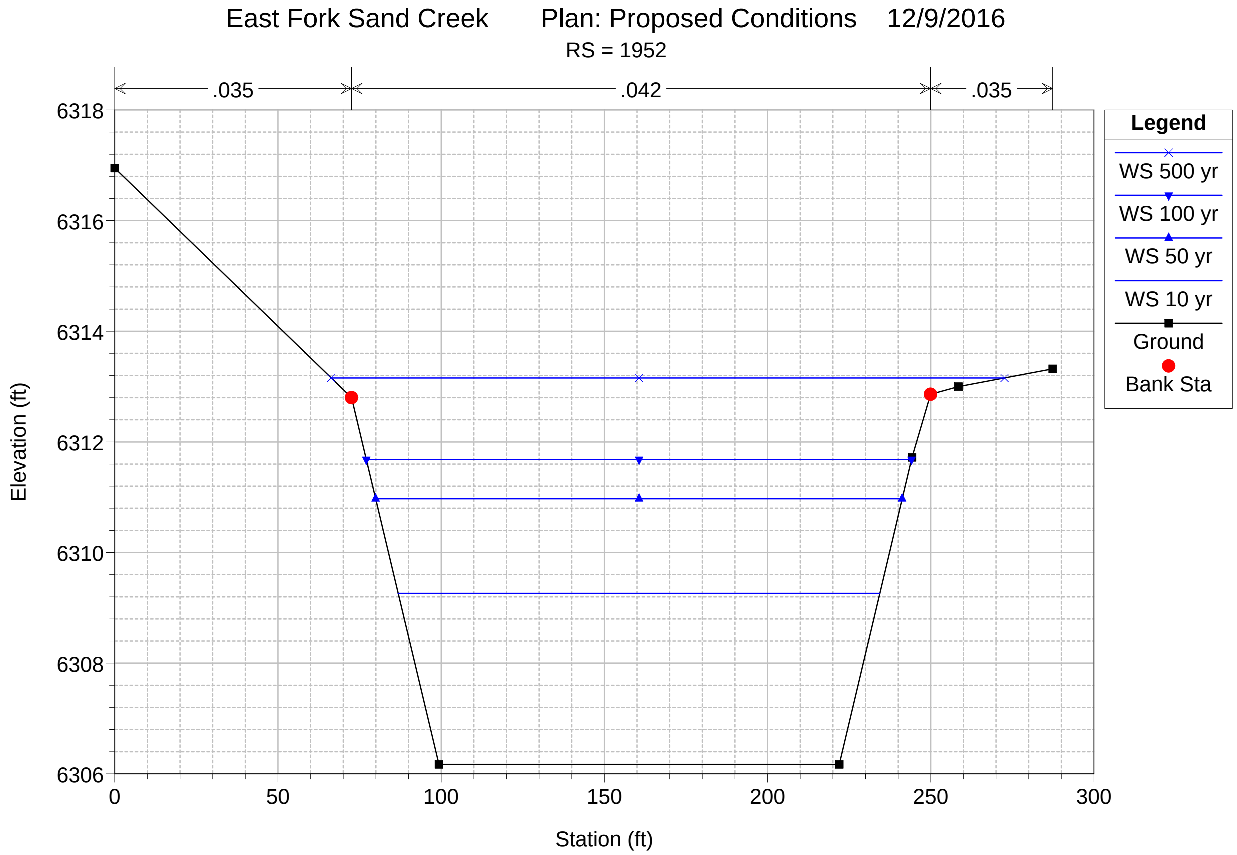
East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 2077
.035
.03
.04
Elevation (ft)
6320
6318
6316
6314
6312
6310
6308
0
50
100
150
200
250
300
350
Station (ft)
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta

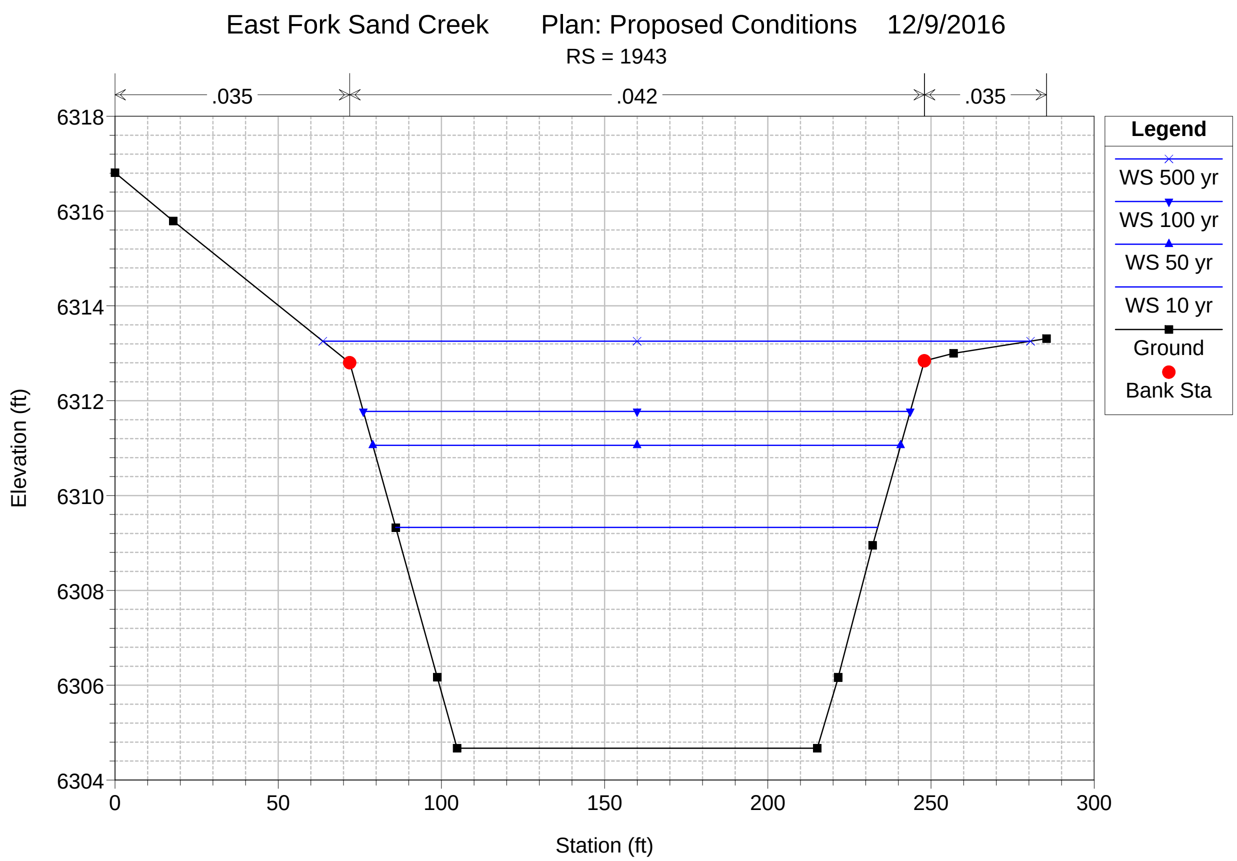


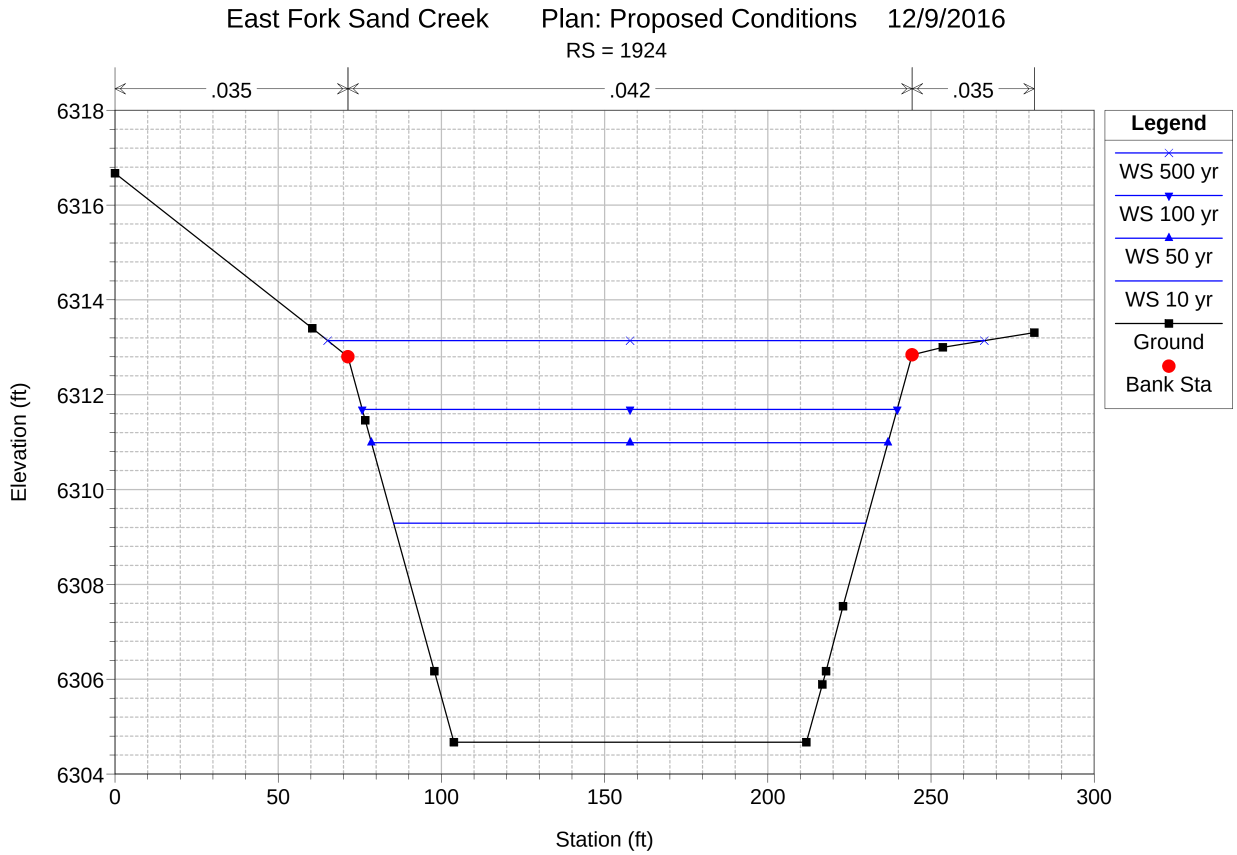
East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1993
.035
.042
.035
Elevation (ft)
6318
6316
6314
6312
6310
6308
6306
0
50
100
150
200
250
300
Station (ft)
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta

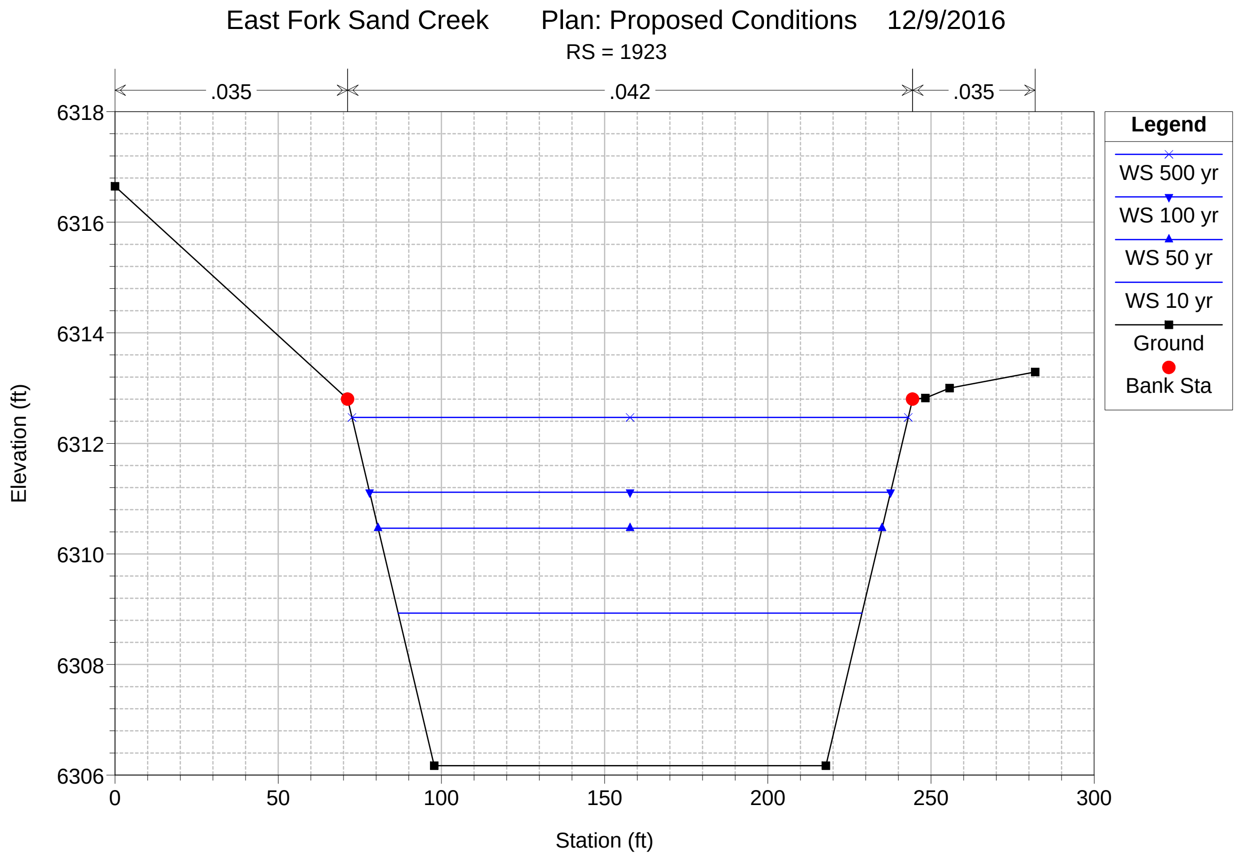

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1983
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6318
6316
6314
6312
6310
6308
0
50
100
150
200
250
300
Station (ft)

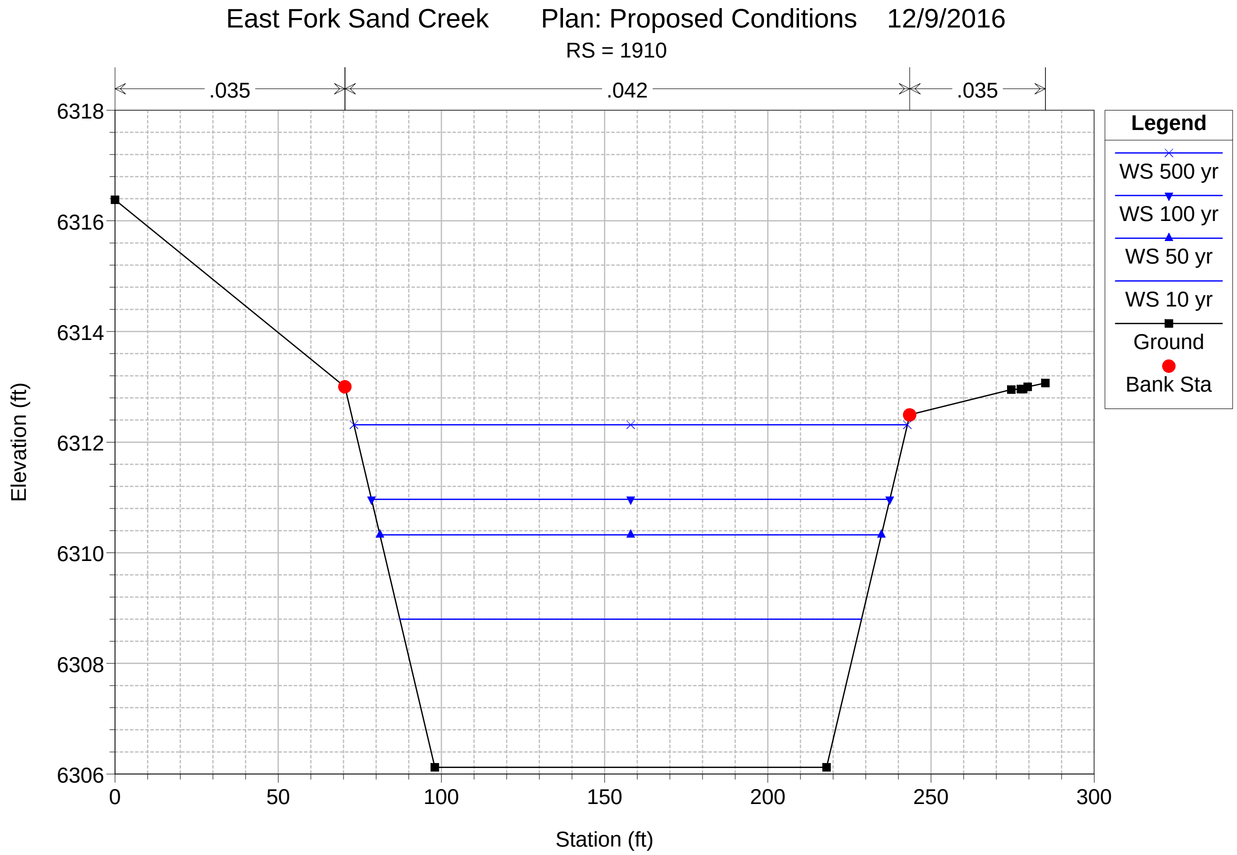

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1973
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6318
6316
6314
6312
6310
6308
0
50
100
150
200
250
300
Station (ft)

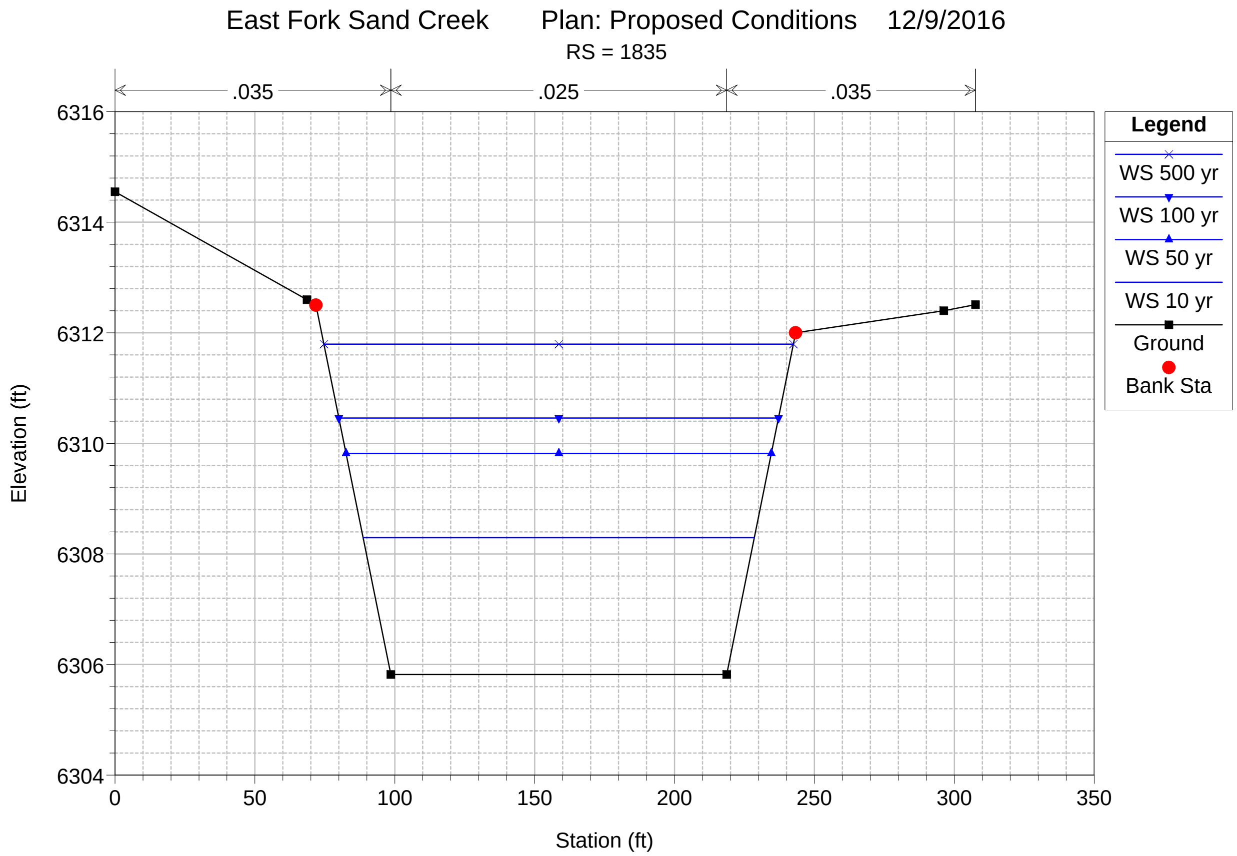

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1952
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6318
6316
6314
6312
6310
6308
6306
0
50
100
150
200
250
300
Station (ft)

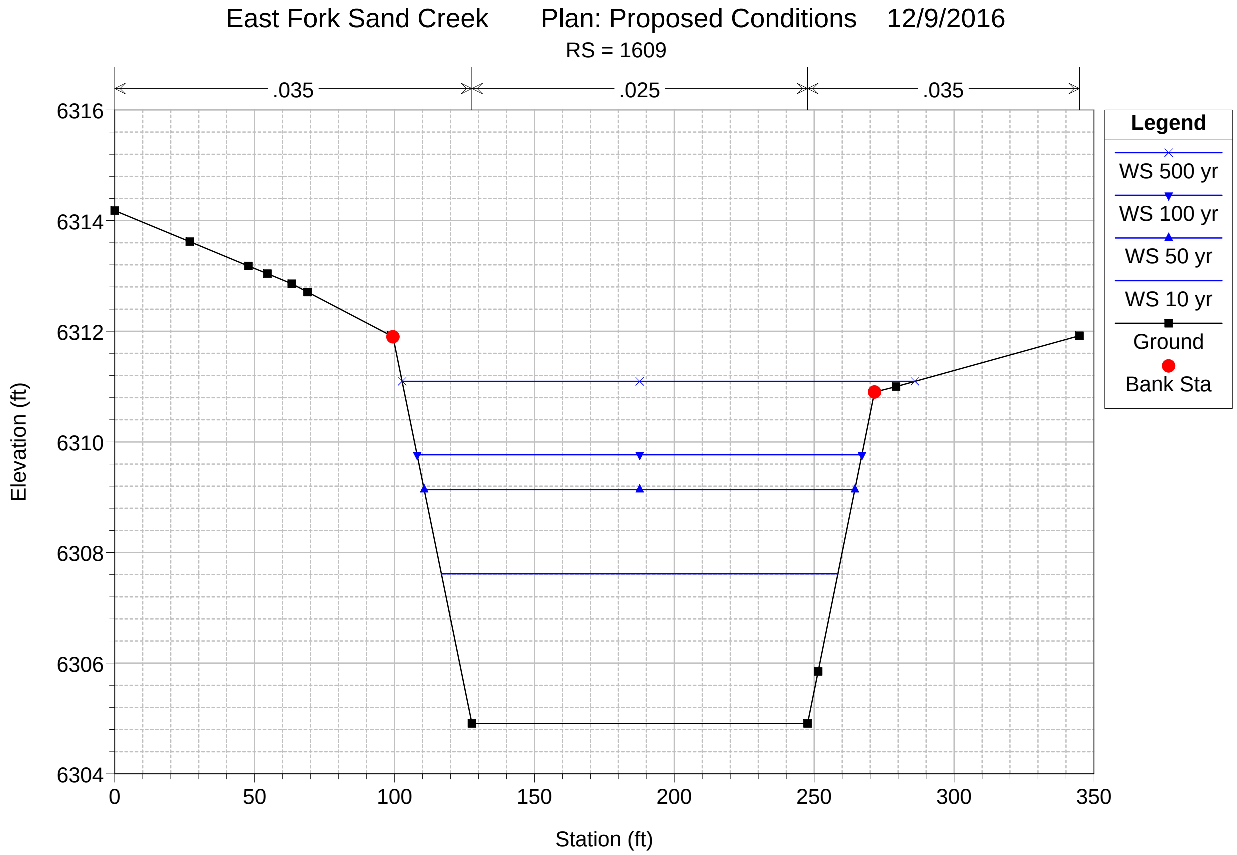

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1943
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6318
6316
6314
6312
6310
6308
6306
6304
0
50
100
150
200
250
300
Station (ft)

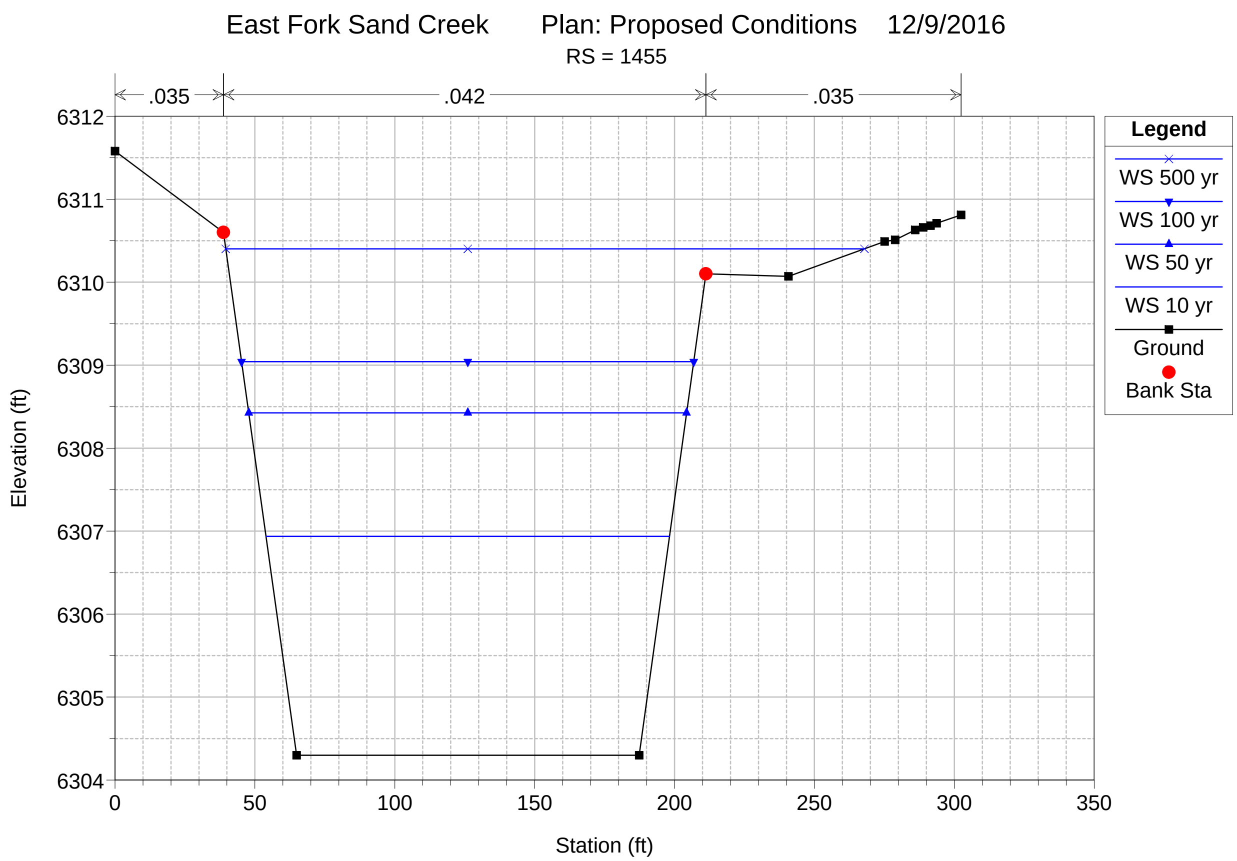

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1924
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
6318
6316
6314
6312
6310
6308
6306
6304
0
50
100
150
200
250
300

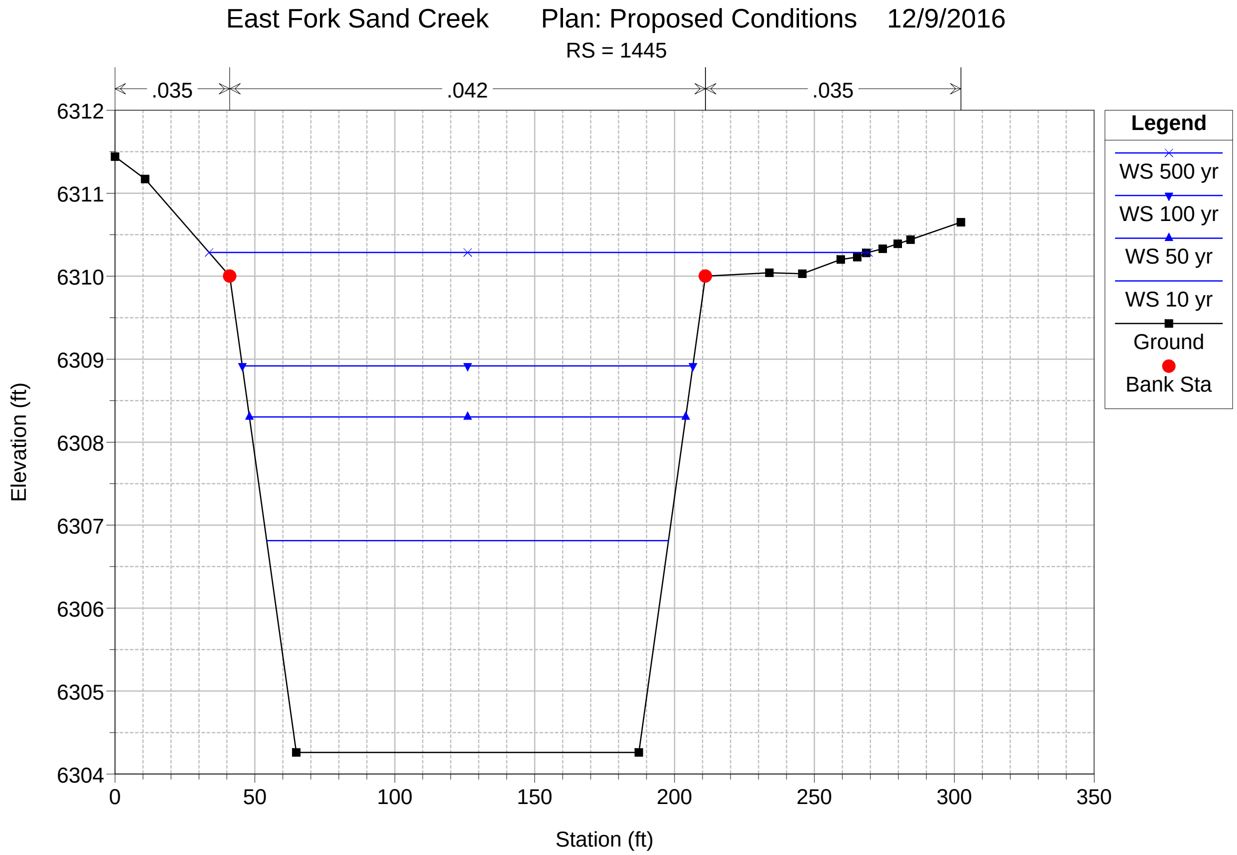

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1923
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
6318
6316
6314
6312
6310
6308
6306
0
50
100
150
200
250
300

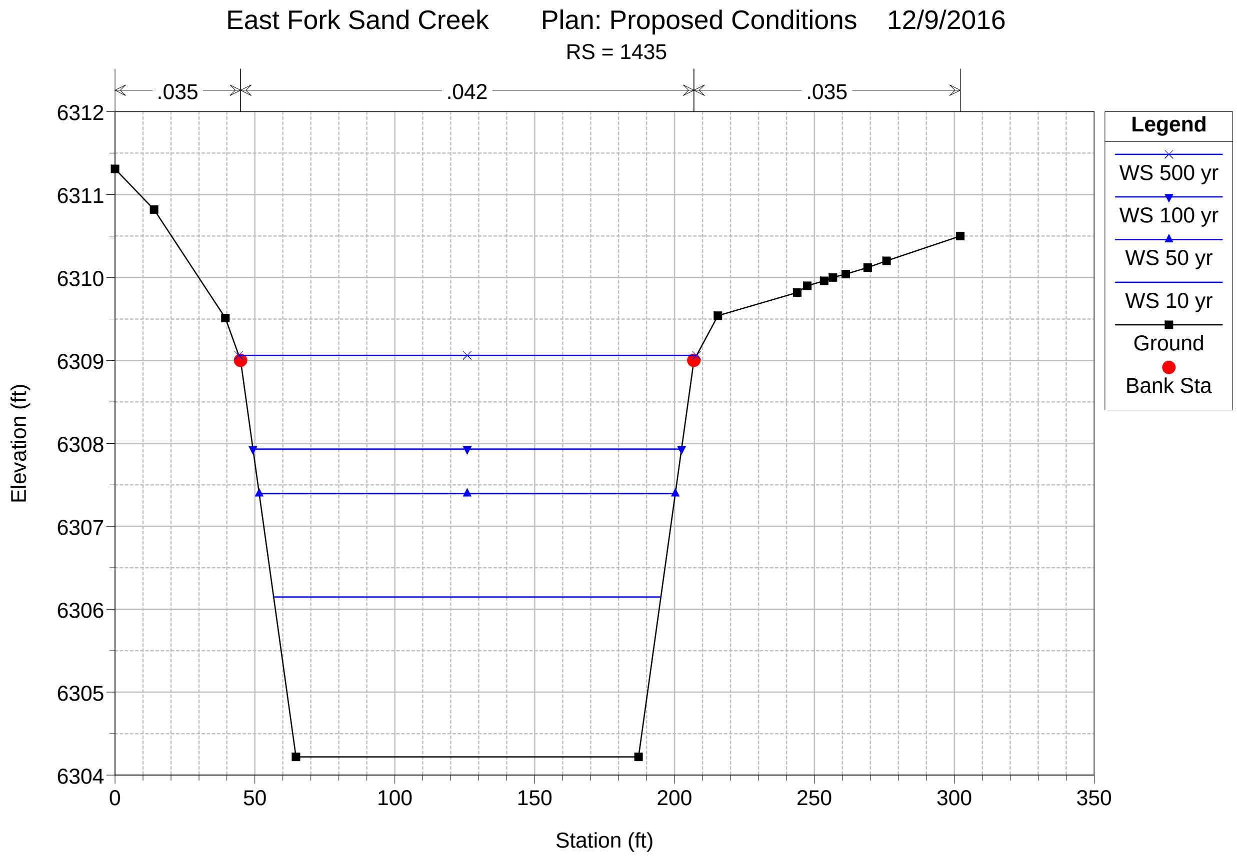

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1910
.035
.042
.035
Elevation (ft)
Station (ft)
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta

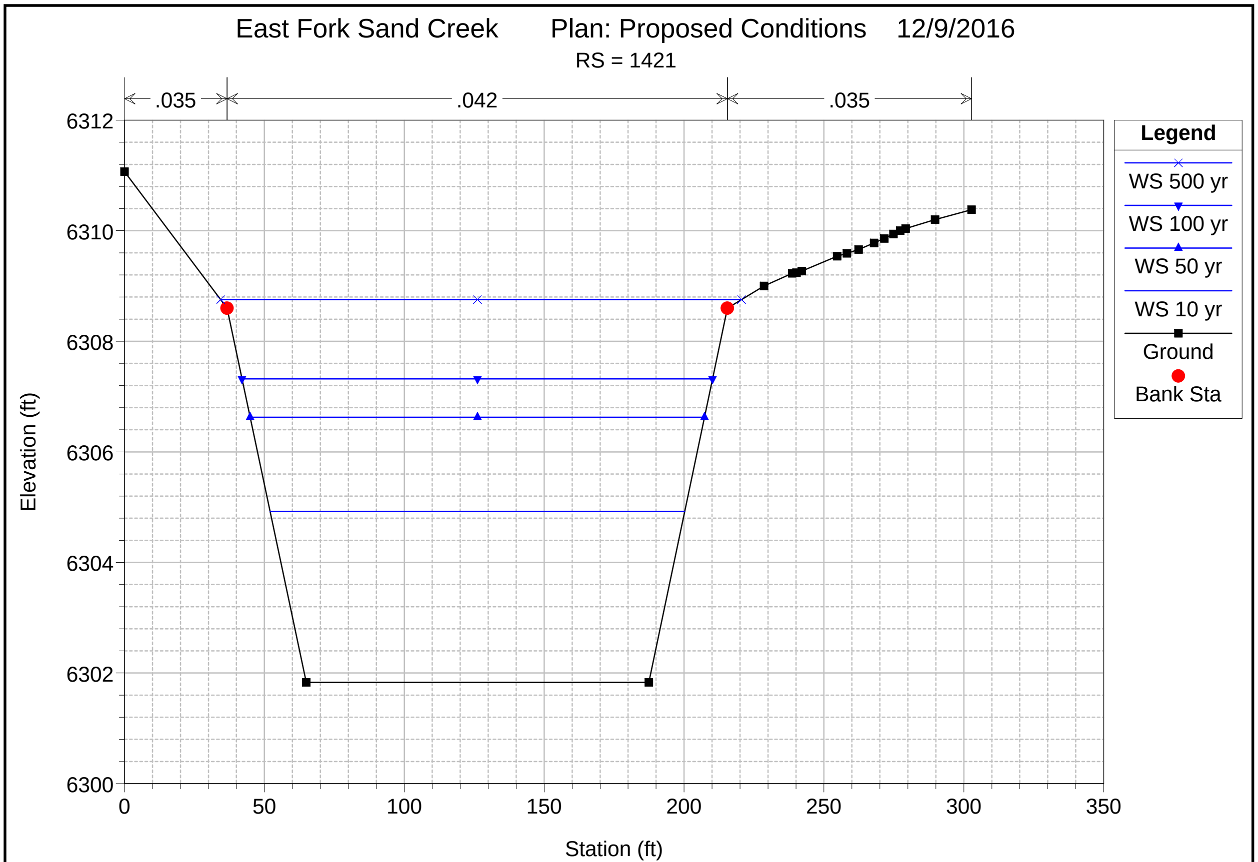

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1835
.035
.025
.035
Elevation (ft)
Station (ft)
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta

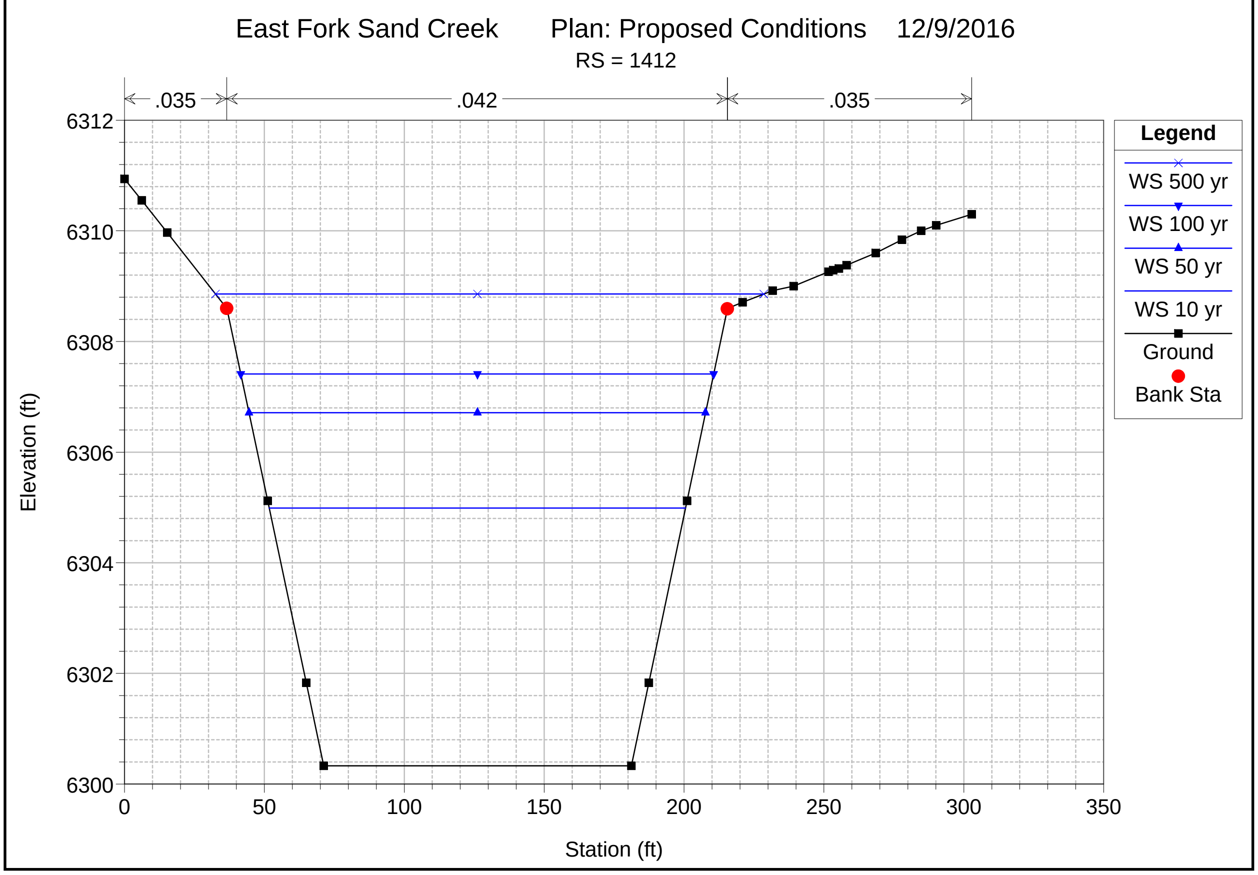

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1609
.035
.025
.035
Elevation (ft)
Station (ft)
6316
6314
6312
6310
6308
6306
6304
0
50
100
150
200
250
300
350
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta

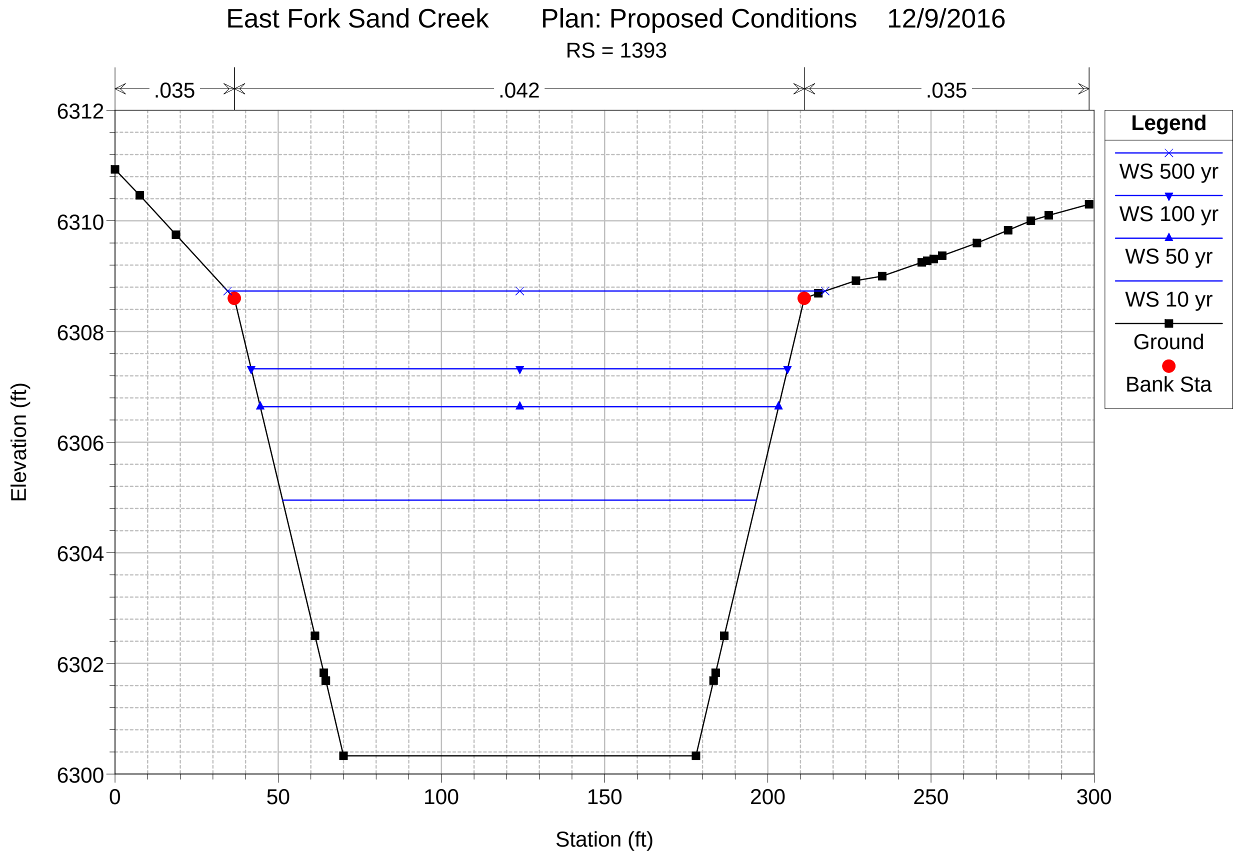

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1455
.035
.042
.035
Elevation (ft)
Station (ft)
6312
6311
6310
6309
6308
6307
6306
6305
6304
0
50
100
150
200
250
300
350
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta

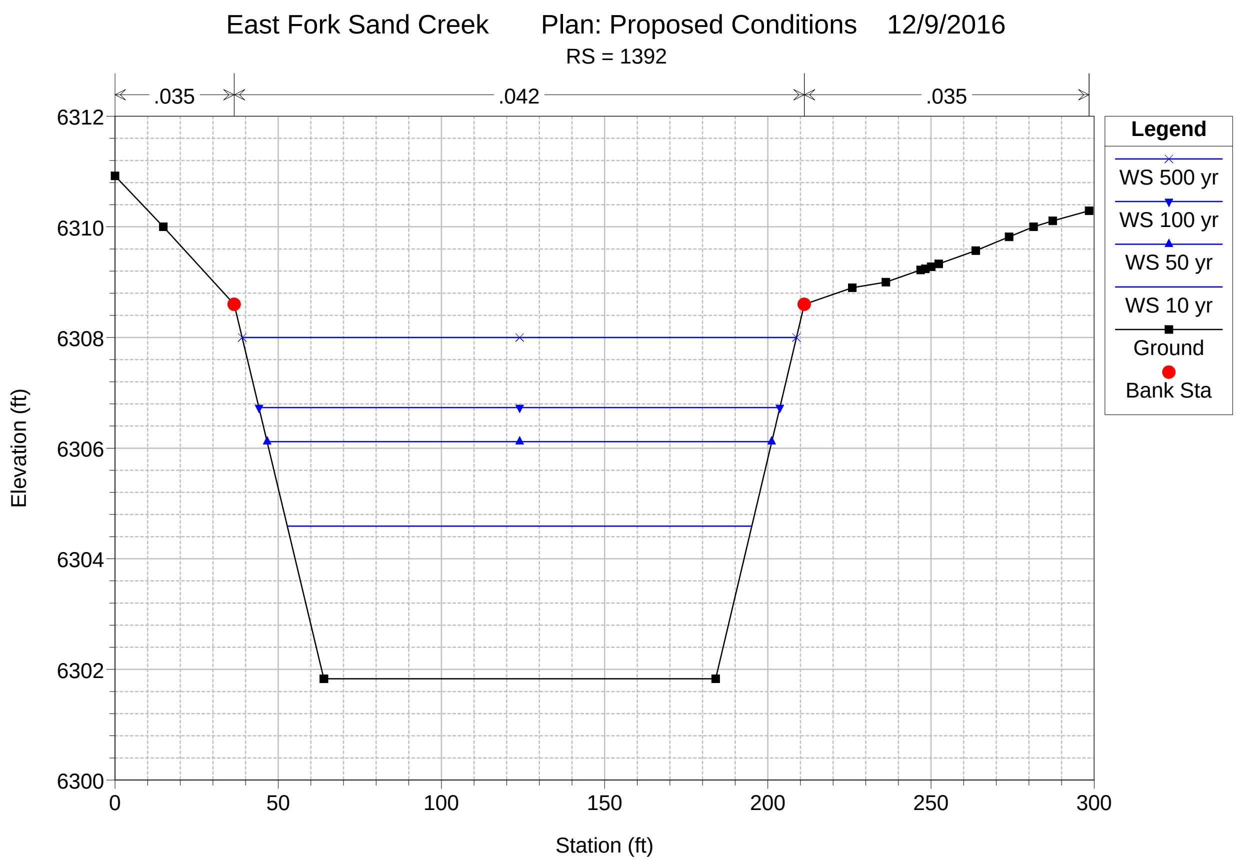

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1445
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6312
6311
6310
6309
6308
6307
6306
6305
6304
0
50
100
150
200
250
300
350
Station (ft)

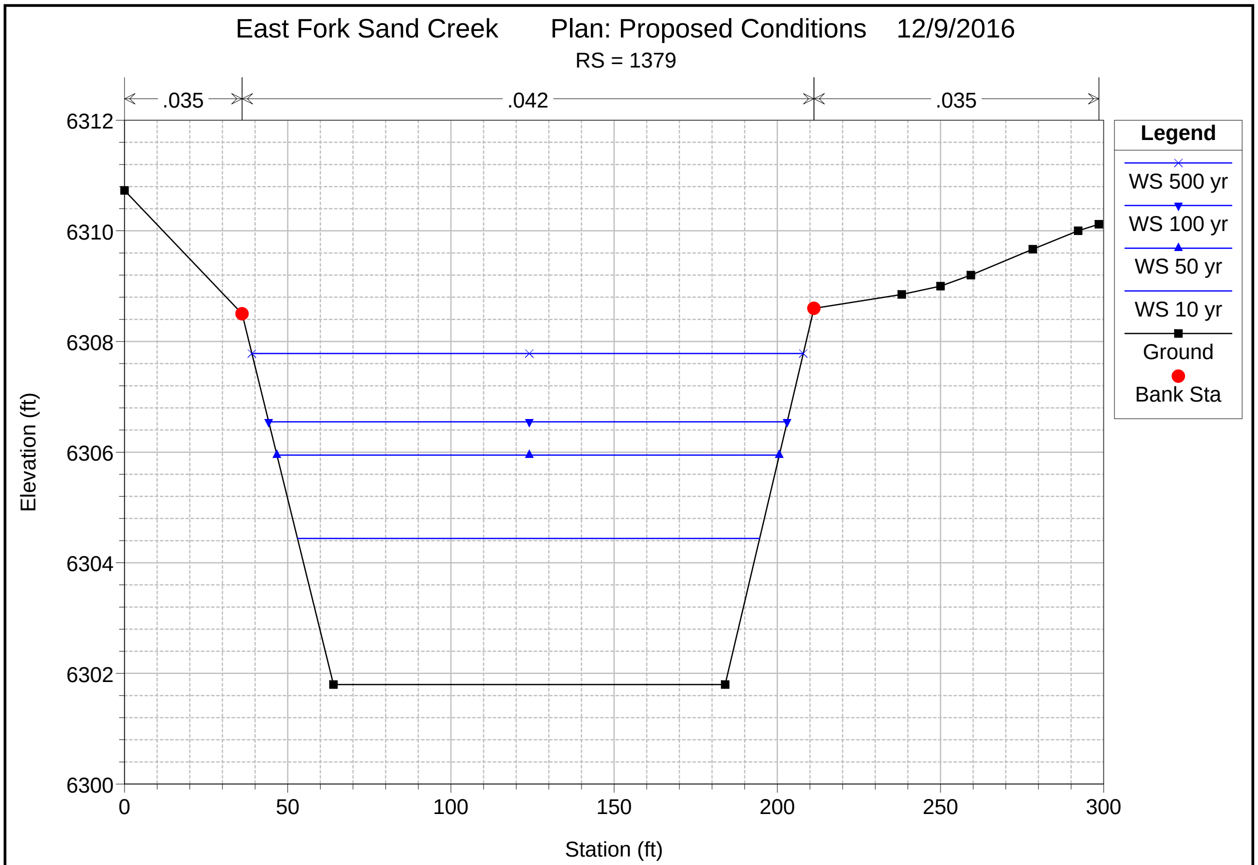

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1435
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6312
6311
6310
6309
6308
6307
6306
6305
6304
0
50
100
150
200
250
300
350
Station (ft)

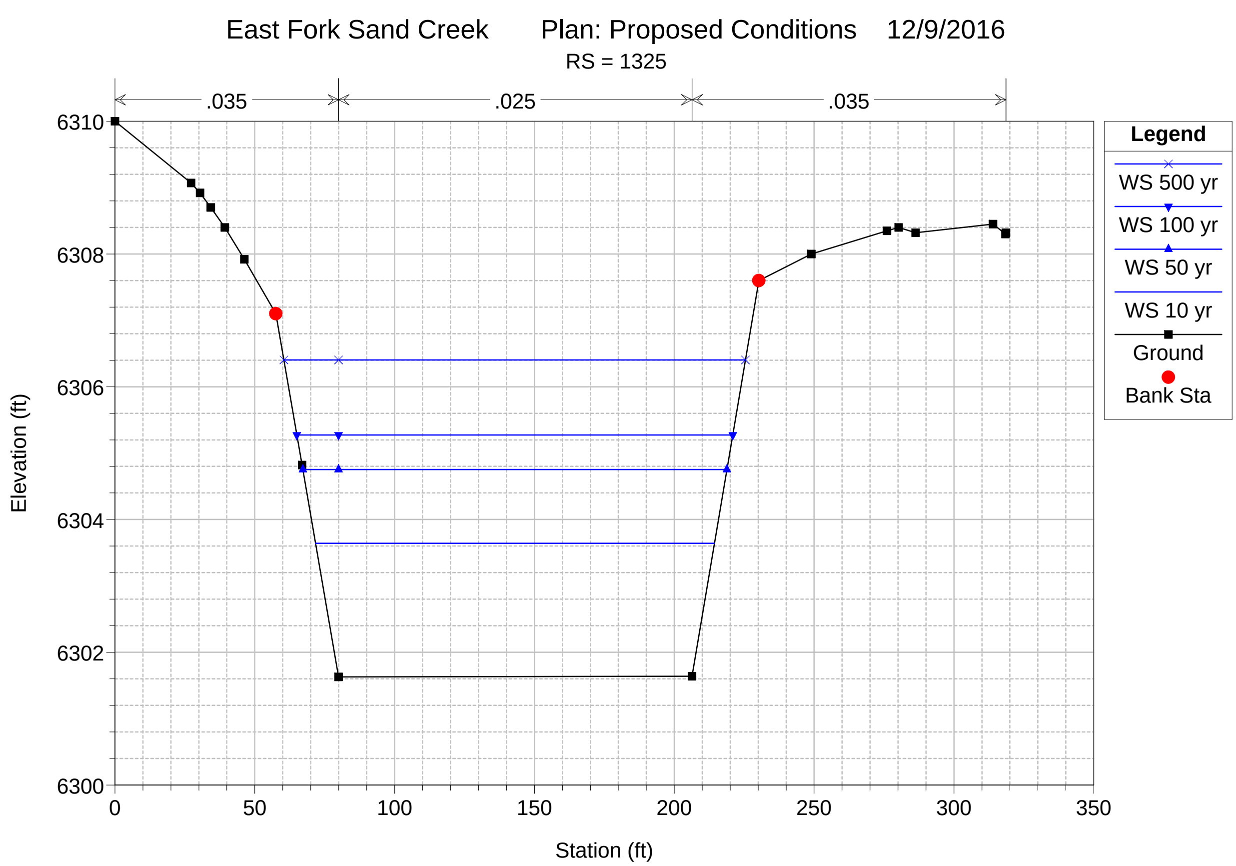

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1421
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6312
6310
6308
6306
6304
6302
6300
0
50
100
150
200
250
300
350
Station (ft)

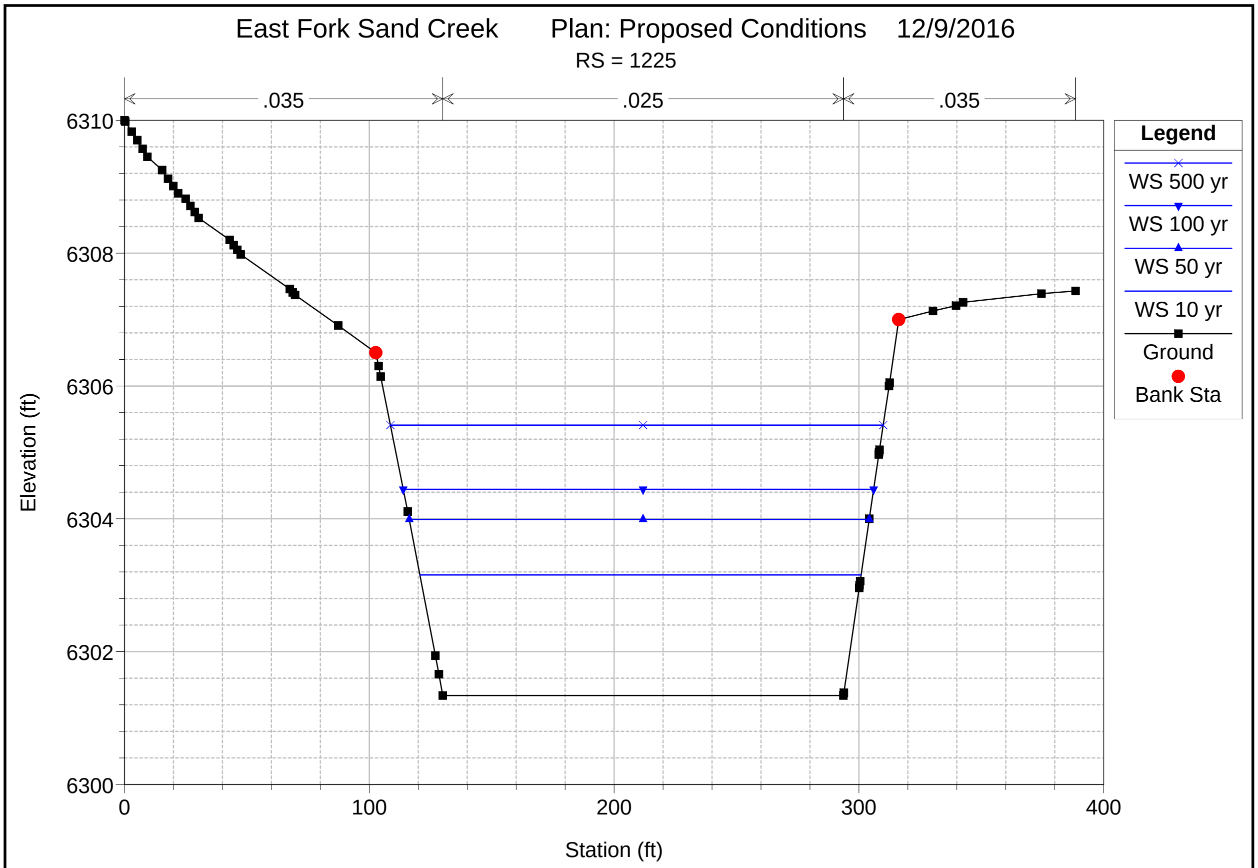

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1412
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6312
6310
6308
6306
6304
6302
6300
0
50
100
150
200
250
300
350
Station (ft)

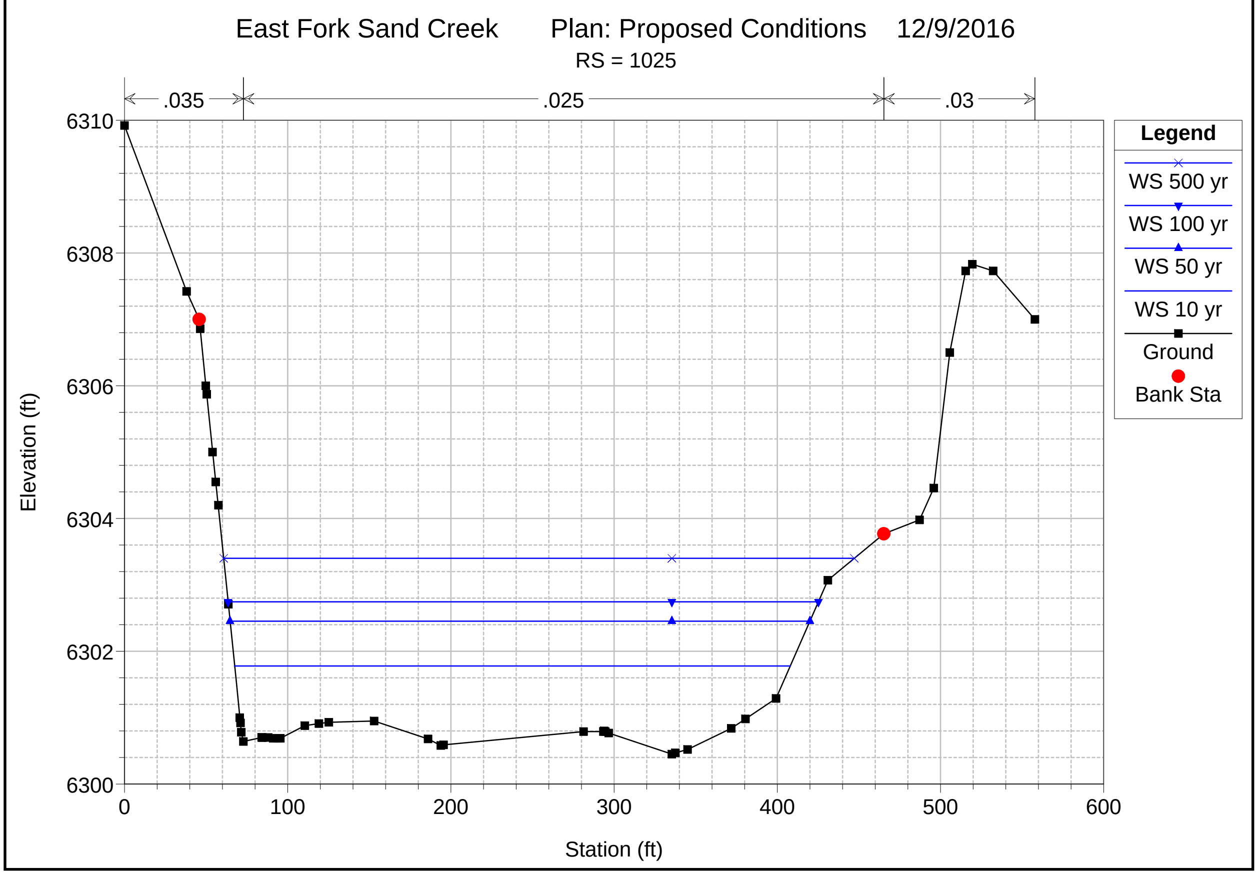

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1393
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6312
6310
6308
6306
6304
6302
6300
0
50
100
150
200
250
300
Station (ft)

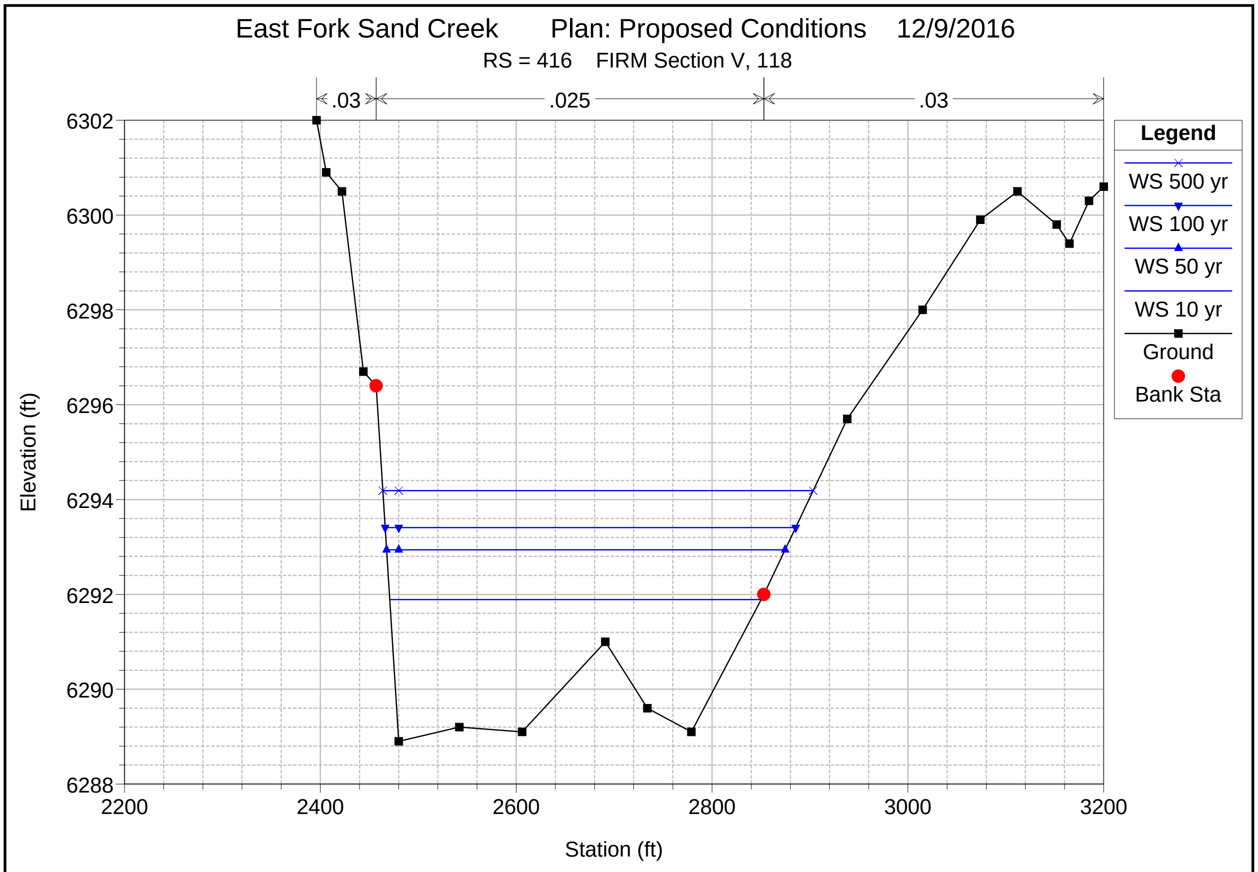

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1392
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6312
6310
6308
6306
6304
6302
6300
0
50
100
150
200
250
300
Station (ft)


East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1379
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6312
6310
6308
6306
6304
6302
6300
0
50
100
150
200
250
300
Station (ft)


East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1325
.035
.025
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6310
6308
6306
6304
6302
6300
0
50
100
150
200
250
300
350
Station (ft)


East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1225
.035
.025
.035
Elevation (ft)
Station (ft)
6300
6302
6304
6306
6308
6310
0
100
200
300
400
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta


East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 1025
.035
.025
.03
Elevation (ft)
Station (ft)
6300
6302
6304
6306
6308
6310
0
100
200
300
400
500
600
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta

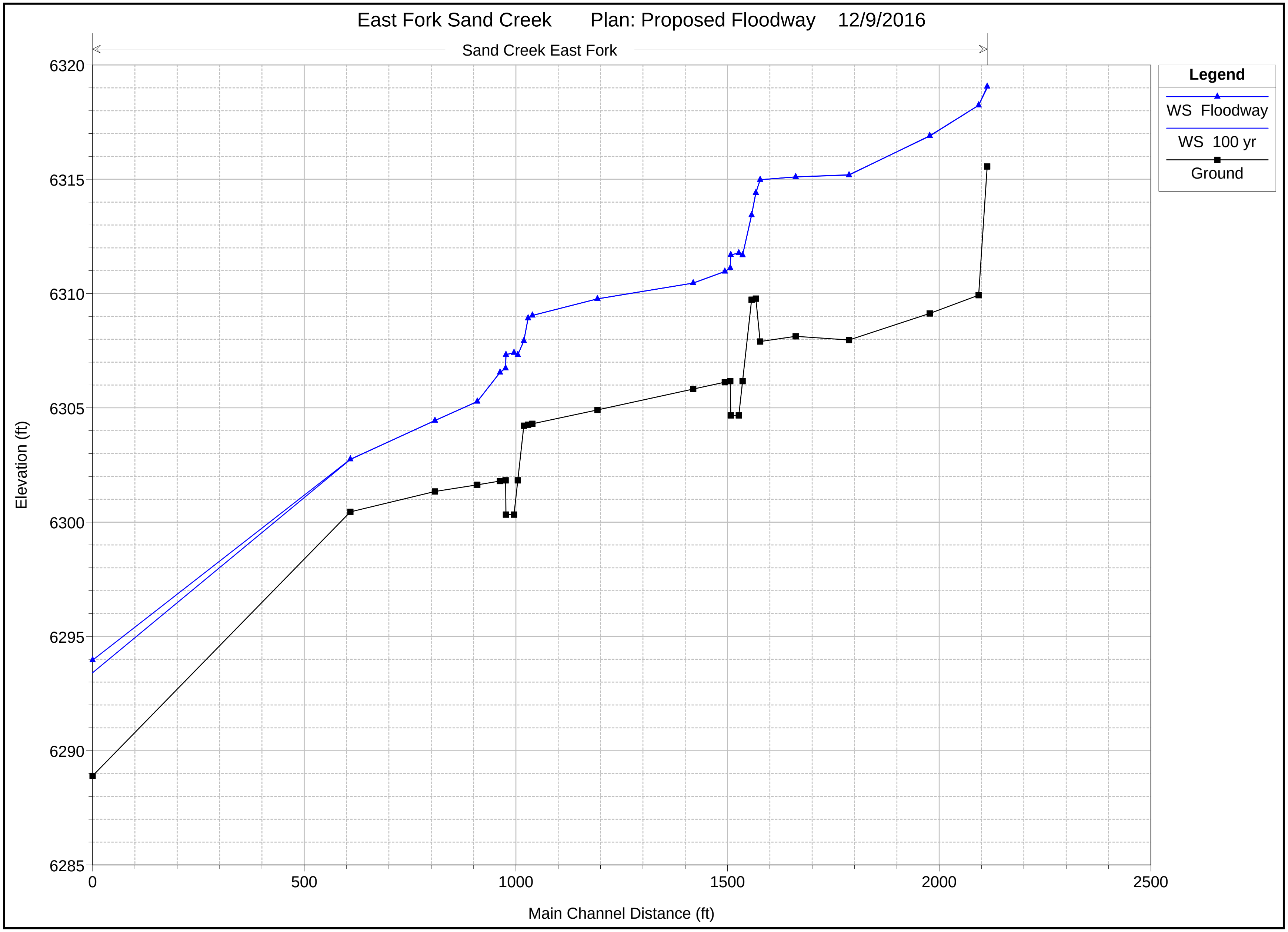

East Fork Sand Creek Plan: Proposed Conditions 12/9/2016
RS = 416 FIRM Section V, 118
.03
.025
.03
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6302
6300
6298
6296
6294
6292
6290
6288
2200
2400
2600
2800
3000
3200
Station (ft)

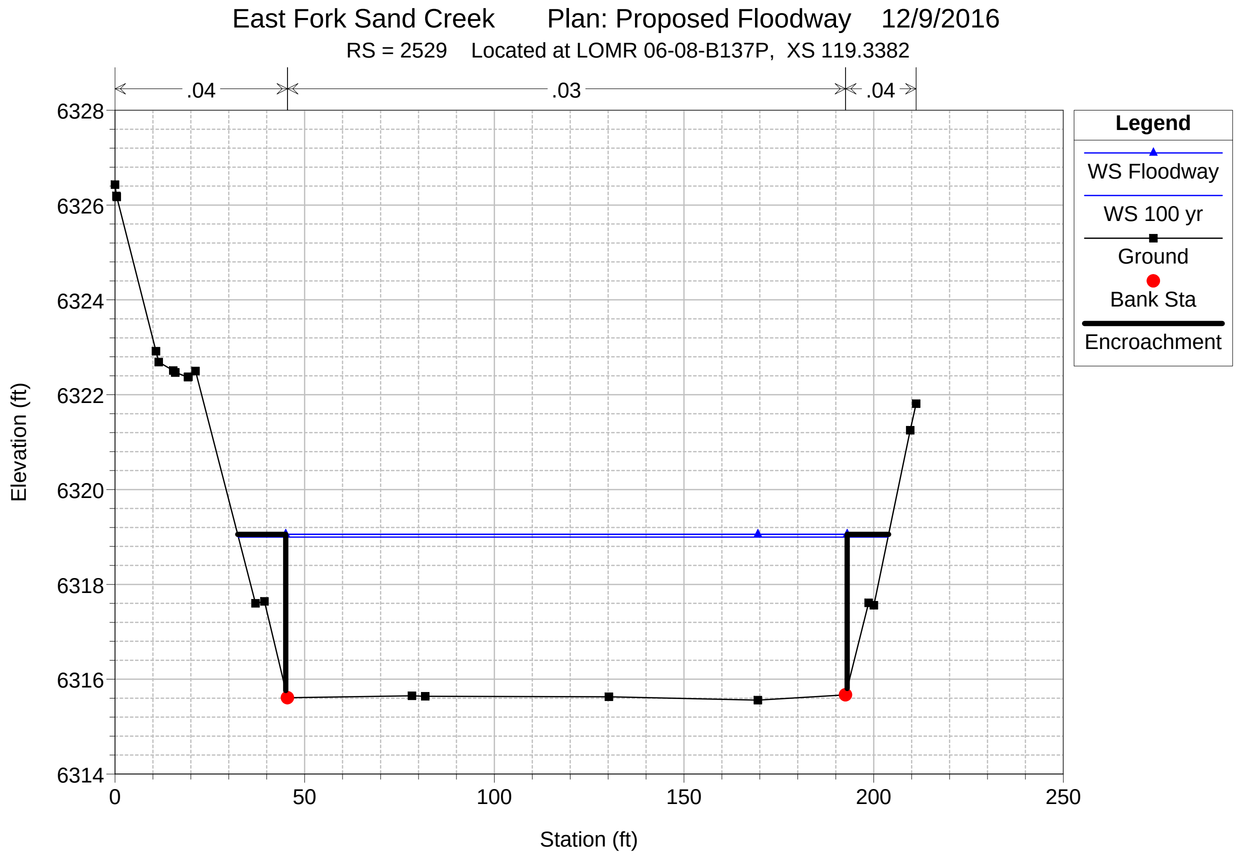
HEC-RAS Plan: Proposed Fldwy River: Sand Creek Reach: East Fork

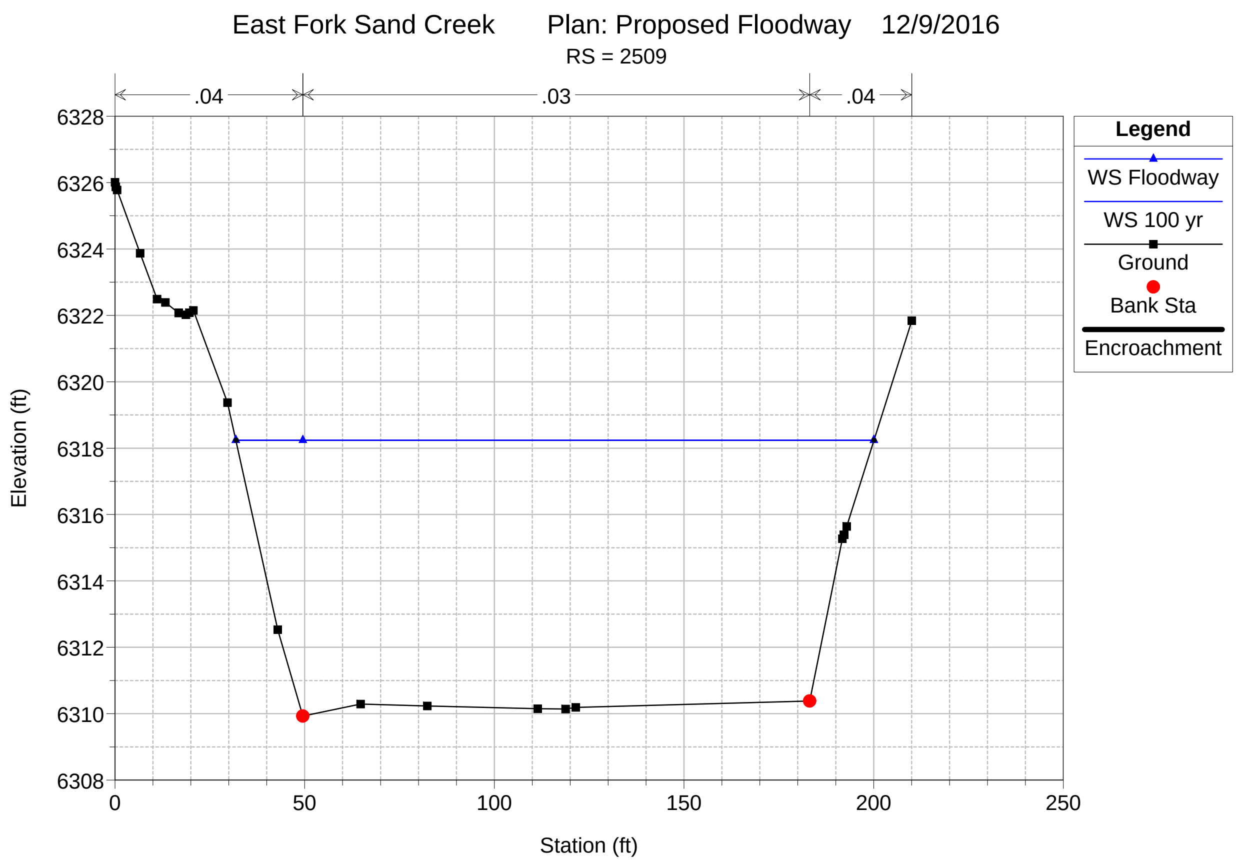
Reach	River Sta	Profile	Top Wdth Act	Area	Vel Total	W.S. Elev	Base WS	Prof Delta WS
			(ft)	(sq ft)	(ft/s)	(ft)	(ft)	(ft)
East Fork	2529	100 yr	171.26	536.56	9.93	6319.00	6319.00	
East Fork	2529	Floodway	148.00	508.29	10.49	6319.06	6319.00	0.06
East Fork	2509	100 yr	168.24	1207.04	4.42	6318.24	6318.24	
East Fork	2509	Floodway	168.24	1207.29	4.41	6318.24	6318.24	0.00
East Fork	2394	100 yr	161.19	568.07	9.38	6316.89	6316.89	
East Fork	2394	Floodway	161.21	570.19	9.35	6316.90	6316.89	0.01
East Fork	2203	100 yr	149.92	534.57	9.97	6315.20	6315.20	
East Fork	2203	Floodway	149.83	532.22	10.01	6315.18	6315.20	-0.02
East Fork	2077	100 yr	153.31	731.09	7.29	6315.10	6315.10	
East Fork	2077	Floodway	153.30	731.24	7.29	6315.10	6315.10	0.00
East Fork	1993	100 yr	165.50	840.34	6.34	6314.98	6314.98	
East Fork	1993	Floodway	165.50	840.51	6.34	6314.98	6314.98	0.00
East Fork	1983	100 yr	161.02	656.31	8.12	6314.41	6314.41	
East Fork	1983	Floodway	161.02	656.39	8.12	6314.41	6314.41	0.00
East Fork	1973	100 yr	153.35	511.74	10.42	6313.44	6313.44	
East Fork	1973	Floodway	153.33	511.36	10.42	6313.44	6313.44	0.00
East Fork	1952	100 yr	167.05	798.49	6.68	6311.68	6311.68	
East Fork	1952	Floodway	167.05	798.49	6.68	6311.68	6311.68	0.00
East Fork	1943	100 yr	167.54	987.37	5.40	6311.77	6311.77	
East Fork	1943	Floodway	167.55	987.53	5.40	6311.78	6311.77	0.00
East Fork	1924	100 yr	163.89	953.90	5.59	6311.69	6311.69	
East Fork	1924	Floodway	163.90	954.14	5.59	6311.69	6311.69	0.00
East Fork	1923	100 yr	159.61	691.59	7.71	6311.12	6311.12	
East Fork	1923	Floodway	159.60	691.36	7.71	6311.12	6311.12	0.00
East Fork	1910	100 yr	158.79	675.60	7.89	6310.97	6310.97	
East Fork	1910	Floodway	158.78	675.52	7.89	6310.97	6310.97	0.00
East Fork	1835	100 yr	157.12	642.83	8.29	6310.46	6310.46	
East Fork	1835	Floodway	157.12	642.76	8.29	6310.46	6310.46	0.00
East Fork	1609	100 yr	158.99	677.77	7.86	6309.77	6309.77	
East Fork	1609	Floodway	159.00	677.84	7.86	6309.77	6309.77	0.00
East Fork	1455	100 yr	161.60	673.43	7.91	6309.04	6309.04	
East Fork	1455	Floodway	161.62	673.66	7.91	6309.04	6309.04	0.00
East Fork	1445	100 yr	161.05	660.42	8.07	6308.92	6308.92	
East Fork	1445	Floodway	161.07	660.73	8.07	6308.92	6308.92	0.00
East Fork	1435	100 yr	153.19	511.43	10.42	6307.93	6307.93	
East Fork	1435	Floodway	153.17	511.05	10.43	6307.93	6307.93	0.00
East Fork	1421	100 yr	168.18	797.87	6.68	6307.32	6307.32	
East Fork	1421	Floodway	168.16	797.55	6.68	6307.32	6307.32	0.00

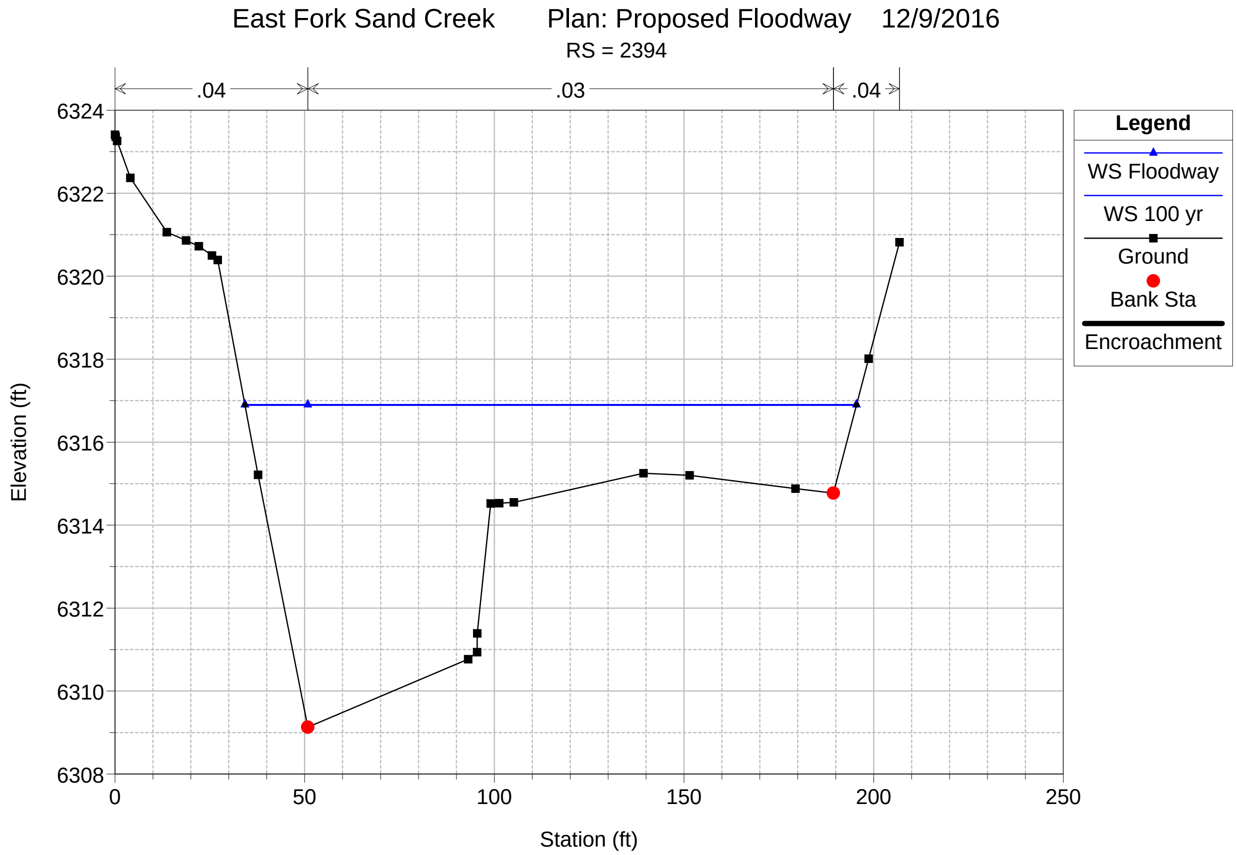
HEC-RAS Plan: Proposed Fldwy River: Sand Creek Reach: East Fork (Continued)

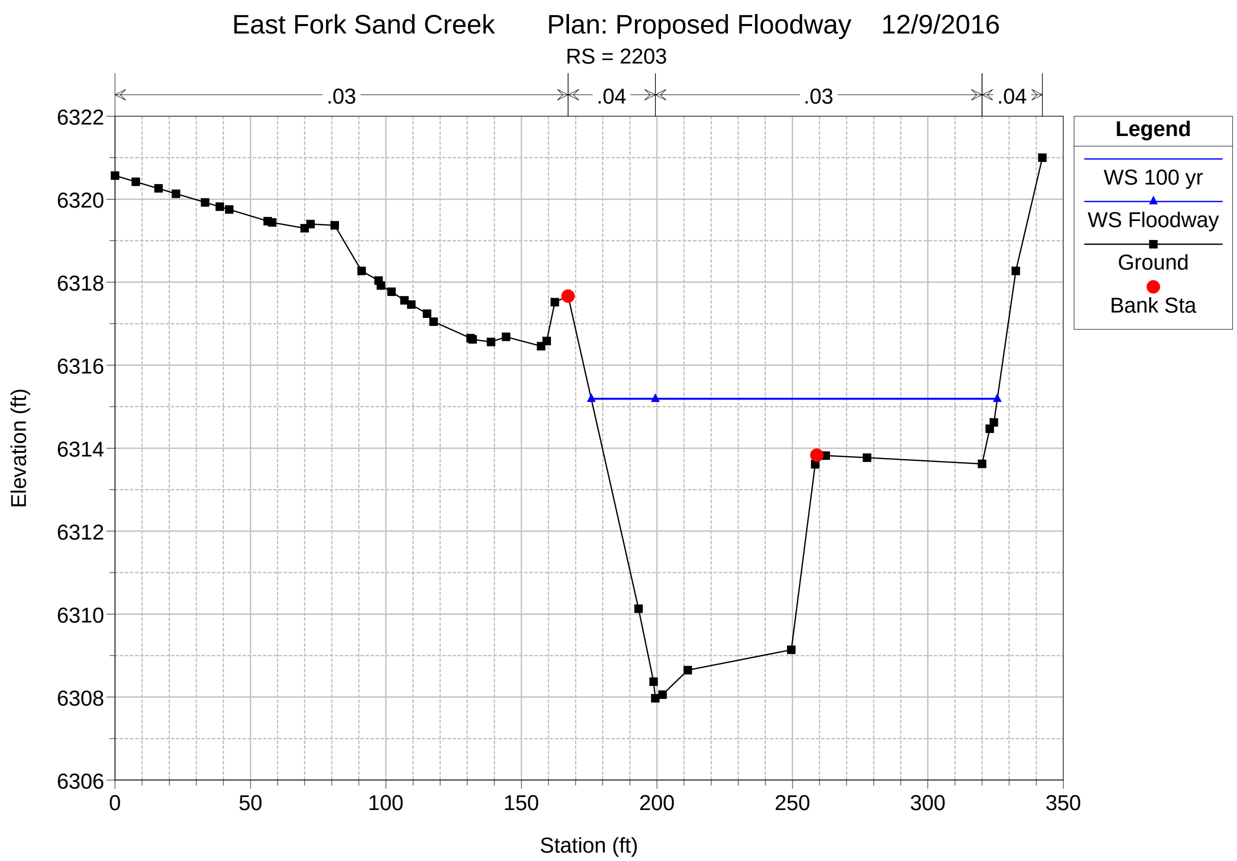
Reach	River Sta	Profile	Top Wdth Act	Area	Vel Total	W.S. Elev	Base WS	Prof Delta WS
			(ft)	(sq ft)	(ft/s)	(ft)	(ft)	(ft)
East Fork	1412	100 yr	169.04	988.05	5.39	6307.41	6307.41	
East Fork	1412	Floodway	169.03	987.89	5.40	6307.41	6307.41	0.00
East Fork	1393	100 yr	164.32	951.95	5.60	6307.33	6307.33	
East Fork	1393	Floodway	164.31	951.87	5.60	6307.32	6307.33	0.00
East Fork	1392	100 yr	159.57	685.45	7.78	6306.73	6306.73	
East Fork	1392	Floodway	159.57	685.37	7.78	6306.73	6306.73	0.00
East Fork	1379	100 yr	158.84	662.11	8.05	6306.55	6306.55	
East Fork	1379	Floodway	158.83	661.96	8.05	6306.55	6306.55	0.00
East Fork	1325	100 yr	155.88	513.62	10.38	6305.27	6305.27	
East Fork	1325	Floodway	155.88	513.77	10.37	6305.28	6305.27	0.00
East Fork	1225	100 yr	192.17	552.26	9.65	6304.45	6304.45	
East Fork	1225	Floodway	192.13	551.51	9.66	6304.44	6304.45	0.00
East Fork	1025	100 yr	361.72	678.29	7.86	6302.74	6302.74	
East Fork	1025	Floodway	361.72	680.59	7.83	6302.75	6302.74	0.01
East Fork	416	100 yr	419.23	1410.69	3.78	6293.41	6293.41	
East Fork	416	Floodway	388.48	1601.00	3.33	6293.96	6293.41	0.55

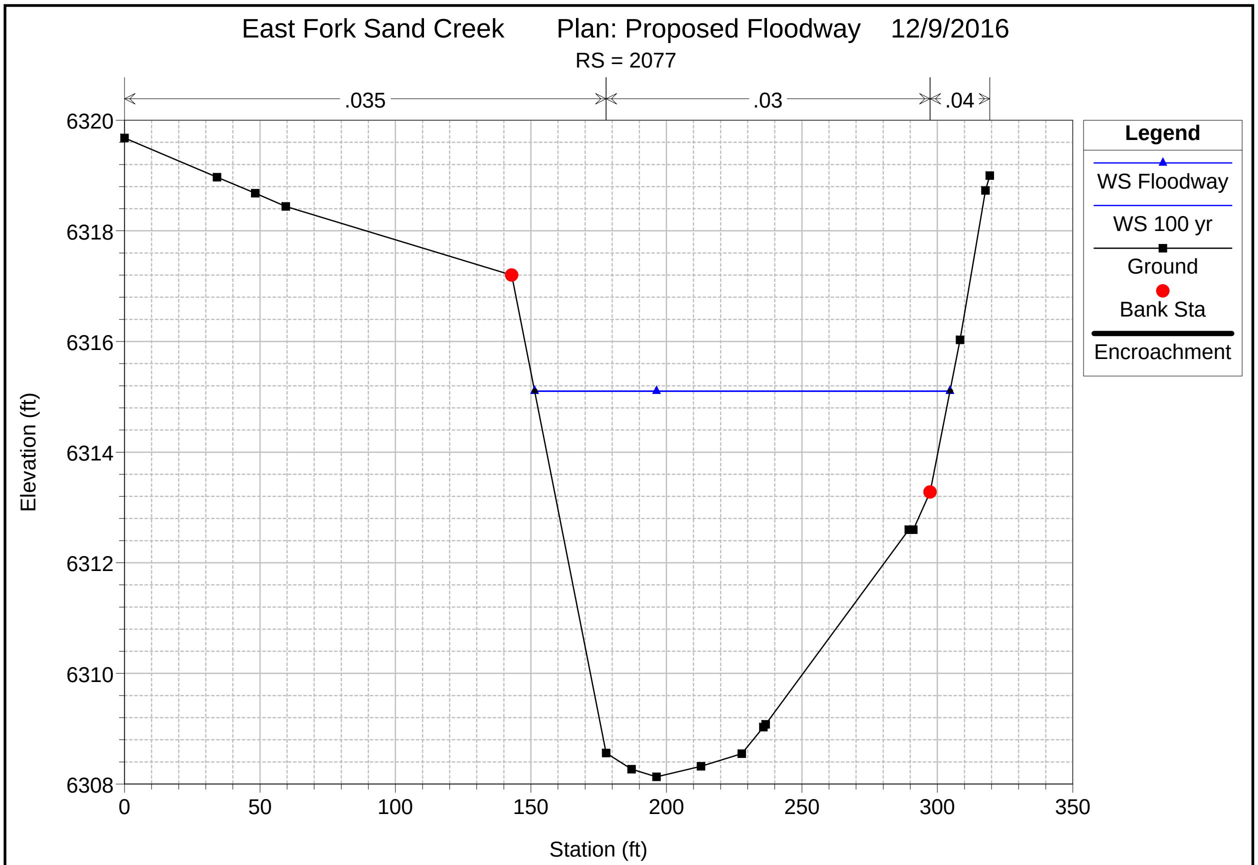

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
Sand Creek East Fork
Legend
WS Floodway
WS 100 yr
Ground
Elevation (ft)
6320
6315
6310
6305
6300
6295
6290
6285
0
500
1000
1500
2000
2500
Main Channel Distance (ft)

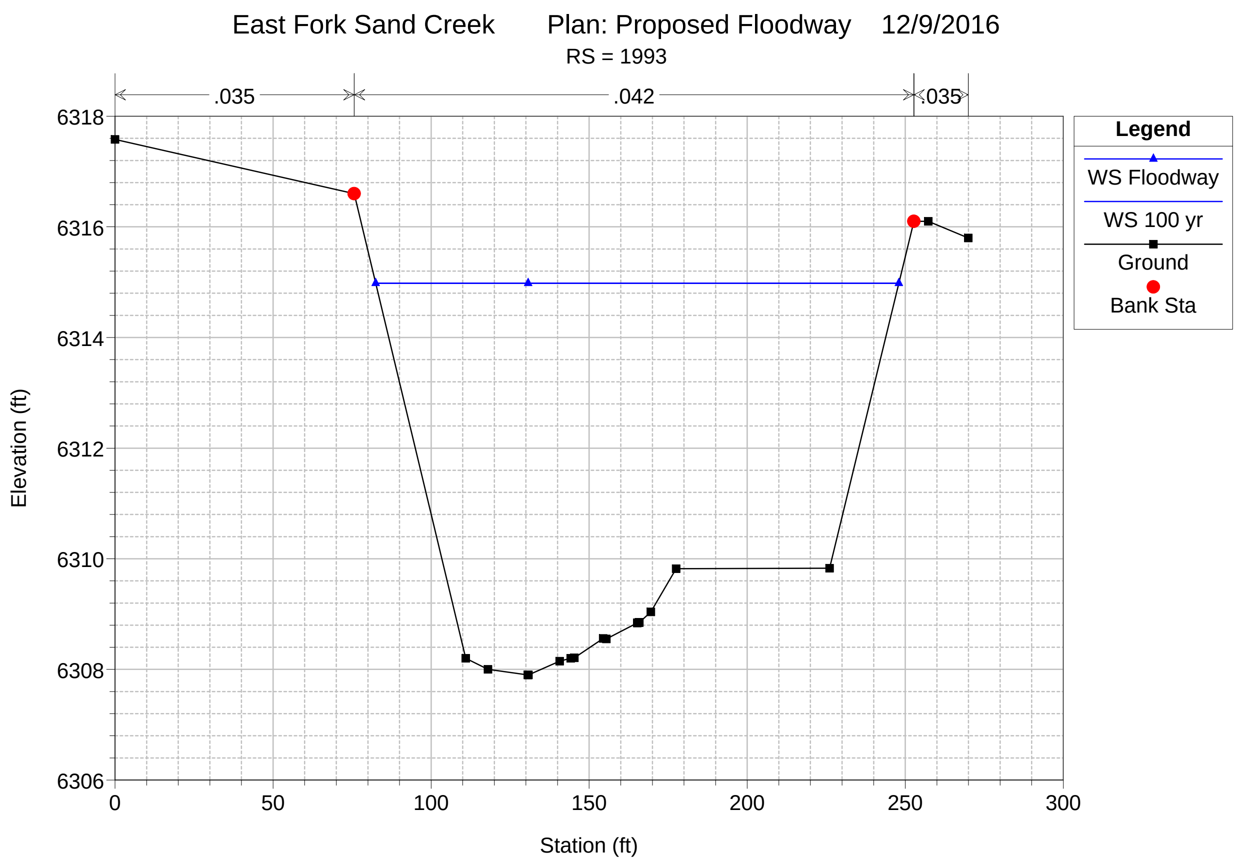

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 2529 Located at LOMR 06-08-B137P, XS 119.3382
.04
.03
.04
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
6328
6326
6324
6322
6320
6318
6316
6314
0
50
100
150
200
250

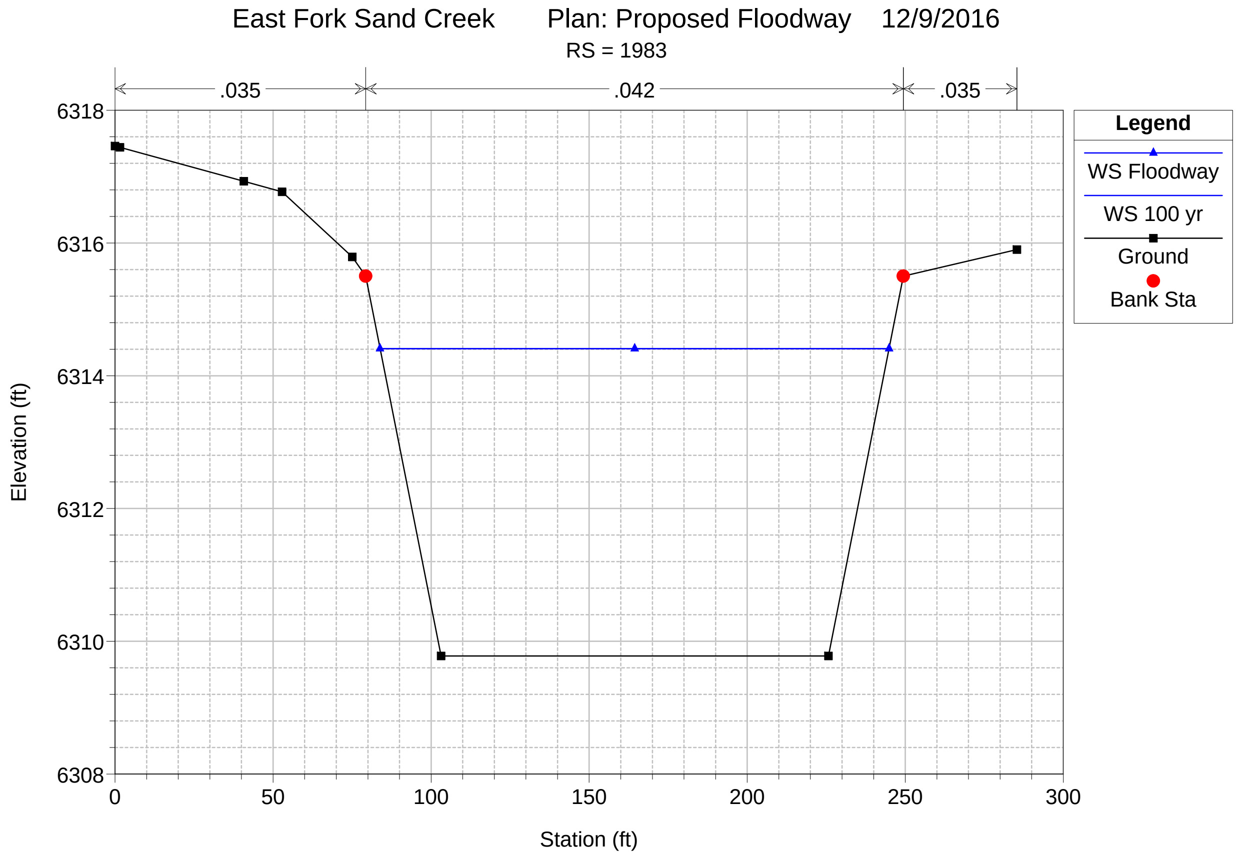

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 2509
.04
.03
.04
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
6328
6326
6324
6322
6320
6318
6316
6314
6312
6310
6308
0
50
100
150
200
250

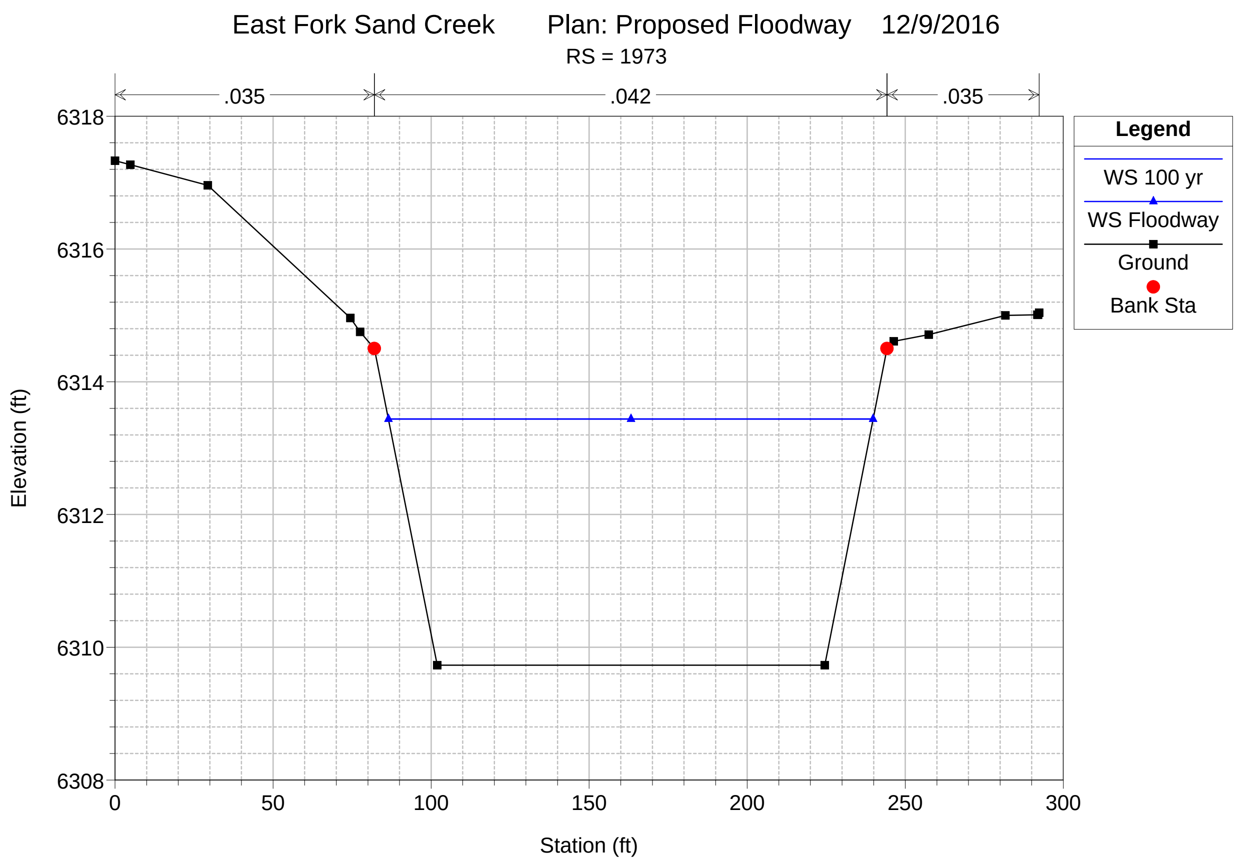

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 2394
.04
.03
.04
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
6324
6322
6320
6318
6316
6314
6312
6310
6308
0
50
100
150
200
250

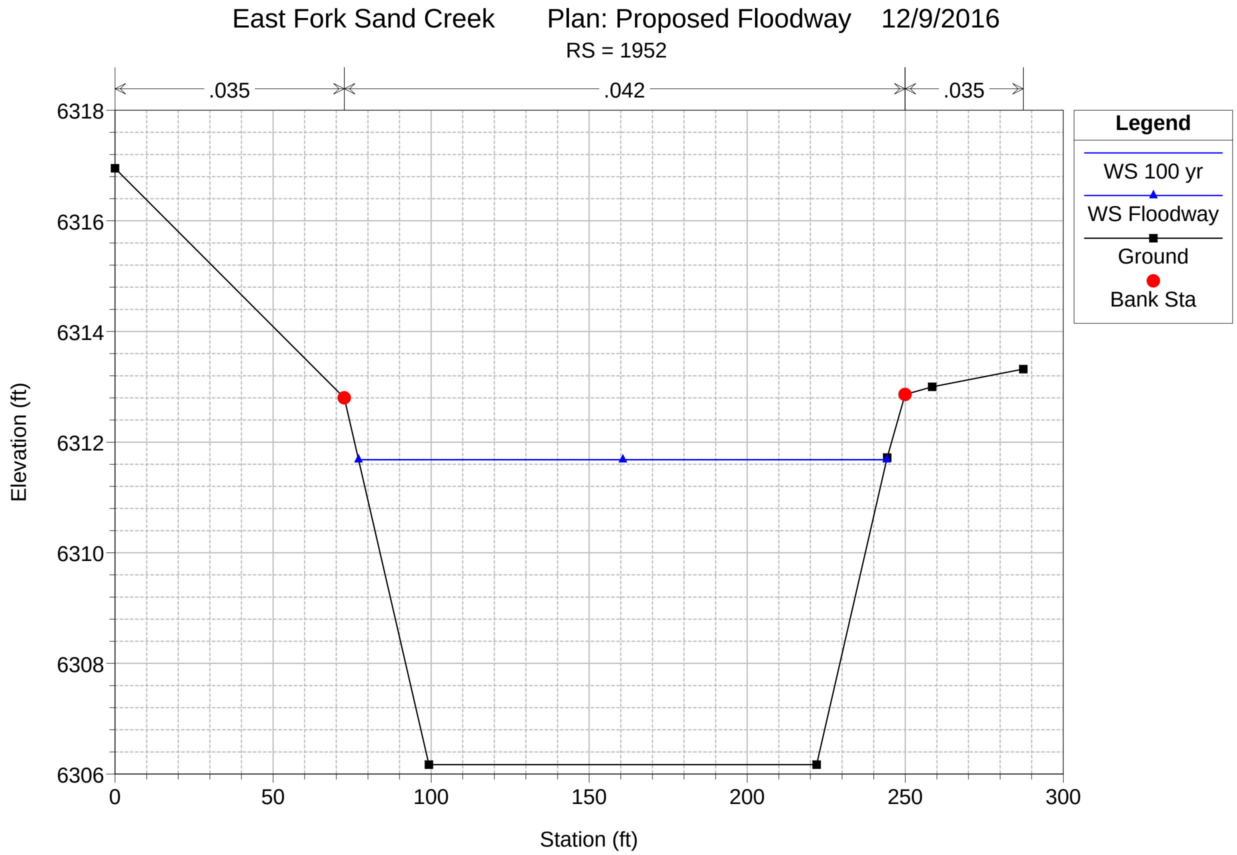

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 2203
.03
.04
.03
.04
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
6322
6320
6318
6316
6314
6312
6310
6308
6306
0
50
100
150
200
250
300
350

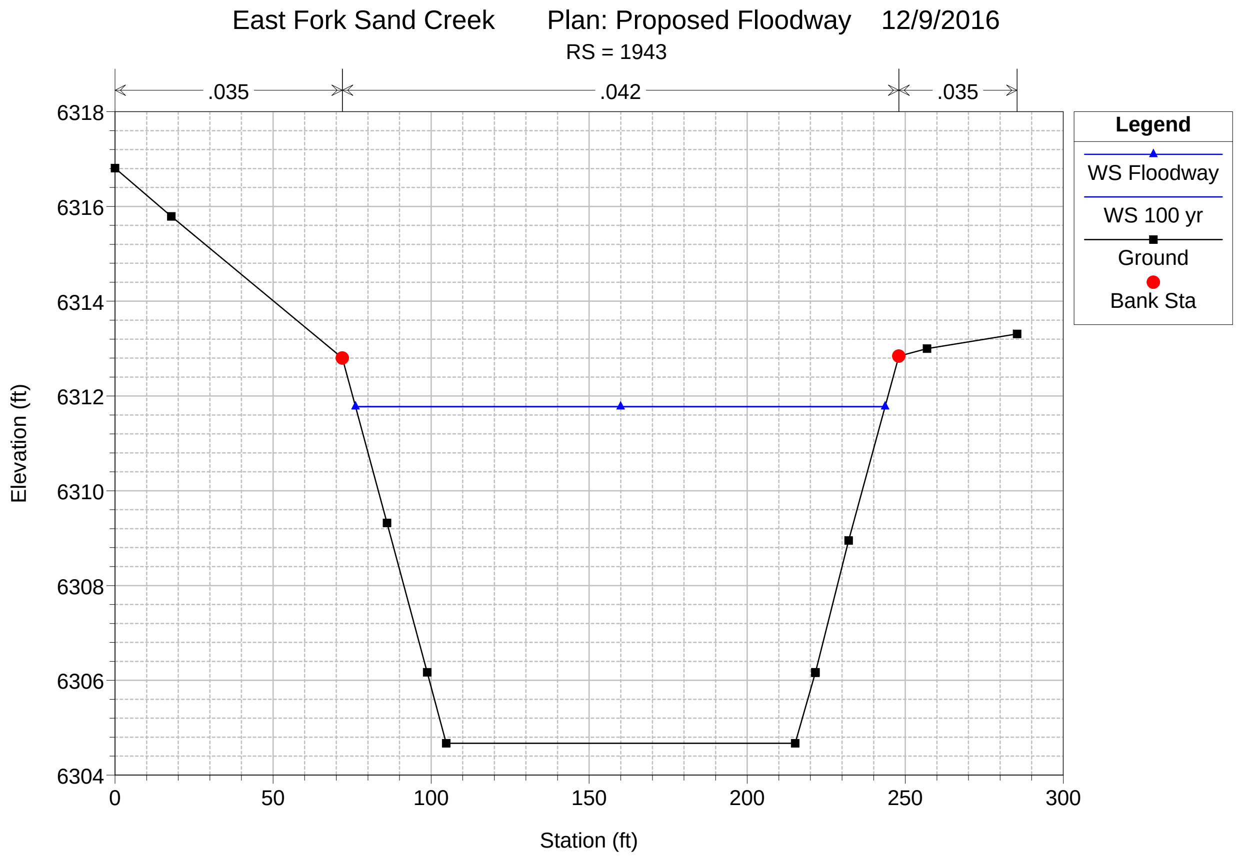

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 2077
.035
.03
.04
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
Elevation (ft)
6320
6318
6316
6314
6312
6310
6308
0
50
100
150
200
250
300
350
Station (ft)

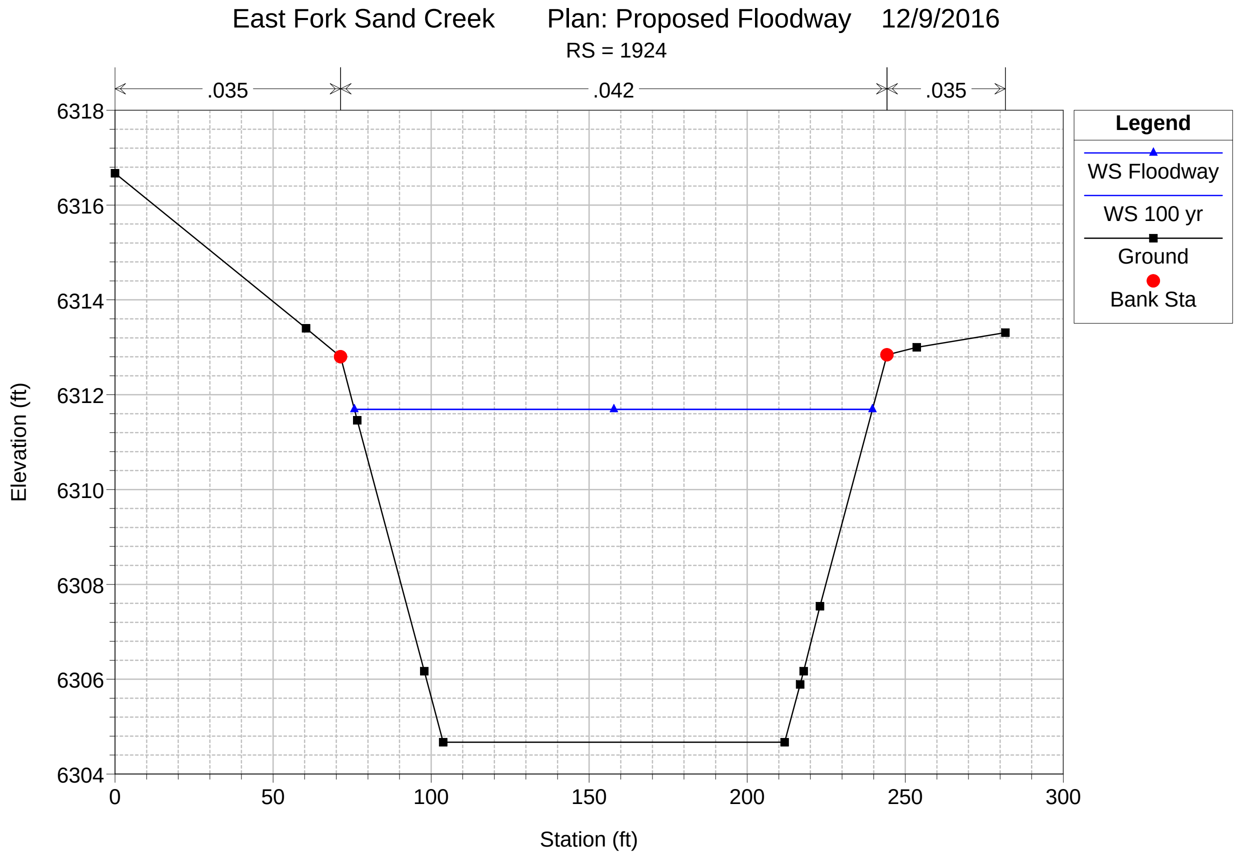

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1993
.035
.042
.035
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Elevation (ft)
6318
6316
6314
6312
6310
6308
6306
0
50
100
150
200
250
300
Station (ft)

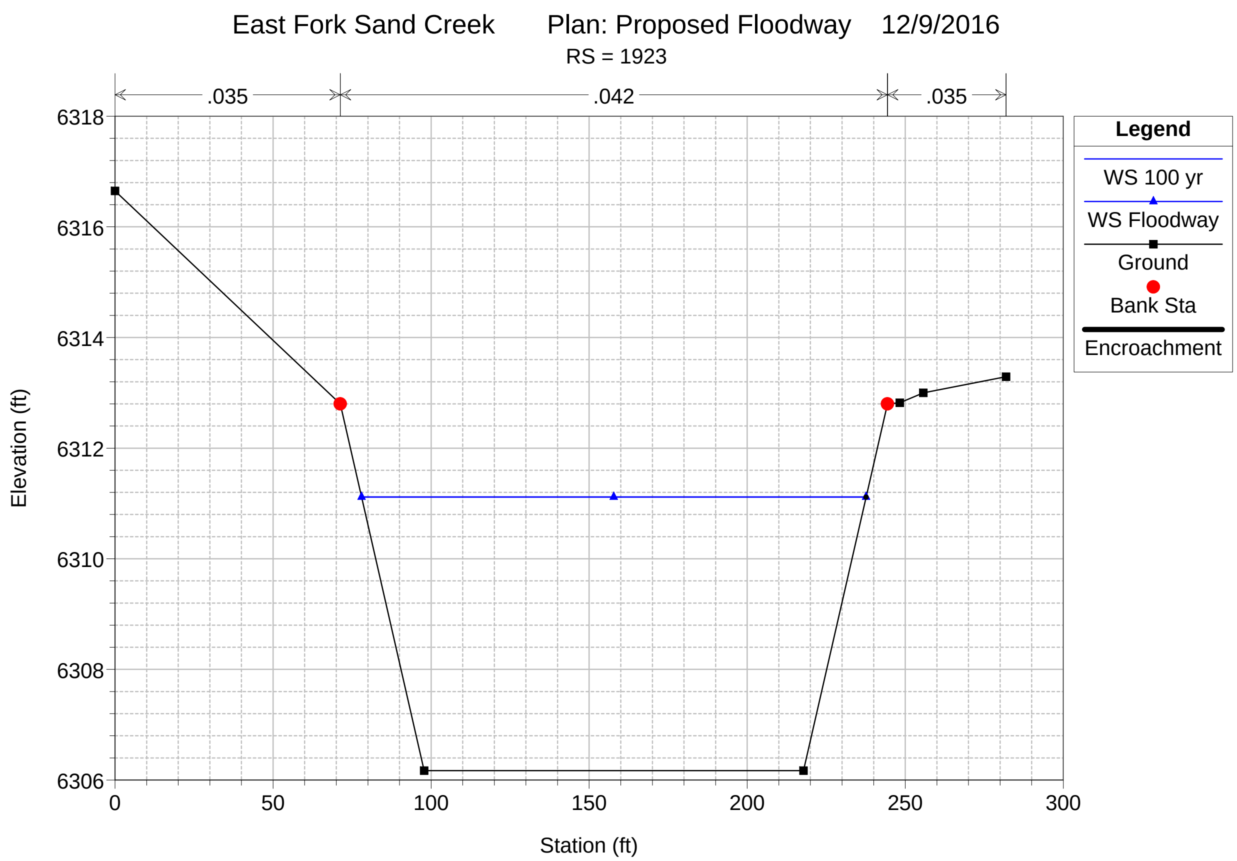

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1983
.035
.042
.035
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Elevation (ft)
6318
6316
6314
6312
6310
6308
0
50
100
150
200
250
300
Station (ft)

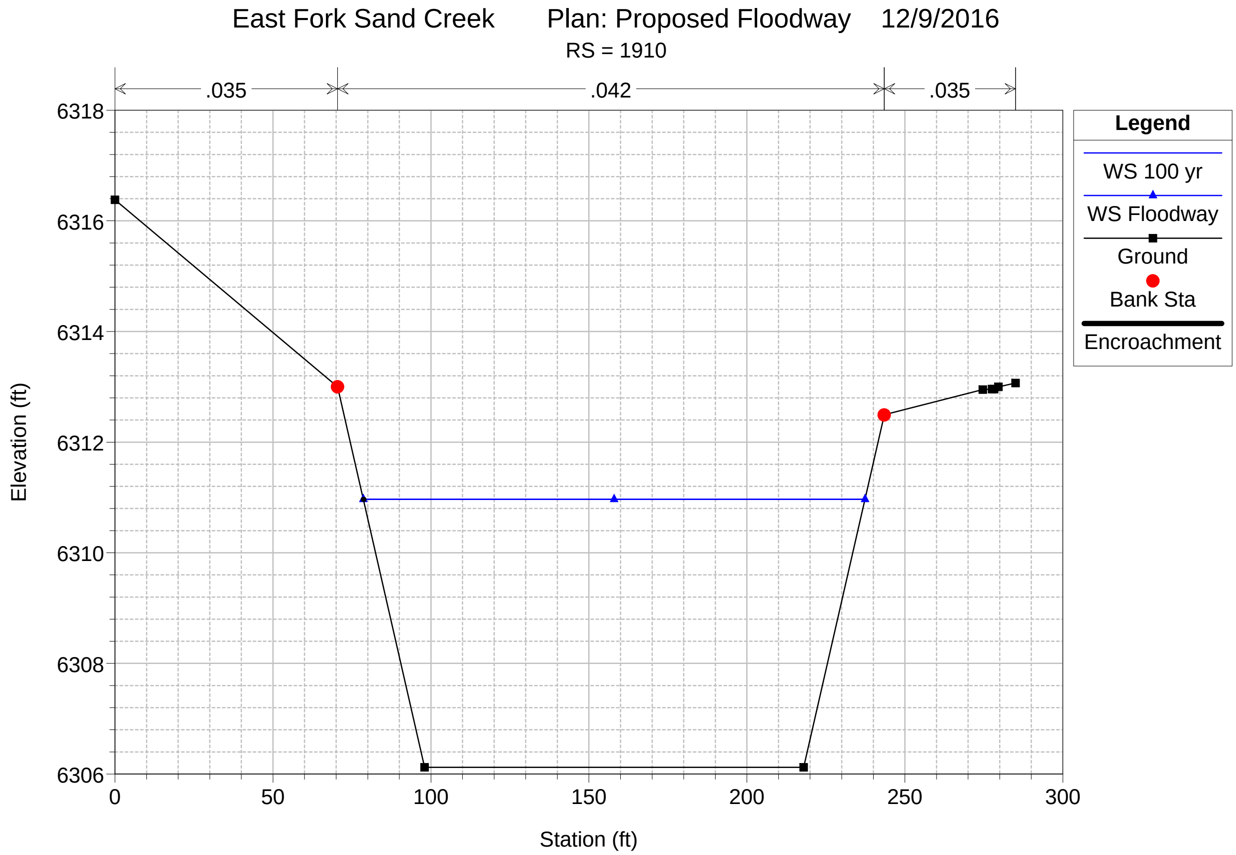

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1973
.035
.042
.035
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Elevation (ft)
6318
6316
6314
6312
6310
6308
0
50
100
150
200
250
300
Station (ft)

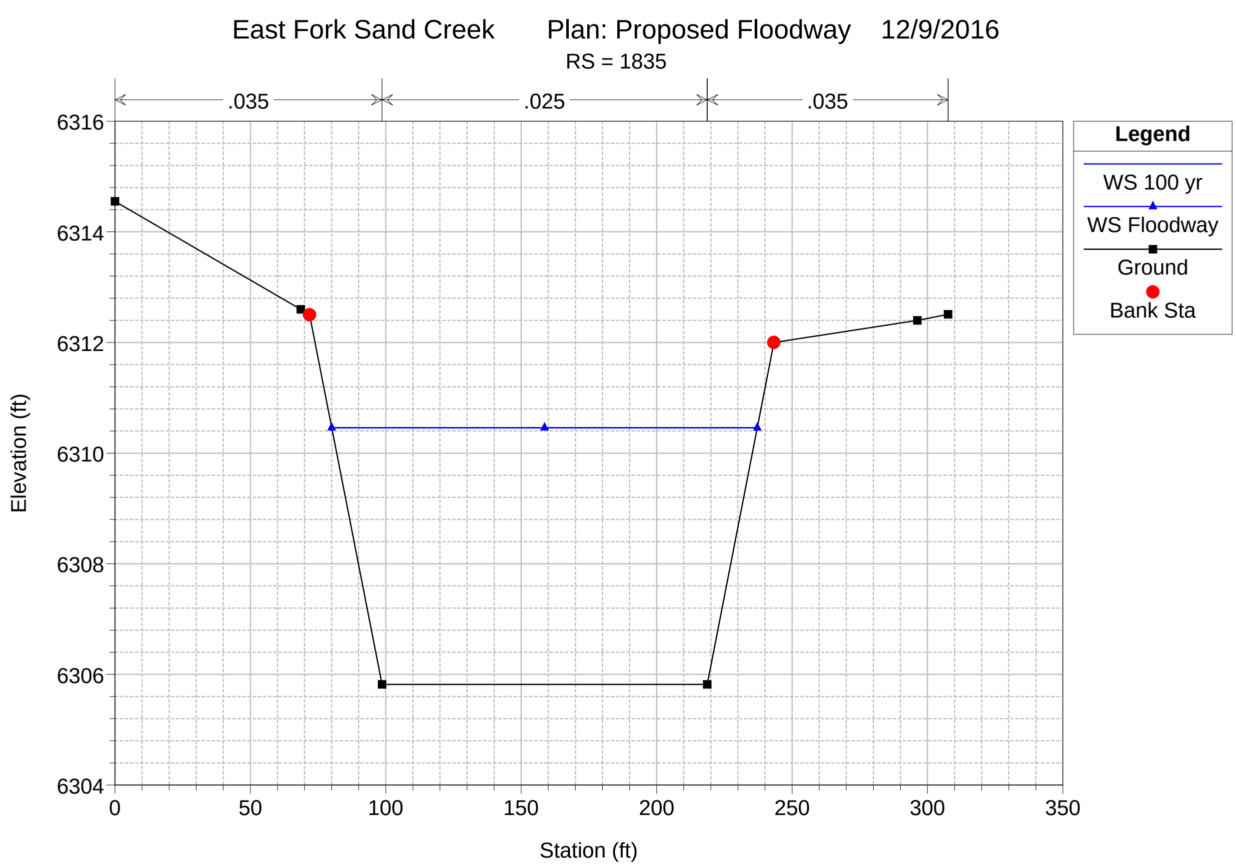

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1952
.035
.042
.035
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Elevation (ft)
6318
6316
6314
6312
6310
6308
6306
0
50
100
150
200
250
300
Station (ft)

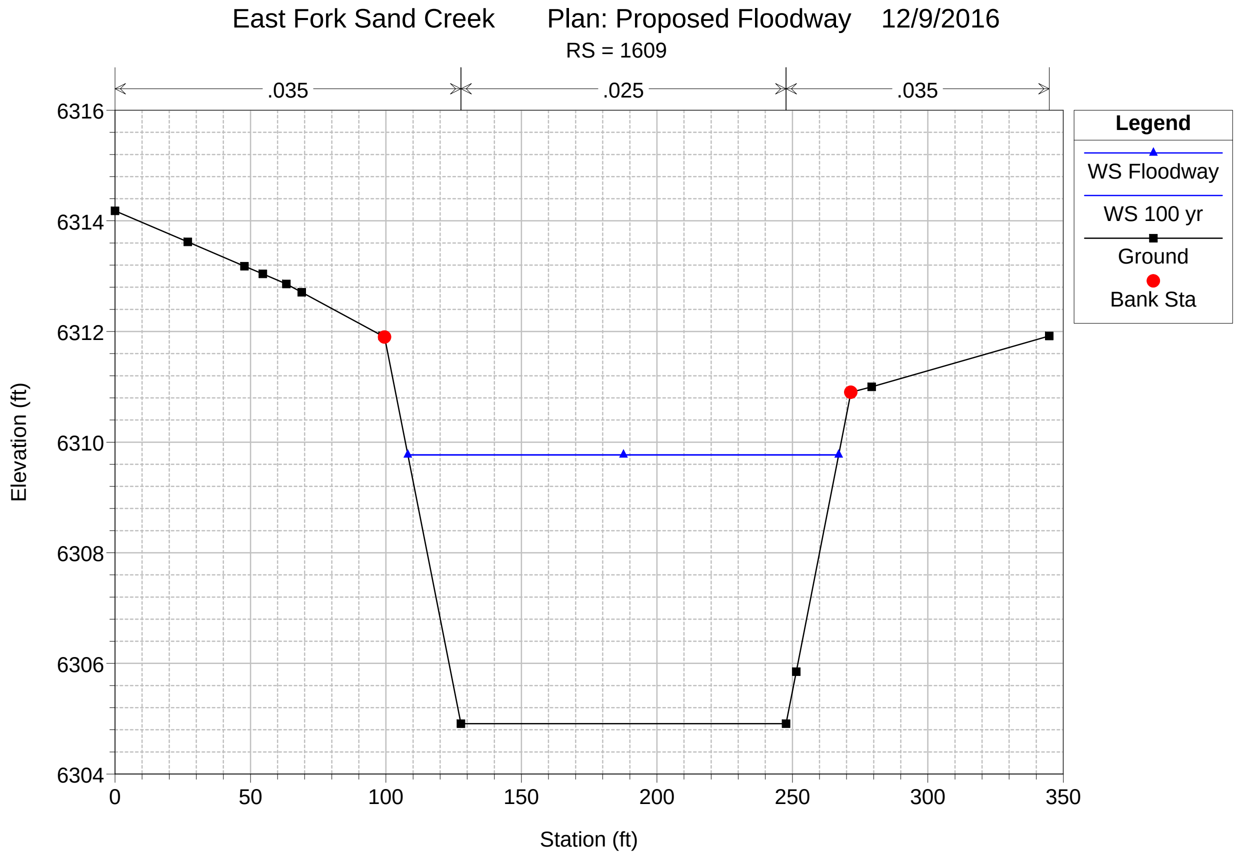

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1943
.035
.042
.035
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Elevation (ft)
6318
6316
6314
6312
6310
6308
6306
6304
0
50
100
150
200
250
300
Station (ft)

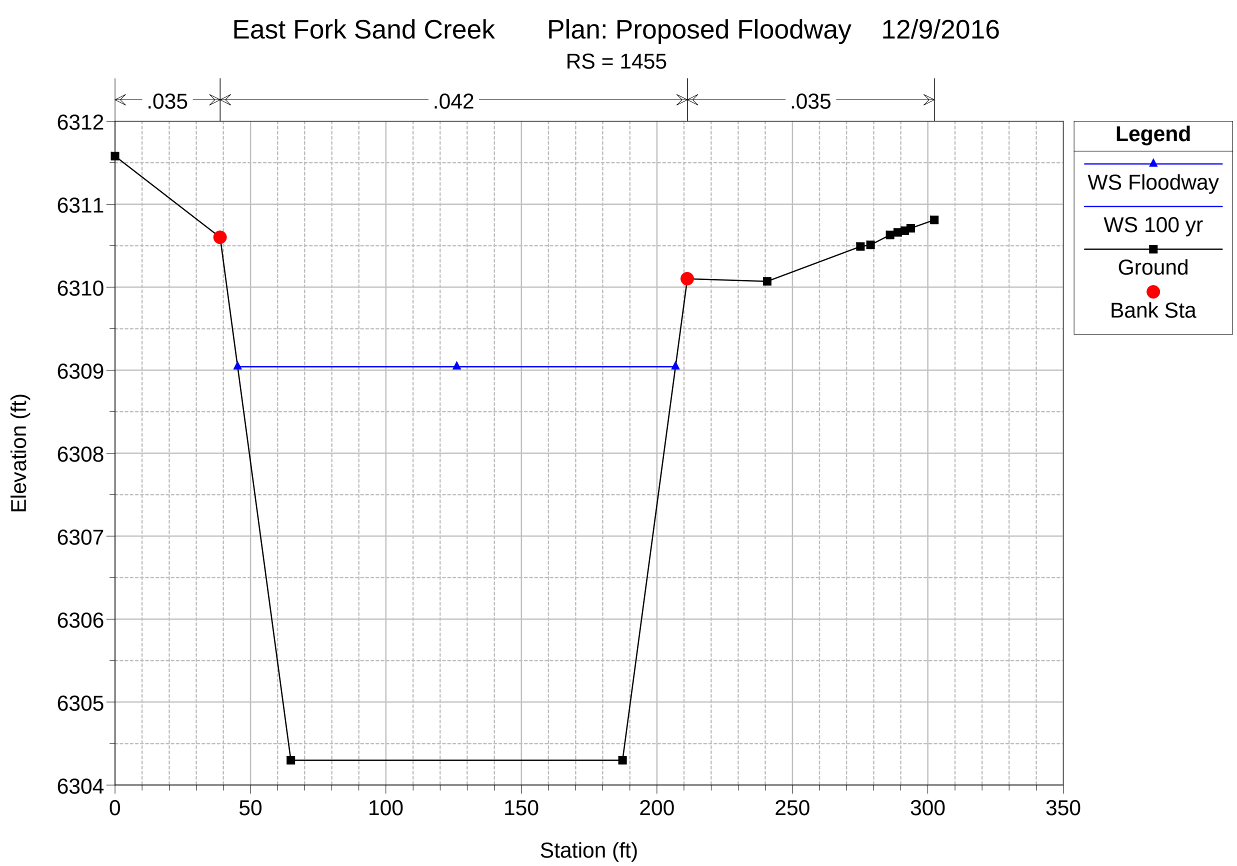

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1924
.035
.042
.035
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
6318
6316
6314
6312
6310
6308
6306
6304
0
50
100
150
200
250
300

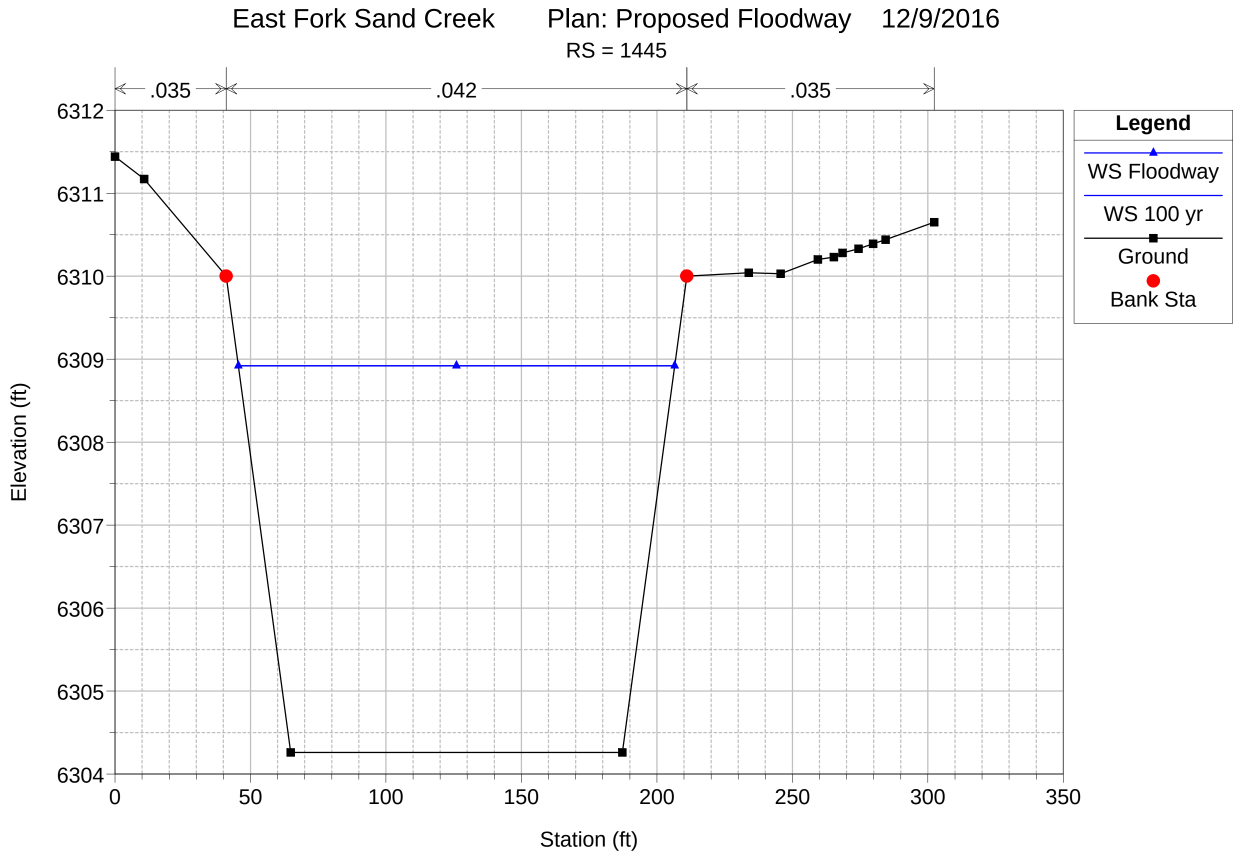

East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1923
.035
.042
.035
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
6318
6316
6314
6312
6310
6308
6306
0
50
100
150
200
250
300


East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1910
.035
.042
.035
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Encroachment
Elevation (ft)
6318
6316
6314
6312
6310
6308
6306
0
50
100
150
200
250
300
Station (ft)


East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1835
.035
.025
.035
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Elevation (ft)
6316
6314
6312
6310
6308
6306
6304
0
50
100
150
200
250
300
350
Station (ft)


East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1609
.035
.025
.035
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Elevation (ft)
6316
6314
6312
6310
6308
6306
6304
0
50
100
150
200
250
300
350
Station (ft)


East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1455
.035
.042
.035
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Elevation (ft)
6312
6311
6310
6309
6308
6307
6306
6305
6304
0
50
100
150
200
250
300
350
Station (ft)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6311
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6305
6304
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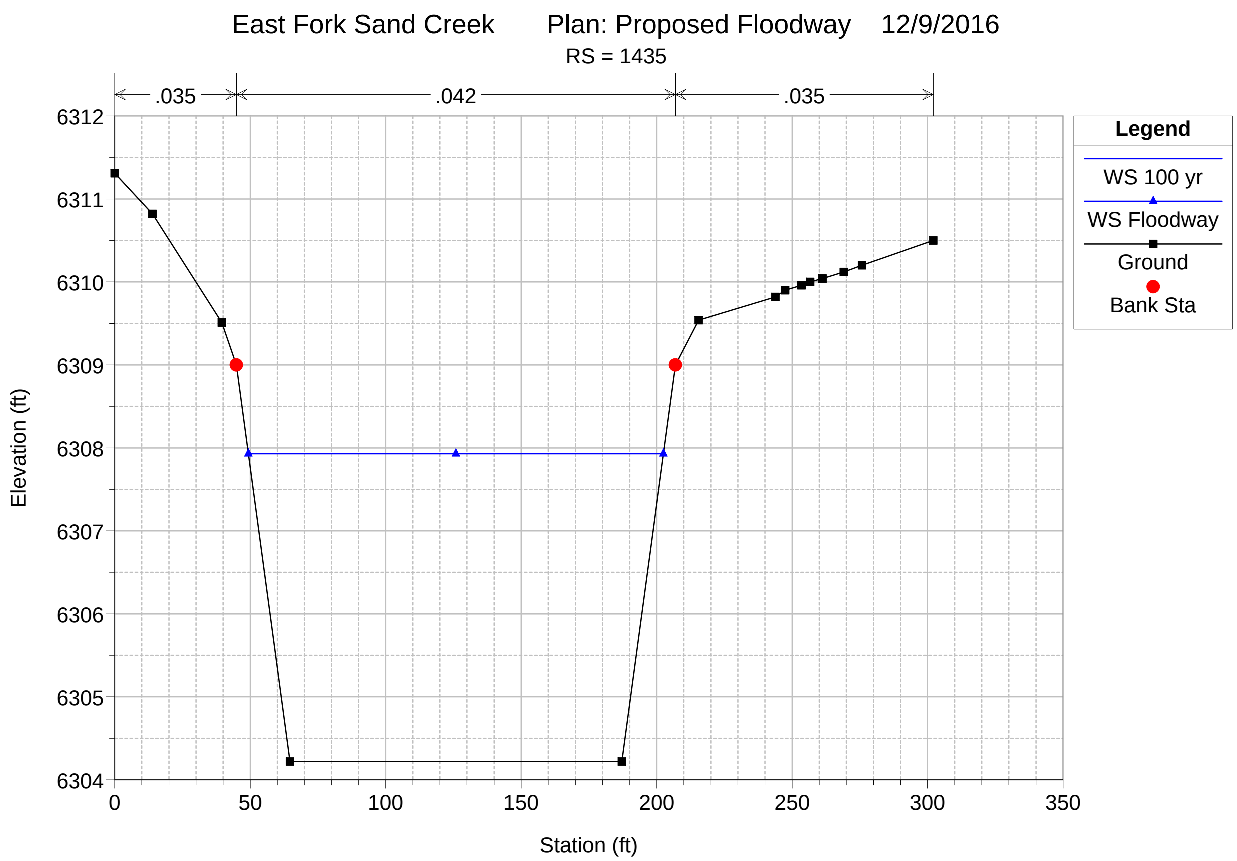
150
200
250
300
350
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta


East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1435
.035
.042
.035
6312
6311
6310
6309
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6306
6305
6304
Elevation (ft)
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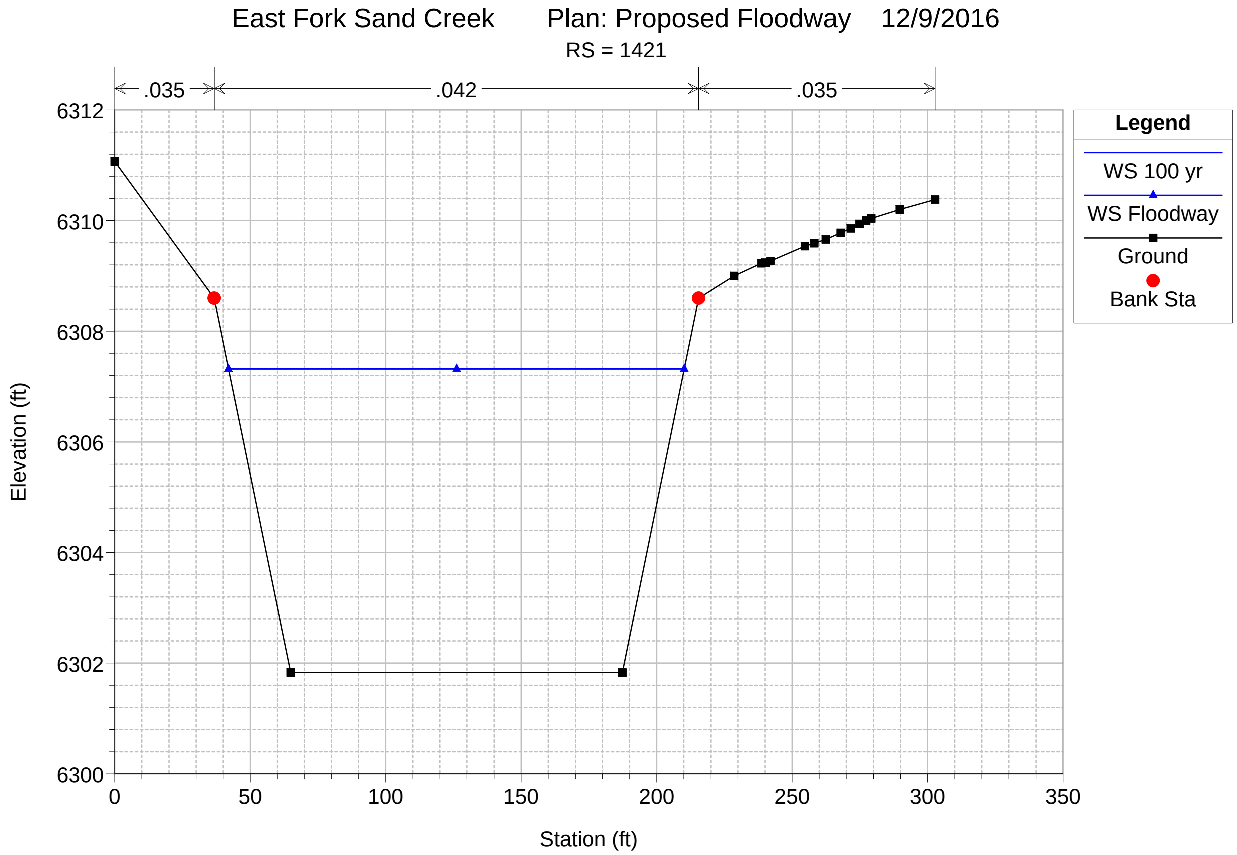
100
150
200
250
300
350
Station (ft)
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta



East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
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Legend
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WS Floodway
Ground
Bank Sta
Elevation (ft)
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6302
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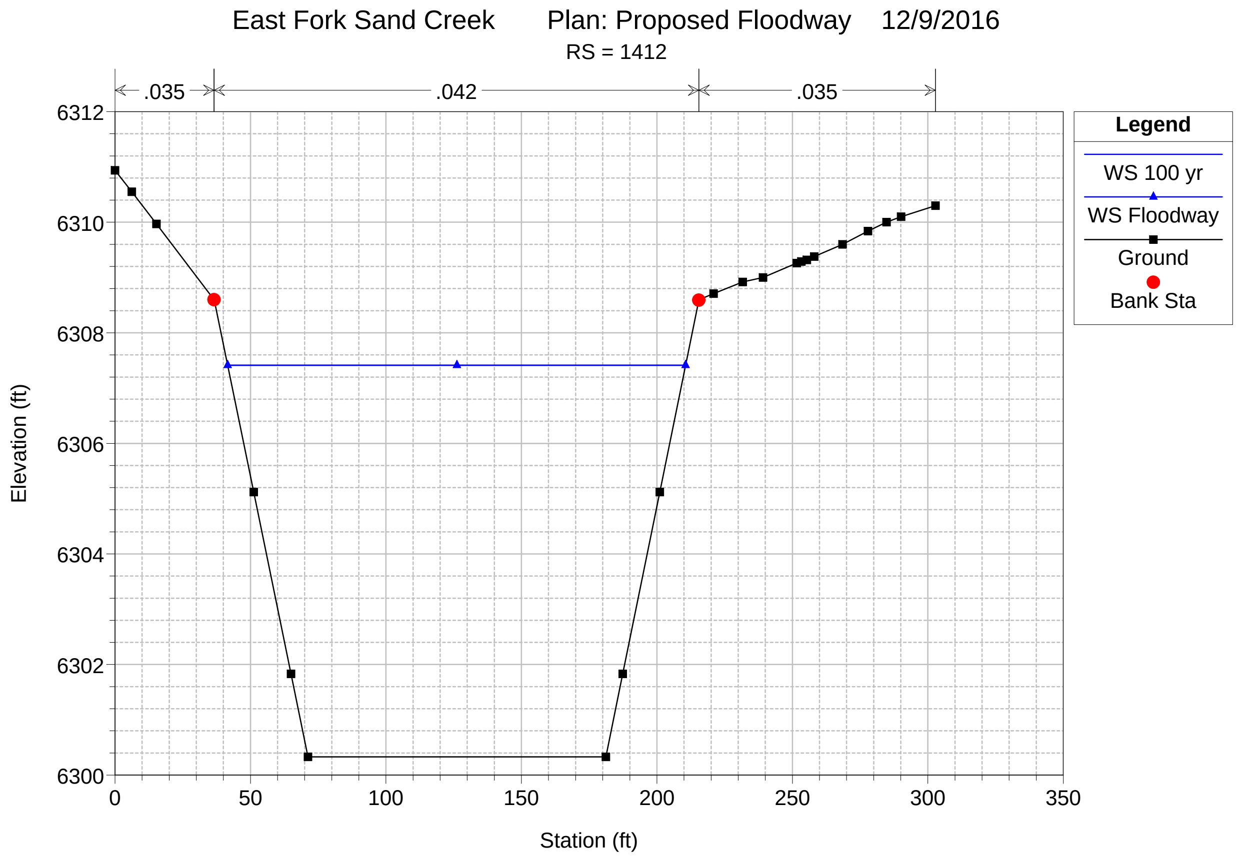
100
150
200
250
300
350
Station (ft)



East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
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Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Elevation (ft)
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6302
6300
0
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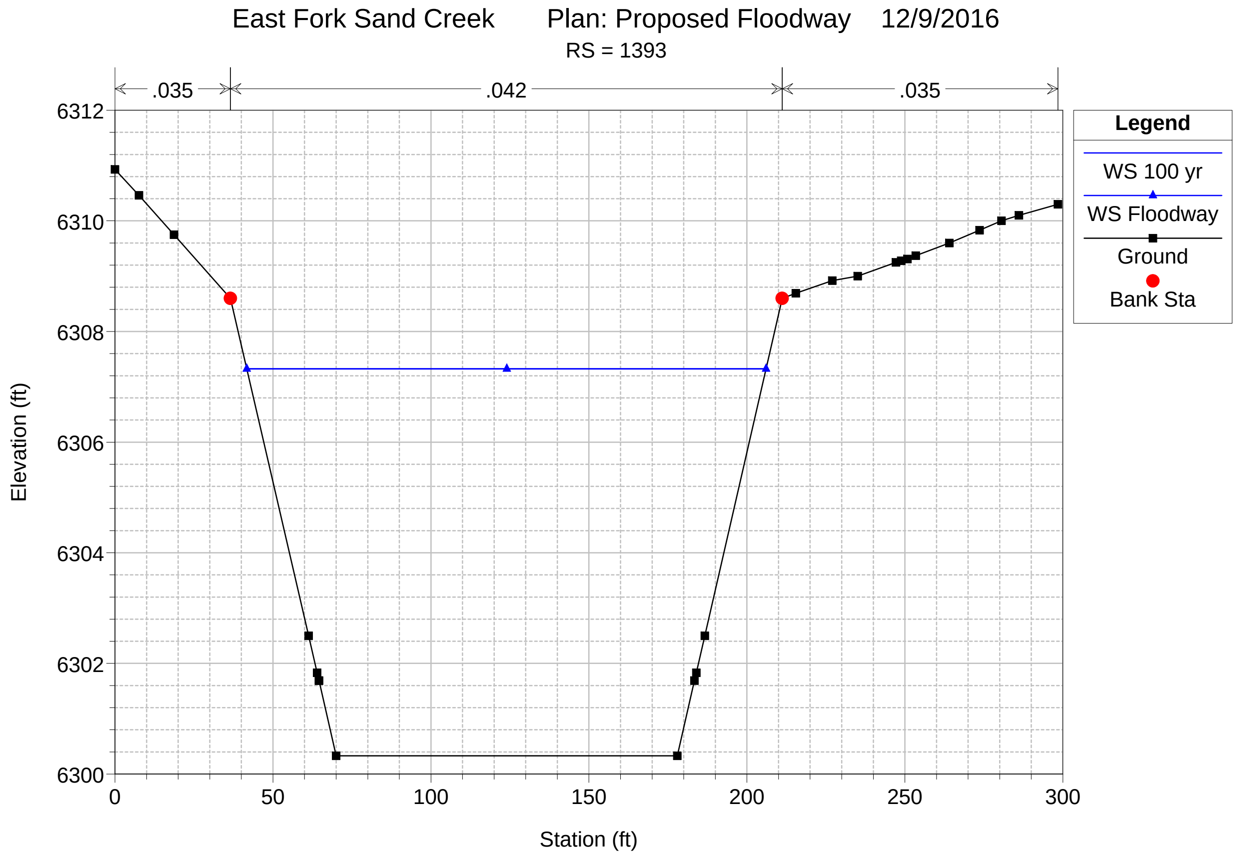
100
150
200
250
300
350
Station (ft)


East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1393
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Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Elevation (ft)
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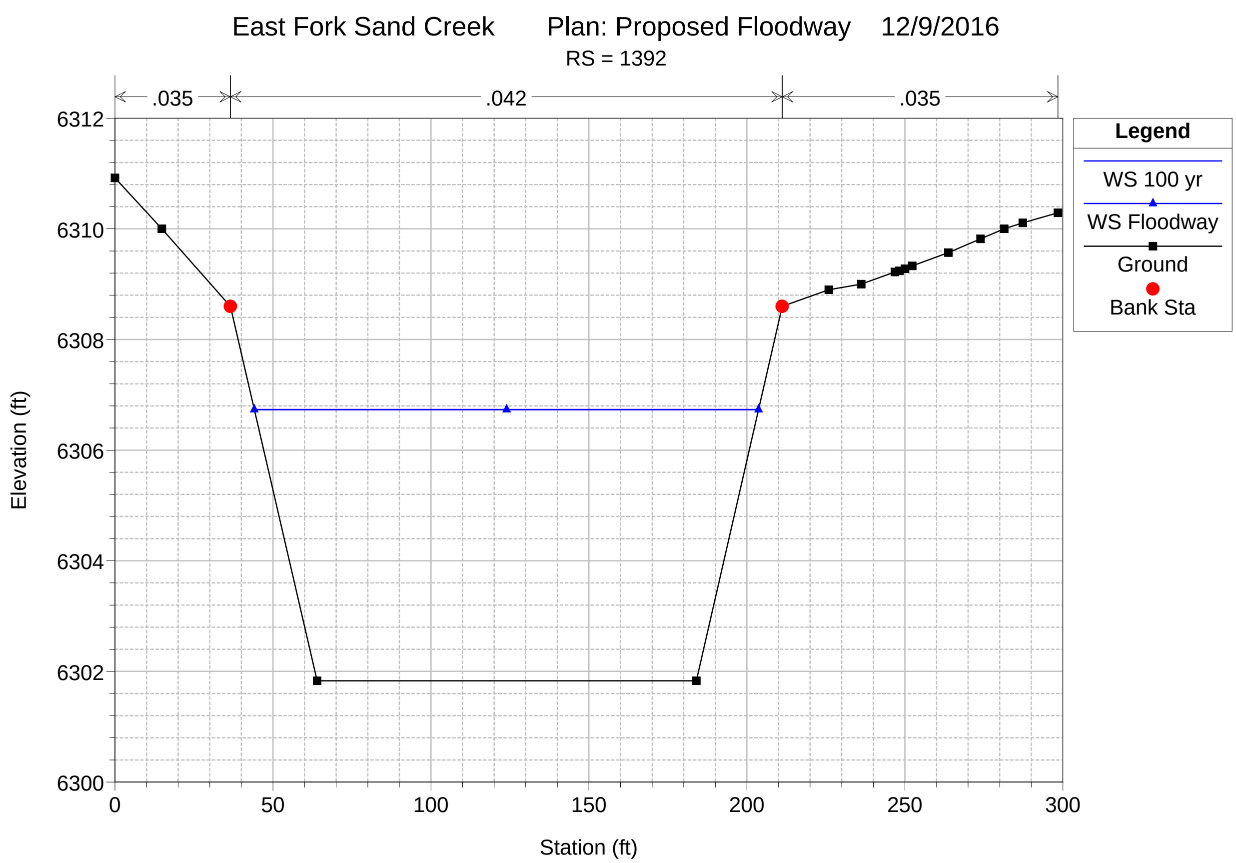
6308
6306
6304
6302
6300
0
50
100
150
200
250
300
Station (ft)


East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1392
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Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Elevation (ft)
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6306
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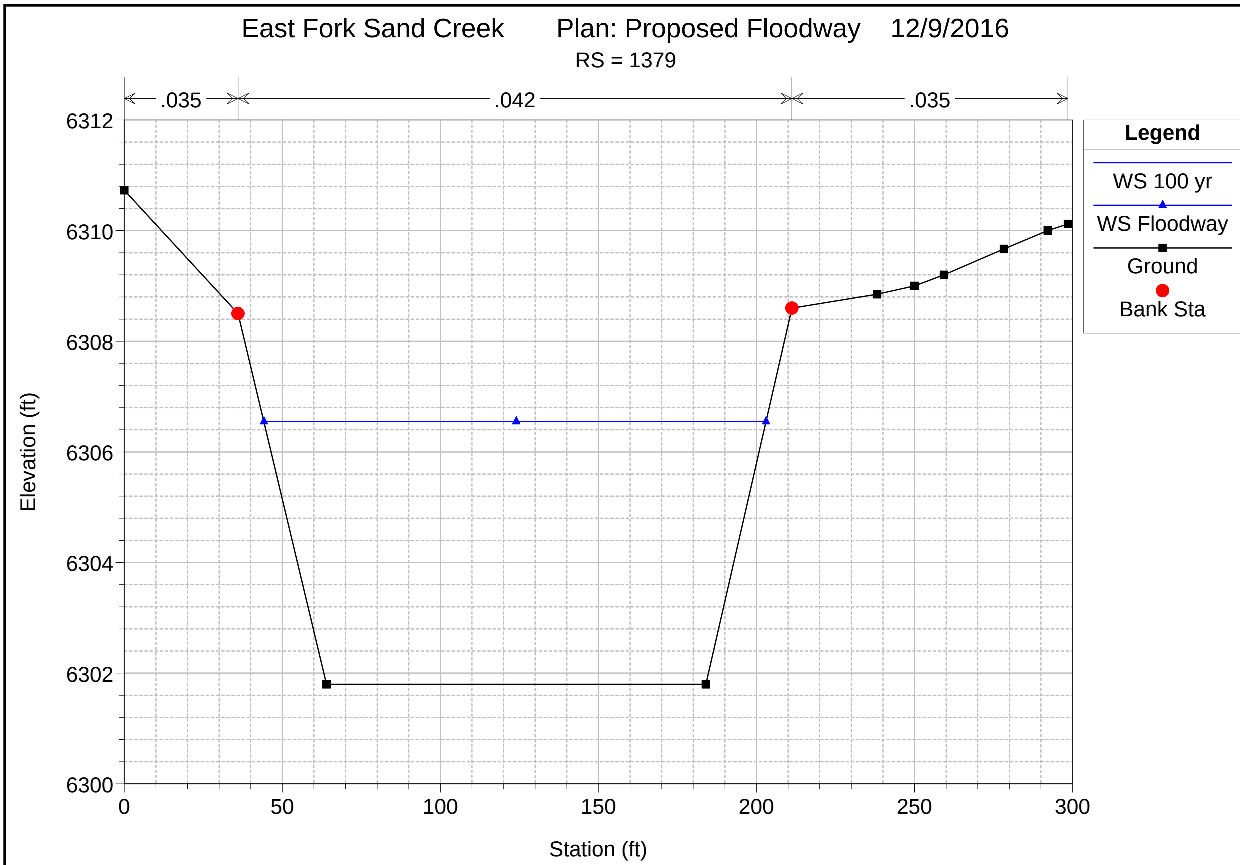
100
150
200
250
300
Station (ft)



East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1379
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.042
.035
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Elevation (ft)
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6306
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6300
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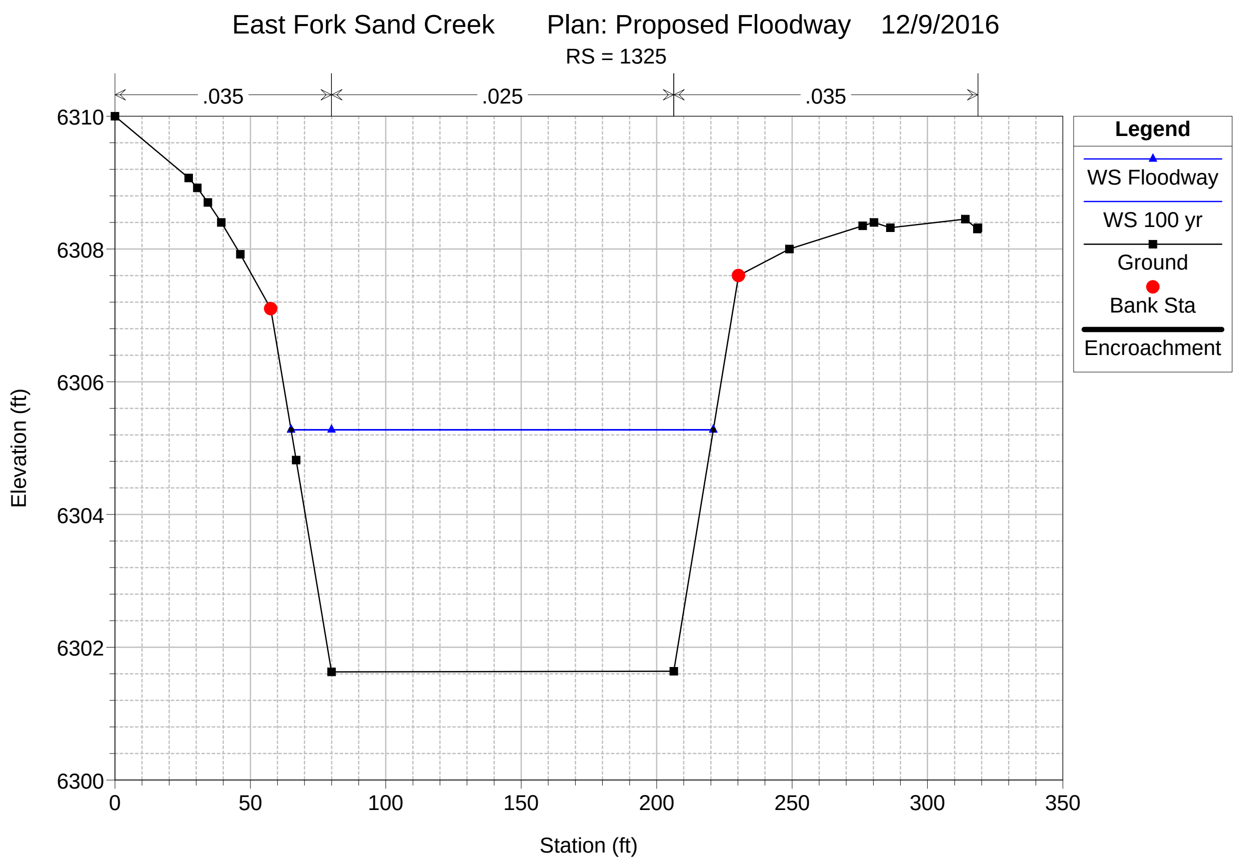
50
100
150
200
250
300
Station (ft)



East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 1325
.035
.025
.035
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
Elevation (ft)
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6308
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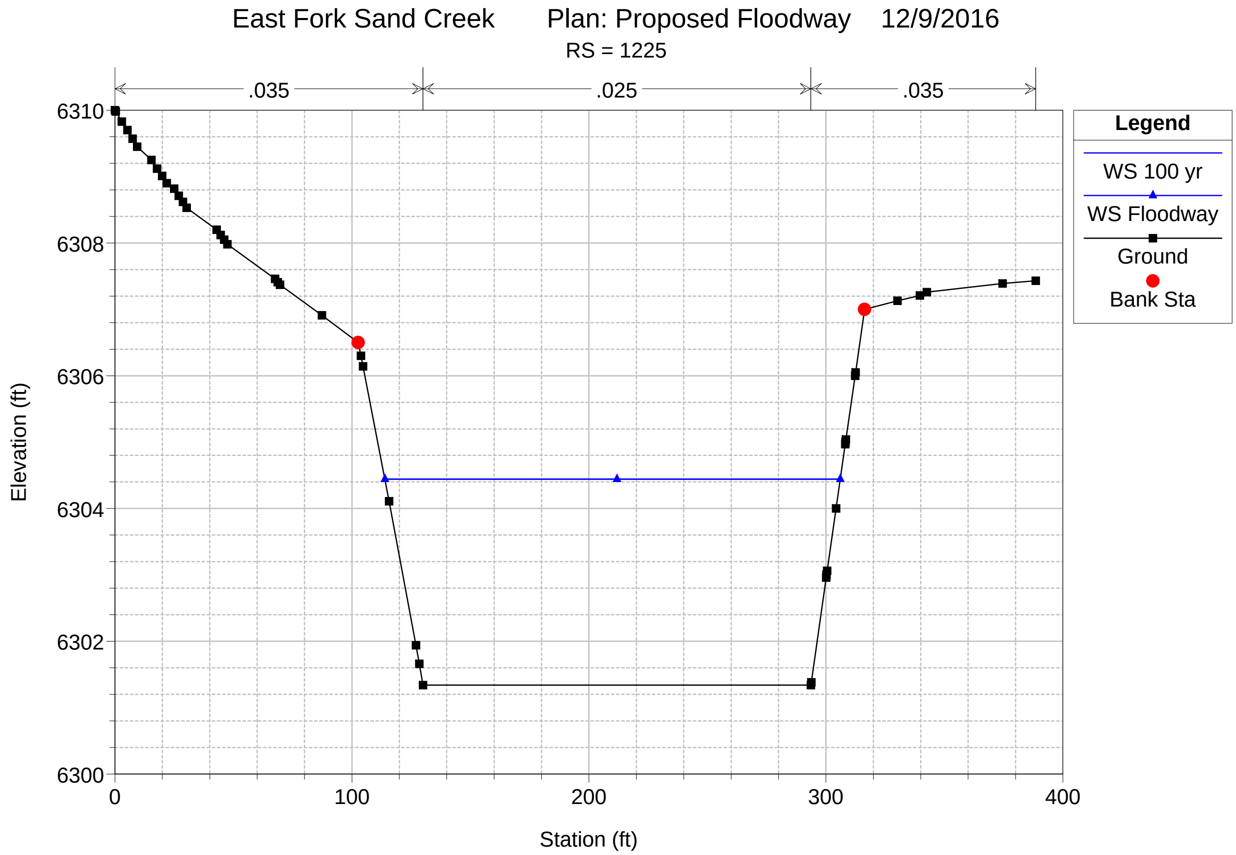
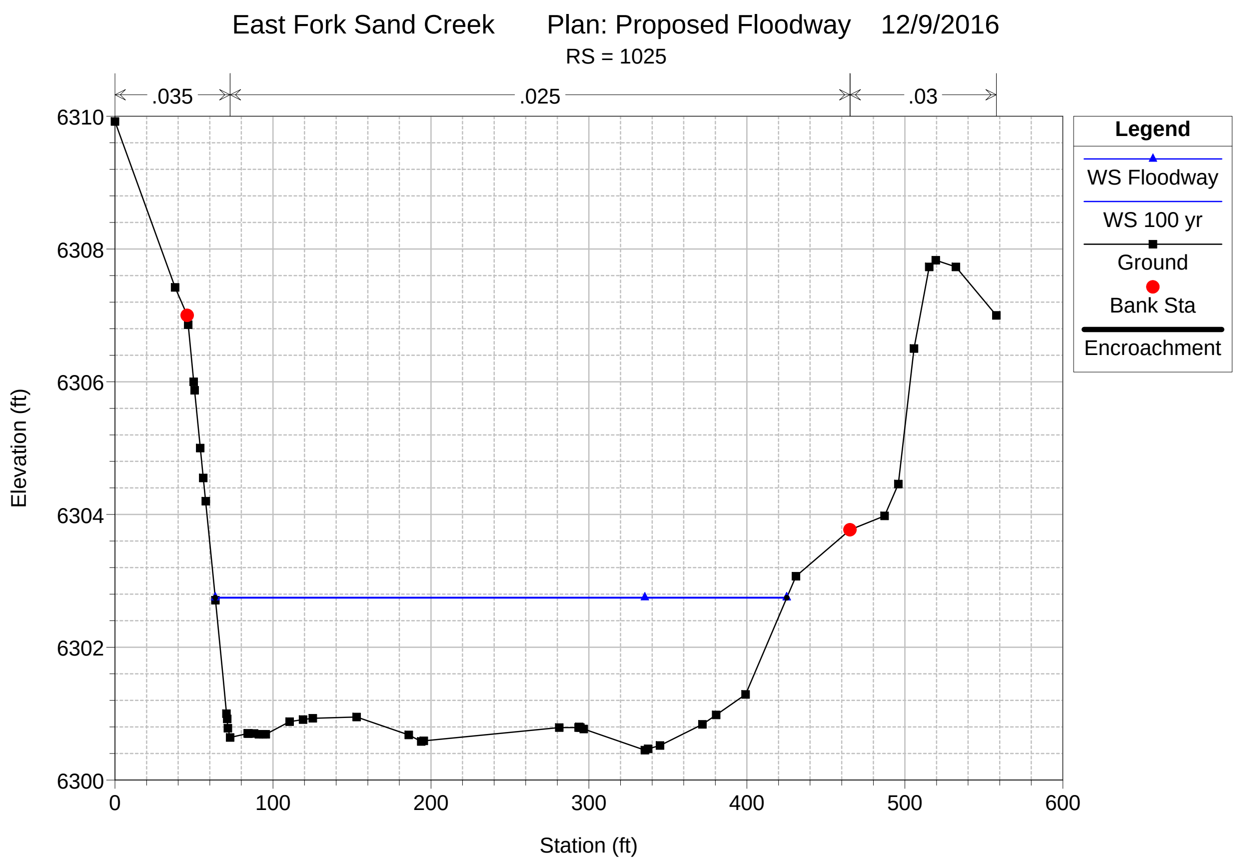
6304
6302
6300
0
50
100
150
200
250
300
350
Station (ft)


East Fork Sand Creek
Plan: Proposed Floodway
12/9/2016
RS = 1225
.035
.025
.035
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
6310
6308
6306
6304
6302
6300
0
100
200
300
400


East Fork Sand Creek
Plan: Proposed Floodway
12/9/2016
RS = 1025
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.03
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
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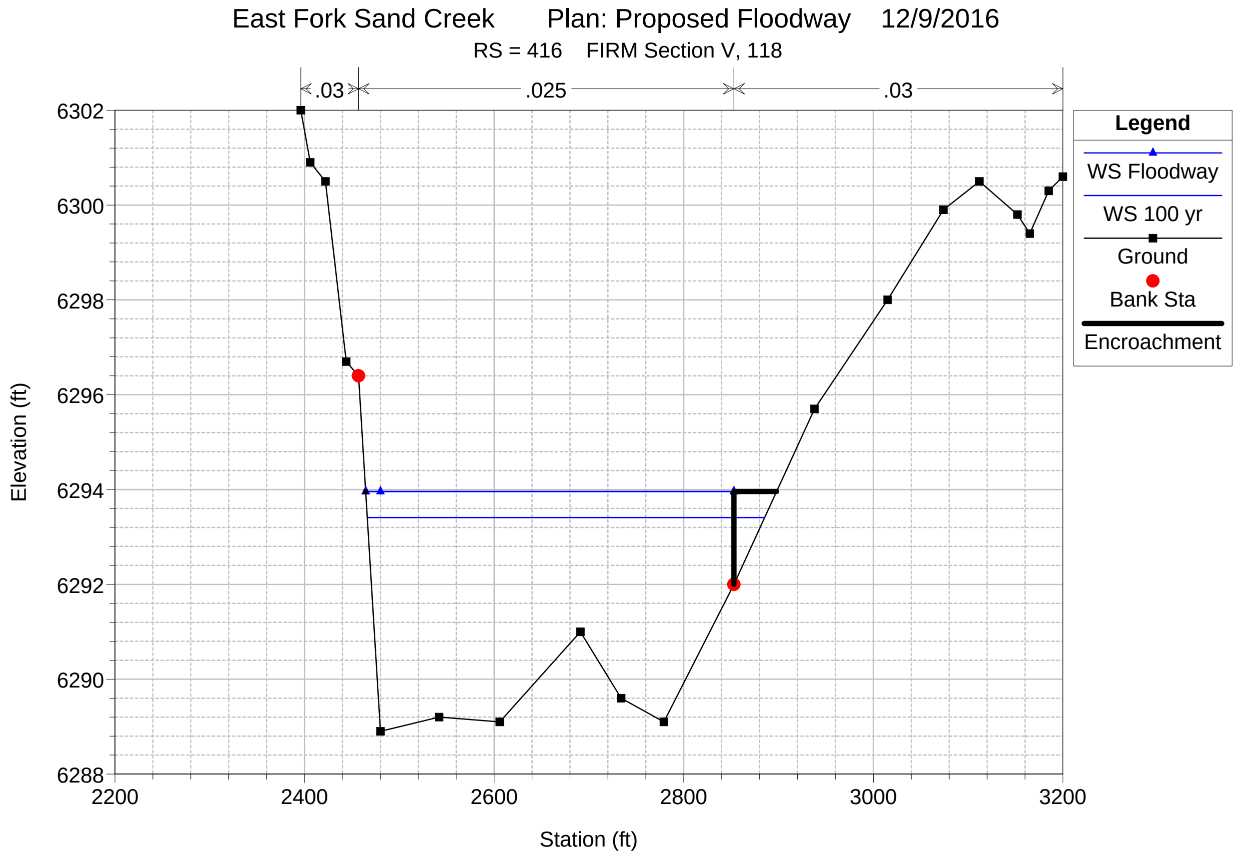
6302
6300
0
100
200
300
400
500
600


East Fork Sand Creek Plan: Proposed Floodway 12/9/2016
RS = 416 FIRM Section V, 118
.03
.025
.03
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
6302
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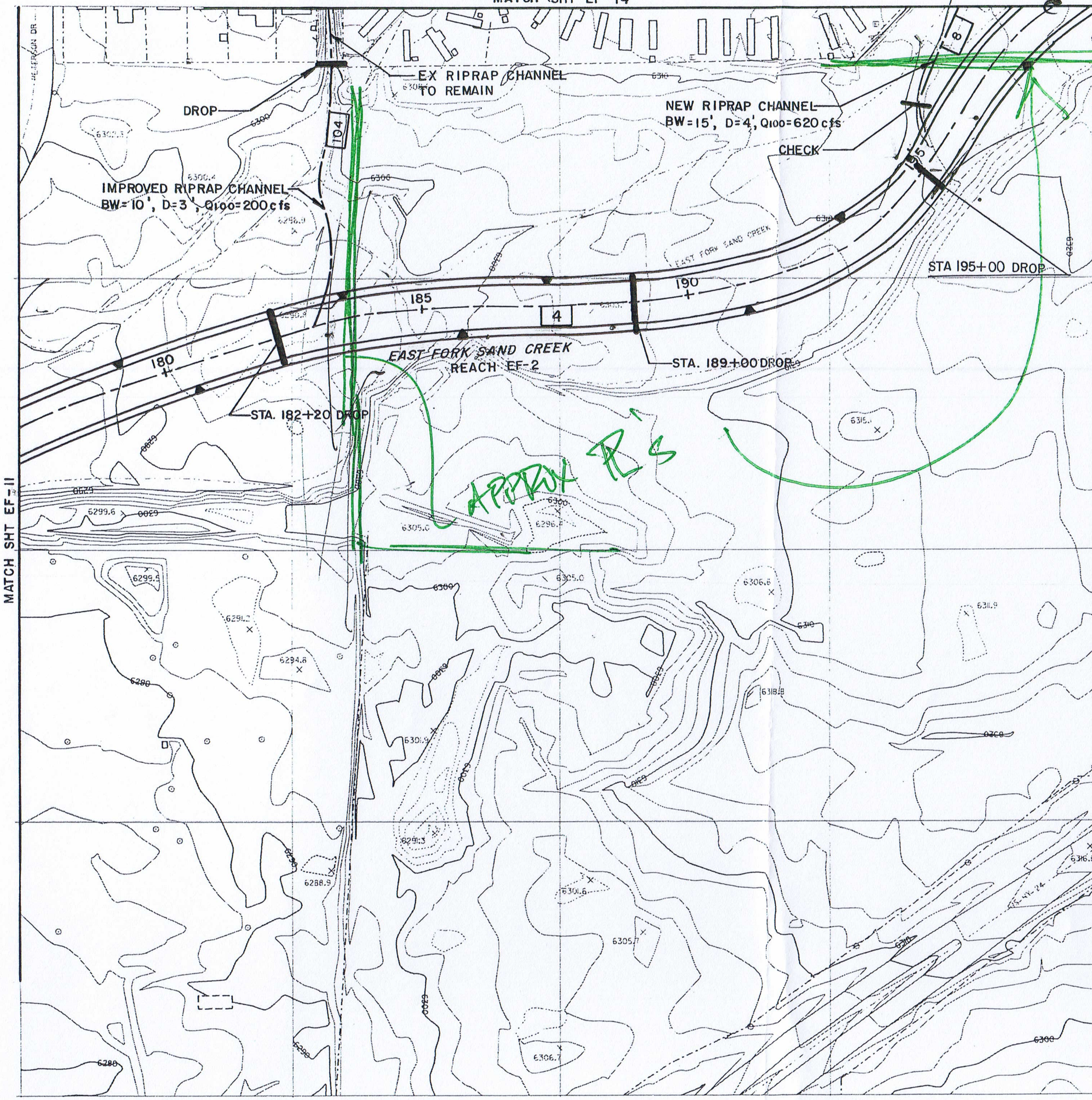
6290
6288
2200
2400
2600
2800
3000
3200



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.

CHANNEL IMPROVEMENTS

SEGMENT NO.	BOTTOM WIDTH (FT) (FT)	CHANNEL TYPE
4	80	100-YEAR RIPRAP LININGS 5' DEPTH

FOR PROFILE SEE SHEET EFP-4

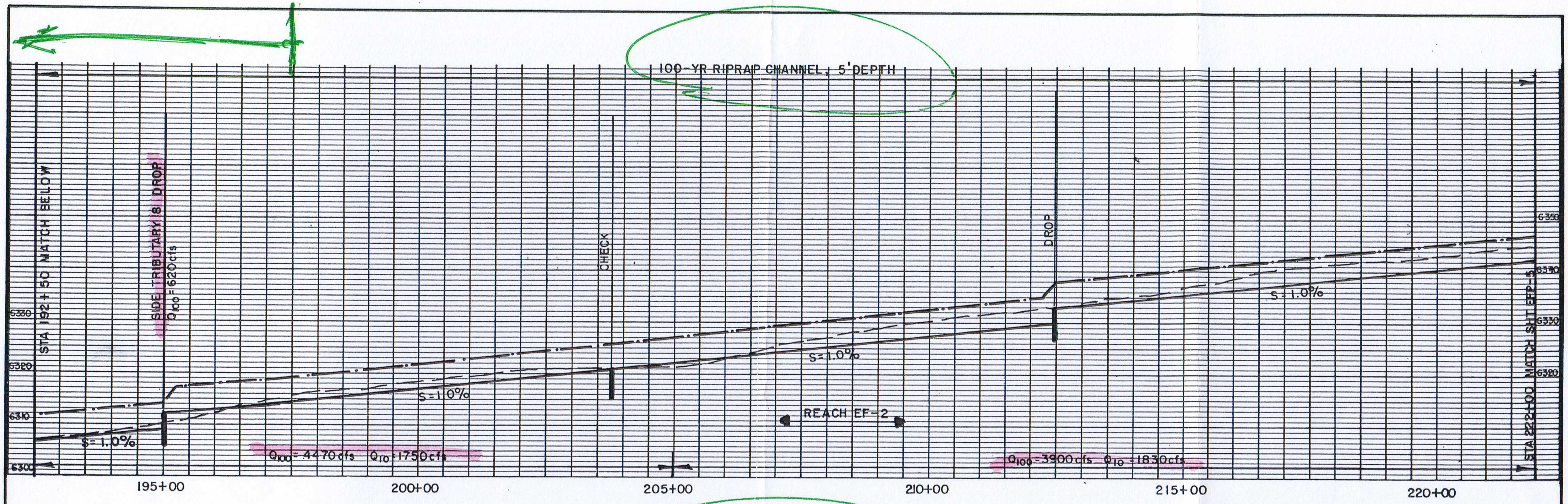
0' 200' 400'

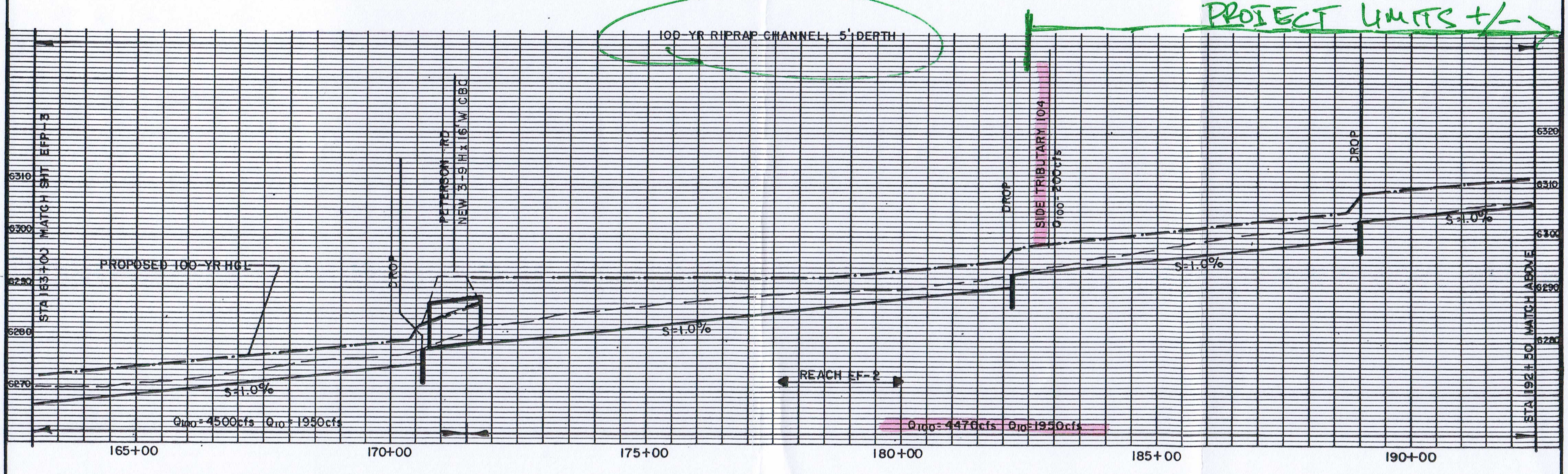
Kiowa Engineering Corporation
419 W. Bijou Street
Colorado Springs, Colorado
80905-1308

SAND CREEK DRAINAGE BASIN PLANNING STUDY
PRELIMINARY DESIGN PLANS

Project No	90 04·09
Date:	10/93
Design:	
Drawn:	
Check:	
Revisions:	

EF-12



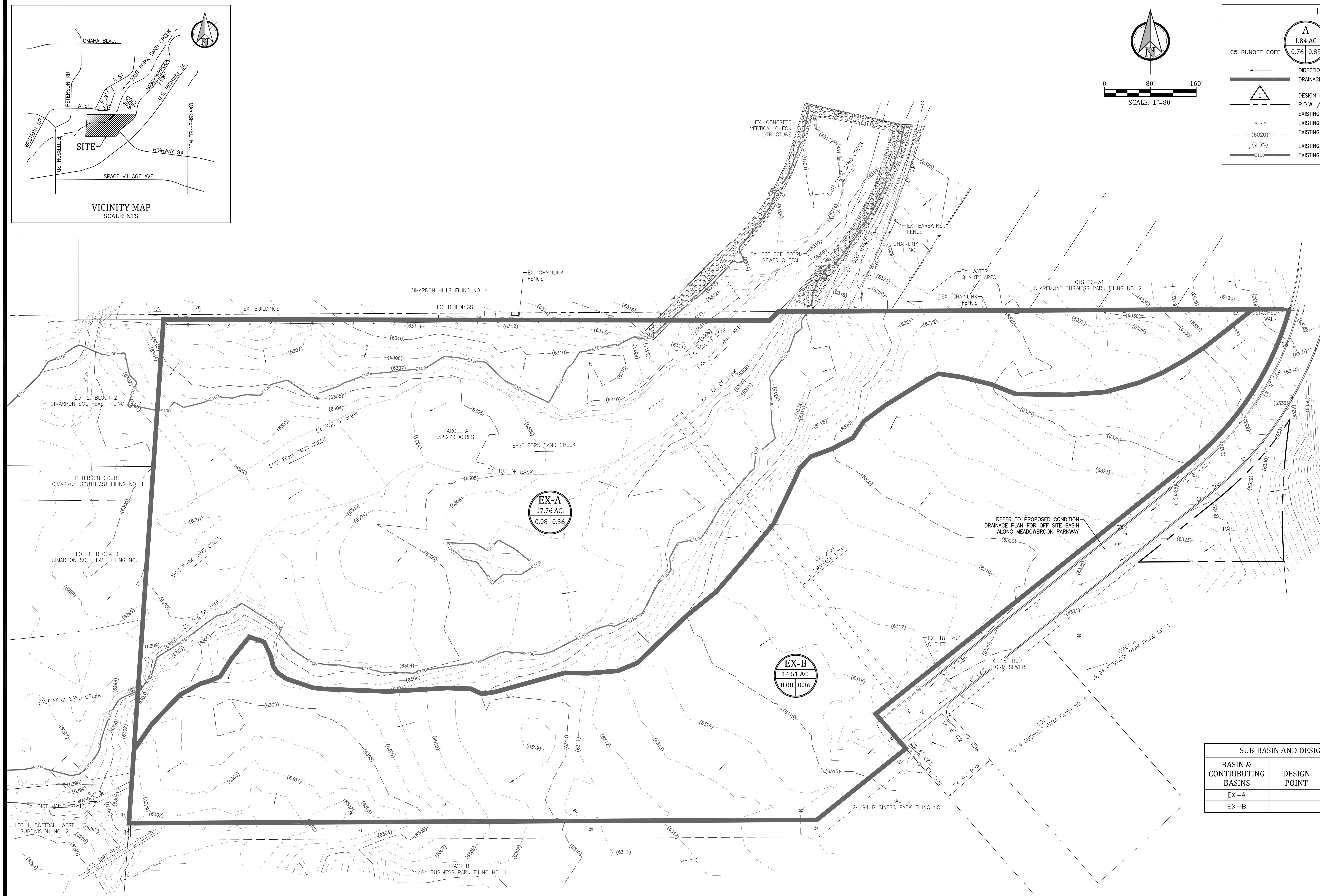


Kiowa Engineering Corporation	DESIGNED RNW DATE CHECKED DATE DRAWN EAK DATE REVISED DATE	SAND CREEK DRAINAGE BASIN PLANNING STUDY PRELIMINARY DESIGN PROFILES	CITY OF COLORADO SPRINGS EL PASO COUNTY, COLORADO	EAST FORK SAND CREEK Station 163+00 to 222+00	EFP-4

APPENDIX E

Exhibit A: Drainage Plan – Existing Conditions

Exhibit B: Drainage Plan – Proposed Conditions



LEGEND

A	PROPOSED BASIN DESIGNATION
1.84 AC	DRAINAGE BASIN ACRES
C5 RUNOFF COEF 0.76 / 0.83	C100 RUNOFF COEFFICIENT
←	DIRECTIONAL FLOW ARROW
	DRAINAGE BASIN BOUNDARY
△1	DESIGN POINT
	R.O.W. / PROPERTY LINE
	EXISTING EASEMENT
EX STM	EXISTING STORM SEWER
(6020)	EXISTING CONTOURS
(2.3%)	EXISTING FLOW DIRECTION AND SLOPE
E100	EXISTING 100 YEAR FLOODPLAIN

SUB-BASIN AND DESIGN POINT DISCHARGES

BASIN & CONTRIBUTING BASINS	DESIGN POINT	5-YR FLOW	100-YR FLOW
EX–A		2.0 cfs	15.2 cfs
EX–B		2.5 cfs	18.6 cfs

Kiowa Engineering Corporation
7175 West Jefferson Avenue, Suite 1300
Lakewood, Colorado 80235
(303) 692-0369

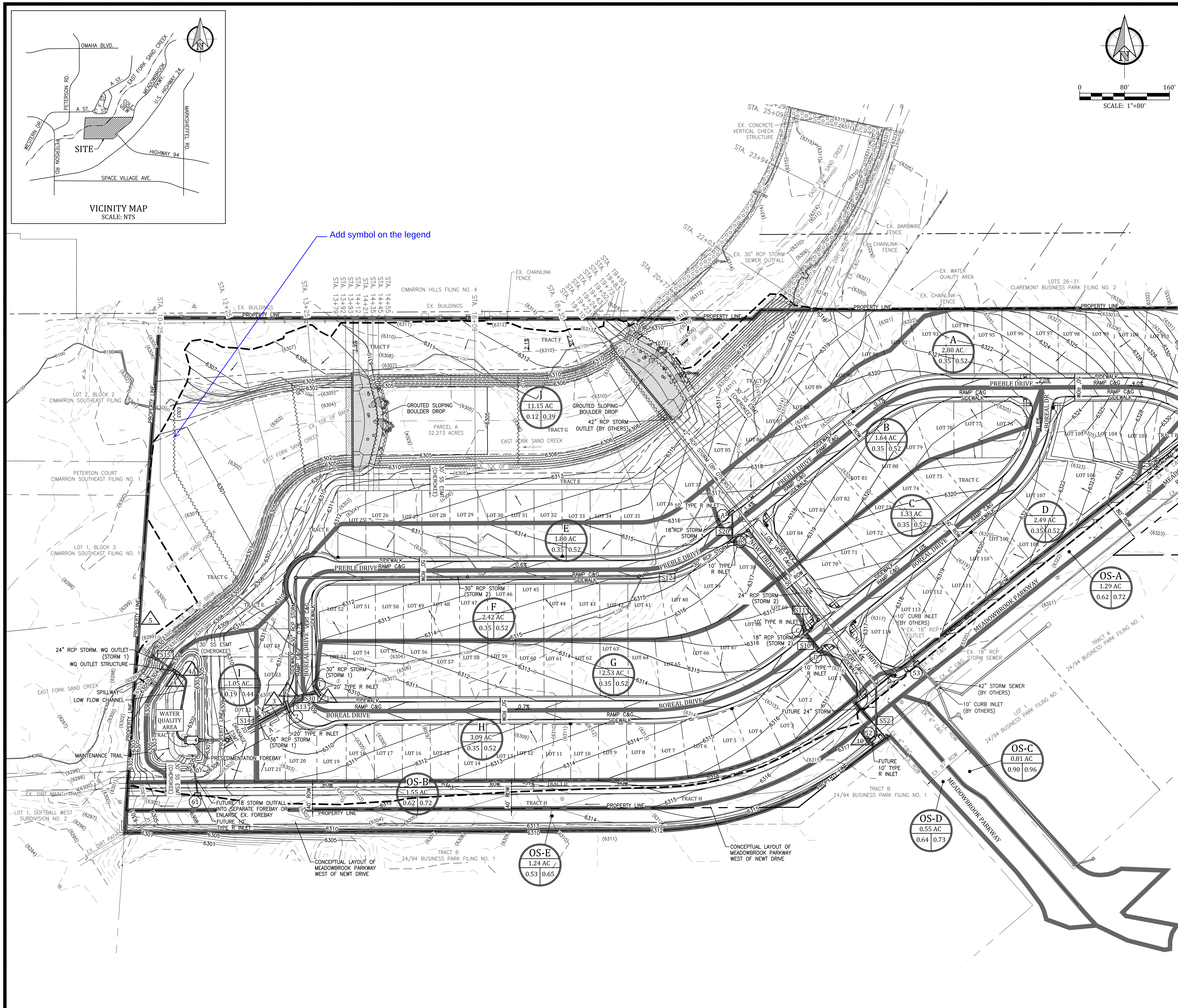
MEADOWBROOK SUBDIVISION
PRELIMINARY/FINAL DRAIANGE REPORT
DRAINAGE PLAN - EXISTING CONDITION
EL PASO COUNTY, COLORADO

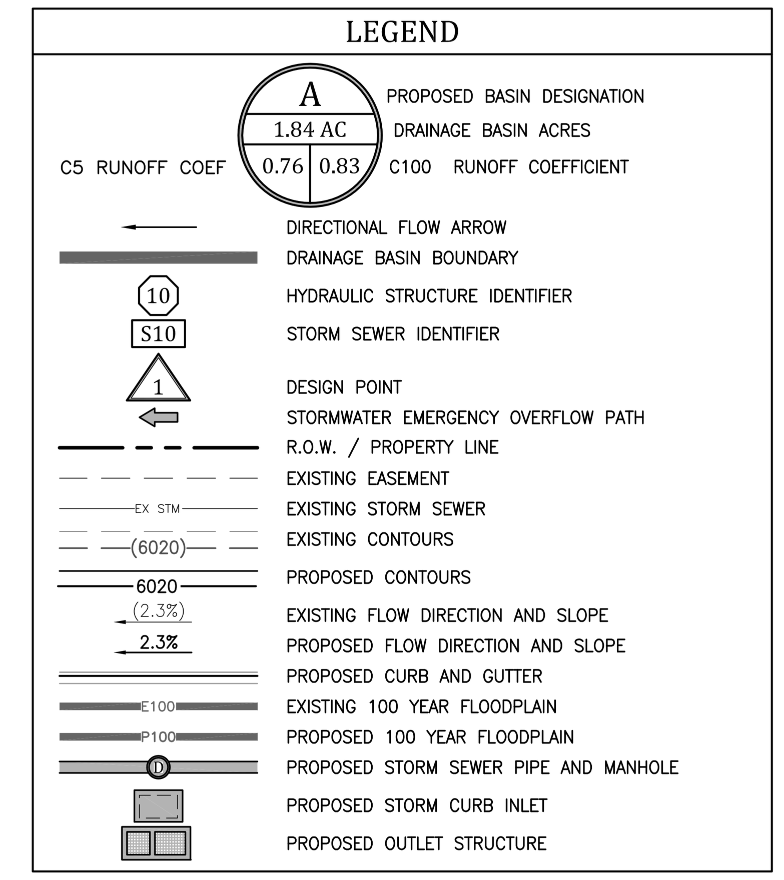
Project No.:	16039
Date:	May 2, 2017
Design:	ELS
Drawn:	ELS
Check:	MWE
Revisions:	

EXHIBIT

A

Add symbol on the legend





WATER QUALITY BASIN

	WATER SURFACE ELEV. (FT)	REQUIRED STORAGE VOLUME	RELEASE RATE	PROVIDED STORAGE VOLUME
WQCV	6303.62	0.36 AC-FT		

SPILLWAY CREST ELEVATION: 6305.00

TOP OF EMBANKMENT MINIMUM ELEVATION: 6306.50

NOTES:
1. AS-BUILT SURVEY AND VOLUME CERTIFICATION REQUIRED BY A LICENSED PROFESSIONAL LAND SURVEYOR, SEE GRADING NOTES.

SUB-BASIN AND DESIGN POINT DISCHARGES

BASIN & CONTRIBUTING BASINS	DESIGN POINT	5-YR FLOW	100-YR FLOW
OS-A		3.0 cfs	5.9 cfs
OS-B		3.5 cfs	6.9 cfs
OS-C		3.8 cfs	6.7 cfs
OS-D		1.8 cfs	3.4 cfs
OS-E		2.4 cfs	5.0 cfs
A		3.4 cfs	8.6 cfs
B		2.1 cfs	5.3 cfs
C		1.8 cfs	4.4 cfs
D		3.1 cfs	7.9 cfs
E		2.2 cfs	5.4 cfs
F		2.9 cfs	7.3 cfs
G		3.1 cfs	7.7 cfs
H		3.7 cfs	9.3 cfs
I		0.8 cfs	3.1 cfs
J		4.1 cfs	23.4 cfs
F,G	DP 1	5.9 cfs	15.0 cfs
E,H	DP 2	5.8 cfs	14.6 cfs
A-H	DP 3	19.2 cfs	48.4 cfs
A-I	DP 4	19.6 cfs	50.2 cfs
A-I, OSB	DP 4A	22.1 cfs	55.1 cfs
A-J, OSB	DP 5	26.3 cfs	77.7 cfs
OSC, OSD	DP 10	5.5 cfs	10.1 cfs

16039 Base - Drainage Plan.dwg/Apr 29, 2017

Kiowa Engineering Corporation
7175 West Jefferson Avenue, Suite 1300
Lakewood, Colorado 80235
(303) 692-0369

MEADOWBROOK SUBDIVISION
PRELIMINARY/FINAL DRAIANGE REPORT
DRAINAGE PLAN - PROPOSED CONDITION
EL PASO COUNTY, COLORADO

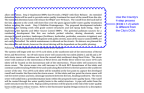
Project No.:	16039
Date:	May 2, 2017
Design:	ELS
Drawn:	ELS
Check:	MWE
Revisions:	

EXHIBIT

B

Markup Summary

dsdlaforce (3)



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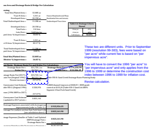
Status:
Checkmark: Unchecked
Author: dsdlaforce
Date: 5/22/2017 10:17:26 AM
Color:

Use the County's 4-step process (ECM I.7.2) which is different from the City's DCM.



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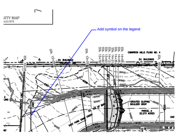
Date: 5/22/2017 12:32:53 PM
Color:

These two are different units. Prior to September 1999 (resolution 99-383), fees were based on "per acre" while current fee is based on "per impervious acre".

You will have to convert the 1996 "per acre" to "per impervious acre" and only applies from the 1996 to 1999 or determine the construction cost index between 1996 to 1999 for inflation cost.

Revise calculation.



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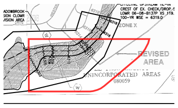
Add symbol on the legend

merichsen (4)



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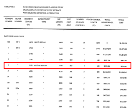
SITE



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Subject: Text Box
Page Label: 24
Lock: Unlocked
Status:
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Author: merichsen
Date: 3/28/2017 10:21:58 AM
Color:

Channel Improvements: $268/lf
Grade Control: $155/lf