



# Arborwalk East Multi-Family Storm Drainage Study

*Lee's Summit, Missouri. Jackson County*

**1<sup>st</sup> Submittal:** February 9<sup>th</sup>, 2023  
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Prepared For: **Milhaus Development, LLC**  
460 Virginia Avenue  
Indianapolis, IN 46203  
Devon Coffey  
[Devon.Coffey@milhaus.com](mailto:Devon.Coffey@milhaus.com)

Prepared By: **Kimley-Horn & Associates**  
805 Pennsylvania Avenue, Suite 150  
Kansas City, MO 64105

Matt Kist, P.E.  
[Matt.Kist@kimley-horn.com](mailto:Matt.Kist@kimley-horn.com)

Secondary Contact: Tyler Wysong, P.E.  
[Tyler.Wysong@kimley-horn.com](mailto:Tyler.Wysong@kimley-horn.com)



# Kimley»Horn

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## GENERAL INFORMATION

Kimley-Horn and Associates, Inc. (Kimley-Horn) has been hired by Milhaus Development, LLC to provide professional civil engineering services for the proposed Arborwalk East Multi-Family Development. The project is generally located at the northeast corner of MO-150 Highway and SW Ward Rd in Lee's Summit Missouri (See **Exhibit 1**). According to the Arborwalk Development Drainage Master Plan (See **Appendix A**), the project is located within a +/- 22.26-acre designated commercial area. Currently, there are 3 parcels within the commercial area. The largest parcel, with an area of +/- 18.88 acres, will be subdivided into two parcels. The northernmost +/- 11.46-acre parcel will contain the proposed multi-family development, while the remaining +/- 7.42-acre parcel will remain unimproved and is not within the scope of the project. It is understood this will ultimately be developed as a commercial property by others. The existing site is covered in grasses and woodland. The surface runoff generally flows southeast into an existing box culvert located at the northeast corner of the MO-150 and SW Ward Rd intersection, ultimately discharging into Raintree Lake.

The proposed multi-family development will generally include the construction of 8 walk-up garden style apartment buildings, as well as, associated new surface parking, new garage parking, new sidewalk plazas, new site access drives, new utility services, and streetscape improvements to serve the site. As referenced by the aforementioned drainage master plan, stormwater detention is provided upstream, adequately controlling peak flows for the entire planned commercial development. Therefore, no additional stormwater detention is proposed on site. The stormwater exiting the site will be routed through hydrodynamic separators designed to filter out pollutants per the MARC BMP Manual to treat water quality requirements.

The property is generally situated within Section 25, Township 47N, Range 32W in Jackson County, Missouri (See **Exhibit 2**).

## FEMA & STREAM BUFFER WAIVER

According to FEMA's (Federal Emergency Management Agency) Flood Insurance firm panel 29095C0532G, the site is located in Zone X, an "Area of Minimal Flood Hazard" (See **Exhibit 3**).

Based on USGS mapping, there is a designated blue line stream that traverses through the middle of the site (See **Exhibit 2**). The development team has worked with the Corps of Engineers to prepare a jurisdictional assessment and the proper permitting documentation to relocate the surface water into an underground storm pipe sized for the 100-year storm event by others. See **Appendix B** for a copy of these proposed plans. Per discussions with the city regarding the stream, a stream buffer waiver is also required for development to occur as planned. It is our opinion the stream functions more as an engineered drainage channel, conveying stormwater to the temporary sediment basin at the NW corner of 150 & Ward, and is not a natural stream. It was constructed, along with the upstream dry and wet detention basins, to temporarily act as an erosion control measure until the designated commercial area was ultimately improved. The potential for excess sediment leaving the site will be greatly reduced when the site is stabilized upon final development, improving downstream water quality. See **Appendix C** for the full Stream Buffer Waiver request prepared by others.

## SOILS

**Table 1** below shows the typical soil classifications found on site. For more information, see the data obtained from the USDA Soil Survey of Jackson County, Missouri (See **Exhibit 4**).

Table 1: USDA Soil Survey – On-Site Soil Characteristics

Hydrologic Soil Group (HSG)	Map Symbol	Type	Slopes
C	10082	Arisburg-Urban land Complex	1-5%
D	10128	Sharpsburg-Urban land complex	2-5%
C	10181	Udarents-Urban land-Sampsel Complex	5-9%

## METHODOLOGY

The Hydraflow Hydrograph Package and Bentley Pondpack software were utilized to determine the effects of the development and ensure that the existing hydrologic conditions were restored, and even improved. Following the American Public Works Association (APWA) Section 5600 Storm Drainage Systems and Facilities guide, Curve Numbers (CN's) and runoff coefficients (C's) were calculated depending on the cover type, condition, and hydrologic soil group, and rainfall intensities (See **Calculations 1**). Chapter 6 of the MARC BMP manual was used to determine the water quality volume and treatment flows, and the overall manual was used as guidance when determining an appropriate stormwater treatment solution for the project.

## EXISTING CONDITIONS

The proposed project is located within a designated commercial area, per the attached Arborwalk Development Drainage Master Plan. The commercial area is +/- 22.26 acres, and was initially divided into three parcels. The largest parcel, with an area of +/- 18.88 acres, will be subdivided into two parcels, for a total of four parcels within the commercial area. These four parcels (Lot "A", Lot "B", Lot "C", and Lot "D") all generally drain southeast towards a sedimentation basin installed previously to treat runoff until the site was ultimately developed. Runoff from the upstream detention basins flows through a stream, discharging at the aforementioned sedimentation basin. Stormwater ultimately drains toward a box culvert located in the southeast corner of the commercial area, carrying the runoff underneath the intersection and discharging into Raintree Lake.

The overall commercial area contains a wide variety of soils with slopes ranging from 1-9%. The soils belong to hydrologic soil groups C or D. The existing soils are described as moderately well drained to somewhat poorly drained. The existing site primarily consists of 1.52 acres of woods in good condition yielding a CN of 74, 5.05 acres of woods in good condition yielding a CN of 70, 12.64 acres of open space in good condition yielding a CN of 74, and 3.05 acres of open space in good condition yielding a CN of 80 (See **Exhibit 5**). This results in a cumulative pre-development CN of 74 with a time of concentration of 15 minutes. **Table 2** below presents the rainfall intensity and peak flows for the overall commercial area at Critical Point 1 in the pre-development condition.

Table 2: Pre-Development Overall Commercial Area Rainfall Intensity & Peak Flows				
	2-Year	10-Year	50-Year	100-Year
Rainfall Intensity (in/hr)	2.16	3.07	4.02	4.47
Pre-Development Peak Flow (CFS)	25.05	34.88	45.12	49.56

Based on the existing topography, the previously planned commercial area could be defined and analyzed as one overall drainage area. However, the report will divide them into four separate drainage areas (areas A through D) to allow for a more in-depth analysis of the existing and proposed conditions (See **Exhibit 6**). The four drainage areas are described below:

#### **Drainage Area “A”**

Drainage area “A” generally drains 11.46 acres of sheet flow and shallow concentrated flow inwards towards an unregulated rivulet and a stream, discharging into the existing sediment basin located in drainage area “B”. A ridge along the eastern third of the area promotes flow away from the unregulated rivulet and into storm inlets along SW Ward Road. In both scenarios, the flow enters underground storm sewer and is discharged south across the intersection into a small channel. The small channel carries runoff towards a box culvert directing flow east, ultimately discharging at Raintree Lake. There is approximately 3.05 acres of open space in good condition yielding a CN of 80, 1.52 acres of woods in good condition yielding a CN of 74, 5.13 acres of open space in good condition yielding a CN of 74, and 1.75 acres of woods in good condition yielding a CN of 70. The cumulative CN is 75 with a time of concentration of 12 minutes. **Table 3** below represents the rainfall intensity and peak flows for drainage area A in the pre-development condition.

Table 3: Pre-Development Drainage Area "A" Peak Flows				
	2-Year	10-Year	50-Year	100-Year
Rainfall Intensity (in/hr)	2.22	3.16	4.13	4.53
Pre-Development Peak Flow (CFS)	14.54	20.10	25.90	28.45

#### **Drainage Area “B”**

Drainage area “B” generally drains 7.45 acres of sheet flow and shallow concentrated flow east into the existing sedimentation basin and/or into the culvert located near the southeast corner of the entire commercial area. The culvert discharges into an unregulated tributary stream, ultimately flowing into Raintree Lake to the southeast. There is approximately 3.30 acres of woods in good condition yielding a CN of 70 and 4.15 acres of open space in good condition yielding a CN of 74. The cumulative CN is 75 with a time of concentration of 14 minutes. **Table 4** below represents the rainfall intensity and peak flows for drainage area B in the pre-development condition.

Table 4: Pre-Development Drainage Area "B" Peak Flows				
	2-Year	10-Year	50-Year	100-Year
Rainfall Intensity (in/hr)	2.19	3.07	4.02	4.47
Pre-Development Peak Flow (CFS)	8.82	12.25	15.81	17.37

### **Drainage Area "C"**

Drainage area C generally drains 1.59 acres of sheet flow and shallow concentrated flow east, collecting in the existing sedimentation basin and ultimately discharging at Raintree Lake. The "Micro Stormwater Drainage Study for McBee's Coffee 'N Carwash" analyzes the existing conditions for what is referred to as "Drainage Area C" in this study, and was approved through the City of Lee's Summit, MO. Therefore, no further analysis of Drainage Area C is required. The aforementioned drainage study can be found in **Appendix D**.

### **Drainage Area "D"**

Drainage area "D" generally drains 1.77 acres of sheet flow and shallow concentrated flow east into Drainage Area "C". The flow is generally routed through the existing sedimentation basin located on the eastern half of the designated commercial area. The runoff is then conveyed through underground storm sewer south and discharged into an unregulated Raintree Lake tributary stream across MO 150 Highway. Ultimately, the runoff is discharged into Raintree Lake. There is approximately 1.77 acres of open space in good condition yielding a CN of 70. The cumulative CN is 70 with a time of concentration of 13 minutes. **Table 5** below presents the rainfall intensity and peak flows for drainage area D in the pre-development condition.

Table 5: Pre-Development Drainage Area "D" Peak Flows				
	2-Year	10-Year	50-Year	100-Year
Rainfall Intensity (in/hr)	2.16	3.07	4.02	4.41
Pre-Development Peak Flow (CFS)	2.15	2.98	3.84	4.22

Calculations for the Existing Conditions section can be found in the **Exhibits & Calculations** section of the report.

## **PROPOSED CONDITIONS**

The proposed improvements to the previously planned commercial area designated by the Arborwalk Development Drainage Master Plan will include improvements to Lots "A", "B", "C", and "D". Improvements to the +/- 11.46-acre Lot "A" generally include the construction of 8 new garden style walk-up apartment buildings, as well as, associated new surface parking, new garage parking, new sidewalk plaza, new site access drives, new utility services, and streetscape improvements to serve the site. Improvements to the +/- 7.45-acre Lot "B" will generally include the construction of 5 commercial

buildings, as well as, associated new surface parking, new sidewalk, new site access drives, new utility services, and new streetscape improvements to serve the site. Additionally, improvements to Lot “B” include the design and construction of public storm sewer intended to enclose an existing stream. The proposed public storm sewer will continue serving Lots “A” and “B”, as well as, upstream developments, during the 100-year storm event. See **Appendix B** for the public storm sewer plans prepared by others. Improvements to the 1.59-acre Lot “C” will generally include the construction of a commercial carwash building, as well as, associated new surface parking and new underground detention. Improvements to the +/- 1.77-acre Lot “D” generally include the construction of a commercial building and pump stations, as well as, associated new surface parking, new utility services, new site access drives. At the time of this report, Lot “D” has been developed. Lots “B”, “C”, and “D” were studied to confirm detention requirements were met based on the outlined requirements of the Arborwalk Development Drainage Master Plan. The proposed improvements of these areas will be performed by others.

The overall previously proposed commercial area primarily consists of 11.46 acres of Lot “A” multi-family development yielding a CN of 92, 7.45 acres of Lot “B” commercial development yielding a CN of 93, 1.59 acres of Lot “C” commercial development yielding an approximate CN of 90 (See approved drainage report in **Appendix D**), and 1.80 acres of commercial development yielding a CN of 94 (See **Exhibit 7**). This distribution results in a post-development cumulative CN of 92 for the overall commercial area with a conservative time of concentration of 5 minutes. **Table 6** below presents the rainfall intensity and peak flows for the area studied at Critical Point 1 in the post-development condition.

Table 6: Post-Development Overall Commercial Area Peak Flows				
	2-Year	10-Year	50-Year	100-Year
Rainfall Intensity (in/hr)	2.16	3.07	4.02	4.47
Post-Development Peak Flow (CFS)	34.69	49.36	64.56	71.83

Based on the proposed topography, the previously planned commercial area could be defined and analyzed as one overall drainage area. However, the report will divide them into four separate drainage areas (areas A through D) to allow for a more in-depth analysis of the proposed conditions (See **Exhibit 8**). The four drainage areas are described below:

**Drainage Area “A”**

Drainage Area “A” generally drains 11.46 acres of the overall area through a series of conveyance measures including new enclosed storm sewer and surface runoff. The captured runoff will be routed through water quality units (discussed further in the BMP Analysis section) and connected to a new RCB storm sewer constructed during Lot “B” improvements. It will ultimately be conveyed south to the box culvert at the northeast corner of MO 150 Highway and SW Ward Road, and discharged into Raintree Lake. Drainage Area “A” contains approximately 7.69 acres of impervious area and 3.77 acres of pervious area, resulting in a runoff coefficient of 0.70. The cumulative CN is 92 with a time of concentration of 5 minutes. **Table 7** below represents the rainfall intensity and peak flows for drainage area “A” in the post-development condition.

Table 7: Drainage Area "A" Post-Development Peak Flow Rates				
	2-Year	10-Year	50-Year	100-Year
Rainfall Intensity (in/hr)	2.22	3.16	4.13	4.53
Post-Development Peak Flow (CFS)	18.08	25.69	33.58	36.86

The post-development peak flows exceed the requirements set by APWA Section 5608.4.C.1.a, traditionally requiring on-site detention. However, the overall Arborwalk development drainage master plan accounts for unrestricted flow discharging from the designated commercial area. This will be discussed in more detail in the Detention Analysis section below.

#### **Drainage Area "B"**

Drainage Area "B" generally drains 7.45 acres of the overall area through a series of conveyance measures including new enclosed storm sewer and surface runoff south to the NW corner of the MO 150 Highway and SW Ward Road intersection. A box culvert carries the flow south across MO-150 Highway, discharging into an unregulated tributary stream before quickly flowing east underneath SW Ward Road through another culvert, and ultimately discharging into Raintree Lake. Drainage Area "B" contains approximately 5.33 acres of impervious area and 2.12 acres of pervious area, resulting in a runoff coefficient of 0.73. The cumulative CN is 93 with a conservative time of concentration of 5 minutes. **Table 8** below represents the rainfall intensity and peak flows for drainage area D in the post-development condition.

Table 8: Drainage Area "B" Post-Development Peak Flow Rates				
	2-Year	10-Year	50-Year	100-Year
Rainfall Intensity (in/hr)	2.19	3.07	4.02	4.47
Post-Development Peak Flow (CFS)	12.02	16.85	22.04	24.53

The post-development peak flows exceed the requirements set by APWA Section 5608.4.C.1.a, traditionally requiring on-site detention. However, the overall Arborwalk development drainage master plan accounts for unrestricted flow discharging from the designated commercial area. This will be discussed in more detail in the Detention Analysis section below.

#### **Drainage Area "C"**

Drainage area C generally drains 1.59 acres of the overall area through a series of conveyance measures including new enclosed storm sewer and surface runoff. The runoff is routed through an underground detention basin, controlling flows per APWA's "Comprehensive Control", and ultimately discharging into a swale off-site into Drainage Area "B". The "Micro Stormwater Drainage Study for McBee's Coffee 'N Carwash" analyzes the proposed conditions for what is referred to as "Drainage Area C" in this study. This study was approved through the City of Lee's Summit, MO so, therefore, no further analysis of Drainage Area C is required. The aforementioned drainage study can be found in **Appendix D**.

### **Drainage Area “D”**

Drainage Area “D” generally drains 1.77 acres of the overall area through a series of conveyance measures including new enclosed storm sewer and sheet-flow runoff. The runoff is generally conveyed east, flowing offsite and ultimately discharging into Raintree Lake. The improvements to Drainage Area “D” were constructed at the time of this report, so the as-built condition was used to calculate cover-type data. Drainage Area “D” contains approximately 1.41 acres of impervious area and 0.35 acres of pervious area, resulting in a runoff coefficient of 0.78. The cumulative CN is 94 with a conservative time of concentration of 5 minutes. **Table 9** below represents the rainfall intensity and peak flows for drainage area D in the post-development condition.

Table 9: Drainage Area "D" Post-Development Peak Flow Rates				
	2-Year	10-Year	50-Year	100-Year
Rainfall Intensity (in/hr)	2.16	3.07	4.02	4.41
Post-Development Peak Flow (CFS)	3.00	4.27	5.58	6.12

The post-development peak flows exceed the requirements set by APWA Section 5608.4.C.1.a, traditionally requiring on-site detention. However, the overall Arborwalk development drainage master plan accounts for unrestricted flow discharging from the designated commercial area. This will be discussed in more detail in the Detention Analysis section below.

Calculations for the Proposed Conditions can be found in the **Exhibits & Calculations** section of the report.

## **DETENTION ANALYSIS**

Post-development peak discharge rates shall not exceed the “Comprehensive Control” requirements set forth by APWA Section 5608.4.C.1.a shown below:

- 50% storm peak rate less than or equal to 0.5 cfs per site acre
- 10% storm peak rate less than or equal to 2.0 cfs per site acre
- 1% storm peak rate less than or equal to 3.0 cfs per site acre

The post-development peak flows for the 22.46-acre designated overall commercial area are compared against the APWA requirements in **Table 10** below.

Table 10: Overall Commercial Peak Flows Compared to APWA's			
	2-Year	10-Year	100-Year
Rainfall Intensity (in/hr)	2.16	3.07	4.47
Post-Development Peak Flow (CFS)	34.69	49.36	71.83
Maximum Peak Flow Per APWA (CFS)	11.23	44.92	67.38



The post-development peak flows exceed the minimum peak flows established by APWA's Comprehensive Control during the 50% and 10% storm conditions, typically requiring a stormwater detention or retention facility. However, according to the Arborwalk Development Drainage Master Plan (See **Appendix A**), the extended dry detention basin and extended wet detention basin upstream of the commercial development provides satisfactory storage for downstream development in the designated commercial area. Page 2 of the attached Arborwalk drainage master plan states that:

*"The combination of the two basins will adequately hold the required volume of storage for both the southeast drainage basin including the future commercial development at the intersection of Ward Road and Highway 150"*

On Page 3, the report clarifies further that:

*"The proposed size of storage required for [limiting post-development flow] is approximately 7 acre-feet for the 25-year storm event and for the 100-year storm event the required storage is 10.9 acre-feet. The commercial area to the southeast when developed will require 4.8 acre-feet of storage for detention that is part of the required storage listed above"*

According to the master plan, 4.8 acre-feet of storage is provided in the upstream detention basins to help regulate flow in the designated commercial development that has been studied throughout this report. PondPack software was used to estimate the storage required to reduce post-development flow to the peak flow rates defined by APWA's Comprehensive Control. The required storage is found to be 96,047 cubic feet or 2.20 acre-feet, far below the provided upstream storage of 4.8 acre-feet.

Due to the upstream detention ponds providing more than adequate storage to control peak flows from the designated commercial area, as defined by the Arborwalk Drainage Master Plan, no additional stormwater management facilities are required for the proposed developments.

## BMP ANALYSIS

The Mid-America Regional Council, Manual of Best Management Practices for Stormwater Quality, October 2012 requires the site to be designed to treat the additional impervious runoff during the 90% mean annual storm (1.37"/24 hr) created by site improvements. Each proposed development within the designated commercial area will be required to sufficiently treat the 90% mean annual event, per the City of Lee's Summit's approval.

The proposed multi-family development in Lot "A", being proposed alongside this drainage report, will satisfy the MARC BMP Manual's guidance by routing approximately 9.77 acres of runoff through two Hydro International First Defense hydrodynamic separators (See **Appendix E** for the product specification sheet). The separators are designed to handle the treatment flow (calculated per Chapter 6 of the MARC Manual) to remove total suspended solids. Oils, cigarette butts, and larger sand particles would be removed from the runoff prior to it being discharged off-site. Following the MARC BMP Manual's Value Rating (VR) and Level of Service system, the hydrodynamic separators provide a VR of 5 while the overall site receives a Level of Service of 4.

## SUMMARY & RECOMMENDATIONS

The proposed improvements for the Arborwalk East Multi-Family Development is located within an area designated for commercial development, as described in the Arborwalk Development Drainage Master Plan. The proposed private improvements within the designated commercial development area will increase the impervious areas which increases the peak flow runoff when compared to pre-development conditions. However, the aforementioned drainage master plan accounts for future development in this area by setting aside 4.8 acre-feet of storage in the extended wet & extended dry detention basins upstream. The proposed improvements in the previously designated commercial area would require approximately 2.20 acre-feet of storage to meet APWA's Comprehensive Control Requirements in the post-development condition. Therefore, no additional detention is required within not only the proposed multi-family development, but also the entire designated commercial area.

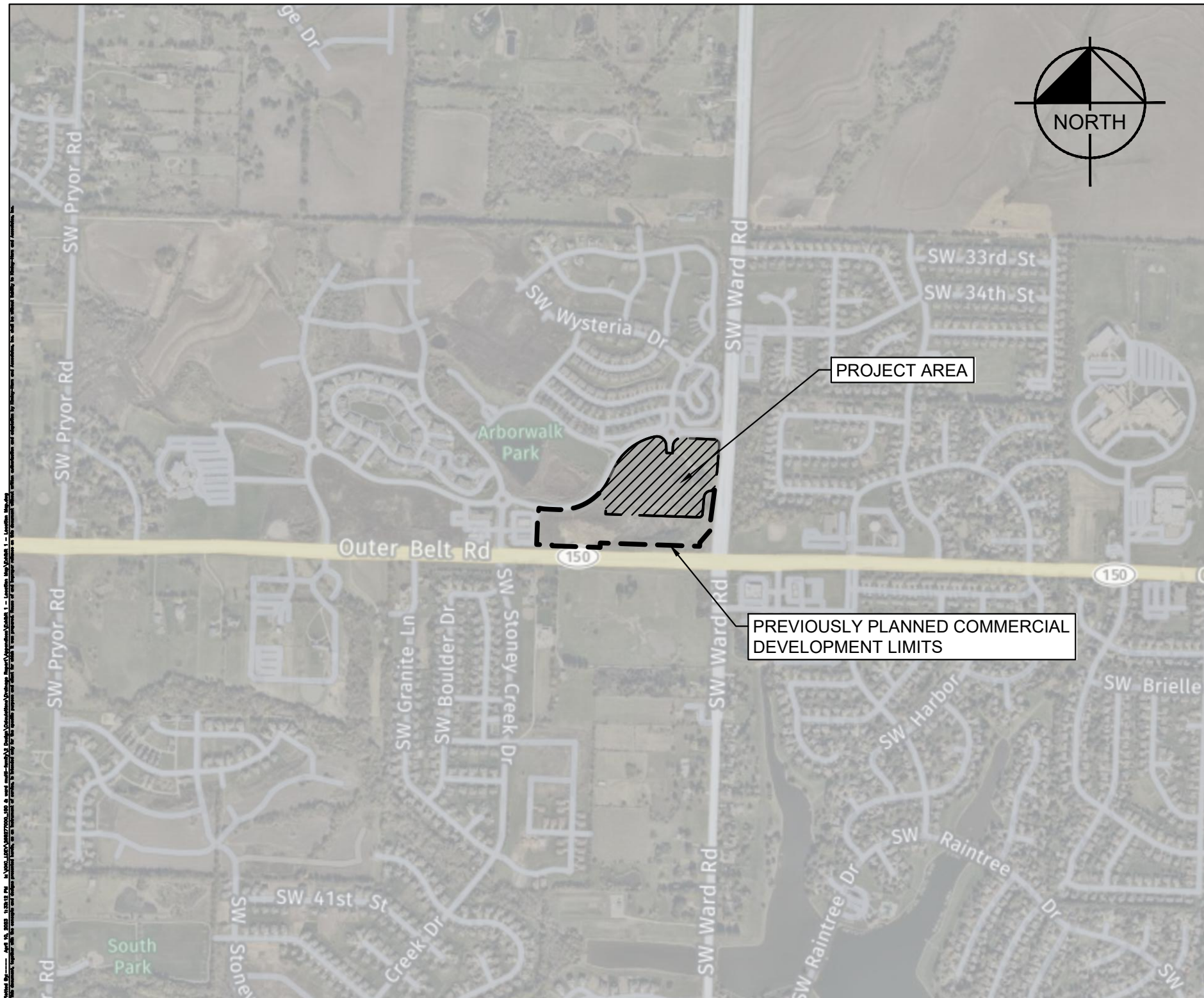
An analysis of the existing stream located within the residential & commercial lots suggests to Kimley-Horn that the channel was intended to be an engineered channel, not a natural stream, and was intended to temporarily serve the upstream drainage areas until further development was approved. Thus, a stream buffer waiver is requested, and it is proposed that the existing channel be enclosed in public storm sewer that would continue to serve the adjacent and upstream developments. The stream buffer waiver and public sewer relocation were prepared by another consultant, and have been provided in this report for reference.

Each development within the previously designated commercial area will be required to propose stormwater treatment measures that sufficiently treat the 90% mean annual event. The proposed improvements for the Arborwalk East Multi-Family Development include two hydrodynamic separators designed to remove total suspended solids from the runoff prior to it entering the public storm sewer system. The separators provide a Value Rating of 5, and results in an overall Level of Service of 4 for the proposed multi-family site.

Separate storm memos will be required, at the time of future development, for Lot "B" and Lot "C" to confirm that the proposed improvements align with this macro study.

Because the Arborwalk East Multi-Family Development meets all the requirements of APWA section 5600, the MARC BMP Manual, it has no adverse impacts to the downstream system, and the overall drainage patterns of the entire site will remain unchanged; it is recommended that the site be developed as planned.

## **Exhibits & Calculations**

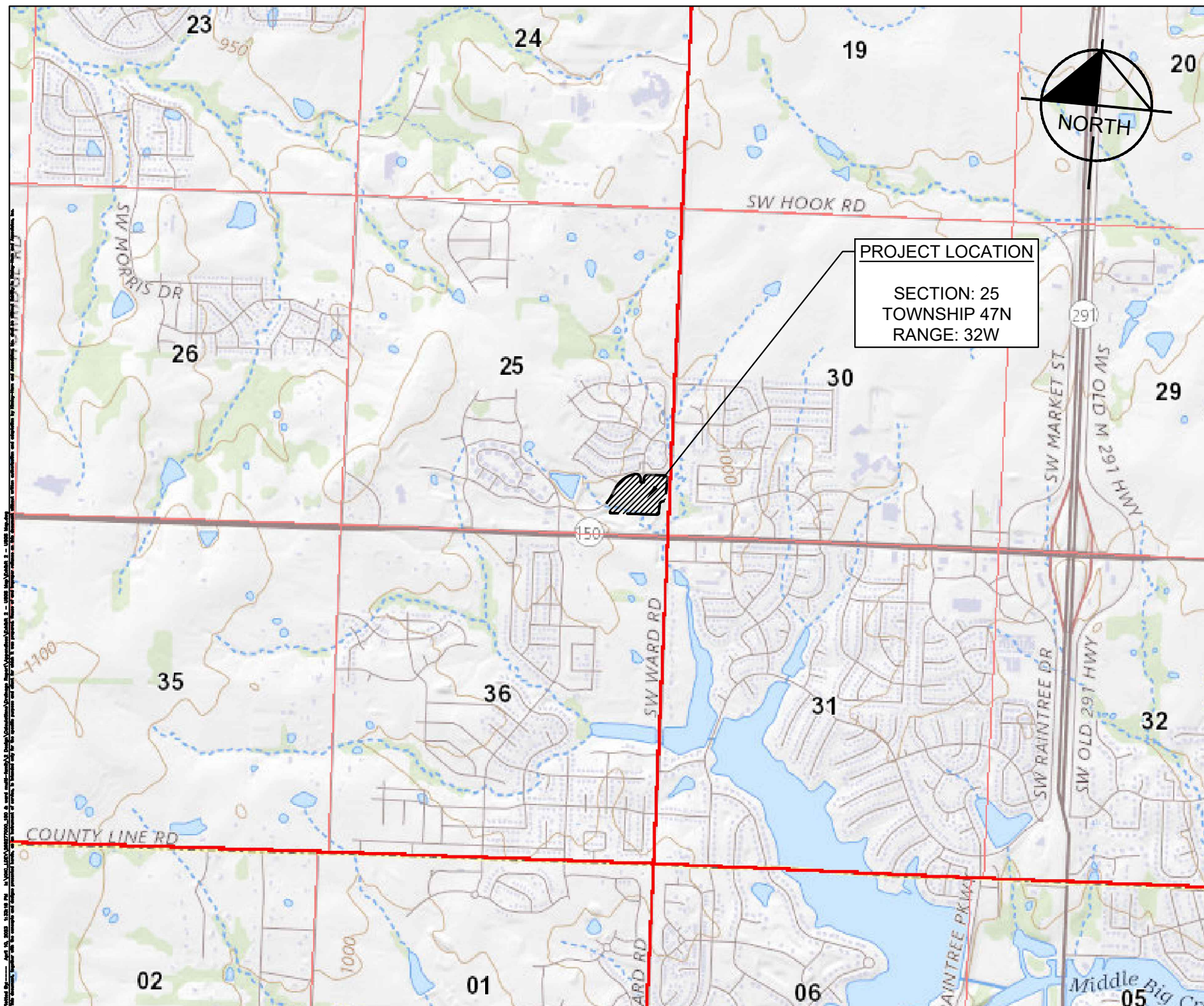


PROJECT AREA

PREVIOUSLY PLANNED COMMERCIAL  
DEVELOPMENT LIMITS



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**FLOOD HAZARD INFORMATION**  
SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP  
FOR DRAFT FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) Zone A, V, A99
		With BFE or Depth Zone AE, AO, AH, VE, AR
OTHER AREAS OF FLOOD HAZARD		Regulatory Floodway
		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
		Future Conditions 1% Annual Chance Flood Hazard Zone X
		Area with Reduced Flood Risk due to Levee See Notes Zone X
OTHER AREAS		Area with Flood Risk due to Levee Zone D
		NO SCREEN Area of Minimal Flood Hazard Zone X
GENERAL STRUCTURES		Effective LOMRs
		Area of Undetermined Flood Hazard Zone D
OTHER FEATURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
		Cross Sections with 1% Annual Chance Water Surface Elevation
		Coastal Transect
		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary

**NOTES TO USERS**

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at <https://mms.fema.gov>. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates, refer to the Flood Insurance Study Report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Base map information shown on this FIRM was provided in digital format by the United States Geological Survey (USGS). The base map shown is the USGS National Map: Orthoimagery, Last refreshed October, 2020.

This map was exported from FEMA's National Flood Hazard Layer (NFHL) on 1/26/2023 1:03 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL, and effective information may change or become superseded by new data over time. For additional information, please see the Flood Hazard Mapping Updates Overview Fact Sheet at <https://www.fema.gov/media-library/assets/documents/116418>

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The base map shown complies with FEMA's base map accuracy standards. This map image is void if the one or more of the following map elements do not appear: base map imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date.

**FLOODPLAIN INFORMATION**

ACCORDING TO FEMA FLOOD MAP 29095C0532G, THE SITE IS LOCATED IN "ZONE X", DESCRIBED AS AN AREA OF MINIMAL FLOOD HAZARD.



**NATIONAL FLOOD INSURANCE PROGRAM**  
FLOOD INSURANCE RATE MAP

PANEL 532 OF 605

Panel Contains:

COMMUNITY	NUMBER	PANEL
CITY OF LEE'S SUMMIT	290174	0532

MAP NUMBER  
29095C0532G  
EFFECTIVE DATE  
January 20, 2017

**Kimley»Horn**

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805 PENNSYLVANIA AVENUE, SUITE 150, KANSAS CITY, MO 64105  
PHONE: 816-652-0350 WWW.KIMLEY-HORN.COM

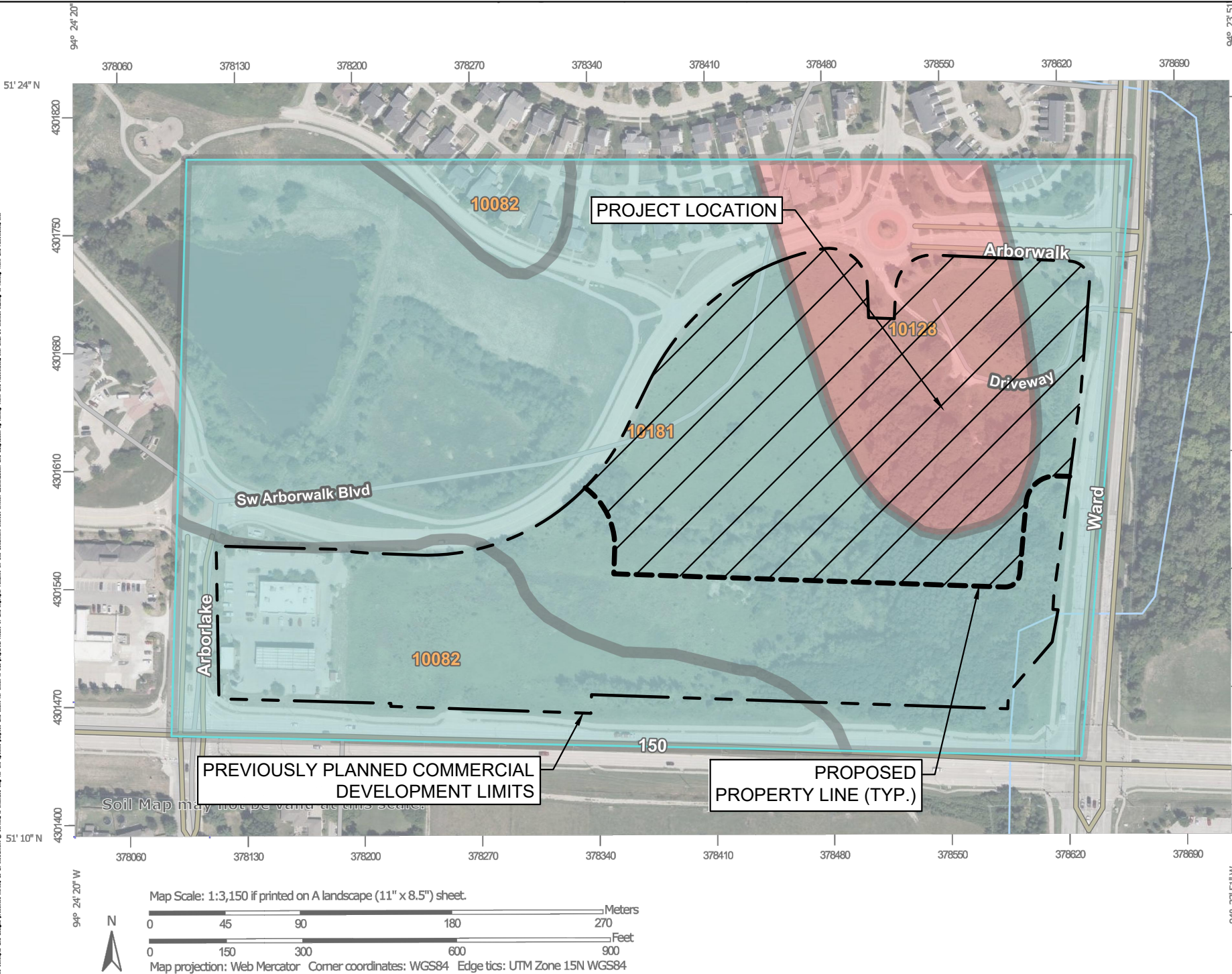
**FEMA MAP**

MHC KENWORTH - CHEYENNE

SHEET NUMBER  
EXHIBIT 3



Printed on: April 13, 2023 11:53:23 PM. In View: L:\Data\150770000\_150 & 151.mxd. Map: 150770000\_150 & 151.mxd. Map Scale: 1:3,150 if printed on A landscape (11" x 8.5") sheet. Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84. This document is prepared only for the specific project and site for which it was prepared. It is not to be used for any other purpose without the written consent of Kimley-Horn and Associates, Inc. All rights reserved. Kimley-Horn and Associates, Inc. shall be held harmless by the user of this document. No warranty is made by Kimley-Horn and Associates, Inc. for any use of this document other than for the specific project and site for which it was prepared.



Natural Resources  
Conservation Service

Web Soil Survey  
National Cooperative Soil Survey

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Page 1 of 1

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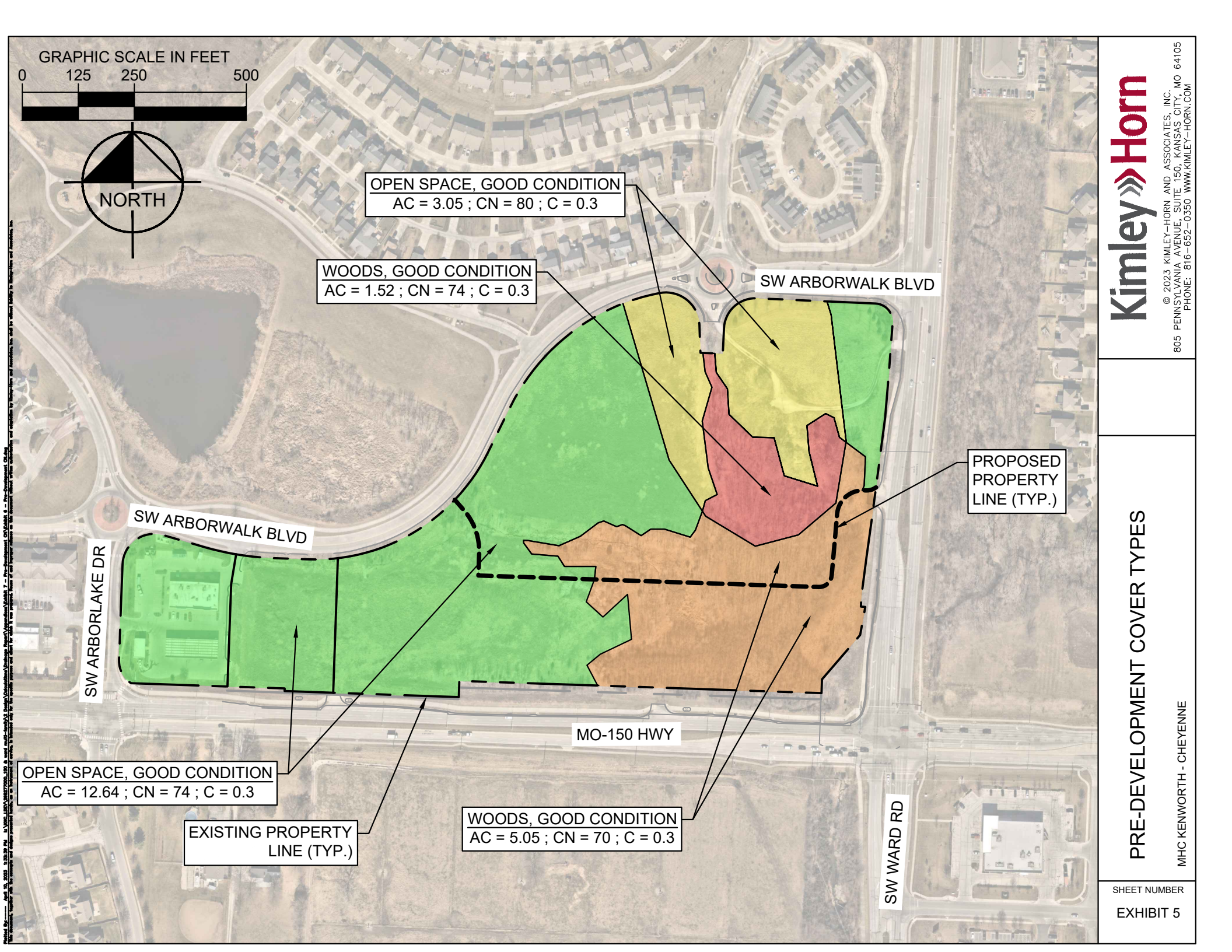
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805 PENNSYLVANIA AVENUE, SUITE 150, KANSAS CITY, MO 64105  
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SOIL MAP

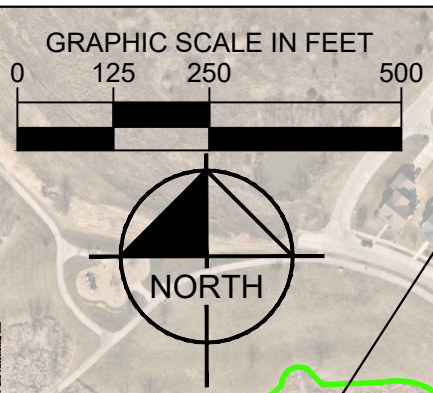
MHC KENWORTH - CHEYENNE

SHEET NUMBER  
EXHIBIT 4



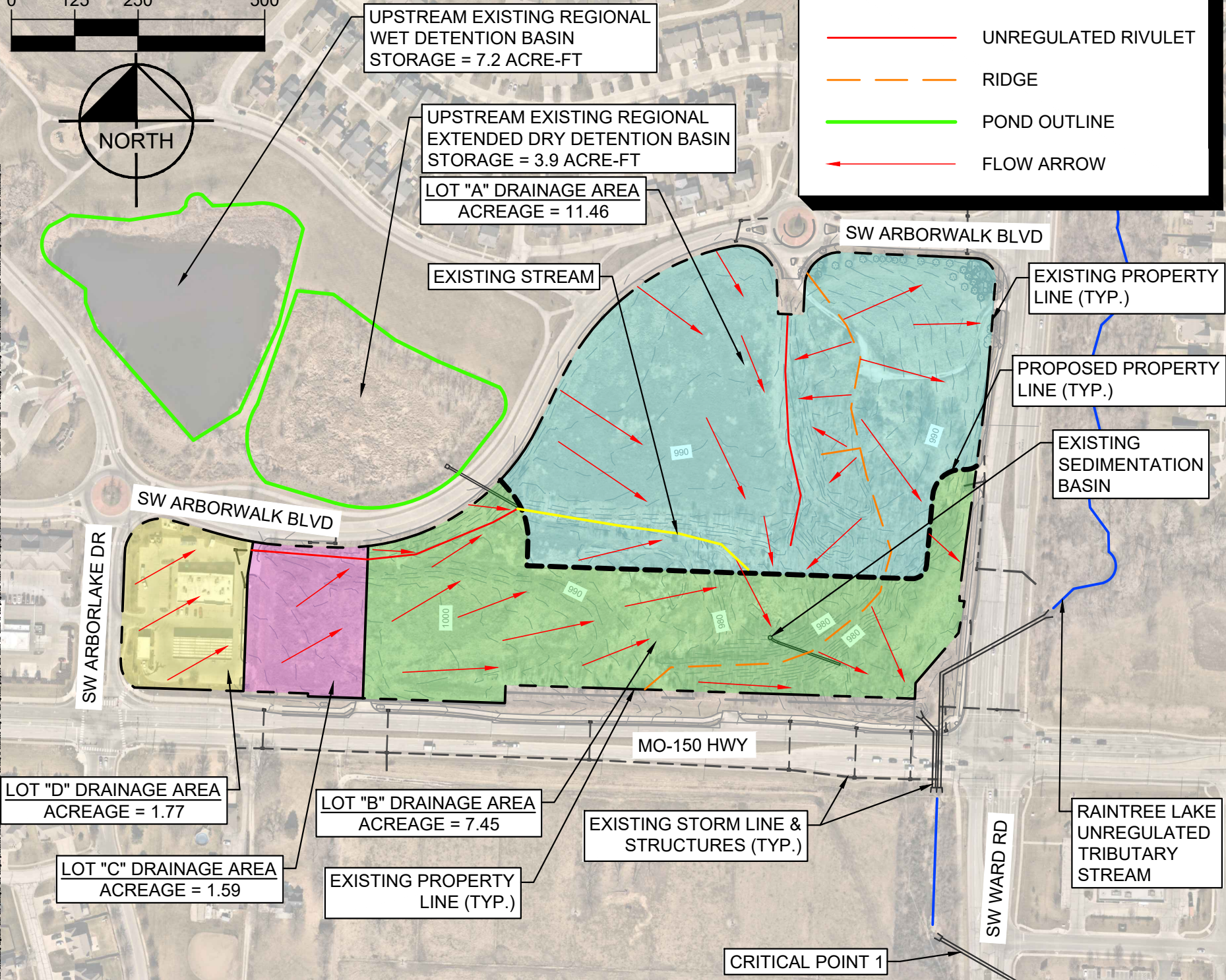






DRAINAGE LEGEND

UNREGULATED RIVULET

RIDGE

Kimley»Horn

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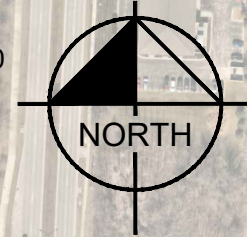
EXISTING CONDITIONS

MHC KENWORTH - CHEYENNE

SHEET NUMBER

EXHIBIT 6





SW WARD RD

SW ARBORWALK BLVD

SW ARBORLAKE DR

MO-150 HWY

PROPERTY LINE (TYP.)

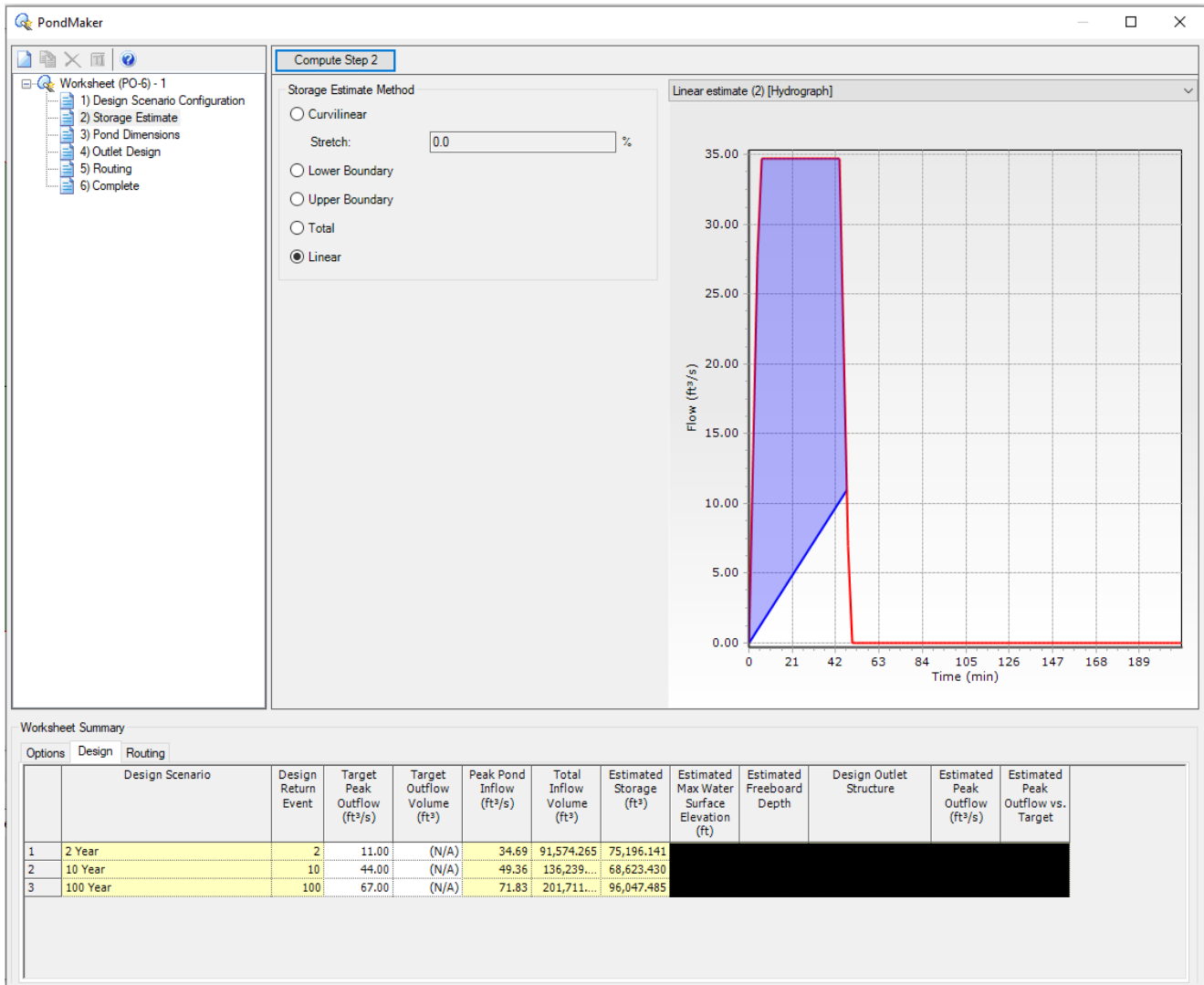
LOT "D" COMMERCIAL DEVELOPMENT  
AC = 1.80 ; CN = 94 ; C = 0.78

Notified By:----- April 10, 2023 1:34:53 PM In: [V040\\_LIVE1/202277000\\_180](#) & word multi-family-2 Design/[Calculations/Drawings](#) Report/[Appendices/Exhibit 9 - Post-Development CIV/Post-Development CM/Design](#)





# PONDPACK PONDMAKER ESTIMATE



Hydrodynamic Separator Treatment Flow Calculations Per MARC BMP Manual - Chapter 6

Treatment Unit - West

Impervious (AC)	3.9
Pervious (AC)	0.96
<b>Total Area (AC)</b>	<b>4.86</b>

K	1
C	0.78
I (ft/s)	4.40E-05
A (ft^2)	211701.6

**Treatment Flow (CFS)**      **7.28**

Treatment Unit - East

Impervious (AC)	4.153
Pervious (AC)	0.737
<b>Total Area (AC)</b>	<b>4.89</b>

K	1
C	0.81
I (ft/s)	4.40E-05
A (ft^2)	213008.4

**Treatment Flow (CFS)**      **7.58**

## Time of Concentration - Overall

### Sheet Flow (Inlet Time, Tt)

Tt (hr)=	12.581259
C=	0.3
l(ft)=	100
P2=	3.58
S=	1.5

Tt Total (min)
12.58

Note: The inlet time equation is located in Section 5602.7.A from KCMetro APWA 5600

### Shallow Concentrated Flow

Segment 1	
Cover	Grassland
Tt (min)=	0.53433333
l(ft)=	320.6
V (ft/s)=	10

Segment 2	
Cover	Wooded
Tt (min)=	0.19333333
l(ft)=	174
V (ft/s)=	15

Segment 3	
Cover	Wooded
Tt (min)=	1.47111111
l(ft)=	132.4
V (ft/s)=	1.5

Tt Total (min)
2.20

Note: Velocity Values are calculated using Table 5602-6 in the KCMetro APWA 5600

### CUMULATIVE TRAVEL TIME (min)

14.78

## Time of Concentration - Lot A

### Sheet Flow (Inlet Time, Tt)

Tt (hr)=	10.7885323
C=	0.3
l(ft)=	100
P2=	3.58
S=	2.38

Tt Total (min)
10.79

Note: The inlet time equation is located in Section 5602.7.A from KCMetro APWA 5600

### Shallow Concentrated Flow

Segment 1	
Cover	Grassland
Tt (min)=	0.63333333
l(ft)=	380
V (ft/s)=	10

Segment 2	
Cover	Wooded
Tt (min)=	0.12444444
l(ft)=	112
V (ft/s)=	15

Tt Total (min)
0.76

Note: Velocity Values are calculated using Table 5602-6 in the KCMetro APWA 5600

### CUMULATIVE TRAVEL TIME (min)

11.55

## Time of Concentration - Lot B

### Sheet Flow (Inlet Time, Tt)

Tt (hr)=	12.0676582
C=	0.3
l(ft)=	100
P2=	3.58
S=	1.7

Tt Total (min)
12.07

Note: The inlet time equation is located in Section 5602.7.A from KCMetro APWA 5600

### Shallow Concentrated Flow

Segment 1	
Cover	Grassland
Tt (min)=	0.925
l(ft)=	555
V (ft/s)=	10

Segment 2	
Cover	Wooded
Tt (min)=	0.58333333
l(ft)=	350
V (ft/s)=	10

Tt Total (min)
1.51

Note: Velocity Values are calculated using Table 5602-6 in the KCMetro APWA 5600

### CUMULATIVE TRAVEL TIME (min)

13.58



## Time of Concentration - Lot D

### Sheet Flow (Inlet Time, Tt)

Tt (hr)=	12.581259
C=	0.3
l(ft)=	100
P2=	3.58
S=	1.5

Tt Total (min)
12.58

Note: The inlet time equation is located in Section 5602.7.A from KCMetro APWA 5600

### Shallow Concentrated Flow

Segment 1	
Cover	Grassland
Tt (min)=	0.29166667
l(ft)=	175
V (ft/s)=	10

Tt Total (min)
0.29

Note: Velocity Values are calculated using Table 5602-6 in the KCMetro APWA 5600

### CUMULATIVE TRAVEL TIME (min)

12.87

## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: Modified Rational Grand Summary

### Modified Rational Method

**Q = CiA \* Units Conversion; Where conversion = 43560 / (12 \* 3600)**

Frequency (years)	Area (acres)	Adjusted C Coefficient	Duration (min)	Intensity (in/h)	Flow (Peak) (ft <sup>3</sup> /s)	Flow (Allowable) (ft <sup>3</sup> /s)	Volume (inflow) (ft <sup>3</sup> )	Volume (Storage) (ft <sup>3</sup> )
2	22.260	0.715	44	2.162	34.69	25.05	91,574.26 6	54,751.97 4
2	22.260	0.715	44	2.162	34.69	25.05	91,574.26 6	54,751.97 4
10	22.260	0.715	46	3.077	49.36	34.88	136,239.5 99	82,872.72 9
25	22.260	0.715	47	3.604	57.83	40.47	163,075.1 87	99,943.17 8
50	22.260	0.715	47	4.024	64.56	45.12	182,047.5 89	111,667.4 79
100	22.260	0.715	47	4.477	71.83	49.56	202,573.3 75	125,260.3 00

## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: C and Area (Pre-Development)

Return Event: 2 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 2  
Year

Scenario: 2 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	22.260	(N/A)
Weighted C & Total Area --->	0.300	22.260	6.678

## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: C and Area (Post-Development)

Return Event: 2 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 2  
Year

Scenario: 2 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	15.390	(N/A)
Pervious	0.300	6.870	(N/A)
Weighted C & Total Area --->	0.715	22.260	15.912

## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: Modified Rational Graph

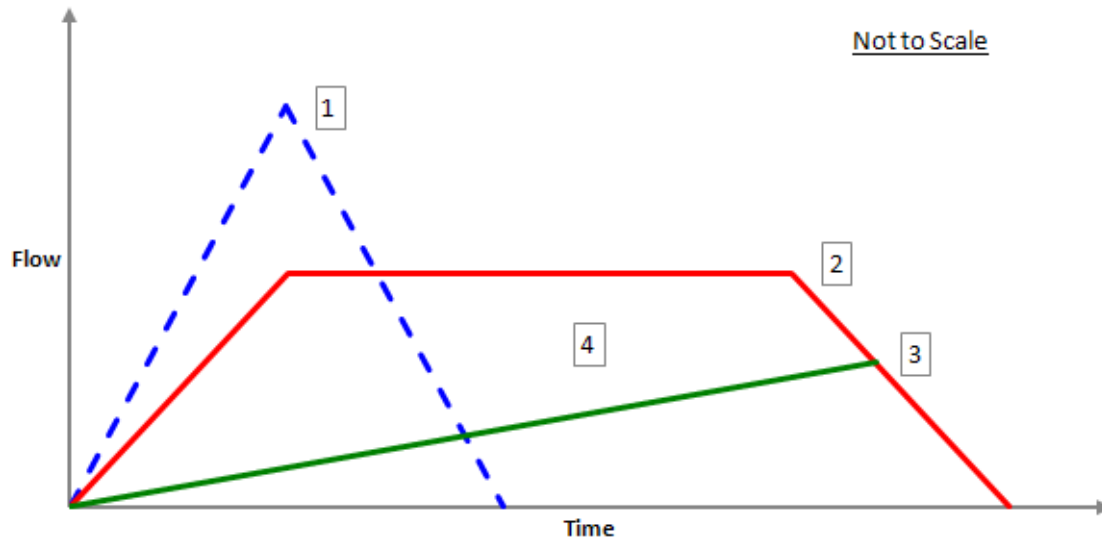
Return Event: 2 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 2  
Year

Scenario: 2 Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	44 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	44	min
Intensity (Modified Rational, Peak)	5.410	in/h	Intensity (Modified Rational, Critical)	2.162	in/h
Flow (Modified Rational, Peak)	86.80	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	34.69	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	45	min	Storage (Modified Rational, Estimated)	54,751.974	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	25.05	ft <sup>3</sup> /s			

## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: C and Area (Pre-Development)

Return Event: 10 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 10  
Year

Scenario: 10 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	22.260	(N/A)
Weighted C & Total Area --->	0.300	22.260	6.678

## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: C and Area (Post-Development)

Return Event: 10 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 10  
Year

Scenario: 10 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	15.390	(N/A)
Pervious	0.300	6.870	(N/A)
Weighted C & Total Area --->	0.715	22.260	15.912

## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: Modified Rational Graph

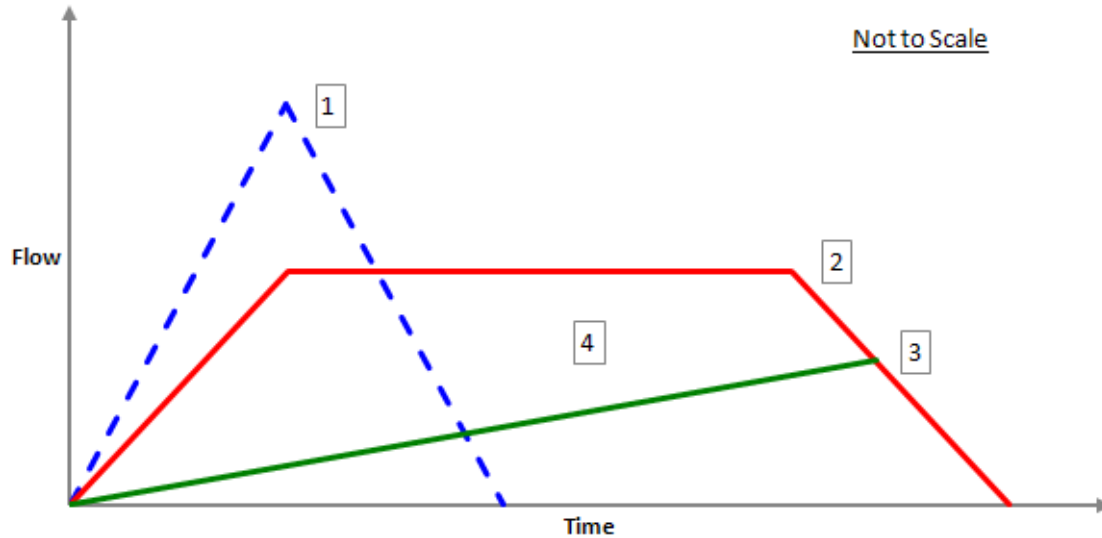
Return Event: 10 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 10  
Year

Scenario: 10 Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	46 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	46	min
Intensity (Modified Rational, Peak)	7.350	in/h	Intensity (Modified Rational, Critical)	3.077	in/h
Flow (Modified Rational, Peak)	117.92	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	49.36	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	47	min	Storage (Modified Rational, Estimated)	82,872.729	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	34.88	ft <sup>3</sup> /s			



## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: C and Area (Pre-Development)

Return Event: 50 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 50  
Year

Scenario: 50 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	22.260	(N/A)
Weighted C & Total Area --->	0.300	22.260	6.678

## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: C and Area (Post-Development)

Return Event: 50 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 50  
Year

Scenario: 50 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	15.390	(N/A)
Pervious	0.300	6.870	(N/A)
Weighted C & Total Area --->	0.715	22.260	15.912

## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: Modified Rational Graph

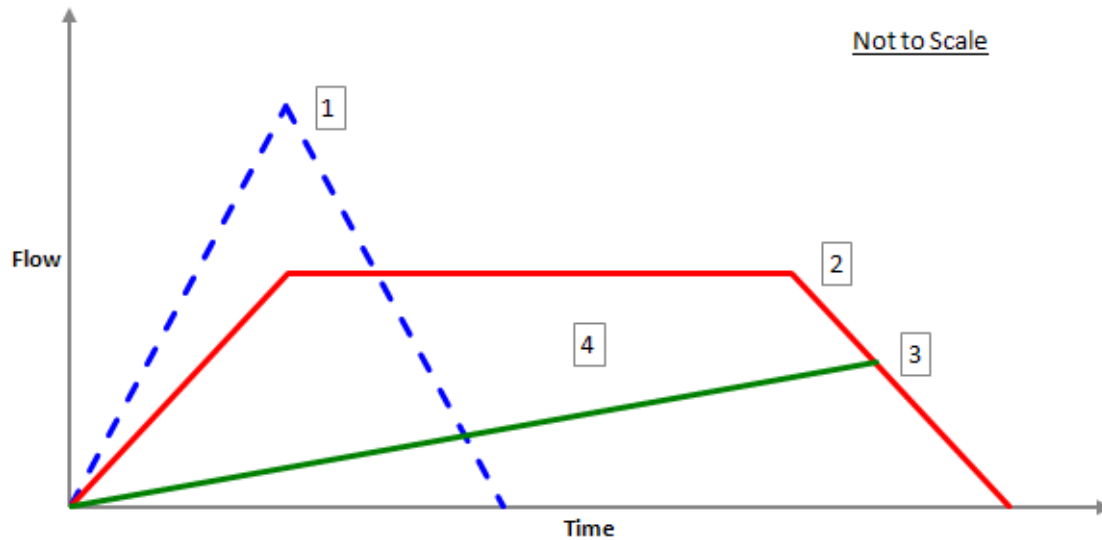
Return Event: 50 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 50  
Year

Scenario: 50 Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	47 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	47	min
Intensity (Modified Rational, Peak)	9.400	in/h	Intensity (Modified Rational, Critical)	4.024	in/h
Flow (Modified Rational, Peak)	150.81	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	64.56	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	49	min	Storage (Modified Rational, Estimated)	111,667.479	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	45.12	ft <sup>3</sup> /s			

## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: C and Area (Pre-Development)

Return Event: 100 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 -  
100 Year

Scenario: 100 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	22.260	(N/A)
Weighted C & Total Area --->	0.300	22.260	6.678

## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: C and Area (Post-Development)

Return Event: 100 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 -  
100 Year

Scenario: 100 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	15.390	(N/A)
Pervious	0.300	6.870	(N/A)
Weighted C & Total Area --->	0.715	22.260	15.912

## 150 & Ward Multi-Family - Overall Commercial Area

Subsection: Modified Rational Graph

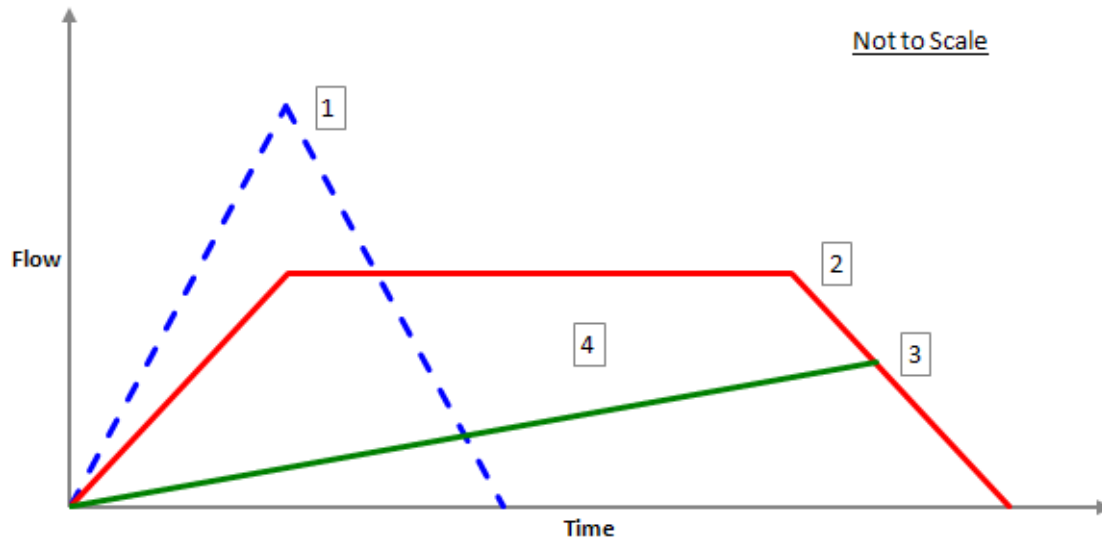
Label: CM-2

Scenario: 100 Year

Return Event: 100 years

Storm Event: User Defined IDF Table - 1 -  
100 Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	47 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	47	min
Intensity (Modified Rational, Peak)	10.320	in/h	Intensity (Modified Rational, Critical)	4.477	in/h
Flow (Modified Rational, Peak)	165.57	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	71.83	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	49	min	Storage (Modified Rational, Estimated)	125,260.300	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	49.56	ft <sup>3</sup> /s			

## 150 & Ward Multi-Family - Lot A

Subsection: Modified Rational Grand Summary

### Modified Rational Method

**Q = CiA \* Units Conversion; Where conversion = 43560 / (12 \* 3600)**

Frequency (years)	Area (acres)	Adjusted C Coefficient	Duration (min)	Intensity (in/h)	Flow (Peak) (ft <sup>3</sup> /s)	Flow (Allowable) (ft <sup>3</sup> /s)	Volume (inflow) (ft <sup>3</sup> )	Volume (Storage) (ft <sup>3</sup> )
2	11.460	0.703	42	2.226	18.08	14.54	45,556.06 4	25,052.78 5
10	11.460	0.703	44	3.163	25.69	20.10	67,821.81 1	38,270.37 5
25	11.460	0.703	45	3.705	30.09	23.31	81,240.47 8	46,269.33 7
50	11.460	0.703	45	4.135	33.58	25.90	90,669.19 8	51,824.38 8
100	11.460	0.703	46	4.539	36.86	28.45	101,732.0 66	58,208.52 7

## 150 & Ward Multi-Family - Lot A

Subsection: C and Area (Pre-Development)

Return Event: 2 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 2  
Year

Scenario: 2 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	11.456	(N/A)
Weighted C & Total Area --->	0.300	11.456	3.437



## 150 & Ward Multi-Family - Lot A

Subsection: C and Area (Post-Development)

Return Event: 2 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 2  
Year

Scenario: 2 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	7.694	(N/A)
Pervious	0.300	3.766	(N/A)
Weighted C & Total Area --->	0.703	11.460	8.054

## 150 & Ward Multi-Family - Lot A

Subsection: Modified Rational Graph

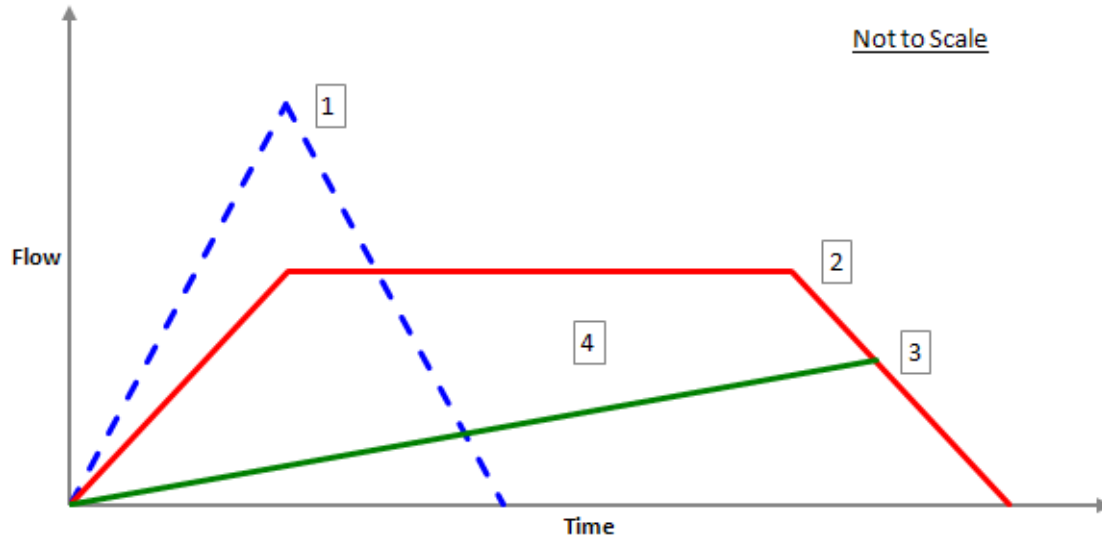
Label: CM-2

Scenario: 2 Year

Return Event: 2 years

Storm Event: User Defined IDF Table - 1 - 2  
Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	42 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	42	min
Intensity (Modified Rational, Peak)	5.410	in/h	Intensity (Modified Rational, Critical)	2.226	in/h
Flow (Modified Rational, Peak)	43.94	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	18.08	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	43	min	Storage (Modified Rational, Estimated)	25,052.785	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	14.54	ft <sup>3</sup> /s			

## 150 & Ward Multi-Family - Lot A

Subsection: C and Area (Pre-Development)

Return Event: 10 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 10  
Year

Scenario: 10 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	11.456	(N/A)
Weighted C & Total Area --->	0.300	11.456	3.437

## 150 & Ward Multi-Family - Lot A

Subsection: C and Area (Post-Development)

Return Event: 10 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 10  
Year

Scenario: 10 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	7.694	(N/A)
Pervious	0.300	3.766	(N/A)
Weighted C & Total Area --->	0.703	11.460	8.054

## 150 & Ward Multi-Family - Lot A

Subsection: Modified Rational Graph

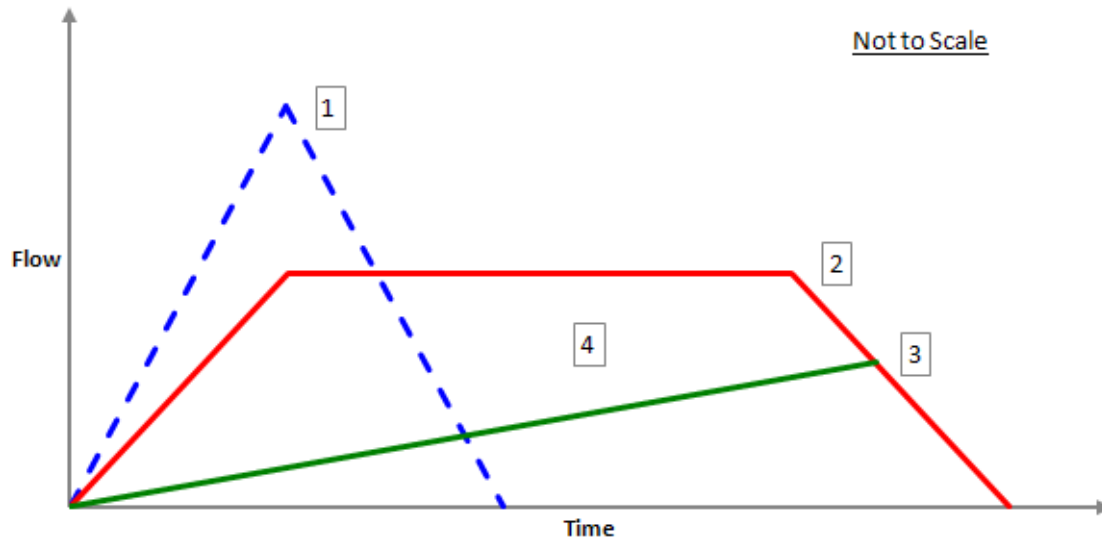
Label: CM-2

Scenario: 10 Year

Return Event: 10 years

Storm Event: User Defined IDF Table - 1 - 10  
Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	44 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	44	min
Intensity (Modified Rational, Peak)	7.350	in/h	Intensity (Modified Rational, Critical)	3.163	in/h
Flow (Modified Rational, Peak)	59.69	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	25.69	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	45	min	Storage (Modified Rational, Estimated)	38,270.375	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	20.10	ft <sup>3</sup> /s			

## 150 & Ward Multi-Family - Lot A

Subsection: C and Area (Pre-Development)

Return Event: 50 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 50  
Year

Scenario: 50 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	11.456	(N/A)
Weighted C & Total Area --->	0.300	11.456	3.437

## 150 & Ward Multi-Family - Lot A

Subsection: C and Area (Post-Development)

Return Event: 50 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 50  
Year

Scenario: 50 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	7.694	(N/A)
Pervious	0.300	3.766	(N/A)
Weighted C & Total Area --->	0.703	11.460	8.054

## 150 & Ward Multi-Family - Lot A

Subsection: Modified Rational Graph

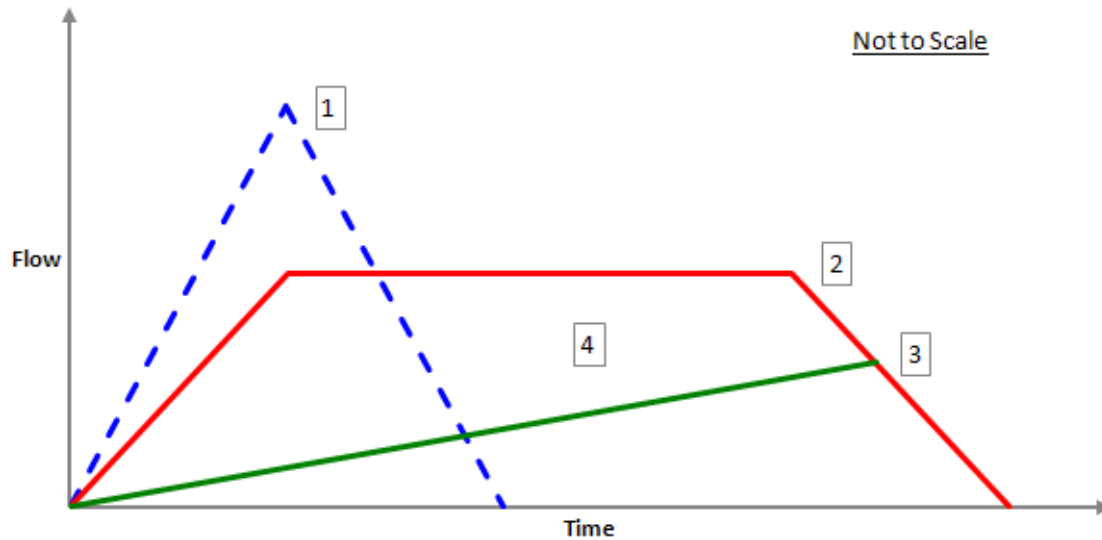
Label: CM-2

Scenario: 50 Year

Return Event: 50 years

Storm Event: User Defined IDF Table - 1 - 50  
Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	45 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	45	min
Intensity (Modified Rational, Peak)	9.400	in/h	Intensity (Modified Rational, Critical)	4.135	in/h
Flow (Modified Rational, Peak)	76.34	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	33.58	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	46	min	Storage (Modified Rational, Estimated)	51,824.388	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	25.90	ft <sup>3</sup> /s			



## 150 & Ward Multi-Family - Lot A

Subsection: C and Area (Pre-Development)

Return Event: 100 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 -  
100 Year

Scenario: 100 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	11.456	(N/A)
Weighted C & Total Area --->	0.300	11.456	3.437

## 150 & Ward Multi-Family - Lot A

Subsection: C and Area (Post-Development)

Return Event: 100 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 -  
100 Year

Scenario: 100 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	7.694	(N/A)
Pervious	0.300	3.766	(N/A)
Weighted C & Total Area --->	0.703	11.460	8.054

## 150 & Ward Multi-Family - Lot A

Subsection: Modified Rational Graph

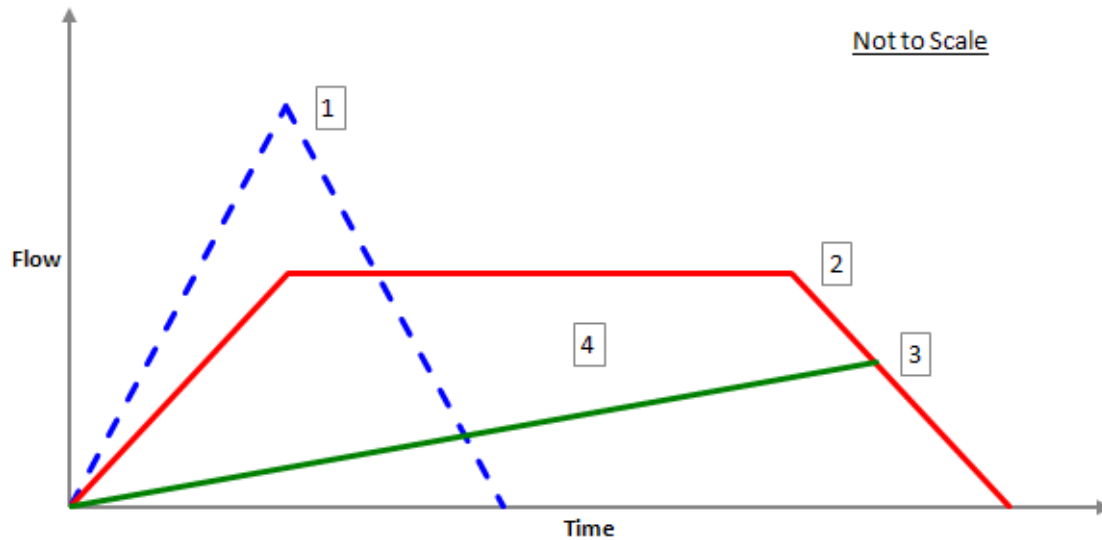
Label: CM-2

Scenario: 100 Year

Return Event: 100 years

Storm Event: User Defined IDF Table - 1 -  
100 Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	46 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	46	min
Intensity (Modified Rational, Peak)	10.320	in/h	Intensity (Modified Rational, Critical)	4.539	in/h
Flow (Modified Rational, Peak)	83.81	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	36.86	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	47	min	Storage (Modified Rational, Estimated)	58,208.527	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	28.45	ft <sup>3</sup> /s			

## 150 & Ward Multi-Family - Lot B

Subsection: Modified Rational Grand Summary

### Modified Rational Method

**Q = CiA \* Units Conversion; Where conversion = 43560 / (12 \* 3600)**

Frequency (years)	Area (acres)	Adjusted C Coefficient	Duration (min)	Intensity (in/h)	Flow (Peak) (ft <sup>3</sup> /s)	Flow (Allowable) (ft <sup>3</sup> /s)	Volume (inflow) (ft <sup>3</sup> )	Volume (Storage) (ft <sup>3</sup> )
2	7.449	0.729	43	2.194	12.02	8.82	31,007.34 9	18,302.60 9
10	7.449	0.729	46	3.077	16.85	12.25	46,515.51 6	27,778.34 7
50	7.449	0.729	47	4.024	22.04	15.81	62,155.47 9	37,488.95 4
100	7.449	0.729	47	4.477	24.53	17.37	69,163.48 2	42,067.44 9

## 150 & Ward Multi-Family - Lot B

Subsection: C and Area (Pre-Development)

Return Event: 2 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 2  
Year

Scenario: 2 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	7.448	(N/A)
Weighted C & Total Area --->	0.300	7.448	2.234

## 150 & Ward Multi-Family - Lot B

Subsection: C and Area (Post-Development)

Return Event: 2 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 2  
Year

Scenario: 2 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	5.330	(N/A)
Pervious	0.300	2.119	(N/A)
Weighted C & Total Area --->	0.729	7.449	5.433

## 150 & Ward Multi-Family - Lot B

Subsection: Modified Rational Graph

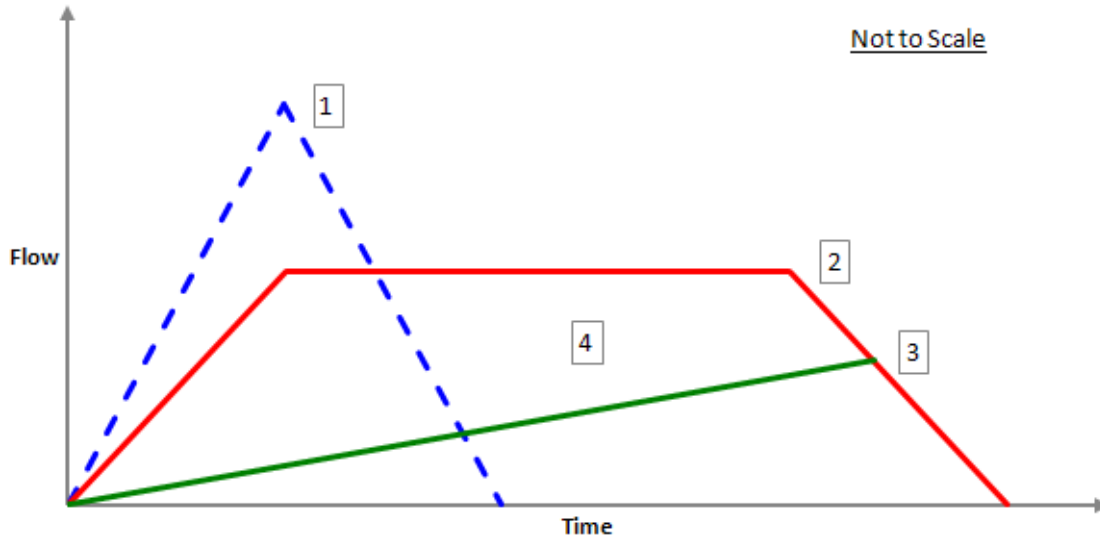
Label: CM-2

Scenario: 2 Year

Return Event: 2 years

Storm Event: User Defined IDF Table - 1 - 2  
Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	43 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	43	min
Intensity (Modified Rational, Peak)	5.410	in/h	Intensity (Modified Rational, Critical)	2.194	in/h
Flow (Modified Rational, Peak)	29.64	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	12.02	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	44	min	Storage (Modified Rational, Estimated)	18,302.609	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	8.82	ft <sup>3</sup> /s			

## 150 & Ward Multi-Family - Lot B

Subsection: C and Area (Pre-Development)

Return Event: 10 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 10  
Year

Scenario: 10 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	7.448	(N/A)
Weighted C & Total Area --->	0.300	7.448	2.234



## 150 & Ward Multi-Family - Lot B

Subsection: C and Area (Post-Development)

Return Event: 10 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 10  
Year

Scenario: 10 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	5.330	(N/A)
Pervious	0.300	2.119	(N/A)
Weighted C & Total Area --->	0.729	7.449	5.433

## 150 & Ward Multi-Family - Lot B

Subsection: Modified Rational Graph

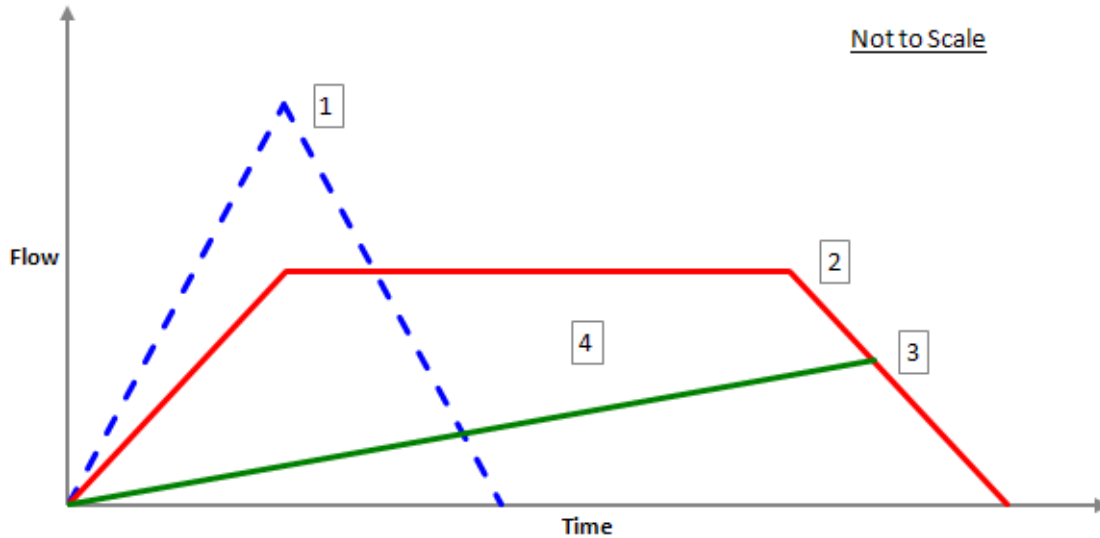
Label: CM-2

Scenario: 10 Year

Return Event: 10 years

Storm Event: User Defined IDF Table - 1 - 10  
Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	46 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	46	min
Intensity (Modified Rational, Peak)	7.350	in/h	Intensity (Modified Rational, Critical)	3.077	in/h
Flow (Modified Rational, Peak)	40.26	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	16.85	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	47	min	Storage (Modified Rational, Estimated)	27,778.347	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	12.25	ft <sup>3</sup> /s			

## 150 & Ward Multi-Family - Lot B

Subsection: C and Area (Pre-Development)

Return Event: 50 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 50  
Year

Scenario: 50 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	7.448	(N/A)
Weighted C & Total Area --->	0.300	7.448	2.234

## 150 & Ward Multi-Family - Lot B

Subsection: C and Area (Post-Development)

Return Event: 50 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 50  
Year

Scenario: 50 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	5.330	(N/A)
Pervious	0.300	2.119	(N/A)
Weighted C & Total Area --->	0.729	7.449	5.433

## 150 & Ward Multi-Family - Lot B

Subsection: Modified Rational Graph

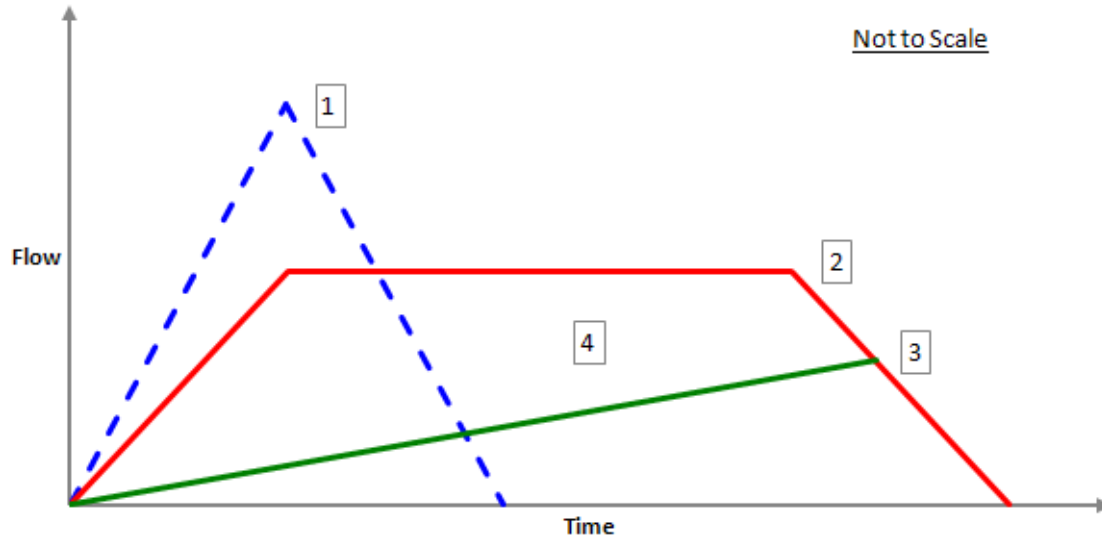
Label: CM-2

Scenario: 50 Year

Return Event: 50 years

Storm Event: User Defined IDF Table - 1 - 50  
Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	47 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	47	min
Intensity (Modified Rational, Peak)	9.400	in/h	Intensity (Modified Rational, Critical)	4.024	in/h
Flow (Modified Rational, Peak)	51.49	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	22.04	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	48	min	Storage (Modified Rational, Estimated)	37,488.954	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	15.81	ft <sup>3</sup> /s			

## 150 & Ward Multi-Family - Lot B

Subsection: C and Area (Pre-Development)

Return Event: 100 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 -  
100 Year

Scenario: 100 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	7.448	(N/A)
Weighted C & Total Area --->	0.300	7.448	2.234

## 150 & Ward Multi-Family - Lot B

Subsection: C and Area (Post-Development)

Return Event: 100 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 -  
100 Year

Scenario: 100 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	5.330	(N/A)
Pervious	0.300	2.119	(N/A)
Weighted C & Total Area --->	0.729	7.449	5.433

## 150 & Ward Multi-Family - Lot B

Subsection: Modified Rational Graph

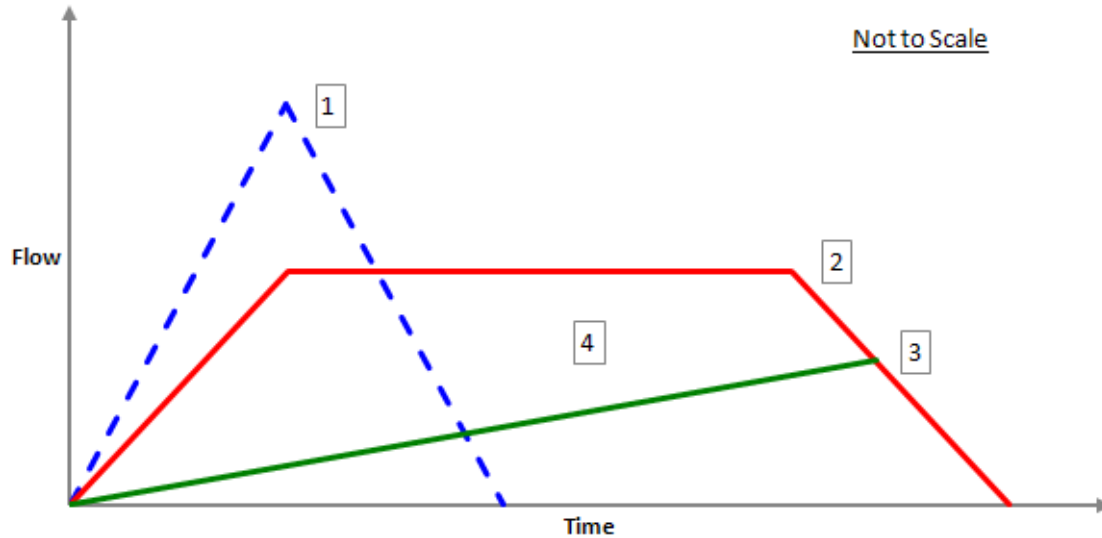
Label: CM-2

Scenario: 100 Year

Return Event: 100 years

Storm Event: User Defined IDF Table - 1 -  
100 Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	47 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	47	min
Intensity (Modified Rational, Peak)	10.320	in/h	Intensity (Modified Rational, Critical)	4.477	in/h
Flow (Modified Rational, Peak)	56.53	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	24.53	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	48	min	Storage (Modified Rational, Estimated)	42,067.449	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	17.37	ft <sup>3</sup> /s			



## 150 & Ward Multi-Family - Lot D

Subsection: Modified Rational Grand Summary

### Modified Rational Method

**Q = CiA \* Units Conversion; Where conversion = 43560 / (12 \* 3600)**

Frequency (years)	Area (acres)	Adjusted C Coefficient	Duration (min)	Intensity (in/h)	Flow (Peak) (ft <sup>3</sup> /s)	Flow (Allowable) (ft <sup>3</sup> /s)	Volume (inflow) (ft <sup>3</sup> )	Volume (Storage) (ft <sup>3</sup> )
2	1.763	0.780	44	2.162	3.00	2.15	7,913.252	4,753.981
10	1.763	0.780	46	3.077	4.27	2.98	11,772.93 9	7,215.400
50	1.763	0.780	47	4.024	5.58	3.84	15,731.36 7	9,736.584
100	1.763	0.780	48	4.416	6.12	4.22	17,632.62 2	10,920.78 7

## 150 & Ward Multi-Family - Lot D

Subsection: C and Area (Pre-Development)

Return Event: 2 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 2  
Year

Scenario: 2 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	1.770	(N/A)
Weighted C & Total Area --->	0.300	1.770	0.531

## 150 & Ward Multi-Family - Lot D

Subsection: C and Area (Post-Development)

Return Event: 2 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 2  
Year

Scenario: 2 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	1.410	(N/A)
Open Space	0.300	0.353	(N/A)
Weighted C & Total Area --->	0.780	1.763	1.375

## 150 & Ward Multi-Family - Lot D

Subsection: Modified Rational Graph

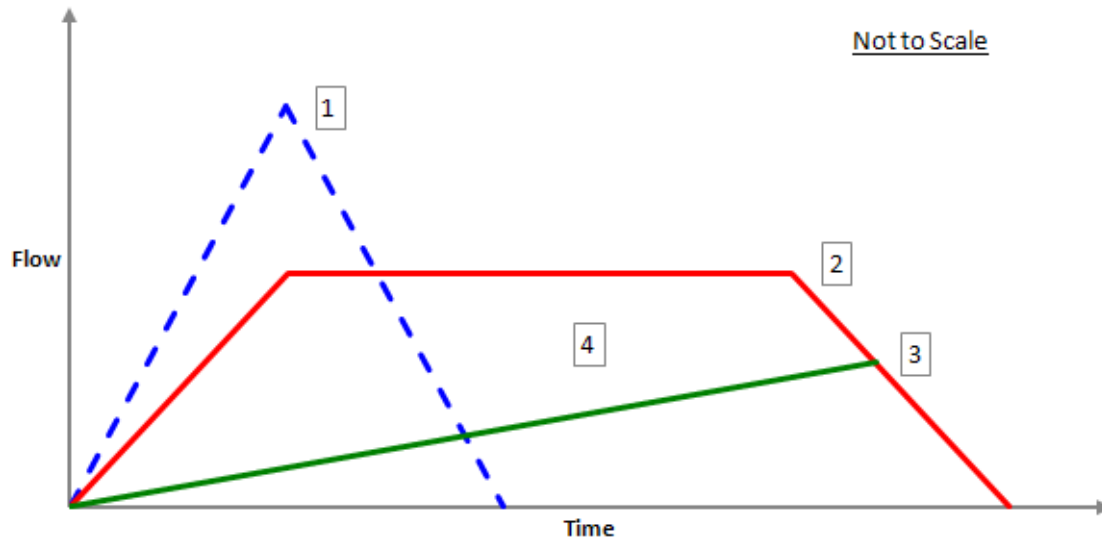
Label: CM-2

Scenario: 2 Year

Return Event: 2 years

Storm Event: User Defined IDF Table - 1 - 2  
Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	44 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	44	min
Intensity (Modified Rational, Peak)	5.410	in/h	Intensity (Modified Rational, Critical)	2.162	in/h
Flow (Modified Rational, Peak)	7.50	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	3.00	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	45	min	Storage (Modified Rational, Estimated)	4,753.981	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	2.15	ft <sup>3</sup> /s			

## 150 & Ward Multi-Family - Lot D

Subsection: C and Area (Pre-Development)

Return Event: 10 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 10  
Year

Scenario: 10 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	1.770	(N/A)
Weighted C & Total Area --->	0.300	1.770	0.531

## 150 & Ward Multi-Family - Lot D

Subsection: C and Area (Post-Development)

Return Event: 10 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 10  
Year

Scenario: 10 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	1.410	(N/A)
Open Space	0.300	0.353	(N/A)
Weighted C & Total Area --->	0.780	1.763	1.375

## 150 & Ward Multi-Family - Lot D

Subsection: Modified Rational Graph

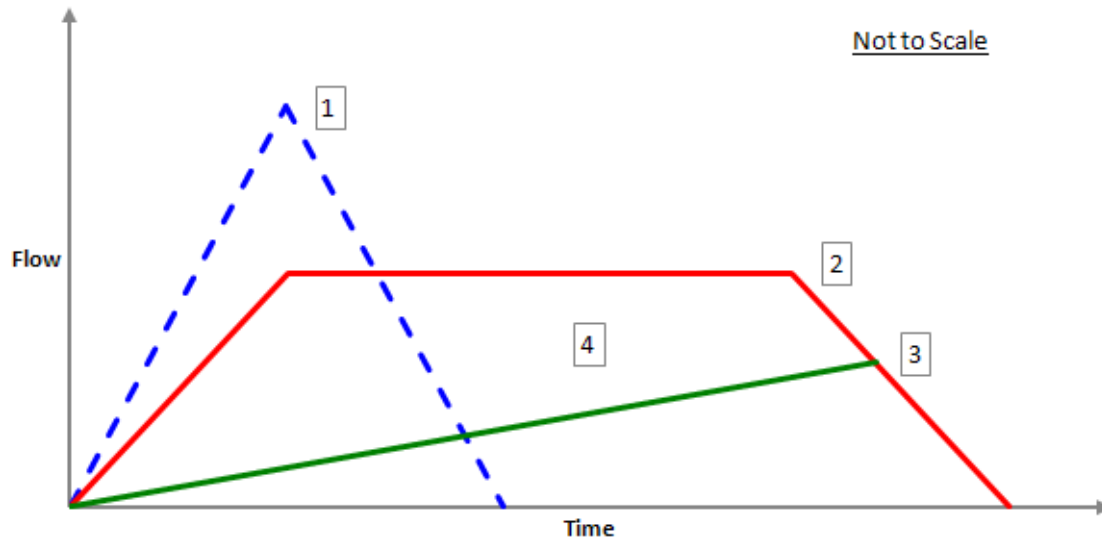
Label: CM-2

Scenario: 10 Year

Return Event: 10 years

Storm Event: User Defined IDF Table - 1 - 10  
Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	46 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	46	min
Intensity (Modified Rational, Peak)	7.350	in/h	Intensity (Modified Rational, Critical)	3.077	in/h
Flow (Modified Rational, Peak)	10.19	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	4.27	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	48	min	Storage (Modified Rational, Estimated)	7,215.400	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	2.98	ft <sup>3</sup> /s			

## 150 & Ward Multi-Family - Lot D

Subsection: C and Area (Pre-Development)

Return Event: 50 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 50  
Year

Scenario: 50 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	1.770	(N/A)
Weighted C & Total Area --->	0.300	1.770	0.531



## 150 & Ward Multi-Family - Lot D

Subsection: C and Area (Post-Development)

Return Event: 50 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 - 50  
Year

Scenario: 50 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	1.410	(N/A)
Open Space	0.300	0.353	(N/A)
Weighted C & Total Area --->	0.780	1.763	1.375

## 150 & Ward Multi-Family - Lot D

Subsection: Modified Rational Graph

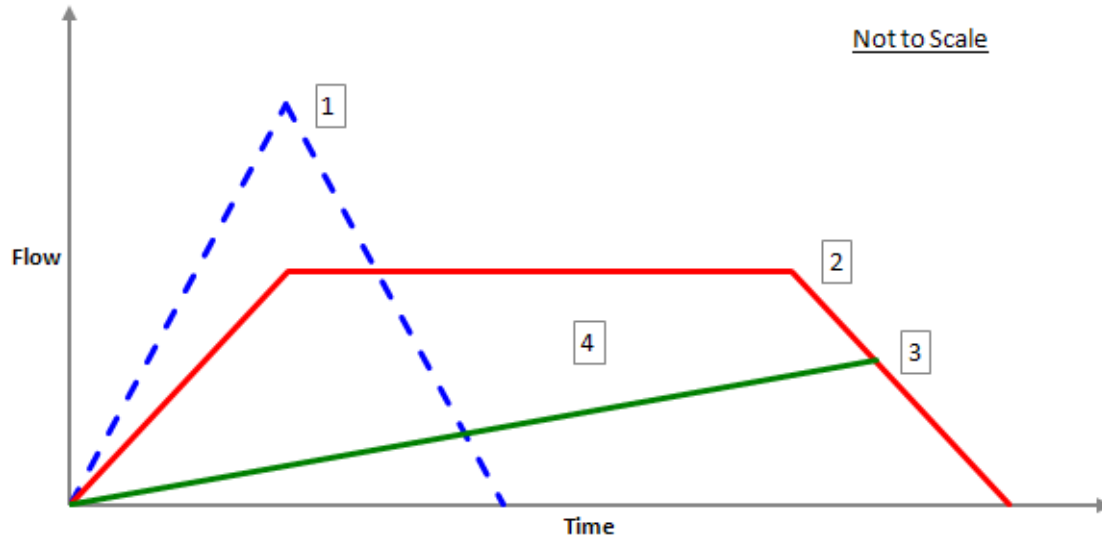
Label: CM-2

Scenario: 50 Year

Return Event: 50 years

Storm Event: User Defined IDF Table - 1 - 50  
Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	47 min



[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	47	min
Intensity (Modified Rational, Peak)	9.400	in/h	Intensity (Modified Rational, Critical)	4.024	in/h
Flow (Modified Rational, Peak)	13.03	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	5.58	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	49	min	Storage (Modified Rational, Estimated)	9,736.584	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	3.84	ft <sup>3</sup> /s			

## 150 & Ward Multi-Family - Lot D

Subsection: C and Area (Pre-Development)

Return Event: 100 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 -  
100 Year

Scenario: 100 Year

### C and Area Results (Pre-Development)

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Pervious Area	0.300	1.770	(N/A)
Weighted C & Total Area --->	0.300	1.770	0.531

## 150 & Ward Multi-Family - Lot D

Subsection: C and Area (Post-Development)

Return Event: 100 years

Label: CM-2

Storm Event: User Defined IDF Table - 1 -  
100 Year

Scenario: 100 Year

### C and Area Results

Soil/Surface Description	C Coefficient	Area (acres)	Area (Adjusted) (acres)
Impervious	0.900	1.410	(N/A)
Open Space	0.300	0.353	(N/A)
Weighted C & Total Area --->	0.780	1.763	1.375

## 150 & Ward Multi-Family - Lot D

Subsection: Modified Rational Graph

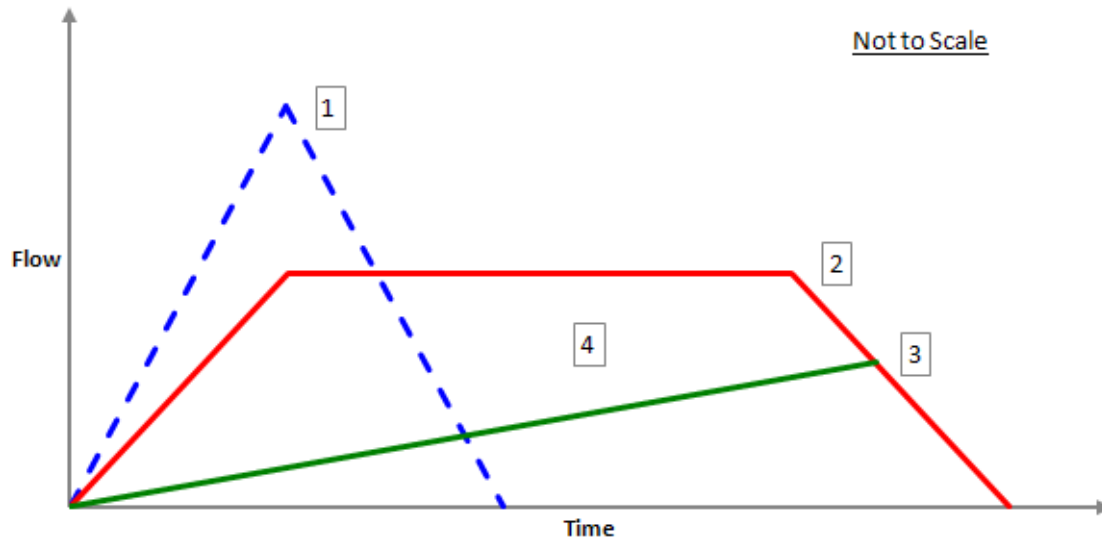
Label: CM-2

Scenario: 100 Year

Return Event: 100 years

Storm Event: User Defined IDF Table - 1 -  
100 Year

Method Type	Method I
Time of Duration (Modified Rational, Critical)	48 min

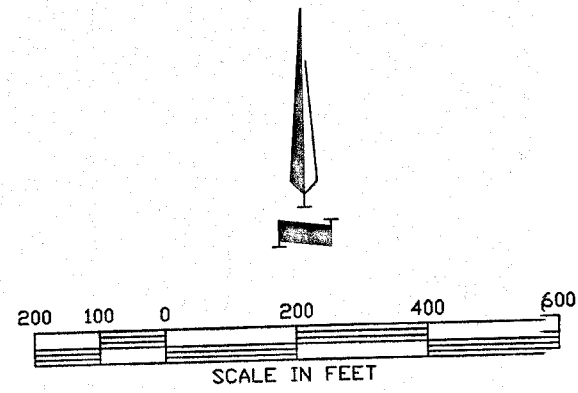


[1]			[2]		
Time of Concentration (Modified Rational, Composite)	5	min	Time of Duration (Modified Rational, Critical)	48	min
Intensity (Modified Rational, Peak)	10.320	in/h	Intensity (Modified Rational, Critical)	4.416	in/h
Flow (Modified Rational, Peak)	14.31	ft <sup>3</sup> /s	Flow (Modified Rational, Critical)	6.12	ft <sup>3</sup> /s
[3]			[4]		
Second Outflow Breakpoint (Modified Rational)	50	min	Storage (Modified Rational, Estimated)	10,920.787	ft <sup>3</sup>
Flow (Modified Rational, Allowable)	4.22	ft <sup>3</sup> /s			

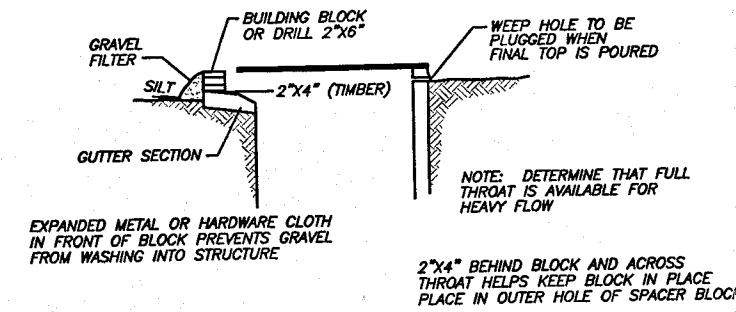
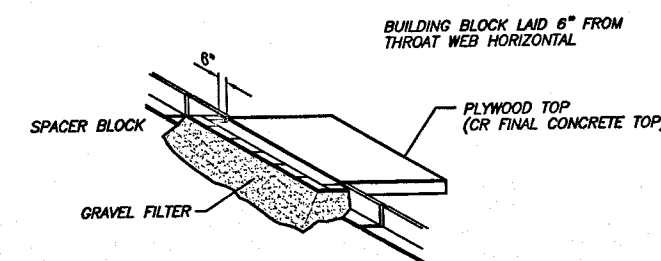
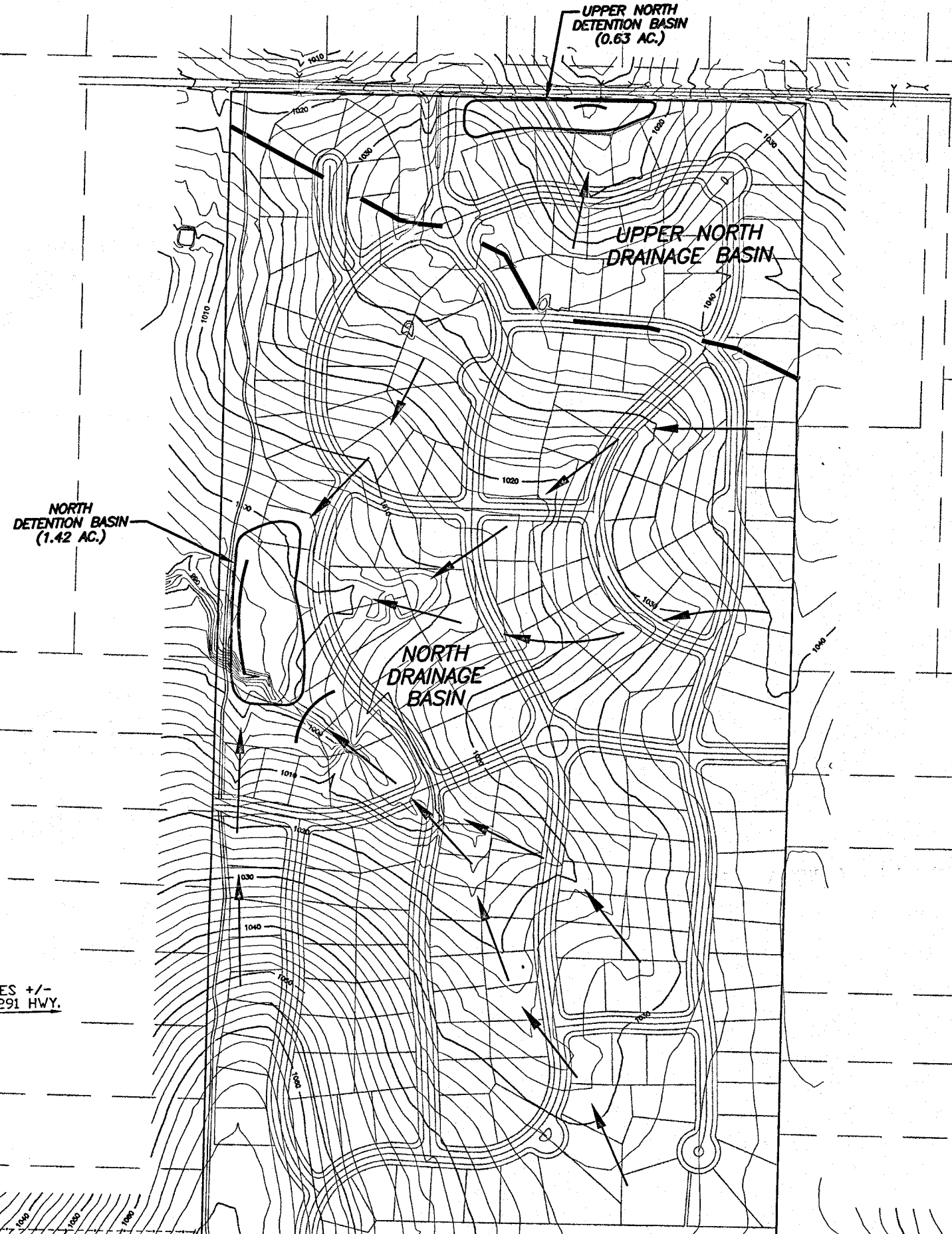
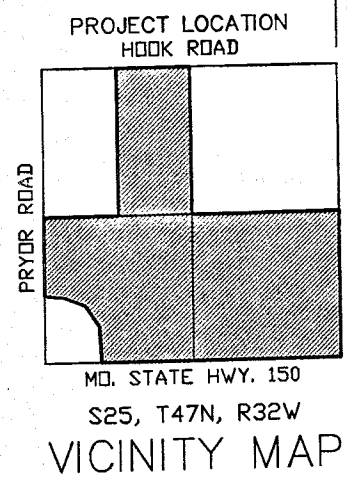
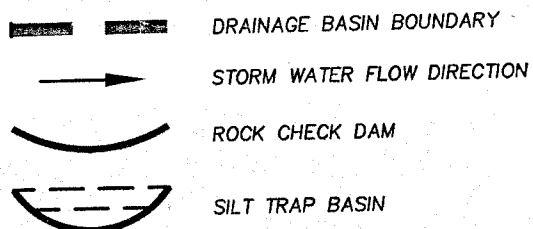
## **Appendix A**



DRAINAGE MASTER PLAN  
ARBORWALK  
IN THE CITY OF LEE'S SUMMIT, MISSOURI

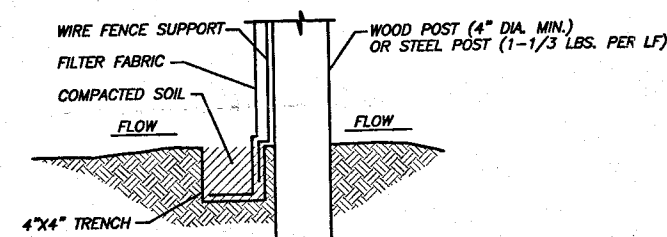


LEGEND

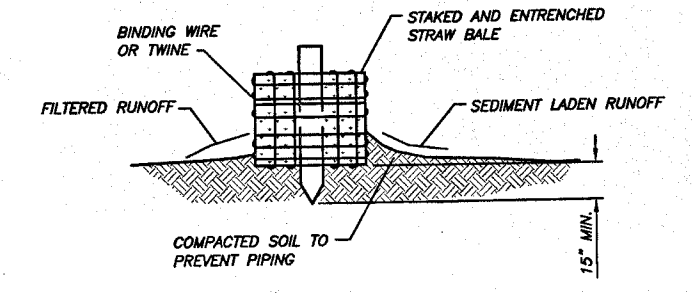


BLOCK AND GRAVEL CURB INLET PROTECTION  
(FROM RICHMOND, VIRGINIA-EROSION AND SEDIMENT CONTROL HANDBOOK, NOVEMBER 1975)

SD-45 INLET PROTECTION  
N.T.S.



SECTION



SECTION

- NOTES:
1. EXCAVATE A TRENCH ALONG THE AREAS THAT THE STRAW BALES WILL BE USED AS EROSION CONTROL TO DEPTH OF 4" AND TO THE WIDTH OF ONE STRAW BALE. THE STRAW BALES THEN SHALL BE PLACED IN THE TRENCH. SAVE EXCAVATED MATERIAL ON THE UPSTREAM SIDE OF THE TRENCH.
  2. STRAW BALES SHOULD BE ANCHORED WITH A MINIMUM OF 5 STAKES OR REBARS DRIVEN INTO THE UNDERLYING SOIL, MAKING SURE THAT THE BINDING WIRE OR TWINE IS TIGHTENING THE SIDES AND NOT TOUCHING THE SOIL. THE FIRST STAKE INTO EACH BALE SHOULD BE DRIVEN TOWARD THE PREVIOUSLY LAID BALE TO FORCE THEM TOGETHER.
  3. SPACING BETWEEN THE BALES SHOULD BE TIGHTLY CHINKED WITH LOOSE STRAW.
  4. AFTER STRAW BALES ARE IN PLACE, THE EXCAVATED SOIL SHOULD BE BACKFILLED AGAINST THE UPSLOPE SIDE OF THE STRAW BALES TO A HEIGHT OF 4" AFTER COMPACTING.
  5. STRAW BALES SHOULD BE INSPECTED AFTER EACH RAINFALL TO DETERMINE IF ANY REPAIRS OR REPLACEMENTS TO THE STRAW BALES ARE NEEDED. IF IT IS DETERMINED THAT THE STRAW BALES NEED TO BE REPAIRED OR REPLACED, THIS SHOULD BE DONE IMMEDIATELY. SEDIMENT ACCUMULATIONS MUST BE REMOVED WHEN THEY REACH A HEIGHT 1/2 THE BARRIER HEIGHT.

SD-48 STRAW BALE INSTALLATION  
N.T.S.

- NOTES:
1. THE MAXIMUM SLOPE LENGTH ABOVE THE FENCE SHOULD BE LESS THAN 100 FEET.
  2. NO DITCH OR DRAINAGE WAY WITH AN AREA GREATER THAN 5 ACRES SHALL BE ENCLOSED ABOVE A SILT FENCE.
  3. NO SILT FENCE SHALL BE CONSTRUCTED IN A LIVE STREAM OR DRAINAGE WAY WITH EXPECTED FLOWS GREATER THAN 1 CPS.
  4. THE FILTER FABRIC SHALL HAVE A MINIMUM FILTERING EFFICIENCY OF 75%, A MINIMUM TENSILE STRENGTH OF 30 LBS. PER LINEAR INCH AND A FLOW RATE OF 0.5 GALLONS PER SQUARE FOOT PER MINUTE. THE FILTER FABRIC SHALL ALSO HAVE ULTRAVIOLET RAY INHIBITORS TO ASSURE A LIFE USE EXPECTANCY OF 6 MONTHS AT 0 TO 100 DEGREES FAHRENHEIT.
  5. THE FILTER FABRIC SHALL BE 36 INCHES OR LESS IN HEIGHT, WITH JOINTS AT EVERY POST. AVOIDING OVERLAP IF POSSIBLE. IF MIN. OVERLAP IF NECESSARY, AND POSTS SPACED EVERY 10 FEET WITH WIRE MESH SUPPORT OR 6 FEET WITHOUT SUPPORT, MAKING SURE THAT A MIN. OF 8" OF FABRIC IS BURIED IN THE 4"x4" TRENCH.
  6. THE SILT FENCE SHALL BE INSPECTED AFTER EVERY RAINFALL TO DETERMINE IF ANY PART OF THE FENCE NEEDS TO BE REPAIRED OR REPLACED. IF IT IS DETERMINED THAT THE FENCE NEEDS ANY REPAIR OR REPLACEMENT THIS SHALL BE DONE IMMEDIATELY.
- SEDIMENT DEPOSITS SHALL BE REMOVED AFTER EACH RAINFALL OR BEFORE THEY ACCUMULATE TO 1/2 OF THE FENCE HEIGHT.

SD-48A SILT FENCE INSTALLATION  
N.T.S.

DEVELOPER:  
MR. DAVID GALE  
GALE COMMUNITIES, INC.  
3620 SW. WARD ROAD  
LEE'S SUMMIT, MO 64082  
PHONE: 816-537-4200

FILE: STORM-WATER-PLAN.DWG  
SCALE: 1"=200'  
DATE: 11/19/02  
DRAWN BY: RUL  
CHECKED BY: MD

No.	DATE	BY	REVISION
1	11/19/02	MD	DESIGNED BY
2		MD	DRAWN BY
3		RUL	CHECKED BY
4		MD	

DATE: 11/19/02  
DESIGNED BY: MD  
DRAWN BY: RUL  
CHECKED BY: MD

E. T. ARCHER CORPORATION D.B.A.  
**ARCHER**  
TOTAL PROJECT MANAGEMENT  
CORPORATE OFFICE: 3741 NE. TROON DRIVE  
LEE'S SUMMIT, MO. 64064  
816-554-3019 • FAX 816-554-3061

OTHER OFFICE LOCATIONS  
• 187 E. DAVID, P.O. BOX 989, FORTSMO, MO 65053 • 417-546-3218 • FAX 417-546-5324  
• 800 STARKS BUILDING, LOUISVILLE, KY 40202 • 502-581-9484 • FAX 502-581-9485  
• 1000 CITY PARKWAY, OSAGE BEACH, MO 65055 • 573-348-3222 • FAX 573-348-3499  
• 1007 HAUCK DR., SUITE B, P.O. BOX 537, ROLLA, MO 65402 • 573-364-5420 • FAX 573-364-4170  
• 6300 HALL, P.O. BOX 439, SHAWNEE MISSION, KS 66201 • 913-382-9753 • FAX 913-382-8847  
• 255 SO. UNION, SPRINGFIELD, MO 65802 • 417-885-4083 • FAX 417-885-4085  
• 2480 EXECUTIVE DRIVE, SUITE 116, ST. CHARLES, MO 63303 • 636-477-0288 • FAX 636-477-7599

DRAINAGE MASTER PLAN  
FOR  
ARBORWALK, LEE'S SUMMIT, MO.  
FOR: GALE COMMUNITIES, INC.  
LEE'S SUMMIT, MISSOURI

PROJECT NO.  
21126701  
DRAWING NO.  
1 OF 1



# **DRAINAGE MASTER PLAN**

## **INTRODUCTION**

Gale Communities, Inc., of Lee's Summit, Missouri employed the services of Archer Engineers to evaluate and recommend a storm water management plan for the watershed associated with the development called Arborwalk. Arborwalk is located in the southern portion of the City of Lee's Summit north of Missouri State Highway 150 and between Ward and Pryor Roads. The development is 380 acres and is in Section 25, Township 47, Range 32 of Jackson County. General topography is gentle rolling hills with both open fields and timber areas.

## **WATERSHED DESCRIPTION**

Arborwalk development is divided into 5 drainage basins, Southeast, Southwest, East, Northwest, and North. The 5 drainage basins have their own modified storm water management system that is described in detail in the following text. A check of the Federal Emergency Management Agency (FEMA) indicated that there is no 100-year flood plain within the boundary of the development.

The 5 drainage basins are outlined on the attached Figure named Drainage Master Plan (enclosed). The Figure indicates the different drainage basins, flow direction, location and approximate size of major detention basins, location of major rock check dams and silt trap basins. Soil type was obtained from the Soil Conservation Service's (SCS) "Soil Survey of Jackson County, Missouri". Existing land use was obtained from the city zoning records and field inspection. Table A at the end of this report provides data for the different drainage basins and pre and post watershed conditions respectfully.

## **OVERVIEW**

Storm water management is knowledge used to understand, control, and utilize waters in different forms within the hydrologic cycle. The natural condition of a watershed is termed undeveloped condition. Natural streams, creeks, and waterways have been continuously shaped over time by storm runoff. Development of a watershed results in more paved areas that increase the frequency, magnitude, and volume of storm runoff. Man made drainage facilities cause storm water to move faster and to become more concentrated causing erosion within the watershed. The factors that impact severity of erosion include storm intensity, soil conditions, vegetation characteristics, and topography.

The goal of this report is to provide concepts and design criteria for best management of storm water and the functions of the storm water drainage system. Various types of systems will be used in the development to manage the storm water and may include storm sewers, streets with curb & gutter, swales, detention, off-line detention, and wetlands.

Detention basins are small to medium size basins that impound water for 24 hours or less and are normally 10 acre-ft or less. Retention basins are usually larger than detention basins and hold water for much longer periods, usually have a defined pool elevation, and release any stored water at a much slower rate. Additional concepts will consist of oversized storm sewer piping, off-line detention basins, and shallow green space detention. Oversized storm sewer piping could be placed at critical locations to hold limited volumes of storm water to decrease the peak outflow leaving the detention basin during normal storm events. Off-line detention basins might be developed within the watershed to reduce the overall detention areas required within the watershed. An example of an off-line detention basin might be a defined swale running down the back lot lines of a series of houses. This swale would be connected to the storm sewers at each end and controlled with an inlet of greater capacity than the outlet of the storm sewer. The storm sewer would be designed to pass the dry weather flows and the 2, 5, and 10-year storms. During a storm event larger than the 10-year event, the volume difference between the inflow and outflow would be detained in the swale area defined. This type of design using the concept of off-line detention within the on-line sewer system would allow for better control of storm detention within the drainage basin before reaching the detention basin(s) down stream.

### **SOUTHEAST DRAINAGE AREA**

The Southeast Drainage Area will consist of all the various type of storm water management systems that are practicable for the given size and use of the area. The systems will consist of inlets and storm sewer piping, oversized storm sewer piping for limited detention upstream of the detention basin, existing open channels with riparian vegetation and wetlands, a retention basin with a fixed pool elevation and with detention included within the retention basin, and shallow off-line detention combined with the storm sewer system for increased storage upstream of the retention/detention basin. In addition, upland detention will utilize green space for shallow storage of storm events smaller than the 25-year event. The Drainage area is 103 acres with a weighed curve number of 85 and a time of concentration of 27 minutes.

The existing farm lake will be retained and utilized by increasing the dam height and excavation to create a detention basin above the normal pool elevation for the 25-year design storage. The detention provided above the normal pool elevation will be approximately 7.2 acre-feet of storage (3-feet in depth). The green space southeast of the basin will be designed to hold an additional 3.9 acre-feet of storage (1-foot in depth). The combination of the two basins will adequately hold the required volume of storage for both the southeast drainage basin including the future commercial development at the



intersection of Ward Road and Highway 150. If in final design, it is determined that additional space will be needed in the Southeast Basin, one option that will be considered is the installation of an underground storm sewer detention under the commercial area near the intersection of Ward Road and Highway 150.

To provide improved water quality in the Southeast Drainage Basin, additional upland/wetland area will be developed north of the retention/detention basin. This upland area will provide a vegetative interface with the lower storm events by allowing low flows to pass through a native grass and tree area where the velocities will be lowered to allow for sediment to collect in this upland area instead of the basins and potential exiting the basin.

The area defined as commercial will have limited detention within their boundaries. The required detention volumes for this area will be held in the Southeast detention area upstream. An outlet structure with limited underground storage will be built at the outlet (near the intersection of Ward Road and Highway 150) to allow only pre-developed flows to exist the watershed.

Erosion control efforts for the area will include improved vegetative stabilization practices such as temporary seeding using degradable stabilization blankets on slopes, buffer zones at the top and bottom of slopes to reduced runoff flows, silt fence, straw bales, storm inlet protection, and erosion control matting. In addition, check dams will be used extensively both upstream and downstream of the green area to limit the amount of sediment that could enter the Southeast Detention area. The southeast corner of the development will have a series of temporary sedimentation basins to control and contain the sediment load as storm water exists the site during the development of the project.

The pre-developed flow for the Southeast Drainage Basin is 340 cubic feet per second (cfs) and the post-developed flow is 431 cfs. The proposed size of storage required for this is approximately 7 acre-feet for the 25-year storm event and for the 100-year storm event the required storage is 10.9 acre-feet. The commercial area to the southeast when developed will require 4.8 acre-feet of storage for detention that is part of the required storage listed above.

### **SOUTHWEST DRAINAGE AREA**

The Southwest Drainage Area systems will consist of inlets and storm sewer piping, oversized storm sewer piping for limited detention upstream of the detention basin, existing open channels with riparian vegetation and wetlands, detention basins, and shallow off-line detention combined with the storm sewer system for increased storage upstream of the detention basins. The detention basins will consist of a two dry detention basins to control the 2, 5, and 10-year storm for water quality and the 25-year storm for downstream flood control. The small storm events will be held longer in the basins to allow for improved water quality. This will be accomplished by designing around the existing creek, by the addition of a control structure near Highway 150, and using the



change in elevations in creating steps. The upper (smaller) basin that has a storage volume of approximately 1.2 acre-feet (3-foot depth) will be used as an equalization basin before entering the lower detention basin. The lower detention basin which has a storage volume of approximately 12.3 acre-feet will be gentle and blend into the surrounding land by using native trees, bushes, and grasses. During the higher storm events, water will be allowed to pond over most of the basin floor up to depth of 42-inches. This will allow for planting of grasses in the basin bottom that can survive for short times during submergence and the usage of tree plantings and treescape islands that will be scattered through out the basin floor. These treescape islands will consist of trees, shrubs, and grasses native to the area and particularly to stream areas. There will be field inlets scattered through out the basin floor to handle the larger storm events by allowing flow into smaller diameter piping that would converge at the primary outlet structure. This would allow for subcritical flow to exit the site, thereby reducing the potential for erosion downstream. Additional rock levels with rock waterfalls will allow for transition of elevations and add aeration to the storm water for quality. The drainage area is 129 acres with a weighed curve number of 88 and a time of concentration of 20 minutes.

Erosion control efforts for the area will include improved vegetative stabilization practices such as temporary seeding using degradable stabilization blankets on slopes, buffer zones at the top and bottom of slopes to reduced runoff flows, silt fence, straw bales, storm inlet protection, and erosion control matting. In addition, check dams will be used extensively both upstream and downstream of the green area to limit the amount of sediment that could enter the southwest green area.

The pre-developed flow for the Southwest Drainage Basin is 465 cubic feet per second (cfs) and the post-developed flow is 622 cfs. The proposed size of storage required for this is approximately 11 acre-feet for the 25-year storm event and for the 100-year storm event the required storage is 13.6 acre-feet. The office area to the east of the lower detention area when developed will require 2.9 acre-feet of storage for detention that is part of the required storage listed above.

### **NORTHWEST DRAINAGE AREA**

The Northwest Drainage Area systems will consist of inlets and storm sewer piping, oversized storm sewer piping for limited detention upstream of the shallow detention basin, existing open channels with riparian vegetation and wetlands, a shallow detention basin, and shallow off-line detention combined with the storm sewer system for increased storage upstream of the shallow detention basin. Shallow detention will consist of a series of small dry detention areas incorporated into the proposed green space along the north edge of the property and the buffer zone along Pryor Road. The outlet structure for this basin will be positioned at the northwest corner of development at Pryor and allow the release the pre-developed flows from the drainage basin. The green space along the northern edge of the development will consist of swales running in a curve pattern and dotted with treescape islands and native vegetation in the swales. This green space will provide approximately 0.9 acre-feet of storage. The buffer zone along Pryor Road will



have the same type layout of a meandering swale with larger treescape islands to meet the needs of a buffer zone between the residences and street. The buffer zone will provide approximately 0.9 acre-feet of storage. The combined storage of the two areas is approximately 1.8 acre-feet. The storage is less than the required 2.3 acre-feet for the 25-year event. Additional storage will be developed within the development by the use of large diameter storm sewer piping and off-line detention. Additional storm water swales will be included in the development design to account for and control the 100-year event. The drainage area is 33.1 acres with a weighed curve number of 81 and a time of concentration of 13 minutes.

Erosion control efforts for the area will include improved vegetative stabilization practices such as temporary seeding using degradable stabilization blankets on slopes, buffer zones at the top and bottom of slopes to reduced runoff flows, silt fence, straw bales, storm inlet protection, and erosion control mating. In addition, check dams will be used extensively both upstream and downstream of the green area to limit the amount of sediment that could enter the northwest green area.

The pre-developed flow for the Northwest Drainage Area is 123 cubic feet per second (cfs) and the post-developed flow is 170 cfs. The proposed size of storage required for this is 2.3 acre-feet for the 25-year storm event and for the 100-year storm event the required storage is 3.1 acre-feet.

### **EAST DRAINAGE AREA**

The East Drainage Area will consist of inlets and storm sewer piping, oversized storm sewer piping for limited detention upstream of the detention basin, existing open channels with riparian vegetation and wetlands, shallow detention, and shallow off-line detention combined with the storm sewer system for increased storage upstream of the retention/detention basin. Shallow detention will consist of a dry detention area incorporated into the proposed green space along the buffer zone along Ward Road. The outlet structure will be positioned at the existing culvert structure that is under Ward Road and will allow the release the pre-developed flows from the drainage basin. The green space along Ward Road will consist of swales running in a curve pattern and dotted with treescape islands and native vegetation in the swales. A small shallow dry detention basin consisting of native grass will be positioned near the outlet structure for better control for the storm events. The green space along Ward Road combined with the shallow detention basin near the existing outlet structure will provide approximately 0.95 acre-feet of storage. Additional storage will be developed within the development by the use of large diameter storm sewer piping and off-line detention. Additional storm water swales will be included in the development design to account for and control the 100-year event. The drainage area is 21.6 acres with a weighed curve number of 84 and a time of concentration of 20 minutes.

Erosion control efforts for the area will include improved vegetative stabilization practices such as temporary seeding using degradable stabilization blankets on slopes,

buffer zones at the top and bottom of slopes to reduced runoff flows, silt fence, straw bales, storm inlet protection, and erosion control mating. In addition, check dams will be used extensively both upstream and downstream of the green area to limit the amount of sediment that could enter the East Green Area.

The pre-developed flow for the East Green Area is 76 cubic feet per second (cfs) and the post-developed flow is 102 cfs. The proposed size of storage required for this is 1.6 acre-feet for the 25-year storm event and for the 100-year storm event the required storage is 2.1 acre-feet.

### **NORTH DRAINAGE AREA**

The North Drainage Area will consist of inlets and storm sewer piping, oversized storm sewer piping for limited detention upstream of the detention basin, existing open channels with riparian vegetation and wetlands, two detention basins (one normal depth and one shallow), and shallow off-line detention combined with the storm sewer system for increased storage upstream of the retention/detention basin. The drainage areas will consist of two drainage basins with two outlet points. The westerly outlet will be the north dry detention basin and the northerly outlet will be the upper north dry detention basin. The upper detention basin will incorporate the proposed green space along the north edge of the property and the buffer zone along Hook Road. The outlet structure will be positioned at the existing culvert structure that is under Hook Road and will allow the release the pre-developed flows from the drainage basin. The green space along the north edges will consist of swales running in a curve pattern and dotted with treescape islands and native vegetation in the swales. The north detention basin will consist of the buffer zone along the western edge of the development will have the same type layout of a meandering swale with larger treescape islands to meet the needs of a buffer zone between the residences and street. A larger dry detention basin consisting of native grass will be positioned near the outlet structure for better control for the storm events. The combined detention of the northern and upper north detention basins is 8.2 acre-feet, which is more than adequate for current volumes. If it is determined that additional storage is required. Additional storage will be developed using large diameter piping and off-line detention in the development. Additional storm water swales will be included in the development design to account for and control the 100-year event. The drainage area consists of 68.2 acres for the North Drainage Basin and 11.9 acres for the Upper North Drainage Basin. The weighted curve number is 81 and the time of concentration is 16 minutes.

Erosion control efforts for the area will include improved vegetative stabilization practices such as temporary seeding using degradable stabilization blankets on slopes, buffer zones at the top and bottom of slopes to reduced runoff flows, silt fence, straw bales, storm inlet protection, and erosion control mating. In addition, check dams will be used extensively both upstream and downstream of the green area to limit the amount of sediment that could enter the southeast green area.



The pre-developed flow for the North Drainage Area is 226 cubic feet per second (cfs) and the post-developed flow is 296 cfs. The proposed size of storage required for this is 5.3 acre-feet for the 25-year storm event and for the 100-year event the required storage is 7.1 acre-feet.

## **CONCLUSION**

Table A is a summary of the design storm events, drainage areas, and pre and post development flows and recommended detention. The recommended detention will be completed with a combination of retention/detention lakes, detention basins, and shall deter erosion utilizing gentle slopes, native grasses, and trees to create a storm water scape that will co-exist with the existing surroundings.



# Storm Water Quantities Arborwalk Development TABLE A

11/19/02

Table 1: 10, 25, 100 Year Storm Water Quantities

Event	Sub Watershed	CN	Area (acre)	Discharge (cfs)		Det. Vol. (acre-ft.)
				Pre	Post	
25-Year	Southwest	88	129	465.0	662.0	11.0
	Southeast	85	103	340.0	431.0	7.0
	Northwest	81	33.1	123.0	170.0	2.3
	North	81	80.2	226.0	296.0	5.3
	East	84	21.6	76.0	102.0	1.6
100-Year	Southwest	88	129	634.0	866.0	13.6
	Southeast	85	103	456.0	571.0	10.9
	Northwest	81	33.1	166.0	230.0	3.1
	North	81	80.2	307.0	400.0	7.1
	East	84	21.6	98.0	146.0	1.7

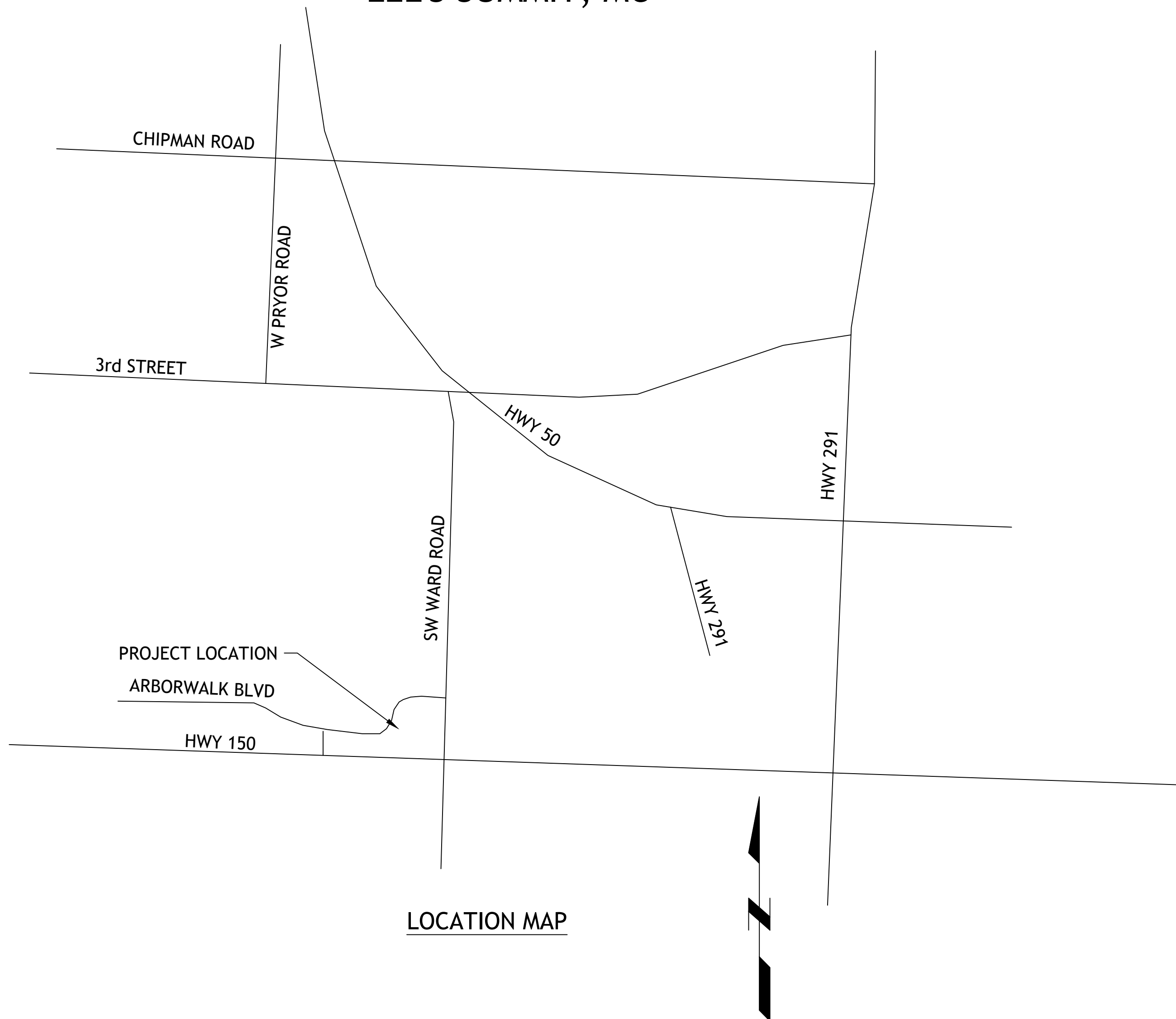
## **Appendix B**

# PUBLIC STORM SEWER PLANS

## TO SERVE

# ARBORWALK EAST

LEE'S SUMMIT, MO



LOCATION MAP

### INDEX OF SHEETS

- C-1 COVER SHEET
- C-2 EXISTING CONDITIONS
- C-3 OVERALL LAYOUT PLAN
- C-4 GRADING / EROSION CONTROL PLAN
- C-5 STORM LINE A PLAN AND PROFILE
- C-6 STORM LINE A PLAN AND PROFILE
- C-7 STORM LINE A PLAN AND PROFILE
- C-8 DRAINAGE PLAN
- C-9 DETAILS
- C-10 DETAILS

### DEVELOPER

MARTIN CITY PARTNERS, LLC  
7217 W 110TH STREET  
OVERLAND PARK, KS 66210  
CONTACT: GARRETT FUGATE  
PHONE: 913.649.4500  
EMAIL: GARRET@CHRISTIEDEV.COM

### ENGINEER

SM ENGINEERING  
SAM MALINOWSKY  
5507 HIGH MEADOW CIRCLE  
MANHATTAN KANSAS, 66503  
SMCIVILENGR@GMAIL.COM  
785.341.9747

### SURVEYOR

J & J SURVEY, INC.  
6500 NW TOWER DR SUITE 102  
PLATTE WOODS, MO 64151  
816-741-1017



SAMUEL D. MALINOWSKY  
PROFESSIONAL ENGINEER

SM Engineering  
5507 High Meadow Circle  
Manhattan Kansas, 66503  
smcivilengr@gmail.com  
785.341.9747

Drawings and/or Specifications are original proprietary work and property of the Engineer and intended specifically for this project. Use of items contained herein without consent of the Engineer is prohibited. Drawings illustrate best information available to the Engineer. Field verification of actual elements, conditions, and dimensions is required.

Revisions

PUBLIC STORM LINE  
ARBORWALK EAST  
LEE'S SUMMIT, MO.

s h e e t  
C1.0  
Civil  
Site Improvement Plan  
permit  
11 APRIL 2023

UTILITIES  
Electric Service  
Evergy  
Nathan Michael  
913-347-4310  
Nathan.michael@evergy.com

Gas Service  
Spire  
Katie Darnell  
816-969-2247  
Katie.darnell@spireenergy.com

Water/Sanitary Sewer  
Water Utilities Department  
1200 SE Hamblen Road  
Lee's Summit, Mo 64081  
Jeff Thorn  
816-969-1900  
jeff.thorn@cityofls.net

Communication Service  
AT&T Carrie Cilke  
816-703-4386  
cc3527@att.com

Time Warner Cable  
Steve Baxter  
913-643-1928  
steve.baxter@charter.com

Comcast  
Ryan Alkire  
816-795-2218  
ryan.alkire@cable.comcast.com

Google Fiber  
Becky Davis  
913-725-8745  
rebeccadavis@google.com



### UTILITY STATEMENT:

THE UNDERGROUND UTILITIES SHOWN HEREON ARE FROM FIELD SURVEY INFORMATION OF ONE-CALL LOCATED UTILITIES, FIELD SURVEY INFORMATION OF ABOVE GROUND OBSERVABLE EVIDENCE, AND/OR THE SCALING AND PLOTTING OF EXISTING UTILITY MAPS AND DRAWINGS AVAILABLE TO THE SURVEYOR AT THE TIME OF SURVEY. THE SURVEYOR MAKES NO GUARANTEE THAT THE UNDERGROUND UTILITIES SHOWN COMPRISE ALL SUCH UTILITIES IN THE AREA, EITHER IN SERVICE OR ABANDONED. FURTHERMORE, THE SURVEYOR DOES NOT WARRANT THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATION INDICATED ALTHOUGH HE DOES CERTIFY THAT THEY ARE LOCATED AS ACCURATELY AS POSSIBLE FROM INFORMATION AVAILABLE. THE SURVEYOR HAS NOT PHYSICALLY LOCATED THE UNDERGROUND UTILITIES BY EXCAVATION UNLESS OTHERWISE NOTED ON THIS SURVEY.

### SAFETY NOTICE TO CONTRACTOR

IN ACCORDANCE WITH GENERALLY ACCEPTED CONSTRUCTION PRACTICE, THE CONTRACTOR WILL BE SOLELY AND COMPLETELY RESPONSIBLE FOR CONDITIONS OF THE JOB SITE, INCLUDING SAFETY OF ALL PERSONS AND PROPERTY DURING PERFORMANCE OF THE WORK. THIS REQUIREMENT WILL APPLY CONTINUOUSLY AND NOT BE LIMITED TO NORMAL WORKING HOURS.

### WARRANTY/DISCLAIMER

THE DESIGNS REPRESENTED IN THESE PLANS ARE IN ACCORDANCE WITH ESTABLISHED PRACTICES OF CIVIL ENGINEERING FOR THE DESIGN FUNCTIONS AND USES INTENDED BY THE OWNER AT THIS TIME. HOWEVER, NEITHER SM ENGINEERING NOR ITS PERSONNEL CAN OR DO WARRANTY THESE DESIGNS OR PLANS AS CONSTRUCTED, EXCEPT IN THE SPECIFIC CASES WHERE SM ENGINEERING PERSONNEL INSPECT AND CONTROL THE PHYSICAL CONSTRUCTION ON A CONTEMPORARY BASIS AT THE SITE.

### CAUTION- NOTICE TO CONTRACTOR

THE CONTRACTOR IS SPECIFICALLY CAUTIONED THAT THE LOCATION AND/OR ELEVATION OF EXISTING UTILITIES AS SHOWN ON THESE PLANS IS BASED ON RECORDS OF THE VARIOUS UTILITY COMPANIES AND, WHERE POSSIBLE, MEASUREMENTS TAKEN IN THE FIELD. THE INFORMATION IS NOT TO BE RELIED ON AS BEING EXACT OR COMPLETE. THE CONTRACTOR MUST CALL THE APPROPRIATE UTILITY COMPANY AT LEAST 72 HOURS BEFORE ANY EXCAVATION TO REQUEST EXACT FIELD LOCATION OF UTILITIES. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO RELOCATE ALL EXISTING UTILITIES WHICH CONFLICT WITH PROPOSED IMPROVEMENTS SHOWN ON THE PLANS. THE CONTRACTOR SHALL EXPOSE EXISTING UTILITIES AT LOCATIONS OF POSSIBLE CONFLICTS PRIOR TO ANY CONSTRUCTION.

### NOTES

- ALL CONSTRUCTION SHALL FOLLOW THE CITY OF LEE'S SUMMIT DESIGN AND CONSTRUCTION MANUAL AS ADOPTED BY ORDINANCE 5813. WHERE DISCREPANCIES EXIST BETWEEN THESE PLANS AND THE DESIGN AND CONSTRUCTION MANUAL, THE MORE STRINGENT SHALL PREVAIL.
- THERE ARE NO GAS/OIL WELLS PER MDNR DATABASE OF OIL AND GAS PERMITS.
- THE CONTRACTOR SHALL CONTACT THE CITY DEVELOPMENT SERVICES ENGINEERING INSPECTION TO SCHEDULE A PRE-CONSTRUCTION MEETING WITH A FIELD ENGINEERING INSPECTOR PRIOR TO ANY LAND DISTURBANCE WORK AT 816-969-1200.



TITLE DESCRIPTION:

Tract 1:  
Lot 2002 and Lot 2003, ARBORWALK — 5TH PLAT, LOTS 2001 THRU 2003, a subdivision in Lee's Summit, Jackson County, Missouri, according to the recorded plat thereof.

Tract 2:  
All that part of the Southeast 1/4 of Section 25, Township 47, Range 32, being more particularly described as follows: Beginning at the Northeast corner of Lot 2003, ARBORWALK — 5TH PLAT, LOTS 2001—2003, a subdivision in Lees Summit, Jackson County, Missouri; thence Northeasterly along a curve to the left, having a radius of 430.00 feet and an arc distance of 326.97 feet; thence North 26 degrees 08 minutes 12 seconds East 110 feet; thence Northeasterly along a curve to the right, having a radius of 470.00 feet and an arc distance of 434.56 feet; thence Southeasterly along a curve to the right, having a radius of 75.00 feet, on an arc distance of 129.34 feet; thence South 02 degrees 04 minutes 54 seconds East 62.45 feet; thence South 87 degrees 28 minutes 08 seconds East 50.00 feet; thence North 02 degrees 31 minutes 44 seconds East 57.00 feet; thence Northeasterly along a curve to the right, having a radius of 70.00 feet, on an arc distance of 109.96 feet; thence South 67 degrees 28 minutes 08 seconds East 265.66 feet; thence Southeasterly along a curve to the right, having a radius of 40.00 feet, on an arc distance of 60.52 feet; thence Southwesterly along a curve to the right, having a radius of 10,437.02 feet, on an arc distance of 215.03 feet; thence South 07 degrees 26 minutes 42 seconds West 230.61 feet; thence Southwesterly along a curve to the right, having a radius of 10,572.00, on an arc distance of 168.89 feet; thence South 04 degrees 03 minutes 55 seconds West 12.00 feet; thence South 03 degrees 06 minutes 01 seconds West 14.64 feet; thence South 66 degrees 00 minutes 58 seconds East 10.00 feet; thence South 10 degrees 22 minutes 02 seconds West 63.64 feet; thence South 40 degrees 43 minutes 06 seconds West 130.68 feet; thence South 01 degrees 51 minutes 56 seconds West 45.00 degrees; thence North 86 degrees 08 minutes 04 seconds West 808.65 feet; thence South 02 degrees 06 minutes 17 seconds West 25.71 feet; thence North 87 degrees 53 minutes 43 seconds West 369.36 feet; thence North 02 degrees 06 minutes 17 seconds East 51.07 feet; thence South 87 degrees 54 minutes 12 seconds East 21.50 feet; thence North 02 degrees 05 minutes 48 seconds East 88.00 feet; thence South 87 degrees 54 minutes 12 seconds East 17.60 feet; thence South 84 degrees 52 minutes 58 seconds East 37.95 feet; thence South 87 degrees 54 minutes 12 seconds East 18.50 feet; thence North 02 degrees 05 minutes 48 seconds East 10.00 feet; thence South 87 degrees 54 minutes 12 seconds East 106.00 feet; thence South 02 degrees 05 minutes 48 seconds West 26.00 feet; thence South 87 degrees 54 minutes 12 seconds East 52.00; thence North 02 degrees 05 minutes 48 seconds East 51.50 feet; thence North 87 degrees 54 minutes 12 seconds West 25.50 feet; thence North 02 degrees 05 minutes 48 seconds East 41.50 feet; thence North 87 degrees 54 minutes 12 seconds West 12.50 feet; thence North 02 degrees of minutes 48 seconds East 95.00, thence North 20 degrees 17 minutes 45 seconds West 24.80 feet to the point of beginning.

SCHEDULE B — PART II NOTES:

Items 1—7, 12 and 13 are non survey related items.  
8. An easement granted to the City of Lee's Summit, a municipal corporation, described by instrument recorded June 25, 2001 as Document No. 200110048744. Does not affect subject property but has been shown.

9. Boundaries; streets; grades; set back lines; easements, including but not limited to ingress and egress; cross parking agreement; dedications, including but not limited to sidewalk dedications; shown and or noted on the plat of ARBORWALK, — 5th Plat, recorded June 1, 2005 as Document No. 200510045420 in Plat Book 87 at Page 28. Does not affect subject property.

10. Terms and provisions of the Restrictions, recorded June 1, 2005 as Document No. 2005 1 0045421, together with the terms and provisions of the Assignment and Assumption of Declarant Rights, recorded August 18, 2014 as Document No. 2014E0068343; but omitting any covenants or restrictions, if any, including but not limited to those based upon race, color, religion, sex, sexual orientation, familial status, marital status, disability, handicap, national origin, ancestry, source of income, gender, gender identity, gender expression, medical condition or genetic information, as set forth in applicable state or federal laws, except to the extent that said covenant or restriction is permitted by applicable law.  
Affected by the Assignment and Assumption of Declarant rights dated February 16, 2022, recorded February 16, 2022 as Document No. 2022E0015432. Affects subject property and is blanket in nature.

11. Boundaries, easements and features shown by the Survey recorded July 9, 2009 as Document No. 2009E0068194. Does not affect subject property but has been shown.

GENERAL SURVEY NOTES:

1.) The plat of ARBORWALK—1ST PLAT, is recorded in Book 82 at Page 50 in the Recorder of Deeds Office in Jackson County, Missouri.

2.) The plat of ARBORWALK—5TH PLAT, is recorded in Book I—87 at Page 28 in the Recorder of Deeds Office in Jackson County, Missouri.

3.) Title Report # KCC222158, dated September 8, 2022 at 8:00 AM provided by Chicago Title Insurance Company, was provided by client.

4.) Basis of Bearings was established by the Missouri State Plane Coordinate System from GPS Observation.

5.) The subject property is located in Zone X, areas determined to be outside the 0.2% annual chance floodplain, as shown on Flood Insurance Rate Map (FIRM) 29095C05320, effective January 20, 2017.

6.) The subject property contains 892,586 square feet or 20.49 acres.

UTILITY NOTES:

The utilities on this survey are shown based on source information from plans and markings and were combined with observed evidence of utilities pursuant to Section 5.E.iv. to develop a view of the underground utilities. However, lacking excavation, the exact location of underground features cannot be accurately, completely, and reliably depicted. In addition, in some jurisdictions, 811 or other similar utility locate requests from surveyors may be ignored or result in an incomplete response, in which case the surveyor shall note on the plat or map how this affected the surveyor's assessment of the location of the utilities. Where additional or more detailed information is required, the client is advised that excavation and/or a private utility locate request may be necessary.

SURVEYORS RECOMMENDED PROPERTY DESCRIPTION:

A tract of land being part of the Southeast Quarter of Section 25, Township 47 North, Range 32 West, in the City of Lee's Summit, Jackson County, Missouri, being more particularly described as follows:

Commencing at the Southeast corner of said Southeast Quarter; Thence North 02°36'29" East, along the East line of said Southeast Quarter, 575.15 feet; Thence North 87°23'31" West, 80.02 feet to the West Right-of-Way line of SW Ward Road, as now established, said point also being the Point of Beginning; Thence on a curve to the right, having an initial tangent bearing South 54°41'29" West, a radius of 35.00 feet and an arc length of 22.75 feet; Thence North 88°03'54" West, 5.35 feet; Thence on a curve to the left, tangent to the last described course, having a radius 57.46 feet and an arc length of 87.14 feet; Thence South 05°03'17" West, 137.84 feet; Thence on a curve to the right, tangent to the last described course, having a radius of 28.54 feet and an arc length of 43.27 feet; Thence North 88°03'54" West, 759.59 feet; Thence North 01°56'06" East, 49.98 feet; Thence on a curve to the left, tangent to the last described course, having a radius of 138.80 feet and an arc length of 104.30 feet; Thence North 41°07'14" West, 31.46 feet to the South Right-of-Way line of SW Arborwalk Boulevard, as now established; Thence along said South Right-of-Way line the following ten courses; Thence on a curve to the left, having an initial tangent North 43°36'02" East, having a radius of 430.00 feet and an arc length of 131.07 feet; Thence North 26°08'12" East, 110.99 feet; Thence on a curve to the right, tangent to the last described course, having a radius of 470.00 feet and an arc length of 434.56 feet; Thence on a curve to the right, tangent to the last described course, having a radius of 75.00 feet, and an arc length of 129.34 feet; Thence South 02°04'46" East, 62.45 feet; Thence South 87°28'08" East, 50.00 feet; Thence North 02°31'52" East, 57.00 feet; Thence on a curve to the right, tangent to the last described course, having a radius of 70.00 feet and an arc length of 109.96 feet; Thence South 87°28'08" East, 265.53 feet; Thence on a curve to the right, tangent to the last described course, having a radius of 40.00 feet and an arc length of 63.79 feet to the West Right-of-Way line of said SW Ward Road; Thence along said West Right-of-Way line the following three courses; Thence South 04°28'39" West, 211.75 feet; Thence South 07°28'42" West, 158.69 feet to the Point of Beginning. Contains 499,350 square feet or 11.46 acres more or less.

SURVEY CONTROL POINTS			
Point #	Northing	Easting	Elevation
1	974540.74	2824139.37	993.44
40	978301.91	2817160.68	977.88
41	978327.36	2816366.85	1004.50
50	978308.82	2817086.59	981.07
51	978327.61	2816255.51	1007.48

BENCHMARK:

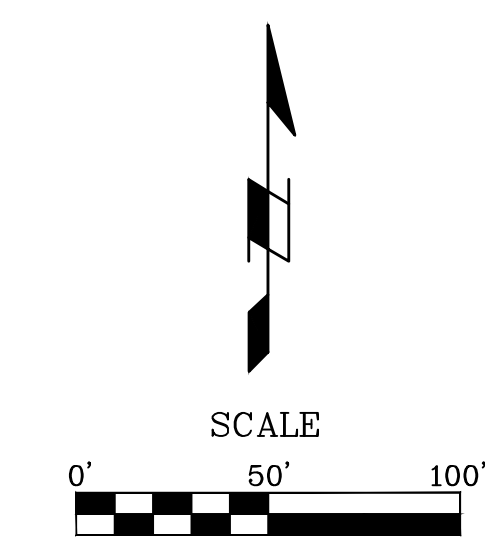
JA-132: KC Metro Aluminum GRS Disk, located approximately 0.7 miles South of intersection Highway 150 and Highway 291, 32" East of the center of Highway 291.  
Elevation = 993.44

CLIENT:

Kimley Horn

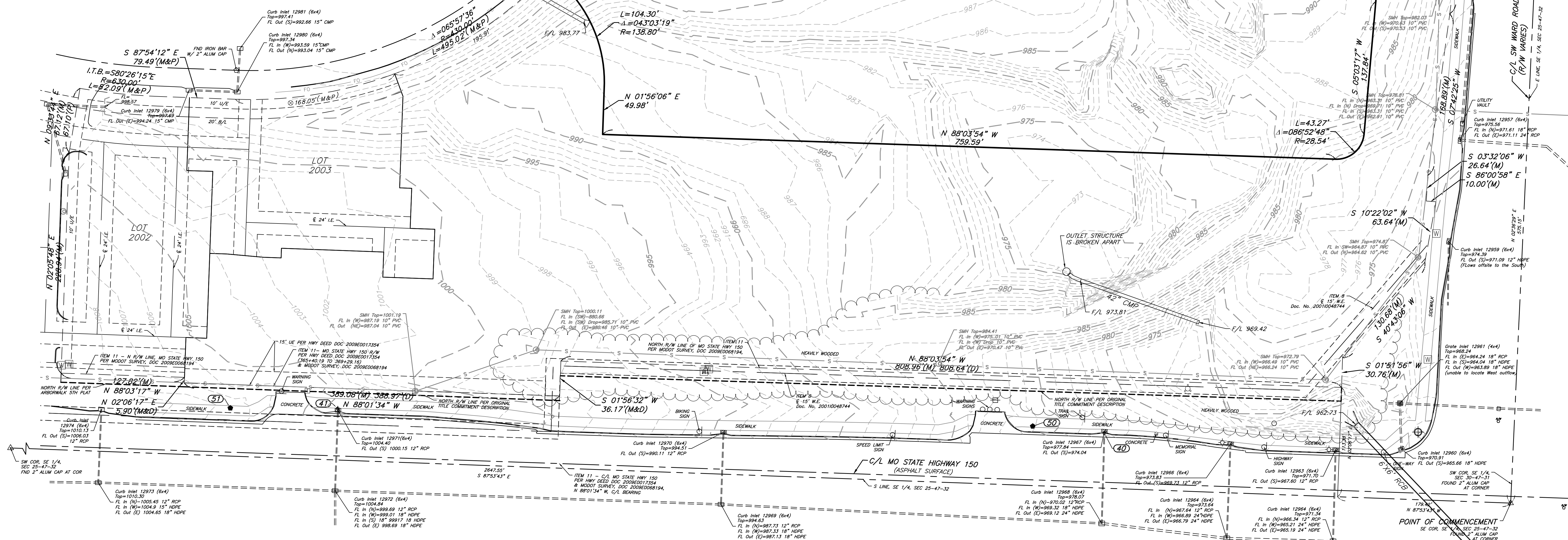
PROPERTY LOCATION:

NE corner M-150 & SW Ward Road  
Lee's Summit, MO

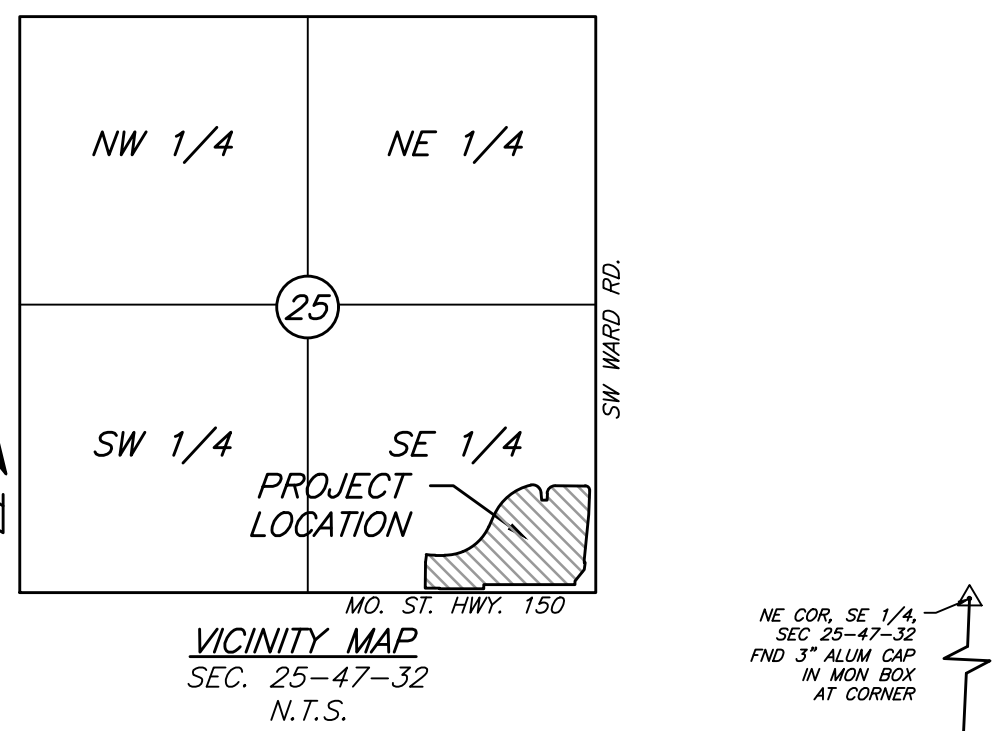


LEGEND

- BENCHMARK
- SECTION CORNER AS NOTED
- MONUMENT FOUND AS NOTED
- SET MONUMENT AS NOTED
- FOUND 1/2" IRON BAR AT CORNER UNLESS OTHERWISE NOTED
- SET 1/2" IRON BAR AT CORNER W/ J & J CAP
- (P) — PLATTED DISTANCE
- (M) — MEASURED DISTANCE
- (D) — DESCRIBED DISTANCE IN MODOT R/W PLANS
- I.E. — INGRESS/EGRESS EASEMENT
- W/E — WATER EASEMENT
- U/E — UTILITY EASEMENT
- EXISTING TREE
- WATER METER
- WATER VALVE
- FIRE HYDRANT
- SANITARY MANHOLE
- STORM MANHOLE
- POWER POLE
- LIGHT POLE
- TRAFFIC SIGNAL POLE
- GUY WIRE
- TELEPHONE PEDESTAL
- SIGN AS NOTED
- FIBER OPTIC MARKER
- SANITARY SEWER LINE
- STORM LINE
- OVERHEAD ELECTRIC
- UNDERGROUND WATER
- WATER SERVICE
- TELEPHONE
- FIBER OPTIC LINE
- CABLE
- TREE LINE



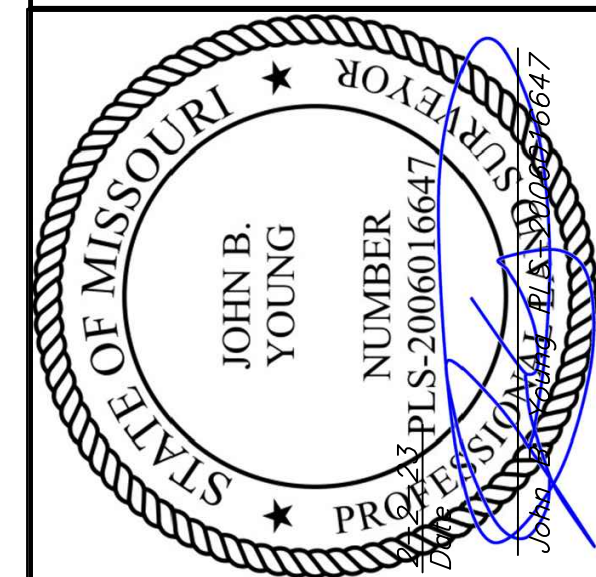
ALTA/NSPS LAND TITLE SURVEY  
SE 1/4, SECTION 25, TOWNSHIP 47 NORTH, RANGE 32 WEST  
LEE'S SUMMIT, JACKSON COUNTY, MISSOURI



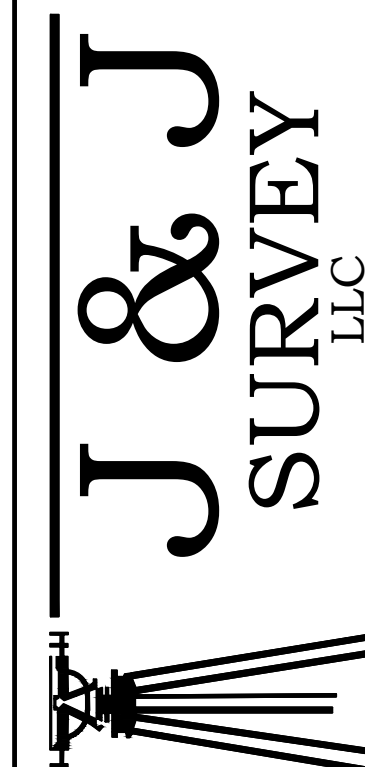
CERTIFICATION:

To Milhaus Properties LLC, an Indiana limited liability company and Chicago Title Insurance Company:

This is to certify that this map or plat and the survey on which it is based were made in accordance with the 2016 Minimum Standard Detail Requirements for ALTA/NSPS Land Title Surveys, jointly established and adopted by ALTA and NSPS, and includes Items 1, 2, 3, 4, 7a, 8, 9, 10, 12 and 13 of Table A thereof. The field work was completed on the 26th day of October, 2022.



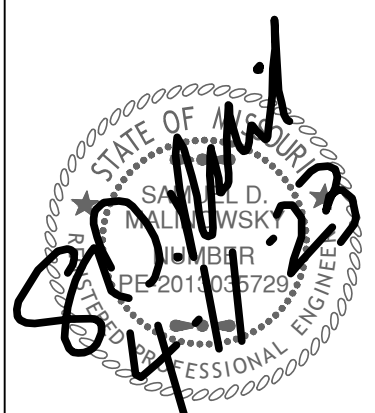
Location: S:\22.408 — NE Corner M-150 & SW Ward Rd \DRAWINGS\2023.01.31—ALTA 22.408ALTA.dwg—Feb 02, 2023—8:33am



6600 NW TOWER DR., SUITE 102 • PLATE WOODS, MO 64151  
PHONE (816) 411-1017 • FAX (816) 411-1018

	10-29-22	11-17-22	12-14-22	02-02-23
1	INITIAL SUBMITTAL			
2	ADDED CONTOURS/TOPOGRAPHY			
3	REVISED BOUNDARY			
4	REVISED BOUNDARY & DESCRIPTION			
SHEET 1 OF 1				

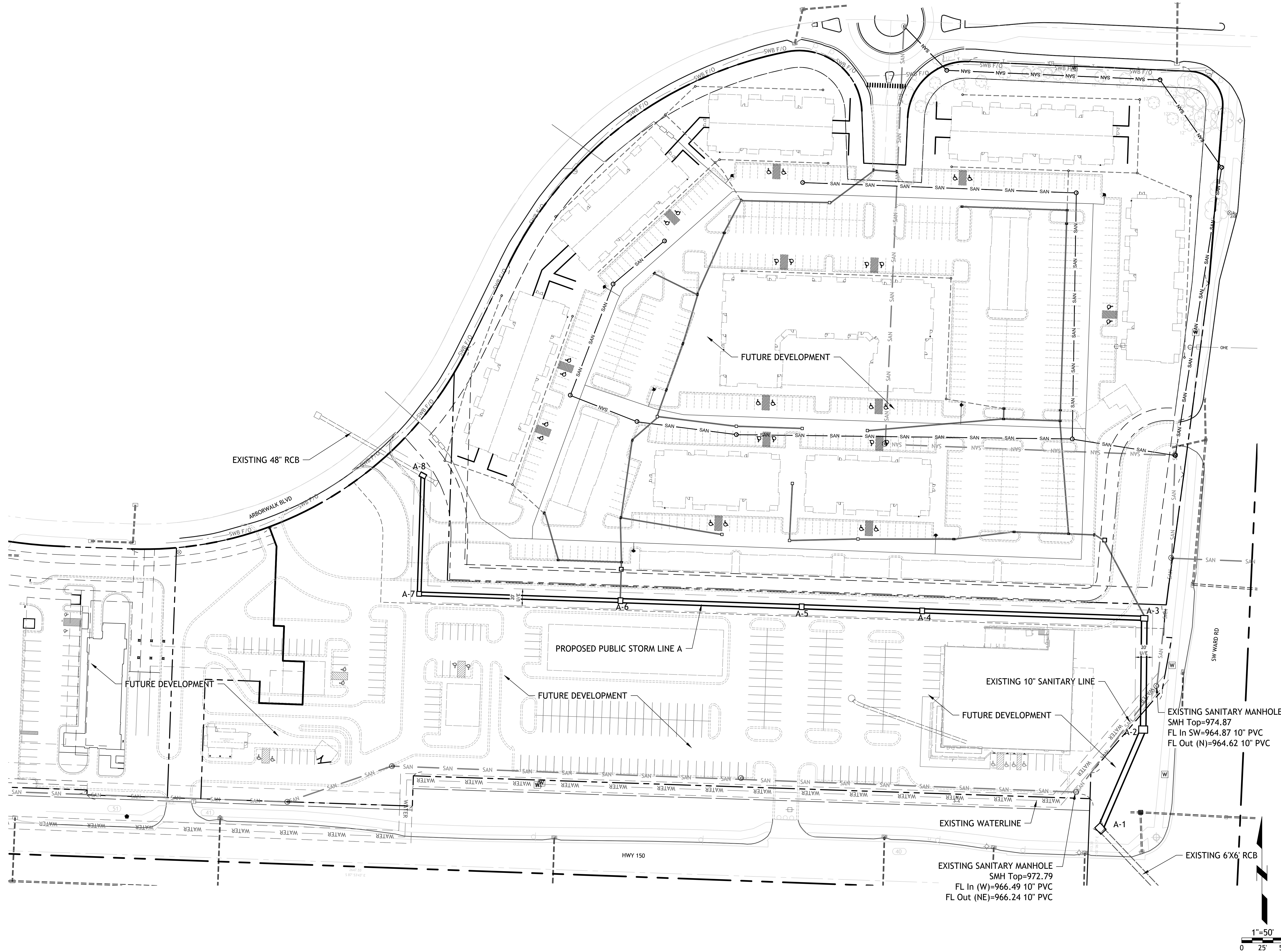




Revisions

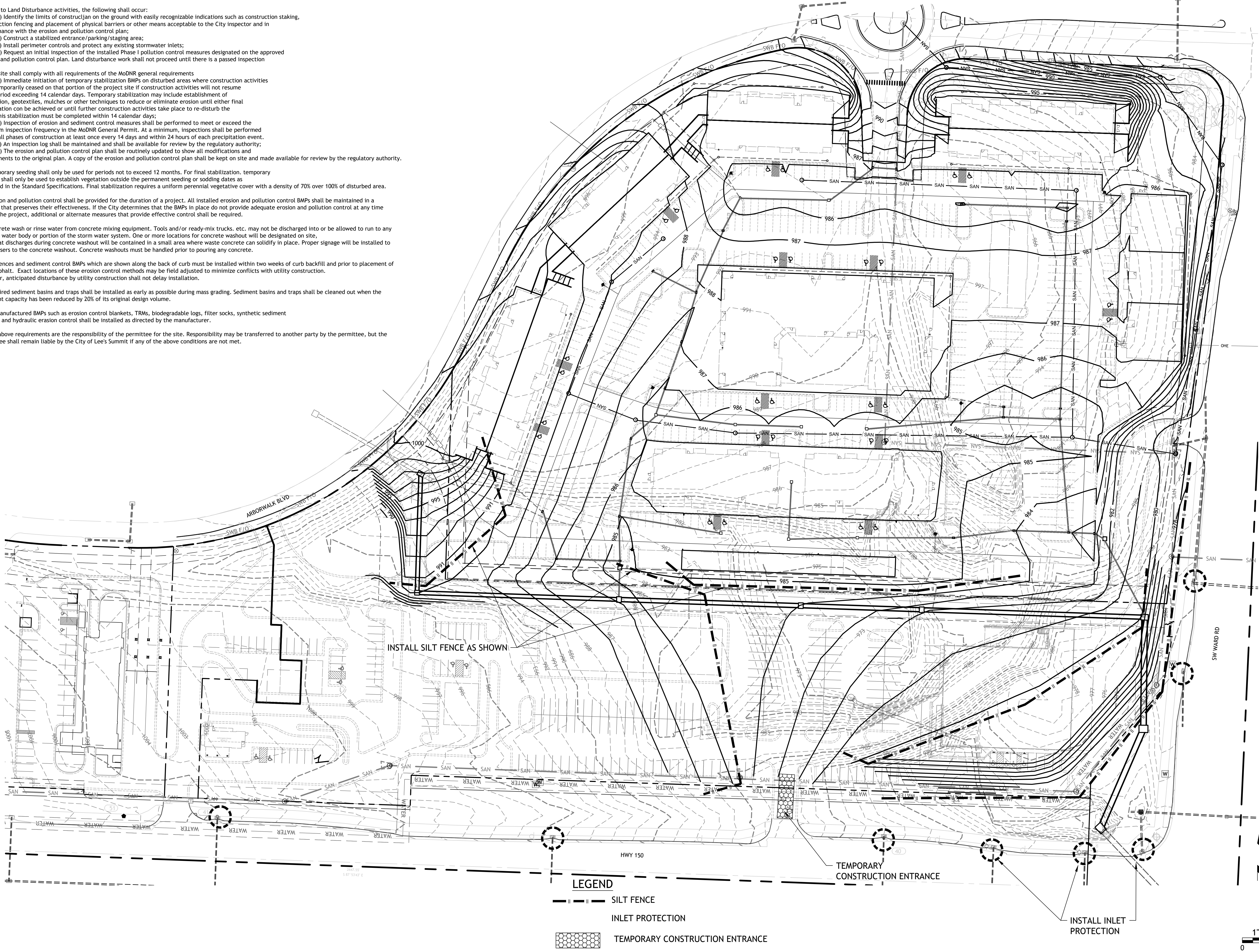
**PUBLIC STORM LINE  
ARBORWALK EAST**  
LEES SUMMITT, MO.

**sheet**  
**C3.0**  
Civil  
LAYOUT PLAN  
permit  
11 APRIL 2023





- NOTES:
1. Prior to Land Disturbance activities, the following shall occur:
    - a) Identify the limits of construction on the ground with easily recognizable indications such as construction staking, construction fencing and placement of physical barriers or other means acceptable to the City Inspector and in conformance with the erosion and pollution control plan;
    - b) Construct a stabilized entrance/parking/staging area;
    - c) Install perimeter controls and protect any existing stormwater inlets;
    - d) Request an initial inspection of the installed Phase I pollution control measures designated on the approved erosion and pollution control plan. Land disturbance work shall not proceed until there is a passed inspection
  2. The site shall comply with all requirements of the MoDNR general requirements
    - a) Immediate initiation of temporary stabilization BMPs on disturbed areas where construction activities have temporarily ceased on that portion of the project site if construction activities will not resume for a period exceeding 14 calendar days. Temporary stabilization may include establishment of vegetation, geotextiles, mulches or other techniques to reduce or eliminate erosion until either final stabilization can be achieved or until further construction activities take place to re-disturb the area. This stabilization must be completed within 14 calendar days;
    - b) Inspection of erosion and sediment control measures shall be performed to meet or exceed the minimum inspection frequency in the MoDNR General Permit. At a minimum, inspections shall be performed during all phases of construction at least once every 14 days and within 24 hours of each precipitation event.
    - c) An inspection log shall be maintained and shall be available for review by the regulatory authority;
    - d) The erosion and pollution control plan shall be routinely updated to show all modifications and amendments to the original plan. A copy of the erosion and pollution control plan shall be kept on site and made available for review by the regulatory authority.
  3. Temporary seeding shall only be used for periods not to exceed 12 months. For final stabilization, temporary seeding shall only be used to establish vegetation outside the permanent seeding or sodding dates as specified in the Standard Specifications. Final stabilization requires a uniform perennial vegetative cover with a density of 70% over 100% of disturbed area.
  4. Erosion and pollution control shall be provided for the duration of a project. All installed erosion and pollution control BMPs shall be maintained in a manner that preserves their effectiveness. If the City determines that the BMPs in place do not provide adequate erosion and pollution control at any time during the project, additional or alternate measures that provide effective control shall be required.
  5. Concrete wash or rinse water from concrete mixing equipment. Tools and/or ready-mix trucks, etc. may not be discharged into or be allowed to run to any existing water body or portion of the storm water system. One or more locations for concrete washout will be designated on site, such that discharges during concrete washout will be contained in a small area where waste concrete can solidify in place. Proper signage will be installed to direct users to the concrete washout. Concrete washouts must be handled prior to pouring any concrete.
  6. Silt fences and sediment control BMPs which are shown along the back of curb must be installed within two weeks of curb backfill and prior to placement of base asphalt. Exact locations of these erosion control methods may be field adjusted to minimize conflicts with utility construction. However, anticipated disturbance by utility construction shall not delay installation.
  7. Required sediment basins and traps shall be installed as early as possible during mass grading. Sediment basins and traps shall be cleaned out when the sediment capacity has been reduced by 20% of its original design volume.
  8. All manufactured BMPs such as erosion control blankets, TRMs, biodegradable logs, filter socks, synthetic sediment barriers and hydraulic erosion control shall be installed as directed by the manufacturer.
  9. The above requirements are the responsibility of the permittee for the site. Responsibility may be transferred to another party by the permittee, but the permittee shall remain liable by the City of Lee's Summit if any of the above conditions are not met.



SM Engineering  
**SAE**  
5507 High Meadow Circle  
Manhattan Kansas, 66503  
smcviengr@gmail.com  
785.341.9747

Drawings and/or Specifications are original proprietary work and property of the Engineer and intended specifically for this project. Use of items contained herein without consent of the Engineer's prohibited. Drawings illustrate best information available to the Engineer. Field verification of actual elements, conditions, and dimensions is required.

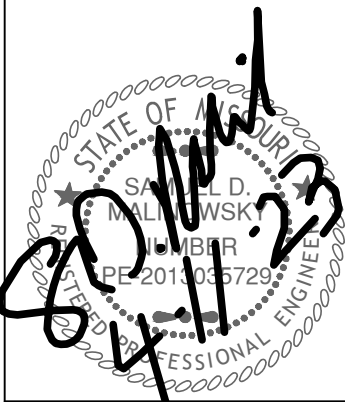
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11-11-23

Revisions

PUBLIC STORM LINE  
ARBORWALK EAST  
LEES SUMMITT, MO.

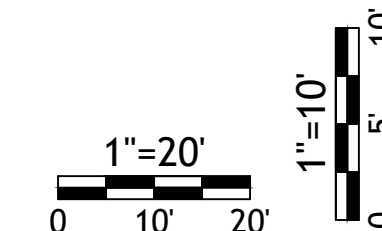
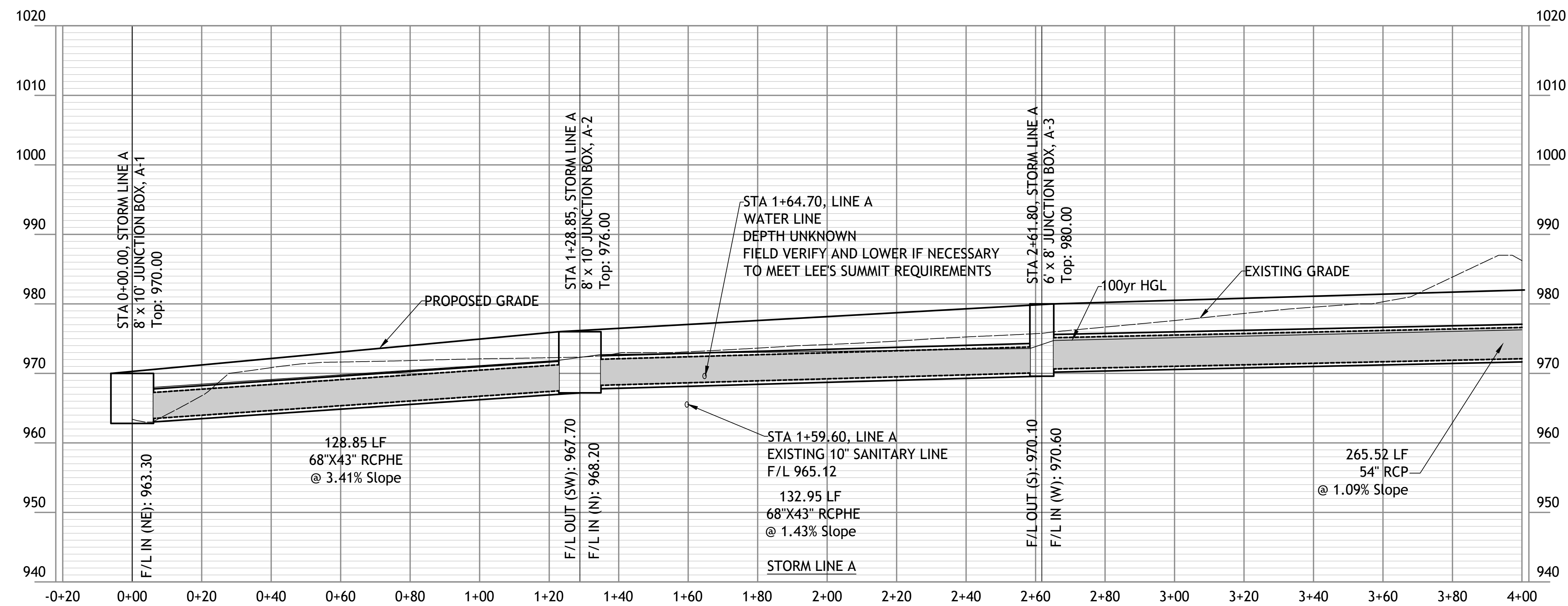
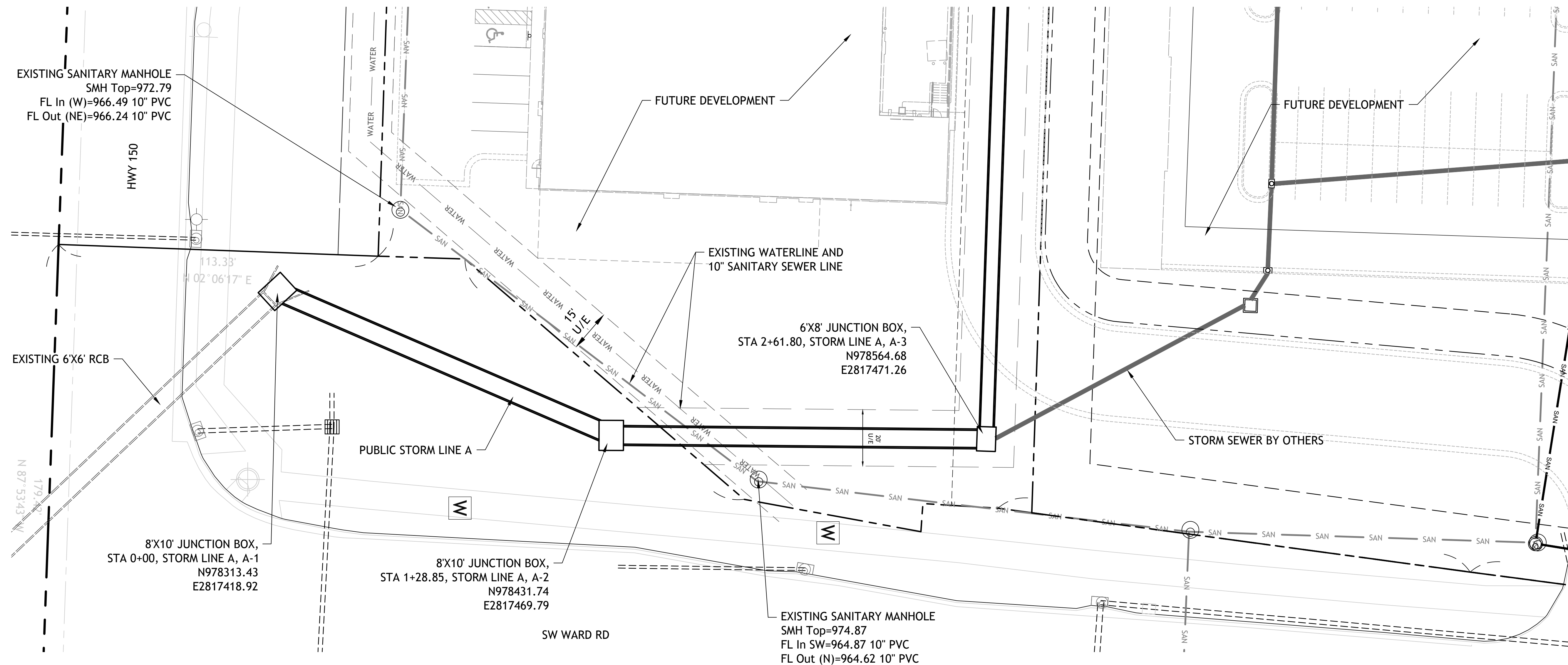
sheet  
**C4.0**  
Civil  
GRADING/EROSION  
CONTROL PLAN  
permit  
11 APRIL 2023



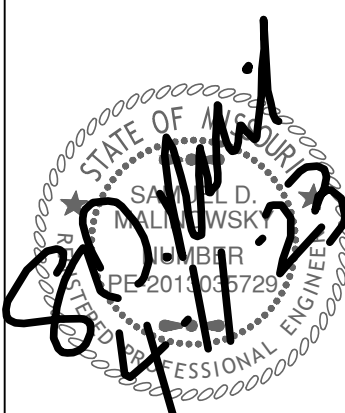


Revisions

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ARBORWALK EAST  
LEES SUMMITT, MO.

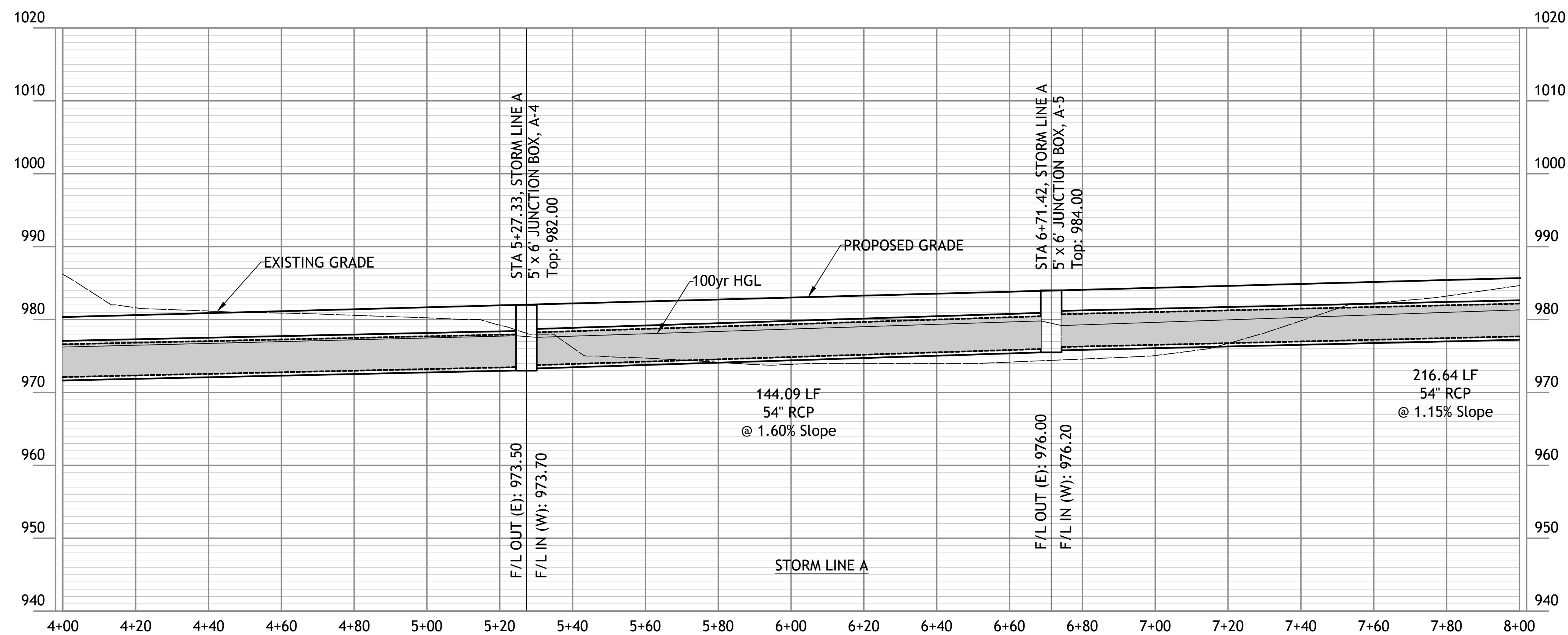
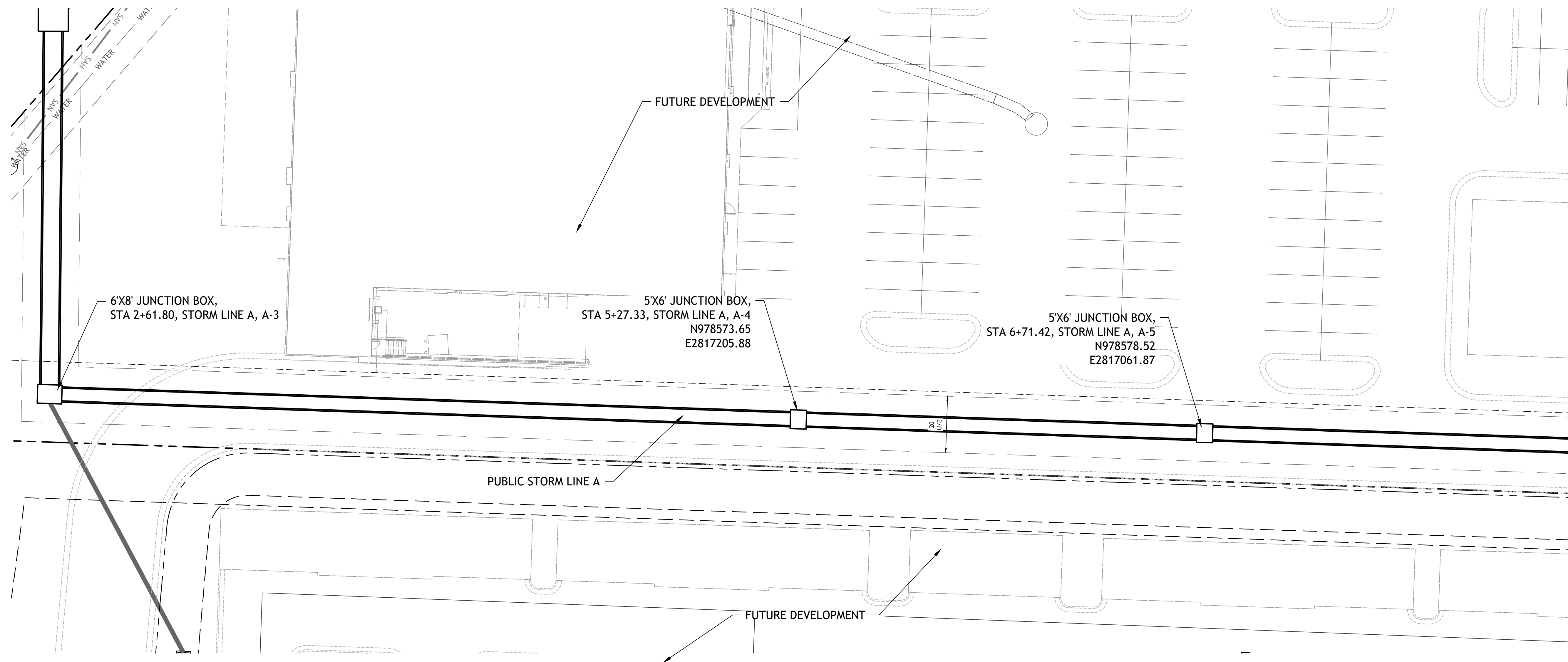


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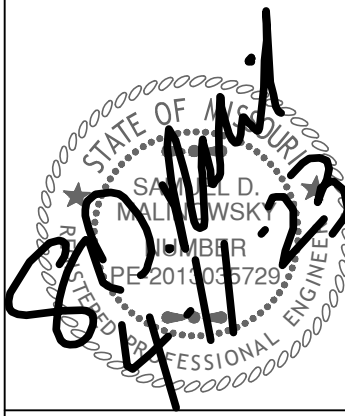
Revisions

PUBLIC STORM LINE  
ARBORWALK EAST  
LEES SUMMITT, MO.



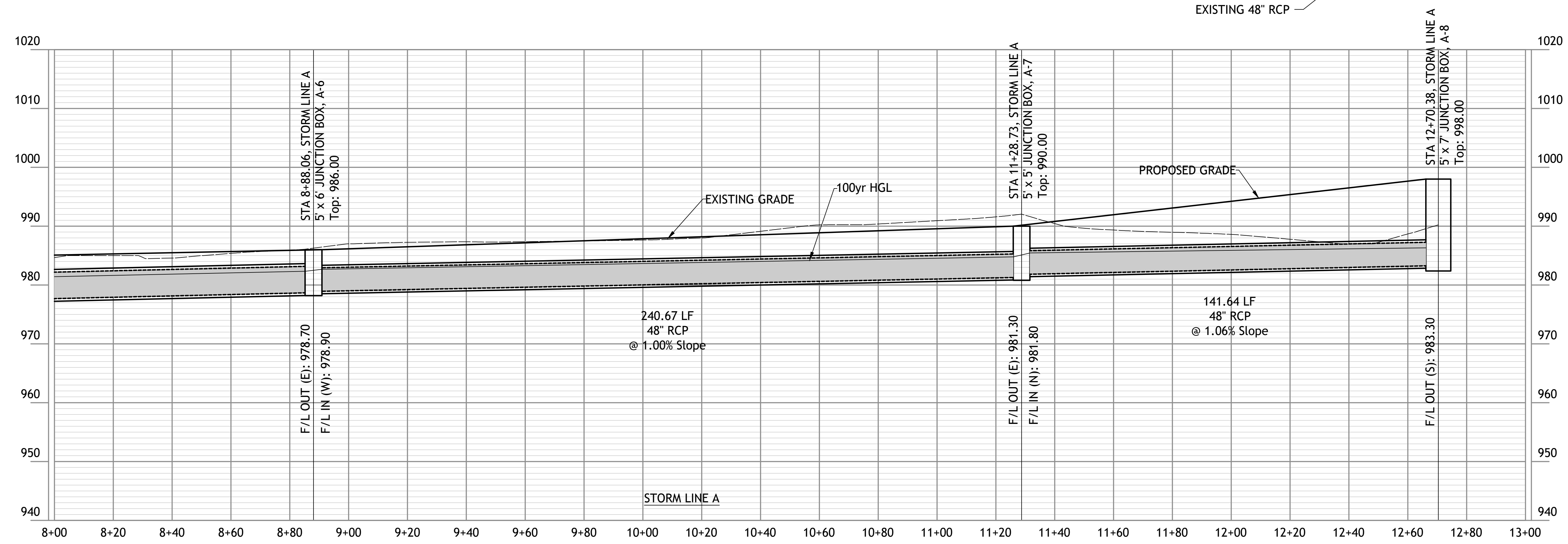
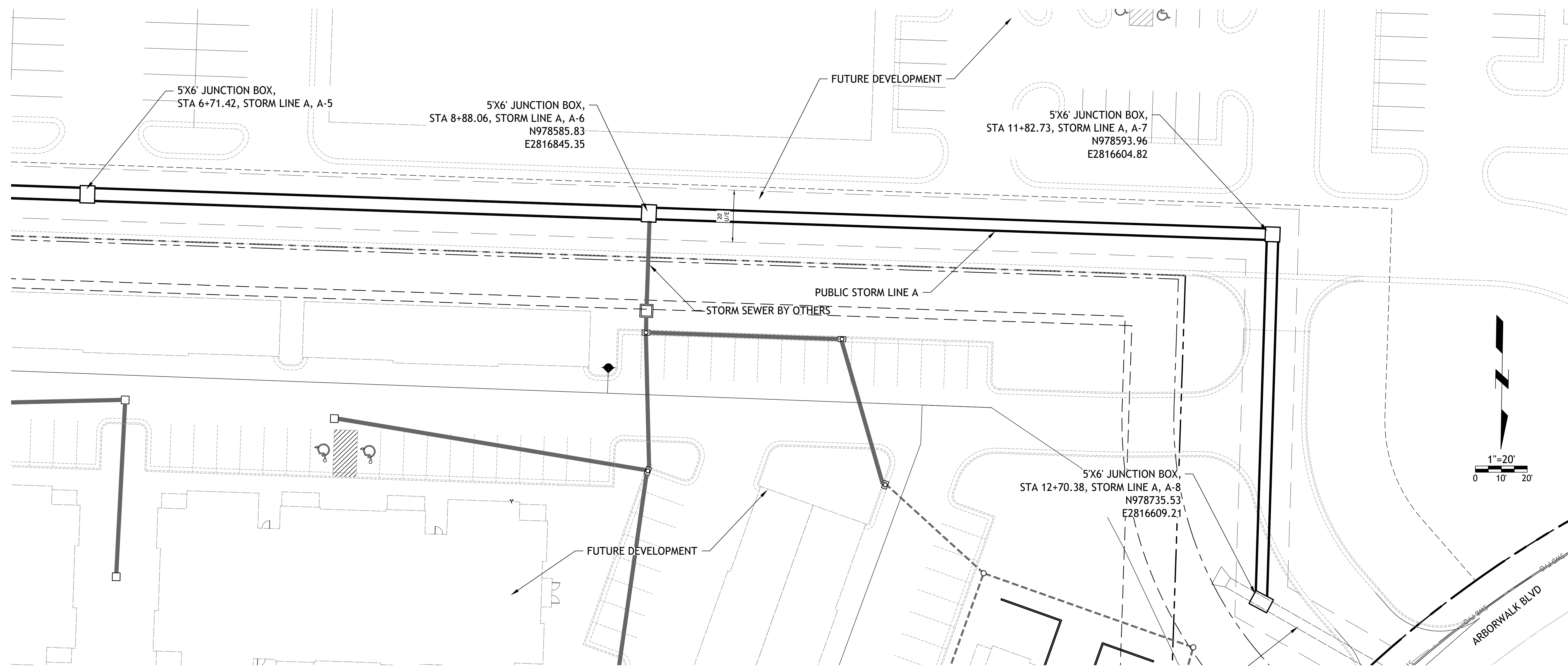


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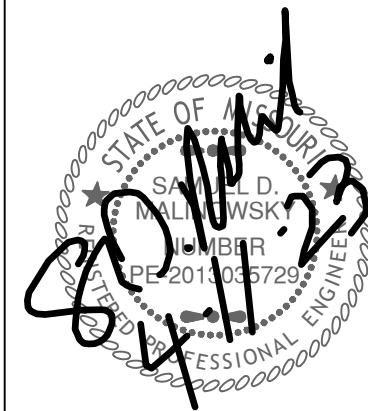
Revisions

**PUBLIC STORM LINE  
ARBORWALK EAST**  
LEES SUMMITT, MO.



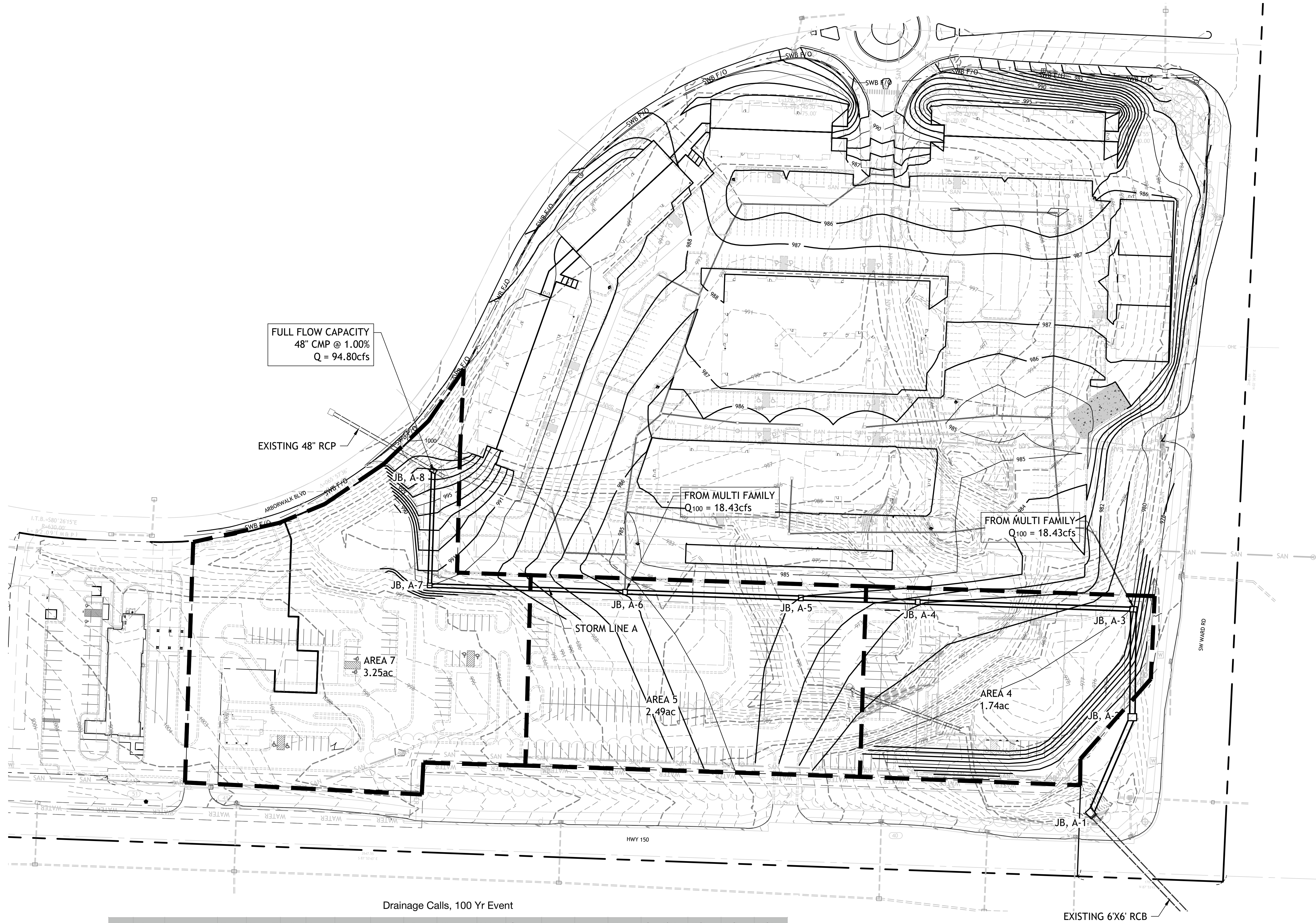


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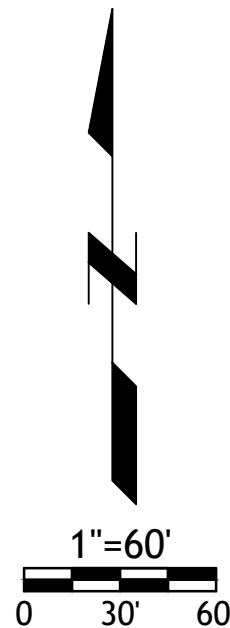
Revisions

PUBLIC STORM LINE  
ARBORWALK EAST  
LEES SUMMITT, MO.



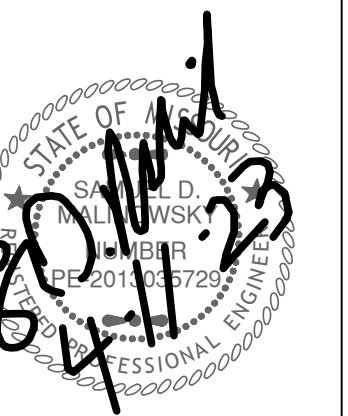
Drainage Calls, 100 Yr Event

Line No.	Line ID	Area ID	Drain Area	Runoff Coeff	Inlet Time	Incr Q	Known Q	Flow Rate	Line Length	Line Size	Vel Ave	Capac. Full	Invert Dn	Invert Up	Line Slope	Grnd/Rim Elev Up	HGL Dn	HGL Up	HGL Junct
			(ac)	(C)	(min)	(cfs)	(cfs)	(cfs)	(ft)	(in)	(ft/s)	(cfs)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft)
1	A2-A1		0.000	0.00	0.0	0.00	0.00	202.89	128.90	43 x 68e	12.72	358.21	963.30	967.70	0.0341	0.00	966.88	971.28	971.28
2	A3-A2		0.000	0.00	0.0	18.43	18.43	203.31	132.95	43 x 68e	12.88	231.89	968.20	970.10	0.0143	980.00	972.28	973.50	973.50
3	A4-A3	A4	1.740	0.81	5.0	18.18	0.00	185.67	265.50	54	13.25	205.48	970.60	973.50	0.0109	982.00	974.12	977.44	977.44
4	A5-A4	A5	2.490	0.81	5.0	26.01	0.00	168.25	144.10	54	13.23	248.46	973.70	976.00	0.016	984.00	976.78	979.72	979.72
5	A6-A5		0.000	0.00	0.0	18.43	18.43	143.06	216.60	54	11.98	210.90	976.20	978.69	0.0115	986.00	979.15	982.12	982.12
6	A7-A6	A7	3.250	0.72	5.0	30.18	0.00	124.98	240.70	48	11.77	143.65	978.90	981.31	0.01	990.00	981.92	984.61	984.61
7	A8-A7	Pond Outlet	0.000	0.00	0.0	94.80	94.80	94.80	141.60	48	10.51	148.91	981.80	983.32	0.0107	998.00	984.34	986.21	986.71

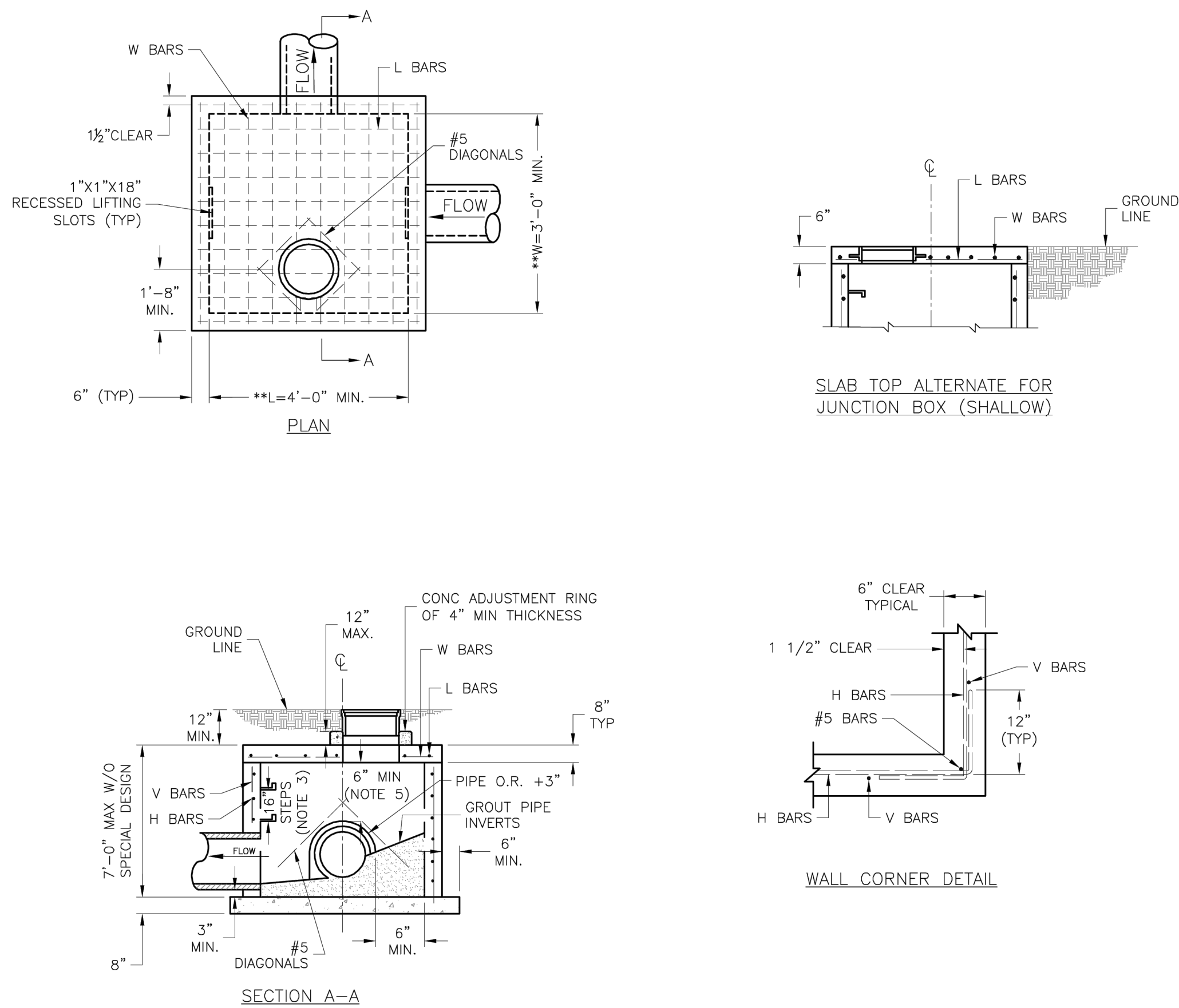
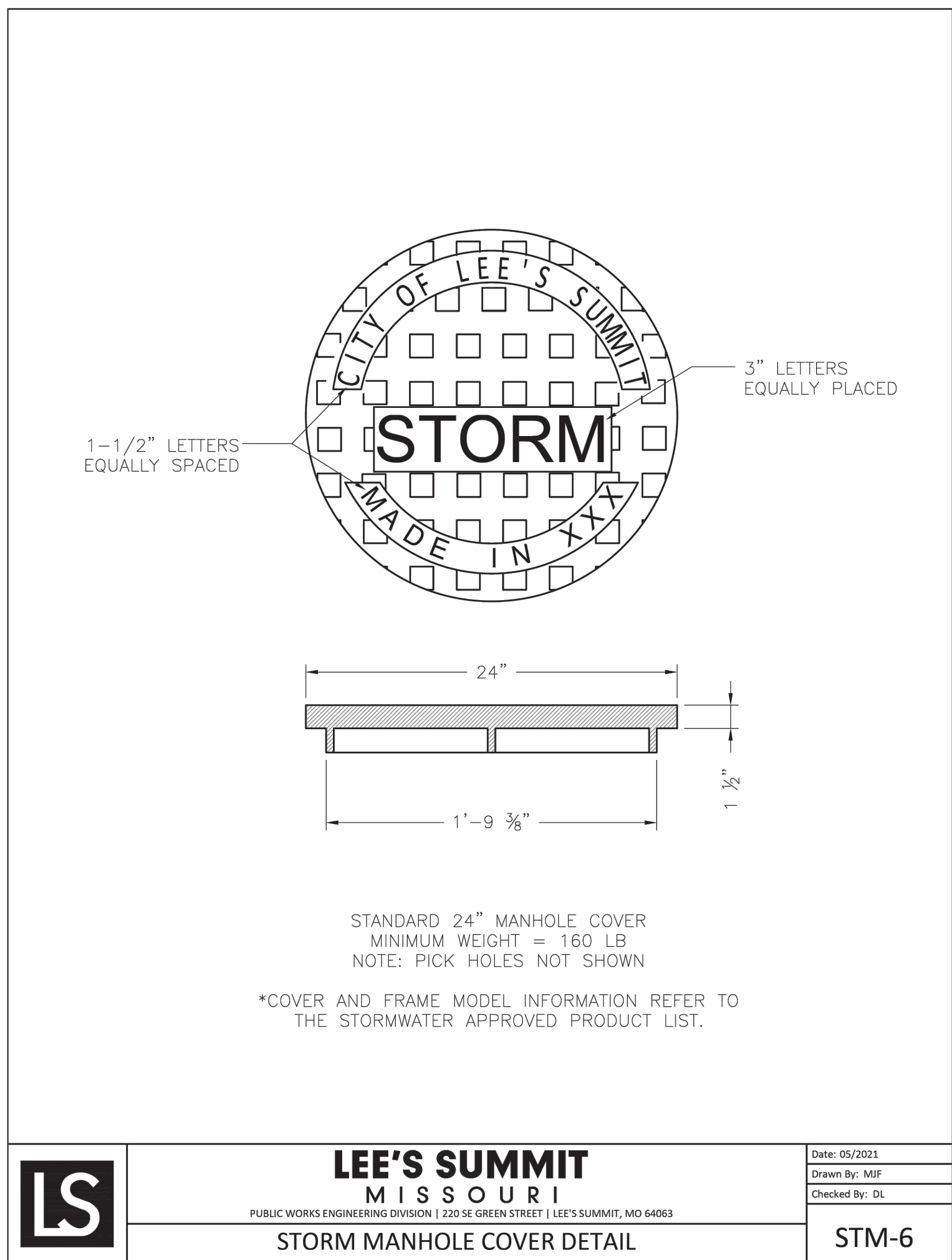




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## Revisions



REINFORCING		
BARS	BAR SIZE	SPACING (IN.)
H	4	12
V	4	12
L	5	6
W	5	6

- GENERAL NOTES:
1. LOCATE RING AND COVER ON BLANK WALL.
2. USE ¾" CHAMFER STRIP OR ¾" R EDGER TOOL ON ALL EXPOSED CONCRETE CORNERS.
3. STEPS REQUIRED AT 16' O.C. WHEN DEPTH FROM TOP OF CASTING TO INVERT EXCEEDS 4' ON BLANK WALL IF POSSIBLE.
4. BOXOUTS WILL NOT BE ALLOWED TO PROJECT THROUGH THE CORNERS OF THE STRUCTURE AND THE MINIMUM DISTANCE BETWEEN BOXOUTS IS 6".
5. THE MINIMUM REINFORCING SHALL BE 1 H-BAR OVER A CAST-IN-PLACE PIPE AND 2 H-BARS OVER A PRECAST BOXOUT.
6. PRECAST LIDS SHALL BE PINNED, SEALED WITH NON-SHRINKABLE GROUT AND REMOVABLE FOR FUTURE MAINTENANCE.
9. REINFORCING OF COVERS IN STREETS REQUIRE SPECIAL DESIGN.
10. FOR RING AND COVER SEE THE STORMWATER APPROVED PRODUCT LIST.

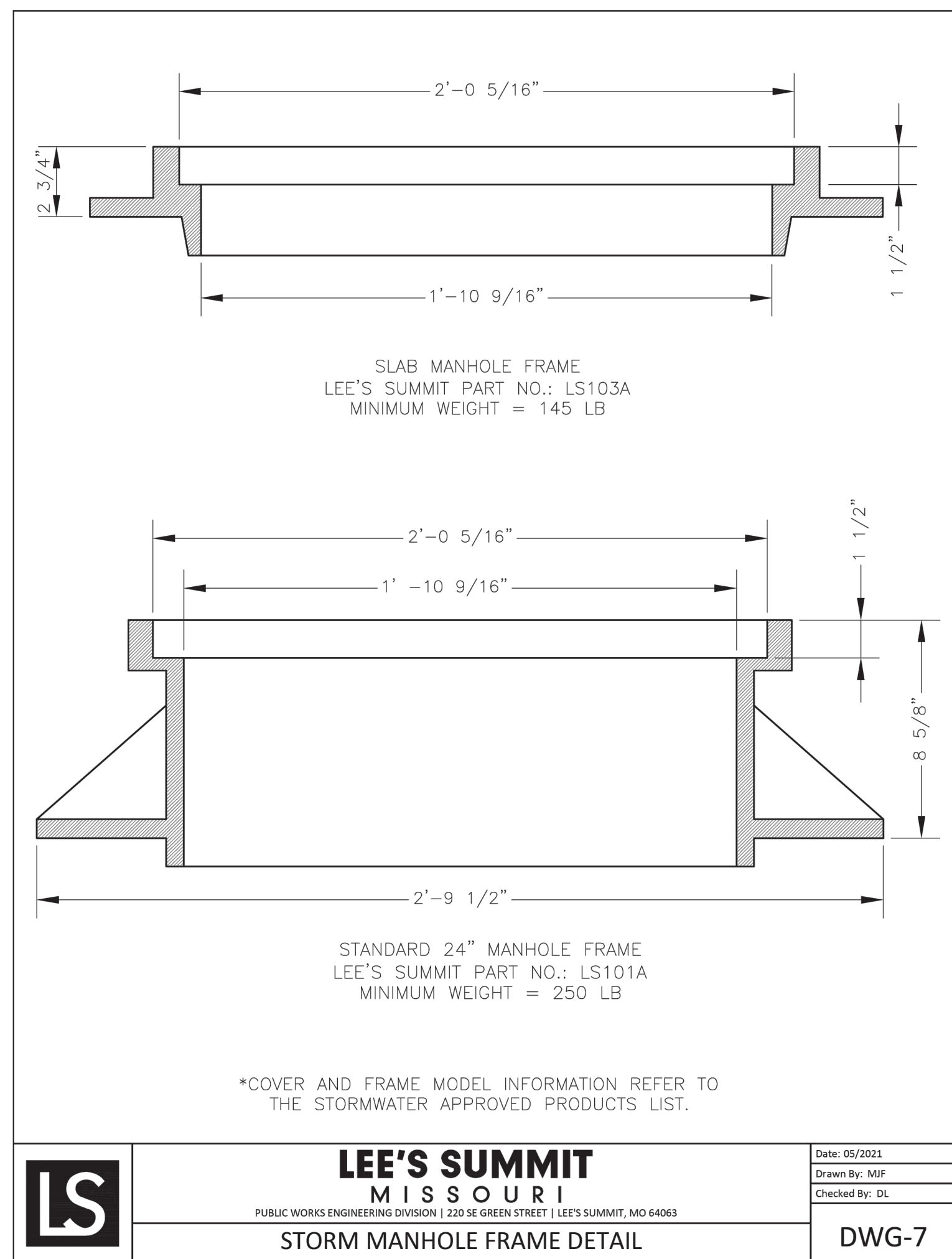
**LS** **LEE'S SUMMIT**  
MISSOURI

PUBLIC WORKS ENGINEERING DIVISION | 220 SE GREEN STREET | LEE'S SUMMIT, MO 64061

Project: STANDARD DETAILS  
CITY OF LEE'S SUMMIT, MO  
LEE'S SUMMIT, JACKSON COUNTY, MO  
Sheet Name: JUNCTION BOX DETAIL

Drawn By: MJF  
Checked By: DL  
Date: 04/17

STM-3



NOTE:  
FOR ALL JUNCTION BOXES EXCEEDING 7'-0" IN DEPTH,  
THE PRECAST BOX MANUFACTURER SHALL PROVIDE AN  
ENGINEERED DESIGN.

BEDDING

1/2"-3/4" CLEAN AGGREGATE, HAND TAMPED OR MECHANICALLY  
COMPACTED IN MAX. 4" LIFTS

INITIAL BACKFILL

-UNDER PAVED AREAS OR WITHIN 4' HORIZONTAL OF PAVED AREAS  
1/2"-3/4" CLEAN AGGREGATE, HAND TAMPED OR MECHANICALLY  
COMPACTED IN MAX. 4" LIFTS

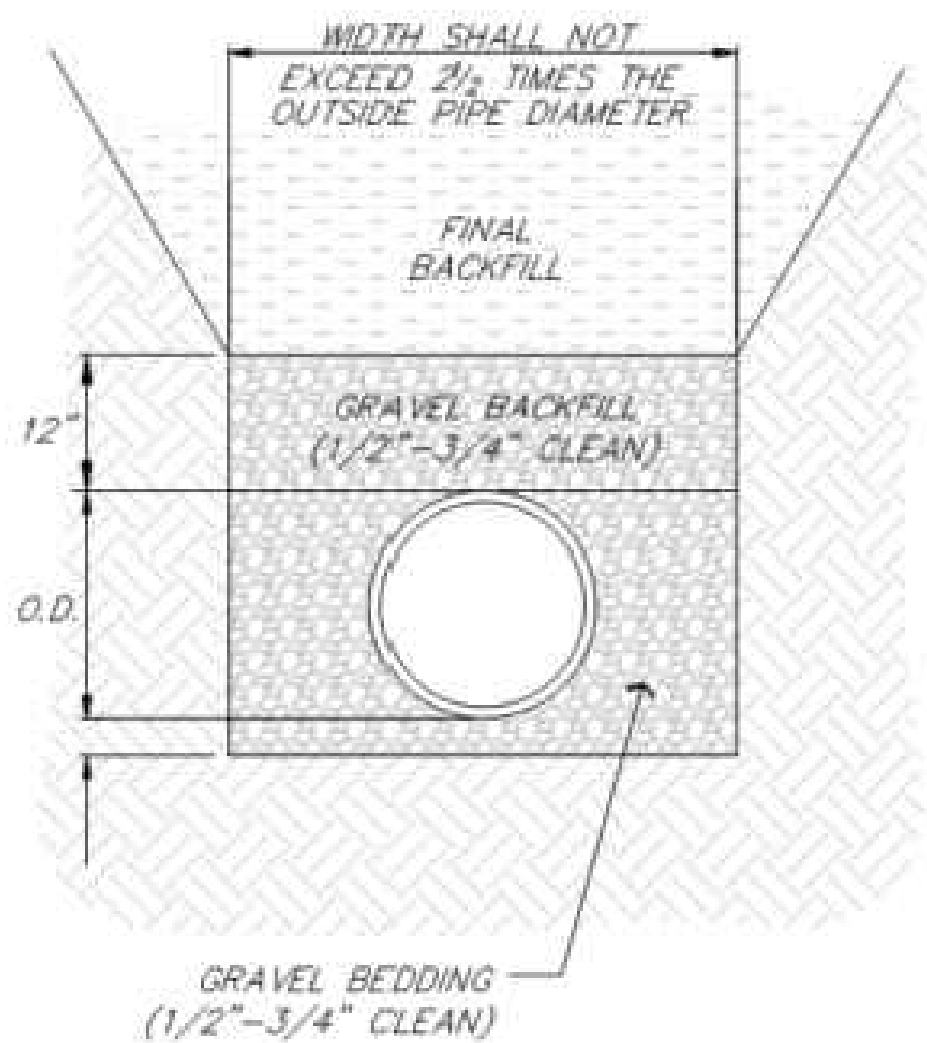
-UNDER OPEN AREAS  
1/2"-3/4" CLEAN AGGREGATE, HAND TAMPED OR MECHANICALLY  
COMPACTED IN MAX. 4" LIFTS

FINAL BACKFILL

-UNDER PAVED AREAS OR WITHIN 4' HORIZONTAL OF PAVED AREAS  
ON-SITE OR IMPORTED MATERIAL FREE OF MUCK, FROZEN  
MATERIAL, EXCESS MOISTURE, ORGANICS, TOPSOIL, RUBBISH,  
CONSTRUCTION DEBRIS, ROCK OR BRICK LARGER THAN 8",  
COMPACTED TO 95% OF STANDARD DENSITY PER ASTM D-698

-UNDER OPEN AREAS  
ON-SITE OR IMPORTED MATERIAL FREE OF MUCK, FROZEN  
MATERIAL, EXCESS MOISTURE, ORGANICS, TOPSOIL, RUBBISH,  
CONSTRUCTION DEBRIS, ROCK OR BRICK LARGER THAN 8",  
COMPACTED TO 90% OF STANDARD DENSITY PER ASTM D-698

BEDDING DEPTH BELOW PIPE		
PIPE DIAMETER	IN SOIL	IN ROCK
24" AND LESS	6"	6"
27" THRU 60"	6"	9"



### PIPE BEDDING DETAIL

NOT TO SCALE

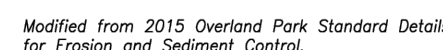
PUBLIC STORM LINE  
ARBORWALK EAST  
LEES SUMMIT, MO.


sheet

C9.0

Civil  
DETAILS  
permit  
11 APRIL 2023





<b>AMERICAN PUBLIC WORKS ASSOCIATION</b> Kansas City Metro Chapter  KANSAS CITY METRO CHAPTER	
AREA INLET AND JUNCTION BOX PROTECTION	STANDARD DRAWING NUMBER ESC-07 ADOPTED: 10/24/2016

## Appendix C



---

# SM Engineering

April 10, 2023

Scott Ready  
City of Lee's Summit, Missouri  
220 SE Green St.  
Lee's Summit, MO 64063

RE: Arborwalk East Street Buffer Waiver

Dear Mr. Ready

Per comments received regarding the Preliminary Development Plan for the Arborwalk East Multi-Family Development a stream buffer waiver is required, because of the proposed rerouting of the existing drainage channel traversing the site. As a result of this and the adjacent commercial development, the potential for sediment to leave the site will be dramatically reduced if not eliminated. As such we respectfully request a waiver to the stream buffer requirement. As shown in Figure 1 below the drainage channel in question is a 350' +/- long drainage channel fed by the outlet to an existing upstream stormwater detention basin along with any surface drainage from the adjacent property. The following information will provide evidence supporting this request.



Figure 1 - Location Map

## Evidence Regarding Stream Classification

There are several factors used when determining whether a drainage channel is natural stream that should be protected. First is whether the stream shows up as a blue line on a USGS topographic map. Figure 2 below is a snippet from the 1954 Raymore Quadrangle Map. As seen, there is no evidence of any stream in this location.

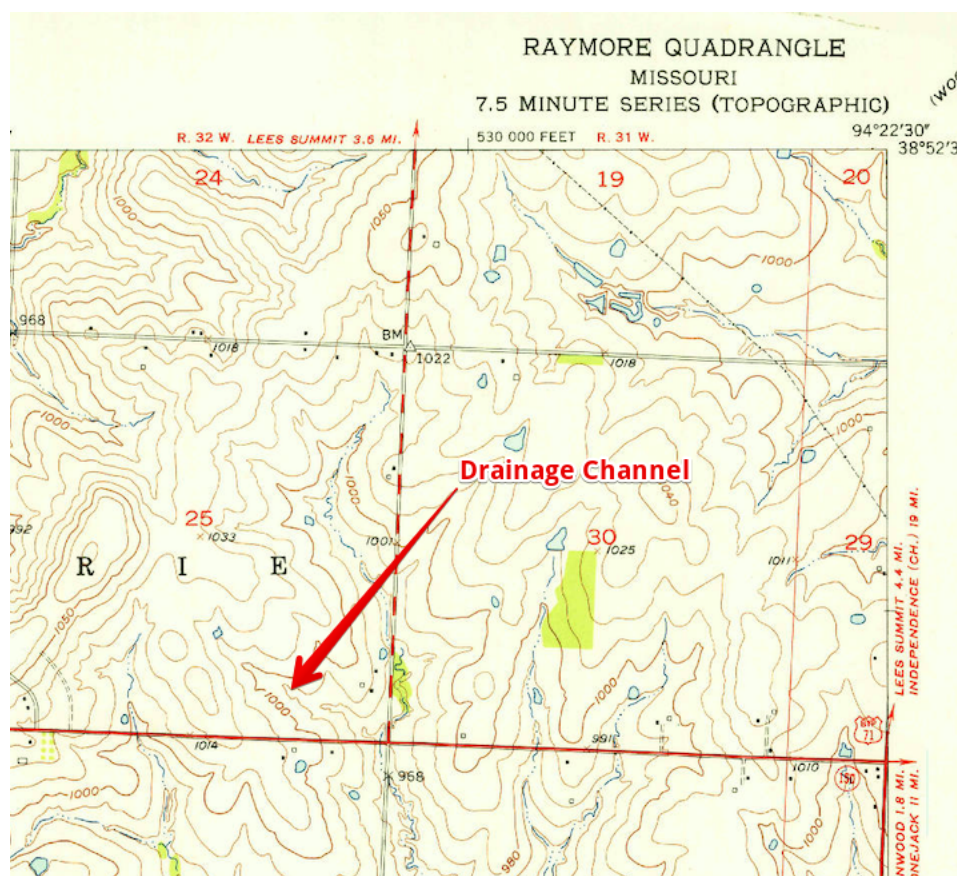
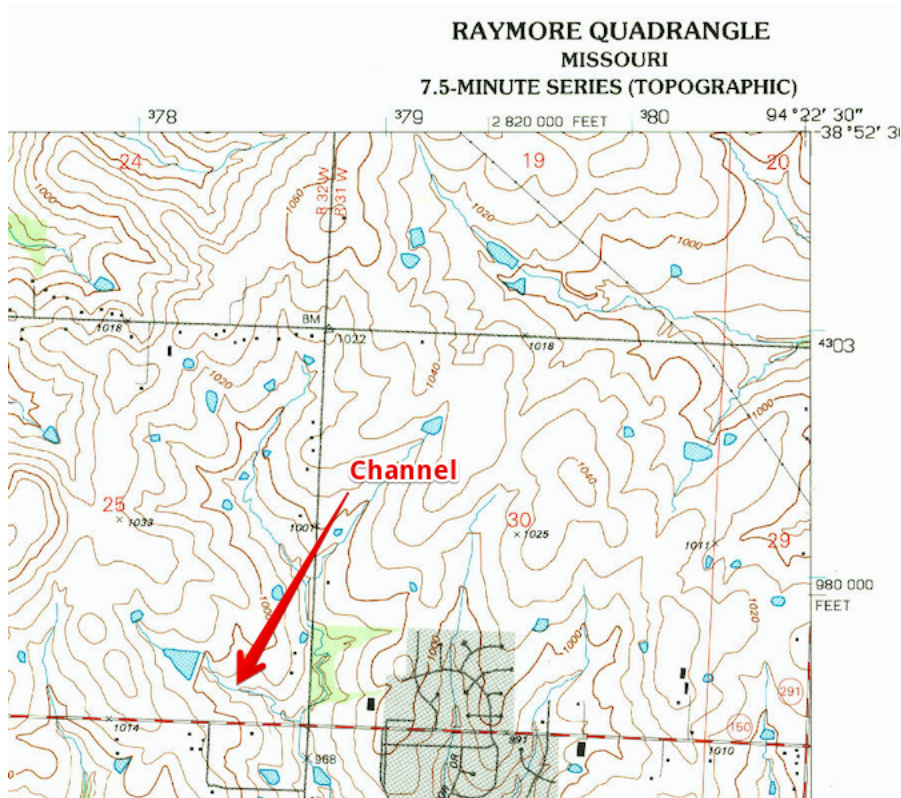


Figure 2 – 1954 USGS Map

The lack of a blue line indicates that this channel did not historically serve a large enough drainage area to warrant classifying it as a stream.

The next available USGS topographic map is from 1990. At this point in time the upstream detention pond has been constructed and Raintree Lake has been created. Figure 3 is a snippet from the 1990 Raymore Quadrangle Map in which we now see the blue line in the location of the drainage channel in question. While this could indicate this may be a natural stream it should be noted this channel is an engineered channel created to provide a path for the outlet of a stormwater detention pond.





## Necessity For A Stream Buffer

Per APWA Section 5605 .2

*Natural streams provide numerous water quality, ecological, and quality of life benefits. Protection and preservation of natural streams is a national environmental objective, as set forth in the Clean Water Act. Streams and their associated wetlands provide critical habitat for plants and wildlife, water quality treatment, and improved infiltration of rainfall which lessens flood impacts, recharges groundwater, and preserves base flow. Streams provide recreational and open space in communities, improve aesthetics, provide natural landscapes, and enhance adjacent property values.*

*Stable streams in nature maintain a shape in plan, profile, and section that most efficiently transports the water and sediment supplied to them. The geometry and processes of natural streams involve unique terminology and concepts not common to engineered channels or pipe systems. Common features of stream geometry and characteristics are presented in Figures 5605–1 through 5606-3. Certain definitions are contained in Section 5601. More complete information regarding the character and function of natural streams is given in Interagency (2001).*

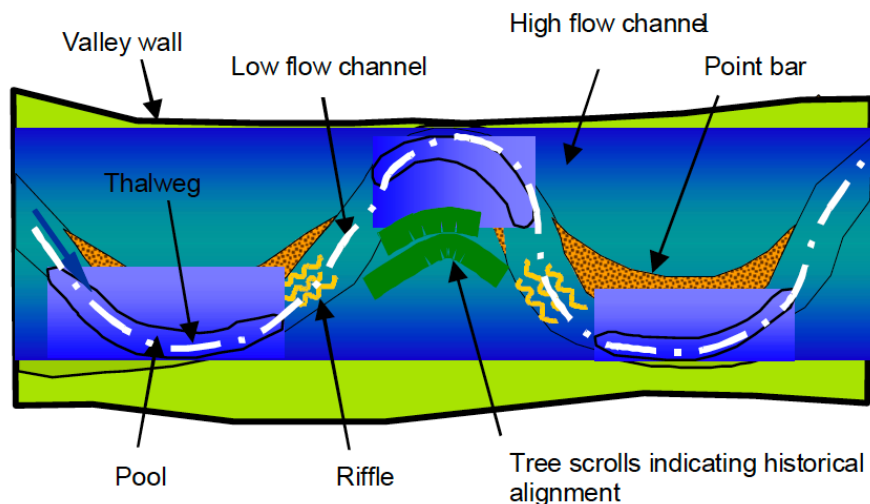


Figure 5605-1: Typical Stream Characteristics

When development is anticipated in the area of a stream, as defined above, then a stream buffer is recommended on either side of the stream. The primary purpose of this buffer is to preserve the character of the stream and to prevent any excess sediment from entering the stream which would degrade the natural characteristics of the stream and to prevent downstream sediment deposits.

Clearly, in this case, the drainage channel does not meet the above criteria and instead is an engineered channel as referenced above. Therefore, a stream buffer would not be applicable.

## Downstream Sediment Concern

The concern has been raised that this site is a source of excess sediment being deposited downstream. As part of preparing the stream buffer waiver an onsite inspection was conducted to determine the validity of this claim.

The first source of potential sediment is from the drainage channel discussed above. There is minimal sediment coming out of the upstream detention pond. This pond is designed to act as a detention pond and as a water quality feature. The outlet structure is such that there is a small pipe at the bottom to allow the smaller rain events to drain at a reduced velocity so as to encourage sediment fall out prior to migrating downstream.

On site surface runoff is from well-established grass lands and forested areas. With no newly disturbed earth, excess sediment leaving the site is minimal. There is also a temporary sediment basin in place toward the eastern end of the site. While the outlet structure has been allowed to deteriorate the basin is still providing for the capture of some sediment.

The runoff leaves the site via an existing 6'x6' reinforced concrete box (RCB) under Highway 150. On the south side of Highway 150 the runoff enters a 340' natural stream channel owned by the City of Lee's Summit. By the nature of this being a natural channel, at a minimal slope, excess sediment is being captured.

This natural channel is then routed underneath Ward Road in a 2 celled RCB. As illustrated in Figure 5 below there is little evidence of excess sediment exiting this box. This can be seen by the relatively clear water in the left cell and the dirt deposit in the right cell with well established vegetation.



### Figure 5 – Ward Rd RCB Outlet

The Ward Rd. RCB outlets directly into an existing storm water detention basin immediately upstream of Raintree Lake. While this pond appears to be designed as a storm water detention facility it is acting as a sediment basin. This pond is constructed such that there are 2 smaller pipes installed above the bottom of the pond. This allows for upstream runoff to captured with the water velocity being slowed to allow for sediment to settle out prior to migrating downstream. The 2 pipes allow for water during low flow events to exit the basin slowly while providing time for excess sediment to settle out. During high flow events water will flow over the concrete weir.

The 2 photos below illustrate the pond appears to be operating as sediment basin. The photo of the pond itself shows that water is present without any evidence of excess silt in the pond. The photo showing the water exiting the pond illustrates the runoff appears to be relatively free of sediment indicating the excess sediment has been trapped in the basin.



### Mitigation Plan

While there is minimal excess sediment being produced from the Arborwalk East development site in its current condition the development plan, when complete, will dramatically reduce the potential for sediment to leave the site. As part of the development the current drainage channel will be enclosed in a concrete pipe designed to handle flows in excess of the 100-year storm event. A site plan showing the proposed storm sewer is attached at the end of this report. By enclosing the channel, the potential for sediment entering the system from the channel banks will be eliminated. To further reduce the potential for sediment the actual building pads within the development will be heavily landscaped. In addition to the landscaping, mechanical water quality systems will be installed at the points where runoff enters the underground system.

## Conclusion

As discussed above the subject stream requiring a buffer is not a natural stream but an engineered drainage channel. Upon completion of the development the potential for excess sediment leaving the site will be greatly reduced thus improving the downstream water quality. For these reasons we believe the stream buffer waiver should be granted

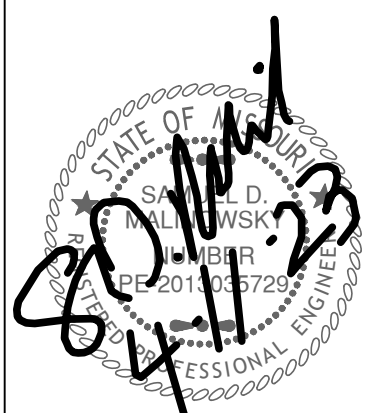


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Samuel D. Malinowsky, P.E.



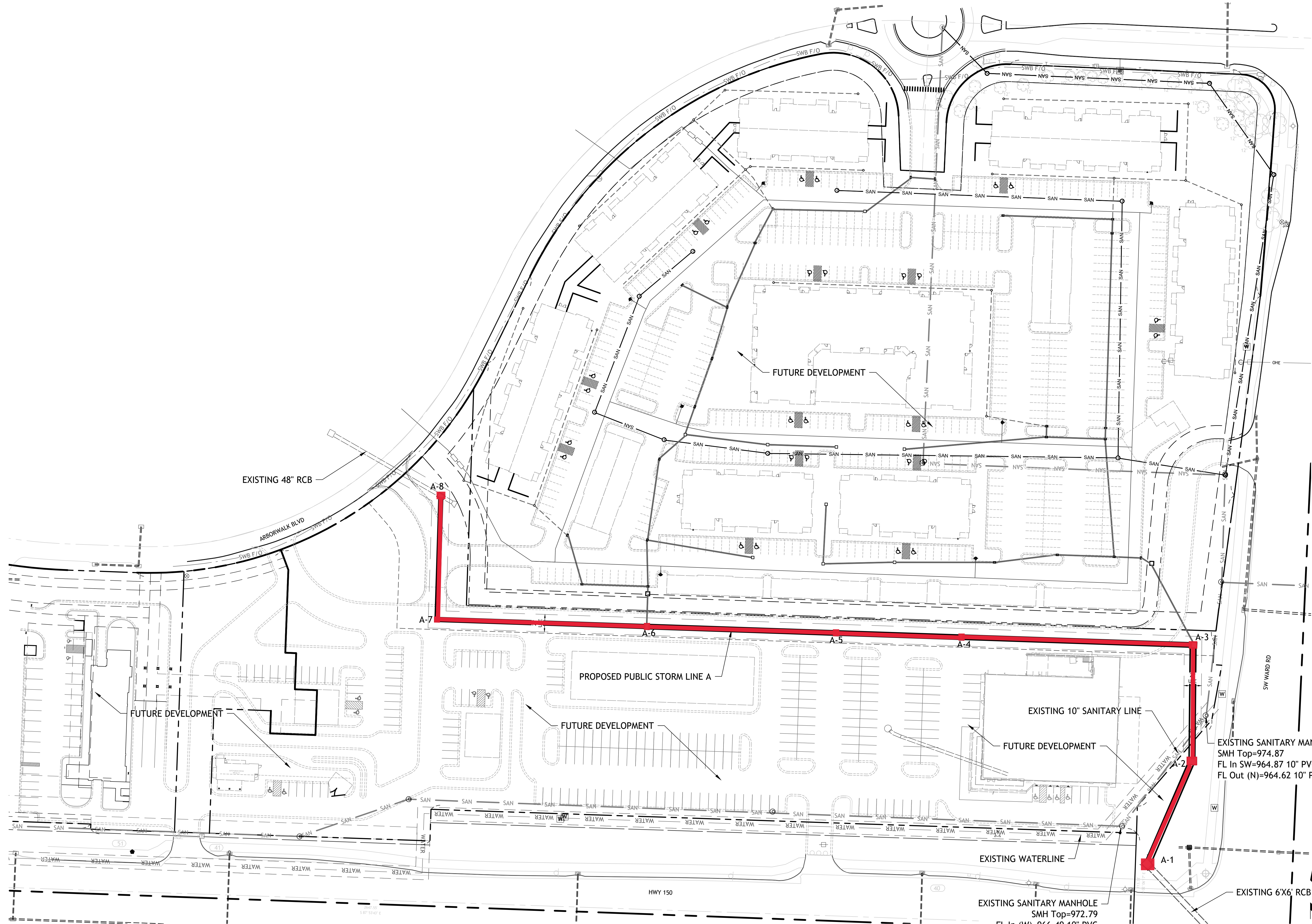




Revisions

PUBLIC STORM LINE  
ARBORWALK EAST  
LEES SUMMITT, MO.

sheet  
**C3.0**  
Civil  
LAYOUT PLAN  
permit  
11 APRIL 2023



**STORM SEWER LAYOUT**

1"=50'  
0 25' 50'



## **Appendix D**

# **Micro Stormwater Drainage Study for McBee's Coffee 'N Carwash Lee's Summit, MO**

Prepared For:

McBee's Coffee 'N Carwash  
103 Industrial Parkway  
Gallatin, MO 64640  
816-832-6864

[gsaltkovska@mcbeecompanies.com](mailto:gsaltkovska@mcbeecompanies.com)

Prepared By:

**DAVIDSON ARCHITECTURE & ENGINEERING, LLC**

Hilary Zerr, P.E.  
4301 Indian Creek Parkway  
Overland Park, Kansas 66207  
913.451.9390 (phone)  
[www.davidsonae.com](http://www.davidsonae.com)



May 11, 2022

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Methodology .....  
Existing Conditions Analysis .....  
Proposed Conditions Analysis .....  
Storm Water Quality.....  
Summary .....  
Supporting Calculations .....  
Maps & Exhibits .....



## GENERAL INFORMATION:

McBee's Coffee N' Carwash is a new development being built on an existing developed lot. Davidson Architecture and Engineering, LLC has prepared a micro storm drainage study for the proposed project.

### A. Project Location & Description

The proposed Project is located at 1295 Southwest Arborwalk Boulevard, north of MO-150, in Lee's Summit, MO. The developer plans to construct a single building for the carwash with a carwash tunnel, dog wash station, vacuums, parking lot, underground detention storage, and associated utilities.



### B. Existing Conditions

The subject property consists of 1.53 acres. Currently, the entire site consists of pervious area generally sloping from the southwest to northeast corner with storm water collecting in a drainage swale along SW Arborwalk Blvd. There is an existing drainage study for the subject area, as part of a larger development that treated this area as a commercial site.

The project site is located in Zone X of the National Flood Insurance Program, Community-Panel Number 29095C0532G, Effective Date: January 20, 2017. Exhibit contained in the appendix of this report.

### C. Proposed Improvements

The development is proposed to be constructed in one phase. A single building, an asphalt & concrete parking lot with concrete curb and gutter, lighting and on-site stormwater detention basin to control runoff for this site. The majority of the development shall be directed to the on-site storm water detention basin. The proposed site will contain approximately 0.95 acres of impervious area and 0.85 acres of pervious area. Storm water will collect by a new storm sewer system, enter dual 48" pipes for storage and will discharge to the same location the runoff is currently going. A new 18" pipe will carry the current roadway ditch runoff to a new 24" pipe, to cross under a new common drive and will discharge to the east of the site where the flow is currently channelized.

## **METHODOLOGY:**

KCAPWA IDF curves were used to determine the rainfall intensity for the 2, 10, and 100-year storm events. Existing and proposed conditions were modeled and analyzed using Hydraflow Hydrographs Extension for AutoCAD Civil 3D 2021 (Hydraflow). Hydrograph routing within Hydraflow used the Rational Method with depths of 3.71", 5.2", and 7.8" for the 50% (2-Yr), 10% (10-Yr), and 1% (100-Yr) storm events, respectively. This method is also used in SCS TR-55. Convolution is known as linear superpositioning, and means that each ordinate of the rainfall hyetograph is multiplied by each ordinate of the unit hydrograph, thus creating a series of hydrographs. These hydrographs are then summed to form the final runoff hydrograph. Rainfall frequencies were determined by using TECHNICAL PAPER NO.40, RAINFALL FREQUENCY ATLAS OF THE UNITED STATES, by the U.S. Department of Commerce, Weather Bureau. The October 2012 American Public Works Association BMP Manual was used for this storm study.

## **EXISTING CONDITION ANALYSIS:**

The existing site, located near 1295 Southwest Arborwalk Boulevard, consists of pervious area that has been graded for a future development. There is a curb cut for a proposed drive on the south side, off MO-150 and a connection in the northwest corner to an existing site. There is a drainage swale along the north property line that carries storm runoff from the west to the east, through an 18" HDPE pipe.

The existing 1.53-acre site is part of a larger development, called Arborwalk that was designed in 2002. The drainage master plan contains this property in the described "Southeast" watershed. The study states that this commercial area will only need limited detention within the boundaries because the upstream detention basins have been designed to control a portion of these sites once developed. It is not clear how much each future site is responsible for detaining.

## **PROPOSED CONDITION ANALYSIS:**

For commercial development of this lot, we've designed a detention basin using dual 48" pipes underground to hold the stormwater runoff from the 1.53 acre site and release it at or less than the allowable release rates.

The detention basin has been designed to effectively capture and discharge the runoff from the developed site, per the requirements set by APWA Section 5601.5.A.4.a. Discharge from the detention basin will be controlled by a proposed outlet structure that will maintain release rates less than allowable rates, while also maintaining water quality requirements specified in APWA Section 5608.4.C.1.b.

Post-development peak discharge rates shall not exceed the requirements set by APWA Section 5608.4.C.1.a that are shown below:

- 50% storm peak rate less than or equal to 0.5 cfs per site acre
  - Site specific allowable release rate: 0.75 cfs
- 10% storm peak rate less than or equal to 2.0 cfs per site acre
  - Site specific allowable release rate: 3.06 cfs
- 1% storm peak rate less than or equal to 3.0 cfs per site acre
  - Site specific allowable release rate: 4.59 cfs

The stormwater on site will be collected by curb and grate inlets and then piped to the underground storage pipes. There will be an outlet structure with a weir plate to control the release rates from this underground detention system.

Once developed, there will be approximately 0.95 acres of impervious area and 0.85 acres of pervious area. A conservative runoff coefficient of 0.90 was used for this commercial development.

Proposed Site Runoff Hydraflow Results				
Storm Event (yr)	Post-developed runoff Routed through detention (cfs)	Post-developed runoff Bypassing detention (cfs)	Total Post-Developed site runoff (cfs)	Allowable release rate for 1.53 acre site
2-Yr	0.15	0.45	0.61	0.75
10-Yr	0.76	0.74	1.39	3.06
100-Yr	1.93	1.00	2.97	4.59

The detention basin is designed to detain runoff to the required discharge rates allowable for the site per the City's current standards. The proposed storm water detention basin result in the following general conditions:

<b>Detention Basin Summary</b>				
Event (yr)	Total Flows to Detention Basin (cfs)	Detention Basin Discharge Qp (cfs)	Top Elevation Max. El. (ft)	Max. Storage (cuft)
2-Yr	6.81	0.15	996.69	2,025
10-Yr	9.25	0.76	997.08	2,647
100-Yr	16.22	1.93	998.27	4,394

## STORM WATER QUALITY

The Mid-America Regional Council, Manual of Best Management Practices for Stormwater Quality, October 2012 requires the site to be designed to capture and treat the additional impervious runoff during the 90% mean annual storm (1.37"/24 hr) created by site improvements. The proposed outlet structure from the detention basin will control discharge from the 90% mean annual event to the minimum forty-hour extended detention requirement for comprehensive control. The outlet structure will have a perforated riser placed at the bottom elevation of the pond to control the discharge from the detention basin to meet this requirement.

## SUMMARY:

Contained in the appendix is the analysis of the proposed runoff hydrographs based on the allowable discharge rates. With the proposed McBee's Coffee N Carwash, the 1.53-acre site will increase the impervious area but the runoff will be controlled and released per the allowable amounts by collecting the storm water in a new storm system and detaining it in the underground pipes, acting as a detention basin.

The drainage maps and storm networks are shown on construction drawings C3.1 and C3.2.

<b>Total Runoff Comparison</b>			
Storm Event (yr)	Post-development rate (cfs)		Allowable release rate (cfs)
2-Yr	0.61	<	0.75
10-Yr	1.39	<	3.06
100-Yr	2.97	<	4.59



## **Appendix A – Supporting Data**

Local Benchmarks:    Δ BM-#

BM#1:  
Set MAG Nail & Washer In Asphalt  
N: 1,073,921.09  
E: 2,820,759.21  
Elev.=1016.22

BM#2:  
Set MAG Nail & Washer In Asphalt  
N: 1,073,954.36  
E: 2,820,861.54  
Elev.=1014.21

Spot Elevation Legend

br = bottom of ramp  
tr = top of ramp  
me = match existing  
pv = pavement  
bw = bottom of wall  
tw = top of wall  
tc = top of curb  
sw = sidewalk  
ti = top of inlet  
mi = mid-point  
hp = high-point  
lp = low-point  
pc = point of curvature  
pt = point of tangency  
bldg = building  
FFE = finished floor elevation  
ex = existing  
mp = match pavement  
gnd = ground  
ts = top of stair  
bs = bottom of stair  
con = concrete

————— standard curb & gutter  
————— standard dry curb & gutter

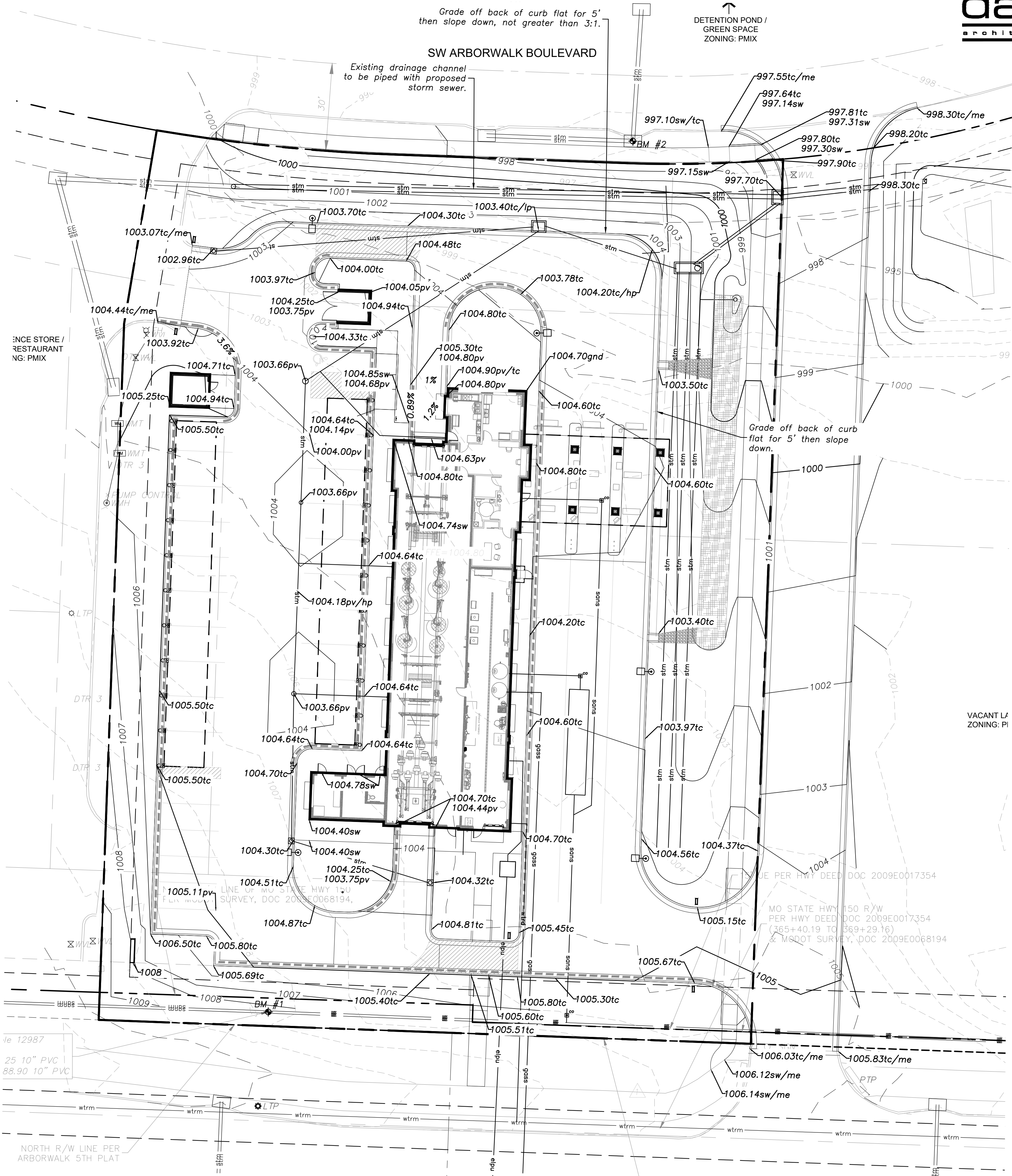
Grading Note:

Connections to existing sidewalks and pavement are based on survey elevations. Contractor shall ensure positive drainage when matching to existing elevations. If elevations in the field do not match the plans or there is a concern about drainage, or ADA compliance CONTACT THE ENGINEER BEFORE INSTALLATION.

Americans with Disabilities Act (ADA) Notes:

The running and cross slopes for all sidewalks, accessible paths, ramps, designated parking stalls, etc., shall be in compliance with latest Federal ADA guidelines, in addition to any accessibility standards adopted by the governing municipality. Prior to installation/construction, if any discrepancies are found within the plans, the Engineer shall be notified.

- Landings (L) shall have slopes less than 2% in all directions.
- Ramps (R) shall have running slopes less than 8.3% and cross slopes less than 2%.
- Sidewalk paths (all sidewalks) shall have running slopes less than 5% and cross slopes less than 2%.



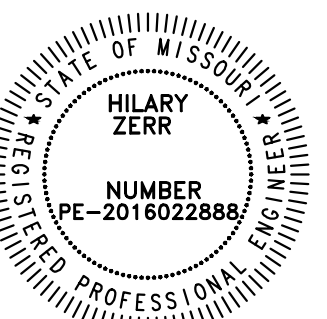
\*\*To be provided for permit drawings.

2 ADA Spot Elevation Plan  
scale: 1"=10'  
0 10 20 40

1 Spot Elevation Plan  
scale: 1"=20'  
0 10 20 40

4301 Indian Creek Parkway  
Overland Park, KS 66207  
phone: 913.451.9390  
fax: 913.451.9391  
www.davidsonae.com

Davidson Architecture  
& Engineering, LLC

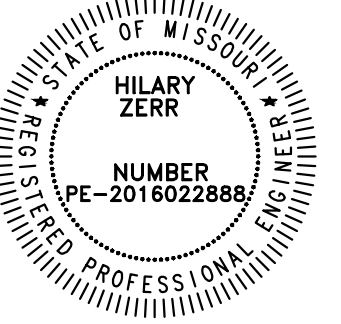


Hilary A. Zerr  
License # 2016022888

a new building for  
**McBee's Coffee 'N Carwash**  
1295 Southwest Arborwalk Boulevard  
Lee's Summit, Missouri 64082

date 09.22.2021  
drawn by DAE  
checked by DAE  
revisions  
11.10.2021 1  
04.29.2022 4

sheet number  
**C2.2**  
drawing type  
planning  
project number  
21072-15



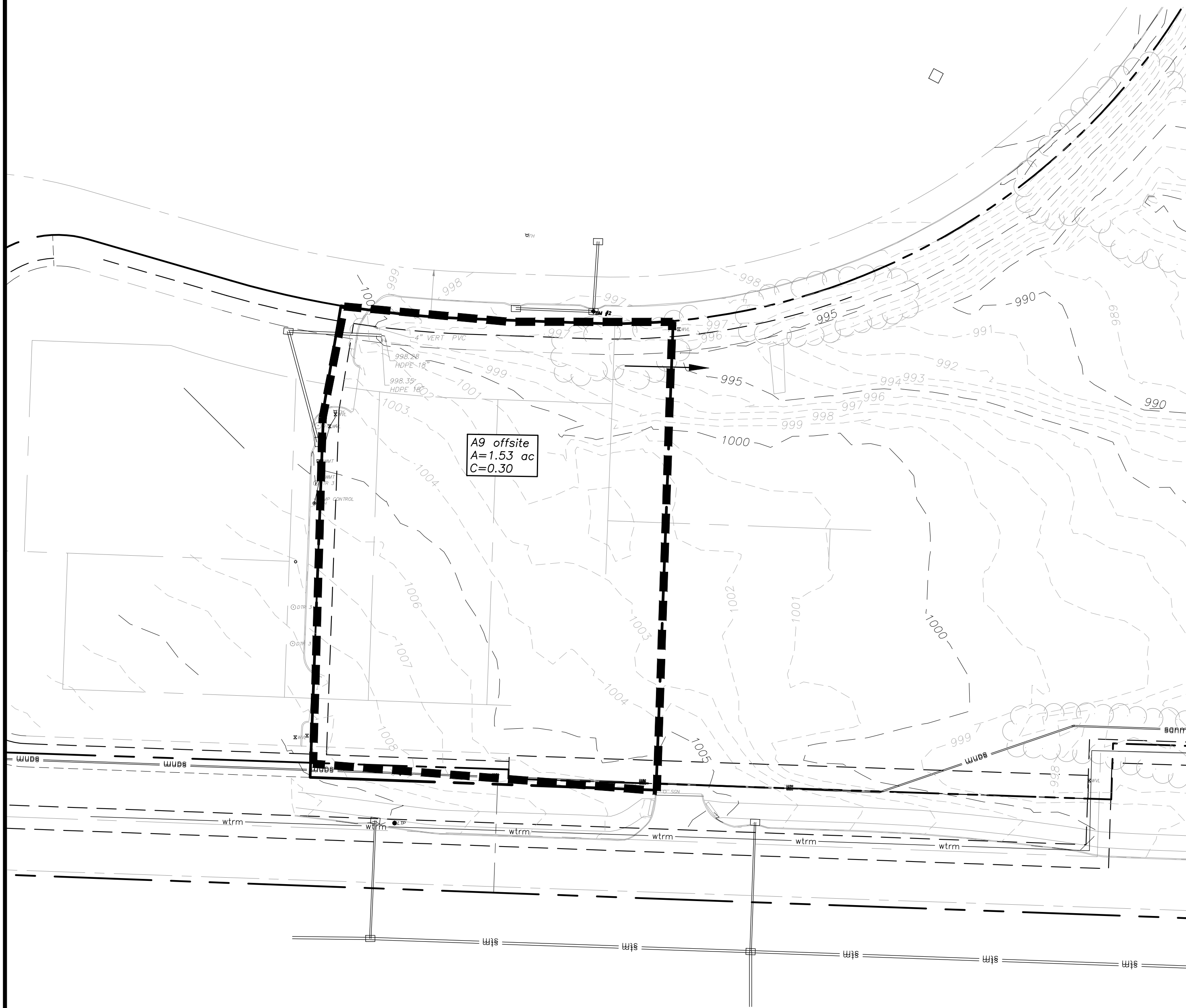
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**McBee's Coffee 'N Carwash**  
1295 Southwest Arborwalk Boulevard  
Lee's Summit, Missouri 64082

date 05.13.2022  
drawn by  
HAZ  
checked by  
DAE  
revisions

sheet number

**C3.1**

drawing type  
planning  
project number  
21072-15

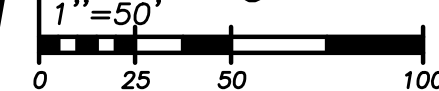


Pre-Construction Impervious Area Calculations

	Square Feet	Acres
Area of Site	66864.30	1.53
Impervious Area	0	0
Pervious Area	66864.30	1.53



1 Existing Drainage Area Map



Drainage Legend

----- drainage area

Property Legend

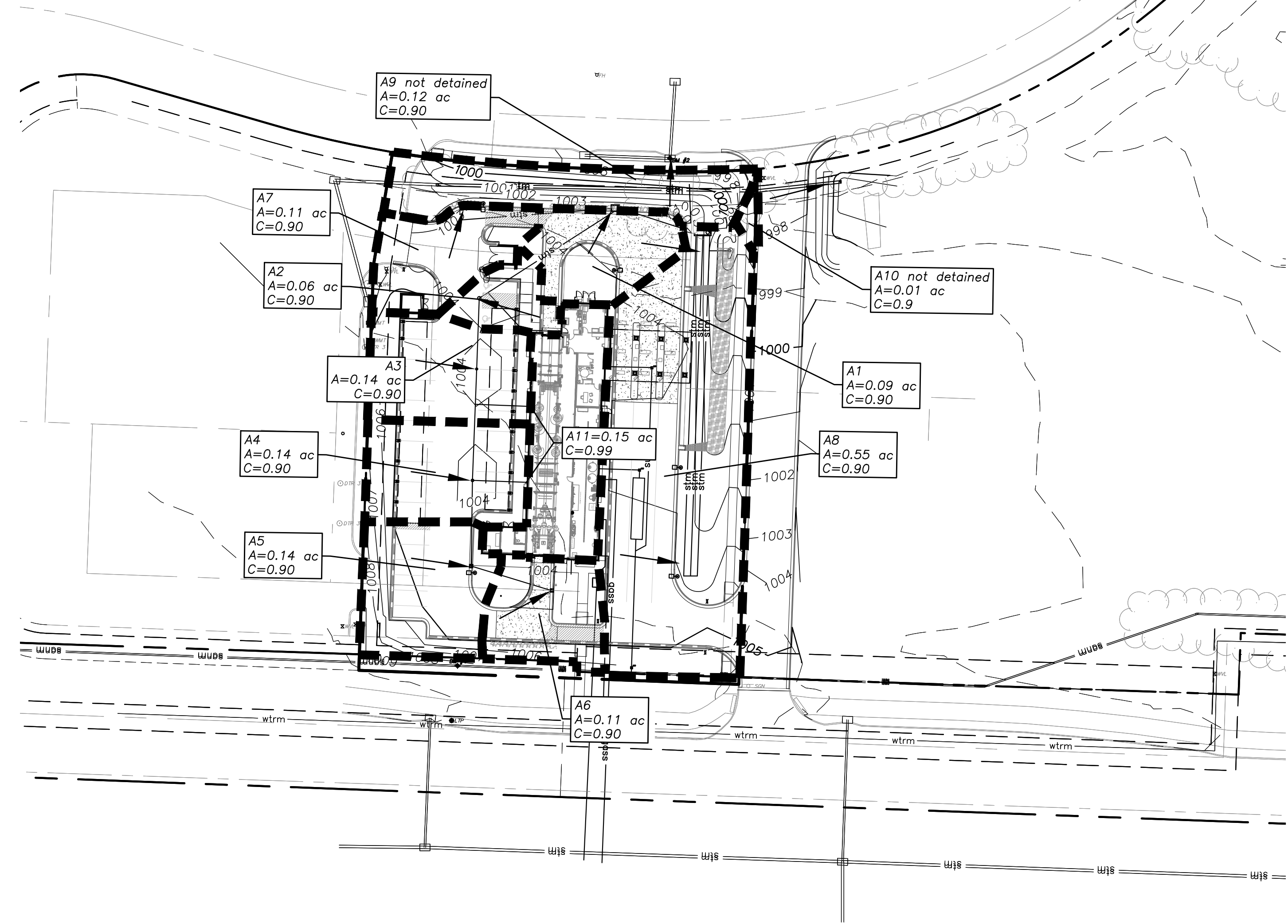
----- right of way  
----- property lines  
----- easements  
----- setbacks

Grading Legend

----- existing minor contour  
----- existing major contour  
----- proposed minor contour  
----- proposed major contour

Floodplain Note:

As referenced in FEMA FIRM Community Panel Number 29095C0532G Effective Date: January 20, 2017 this parcel lies within Zone "X". Areas determined to be outside the 0.2% annual chance Floodplain.



Post-Construction Impervious Area Calculations

	Square Feet	Acres
Area of Site	66864.30	1.53
Impervious Area	41,480	0.95
Pervious Area	25,384	0.85

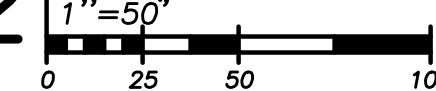
Q: 2 year 0.61 cfs  
10 year 1.39 cfs  
100 year 2.92 cfs

Per APWA 5600, Comprehensive Control Strategy, Release rates are as follows:

2 year = 0.5 cfs/acre x 1.53 acres = 0.75 cfs  
10 year = 2.0 cfs/acre x 1.53 acres = 3.06 cfs  
100 year = 3.0 cfs/acre x 1.53 acres = 4.59 cfs



2 Proposed Drainage Area Map





Local Benchmarks:  BM-#

BM#1:  
Center of Sanitary manhole cover, south of site.  
N: 978356.8105  
E: 2816138.6620  
Elev.=1008.60

BM#2:  
Center of curb inlet, north of site.  
N: 978654.7818  
E: 2816263.4213  
Elev.=997.34

Property Legend

\_\_\_\_\_ right of way  
 - - - - - property lines  
 - - - - - easements  
 \_\_\_\_\_ setbacks

### Grading Legend

existing minor contour

existing major contour




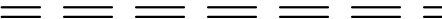



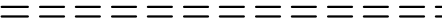












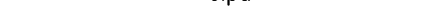










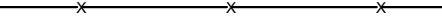















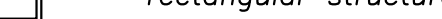




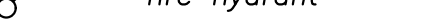




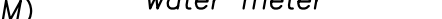

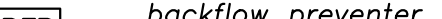















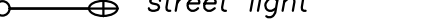



proposed minor contour

proposed major contour




















Utility Legend

	existing	proposed
_____		
_____		

### Linetypes

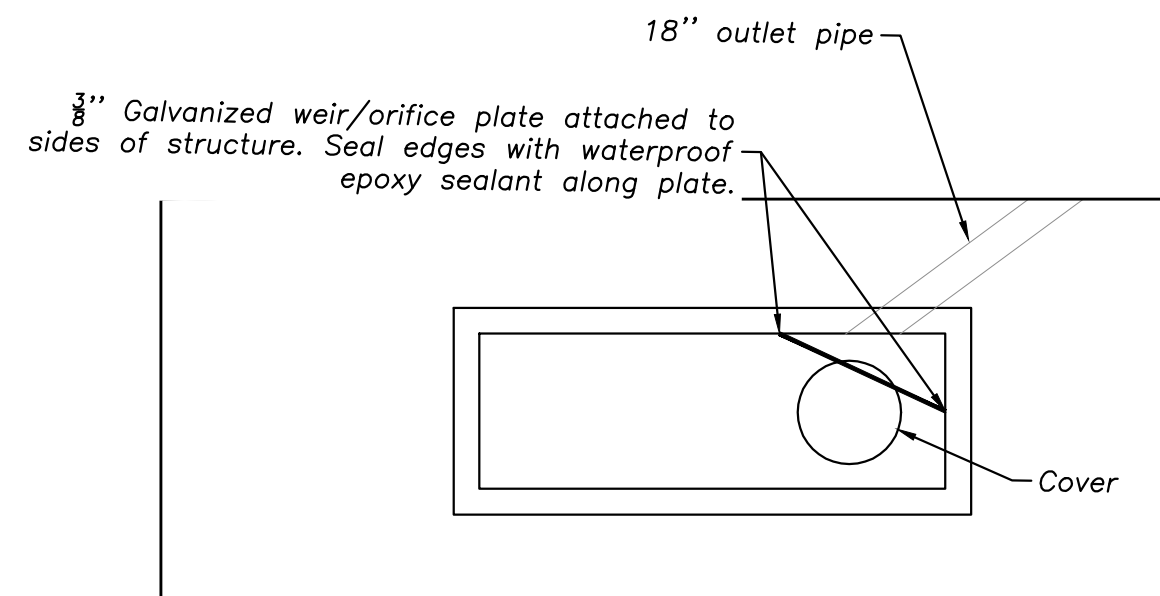
	sanrm	sanitary main
	sans	sanitary service
		storm sewer (existing)
	strm	storm sewer (solid wall, proposed)
		storm sewer (solid wall, proposed)
		storm sewer (perforated, proposed)
	wtrm	water main
	wtrf	water service (fire)
	wtrd	water service (domestic)
	wtri	water service (irrigation)
		
	gasm	natural gas main
	gass	natural gas service schematic
		
	elpu	underground primary electric
	elsu	underground secondary electric
	elpo	overhead electric
		
	datu	underground cable/phone/data
	datas	underground cable/phone/data service
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		

### Symbols

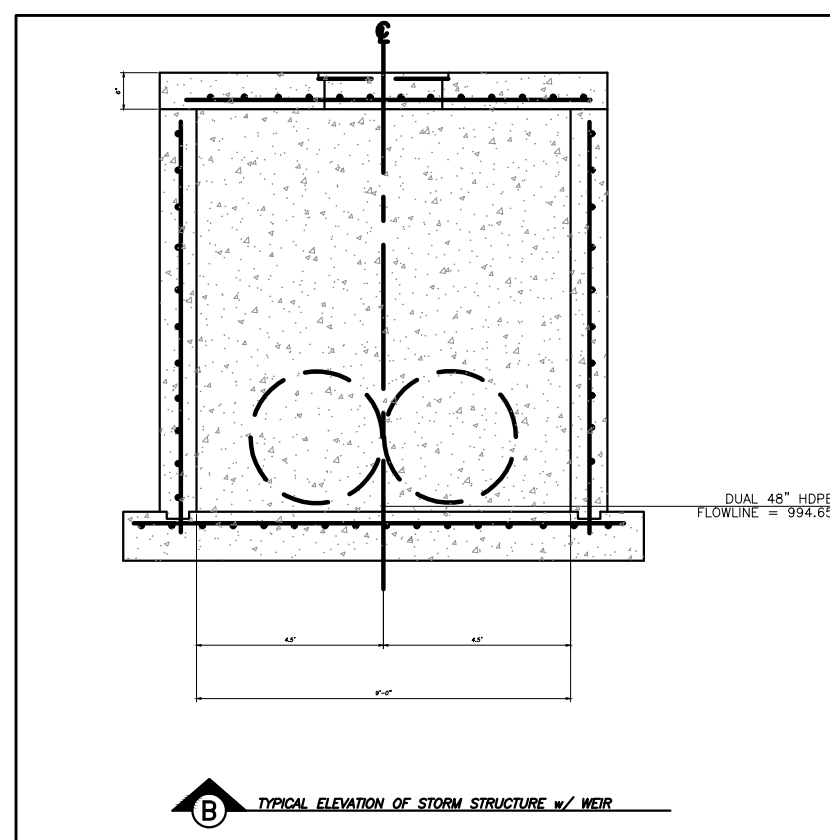
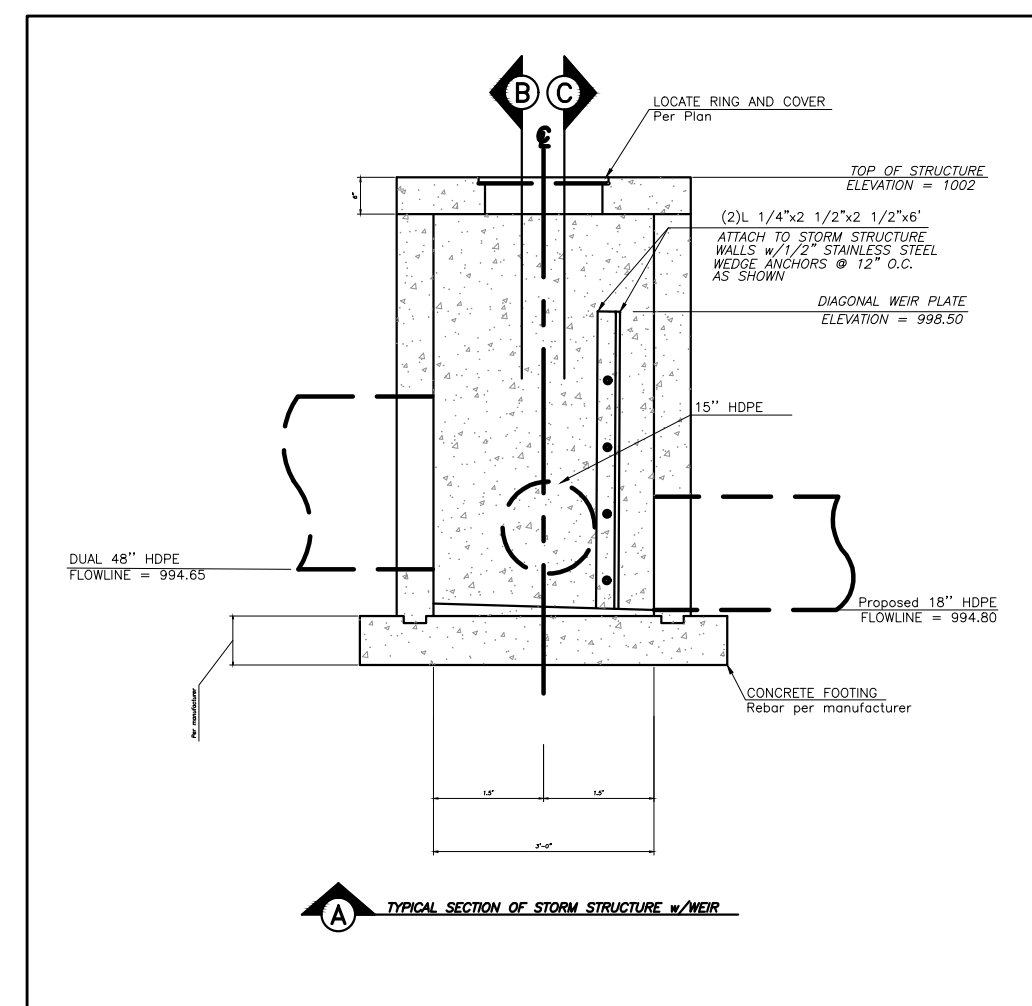
	sanitary manhole
	service cleanout
	force main release valve
	rectangular structure
	circular structure
	fire hydrant
	water valve
	water meter
	backflow preventer
	natural gas meter
	service transformer (pad mount)
	primary switch gear
	light pole
	cable/phone/data junction box
	street light
	pedestrian street light
	electric pole
	guy wire
	end section

100-year Storm

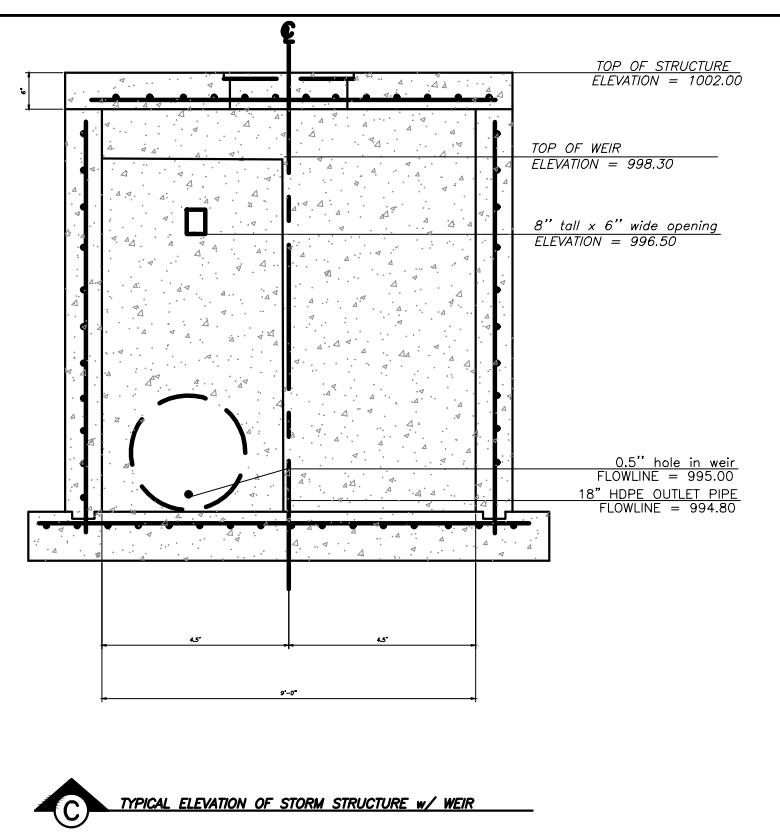
Line No.	Line ID	Drainage Area	Runoff Coeff	Total CxA	Tc (min)	i Sys (in/hr)	Flow Rate (cfs)	Capacity Full (cfs)	Line Size (in)	Line Type	Line Length (ft)	Line Slope (%)	Vel Ave (ft/s)	Vel Dn (ft/s)	n-value Pipe
		(ac)	(C)												
1	Line 1	0.08	0.90	0.77	6.3	11.79	9.13	12.28	15	Cir	53.893	3.08	7.44	7.44	0.012
2	Line 2	0.04	0.90	0.61	6.1	11.99	7.34	7.36	15	Cir	94.941	1.11	5.98	5.98	0.012
3	Line 3	0.13	0.90	0.58	5.9	12.09	6.96	6.96	15	Cir	41.465	0.99	5.67	5.67	0.012
4	Line 4	0.28	0.90	0.46	5.8	12.20	5.60	5.60	12	Cir	65.520	2.11	7.13	7.13	0.012
5	Line 5	0.13	0.90	0.21	5.6	12.39	2.56	2.77	12	Cir	44.588	0.52	3.26	3.26	0.012
6	Line 6	0.10	0.90	0.09	5.0	12.87	1.16	2.74	12	Cir	49.700	0.50	1.48	1.48	0.012
7	Line 7	0.10	0.90	0.09	5.0	12.87	1.16	6.06	12	Cir	108.900	2.47	1.48	1.48	0.012
8	Line 8	0.50	0.80	0.40	15.0	7.81	3.12	4.09	12	Cir	35.562	1.12	4.90	4.90	0.012



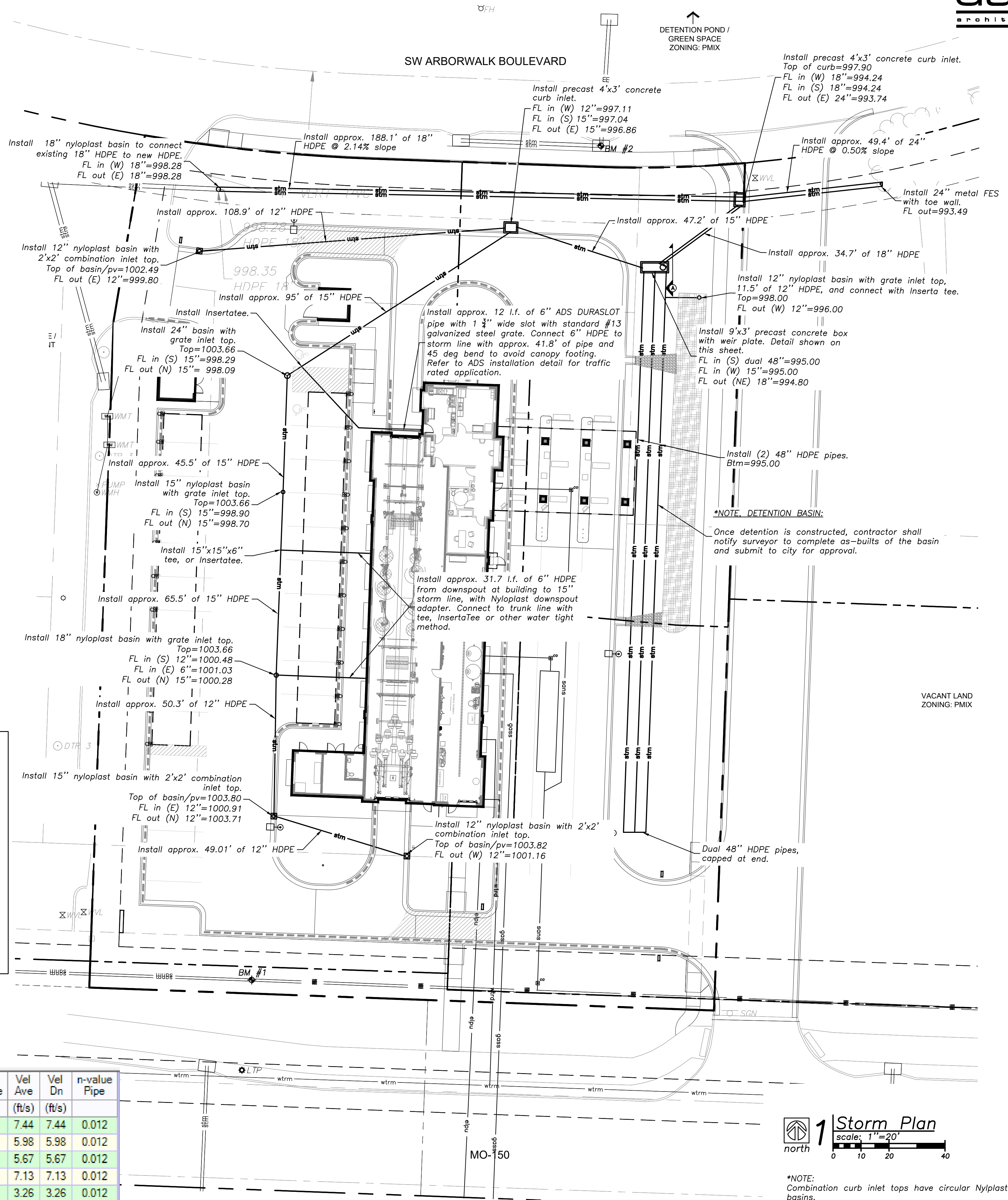
Top of outlet control structure




**B** TYPICAL ELEVATION OF STORM STRUCTURE w/ WIND



 TYPICAL ELEVATION OF STORM STRUCTURE w/ WIND



**1** | Storm Plan  
scale: 1"=20'



**\*NOTE:**  
Combination curb inlet tops have circular Nylplast basins.

Northings & Eastings given for curb inlets are for the center front face of curb.  
For basins with no combination inlet top, coordinates are at center of structure.



NOTES TO USERS

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

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

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study Report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study Report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Missouri State Plane West Zone (FIPS zone 2403). The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRM for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

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

NGS Information Services  
NOAA, NNGS12  
National Geodetic Survey  
SSMC-3, #9202  
1315 East-West Highway  
Silver Spring, Maryland 20910-3282  
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242, or visit its website at <http://www.ngs.noaa.gov>.

**Base map** information shown on this FIRM was derived from the U.S.D.A. Farm Service National Agriculture Imagery Program (NAIP) dated 2014. Produced at scale of 1:24,000.

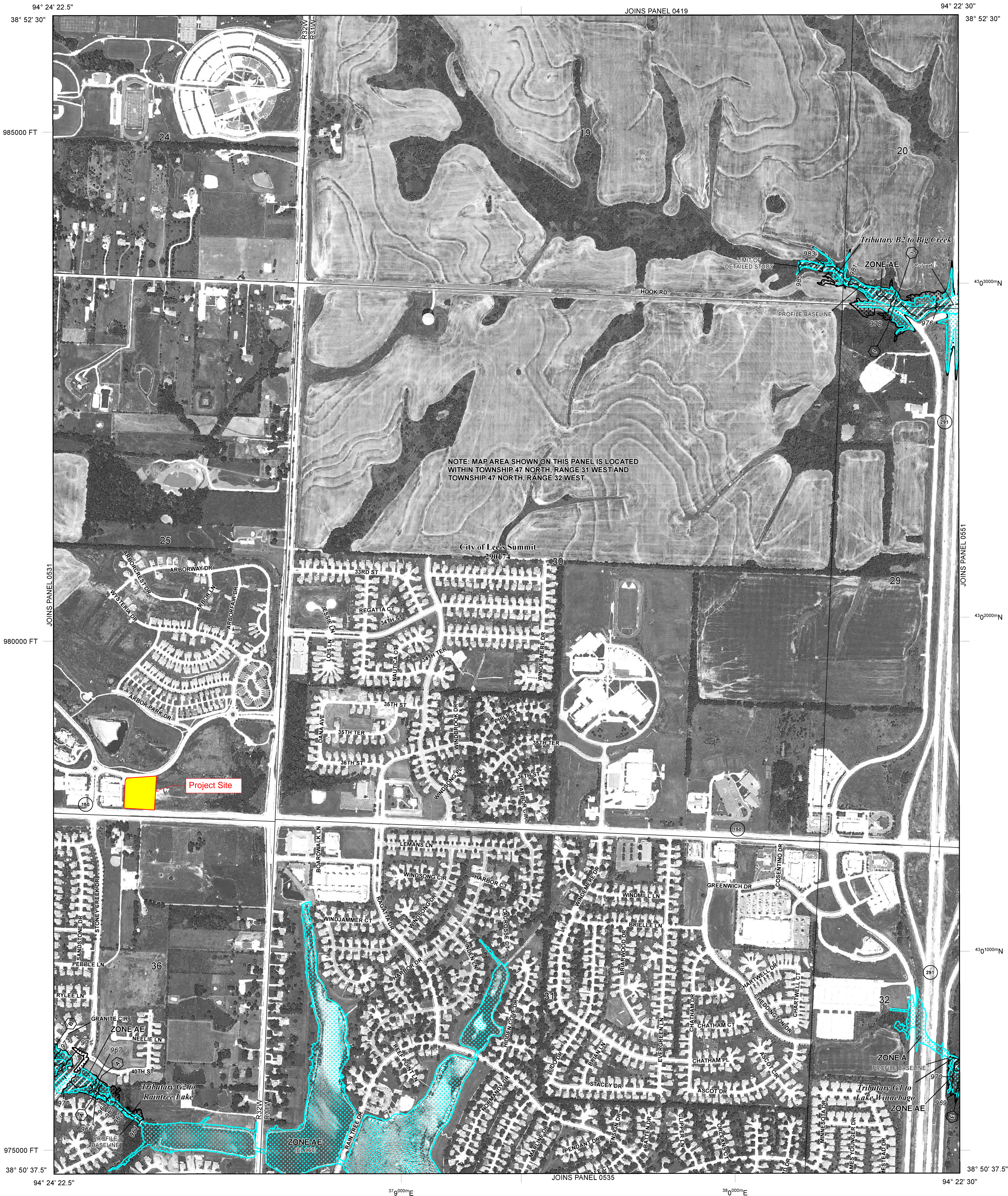
The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

Based on updated topographic information, this map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. As a result, the Flood Profiles and Floodway Data tables for multiple streams in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on the map. Also, the road to floodplain relationships for unrevised streams may differ from what is shown on previous maps.

**Corporate limits** shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

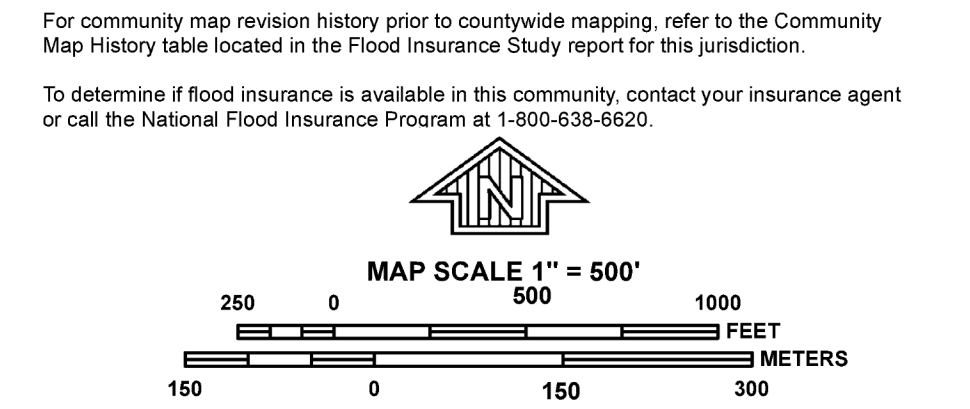
Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels, community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at <http://msc.fema.gov>. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.



LEGEND

- SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD**
- The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.
- ZONE A** No Base Flood Elevations determined.
- ZONE AE** Base Flood Elevations determined.
- ZONE AH** Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
- ZONE AO** Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
- ZONE AR** Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently deauthorized. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
- ZONE A99** Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
- ZONE V** Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
- ZONE VE** Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.
- FLOODWAY AREAS IN ZONE AE**
- The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.
- OTHER FLOOD AREAS**
- ZONE X** Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.
- OTHER AREAS**
- ZONE D** Areas determined to be outside the 0.2% annual chance floodplain.
- ZONE D** Areas in which flood hazards are undetermined, but possible.
- COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS**
- OTHERWISE PROTECTED AREAS (OPAs)**
- CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.
- 1% Annual Chance Floodplain Boundary
- 0.2% Annual Chance Floodplain Boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.
- Base Flood Elevation line and value; elevation in feet\*
- Base Flood Elevation value where uniform within zone; elevation in feet\*
- \*Referenced to the North American Vertical Datum of 1988
- MAP REPOSITORIES**
- Refer to Map Repositories list on Map Index
- EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP**
- September 29, 2006
- EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL**
- January 20, 2017 - to change Special Flood Hazard Areas



**NATIONAL FLOOD INSURANCE PROGRAM**

**PANEL 0532G**

**FIRM**

**FLOOD INSURANCE RATE MAP**

**JACKSON COUNTY, MISSOURI AND INCORPORATED AREAS**

**PANEL 532 OF 625**  
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

**CONTAINS:**

COMMUNITY	NUMBER	PANEL	SUFFIX
LEE'S SUMMIT, CITY OF	290174	0532	G

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

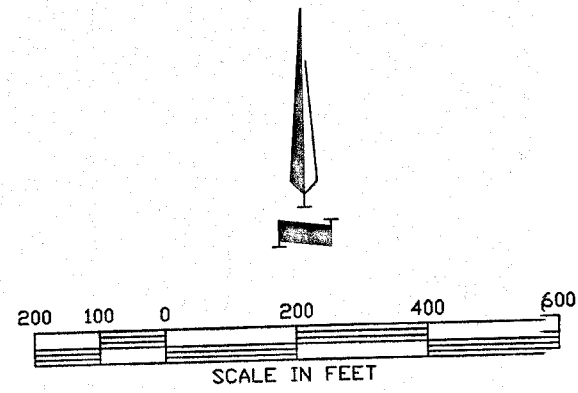
**MAP NUMBER 29095C0532G**

**MAP REVISED JANUARY 20, 2017**

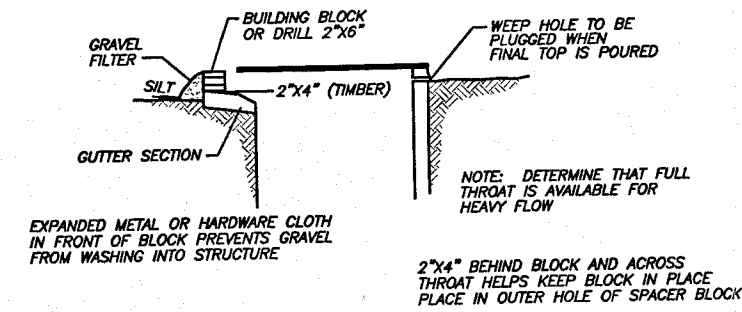
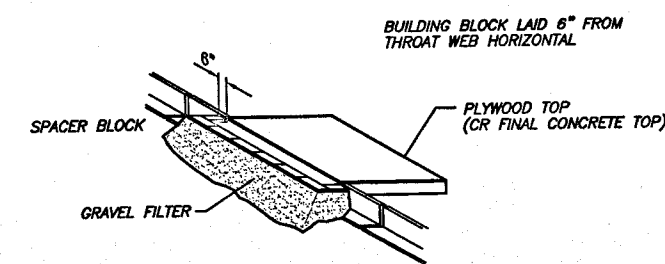
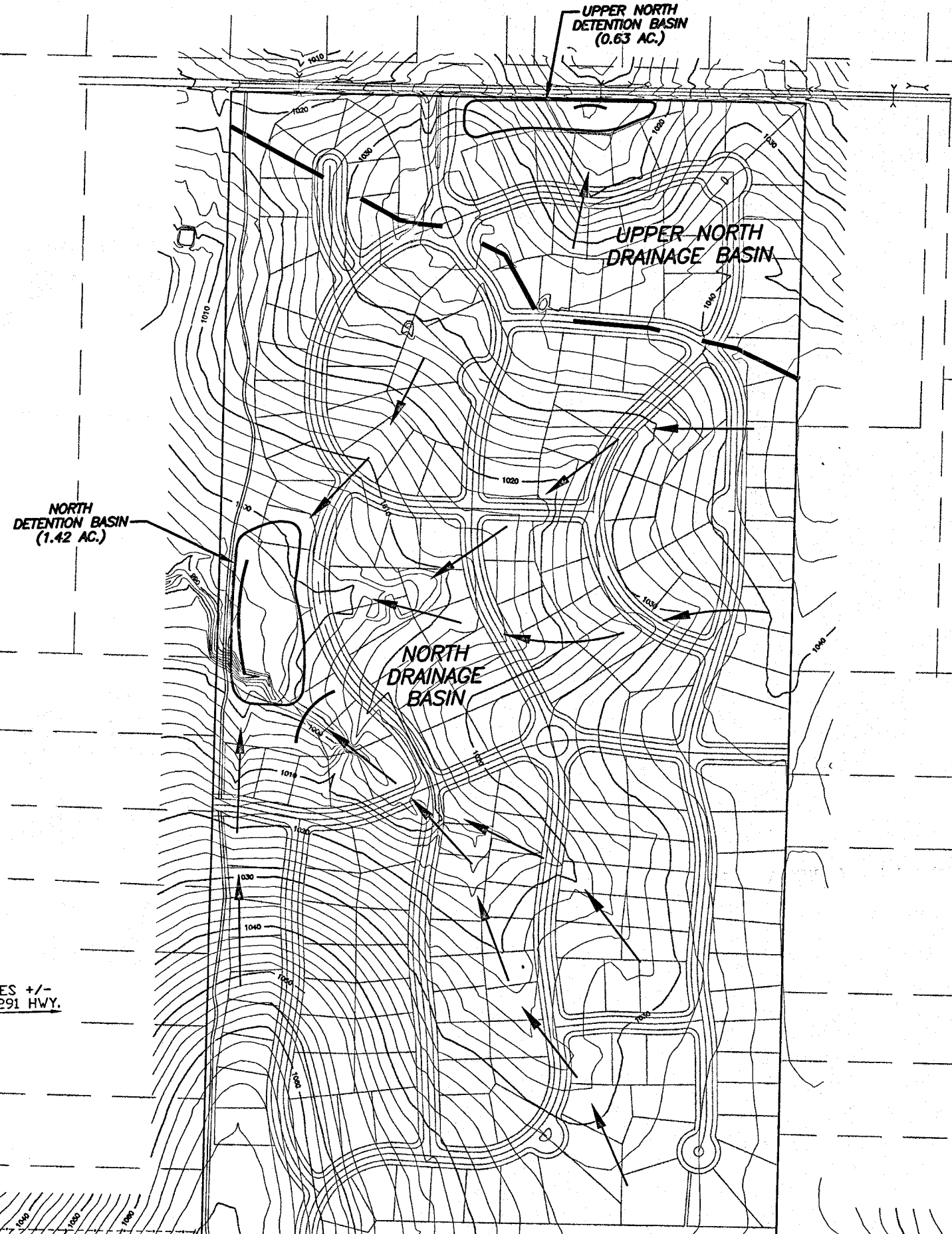
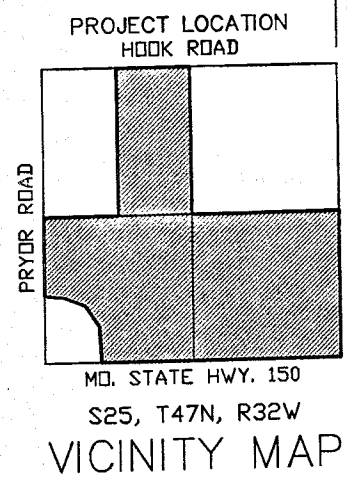
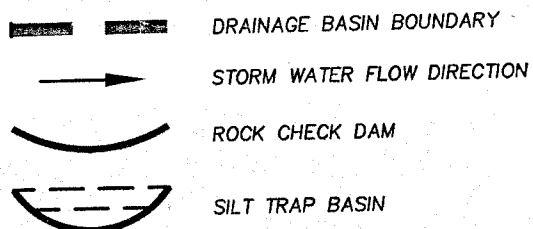
**Federal Emergency Management Agency**



DRAINAGE MASTER PLAN  
ARBORWALK  
IN THE CITY OF LEE'S SUMMIT, MISSOURI

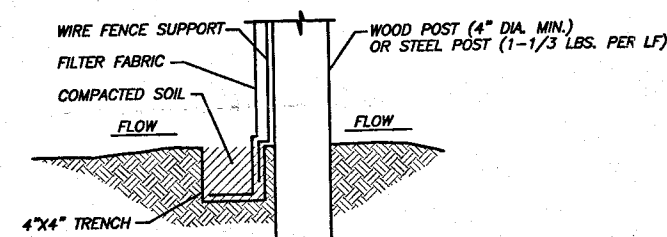


LEGEND

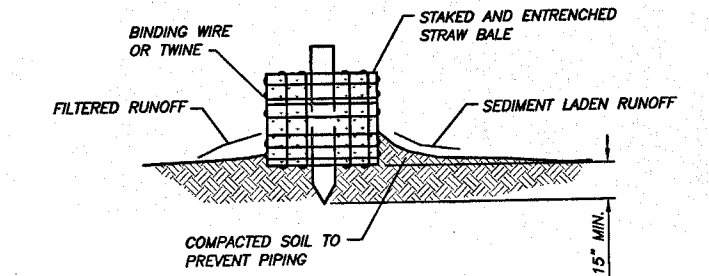


BLOCK AND GRAVEL CURB INLET PROTECTION  
(FROM RICHMOND, VIRGINIA-EROSION AND SEDIMENT CONTROL HANDBOOK, NOVEMBER 1975)

SD-45 INLET PROTECTION  
N.T.S.



SECTION



SECTION

- NOTES:
1. EXCAVATE A TRENCH ALONG THE AREAS THAT THE STRAW BALES WILL BE USED AS EROSION CONTROL TO DEPTH OF 4\"/>
  2. STRAW BALES SHOULD BE ANCHORED WITH A MINIMUM OF 5 STAKES OR REBARS DRIVEN INTO THE UNDERLYING SOIL, MAKING SURE THAT THE BINDING WIRE OR TWINE IS TIGHTENING THE SIDES AND NOT TOUCHING THE SOIL. THE FIRST STAKE INTO EACH BALE SHOULD BE DRIVEN TOWARD THE PREVIOUSLY LAYED BALE TO FORCE THEM TOGETHER.
  3. SPACING BETWEEN THE BALES SHOULD BE TIGHTLY CHINKED WITH LOOSE STRAW.
  4. AFTER STRAW BALES ARE IN PLACE, THE EXCAVATED SOIL SHOULD BE BACKFILLED AGAINST THE UPSLOPE SIDE OF THE STRAW BALES TO A HEIGHT OF 4\"/>
  5. STRAW BALES SHOULD BE INSPECTED AFTER EACH RAINFALL TO DETERMINE IF ANY REPAIRS OR REPLACEMENTS TO THE STRAW BALES ARE NEEDED. IF IT IS DETERMINED THAT THE STRAW BALES NEED TO BE REPAIRED OR REPLACED, THIS SHOULD BE DONE IMMEDIATELY. SEDIMENT ACCUMULATIONS MUST BE REMOVED WHEN THEY REACH A HEIGHT 1/2 THE BARRIER HEIGHT.

SD-48 STRAW BALE INSTALLATION  
N.T.S.

- NOTES:
1. THE MAXIMUM SLOPE LENGTH ABOVE THE FENCE SHOULD BE LESS THAN 100 FEET.
  2. NO DITCH OR DRAINAGE WAY WITH AN AREA GREATER THAN 5 ACRES SHALL BE ENCLOSED ABOVE A SILT FENCE.
  3. NO SILT FENCE SHALL BE CONSTRUCTED IN A LIVE STREAM OR DRAINAGE WAY WITH EXPECTED FLOWS GREATER THAN 1 CFS.
  4. THE FILTER FABRIC SHALL HAVE A MINIMUM FILTERING EFFICIENCY OF 75%, A MINIMUM TENSILE STRENGTH OF 30 LBS. PER LINEAR INCH AND A FLOW RATE OF 0.5 GALLONS PER SQUARE FOOT PER MINUTE. THE FILTER FABRIC SHALL ALSO HAVE ULTRAVIOLET RAY INHIBITORS TO ASSURE A LIFE USE EXPECTANCY OF 6 MONTHS AT 0 TO 100 DEGREES FAHRENHEIT.
  5. THE FILTER FABRIC SHALL BE 36 INCHES OR LESS IN HEIGHT, WITH JOINTS AT EVERY POST. AVOIDING OVERLAP IF POSSIBLE. IF MIN. OVERLAP IF NECESSARY, AND POSTS SPACED EVERY 10 FEET WITH WIRE MESH SUPPORT OR 6 FEET WITHOUT SUPPORT, MAKING SURE THAT A MIN. OF 8\"/>
  6. THE SILT FENCE SHALL BE INSPECTED AFTER EVERY RAINFALL TO DETERMINE IF ANY PART OF THE FENCE NEEDS TO BE REPAIRED OR REPLACED. IF IT IS DETERMINED THAT THE FENCE NEEDS ANY REPAIR OR REPLACEMENT THIS SHALL BE DONE IMMEDIATELY.
- SEDIMENT DEPOSITS SHALL BE REMOVED AFTER EACH RAINFALL OR BEFORE THEY ACCUMULATE TO 1/2 OF THE FENCE HEIGHT.

SD-48A SILT FENCE INSTALLATION  
N.T.S.

DUPLICATE?

DEVELOPER:  
MR. DAVID GALE  
GALE COMMUNITIES, INC.  
3620 SW. WARD ROAD  
LEE'S SUMMIT, MO 64082  
PHONE: 816-537-4200

FILE: STORM-WATER-PLAN.DWG  
SCALE: 1=200  
AFTER:  
NAME:

No.	DATE	BY	REVISION
1	11/19/02	MD	DESIGNED BY:
2		MD	DRAWN BY:
3		RJL	CHECKED BY:
4		MD	

E. T. ARCHER CORPORATION D.B.A.  
**ARCHER**  
TOTAL PROJECT MANAGEMENT  
CORPORATE OFFICE: 3741 NE. TROON DRIVE  
LEE'S SUMMIT, MO. 64064  
816-564-3019 • FAX 816-554-3061

OTHER OFFICE LOCATIONS

- 187 E. DAVID, P.O. BOX 989, FORTSMO, MO 65053 • 417-546-3218 • FAX 417-546-5324
- 800 STARKS BUILDING, LOUISVILLE, KY 40202 • 502-581-9484 • FAX 502-581-9485
- 1000 CITY PARKWAY, OSAGE BEACH, MO 65055 • 573-348-3222 • FAX 573-348-3499
- 1007 HAUCK DR., SUITE B, P.O. BOX 537, ROLLA, MO 65402 • 573-364-5420 • FAX 573-364-4170
- 6300 HALL, P.O. BOX 439, SHAWNEE MISSION, KS 66201 • 913-382-9753 • FAX 913-382-8847
- 255 SO. UNION, SPRINGFIELD, MO 65802 • 417-885-4003 • FAX 417-885-4085
- 2480 EXECUTIVE DRIVE, SUITE 116, ST. CHARLES, MO 63303 • 636-477-0288 • FAX 636-477-7599

DRAINAGE MASTER PLAN  
FOR  
ARBORWALK, LEE'S SUMMIT, MO.  
  
FOR: GALE COMMUNITIES, INC.  
LEE'S SUMMIT, MISSOURI

PROJECT NO.  
21126701  
  
DRAWING NO.  
1 OF 1



# **DRAINAGE MASTER PLAN**

## **INTRODUCTION**

Gale Communities, Inc., of Lee's Summit, Missouri employed the services of Archer Engineers to evaluate and recommend a storm water management plan for the watershed associated with the development called Arborwalk. Arborwalk is located in the southern portion of the City of Lee's Summit north of Missouri State Highway 150 and between Ward and Pryor Roads. The development is 380 acres and is in Section 25, Township 47, Range 32 of Jackson County. General topography is gentle rolling hills with both open fields and timber areas.

## **WATERSHED DESCRIPTION**

Arborwalk development is divided into 5 drainage basins, Southeast, Southwest, East, Northwest, and North. The 5 drainage basins have their own modified storm water management system that is described in detail in the following text. A check of the Federal Emergency Management Agency (FEMA) indicated that there is no 100-year flood plain within the boundary of the development.

The 5 drainage basins are outlined on the attached Figure named Drainage Master Plan (enclosed). The Figure indicates the different drainage basins, flow direction, location and approximate size of major detention basins, location of major rock check dams and silt trap basins. Soil type was obtained from the Soil Conservation Service's (SCS) "Soil Survey of Jackson County, Missouri". Existing land use was obtained from the city zoning records and field inspection. Table A at the end of this report provides data for the different drainage basins and pre and post watershed conditions respectfully.

## **OVERVIEW**

Storm water management is knowledge used to understand, control, and utilize waters in different forms within the hydrologic cycle. The natural condition of a watershed is termed undeveloped condition. Natural streams, creeks, and waterways have been continuously shaped over time by storm runoff. Development of a watershed results in more paved areas that increase the frequency, magnitude, and volume of storm runoff. Man made drainage facilities cause storm water to move faster and to become more concentrated causing erosion within the watershed. The factors that impact severity of erosion include storm intensity, soil conditions, vegetation characteristics, and topography.

The goal of this report is to provide concepts and design criteria for best management of storm water and the functions of the storm water drainage system. Various types of systems will be used in the development to manage the storm water and may include storm sewers, streets with curb & gutter, swales, detention, off-line detention, and wetlands.

Detention basins are small to medium size basins that impound water for 24 hours or less and are normally 10 acre-ft or less. Retention basins are usually larger than detention basins and hold water for much longer periods, usually have a defined pool elevation, and release any stored water at a much slower rate. Additional concepts will consist of oversized storm sewer piping, off-line detention basins, and shallow green space detention. Oversized storm sewer piping could be placed at critical locations to hold limited volumes of storm water to decrease the peak outflow leaving the detention basin during normal storm events. Off-line detention basins might be developed within the watershed to reduce the overall detention areas required within the watershed. An example of an off-line detention basin might be a defined swale running down the back lot lines of a series of houses. This swale would be connected to the storm sewers at each end and controlled with an inlet of greater capacity than the outlet of the storm sewer. The storm sewer would be designed to pass the dry weather flows and the 2, 5, and 10-year storms. During a storm event larger than the 10-year event, the volume difference between the inflow and outflow would be detained in the swale area defined. This type of design using the concept of off-line detention within the on-line sewer system would allow for better control of storm detention within the drainage basin before reaching the detention basin(s) down stream.

### **SOUTHEAST DRAINAGE AREA**

The Southeast Drainage Area will consist of all the various type of storm water management systems that are practicable for the given size and use of the area. The systems will consist of inlets and storm sewer piping, oversized storm sewer piping for limited detention upstream of the detention basin, existing open channels with riparian vegetation and wetlands, a retention basin with a fixed pool elevation and with detention included within the retention basin, and shallow off-line detention combined with the storm sewer system for increased storage upstream of the retention/detention basin. In addition, upland detention will utilize green space for shallow storage of storm events smaller than the 25-year event. The Drainage area is 103 acres with a weighed curve number of 85 and a time of concentration of 27 minutes.

The existing farm lake will be retained and utilized by increasing the dam height and excavation to create a detention basin above the normal pool elevation for the 25-year design storage. The detention provided above the normal pool elevation will be approximately 7.2 acre-feet of storage (3-feet in depth). The green space southeast of the basin will be designed to hold an additional 3.9 acre-feet of storage (1-foot in depth). The combination of the two basins will adequately hold the required volume of storage for both the southeast drainage basin including the future commercial development at the



intersection of Ward Road and Highway 150. If in final design, it is determined that additional space will be needed in the Southeast Basin, one option that will be considered is the installation of an underground storm sewer detention under the commercial area near the intersection of Ward Road and Highway 150.

To provide improved water quality in the Southeast Drainage Basin, additional upland/wetland area will be developed north of the retention/detention basin. This upland area will provide a vegetative interface with the lower storm events by allowing low flows to pass through a native grass and tree area where the velocities will be lowered to allow for sediment to collect in this upland area instead of the basins and potential exiting the basin.

The area defined as commercial will have limited detention within their boundaries. The required detention volumes for this area will be held in the Southeast detention area upstream. An outlet structure with limited underground storage will be built at the outlet (near the intersection of Ward Road and Highway 150) to allow only pre-developed flows to exist the watershed.

Erosion control efforts for the area will include improved vegetative stabilization practices such as temporary seeding using degradable stabilization blankets on slopes, buffer zones at the top and bottom of slopes to reduced runoff flows, silt fence, straw bales, storm inlet protection, and erosion control matting. In addition, check dams will be used extensively both upstream and downstream of the green area to limit the amount of sediment that could enter the Southeast Detention area. The southeast corner of the development will have a series of temporary sedimentation basins to control and contain the sediment load as storm water exists the site during the development of the project.

The pre-developed flow for the Southeast Drainage Basin is 340 cubic feet per second (cfs) and the post-developed flow is 431 cfs. The proposed size of storage required for this is approximately 7 acre-feet for the 25-year storm event and for the 100-year storm event the required storage is 10.9 acre-feet. The commercial area to the southeast when developed will require 4.8 acre-feet of storage for detention that is part of the required storage listed above.

### **SOUTHWEST DRAINAGE AREA**

The Southwest Drainage Area systems will consist of inlets and storm sewer piping, oversized storm sewer piping for limited detention upstream of the detention basin, existing open channels with riparian vegetation and wetlands, detention basins, and shallow off-line detention combined with the storm sewer system for increased storage upstream of the detention basins. The detention basins will consist of a two dry detention basins to control the 2, 5, and 10-year storm for water quality and the 25-year storm for downstream flood control. The small storm events will be held longer in the basins to allow for improved water quality. This will be accomplished by designing around the existing creek, by the addition of a control structure near Highway 150, and using the



change in elevations in creating steps. The upper (smaller) basin that has a storage volume of approximately 1.2 acre-feet (3-foot depth) will be used as an equalization basin before entering the lower detention basin. The lower detention basin which has a storage volume of approximately 12.3 acre-feet will be gentle and blend into the surrounding land by using native trees, bushes, and grasses. During the higher storm events, water will be allowed to pond over most of the basin floor up to depth of 42-inches. This will allow for planting of grasses in the basin bottom that can survive for short times during submergence and the usage of tree plantings and treescape islands that will be scattered through out the basin floor. These treescape islands will consist of trees, shrubs, and grasses native to the area and particularly to stream areas. There will be field inlets scattered through out the basin floor to handle the larger storm events by allowing flow into smaller diameter piping that would converge at the primary outlet structure. This would allow for subcritical flow to exit the site, thereby reducing the potential for erosion downstream. Additional rock levels with rock waterfalls will allow for transition of elevations and add aeration to the storm water for quality. The drainage area is 129 acres with a weighed curve number of 88 and a time of concentration of 20 minutes.

Erosion control efforts for the area will include improved vegetative stabilization practices such as temporary seeding using degradable stabilization blankets on slopes, buffer zones at the top and bottom of slopes to reduced runoff flows, silt fence, straw bales, storm inlet protection, and erosion control matting. In addition, check dams will be used extensively both upstream and downstream of the green area to limit the amount of sediment that could enter the southwest green area.

The pre-developed flow for the Southwest Drainage Basin is 465 cubic feet per second (cfs) and the post-developed flow is 622 cfs. The proposed size of storage required for this is approximately 11 acre-feet for the 25-year storm event and for the 100-year storm event the required storage is 13.6 acre-feet. The office area to the east of the lower detention area when developed will require 2.9 acre-feet of storage for detention that is part of the required storage listed above.

### **NORTHWEST DRAINAGE AREA**

The Northwest Drainage Area systems will consist of inlets and storm sewer piping, oversized storm sewer piping for limited detention upstream of the shallow detention basin, existing open channels with riparian vegetation and wetlands, a shallow detention basin, and shallow off-line detention combined with the storm sewer system for increased storage upstream of the shallow detention basin. Shallow detention will consist of a series of small dry detention areas incorporated into the proposed green space along the north edge of the property and the buffer zone along Pryor Road. The outlet structure for this basin will be positioned at the northwest corner of development at Pryor and allow the release the pre-developed flows from the drainage basin. The green space along the northern edge of the development will consist of swales running in a curve pattern and dotted with treescape islands and native vegetation in the swales. This green space will provide approximately 0.9 acre-feet of storage. The buffer zone along Pryor Road will



have the same type layout of a meandering swale with larger treescape islands to meet the needs of a buffer zone between the residences and street. The buffer zone will provide approximately 0.9 acre-feet of storage. The combined storage of the two areas is approximately 1.8 acre-feet. The storage is less than the required 2.3 acre-feet for the 25-year event. Additional storage will be developed within the development by the use of large diameter storm sewer piping and off-line detention. Additional storm water swales will be included in the development design to account for and control the 100-year event. The drainage area is 33.1 acres with a weighed curve number of 81 and a time of concentration of 13 minutes.

Erosion control efforts for the area will include improved vegetative stabilization practices such as temporary seeding using degradable stabilization blankets on slopes, buffer zones at the top and bottom of slopes to reduced runoff flows, silt fence, straw bales, storm inlet protection, and erosion control mating. In addition, check dams will be used extensively both upstream and downstream of the green area to limit the amount of sediment that could enter the northwest green area.

The pre-developed flow for the Northwest Drainage Area is 123 cubic feet per second (cfs) and the post-developed flow is 170 cfs. The proposed size of storage required for this is 2.3 acre-feet for the 25-year storm event and for the 100-year storm event the required storage is 3.1 acre-feet.

### **EAST DRAINAGE AREA**

The East Drainage Area will consist of inlets and storm sewer piping, oversized storm sewer piping for limited detention upstream of the detention basin, existing open channels with riparian vegetation and wetlands, shallow detention, and shallow off-line detention combined with the storm sewer system for increased storage upstream of the retention/detention basin. Shallow detention will consist of a dry detention area incorporated into the proposed green space along the buffer zone along Ward Road. The outlet structure will be positioned at the existing culvert structure that is under Ward Road and will allow the release the pre-developed flows from the drainage basin. The green space along Ward Road will consist of swales running in a curve pattern and dotted with treescape islands and native vegetation in the swales. A small shallow dry detention basin consisting of native grass will be positioned near the outlet structure for better control for the storm events. The green space along Ward Road combined with the shallow detention basin near the existing outlet structure will provide approximately 0.95 acre-feet of storage. Additional storage will be developed within the development by the use of large diameter storm sewer piping and off-line detention. Additional storm water swales will be included in the development design to account for and control the 100-year event. The drainage area is 21.6 acres with a weighed curve number of 84 and a time of concentration of 20 minutes.

Erosion control efforts for the area will include improved vegetative stabilization practices such as temporary seeding using degradable stabilization blankets on slopes,

buffer zones at the top and bottom of slopes to reduced runoff flows, silt fence, straw bales, storm inlet protection, and erosion control matting. In addition, check dams will be used extensively both upstream and downstream of the green area to limit the amount of sediment that could enter the East Green Area.

The pre-developed flow for the East Green Area is 76 cubic feet per second (cfs) and the post-developed flow is 102 cfs. The proposed size of storage required for this is 1.6 acre-feet for the 25-year storm event and for the 100-year storm event the required storage is 2.1 acre-feet.

### **NORTH DRAINAGE AREA**

The North Drainage Area will consist of inlets and storm sewer piping, oversized storm sewer piping for limited detention upstream of the detention basin, existing open channels with riparian vegetation and wetlands, two detention basins (one normal depth and one shallow), and shallow off-line detention combined with the storm sewer system for increased storage upstream of the retention/detention basin. The drainage areas will consist of two drainage basins with two outlet points. The westerly outlet will be the north dry detention basin and the northerly outlet will be the upper north dry detention basin. The upper detention basin will incorporate the proposed green space along the north edge of the property and the buffer zone along Hook Road. The outlet structure will be positioned at the existing culvert structure that is under Hook Road and will allow the release the pre-developed flows from the drainage basin. The green space along the north edges will consist of swales running in a curve pattern and dotted with treescape islands and native vegetation in the swales. The north detention basin will consist of the buffer zone along the western edge of the development will have the same type layout of a meandering swale with larger treescape islands to meet the needs of a buffer zone between the residences and street. A larger dry detention basin consisting of native grass will be positioned near the outlet structure for better control for the storm events. The combined detention of the northern and upper north detention basins is 8.2 acre-feet, which is more than adequate for current volumes. If it is determined that additional storage is required. Additional storage will be developed using large diameter piping and off-line detention in the development. Additional storm water swales will be included in the development design to account for and control the 100-year event. The drainage area consists of 68.2 acres for the North Drainage Basin and 11.9 acres for the Upper North Drainage Basin. The weighted curve number is 81 and the time of concentration is 16 minutes.

Erosion control efforts for the area will include improved vegetative stabilization practices such as temporary seeding using degradable stabilization blankets on slopes, buffer zones at the top and bottom of slopes to reduced runoff flows, silt fence, straw bales, storm inlet protection, and erosion control matting. In addition, check dams will be used extensively both upstream and downstream of the green area to limit the amount of sediment that could enter the southeast green area.



The pre-developed flow for the North Drainage Area is 226 cubic feet per second (cfs) and the post-developed flow is 296 cfs. The proposed size of storage required for this is 5.3 acre-feet for the 25-year storm event and for the 100-year event the required storage is 7.1 acre-feet.

## **CONCLUSION**

Table A is a summary of the design storm events, drainage areas, and pre and post development flows and recommended detention. The recommended detention will be completed with a combination of retention/detention lakes, detention basins, and shall deter erosion utilizing gentle slopes, native grasses, and trees to create a storm water scape that will co-exist with the existing surroundings.

# Storm Water Quantities Arborwalk Development TABLE A

11/19/02

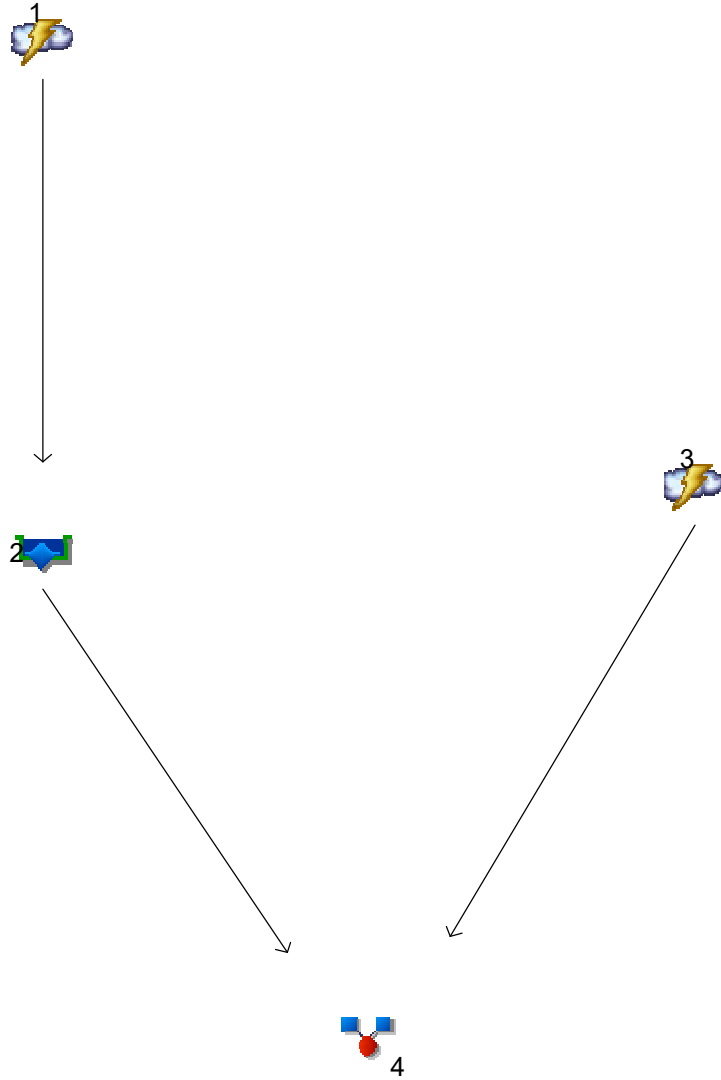
Table 1: 10, 25, 100 Year Storm Water Quantities

Event	Sub Watershed	CN	Area (acre)	Discharge (cfs)		Det. Vol. (acre-ft.)
				Pre	Post	
25-Year	Southwest	88	129	465.0	662.0	11.0
	Southeast	85	103	340.0	431.0	7.0
	Northwest	81	33.1	123.0	170.0	2.3
	North	81	80.2	226.0	296.0	5.3
	East	84	21.6	76.0	102.0	1.6
100-Year	Southwest	88	129	634.0	866.0	13.6
	Southeast	85	103	456.0	571.0	10.9
	Northwest	81	33.1	166.0	230.0	3.1
	North	81	80.2	307.0	400.0	7.1
	East	84	21.6	98.0	146.0	1.7

## **Appendix B – Hydraflow Hydrograph Output**

# Watershed Model Schematic

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021





# Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	Rational	-----	3.679	6.811	-----	8.152	9.259	10.73	11.83	16.22	Post Developed
2	Reservoir	1	0.007	0.152	-----	0.461	0.767	1.111	1.303	1.935	<no description>
3	Rational	-----	0.304	0.458	-----	0.557	0.632	0.742	0.813	1.002	No detention
4	Combine	2, 3	0.310	0.610	-----	1.017	1.399	1.851	2.111	2.927	Total Post
Proj. file: 21072.15 Detention.gpw											Thursday, 05 / 12 / 2022

# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

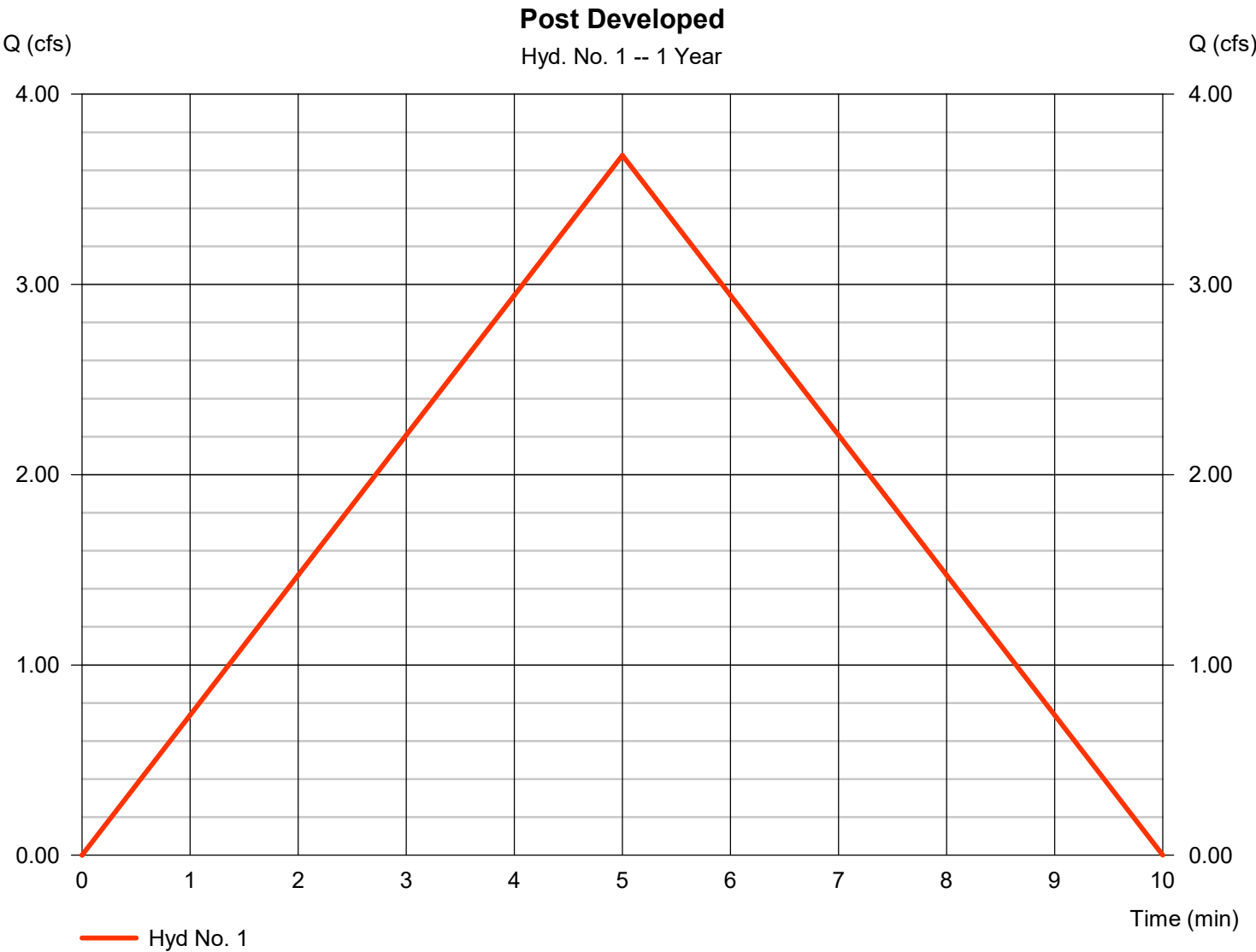
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	Rational	3.679	1	5	1,104	-----	-----	-----	Post Developed
2	Reservoir	0.007	1	10	907	1	996.08	1,101	<no description>
3	Rational	0.304	1	10	182	-----	-----	-----	No detention
4	Combine	0.310	1	10	1,089	2, 3	-----	-----	Total Post
21072.15 Detention.gpw					Return Period: 1 Year			Thursday, 05 / 12 / 2022	

# Hydrograph Report

## Hyd. No. 1

Post Developed

Hydrograph type	= Rational	Peak discharge	= 3.679 cfs
Storm frequency	= 1 yrs	Time to peak	= 5 min
Time interval	= 1 min	Hyd. volume	= 1,104 cuft
Drainage area	= 1.400 ac	Runoff coeff.	= 0.9
Intensity	= 2.920 in/hr	Tc by User	= 5.00 min
IDF Curve	= KCAPWA 1.37".IDF	Asc/Rec limb fact	= 1/1





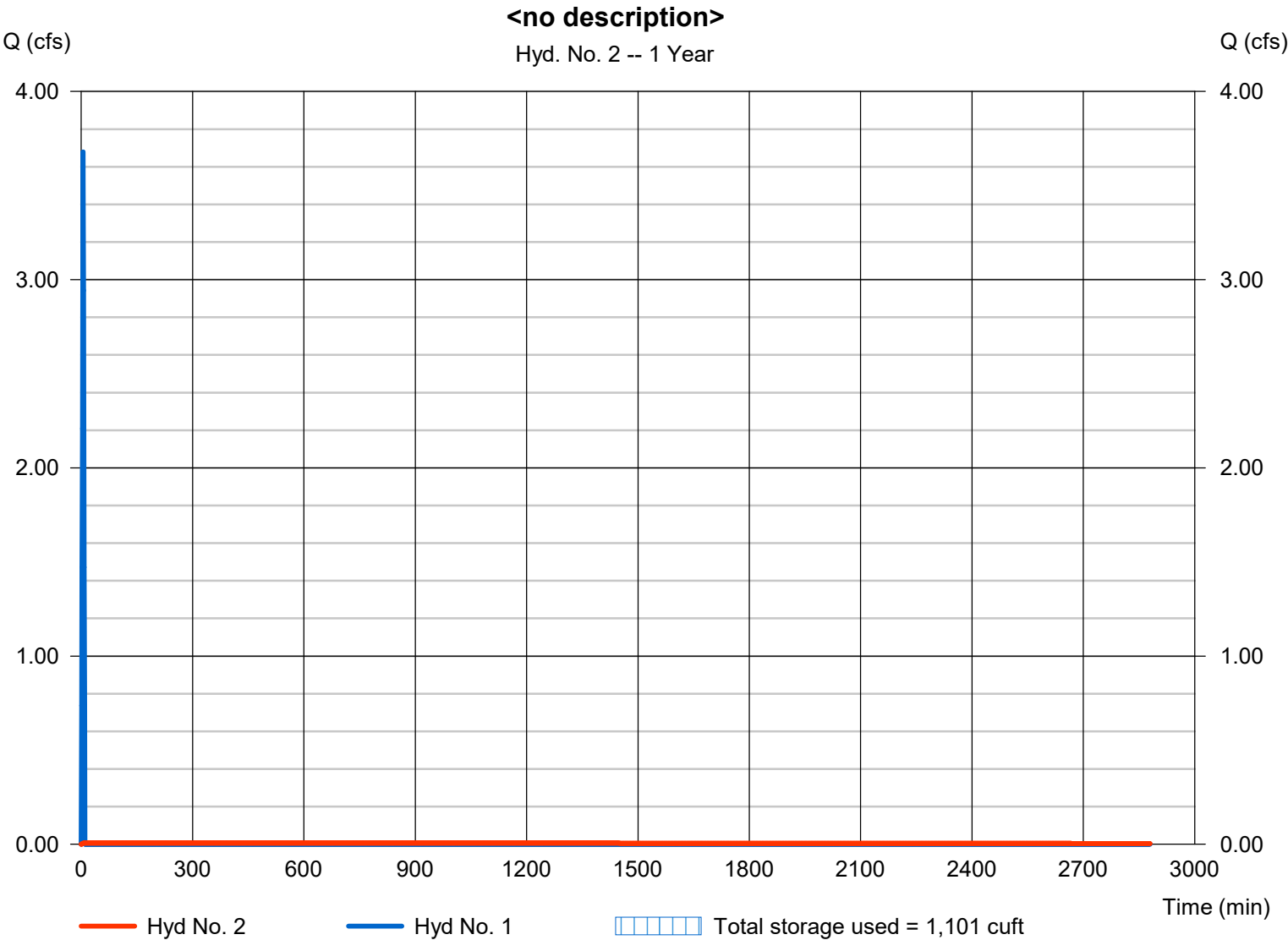
# Hydrograph Report

## Hyd. No. 2

<no description>

Hydrograph type	= Reservoir	Peak discharge	= 0.007 cfs
Storm frequency	= 1 yrs	Time to peak	= 10 min
Time interval	= 1 min	Hyd. volume	= 907 cuft
Inflow hyd. No.	= 1 - Post Developed	Max. Elevation	= 996.08 ft
Reservoir name	= UG pipes	Max. Storage	= 1,101 cuft

Storage Indication method used.



# Pond Report

## Pond No. 2 - UG pipes

### Pond Data

**UG Chambers** -Invert elev. = 995.00 ft, Rise x Span = 4.00 x 4.00 ft, Barrel Len = 200.00 ft, No. Barrels = 2, Slope = 0.00%, Headers = No

### Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	995.00	n/a	0	0
0.40	995.40	n/a	262	262
0.80	995.80	n/a	454	716
1.20	996.20	n/a	553	1,269
1.60	996.60	n/a	609	1,878
2.00	997.00	n/a	636	2,514
2.40	997.40	n/a	636	3,151
2.80	997.80	n/a	609	3,759
3.20	998.20	n/a	553	4,312
3.60	998.60	n/a	454	4,766
4.00	999.00	n/a	261	5,028

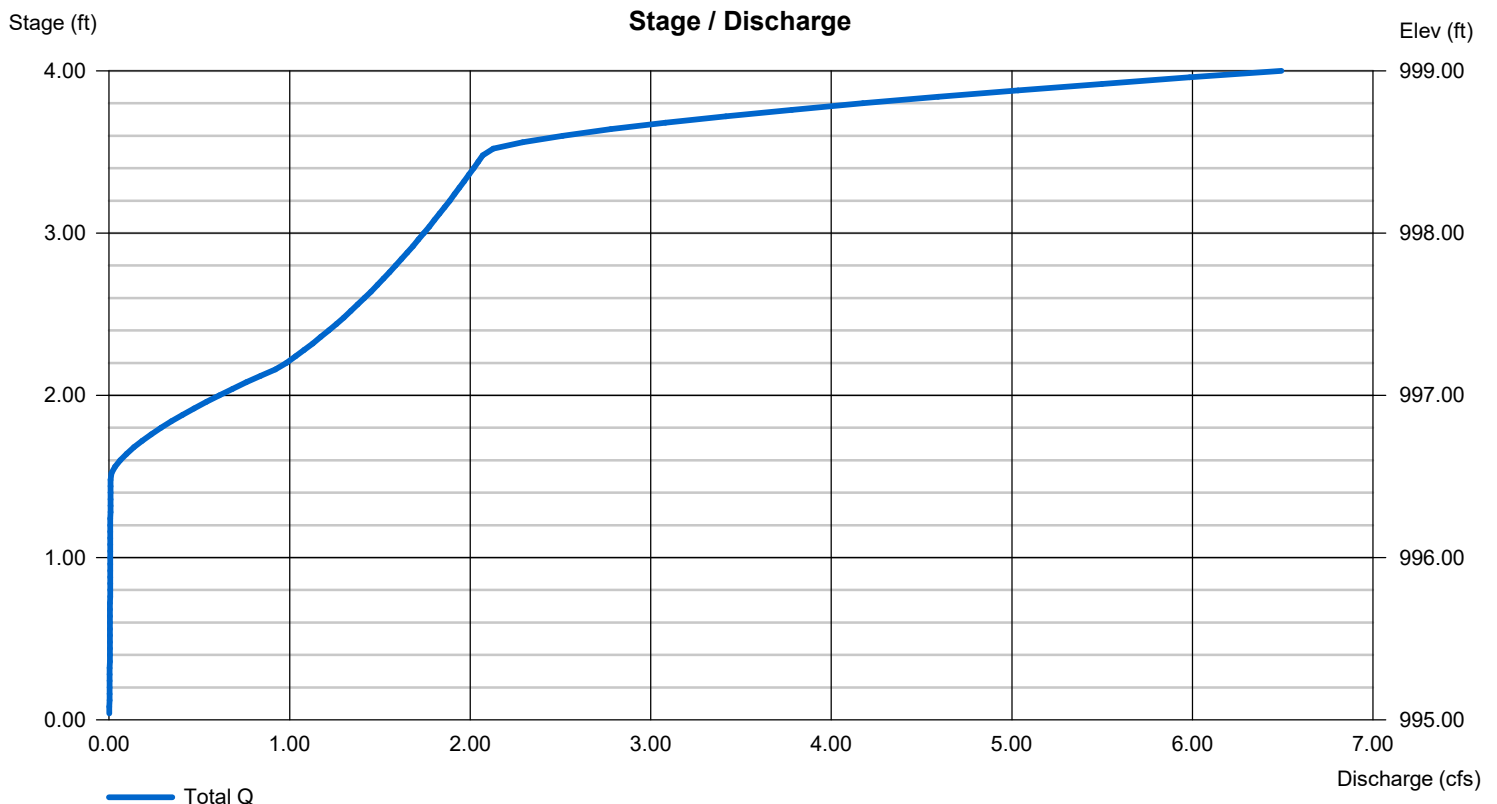
### Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 18.00	0.50	8.00	0.00
Span (in)	= 18.00	0.50	6.00	0.00
No. Barrels	= 1	1	1	0
Invert El. (ft)	= 995.00	995.00	996.50	0.00
Length (ft)	= 25.00	0.10	0.10	0.00
Slope (%)	= 0.50	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	Yes	No

### Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 3.50	0.00	0.00	0.00
Crest El. (ft)	= 998.50	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= Rect	---	---	---
Multi-Stage	= Yes	No	No	No
Exfil.(in/hr)	= 0.000 (by Wet area)			
TW Elev. (ft)	= 0.00			

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).

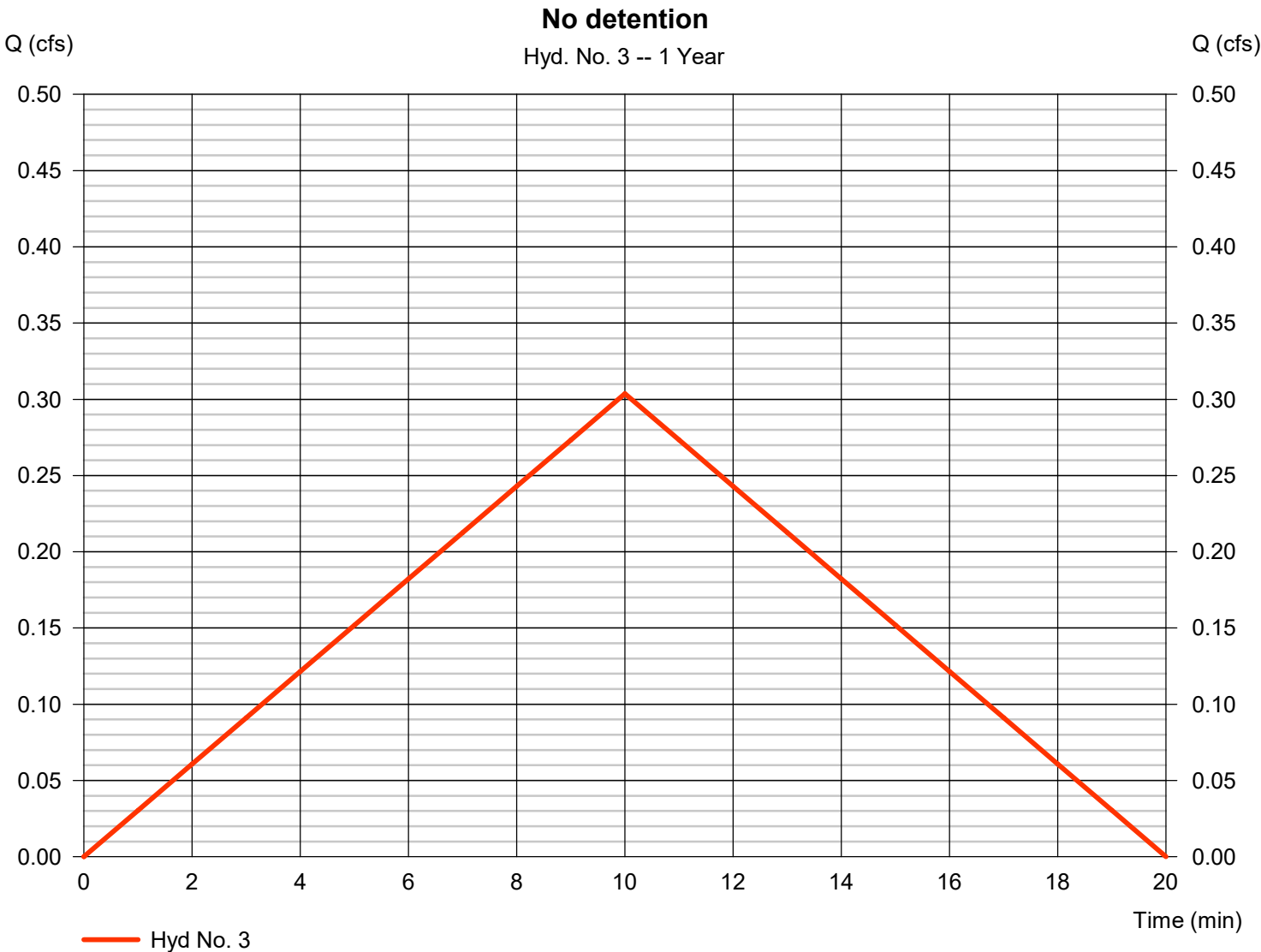


# Hydrograph Report

## Hyd. No. 3

No detention

Hydrograph type	= Rational	Peak discharge	= 0.304 cfs
Storm frequency	= 1 yrs	Time to peak	= 10 min
Time interval	= 1 min	Hyd. volume	= 182 cuft
Drainage area	= 0.130 ac	Runoff coeff.	= 0.8
Intensity	= 2.920 in/hr	Tc by User	= 10.00 min
IDF Curve	= KCAPWA 1.37".IDF	Asc/Rec limb fact	= 1/1



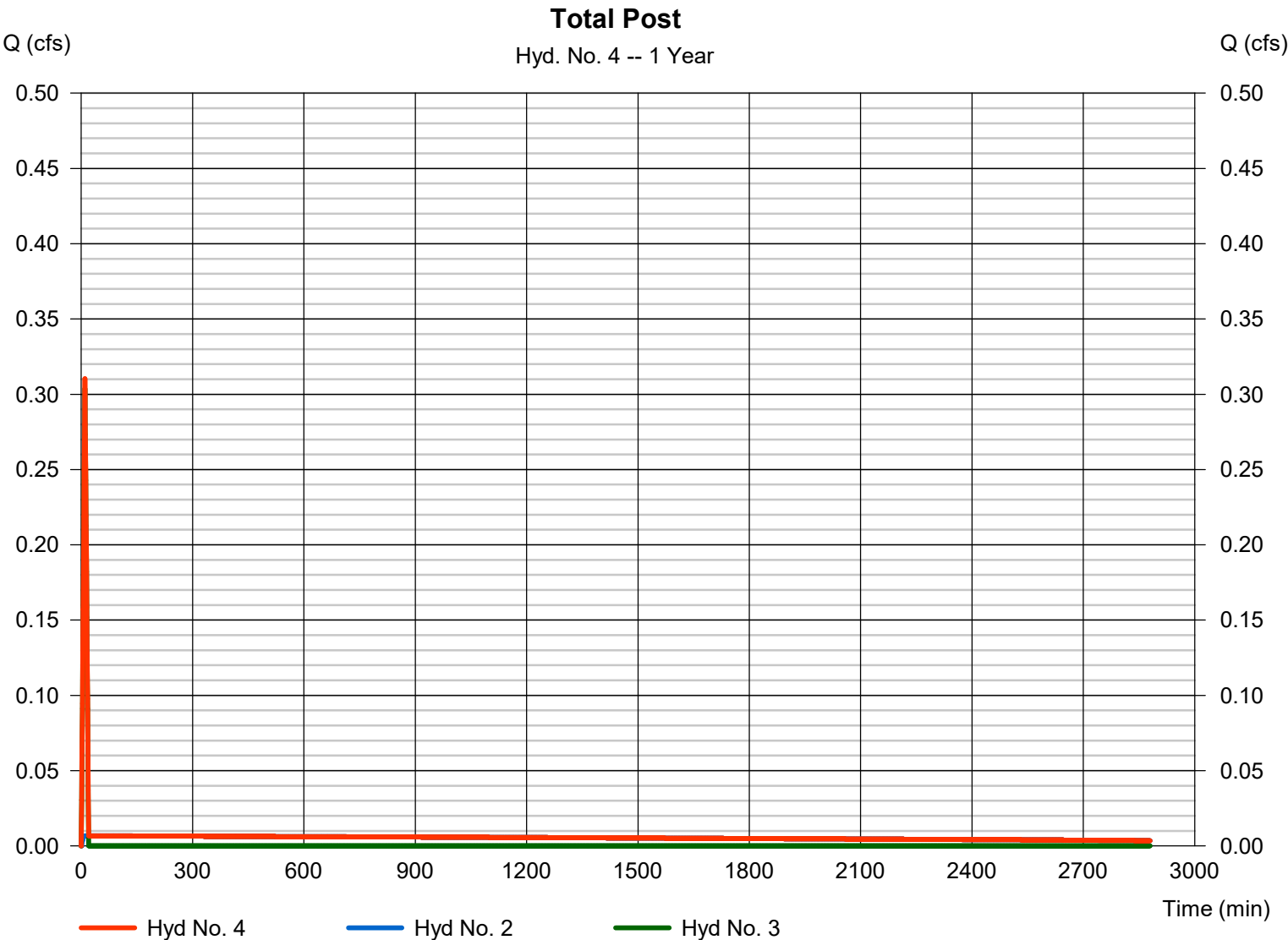


# Hydrograph Report

## Hyd. No. 4

Total Post

Hydrograph type	= Combine	Peak discharge	= 0.310 cfs
Storm frequency	= 1 yrs	Time to peak	= 10 min
Time interval	= 1 min	Hyd. volume	= 1,089 cuft
Inflow hyds.	= 2, 3	Contrib. drain. area	= 0.130 ac



# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	Rational	6.811	1	5	2,043	-----	-----	-----	Post Developed
2	Reservoir	0.152	1	10	1,425	1	996.69	2,025	<no description>
3	Rational	0.458	1	10	275	-----	-----	-----	No detention
4	Combine	0.610	1	10	1,699	2, 3	-----	-----	Total Post
21072.15 Detention.gpw					Return Period: 2 Year			Thursday, 05 / 12 / 2022	

# Hydrograph Report

## Hyd. No. 1

Post Developed

Hydrograph type	= Rational	Peak discharge	= 6.811 cfs
Storm frequency	= 2 yrs	Time to peak	= 5 min
Time interval	= 1 min	Hyd. volume	= 2,043 cuft
Drainage area	= 1.400 ac	Runoff coeff.	= 0.9
Intensity	= 5.406 in/hr	Tc by User	= 5.00 min
IDF Curve	= KCAPWA 1.37".IDF	Asc/Rec limb fact	= 1/1





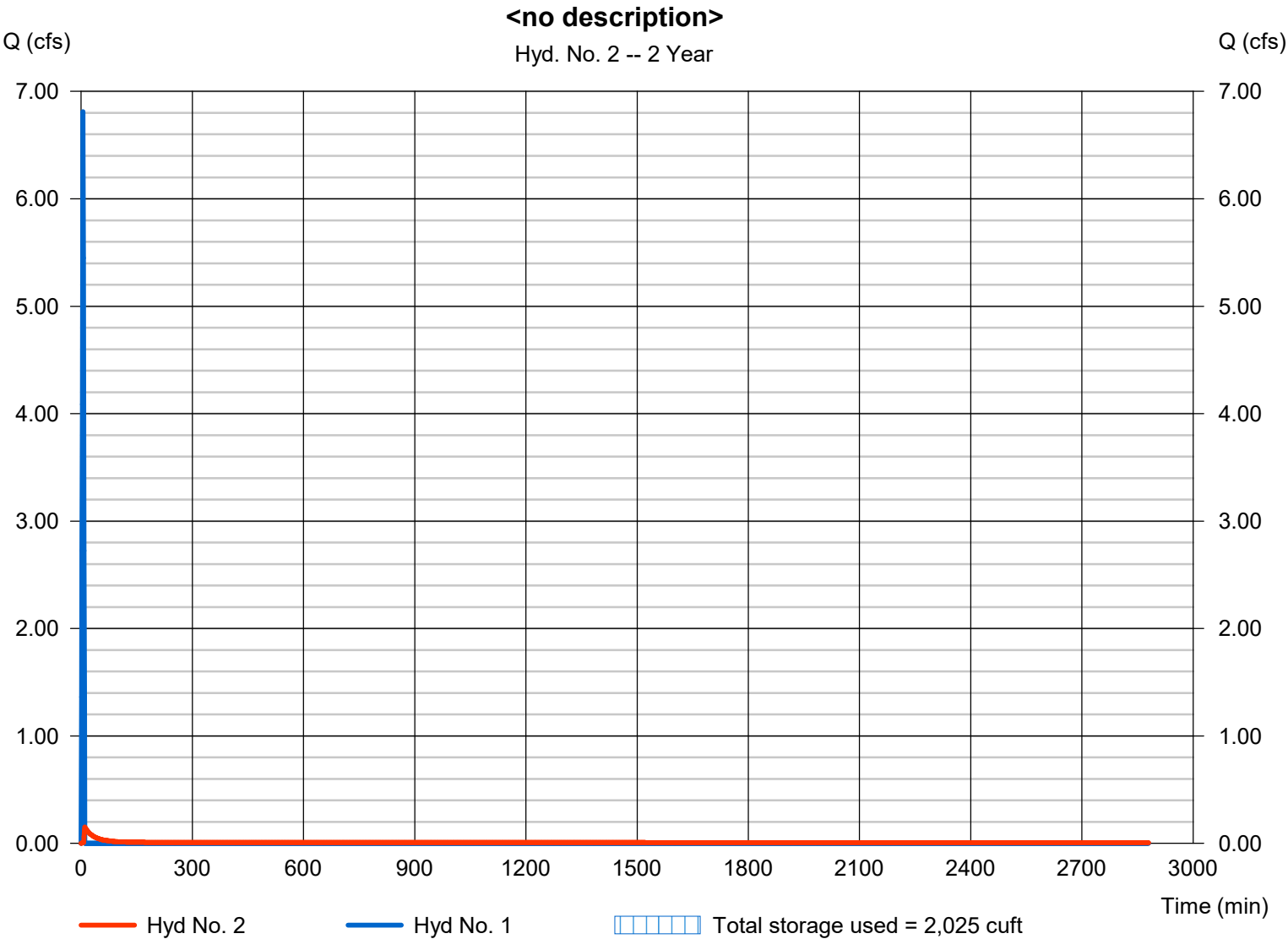
# Hydrograph Report

## Hyd. No. 2

<no description>

Hydrograph type	= Reservoir	Peak discharge	= 0.152 cfs
Storm frequency	= 2 yrs	Time to peak	= 10 min
Time interval	= 1 min	Hyd. volume	= 1,425 cuft
Inflow hyd. No.	= 1 - Post Developed	Max. Elevation	= 996.69 ft
Reservoir name	= UG pipes	Max. Storage	= 2,025 cuft

Storage Indication method used.

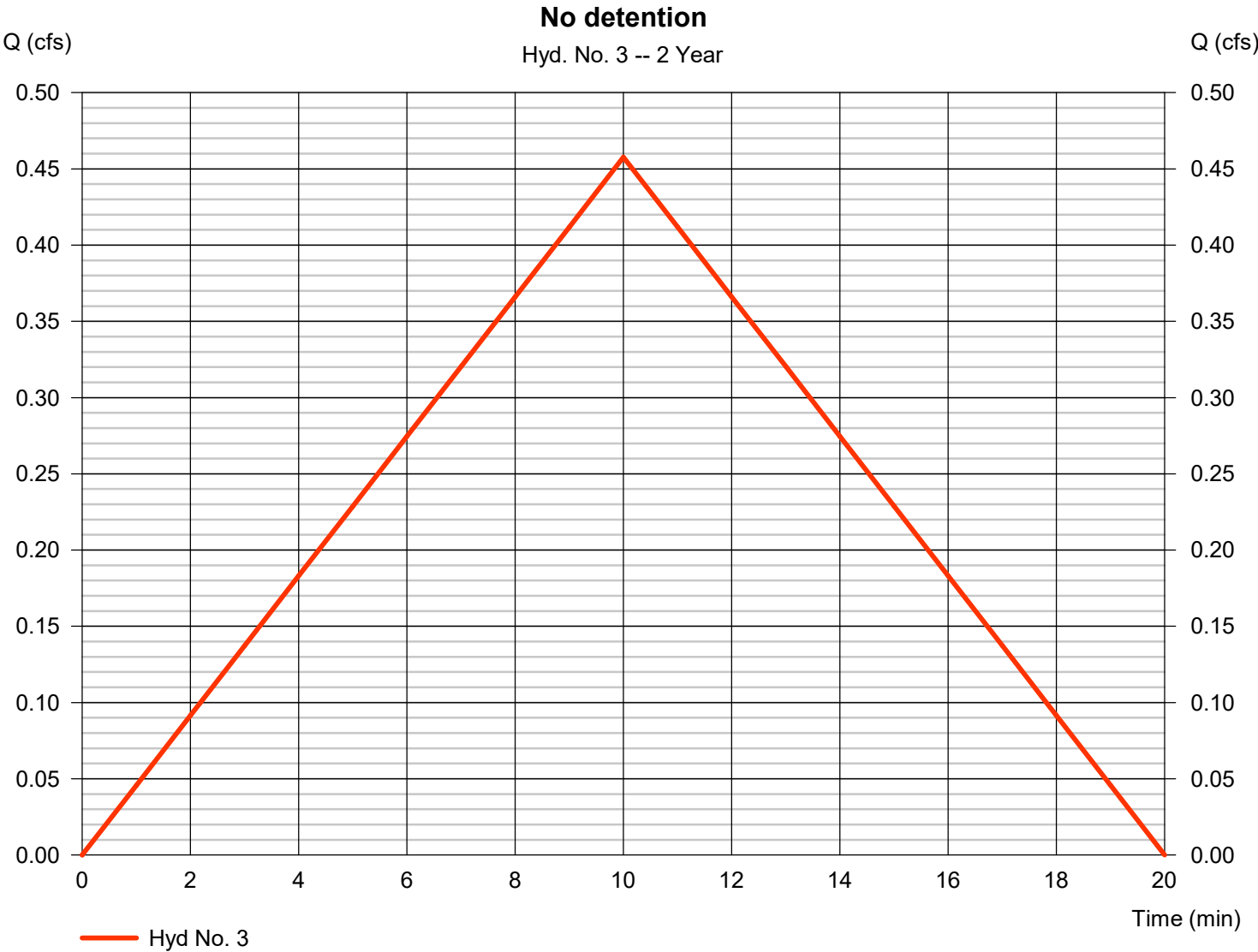


# Hydrograph Report

## Hyd. No. 3

No detention

Hydrograph type	= Rational	Peak discharge	= 0.458 cfs
Storm frequency	= 2 yrs	Time to peak	= 10 min
Time interval	= 1 min	Hyd. volume	= 275 cuft
Drainage area	= 0.130 ac	Runoff coeff.	= 0.8
Intensity	= 4.400 in/hr	Tc by User	= 10.00 min
IDF Curve	= KCAPWA 1.37".IDF	Asc/Rec limb fact	= 1/1

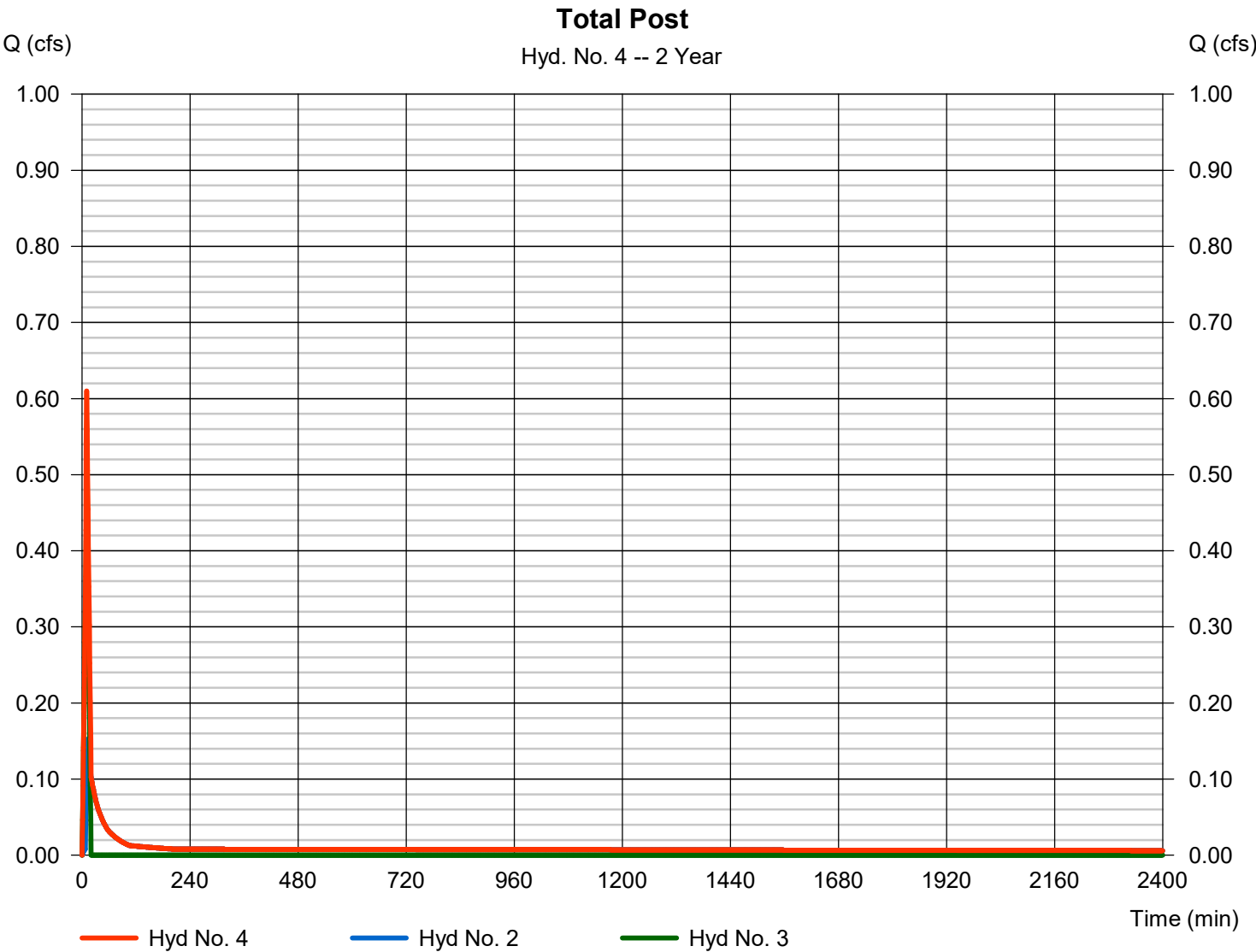


# Hydrograph Report

## Hyd. No. 4

Total Post

Hydrograph type	= Combine	Peak discharge	= 0.610 cfs
Storm frequency	= 2 yrs	Time to peak	= 10 min
Time interval	= 1 min	Hyd. volume	= 1,699 cuft
Inflow hyds.	= 2, 3	Contrib. drain. area	= 0.130 ac





# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

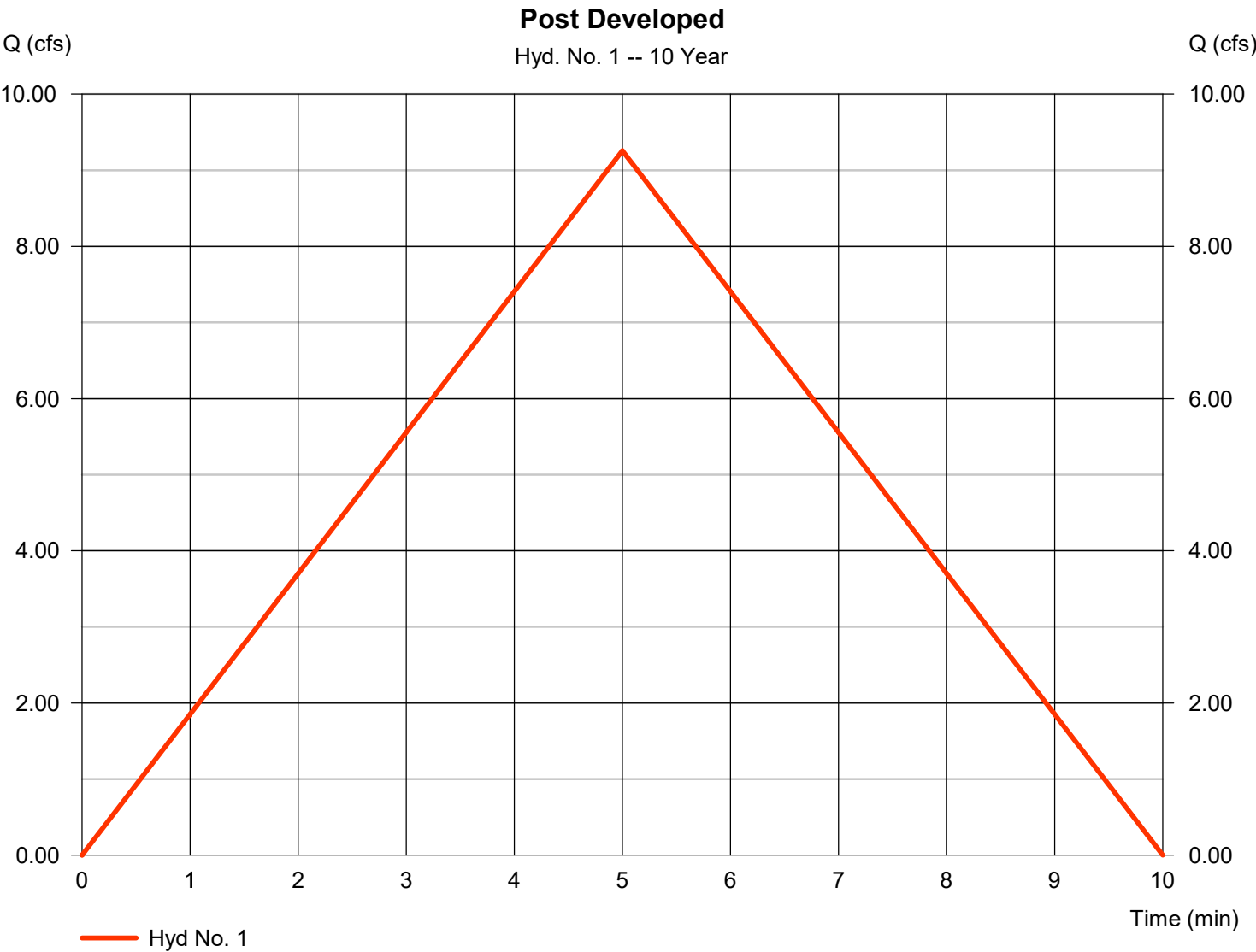
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	Rational	9.259	1	5	2,778	-----	-----	-----	Post Developed
2	Reservoir	0.767	1	10	2,150	1	997.08	2,647	<no description>
3	Rational	0.632	1	10	379	-----	-----	-----	No detention
4	Combine	1.399	1	10	2,529	2, 3	-----	-----	Total Post
21072.15 Detention.gpw					Return Period: 10 Year			Thursday, 05 / 12 / 2022	

# Hydrograph Report

## Hyd. No. 1

Post Developed

Hydrograph type	= Rational	Peak discharge	= 9.259 cfs
Storm frequency	= 10 yrs	Time to peak	= 5 min
Time interval	= 1 min	Hyd. volume	= 2,778 cuft
Drainage area	= 1.400 ac	Runoff coeff.	= 0.9
Intensity	= 7.348 in/hr	Tc by User	= 5.00 min
IDF Curve	= KCAPWA 1.37".IDF	Asc/Rec limb fact	= 1/1



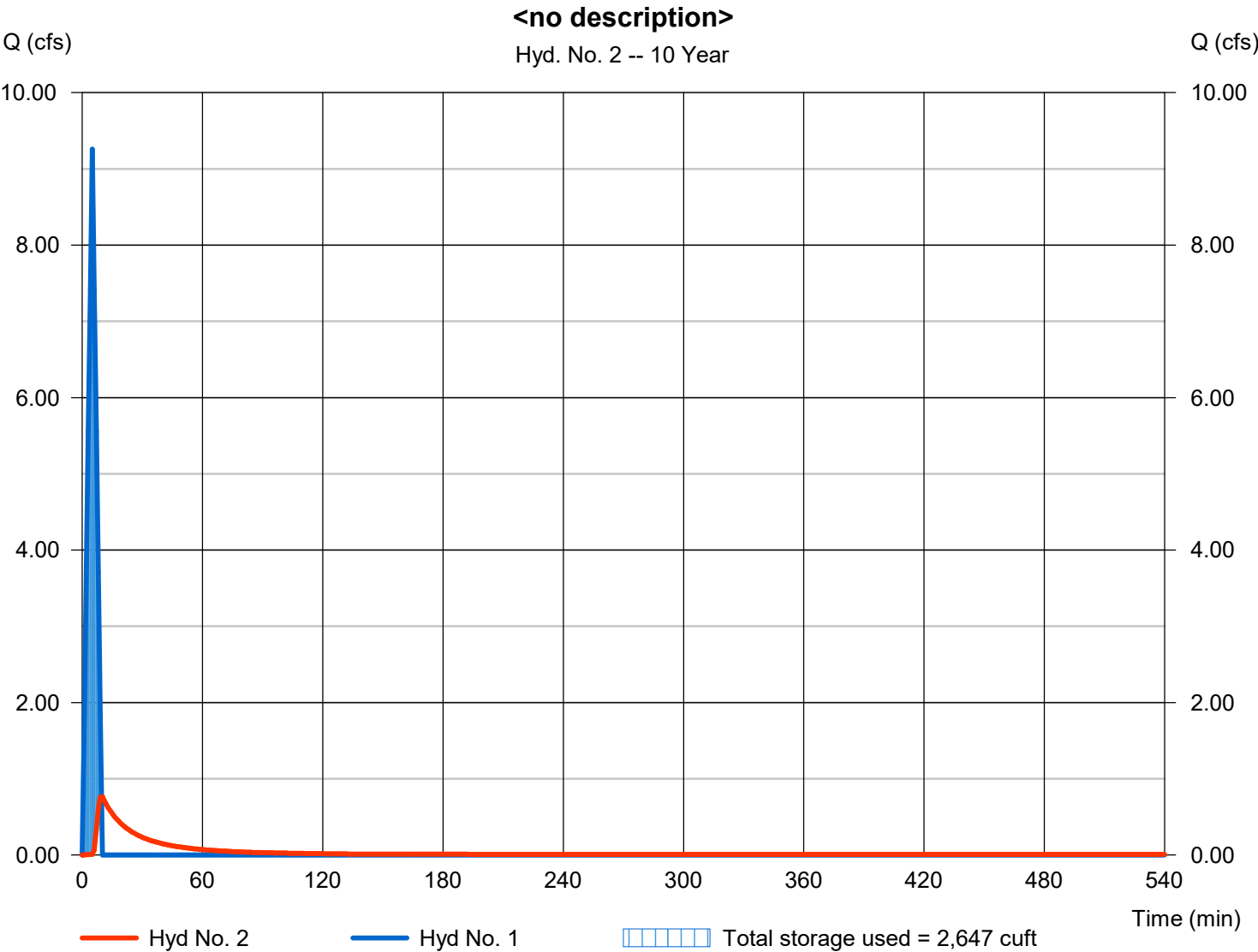
# Hydrograph Report

## Hyd. No. 2

<no description>

Hydrograph type	= Reservoir	Peak discharge	= 0.767 cfs
Storm frequency	= 10 yrs	Time to peak	= 10 min
Time interval	= 1 min	Hyd. volume	= 2,150 cuft
Inflow hyd. No.	= 1 - Post Developed	Max. Elevation	= 997.08 ft
Reservoir name	= UG pipes	Max. Storage	= 2,647 cuft

Storage Indication method used.





# Hydrograph Report

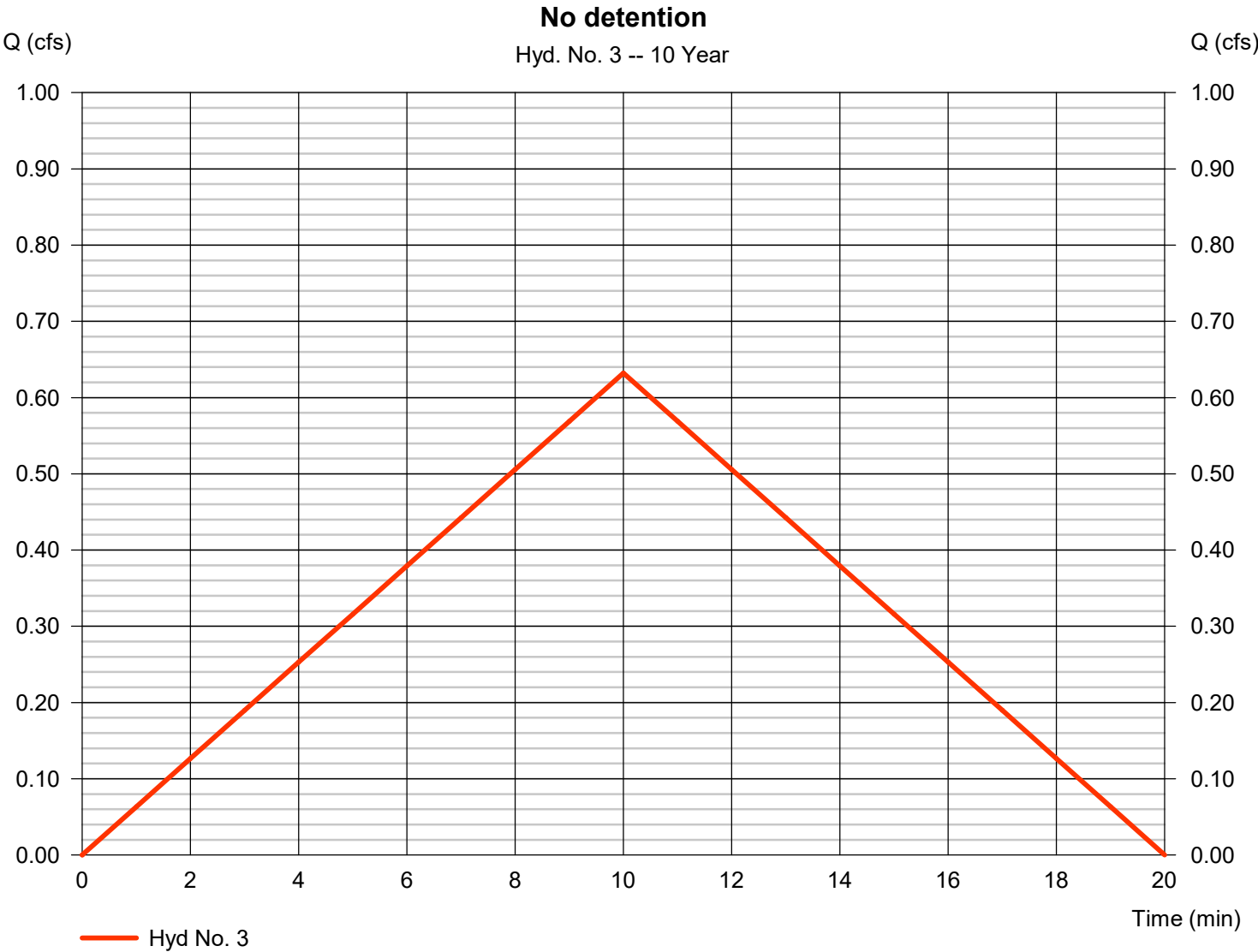
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 05 / 12 / 2022

## Hyd. No. 3

No detention

Hydrograph type	= Rational	Peak discharge	= 0.632 cfs
Storm frequency	= 10 yrs	Time to peak	= 10 min
Time interval	= 1 min	Hyd. volume	= 379 cuft
Drainage area	= 0.130 ac	Runoff coeff.	= 0.8
Intensity	= 6.079 in/hr	Tc by User	= 10.00 min
IDF Curve	= KCAPWA 1.37".IDF	Asc/Rec limb fact	= 1/1

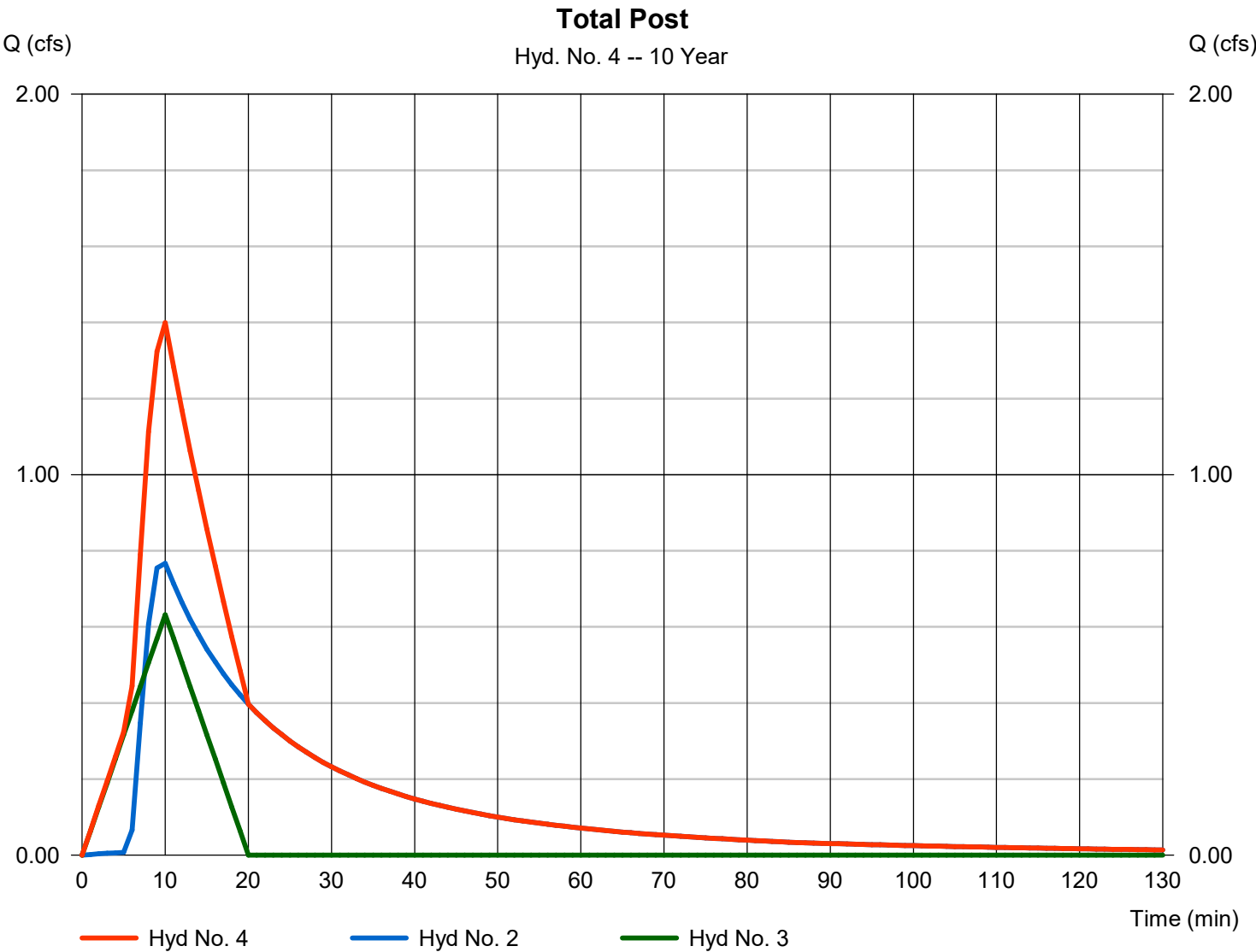


# Hydrograph Report

## Hyd. No. 4

### Total Post

Hydrograph type	= Combine	Peak discharge	= 1.399 cfs
Storm frequency	= 10 yrs	Time to peak	= 10 min
Time interval	= 1 min	Hyd. volume	= 2,529 cuft
Inflow hyds.	= 2, 3	Contrib. drain. area	= 0.130 ac



# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	Rational	16.22	1	5	4,865	-----	-----	-----	Post Developed
2	Reservoir	1.935	1	9	4,230	1	998.27	4,394	<no description>
3	Rational	1.002	1	10	601	-----	-----	-----	No detention
4	Combine	2.927	1	10	4,831	2, 3	-----	-----	Total Post
21072.15 Detention.gpw					Return Period: 100 Year			Thursday, 05 / 12 / 2022	



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 05 / 12 / 2022

## Hyd. No. 1

Post Developed

Hydrograph type	= Rational	Peak discharge	= 16.22 cfs
Storm frequency	= 100 yrs	Time to peak	= 5 min
Time interval	= 1 min	Hyd. volume	= 4,865 cuft
Drainage area	= 1.400 ac	Runoff coeff.	= 0.9
Intensity	= 12.871 in/hr	Tc by User	= 5.00 min
IDF Curve	= KCAPWA 1.37".IDF	Asc/Rec limb fact	= 1/1



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

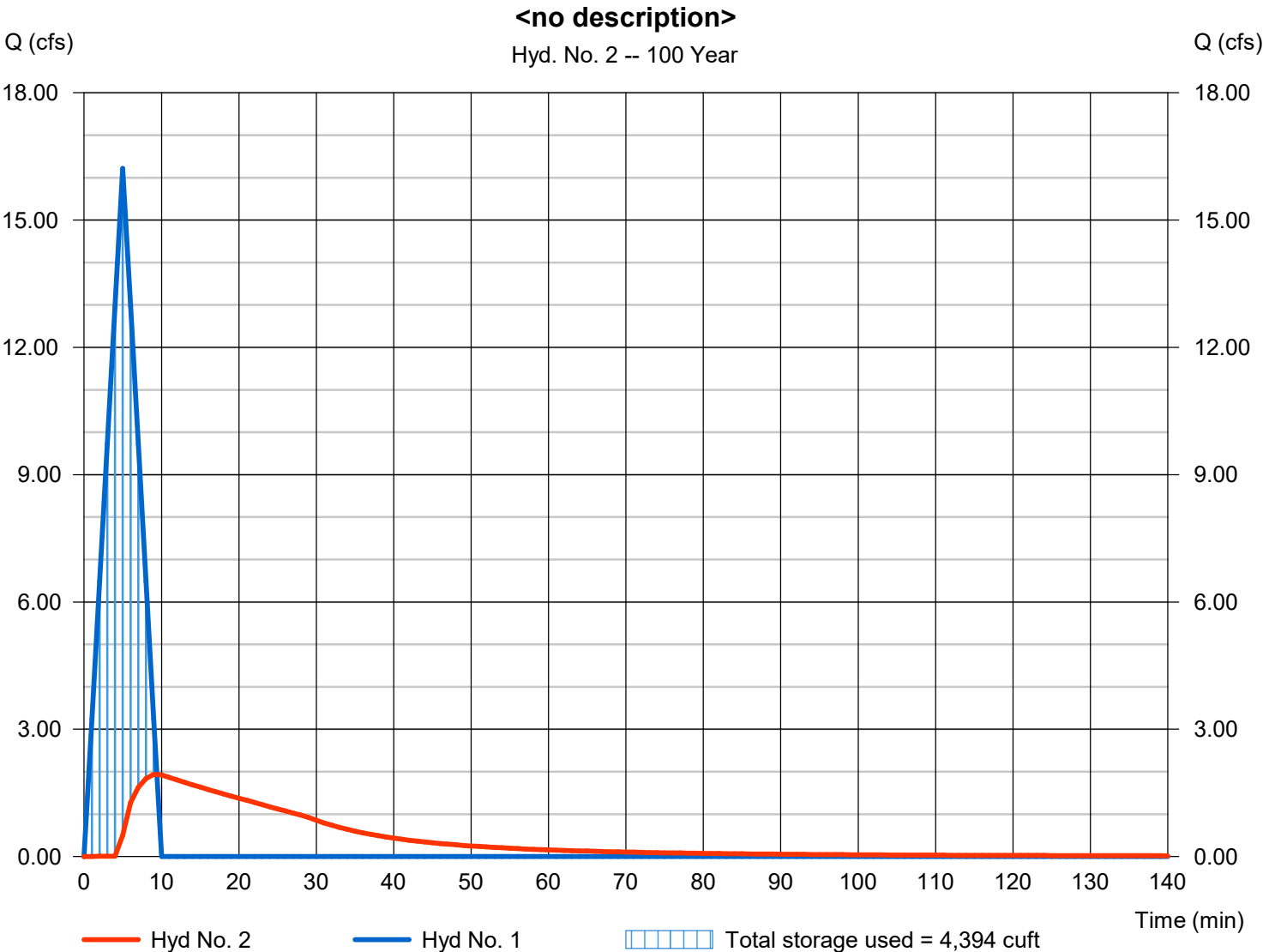
Thursday, 05 / 12 / 2022

## Hyd. No. 2

<no description>

Hydrograph type	= Reservoir	Peak discharge	= 1.935 cfs
Storm frequency	= 100 yrs	Time to peak	= 9 min
Time interval	= 1 min	Hyd. volume	= 4,230 cuft
Inflow hyd. No.	= 1 - Post Developed	Max. Elevation	= 998.27 ft
Reservoir name	= UG pipes	Max. Storage	= 4,394 cuft

Storage Indication method used.



# Hydrograph Report

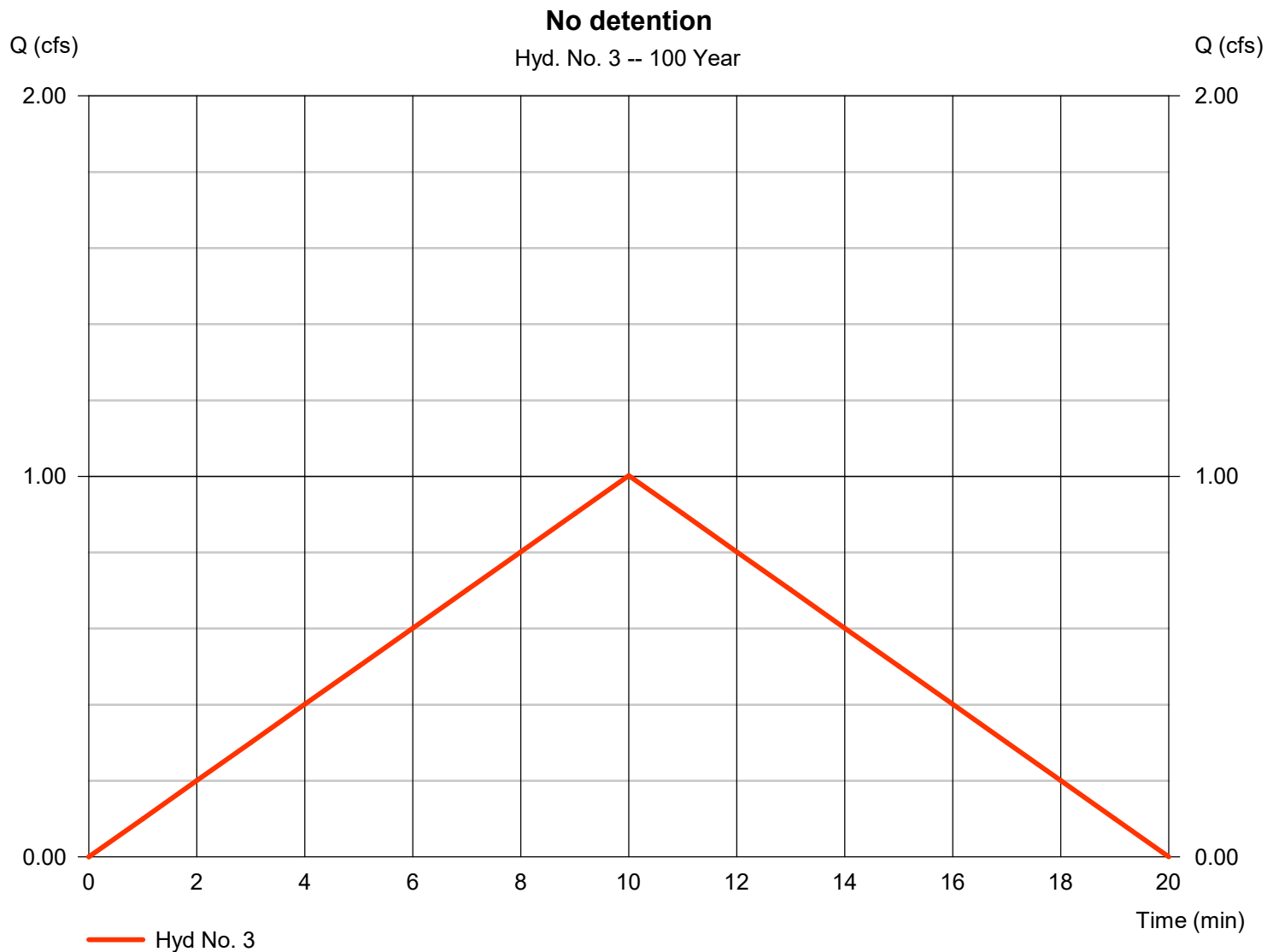
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 05 / 12 / 2022

## Hyd. No. 3

No detention

Hydrograph type	= Rational	Peak discharge	= 1.002 cfs
Storm frequency	= 100 yrs	Time to peak	= 10 min
Time interval	= 1 min	Hyd. volume	= 601 cuft
Drainage area	= 0.130 ac	Runoff coeff.	= 0.8
Intensity	= 9.636 in/hr	Tc by User	= 10.00 min
IDF Curve	= KCAPWA 1.37".IDF	Asc/Rec limb fact	= 1/1





# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

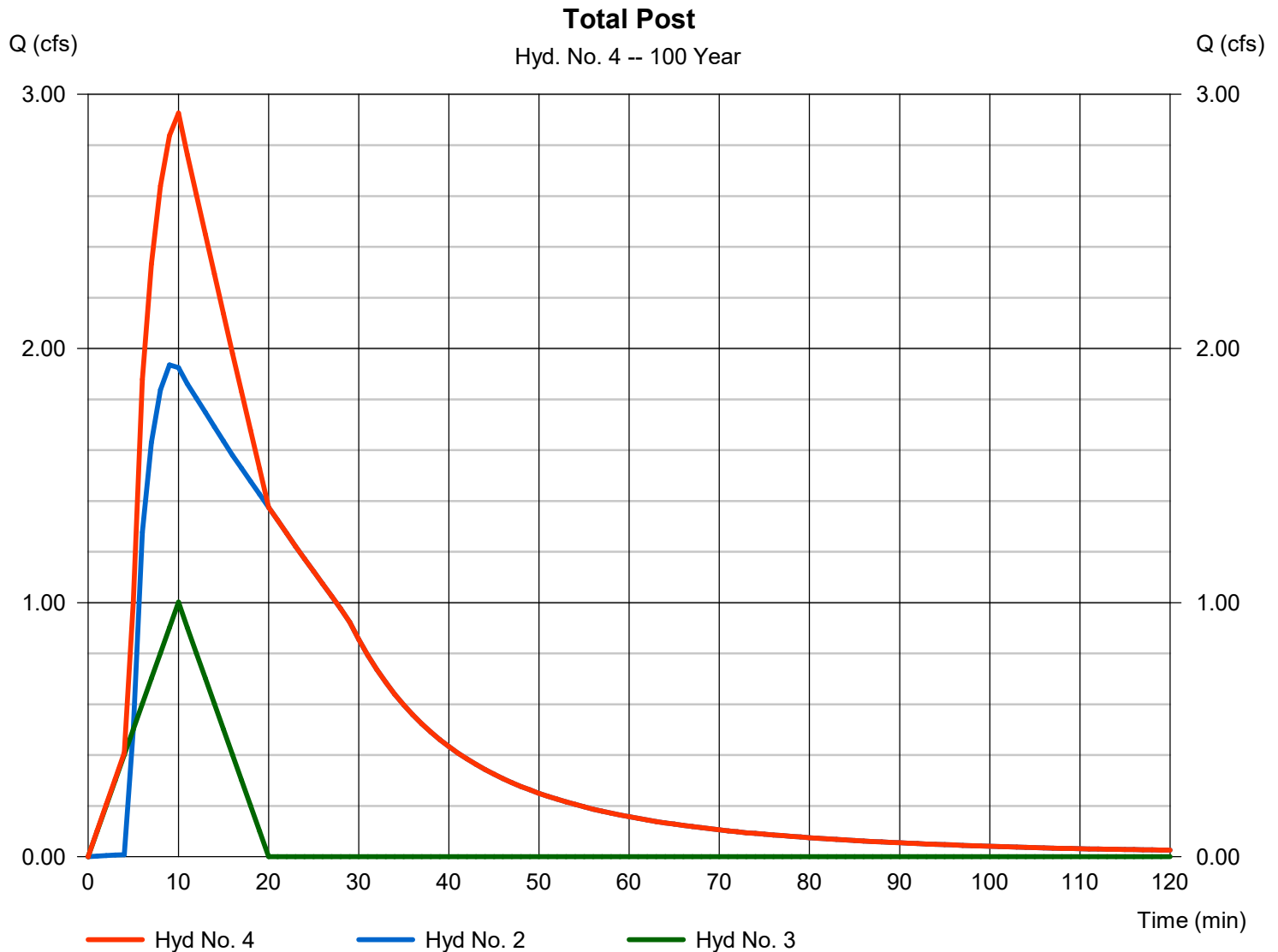
Thursday, 05 / 12 / 2022

## Hyd. No. 4

### Total Post

Hydrograph type = Combine  
Storm frequency = 100 yrs  
Time interval = 1 min  
Inflow hyds. = 2, 3

Peak discharge = 2.927 cfs  
Time to peak = 10 min  
Hyd. volume = 4,831 cuft  
Contrib. drain. area = 0.130 ac



# Hydraflow Rainfall Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 05 / 12 / 2022

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	2.9200	0.1000	0.0000	-----
2	110.7137	16.5000	0.9842	-----
3	0.0000	0.0000	0.0000	-----
5	168.3971	19.5000	1.0189	-----
10	183.3473	19.2000	1.0096	-----
25	103.5313	15.9000	0.8218	-----
50	235.4014	19.9000	1.0020	-----
100	83.7894	6.1000	0.7783	-----

File name: KCAPWA 1.37".IDF

$$\text{Intensity} = B / (T_c + D)^E$$

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92
2	5.41	4.40	3.71	3.21	2.83	2.53	2.29	2.09	1.92	1.78	1.66	1.55
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.47	5.35	4.56	3.98	3.52	3.16	2.86	2.62	2.41	2.24	2.08	1.95
10	7.35	6.08	5.18	4.52	4.00	3.59	3.26	2.98	2.74	2.54	2.37	2.22
25	8.51	7.14	6.17	5.46	4.90	4.46	4.10	3.79	3.54	3.31	3.12	2.95
50	9.39	7.82	6.70	5.86	5.20	4.68	4.25	3.90	3.60	3.34	3.12	2.92
100	12.87	9.64	7.81	6.62	5.77	5.14	4.65	4.25	3.92	3.65	3.41	3.21

T<sub>c</sub> = time in minutes. Values may exceed 60.

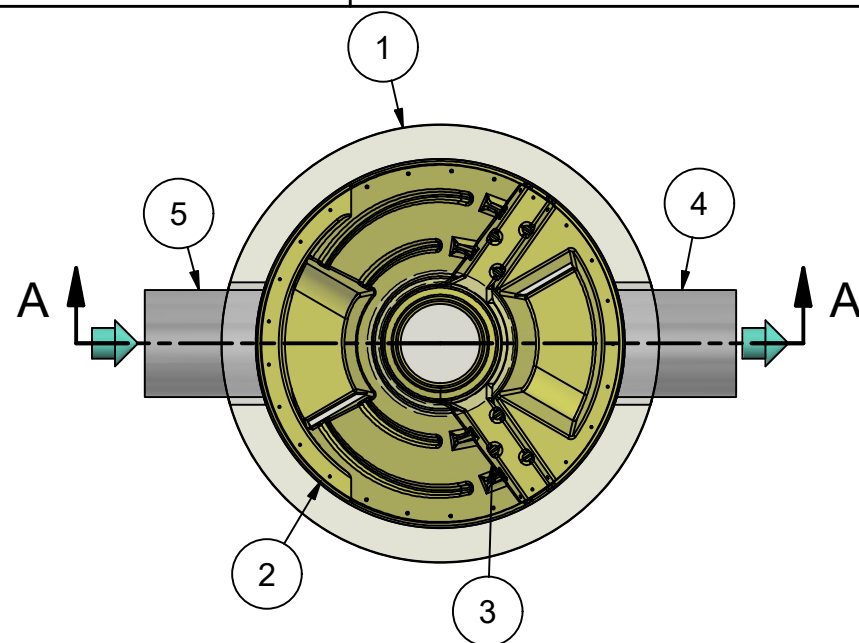
Precip. file name: P:\Civil Details\Davidson AE\Hydraflow Storm Sewer\SCS 24-hr Rainfall.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	2.85	3.50	0.00	4.50	5.30	6.10	6.90	7.50
SCS 6-Hr	0.00	1.80	0.00	0.00	2.60	2.90	0.00	4.00
Huff-1st	0.00	1.55	0.00	2.75	4.00	5.38	6.50	8.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	1.75	0.00	2.80	3.90	5.25	6.00	7.10

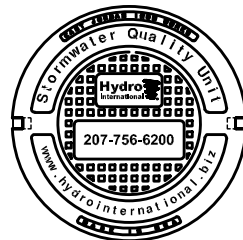
<b>Watershed Model Schematic.....</b>	<b>1</b>
<b>Hydrograph Return Period Recap.....</b>	<b>2</b>
<b>1 - Year</b>	
<b>Summary Report.....</b>	<b>3</b>
<b>Hydrograph Reports.....</b>	<b>4</b>
Hydrograph No. 1, Rational, Post Developed.....	4
Hydrograph No. 2, Reservoir, <no description>.....	5
Pond Report - UG pipes.....	6
Hydrograph No. 3, Rational, No detention.....	7
Hydrograph No. 4, Combine, Total Post.....	8
<b>2 - Year</b>	
<b>Summary Report.....</b>	<b>9</b>
<b>Hydrograph Reports.....</b>	<b>10</b>
Hydrograph No. 1, Rational, Post Developed.....	10
Hydrograph No. 2, Reservoir, <no description>.....	11
Hydrograph No. 3, Rational, No detention.....	12
Hydrograph No. 4, Combine, Total Post.....	13
<b>10 - Year</b>	
<b>Summary Report.....</b>	<b>14</b>
<b>Hydrograph Reports.....</b>	<b>15</b>
Hydrograph No. 1, Rational, Post Developed.....	15
Hydrograph No. 2, Reservoir, <no description>.....	16
Hydrograph No. 3, Rational, No detention.....	17
Hydrograph No. 4, Combine, Total Post.....	18
<b>100 - Year</b>	
<b>Summary Report.....</b>	<b>19</b>
<b>Hydrograph Reports.....</b>	<b>20</b>
Hydrograph No. 1, Rational, Post Developed.....	20
Hydrograph No. 2, Reservoir, <no description>.....	21
Hydrograph No. 3, Rational, No detention.....	22
Hydrograph No. 4, Combine, Total Post.....	23
<b>IDF Report.....</b>	<b>24</b>



## **Appendix E**

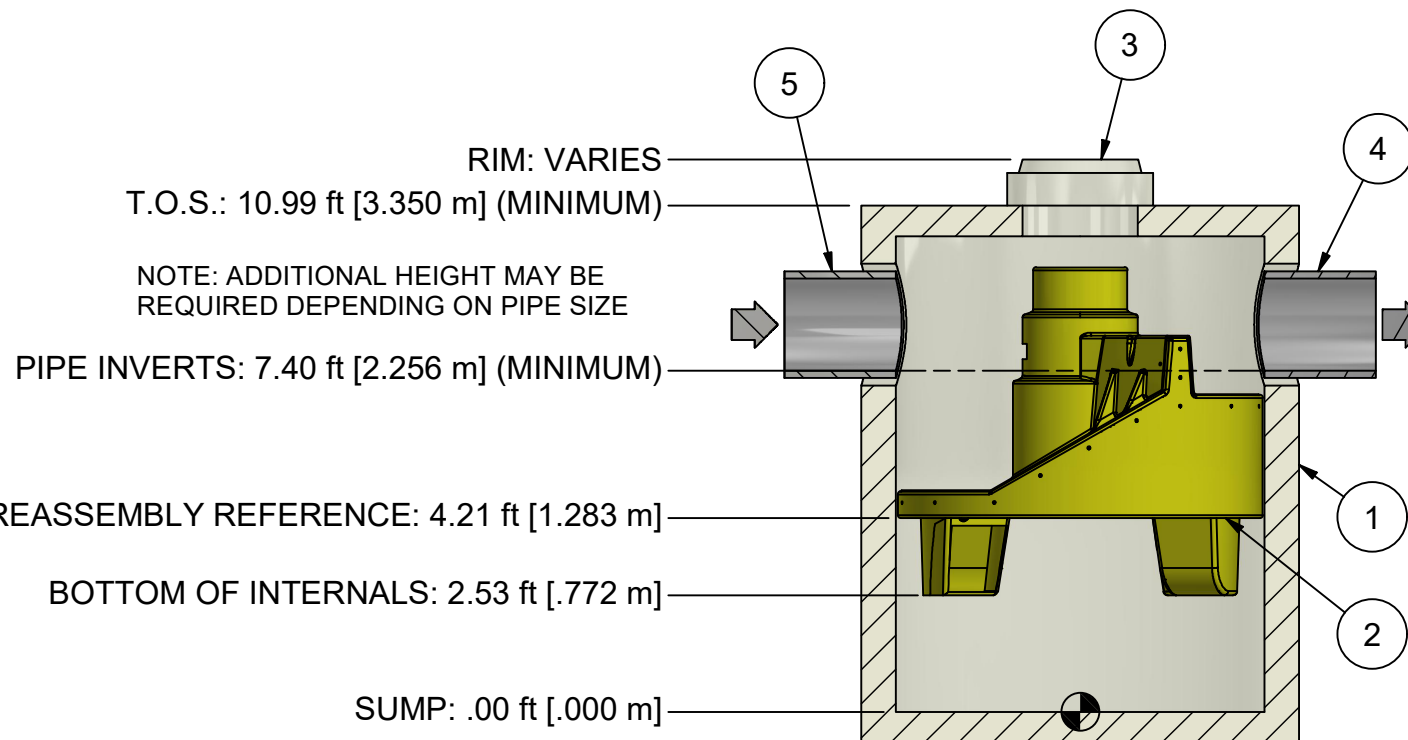


PLAN VIEW



## HYDRO FRAME AND COVER (INCLUDED)

GRADE RINGS BY OTHERS  
AS REQUIRED



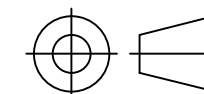
SECTION A-A

1. MANHOLE WALL AND SLAB THICKNESSES ARE NOT TO SCALE.

2. CONTACT HYDRO INTERNATIONAL FOR A BOTTOM OF STRUCTURE ELEVATION PRIOR TO SETTING FIRST DEFENSE MANHOLE.

3. CONTRACTOR TO CONFIRM RIM, PIPE INVERTS, PIPE DIA. AND PIPE ORIENTATION PRIOR TO RELEASE OF UNIT TO FABRICATION.

PROJECTION



IF IN DOUBT ASK

DATE:  
11/2/2021

SCALE:  
1:50

DRAWN BY:  
ER

CHECKED BY:  
MRJ

APPROVED BY

Title  
8-ft DIAMETER  
FIRST DEFENSE

GENERAL ARRANGEMENT

**Hydro**  
**International**

hydro-int.com

HYDRO INTERNATIONAL

WEIGHT:

MATERIAL:

STOCK NUMBER:

DRAWING NO.:  
FD GA-8

SHEET SIZE:  
B

SHEET:  
1 OF 1

Rev:  
-

### PRODUCT SPECIFICATION:

1. Peak Hydraulic Flow: 50.0 cfs (1415 l/s)
2. Min Sediment Storage Capacity: 2.8 cu. yd. (2.1 cu. m.)
3. Maximum Inlet/Outlet Pipe Diameters: 48 in. (1200 mm)
4. The treatment system shall use an induced vortex to separate pollutants from stormwater runoff.
5. For more product information including regulatory acceptances, please visit <https://hydro-int.com/en/products/first-defense>

### GENERAL NOTES:

1. General Arrangement drawings only. Contact Hydro International for site specific drawings.
2. The diameter of the inlet and outlet pipes may be no more than 48".
3. Multiple inlet pipes possible (refer to project plan).
4. Inlet/outlet pipe angle can vary to align with drainage network (refer to project plans).
5. Peak flow rate and minimum height limited by available cover and pipe diameter.
6. Larger sediment storage capacity may be provided with a deeper sump depth.

### PARTS LIST

ITEM	QTY	SIZE (in)	SIZE (mm)	DESCRIPTION
1	1	96	2400	I.D. PRECAST MANHOLE
2	1			INTERNAL COMPONENTS (PRE-INSTALLED)
3	1	30	750	FRAME AND COVER (ROUND)
4	1	48 (MAX)	1200 (MAX)	OUTLET PIPE (BY OTHERS)
5	1	48 (MAX)	1200 (MAX)	INLET PIPE (BY OTHERS)