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# WESTERLY CREEK AT STANLEY MARKETPLACE STREAM RESTORATION FINAL DRAINAGE REPORT

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Subdivision: Stanley Marketplace #01

APPROVED FOR ONE YEAR FROM THIS DATE

\_\_\_\_\_  
Aurora Water Drainage Division

\_\_\_\_\_  
Date

**July 3<sup>rd</sup>, 2024**



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## ENGINEERING CERTIFICATION

I hereby affirm that this report and plan for the Westerly Creek Stream Restoration at Stanley Marketplace project was prepared by me, or under my direct supervision, for the owners thereof, in accordance with the provisions of the City of Aurora Drainage Criteria Manual and the Mile High Flood Control District Criteria Manual, and approved variances and exceptions thereto. I understand that the City of Aurora does not and will not assume liability for drainage facilities designed by others.

SIGNATURE:

Jeremy Deischer, P.E.  
Registered Professional Engineer  
State of Colorado No. 00533355

## A INTRODUCTION

The original need for the project was identified in the Original Aurora Stormwater Master Plan (Reference 1). Goals from that study included addressing water quality issues and encouraging redevelopment within the Original Aurora area. The Original Aurora Stormwater Master Plan identified an opportunity for a 1.7 Ac-ft. water quality basin on the Stanley Marketplace property that would serve as an exemption pond for the surrounding neighborhood. See Appendix A for a map of the area that will be exempt from on-site water quality requirements after the project completion.

Following the completion of the master plan, ICON Engineering and Stream Landscape + Planning in collaboration with the Mile High Flood District and City of Aurora developed a feasibility and concept design for a multi-beneficial solution for the entire corridor that expands regional water quality, restores and enhances Westerly Creek, reduces flood hazard area impacts, and provides extraordinary recreation and trail amenities for the area. The concepts proposed in the vision plan were advanced to final design level and proposed in this project.

### A.1 Location

The Westerly Creek at Stanley Marketplace Stream Restoration project is located within the City of Aurora and City of Denver. The project area is generally bounded by 26<sup>th</sup> Avenue to the north, Montview Boulevard to the south, Beeler Street to the west, and Dallas Street to the east and is within the northwest corner of Section 34 Township 3 South, Range 67 West.

The stream restoration, regional trail, and water quality basin improvements will span multiple properties along Westerly Creek. The subdivisions that will be impacted include Stanley Marketplace #01, Clinton Street #01, and Montview Plaza #01. Each adjacent development east of Westerly Creek is zoned OA-G, with a small Parks and Open Space parcel located near Montview Boulevard to the south.

A vicinity map of the project area can be found in Figure 1, below.



Figure 1: Vicinity Map



## A.2 Proposed Development

### Property Description

The existing project area is developed, consisting of the channel corridor, Stanley Marketplace and adjacent residential developments (Stanley Residential, 2201 Clinton, Montview Plaza). The City of Aurora and Denver border runs parallel to the channel centerline on the western edge of the site.

In general, the topography throughout the project area slopes from south to north. Westerly Creek channel bisects the project area with flows draining towards the creek on both respective sides of the existing channel.

As part of the design process, a geotechnical evaluation was performed by GROUND Engineering Consultants, Inc. (GROUND). Subsurface exploration of eight test holes was conducted throughout the site in February 2022. As described further in the geotechnical report, the site is underlain by Holocene Artificial Fill, Holocene Piney Creek Alluvium, and Holocene and Pleistocene Loess. Alluvial deposits, in the project area, commonly consist of fine to coarse sands and gravels with varying fractions of silts and clays. Cobbles and boulders are also present locally. Loess (windblown) deposits typically consist of fine sands and silts with varying fractions of clays.

In general, the test holes penetrated about 3 to 9 inches of topsoil before penetrating fill soils that extended to depths of about 3 to 12 feet below existing grades. Beneath the fill soils, native clays were encountered commonly, extending to depths of about 5 to 18 feet below existing grade. Sands were encountered beneath the fill soils or clays. Beneath the sands or clays, weathered claystone and siltstone was encountered.

Additional geotechnical information can be found in the geotechnical report.

### Type of Development

The Westerly Creek at Stanley Marketplace Stream Restoration project (Project) proposes a multi-beneficial solution that expands regional water quality, restores and enhances Westerly Creek, reduces flood hazard area, and provides regional trail and recreational amenity for the community.

The majority of the proposed improvements will occur on the Stanley Marketplace property. Improvements consist of stream restoration, regional trail improvements, implementation of a regional water quality basin, site and park amenities, and storm drain improvements.

The regional trail improvements extend south of Stanley Marketplace, through the Stanley Residential and 2201 Clinton properties, connecting to the existing regional trail north of Montview Boulevard. The proposed improvements will unify the portion of Westerly Creek by tying into existing parks, and trails south of Montview Boulevard.

## A.3 Changes from the PDR and MDR

This section is not applicable to the project.

## A.4 Requested Variances

The following variances are being requested:

- Variance to the City of Aurora Roadway Design and Construction Specification Manual 2.03 Civil Construction Plan Requirements – The entire site cannot be captured by a 1:500 minimum scale, a 1:1700 Key Map is being requested.



- Variance to the City of Aurora Roadway Design and Construction Specification Manual 4.05 Vertical Alignment – There are limits to how much the trail can be sloped throughout the site, but in areas where the minimum longitudinal slope cannot be attained a 2% cross-slope has been incorporated into the design. The requested variance is for there to be no minimum to the allowable grades for the trail.
- Variance to the Aurora Water Storm Drainage Design and Technical Criteria 10.9.4 Emergency Spillway Overflow Path, and Freeboard – Due to the overflow bubbler structure diverting flows in excess of the water quality flow event from the Water Quality Capture Volume Basin. An emergency overflow spillway with design discharges corresponding to the water quality flow event is requested.

## B HISTORIC DRAINAGE

### B.1 Description of Property and Drainage Basin

The project area lies within the lower reaches of the Westerly Creek Watershed. The Westerly Creek watershed is a highly urbanized watershed comprised of commercial, residential, and industrial areas. Frequent pluvial flooding throughout the urban corridor is common with stormwater infrastructure undersized to convey the larger storm events.

Easterly Creek, conveyed through existing storm drain systems, discharges to Westerly Creek within the project area. Several other storm drains, including the 22<sup>nd</sup> Avenue and 23<sup>rd</sup> Avenue storm drains convey water towards Westerly and discharge within the project reach. Systems are undersized to convey the 100-yr design event and rely on conveyance through the street corridors to direct flow towards Westerly Creek during major storm events.

The historic drainage pattern of the area will remain unchanged after the proposed improvements. All stormwater runoff will remain tributary to Westerly Creek.

Several recent hydrologic and hydraulic studies have encompassed the project area and were utilized for design information for offsite flows. Each of these studies is further described in Section 0, below.

#### Off-site basins

ICON Engineering assisted MHFD and the City of Aurora with additional pluvial flooding hydraulic analysis of the surrounding area in conjunction with the ongoing developments with Stanley Residential and 2201 Clinton. The memorandum *2201 Clinton and Stanley Residential FLO-2D Analysis* (Reference 4) details the methodology of two-dimensional modeling to evaluate the flooding hazards of pluvial flooding across Montview Boulevard into the adjacent developments. Both 2201 Clinton and Stanley Residential implemented flood mitigation collection systems to convey runoff west to Westerly Creek before inundating buildings within the development for the 1% annual chance design storm. Such a densely developed area prohibited the developments from implementing solutions to convey the entirety of the 1% annual chance storm in a storm drain system. The retrofit storm drain solutions intercepts flow to mitigate flooding on structures but relies on street flow conveyance to direct flows to Westerly Creek during major storm events.

Two additional storm drain outfalls, at 23<sup>rd</sup> Avenue and 22<sup>nd</sup> Avenue discharge offsite flows into the project area. The 23<sup>rd</sup> Avenue Outfall extends west from Lola Street to Westerly Creek intercepting stormwater runoff from the adjacent neighborhood. The Easterly Creek Outfall collects flow east of Westerly Creek and south of Montview and discharges into Westerly Creek just west of 22<sup>nd</sup> Avenue.

The 22<sup>nd</sup> Avenue Outfall was designed as a 66-inch reinforced concrete pipe (RCP) to intercept approximately 200 cfs during the 1% annual chance design storm. The Stanley Residential Outfall consists of a 76-inch wide by 48-inch tall horizontal reinforced concrete pipe (HERCP) designed a maximum discharge of 222 cfs during the 1% annual chance design storm.





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Flows in excess of the 22<sup>nd</sup> and 23<sup>rd</sup> Avenue storm drain systems are directed in a general northwest direction from 23<sup>rd</sup> Avenue through the project area to Westerly Creek. The project will intercept the capacity of the existing 23<sup>rd</sup> Avenue system and direct flows to the water quality basin, improving the water quality as much as possible given the retrofit site constraints on private property.

### Major Drainageway / Existing Floodplain Information

The site spans multiple FEMA Flood Insurance Rate Map (FIRM) panels. Within the City of Aurora, the project is contained within panel 08005C0019K, 08005C0157K, dated December 17, 2010. Within the City of Denver, panels 0800460207H, and 0800460094H would be impacted, effective November 20<sup>th</sup>, 2013. An existing floodplain and floodway are present throughout the project location. A composite of effective floodplain information from the City of Aurora's NFHL map can be found in Appendix A. The current Flood Insurance Studies (FISs) for both Arapahoe County and for City and County of Denver were issued September 4, 2020.

On the effective FIRM, Westerly Creek is defined by a Zone AE full detailed study 1% Annual Chance (A.C.) floodplain with base flood elevations (BFEs) and regulatory floodway, as well as a 0.2% A.C. floodplain. The project will not result in a rise on any insurable structures. This project will also require floodplain permits from City of Aurora and City and County of Denver.

In 1991, a LOMR from 11th Avenue to E-W Runway by Love and Associates updated the effective hydrology to reflect construction of the Westerly Creek Dam.

The current effective information comes from LOMR Case No. 19-08-0731P prepared by Muller Engineering Company from just downstream of East Montview Boulevard to approximately 1,900 feet downstream, and from LOMR Case No. 03-08-0210P prepared by Matrix Design Group from just upstream of East 26th Avenue to approximately 1,900 feet downstream of East Montview Boulevard. LOMR 19-08-0731P updated hydrology but downstream of that LOMR, the 1991 LOMR hydrology remains in effect.

Development along the east overbank of Westerly Creek was permitted by City of Aurora under a no-rise condition, based on supporting analyses.

A Flood Hazard Area Delineation (FHAD) updating Westerly Creek is currently being prepared by Matrix Design Group for Mile High Flood District (MHFD), using a 2016 hydrology update also prepared by Matrix Design Group. While this FHAD is still in a draft phase, it has been through at least five submittals as of November 2021, and is therefore considered reasonably close to a final product. This study represents the future effective information, and it may be included in a preliminary FEMA Physical Map Revision (PMR) by the time the LOMR for this project is issued.

A CLOMR submittal is currently under review by the City of Aurora and will be submitted to FEMA following that review. The associated CLOMR number will be provided in following submittals.

### Drainage Patterns through Property

Historically, drainage from the site is conveyed to Westerly Creek through existing storm drain systems from the existing building and parking lot and overland flow throughout the site. None of the historic drainage patterns will be altered with the proposed improvements and stormwater runoff will continue to be tributary to the Westerly Creek drainageway.

### Outfalls Downstream from Property

All stormwater conveyed to the project location will discharge into Westerly Creek channel. Westerly Creek continues to the north underneath the 26<sup>th</sup> Avenue bridge to Sand Creek.



### C DESIGN CRITERIA

#### C.1 Hydrologic / Criteria

Design flow rates are further described in Section D below pertaining to each specific aspect of the project. Hydrology for Westerly Creek channel was completed by Matrix Design Group and accepted by MHFD in August of 2017. Following the completion of that study, Bohanon Huston was contracted to complete the Outfall Systems Planning of Westerly Creek Downstream of Westerly Creek Dam (OSP) which updated the design flows along Easterly Creek. The hydrology acceptance letter from the MHFD as well as excerpts from the Outfall Systems Plan and relevant adjacent development drainage studies can be found in Appendix A.

#### C.2 Hydraulic Criteria

Various programs were used to develop the hydraulic calculations for the site including EPA-SWMM for the storm drain infrastructure, and HEC-RAS for the riverine corridor. Both one and two-dimensional HEC-RAS models were developed to assess the water surface elevations and shear stress throughout the project area.

#### References

Numerous existing studies were used as reference for hydrologic and hydraulic information for the project. These studies include:

- Original Aurora Stormwater Master Plan
- Outfall Systems Planning of Westerly Creek Downstream of Westerly Creek Dam
- Flood Hazard Area Delineation – Westerly Creek Downstream of Westerly Creek Dam
- 2201 Clinton and Stanley Residential FLO-2D Analysis
- Clinton Street Subdivision Filing No. 1 Final Drainage Report
- Urban Storm Drainage Criteria Manual Volume 1, 2, 3
- Roadway Design & Construction Specifications, Revised Jan 2023
- City of Aurora Storm Drainage Criteria, effective 11, 2010

### D DRAINAGE PLAN

#### D.1 General Concept

In general, the proposed improvements will keep main historic flow patterns throughout the project area. Overland flow will continue to drain to Westerly Creek and through the 26<sup>th</sup> Avenue bridge to the north. The Easterly Creek outfall will discharge into Westerly Creek approximately 180 feet northwest of its current location. The 23<sup>rd</sup> Avenue will be altered to collect flows from the Stanley Residential flood mitigation storm drain and convey stormwater north to the water quality basin before discharging into Westerly Creek.

Water quality from each stormwater outfall will be enhanced with the proposed improvements. At Easterly Creek, a trash vault located near the 22<sup>nd</sup> Avenue cul-de-sac will collect debris from the upstream urban corridor. Flows within the existing 23<sup>rd</sup> Avenue Outfall will be treated through a trash vault in the 23<sup>rd</sup> Avenue cul-de-sac to collect debris and floatables before being treated within the WQCV basin.

No offsite basin drainage patterns should be impacted with the proposed project. Coordination is ongoing with Stanley Residential (CN: 2014-6055-02), 2201 Clinton (CN: 2019-6054-00), and Montview Plaza (CN: 2021-6022-00). Stanley Residential will have impacts to grading on the westernmost edge of the property as well as the stormwater outfall that will be intercepted and conveyed to the water quality basin. Along the channel corridor on the 2201 Clinton property, the regional trail will require grading of the channel banks and a grade control boulder wall. The open space park seating node at 2201 will be modified to better incorporate the regional trail improvements.



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### D.2 Specific Details

A geomorphic analysis was completed to support the stream restoration design along Westerly Creek. Key elements of the existing and proposed geomorphic assessment are included below. The entirety of the geomorphology can be found in Appendix D.

The existing channel along the Stanley Reach is characterized by a linear alignment and a relatively featureless profile without significant geomorphic pools or riffles. Additionally, a high proportion of non-native riprap was observed in the channel bottom. This riprap is likely a maintenance response to the downcutting and channel incision. Outside of the channel, tall grasses make up the predominant vegetation along with sparse trees and shrubs.

The proposed design will increase channel function by creating a realigned, multi-stage, geomorphic channel to replace the incised, linear channel. The channel will be realigned, and the corridor will be re-graded to create a multi-stage channel to reduce flood risk and enhance stability. The multi-stage channel would help connect active hydrology to the floodplain and encourage the establishment of riparian habitats. The project will incorporate a multi-beneficial solution that will follow a high-function lower maintenance stream (HFLMS) approach to stabilize the reach.

The base flow channel was sized by correlating the inner berm depth to 35% of the existing bankfull depth. This yields an inner berm depth of 1.25 ft (capable of conveying 37.4 cfs) for the Stanley Reach. The proposed bankfull section was sized to convey the effective bankfull discharge of 235 cfs.

The floodplain channel was sized to convey the 100-year discharge of 3469 cfs as identified in the Westerly Creek FHAD.

A drainage easement will be acquired for the 100-year floodplain limits. Maintenance for the channel corridor will be performed by Aurora Water and will be MHFD maintenance eligible.

#### Floodplain Modeling

The basis of hydrology for the floodplain analysis is the ongoing Westerly Creek FHAD by Matrix Design Group. The hydrology change has been accepted by MHFD at this time, the acceptance letter can be found in Appendix A. Discharges throughout the project reach can be found in Table 1, below.

*Table 1: FHAD Discharges for Westerly Creek*

Cross Section	10% A.C.	2% A.C.	1% A.C.	0.2% A.C.
	Discharge	Discharge	Discharge	Discharge
	(cfs)	(cfs)	(cfs)	(cfs)
8784	771	1,585	2,034	3,010
8409.5	907	1,840	2,403	3,523
7787.6	1,188	2,538	3,469	5,644
6151.5	1,351	2,809	3,809	6,218

A phased floodplain permitting approach is underway for the proposed project. In addition to the CLOMR that is currently under review by the City of Aurora, a no-rise permit was prepared to allow for the start of construction while the CLOMR is under review. The no-rise analysis is dependent on prohibiting the installation of the northern bridge until the CLOMR is approved.

The proposed 100-year floodplain boundary is shown on the Drainage Plan found in Appendix A. The CLOMR and no-rise permit is currently under review by the City and more information will be provided in subsequent submittals.



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### Channel Grade Control

Grade control along the channel is proposed through riffle drop structures. The riffles will be constructed of void filled riprap. The void filled riprap has been sized for the 100-year design storm.

### Channel Bank Stabilization

The proposed design consists of three separate types of bank stabilization, further described below.

**Bank Stabilization #1:** Stabilization #1 proposes coir matting to hold soil in place until natural vegetation can be established. This is a temporary stabilization measure that will decompose over a period of years. This stabilization method is primarily used in riffle sections that are mainly straight.

**Bank Stabilization #2:** Stabilization #2 utilizes a void filled riprap toe to provide bank stabilization below the water surface elevation on outer bends in pool sections. Coir matting, willow stakes, and native vegetation is used to support the bank above the water surface elevation.

**Bank Stabilization #3:** Stabilization #3 proposes bank stability for very steep slopes through the use of a soil lift. Soil lifts are constructed by placing fill material into forms and compacted as a one-foot lift. Coir matting is wrapped around the compacted fill and tied below a subsequent lift. Willow stakes and other brushy plantings provide an added layer of bio stabilization.

Alongside the channel bank stabilization described above, riprap is proposed at each stormwater outfall to dissipate energy and provide protection from erosion.

### Water Quality Basin Design

The proposed project provides water quality to Basin 3 – 23<sup>rd</sup> Avenue Outfall Basin as identified in the Original Aurora Stormwater Master Plan (Reference 1). Project No. 301D proposed a 1.7 Ac-ft. water quality basin on the Stanley Marketplace parcel. The proposed project enlarges the exemption water quality volume, and provides water quality storage for the entirety of Basin 3. To determine the water quality volume for all of Basin 3, an overall area and composite percent imperviousness was determined from basin information from the Original Aurora Stormwater Masterplan. The future land use scenario was used when developing the composite basin imperviousness. Basin 3 is comprised of 135 acres, with a future land use percent impervious of 63 percent. UD-Detention was used to determine the required WQCV of 2.78 Ac-ft. to provide regional water quality for Basin 3. A list of contributing basins can be found in Appendix A.

Runoff from Basin 3 is currently collected in the existing 23<sup>rd</sup> Avenue storm drain system and discharged directly into Westerly Creek. The existing 23<sup>rd</sup> Avenue will be directed towards the water quality basin in the 23<sup>rd</sup> Avenue cul-de-sac. The proposed storm drain improvements are further described in the sections below.

A trash vault located in the 23<sup>rd</sup> Avenue cul-de-sac will collect debris from the storm drain system before flow enters the overflow bubbler structure. The overflow bubbler structure directs water quality flows into the basin and discharge the rest of the stormwater into Westerly Creek. A level spreader on the interior of the basin will dissipate velocity before flow enters the basin. The low flow Grasscrete channel conveys flow north to the water quality outlet. The outlet structure will include a multi-stage orifice plate to achieve release rates to drain the water quality volume within 40 hours.

The drainage easement that will be acquired to encompass the 100-year floodplain limits includes the entirety of the water quality basin.

Maintenance will be provided by Aurora Water. In addition to the drainage easement that will encompass the water quality basin, an access easement will be acquired to allow vac truck access. The proposed access will be from the southern edge of the Stanley parking lot along the loop trail to the overflow bubbler structure.



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The trail to the east of the water quality basin will allow access to the outlet structure and the creekside level spreader located at the northern edge of the basin.

### Bridge Design

Two bridge crossings are proposed to span Westerly Creek as part of the project. On the northern end of the site, an 8-foot-wide pedestrian is proposed to increase connectivity throughout the trail system. On the southern end, a 12-foot-wide bridge will provide maintenance access along the regional trail corridor. A bridge scour analysis was completed and is further described below.

### Bridge Scour Analysis

HEC-RAS is unable to evaluate the impact of countermeasures on scouring abutments. For this reason, ICON utilized HEC-23 methodologies to confirm that the proposed countermeasures would be effective at eliminating scour at the abutments of the proposed bridge. HEC-23 recommends the use of the below listed equation for sizing riprap as a countermeasure to abutment scour.

$$(\text{Eqn. 1}) \quad \frac{D_{50}}{y} = \frac{K}{S_s - 1} \left[ \frac{V^2}{g y} \right] \quad \text{HEC-23 Equation 8.2, Rock Sizing at Abutment for Froude Numbers} < 0.80$$

Where:  $D_{50}$  = median stone diameter (ft)

$V$  = Average Velocity (ft/s)

$S_s$  = Specific Gravity of Riprap

$g$  = gravitational acceleration (32.2 ft/s<sup>2</sup>)

$y$  = depth of flow

$K$  = 0.89 for spill through abutment

### HEC-23 Results

#### General Hydraulic Performance of Bridge

After ICON updated the 1-dimensional HEC-RAS model to reflect the current bridge design, channel hydraulics near the proposed bridge were examined across a range of discharges. Table 2 summarizes the existing and proposed conditions of water surface elevation, flow velocity, backwater, and Froude number. Table 3 and

Table 4 detail the low chord elevation and water surface elevation at the upstream and downstream faces of the proposed bridge for the 10-, 50-, 100-, and 500-year discharges.

*Table 2: Comparison of Hydraulics at the Downstream Proposed Bridge and an Upstream Approach Section*

Profile	Condition	Cross Section	Water Surface Elevation (Feet NAVD88)	Velocity (ft/s)		Froude Number
				Average	Channel	
100-Year	Proposed	685	5298.66	3.73	5.25	0.32
500-Year	Proposed	685	5300.74	3.4	4.23	0.23

*Table 3: Water Surface Elevation at the Downstream Proposed Pedestrian Bridge*

Recurrence Interval (years)	Discharge (cfs)	Low Chord Elevation At Abut. Front Face (Feet NAVD88)		Water Surface Elevation (Feet NAVD88)
		Abut. 1	Abut. 4	
10	1,188	5294.54	5294.39	5294.85'
50	2,538			5297.43'
100	3,469			5298.66'





500	5,644			5300.74'
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*Table 4: Comparison of Hydraulics at the Upstream Proposed Bridge and an Upstream Approach Section*

Profile	Condition	Cross Section	Water Surface Elevation (Feet NAVD88)	Velocity (ft/s)		Froude Number
				Average	Channel	
100-Year	Proposed	1536	5302.16	3.43	4.55	0.24
500-Year	Proposed	1536	5303.33	3.93	4.75	0.24

*Table 5: Water Surface Elevation at Upstream Proposed HS-10 Bridge (XS 1502, BR)*

Recurrence Interval (years)	Discharge (cfs)	Low Chord Elevation At Abut. Front Face (Feet NAVD88)		Water Surface Elevation (Feet NAVD88)
		Abut. 1	Abut. 4	
10	1,188	5296.28'	5296.94'	5298.26'
50	2,538			5301.49'
100	3,469			5302.16'
500	5,644			5303.02'

## Scour Results

The following sections provide discussion of anticipated contraction, pier, and abutment scour under the proposed condition and accounting for countermeasure design. A summary is provided below in Table 6.

### Contraction Scour

HEC-RAS analysis indicated that the proposed countermeasure design eliminates any measurable contraction scour at the proposed bridge during the 100- and 500-year flooding events.

### Pier Scour

Hydraulic modeling indicated that pier scour would be likely to occur despite countermeasure design for the 100- and 500-year flooding events. Scour depths were estimated to be 4.6' during the 500-year event and 4.5' during the 100-year event.

### Abutment Scour

HEC-23 was utilized to provide a check of countermeasure design at the abutments. Equation 1, provided above, was utilized to size riprap at the abutments and provide a check of the proposed countermeasure design. Results of this analysis are shown in

Table 5 and indicate that rock at the abutments shall be at least 0.35' in size to prevent scour. The current countermeasure design provides 9" riprap at the toe of the bridge abutments. Therefore, no scour is anticipated at these locations.

*Table 6: Abutment Countermeasure Sizing Proposed HS-10 Bridge*

Parameter	Design Flood	
	100-Year	500-Year
V (ft/s)	4.17	3.78
S <sub>s</sub>	2.6	2.6

$g$ (ft/s <sup>2</sup> )	32.2	32.2
$y$ (ft)	10.64	12.18
$K$	0.59	0.59
$D_{50}$ (ft)	0.19	0.16

Table 7: Anticipated Scour under Proposed Conditions at Proposed HS-10 Bridge

Design Flood	Contraction Scour (ft)			Pier Scour (ft)	Abutment Scour (ft)	
	LOB	Channel	ROB		Left	Right
100-Year	0	0	0	0	8.87	8.43
500-Year	0	0	0	0	16.25	14.73

Table 8: Abutment Countermeasure Sizing Proposed Pedestrian Bridge

Parameter	Design Flood	
	100-Year	500-Year
$V$ (ft/s)	4.56	4.05
$S_s$	2.6	2.6
$g$ (ft/s <sup>2</sup> )	32.2	32.2
$y$ (ft)	11.12	12.92
$K$	0.59	0.59
$D_{50}$ (ft)	0.24	0.19

Table 9: Anticipated Scour under Proposed Conditions at Proposed Pedestrian Bridge

Design Flood	Contraction Scour (ft)			Pier Scour (ft)	Abutment Scour (ft)	
	LOB	Channel	ROB		Left	Right
100-Year	0	0	0	0	12.04	17.38
500-Year	0	0	0	0	19.06	25.18

## Project Bridge Phasing

The northern pedestrian bridge is a phased improvement that cannot be installed until the No-Rise is approved.

## Storm Drainage Design

To evaluate the storm drain network, new dynamic wave EPA-SWMM models were developed for the project area. The models extracted inflow hydrographs from the Westerly Creek OSP for the offsite flows into the project area.

Each structure is described in additional detail below.

## 23<sup>rd</sup> Avenue Junction Structure

The 23<sup>rd</sup> Avenue Junction Structure intercepts stormwater conveyed from the east in the 2201 Clinton flood mitigation storm drain outfall and the south from the reconfigured existing 23<sup>rd</sup> Avenue storm drain outfall.



## FINAL DRAINAGE REPORT

---

The existing 5-foot Type R Inlet in the cul-de-sac of 23<sup>rd</sup> Avenue, installed with EDN 220030, will be replaced in kind with a proposed 5-foot Type R inlet located northeast of the existing location. After flows confluence in the structure, the combined discharge is conveyed north in the 53-inch tall by 83-inch wide HERCP. The 100-year peak discharge leaving the 23<sup>rd</sup> Avenue Junction Structure is approximately 290 cfs.

### Overflow Bubbler Structure

The overflow bubbler structure is located just upstream (south) of the water quality basin. The structure will serve as a diversion for flow in excess of the water quality event.

The 100-year peak discharge into the overflow bubbler structure is approximately 290 cfs. Of the 290 cfs, a peak discharge of 55 cfs enters the water quality basin while the remaining 235 cfs spills into Westerly Creek. The flow spills into Westerly Creek through a 40-foot slotted opening on the creek side of the structure before spilling through the grated opening at the top.

### Water Quality Basin Level Spreader

After flows are diverted in the Overflow Bubbler Structure, water quality flows are directed north into the Water Quality Basin Level Spreader. The structure also intercepts flow from the existing storm drain from the Stanley Marketplace parking lot.

### Water Quality Basin Outlet Structure

UD-Detention v. 4.03 was used to design the outlet structure of the water quality basin. As described previously in D.3, the maximum storage of 2.78 Ac-ft. will be released over 40 hours. To achieve the desired release time, an orifice plate comprised of three rows spaced 3.3 feet apart is proposed. Each row will contain 9.62 square inches of open area to achieve the peak outflow of 1.6 cfs. No additional design storms were analyzed in the water quality basin since flows in excess of the water quality storm will be discharged to Westerly Creek through the Overflow Bubbler Structure. For additional protection, the 36-inch outlet pipe leaving the water quality pond has been sized to convey flow exceeding the peak discharge of the water quality even with a maximum pipe capacity of 34 cfs.

### Creekside Level Spreader

Flow from the water quality basin is conveyed underneath the northern loop trail to the creekside level spreader. Flow from the water quality basin spreads along the 20 foot long creekside level spreader before discharging to Westerly Creek.

### Easterly Creek Outfall Structure

The Easterly Creek Outfall is located directly west of the 22<sup>nd</sup> Avenue cul-de-sac. The 22<sup>nd</sup> Avenue storm drain and existing Easterly Creek Outfall will confluence and convey flows in a 10-foot by 4-foot box culvert towards the Easterly Creek Outfall.

The 100-year peak discharge of 395 cfs will be discharged through the openings located at the bottom of the Easterly Creek Outfall. Openings in the face of the structure will be a total length of 24 feet, each 1.7 feet tall, for a combined open area of 40 square feet. The 100-year discharge of 395 cfs will have a maximum velocity of 9.9 feet per second leaving the structure.

Similar to the Overflow Bubbler structure, an overflow grate is provided on the Easterly Creek structure to serve for both maintenance access and hydraulic overflow.



## CONCLUSIONS

### Compliance with Standards

The project is in compliance with City of Aurora's and MHFD criteria for storm drainage and open channel design. The proposed improvements will provide a lower maintenance high function stream corridor and enhance water quality throughout the basin.

## E REFERENCES

1. Calibre Engineering, Inc. *Original Aurora Stormwater Master Plan*. 2017
2. ICON Engineering & Stream Landscape Architecture + Planning. *Westerly Creek Restoration & Water Quality Vision Plan – Montview to E. 26<sup>th</sup> Ave.* April 2020
3. Ground Engineering. *Geotechnical Evaluation Westerly Creek Improvements at Stanley Marketplace*. March 2023
4. Bohannon Huston. *Outfall Systems Planning of Westerly Creek Downstream of the Westerly Creek Dam*. March 2022



# **FINAL DRAINAGE REPORT**

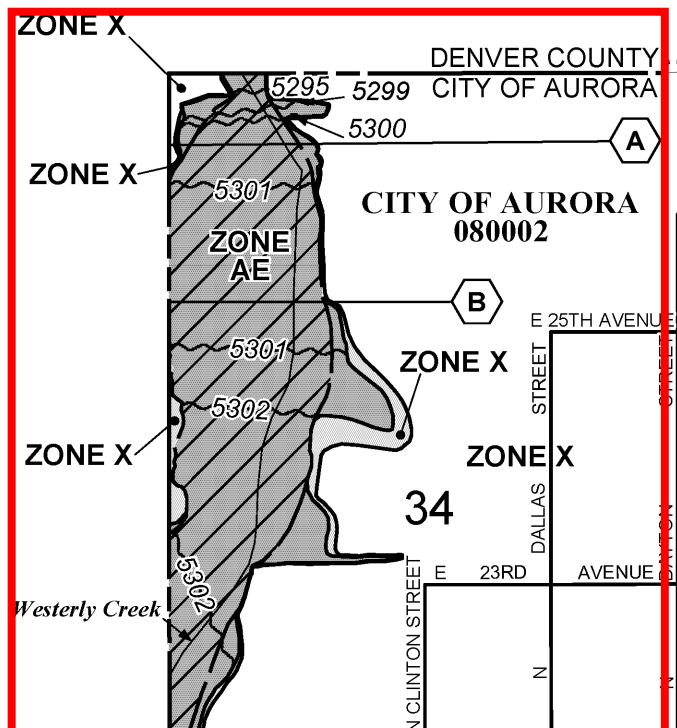
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## **APPENDICES**

### **APPENDIX A – SOIL, PRECIPITATION, FLOODPLAIN, AND AIRPORT POND BUFFER INFORMATION**



NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED  
WITHIN TOWNSHIP 67 WEST, RANGE 3 SOUTH.



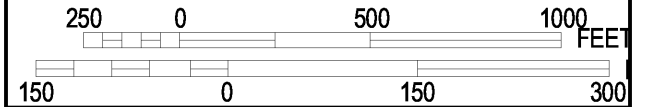
39°45'00.00"

104°52'30.00"

the National Flood Insurance Program at 1-800-638-6620.



MAP SCALE 1" = 500'



NFIP

PANEL 0019K

NATIONAL FLOOD INSURANCE PROGRAM

**FIRM**

**FLOOD INSURANCE RATE MAP**

**ARAPAHOE COUNTY,**

**COLORADO**

**AND INCORPORATED AREAS**

**PANEL 19 OF 725**

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
AURORA, CITY OF	080002	0019	K

**PROJECT  
LOCATION**

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

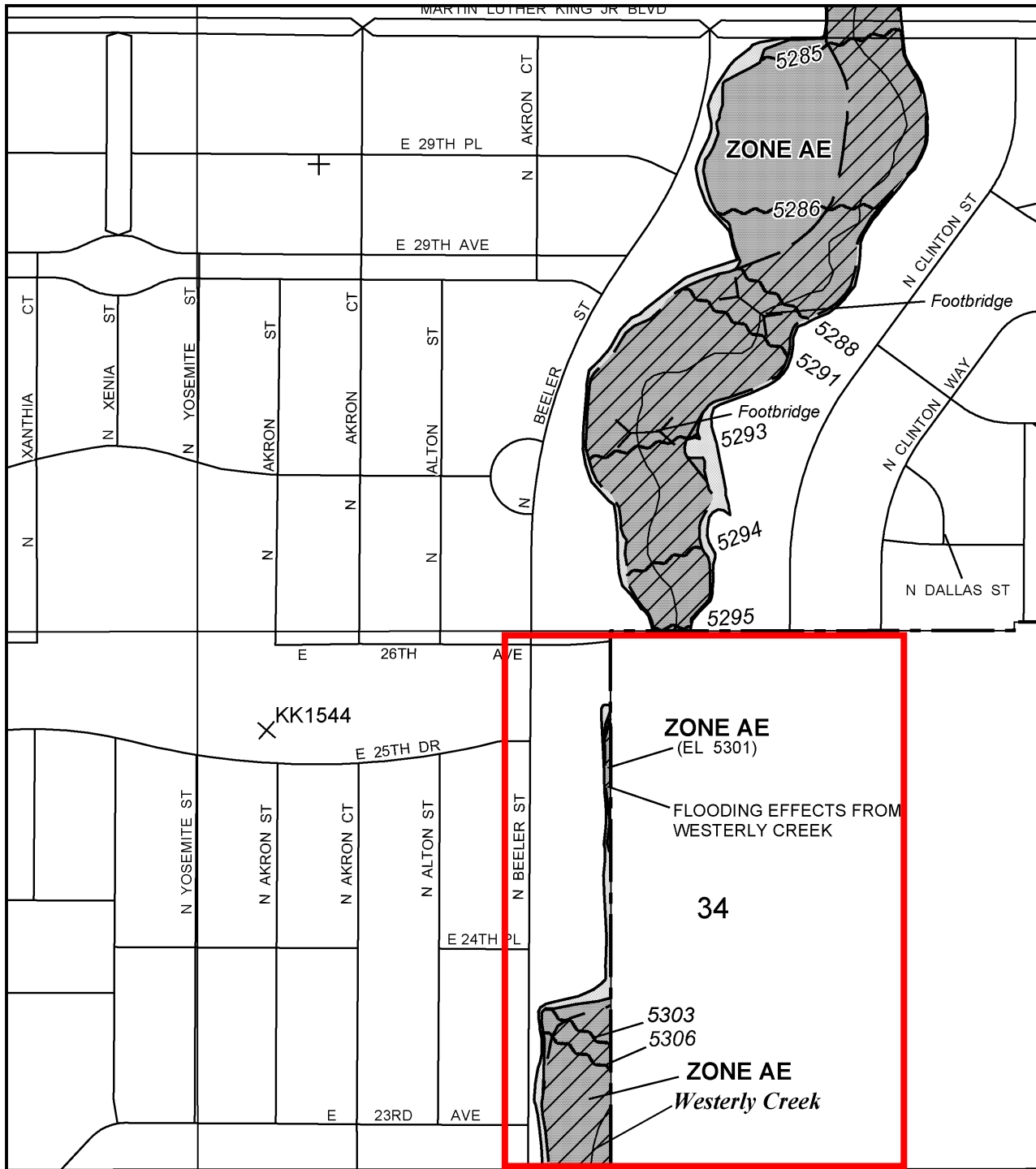


**MAP NUMBER  
08005C0019K**

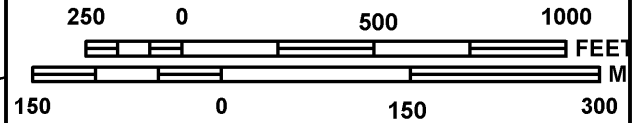
**MAP REVISED  
DECEMBER 17, 2010**

Federal Emergency Management Agency

This is an official FIRMette showing a portion of the above-referenced flood map created from the MSC FIRMette Web tool. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For additional information about how to make sure the map is current, please see the Flood Hazard Mapping Updates Overview Fact Sheet available on the FEMA Flood Map Service Center home page at <https://msc.fema.gov>.



MAP SCALE 1" = 500'



NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0094H

**FIRM**

FLOOD INSURANCE RATE MAP

CITY AND COUNTY OF  
DENVER,  
COLORADO

PANEL 94 OF 300

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
CITY AND COUNTY OF DENVER	080046	0094	H

**PROJECT  
LOCATION**

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



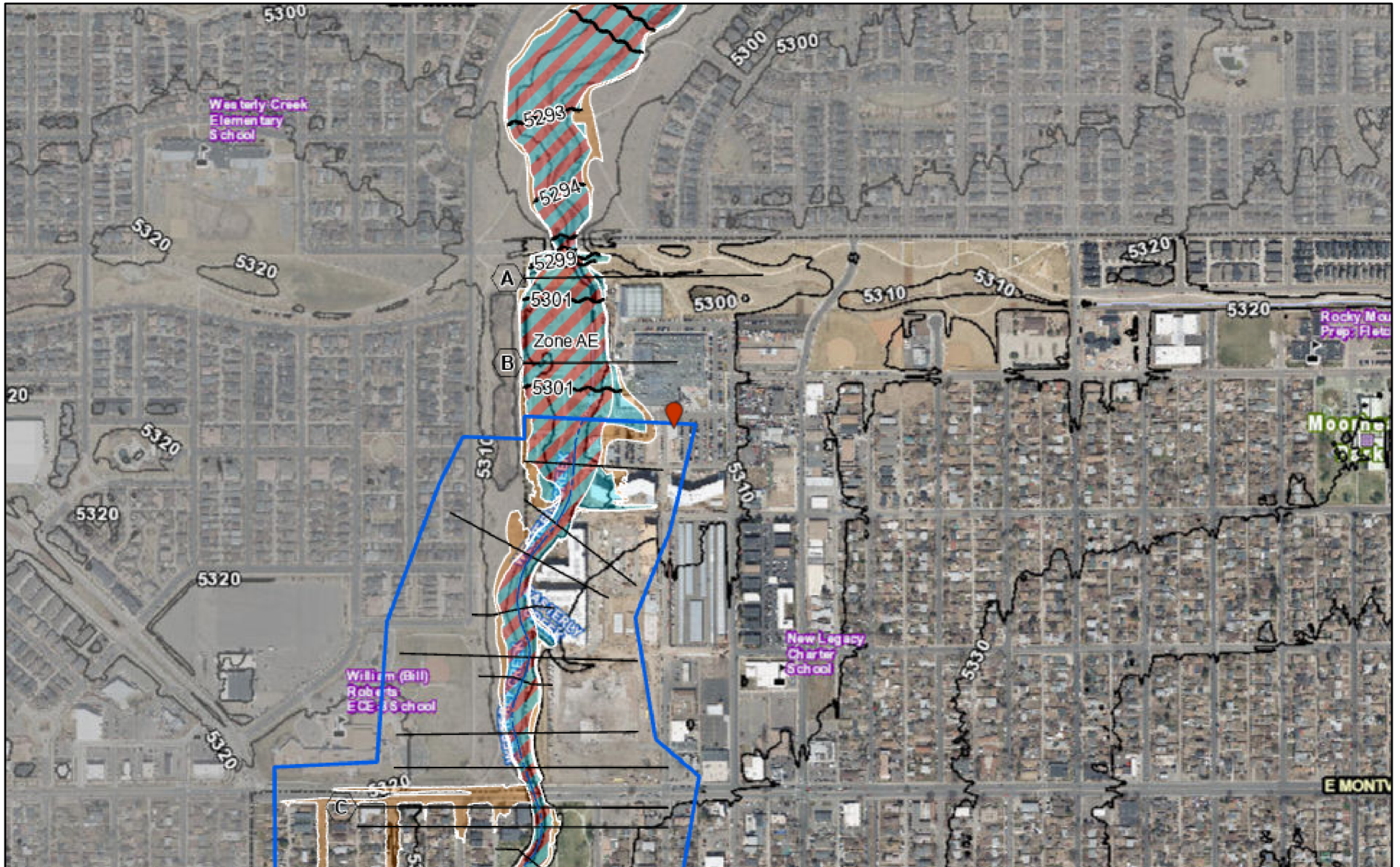
**MAP NUMBER**  
0800460094H  
**MAP REVISED**  
NOVEMBER 20, 2013

Federal Emergency Management Agency

This is an official FIRMette showing a portion of the above-referenced flood map created from the MSC FIRMette Web tool. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For additional information about how to make sure the map is current, please see the Flood Hazard Mapping Updates Overview Fact Sheet available on the FEMA Flood Map Service Center home page at <https://msc.fema.gov>.



# ArcGIS Web Map



7/2/2024, 6:38:14 PM

 Elevation Certificates


Flood Hazard Zones

 1% Annual Chance Flood Hazard

 Regulatory Floodway


 0.2% Annual Chance Flood Hazard

Flood Hazard Boundaries

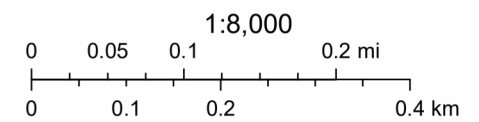
 SFHA / Flood Zone Boundary

 Base Flood Elevations

 Cross-Sections

 Profile Baselines

 Effective



City of Aurora



# **FINAL DRAINAGE REPORT**

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## **APPENDIX B – HYDROLOGIC COMPUTATIONS**



## URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

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Ken MacKenzie, Executive Director  
2480 W. 26th Avenue, Suite 156B  
Denver, CO 80211-5304

Telephone 303-455-6277  
Fax 303-455-7880  
[www.udfcd.org](http://www.udfcd.org)

### MEMORANDUM

**TO:** Robert Krehbiel, Matrix Design Group

**FROM:** Shea Thomas, UDFCD

**DATE:** 8/7/17

**RE:** Westerly Creek (Lower) FHAD

---

We reviewed the hydrology information you submitted for the Westerly Creek (Downstream of Westerly Creek Dam) Flood Hazard Area Delineation (FHAD) study. The hydrologic parameters submitted on July 15, 2016 are approved (summary of results attached). You may proceed with hydraulic modeling using the approved hydrology.



## Data Collection

*Westerly Creek Drainageway Update (Downstream of Westerly Creek Dam) Major Drainageway Plan, July 2010, by Kiowa Engineering Corporation*

- CUHP-SWMM
  - Input files of CUHP are not available
  - Output files of CUHP 2005 Version 1.2.1 for return periods of 2-, 5-, 10-, 25-, 50- and 100-year events were provided by UDFCD.
  - Input file of EPA-SWMM was provided by UDFCD
  - Westerly Creek subcatchment delineation was provided in CAD by UDFCD
- Kelly Road Dam
  - South Platte River Basin Kelly Road Dam – Westerly Creek, Plans for Dam Rehabilitation, June 1978, US Army CORPS.
  - Draft Emergency Action Plan, Kelly Road Dam and Reservoir, Denver Colorado, Revised April 15, 2016 was provided by UDFCD.
  - Kelly Road Dam Rating Curve in Excel spreadsheet was provided by UDFCD.

*Easterly Creek Outfall Systems Plan, December 2012, by SHE*

- CUHP-SWMM
  - Input files of CUHP 2005 Version 1.3.3 were provided by UDFCD.
  - Input files of EPA-SWMM 5.0 were provided by UDFCD.
  - Easterly Creek subcatchment delineation was provided in GIS by UDFCD.

## Hydrologic Analysis

1. A QA/QC was completed for the CUHP model hydrologic parameters for both the Westerly Creek MDP 2010 and Easterly Creek OSP 2012.
2. Converted CUHP-SWMM models of both Westerly Creek MDP 2010 and Easterly Creek OSP 2012 to the latest CUHP 2005 Version 1.4.4 and EPA-SWMM 5.1.010
3. Revised CUHP-SWMM models of both Westerly Creek MDP 2010 and Easterly Creek OSP 2012 with new hydrologic parameters derived from the QA/QC process.
4. A split flow analysis was done using FLO-2D to determine directions and discharges of flow splits at key design points in the Easterly Creek watershed into the Westerly Creek watershed.
  - The revised CUHP-SWMM hydrologic model of the Easterly Creek OSP 2012 was used as the base model for separating pipe flow out of the inflow hydrographs for the FLO-2D analysis.
  - The hydrograph routing in SWMM was revised to separate the pipe flow and surface flow at those design points associated with the inflow locations in the FLO-2D model. The surface flows were diverted out of the system and used for input hydrographs in the FLO-2D model, however, pipe flows were continued to be routed to the downstream design points.
  - The floodplain cross sections and results of the FLO-2D analysis are shown on **Figure B-2**. The rating curves of flow splits were determined from the hydrographs calculated at

each floodplain cross section in the FLO-2D model. **Table B-4a to B-4i** show the flood hydrographs at each floodplain cross section and the rating curves.

5. Sub-basin delineation
  - Sub-basins AD8, AR3, AR4, AR5, 7a and 5C of the Westerly Creek MDP 2010 were removed and replaced with sub-basins of the Easterly Creek OSP 2012.
  - The boundary of sub-basins ST4 and ST6 were revised at their east boundary to reflect the 100-year drainage system of the Stapleton development.
  - The boundary of sub-basins ST6, ST8, ST9, AD1, AD3, AD4, 7D and AR2 in the Westerly Creek MDP 2010 were revised to match the delineation of the Easterly Creek OSP 2012.
6. Original CUHP and EPA-SWMM (CUHP 1.4.4 with NOAA Atlas 2 Volume 3, no Ct/Cp adjustment)
  - Combined the EPA-SWMM model of Westerly Creek MDP 2010 with the Easterly Creek OSP 2012 by removing common design points and conveyance elements for Easterly Creek within the Westerly Creek model and replaced them with the design points and conveyance elements from the Easterly Creek OSP 2012.
  - Revised flow split design points and conveyance elements based on FLO-2D results.
  - Inserted rating curves for split flow from the FLO-2D analysis.
  - Revised Manning's n by increasing 25% for engineered conveyance elements in the SWMM model to comply with the USDCM of UDFCD.
  - Added overflow elements to resolve flooding at design points which are mostly located in the Lowry Development Authority.
  - Compared rating curves for Kelly Road Dam using the 2016 EAP. The rating curves of the 2016 EAP and the Westerly Creek MDP 2010 are similar; however, the rating curve of 2016 EAP was used in this study to replace the rating curve of 2010 MDP. **Table B-3a** and **Table B-3b** shows the comparison of the rating curves.
  - The final sub-basin delineation and flood routing schematics are shown on **Figure B-1**, Hydrology Work Map.
7. Adjusted CUHP and EPA-SWMM ( $C_t$  &  $C_p$  adjustment)
  - The  $C_t$  and  $C_p$  of the CUHP model were adjusted using spreadsheet, CpCtOverride\_Version2.0, provided by UDFCD.
8. New CUHP Version 1.5.2b and NOAA Atlas 14
  - New CUHP Version 1.5.2b was provided by UDFCD which has been integrated with new equations for calculating  $C_t/C_p$ .
  - Point rainfall depths were derived from NOAA Atlas 14.

## Results of Analysis

- The original peak flows, the adjusted peak flows and NOAA 14 peak flows of this hydrologic analysis were compared to the Regulatory Hydrology (FEMA), Westerly Creek MDP 2010 Baseline Hydrology at the locations where direct comparisons are possible. **Table 3-1** shows the locations and peak flow comparisons. **Figure 3-1** shows the discharge profile comparison.
- **Figure 3-2** shows the discharge profiles calculated using new CUHP and NOAA 14 for all events.
- **Table B-5** shows peak discharges and total volumes calculated using new CUHP and NOAA 14 at all design points.
- **Figure B-3** shows comparison of peak flow diversion to the previous studies.

Figure 3-1 Westerly Creek \_ Peak Discharges vs. Channel Stations - Hydrology Comparison

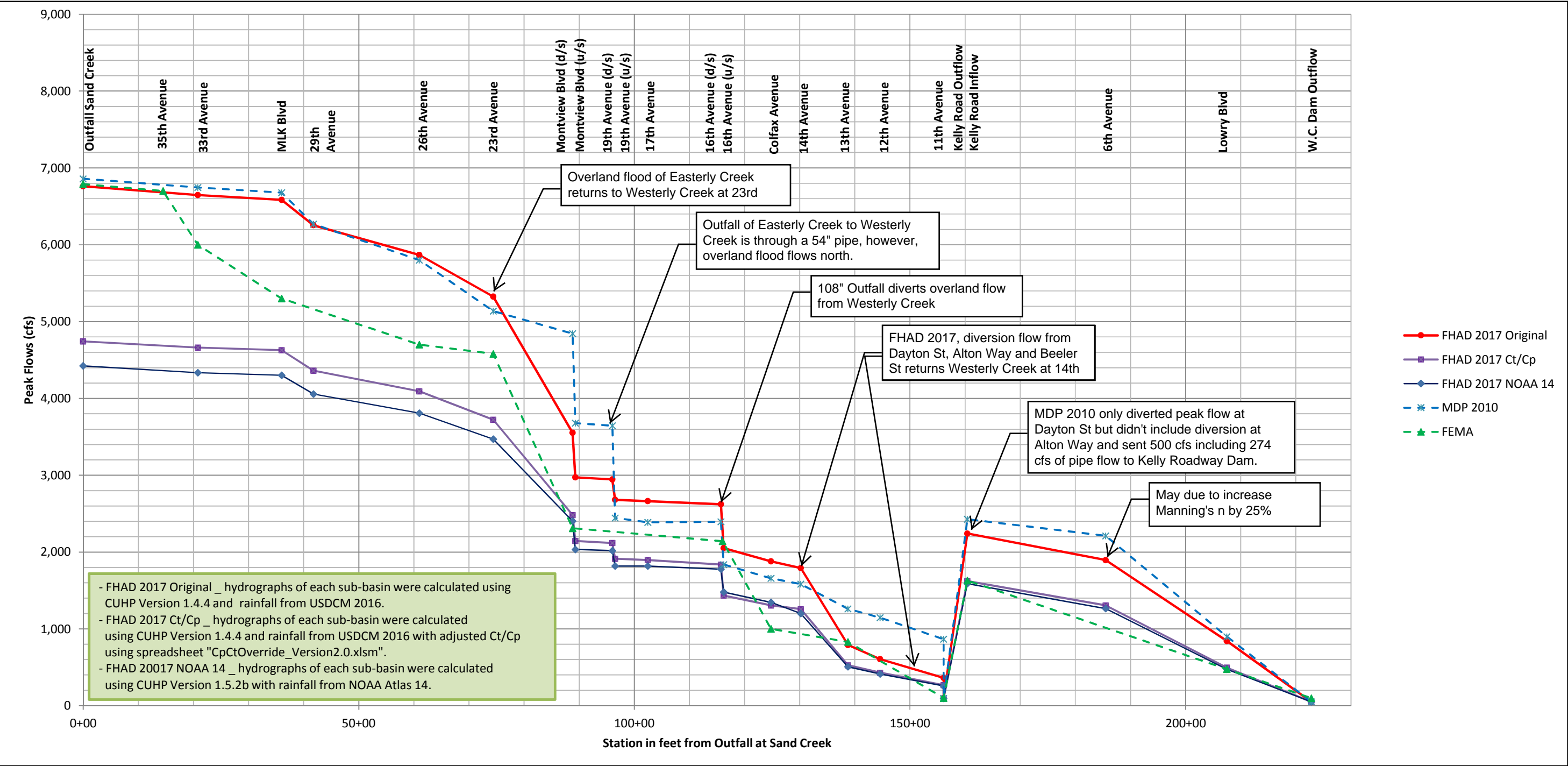
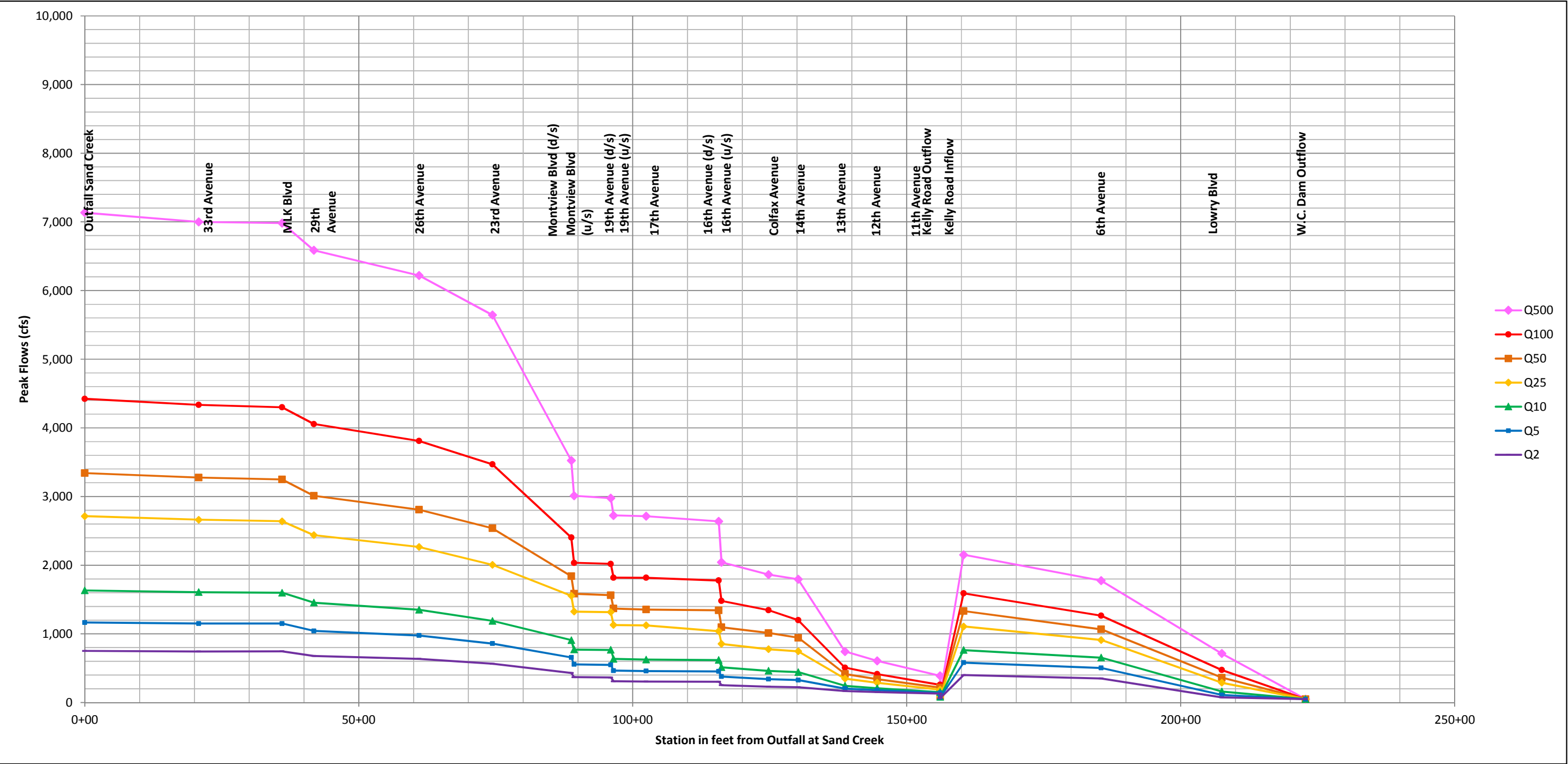
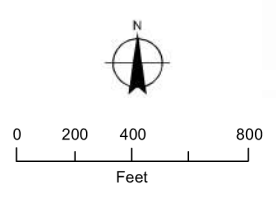
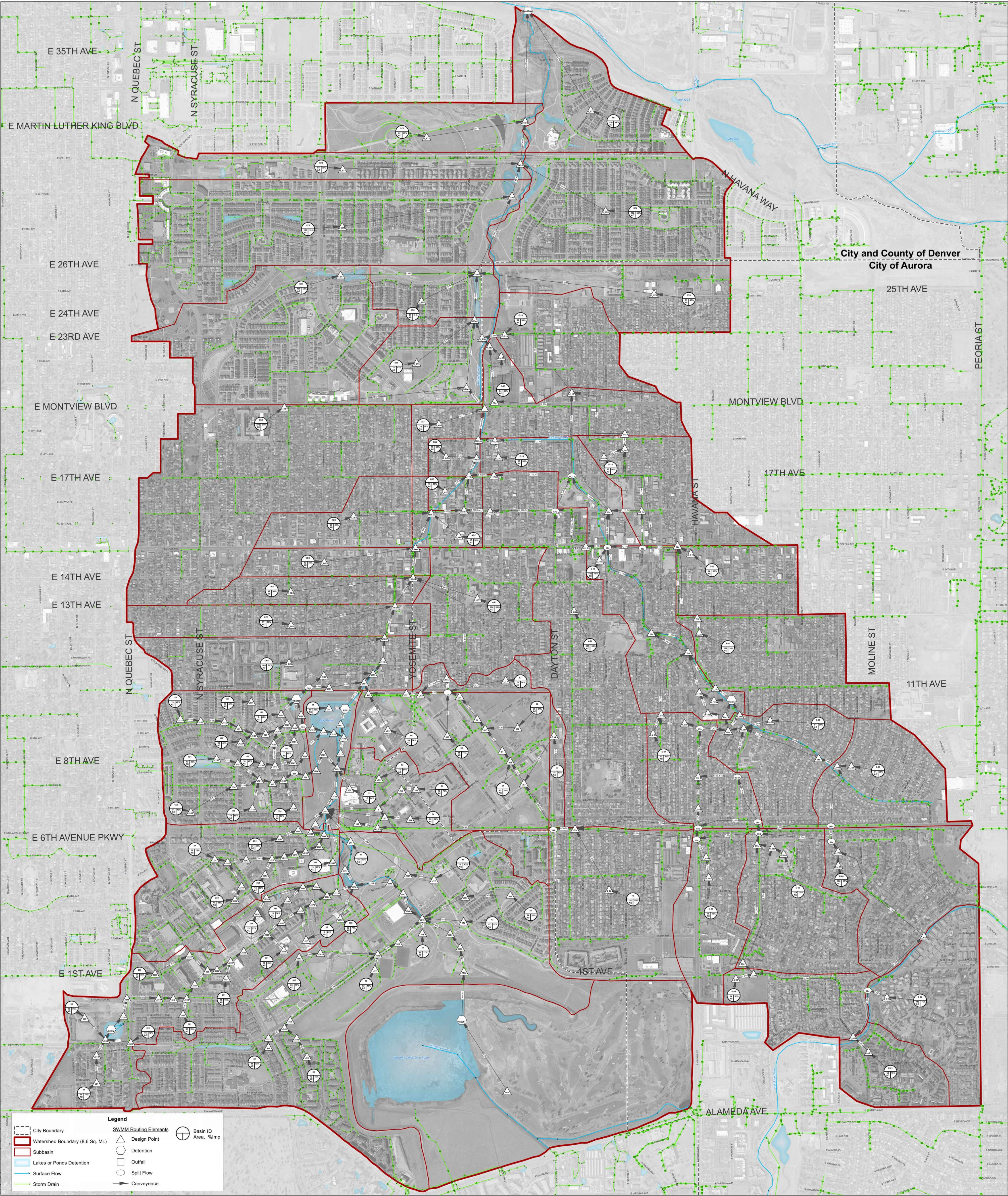


Figure 3-2 Westerly Creek \_ Peak Discharges vs. Channel Stations \_ Future Conditions \_ NOAA 14







**Figure B-1**  
**Hydrology Map**  
Westerly Creek Flood Hazard Area Delineation

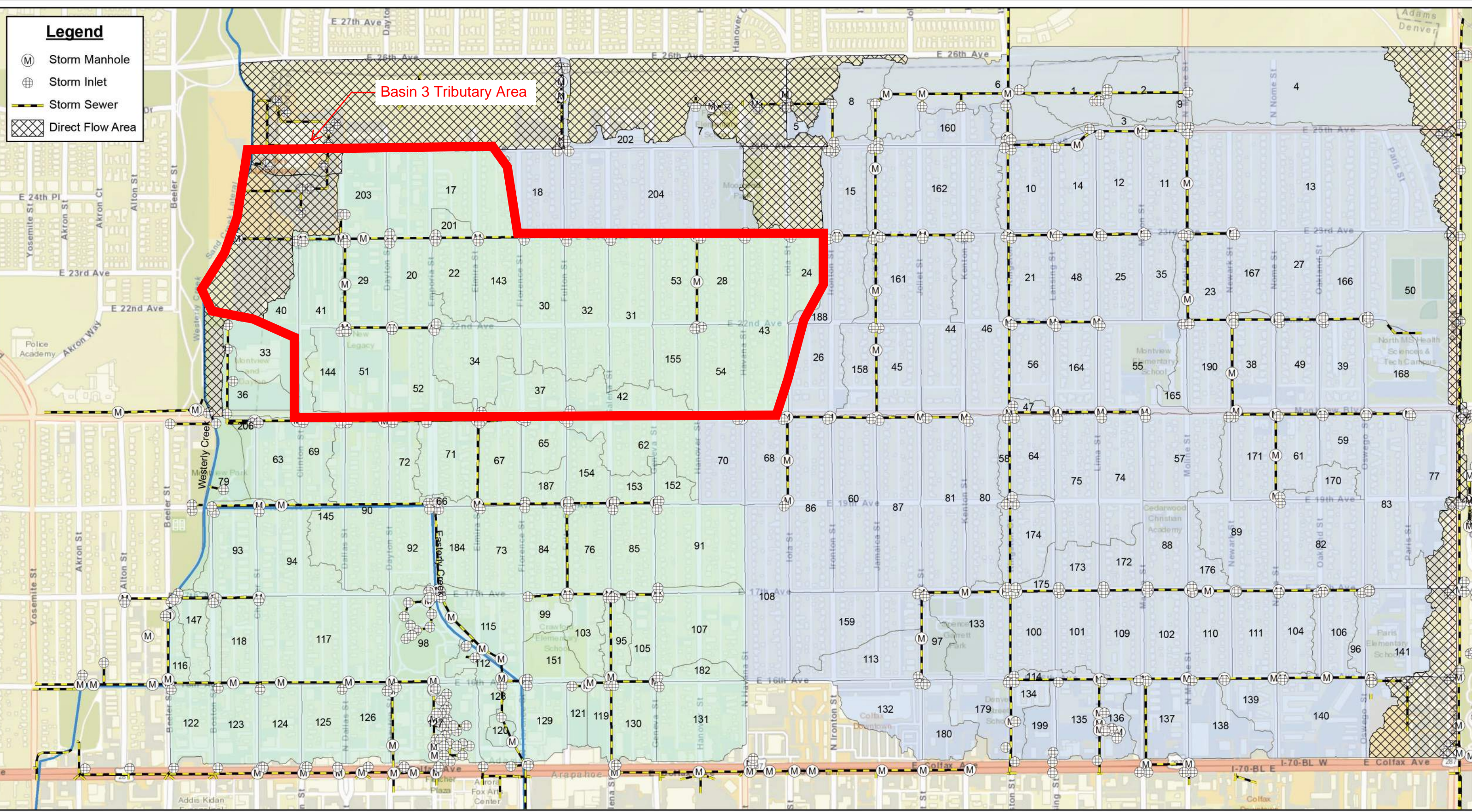


Table 3-1 Westerly Creek Baseline Hydrology Peak Flows at Key Points

Locations	Design Points / Conveyance Elements	Total Drainage Area		Station	FHAD 2017 _ NOAA 14 _ Future Conditions Peak Flow (cfs)							100-Year Hydrology Comparison (cfs)				
		(acres)	(mi <sup>2</sup> )		Q <sub>2</sub>	Q <sub>5</sub>	Q <sub>10</sub>	Q <sub>25</sub>	Q <sub>50</sub>	Q <sub>100</sub>	Q <sub>500</sub>	MDP 2010	FEMA	FHAD 2017 NOAA 14	FHAD 2017 Ct/Cp	FHAD 2017 Original
Outfall	JSandCreek	11,602	18.13	0+00	752	1,165	1,632	2,714	3,342	4,424	7,134	6,859	6,900	4,424	4,742	6,762
33rd Avenue	J33rd	11,492	17.96	20+80	744	1,150	1,606	2,662	3,277	4,335	6,999	6746	6,000	4,335	4,662	6,647
MLK Blvd	JMLK	11,410	17.83	36+00	746	1,151	1,599	2,640	3,249	4,300	6,984	6679	5,300	4,300	4,628	6,584
29th Avenue	J29th	11,132	17.39	41+80	678	1,043	1,455	2,438	3,011	4,056	6,586	6,268		4,056	4,362	6,254
26th Avenue	J26th	10,851	16.95	61+00	637	977	1,351	2,266	2,809	3,809	6,218	5800	4,700	3,809	4,093	5,867
23rd Avenue	J23rd	10,508	16.42	74+40	565	859	1,188	2,005	2,538	3,469	5,644	5136	4,580	3,469	3,722	5,325
Montview Blvd (d/s)	JMontview-ds	9,987	15.60	88+80	431	655	907	1,554	1,840	2,403	3,523	4844	2,310	2,403	2,481	3,552
Montview Blvd (u/s)	JMontview-us	9,707	15.17	89+30	370	556	771	1,325	1,585	2,034	3,010	3,678		2,034	2,144	2,971
19th Avenue (d/s)	J19th-ds	9,683	15.13	96+00	365	548	766	1,316	1,563	2,019	2,975	3,645		2,019	2,118	2,945
19th Avenue (u/s)	J19th-us	7,584	11.85	96+50	310	465	635	1,128	1,369	1,819	2725	2444		1819	1913	2680
17th Avenue	J17th	7,568	11.83	102+45	306	458	625	1,124	1,354	1,818	2712	2387		1818	1897	2663
16th Avenue (d/s)	J16th-DIV	7,553	11.80	115+70	303	453	618	1,039	1,343	1,778	2637	2394	2140	1778	1837	2623
16th Avenue (u/s)	J16th-us	7,316	11.43	116+20	253	379	514	854	1,097	1,480	2043	1837		1480	1435	2052
Colfax Avenue	JColfax-DIV	7,231	11.30	124+80	231	341	461	775	1,012	1,345	1863	1659	1000	1345	1306	1878
14th Avenue	J14th-DIV	7,189	11.23	130+20	222	327	442	745	943	1,200	1795	1583		1200	1257	1790
13th Avenue	J13th-DIV	7,027	10.98	138+75	167	204	244	348	416	507	743	1261	830	507	526	790
12th Avenue	J12th	6,950	10.86	144+60	153	179	209	287	340	413	606	1146		413	430	605
11th Avenue	J11th	6,841	10.69	156+10	131	140	151	189	217	258	388	865		258	268	361
Kelly Road Outflow	OUT130	6,612	10.33	156+12	66	74	81	86	91	95	130	96	100	95	94	97
Kelly Road Inflow	RES130	6,612	10.33	160+40	400	581	763	1,108	1,332	1,590	2151	2428	1630	1590	1621	2240
6th Avenue	J151	6,405	10.01	185+50	351	504	654	910	1,066	1,264	1775	2211		1264	1306	1895
Lowry Blvd	J347	5,821	9.10	207+50	75	109	161	289	362	473	714	898	475	473	496	842
W.C. Dam Outflow	J202	5,546	8.67	222+80	50	50	50	50	50	50	50	50	98	50	50	50

1. FHAD 2017 Original \_ hydrographs of each sub-basin were calculated using CUHP Version 1.4.4 and rainfall from USDCM 2016.  
2. FHAD 2017 Ct/Cp \_ hydrographs of each sub-basin were calculated using CUHP Version 1.4.4 and rainfall from USDCM 2016 with adjusted Ct/Cp using spreadsheet "CpCtOverride\_Version2.0.xlsm".  
3. FHAD 20017 NOAA 14 \_ hydrographs of each sub-basin were calculated using CUHP Version 1.5.2b with rainfall from NOAA Atlas 14.



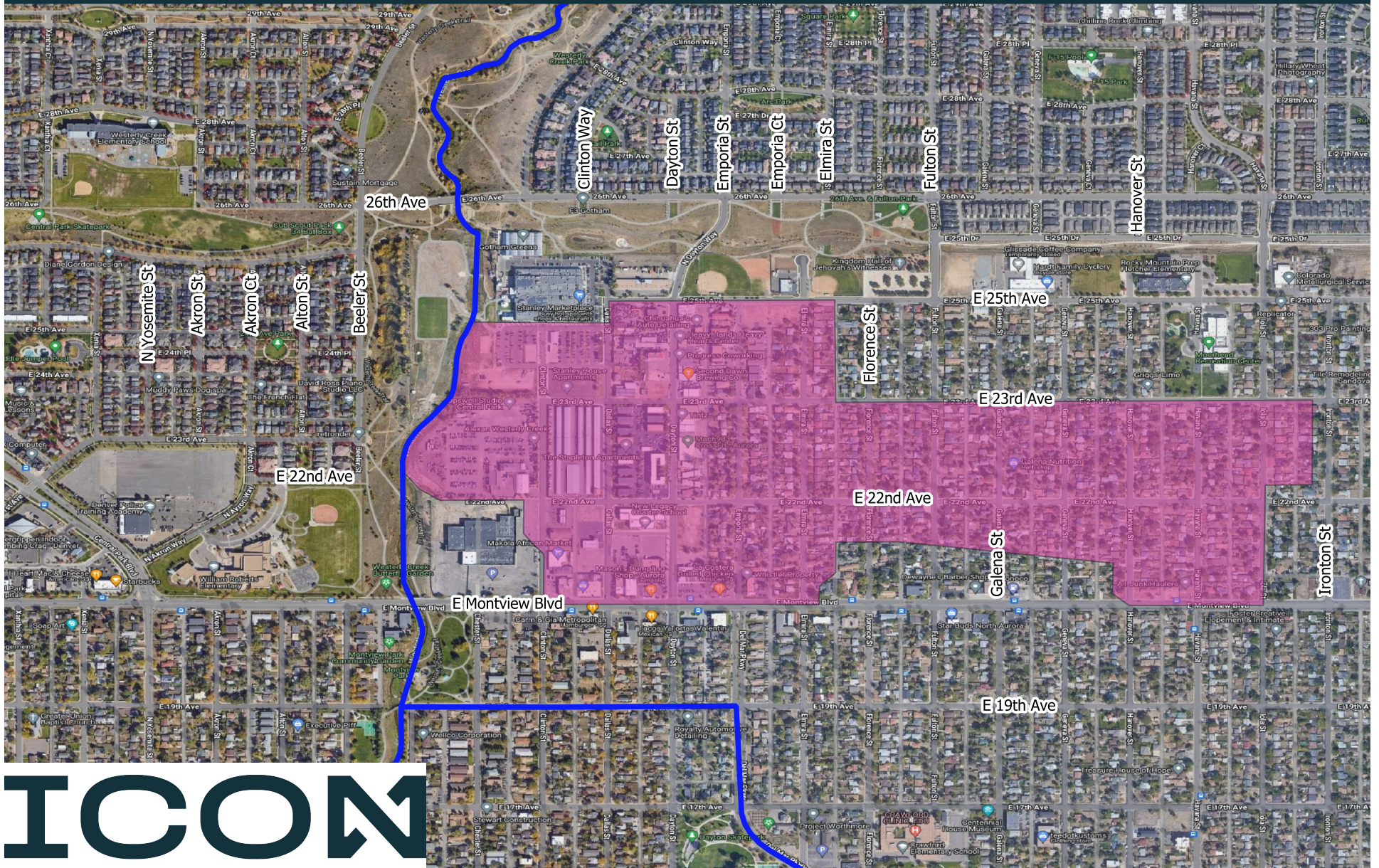


**WWE**  
WRIGHT WATER  
ENGINEERS, INC.

**Calibre**



# AREA EXEMPT FROM ON-SITE WATER QUALITY REQUIREMENTS EXHIBIT



# ICON



Westerly Creek at Stanley - WQCV Basin Tributary Area				
Original Aurora Basin	Size (Sq. Mi)	Size (Ac.)	% Imp	A*I
40	0.003	1.9	87%	1.66
41	0.011	6.9	90%	6.23
144	0.006	3.6	84%	3.02
203	0.008	5.3	74%	3.89
29	0.008	5.0	83%	4.15
51	0.008	5.0	84%	4.25
17	0.020	12.7	61%	7.77
20	0.008	5.0	67%	3.37
201	0.002	1.2	55%	0.66
22	0.006	4.2	55%	2.29
52	0.010	6.5	69%	4.48
34	0.011	6.9	56%	3.86
143	0.007	4.8	55%	2.61
30	0.012	7.4	55%	4.06
37	0.007	4.6	63%	2.89
32	0.012	7.8	55%	4.31
42	0.008	4.9	63%	3.09
31	0.013	8.4	55%	4.61
155	0.006	4.1	55%	2.25
53	0.008	5.0	55%	2.75
54	0.008	5.4	55%	2.96
28	0.008	5.2	55%	2.86
24	0.005	3.4	55%	1.85
43	0.016	10.1	55%	5.56
<b>Total</b>		<b>135.2</b>	<b>63%</b>	

## Parking Lot Outfall – 2-YR

### [OPTIONS]

```
;;Option      Value
FLOW_UNITS    CFS
INFILTRATION  HORTON
FLOW_ROUTING  DYNWAVE
LINK_OFFSETS  DEPTH
MIN_SLOPE     0
ALLOW_PONDING NO
SKIP_STEADY_STATE NO

START_DATE    06/18/2024
START_TIME    00:00:00
REPORT_START_DATE 06/18/2024
REPORT_START_TIME 00:00:00
END_DATE      06/18/2024
END_TIME      06:00:00
SWEEP_START   1/1
SWEEP_END     12/31
DRY_DAYS      0
REPORT_STEP   00:15:00
WET_STEP      00:05:00
DRY_STEP      01:00:00
ROUTING_STEP  0:00:20
RULE_STEP     00:00:00
```

```
INERTIAL_DAMPING PARTIAL
NORMAL_FLOW_LIMITED BOTH
FORCE_MAIN_EQUATION H-W
VARIABLE_STEP 0.75
LENGTHENING_STEP 0
MIN_SURFAREA 0
MAX_TRIALS 0
HEAD_TOLERANCE 0
SYS_FLOW_TOL 5
LAT_FLOW_TOL 5
MINIMUM_STEP 0.5
THREADS 1
```

### [EVAPORATION]

```
;;Data Source Parameters
;;-----
CONSTANT 0.0
DRY_ONLY NO
```

### [JUNCTIONS]

```
;;Name      Elevation MaxDepth InitDepth SurDepth Aponded
;;-----
EX-MH       5296.6 0 0 020 0
PR-MH       5294.29 0 0 20 0
PondLevelSpreader 5293.6 0 0 10 0
```

### [OUTFALLS]

```
;;Name      Elevation Type Stage Data Gated Route To
;;-----
4 0 FREE NO
```

[CONDUITS]

;;Name	From Node	To Node	Length	Roughness	InOffset	OutOffset	InitFlow	MaxFlow
1	EX-MH	PR-MH	224.92	0.013	0	0	0	0
2	PR-MH	PondLevelSpreader	67.24	0.013	0	0	0	0
3	PondLevelSpreader	4	400	0.01	0	0	0	0

[XSECTIONS]

;;Link	Shape	Geom1	Geom2	Geom3	Geom4	Barrels	Culvert
1	CIRCULAR	2.5	0	0	0	1	
2	CIRCULAR	2.5	0	0	0	1	
3	CIRCULAR	1	0	0	0	1	

[INFLOWS]

;;Node	Constituent	Time Series	Type	Mfactor	Sfactor	Baseline	Pattern
EX-MH	FLOW	""	FLOW	1.0	1.0	6.75	

[REPORT]

;;Reporting Options  
SUBCATCHMENTS ALL  
NODES ALL  
LINKS ALL

[TAGS]

[MAP]

DIMENSIONS 0.000 0.000 10000.000 10000.000  
Units None

[COORDINATES]

;;Node	X-Coord	Y-Coord
EX-MH	5287.486	5907.554
PR-MH	2976.325	5772.266
PondLevelSpreader	349.493	5535.513
4	-45.096	5558.061

[VERTICES]

;;Link	X-Coord	Y-Coord
--------	---------	---------

[Polygons]

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.2 (Build 5.2.4)

-----  
WARNING 08: elevation drop exceeds length for Conduit 3

\*\*\*\*\*

Analysis Options

\*\*\*\*\*

Flow Units ..... CFS

Process Models:

Rainfall/Runoff ..... NO

RDII ..... NO

Snowmelt ..... NO

Groundwater ..... NO

Flow Routing ..... YES

Ponding Allowed ..... NO

Water Quality ..... NO

Flow Routing Method ..... DYNWAVE

Surcharge Method ..... EXTRAN

Starting Date ..... 06/18/2024 00:00:00

Ending Date ..... 06/18/2024 06:00:00

Antecedent Dry Days ..... 0.0

Report Time Step ..... 00:15:00

Routing Time Step ..... 20.00 sec

Variable Time Step ..... YES

Maximum Trials ..... 8

Number of Threads ..... 1

Head Tolerance ..... 0.005000 ft

\*\*\*\*\*      Volume      Volume

Flow Routing Continuity      acre-feet      10^6 gal

\*\*\*\*\*      -----      -----

Dry Weather Inflow .....      0.000      0.000

Wet Weather Inflow .....      0.000      0.000

Groundwater Inflow .....      0.000      0.000

RDII Inflow .....      0.000      0.000

External Inflow .....      3.347      1.091

External Outflow .....      3.341      1.089

Flooding Loss .....      0.000      0.000

Evaporation Loss .....      0.000      0.000

Exfiltration Loss .....      0.000      0.000

Initial Stored Volume ....      0.000      0.000

Final Stored Volume .....      0.007      0.002

Continuity Error (%) .....      -0.031

\*\*\*\*\*

Time-Step Critical Elements

\*\*\*\*\*

Link 3 (99.89%)

\*\*\*\*\*

Highest Flow Instability Indexes

\*\*\*\*\*

All links are stable.

\*\*\*\*\*

### Most Frequent Nonconverging Nodes

\*\*\*\*\*

Node PondLevelSpreader (0.06%)

Node 4 (0.06%)

\*\*\*\*\*

### Routing Time Step Summary

\*\*\*\*\*

Minimum Time Step : 0.74 sec  
Average Time Step : 2.75 sec  
Maximum Time Step : 17.11 sec  
% of Time in Steady State : 0.00  
Average Iterations per Step : 3.00  
% of Steps Not Converging : 0.06  
Time Step Frequencies :  
20.000 - 9.564 sec : 0.03 %  
9.564 - 4.573 sec : 0.06 %  
4.573 - 2.187 sec : 99.89 %  
2.187 - 1.046 sec : 0.01 %  
1.046 - 0.500 sec : 0.01 %

\*\*\*\*\*

### Node Depth Summary

\*\*\*\*\*

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min	Max Depth Feet	Reported
EX-MH	JUNCTION	0.68	0.76	5297.36	0 00:00	0.68	
PR-MH	JUNCTION	0.71	0.73	5295.02	0 00:01	0.71	
PondLevelSpreader	JUNCTION	0.12	0.17	5293.77	0 00:00	0.12	
4	OUTFALL	0.14	0.22	0.22	0 00:01	0.14	

\*\*\*\*\*

### Node Inflow Summary

\*\*\*\*\*

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Maximum Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal	Flow Balance Error Percent
EX-MH	JUNCTION	6.75	6.75	0 00:00	1.09	1.09	0.091
PR-MH	JUNCTION	0.00	7.57	0 00:01	0	1.09	0.133
PondLevelSpreader	JUNCTION	0.00	7.21	0 00:01	0	1.09	-0.040
4	OUTFALL	0.00	18.33	0 00:01	0	1.09	0.000

\*\*\*\*\*

### Node Surcharge Summary

\*\*\*\*\*

No nodes were surcharged.

\*\*\*\*\*  
Node Flooding Summary  
\*\*\*\*\*

No nodes were flooded.

\*\*\*\*\*  
Outfall Loading Summary  
\*\*\*\*\*

-----				
Outfall Node	Flow Freq	Avg Flow Pcnt	Max Flow CFS	Total Volume CFS 10^6 gal
-----				
4	99.91	6.76	18.33	1.089
-----				
System	99.91	6.76	18.33	1.089

\*\*\*\*\*  
Link Flow Summary  
\*\*\*\*\*

-----						
Link	Type	Maximum  Flow  CFS	Time of Max Occurrence days hr:min	Max  Veloc  ft/sec	Max/ Full Flow	Max/ Full Depth
-----						
1	CONDUIT	7.57	0 00:01	7.04	0.18	0.29
2	CONDUIT	7.21	0 00:01	13.04	0.17	0.17
3	CONDUIT	18.33	0 00:01	>50.00	0.11	0.16

\*\*\*\*\*  
Flow Classification Summary  
\*\*\*\*\*

-----										
Conduit	Adjusted /Actual Length	Up Dry	Down Dry	Sub Dry	Sup Crit	Up Crit	Down Crit	Norm Crit	Inlet Ltd	Ctrl
-----										
1	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
2	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
3	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00

\*\*\*\*\*  
Conduit Surchage Summary  
\*\*\*\*\*

No conduits were surcharged.

Analysis begun on: Wed Jul 3 12:17:38 2024  
Analysis ended on: Wed Jul 3 12:17:38 2024  
Total elapsed time: < 1 sec

## Parking Lot Outfall – 100 -YR

### [OPTIONS]

;;Option Value

FLOW\_UNITS CFS

INFILTRATION HORTON

FLOW\_ROUTING DYNWAVE

LINK\_OFFSETS DEPTH

MIN\_SLOPE 0

ALLOW\_PONDING NO

SKIP\_STEADY\_STATE NO

START\_DATE 06/18/2024

START\_TIME 00:00:00

REPORT\_START\_DATE 06/18/2024

REPORT\_START\_TIME 00:00:00

END\_DATE 06/18/2024

END\_TIME 06:00:00

SWEEP\_START 1/1

SWEEP\_END 12/31

DRY\_DAYS 0

REPORT\_STEP 00:15:00

WET\_STEP 00:05:00

DRY\_STEP 01:00:00

ROUTING\_STEP 0:00:20

RULE\_STEP 00:00:00

INERTIAL\_DAMPING PARTIAL

NORMAL\_FLOW\_LIMITED BOTH

FORCE\_MAIN\_EQUATION H-W

VARIABLE\_STEP 0.75

LENGTHENING\_STEP 0

MIN\_SURFAREA 0

MAX\_TRIALS 0

HEAD\_TOLERANCE 0

SYS\_FLOW\_TOL 5

LAT\_FLOW\_TOL 5

MINIMUM\_STEP 0.5

THREADS 1

### [EVAPORATION]

;;Data Source Parameters

;;-----

CONSTANT 0.0

DRY\_ONLY NO

### [JUNCTIONS]

;;Name Elevation MaxDepth InitDepth SurDepth Aponded

;;-----

EX-MH 5296.6 0 0 020 0

PR-MH 5294.29 0 0 20 0

### [OUTFALLS]

;;Name Elevation Type Stage Data Gated Route To

;;-----

PondLevelSpreader 5293.6 FREE NO

### [CONDUITS]



;;Name	From Node	To Node	Length	Roughness	InOffset	OutOffset	InitFlow	MaxFlow
1	EX-MH	PR-MH	224.92	0.013	0	0	0	0
2	PR-MH	PondLevelSpreader	67.24	0.013	0	0	0	0

#### [XSECTIONS]

;;Link	Shape	Geom1	Geom2	Geom3	Geom4	Barrels	Culvert
1	CIRCULAR	2.5	0	0	0	1	
2	CIRCULAR	2.5	0	0	0	1	

#### [INFLOWS]

;;Node	Constituent	Time Series	Type	Mfactor	Sfactor	Baseline	Pattern
EX-MH	FLOW	""	FLOW	1.0	1.0	20.11	

#### [REPORT]

;;Reporting Options  
SUBCATCHMENTS ALL  
NODES ALL  
LINKS ALL

#### [TAGS]

#### [MAP]

DIMENSIONS 0.000 0.000 10000.000 10000.000  
Units None

#### [COORDINATES]

;;Node	X-Coord	Y-Coord
EX-MH	5287.486	5907.554
PR-MH	2976.325	5772.266
PondLevelSpreader	349.493	5535.513

#### [VERTICES]

;;Link	X-Coord	Y-Coord
--------	---------	---------

#### [Polygons]

\*\*\*\*\*

#### Analysis Options

\*\*\*\*\*

Flow Units ..... CFS

Process Models:

Rainfall/Runoff ..... NO

RDII ..... NO

Snowmelt ..... NO

Groundwater ..... NO

Flow Routing ..... YES

Ponding Allowed ..... NO

Water Quality ..... NO

Flow Routing Method ..... DYNWAVE

Surcharge Method ..... EXTRAN

Starting Date ..... 06/18/2024 00:00:00

Ending Date ..... 06/18/2024 06:00:00

Antecedent Dry Days ..... 0.0

Report Time Step ..... 00:15:00

Routing Time Step ..... 20.00 sec

Variable Time Step ..... YES

Maximum Trials ..... 8

Number of Threads ..... 1

Head Tolerance ..... 0.005000 ft

\*\*\*\*\*      Volume      Volume

Flow Routing Continuity      acre-feet      10<sup>6</sup> gal

\*\*\*\*\*      -----      -----

Dry Weather Inflow ..... 0.000      0.000

Wet Weather Inflow ..... 0.000      0.000

Groundwater Inflow ..... 0.000      0.000

RDII Inflow ..... 0.000      0.000

External Inflow ..... 9.971      3.249

External Outflow ..... 9.956      3.244

Flooding Loss ..... 0.000      0.000

Evaporation Loss ..... 0.000      0.000

Exfiltration Loss ..... 0.000      0.000

Initial Stored Volume .... 0.000      0.000

Final Stored Volume ..... 0.016      0.005

Continuity Error (%) ..... -0.006

\*\*\*\*\*

#### Time-Step Critical Elements

\*\*\*\*\*

Link 2 (99.93%)

\*\*\*\*\*

#### Highest Flow Instability Indexes

\*\*\*\*\*

All links are stable.

\*\*\*\*\*

#### Most Frequent Nonconverging Nodes

\*\*\*\*\*

Convergence obtained at all time steps.

\*\*\*\*\*

#### Routing Time Step Summary

\*\*\*\*\*

Minimum Time Step : 1.51 sec  
Average Time Step : 3.62 sec  
Maximum Time Step : 9.18 sec  
% of Time in Steady State : 0.00  
Average Iterations per Step : 2.00  
% of Steps Not Converging : 0.00  
Time Step Frequencies :  
20.000 - 9.564 sec : 0.00 %  
9.564 - 4.573 sec : 0.10 %  
4.573 - 2.187 sec : 99.88 %  
2.187 - 1.046 sec : 0.02 %  
1.046 - 0.500 sec : 0.00 %

\*\*\*\*\*

#### Node Depth Summary

\*\*\*\*\*

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min	Reported Max Depth Feet
EX-MH	JUNCTION	1.23	1.23	1.49	5298.09 0 00:00	1.23
PR-MH	JUNCTION	1.23	1.23	1.45	5295.74 0 00:00	1.23
PondLevelSpreader	OUTFALL	1.23	1.23	1.37	5294.97 0 00:01	1.23

\*\*\*\*\*

#### Node Inflow Summary

\*\*\*\*\*

Node	Type	Maximum Inflow CFS	Maximum Lateral Inflow CFS	Maximum Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal	Flow Balance Error Percent
EX-MH	JUNCTION	20.11	20.11	0 00:00	3.25	3.25	0.064
PR-MH	JUNCTION	0.00	23.65	0 00:00	0	3.25	0.091
PondLevelSpreader	OUTFALL	0.00	24.12	0 00:01	0	3.24	0.000

\*\*\*\*\*

#### Node Surcharge Summary

\*\*\*\*\*

No nodes were surcharged.

\*\*\*\*\*

#### Node Flooding Summary

\*\*\*\*\*

No nodes were flooded.

\*\*\*\*\*  
Outfall Loading Summary  
\*\*\*\*\*

-----					
Outfall Node	Flow Freq	Avg Flow Pcnt	Max Flow CFS	Total Volume CFS	10^6 gal
	-----				
PondLevelSpreader		99.98	20.10	24.12	3.244
-----					
System		99.98	20.10	24.12	3.244

\*\*\*\*\*  
Link Flow Summary  
\*\*\*\*\*

Link	Type	Maximum Time of Max		Maximum	Max/	Max/
		Flow	Occurrence	Veloc	Full	Full
-----						
		CFS	days hr:min	ft/sec	Flow	Depth
-----						
1	CONDUIT	23.65	0 00:00	8.94	0.57	0.55
2	CONDUIT	24.12	0 00:01	8.74	0.58	0.56

\*\*\*\*\*  
Flow Classification Summary  
\*\*\*\*\*

Conduit	Adjusted	Fraction of Time in Flow Class -----									
	/Actual	Up	Down	Sub	Sup	Up	Down	Norm	Inlet		
-----											
	Length	Dry	Dry	Dry	Crit	Crit	Crit	Crit	Ltd	Ctrl	
-----											
1	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	
2	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	

\*\*\*\*\*  
Conduit Surge Summary  
\*\*\*\*\*

No conduits were surcharged.

Analysis begun on: Sat Jun 29 12:00:46 2024  
Analysis ended on: Sat Jun 29 12:00:46 2024  
Total elapsed time: < 1 sec

## 23<sup>rd</sup> Avenue System – 2-YR

### [OPTIONS]

```
;;Option      Value
FLOW_UNITS    CFS
INFILTRATION  HORTON
FLOW_ROUTING  DYNWAVE
LINK_OFFSETS  DEPTH
MIN_SLOPE     0
ALLOW_PONDING NO
SKIP_STEADY_STATE NO

START_DATE    06/18/2024
START_TIME    00:00:00
REPORT_START_DATE 06/18/2024
REPORT_START_TIME 00:00:00
END_DATE      06/18/2024
END_TIME      06:00:00
SWEEP_START   01/01
SWEEP_END     12/31
DRY_DAYS      0
REPORT_STEP   00:01:00
WET_STEP      00:05:00
DRY_STEP      01:00:00
ROUTING_STEP  0:00:20
RULE_STEP     00:00:00
```

```
INERTIAL_DAMPING PARTIAL
NORMAL_FLOW_LIMITED BOTH
FORCE_MAIN_EQUATION H-W
VARIABLE_STEP 0.75
LENGTHENING_STEP 0
MIN_SURFAREA 12.566
MAX_TRIALS 8
HEAD_TOLERANCE 0.005
SYS_FLOW_TOL 5
LAT_FLOW_TOL 5
MINIMUM_STEP 0.5
THREADS 1
```

### [EVAPORATION]

```
;;Data Source Parameters
;;-----
CONSTANT 0.0
DRY_ONLY NO
```

### [JUNCTIONS]

```
;;Name      Elevation MaxDepth InitDepth SurDepth Aponded
;;-----
JUNCTION_STRUCTURE 5294.91 8.5 0 020 0
OverflowBubbler 5293.76 0 0 20 0
3 5297.91 7.35 0 20 0
PR-MH 5295.75 11.5 0 20 0
5 5296.68 9.32 0 20 0
```

### [OUTFALLS]

```
;;Name      Elevation Type Stage Data Gated Route To
;;-----
```

PondLevelSpreader 5293.6 FREE NO

[CONDUITS]

;;Name	From Node	To Node	Length	Roughness	InOffset	OutOffset	InitFlow	MaxFlow
PR_HERCP	JUNCTION_STRUCTURE	OverflowBubbler	192	0.013	0	0	0	0
OBSToLS	OverflowBubbler	PondLevelSpreader	34	0.013	0	0	0	0
EX_HERCP	3	JUNCTION_STRUCTURE	177	0.013	0	0	0	0
PR_48	PR-MH	JUNCTION_STRUCTURE	60.64	0.013	0	0	0	0
EX_48	5	PR-MH	380	0.013	0	0	0	0

[XSECTIONS]

;;Link	Shape	Geom1	Geom2	Geom3	Geom4	Barrels	Culvert
PR_HERCP	HORIZ_ELLIPSE	4.42	6.92	0	0	1	
OBSToLS	CIRCULAR	2.5	0	0	0	1	
EX_HERCP	HORIZ_ELLIPSE	4	6.3	0	0	1	
PR_48	CIRCULAR	4	0	0	0	1	
EX_48	CIRCULAR	4	0	0	0	1	

[LOSSES]

;;Link	Kentry	Kexit	Kavg	Flap Gate	Seepage
EX_48	0	1	0	NO	0

[INFLOWS]

;;Node	Constituent	Time Series	Type	Mfactor	Sfactor	Baseline	Pattern
JUNCTION_STRUCTURE	FLOW	""	FLOW	1.0	1.0	20.11	
5	FLOW	existingrcp48	FLOW	1.0	1.0		

[TIMESERIES]

;;Name	Date	Time	Value
existingrcp48		0:05:00	0
existingrcp48		0:10:00	0
existingrcp48		0:15:00	0
existingrcp48		0:20:00	1.25
existingrcp48		0:25:00	9.18
existingrcp48		0:30:00	24.8
existingrcp48		0:35:00	38.08
existingrcp48		0:40:00	42.03
existingrcp48		0:45:00	40.26
existingrcp48		0:50:00	36.64
existingrcp48		0:55:00	33.06
existingrcp48		1:00:00	30.17
existingrcp48		1:05:00	27.79
existingrcp48		1:10:00	25.46
existingrcp48		1:15:00	22.92
existingrcp48		1:20:00	20.63
existingrcp48		1:25:00	18.92
existingrcp48		1:30:00	17.59
existingrcp48		1:35:00	16.4
existingrcp48		1:40:00	15.28
existingrcp48		1:45:00	14.16
existingrcp48		1:50:00	13.04
existingrcp48		1:55:00	11.94
existingrcp48		2:00:00	10.54

existingrcp48	2:05:00	9.18
existingrcp48	2:10:00	7.72
existingrcp48	2:15:00	6.31
existingrcp48	2:20:00	5.09
existingrcp48	2:25:00	4.13
existingrcp48	2:30:00	3.32
existingrcp48	2:35:00	2.66
existingrcp48	2:40:00	2.11
existingrcp48	2:45:00	1.68
existingrcp48	2:50:00	1.33
existingrcp48	2:55:00	1.04
existingrcp48	3:00:00	0.8
existingrcp48	3:05:00	0.59
existingrcp48	3:10:00	0.42
existingrcp48	3:15:00	0.27
existingrcp48	3:20:00	0.16
existingrcp48	3:25:00	0.08
existingrcp48	3:30:00	0.03
existingrcp48	3:35:00	0.01
existingrcp48	3:40:00	0
existingrcp48	3:45:00	0
existingrcp48	3:50:00	0
existingrcp48	3:55:00	0
existingrcp48	4:00:00	0
existingrcp48	4:05:00	0
existingrcp48	4:10:00	0
existingrcp48	4:15:00	0
existingrcp48	4:20:00	0
existingrcp48	4:25:00	0
existingrcp48	4:30:00	0
existingrcp48	4:35:00	0
existingrcp48	4:40:00	0
existingrcp48	4:45:00	0
existingrcp48	4:50:00	0
existingrcp48	4:55:00	0
existingrcp48	5:00:00	0
existingrcp48	5:05:00	0
existingrcp48	5:10:00	0
existingrcp48	5:15:00	0
existingrcp48	5:20:00	0
existingrcp48	5:25:00	0
existingrcp48	5:30:00	0
existingrcp48	5:35:00	0
existingrcp48	5:40:00	0
existingrcp48	5:45:00	0
existingrcp48	5:50:00	0
existingrcp48	5:55:00	0
existingrcp48	6:00:00	0
existingrcp48	6:05:00	0
existingrcp48	6:10:00	0
existingrcp48	6:15:00	0
existingrcp48	6:20:00	0
existingrcp48	6:25:00	0
existingrcp48	6:30:00	0
existingrcp48	6:35:00	0
existingrcp48	6:40:00	0
existingrcp48	6:45:00	0
existingrcp48	6:50:00	0



existingrcp48	6:55:00	0
existingrcp48	7:00:00	0
existingrcp48	7:05:00	0
existingrcp48	7:10:00	0
existingrcp48	7:15:00	0
existingrcp48	7:20:00	0
existingrcp48	7:25:00	0
existingrcp48	7:30:00	0
existingrcp48	7:35:00	0
existingrcp48	7:40:00	0
existingrcp48	7:45:00	0
existingrcp48	7:50:00	0
existingrcp48	7:55:00	0
existingrcp48	8:00:00	0
existingrcp48	8:05:00	0
existingrcp48	8:10:00	0
existingrcp48	8:15:00	0
existingrcp48	8:20:00	0
existingrcp48	8:25:00	0
existingrcp48	8:30:00	0
existingrcp48	8:35:00	0
existingrcp48	8:40:00	0
existingrcp48	8:45:00	0
existingrcp48	8:50:00	0
existingrcp48	8:55:00	0
existingrcp48	9:00:00	0
existingrcp48	9:05:00	0
existingrcp48	9:10:00	0
existingrcp48	9:15:00	0
existingrcp48	9:20:00	0
existingrcp48	9:25:00	0
existingrcp48	9:30:00	0
existingrcp48	9:35:00	0
existingrcp48	9:40:00	0
existingrcp48	9:45:00	0
existingrcp48	9:50:00	0
existingrcp48	9:55:00	0
existingrcp48	10:00:00	0
existingrcp48	10:05:00	0
existingrcp48	10:10:00	0
existingrcp48	10:15:00	0
existingrcp48	10:20:00	0
existingrcp48	10:25:00	0
existingrcp48	10:30:00	0
existingrcp48	10:35:00	0
existingrcp48	10:40:00	0
existingrcp48	10:45:00	0
existingrcp48	10:50:00	0
existingrcp48	10:55:00	0
existingrcp48	11:00:00	0
existingrcp48	11:05:00	0
existingrcp48	11:10:00	0
existingrcp48	11:15:00	0
existingrcp48	11:20:00	0
existingrcp48	11:25:00	0
existingrcp48	11:30:00	0
existingrcp48	11:35:00	0
existingrcp48	11:40:00	0

existingrcp48	11:45:00	0
existingrcp48	11:50:00	0
existingrcp48	11:55:00	0
existingrcp48	12:00:00	0
existingrcp48	12:05:00	0
existingrcp48	12:10:00	0
existingrcp48	12:15:00	0
existingrcp48	12:20:00	0
existingrcp48	12:25:00	0
existingrcp48	12:30:00	0
existingrcp48	12:35:00	0
existingrcp48	12:40:00	0
existingrcp48	12:45:00	0
existingrcp48	12:50:00	0
existingrcp48	12:55:00	0
existingrcp48	13:00:00	0
existingrcp48	13:05:00	0
existingrcp48	13:10:00	0
existingrcp48	13:15:00	0
existingrcp48	13:20:00	0
existingrcp48	13:25:00	0
existingrcp48	13:30:00	0
existingrcp48	13:35:00	0
existingrcp48	13:40:00	0
existingrcp48	13:45:00	0
existingrcp48	13:50:00	0
existingrcp48	13:55:00	0
existingrcp48	14:00:00	0
existingrcp48	14:05:00	0
existingrcp48	14:10:00	0
existingrcp48	14:15:00	0
existingrcp48	14:20:00	0
existingrcp48	14:25:00	0
existingrcp48	14:30:00	0
existingrcp48	14:35:00	0
existingrcp48	14:40:00	0
existingrcp48	14:45:00	0
existingrcp48	14:50:00	0
existingrcp48	14:55:00	0
existingrcp48	15:00:00	0
existingrcp48	15:05:00	0
existingrcp48	15:10:00	0
existingrcp48	15:15:00	0
existingrcp48	15:20:00	0
existingrcp48	15:25:00	0
existingrcp48	15:30:00	0
existingrcp48	15:35:00	0
existingrcp48	15:40:00	0
existingrcp48	15:45:00	0
existingrcp48	15:50:00	0
existingrcp48	15:55:00	0
existingrcp48	16:00:00	0
existingrcp48	16:05:00	0
existingrcp48	16:10:00	0
existingrcp48	16:15:00	0
existingrcp48	16:20:00	0
existingrcp48	16:25:00	0
existingrcp48	16:30:00	0

existingrcp48	16:35:00	0
existingrcp48	16:40:00	0
existingrcp48	16:45:00	0
existingrcp48	16:50:00	0
existingrcp48	16:55:00	0
existingrcp48	17:00:00	0
existingrcp48	17:05:00	0
existingrcp48	17:10:00	0
existingrcp48	17:15:00	0
existingrcp48	17:20:00	0
existingrcp48	17:25:00	0
existingrcp48	17:30:00	0
existingrcp48	17:35:00	0
existingrcp48	17:40:00	0
existingrcp48	17:45:00	0
existingrcp48	17:50:00	0
existingrcp48	17:55:00	0
existingrcp48	18:00:00	0
existingrcp48	18:05:00	0
existingrcp48	18:10:00	0
existingrcp48	18:15:00	0
existingrcp48	18:20:00	0
existingrcp48	18:25:00	0
existingrcp48	18:30:00	0
existingrcp48	18:35:00	0
existingrcp48	18:40:00	0
existingrcp48	18:45:00	0
existingrcp48	18:50:00	0
existingrcp48	18:55:00	0
existingrcp48	19:00:00	0
existingrcp48	19:05:00	0
existingrcp48	19:10:00	0
existingrcp48	19:15:00	0
existingrcp48	19:20:00	0
existingrcp48	19:25:00	0
existingrcp48	19:30:00	0
existingrcp48	19:35:00	0
existingrcp48	19:40:00	0
existingrcp48	19:45:00	0
existingrcp48	19:50:00	0
existingrcp48	19:55:00	0
existingrcp48	20:00:00	0
existingrcp48	20:05:00	0
existingrcp48	20:10:00	0
existingrcp48	20:15:00	0
existingrcp48	20:20:00	0
existingrcp48	20:25:00	0
existingrcp48	20:30:00	0
existingrcp48	20:35:00	0
existingrcp48	20:40:00	0
existingrcp48	20:45:00	0
existingrcp48	20:50:00	0
existingrcp48	20:55:00	0
existingrcp48	21:00:00	0
existingrcp48	21:05:00	0
existingrcp48	21:10:00	0
existingrcp48	21:15:00	0
existingrcp48	21:20:00	0

existingrcp48	21:25:00	0
existingrcp48	21:30:00	0
existingrcp48	21:35:00	0
existingrcp48	21:40:00	0
existingrcp48	21:45:00	0
existingrcp48	21:50:00	0
existingrcp48	21:55:00	0
existingrcp48	22:00:00	0
existingrcp48	22:05:00	0
existingrcp48	22:10:00	0
existingrcp48	22:15:00	0
existingrcp48	22:20:00	0
existingrcp48	22:25:00	0
existingrcp48	22:30:00	0
existingrcp48	22:35:00	0
existingrcp48	22:40:00	0
existingrcp48	22:45:00	0
existingrcp48	22:50:00	0
existingrcp48	22:55:00	0
existingrcp48	23:00:00	0
existingrcp48	23:05:00	0
existingrcp48	23:10:00	0
existingrcp48	23:15:00	0
existingrcp48	23:20:00	0
existingrcp48	23:25:00	0
existingrcp48	23:30:00	0
existingrcp48	23:35:00	0
existingrcp48	23:40:00	0
existingrcp48	23:45:00	0
existingrcp48	23:50:00	0
existingrcp48	23:55:00	0

[REPORT]

;;Reporting Options  
 SUBCATCHMENTS ALL  
 NODES ALL  
 LINKS ALL

[TAGS]

[MAP]

DIMENSIONS -126.832 0.000 10352.311 10000.000  
 Units None

[COORDINATES]

;;Node	X-Coord	Y-Coord
;;-----		
JUNCTION_STRUCTURE	5287.486	5907.554
OverflowBubbler	2976.325	5772.266
3	7429.538	7497.182
PR-MH	8432.920	5794.814
5	9875.986	7452.086
PondLevelSpreader	349.493	5535.513

[VERTICES]

;;Link	X-Coord	Y-Coord
;;-----		

[Polygons]

# EPA STORM WATER MANAGEMENT MODEL - VERSION 5.2 (Build 5.2.4)

\*\*\*\*\*

## Analysis Options

\*\*\*\*\*

Flow Units ..... CFS

Process Models:

Rainfall/Runoff ..... NO

RDII ..... NO

Snowmelt ..... NO

Groundwater ..... NO

Flow Routing ..... YES

Ponding Allowed ..... NO

Water Quality ..... NO

Flow Routing Method ..... DYNWAVE

Surcharge Method ..... EXTRAN

Starting Date ..... 06/18/2024 00:00:00

Ending Date ..... 06/18/2024 06:00:00

Antecedent Dry Days ..... 0.0

Report Time Step ..... 00:01:00

Routing Time Step ..... 20.00 sec

Variable Time Step ..... YES

Maximum Trials ..... 8

Number of Threads ..... 1

Head Tolerance ..... 0.005000 ft

\*\*\*\*\* Volume Volume

Flow Routing Continuity      acre-feet      10^6 gal

\*\*\*\*\*

Dry Weather Inflow ..... 0.000      0.000

Wet Weather Inflow ..... 0.000      0.000

Groundwater Inflow ..... 0.000      0.000

RDII Inflow ..... 0.000      0.000

External Inflow ..... 13.532      4.410

External Outflow ..... 13.498      4.398

Flooding Loss ..... 0.000      0.000

Evaporation Loss ..... 0.000      0.000

Exfiltration Loss ..... 0.000      0.000

Initial Stored Volume .... 0.000      0.000

Final Stored Volume ..... 0.033      0.011

Continuity Error (%) ..... 0.012

\*\*\*\*\*

## Time-Step Critical Elements

\*\*\*\*\*

Link OBSToLS (99.18%)

\*\*\*\*\*

## Highest Flow Instability Indexes

\*\*\*\*\*

Link OBSToLS (1)

\*\*\*\*\*

Most Frequent Nonconverging Nodes

\*\*\*\*\*

Node OverflowBubbler (0.01%)  
Node PR-MH (0.01%)  
Node PondLevelSpreader (0.01%)

\*\*\*\*\*

Routing Time Step Summary

\*\*\*\*\*

Minimum Time Step : 0.92 sec  
Average Time Step : 1.73 sec  
Maximum Time Step : 13.48 sec  
% of Time in Steady State : 0.00  
Average Iterations per Step : 2.00  
% of Steps Not Converging : 0.01  
Time Step Frequencies :  
20.000 - 9.564 sec : 0.02 %  
9.564 - 4.573 sec : 0.02 %  
4.573 - 2.187 sec : 0.97 %  
2.187 - 1.046 sec : 91.02 %  
1.046 - 0.500 sec : 7.97 %

\*\*\*\*\*

Node Depth Summary

\*\*\*\*\*

-----							
	Average	Maximum	Maximum	Time of Max	Reported		
	Depth	Depth	HGL	Occurrence	Max Depth		
Node	Type	Feet	Feet	Feet days hr:min	Feet		
-----							
JUNCTION_STRUCTURE	JUNCTION	1.06	1.66	5296.57 0 00:43	1.65		
OverflowBubbler	JUNCTION	1.89	3.08	5296.84 0 00:43	3.08		
3	JUNCTION	0.00	0.00	5297.91 0 00:00	0.00		
PR-MH	JUNCTION	0.48	1.42	5297.17 0 00:42	1.42		
5	JUNCTION	0.75	2.37	5299.05 0 00:40	2.37		
PondLevelSpreader	OUTFALL	1.78	2.50	5296.10 0 00:41	2.50		

\*\*\*\*\*

Node Inflow Summary

\*\*\*\*\*

-----								
	Maximum	Maximum		Lateral	Total	Flow		
	Lateral	Total	Time of Max	Inflow	Inflow	Balance		
	Inflow	Inflow	Occurrence	Volume	Volume	Error		
Node	Type	CFS	CFS days hr:min	10^6 gal	10^6 gal	Percent		
-----								
JUNCTION_STRUCTURE	JUNCTION	20.11	62.07	0 00:40	3.25	4.41	0.119	
OverflowBubbler	JUNCTION	0.00	61.98	0 00:42	0	4.4	0.137	
3	JUNCTION	0.00	0.00	0 00:00	0	0	0.000 gal	
PR-MH	JUNCTION	0.00	41.99	0 00:40	0	1.16	0.010	
5	JUNCTION	42.03	42.03	0 00:40	1.16	1.16	-0.007	
PondLevelSpreader	OUTFALL	0.00	61.63	0 00:42	0	4.4	0.000	

\*\*\*\*\*

Node Surcharge Summary

\*\*\*\*\*

No nodes were surcharged.

\*\*\*\*\*

Node Flooding Summary

\*\*\*\*\*

No nodes were flooded.

\*\*\*\*\*

Outfall Loading Summary

\*\*\*\*\*

Outfall Node	Flow Freq	Avg Flow Pcnt	Max Flow CFS	Total Volume CFS	10^6 gal
PondLevelSpreader		99.99	29.69	61.63	4.398
System		99.99	29.69	61.63	4.398

\*\*\*\*\*

Link Flow Summary

\*\*\*\*\*

Link	Type	Maximum  Flow  CFS	Time of Occurrence days hr:min	Max  Veloc  ft/sec	Maximum Full Flow	Max/ Full Flow	Max/ Full Depth
PR_HERCP	CONDUIT	61.98	0 00:42	5.28	0.23	0.53	
OBSToLS	CONDUIT	61.63	0 00:42	12.62	2.19	1.00	
EX_HERCP	CONDUIT	0.00	0 00:00	0.00	0.00	0.21	
PR_48	CONDUIT	41.96	0 00:40	9.65	0.25	0.38	
EX_48	CONDUIT	41.99	0 00:40	7.18	0.59	0.47	

\*\*\*\*\*

Flow Classification Summary

\*\*\*\*\*

Conduit	Adjusted /Actual Length	Up Dry	Down Dry	Sub Dry	Sup Crit	Up Crit	Down Crit	Norm Crit	Inlet Ltd	Ctrl
PR_HERCP	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.95	0.00
OBSToLS	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
EX_HERCP	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PR_48	1.00	0.00	0.00	0.00	0.72	0.28	0.00	0.00	0.25	0.00
EX_48	1.00	0.00	0.32	0.00	0.25	0.43	0.00	0.00	0.40	0.00

\*\*\*\*\*

Conduit Surcharge Summary

\*\*\*\*\*

-----						
Conduit	----- Hours Full -----		Hours Above Full		Capacity	
	Both Ends	Upstream	Dnstream	Normal Flow	Limited	
-----						
OBSToLS	0.06	0.70	0.06	1.74	0.06	

Analysis begun on: Tue Jul 2 18:12:05 2024  
Analysis ended on: Tue Jul 2 18:12:05 2024  
Total elapsed time: < 1 sec



## 23<sup>rd</sup> Avenue System – 100-YR

### [OPTIONS]

;;Option Value

FLOW\_UNITS CFS

INFILTRATION HORTON

FLOW\_ROUTING DYNWAVE

LINK\_OFFSETS DEPTH

MIN\_SLOPE 0

ALLOW\_PONDING NO

SKIP\_STEADY\_STATE NO

START\_DATE 06/18/2024

START\_TIME 00:00:00

REPORT\_START\_DATE 06/18/2024

REPORT\_START\_TIME 00:00:00

END\_DATE 06/18/2024

END\_TIME 06:00:00

SWEEP\_START 01/01

SWEEP\_END 12/31

DRY\_DAYS 0

REPORT\_STEP 00:01:00

WET\_STEP 00:05:00

DRY\_STEP 01:00:00

ROUTING\_STEP 0:00:20

RULE\_STEP 00:00:00

INERTIAL\_DAMPING PARTIAL

NORMAL\_FLOW\_LIMITED BOTH

FORCE\_MAIN\_EQUATION H-W

VARIABLE\_STEP 0.75

LENGTHENING\_STEP 0

MIN\_SURFAREA 12.566

MAX\_TRIALS 8

HEAD\_TOLERANCE 0.005

SYS\_FLOW\_TOL 5

LAT\_FLOW\_TOL 5

MINIMUM\_STEP 0.5

THREADS 1

### [EVAPORATION]

;;Data Source Parameters

;;-----

CONSTANT 0.0

DRY\_ONLY NO

### [JUNCTIONS]

;;Name Elevation MaxDepth InitDepth SurDepth Aponded

;;-----

JUNCTION\_STRUCTURE 5294.91 8.5 0 020 0

OverflowBubbler 5293.76 0 0 20 0

3 5297.91 7.35 0 20 0

PR-MH 5295.75 11.5 0 20 0

5 5296.68 9.32 0 20 0

### [OUTFALLS]

;;Name Elevation Type Stage Data Gated Route To

;;-----

PondLevelSpreader 5293.6 FREE NO

[CONDUITS]

;;Name	From Node	To Node	Length	Roughness	InOffset	OutOffset	InitFlow	MaxFlow
PR_HERCP	JUNCTION_STRUCTURE	OverflowBubbler	192	0.013	0	0	0	0
OBSToLS	OverflowBubbler	PondLevelSpreader	34	0.013	0	0	0	0
EX_HERCP	3	JUNCTION_STRUCTURE	177	0.013	0	0	0	0
PR_48	PR-MH	JUNCTION_STRUCTURE	60.64	0.013	0	0	0	0
EX_48	5	PR-MH	380	0.013	0	0	0	0

[XSECTIONS]

;;Link	Shape	Geom1	Geom2	Geom3	Geom4	Barrels	Culvert
PR_HERCP	HORIZ_ELLIPSE	4.42	6.92	0	0	1	
OBSToLS	CIRCULAR	2.5	0	0	0	1	
EX_HERCP	HORIZ_ELLIPSE	4	6.3	0	0	1	
PR_48	CIRCULAR	4	0	0	0	1	
EX_48	CIRCULAR	4	0	0	0	1	

[LOSSES]

;;Link	Kentry	Kexit	Kavg	Flap Gate	Seepage
EX_48	0	1	0	NO	0

[INFLOWS]

;;Node	Constituent	Time Series	Type	Mfactor	Sfactor	Baseline	Pattern
JUNCTION_STRUCTURE	FLOW	""	FLOW	1.0	1.0	20.11	
3	FLOW	ExHERCP	FLOW	1.0	1.0		
5	FLOW	ex48rcp1	FLOW	1.0	1.0		

[TIMESERIES]

;;Name	Date	Time	Value
ex48rcp1		0:01	0
ex48rcp1		0:02	0
ex48rcp1		0:03	0
ex48rcp1		0:04	0
ex48rcp1		0:05	0
ex48rcp1		0:06	0
ex48rcp1		0:07	0
ex48rcp1		0:08	0
ex48rcp1		0:09	0
ex48rcp1		0:10	0
ex48rcp1		0:11	0
ex48rcp1		0:12	0
ex48rcp1		0:13	0
ex48rcp1		0:14	0
ex48rcp1		0:15	0
ex48rcp1		0:16	0
ex48rcp1		0:17	0
ex48rcp1		0:18	0
ex48rcp1		0:19	0
ex48rcp1		0:20	0.01
ex48rcp1		0:21	0.03
ex48rcp1		0:22	0.06
ex48rcp1		0:23	0.13

ex48rcp1	0:24	0.25
ex48rcp1	0:25	0.45
ex48rcp1	0:26	0.77
ex48rcp1	0:27	1.27
ex48rcp1	0:28	2.03
ex48rcp1	0:29	3.12
ex48rcp1	0:30	4.63
ex48rcp1	0:31	6.81
ex48rcp1	0:32	9.96
ex48rcp1	0:33	14.14
ex48rcp1	0:34	19.53
ex48rcp1	0:35	26.6
ex48rcp1	0:36	34.97
ex48rcp1	0:37	45.19
ex48rcp1	0:38	54.28
ex48rcp1	0:39	45.84
ex48rcp1	0:40	32.79
ex48rcp1	0:41	36.38
ex48rcp1	0:42	45.76
ex48rcp1	0:43	54.38
ex48rcp1	0:44	62.68
ex48rcp1	0:45	69.9
ex48rcp1	0:46	76.28
ex48rcp1	0:47	81.78
ex48rcp1	0:48	86.96
ex48rcp1	0:49	91.98
ex48rcp1	0:50	96.49
ex48rcp1	0:51	100.57
ex48rcp1	0:52	104.17
ex48rcp1	0:53	107.23
ex48rcp1	0:54	109.74
ex48rcp1	0:55	111.99
ex48rcp1	0:56	114.03
ex48rcp1	0:57	115.88
ex48rcp1	0:58	117.67
ex48rcp1	0:59	119.69
ex48rcp1	1:00	122.19
ex48rcp1	1:01	125.16
ex48rcp1	1:02	128.4
ex48rcp1	1:03	131.64
ex48rcp1	1:04	128.04
ex48rcp1	1:05	98.65
ex48rcp1	1:06	86.92
ex48rcp1	1:07	86.51
ex48rcp1	1:08	86.67
ex48rcp1	1:09	86.86
ex48rcp1	1:10	87.05
ex48rcp1	1:11	87.26
ex48rcp1	1:12	87.57
ex48rcp1	1:13	87.91
ex48rcp1	1:14	88.26
ex48rcp1	1:15	88.61
ex48rcp1	1:16	88.94
ex48rcp1	1:17	89.27
ex48rcp1	1:18	89.61
ex48rcp1	1:19	89.94
ex48rcp1	1:20	90.27
ex48rcp1	1:21	90.54

ex48rcp1	1:22	90.63
ex48rcp1	1:23	90.68
ex48rcp1	1:24	90.72
ex48rcp1	1:25	90.76
ex48rcp1	1:26	90.76
ex48rcp1	1:27	90.64
ex48rcp1	1:28	90.49
ex48rcp1	1:29	90.33
ex48rcp1	1:30	90.18
ex48rcp1	1:31	90.01
ex48rcp1	1:32	89.83
ex48rcp1	1:33	89.65
ex48rcp1	1:34	89.46
ex48rcp1	1:35	89.27
ex48rcp1	1:36	89.08
ex48rcp1	1:37	88.89
ex48rcp1	1:38	88.71
ex48rcp1	1:39	88.54
ex48rcp1	1:40	88.36
ex48rcp1	1:41	88.17
ex48rcp1	1:42	87.99
ex48rcp1	1:43	87.77
ex48rcp1	1:44	87.56
ex48rcp1	1:45	87.35
ex48rcp1	1:46	87.14
ex48rcp1	1:47	86.95
ex48rcp1	1:48	86.76
ex48rcp1	1:49	86.58
ex48rcp1	1:50	86.4
ex48rcp1	1:51	86.23
ex48rcp1	1:52	86.08
ex48rcp1	1:53	85.94
ex48rcp1	1:54	85.81
ex48rcp1	1:55	85.69
ex48rcp1	1:56	85.6
ex48rcp1	1:57	85.54
ex48rcp1	1:58	85.54
ex48rcp1	1:59	85.68
ex48rcp1	2:00	90.58
ex48rcp1	2:01	97.5
ex48rcp1	2:02	104.45
ex48rcp1	2:03	110.75
ex48rcp1	2:04	116.27
ex48rcp1	2:05	120.97
ex48rcp1	2:06	124.83
ex48rcp1	2:07	127.74
ex48rcp1	2:08	129.41
ex48rcp1	2:09	128.81
ex48rcp1	2:10	127.74
ex48rcp1	2:11	126.4
ex48rcp1	2:12	124.81
ex48rcp1	2:13	122.99
ex48rcp1	2:14	120.93
ex48rcp1	2:15	118.65
ex48rcp1	2:16	116.14
ex48rcp1	2:17	113.37
ex48rcp1	2:18	110.35
ex48rcp1	2:19	107.28

ex48rcp1	2:20	104.09
ex48rcp1	2:21	100.88
ex48rcp1	2:22	97.67
ex48rcp1	2:23	94.46
ex48rcp1	2:24	91.24
ex48rcp1	2:25	88.03
ex48rcp1	2:26	84.81
ex48rcp1	2:27	81.58
ex48rcp1	2:28	78.36
ex48rcp1	2:29	75.13
ex48rcp1	2:30	71.9
ex48rcp1	2:31	68.65
ex48rcp1	2:32	65.31
ex48rcp1	2:33	61.97
ex48rcp1	2:34	58.67
ex48rcp1	2:35	55.39
ex48rcp1	2:36	52.15
ex48rcp1	2:37	48.98
ex48rcp1	2:38	46.59
ex48rcp1	2:39	43.81
ex48rcp1	2:40	40.88
ex48rcp1	2:41	37.88
ex48rcp1	2:42	34.87
ex48rcp1	2:43	31.91
ex48rcp1	2:44	29
ex48rcp1	2:45	26.18
ex48rcp1	2:46	23.46
ex48rcp1	2:47	20.87
ex48rcp1	2:48	18.43
ex48rcp1	2:49	16.15
ex48rcp1	2:50	14.07
ex48rcp1	2:51	12.19
ex48rcp1	2:52	10.56
ex48rcp1	2:53	9.16
ex48rcp1	2:54	8.03
ex48rcp1	2:55	7.17
ex48rcp1	2:56	6.62
ex48rcp1	2:57	6.35
ex48rcp1	2:58	6.19
ex48rcp1	2:59	6.05
ex48rcp1	3:00	5.93
ex48rcp1	3:01	5.81
ex48rcp1	3:02	5.66
ex48rcp1	3:03	5.51
ex48rcp1	3:04	5.34
ex48rcp1	3:05	5.17
ex48rcp1	3:06	4.99
ex48rcp1	3:07	4.81
ex48rcp1	3:08	4.63
ex48rcp1	3:09	4.46
ex48rcp1	3:10	4.29
ex48rcp1	3:11	4.13
ex48rcp1	3:12	3.97
ex48rcp1	3:13	3.83
ex48rcp1	3:14	3.68
ex48rcp1	3:15	3.55
ex48rcp1	3:16	3.42
ex48rcp1	3:17	3.3

ex48rcp1	3:18	3.19
ex48rcp1	3:19	3.08
ex48rcp1	3:20	2.97
ex48rcp1	3:21	2.87
ex48rcp1	3:22	2.77
ex48rcp1	3:23	2.67
ex48rcp1	3:24	2.58
ex48rcp1	3:25	2.49
ex48rcp1	3:26	2.4
ex48rcp1	3:27	2.32
ex48rcp1	3:28	2.25
ex48rcp1	3:29	2.17
ex48rcp1	3:30	2.1
ex48rcp1	3:31	2.04
ex48rcp1	3:32	1.97
ex48rcp1	3:33	1.92
ex48rcp1	3:34	1.86
ex48rcp1	3:35	1.81
ex48rcp1	3:36	1.76
ex48rcp1	3:37	1.71
ex48rcp1	3:38	1.67
ex48rcp1	3:39	1.62
ex48rcp1	3:40	1.59
ex48rcp1	3:41	1.55
ex48rcp1	3:42	1.52
ex48rcp1	3:43	1.49
ex48rcp1	3:44	1.45
ex48rcp1	3:45	1.42
ex48rcp1	3:46	1.4
ex48rcp1	3:47	1.37
ex48rcp1	3:48	1.34
ex48rcp1	3:49	1.31
ex48rcp1	3:50	1.28
ex48rcp1	3:51	1.25
ex48rcp1	3:52	1.23
ex48rcp1	3:53	1.2
ex48rcp1	3:54	1.18
ex48rcp1	3:55	1.16
ex48rcp1	3:56	1.14
ex48rcp1	3:57	1.11
ex48rcp1	3:58	1.09
ex48rcp1	3:59	1.08
ex48rcp1	4:00	1.06
ex48rcp1	4:01	1.04
ex48rcp1	4:02	1.02
ex48rcp1	4:03	1
ex48rcp1	4:04	0.99
ex48rcp1	4:05	0.97
ex48rcp1	4:06	0.95
ex48rcp1	4:07	0.94
ex48rcp1	4:08	0.92
ex48rcp1	4:09	0.91
ex48rcp1	4:10	0.89
ex48rcp1	4:11	0.88
ex48rcp1	4:12	0.87
ex48rcp1	4:13	0.86
ex48rcp1	4:14	0.84
ex48rcp1	4:15	0.83

ex48rcp1	4:16	0.82
ex48rcp1	4:17	0.81
ex48rcp1	4:18	0.8
ex48rcp1	4:19	0.79
ex48rcp1	4:20	0.78
ex48rcp1	4:21	0.77
ex48rcp1	4:22	0.76
ex48rcp1	4:23	0.75
ex48rcp1	4:24	0.74
ex48rcp1	4:25	0.73
ex48rcp1	4:26	0.73
ex48rcp1	4:27	0.72
ex48rcp1	4:28	0.71
ex48rcp1	4:29	0.7
ex48rcp1	4:30	0.7
ex48rcp1	4:31	0.69
ex48rcp1	4:32	0.69
ex48rcp1	4:33	0.68
ex48rcp1	4:34	0.67
ex48rcp1	4:35	0.67
ex48rcp1	4:36	0.66
ex48rcp1	4:37	0.66
ex48rcp1	4:38	0.65
ex48rcp1	4:39	0.65
ex48rcp1	4:40	0.64
ex48rcp1	4:41	0.64
ex48rcp1	4:42	0.64
ex48rcp1	4:43	0.63
ex48rcp1	4:44	0.63
ex48rcp1	4:45	0.63
ex48rcp1	4:46	0.63
ex48rcp1	4:47	0.63
ex48rcp1	4:48	0.63
ex48rcp1	4:49	0.63
ex48rcp1	4:50	0.63
ex48rcp1	4:51	0.63
ex48rcp1	4:52	0.63
ex48rcp1	4:53	0.63
ex48rcp1	4:54	0.63
ex48rcp1	4:55	0.63
ex48rcp1	4:56	0.63
ex48rcp1	4:57	0.63
ex48rcp1	4:58	0.63
ex48rcp1	4:59	0.63
ex48rcp1	5:00	0.63
ex48rcp1	5:01	0.63
ex48rcp1	5:02	0.62
ex48rcp1	5:03	0.62
ex48rcp1	5:04	0.62
ex48rcp1	5:05	0.63
ex48rcp1	5:06	0.63
ex48rcp1	5:07	0.63
ex48rcp1	5:08	0.63
ex48rcp1	5:09	0.63
ex48rcp1	5:10	0.63
ex48rcp1	5:11	0.63
ex48rcp1	5:12	0.63
ex48rcp1	5:13	0.62

ex48rcp1	5:14	0.62
ex48rcp1	5:15	0.62
ex48rcp1	5:16	0.62
ex48rcp1	5:17	0.62
ex48rcp1	5:18	0.62
ex48rcp1	5:19	0.62
ex48rcp1	5:20	0.62
ex48rcp1	5:21	0.62
ex48rcp1	5:22	0.62
ex48rcp1	5:23	0.62
ex48rcp1	5:24	0.62
ex48rcp1	5:25	0.62
ex48rcp1	5:26	0.62
ex48rcp1	5:27	0.62
ex48rcp1	5:28	0.62
ex48rcp1	5:29	0.62
ex48rcp1	5:30	0.62
ex48rcp1	5:31	0.61
ex48rcp1	5:32	0.61
ex48rcp1	5:33	0.61
ex48rcp1	5:34	0.61
ex48rcp1	5:35	0.61
ex48rcp1	5:36	0.61
ex48rcp1	5:37	0.61
ex48rcp1	5:38	0.61
ex48rcp1	5:39	0.61
ex48rcp1	5:40	0.61
ex48rcp1	5:41	0.61
ex48rcp1	5:42	0.61
ex48rcp1	5:43	0.61
ex48rcp1	5:44	0.61
ex48rcp1	5:45	0.61
ex48rcp1	5:46	0.61
ex48rcp1	5:47	0.61
ex48rcp1	5:48	0.61
ex48rcp1	5:49	0.61
ex48rcp1	5:50	0.61
ex48rcp1	5:51	0.61
ex48rcp1	5:52	0.61
ex48rcp1	5:53	0.61
ex48rcp1	5:54	0.61
ex48rcp1	5:55	0.61
ex48rcp1	5:56	0.61
ex48rcp1	5:57	0.6
ex48rcp1	5:58	0.6
ex48rcp1	5:59	0.6
ex48rcp1	6:00	0.6
;		
ExHERCP	0:01:00	0
ExHERCP	0:02:00	0
ExHERCP	0:03:00	0
ExHERCP	0:04:00	0
ExHERCP	0:05:00	0
ExHERCP	0:06:00	0
ExHERCP	0:07:00	0
ExHERCP	0:08:00	0
ExHERCP	0:09:00	0
ExHERCP	0:10:00	0



ExHERCP	0:11:00	0
ExHERCP	0:12:00	0
ExHERCP	0:13:00	0
ExHERCP	0:14:00	0
ExHERCP	0:15:00	0
ExHERCP	0:16:00	0
ExHERCP	0:17:00	0
ExHERCP	0:18:00	0
ExHERCP	0:19:00	0
ExHERCP	0:20:00	0
ExHERCP	0:21:00	0
ExHERCP	0:22:00	0
ExHERCP	0:23:00	0
ExHERCP	0:24:00	0
ExHERCP	0:25:00	0
ExHERCP	0:26:00	0
ExHERCP	0:27:00	0
ExHERCP	0:28:00	0
ExHERCP	0:29:00	0
ExHERCP	0:30:00	0
ExHERCP	0:31:00	0
ExHERCP	0:32:00	0
ExHERCP	0:33:00	0
ExHERCP	0:34:00	0
ExHERCP	0:35:00	0
ExHERCP	0:36:00	0
ExHERCP	0:37:00	0
ExHERCP	0:38:00	-2.89
ExHERCP	0:39:00	-14.69
ExHERCP	0:40:00	2.18
ExHERCP	0:41:00	-0.17
ExHERCP	0:42:00	-1.13
ExHERCP	0:43:00	-1.19
ExHERCP	0:44:00	-1.19
ExHERCP	0:45:00	-1.05
ExHERCP	0:46:00	-0.92
ExHERCP	0:47:00	-0.97
ExHERCP	0:48:00	-0.51
ExHERCP	0:49:00	-0.44
ExHERCP	0:50:00	-0.36
ExHERCP	0:51:00	-0.33
ExHERCP	0:52:00	-0.31
ExHERCP	0:53:00	-0.5
ExHERCP	0:54:00	-0.46
ExHERCP	0:55:00	-0.42
ExHERCP	0:56:00	-0.39
ExHERCP	0:57:00	-0.35
ExHERCP	0:58:00	-0.34
ExHERCP	0:59:00	-0.39
ExHERCP	1:00:00	-0.47
ExHERCP	1:01:00	-0.53
ExHERCP	1:02:00	-0.67
ExHERCP	1:03:00	0.04
ExHERCP	1:04:00	25.18
ExHERCP	1:05:00	105.58
ExHERCP	1:06:00	124.56
ExHERCP	1:07:00	125.77
ExHERCP	1:08:00	126.05

ExHERCP	1:09:00	126.22
ExHERCP	1:10:00	126.35
ExHERCP	1:11:00	126.47
ExHERCP	1:12:00	126.6
ExHERCP	1:13:00	126.74
ExHERCP	1:14:00	126.85
ExHERCP	1:15:00	126.95
ExHERCP	1:16:00	127.03
ExHERCP	1:17:00	127.07
ExHERCP	1:18:00	127.1
ExHERCP	1:19:00	127.12
ExHERCP	1:20:00	127.14
ExHERCP	1:21:00	127.14
ExHERCP	1:22:00	127.15
ExHERCP	1:23:00	127.15
ExHERCP	1:24:00	127.15
ExHERCP	1:25:00	127.15
ExHERCP	1:26:00	127.15
ExHERCP	1:27:00	127.15
ExHERCP	1:28:00	127.15
ExHERCP	1:29:00	127.15
ExHERCP	1:30:00	127.15
ExHERCP	1:31:00	127.14
ExHERCP	1:32:00	127.13
ExHERCP	1:33:00	127.12
ExHERCP	1:34:00	127.11
ExHERCP	1:35:00	127.09
ExHERCP	1:36:00	127.07
ExHERCP	1:37:00	127.05
ExHERCP	1:38:00	127
ExHERCP	1:39:00	126.96
ExHERCP	1:40:00	126.92
ExHERCP	1:41:00	126.88
ExHERCP	1:42:00	126.82
ExHERCP	1:43:00	126.65
ExHERCP	1:44:00	126.48
ExHERCP	1:45:00	126.31
ExHERCP	1:46:00	126.14
ExHERCP	1:47:00	125.97
ExHERCP	1:48:00	125.81
ExHERCP	1:49:00	125.64
ExHERCP	1:50:00	125.46
ExHERCP	1:51:00	125.26
ExHERCP	1:52:00	125.05
ExHERCP	1:53:00	124.83
ExHERCP	1:54:00	124.58
ExHERCP	1:55:00	124.3
ExHERCP	1:56:00	123.96
ExHERCP	1:57:00	123.56
ExHERCP	1:58:00	123.02
ExHERCP	1:59:00	122.14
ExHERCP	2:00:00	109.68
ExHERCP	2:01:00	94.14
ExHERCP	2:02:00	77.36
ExHERCP	2:03:00	60.98
ExHERCP	2:04:00	45.44
ExHERCP	2:05:00	31.1
ExHERCP	2:06:00	18.2

ExHERCP	2:07:00	7.5
ExHERCP	2:08:00	0.41
ExHERCP	2:09:00	0.2
ExHERCP	2:10:00	0.16
ExHERCP	2:11:00	0.18
ExHERCP	2:12:00	0.22
ExHERCP	2:13:00	0.26
ExHERCP	2:14:00	0.3
ExHERCP	2:15:00	0.34
ExHERCP	2:16:00	0.39
ExHERCP	2:17:00	0.24
ExHERCP	2:18:00	0.39
ExHERCP	2:19:00	0.51
ExHERCP	2:20:00	0.6
ExHERCP	2:21:00	0.61
ExHERCP	2:22:00	0.61
ExHERCP	2:23:00	0.6
ExHERCP	2:24:00	0.59
ExHERCP	2:25:00	0.58
ExHERCP	2:26:00	0.57
ExHERCP	2:27:00	0.56
ExHERCP	2:28:00	0.55
ExHERCP	2:29:00	0.53
ExHERCP	2:30:00	0.51
ExHERCP	2:31:00	0.45
ExHERCP	2:32:00	0.45
ExHERCP	2:33:00	0.44
ExHERCP	2:34:00	0.42
ExHERCP	2:35:00	0.41
ExHERCP	2:36:00	0.39
ExHERCP	2:37:00	0.38
ExHERCP	2:38:00	0.21
ExHERCP	2:39:00	0.37
ExHERCP	2:40:00	0.33
ExHERCP	2:41:00	0.33
ExHERCP	2:42:00	0.33
ExHERCP	2:43:00	0.32
ExHERCP	2:44:00	0.31
ExHERCP	2:45:00	0.29
ExHERCP	2:46:00	0.28
ExHERCP	2:47:00	0.26
ExHERCP	2:48:00	0.25
ExHERCP	2:49:00	0.23
ExHERCP	2:50:00	0.22
ExHERCP	2:51:00	0.2
ExHERCP	2:52:00	0.19
ExHERCP	2:53:00	0.17
ExHERCP	2:54:00	0.16
ExHERCP	2:55:00	0.16
ExHERCP	2:56:00	0.18
ExHERCP	2:57:00	0.11
ExHERCP	2:58:00	0.12
ExHERCP	2:59:00	0.12
ExHERCP	3:00:00	0.1
ExHERCP	3:01:00	0.11
ExHERCP	3:02:00	0.11
ExHERCP	3:03:00	0.1
ExHERCP	3:04:00	0.1

ExHERCP	3:05:00	0.1
ExHERCP	3:06:00	0.1
ExHERCP	3:07:00	0.09
ExHERCP	3:08:00	0.09
ExHERCP	3:09:00	0.09
ExHERCP	3:10:00	0.09
ExHERCP	3:11:00	0.08
ExHERCP	3:12:00	0.08
ExHERCP	3:13:00	0.08
ExHERCP	3:14:00	0.08
ExHERCP	3:15:00	0.07
ExHERCP	3:16:00	0.07
ExHERCP	3:17:00	0.07
ExHERCP	3:18:00	0.07
ExHERCP	3:19:00	0.07
ExHERCP	3:20:00	0.07
ExHERCP	3:21:00	0.06
ExHERCP	3:22:00	0.06
ExHERCP	3:23:00	0.06
ExHERCP	3:24:00	0.06
ExHERCP	3:25:00	0.06
ExHERCP	3:26:00	0.06
ExHERCP	3:27:00	0.06
ExHERCP	3:28:00	0.05
ExHERCP	3:29:00	0.05
ExHERCP	3:30:00	0.05
ExHERCP	3:31:00	0.05
ExHERCP	3:32:00	0.05
ExHERCP	3:33:00	0.05
ExHERCP	3:34:00	0.05
ExHERCP	3:35:00	0.05
ExHERCP	3:36:00	0.04
ExHERCP	3:37:00	0.04
ExHERCP	3:38:00	0.04
ExHERCP	3:39:00	0.04
ExHERCP	3:40:00	0.04
ExHERCP	3:41:00	0.04
ExHERCP	3:42:00	0.04
ExHERCP	3:43:00	0.04
ExHERCP	3:44:00	0.04
ExHERCP	3:45:00	0.04
ExHERCP	3:46:00	0.03
ExHERCP	3:47:00	0.03
ExHERCP	3:48:00	0.03
ExHERCP	3:49:00	0.03
ExHERCP	3:50:00	0.03
ExHERCP	3:51:00	0.03
ExHERCP	3:52:00	0.03
ExHERCP	3:53:00	0.03
ExHERCP	3:54:00	0.03
ExHERCP	3:55:00	0.03
ExHERCP	3:56:00	0.03
ExHERCP	3:57:00	0.03
ExHERCP	3:58:00	0.03
ExHERCP	3:59:00	0.03
ExHERCP	4:00:00	0.03
ExHERCP	4:01:00	0.03
ExHERCP	4:02:00	0.03

ExHERCP	4:03:00	0.02
ExHERCP	4:04:00	0.02
ExHERCP	4:05:00	0.02
ExHERCP	4:06:00	0.02
ExHERCP	4:07:00	0.02
ExHERCP	4:08:00	0.02
ExHERCP	4:09:00	0.02
ExHERCP	4:10:00	0.02
ExHERCP	4:11:00	0.02
ExHERCP	4:12:00	0.02
ExHERCP	4:13:00	0.02
ExHERCP	4:14:00	0.02
ExHERCP	4:15:00	0.02
ExHERCP	4:16:00	0.02
ExHERCP	4:17:00	0.02
ExHERCP	4:18:00	0.02
ExHERCP	4:19:00	0.02
ExHERCP	4:20:00	0.02
ExHERCP	4:21:00	0.02
ExHERCP	4:22:00	0.02
ExHERCP	4:23:00	0.02
ExHERCP	4:24:00	0.02
ExHERCP	4:25:00	0.02
ExHERCP	4:26:00	0.02
ExHERCP	4:27:00	0.02
ExHERCP	4:28:00	0.02
ExHERCP	4:29:00	0.02
ExHERCP	4:30:00	0.02
ExHERCP	4:31:00	0.02
ExHERCP	4:32:00	0.02
ExHERCP	4:33:00	0.02
ExHERCP	4:34:00	0.02
ExHERCP	4:35:00	0.02
ExHERCP	4:36:00	0.02
ExHERCP	4:37:00	0.02
ExHERCP	4:38:00	0.02
ExHERCP	4:39:00	0.02
ExHERCP	4:40:00	0.02
ExHERCP	4:41:00	0.02
ExHERCP	4:42:00	0.02
ExHERCP	4:43:00	0.02
ExHERCP	4:44:00	0.02
ExHERCP	4:45:00	0.02
ExHERCP	4:46:00	0.02
ExHERCP	4:47:00	0.02
ExHERCP	4:48:00	0.02
ExHERCP	4:49:00	0.02
ExHERCP	4:50:00	0.02
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ExHERCP	4:52:00	0.02
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ExHERCP	4:55:00	0.02
ExHERCP	4:56:00	0.02
ExHERCP	4:57:00	0.02
ExHERCP	4:58:00	0.02
ExHERCP	4:59:00	0.02
ExHERCP	5:00:00	0.02

ExHERCP	5:01:00	0.02
ExHERCP	5:02:00	0.02
ExHERCP	5:03:00	0.02
ExHERCP	5:04:00	0.01
ExHERCP	5:05:00	0.02
ExHERCP	5:06:00	0.01
ExHERCP	5:07:00	0.01
ExHERCP	5:08:00	0.01
ExHERCP	5:09:00	0.01
ExHERCP	5:10:00	0.01
ExHERCP	5:11:00	0.01
ExHERCP	5:12:00	0.01
ExHERCP	5:13:00	0.01
ExHERCP	5:14:00	0.01
ExHERCP	5:15:00	0.01
ExHERCP	5:16:00	0.01
ExHERCP	5:17:00	0.01
ExHERCP	5:18:00	0.01
ExHERCP	5:19:00	0.01
ExHERCP	5:20:00	0.01
ExHERCP	5:21:00	0.01
ExHERCP	5:22:00	0.01
ExHERCP	5:23:00	0.01
ExHERCP	5:24:00	0.01
ExHERCP	5:25:00	0.01
ExHERCP	5:26:00	0.01
ExHERCP	5:27:00	0.01
ExHERCP	5:28:00	0.01
ExHERCP	5:29:00	0.01
ExHERCP	5:30:00	0.01
ExHERCP	5:31:00	0.01
ExHERCP	5:32:00	0.01
ExHERCP	5:33:00	0.01
ExHERCP	5:34:00	0.01
ExHERCP	5:35:00	0.01
ExHERCP	5:36:00	0.01
ExHERCP	5:37:00	0.01
ExHERCP	5:38:00	0.01
ExHERCP	5:39:00	0.01
ExHERCP	5:40:00	0.01
ExHERCP	5:41:00	0.01
ExHERCP	5:42:00	0.01
ExHERCP	5:43:00	0.01
ExHERCP	5:44:00	0.01
ExHERCP	5:45:00	0.01
ExHERCP	5:46:00	0.01
ExHERCP	5:47:00	0.01
ExHERCP	5:48:00	0.01
ExHERCP	5:49:00	0.01
ExHERCP	5:50:00	0.01
ExHERCP	5:51:00	0.01
ExHERCP	5:52:00	0.01
ExHERCP	5:53:00	0.01
ExHERCP	5:54:00	0.01
ExHERCP	5:55:00	0.01
ExHERCP	5:56:00	0.01
ExHERCP	5:57:00	0.01
ExHERCP	5:58:00	0.01

ExHERCP 5:59:00 0.01  
ExHERCP 6:00:00 0.01

[REPORT]

;;Reporting Options  
SUBCATCHMENTS ALL  
NODES ALL  
LINKS ALL

[TAGS]

[MAP]

DIMENSIONS -126.832 0.000 10352.311 10000.000  
Units None

[COORDINATES]

;;Node X-Coord Y-Coord

;;-----

JUNCTION\_STRUCTURE 5287.486 5907.554

OverflowBubbler 2976.325 5772.266

3 7429.538 7497.182

PR-MH 8432.920 5794.814

5 9875.986 7452.086

PondLevelSpreader 349.493 5535.513

[VERTICES]

;;Link X-Coord Y-Coord

;;-----

[Polygons]

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.2 (Build 5.2.4)

\*\*\*\*\*

Analysis Options

\*\*\*\*\*

Flow Units ..... CFS

Process Models:

Rainfall/Runoff ..... NO

RDII ..... NO

Snowmelt ..... NO

Groundwater ..... NO

Flow Routing ..... YES

Ponding Allowed ..... NO

Water Quality ..... NO

Flow Routing Method ..... DYNWAVE

Surcharge Method ..... EXTRAN

Starting Date ..... 06/18/2024 00:00:00

Ending Date ..... 06/18/2024 06:00:00

Antecedent Dry Days ..... 0.0

Report Time Step ..... 00:01:00

Routing Time Step ..... 20.00 sec

Variable Time Step ..... YES

Maximum Trials ..... 8

Number of Threads ..... 1

Head Tolerance ..... 0.005000 ft

\*\*\*\*\* Volume Volume

Flow Routing Continuity      acre-feet      10^6 gal

\*\*\*\*\*

Dry Weather Inflow ..... 0.000      0.000

Wet Weather Inflow ..... 0.000      0.000

Groundwater Inflow ..... 0.000      0.000

RDII Inflow ..... 0.000      0.000

External Inflow ..... 36.615      11.932

External Outflow ..... 36.640      11.940

Flooding Loss ..... 0.000      0.000

Evaporation Loss ..... 0.000      0.000

Exfiltration Loss ..... 0.000      0.000

Initial Stored Volume .... 0.000      0.000

Final Stored Volume ..... 0.036      0.012

Continuity Error (%) ..... -0.167

\*\*\*\*\*

Time-Step Critical Elements

\*\*\*\*\*

Link OBSToLS (87.29%)

Link PR\_48 (9.45%)

\*\*\*\*\*

Highest Flow Instability Indexes

\*\*\*\*\*

All links are stable.

\*\*\*\*\*



# Most Frequent Nonconverging Nodes

\*\*\*\*\*

Node PondLevelSpreader (1.72%)  
Node 5 (1.67%)  
Node PR-MH (1.02%)  
Node JUNCTION\_STRUCTURE (0.88%)  
Node 3 (0.77%)

\*\*\*\*\*

## Routing Time Step Summary

\*\*\*\*\*

Minimum Time Step : 0.50 sec  
Average Time Step : 2.46 sec  
Maximum Time Step : 20.00 sec  
% of Time in Steady State : 0.00  
Average Iterations per Step : 2.17  
% of Steps Not Converging : 1.72  
Time Step Frequencies :  
20.000 - 9.564 sec : 3.13 %  
9.564 - 4.573 sec : 0.03 %  
4.573 - 2.187 sec : 7.57 %  
2.187 - 1.046 sec : 85.82 %  
1.046 - 0.500 sec : 3.45 %

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## Node Depth Summary

\*\*\*\*\*

-----									
Average Maximum Maximum Time of Max Reported									
Depth Depth HGL Occurrence Max Depth									
Node	Type	Feet	Feet	Feet	days	hr:min	Feet		
-----									
JUNCTION_STRUCTURE	JUNCTION	1.47	13.46	5308.37	0	01:31	13.46		
OverflowBubbler	JUNCTION	2.23	13.71	5307.47	0	01:32	13.71		
3	JUNCTION	0.30	10.86	5308.77	0	01:31	10.86		
PR-MH	JUNCTION	0.84	12.85	5308.60	0	01:31	12.85		
5	JUNCTION	1.22	14.22	5310.90	0	01:28	14.22		
PondLevelSpreader	OUTFALL	1.76	2.50	5296.10	0	00:38	2.50		

\*\*\*\*\*

## Node Inflow Summary

\*\*\*\*\*

-----									
Maximum Maximum Lateral Total Flow									
Lateral Total Time of Max Inflow Inflow Balance									
Inflow Inflow Occurrence Volume Volume Error									
Node	Type	CFS	CFS	days	hr:min	10^6 gal	10^6 gal	Percent	
-----									
JUNCTION_STRUCTURE	JUNCTION	20.11	237.49	0	01:26	3.25	11.9	0.009	
OverflowBubbler	JUNCTION	0.00	237.19	0	01:30	0	11.9	0.035	
3	JUNCTION	127.15	127.15	0	01:22	3.32	3.34	-0.359	
PR-MH	JUNCTION	0.00	131.38	0	01:03	0	5.35	-0.013	
5	JUNCTION	131.60	131.60	0	01:03	5.35	5.35	-0.009	

PondLevelSpreader    OUTFALL    0.00   237.17   0   01:32    0   11.9   0.000

\*\*\*\*\*

#### Node Surge Summary

\*\*\*\*\*

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Max. Height	Min. Depth	
		Hours Above Crown	Below Rim	
		Surcharged	Feet	Feet
JUNCTION_STRUCTURE	JUNCTION		1.48	9.036    0.000
OverflowBubbler	JUNCTION		1.67	9.288    0.000
3	JUNCTION	1.06	6.862	0.000
PR-MH	JUNCTION	1.46	8.854	0.000
5	JUNCTION	1.71	10.221	0.000

\*\*\*\*\*

#### Node Flooding Summary

\*\*\*\*\*

No nodes were flooded.

\*\*\*\*\*

#### Outfall Loading Summary

\*\*\*\*\*

Outfall Node	Flow	Avg	Max	Total
	Freq	Flow	Flow	Volume
	Pcnt	CFS	CFS	10^6 gal
PondLevelSpreader	99.99	36.71	237.17	11.925
System	99.99	36.71	237.17	11.925

\*\*\*\*\*

#### Link Flow Summary

\*\*\*\*\*

Link	Type	Maximum Time of Max	Maximum	Max/	Max/
		Flow  Occurrence	Veloc  Full	Full	Depth
		CFS days	hr:min	ft/sec	Flow
PR_HERCP	CONDUIT	237.19	0 01:30	9.57	0.88    1.00
OBSToLS	CONDUIT	237.17	0 01:32	48.32	8.43    1.00
EX_HERCP	CONDUIT	127.20	0 01:37	6.26	0.37    1.00
PR_48	CONDUIT	131.91	0 02:07	10.50	0.78    1.00
EX_48	CONDUIT	131.38	0 01:03	10.45	1.85    1.00

\*\*\*\*\*

Flow Classification Summary  
\*\*\*\*\*

Conduit	Adjusted	Fraction of Time in Flow Class								
	/Actual	Up	Down	Sub	Sup	Up	Down	Norm	Inlet	
	Length	Dry	Dry	Dry	Crit	Crit	Crit	Crit	Ltd	Ctrl
PR_HERCP	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.64	0.00
OBSToLS	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
EX_HERCP	1.00	0.00	0.13	0.00	0.87	0.00	0.00	0.00	0.61	0.00
PR_48	1.00	0.00	0.00	0.00	0.90	0.10	0.00	0.00	0.54	0.00
EX_48	1.00	0.00	0.05	0.00	0.69	0.26	0.00	0.00	0.01	0.00

\*\*\*\*\*  
Conduit Surcharge Summary  
\*\*\*\*\*

Conduit	Hours		Hours		Capacity Normal Flow	Limited
	-----	Hours Full	-----	Above Full		
	Both Ends	Upstream	Dnstream			
PR_HERCP	1.48	1.48	1.67	0.01	0.01	
OBSToLS	2.03	2.18	2.03	2.38	2.03	
EX_HERCP	1.06	1.06	1.56	0.01	0.01	
PR_48	1.46	1.46	1.56	0.01	0.01	
EX_48	1.46	1.71	1.46	1.75	1.46	

Analysis begun on: Tue Jul 2 18:13:10 2024  
Analysis ended on: Tue Jul 2 18:13:10 2024  
Total elapsed time: < 1 sec

## Easterly Creek Outfall System – 2-YR

### [OPTIONS]

;;Option Value

FLOW\_UNITS CFS  
INFILTRATION HORTON  
FLOW\_ROUTING DYNWAVE  
LINK\_OFFSETS DEPTH  
MIN\_SLOPE 0  
ALLOW\_PONDING NO  
SKIP\_STEADY\_STATE NO

START\_DATE 07/02/2024  
START\_TIME 00:00:00  
REPORT\_START\_DATE 07/02/2024  
REPORT\_START\_TIME 00:00:00  
END\_DATE 07/02/2024  
END\_TIME 06:00:00  
SWEEP\_START 1/1  
SWEEP\_END 12/31  
DRY\_DAYS 0  
REPORT\_STEP 00:15:00  
WET\_STEP 00:05:00  
DRY\_STEP 01:00:00  
ROUTING\_STEP 0:00:20  
RULE\_STEP 00:00:00

INERTIAL\_DAMPING PARTIAL  
NORMAL\_FLOW\_LIMITED BOTH  
FORCE\_MAIN\_EQUATION H-W  
VARIABLE\_STEP 0.75  
LENGTHENING\_STEP 0  
MIN\_SURFAREA 0  
MAX\_TRIALS 0  
HEAD\_TOLERANCE 0  
SYS\_FLOW\_TOL 5  
LAT\_FLOW\_TOL 5  
MINIMUM\_STEP 0.5  
THREADS 1

### [EVAPORATION]

;;Data Source Parameters

;;-----

CONSTANT 0.0  
DRY\_ONLY NO

### [JUNCTIONS]

;;Name Elevation MaxDepth InitDepth SurDepth Aponded

;;-----

22ndAve\_Junc\_Structure 5298.80 0 0 0 0  
DUMMY\_NODE 5300.50 0 0 0 0

### [OUTFALLS]

;;Name Elevation Type Stage Data Gated Route To

;;-----

Easterly\_Outfall\_Structure 5298.60 FREE NO

### [CONDUITS]

;;Name	From Node	To Node	Length	Roughness	InOffset	OutOffset	InitFlow	MaxFlow
PR_4X10_RCBC	22ndAve_Junc_Structure	Easterly_Outfall_Structure	90	0.013	0	0	0	0
EX_96_IN_RCP	DUMMY_NODE	22ndAve_Junc_Structure	179.28	0.013	0	0.07	0	0

#### [XSECTIONS]

;;Link	Shape	Geom1	Geom2	Geom3	Geom4	Barrels	Culvert
PR_4X10_RCBC	RECT_CLOSED	4	10	0	0	1	
EX_96_IN_RCP	CIRCULAR	8	0	0	0	1	

#### [INFLOWS]

;;Node	Constituent	Time Series	Type	Mfactor	Sfactor	Baseline	Pattern
DUMMY_NODE	FLOW	""	FLOW	1.0	1.0	122	

#### [REPORT]

;;Reporting Options  
SUBCATCHMENTS ALL  
NODES ALL  
LINKS ALL

#### [TAGS]

#### [MAP]

DIMENSIONS 0.000 0.000 10000.000 10000.000  
Units None

#### [COORDINATES]

;;Node	X-Coord	Y-Coord
22ndAve_Junc_Structure	2849.887	5293.454
DUMMY_NODE	332.957	5237.020
Easterly_Outfall_Structure	4057.562	6478.555

#### [VERTICES]

;;Link	X-Coord	Y-Coord
--------	---------	---------

#### [Polygons]

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.2 (Build 5.2.3)

\*\*\*\*\*

Analysis Options

\*\*\*\*\*

Flow Units ..... CFS  
Process Models:  
Rainfall/Runoff ..... NO  
RDII ..... NO  
Snowmelt ..... NO  
Groundwater ..... NO  
Flow Routing ..... YES  
Ponding Allowed ..... NO  
Water Quality ..... NO  
Flow Routing Method ..... DYNWAVE  
Surcharge Method ..... EXTRAN  
Starting Date ..... 07/02/2024 00:00:00  
Ending Date ..... 07/02/2024 06:00:00  
Antecedent Dry Days ..... 0.0  
Report Time Step ..... 00:15:00  
Routing Time Step ..... 20.00 sec  
Variable Time Step ..... YES  
Maximum Trials ..... 8  
Number of Threads ..... 1  
Head Tolerance ..... 0.005000 ft

	Volume	Volume
Flow Routing Continuity	acre-feet	10^6 gal
*****	-----	-----
Dry Weather Inflow .....	0.000	0.000
Wet Weather Inflow .....	0.000	0.000
Groundwater Inflow .....	0.000	0.000
RDII Inflow .....	0.000	0.000
External Inflow .....	60.493	19.713
External Outflow .....	60.427	19.691
Flooding Loss .....	0.000	0.000
Evaporation Loss .....	0.000	0.000
Exfiltration Loss .....	0.000	0.000
Initial Stored Volume ....	0.000	0.000
Final Stored Volume .....	0.076	0.025
Continuity Error (%) .....	-0.016	

\*\*\*\*\*

Time-Step Critical Elements

\*\*\*\*\*

Link PR\_4X10\_RCBC (99.94%)

\*\*\*\*\*

Highest Flow Instability Indexes

\*\*\*\*\*

All links are stable.

\*\*\*\*\*

Most Frequent Nonconverging Nodes

\*\*\*\*\*  
Convergence obtained at all time steps.

\*\*\*\*\*  
Routing Time Step Summary  
\*\*\*\*\*

Minimum Time Step : 1.05 sec  
Average Time Step : 4.63 sec  
Maximum Time Step : 16.12 sec  
% of Time in Steady State : 0.00  
Average Iterations per Step : 2.01  
% of Steps Not Converging : 0.02  
Time Step Frequencies :  
20.000 - 9.564 sec : 0.02 %  
9.564 - 4.573 sec : 99.72 %  
4.573 - 2.187 sec : 0.24 %  
2.187 - 1.046 sec : 0.02 %  
1.046 - 0.500 sec : 0.00 %

\*\*\*\*\*  
Node Depth Summary  
\*\*\*\*\*

-----								
	Average	Maximum	Maximum	Time of Max	Reported			
	Depth	Depth	HGL	Occurrence	Max Depth			
Node	Type	Feet	Feet	Feet	days hr:min	Feet		
-----								
22ndAve_Junc_Structure	JUNCTION	1.72	2.16	5300.96	0 00:00	1.72		
DUMMY_NODE	JUNCTION	2.02	2.47	5302.97	0 00:00	2.02		
Easterly_Outfall_Structure	OUTFALL	1.67	1.95	5300.55	0 00:01	1.67		

\*\*\*\*\*  
Node Inflow Summary  
\*\*\*\*\*

-----								
	Maximum Lateral Inflow	Maximum Total Inflow	Maximum Time of Occurrence	Lateral Inflow Volume	Total Inflow Volume	Flow Balance		
Node	Type	CFS	CFS	days hr:min	10^6 gal	10^6 gal	Error	Percent
-----								
22ndAve_Junc_Structure	JUNCTION	0.00	146.74	0 00:01	0	19.7	0.029	
DUMMY_NODE	JUNCTION	122.00	122.00	0 00:00	19.7	19.7	0.081	
Easterly_Outfall_Structure	OUTFALL	0.00	154.92	0 00:01	0	19.7	0.000	

\*\*\*\*\*  
Node Surcharge Summary  
\*\*\*\*\*

No nodes were surcharged.

\*\*\*\*\*

Node Flooding Summary

\*\*\*\*\*

No nodes were flooded.

\*\*\*\*\*

Outfall Loading Summary

\*\*\*\*\*

-----					
Outfall Node	Flow	Avg	Max	Total	
	Freq	Flow	Flow	Volume	
	Pcnt	CFS	CFS	10^6 gal	
-----					
Easterly_Outfall_Structure	99.98	121.97	154.92	19.689	
-----					
System	99.98	121.97	154.92	19.689	

\*\*\*\*\*

Link Flow Summary

\*\*\*\*\*

-----							
Link	Type	Maximum	Time of Max	Maximum	Max/	Max/	
		Flow	Occurrence	Veloc	Full	Full	
		CFS	days hr:min	ft/sec	Flow	Depth	
-----							
PR_4X10_RCBC	CONDUIT	154.92	0 00:01	7.86	0.57	0.51	
EX_96_IN_RCP	CONDUIT	146.74	0 00:01	13.31	0.17	0.29	

\*\*\*\*\*

Flow Classification Summary

\*\*\*\*\*

-----										
Conduit	Adjusted	Fraction of Time in Flow Class -----								
	/Actual	Up	Down	Sub	Sup	Up	Down	Norm	Inlet	
	Length	Dry	Dry	Dry	Crit	Crit	Crit	Crit	Ltd	Ctrl
-----										
PR_4X10_RCBC	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
EX_96_IN_RCP	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00

\*\*\*\*\*

Conduit Surcharge Summary

\*\*\*\*\*

No conduits were surcharged.

Analysis begun on: Wed Jul 3 12:06:58 2024  
Analysis ended on: Wed Jul 3 12:06:58 2024  
Total elapsed time: < 1 sec



## Easterly Creek Outfall System – 100-YR

### [OPTIONS]

;;Option Value

FLOW\_UNITS CFS  
INFILTRATION HORTON  
FLOW\_ROUTING DYNWAVE  
LINK\_OFFSETS DEPTH  
MIN\_SLOPE 0  
ALLOW\_PONDING NO  
SKIP\_STEADY\_STATE NO

START\_DATE 07/02/2024  
START\_TIME 00:00:00  
REPORT\_START\_DATE 07/02/2024  
REPORT\_START\_TIME 00:00:00  
END\_DATE 07/02/2024  
END\_TIME 06:00:00  
SWEEP\_START 1/1  
SWEEP\_END 12/31  
DRY\_DAYS 0  
REPORT\_STEP 00:15:00  
WET\_STEP 00:05:00  
DRY\_STEP 01:00:00  
ROUTING\_STEP 0:00:20  
RULE\_STEP 00:00:00

INERTIAL\_DAMPING PARTIAL  
NORMAL\_FLOW\_LIMITED BOTH  
FORCE\_MAIN\_EQUATION H-W  
VARIABLE\_STEP 0.75  
LENGTHENING\_STEP 0  
MIN\_SURFAREA 0  
MAX\_TRIALS 0  
HEAD\_TOLERANCE 0  
SYS\_FLOW\_TOL 5  
LAT\_FLOW\_TOL 5  
MINIMUM\_STEP 0.5  
THREADS 1

### [EVAPORATION]

;;Data Source Parameters

;;-----

CONSTANT 0.0  
DRY\_ONLY NO

### [JUNCTIONS]

;;Name Elevation MaxDepth InitDepth SurDepth Aponded

;;-----

22ndAve\_Junc\_Structure 5298.80 0 0 0 0  
DUMMY\_NODE 5300.50 0 0 0 0

### [OUTFALLS]

;;Name Elevation Type Stage Data Gated Route To

;;-----

Easterly\_Outfall\_Structure 5298.60 FREE NO

### [CONDUITS]

;;Name	From Node	To Node	Length	Roughness	InOffset	OutOffset	InitFlow	MaxFlow
PR_4X10_RCBC	22ndAve_Junc_Structure	Easterly_Outfall_Structure	90	0.013	0	0	0	0
EX_96_IN_RCP	DUMMY_NODE	22ndAve_Junc_Structure	179.28	0.013	0	0.07	0	0

#### [XSECTIONS]

;;Link	Shape	Geom1	Geom2	Geom3	Geom4	Barrels	Culvert
PR_4X10_RCBC	RECT_CLOSED	4	10	0	0	1	
EX_96_IN_RCP	CIRCULAR	8	0	0	0	1	

#### [INFLOWS]

;;Node	Constituent	Time Series	Type	Mfactor	Sfactor	Baseline	Pattern
DUMMY_NODE	FLOW	""	FLOW	1.0	1.0	540	

#### [REPORT]

;;Reporting Options  
SUBCATCHMENTS ALL  
NODES ALL  
LINKS ALL

#### [TAGS]

#### [MAP]

DIMENSIONS 0.000 0.000 10000.000 10000.000  
Units None

#### [COORDINATES]

;;Node	X-Coord	Y-Coord
22ndAve_Junc_Structure	2849.887	5293.454
DUMMY_NODE	332.957	5237.020
Easterly_Outfall_Structure	4057.562	6478.555

#### [VERTICES]

;;Link	X-Coord	Y-Coord
--------	---------	---------

#### [Polygons]

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.2 (Build 5.2.3)

\*\*\*\*\*

Analysis Options

\*\*\*\*\*

Flow Units ..... CFS

Process Models:

Rainfall/Runoff ..... NO

RDII ..... NO

Snowmelt ..... NO

Groundwater ..... NO

Flow Routing ..... YES

Ponding Allowed ..... NO

Water Quality ..... NO

Flow Routing Method ..... DYNWAVE

Surcharge Method ..... EXTRAN

Starting Date ..... 07/02/2024 00:00:00

Ending Date ..... 07/02/2024 06:00:00

Antecedent Dry Days ..... 0.0

Report Time Step ..... 00:15:00

Routing Time Step ..... 20.00 sec

Variable Time Step ..... YES

Maximum Trials ..... 8

Number of Threads ..... 1

Head Tolerance ..... 0.005000 ft

\*\*\*\*\* Volume Volume

Flow Routing Continuity      acre-feet      10^6 gal

\*\*\*\*\* -----

Dry Weather Inflow .....      0.000      0.000

Wet Weather Inflow .....      0.000      0.000

Groundwater Inflow .....      0.000      0.000

RDII Inflow .....      0.000      0.000

External Inflow .....      267.756      87.252

External Outflow .....      267.547      87.184

Flooding Loss .....      0.000      0.000

Evaporation Loss .....      0.000      0.000

Exfiltration Loss .....      0.000      0.000

Initial Stored Volume ....      0.000      0.000

Final Stored Volume .....      0.203      0.066

Continuity Error (%) .....      0.002

\*\*\*\*\*

Time-Step Critical Elements

\*\*\*\*\*

Link PR\_4X10\_RCBC (99.95%)

\*\*\*\*\*

Highest Flow Instability Indexes

\*\*\*\*\*

All links are stable.

\*\*\*\*\*

Most Frequent Nonconverging Nodes

\*\*\*\*\*

Node Easterly\_Outfall\_Structure (0.08%)

Node 22ndAve\_Junc\_Structure (0.06%)

Node DUMMY\_NODE (0.04%)

\*\*\*\*\*

Routing Time Step Summary

\*\*\*\*\*

Minimum Time Step : 1.78 sec  
Average Time Step : 2.70 sec  
Maximum Time Step : 5.84 sec  
% of Time in Steady State : 0.00  
Average Iterations per Step : 2.01  
% of Steps Not Converging : 0.08  
Time Step Frequencies :  
20.000 - 9.564 sec : 0.00 %  
9.564 - 4.573 sec : 0.03 %  
4.573 - 2.187 sec : 99.96 %  
2.187 - 1.046 sec : 0.01 %  
1.046 - 0.500 sec : 0.00 %

\*\*\*\*\*

Node Depth Summary

\*\*\*\*\*

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min	Reported Max Depth Feet
22ndAve_Junc_Structure	JUNCTION	4.47	6.50	5305.30	0 00:00	4.47
DUMMY_NODE	JUNCTION	4.57	6.81	5307.31	0 00:00	4.56
Easterly_Outfall_Structure	OUTFALL	3.88	3.88	5302.48	0 00:00	3.88

\*\*\*\*\*

Node Inflow Summary

\*\*\*\*\*

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Maximum Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal	Flow Balance Error Percent
22ndAve_Junc_Structure	JUNCTION	0.00	627.89	0 00:00	0	87.2	0.021
DUMMY_NODE	JUNCTION	540.00	540.00	0 00:00	87.2	87.2	0.057
Easterly_Outfall_Structure	OUTFALL	0.00	737.80	0 00:00	0	87.2	0.000

\*\*\*\*\*

Node Surcharge Summary

\*\*\*\*\*

No nodes were surcharged.

\*\*\*\*\*

Node Flooding Summary

\*\*\*\*\*

No nodes were flooded.

\*\*\*\*\*

Outfall Loading Summary

\*\*\*\*\*

```

-----
          Flow   Avg   Max   Total
          Freq   Flow   Flow   Volume
Outfall Node    Pcnt   CFS   CFS   10^6 gal
-----
Easterly_Outfall_Structure 100.00  539.78  737.80  87.178
-----
System      100.00  539.78  737.80  87.178

```

\*\*\*\*\*  
Link Flow Summary  
\*\*\*\*\*

```

-----
          Maximum Time of Max   Maximum   Max/   Max/
          |Flow| Occurrence |Veloc| Full Full
Link      Type    CFS days hr:min  ft/sec Flow Depth
-----
PR_4X10_RCBC    CONDUIT  737.80  0 00:00  18.73  2.70  0.99
EX_96_IN_RCP    CONDUIT  627.89  0 00:00  18.41  0.72  0.76

```

\*\*\*\*\*  
Flow Classification Summary  
\*\*\*\*\*

```

-----
          Adjusted ----- Fraction of Time in Flow Class -----
          /Actual   Up   Down Sub Sup Up   Down Norm Inlet
Conduit    Length Dry Dry Dry Crit Crit Crit Crit Ltd Ctrl
-----
PR_4X10_RCBC    1.00  0.00  0.00  0.00  0.00  1.00  0.00  0.00  0.00  0.00
EX_96_IN_RCP    1.00  0.00  0.00  0.00  0.00  0.00  0.00  1.00  0.00  0.0

```

\*\*\*\*\*  
Conduit Surge Summary  
\*\*\*\*\*

```

-----
          Hours   Hours
          ----- Hours Full ----- Above Full Capacity
Conduit    Both Ends Upstream Dnstream Normal Flow Limited
-----
PR_4X10_RCBC    0.01  5.99  0.01  5.99  0.01

```

Analysis begun on: Wed Jul 3 11:59:56 2024  
Analysis ended on: Wed Jul 3 11:59:56 2024  
Total elapsed time: < 1 sec

## Westerly Creek at Stanley – 23<sup>rd</sup> Avenue to Pond System - 2 -YR

### [OPTIONS]

```
;;Option      Value
FLOW_UNITS    CFS
INFILTRATION  HORTON
FLOW_ROUTING  DYNWAVE
LINK_OFFSETS  DEPTH
MIN_SLOPE     0
ALLOW_PONDING NO
SKIP_STEADY_STATE NO

START_DATE    01/08/2024
START_TIME    00:00:00
REPORT_START_DATE 01/08/2024
REPORT_START_TIME 00:00:00
END_DATE      01/08/2024
END_TIME      06:00:00
SWEEP_START   01/01
SWEEP_END     12/31
DRY_DAYS      0
REPORT_STEP   00:00:15
WET_STEP      00:05:00
DRY_STEP      01:00:00
ROUTING_STEP  0:00:01
RULE_STEP     00:00:00
```

```
INERTIAL_DAMPING PARTIAL
NORMAL_FLOW_LIMITED BOTH
FORCE_MAIN_EQUATION H-W
VARIABLE_STEP 0.75
LENGTHENING_STEP 0
MIN_SURFAREA 12.566
MAX_TRIALS 8
HEAD_TOLERANCE 0.005
SYS_FLOW_TOL 5
LAT_FLOW_TOL 5
MINIMUM_STEP 0.5
THREADS 1
```

### [EVAPORATION]

```
;;Data Source Parameters
;;-----
CONSTANT 0.0
DRY_ONLY NO
```

### [JUNCTIONS]

```
;;Name      Elevation MaxDepth InitDepth SurDepth Aponded
;;-----
1          5293    1.33    0    0    0
```

### [OUTFALLS]

```
;;Name      Elevation Type      Stage Data      Gated Route To
;;-----
2          5292.44 FREE          NO
```

### [CONDUITS]

```
;;Name      From Node      To Node      Length      Roughness InOffset OutOffset InitFlow MaxFlow
```

```
;;-----  
1      1      2      119    0.011  0    0    0    0
```

[XSECTIONS]

```
;;Link      Shape      Geom1      Geom2      Geom3      Geom4      Barrels      Culvert  
;;-----  
1          CIRCULAR    .5        0        0        0        1
```

[LOSSES]

```
;;Link      Kentry      Kexit      Kavg      Flap Gate      Seepage  
;;-----  
1          1          1          0        NO          0
```

[INFLOWS]

```
;;Node      Constituent      Time Series      Type      Mfactor      Sfactor      Baseline Pattern  
;;-----  
1          FLOW          ""          FLOW      1.0      1.0      0.45
```

[REPORT]

```
;;Reporting Options  
SUBCATCHMENTS ALL  
NODES ALL  
LINKS ALL
```

[TAGS]

[MAP]

```
DIMENSIONS 0.000 0.000 10000.000 10000.000  
Units      None
```

[COORDINATES]

```
;;Node      X-Coord      Y-Coord  
;;-----  
1          1860.203      5028.185  
2          777.903      5005.637
```

[VERTICES]

```
;;Link      X-Coord      Y-Coord  
;;-----
```

[Polygons]

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.2 (Build 5.2.4)

\*\*\*\*\*

Analysis Options

\*\*\*\*\*

Flow Units ..... CFS

Process Models:

Rainfall/Runoff ..... NO

RDII ..... NO

Snowmelt ..... NO

Groundwater ..... NO

Flow Routing ..... YES

Ponding Allowed ..... NO

Water Quality ..... NO

Flow Routing Method ..... DYNWAVE

Surcharge Method ..... EXTRAN

Starting Date ..... 01/08/2024 00:00:00

Ending Date ..... 01/08/2024 06:00:00

Antecedent Dry Days ..... 0.0

Report Time Step ..... 00:00:15

Routing Time Step ..... 1.00 sec

Variable Time Step ..... YES

Maximum Trials ..... 8

Number of Threads ..... 1

Head Tolerance ..... 0.005000 ft

\*\*\*\*\* Volume Volume

Flow Routing Continuity acre-feet 10^6 gal

\*\*\*\*\*

Dry Weather Inflow ..... 0.000 0.000

Wet Weather Inflow ..... 0.000 0.000

Groundwater Inflow ..... 0.000 0.000

RDII Inflow ..... 0.000 0.000

External Inflow ..... 0.223 0.073

External Outflow ..... 0.223 0.073

Flooding Loss ..... 0.000 0.000

Evaporation Loss ..... 0.000 0.000

Exfiltration Loss ..... 0.000 0.000

Initial Stored Volume .... 0.000 0.000

Final Stored Volume ..... 0.000 0.000

Continuity Error (%) ..... -0.080

\*\*\*\*\*

Time-Step Critical Elements

\*\*\*\*\*

None

\*\*\*\*\*

Highest Flow Instability Indexes

\*\*\*\*\*

All links are stable.

\*\*\*\*\*

Most Frequent Nonconverging Nodes



\*\*\*\*\*  
 Convergence obtained at all time steps.

\*\*\*\*\*  
 Routing Time Step Summary  
 \*\*\*\*\*

Minimum Time Step : 0.50 sec  
 Average Time Step : 1.00 sec  
 Maximum Time Step : 1.00 sec  
 % of Time in Steady State : 0.00  
 Average Iterations per Step : 2.00  
 % of Steps Not Converging : 0.00  
 Time Step Frequencies :  
 1.000 - 0.871 sec : 100.00 %  
 0.871 - 0.758 sec : 0.00 %  
 0.758 - 0.660 sec : 0.00 %  
 0.660 - 0.574 sec : 0.00 %  
 0.574 - 0.500 sec : 0.00 %

\*\*\*\*\*  
 Node Depth Summary  
 \*\*\*\*\*

Node	Type	Average Maximum Maximum Time of Max Reported					Feet
		Depth	Depth	HGL	Occurrence	Max Depth	
		Feet	Feet	Feet	days hr:min	Feet	
1	JUNCTION	0.58	0.59	5293.59	0 00:01	0.58	
2	OUTFALL	0.34	0.34	5292.78	0 00:01	0.34	

\*\*\*\*\*  
 Node Inflow Summary  
 \*\*\*\*\*

Node	Type	Maximum Maximum Lateral Total Flow					Error
		Lateral	Total	Time of Max	Inflow	Inflow	
		Inflow	Inflow	Occurrence	Volume	Volume	
		CFS	CFS	days hr:min	10^6 gal	10^6 gal	Percent
1	JUNCTION	0.45	0.45	0 00:00	0.0727	0.0727	0.128
2	OUTFALL	0.00	0.45	0 00:01	0	0.0726	0.000

\*\*\*\*\*  
 Node Surge Summary  
 \*\*\*\*\*

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Max. Height Min. Depth		
		Hours	Above Crown	Below Rim
		Surcharged	Feet	Feet

1            JUNCTION    5.98    0.095    0.735

\*\*\*\*\*  
Node Flooding Summary  
\*\*\*\*\*

No nodes were flooded.

\*\*\*\*\*  
Outfall Loading Summary  
\*\*\*\*\*

-----					
	Flow	Avg	Max	Total	
	Freq	Flow	Flow	Volume	
Outfall Node		Pcnt	CFS	CFS	10^6 gal
-----					
2	99.99	0.45	0.45	0.073	
-----					
System	99.99	0.45	0.45	0.073	

\*\*\*\*\*  
Link Flow Summary  
\*\*\*\*\*

-----							
	Maximum Time o	Max	Maximum	Max/	Max/		
	Flow	Occurrence	Veloc	Full	Full		
Link	Type	CFS	days hr:min	ft/sec	Flow	Depth	
-----							
1	CONDUIT	0.45	0 00:01	2.56	0.99	0.84	

\*\*\*\*\*  
Flow Classification Summary  
\*\*\*\*\*

-----										
	Adjusted	Fraction oTime in Flow Class -----								
	/Actual	Up	Down	Sub	Sup	Up	Down	Norm	Inlet	
Conduit	Length	Dry	Dry	Dry	Crit	Crit	Crit	Crit	Ltd	Ctrl
-----										
1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00

\*\*\*\*\*  
Conduit Surcharge Summary  
\*\*\*\*\*

-----						
	Hours	Hours				
	-----	Hours Full	-----	Above Full	Capacity	
Conduit		Both Ends	Upstream	Dnstream	Normal Flow	Limited
-----						
1	0.01	5.98	0.01	0.01	0.01	

Analysis begun on: Wed Jul 3 12:36:35 2024  
Analysis ended on: Wed Jul 3 12:36:35 2024  
Total elapsed time: < 1 sec

# Westerly Creek at Stanley – 23<sup>rd</sup> Avenue to Pond System - 100 -YR

## [OPTIONS]

```
;;Option      Value
FLOW_UNITS    CFS
INFILTRATION  HORTON
FLOW_ROUTING  DYNWAVE
LINK_OFFSETS  DEPTH
MIN_SLOPE     0
ALLOW_PONDING NO
SKIP_STEADY_STATE NO

START_DATE    01/08/2024
START_TIME    00:00:00
REPORT_START_DATE 01/08/2024
REPORT_START_TIME 00:00:00
END_DATE      01/08/2024
END_TIME      06:00:00
SWEEP_START   01/01
SWEEP_END     12/31
DRY_DAYS      0
REPORT_STEP   00:00:15
WET_STEP      00:05:00
DRY_STEP      01:00:00
ROUTING_STEP  0:00:01
RULE_STEP     00:00:00
```

```
INERTIAL_DAMPING PARTIAL
NORMAL_FLOW_LIMITED BOTH
FORCE_MAIN_EQUATION H-W
VARIABLE_STEP 0.75
LENGTHENING_STEP 0
MIN_SURFAREA 12.566
MAX_TRIALS 8
HEAD_TOLERANCE 0.005
SYS_FLOW_TOL 5
LAT_FLOW_TOL 5
MINIMUM_STEP 0.5
THREADS 1
```

## [EVAPORATION]

```
;;Data Source Parameters
;;-----
CONSTANT 0.0
DRY_ONLY NO
```

## [JUNCTIONS]

```
;;Name      Elevation MaxDepth InitDepth SurDepth Aponded
;;-----
1          5293    1.9    0    0    0
```

## [OUTFALLS]

```
;;Name      Elevation Type      Stage Data      Gated Route To
;;-----
2          5292.53 FREE              NO
```

## [CONDUITS]

```
;;Name      From Node      To Node      Length      Roughness InOffset OutOffset InitFlow MaxFlow
```

```
;;-----  
1      1      2      125    0.011  0    0    0    0
```

[XSECTIONS]

```
;;Link      Shape      Geom1      Geom2      Geom3      Geom4      Barrels      Culvert  
;;-----  
1          CIRCULAR    .667      0      0      0      1
```

[LOSSES]

```
;;Link      Kentry      Kexit      Kavg      Flap Gate      Seepage  
;;-----  
1          1          1          0      NO      0
```

[INFLOWS]

```
;;Node      Constituent      Time Series      Type      MFactor      SFactor      Baseline Pattern  
;;-----  
1          FLOW      ""      FLOW      1.0      1.0      4.24
```

[REPORT]

```
;;Reporting Options  
SUBCATCHMENTS ALL  
NODES ALL  
LINKS ALL
```

[TAGS]

[MAP]

```
DIMENSIONS 0.000 0.000 10000.000 10000.000  
Units      None
```

[COORDINATES]

```
;;Node      X-Coord      Y-Coord  
;;-----  
1          1860.203      5028.185  
2          777.903      5005.637
```

[VERTICES]

```
;;Link      X-Coord      Y-Coord  
;;-----
```

[Polygons]

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.2 (Build 5.2.4)

\*\*\*\*\*

Analysis Options

\*\*\*\*\*

Flow Units ..... CFS

Process Models:

Rainfall/Runoff ..... NO

RDII ..... NO

Snowmelt ..... NO

Groundwater ..... NO

Flow Routing ..... YES

Ponding Allowed ..... NO

Water Quality ..... NO

Flow Routing Method ..... DYNWAVE

Surcharge Method ..... EXTRAN

Starting Date ..... 01/08/2024 00:00:00

Ending Date ..... 01/08/2024 06:00:00

Antecedent Dry Days ..... 0.0

Report Time Step ..... 00:00:15

Routing Time Step ..... 1.00 sec

Variable Time Step ..... YES

Maximum Trials ..... 8

Number of Threads ..... 1

Head Tolerance ..... 0.005000 ft

\*\*\*\*\* Volume Volume

Flow Routing Continuity acre-feet 10^6 gal

\*\*\*\*\*

Dry Weather Inflow ..... 0.000 0.000

Wet Weather Inflow ..... 0.000 0.000

Groundwater Inflow ..... 0.000 0.000

RDII Inflow ..... 0.000 0.000

External Inflow ..... 2.102 0.685

External Outflow ..... 0.715 0.233

Flooding Loss ..... 1.387 0.452

Evaporation Loss ..... 0.000 0.000

Exfiltration Loss ..... 0.000 0.000

Initial Stored Volume .... 0.000 0.000

Final Stored Volume ..... 0.001 0.000

Continuity Error (%) ..... -0.020

\*\*\*\*\*

Time-Step Critical Elements

\*\*\*\*\*

None

\*\*\*\*\*

Highest Flow Instability Indexes

\*\*\*\*\*

All links are stable.

\*\*\*\*\*

Most Frequent Nonconverging Nodes

\*\*\*\*\*  
 Convergence obtained at all time steps.

\*\*\*\*\*  
 Routing Time Step Summary  
 \*\*\*\*\*

Minimum Time Step : 0.50 sec  
 Average Time Step : 1.00 sec  
 Maximum Time Step : 1.00 sec  
 % of Time in Steady State : 0.00  
 Average Iterations per Step : 2.00  
 % of Steps Not Converging : 0.00  
 Time Step Frequencies :  
     1.000 - 0.871 sec : 100.00 %  
     0.871 - 0.758 sec : 0.00 %  
     0.758 - 0.660 sec : 0.00 %  
     0.660 - 0.574 sec : 0.00 %  
     0.574 - 0.500 sec : 0.00 %

\*\*\*\*\*  
 Node Depth Summary  
 \*\*\*\*\*

Node	Type	Average Maximum Maximum Time of Max Reported				Max Depth
		Depth	Depth	HGL	Occurrence	
		Feet	Feet	Feet	days hr:min	Feet
1	JUNCTION	1.90	1.90	5294.90	0 00:00	1.90
2	OUTFALL	0.56	0.56	5293.09	0 06:00	0.56

\*\*\*\*\*  
 Node Inflow Summary  
 \*\*\*\*\*

Node	Type	Maximum Maximum			Lateral Inflow Volume	Total Inflow Volume	Flow Balance	
		Lateral Inflow	Total Inflow	Time of Max Occurrence			Error	Percent
		CFS	CFS	days hr:min	10^6 gal	10^6 gal		
1	JUNCTION	4.24	4.24	0 00:00	0.685	0.685	0.025	
2	OUTFALL	0.00	1.44	0 06:00	0	0.233	0.000	

\*\*\*\*\*  
 Node Surge Summary  
 \*\*\*\*\*

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Max. Height Min. Depth		
		Hours	Above Crown	Below Rim
		Surcharged	Feet	Feet

1            JUNCTION      6.00      1.233      0.000

\*\*\*\*\*  
Node Flooding Summary  
\*\*\*\*\*

Flooding refers to all water that overflows a node, whether it ponds or not.

Node	Total Maximum					
	Maximum Hours Flooded	Time o Rate CFS	Max Occurrence days	Max Flood hr:min	Ponded Volume 10^6 gal	Depth Feet
1	6.00	3.73	0	00:00	0.452	0.000

\*\*\*\*\*  
Outfall Loading Summary  
\*\*\*\*\*

Outfall Node	Flow Freq	Avg Flow Pcnt	Max Flow CFS	Total Volume CFS	10^6 gal
	2	100.00	1.44	1.44	0.233
System	100.00	1.44	1.44	0.233	

\*\*\*\*\*  
Link Flow Summary  
\*\*\*\*\*

Link	Type	Maximum  Flow  CFS	Time o Occurrence days	Max Max hr:min	Maximum  Veloc  ft/sec	Max/ Full Flow	Max/ Full Depth
		1	CONDUIT	1.44	0	06:00	4.28

\*\*\*\*\*  
Flow Classification Summary  
\*\*\*\*\*

Conduit	Adjusted /Actual Length	Fraction o Time in Flow Class									
		Up Dry	Down Dry	Sub Dry	Sup Dry	Up Crit	Down Crit	Norm Crit	Inlet Ltd	Ctrl	
1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	

\*\*\*\*\*  
Conduit Surge Summary  
\*\*\*\*\*



-----					
Conduit	Hours		Hours		Capacity
	----- Hours Full -----		Above Full -----		
	Both Ends	Upstream	Dnstream	Normal Flow	
-----					
1	0.01	6.00	0.01	6.00	0.01

Analysis begun on: Mon Jul 1 17:58:45 2024  
Analysis ended on: Mon Jul 1 17:58:45 2024  
Total elapsed time: < 1 sec

## Westerly Creek at Stanley – Southern Underdrain - 2 -YR

### [OPTIONS]

```
;;Option      Value
FLOW_UNITS    CFS
INFILTRATION  HORTON
FLOW_ROUTING  DYNWAVE
LINK_OFFSETS  DEPTH
MIN_SLOPE     0
ALLOW_PONDING NO
SKIP_STEADY_STATE NO

START_DATE    01/08/2024
START_TIME    00:00:00
REPORT_START_DATE 01/08/2024
REPORT_START_TIME 00:00:00
END_DATE      01/08/2024
END_TIME      06:00:00
SWEEP_START   01/01
SWEEP_END     12/31
DRY_DAYS      0
REPORT_STEP   00:00:15
WET_STEP      00:05:00
DRY_STEP      01:00:00
ROUTING_STEP  0:00:01
RULE_STEP     00:00:00
```

```
INERTIAL_DAMPING PARTIAL
NORMAL_FLOW_LIMITED BOTH
FORCE_MAIN_EQUATION H-W
VARIABLE_STEP 0.75
LENGTHENING_STEP 0
MIN_SURFAREA 12.566
MAX_TRIALS 8
HEAD_TOLERANCE 0.005
SYS_FLOW_TOL 5
LAT_FLOW_TOL 5
MINIMUM_STEP 0.5
THREADS 1
```

### [EVAPORATION]

```
;;Data Source Parameters
;;-----
CONSTANT 0.0
DRY_ONLY NO
```

### [JUNCTIONS]

```
;;Name      Elevation MaxDepth InitDepth SurDepth Aponded
;;-----
1          5301.80 .6    0    0    0
```

### [OUTFALLS]

```
;;Name      Elevation Type      Stage Data      Gated Route To
;;-----
2          5301.59 FREE          NO
```

### [CONDUITS]

```
;;Name      From Node      To Node      Length      Roughness InOffset OutOffset InitFlow MaxFlow
```

```
;;-----  
1      1      2      42      0.011  0      0      0      0
```

[XSECTIONS]

```
;;Link      Shape      Geom1      Geom2      Geom3      Geom4      Barrels      Culvert  
;;-----  
1      CIRCULAR      .5      0      0      0      1
```

[LOSSES]

```
;;Link      Kentry      Kexit      Kavg      Flap Gate      Seepage  
;;-----  
1      1      1      0      NO      0
```

[INFLOWS]

```
;;Node      Constituent      Time Series      Type      Mfactor      Sfactor      Baseline Pattern  
;;-----  
1      FLOW      ""      FLOW      1.0      1.0      0.03
```

[REPORT]

```
;;Reporting Options  
SUBCATCHMENTS ALL  
NODES ALL  
LINKS ALL
```

[TAGS]

[MAP]

```
DIMENSIONS 0.000 0.000 10000.000 10000.000  
Units      None
```

[COORDINATES]

```
;;Node      X-Coord      Y-Coord  
;;-----  
1      1860.203      5028.185  
2      777.903      5005.637
```

[VERTICES]

```
;;Link      X-Coord      Y-Coord  
;;-----
```

[Polygons]

# EPA STORM WATER MANAGEMENT MODEL - VERSION 5.2 (Build 5.2.4)

\*\*\*\*\*

## Analysis Options

\*\*\*\*\*

Flow Units ..... CFS

Process Models:

Rainfall/Runoff ..... NO

RDII ..... NO

Snowmelt ..... NO

Groundwater ..... NO

Flow Routing ..... YES

Ponding Allowed ..... NO

Water Quality ..... NO

Flow Routing Method ..... DYNWAVE

Surcharge Method ..... EXTRAN

Starting Date ..... 01/08/2024 00:00:00

Ending Date ..... 01/08/2024 06:00:00

Antecedent Dry Days ..... 0.0

Report Time Step ..... 00:00:15

Routing Time Step ..... 1.00 sec

Variable Time Step ..... YES

Maximum Trials ..... 8

Number of Threads ..... 1

Head Tolerance ..... 0.005000 ft

\*\*\*\*\* Volume Volume

Flow Routing Continuity acre-feet 10^6 gal

\*\*\*\*\*

Dry Weather Inflow ..... 0.000 0.000

Wet Weather Inflow ..... 0.000 0.000

Groundwater Inflow ..... 0.000 0.000

RDII Inflow ..... 0.000 0.000

External Inflow ..... 0.015 0.005

External Outflow ..... 0.015 0.005

Flooding Loss ..... 0.000 0.000

Evaporation Loss ..... 0.000 0.000

Exfiltration Loss ..... 0.000 0.000

Initial Stored Volume .... 0.000 0.000

Final Stored Volume ..... 0.000 0.000

Continuity Error (%) ..... 0.000

\*\*\*\*\*

## Time-Step Critical Elements

\*\*\*\*\*

None

\*\*\*\*\*

## Highest Flow Instability Indexes

\*\*\*\*\*

All links are stable.

\*\*\*\*\*

## Most Frequent Nonconverging Nodes

\*\*\*\*\*  
 Convergence obtained at all time steps.

\*\*\*\*\*  
 Routing Time Step Summary  
 \*\*\*\*\*  
 Minimum Time Step : 0.50 sec  
 Average Time Step : 1.00 sec  
 Maximum Time Step : 1.00 sec  
 % oTime in Steady State : 0.00  
 Average Iterations per Step : 2.00  
 % oSteps Not Converging : 0.00  
 Time Step Frequencies :  
     1.000 - 0.871 sec : 100.00 %  
     0.871 - 0.758 sec : 0.00 %  
     0.758 - 0.660 sec : 0.00 %  
     0.660 - 0.574 sec : 0.00 %  
     0.574 - 0.500 sec : 0.00 %

\*\*\*\*\*

Node Depth Summary

\*\*\*\*\*

-----							
Node	Type	Average		Maximum		Time oMax	
		Depth	Depth	HGL	Occurrence	Max	Reported
		Feet	Feet	Feet	days hr:min	Max	Depth
-----							
1	JUNCTION	0.09	0.09	5301.89	0 00:07	0.09	0.09
2	OUTFALL	0.08	0.08	5301.67	0 00:07	0.08	0.08

\*\*\*\*\*

Node Inflow Summary

\*\*\*\*\*

-----							
Node	Type	Maximum		Lateral	Total	Flow	
		Lateral	Total				
		Inflow	Inflow	Time oMax	Inflow	Inflow	Balance
		CFS	CFS	Occurrence	Volume	Volume	Error
-----							
1	JUNCTION	0.03	0.03	0 00:00	0.00485	0.00485	0.179
2	OUTFALL	0.00	0.03	0 00:07	0	0.00484	0.000

\*\*\*\*\*  
 Node Surcharge Summary  
 \*\*\*\*\*

No nodes were surcharged.

\*\*\*\*\*  
 Node Flooding Summary  
 \*\*\*\*\*

No nodes were flooded.

\*\*\*\*\*  
Outfall Loading Summary  
\*\*\*\*\*

-----				
Outfall Node	Flow Freq	Avg Flow Pcnt	Max Flow CFS	Total Volume CFS 10^6 gal
2	99.95	0.03	0.03	0.005
-----				
System	99.95	0.03	0.03	0.005

\*\*\*\*\*  
Link Flow Summary  
\*\*\*\*\*

-----						
Link	Type	Maximum  Flow	Time of Occurrence	Maximum  Veloc	Max/ Full Flow	Max/ Full Depth
		CFS	days hr:min	ft/sec		
1	CONDUIT	0.03	0 00:07	1.29	0.06	0.18

\*\*\*\*\*  
Flow Classification Summary  
\*\*\*\*\*

-----										
Conduit	Adjusted /Actual Length	----- Fraction of Time in Flow Class -----								
		Up Dry	Down Dry	Sub Dry	Sup Crit	Up Crit	Down Crit	Norm Crit	Inlet Ltd	Ctrl
1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00

\*\*\*\*\*  
Conduit Surcharge Summary  
\*\*\*\*\*

No conduits were surcharged.

Analysis begun on: Mon Jul 1 17:29:20 2024  
Analysis ended on: Mon Jul 1 17:29:20 2024  
Total elapsed time: < 1 sec



# **FINAL DRAINAGE REPORT**

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## **APPENDIX C – HYDRAULIC COMPUTATIONS**

# ICONENGINEERING

## MEMORANDUM

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**TO:** City of Aurora, MHFD

**FROM:** ICON Engineering

**DATE:** May 27th, 2021

**RE:** 2201 Clinton and Stanley Residential FLO-2D Analysis

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The purpose of this memorandum is to document the methodology and results of the Easterly Creek pluvial flooding analysis for the developments adjacent to Westerly Creek. Various storm drain improvements alternatives were developed to assist the proposed developments north of Montview Boulevard, including 2201 Clinton and Stanley Residential, in mitigating pluvial flooding hazards for each respective site. Residual flooding depths associated with each storm drain alternative were evaluated using an integrated FLO-2D and EPA SWMM model.

### **Baseline Hydrology**

The baseline hydrology for the study area was initially developed as part of the Easterly Creek Outfall System Plan in 2012. A hydrology update was completed in conjunction with the 2017 Westerly Creek Flood Hazard Area Delineation (FHAD) study. The EPA SWMM model was subsequently updated in 2021 by the ongoing Outfall Systems Plan (OSP) by Bohannon Huston. The 2021 update incorporated a detention basin constructed following the completion of the FHAD at East 1<sup>st</sup> Avenue and Lansing Street along Easterly Creek. The East 1<sup>st</sup> Avenue and Lansing Street detention basin reduced the flow overtopping Montview Boulevard from approximately 1000 cfs to 635 cfs. The FLO-2D hydraulic analysis, further described below, utilized the revised flow of 635 cfs overtopping Montview Boulevard.

### **FLO-2D Hydraulic Analysis**

FLO-2D is a two-dimensional flood routing software model that was used to identify residual flood potential within the study area. FLO-2D simulates channel flow, unconfined overland flow and street flow over complex topography. The model uses the full dynamic wave momentum equation and a central finite difference routing scheme with eight potential flow directions to predict the progression of a flood wave over a system of square grid elements.

The basis of the FLO-2D model was originally developed in support of the Westerly Creek FHAD and is being updated as part of the ongoing OSP. Terrain for the FLO-2D model was updated to incorporate drone LiDAR flown for the Westerly Creek Stream Restoration at Stanley Marketplace project. Site grading (1-ft contours) for each development and the adjacent roadways was obtained from each developer and combined to represent the fully developed site grading condition.

The hydraulic model isolated the study area north of Montview Boulevard by placing a steady state hydrograph representing the peak flow overtopping Montview Boulevard (635 cfs) obtained from the revised baseline hydrology model. The existing storm drain infrastructure north of Montview Boulevard does not contain any extra flood conveyance capacity during the 100-yr storm and was not included in any of the analysis. This includes the storm drain in 23<sup>rd</sup> Avenue and the storm drain system that extends south in Dallas from 23<sup>rd</sup> Avenue and east in 22<sup>nd</sup> Avenue. The existing conditions pluvial flooding can be found in Figure 1.

EPA SWMM was utilized to evaluate each of the storm drain alternatives. Each alternative aimed to reduce surface flooding to lower all water surface elevations beneath adjacent proposed structures finished floor elevations. The EPA SWMM models were integrated into FLO-2D to evaluate the resulting residual surface flooding.

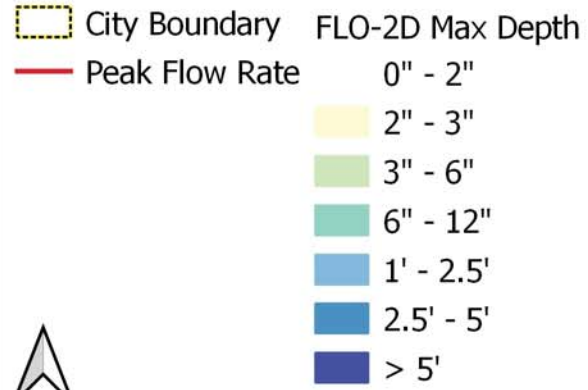
A full list of the proposed improvement scenarios along with the residual flooding of each alternative are included in the Appendix. The proposed improvements for 22<sup>nd</sup> Avenue and 23<sup>rd</sup> Avenue are further described below.



# Westerly Creek at Stanley Marketplace

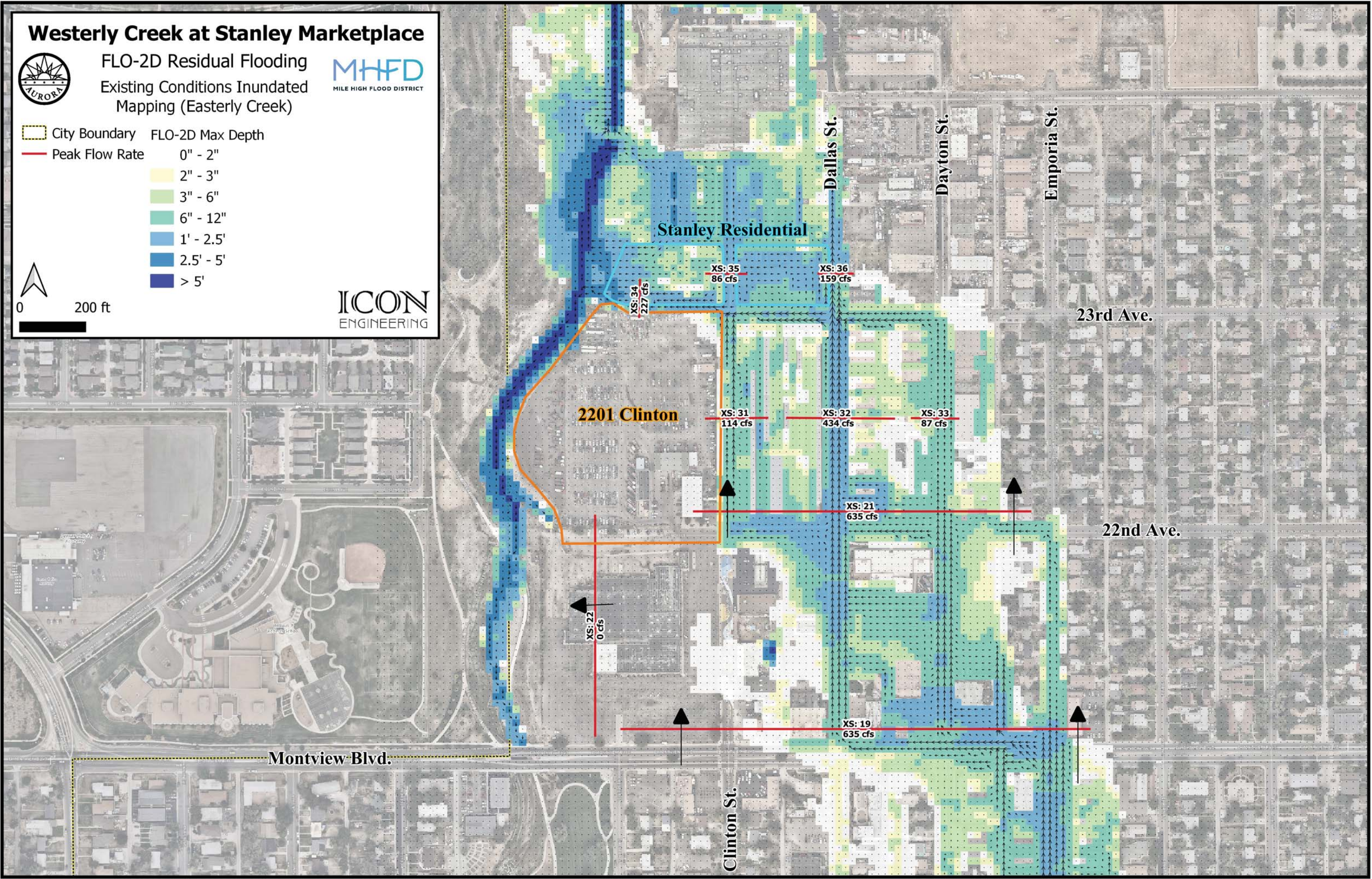


FLO-2D Residual Flooding  
Existing Conditions Inundated  
Mapping (Easterly Creek)



0 200 ft

ICON  
ENGINEERING





## **Proposed Storm Drain Improvements**

Storm drain improvements along 22nd Avenue and 23rd Avenue have been proposed to mitigate the Easterly Creek pluvial flooding on buildings both the 2201 Clinton and Stanley Residential development sites. Although additional upstream improvements are needed to eliminate all flood risk during the 100-year design storm, the combination of the 22nd Avenue and 23rd Avenue storm improvements reduce flooding such that water surface elevations adjacent to buildings are below the proposed finished floor elevations at each property. Both the 22nd Avenue and 23rd Avenue storm drain improvements provide between a 10-year and 25-year design storm level of protection, in which all surface flow is intercepted during the 10-year design storm.

The post project residual flooding for the 100-year design storm can be found in Figure 2. A water surface elevation comparison between existing and proposed conditions can be found in Figure 3. Areas where the proposed improvements reduce the water surface elevation are depicted on the figure with green, whereas increases in water surface elevations compared to existing conditions are depicted by purple. The 22nd Avenue and 23rd Avenue Outfalls are further described in the following sections.

### ***22nd Avenue Outfall***

Proposed improvements along 22nd Avenue include a 60" RCP extending from the existing Easterly Creek Outfall at Westerly Creek upstream to Dallas Street. At Dallas Street, approximately 200 cfs is proposed to be intercepted from the surface flooding overtopping Montview. The 60" RCP reduces the water surface elevation in Clinton Street below all adjacent proposed structures for the 2201 Clinton Development. Cross sections at each proposed building along Clinton Street for both existing and proposed water surface elevations are provided in the Appendix.

To evaluate the tailwater condition of the existing Easterly Creek storm drain, a StormCAD model was developed north of Montview Boulevard. Pipe size dimensions and elevations of the existing system were collected as part of a field survey for the Westerly Creek Restoration at Stanley Marketplace project by Daley Surveying in January 2020. The peak discharge in the 22nd Avenue Outfall was assumed to be coincident with the peak flow in the existing Easterly Creek storm drain. The flow in the existing storm drain during the 100-yr design storm, 193 cfs, was obtained from the revised baseline hydrologic model described above. Loss coefficients for manhole and pipe transitions were calculated through StormCAD using the HEC-22 2nd Edition Loss Method. The 100-yr tailwater in the existing Easterly Creek storm drain at the outfall of the 22nd Avenue storm drain was determined to be 5303.50.

### ***23rd Avenue Outfall***

Proposed improvements along 23rd Avenue include a 48-inch RCP beginning at the 23rd Avenue and Dallas Street intersection where approximately 93 cfs is proposed to be intercepted from the surface. The proposed improvements continue downstream where an additional 107 cfs are intercepted at 23rd Avenue and Clinton Street as the pipe increases in size to a 76" wide by 48" tall horizontal elliptical RCP (60" RCP equivalent). The combined 210 cfs continues downstream to the west to a new outfall location on the eastern bank of Westerly Creek.



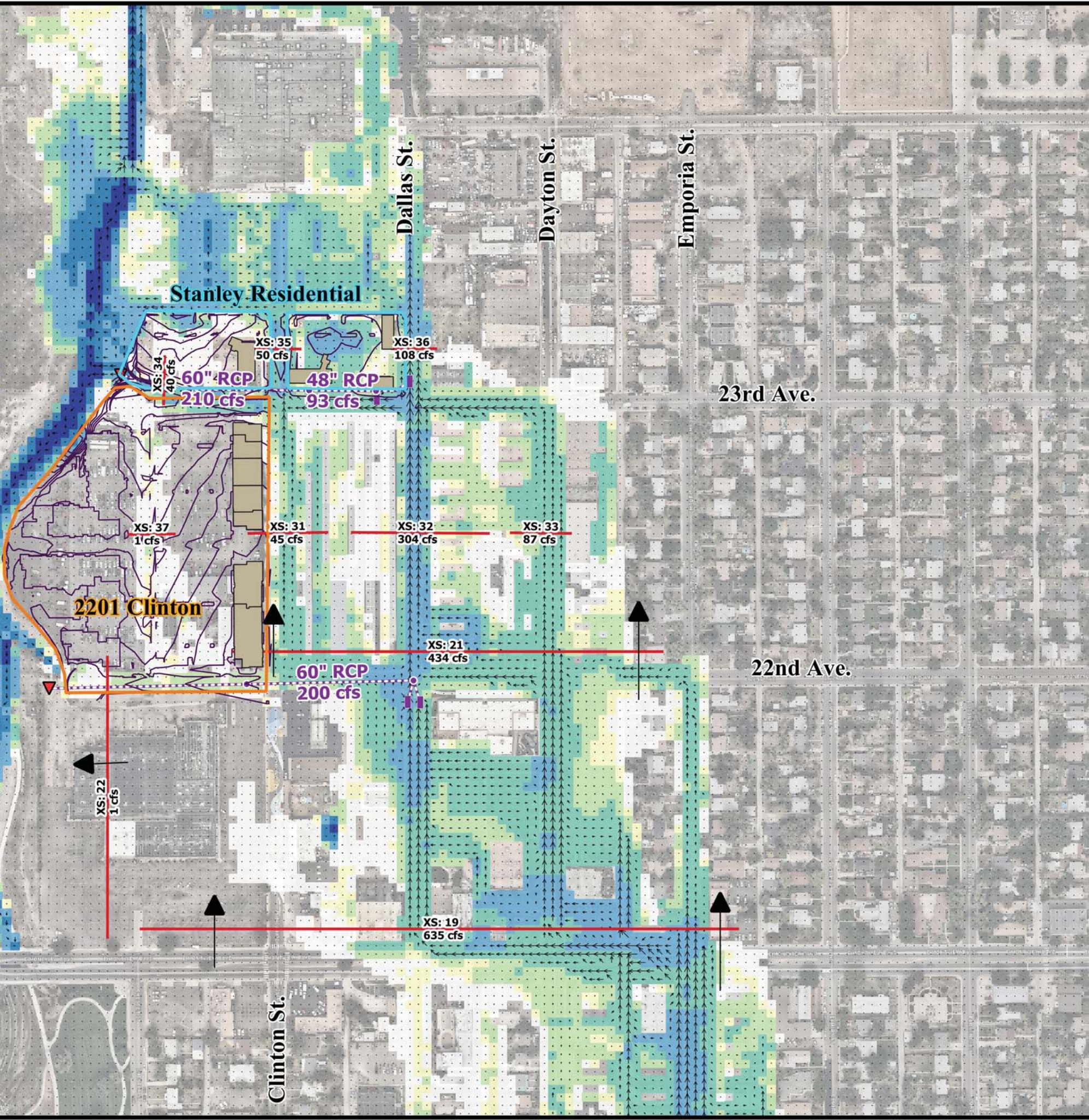
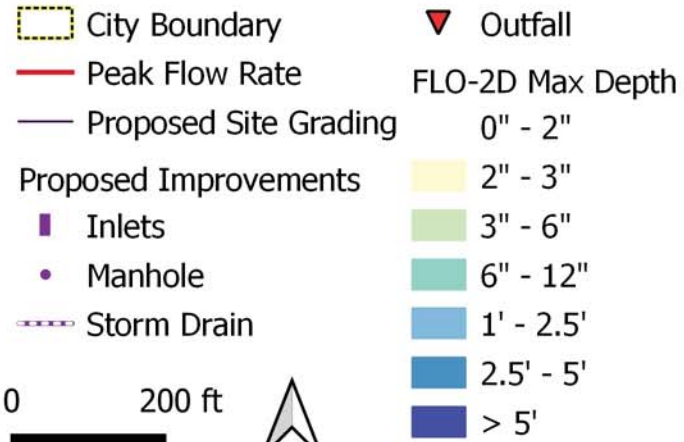
# Westerly Creek at Stanley Marketplace



FLO-2D Residual Flooding



Proposed Development Grading with  
Proposed 22nd Avenue Outfall (60" RCP) &  
Stanley Residential Outfall (48" RCP - 60" RCP)





# Westerly Creek at Stanley Marketplace



FLO-2D Flooding Depth  
Comparison

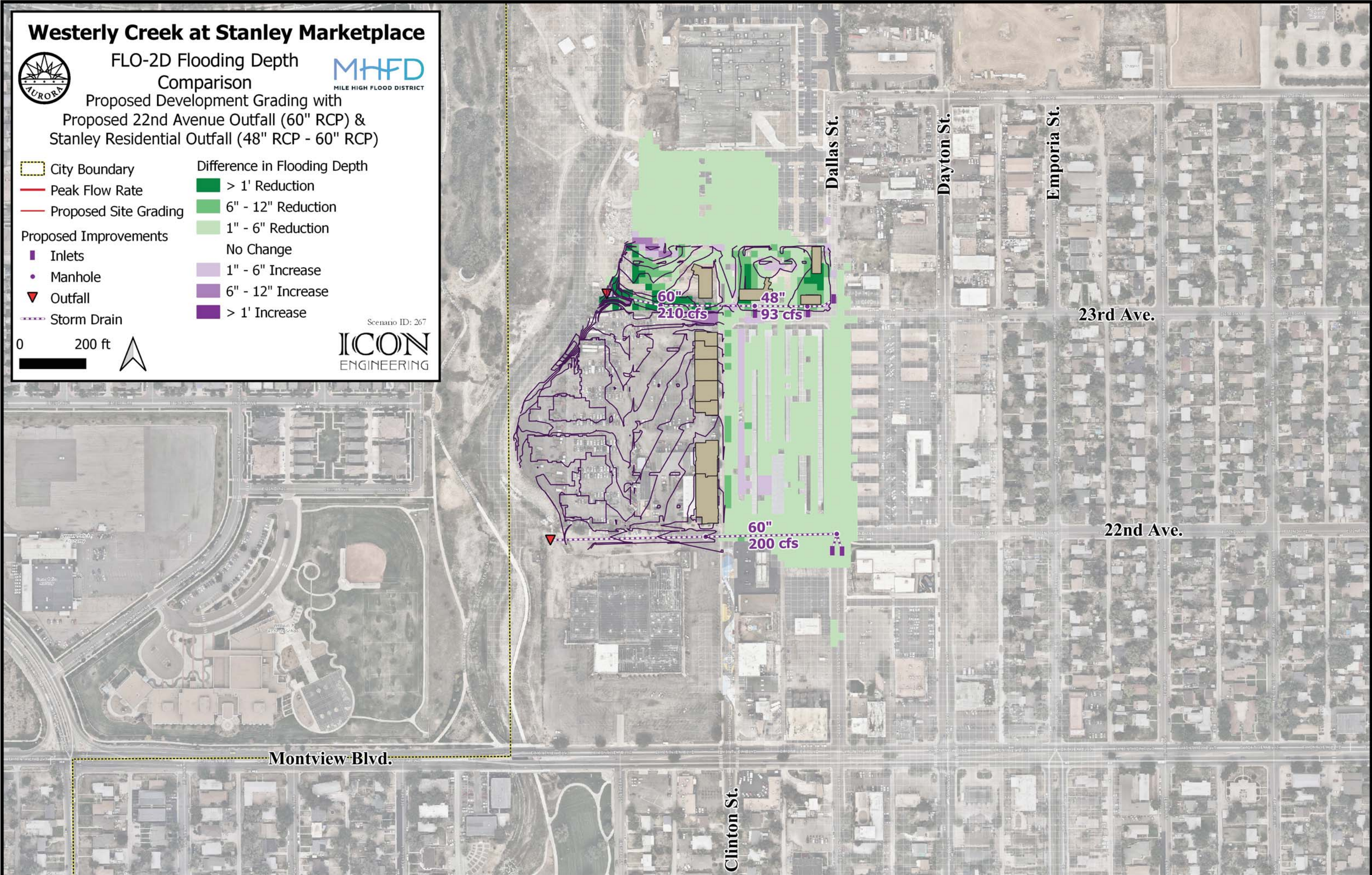


Proposed Development Grading with  
Proposed 22nd Avenue Outfall (60" RCP) &  
Stanley Residential Outfall (48" RCP - 60" RCP)

- |                              |                                     |
|------------------------------|-------------------------------------|
| City Boundary                | <b>Difference in Flooding Depth</b> |
| Peak Flow Rate               | > 1' Reduction                      |
| Proposed Site Grading        | 6" - 12" Reduction                  |
| <b>Proposed Improvements</b> | 1" - 6" Reduction                   |
| Inlets                       | No Change                           |
| Manhole                      | 1" - 6" Increase                    |
| Outfall                      | 6" - 12" Increase                   |
| Storm Drain                  | > 1' Increase                       |

Scenario ID: 267

ICON  
ENGINEERING





### **Appendix – Alternatives**

Various alternatives were developed to evaluate the pluvial flooding for the adjacent developments. A description of each alternative is included below with flooding depth figures for each respective scenario included in the Appendix.

#### ***Scenario 203 – Existing Site Grading – Existing Storm Drain***

Scenario 203 evaluates the existing conditions pluvial flooding depth north of Montview Boulevard.

#### ***Scenario 207 – Proposed Site Grading – Existing Storm Drain***

Scenario 207 incorporates the proposed site grading for both 2201 Clinton and Stanley Residential. This scenario does not include any proposed storm drain improvements. Increased discharges were observed compared to existing conditions in Dallas Street and Clinton Street north of 23<sup>rd</sup> Avenue due to the proposed site grading of the developments. Water surface elevations exceed the proposed finished floor elevations for both proposed developments.

#### ***Scenario 217 – Proposed Site Grading – Pr. 60” RCP in 22<sup>nd</sup> Ave.***

Scenario 217 proposes a 60” RCP storm drain from the 22<sup>nd</sup> Avenue and Dallas Street intersection west to Westerly Creek. The proposed improvements intercept ~200 cfs of surface flooding at 22<sup>nd</sup> Avenue and Dallas Street. The 60” RCP storm drain reduce the water surface elevations below the proposed finish flood elevations along Clinton Street for the 2201 Clinton development.

#### ***Scenario 227 – Proposed Site Grading – Pr. 60” RCP in 22<sup>nd</sup> Ave., Pr. 36” RCP in 23<sup>rd</sup> Ave.***

Scenario 227 proposes the 22<sup>nd</sup> Avenue 60” RCP with an additional 36” in Dallas Street north of 23<sup>rd</sup> Avenue. This scenario reduced the discharge in Dallas (140 cfs) below existing conditions (159 cfs) but the flow in Clinton (99 cfs) is still larger than the existing conditions (86 cfs) due to site grading.

#### ***Scenario 257 – Proposed Site Grading – Pr. 60” RCP in 22<sup>nd</sup> Ave., Pr. 48” RCP in 23<sup>rd</sup> Ave.***

Scenario 257 proposes a parallel 48” from the 23<sup>rd</sup> Avenue and Dallas Street intersection west to Westerly Creek. This scenario reduces street flow on Dallas and Clinton back to existing levels. A small amount of adverse flooding depth (0.1-0.2 ft) compared to existing were observed along Dallas in the street north of 23<sup>rd</sup>.

#### ***Scenario 267 – Proposed Site Grading – Pr. 60” RCP in 22<sup>nd</sup> Ave., 48” RCP to 60” RCP in 23<sup>rd</sup> Ave.***

Scenario 267 increases the downstream capacity of Scenario 257 by increasing the storm drain from Clinton Street to the west to 60” RCP. The additional capacity eliminated the small adverse impacts observed on Dallas Street north of 23<sup>rd</sup> Avenue but did not reduce the WSEL below the finished floor without additional site changes.

#### ***Scenario 277 – Proposed Site Grading – Pr. 60” RCP in 22<sup>nd</sup> Ave., 8’ x 5’ RCBC in 23<sup>rd</sup> Ave.***

Scenario 277 proposes an 8 ft. x 5 ft. RCBC was modeled from the Dallas Street intersection west along 23<sup>rd</sup> Avenue. The additional intercept flows resulted in proposed water surface elevations beneath existing conditions the study area. Sheet flow was still observed to overtop 23<sup>rd</sup> Avenue and enter the eastern pad of the Stanley Residential site.

#### ***Scenario 287 – Proposed Site Grading – Pr. 60” RCP in 22<sup>nd</sup> Ave, 12’ x 5’ RCBC in 23<sup>rd</sup> Ave.***

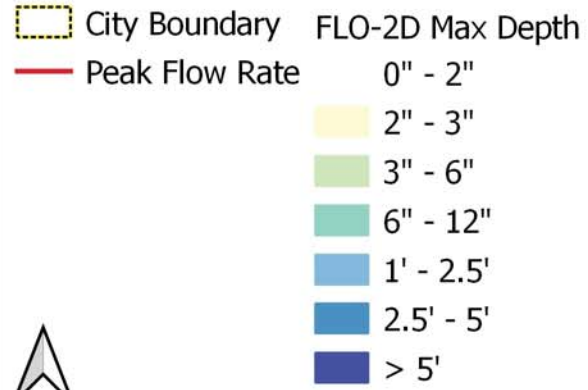
Scenario 287 increases the proposed infrastructure in 23<sup>rd</sup> Avenue to eliminate the overtopping flow into the eastern pad of the Stanley Residential site. In addition to the 22<sup>nd</sup> Avenue Outfall, a 12’ x 5’ RCBC is proposed in 23<sup>rd</sup> Avenue, intercepting approximately 385 cfs. This scenario intercepts the most surface flow of any alternative, resulting in the lowest water surface elevations, and flooding risk of any alternative.



# Westerly Creek at Stanley Marketplace



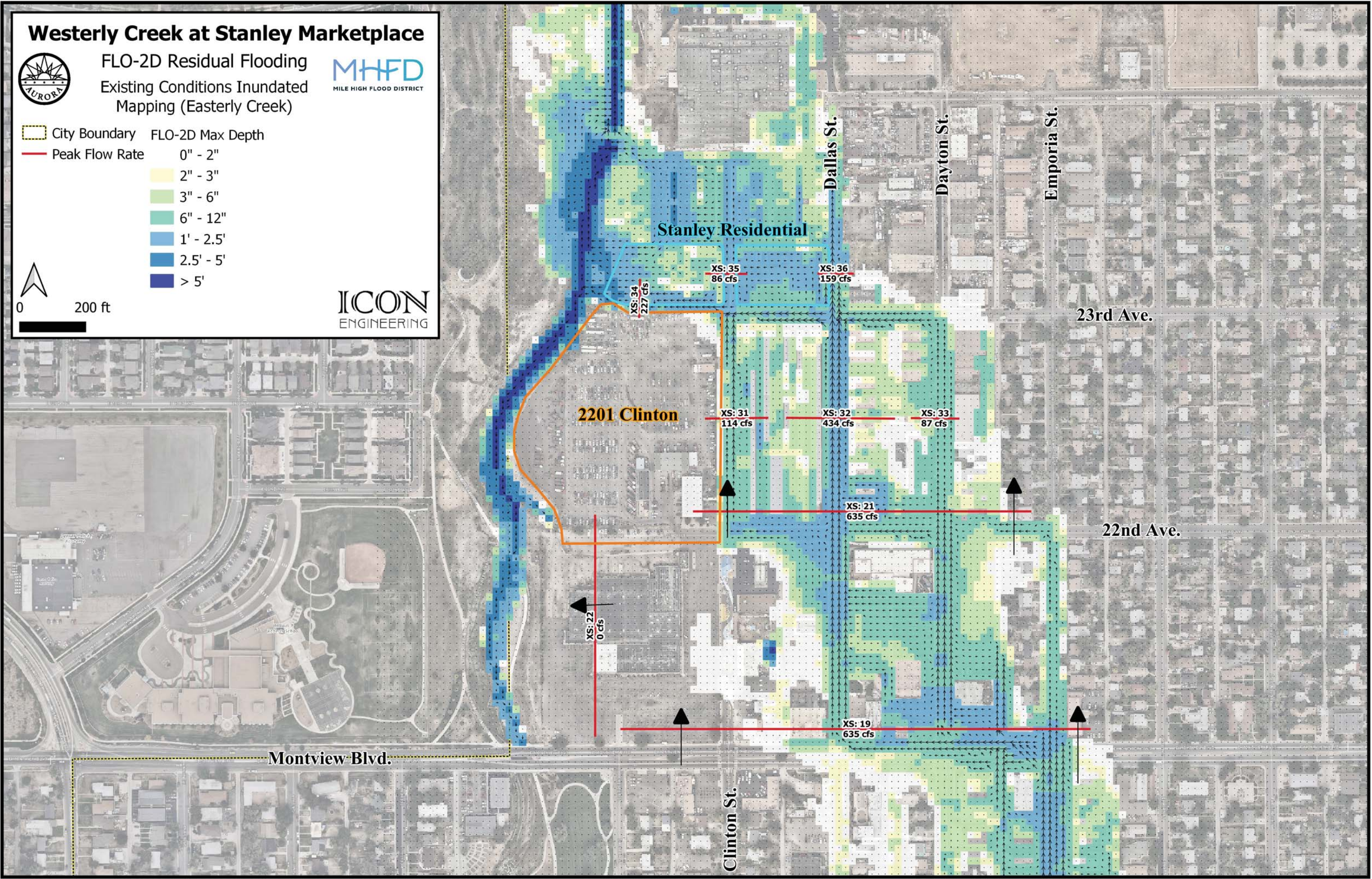
FLO-2D Residual Flooding  
Existing Conditions Inundated  
Mapping (Easterly Creek)



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ENGINEERING



0 200 ft





# Westerly Creek at Stanley Marketplace



FLO-2D Residual Flooding



Proposed Development Grading with  
No Storm Drain Improvements

City Boundary

Peak Flow Rate

Proposed Site Grading

FLO-2D Max Depth

0" - 2"

2" - 3"

3" - 6"

6" - 12"

1' - 2.5'

2.5' - 5'

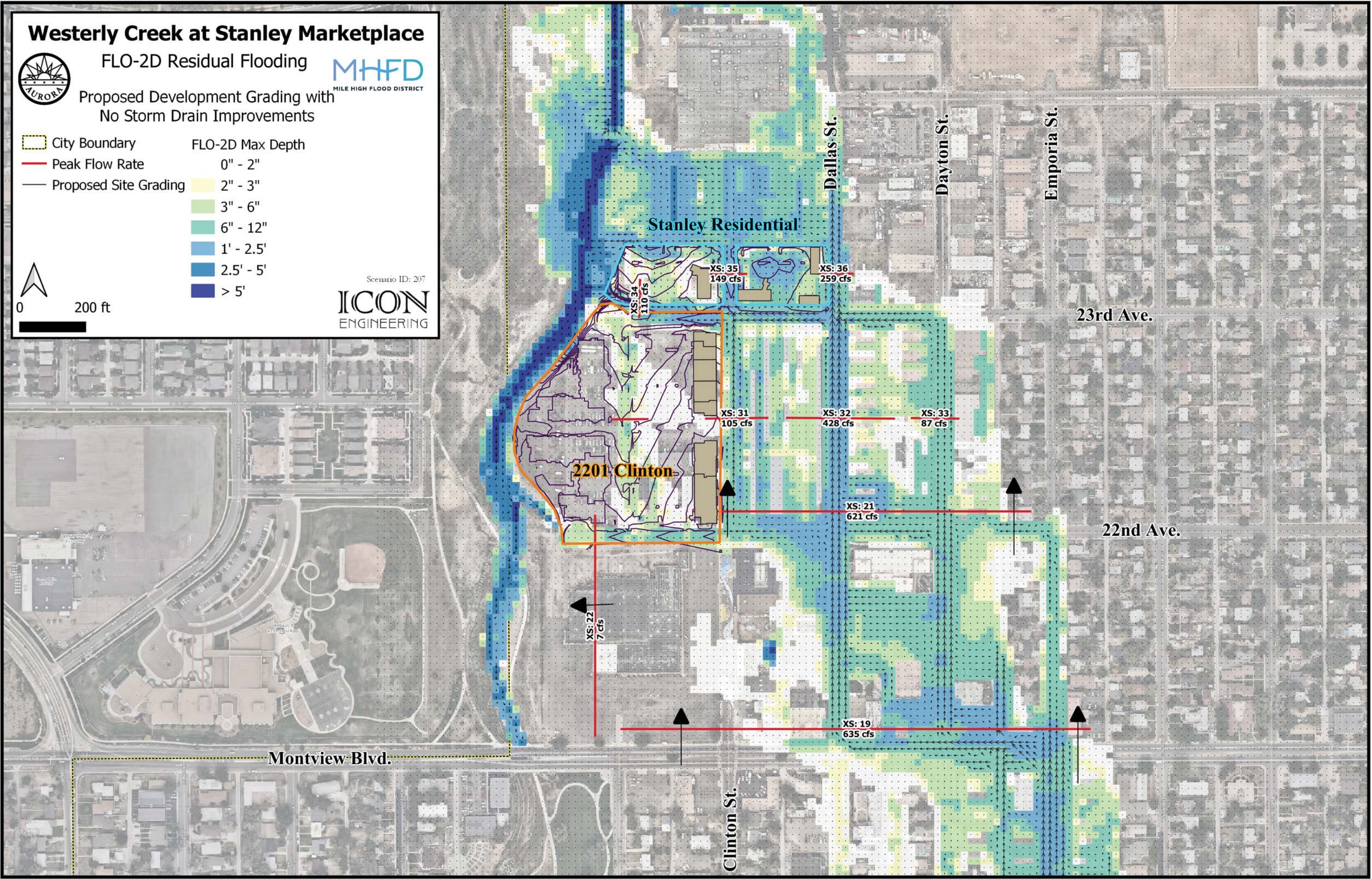
> 5'

Scenario ID: 207

ICON  
ENGINEERING



0 200 ft





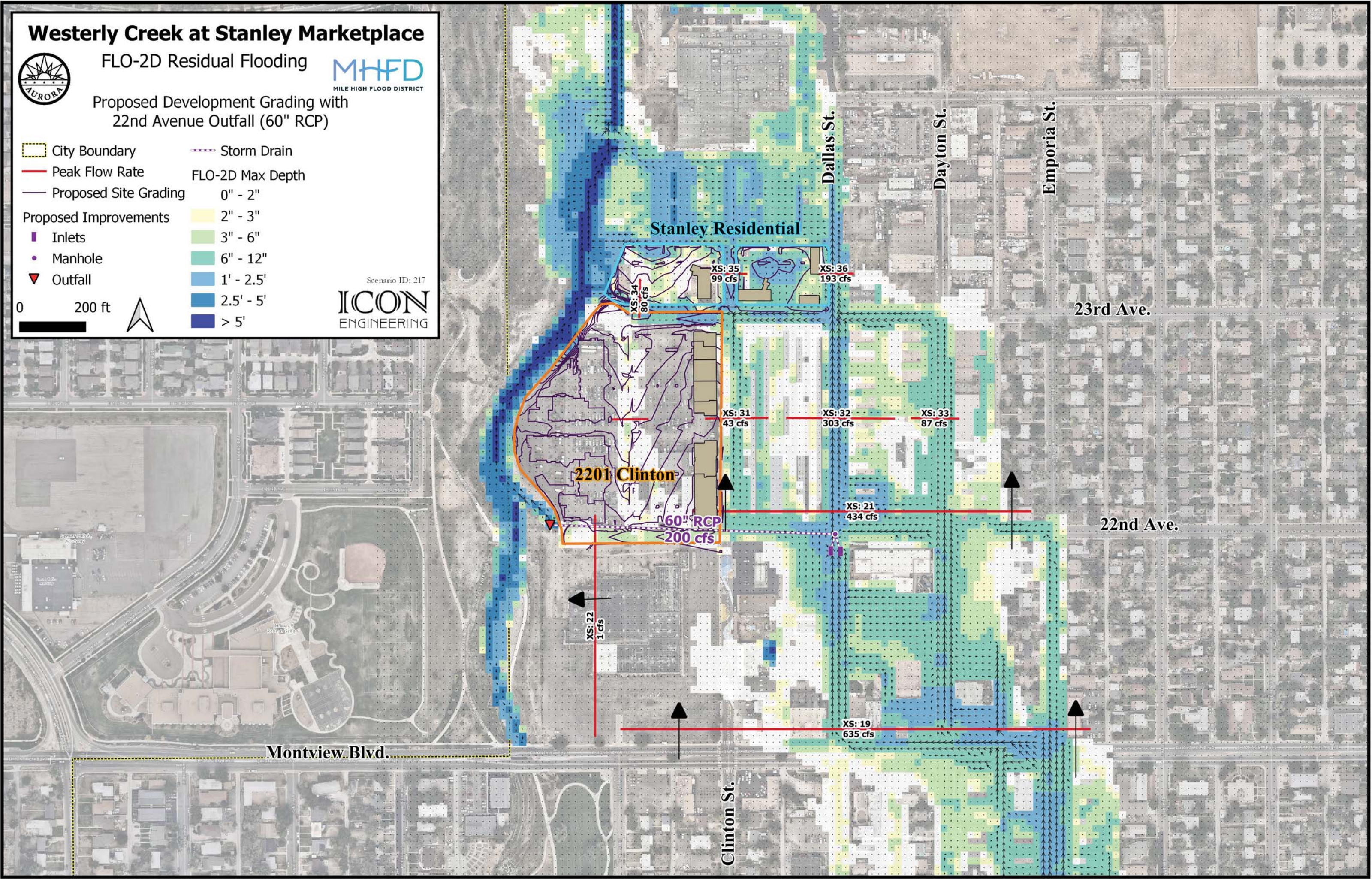
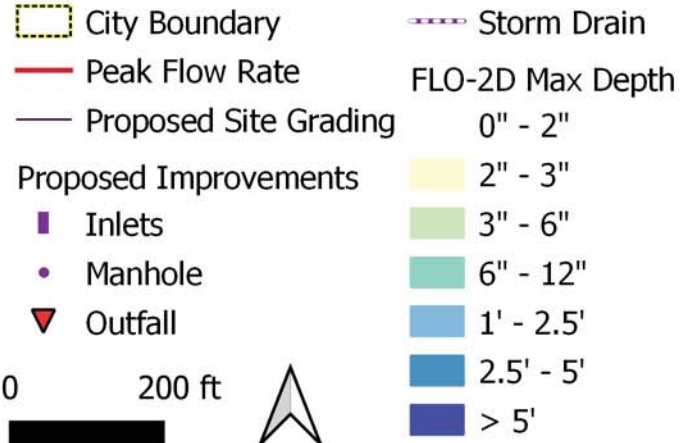
# Westerly Creek at Stanley Marketplace



FLO-2D Residual Flooding



Proposed Development Grading with  
22nd Avenue Outfall (60" RCP)





# Westerly Creek at Stanley Marketplace



FLO-2D Residual Flooding

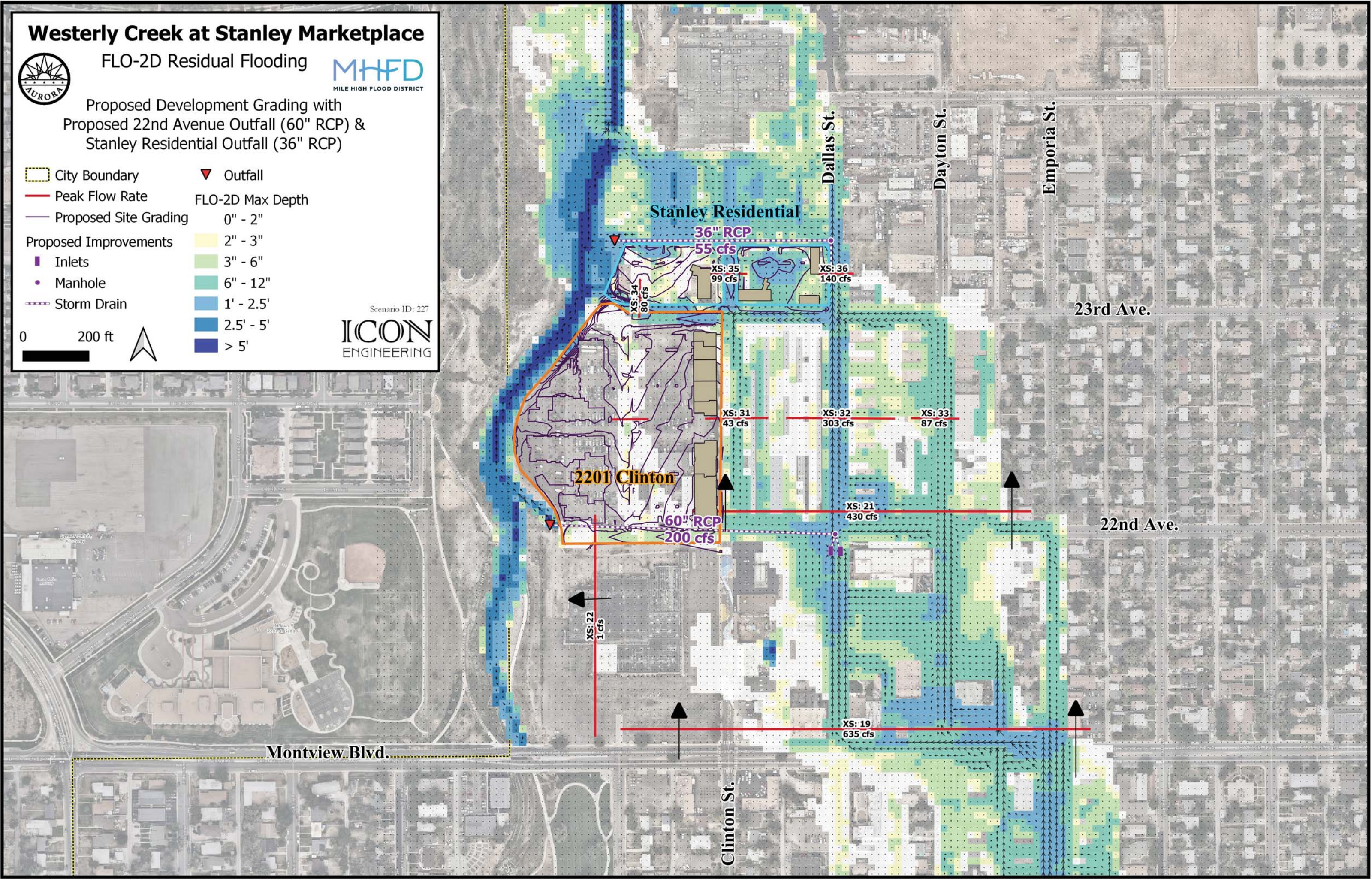


Proposed Development Grading with  
Proposed 22nd Avenue Outfall (60" RCP) &  
Stanley Residential Outfall (36" RCP)

- City Boundary
- Peak Flow Rate
- Proposed Site Grading
- Proposed Improvements
- Inlets
- Manhole
- Storm Drain
- Outfall
- FLO-2D Max Depth
  - 0" - 2"
  - 2" - 3"
  - 3" - 6"
  - 6" - 12"
  - 1' - 2.5'
  - 2.5' - 5'
  - > 5'

Scenario ID: 227

ICON  
ENGINEERING





# Westerly Creek at Stanley Marketplace



FLO-2D Residual Flooding

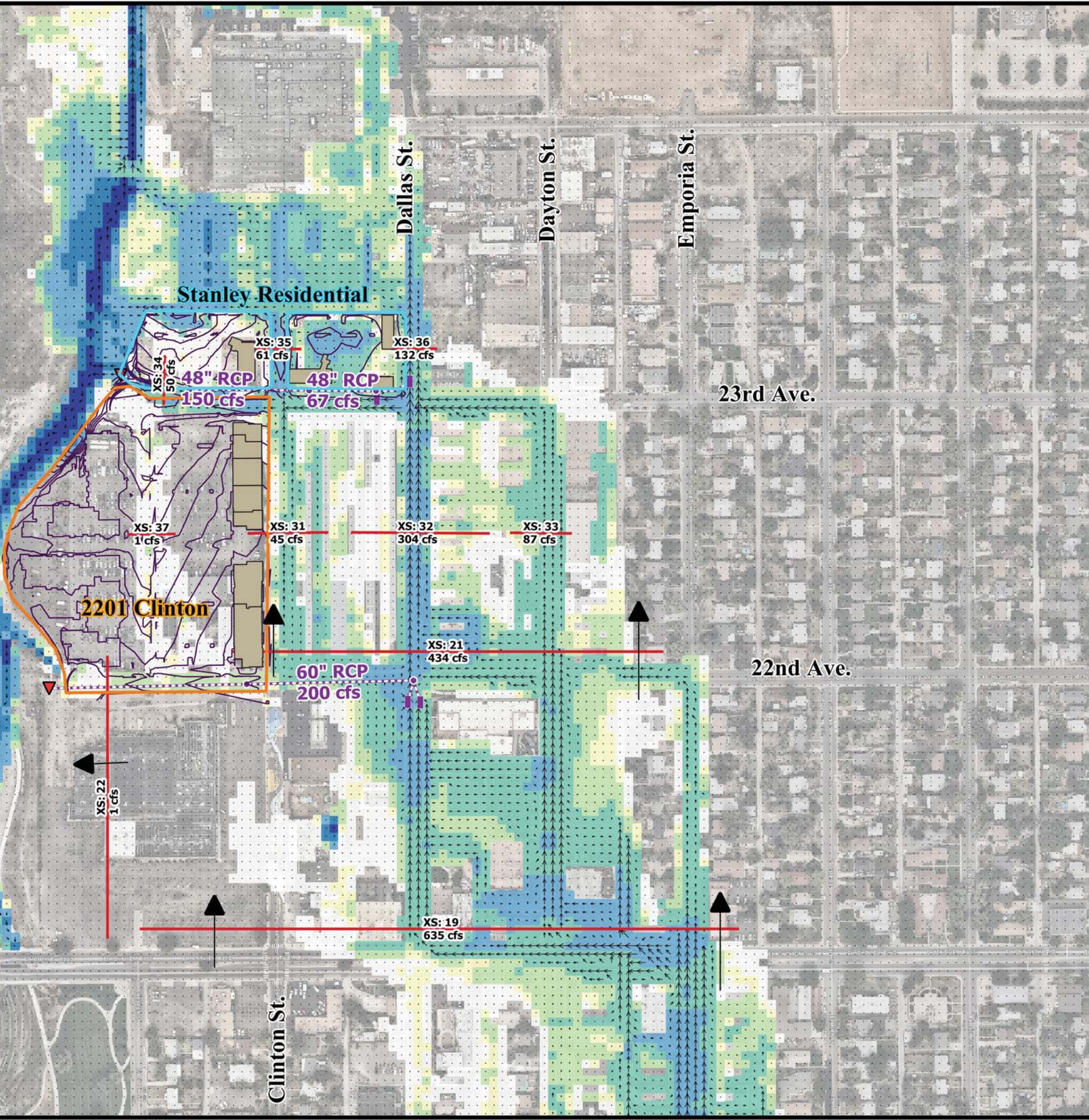


Proposed Development Grading with  
Proposed 22nd Avenue Outfall (60" RCP) &  
Stanley Residential Outfall (48" RCP)

- City Boundary
- Peak Flow Rate
- Proposed Site Grading
- Proposed Improvements
- Inlets
- Manhole
- Storm Drain
- Outfall
- FLO-2D Max Depth
  - 0" - 2"
  - 2" - 3"
  - 3" - 6"
  - 6" - 12"
  - 1' - 2.5'
  - 2.5' - 5'
  - > 5'

Scenario ID: 257

ICON  
ENGINEERING







MILE HIGH FLOOD DISTRICT

 City Boundary

▼ Outfall

— Peak Flow Rate

FLO-2D Max Depth

— Proposed Site Grading

0" - 2"

## Proposed Improvements

2" - 3"

- Inlets

3" - 6"

- Manhole

■ 6" - 12"

 Storm Drain

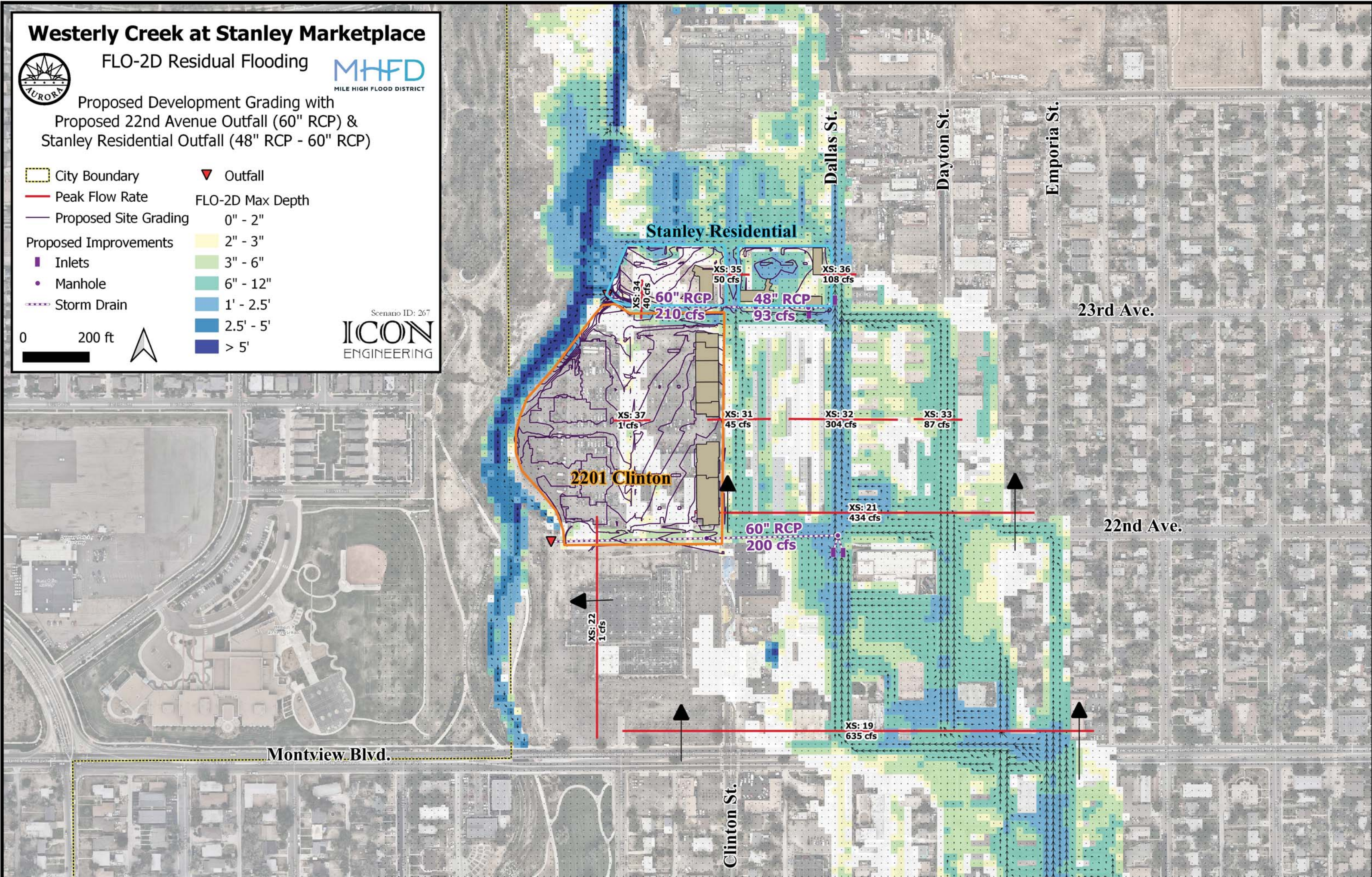
■ 1' - 2.5'

0 200 ft



Scenario ID: 267

ICON  
ENGINEERING





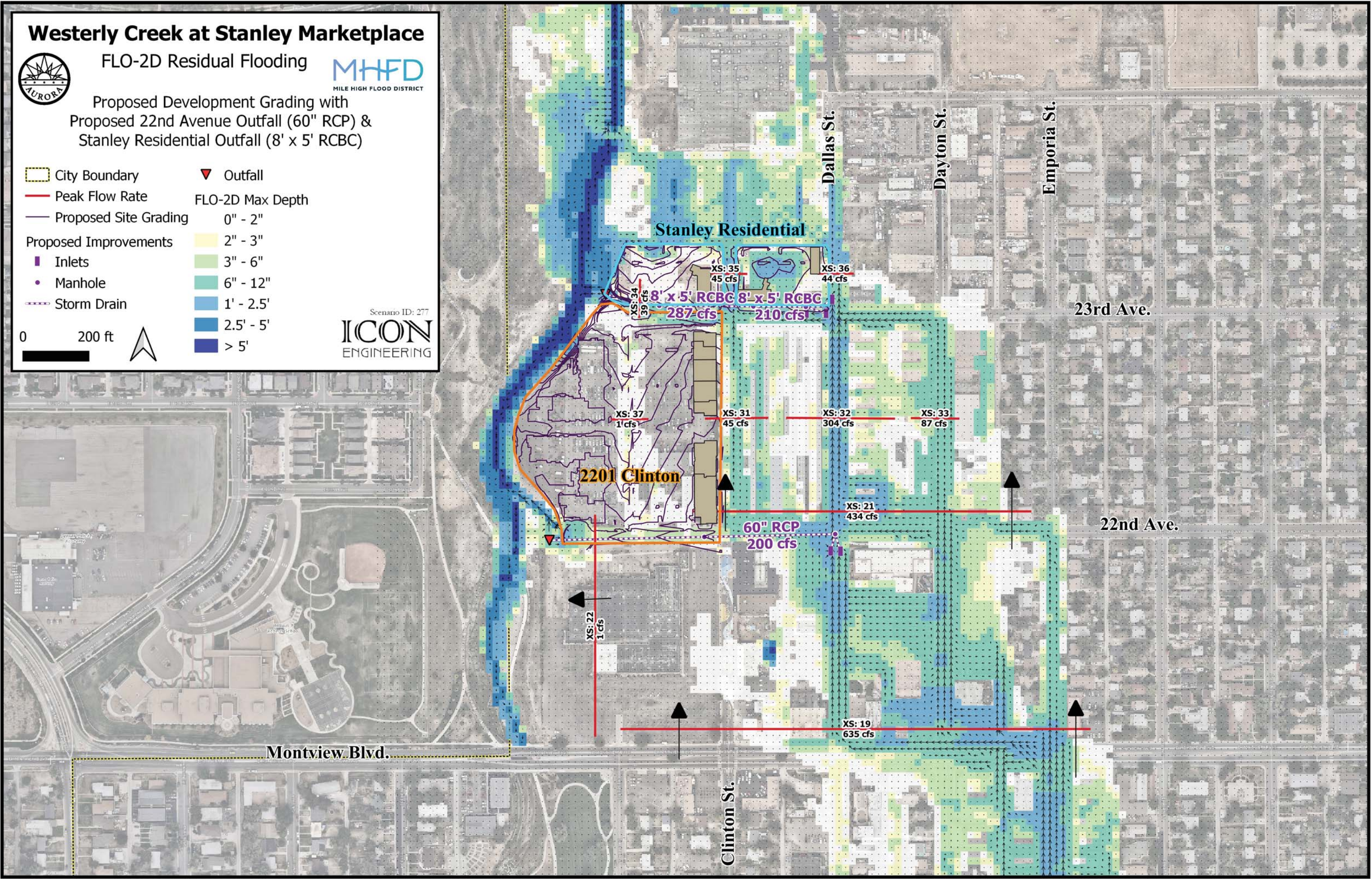
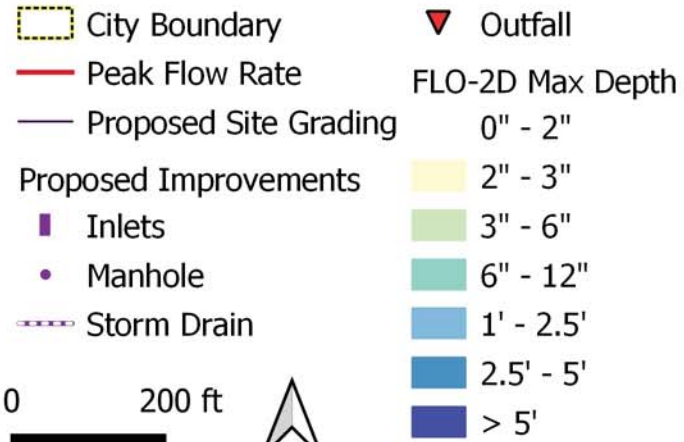
# Westerly Creek at Stanley Marketplace



FLO-2D Residual Flooding



Proposed Development Grading with  
Proposed 22nd Avenue Outfall (60" RCP) &  
Stanley Residential Outfall (8' x 5' RCBC)





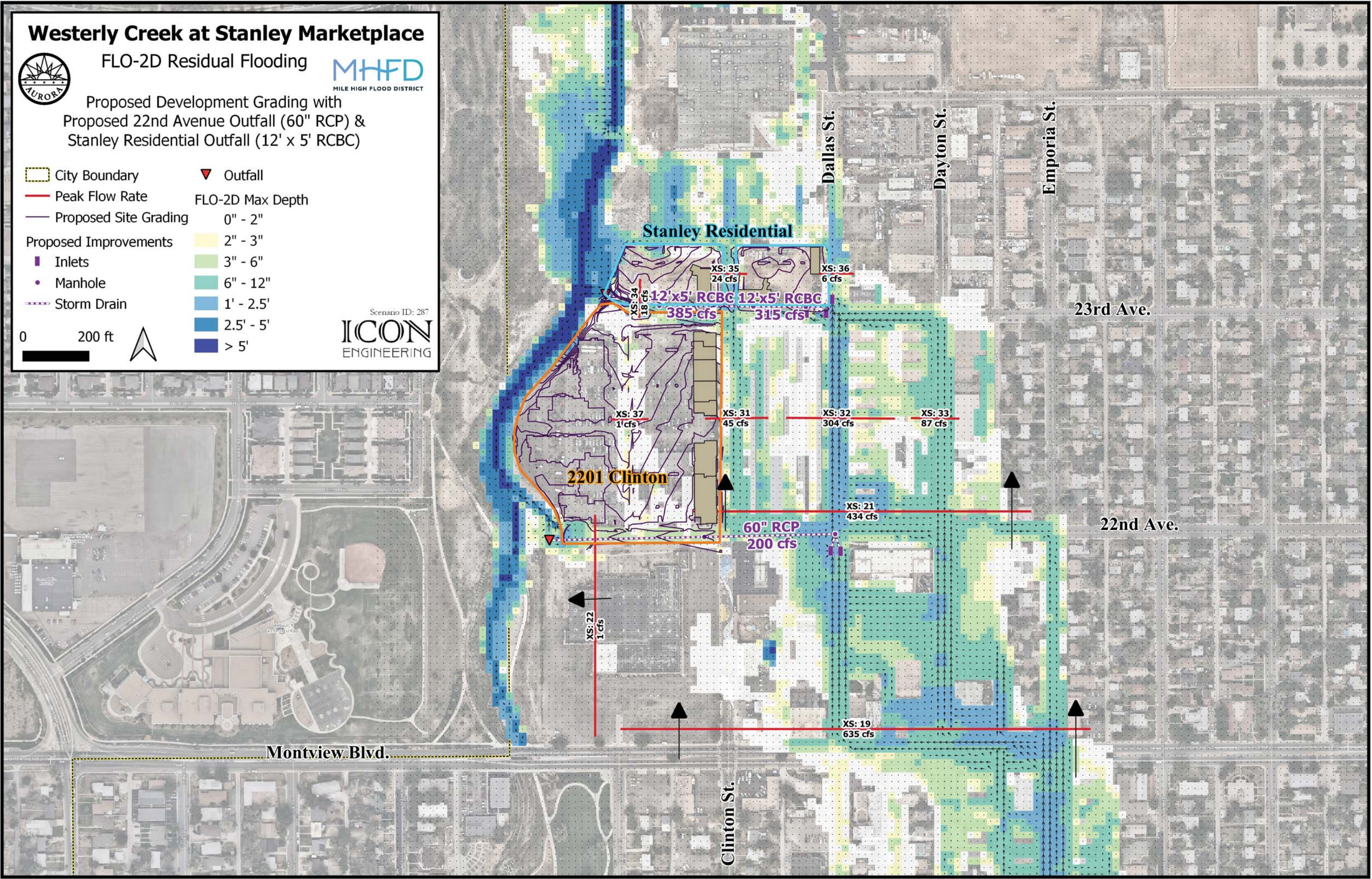
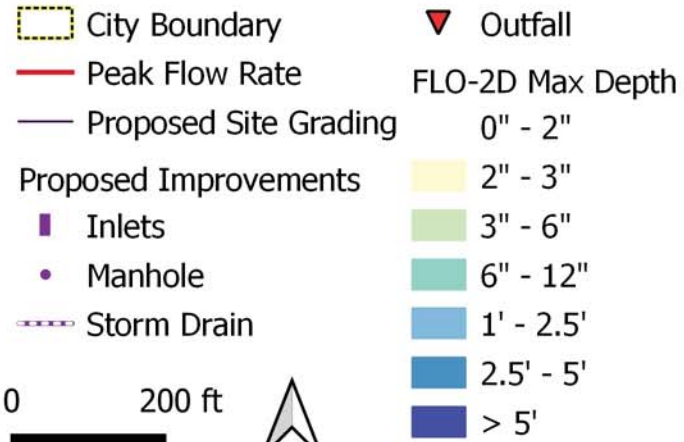
# Westerly Creek at Stanley Marketplace



FLO-2D Residual Flooding



Proposed Development Grading with  
Proposed 22nd Avenue Outfall (60" RCP) &  
Stanley Residential Outfall (12' x 5' RCBC)



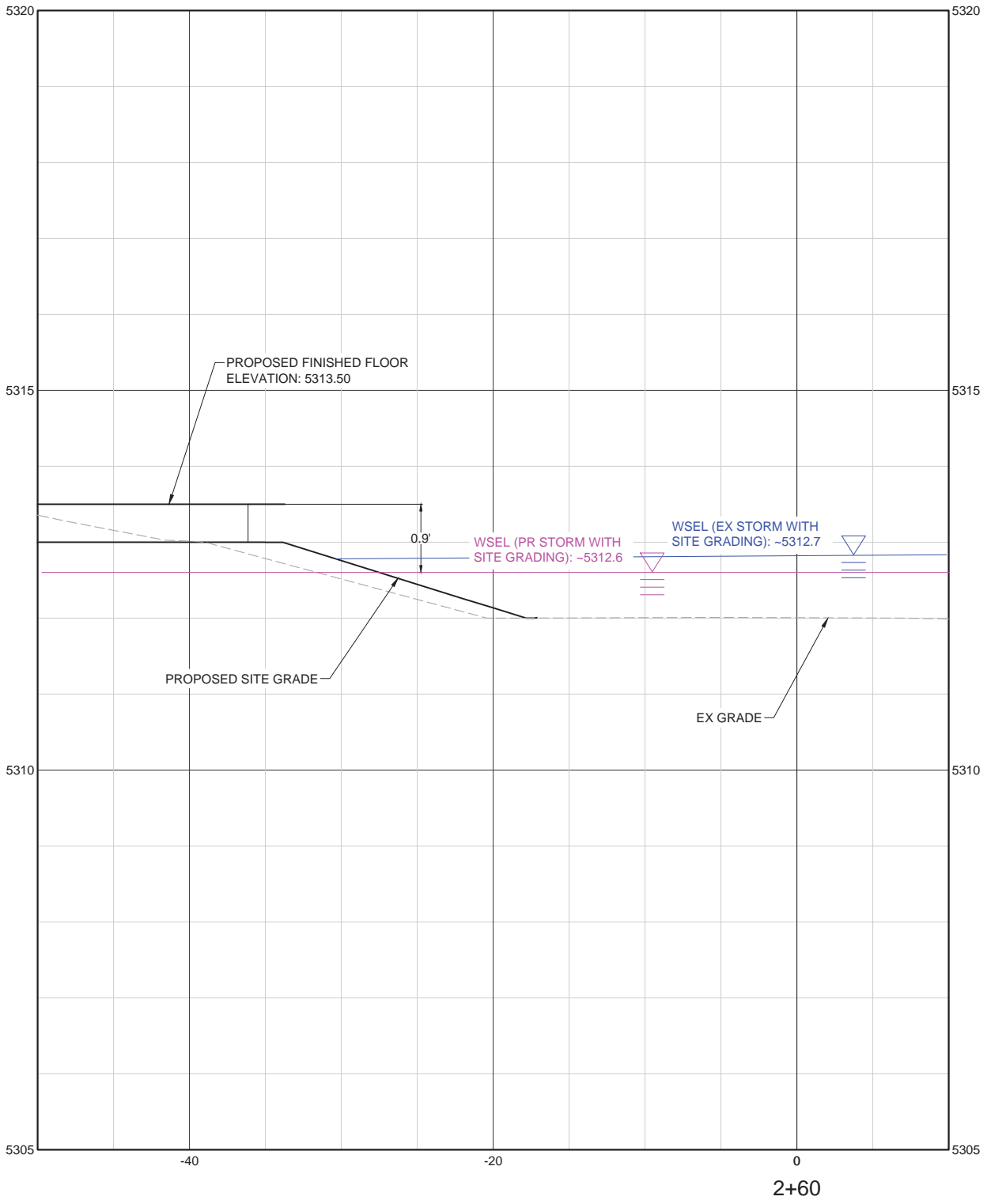
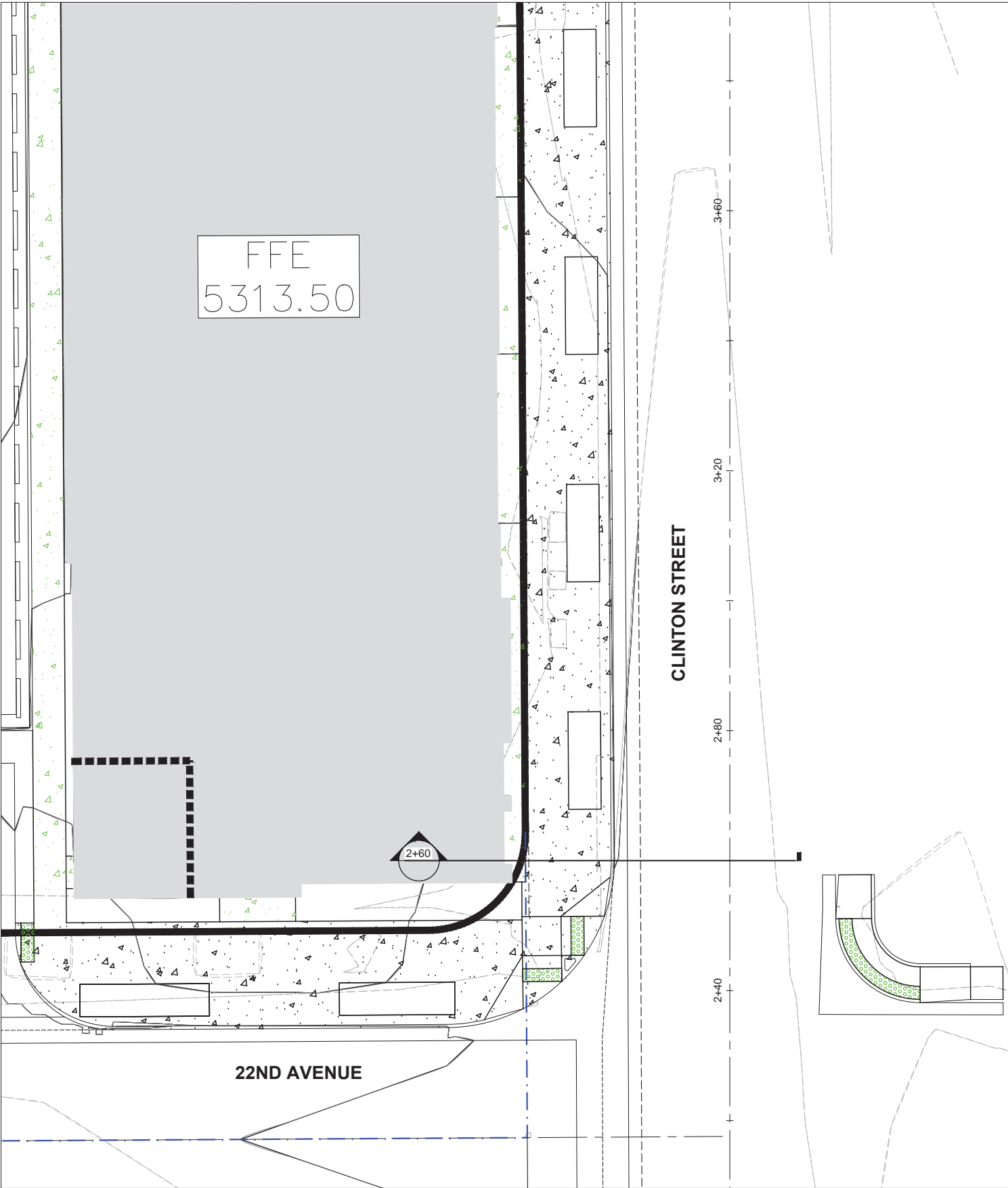


## **Appendix – 2201 Clinton WSEL Cross Sections**

Cross sections were developed for each building along Clinton Street for the 2201 Clinton development. The cross sections show the existing and proposed water surface elevations in comparison to the proposed finished floor elevations. Each cross section was placed at the proposed building opening. As seen in the cross sections on the following pages, the storm drain improvements in 22<sup>nd</sup> Avenue (60" RCP) reduce water surface elevations along Clinton Street beneath the proposed finished floor elevations for each structure.

Similar analysis was completed for the Stanley Residential site. This information is not included as it has been superseded by information developed by the Stanley Residential development design team to ensure all proposed finish floor elevations are above the 100-year design storm water surface elevation.

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APPROVED BY:	



PREPARED FOR:

**M+HFD**

**MILE HIGH FLOOD DISTRICT**

PREPARED BY:

**ICON ENGINEERING**

**stream**

landscape architecture + planning

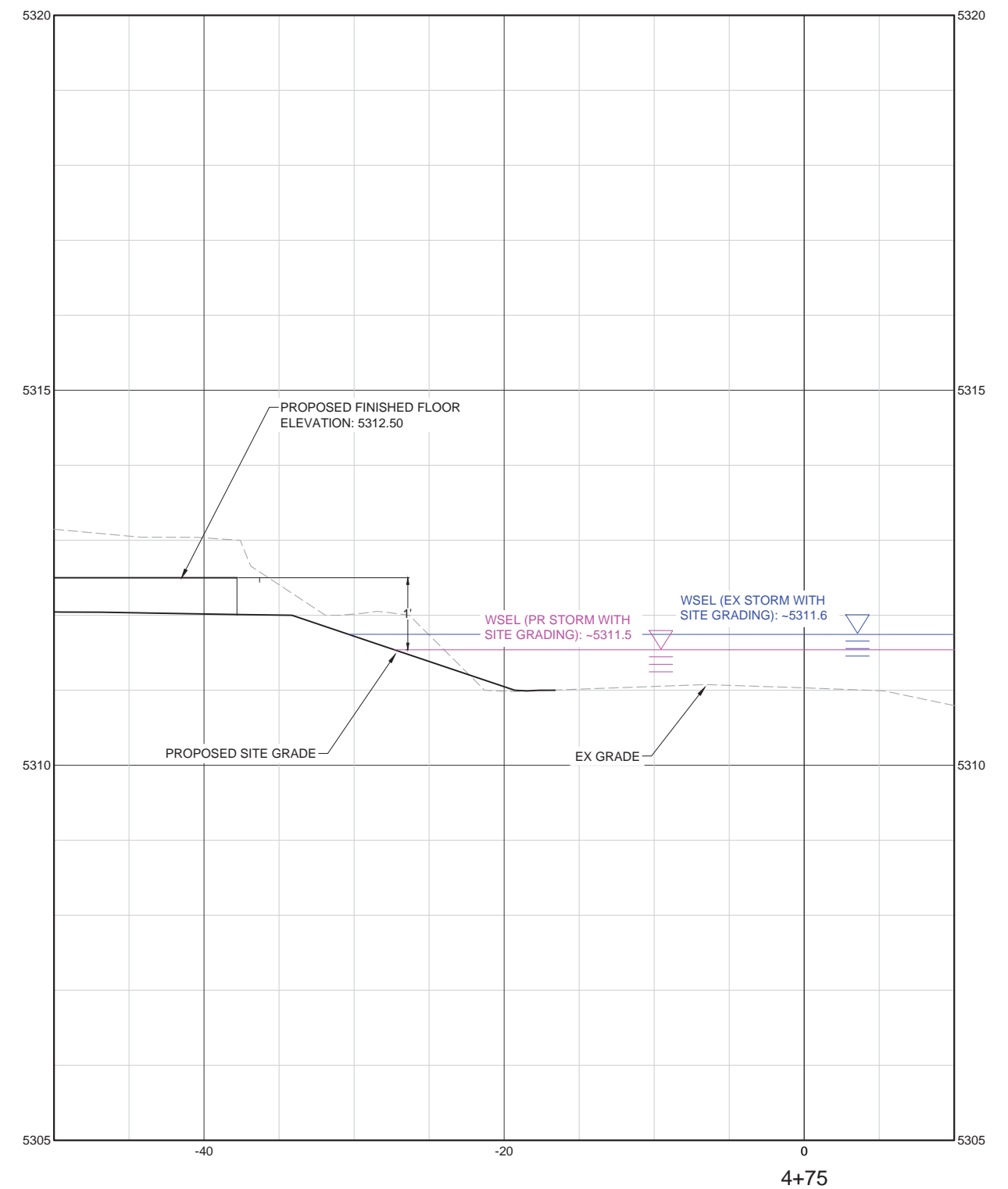
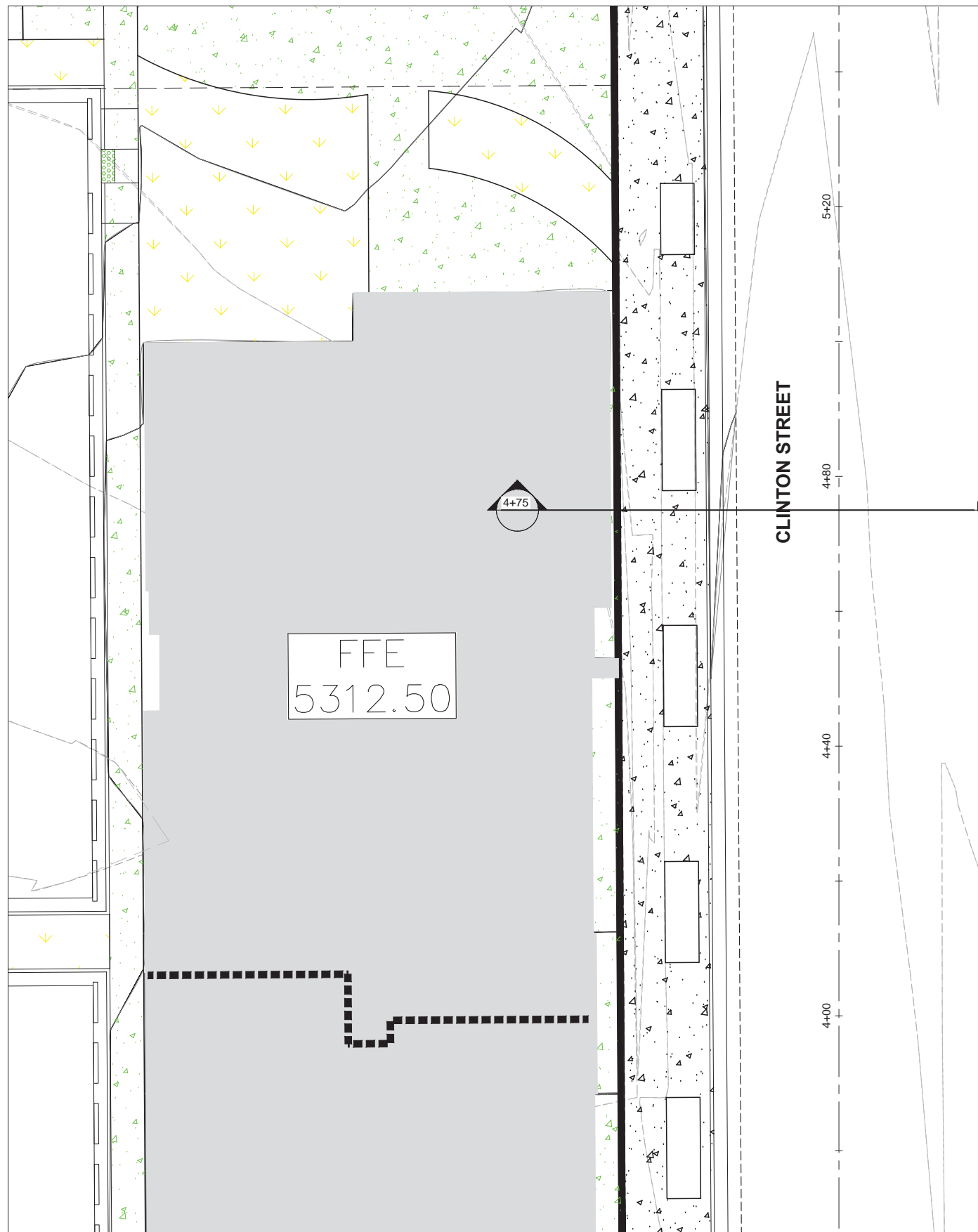
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Centennial, CO 80112  
Phone (303) 221-0902

**WESTERLY CREEK AT STANLEY MARKETPLACE**

2201 CLINTON DEVELOPMENT

PROPOSED FLO-2D WSEL FFE COMPARSION - STA 2+60

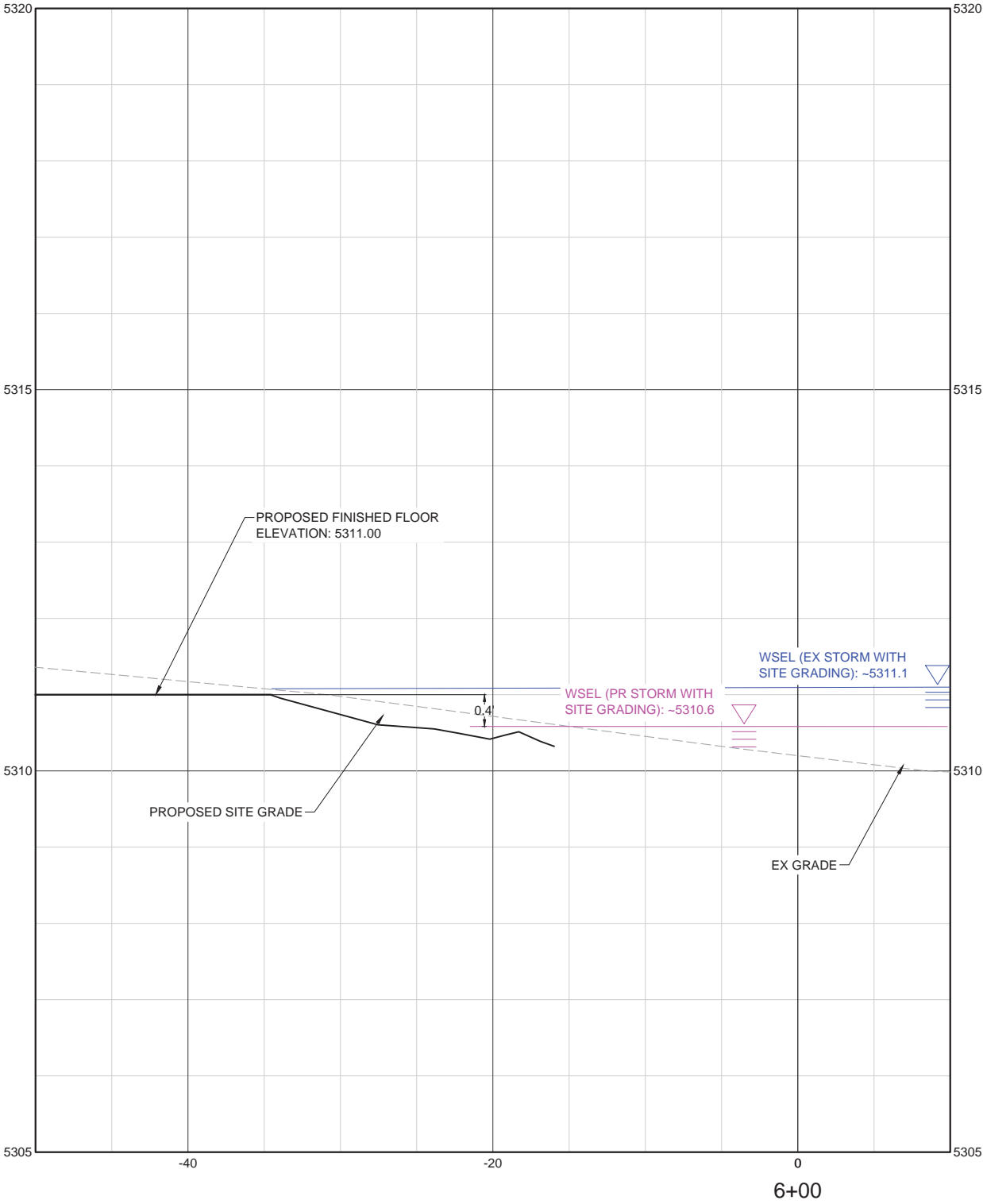
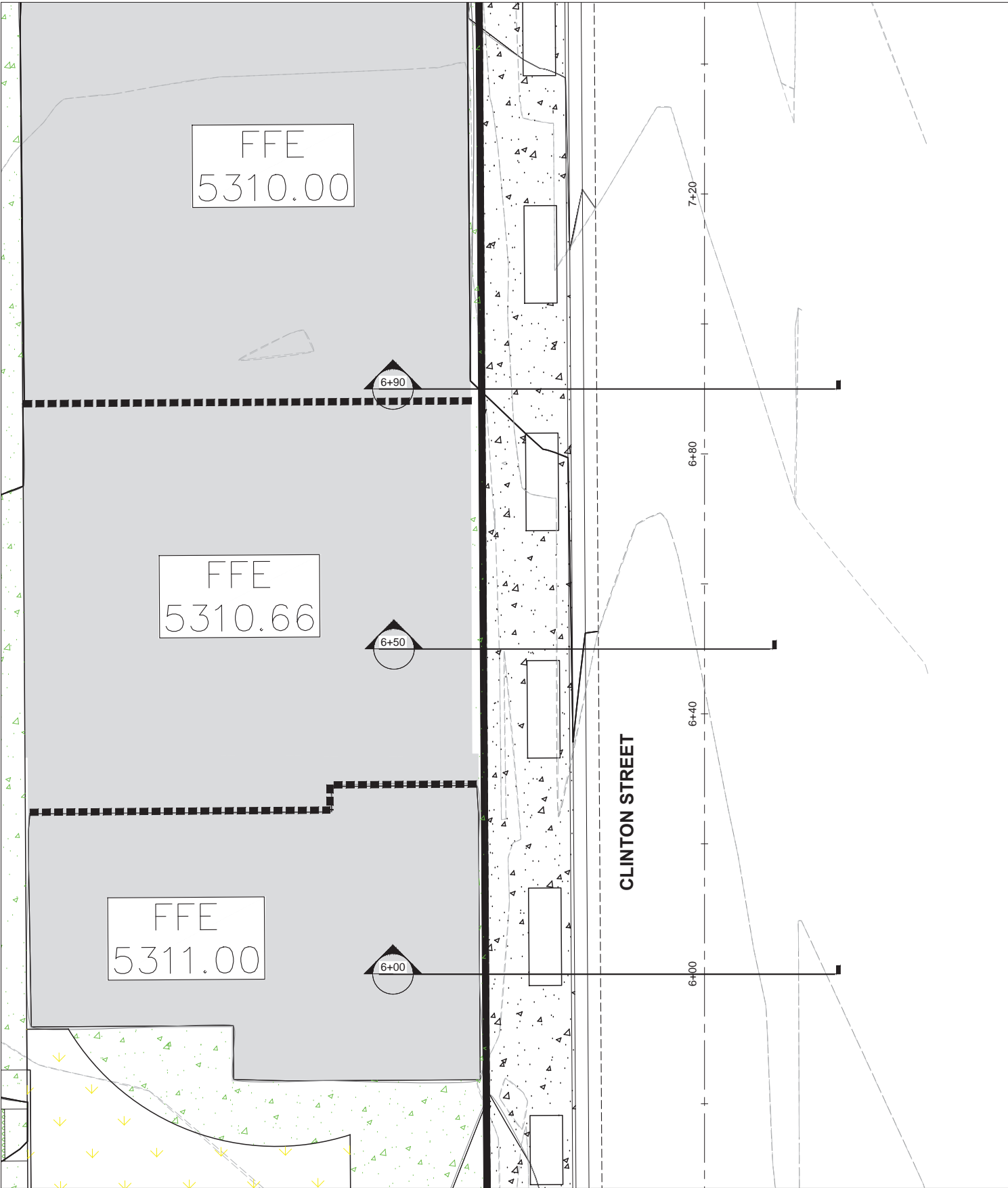
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PREPARED FOR:

MILE HIGH FLOOD DISTRICT

PREPARED BY:

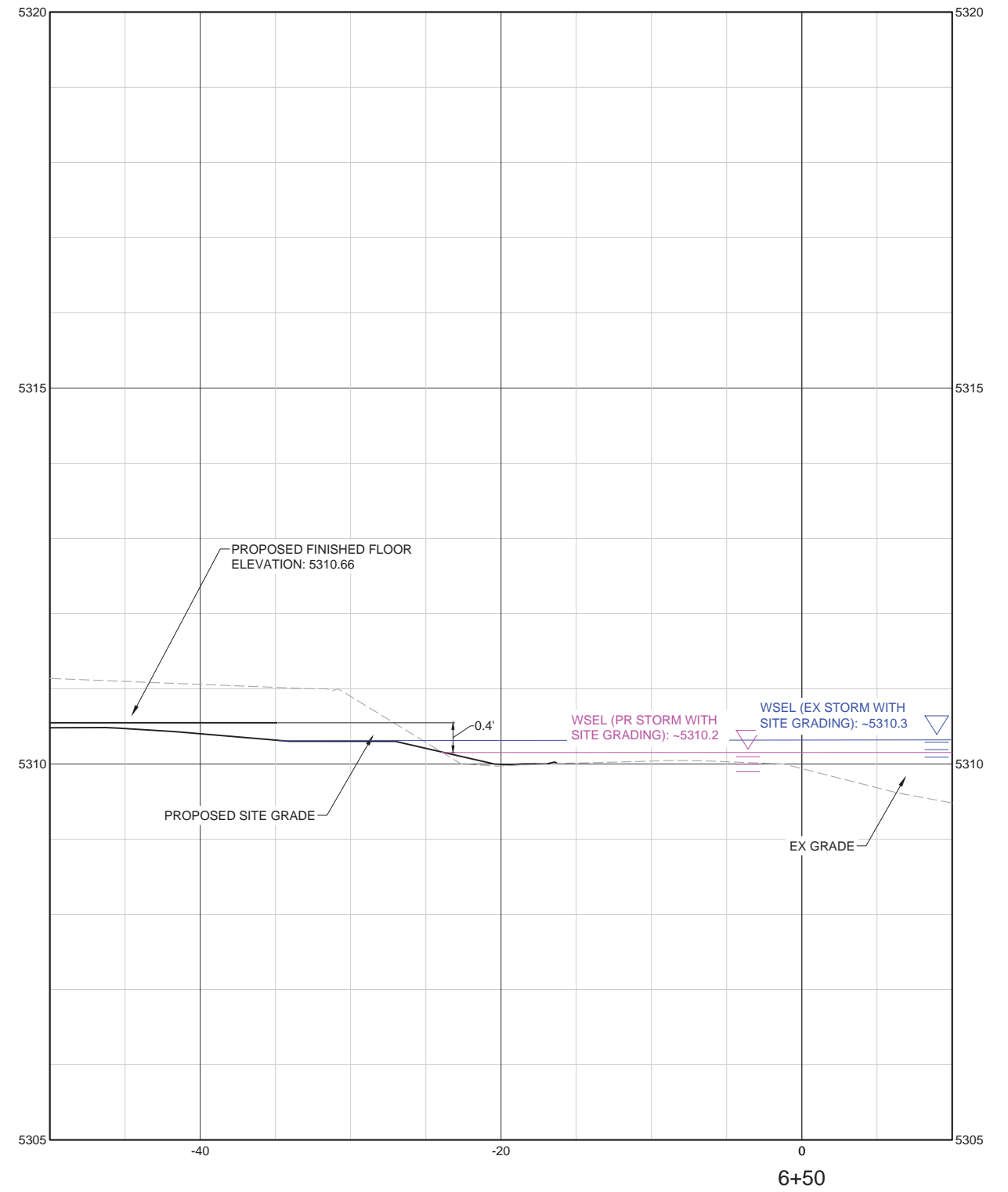
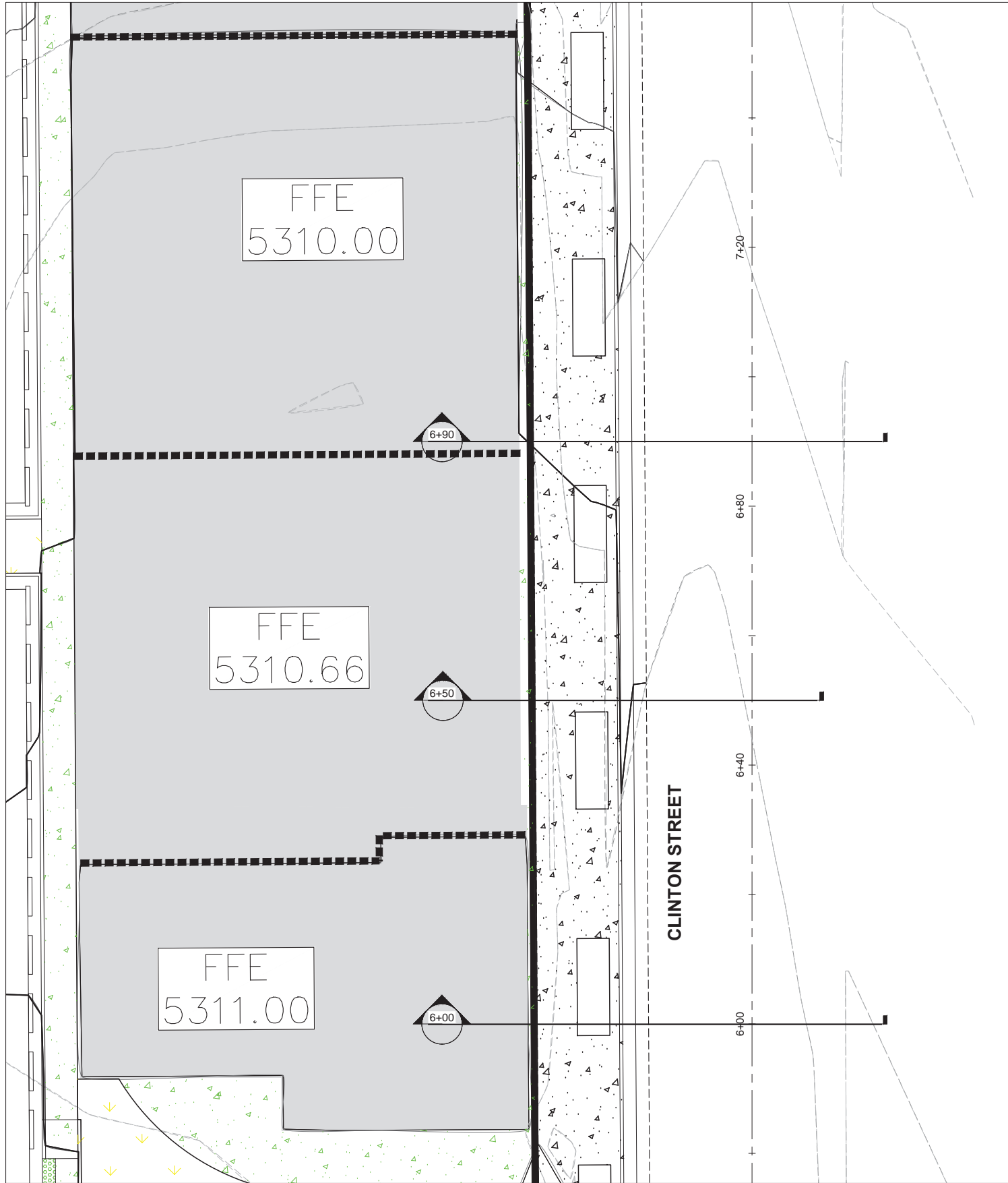
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WESTERLY CREEK AT STANLEY MARKETPLACE	
2201 CLINTON DEVELOPMENT	
PROPOSED FLO-2D WSEL FFE COMPARSION - STA 6+00	

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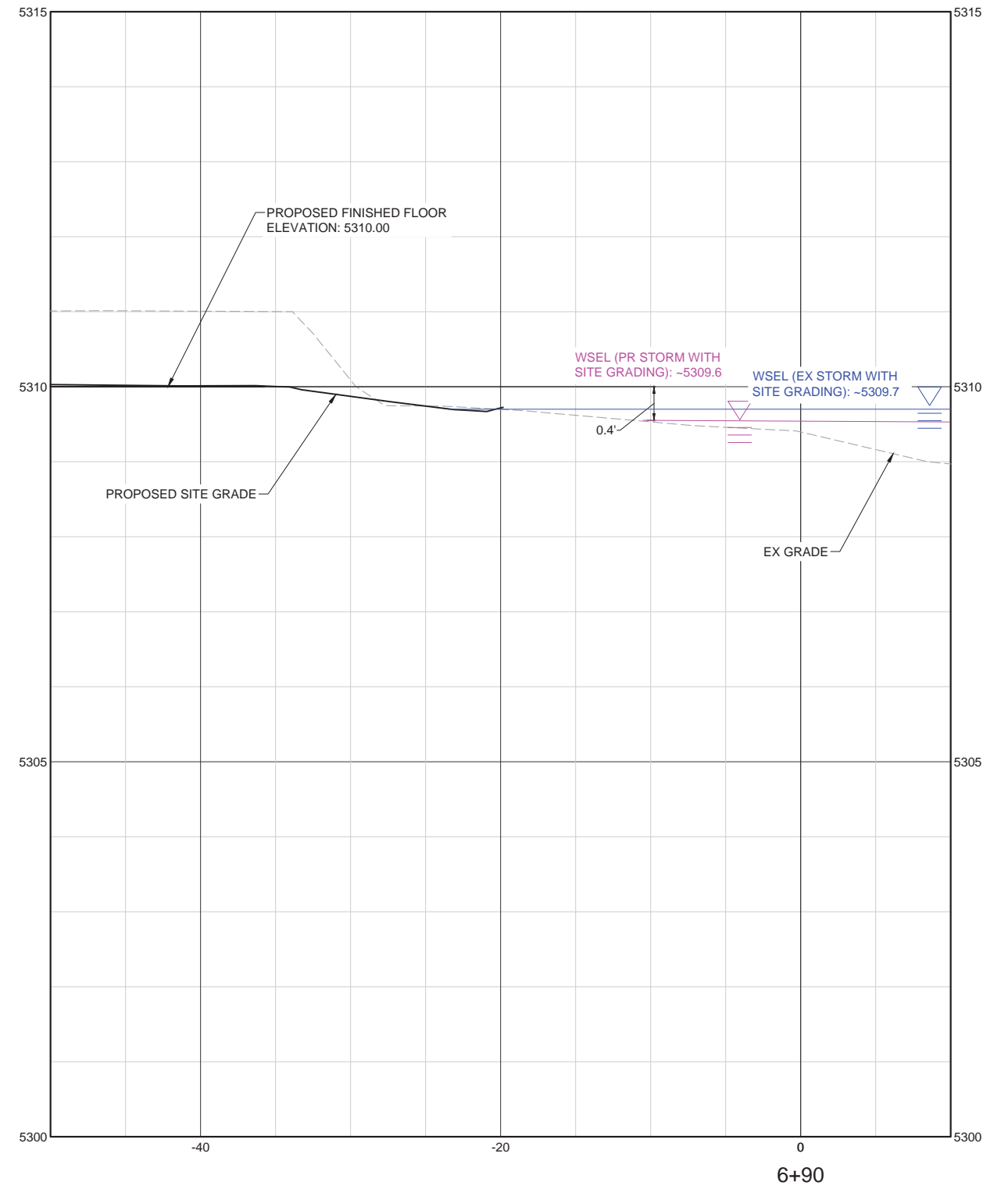
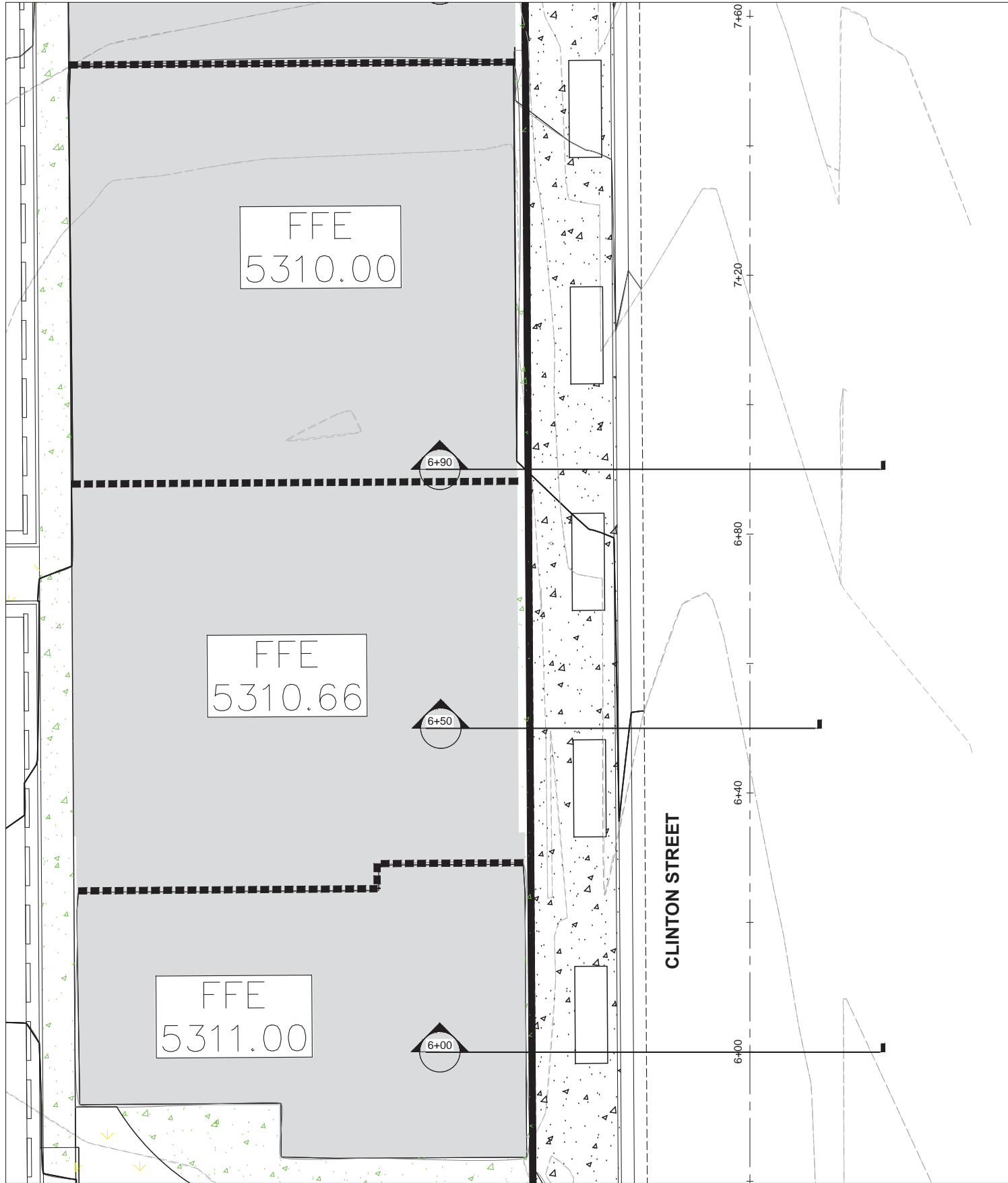
**WESTERLY CREEK AT STANLEY MARKETPLACE**

2201 CLINTON DEVELOPMENT

PROPOSED FLO-2D WSEL FFE COMPARSION - STA 6+50

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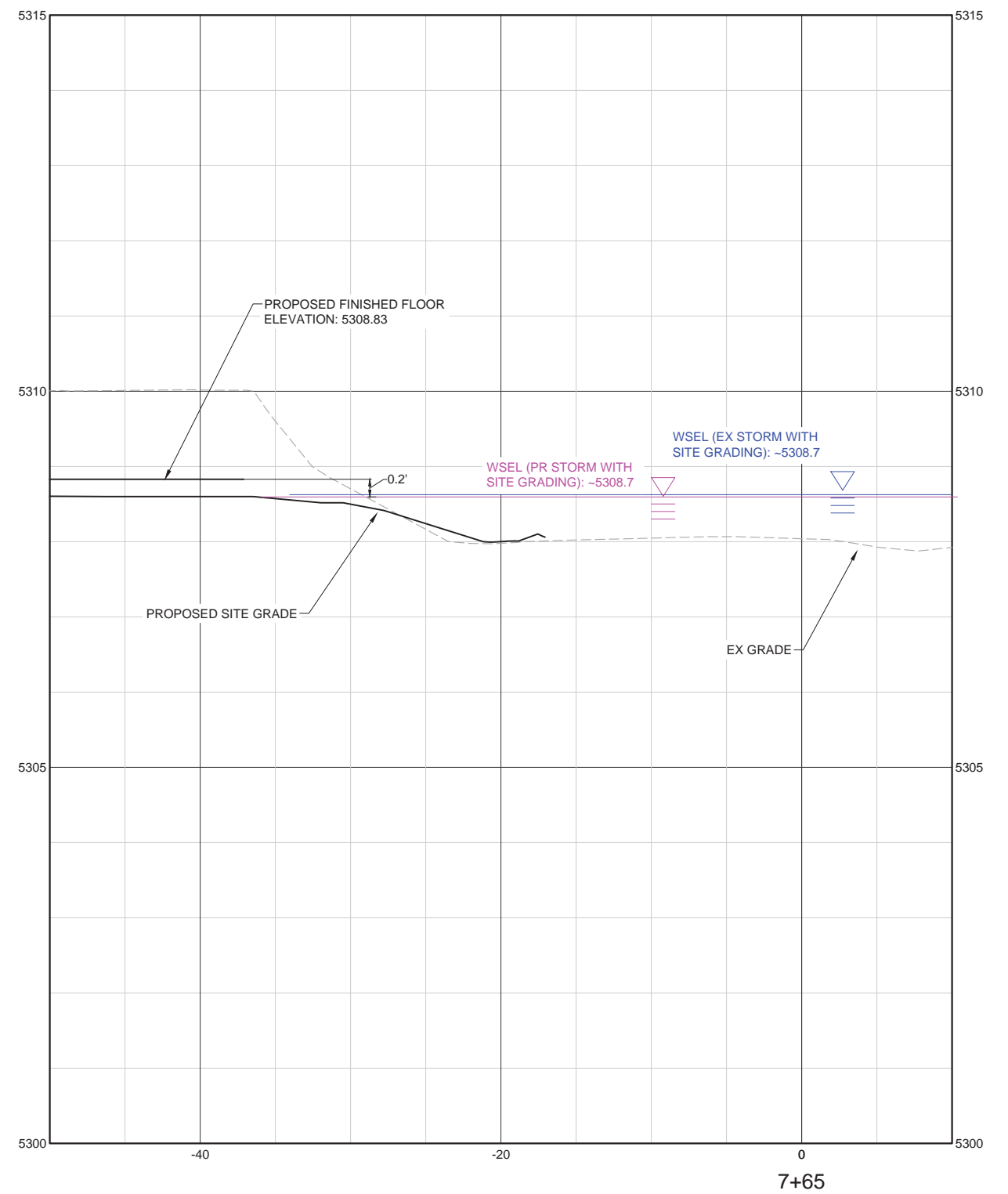
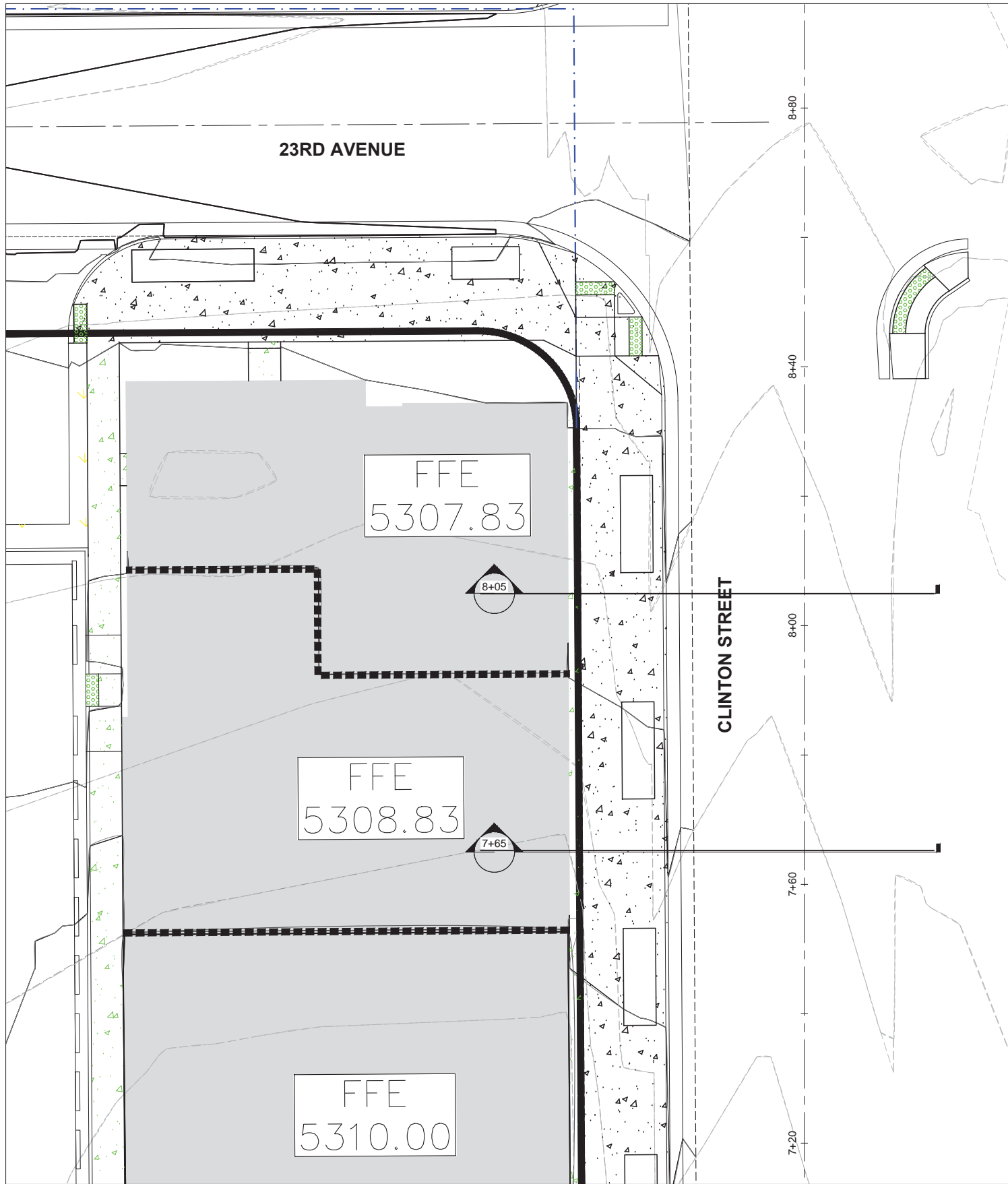
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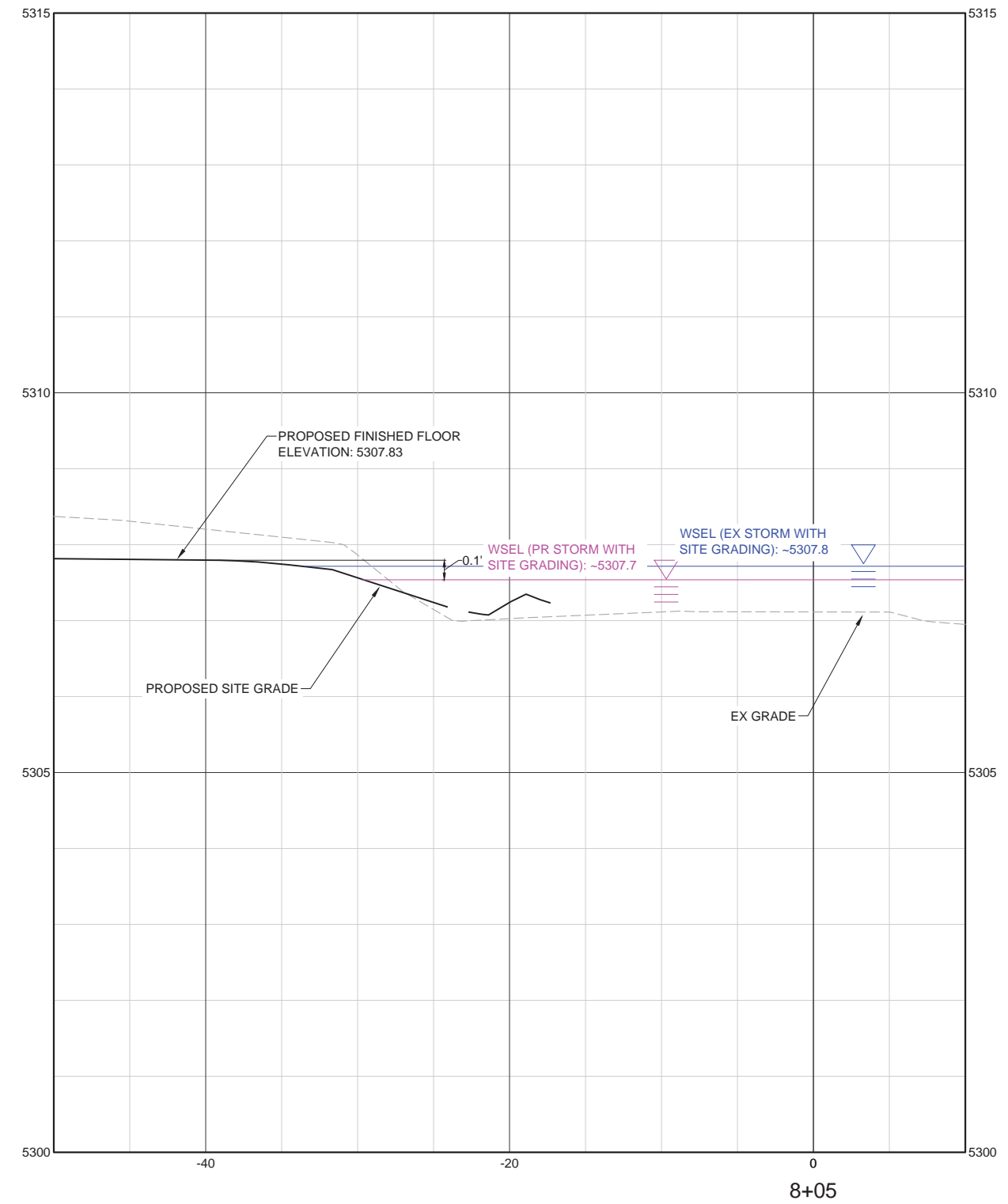
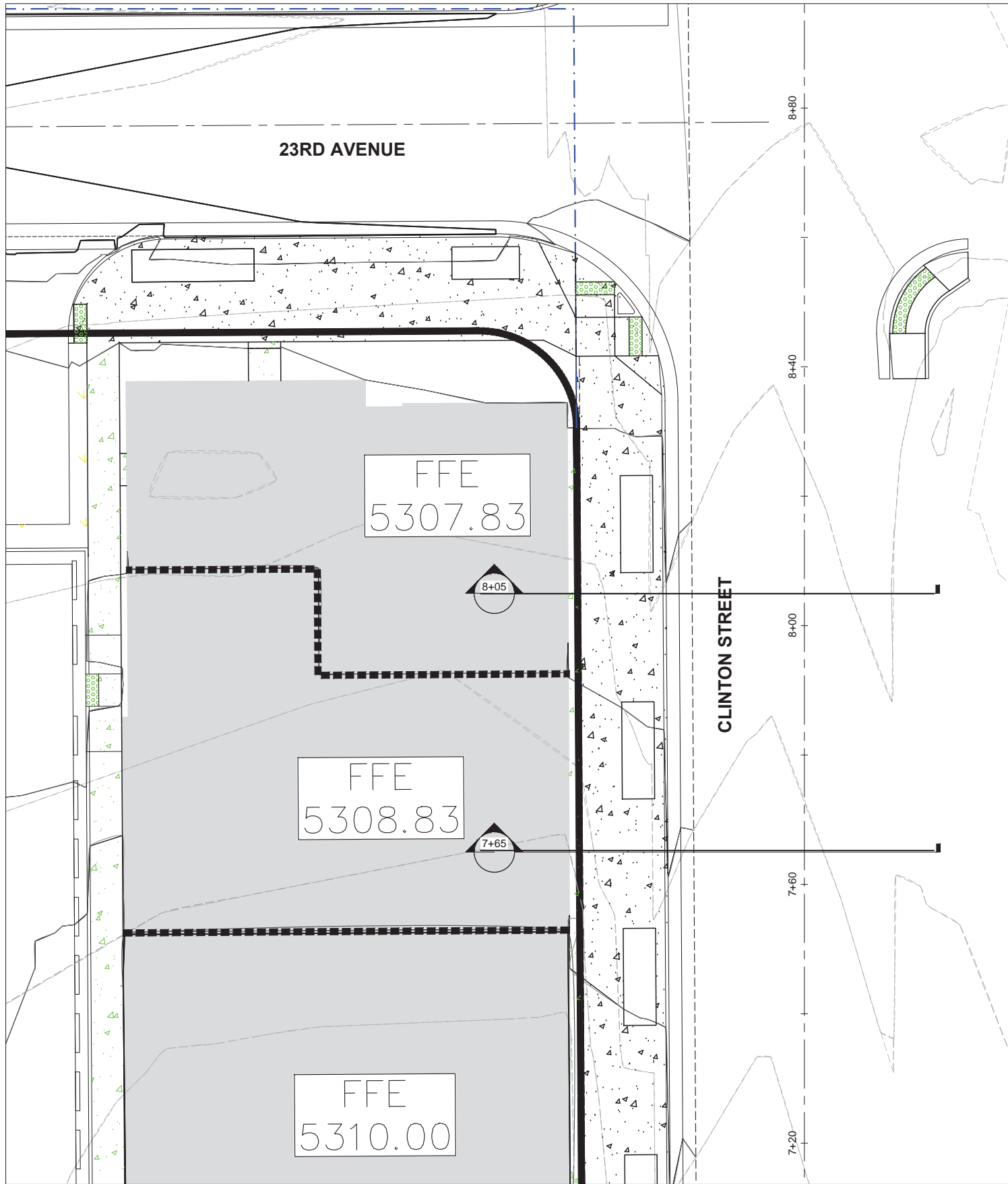


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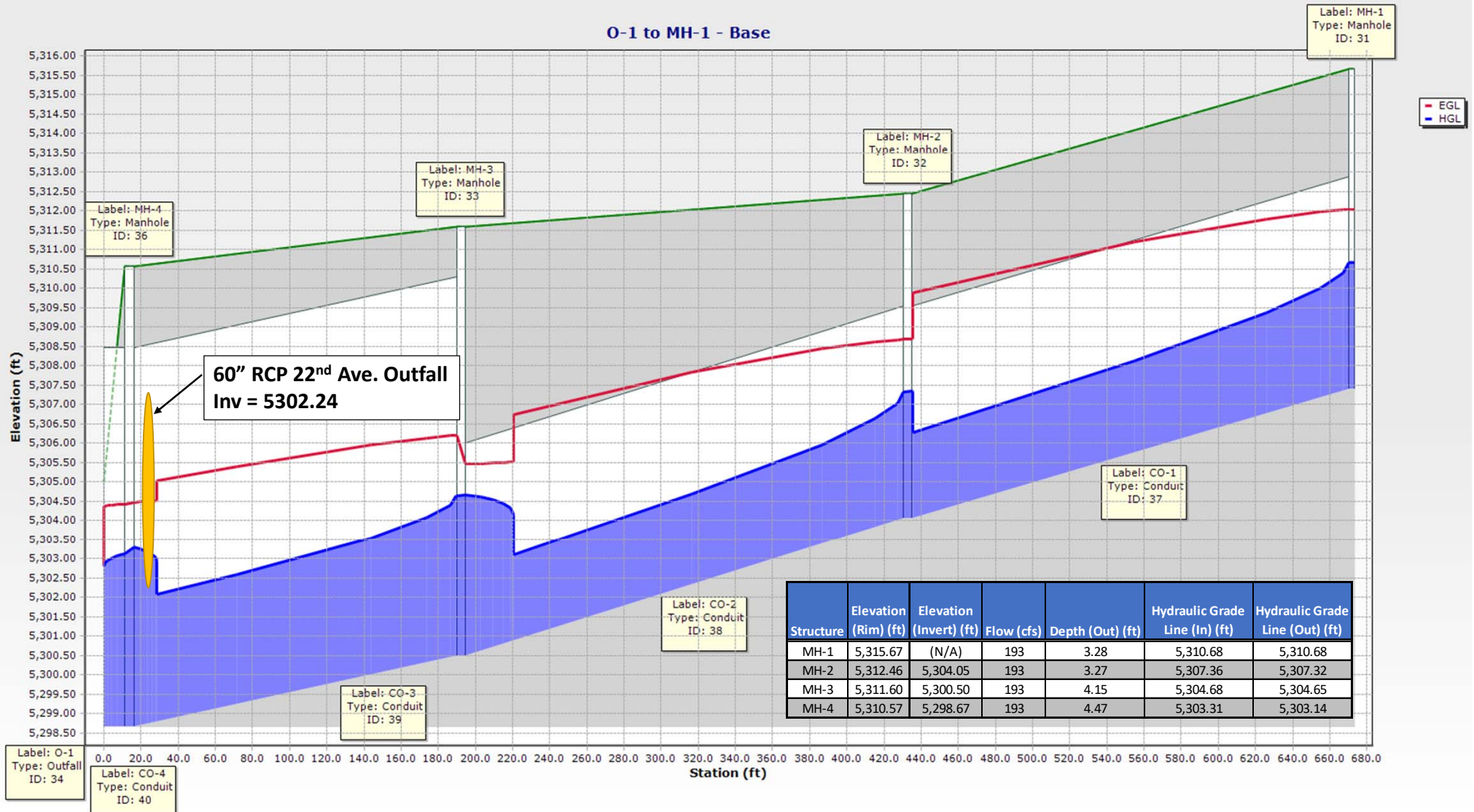
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7 OF 7

## **Appendix – Easterly Creek Outfall StormCAD**

As described previously, a StormCAD model was developed to establish a tailwater condition for the 22<sup>nd</sup> Avenue Outfall. The peak discharge for the 100-yr design storm was obtained from the modified EPA SWMM model, 193 cfs. Loss coefficients at each manhole and transition structure were evaluated using the HEC-22 2<sup>nd</sup> Edition Loss Method. The StormCAD results, including the profile of the existing Easterly Creek Outfall is included on the following pages.



# O-1 to MH-1 - Base



HEC-RAS Plan: Prop MP No 1429 IFA River: Westerly Creek Reach: Reach 1

Reach	River Sta	Profile	Q Total	W.S. Elev	Vel Total	Vel Chnl	Froude # Chl
			(cfs)	(ft)	(ft/s)	(ft/s)	
Reach 1	3018	10yr	771.00	5303.23	3.26	3.33	0.29
Reach 1	3018	50yr	1585.00	5305.20	4.08	4.26	0.31
Reach 1	3018	100yr	2034.00	5305.96	4.48	4.72	0.32
Reach 1	3018	500yr	3010.00	5307.43	5.07	5.44	0.34
Reach 1	2846	10yr	907.00	5302.41	4.76	5.39	0.50
Reach 1	2846	50yr	1840.00	5304.51	4.96	6.05	0.44
Reach 1	2846	100yr	2403.00	5305.23	5.35	6.58	0.45
Reach 1	2846	500yr	3523.00	5306.99	5.23	6.28	0.39
Reach 1	2576	10yr	907.00	5302.15	2.13	2.52	0.20
Reach 1	2576	50yr	1840.00	5304.38	2.55	2.91	0.19
Reach 1	2576	100yr	2403.00	5305.17	2.57	2.99	0.19
Reach 1	2576	500yr	3523.00	5306.96	2.72	3.07	0.17
Reach 1	2535	10yr	907.00	5302.10	2.25	2.63	0.20
Reach 1	2535	50yr	1840.00	5304.33	2.76	3.03	0.20
Reach 1	2535	100yr	2403.00	5305.12	2.81	3.26	0.20
Reach 1	2535	500yr	3523.00	5306.91	2.94	3.30	0.18
Reach 1	2491		Bridge				
Reach 1	2443	10yr	907.00	5301.19	3.92	3.76	0.33
Reach 1	2443	50yr	1840.00	5303.69	3.96	3.45	0.24
Reach 1	2443	100yr	2403.00	5304.74	3.71	3.46	0.22
Reach 1	2443	500yr	3523.00	5306.64	3.67	3.54	0.20
Reach 1	2416	10yr	907.00	5301.11	3.81	4.37	0.36
Reach 1	2416	50yr	1840.00	5303.59	4.37	5.09	0.34
Reach 1	2416	100yr	2403.00	5304.73	3.47	3.81	0.23
Reach 1	2416	500yr	3523.00	5306.64	3.45	3.84	0.21
Reach 1	2195	10yr	1188.00	5300.64	3.47	3.87	0.31
Reach 1	2195	50yr	2538.00	5303.17	4.39	4.81	0.31
Reach 1	2195	100yr	3469.00	5304.24	4.60	5.42	0.33
Reach 1	2195	500yr	5644.00	5306.01	5.46	6.49	0.36
Reach 1	2064	10yr	1188.00	5299.87	5.43	5.81	0.48
Reach 1	2064	50yr	2538.00	5302.35	6.23	7.23	0.48
Reach 1	2064	100yr	3469.00	5303.14	7.05	8.55	0.54
Reach 1	2064	500yr	5644.00	5305.03	7.27	9.04	0.51
Reach 1	1926	10yr	1188.00	5299.15	5.48	6.85	0.47
Reach 1	1926	50yr	2538.00	5301.70	6.48	8.35	0.49
Reach 1	1926	100yr	3469.00	5302.23	7.89	10.01	0.57
Reach 1	1926	500yr	5644.00	5303.10	10.75	13.08	0.71
Reach 1	1836	10yr	1188.00	5298.95	4.56	5.19	0.37
Reach 1	1836	50yr	2538.00	5301.72	4.73	4.95	0.29
Reach 1	1836	100yr	3469.00	5302.25	5.79	5.94	0.34
Reach 1	1836	500yr	5644.00	5303.18	7.91	7.86	0.43



HEC-RAS Plan: Prop MP No 1429 IFA River: Westerly Creek Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	W.S. Elev	Vel Total	Vel Chnl	Froude # Chl
			(cfs)	(ft)	(ft/s)	(ft/s)	
Reach 1	1697	10yr	1188.00	5298.69	3.71	5.26	0.35
Reach 1	1697	50yr	2538.00	5301.62	3.96	4.91	0.27
Reach 1	1697	100yr	3469.00	5302.31	3.62	5.15	0.28
Reach 1	1697	500yr	5644.00	5303.45	4.31	6.52	0.34
Reach 1	1593	10yr	1188.00	5298.48	3.78	5.14	0.34
Reach 1	1593	50yr	2538.00	5301.52	3.83	4.72	0.26
Reach 1	1593	100yr	3469.00	5302.22	3.33	4.76	0.26
Reach 1	1593	500yr	5644.00	5303.40	3.78	5.20	0.27
Reach 1	1536	10yr	1188.00	5298.26	4.20	5.71	0.38
Reach 1	1536	50yr	2538.00	5301.49	3.48	4.52	0.25
Reach 1	1536	100yr	3469.00	5302.16	3.43	4.55	0.24
Reach 1	1536	500yr	5644.00	5303.33	3.93	4.75	0.24
Reach 1	1526		Bridge				
Reach 1	1512	10yr	1188.00	5297.68	4.77	5.60	0.42
Reach 1	1512	50yr	2538.00	5299.93	5.40	6.66	0.42
Reach 1	1512	100yr	3469.00	5300.73	5.66	6.96	0.42
Reach 1	1512	500yr	5644.00	5301.84	6.12	7.54	0.42
Reach 1	1429	10yr	1188.00	5297.52	3.61	4.52	0.32
Reach 1	1429	50yr	2538.00	5299.87	3.91	4.79	0.29
Reach 1	1429	100yr	3469.00	5300.67	4.18	5.05	0.29
Reach 1	1429	500yr	5644.00	5301.81	4.73	5.24	0.29
Reach 1	1192	10yr	1188.00	5296.54	5.23	5.69	0.44
Reach 1	1192	50yr	2538.00	5298.85	6.28	6.88	0.44
Reach 1	1192	100yr	3469.00	5299.52	6.54	7.66	0.47
Reach 1	1192	500yr	5644.00	5301.15	5.43	6.36	0.36
Reach 1	1055	10yr	1188.00	5295.94	5.00	5.68	0.44
Reach 1	1055	50yr	2538.00	5298.53	5.28	5.92	0.38
Reach 1	1055	100yr	3469.00	5299.05	6.36	7.10	0.44
Reach 1	1055	500yr	5644.00	5300.95	4.89	5.80	0.32
Reach 1	905	10yr	1188.00	5295.69	3.42	3.75	0.31
Reach 1	905	50yr	2538.00	5298.44	3.71	4.04	0.26
Reach 1	905	100yr	3469.00	5298.97	4.10	4.77	0.30
Reach 1	905	500yr	5644.00	5300.88	3.68	4.40	0.25
Reach 1	782	10yr	1188.00	5295.35	4.11	4.52	0.36
Reach 1	782	50yr	2538.00	5298.17	4.20	4.94	0.31
Reach 1	782	100yr	3469.00	5298.87	3.21	4.56	0.28
Reach 1	782	500yr	5644.00	5300.84	3.13	4.07	0.22
Reach 1	685	10yr	1188.00	5294.85	5.35	5.61	0.46
Reach 1	685	50yr	2538.00	5297.43	6.30	7.16	0.47
Reach 1	685	100yr	3469.00	5298.66	3.73	5.25	0.32

Table 4  
and 5 Data

Table 2  
and 3 Data

HEC-RAS Plan: Prop MP No 1429 IFA River: Westerly Creek Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	W.S. Elev	Vel Total	Vel Chnl	Froude # Chl
			(cfs)	(ft)	(ft/s)	(ft/s)	
Reach 1	685	500yr	5644.00	5300.74	3.40	4.23	0.23
Reach 1	682		Bridge				
Reach 1	663	10yr	1188.00	5294.66	5.74	5.95	0.51
Reach 1	663	50yr	2538.00	5296.69	7.30	7.92	0.56
Reach 1	663	100yr	3469.00	5298.22	4.15	5.54	0.35
Reach 1	663	500yr	5644.00	5300.61	3.50	4.03	0.22
Reach 1	573	10yr	1188.00	5294.19	5.33	6.28	0.49
Reach 1	573	50yr	2538.00	5296.60	4.45	6.11	0.39
Reach 1	573	100yr	3469.00	5298.10	3.63	4.92	0.29
Reach 1	573	500yr	5644.00	5300.55	3.27	3.93	0.20
Reach 1	452	10yr	1351.00	5293.26	6.12	7.81	0.62
Reach 1	452	50yr	2809.00	5295.79	6.57	8.06	0.52
Reach 1	452	100yr	3809.00	5297.23	6.95	8.24	0.49
Reach 1	452	500yr	6218.00	5299.25	8.67	9.93	0.53
Reach 1	404	10yr	1351.00	5292.84	6.91	7.39	0.59
Reach 1	404	50yr	2809.00	5294.13	10.46	11.63	0.83
Reach 1	404	100yr	3809.00	5294.87	12.09	13.70	0.92
Reach 1	404	500yr	6218.00	5298.21	9.08	12.56	0.69
Reach 1	350	10yr	1351.00	5292.37	7.10	8.04	0.72
Reach 1	350	50yr	2809.00	5293.47	10.48	11.94	0.94
Reach 1	350	100yr	3809.00	5294.65	9.94	11.92	0.85
Reach 1	350	500yr	6218.00	5296.06	11.47	14.47	0.93
Reach 1	285	10yr	1351.00	5292.18	5.25	6.88	0.56
Reach 1	285	50yr	2809.00	5293.80	6.17	8.18	0.57
Reach 1	285	100yr	3809.00	5294.69	6.50	8.56	0.56
Reach 1	285	500yr	6218.00	5296.47	7.16	9.24	0.54
Reach 1	248	10yr	1351.00	5292.06	5.39	6.55	0.56
Reach 1	248	50yr	2809.00	5293.68	6.43	7.84	0.57
Reach 1	248	100yr	3809.00	5294.41	7.20	8.75	0.60
Reach 1	248	500yr	6218.00	5295.98	8.39	10.01	0.62
Reach 1	208		Bridge				
Reach 1	168	10yr	1351.00	5291.51	4.62	5.61	0.48
Reach 1	168	50yr	2809.00	5293.55	5.21	6.40	0.45
Reach 1	168	100yr	3809.00	5294.28	6.03	7.34	0.49
Reach 1	168	500yr	6218.00	5295.67	7.64	9.22	0.56
Reach 1	45	10yr	1351.00	5290.84	5.53	6.84	0.57
Reach 1	45	50yr	2809.00	5292.83	5.52	8.39	0.58
Reach 1	45	100yr	3809.00	5293.86	5.31	8.38	0.54
Reach 1	45	500yr	6218.00	5295.41	5.70	9.18	0.54



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19-013 - Westerly Creek at Stanley Marketplace  
Easterly Creek Outfall - 100-YR  
7/3/2024

Structure Opening Parameters		
Opening Length	24	ft
Opening Height	1.67	ft
Opening Area	40	ft^2
Opening Invert	5298.50	ft
Opening Centroid	5299.33	ft
Overflow Elevation	5304.00	ft
Maximum Orifice Flow	4.67	ft
Maximum Orifice Flow		
Orifice Coefficient	0.65	
Orifice Flow	450.7	ft^2

*Orifice Equation*

$$Q = C_d A \sqrt{2gh}$$

Inflow Parameters				
	2-yr	5-yr	100-yr	
Incoming Peak Discharge	121	177	395	cfs
Design Hydraulic Results				
Orifice Depth in Structure	0.34	0.72	3.58	ft
Water Depth in Structure	1.17	1.55	4.42	ft
Water Surface Elevation	5298.84	5299.22	5302.08	ft
Velocity	3.0	4.4	9.9	fps

*Orifice Equation*

$$Q = C_d A \sqrt{2gh}$$



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Project  
Subject  
Date

19-013 - Westerly Creek at Stanley Marketplace  
Overflow Bubbler  
7/3/2024

Overflow Weir Parameters		
Weir Coefficient	3	
Weir Elevation	5299.0	ft
Weir Length	50.0	ft
Weir Height	0.50	ft
Maximum Weir Flow	53.0	cfs
Structure Grate Opening Parameters		
Opening Grate Area	120	ft^2
Opening Invert	5299.50	ft
Opening Centroid	5299.50	ft
Overflow Elevation	5299.75	ft
Maximum Orifice Flow Depth	0.25	ft
Maximum Orifice Flow		
Orifice Coefficient	0.65	
Orifice Flow	313.0	ft^2

*Orifice Equation*

$$Q = C_d A \sqrt{2gh}$$

Inflow Parameters				
	2-yr	5-yr	100-yr	
Incoming Peak Discharge	135	135	290	cfs
Flow into WQCV Basin	51	51	49	cfs
Spill Flow	84	84	241	cfs
Design Hydraulic Results				
Depth over weir	0.68	0.68	1.37	ft
Water Depth in Structure	0.93	0.93	1.62	ft
Water Surface Elevation	5300.18	5300.18	5300.87	ft
Velocity	3.4	3.4	9.6	fps

*Velocity Equation*

$$Q = Q/A_{open}$$



# ICON

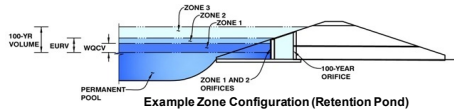
Project  
Subject  
Date

19-013 - Westerly Creek at Stanley Marketplace  
Leveler Spreader Design  
7/3/2024

Inflow Parameters		
Incoming Pipe Diameter	30	in
Incoming WQ Peak Discharge	51.4	cfs
Level Spreader Parameters		
Level Spreader Opening	8	in
Height to Center of Orifice	4	in
Depth of Water in Spreader	30	in
Weir Flow Spreader Design		
Weir Flow Coefficient	2.6	
Weir Flow Length	36.3	ft
Velocity	2.1	fps
Orifice Flow Spreader Design		
Orifice Coefficient	0.65	
Opening Area	6.7	ft^2
Orifice Flow Length	10.0	ft
Minimum Level Spreader Length	36.3	ft

MHFD-Detention, Version 4.06 (July 2022)

**Basin ID:**



Selected BMP Type =	<b>EDB</b>	
Watershed Area =	135.00	acres
Watershed Length =	5,000	ft
Watershed Length to Centroid =	1,500	ft
Watershed Slope =	0.005	ft/ft
Watershed Imperviousness =	63.00%	percent
Percentage Hydrologic Soil Group A	0.0%	percent
Percentage Hydrologic Soil Group B	0.0%	percent
Percentage Hydrologic Soil Groups C/D	100.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths = Aurora - Municipal Center		

### Optional User Overrides

Water Quality Capture Volume (WQCV) =	2,775	acre-feet
Excess Urban Runoff Volume (EQRV) =	8,196	acre-feet
2-yr Runoff Volume ( $P1 = 0.87$ in.) =	5,780	acre-feet
5-yr Runoff Volume ( $P1 = 1.14$ in.) =	8,409	acre-feet
10-yr Runoff Volume ( $P1 = 1.39$ in.) =	11,114	acre-feet
25-yr Runoff Volume ( $P1 = 1.76$ in.) =	15,752	acre-feet
50-yr Runoff Volume ( $P1 = 2.08$ in.) =	19,521	acre-feet
100-yr Runoff Volume ( $P1 = 2.42$ in.) =	23,856	acre-feet
500-yr Runoff Volume ( $P1 = 3.3$ in.) =	34,457	acre-feet
Approximate 2-yr Detention Volume =	5,325	acre-feet
Approximate 5-yr Detention Volume =	7,924	acre-feet
Approximate 10-yr Detention Volume =	9,462	acre-feet
Approximate 25-yr Detention Volume =	11,201	acre-feet
Approximate 50-yr Detention Volume =	12,120	acre-feet
Approximate 100-yr Detention Volume =	13,822	acre-feet

Zone 1 Volume (WQCV) =	2.775	acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =	2.775	acre-feet
Initial Surcharge Volume (ISV) =	user	ft <sup>3</sup>
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	Ht/V
Basin Length-to-Width Ratio ( $R_{LW}$ ) =	user	

**Total detention volume is less than 100-year volume.**

Initial Surcharge Area ( $A_{SV}$ )	=	user	ft <sup>2</sup>
Surcharge Volume Length ( $L_{SV}$ )	=	user	ft
Surcharge Volume Width ( $W_{SV}$ )	=	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 <sup>2</sup>
Volume of Basin Floor ( $V_{FLOOR}$ )	=	user	ft <sup>3</sup>
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 <sup>2</sup>
Volume of Main Basin ( $V_{MAIN}$ )	=	user	ft <sup>3</sup>
Calculated Total Basin Volume ( $V_{TOTAL}$ )	=	user	acre-feet

MHFD-Detention v4-06.xlsm, Basin

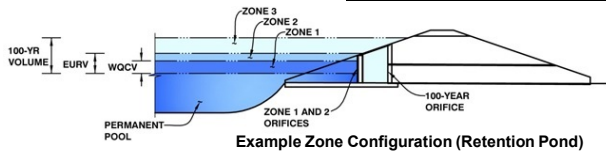


# DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project: Westerly Creek at Stanley Marketplace

Basin ID:



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	6.95	2.775	Orifice Plate
Zone 2			
Zone 3			
Total (all zones)		2.775	

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

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

Calculated Parameters for Underdrain  
Underdrain Orifice Area =  ft<sup>2</sup>  
Underdrain Orifice Centroid =  feet

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

Centroid of Lowest Orifice =  ft (relative to basin bottom at Stage = 0 ft)  
Depth at top of Zone using Orifice Plate =  ft (relative to basin bottom at Stage = 0 ft)  
Orifice Plate: Orifice Vertical Spacing =  inches  
Orifice Plate: Orifice Area per Row =  sq. inches (use rectangular openings)

Calculated Parameters for Plate  
WQ Orifice Area per Row =  ft<sup>2</sup>  
Elliptical Half-Width =  feet  
Elliptical Slot Centroid =  feet  
Elliptical Slot Area =  ft<sup>2</sup>

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	3.30	6.60					
Orifice Area (sq. inches)	9.62	9.62	9.62					

	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)

Invert of Vertical Orifice =   ft (relative to basin bottom at Stage = 0 ft)  
Depth at top of Zone using Vertical Orifice =   ft (relative to basin bottom at Stage = 0 ft)  
Vertical Orifice Diameter =   inches

Calculated Parameters for Vertical Orif  
Vertical Orifice Area =   ft<sup>2</sup>  
Vertical Orifice Centroid =   feet

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

Overflow Weir Front Edge Height, Ho =   ft (relative to basin bottom at Stage = 0 ft)  
Overflow Weir Front Edge Length =   feet  
Overflow Weir Grate Slope =   H:V  
Horiz. Length of Weir Sides =   feet  
Overflow Grate Type =    
Debris Clogging % =   %

Calculated Parameters for Overflow W  
Height of Grate Upper Edge, H<sub>t</sub> =   feet  
Overflow Weir Slope Length =   feet  
Grate Open Area / 100-yr Orifice Area =    
Overflow Grate Open Area w/o Debris =   ft<sup>2</sup>  
Overflow Grate Open Area w/ Debris =   ft<sup>2</sup>

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

Depth to Invert of Outlet Pipe =   ft (distance below basin bottom at Stage = 0 ft)  
Circular Orifice Diameter =   inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Pl  
Outlet Orifice Area =   ft<sup>2</sup>  
Outlet Orifice Centroid =   feet  
Half-Central Angle of Restrictor Plate on Pipe =   degrees

User Input: Emergency Spillway (Rectangular or Trapezoidal)

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

Calculated Parameters for Spillway  
Spillway Design Flow Depth =   feet  
Stage at Top of Freeboard =   feet  
Basin Area at Top of Freeboard =   acres  
Basin Volume at Top of Freeboard =   acre-ft

## Routed Hydrograph Results

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

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Design Storm Return Period =	N/A	N/A	0.87	1.14	1.39	1.76	2.08	2.42
One-Hour Rainfall Depth (in) =	N/A	N/A	0.87	1.14	1.39	1.76	2.08	2.42
CUHP Runoff Volume (acre-ft) =	2.775	8.196	5.780	8.409	11.114	15.752	19.521	23.856
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	5.780	8.409	11.114	15.752	19.521	23.856
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	1.0	10.9	26.5	65.5	90.7	124.3
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A						
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.01	0.08	0.20	0.48	0.67	0.92
Peak Inflow Q (cfs) =	N/A	N/A	68.3	99.9	131.2	198.4	246.2	300.2
Peak Outflow Q (cfs) =	1.6	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.2	0.1	0.0	0.0	0.0
Structure Controlling Flow =	Plate	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	38	70	57	72	89	117	>120	>120
Time to Drain 99% of Inflow Volume (hours) =	41	76	60	77	95	>120	>120	>120
Maximum Ponding Depth (ft) =	6.95	7.25	7.25	7.25	7.25	7.25	7.25	7.25
Area at Maximum Ponding Depth (acres) =	0.72	0.73	0.73	0.73	0.73	0.73	0.73	0.73
Maximum Volume Stored (acre-ft) =	2.779	2.997	2.997	2.997	2.997	2.997	2.997	2.997

### 3.2.2 Low Tailwater Basin

The design of low tailwater riprap basins is necessary when the receiving channel may have little or no flow or tailwater at time when the pipe or culvert is in operation. Figure 9-37 provides a plan and profile view of a typical low tailwater riprap basin.

By providing a low tailwater basin at the end of a storm drain conduit or culvert, the kinetic energy of the discharge dissipates under controlled conditions without causing scour at the channel bottom.

Low tailwater is defined as being equal to or less than  $\frac{1}{3}$  of the height of the storm drain, that is:

$$y_t \leq \frac{D}{3} \quad \text{or} \quad y_t \leq \frac{H}{3}$$

Where:

$y_t$  = tailwater depth at design flow (feet)

$D$  = diameter of circular pipe (feet)

$H$  = height of rectangular pipe (feet)

#### Rock Size

The procedure for determining the required riprap size downstream of a conduit outlet is in Section 3.2.3.

After selecting the riprap size, the minimum thickness of the riprap layer,  $T$ , in feet, in the basin is defined as:

$$T = 2D_{50} \quad \text{Equation 9-15}$$

#### Basin Geometry

Figure 9-37 includes a layout of a standard low tailwater riprap basin with the geometry parameters provided. The minimum length of the basin ( $L$ ) and the width of the bottom of the basin ( $W1$ ) are provided in a table at the bottom of Figure 9-37. All slopes in the low tailwater basin shall be 3(H):1(V), minimum.

#### Other Design Requirements

Extend riprap up the outlet embankment slope to the mid-pipe level, minimum. It is recommended that riprap that extends more than 1 foot above the outlet pipe invert be installed 6 inches below finished grade and buried with topsoil.

Provide pipe end treatment in the form of a pipe headwall or a flared-end section headwall. See Section 3.1 for options.

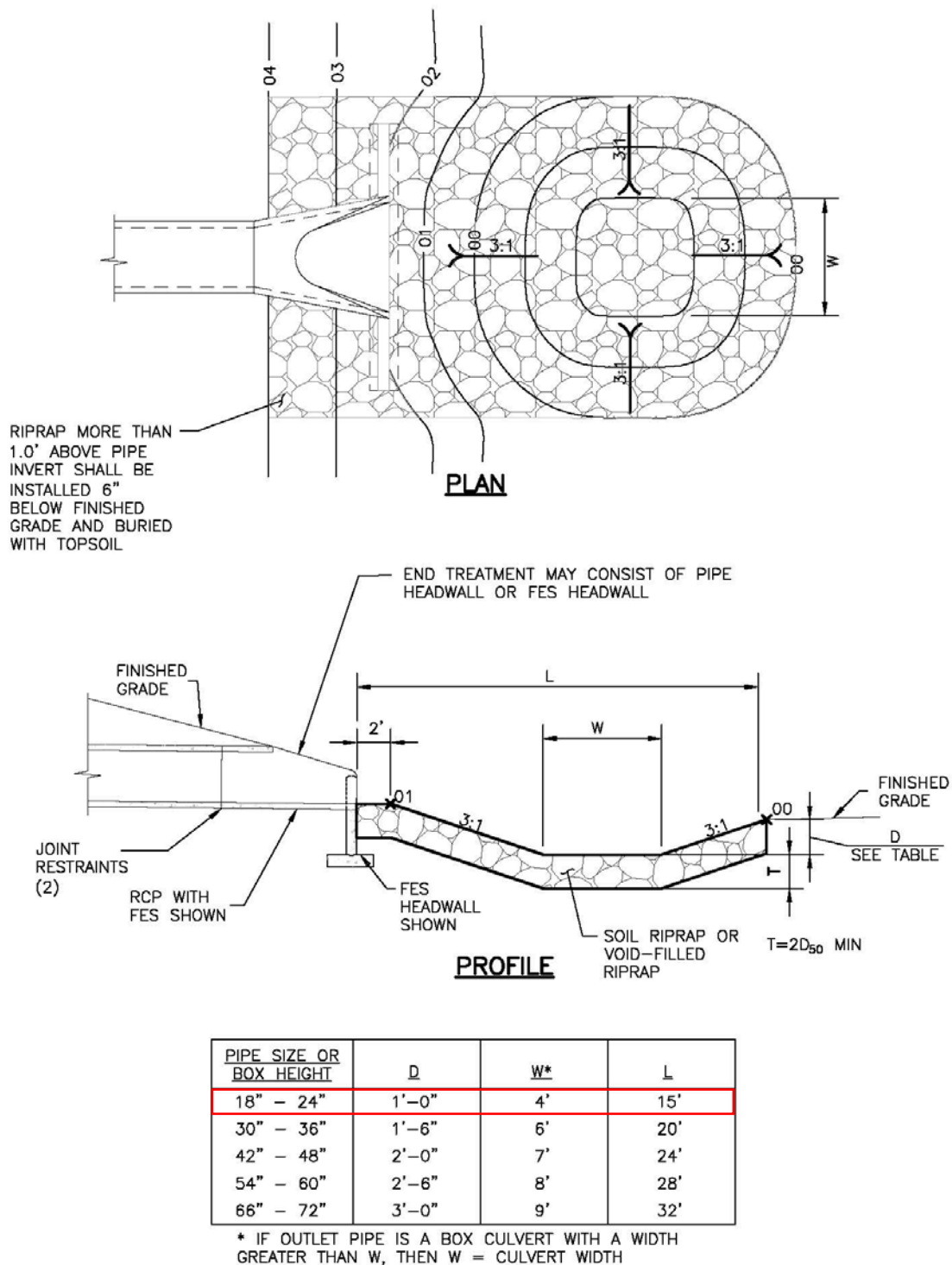


Figure 9-37. Low tailwater riprap basin



### 3.2.3 Rock Sizing for Riprap Apron and Low Tailwater Basin

Scour resulting from highly turbulent, rapidly decelerating flow is a common problem at conduit outlets. The following section summarizes the method for sizing riprap protection for both riprap aprons (Section 3.2.1) and low tailwater basins (Section 3.2.2).

Use Figure 9-38 to determine the required rock size for circular conduits and Figure 9-39 for rectangular conduits. Figure 9-38 is valid for  $Q/D_c^{2.5}$  of 6.0 or less and Figure 9-39 is valid for  $Q/WH^{1.5}$  of 8.0 or less. The parameters in these two figures are:

1.  $Q/D_c^{1.5}$  or  $Q/WH^{0.5}$  in which  $Q$  is the design discharge in cfs,  $D_c$  is the diameter of a circular conduit in feet, and  $W$  and  $H$  are the width and height of a rectangular conduit in feet.
2.  $Y_t/D_c$  or  $Y_t/H$  in which  $Y_t$  is the tailwater depth in feet,  $D_c$  is the diameter of a circular conduit in feet, and  $H$  is the height of a rectangular conduit in feet. In cases where  $Y_t$  is unknown or a hydraulic jump is suspected downstream of the outlet, use  $Y_t/D_t = Y_t/H = 0.40$  when using Figures 9-38 and 9-39.
3. The riprap size requirements in Figures 9-38 and 9-39 are based on the non-dimensional parametric Equations 9-16 and 9-17 (Steven, Simons, and Watts 1971 and Smith 1975).

Circular culvert:

$$d_{50} = \frac{0.023Q}{Y_t^{1.2} D_c^{0.3}} \quad \text{Equation 9-16}$$

Rectangular culvert:

$$d_{50} = \frac{0.014H^{0.5}Q}{Y_t W} \quad \text{Equation 9-17}$$

These rock size requirements assume that the flow in the culvert is subcritical. It is possible to use Equations 9-16 and 9-17 when the flow in the culvert is supercritical (and less than full) if the value of  $D_c$  or  $H$  is modified for use in Figures 9-38 and 9-39. Note that rock sizes referenced in these figures are defined in the *Open Channels* chapter. Whenever the flow is supercritical in the culvert, substitute  $D_a$  for  $D_c$  and  $H_a$  for  $H$ , in which  $D_a$  is defined as:

$$D_a = \frac{(D_c + Y_n)}{2} \quad \text{Equation 9-18}$$

Where the maximum value of  $D_a$  shall not exceed  $D_c$ , and

$$H_a = \frac{(H + Y_n)}{2}$$

Equation 9-19

Where the maximum value of  $H_a$  shall not exceed  $H$ , and:

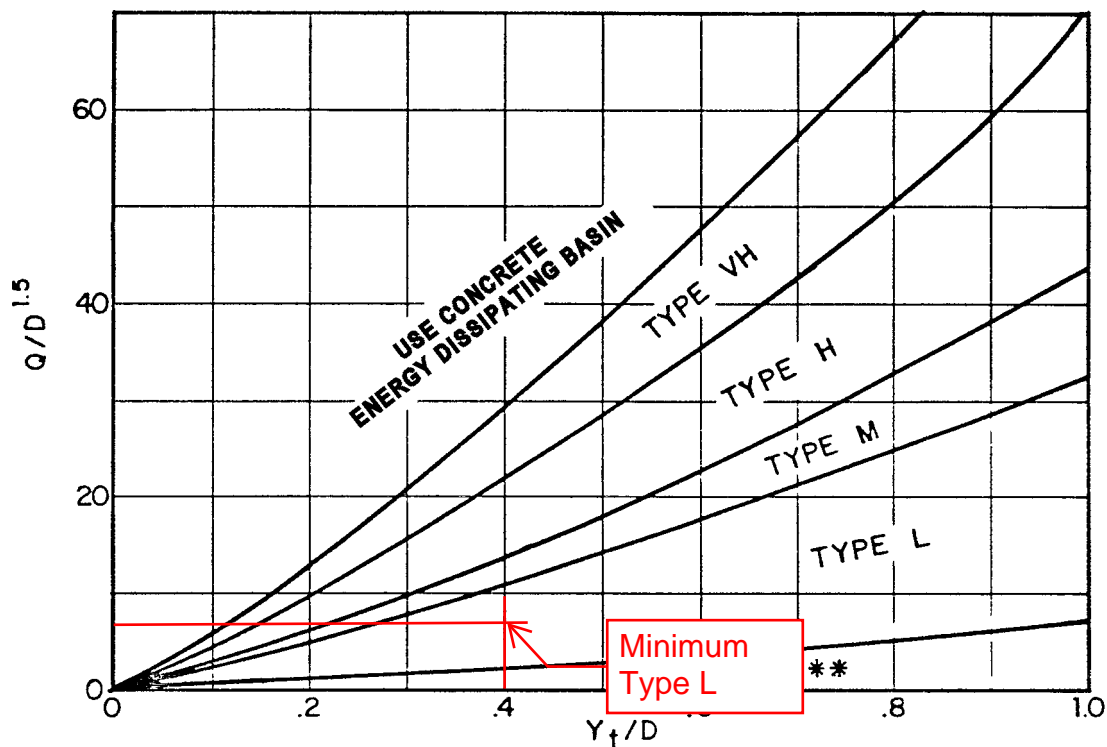
$D_a$  = parameter to use in place of  $D$  in Figure 9-38 when flow is supercritical (ft)

$D_c$  = diameter of circular culvert (ft)

$H_a$  = parameter to use in place of  $H$  in Figure 9-39 when flow is supercritical (ft)

$H$  = height of rectangular culvert (ft)

$Y_n$  = normal depth of supercritical flow in the culvert (ft)



Use  $D_a$  instead of  $D$  whenever flow is supercritical in the barrel.

\*\* Use Type L for a distance of  $3D$  downstream.

Figure 9-38. Riprap erosion protection at circular conduit outlet (valid for  $Q/D^{2.5} \leq 6.0$ )



# **FINAL DRAINAGE REPORT**

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## **APPENDIX D – GEOMORPHOLOGY**



# **GEOMORPHOLOGY REPORT**

**Westerly Creek at Stanley Marketplace  
City of Aurora, Colorado**

**Prepared for:**

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**ICON**  
ENGINEERING

**March 30, 2022**

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- A. SITE PHOTOS
- B. EXISTING CONDITIONS SURVEY
- C. DESIGN FLOW COMPARISON: 2017 WESTERLY CREEK FHAD
- D. PROPOSED ALIGNMENT EXHIBIT

## **I. INTRODUCTION**

This geomorphology report pertains to Westerly Creek between Montview Boulevard and E. 26<sup>th</sup> Avenue. The 2020 “Westerly Creek Restoration & Water Quality Vision Plan – Montview Blvd. to E. 26<sup>th</sup> Avenue” provides conceptual design for regional water quality in the ‘Stanley’ area of the City of Aurora, including Stanley Marketplace, Stanley Residential, Trammell Crow, and Montview Plaza. The Vision Plan includes consideration of water quality, storm infrastructure, flood conveyance, and channel health (including geomorphology) in Westerly Creek and the adjacent drainage area. This portion of Westerly Creek is one of the last remaining unimproved portions of the channel. Upstream of the project, Westerly Creek is an improved open channel to E. 17<sup>th</sup> Avenue and becomes intermittently piped and open channel beyond. Downstream, Westerly Creek flows through Westerly Creek Park and Central Park to the confluence with Sand Creek approximately 1 mile to the north.

Included in this report is geomorphic assessment of existing Westerly Creek channel corridor conditions at the project location and just upstream of the project. The existing conditions survey data is used to provide a baseline for sediment transport analysis and channel design including a proposed channel cross section and alignment.

## **II. HISTORIC CONDITIONS**

The Stapleton neighborhood surrounding Westerly Creek has undergone high levels of development and redevelopment. The current Stanley Marketplace site was converted from a municipal landfill to the Stanley Aviation Corporation manufacturing facility in 1940. Stanley Aviation operated until 2009 and the Stanley Marketplace redevelopment was completed in 2016. The Stapleton Airport demolition in 2002 kicked off a large number of brownfield construction projects. From 2003 to 2006, medium-density residential development, including William Roberts Elementary School, were built north and west of the Stanley Marketplace site. Westerly Creek downstream of E. 26<sup>th</sup> Avenue was daylighted in 2003 with the creation of Westerly Creek Park. Discussed in more detail in Section III.B below, Montview Park and a portion of Westerly Creek downstream of E. Montview Boulevard were completed in 2016. The most recent pre-project update involved the construction of sidewalk and a sports field on the west side of Westerly Creek, across from Stanley Marketplace.

### **II.A – Watershed Characteristics**

The Westerly Creek watershed has a drainage area of 16.42 square miles at the 23<sup>rd</sup> Avenue junction point, as documented in the 2017 Westerly Creek (Downstream of Westerly Creek Dam) FHAD study. The FHAD also identified drainage subbasins



adjacent to the project reach as having impervious percentages ranging from 31% to 69%, representing an almost fully developed condition.

### **III. FIELD SURVEY AND EXISTING CONDITIONS ANALYSIS**

ICON Engineering performed an assessment of existing geomorphic conditions at Westerly Creek between E. 26<sup>th</sup> Avenue and Montview Boulevard. The survey took place on October 6, 2020. Cross section and longitudinal profile surveys were taken in the channel adjacent to the Stanley property at approximately 24<sup>th</sup> Place, hereafter referred to as the Stanley Reach, and at a second location further upstream at approximately 23<sup>rd</sup> Avenue, referred to as the Montview Reach.



**Figure 1. Overall site layout for Westerly Creek at Stanley Marketplace.**

#### **III.A – Stanley Reach**

The existing channel along the Stanley Reach is characterized by a linear alignment and a relatively featureless profile without significant geomorphic pools or riffles. Additionally, a high proportion of non-native riprap was observed in the channel bottom. This riprap is likely a maintenance response to the downcutting and channel incision observed along the Stanley Reach during the field visit. Outside of the channel, tall grasses make up the predominant vegetation along with sparse trees and shrubs. The dense willows present along the banks of the Montview Reach are not present in the

Stanley Reach. Survey along the Stanley Reach measured a 12.5' bottom width and 0.36% longitudinal slope.

The field study did not yield any confident indicators of bankfull stage along the Stanley Reach. Additionally, the upstream and downstream segments of Westerly Creek have been modified in the last 20 years and could not be used as a reference reach for consideration. Bankfull flow can be estimated from gage data where sufficient data history exists. An Alert5 stream gage, maintained and operated by the Mile High Flood District, is present on Westerly Creek at Montview Park just upstream of Montview Boulevard. While this stream gage network is designed primarily for advance flood warning, and not detailed hydrologic record keeping, it was the best available source of data as the USGS and Colorado Department of Water Resources do not operate any gages on Westerly Creek. Data from the Montview Park stream gage was available from 2018 to 2020. This period of data is insufficient to perform a reliable magnitude-frequency analysis. Due to the short gage record, 2020 Westerly Creek at Montview Park gage data from April to October was used to estimate the bankfull flow (which can be approximated as the 1.1-year recurrence interval flow) as the maximum observed average daily flow. Bankfull flow was estimated to be 235 cfs.

The surveyed Stanley Reach cross-section geometry was then input into Hydraflow, a 1D steady-state model, for the purpose of back calculating bankfull depth. The bankfull flow of 235 cfs was found to correspond to a flow depth of 3.57 feet in the existing channel.

The estimated bankfull depth was then compared with the existing cross section survey data to calculate entrenchment ratio ( $ER = 2.1$ ) and width-to-depth ratio ( $WDR = 8.22$ ). The calculated entrenchment ratio and width-to-depth ratios are in line with the field observations of steep 2-3' tall cut banks and a moderately entrenched channel that may be inhibiting floodplain connectivity. Surveyed profile and cross section plots for the Stanley Reach are included in Appendix B.

### **III.B – Montview Reach**

The Montview Reach was surveyed to provide context to the Stanley Reach field measurements. Surveyed profile and cross section plots are included in Appendix B. The Montview Reach was part of a 2014 channel and storm outfall improvements project along Westerly Creek, see “Lower Westerly Creek Flood Control Improvements at Montview Boulevard” (City of Aurora EDN #214125). Rather than serving as a reference reach, the 2020 ICON survey revealed how this section of channel has evolved over the 4 years following construction completion in Spring 2016 (Appendix A, Photos 5 and 6). The Lower Westerly Creek as-built survey noted a 20' bottom width

and 0.35% longitudinal slope whereas the 2020 survey measured a 13' bottom width and 0.18% slope. The decrease in slope and channel width points to channel aggradation potentially caused by an overly wide constructed channel with shallower flow depths and lower velocities, allowing sediment to drop out of suspension. This information can help inform the proposed channel design on the Stanley Reach. A detailed sediment transport analysis was performed using the CSR tool, as described in Section V below.

## **IV. PROPOSED DESIGN**

Proposed improvements to Westerly Creek will begin approximately 30 feet upstream of E. 26<sup>th</sup> Avenue and replace 1696' of existing channel. The proposed design will increase channel function by creating a realigned, multi-stage, geomorphic channel to replace the incised, linear channel.

### **IV.A – Design Flows**

The hydrology in the 2017 Westerly Creek FHAD was compared the 2010 MDP flows and the previously effective FEMA flows (see Westerly Creek peak flow comparison table in Appendix C). The updated flows in the 2017 FHAD were calculated using revised SWMM subbasins and different rainfall-runoff parameters. Three updated flow scenarios were evaluated:

- 2017 subbasins with CUHP 1.4.4 and NOAA Atlas 2, Volume 3 rainfall
- 2017 subbasins with adjusted Ct and Cp values in CUHP 1.4.4 and NOAA Atlas 2, Volume 3 rainfall
- 2017 subbasins with CUHP 1.5.2b and rainfall from NOAA Atlas 14

For this project, the third option using CUHP 1.5.2b and NOAA Atlas 14 was selected for the 100-year flow input ( $Q_{100} = 3469$  cfs at design point J23rd). This option was chosen as it used the latest version of CUHP and NOAA Atlas 14. NOAA Atlas 14 was published in 2013 where NOAA Atlas 2, Volume 3 was published in 1973.

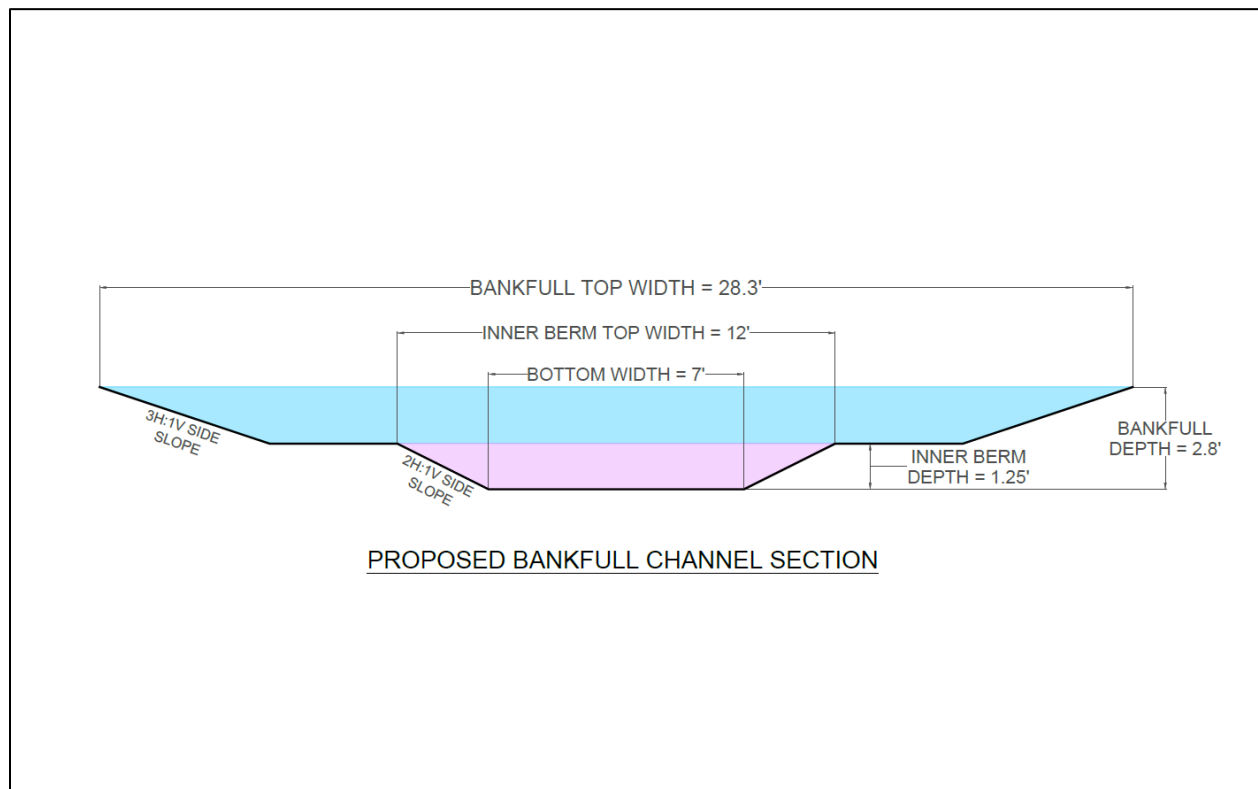
### **IV.B – Channel Cross Section**

The proposed channel cross section contains inner berm and bankfull stages. See Figure 2 below for proposed channel cross section dimensions.

The base flow channel was sized by correlating the inner berm depth to 35% of the existing bankfull depth. This yields an inner berm depth of 1.25 ft (capable of conveying 37.4 cfs) for the Stanley Reach. The proposed bankfull section was sized to convey the



effective bankfull discharge of 235 cfs. Using 1D steady-state calculations in Hydraflow, a proposed riffle cross section with a bankfull depth of 2.8 feet and a bankfull top width of 28.2 feet was found to sufficiently convey the bankfull flow and improve the width-to-depth ratio ( $WDR = 10.1$ ) for a C-Type channel compared to the existing condition. A flood terrace stage will be designed in the future to convey flows above the bankfull flow. The sizing of the flood terrace will consider unique site goals and physical constraints in determining allowable depths and top widths for design flows such as the 100-year recurrence interval flow. As such, defining the flood terrace dimensions was not included in this report.



**Figure 2. Proposed bankfull channel cross section.**

#### **IV.C - Alignment and Profile**

The proposed Westerly Creek alignment and profile were designed to follow geomorphic principles regarding riffle and pool sequencing. Bounding parameters for the alignment curves and tangents are listed in Table 1.

**Table 1 – Recommended parameters for proposed channel alignment.**

Bankfull Width = 28.2 ft		Min	Max
Bend to Bend Spacing; ft	5 -6 times Bankfull Width	141	169.2
Radius of Curvature (ROC); ft	2 - 4 times Bankfull Width	56.4	112.8
Tangent Lengths; ft	1.5 - 3 times Bankfull Width	42.3	84.6
Meander Wavelength; ft	9- 12 times Bankfull Width	253.8	338.4
Meander Beltwidth; ft	2 - 3.5 times Bankfull Width	56.4	98.7
Curve Length; ft	2 – 3.5 times Bankfull Width	56.4	98.7

The proposed alignment is 1722.6' in length and contains 10 pools in the curves and 11 riffles in the tangents. An exhibit showing the proposed alignment is provided in Appendix D. This alignment allows for a channel with a pool spacing ratio of 5.84 and 52.7 percent riffle. The pools will be 3' depth, yielding a pool depth ratio of 2.1. While the average slope of the Stanley reach remains unchanged, the proposed profile features riffle slopes of 0.78% and flat, geomorphic pools. Additional modeling is needed to include the impacts of the pool sections and channel alignment on flood conveyance and to determine if the preliminary design sufficiently meets the specific goals and site constraints of the project.

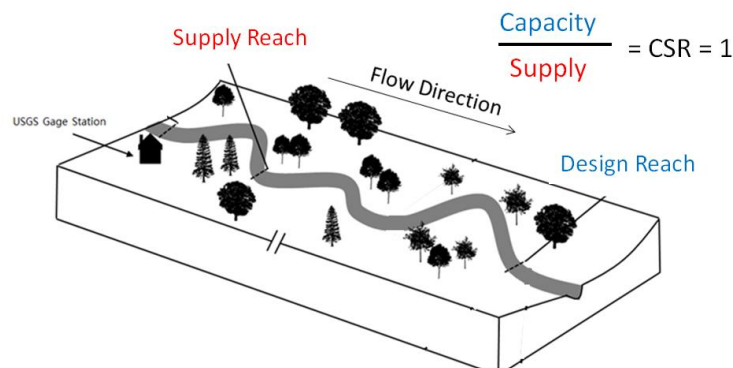
## **V. Capacity Supply Ratio Design Analysis**

### **V.A - Introduction**

A Capacity Supply Ratio (CSR) analysis was performed on Westerly Creek for two purposes. The first purpose (Analysis 1) was to assess the sediment transport capacity of the existing channel within the design reach (Stanley Reach) as compared to the supply reach (Montview Reach) to gain context for the existing channel. The second purpose (Analysis 2) was to repeat the initial assessment for the proposed channel cross section at the Stanley reach to assess if the proposed design will be more stable than existing conditions.

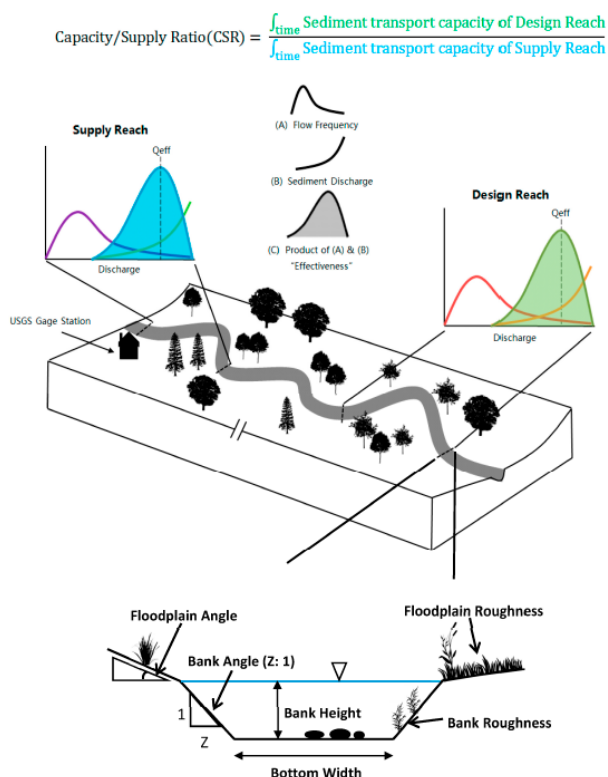
The CSR analysis concept was first developed by Copeland (1994) and was used as a straightforward channel design process that considered sediment transport supply and capacity. The analysis method, which was eventually incorporated into HEC-RAS worked under the simple premise that if you could match the sediment transport capacity of your design channel to incoming sediment supply, you could minimize opportunities for aggradation or degradation. Estimating sediment supply requires a detailed understanding of watershed characteristics and can be a very difficult process. Copeland's solution to this problem was to instead estimate sediment transport capacity at an upstream supply reach and use this as a proxy for sediment supply. The thought process is that if supply and design reaches are close in proximity, nearly all suspended and bedload delivered to the design reach will first have to pass through the supply

reach. Therefore, the sediment supply to the design reach can be approximated as the sediment transport capacity of the supply reach (Figure 1).



**Figure 3. CSR Supply and Design Reaches (Single Discharge)**

In recent years, researchers at Colorado State University (CSU) (Stroh et al., 2017) published an improved CSR method that built on the Copeland CSR method by analyzing sediment transport capacity across a full spectrum of discharges rather than the single design discharge Copeland used (Figure 2). This improved method and accompanying macro-enabled spreadsheet tool, allowed users to input hydrologic gage station data into their CSR analysis. For this analysis of Westerly Creek, ICON utilized the new CSU macro-enabled workbook.



**Figure 4. CSU full spectrum CSR (range of discharges)**



## V.B - Data Input

The CSU CSR tool requires users to: define supply and design reaches, define channel cross section characteristics, define channel slope, provide sediment gradation information, and choose an appropriate sediment transport relationship and import hydraulic gaging data.

For both Analysis 1 & 2, the supply reach was defined as the Montview Reach of Westerly Creek. The design reach for Analysis 1 was defined as the existing Stanley Reach of Westerly Creek. The design reach for Analysis 2 was defined as the proposed Stanley Reach of Westerly Creek. Existing conditions channel cross sectional geometry and slope information were taken from the October 2020 survey. Proposed geometry for Analysis 2 was taken from the conceptual design.

Hydrologic data for the analysis was taken from the Alert5 stream gage at Montview Park. Typically, several years of daily average flow data is collected and used within the CSU CSR tool. However, as noted above, record keeping restrictions did not allow for this on Westerly Creek. Instead, one year (2020) of gage records were downloaded from the Alert5 Gage and used as input for the CSR tool.

While conducting field work on-site, ICON noted that other than engineered riprap in the channel, the channel bed was primarily composed of sand. For this reason, the Brownlie (1983) sediment transport relationship was selected for this analysis. The Brownlie sediment transport relationship is the industry standard sediment transport relationship for streams where sand is the primary sediment.

## V.C – Results: Analysis 1

Analysis 1 compared the total sediment transport capacity (effectiveness) of the Montview Reach (Supply) to the existing conditions Stanley Reach (Design). As shown in Table 1, the existing conditions Stanley Reach was found to have a much higher sediment transport capacity than the Montview Reach. The computed CSR was 1.43 indicating that a degradational channel response is expected at the Stanley Reach.

**Table 1. Results of Analysis 1**

Effectiveness (tons/year)		CSR	Response
Design Reach	Supply Reach		
922.07	644.2	1.43	Degradation

## V.D – Results: Analysis 2

Analysis 2 compared the total sediment transport capacity (effectiveness) of the Montview Reach (Supply) to the proposed conditions Stanley Reach (Design). As shown in Table 2, the proposed conditions Stanley reach was expected to have a sediment transport capacity much closer to the supply reach. The resultant CSR was 0.95 which indicates a slight chance of aggradation over time.

**Table 2. Results of Analysis 2**

Effectiveness (tons/year)		CSR	Reponse
Design Reach	Supply Reach		
613.42	644.2	0.95	Aggradation

## V.E - Discussion

The severely incised nature of the existing conditions Stanley Reach was the primary contributing factor to the excessive sediment transport capacity of the reach. Flows are unable to easily access the floodplain, which increases shear stresses in the channel and contributes to channel degradation.

Conversely, the proposed conditions Stanley Reach has a larger and more appropriate width to depth ratio. Flows within the proposed channel can more easily access the floodplain, which reduces shear stresses as well as the chance of channel degradation.

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Stroth, T. R., Bledsoe, B. P., & Nelson, P. A. (2017). Full spectrum analytical channel design with the capacity/supply ratio (CSR). *Water*, 9(4), 271.



## **APPENDIX A – SITE PHOTOS**



Photo 1 – Stanley Reach looking upstream from the downstream end of the project (11/14/2021).



Photo 2 – Stanley Reach looking downstream from the dual box culvert adjacent to Stanley Marketplace (10/6/2020).





Photo 3 – Stanley Reach cross section location just upstream from Stanley Marketplace (10/6/2020).



Photo 4 – Looking upstream at the riprap drop structure at the downstream end of the Montview Reach transitioning to the Stanley Reach (10/6/2020).





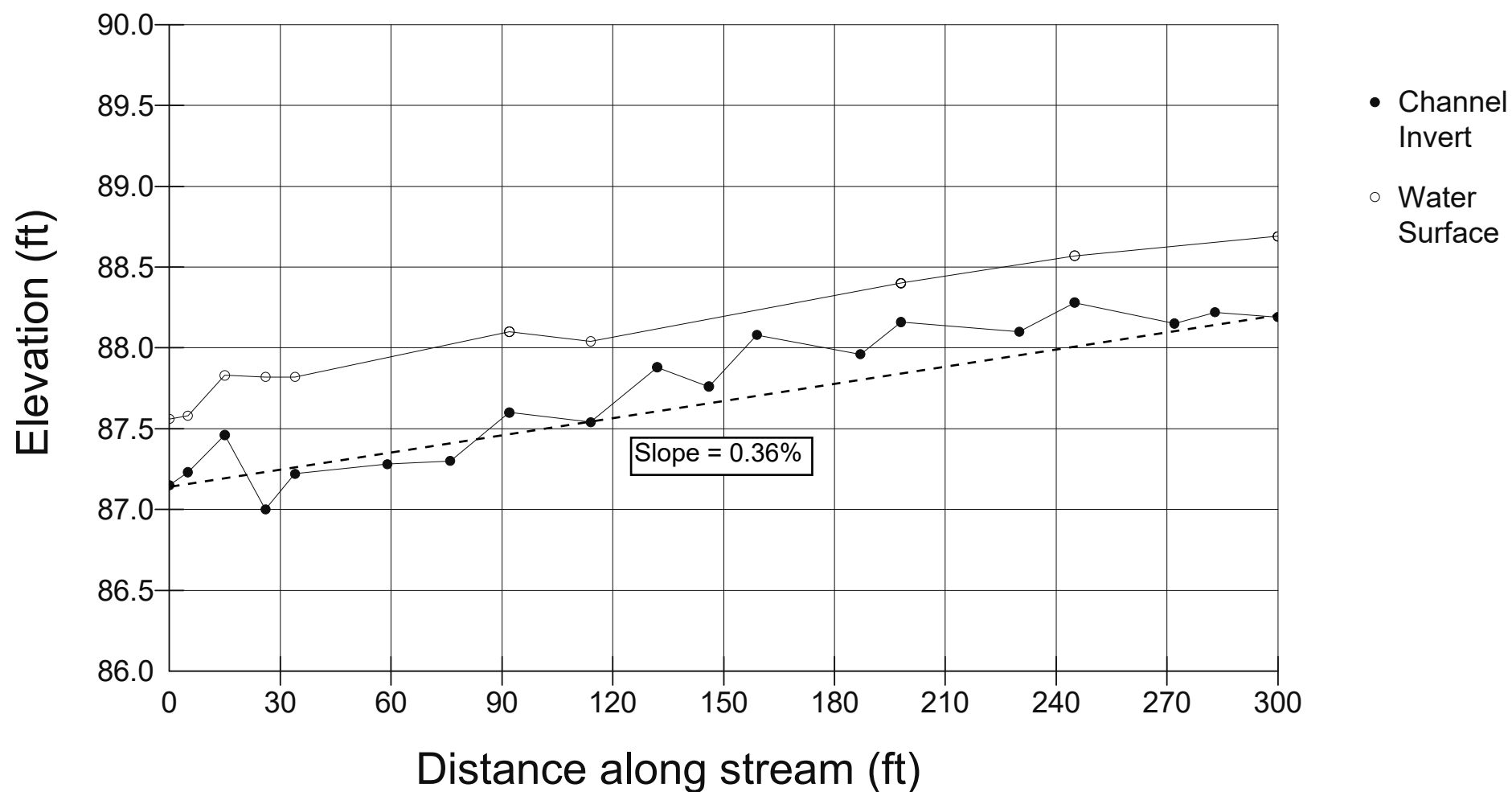
Photo 5 – Montview Reach looking upstream at the E. 22<sup>nd</sup> Avenue outfall (10/6/2020).



Photo 6 – Montview Reach looking upstream from Montview Boulevard into Montview Park (10/6/2020).

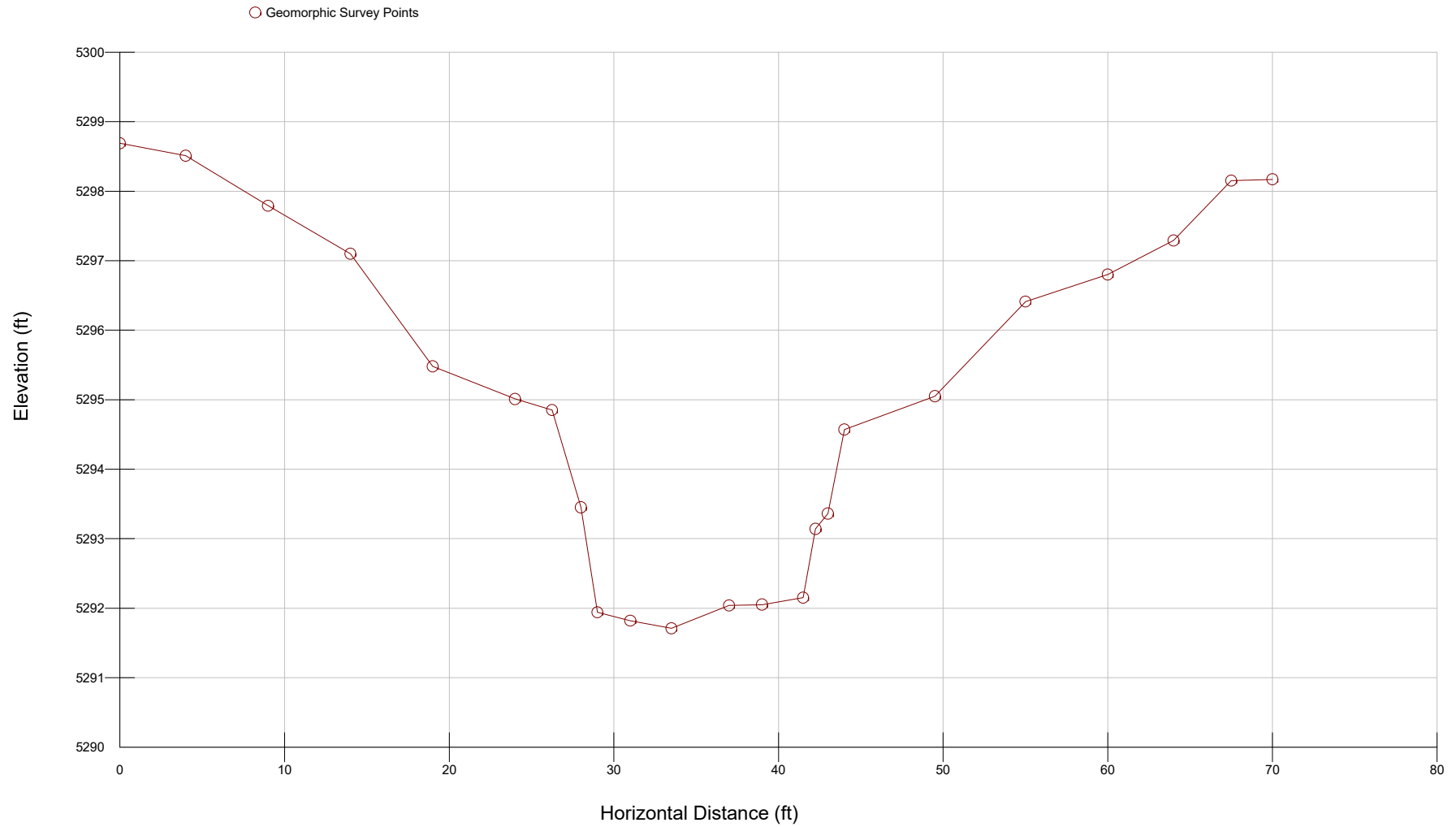
## **APPENDIX B – EXISTING CONDITIONS SURVEY**

# Existing Westerly Creek Channel Profile Stanley Reach

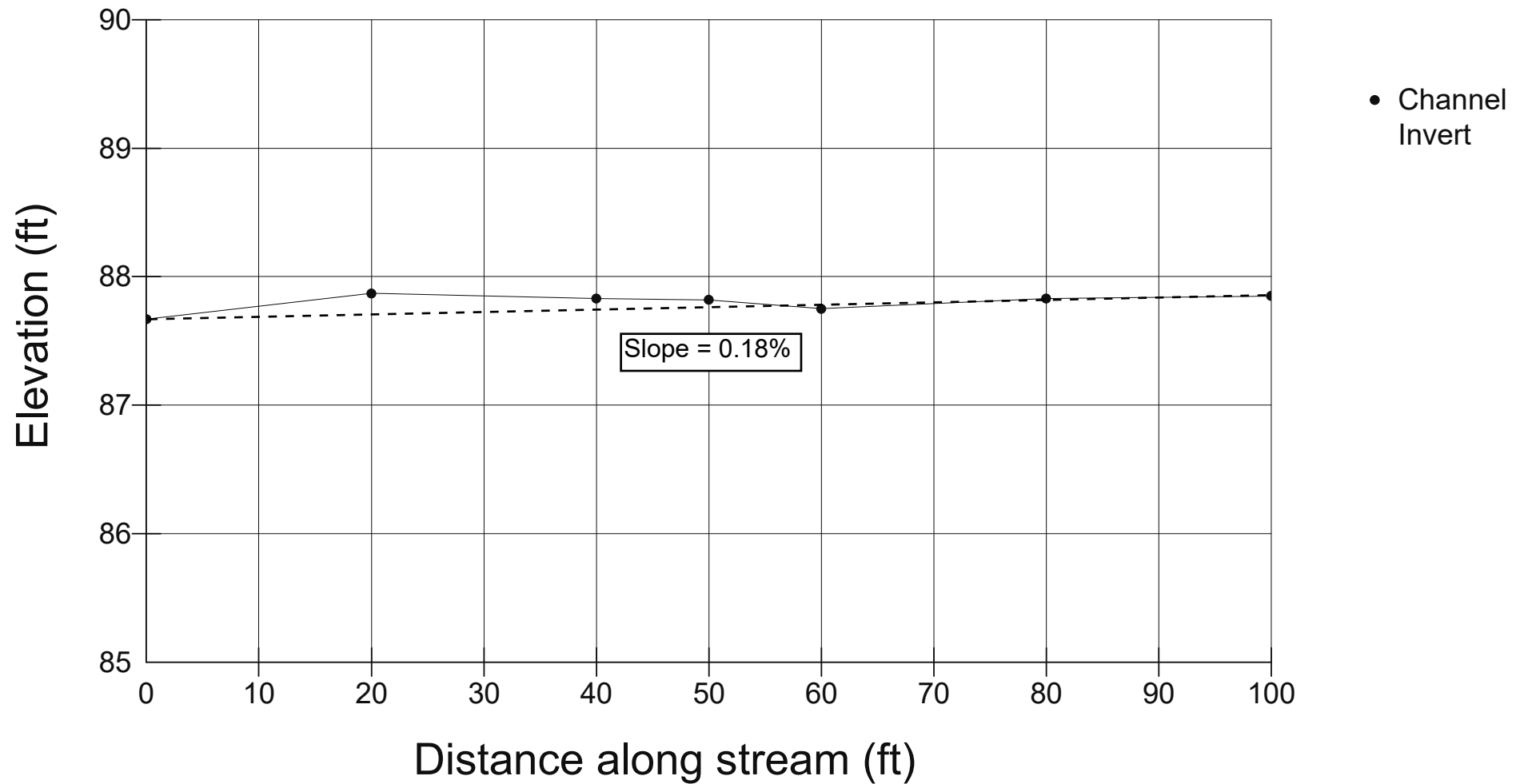




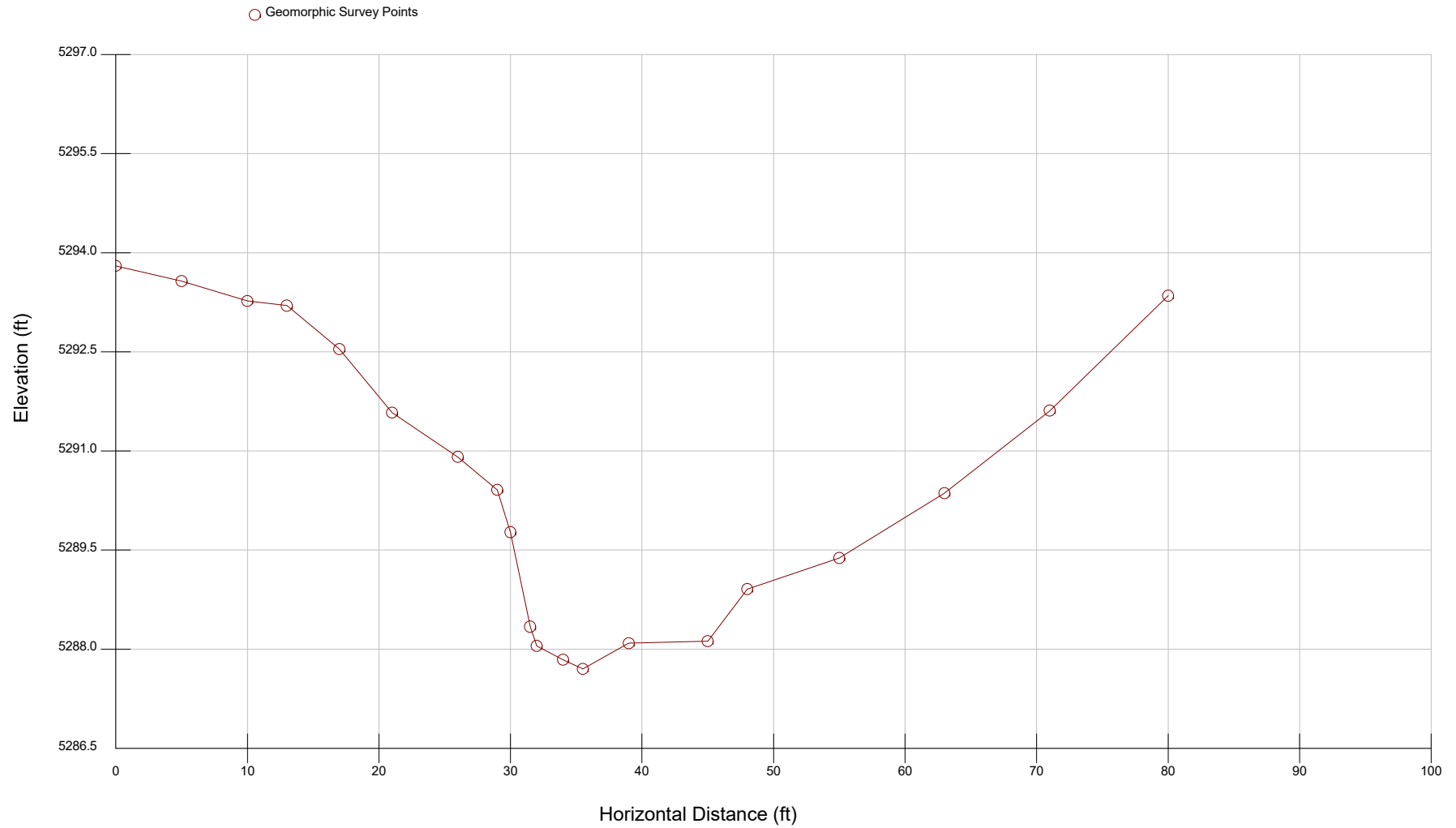
# Existing Channel Cross Section Stanley Reach



# Existing Westerly Creek Channel Profile Montview Reach



# Existing Channel Cross Section Montview Reach





## **APPENDIX C – DESIGN FLOW COMPARISON: 2017 WESTERLY CREEK FHAD**

Table 3-1 Westerly Creek Baseline Hydrology Peak Flows at Key Points

Locations	Design Points / Conveyance Elements	Total Drainage Area		Station	FHAD 2017 _ NOAA 14 _ Future Conditions Peak Flow (cfs)							100-Year Hydrology Comparison (cfs)				
		(acres)	(mi <sup>2</sup> )		Q <sub>2</sub>	Q <sub>5</sub>	Q <sub>10</sub>	Q <sub>25</sub>	Q <sub>50</sub>	Q <sub>100</sub>	Q <sub>500</sub>	MDP 2010	FEMA	FHAD 2017 NOAA 14	FHAD 2017 Ct/Cp	FHAD 2017 Original
Outfall	JSandCreek	11,602	18.13	0+00	752	1,165	1,632	2,714	3,342	4,424	7,134	6,859	6,900	4,424	4,742	6,762
33rd Avenue	J33rd	11,492	17.96	20+80	744	1,150	1,606	2,662	3,277	4,335	6,999	6746	6,000	4,335	4,662	6,647
MLK Blvd	JMLK	11,410	17.83	36+00	746	1,151	1,599	2,640	3,249	4,300	6,984	6679	5,300	4,300	4,628	6,584
29th Avenue	J29th	11,132	17.39	41+80	678	1,043	1,455	2,438	3,011	4,056	6,586	6,268		4,056	4,362	6,254
26th Avenue	J26th	10,851	16.95	61+00	637	977	1,351	2,266	2,809	3,809	6,218	5800	4,700	3,809	4,093	5,867
23rd Avenue	J23rd	10,508	16.42	74+40	565	859	1,188	2,005	2,538	3,469	5,644	5136	4,580	3,469	3,722	5,325
Montview Blvd (d/s)	JMontview-ds	9,987	15.60	88+80	431	655	907	1,554	1,840	2,403	3,523	4844	2,310	2,403	2,481	3,552
Montview Blvd (u/s)	JMontview-us	9,707	15.17	89+30	370	556	771	1,325	1,585	2,034	3,010	3,678		2,034	2,144	2,971
19th Avenue (d/s)	J19th-ds	9,683	15.13	96+00	365	548	766	1,316	1,563	2,019	2,975	3,645		2,019	2,118	2,945
19th Avenue (u/s)	J19th-us	7,584	11.85	96+50	310	465	635	1,128	1,369	1,819	2725	2444		1819	1913	2680
17th Avenue	J17th	7,568	11.83	102+45	306	458	625	1,124	1,354	1,818	2712	2387		1818	1897	2663
16th Avenue (d/s)	J16th-DIV	7,553	11.80	115+70	303	453	618	1,039	1,343	1,778	2637	2394	2140	1778	1837	2623
16th Avenue (u/s)	J16th-us	7,316	11.43	116+20	253	379	514	854	1,097	1,480	2043	1837		1480	1435	2052
Colfax Avenue	JColfax-DIV	7,231	11.30	124+80	231	341	461	775	1,012	1,345	1863	1659	1000	1345	1306	1878
14th Avenue	J14th-DIV	7,189	11.23	130+20	222	327	442	745	943	1,200	1795	1583		1200	1257	1790
13th Avenue	J13th-DIV	7,027	10.98	138+75	167	204	244	348	416	507	743	1261	830	507	526	790
12th Avenue	J12th	6,950	10.86	144+60	153	179	209	287	340	413	606	1146		413	430	605
11th Avenue	J11th	6,841	10.69	156+10	131	140	151	189	217	258	388	865		258	268	361
Kelly Road Outflow	OUT130	6,612	10.33	156+12	66	74	81	86	91	95	130	96	100	95	94	97
Kelly Road Inflow	RES130	6,612	10.33	160+40	400	581	763	1,108	1,332	1,590	2151	2428	1630	1590	1621	2240
6th Avenue	J151	6,405	10.01	185+50	351	504	654	910	1,066	1,264	1775	2211		1264	1306	1895
Lowry Blvd	J347	5,821	9.10	207+50	75	109	161	289	362	473	714	898	475	473	496	842
W.C. Dam Outflow	J202	5,546	8.67	222+80	50	50	50	50	50	50	50	50	98	50	50	50

1. FHAD 2017 Original \_ hydrographs of each sub-basin were calculated using CUHP Version 1.4.4 and rainfall from USDCM 2016.

2. FHAD 2017 Ct/Cp \_ hydrographs of each sub-basin were calculated using CUHP Version 1.4.4 and rainfall from USDCM 2016 with adjusted Ct/Cp using spreadsheet "CpCtOverride\_Version2.0.xlsm".

3. FHAD 20017 NOAA 14 \_ hydrographs of each sub-basin were calculated using CUHP Version 1.5.2b with rainfall from NOAA Atlas 14.

## **APPENDIX D – PROPOSED ALIGNMENT EXHIBIT**





**LEGEND**

- EXISTING ALIGNMENT
- PROPOSED ALIGNMENT

No.	DATE	REVISIONS	APPR.



PREPARED FOR:

**MHFD**

**MILE HIGH FLOOD DISTRICT**



PREPARED BY:

**ICON**

**ENGINEERING, INC.**

IN COOPERATION WITH:

**stream**

1245 E. COLFAX AVE. STE. 401 DENVER, CO 80211  
www.streaminc.com | 720.663.7352

**WESTERLY CREEK AT STANLEY MARKETPLACE  
PROPOSED GEOMORPHIC ALIGNMENT**

ICON PROJECT No.

DATE
SHEET





# **FINAL DRAINAGE REPORT**

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## **APPENDIX E – CLOMR REPORT**



**FINAL DRAINAGE REPORT**

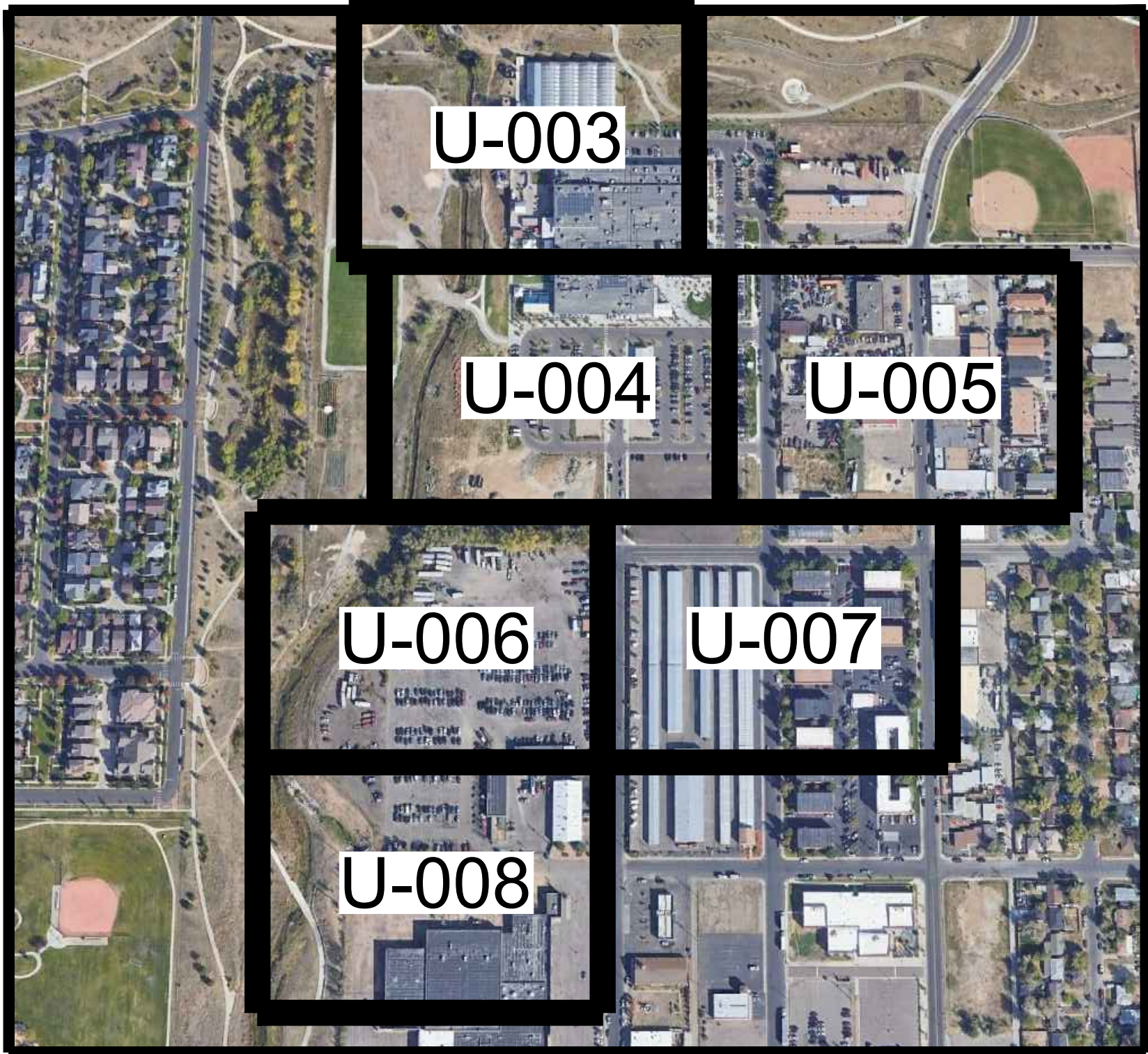
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**APPENDIX F – SUE PLANS**

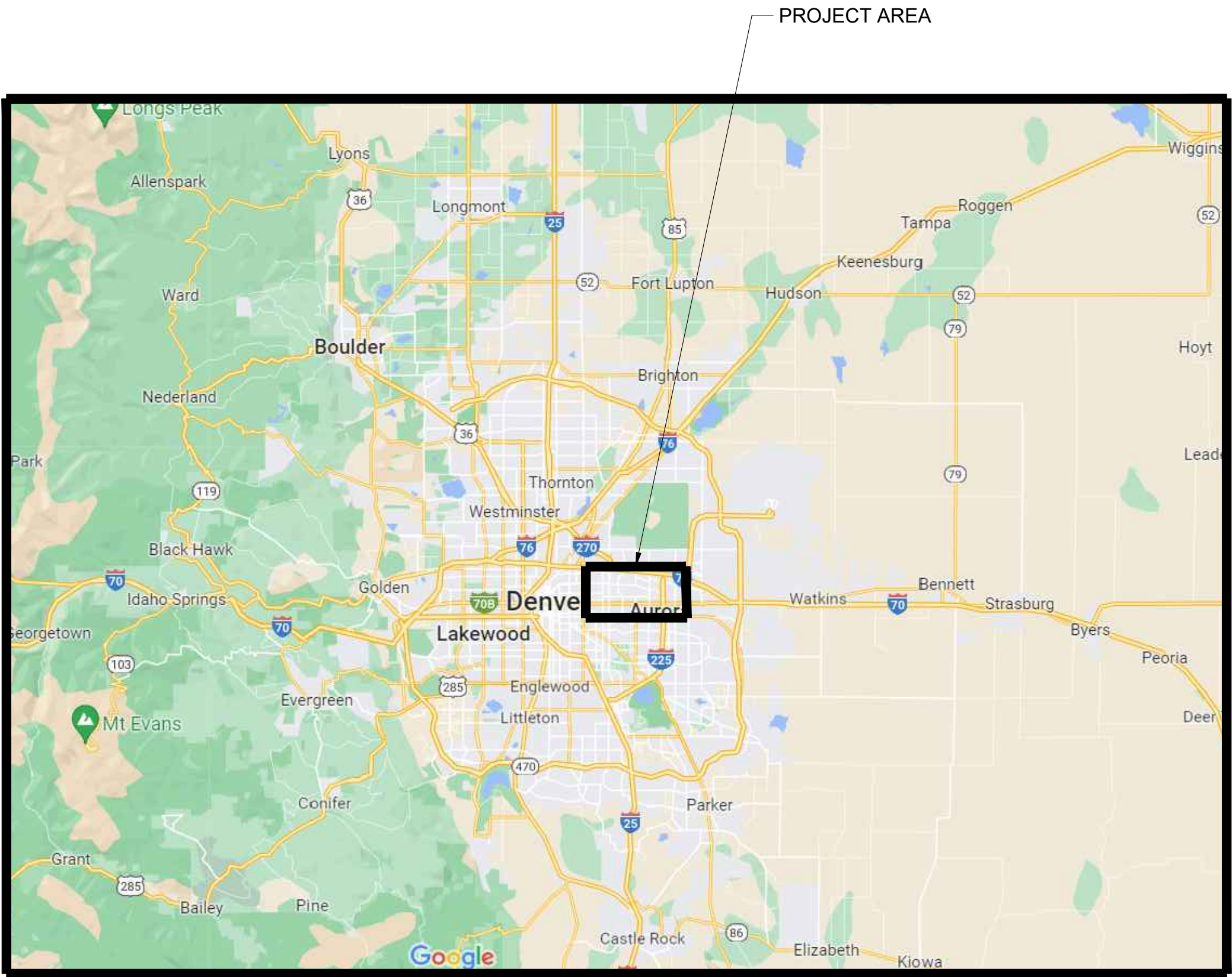


SUBSURFACE UTILITY ENGINEERING INVESTIGATION  
WESTERLY CREEK  
AURORA, COLORADO

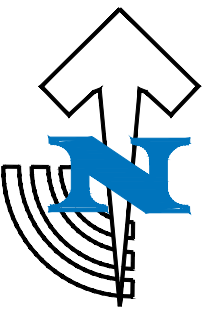
PREPARED FOR:  
ICON ENGINEERING



KEY MAP  
N.T.S.



VICINITY MAP  
N.T.S.



SHEET INDEX	
SHEET NO.	DESCRIPTION
U-001 - U-002	TITLE SHEET, KEY MAP & VICINITY MAP, GENERAL NOTES, LEGEND, AND ABBREVIATIONS
U-003 - U-008	UTILITY INVESTIGATION PLAN SHEET

UTILITY INVESTIGATION STATEMENT OF ASCE 38 COMPLIANCE  
THE UTILITIES DEPICTED HAVE BEEN INVESTIGATED IN GENERAL ACCORDANCE WITH THE ASCE 38-02, "STANDARD GUIDELINE FOR THE COLLECTION AND DEPICTION OF EXISTING SUBSURFACE UTILITY DATA," STANDARD AND SHOWN AT THEIR ACHIEVED QUALITY LEVELS. ALL OTHER INFORMATION HAS BEEN PROVIDED BY OTHERS AND INCLUDED AS REFERENCE ONLY.



FOR INFORMATION ONLY

UTILITY INVESTIGATION PLANS

WESTERLY CREEK

ICON

AURORA, CO

#	DATE	DESCRIPTION	BY

FOR  
INFORMATION  
ONLY

DATE	01/11/23
DRAWN	BF
SURVEYED	EPS
CHECKED	KM
PROJECT #	CO03000300
SHEET TITLE	COVER SHEET
SHEET NUMBER	

U-001



Plot Stamp: 1/11/2023 12:57:06 PM - Brandon Fisher  
File: O:\Projects\CON\CO-03000300 - Westerly Creek\2\_CADD\DWG\Model\Stanley Marketplace NEW UTIL\_BASE.dwg

UTILITY LINETYPES

	STORM DRAINAGE LINE
	SANITARY SEWER LINE
	ELECTRIC LINE
	OVERHEAD UTILITY LINE
	GAS LINE
	UNKNOWN LINE
	TELEPHONE LINE
	OVERHEAD TELEPHONE LINE
	CABLE TV LINE
	FIBER OPTIC LINE
	WATER LINE
	LIMITS OF ASCE 38 INVESTIGATION
	SITE

ABBREVIATIONS

ABDN	ABANDONED
ACP	ASBESTOS CLAY PIPE
CCP	CONCRETE CYLINDER PIPE
CHWTR	CHILLED WATER
CIP	CAST IRON PIPE
CL	CENTERLINE
CL/MH	INVERT AT CENTERLINE OF MANHOLE
CONC.	CONCRETE
CP	CONCRETE PIPE
CPP	CORRUGATED PLASTIC PIPE
CU	COPPER PIPE
CMP	CORRUGATED METAL PIPE
CSP	CORRUGATED STEEL PIPE
DIP	DUCTILE IRON PIPE
FM	FORCED MAIN
FO	FIBER OPTIC
INV	INVERT
JT	BURIED JOINT TRENCH
OH	OVERHEAD
OHE	OVERHEAD ELECTRIC
OHT	OVERHEAD TELEPHONE
PE	POLYETHYLENE
PL	PLASTIC
PRI	PRIVATE
PVC	POLYVINYL CHLORIDE
RCP	REINFORCED CONCRETE PIPE
SD	STORM DRAIN
SS	SANITARY SEWER
SSC	SANITARY SEWER CLEANOUT
STL	STEEL
SW	STEEL WRAPPED
TELE	TELEPHONE
TV	TELEVISION
UNK	UNKNOWN
VCP	VITRIFIED CLAY PIPE

UTILITY DETECTION EQUIPMENT UTILIZED
RADIO DETECTION RD8100PDL
PIPEHORN 800H
SCHONSTEDT MAGNETIC LOCATOR
DETECTABLE RODDER
IDS GEORADAR IS MF HI-MOD GPR
VIVAX METROTECH VM810

SUBSURFACE UTILITY ENGINEERING SYMBOLS

	CHANGE OF ASCE 38 QUALITY LEVEL
	LIMITS OF ASCE 38 INVESTIGATION
	LOSS OF SIGNAL
	END OF PIPE
	(UTILITY OWNER)-(SIZE AND/OR TYPE)-(ASCE QUALITY LEVEL)
	TYPE R INLET
	STORM MANHOLE
	STORM PIPE END SECTION
	TYPE C INLET
	SANITARY MANHOLE
	BURIED GAS LINE MARKER
	GAS VALVE
	GAS METER
	UTILITY POLE
	GUY WIRE
	LIGHT POLE
	ELECTRICAL METER
	ELECTRICAL TRANSFORMER
	ELECTRIC MANHOLE
	ELECTRIC CABINET
	TELEPHONE VAULT
	TELEPHONE/FIBER MANHOLE
	TELEPHONE JUNCTION BOX
	CATV RISER/PULL BOX
	CATV/TELEPHONE CABINET
	BURIED TELE/FIBER LINE MARKER
	WATER METER
	WATER MANHOLE
	WATER VALVE
	FIRE HYDRANT
	BURIED WATER LINE MARKER
	MONITOR WELL
	CATV RISER
	CATV VAULT
	FIBER OPTIC PULL BOX

UTILITY QUALITY LEVELS

- **QUALITY LEVEL D (QLD):** UTILITY QUALITY LEVEL D (QLD) INFORMATION IS DETERMINED PRIMARILY FROM THE REVIEW AND DOCUMENTATION OF EXISTING SECOND-PARTY INFORMATION, SUCH AS UTILITY RECORDS, HISTORICAL PROJECT RECORDS, PERMITS, VERBAL ACCOUNTS, THE EXISTENCE OF SERVICE, VISUAL INDICATORS, AND/OR ONE-CALL MARKINGS, PUT INTO CONTEXT WITH ANY OTHER INFORMATION THE SUE PROFESSIONAL HAS IN THEIR POSSESSION DURING A UTILITY INVESTIGATION.
- **QUALITY LEVEL C (QLC):** UTILITY QUALITY LEVEL C (QLC) INFORMATION IS DETERMINED BY CORRELATING UNDERGROUND UTILITY SEGMENTS FROM EXISTING SECOND-PARTY INFORMATION TO OBSERVABLE AND MEASURABLE VISIBLE UTILITY FEATURES. QLC DOES NOT REFER TO THE UTILITY FEATURE OR PORTION OF THE UTILITY SEGMENT THAT IS VISIBLE. IT REFERS TO THE UNOBSERVABLE PORTION OF THE UTILITY FEATURE OR UTILITY SEGMENT THAT CONNECTS TO VISIBLE, TYPICALLY ABOVEGROUND OR WITHIN AN ACCESSIBLE VAULT, SURVEYED UTILITY FEATURES.
- **QUALITY LEVEL B (QLB):** A UTILITY QUALITY LEVEL B (QLB) MAY BE ASSIGNED TO A UTILITY SEGMENT AFTER THE APPLICATION OF APPROPRIATE SURFACE GEOPHYSICAL METHODS TO IDENTIFY THE EXISTENCE AND APPROXIMATE HORIZONTAL POSITION OF UTILITIES (A UTILITY'S "DESIGNATION"), FOLLOWED BY SURVEY AND DOCUMENTATION, REVIEW OF AVAILABLE FIELD AND OFFICE DATA, AND A FINAL DETERMINATION OF THE POSITION FOR THE UTILITY SEGMENT OR UTILITY FEATURE ON THE DELIVERABLES. ALL AFOREMENTIONED TASKS ARE PERFORMED UNDER THE DIRECT RESPONSIBLE CHARGE OF THE SUE PROFESSIONAL. THE LARGEST SOURCE OF POTENTIAL ERROR IS USUALLY THE INTERPRETATION OF THE GEOPHYSICAL FINDINGS AND RESULTS.
- **QUALITY LEVEL A (QLA):** QUALITY LEVEL A (QLA) BUILDS ON QLB INFORMATION BY CONFIRMING THE EXISTENCE, EXACT LOCATIONS, AND OTHER ATTRIBUTES OF SUBSURFACE UTILITY THROUGH THE EXPOSURE OF THE UTILITY USING SAFE EXCAVATING PRACTICES. QLA DATA ARE DETERMINED BY PHYSICALLY EXPOSING AN UNOBSERVABLE UTILITY FEATURE OR UTILITY SEGMENT (ESSENTIALLY MAKING IT OBSERVABLE) AND DOCUMENTING ITS SPATIAL EXTENT AND CHARACTERISTICS WITH A HIGH DEGREE OF ACCURACY. CONVENTIONAL ACCURACIES SHALL BE 0.1FT (30MM) VERTICAL AND 0.2FT (60 MM) HORIZONTAL FOR THE MEASUREMENTS OF THE OUTSIDE LIMITS OF THE UTILITY FEATURES OR UTILITY SEGMENT THAT IS EXPOSED.

SURVEY CONTROL				
CP #	GRID NORTHING	GRID EASTING	NAD 1983(CONUS) ELEVATION	DESCRIPTION
J 392	1700529.21811	3174106.52902	5313.08	NGS J 392 1983
240	1711371.326	3163760.739	5251.18	ADCO 95.0240

SURVEY CONTROL

ALL DATA SHOWN IS BASED ON GRID COLORADO STATE PLANE CENTRAL ZONE (0502). ALL COORDINATES HORIZONTAL AND VERTICAL WERE BASED ON NAD 1983 (CONUS) AND GEOID COLOG128

811 RECORDS RESEARCH RESPONSES

OWNER	UTILITY	ABBREVIATION	CONTACT	PHONE/EMAIL	OFFICIAL 811 RESPONSE	ADDITIONAL INFORMATION OBTAINED	NOTE
CITY OF AURORA	WATER, SEWER, STORM, RAW, RECLA		CITY OF AURORA - WATER	(303)326-8645 / WATERENRGIS@AURORAGOV.COM	CLEAR	No	
CITY AND COUNTY OF DENVER	GAS, ELECTRIC, FIBER, WATER	CCD	CITY AND COUNTY OF DENVER	(720)865-6985 / HTTPS://WWW.DENVERGOV.ORG	MAPS PROVIDED	No	
COMCAST	CATV & FIBER	CMCST	USIC - COMCAST	(800)778-9140	CLEAR	No	
DENVER WATER	WATER	DW	DENVER WATER - ONLINE GIS	(303)628-6666 / WWW.DENVERWATER.ORG	CLEAR	No	
METRO WATER RECOVERY	SEWER	MWR	METRO WATER RECOVERY	(303)286-3296 / HTTPS://WWW.METROWATERRECOVERY.COM	MAPS PROVIDED	No	
PARK CREEK METRO DISTRICT	ELECTRIC, SEWER, WATER	PKCRK	PARK CREEK METRO DISTRICT LOCATING SERVICE	(303)904-7422 / (303)393-7700	CLEAR	No	
CENTURY LINK	FIBER & TELECOM	CLN	USIC - CENTURY LINK	(800)778-9140 / NATIONALRELO@CENTURYLINK.COM	CLEAR	No	
XCEL ENERGY	ELECTRIC & GAS	XCEL	XCEL ENERGY - STAKE CENTER	(801)364-1063	MAPS PROVIDED	No	

GENERAL NOTES

- SUBSURFACE UTILITY ENGINEERING IS A PROFESSIONAL PRACTICE DEFINED BY THE AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE.) T2UE CONDUCTS UTILITY INVESTIGATIONS IN ACCORDANCE WITH *ASCE 38: STANDARD GUIDELINE FOR THE COLLECTION AND DEPICTION OF EXISTING SUBSURFACE UTILITY DATA*. IDENTIFYING AND MAPPING UNDERGROUND UTILITIES IS A RESULT OF GATHERING EVIDENCE FROM VARIOUS SOURCES AND EXACT UTILITY LOCATIONS ARE NOT CONFIRMED UNLESS VISUALLY EXPOSED AND SURVEYED, AND THEN ONLY AT THOSE SPECIFIC EXPOSED LOCATIONS. ADDITIONALLY, T2UE CANNOT GUARANTEE THAT ALL UTILITIES HAVE BEEN DISCOVERED AND DEPICTED.
- IN ACCORDANCE WITH 2018 COLORADO REVISED STATUES TITLE 9 ARTICLE 1.5 T2 UES INC. SUBMITTED A SUBSURFACE UTILITY ENGINEERING NOTIFICATION TO THE COLORADO 811 ASSOCIATION ON 9/22/22.
- T2UE INVESTIGATED ALL UTILITIES, INCLUDED WITHIN THE SCOPE OF WORK, INSIDE THE PROJECT LIMITS. THOSE UTILITIES ARE DEPICTED AS INDICATED IN THE LEGEND. OTHERS PROVIDED ALL OTHER INFORMATION, AND T2UE DISCLAIMS RESPONSIBILITY FOR ITS ACCURACY.
- INVESTIGATIONS OF DEPICTED UTILITIES WERE COMPLETED ON 10/19/22. T2UE DISCLAIMS RESPONSIBILITY FOR NEW INSTALLATIONS OR ALTERATIONS TO EXISTING UTILITIES AFTER THIS DATE. CONSIDERATION SHOULD BE GIVEN TO UPDATING THIS INVESTIGATION PRIOR TO FINAL DESIGN AND/OR CONSTRUCTION.
- UTILITY SIZE AND MATERIAL ARE SHOWN IF AVAILABLE FROM RECORD INFORMATION. ADDITIONALLY, FIELD OBSERVATIONS WERE CONDUCTED, WHERE POSSIBLE, TO CORROBORATE AND SUPPLEMENT RECORD INFORMATION BUT DO NOT GUARANTEE ITS ACCURACY OR COMPLETENESS. PIPE DIAMETERS ARE NOMINAL AND NOT EXACT, UNLESS OTHERWISE NOTED.
- PROFESSIONAL ASSISTANCE IS RECOMMENDED IN SELECTING LOCATIONS FOR QUALITY LEVEL A DATA FOR SPECIFIC DESIGN DECISIONS.
- THIS INVESTIGATION DEPICTS UTILITIES FOR PLANNING AND DESIGN PURPOSES AND NOT FOR CONSTRUCTION. FOR DAMAGE PREVENTION DURING CONSTRUCTION, COMPLY WITH APPLICABLE ONE-CALL LAWS(CALL 811).
- THESE PLANS HAVE BEEN PREPARED FOR THE USE OF T2UE'S CLIENT AND MAY NOT BE USED, REPRODUCED OR RELIED UPON BY THIRD PARTIES EXCEPT AS AGREED BY T2UE AND ITS CLIENT OR AS REQUIRED BY LAW.
- AS DEFINED BY THE PROJECT SCOPE, T2UE ATTEMPTED TO FIND UNDOCUMENTED UTILITIES DEPICTED AND LABELED AS UNKNOWN UTILITIES ON THE PLAN SET, AS THE HAVE NO CORRELATED RECORDS OR VISIBLE APPURTENANCES TO DETERMINE FUNCTION TYPE. HOWEVER, UNDOCUMENTED UTILITIES MAY BE PRESENT IN THE PROJECT AREA THAT WERE NOT DISCOVERABLE BY THE SCOPED EFFORT AND THEREFORE NOT DEPICTED.
- AS PER PROJECT SCOPE, THE POSITIONING AND SIZE OF SUBSURFACE UTILITY VAULTS WERE NOT INCLUDED AS PART OF THIS INVESTIGATION. IF FOUND TO BE IN CONFLICT WITH PROPOSED PLANS, THE POSITIONING AND SIZE OF VAULTS SHOULD BE CONFIRMED.
- UNDER THE PROJECT SCOPE, THE FOLLOWING UTILITIES WERE EXPRESSLY EXCLUDED FROM THIS INVESTIGATION: LANDSCAPE IRRIGATION SYSTEMS, TRAFFIC LOOP DETECTION DEVICE, CTHODIC PROTECTION SYSTEMS AND THEIR APPURTENCES, SEWER LATERALS AND UNDERGROUND STORAGE TANKS / ASSOCIATED PIPING OR SEPTIC SYSTEMS.
- UTILITIES ARE GENERALLY DEPICTED BY A SINGLE LINE. HOWEVER LARGER UTILITIES (12" AND GREATER) MAY BE DEPICTED AT THEIR REPORTED WIDTH CENTERED OVER THE ACTUAL QUALITY LEVEL RESULTS. THEREFORE, ANY UTILITY EDGES SHOWN ARE FOR SCHEMATIC DEPICTION ONLY AND SHOULD NOT BE CONSIDERED RELIABLE FOR DESIGN. IF EXACT EDGES OF UTILITY ARE NEEDED, QLA DATA IS REQUIRED.
- NON-CONDUCTIVE UTILITY PIPES, WHERE TRACER WIRE IS AVAILABLE, ARE DESIGNATED AND LABELED QLB. HOWEVER, DUE TO THE UNKNOWN WIRE INSTALLATION MEANS AND METHODS DURING CONSTRUCTION, THE ALIGNMENT LOCATION OF THE TRACER WIRE MAY BE DIFFERENT FROM THE ALIGNMENT LOCATION OF THE ACTUAL UTILITY PIPE. TYPE AND QUANTITY OF NON-CONDUCTIVE PIPE MAY ALSO NOT BE REFLECTED DUE TO THE NATURE OF GEOPHYSICS.
- OVERHEAD UTILITIES ARE OT ASSIGNED A QUALITY LEVEL, UNLESS OTHERWISE NOTED.
- ACTIVE CONSTRUCTION THROUGHOUT PROJECT LIMITS. UTILITIES MIGHT HAVE BEEN REMOVED OR INSTALLED AFTER T2UE'S INVESTIGATION.

ENGINEERING NOTES(TBD)

- A.)  
B.)  
C.)

UTILITY INVESTIGATION PLANS

WESTERLY CREEK

ICON

AURORA, CO

#	DATE	DESCRIPTION	BY

FOR INFORMATION ONLY

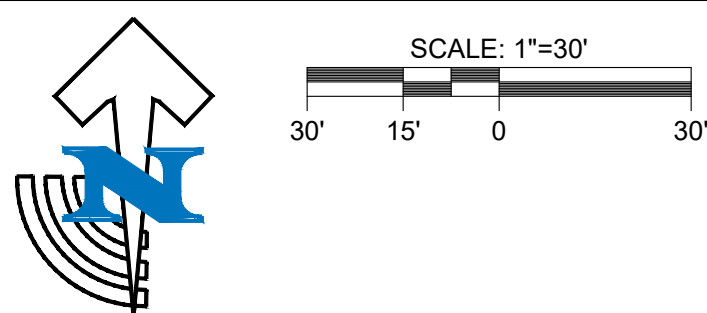
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CHECKED	KM
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SHEET TITLE	STANDARD SHEET
SHEET NUMBER	

U-002



UTILITY INVESTIGATION STATEMENT OF ASCE 38 COMPLIANCE  
THE UTILITIES DEPICTED HAVE BEEN INVESTIGATED IN GENERAL ACCORDANCE WITH THE ASCE 38-02, "STANDARD GUIDELINE FOR THE COLLECTION AND DEPICTION OF EXISTING SUBSURFACE UTILITY DATA," STANDARD AND SHOWN AT THEIR ACHIEVED QUALITY LEVELS. ALL OTHER INFORMATION HAS BEEN PROVIDED BY OTHERS AND INCLUDED AS REFERENCE ONLY.

FOR INFORMATION ONLY



**T2 utility engineers**  
1-855-222-T2UE | WWW.T2UE.COM

**DENVER**  
150 CAPITAL DR. SUITE 190  
GOLDEN, CO 80401  
TEL: (720) 452-9873

AURORA, CO

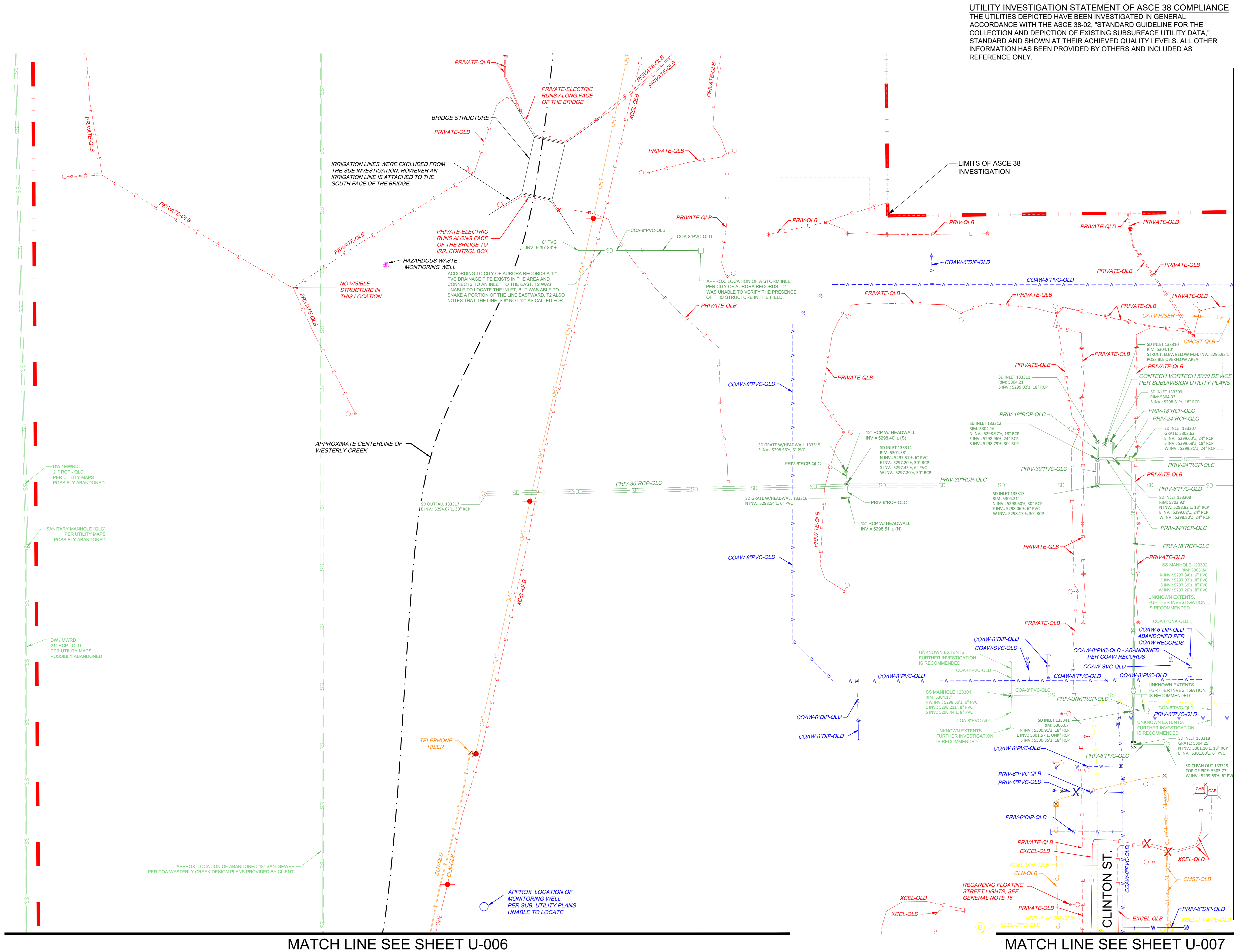
FOR  
INFORMATION  
ONLY

**U-003**



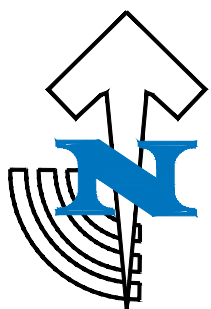
FOR INFORMATION ONLY





UTILITY INVESTIGATION STATEMENT OF ASCE 38 COMPLIANCE  
THE UTILITIES DEPICTED HAVE BEEN INVESTIGATED IN GENERAL  
ACCORDANCE WITH THE ASCE 38-02, "STANDARD GUIDELINE FOR THE  
COLLECTION AND DEPICTION OF EXISTING SUBSURFACE UTILITY DATA,"  
STANDARD AND SHOWN AT THEIR ACHIEVED QUALITY LEVELS. ALL OTHER  
INFORMATION HAS BEEN PROVIDED BY OTHERS AND INCLUDED AS  
REFERENCE ONLY.

SCALE: 1"=30'  
30' 15' 0' 30'



MATCH LINE SEE SHEET U-005

MATCH LINE SEE SHEET U-006

MATCH LINE SEE SHEET U-007

FOR INFORMATION ONLY

# UTILITY INVESTIGATION PLANS

WESTERLY CREEK

ICON

AURORA, CO

DATE	DESCRIPTION	BY

FOR  
INFORMATION  
ONLY

DATE	01/11/23
DRAWN	BF
SURVEYED	EPS
CHECKED	KM
PROJECT #	CO03000300
SHEET TITLE	PLAN SHEET
SHEET NUMBER	





FOR INFORMATION ONLY

BY —

DATE	01/11/23
------	----------

DRAWN | BF

SURVEYED	EPS
----------	-----

CHECKED | KM

PROJECT # | CO03000300

SHEET TITLE  
PLAN SHEET

SHEET NUMBER

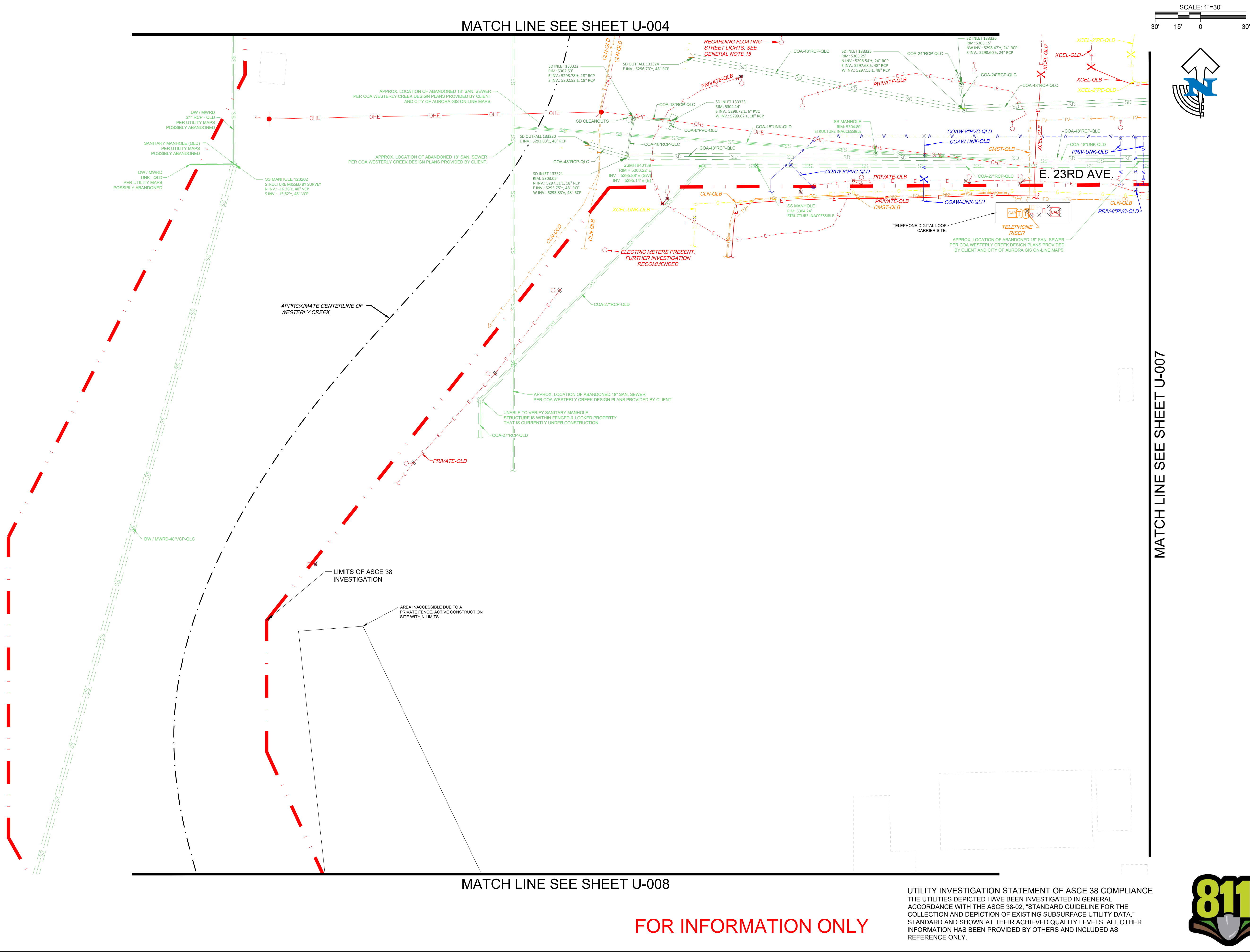
## II.0

U-005

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Plot Stamp: 1/11/2023 12:57:21 PM - Brandon Fisher  
File: O:\Projects\CON\CO-03000300 - Westerly Creek2\_CADD\DWG\Model\Stanley Marketplace NEW UTIL BASE.dwg



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# UTILITY INVESTIGATION PLANS

WESTERLY CREEK

ICON

AURORA, CO

#	DATE	DESCRIPTION	BY

FOR INFORMATION ONLY

DATE	01/11/23
DRAWN	BF
SURVEYED	EPS
CHECKED	KM
PROJECT #	CO03000300
SHEET TITLE	PLAN SHEET
SHEET NUMBER	U-006

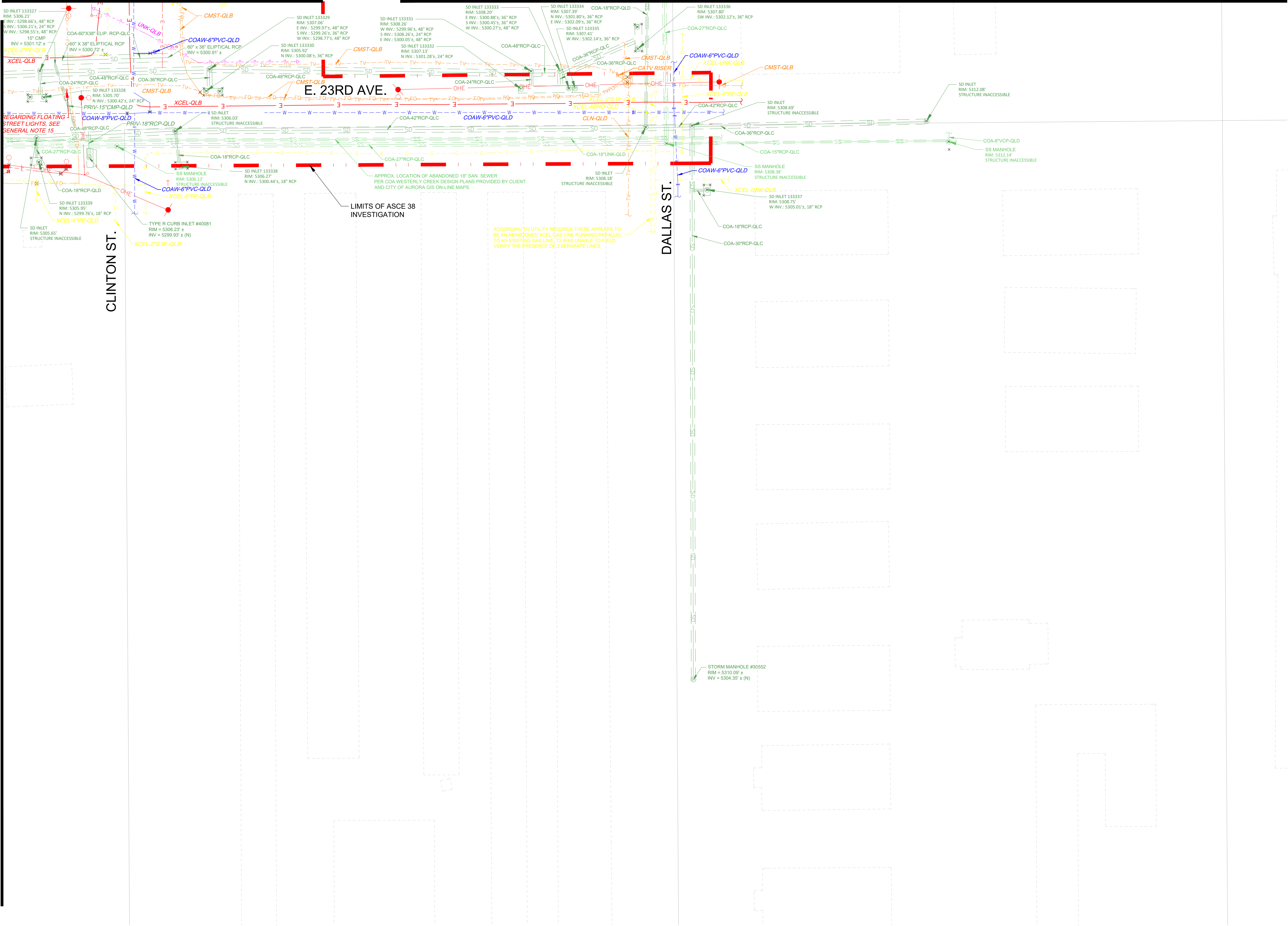
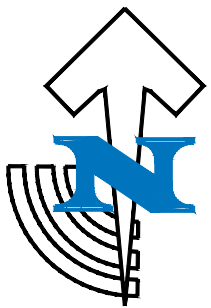


MATCH LINE SEE SHEET U-006

MATCH LINE SEE SHEET U-004

MATCH LINE SEE SHEET U-005

SCALE: 1"=30'



ACCORDING TO UTILITY RECORDS THERE APPEARS TO BE AN ABANDONED XCEL GAS LINE RUNNING PARALLEL TO AN EXISTING GAS LINE. T2 WAS UNABLE TO FIELD VERIFY THE PRESENCE OF 2 SEPARATE LINES.

LIMITS OF ASCE 38 INVESTIGATION

APPROX. LOCATION OF ABANDONED 18\"/>

UTILITY INVESTIGATION STATEMENT OF ASCE 38 COMPLIANCE  
THE UTILITIES DEPICTED HAVE BEEN INVESTIGATED IN GENERAL ACCORDANCE WITH THE ASCE 38-02, "STANDARD GUIDELINE FOR THE COLLECTION AND DEPICTION OF EXISTING SUBSURFACE UTILITY DATA," STANDARD AND SHOWN AT THEIR ACHIEVED QUALITY LEVELS. ALL OTHER INFORMATION HAS BEEN PROVIDED BY OTHERS AND INCLUDED AS REFERENCE ONLY.



FOR  
INFORMATION  
ONLY

DATE	01/11/23
DRAWN	BF
SURVEYED	EPS
CHECKED	KM
PROJECT #	CO03000300
SHEET TITLE	PLAN SHEET
SHEET NUMBER	

U-007

## UTILITY INVESTIGATION PLANS

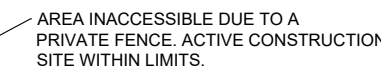
WESTERLY CREEK

ICON

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INFORMATION  
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# U-008

# U-008