STORMWATER REPORT

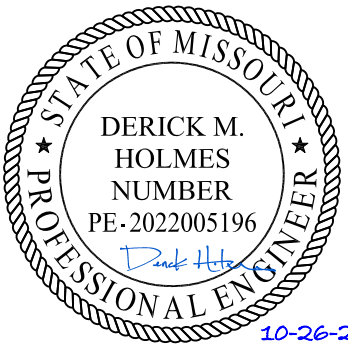
Proposed Fire Station #5

801 Missouri Highway 150
Lee's Summit, MO 64082

GLMVArchitecture

PREPARED BY: Derick Holmes, P.E.

REVISION 0: October 26, 2022



REVISION NUMBER	DESCRIPTION	DATE	PROFESSIONAL	NOTES
0	INITIAL ISSUE	2022-10-26	DERICK HOLMES	

CONTENTS

Appendices

References:

1. City of Lee's Summit, MO (January 13, 2022). *Section 5600 – Storm Drainage System & Facilities; City of Lee's Summit, Missouri Design Criteria*. Retrieved from https://cityofls.net/development-services/design/design-criteria/design-construction-manual-infrastructure
2. Kansas City Metropolitan Chapter of American Public Works Association (January 13, 2022). *Section 5600; Storm Drainage Systems & Facilities; February 16, 2011*. Retrieved from https://cityofls.net/development-services/design/design-criteria/design-construction-manual-infrastructure
3. City of Lee's Summit, MO (January 13, 2022). *City of Lee's Summit Watershed with Outfall Map.* Retrieved from https://cityofls.net/map-gallery/index.html?group=98ce512922a144cdbad6a03516df5897
4. NOAA. (January 5, 2022). *Point Precipitation Frequency (PF) Estimates*. Retrieved from https://hdsc.new.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nc
5. United States Department of Agriculture Natural Resources Conservation Service. (January 5, 2022). *Web Soil Survey.* Retrieved from https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
6. Kansas City Metropolitan Chapter of American Public Works Association (January 13, 2022). *Manual of Best Management Practices for Stormwater Quality, October 2012.* Retrieved from https://kcmetro.apwa.net/content/chapters/kcmetro.apwa.net/file/Specifications/BMPManual_Oct2012.pdf
7. Autodesk Civil 3D 2021
8. Autodesk Storm and Sanitary Analysis 2021

1.0 INTRODUCTION

1.1 PURPOSE STATEMENT

The purpose of this Report is to document the steps taken to size the stormwater system for the new Fire Station No. 5 to meet the City of Lee's Summit and Raintree Lake Village HOA stormwater requirements.

1.2 PROJECT BACKGROUND

The purpose of this proposed Project is to construct a new Fire Station No. 5. The project will be located at 801 Missouri Highway 150, Lee's Summit, MO 64082. As shown in Figure 1, the site is located at the intersection of Missouri Highway 150 and Regatta Drive.

Figure 1 - Site Vicinity Map

1.3 EXISTING LAND USES

The Project currently consists of 1.00 acre of undeveloped grassland. Surrounding land uses are developed. Adjacent properties include Commerce Bank and a Scooter's Coffee.

1.4 EXISTING STORMWATER RUNOFF

The topography for the property generally slopes from east to west with elevations varying between 1004 feet above mean sea level on the northeast side of the site to 994 feet at the site's lowest point at the southwest corner. An existing conditions plan is provided in Appendix A of this report (GS001).

Existing site runoff is currently captured in the existing stormwater conveyance system that outlets to Raintree Lake. As shown in Appendix C.3, the Project is in the Middle Big Creek Watershed.

1.5 EXISTING SOIL CONDITIONS

A United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey was performed and is documented in Appendix C.5. The report outlines the following soil classifications found:

Table 1 - USDA NRCS Web Soil Survey Soil Classifications

MAP UNIT SYMBOL	MAP UNIT NAME	ACRES IN AOI	PERCENT IN AOI	HYDROLOGIC SOIL GROUP
10082	Arisburg-Urban land complex, 1 to 5 percent slopes	1.00	100%	C
Totals for Area of Interest				

1.6 PROPOSED DRAINAGE CONCEPT

The proposed drainage includes capturing site runoff via curb inlet and area inlets located throughout the site. Two bioretention basins are located on the south side of the site to capture sheet runoff from the parking lot to comply with Raintree Lake HOA requirements for development of the site. See Appendix A for more information regarding the proposed drainage concept.

2.0 DESIGN BASIS

Per the City of Lee's Summit, MO (Appendices C.1 and C.2) and Raintree Lake HOA (Appendix C.6) requirements, the following applies to stormwater design of the Project:

Table 2 - Design Basis

#	REFERENCE	DESIGN BASIS ITEM	NOTES
1	2 5601.3 B2	***5601.3 General Requirements and Applicability*** *The design shall be accomplished under the direction of a Registered Professional Engineer qualified in the field of stormwater design. The design shall be based on land use in the tributary area as zoned, actually developed, or indicated by an adopted future land use plan, whichever basis produces the greatest runoff.*	Because the existing regional detention basin exists, this project is not required to utilize the Comprehensive Protection Method, as outlined in 5601.5 of Reference 1, for stormwater design.

		This design criterion shall apply to all development, including subdivision, which alters the surface of the land to create additional impervious surfaces, including, but not limited to, pavement, buildings, and structures with the following exceptions: ***B. New Construction Meeting the Following Criteria*** *2. Construction of any buildings, structures, and/or appurtenant service roads, drives, and walks on a site having previously provided stormwater management, as defined in Section 5601.5 A4 as part of a larger unit of development, OR a site previously relieved of stormwater management requirements.*	
2	2 5601.8	***5601.8 Levels of Service*** *A storm drainage system shall be provided that is capable of conveying the peak discharge generated by the 1% storm. If the in-system capacity established in this section is less the 1% storm peak discharge, then an overflow system as specified in Section 5601.5 -A-3 may provide the additional system capacity.* ***B. Protection for Streets*** ***1. Gutter Spread:*** *Water spread in streets shall meet the requirements in Section 5604.2 for the 10% design storm. These values are intended to establish a standard of accessibility for the widths (classes) of roadways listed during the 10% storm. When the local jurisdiction requires a higher standard for curb inlets, the conveyance system connected to the roadway must also meet that higher standard. If the roadway conveyance system connects to an underground system with lesser capacity, the system must be constructed to allow the discharge of that excess capacity into the overflow system.*	
3	2 5602.2	***5602.2 Computation Methods for Runoff*** *B. Baseline Unit Hydrograph Method: The following computer implementations of the unit hydrograph method are acceptable for all watersheds:* *SCS Technical Release No. 55 "Urban Hydrology for Small Watersheds", 2nd Edition, June 1986.*	

<table>
<tr><td>4</td><td>1
5603.1</td><td>Hydraulic Calculation for Pipes, Culverts, and Open Channels

“Enclosed systems will use the open channel, or gravity, flow design method for the appropriate design storm.”</td><td></td></tr>
<tr><td>5</td><td>2
5604.2</td><td>5604.2 Gutter Flow

Inlets shall be located to limit the width of flow in street gutters at the time of peak discharge for the design storm specified in 5601.8 B to the limits indicated in Table 5604-2.

Table 5604-2: Gutter Spread Criteria
<table><tr><th>Back to Back of Curb Street Width (feet)</th><th>Maximum Allowable Spread in Each Outside Curb Lane from Back of Curb* (feet)</th></tr><tr><td>28 or Less</td><td>12.0</td></tr><tr><td>Over 28 to 36</td><td>12.0</td></tr><tr><td>Over 36</td><td>12.0</td></tr><tr><td>Divided Roadways</td><td>As above for each direction roadway</td></tr></table>* spread may exceed these limits within 50 feet of a sump inlet.</td><td></td></tr>
<tr><td>6</td><td>Appendices C.6</td><td>A bio-swale or equivalent stormwater feature that is designed to concentrate and convey stormwater runoff, remove debris and pollution, and increase infiltration capabilities at the site, as approved by the City Engineer, shall be constructed on the site. This feature will be sized to treat the Water Quality Volume (WQV, 1.37”/24-hour rainfall), per American Public Works Association (APWA) Section 5600, for the site’s parking lot runoff. Treating the WQv will increase infiltration and reduce the amount of stormwater discharged into the existing detention basin.</td><td>See Drawing C-401 (Appendix A) for proposed Bioretention Basins.

Biorention Basin design based off Appendix C.7.</td></tr>
</table>

2.1 METHODOLOGY

To satisfy the requirements set forth in Table 2 above, the following design steps were taken:

1. Size the Project’s stormwater conveyance system for the 1 (100%), 10 (10%) and 100-year (1%), 24-hr storm event utilizing the SCS TR-55 Unit Hydrograph Method.
    a. The site’s post-development drainage characteristics were computed and documented in Appendix B.
        i. Each drainage area was assigned a composite curve number utilizing Table 5602-3 of Reference 2 (see Appendix C.2).

ii. A minimum system time of concentration of 5 minutes was assumed per Reference 2 (Appendix C.2).
iii. Point precipitation frequency estimates were found utilizing Reference 4 (Appendix C.4).
iv. Stage-storage curves for both bioretention basins were calculated and documented in Appendix B.5.

b. A stormwater model was created in AutoCAD Storm & Sanitary Analysis (SSA) (Reference 8). The peak discharges for the 1-, 10-, and 100-year, 24-hour storm events were documented in Appendix B. Gutter spreads for the system were checked for the 10-year, 24-hr storm event. The hydraulic grade line was checked in Structures 1001.AI and 1005.AI and verified to not rise above the lowest perforated pipe invert on the structure.

2. Size the Project's bioretention basins to comply with Appendix C.6 and C.7.
   a. Bioretention Basins 1 and 2 were sized for the Water Quality Volume (WQv) Storm Event per the design guidance provided in the Kansas City APWA Marc BMP Manual (Appendix C.7). Sizing calculations for the basins can be found in Appendix B.5.

3.0 SUMMARY

In summary, all stormwater conveyance pipes can safely pass the 100-year, 24-hour stormwater event. All inlet gutter spreads were checked against the 10-year, 24-hour storm event and were found to be satisfactory against the design criteria. Bioretention Basins 1 and 2 were sized to handle the WQv storm event.

APPENDIX A
PROJECT DRAWINGS

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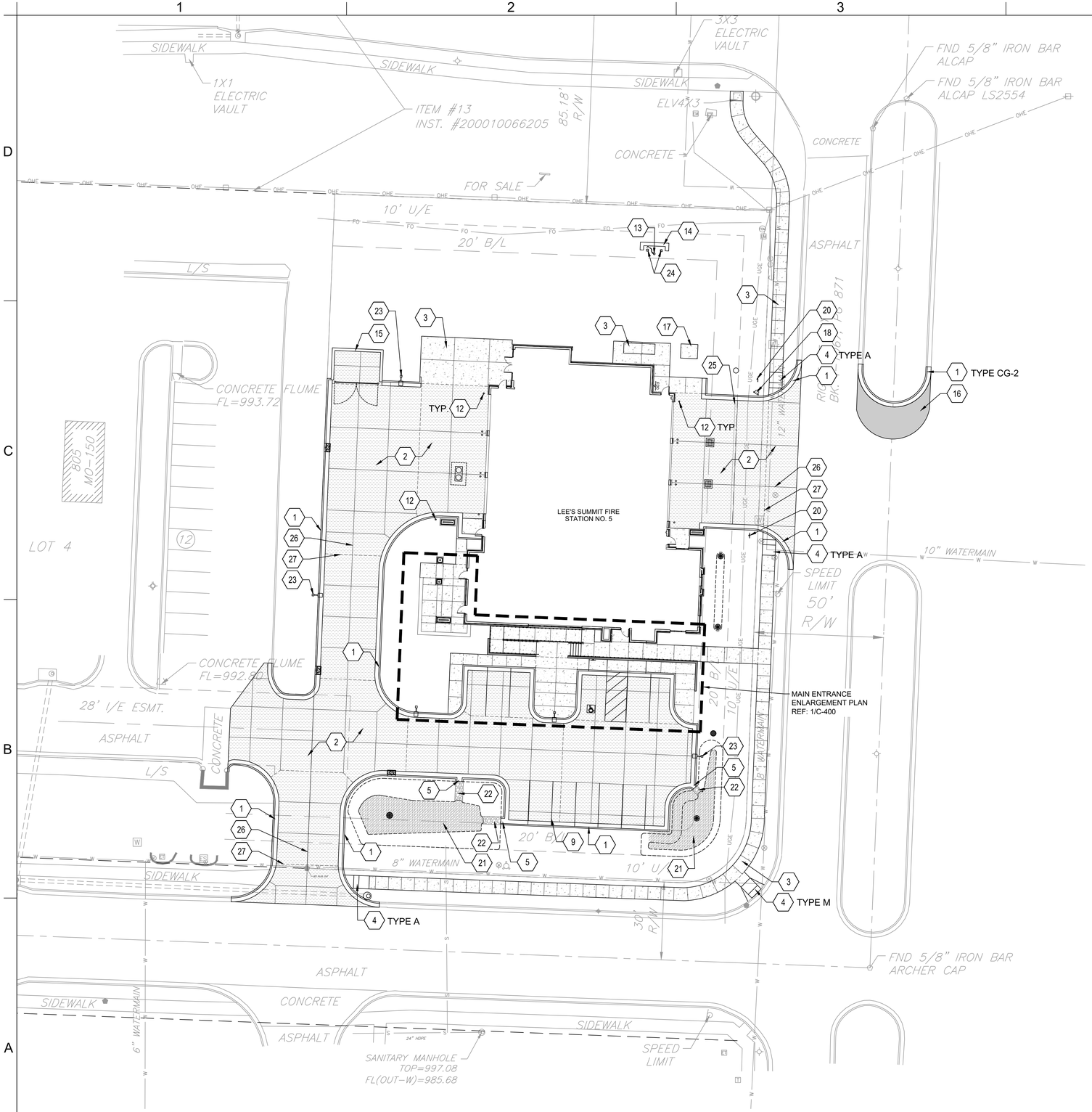
NOTE: THE DRAWINGS PRESENTED IN THIS APPENDIX ARE FOR REFERENCE ONLY AND ARE NOT TO BE USED AS THE BASIS OF CONSTRUCTION.



1 SITE PLAN

1" = 20'-0"

0 20' 40'

GRAPHIC SCALE 20'

N

GENERAL SITE NOTES:

1. PRIOR TO STARTING CONSTRUCTION THE CONTRACTOR SHALL BE RESPONSIBLE TO MAKE SURE THAT ALL REQUIRED PERMITS AND APPROVALS HAVE BEEN OBTAINED. NO CONSTRUCTION OR FABRICATION SHALL BEGIN UNTIL THE CONTRACTOR HAS RECEIVED AND THOROUGHLY REVIEWED ALL PLANS AND OTHER DOCUMENTS APPROVED BY ALL OF THE PERMITTING AUTHORITIES.
2. ALL WORK SHALL BE PERFORMED IN ACCORDANCE WITH THESE PLANS, SPECIFICATIONS AND THE REQUIREMENTS AND STANDARDS OF THE LOCAL GOVERNING AUTHORITY.
3. CONTRACTOR SHALL CONTACT DIG SAFE PRIOR TO ANY EXCAVATION/DIGGING.
4. ALL EXISTING CONDITIONS, DIMENSIONS, AND GRADES SHOWN ON THE PLANS SHALL BE FIELD VERIFIED BY THE CONTRACTOR PRIOR TO CONSTRUCTION. CONTRACTOR SHALL NOTIFY THE CONSTRUCTION MANAGER IF ANY DISCREPANCIES EXIST, PRIOR TO PROCEEDING WITH CONSTRUCTION, FOR NECESSARY PLAN OR GRADE CHANGES. NO EXTRA COMPENSATION SHALL BE PAID TO THE CONTRACTOR FOR WORK HAVING TO BE REDONE DUE TO DIMENSIONS OR GRADES SHOWN INCORRECTLY ON THESE PLANS IF SUCH NOTIFICATION HAS NOT BEEN GIVEN.
5. CONTRACTOR SHALL REPAIR ALL DISTURBED LANDSCAPING.
6. REFERENCE GRADING & DRAINAGE PLAN FOR DETAILED CURB TRANSITION POINTS.

KEYNOTES

1. TYP. CURB & GUTTER TYPE CG-1 UNLESS OTHERWISE NOTED. LEE'S SUMMIT STANDARD DETAIL REF: 3/C-503
2. TYP. CONCRETE PAVING REF: 1/C-500
3. CONCRETE SIDEWALK PAVING REF: 1/C-504
4. ADA SIDEWALK RAMP. REF: 3/C-504
5. CURB CUT REF: 11/C-500
6. RETAINING WALL REF: STRUCTURAL
7. CONCRETE STEPS REF: 4/C-502
8. ADA RAMP AND GALVANIZED HANDRAIL REF: 2, 3, 4, 5/C-502
9. PAVEMENT STRIPING REF: 3/C-500
10. ADA PAVEMENT MARKING REF: 4/C-500
11. ADA PARKING SIGN REF: 5/C-500
12. TYP. SAFETY BOLLARD REF: 2/C-500
13. FLAG POLE REF: 7/C-500
14. MONUMENT SIGN REF: 8-10/C-500
15. DUMPSTER ENCLOSURE REF: 1-6/C-501
16. ROADWAY ASPHALT PATCH LEE'S SUMMIT STANDARD DETAIL REF: 2/C-504
17. TRANSFORMER CONCRETE PAD REF: MEP
18. RELOCATED FIRE HYDRANT REF: C-220
19. SCREEN WALL REF: ARCH
20. DO NOT ENTER SIGN REF: 6/C-500
21. MISSOURI RIVER ROCK, 1"-1½" IN SIZE. PLACED OVER GEOTEXTILE FABRIC. REF: 3 & 4/C-401
22. MISSOURI RIVER ROCK RIPRAP, 3"-5" IN SIZE. PLACED OVER GEOTEXTILE FABRIC. REF: 11/C-500
23. TYP. AREA LIGHTING REF: ELECTRICAL
24. TYP. FLAG POLE LIGHTING REF: ELECTRICAL
25. LIMIT OF SNOW MELT SYSTEM REF: MEP
26. CONSTRUCTION JOINT REF: 2/C-503
27. ISOLATION JOINT REF: 2/C-503

LEGEND

- TYP. CURB & GUTTER
- TYP. CONCRETE PAVING
- ASPHALT PATCH
- CONCRETE SIDEWALK
- MISSOURI RIVER ROCK
- RETAINING WALL

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FIRE STATION #5
CITY OF LEE'S SUMMIT

801 MISSOURI HIGHWAY 150
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100% CONSTRUCTION DOCUMENT DRAWINGS

REVISIONS:

#	Description	Date

DERICK HOLMES - CIVIL ENGINEER
MO# PE-2022005196

PROJECT NO:	18225R21001
DATE:	10.26.2022
DRAWN BY:	KDW
CHK'D BY:	DMH

SITE PLAN

C-100

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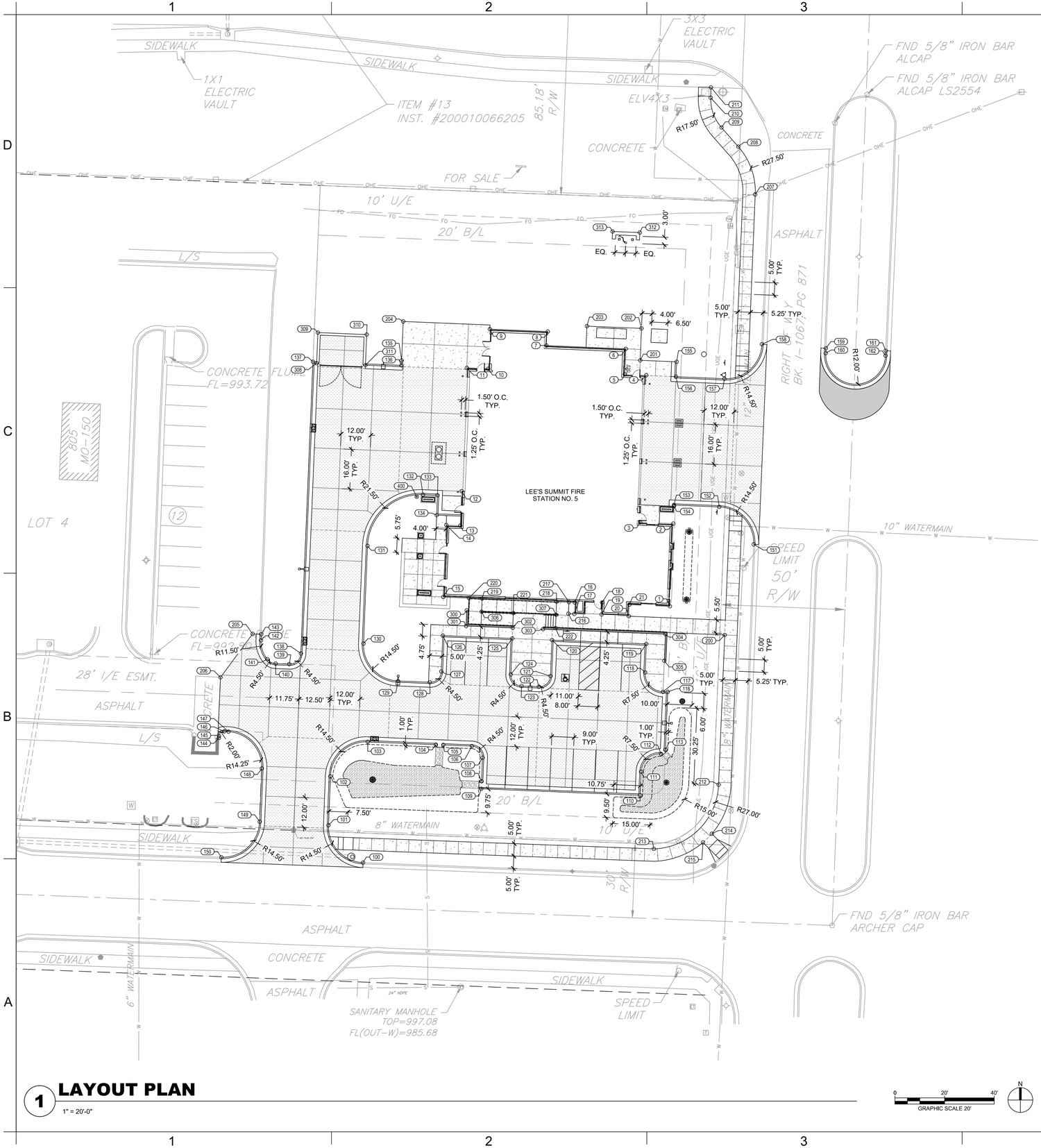

1 LAYOUT PLAN

1" = 20'-0"

LAYOUT NOTES

1. ALL CURB POINTS INDICATE BACK OF CURB UNLESS OTHERWISE NOTED.
2. SEE UTILITY PLAN FOR ALL UTILITY LOCATIONS AND LAYOUT.

LAYOUT TABLE

POINT NO.	NORTHING	EASTING	DESCRIPTION
1	977961.0508	2818527.9968	BLDG
2	977994.3558	2818529.3645	BLDG
3	977994.9029	2818516.0424	BLDG
4	978054.1030	2818518.4736	BLDG
5	978054.4586	2818509.8143	BLDG
6	978064.7417	2818510.2357	BLDG
7	978066.0534	2818478.2947	BLDG
8	978071.7029	2818478.8291	BLDG
9	978072.6603	2818455.5154	BLDG
10	978056.7154	2818454.8606	BLDG
11	978057.0711	2818446.2012	BLDG
12	978007.4046	2818444.1615	BLDG
13	977993.5413	2818443.5922	BLDG
14	977993.7738	2818437.9302	BLDG
15	977964.7985	2818436.7403	BLDG
16	977962.6237	2818489.6956	BLDG
17	977957.9610	2818489.5041	BLDG
18	977962.5471	2818500.7018	BLDG
19	977957.7594	2818500.5051	BLDG
20	977957.0583	2818511.4856	BLDG
21	977961.7210	2818511.6771	BLDG
100	977857.8114	2818404.4309	CURB
101	977872.8579	2818390.5043	CURB
102	977892.5228	2818391.2609	CURB
103	977906.4532	2818406.3451	CURB
104	977905.3279	2818433.7559	CURB
105	977905.2049	2818436.7534	CURB
106	977904.7332	2818448.2432	CURB
107	977900.0523	2818452.5548	CURB
108	977890.5603	2818452.1650	CURB
109	977887.5629	2818452.0419	CURB
110	977884.9368	2818515.9880	CURB
111	977894.4288	2818516.3778	CURB
112	977901.6058	2818524.3953	CURB
113	977903.2415	2818526.1710	CURB
116	977926.5147	2818527.1267	CURB
117	977926.5937	2818525.2050	CURB
118	977934.3951	2818518.0191	CURB
119	977945.8854	2818518.4910	CURB
120	977947.4446	2818480.5230	CURB
121	977932.9569	2818479.9280	CURB
122	977928.6453	2818475.2471	CURB
123	977928.9325	2818468.2530	CURB
124	977933.6134	2818463.9415	CURB
125	977948.1012	2818464.5365	CURB
126	977949.2501	2818436.5600	CURB
127	977934.7623	2818435.9651	CURB
128	977930.4507	2818431.2842	CURB
129	977930.9750	2818418.5014	CURB
130	977946.0563	2818404.6086	CURB
131	977985.3941	2818406.2199	CURB
132	978005.9963	2818428.5798	CURB
133	978005.7578	2818434.4152	CURB
134	977997.7681	2818434.0887	CURB
135	978060.0648	2818419.9688	CURB
136	978058.0664	2818419.8867	CURB
137	978059.5293	2818384.2588	CURB
138	977942.0584	2818379.4156	CURB
139	977937.7481	2818374.7335	CURB
140	977937.9760	2818369.2236	CURB
141	977939.7570	2818365.8193	CURB
142	977947.3249	2818363.3264	CURB
143	977949.8057	2818363.4146	CURB
144	977908.0055	2818346.3667	CURB
145	977908.7720	2818346.4110	CURB
146	977910.6535	2818348.5228	CURB
147	977910.5543	2818350.2429	CURB

LAYOUT TABLE

POINT NO.	NORTHING	EASTING	DESCRIPTION
148	977895.7090	2818363.6726	CURB
149	977874.3278	2818362.7921	CURB
150	977859.9520	2818347.3463	CURB
151	977985.9905	2818561.7588	CURB
152	978001.0741	2818547.8782	CURB
153	978001.8385	2818529.6722	CURB
154	978001.3499	2818529.6518	CURB
155	978059.5199	2818530.7136	CURB
156	978053.5172	2818530.4621	CURB
157	978052.6995	2818549.9744	CURB
158	978066.5984	2818565.0696	CURB
159	978064.9792	2818590.8405	CURB
160	978062.9815	2818590.7572	CURB
161	978063.9999	2818614.9252	CURB
162	978062.0135	2818614.8424	CURB
200	977949.5112	2818550.0897	PAVE
201	978060.1225	2818516.0497	PAVE
202	978072.9884	2818516.5781	PAVE
203	978073.8911	2818494.5966	PAVE
204	978075.7618	2818420.6133	PAVE
205	977949.9284	2818359.9668	PAVE
206	977932.4304	2818347.0272	PAVE
207	978126.8807	2818562.3780	PAVE
208	978146.1608	2818555.5595	PAVE
209	978153.8724	2818548.7836	PAVE
210	978165.8776	2818544.4357	PAVE
211	978170.0400	2818544.5438	PAVE
212	977889.2129	2818547.6134	PAVE
213	977863.3360	2818521.5435	PAVE
214	977869.4400	2818544.8847	PAVE
215	977865.9177	2818541.3361	PAVE
216	977958.0571	2818487.1638	PAVE
217	977962.7199	2818487.3552	PAVE
218	977962.9161	2818482.3591	PAVE
219	977964.1560	2818452.3847	PAVE
220	977964.3751	2818447.0505	PAVE
221	977958.3239	2818464.9486	PAVE
222	977952.3103	2818481.9326	PAVE
300	977959.3831	2818446.1832	WALL
301	977953.1180	2818445.9361	WALL
302	977952.3469	2818464.7108	WALL
303	977951.8460	2818476.9093	WALL
304	977949.8217	2818526.2015	WALL
305	977939.0807	2818525.7604	WALL
306	977958.8485	2818452.1754	WALL
307	977957.6175	2818482.1505	WALL
308	978058.9715	2818385.7372	WALL
309	978071.2940	2818386.2453	WALL
310	978070.4837	2818405.8986	WALL
311	978058.1613	2818405.3905	WALL
312	978111.5826	2818515.8967	WALL
313	978112.0038	2818504.9051	WALL
400	978005.1651	2818426.0425	BOLLARD

LEGEND

- TYP. CURB & GUTTER
- TYP. CONCRETE PAVING
- ASPHALT PATCH
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CITY OF LEE'S SUMMIT

801 MISSOURI HIGHWAY 150
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100% CONSTRUCTION DOCUMENT DRAWINGS

REVISIONS:

#	Description	Date

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MO# PE-2022005196

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PROJECT NO:	18225R21001
DATE:	10.26.2022
DRAWN BY:	KDW
CHK'D BY:	DMH

LAYOUT PLAN

C-101

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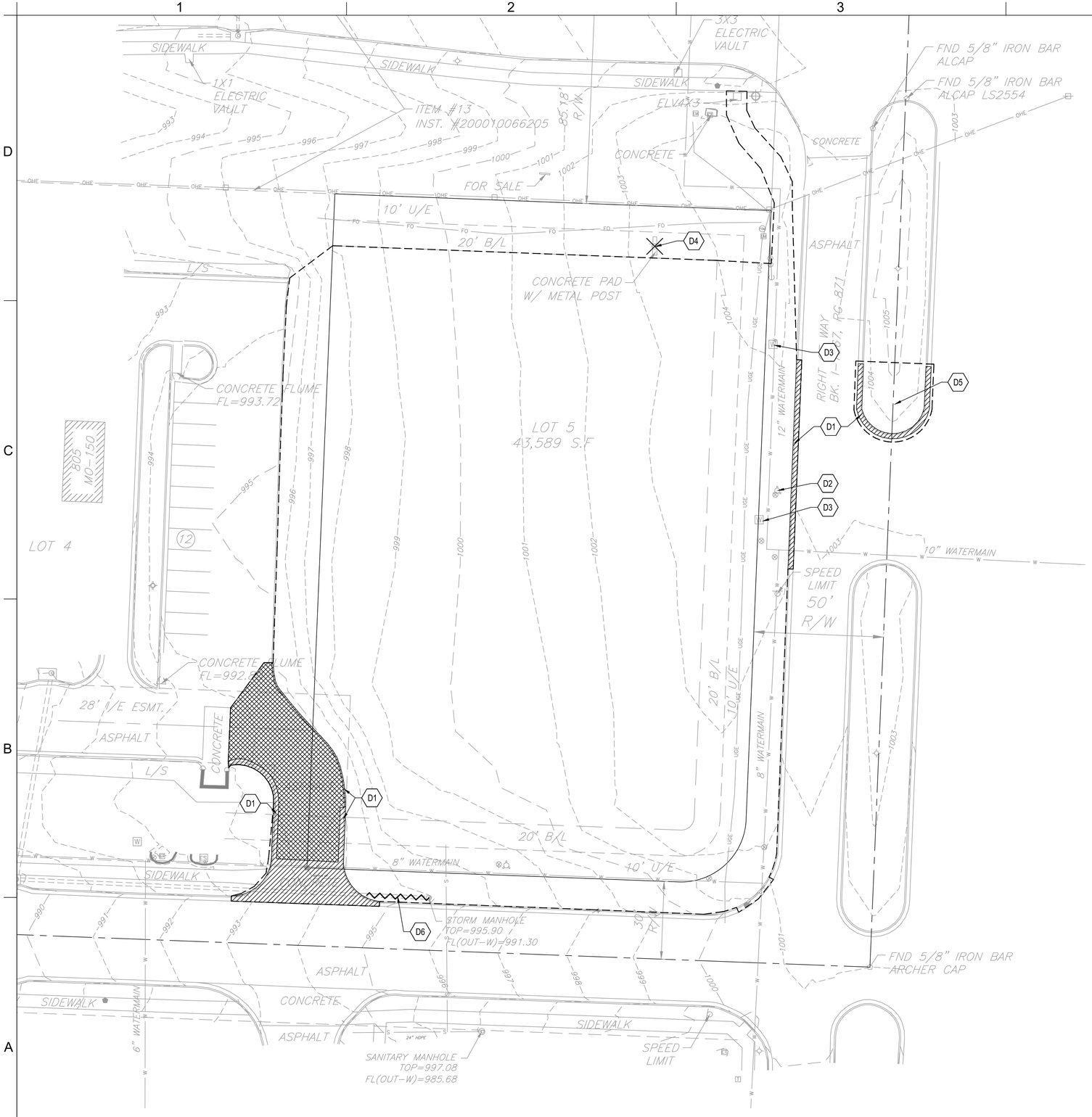

1 DEMOLITION PLAN

1" = 20'-0"

GRAPHIC SCALE 20'

GENERAL DEMOLITION NOTES:

1. THE CONTRACTOR IS RESPONSIBLE FOR THE DEMOLITION, REMOVAL, AND DISPOSAL (IN A LOCATION APPROVED BY ALL GOVERNING AUTHORITIES) OF ALL STRUCTURES, PADS, WALLS, FLUMES, FOUNDATIONS, PARKING, DRIVES, DRAINAGE STRUCTURES, UTILITIES, UNDERGROUND STORAGE TANKS, ETC., SUCH THAT THE IMPROVEMENTS SHOWN ON THE REMAINING PLANS CAN BE CONSTRUCTED. ALL FACILITIES TO BE REMOVED SHALL BE UNDERCUT TO SUITABLE MATERIAL AND BROUGHT TO GRADE WITH SUITABLE COMPACTED FILL MATERIAL.
2. THE CONTRACTOR IS RESPONSIBLE FOR REMOVING ALL DEBRIS FROM THE SITE AND DISPOSING THE DEBRIS IN A LAWFUL MANNER. THE CONTRACTOR IS RESPONSIBLE FOR OBTAINING ALL PERMITS REQUIRED FOR DEMOLITION AND DISPOSAL.
3. THE CONTRACTOR SHALL COORDINATE WITH RESPECTIVE UTILITY COMPANIES PRIOR TO THE REMOVAL AND/OR RELOCATION OF UTILITIES. THE CONTRACTOR SHALL COORDINATE WITH THE UTILITY COMPANY CONCERNING PORTIONS OF WORK WHICH MAY BE PERFORMED BY THE UTILITY COMPANY'S FORCES AND ANY FEES WHICH ARE TO BE PAID TO THE UTILITY COMPANY FOR THEIR SERVICES. THE CONTRACTOR IS RESPONSIBLE FOR PAYING ALL FEES AND CHARGES.
4. EXISTING PIPING AND UTILITIES SHOWN ARE NOT TO BE INTERPRETED AS THE EXACT LOCATION, OR AS THE ONLY OBSTACLES THAT MAY OCCUR ON THE SITE. VERIFY EXISTING CONDITIONS AND PROCEED WITH CAUTION AROUND ANY ANTICIPATED FEATURES. GIVE NOTICE TO ALL UTILITY COMPANIES REGARDING WORK TO BE PERFORMED AND REMOVAL OF ALL SERVICE LINES. CAP ALL LINES BEFORE PROCEEDING WITH THE WORK. UTILITIES DETERMINED TO BE ABANDONED AND LEFT IN PLACE SHALL BE GROUTED IF UNDER BUILDING.
5. ELECTRICAL, TELEPHONE, CABLE, WATER, FIBER OPTIC CABLE AND/OR GAS LINES NEEDING TO BE REMOVED OR RELOCATED SHALL BE COORDINATED WITH THE AFFECTED UTILITY COMPANY. ADEQUATE TIME SHALL BE PROVIDED FOR RELOCATION AND CLOSE COORDINATION WITH THE UTILITY COMPANY AS NECESSARY TO PROVIDE A SMOOTH TRANSITION IN UTILITY SERVICE. CONTRACTOR SHALL PAY CLOSE ATTENTION TO EXISTING UTILITIES WITHIN ROAD RIGHT-OF-WAY DURING CONSTRUCTION.
6. CONTRACTOR MUST PROTECT THE PUBLIC AT ALL TIMES WITH FENCING, BARRICADES, ENCLOSURES, ETC., (AND OTHER APPROPRIATE BMP'S) AS APPROVED BY OWNER, AUTHORITY HAVING JURISDICTION, AND CONSTRUCTION MANAGER.
7. CONTINUOUS ACCESS SHALL BE MAINTAINED FOR THE SURROUNDING PROPERTIES AT ALL TIMES DURING DEMOLITION OF THE EXISTING FACILITIES.
8. PRIOR TO ANY DEMOLITION OCCURRING, ALL EROSION CONTROL DEVICES MUST BE INSTALLED.
9. ALL DISTURBED FEATURES SHALL BE RESTORED OR RELOCATED AS REQUIRED TO THE SATISFACTION OF THE OWNER. CONTRACTOR SHALL REPAIR/REPLACE ANY SURROUNDING FEATURES DAMAGED AS A RESULT OF CONSTRUCTION ACTIVITIES AT NO ADDITIONAL COST AND TO THE SATISFACTION OF THE OWNER.
10. THE CONTRACTOR SHALL TAKE ALL NECESSARY PRECAUTIONS TO AVOID PROPERTY DAMAGE TO ADJACENT PROPERTIES DURING THE CONSTRUCTION PHASES OF THIS PROJECT. THE CONTRACTOR WILL BE HELD SOLELY RESPONSIBLE FOR ANY DAMAGES TO THE ADJACENT PROPERTIES OCCURRING DURING THE CONSTRUCTION PHASES OF THIS PROJECT.
11. CONTRACTOR TO CLEAR SITE TO EXTENTS NECESSARY TO CONSTRUCT PROPOSED IMPROVEMENTS.
12. CONTRACTOR SHALL REMOVE ALL TREES AND SHRUBS WITHIN PROPERTY BOUNDARY LIMITS NOT INDICATED AS PROTECTED OR TO REMAIN.

KEYNOTES

- D1 REMOVE CURB & GUTTER
- D2 RELOCATE FIRE HYDRANT REF: C-220
- D3 ADJUST WATER VALVE TO PROPOSED GRADE
- D4 REMOVE SIGN POST AND FOUNDATION. CAP AND ABANDON ALL ELECTRICAL IN PLACE
- D5 MOVE BOULDERS AND LANDSCAPE TO BE EQUIDISTANT FROM CURB AS EXISTING CONDITION
- D6 REMOVE STORMWATER PIPE. REMOVE AND RELOCATE STORM STRUCTURE, REF: C-104

LEGEND

- PAVEMENT TO BE REMOVED
- ASPHALT PAVEMENT TO BE REMOVED
- SITE FEATURE TO BE REMOVED
- APPROXIMATE LIMITS OF DISTURBANCE

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FIRE STATION #5
CITY OF LEE'S SUMMIT

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LEE'S SUMMIT, MISSOURI 64082

100% CONSTRUCTION DOCUMENT DRAWINGS

REVISIONS:

#	Description	Date

DERICK HOLMES - CIVIL ENGINEER
MO# PE-2022005196

PROJECT NO:	18225R21001
DATE:	10.26.2022
DRAWN BY:	KDW
CHK'D BY:	DMH

DEMOLITION PLAN

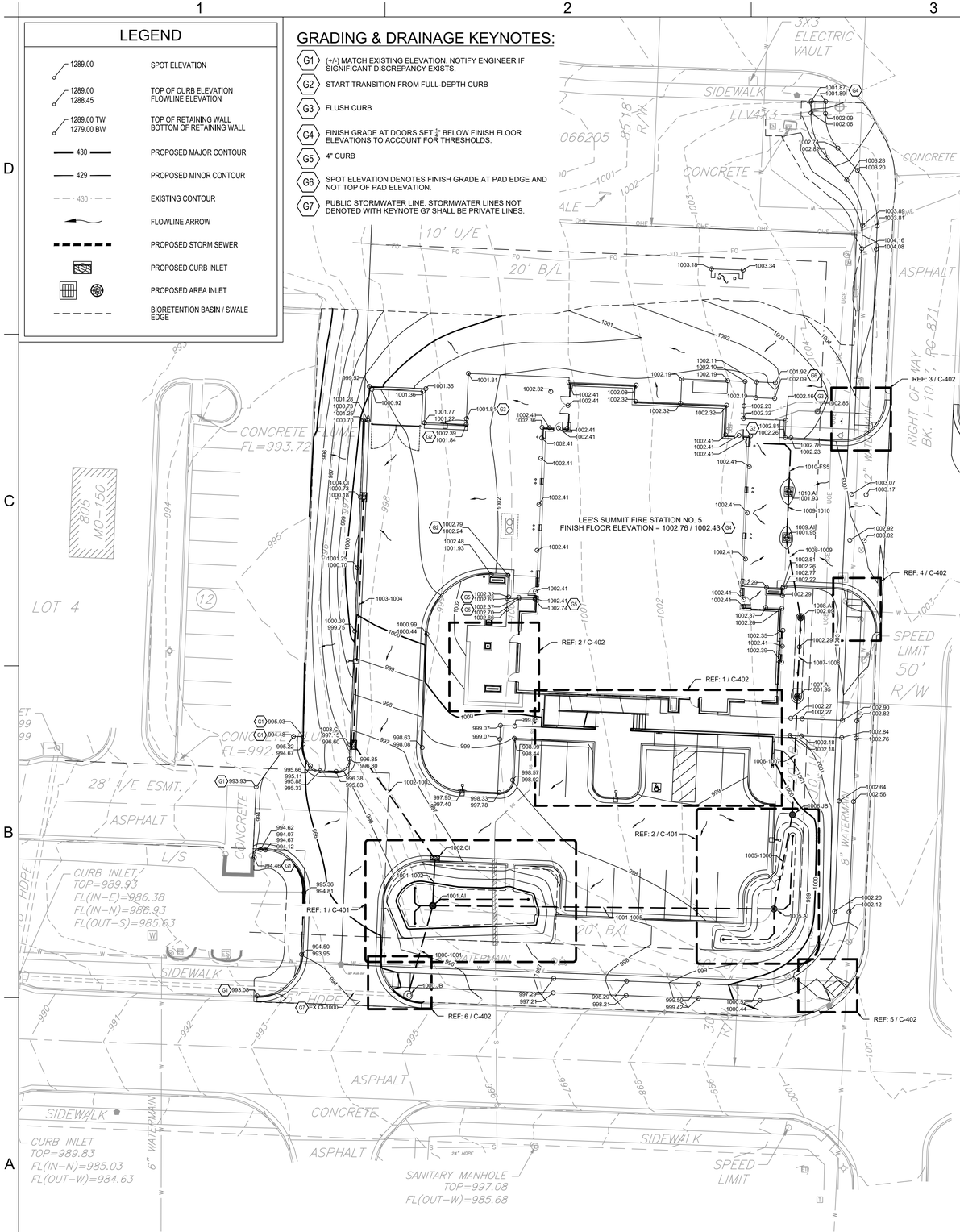
C-102

LEGEND

1289.00	SPOT ELEVATION
1289.00 1288.45	TOP OF CURB ELEVATION FLOWLINE ELEVATION
1289.00 TW 1279.00 BW	TOP OF RETAINING WALL BOTTOM OF RETAINING WALL
430	PROPOSED MAJOR CONTOUR
429	PROPOSED MINOR CONTOUR
430	EXISTING CONTOUR
	FLOWLINE ARROW
	PROPOSED STORM SEWER
	PROPOSED CURB INLET
	PROPOSED AREA INLET
	BIORETENTION BASIN / SWALE EDGE

GRADING & DRAINAGE KEYNOTES:

- G1 (+/-) MATCH EXISTING ELEVATION. NOTIFY ENGINEER IF SIGNIFICANT DISCREPANCY EXISTS.
- G2 START TRANSITION FROM FULL-DEPTH CURB
- G3 FLUSH CURB
- G4 FINISH GRADE AT DOORS SET ½" BELOW FINISH FLOOR ELEVATIONS TO ACCOUNT FOR THRESHOLDS.
- G5 4" CURB
- G6 SPOT ELEVATION DENOTES FINISH GRADE AT PAD EDGE AND NOT TOP OF PAD ELEVATION.
- G7 PUBLIC STORMWATER LINE. STORMWATER LINES NOT DENOTED WITH KEYNOTE G7 SHALL BE PRIVATE LINES.



GENERAL GRADING & DRAINAGE NOTES:

1. SITE GRADING MUST BE PERFORMED IN ACCORDANCE WITH THESE PLANS, SPECIFICATIONS, AND THE RECOMMENDATIONS SET FORTH IN THE GEOTECHNICAL REPORT AS REFERENCED IN THIS PLAN SET. THE CONTRACTOR MUST FOLLOW THE REQUIREMENTS OF ALL MUNICIPAL, COUNTY, STATE, AND FEDERAL LAWS, WHICH HAVE JURISDICTION OVER THIS PROJECT.
2. ALL PROPOSED CONTOUR LINES AND SPOT ELEVATIONS SHOWN ARE FINISH GROUND ELEVATIONS. CONTRACTOR SHALL ACCOUNT FOR PAVEMENT DEPTHS, BUILDING PADS, LOW VOLUME CHANGE MATERIAL, TOPSOIL, ETC. WHEN GRADING THE SITE.
3. ALL DISTURBED AREAS THAT ARE NOT TO BE PAVED (GREEN SPACES) SHALL BE FINISH GRADED WITH A MINIMUM OF SIX INCHES OF TOPSOIL.
4. ALL EXCAVATIONS AND EMBANKMENTS SHALL COMPLY WITH THE RECOMMENDATIONS PROVIDED BY THE GEOTECHNICAL ENGINEER.
5. FINISHED GRADES SHALL NOT BE STEEPER THAN 3:1, UNLESS NOTED OTHERWISE ON THE PLANS.
6. CONTRACTOR SHALL FIELD VERIFY ALL EXISTING ELEVATIONS OF CONNECTION POINTS AS SHOWN ON GRADING PLANS. NOTIFY ENGINEER IF DISCREPANCY EXISTS FOR DIRECTION.
7. ALL GRADES SHALL BE CONTOURED SMOOTHLY WITH GENTLE ROUNDING/SHAPING OF ALL AFFECTED LAND SURFACES. ABRUPT TRANSITIONS AT THE TOP OF SLOPES WHERE PROPOSED GRADES MEET EXISTING ARE NOT ACCEPTABLE. GRADING SHALL BE APPROVED BY THE OWNER'S REPRESENTATIVE PRIOR TO THE ADDITION OF THE TOPSOIL LAYER.
8. SEE DRAWINGS C-230 AND C-231 FOR STORMWATER PROFILE DRAWINGS.

ADA NOTES:

1. ALL ACCESSIBLE (A.K.A. ADA) COMPONENTS AND ACCESSIBLE ROUTES MUST BE CONSTRUCTED TO MEET, AT A MINIMUM, THE MORE STRINGENT OF: (A) THE REQUIREMENTS OF THE "AMERICANS WITH DISABILITIES ACT" (ADA) CODE (42 U.S.C. § 12101 ET SEQ. AND 42 U.S.C. § 4151 ET SEQ.); AND (B) ANY APPLICABLE LOCAL AND STATE GUIDELINES, AND ANY AND ALL AMENDMENTS TO BOTH, WHICH ARE IN EFFECT WHEN THESE PLANS WERE COMPLETED.
2. THE CONTRACTOR MUST REVIEW ALL DOCUMENTS REFERENCED IN THESE NOTES FOR ACCURACY, COMPLIANCE, AND CONSISTENCY WITH INDUSTRY GUIDELINES.
3. THE CONTRACTOR MUST EXERCISE APPROPRIATE CARE AND PRECISION IN CONSTRUCTION OF ACCESSIBLE (ADA) COMPONENTS AND ACCESSIBLE ROUTES FOR THE SITE. FINISHED SURFACES ALONG THE ACCESSIBLE ROUTE OF TRAVEL FROM PARKING SPACES, PUBLIC TRANSPORTATION, PEDESTRIAN ACCESS, AND INTER-BUILDING ACCESS TO POINTS OF ACCESSIBLE BUILDING ENTRANCE/EXIT MUST COMPLY WITH THE ACCESSIBLE GUIDELINES AND REQUIREMENTS WHICH INCLUDE, BUT ARE NOT LIMITED TO THE FOLLOWING:
   - 3.1. ACCESSIBLE PARKING SPACES AND ACCESS AISLE SLOPES MUST NOT EXCEED 1:50 (2.0%) IN ANY DIRECTION.
   - 3.2. PATH OF TRAVEL ALONG ACCESSIBLE ROUTE MUST PROVIDE A 48-INCHES MINIMUM WIDTH. UNOBSTRUCTED WIDTH OF TRAVEL (CAR OVERHANGS AND/OR HANDRAILS) MUST NOT REDUCE THIS MINIMUM WIDTH. THE SLOPE MUST NOT EXCEED 1:20 (5.0%) IN THE DIRECTION OF TRAVEL AND MUST NOT EXCEED 1:50 (2.0%) IN CROSS SLOPE. WHERE ACCESSIBLE PATH OF TRAVEL IS GREATER THAN 1:20 (5.0%), AN ACCESSIBLE RAMP MUST BE PROVIDED. ALONG THE ACCESSIBLE PATH OF TRAVEL, OPENINGS MUST NOT EXCEED 1/2-INCH IN WIDTH. VERTICAL CHANGES OF UP TO 1/2-INCH ARE PERMITTED ONLY IF THEY INCLUDE A 1/4-INCH BEVEL AT A SLOPE NOT STEEPER THAN 1:2. NO VERTICAL CHANGES OVER 1/4-INCH ARE PERMITTED.
   - 3.3. ACCESSIBLE RAMPS MUST NOT EXCEED A SLOPE OF 1:12 (8.3%) AND A RISE OF 30-INCHES. LEVEL LANDINGS MUST BE PROVIDED AT EACH END OF ACCESSIBLE RAMPS. LANDING MUST PROVIDE POSITIVE DRAINAGE AWAY FROM STRUCTURES, AND MUST NOT EXCEED 1:50 (2.0%) SLOPE IN ANY DIRECTION. RAMPS THAT CHANGE DIRECTION BETWEEN RUNS AT LANDINGS MUST HAVE A CLEAR LANDING OF A MINIMUM OF 60-INCHES BY 60-INCHES. HANDRAILS ON BOTH SIDES OF THE RAMP MUST BE PROVIDED ON AN ACCESSIBLE RAMP WITH A RISE GREATER THAN 6-INCHES.
   - 3.4. ACCESSIBLE CURB RAMPS MUST NOT EXCEED A SLOPE OF 1:12 (8.3%). WHERE FLARED SIDES ARE PROVIDED, THEY MUST NOT EXCEED 1:10 (10%) SLOPE. LEVEL LANDING MUST BE PROVIDED AT RAMP'S TOP AT A MINIMUM OF 36-INCHES LONG (48-INCHES PREFERRED). IN ALTERATIONS, WHEN THERE IS NO LANDING AT THE TOP, FLARE SIDES SLOPES MUST NOT EXCEED A SLOPE OF 1:12 (8.3%).
   - 3.5. DOORWAY LANDING AREAS MUST BE PROVIDED ON THE EXTERIOR SIDE OF ANY DOOR LEADING TO AN ACCESSIBLE PATH OF TRAVEL. THIS LANDING MUST BE SLOPED AWAY FROM THE DOOR NO MORE THAN 1:50 (2.0%) FOR POSITIVE DRAINAGE. THIS LANDING AREA MUST BE NO FEWER THAN 60-INCHES (5 FEET) LONG, EXCEPT WHERE OTHERWISE CLEARLY PERMITTED BY ACCESSIBLE STANDARDS FOR ALTERNATIVE DOORWAY OPENING CONDITIONS. (SEE ICC/ANSI A117.1-2009 AND OTHER REFERENCES INCORPORATED BY CODE).
   - 3.6. WHEN THE PROPOSED CONSTRUCTION INVOLVES RECONSTRUCTION, MODIFICATION, REVISION OR EXTENSION OF OR TO ACCESSIBLE COMPONENTS FROM EXISTING DOORWAYS OR SURFACES, THE CONTRACTOR MUST VERIFY ALL EXISTING ELEVATIONS SHOWN ON THE PLAN. NOTE THAT TABLE 405.2 OF THE DEPARTMENT OF JUSTICE'S ADA STANDARDS FOR ACCESSIBLE DESIGN ALLOWS FOR STEEPER RAMP SLOPES IN RARE CIRCUMSTANCES. THE CONTRACTOR MUST IMMEDIATELY NOTIFY THE ENGINEER OF RECORD, IN WRITING, OF ANY DISCREPANCIES AND/OR FIELD CONDITIONS THAT DIFFER IN ANY WAY OR IN ANY RESPECT FROM WHAT IS SHOWN ON THE PLANS BEFORE COMMENCING. ANY CONSTRUCTED IMPROVEMENTS MUST FALL WITHIN THE MAXIMUM AND MINIMUM LIMITATIONS IMPOSED BY THE BARRIER FREE REGULATIONS AND THE ACCESSIBLE GUIDELINES.
   - 3.7. THE CONTRACTOR MUST VERIFY ALL OF THE SLOPES OF THE CONTRACTOR'S FORMS PRIOR TO POURING CONCRETE. IF ANY NON-CONFORMANCE EXISTS OR IS OBSERVED OR DISCOVERED, THE CONTRACTOR MUST IMMEDIATELY NOTIFY THE ENGINEER OF RECORD, IN WRITING, PRIOR TO POURING CONCRETE. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR ALL COSTS TO REMOVE, REPAIR AND/OR REPLACE NON-CONFORMING CONCRETE AND/OR PAVEMENT SURFACES.
4. IT IS STRONGLY RECOMMENDED THAT THE CONTRACTOR REVIEW THE INTENDED CONSTRUCTION TO ENSURE SAME IS CONSISTENT WITH THE LOCAL BUILDING CODE PRIOR TO COMMENCING CONSTRUCTION.

STORMWATER STRUCTURE TABLE

STRUCTURE NAME	GRATE / RIM ELEVATION	PIPES IN	PIPES OUT	CL NORTHING & EASTING	NOTES
1000.JB	995.28	1000-1001, 12" INV IN =990.90	EX CI-1000, 15" INV OUT =990.60	N: 977860.16 E: 2818399.70	EXISTING MANHOLE, SEE NOTE 1
1001.AI	995.50	1001-1005, 12" INV IN =991.71 1001-1002, 12" INV IN =991.71 BIO UNDERDRAIN 1.1, 6" INV IN =992.00 BIO UNDERDRAIN 1.2, 6" INV IN =992.00	1000-1001, 12" INV OUT =991.21	N: 977891.22 E: 2818408.30	30" AREA INLET W/ DOME GRATE, SEE NOTE 2 REF: C-401; 1 / C-530, 5 / C-531 & 1-2 / C-532
1002.CI	996.63	1002-1003, 12" INV IN =992.06	1001-1002, 12" INV OUT =991.86	N: 977907.48 E: 2818409.02	2'X3' CURB INLET REF: 1 / C-530 & 1-2 / C-531
1003.CI	996.60	1003-1004, 12" INV IN =992.73	1002-1003, 12" INV OUT =992.53	N: 977947.03 E: 2818380.76	2'X3' CURB INLET REF: 1 / C-530 & 1-2 / C-531
1004.CI	1000.18		1003-1004, 12" INV OUT =996.00	N: 978032.84 E: 2818384.29	2'X3' CURB INLET REF: 1 / C-530 & 1-2 / C-531
1005.AI	997.86	1005-1006, 12" INV IN =993.66 BIO UNDERDRAIN 2.1, 6" INV IN =994.03 BIO UNDERDRAIN 2.2, 6" INV IN =994.03	1001-1005, 12" INV OUT =993.16	N: 977890.08 E: 2818526.60	24" AREA INLET W/ DOME GRATE, SEE NOTE 2 REF: C-401;1 / C-530 & 2, 3, 5 / C-531
1006.JB	999.40	1006-1007, 12" INV IN =994.21	1005-1006, 12" INV OUT =994.01	N: 977922.79 E: 2818532.99	24" DRAIN BASIN W/ SOLID COVER REF: 1 / C-530 & 2,4, & 5 / C-531
1007.AI	1001.95	1007-1008, 12" INV IN =995.19	1006-1007, 12" INV OUT =994.99	N: 977963.78 E: 2818534.70	24" AREA INLET W/ DOME GRATE REF:1 / C-530 & 2, 3, & 5 / C-531
1008.AI	1002.09	1008-1009, 12" INV IN =995.90	1007-1008, 12" INV OUT =995.70	N: 977991.06 E: 2818535.81	24" AREA INLET W/ DOME GRATE REF: 1 / C-530 & 2, 3, & 5 / C-531
1009.AI	1001.95	1009-1010, 12" INV IN =996.62	1008-1009, 12" INV OUT =996.42	N: 978018.84 E: 2818531.05	STANDARD DOUBLE GRATE INLET REF: 2 / C-530
1010.AI	1001.93	1010-FS5, 6" INV IN =997.09	1009-1010, 12" INV OUT =996.89	N: 978034.78 E: 2818531.72	STANDARD DOUBLE GRATE INLET REF: 2 / C-530
EX CI	989.93	EX CI-1000, 15" INV IN =986.38		N: 977866.28 E: 2818263.15	EXISTING CURB INLET, SEE NOTE 3 REF: 3-4 / C-530

STORMWATER PIPE TABLE

NAME	PIPE DESCRIPTION
BIO UNDERDRAIN 2.2	28.85 L.F. OF PERFORATED 6" PVC @ 0.5%
BIO UNDERDRAIN 2.1	25.92 L.F. OF PERFORATED 6" PVC @ 0.5%
BIO UNDERDRAIN 1.2	17.72 L.F. OF PERFORATED 6" PVC @ 0.5%
BIO UNDERDRAIN 1.1	32.74 L.F. OF PERFORATED 6" PVC @ 0.5%
EX CI-1000	133.81 LF OF 15" HDPE @ 3.16%
1000-1001	31.21 LF OF 12" HDPP @ 1.00%
1001-1002	14.52 LF OF 12" HDPP @ 1.00%
1001-1005	116.32 LF OF 12" HDPP @ 1.25%
1002-1003	47.13 LF OF 12" HDPP @ 1.00%
1003-1004	84.45 LF OF 12" HDPP @ 3.88%
1005-1006	31.33 LF OF 12" HDPP @ 1.12%
1006-1007	39.03 LF OF 12" HDPP @ 2.00%
1007-1008	25.31 LF OF 12" HDPP @ 2.00%
1008-1009	26.08 LF OF 12" HDPP @ 2.00%
1009-1010	13.70 LF OF 12" HDPP @ 2.00%
1010-FS5	23.28 LF OF 6" HDPE @ 1.13%

NOTES

1. CONTRACTOR TO REUSE EXISTING MANHOLE, IF POSSIBLE. SEE C-102. GROUT AND REPAIR EXISTING PIPE PENETRATIONS NO LONGER NECESSARY PER CITY OF LEE'S SUMMIT, MO STANDARDS. NOTIFY ENGINEER IF STRUCTURE IS UNABLE TO BE REUSED. EXISTING INVERT ELEVATION OUT ASSUMED BASED ON LINEAR INTERPOLATION. CONTRACTOR TO FIELD VERIFY AND CONTACT ENGINEER IF DISCREPANCY EXISTS.
2. BIORETENTION BASIN OUTLET CONTROL STRUCTURE. SEE C-401.
3. THIS STRUCTURE HAS ADDITIONAL EXISTING PIPES NOT SHOWN IN THIS STRUCTURE TABLE.

1 GRADING & DRAINAGE PLAN

1" = 20'-0"

GRAPHIC SCALE 20'

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FIRE STATION #5
CITY OF LEE'S SUMMIT

801 MISSOURI HIGHWAY 150
LEE'S SUMMIT, MISSOURI 64082

REVISIONS:

#	Description	Date

DERICK HOLMES - CIVIL ENGINEER
MO# PE-2022005196

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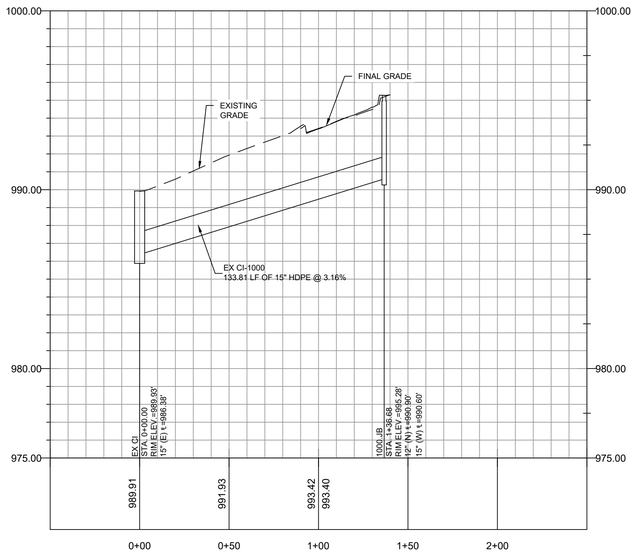
PROJECT NO:	18225R21001
DATE:	10.26.2022
DRAWN BY:	SJB
CHK'D BY:	DMH

GRADING & DRAINAGE PLAN

C-104

PLEASE CONSIDER THE ENVIRONMENT BEFORE PRINTING THIS



1 EX CI - 1000.JB PROFILE

SCALE: HORIZONTAL 1"=40' SCALE:VERTICAL: 1"=4'

GENERAL NOTES:

1. SEE DRAWING C-104 FOR GENERAL NOTES APPLICABLE TO THIS DRAWING.
2. ALL STORMWATER STRUCTURES AND PIPES SHOWN ON THIS DRAWING ARE PUBLIC, UNLESS NOTED OTHERWISE.

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REVISIONS:

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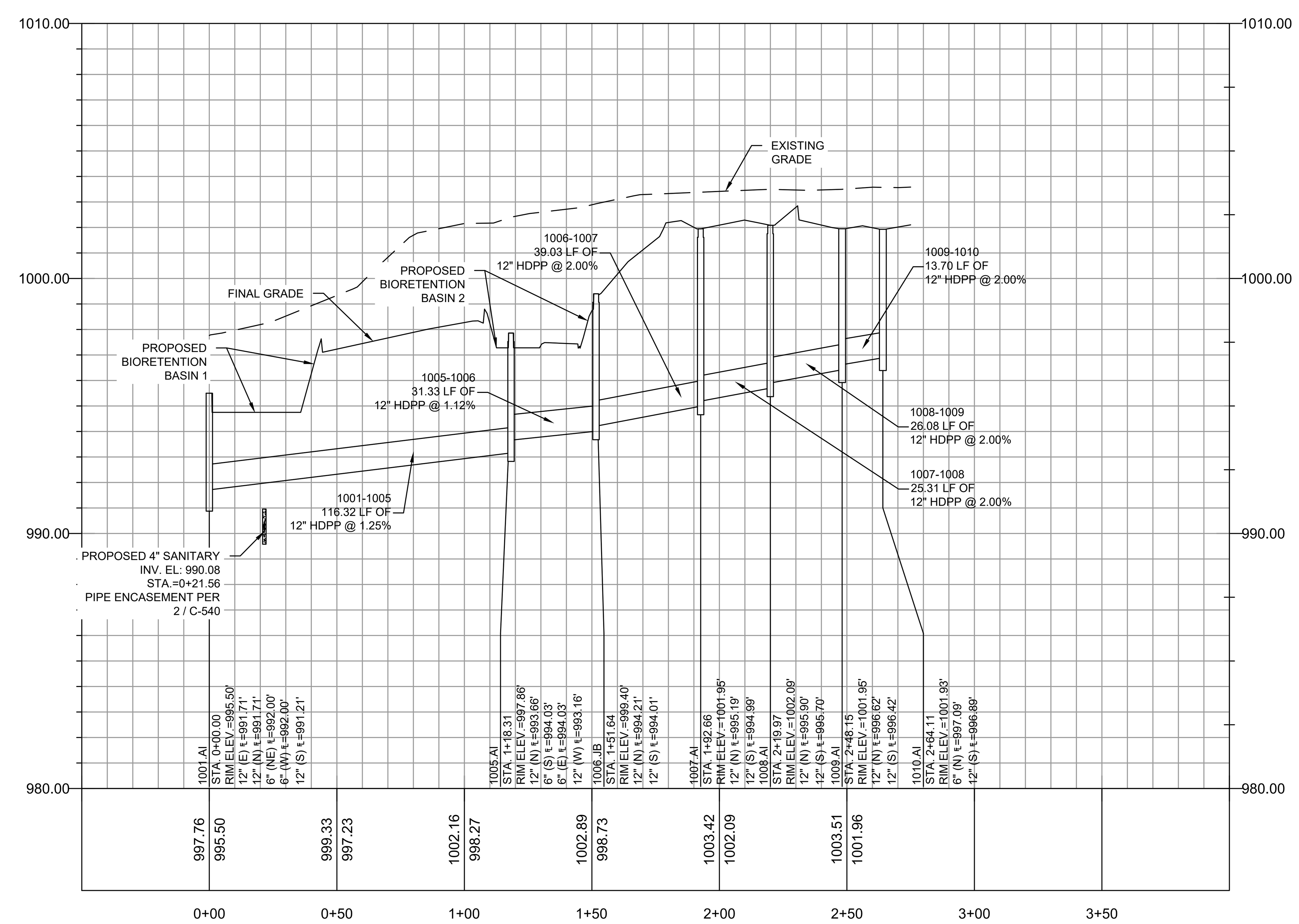
PROJECT NO:	18225R21001
DATE:	10.26.2022
DRAWN BY:	HFL
CHK'D BY:	DMH

PUBLIC STORMWATER PROFILES

C-230

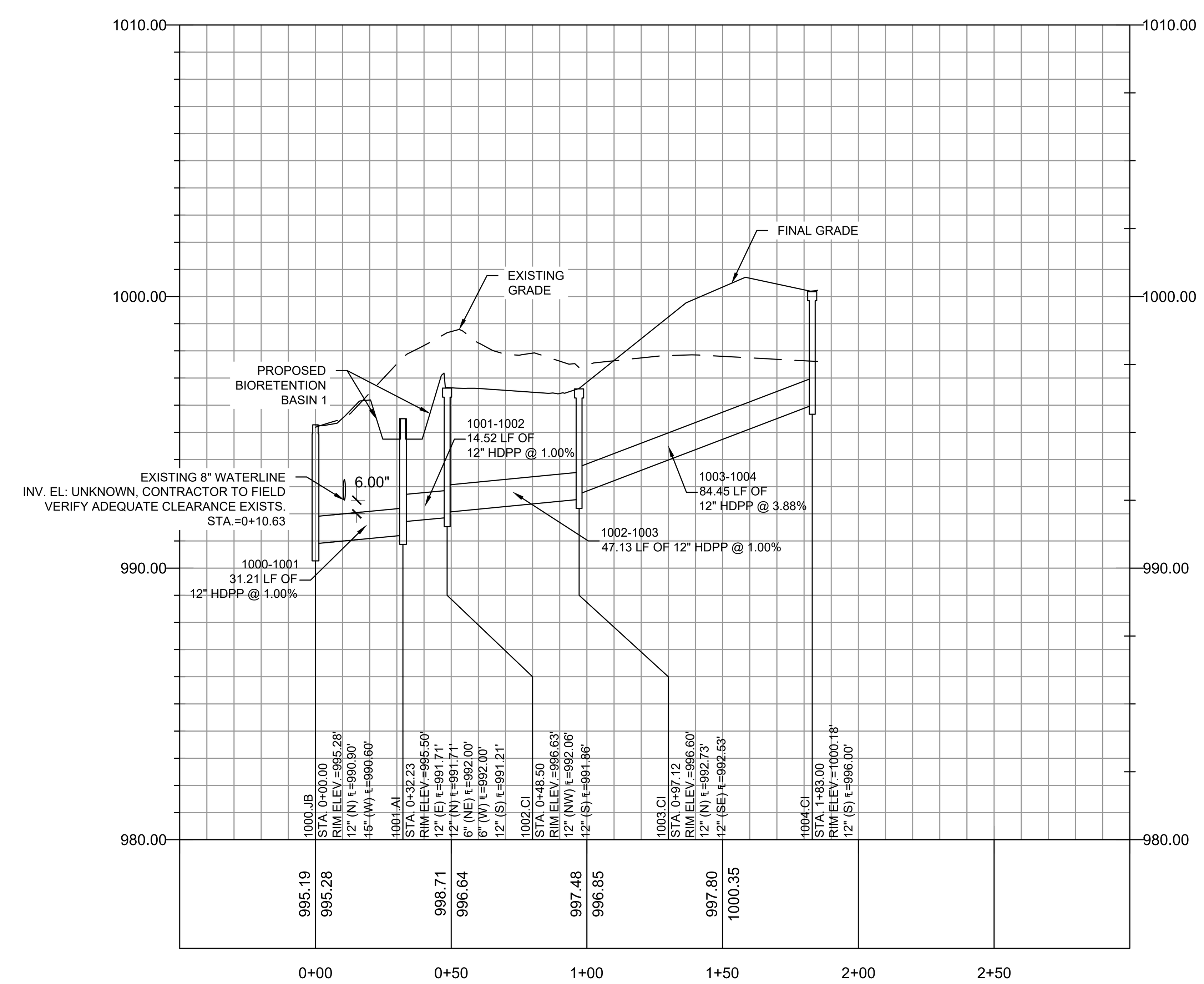
GENERAL NOTES:

1. SEE DRAWING C-104 FOR GENERAL NOTES APPLICABLE TO THIS DRAWING.
2. ALL STORMWATER STRUCTURES AND PIPES SHOWN ON THIS DRAWING ARE PRIVATE, UNLESS NOTED OTHERWISE.



1 1001.AI - 1010.AI PROFILE

SCALE: HORIZONTAL 1"=40' SCALE:VERTICAL: 1"=4'



2 1000.JB - 1004.CI PROFILE

SCALE: HORIZONTAL 1"=40' SCALE:VERTICAL: 1"=4'

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FIRE STATION #5
CITY OF LEE'S SUMMIT
801 MISSOURI HIGHWAY 150
LEE'S SUMMIT, MISSOURI 64082

100% CONSTRUCTION DOCUMENT DRAWINGS

REVISIONS:

#	Description	Date

DERICK HOLMES - CIVIL ENGINEER
MO# PE-2022005196

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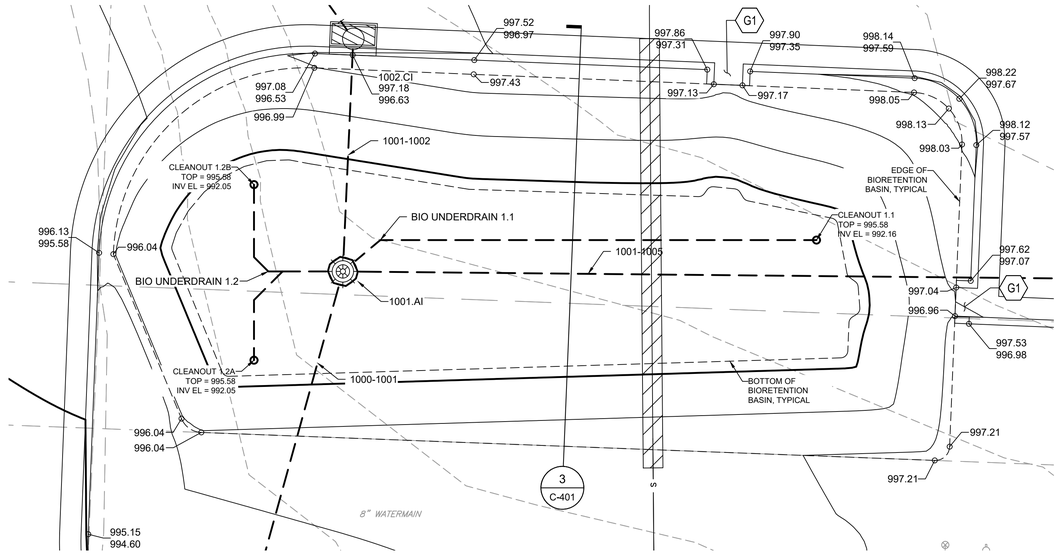
PROJECT NO:	18225R21001
DATE:	10.26.2022
DRAWN BY:	HFL
CHK'D BY:	DMH

PRIVATE STORMWATER PROFILES

C-231

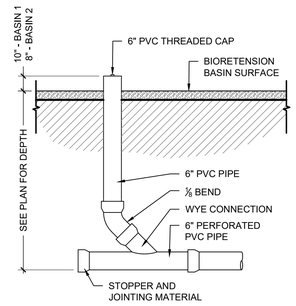


1 BIORETENTION BASIN 1 ENLARGEMENT PLAN

1" = 5'-0"

KEYNOTES

G1 TYP. CURB CUT
REF: 11 / C-500



5 CLEANOUT DETAIL

1/2" = 1'-0"

GENERAL NOTES:

1. BIORETENTION FACILITIES SHALL NOT BE CONSTRUCTED UNTIL ALL CONTRIBUTING DRAINAGE AREAS ARE PERMANENTLY STABILIZED AGAINST EROSION AND SEDIMENTATION. ANY DISCHARGE OF SEDIMENT THAT AFFECTS THE PERFORMANCE OF THE CELL WILL REQUIRE RECONSTRUCTION OF THE CELL TO RESTORE ITS DEFINED PERFORMANCE.
2. NO HEAVY EQUIPMENT SHALL OPERATE WITHIN THE BIORETENTION FACILITY DURING UNDERDRAIN PLACEMENT, BACKFILLING, OR PLANTING OF THE FACILITY.
3. IF THE BIORETENTION FACILITY IS TO BE USED AS A SEDIMENT BASIN, THE BIORETENTION FACILITY SHALL BE EXCAVATED TO THE DIMENSIONS, SIDE SLOPES, AND 1 FOOT ABOVE THE BOTTOM OF THE BIORETENSION SOIL MIXTURE. ANY SEDIMENT FROM CONSTRUCTION OPERATIONS DEPOSITED IN THE BIORETENTION FACILITY SHALL BE COMPLETELY REMOVED FROM THE FACILITY AFTER ALL VEGETATION HAS BEEN ESTABLISHED. THE EXCAVATION LIMITS SHALL THEN BE FINAL GRADED TO THE DIMENSIONS, SIDE SLOPES, AND FINAL ELEVATIONS. LOW GROUND-CONTACT PRESSURE EQUIPMENT IS TO BE USED WHEN CONSTRUCTING THE BIORETENTION FACILITIES TO MINIMIZE DISTURBANCE TO ESTABLISH AREAS AROUND PERIMETER OF CELL. NO HEAVY EQUIPMENT SHALL BE USED WITHIN THE PERIMETER OF THE BIORETENTION FACILITY BEFORE, DURING, OR AFTER THE PLACEMENT OF THE BSM.
4. THE BIORETENTION SOIL MIXTURE (BSM) SHALL BE PLACED IN LAYERS NOT TO EXCEED 12 INCHES. THE BSM SHALL BE SATURATED OVER THE ENTIRE AREA OF THE FACILITY AFTER EACH LIFT OF BSM IS PLACED UNTIL WATER FLOWS FROM THE UNDERDRAIN TO LIGHTLY CONSOLIDATE THE BSM MIXTURE. WATER FOR SATURATION SHALL BE APPLIED BY SPRAYING OR SPRINKLING TO AVOID SEPARATION OF THE BSM COMPONENTS. FINAL GRADING OF THE BSM SHALL BE PERFORMED AFTER A 24-HOUR SETTLING PERIOD. UPON FINAL GRADING THE SURFACE OF THE BSM SHALL BE ROTO-TILLED TO A DEPTH OF 6".
5. SEE DRAWING L-100 AND L-101 FOR PLANTING SCHEDULE. PESTICIDES, HERBICIDES, AND FERTILIZER SHALL NOT BE APPLIED DURING PLANTING UNDER ANY CIRCUMSTANCES.

BIORETENTION SOIL MIXTURE (BSM) SPECIFICATIONS:

MATERIALS

A. BIORTENTION SOIL MIXUTRE: THE BIORETENTION SOIL MIXTURE (BSM) IS A MIXTURE OF PLANTING SOIL, COMPOST, AND SAND CONSISTING OF THE FOLLOWING:

ITEM	COMPOSITION BY VOLUME	REFERENCE
PLANTING SOIL	30%	SEE BELOW
ORGANIC COMPOST	20%	SEE BELOW
SAND	50%	ASTM C33 FINE AGGREGATE

B. PLANTING SOIL: THE USDA TEXTURAL CLASSIFICATION OF THE PLANTING SOIL FOR THE BSM SHALL BE LOAMY SAND OR SANDY LOAM. THE PLANTING SOIL SHALL BE TESTED AND MEET THE FOLLOWING CRITERIA:

ITEM	PERCENT BY WEIGHT	TEST METHOD
SAND (2.0 - 0.050 MM)	50-85%	AASHTO T88
SILT (0.050 - 0.002 MM)	0-50%	AASHTO T88
CLAY (LESS THAN 0.002 MM)	2-5%	AASHTO T88
ORGANIC MATTER	3-10%	AASHTO T194

THE TEXTURAL ANALYSIS OF THE PLANTING SOIL SHALL BE AS FOLLOWS:

ASTM E11 SIEVE SIZE	MINIMUM PERCENT PASSING BY WEIGHT
2 IN.	100%
NO. 4	90
NO. 10	80

AT LEAST 45 DAYS PRIOR TO THE START OF CONSTRUCTION OF THE BIORETENTION FACILITIES, THE CONTRACTOR SHALL SUBMIT THE SOURCE AND TESTING RESULTS OF THE PLANTING SOIL FOR THE BSM TO THE ENGINEER FOR APPROVAL.

C. ORGANIC COMPOST:

COMPOST IS DEEMED ACCEPTABLE IF IT MEETS 2 OF THE FOLLOWING REQUIREMENTS:
1. C/N RATIO <= 25;
2. OXYGEN UPTAKE RATE <= 150 mg/ O2/kg VOLATILE SOLIDS PER HOUR
3. COMPOST MUST NOT CONTAIN MORE THAN 1 PERCENT FOREIGN MATTER. FOREIGN MATTER IS DEFINED AS: "ANY MATTER OVER A 2 MM DIMENSION THAT RESULTS FROM HUMAN INTERVENTION AND HAVING ORGANIC OR INORGANIC CONSTITUENTS SUCH AS METAL, GLASS AND SYNTHETIC POLYMERS (E.G., PLASTIC OR RUBBER) THAT MAY BE PRESENT IN THE COMPOST BUT EXCLUDING MINERAL SOILS, WOODY MATERIAL AND ROCKS."
4. FOREIGN MATTER LESS THAN 1 PERCENT BY WEIGHT MUST NOT EXCEED 12.5 MM IN ANY DIMENSION.

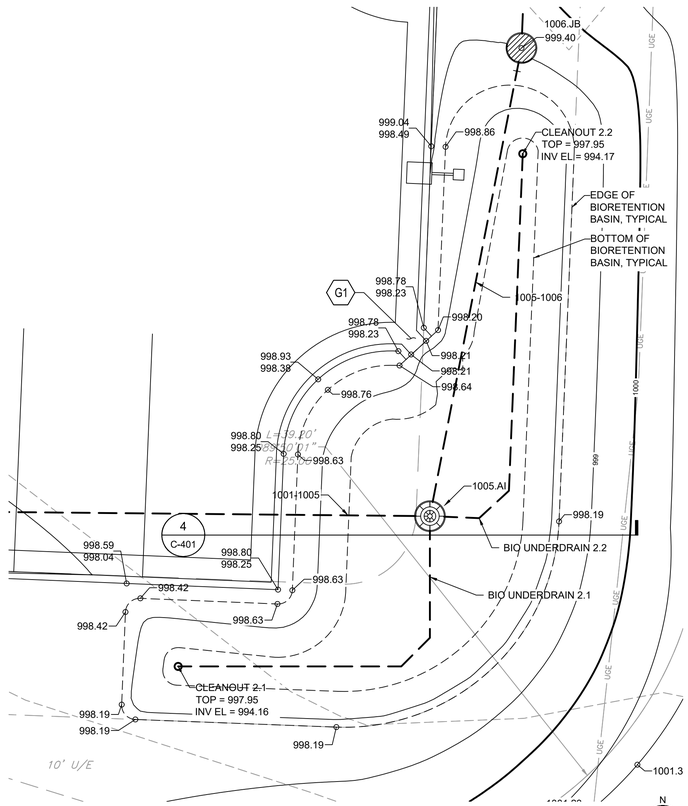
D. THE BIORETENTION SOIL MIXTURE (BSM) SHALL BE A UNIFORM MIX, FREE OF PLANT RESIDUE, STONES, STUMPS, ROOTS OR OTHER SIMILAR OBJECTS LARGER THAN TWO INCHES EXCLUDING MULCH. NO OTHER MATERIALS OR SUBSTANCES SHALL BE MIXED OR DUMPED WITHIN THE BIORETENTION AREA THAT MAY BE HARMFUL TO PLANT GROWTH, OR PROVE A HINDRANCE TO THE PLANTING OR MAINTENANCE OPERATIONS.

1. THE BIORETENTION SOIL MIXTURE SHALL BE TESTED AND MEET THE FOLLOWING CRITERIA:

ITEM	CRITERIA	TEST METHOD
CORRECTED pH	5.5 - 7.5	ASTM D4972
MAGNESIUM	MINIMUM 32 PPM	*
PHOSPHORUS (PHOSPHATE - P_2O_5)	NOT TO EXCEED 60 PPM PLANT AVAILABLE PHOSPHORUS	*
POTASSIUM (K_2O)	MINIMUM 78 PPM	*
SOLUBLE SALTS	NOT TO EXCEED 500 PPM	*

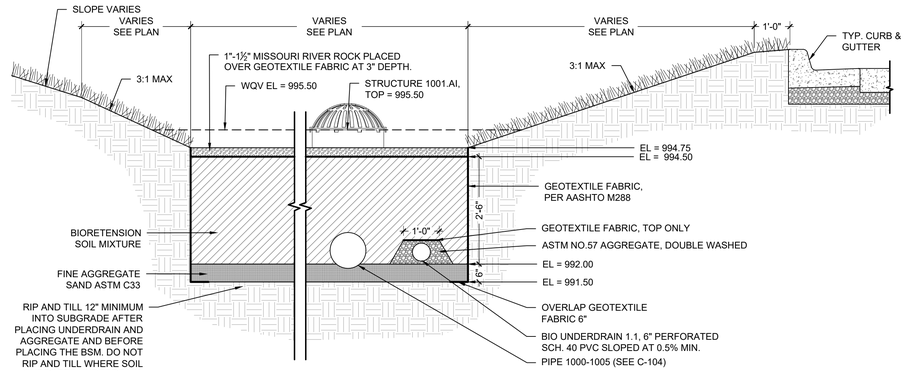
*USE AUTHORIZED SOIL TEST PROCEDURES

2. SHOULD THE pH FALL OUTSIDE OF THE ACCEPTABLE RANGE, IT MAY BE MODIFIED WITH LIME (TO RAISE) OR AMMONIUM SULFATE (TO LOWER). THE LIME OR AMMONIUM SULFATE MUST BE MIXED UNIFORMLY INTO THE BSM PRIOR TO USE IN BIORETENTION FACILITIES.
3. SHOULD THE BSM NOT MEET THE MINIMUM REQUIREMENT FOR MAGNESIUM, IT MAY BE MODIFIED WITH MAGNESIUM SULFATE. LIKEWISE, SHOULD THE BSM NOT MEET THE MINIMUM REQUIREMENT FOR POTASSIUM, IT MAY BE MODIFIED WITH POTASH. MAGNESIUM SULFATE AND POTASH MUST BE MIXED UNIFORMLY INTO THE BSM PRIOR TO USE IN BIORETENTION FACILITIES.
4. PLANTING SOIL AND/OR BSM THAT FAILS TO MEET THE MINIMUM REQUIREMENTS SHALL BE REPLACED AT THE CONTRACTOR'S EXPENSE. MIXING OF THE CORRECTIVE ADDITIVES TO THE BSM IS INCIDENTAL AND SHALL BE AT THE CONTRACTOR'S EXPENSE.
5. MIXING OF THE BSM TO A HOMOGENOUS CONSISTENCY SHALL BE DONE TO THE SATISFACTION OF THE ENGINEER. UPON APPROVAL OF ALL REQUIREMENTS AND TESTING ABOVE, THE BSM SHALL BE STOCKPILED, AND NO MATERIAL SHALL BE ADDED TO THE BSM IN THE STOCKPILE OR DURING TRANSPORT TO THE BIORETENTION FACILITY.



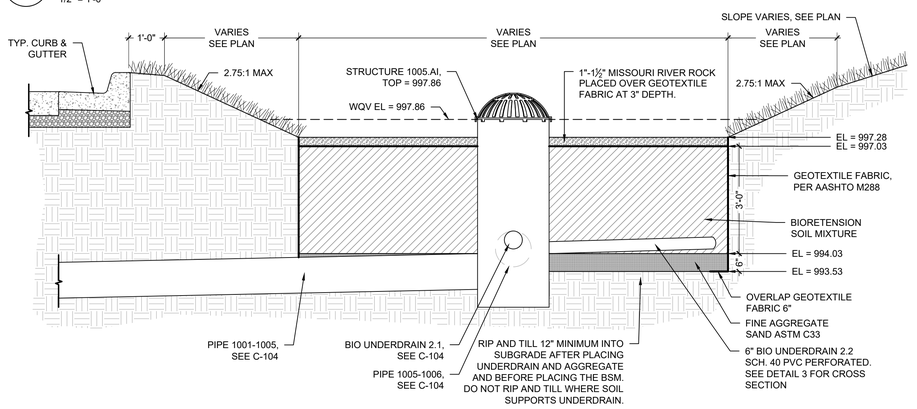
2 BIORETENTION BASIN 2 ENLARGEMENT PLAN

1" = 5'-0"



3 BIORETENTION BASIN 1 CROSS SECTION

1/2" = 1'-0"



4 BIORETENTION BASIN 2 CROSS SECTION

1/2" = 1'-0"

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CITY OF LEE'S SUMMIT

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LEE'S SUMMIT, MISSOURI 64082

100% CONSTRUCTION DOCUMENT DRAWINGS

REVISIONS:

#	Description	Date

DERICK HOLMES - CIVIL ENGINEER
MO# PE-2022005196

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PROJECT NO:	18225R21001
DATE:	10.26.2022
DRAWN BY:	KDW
CHK'D BY:	DMH

SITE ENLARGEMENTS

C-401

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Section 2721

Engineered Surface Drainage Products

GENERAL
PVC surface drainage inlets shall include the drain basin type as indicated on the contract drawing and referenced within the contract specifications. The ductile iron grates for each of these fittings are to be considered an integral part of the surface drainage inlet and shall be furnished by the same manufacturer. The surface drainage inlets shall be as manufactured by Nyloplast a division of Advanced Drainage Systems, Inc., or prior approved equal.

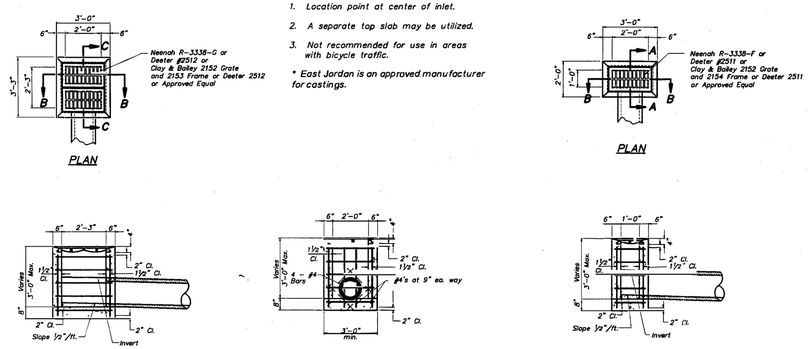
MATERIALS
The drain basins required for this contract shall be manufactured from PVC pipe stock, utilizing a thermoforming process to reform the pipe stock to the specified configuration. The drainage pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the specified pipe system. This joint tightness shall conform to ASTM D3212 for joints for drain and sewer plastic pipe using flexible elastomeric seals. The flexible elastomeric seals shall conform to ASTM F477. The pipe bell spigot shall be joined to the main body of the drain basin or catch basin. The raw material used to manufacture the pipe stock that is used to manufacture the main body and pipe stubs of the surface drainage inlets shall conform to ASTM D1784 cell class 12454.

The grates and frames furnished for all surface drainage inlets shall be ductile iron for structure sizes 8", 10", 12", 15", 18", 24", 30" and 36" and shall be made specifically for each basin so as to provide a round bottom flange that closely matches the diameter of the surface drainage inlet. Grates for drain basins shall be capable of supporting various wheel loads as specified by Nyloplast. 12" and 15" square grates will be hinged to the frame using pins. Ductile iron used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05. Grates and covers shall be provided painted black.

INSTALLATION
The specified PVC surface drainage inlet shall be installed using conventional flexible pipe backfill materials and procedures. The backfill material shall be crushed stone or other granular material meeting the requirements of class 1, class 2, or class 3 material as defined in ASTM D2321. Bedding and backfill for surface drainage inlets shall be well placed and compacted uniformly in accordance with ASTM D2321. The drain basin body will be cut at the time of the final grade. No brick, stone or concrete block will be required to set the grate to the final grade height. For load rated installations, a concrete slab shall be poured under and around the grate and frame. The concrete slab must be designed taking into consideration local soil conditions, traffic loading, and other applicable design factors. For other installation considerations such as migration of fines, ground water, and soft foundations refer to ASTM D2321 guidelines.

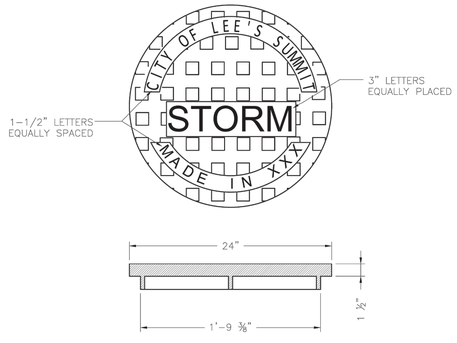
DRAWN BY CJA	MATERIAL	Nyloplast	3126 VERONA AVE BUFORD, GA 30518 PHN (770) 932-2443 FAX (770) 932-2490 www.nyloplast-us.com
DATE 3-10-00			
REVISED BY NMH	PROJECT NO./NAME	TITLE	
DATE 02-21-18		8 IN - 36 IN DRAIN BASIN SPECIFICATIONS	
DWG SIZE A	SCALE 1:1 SHEET 1 OF 1	DWG NO. 7001-110-011	REV J

1 8 IN - 36 IN DRAIN BASIN SPECIFICATIONS
NTS



AMERICAN PUBLIC WORKS ASSOCIATION	KANSAS CITY METROPOLITAN CHAPTER
APWA GRATE INLET DETAILS	STANDARD DRAWING NUMBER G-1 ADOPTED: APRIL 17, 1996

2 GRATE INLET DETAIL
NTS

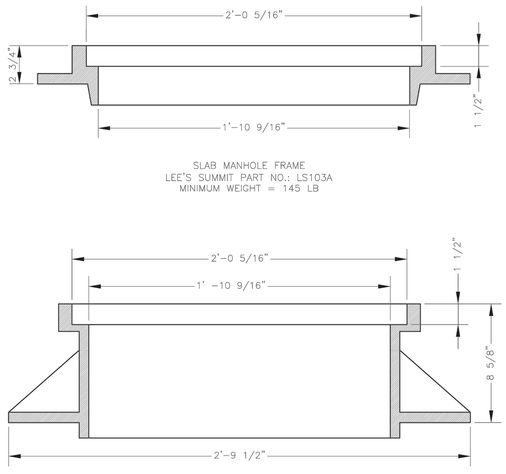


STANDARD 24" MANHOLE COVER
MINIMUM WEIGHT = 160 LB
NOTE: PICK HOLES NOT SHOWN

*COVER AND FRAME MODEL INFORMATION REFER TO THE STORMWATER APPROVED PRODUCT LIST.

LS	LEE'S SUMMIT MISSOURI PUBLIC WORKS ENGINEERING DIVISION | 220 SE GREEN STREET | LEE'S SUMMIT, MO 64063	Date: 05/2021 Drawn By: MJF Checked By: DL
	STORM MANHOLE COVER DETAIL	STM-6

3 STORM MANHOLE COVER DETAIL
NTS



*COVER AND FRAME MODEL INFORMATION REFER TO THE STORMWATER APPROVED PRODUCTS LIST.

LS	LEE'S SUMMIT MISSOURI PUBLIC WORKS ENGINEERING DIVISION | 220 SE GREEN STREET | LEE'S SUMMIT, MO 64063	Date: 05/2021 Drawn By: MJF Checked By: DL
	STORM MANHOLE FRAME DETAIL	DWG-7

4 STORM MANHOLE FRAME DETAIL
NTS

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100% CONSTRUCTION DOCUMENT DRAWINGS

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#	Description	Date

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MO# PE-2022005196
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PROJECT NO:	18225R21001
DATE:	10.26.2022
DRAWN BY:	SJB
CHK'D BY:	DMH

STORMWATER DETAILS

C-530

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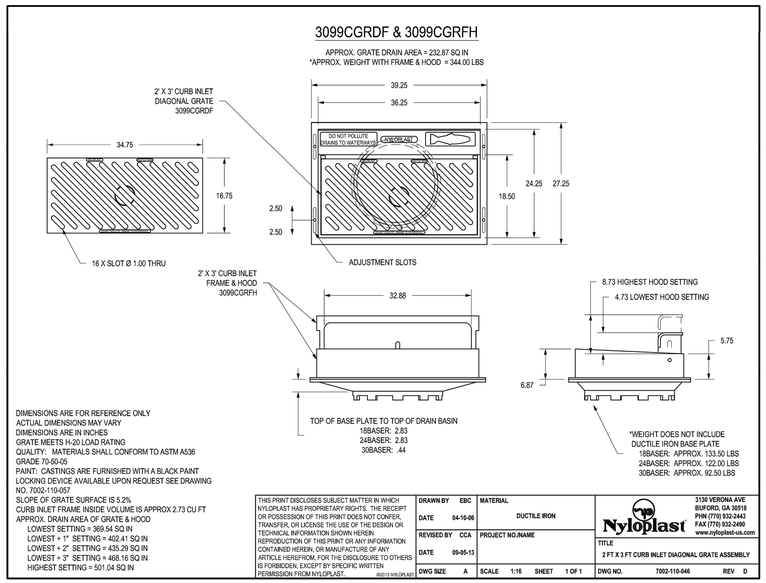


DIMENSIONS ARE FOR REFERENCE ONLY
ACTUAL DIMENSIONS MAY VARY
DIMENSIONS ARE IN INCHES
GRATE MEETS H-20 LOAD RATING
QUALITY: MATERIALS SHALL CONFORM TO ASTM A536 GRADE 70-50-05
PAINT: CASTINGS ARE FURNISHED WITH A BLACK PAINT
LOCKING DEVICE AVAILABLE UPON REQUEST SEE DRAWING NO. 7002-110-057
SLOPE OF GRATE SURFACE IS 5.2%
CURB INLET FRAME INSIDE VOLUME IS APPROX 2.73 CU FT
APPROX. DRAIN AREA OF GRATE & HOOD
LOWEST SETTING = 369.54 SQ IN
LOWEST + 1" SETTING = 402.41 SQ IN
LOWEST + 2" SETTING = 435.29 SQ IN
LOWEST + 3" SETTING = 468.16 SQ IN
HIGHEST SETTING = 501.04 SQ IN

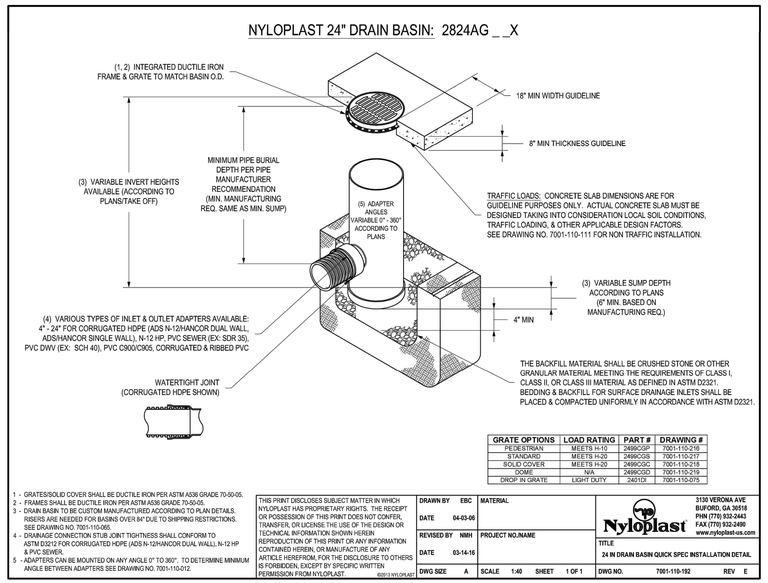
DRAWN BY	EBC	MATERIAL	DUCTILE IRON
DATE	04-10-06		
REVISED BY	CCA	PROJECT NO./NAME	
DATE	09-05-13		
DWG SIZE	A	SCALE 1:16	SHEET 1 OF 1

Nyloplast
3130 VERONA AVE
BUFORD, GA 30518
PHN (770) 932-2443
FAX (770) 932-2490
www.nyloplast-us.com

TITLE: 2 FT X 3 FT CURB INLET DIAGONAL GRATE ASSEMBLY
DWG NO. 7002-110-046 REV D

1 2'x3' CURB INLET DIAGONAL GRATE ASSEMBLY

NTS



GRATE OPTIONS	LOAD RATING	PART #	DRAWING #
PEDESTRIAN	MEETS H-10	2499CGP	7001-110-216
STANDARD	MEETS H-20	2499CGS	7001-110-217
SOLID COVER	MEETS H-20	2499CGC	7001-110-218
DOME	N/A	2499CGO	7001-110-219
DROP IN GRATE	LIGHT DUTY	2401DI	7001-110-075

1 - GRATES/SOLID COVER SHALL BE DUCTILE IRON PER ASTM A536 GRADE 70-50-05.
2 - FRAMES SHALL BE DUCTILE IRON PER ASTM A536 GRADE 70-50-05.
3 - DRAIN BASIN TO BE CUSTOM MANUFACTURED ACCORDING TO PLAN DETAILS. RISERS ARE NEEDED FOR BASINS OVER 84" DUE TO SHIPPING RESTRICTIONS. SEE DRAWING NO. 7001-110-065.
4 - DRAINAGE CONNECTION STUB JOINT TIGHTNESS SHALL CONFORM TO ASTM D3212 FOR CORRUGATED HDPE (ADS N-12/HANCOR DUAL WALL), N-12 HP & PVC SEWER.
5 - ADAPTERS CAN BE MOUNTED ON ANY ANGLE 0° TO 360°. TO DETERMINE MINIMUM ANGLE BETWEEN ADAPTERS SEE DRAWING NO. 7001-110-012.

DRAWN BY	EBC	MATERIAL	
DATE	04-03-06		
REVISED BY	NMH	PROJECT NO./NAME	
DATE	03-14-16		
DWG SIZE	A	SCALE 1:40	SHEET 1 OF 1

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3130 VERONA AVE
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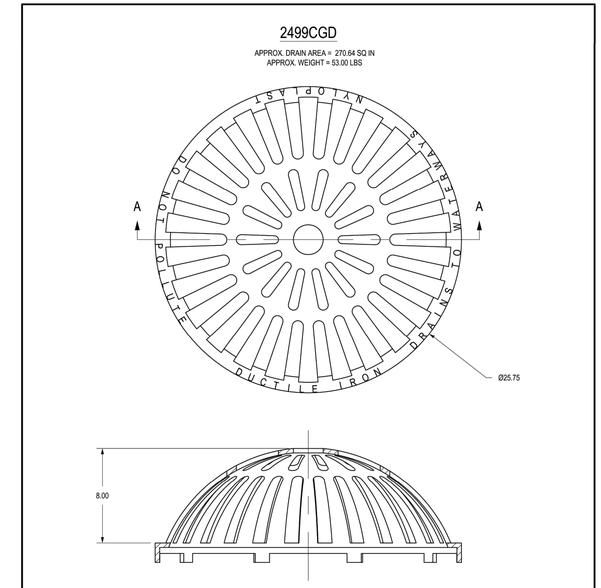
FAX (770) 932-2490
www.nyloplast-us.com

TITLE: 24 IN DRAIN BASIN QUICK SPEC INSTALLATION DETAIL.
DWG NO. 7001-110-192 REV E

2 24" DRAIN BASIN QUICK SPEC INSTALLATION DETAIL

NTS



DIMENSIONS ARE FOR REFERENCE ONLY
ACTUAL DIMENSIONS MAY VARY
DIMENSIONS ARE IN INCHES
QUALITY: MATERIALS SHALL CONFORM TO ASTM A536 GRADE 70-50-05
PAINT: CASTINGS ARE FURNISHED WITH A BLACK PAINT
LOCKING DEVICE AVAILABLE UPON REQUEST

DRAWN BY	EBC	MATERIAL	DUCTILE IRON
DATE	3-8-06		
REVISED BY	EBC	PROJECT NO./NAME	
DATE	3-24-11		
DWG SIZE	A	SCALE 1:6	SHEET 1 OF 1

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3130 VERONA AVE
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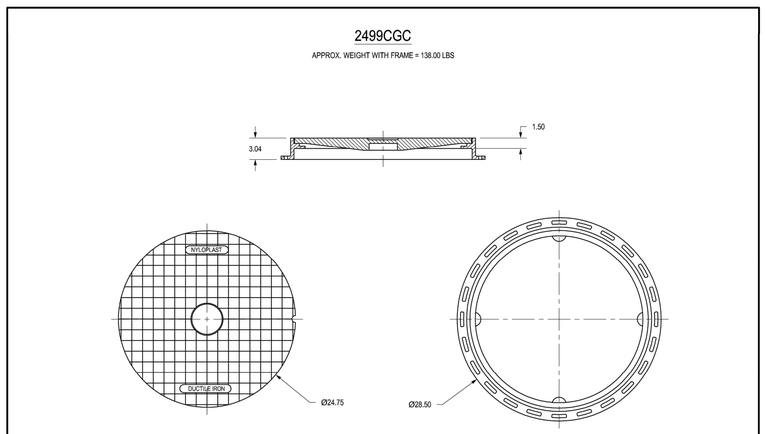
PHN (770) 932-2443
FAX (770) 932-2490
www.nyloplast-us.com

TITLE: 24 IN DOME GRATE
DWG NO. 7001-110-219 REV D

3 24" DOME GRATE

NTS



DIMENSIONS ARE FOR REFERENCE ONLY
ACTUAL DIMENSIONS MAY VARY
DIMENSIONS ARE IN INCHES
GRATE MEETS H-20 LOAD RATING
QUALITY: MATERIALS SHALL CONFORM TO ASTM A536 GRADE 70-50-05
PAINT: CASTINGS ARE FURNISHED WITH A BLACK PAINT
LOCKING DEVICE AVAILABLE UPON REQUEST SEE DRAWING NO. 7001-110-025

DRAWN BY	EBC	MATERIAL	DUCTILE IRON
DATE	3-8-06		
REVISED BY	EBC	PROJECT NO./NAME	
DATE	3-13-16		
DWG SIZE	A	SCALE 1:10	SHEET 1 OF 1

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3130 VERONA AVE
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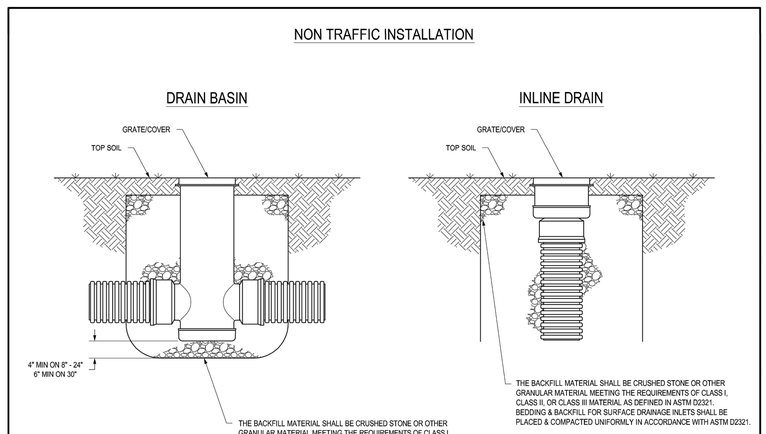
FAX (770) 932-2490
www.nyloplast-us.com

TITLE: 24 IN SOLID COVER ASSEMBLY - TYPE B
DWG NO. 7001-110-218 REV C

4 24" SOLID COVER ASSEMBLY - TYPE B

NTS



DRAWN BY	CJA	MATERIAL	
DATE	9-30-99		
REVISED BY	NMH	PROJECT NO./NAME	
DATE	03-11-16		
DWG SIZE	A	SCALE 1:25	SHEET 1 OF 1

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TITLE: DRAIN BASIN & INLINE DRAIN NON TRAFFIC INSTALLATION
DWG NO. 7001-110-111 REV E

5 DRAIN BASIN & INLINE DRAIN NON-TRAFFIC INSTALLATION

NTS

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100% CONSTRUCTION DOCUMENT DRAWINGS

FIRE STATION #5
CITY OF LEE'S SUMMIT

801 MISSOURI HIGHWAY 150
LEE'S SUMMIT, MISSOURI 64082

REVISIONS:

#	Description	Date

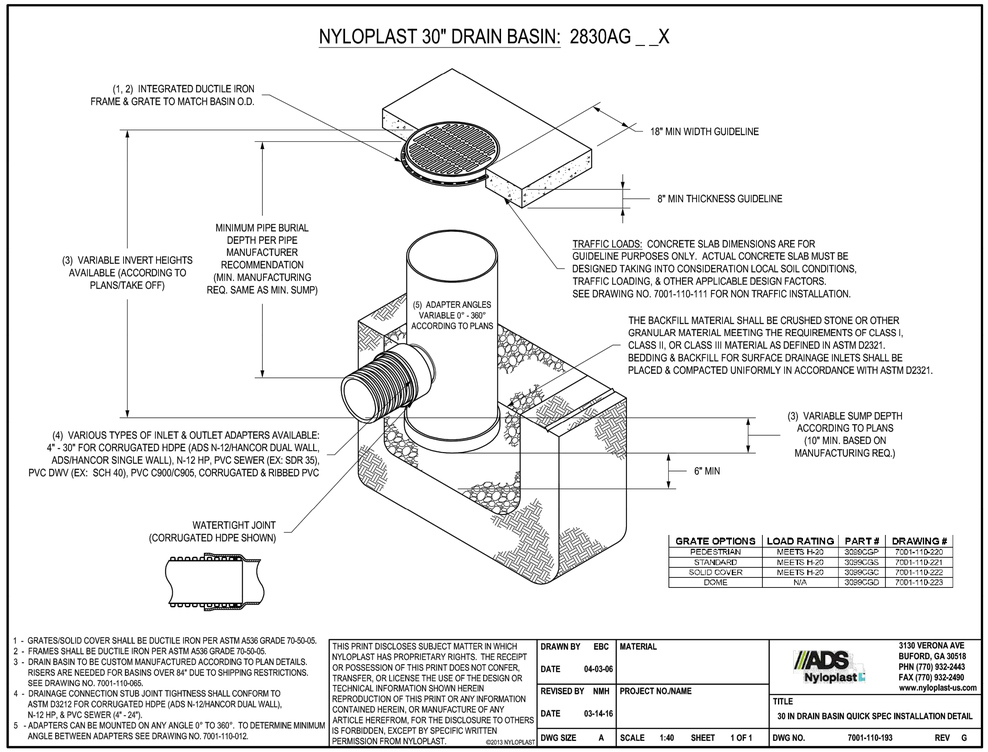
DERICK HOLMES - CIVIL ENGINEER
MO# PE-2022005196
The Professional Engineers seal affixed to this sheet applies only to the material and items shown on this sheet. All modifications made to these documents after affixing this seal shall not be considered prepared by this engineer, and this engineer expressly disclaims any and all responsibility for such plan, drawings, or documents not exhibiting this seal.

PROJECT NO:	18225R21001
DATE:	10.26.2022
DRAWN BY:	SJB
CHK'D BY:	DMH

STORMWATER DETAILS

C-531

PLEASE CONSIDER THE ENVIRONMENT BEFORE PRINTING THIS



GRATE OPTIONS	LOAD RATING	PART #	DRAWING #
PEDESTRIAN	MEETS H-20	3099CGP	7001-110-220
STANDARD	MEETS H-20	3099CGS	7001-110-221
SOLID COVER	MEETS H-20	3099CGC	7001-110-222
DOME	N/A	3099CGD	7001-110-223

1 - GRATES/SOLID COVER SHALL BE DUCTILE IRON PER ASTM A536 GRADE 70-50-05.
2 - FRAMES SHALL BE DUCTILE IRON PER ASTM A536 GRADE 70-50-05.
3 - DRAIN BASIN TO BE CUSTOM MANUFACTURED ACCORDING TO PLAN DETAILS. RISERS ARE NEEDED FOR BASINS OVER 84" DUE TO SHIPPING RESTRICTIONS. SEE DRAWING NO. 7001-110-065.
4 - DRAINAGE CONNECTION STUB JOINT TIGHTNESS SHALL CONFORM TO ASTM D3212 FOR CORRUGATED HDPE (ADS N-12/HANCOR DUAL WALL), N-12 HP, & PVC SEWER (4" - 24").
5 - ADAPTERS CAN BE MOUNTED ON ANY ANGLE 0° TO 360°. TO DETERMINE MINIMUM ANGLE BETWEEN ADAPTERS SEE DRAWING NO. 7001-110-012.

DRAWN BY	EBC	MATERIAL	
DATE	04-03-06		
REVISED BY	NMH	PROJECT NO./NAME	
DATE	03-14-16		
DWG SIZE	A	SCALE 1:40	SHEET 1 OF 1

ADS Nyloplast
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BUFORD, GA 30518
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FAX (770) 932-2490
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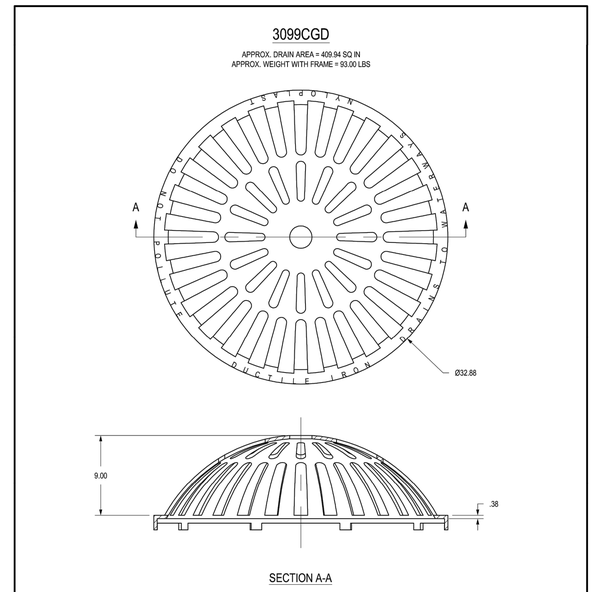
TITLE: 30 IN DRAIN BASIN QUICK SPEC INSTALLATION DETAIL

DWG NO. 7001-110-193 REV G

1 30" DRAIN BASIN QUICK SPEC INSTALLATION DETAIL
NTS



SECTION A-A

DIMENSIONS ARE FOR REFERENCE ONLY
ACTUAL DIMENSIONS MAY VARY
DIMENSIONS ARE IN INCHES
QUALITY: MATERIALS SHALL CONFORM TO ASTM A536 GRADE 70-50-05
PAINT: CASTINGS ARE FURNISHED WITH A BLACK PAINT
LOCKING DEVICE AVAILABLE UPON REQUEST

DRAWN BY	EBC	MATERIAL	DUCTILE IRON
DATE	03-08-06		
REVISED BY	CCA	PROJECT NO./NAME	
DATE	08-30-13		
DWG SIZE	A	SCALE 1:8	SHEET 1 OF 1

ADS Nyloplast
3130 VERONA AVE
BUFORD, GA 30518
PHN (770) 932-2443
FAX (770) 932-2490
www.nyloplast-us.com

TITLE: 30 IN DOME GRATE

DWG NO. 7001-110-223 REV E

2 30" DOME GRATE
NTS

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LEE'S SUMMIT, MISSOURI 64082

100% CONSTRUCTION DOCUMENT DRAWINGS

REVISIONS:

#	Description	Date

DERICK HOLMES - CIVIL ENGINEER
MO# PE-2022005196

PROJECT NO:	18225R21001
DATE:	10.26.2022
DRAWN BY:	SJB
CHK'D BY:	DMH

STORMWATER DETAILS

C-532

APPENDIX B
STORMWATER ANALYSIS

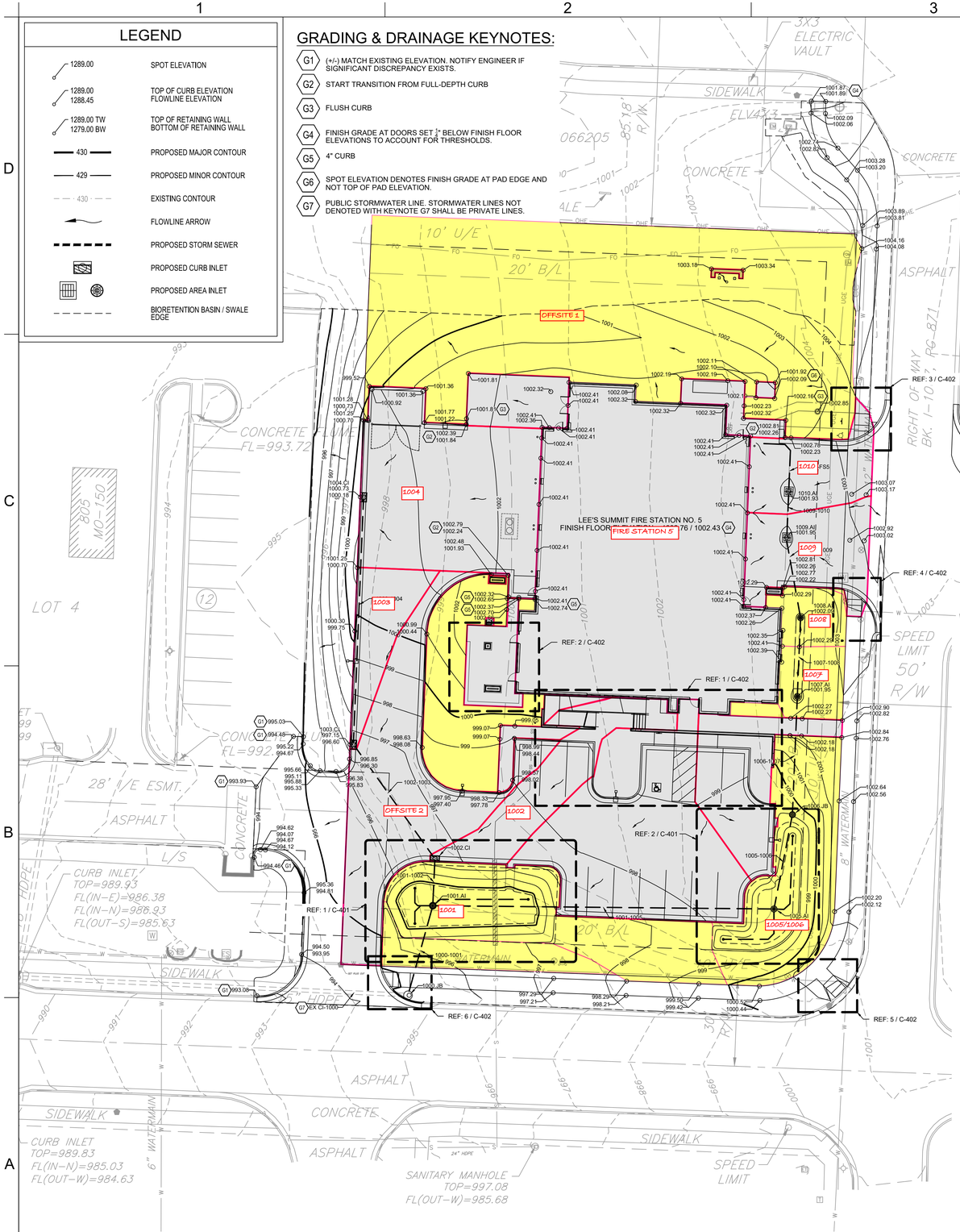
APPENDIX B.1
POST-DEVELOPMENT DRAINAGE MAPS

LEGEND

1289.00	SPOT ELEVATION
1289.00 1288.45	TOP OF CURB ELEVATION FLOWLINE ELEVATION
1289.00 TW 1279.00 BW	TOP OF RETAINING WALL BOTTOM OF RETAINING WALL
430	PROPOSED MAJOR CONTOUR
429	PROPOSED MINOR CONTOUR
430	EXISTING CONTOUR
	FLOWLINE ARROW
	PROPOSED STORM SEWER
	PROPOSED CURB INLET
	PROPOSED AREA INLET
	BIORETENTION BASIN / SWALE EDGE

GRADING & DRAINAGE KEYNOTES:

- G1 (+/-) MATCH EXISTING ELEVATION. NOTIFY ENGINEER IF SIGNIFICANT DISCREPANCY EXISTS.
- G2 START TRANSITION FROM FULL-DEPTH CURB
- G3 FLUSH CURB
- G4 FINISH GRADE AT DOORS SET 1" BELOW FINISH FLOOR ELEVATIONS TO ACCOUNT FOR THRESHOLDS.
- G5 4" CURB
- G6 SPOT ELEVATION DENOTES FINISH GRADE AT PAD EDGE AND NOT TOP OF PAD ELEVATION.
- G7 PUBLIC STORMWATER LINE. STORMWATER LINES NOT DENOTED WITH KEYNOTE G7 SHALL BE PRIVATE LINES.



GENERAL GRADING & DRAINAGE NOTES:

1. SITE GRADING MUST BE PERFORMED IN ACCORDANCE WITH THESE PLANS, SPECIFICATIONS, AND THE RECOMMENDATIONS SET FORTH IN THE GEOTECHNICAL REPORT AS REFERENCED IN THIS PLAN SET. THE CONTRACTOR MUST FOLLOW THE REQUIREMENTS OF ALL MUNICIPAL, COUNTY, STATE, AND FEDERAL LAWS, WHICH HAVE JURISDICTION OVER THIS PROJECT.
2. ALL PROPOSED CONTOUR LINES AND SPOT ELEVATIONS SHOWN ARE FINISH GROUND ELEVATIONS. CONTRACTOR SHALL ACCOUNT FOR PAVEMENT DEPTHS, BUILDING PADS, LOW VOLUME CHANGE MATERIAL, TOPSOIL, ETC. WHEN GRADING THE SITE.
3. ALL DISTURBED AREAS THAT ARE NOT TO BE PAVED (GREEN SPACES) SHALL BE FINISH GRADED WITH A MINIMUM OF SIX INCHES OF TOPSOIL.
4. ALL EXCAVATIONS AND EMBANKMENTS SHALL COMPLY WITH THE RECOMMENDATIONS PROVIDED BY THE GEOTECHNICAL ENGINEER.
5. FINISHED GRADES SHALL NOT BE STEEPER THAN 3:1, UNLESS NOTED OTHERWISE ON THE PLANS.
6. CONTRACTOR SHALL FIELD VERIFY ALL EXISTING ELEVATIONS OF CONNECTION POINTS AS SHOWN ON GRADING PLANS. NOTIFY ENGINEER IF DISCREPANCY EXISTS FOR DIRECTION.
7. ALL GRADES SHALL BE CONTOURED SMOOTHLY WITH GENTLE ROUNDING/SHAPING OF ALL AFFECTED LAND SURFACES. ABRUPT TRANSITIONS AT THE TOP OF SLOPES WHERE PROPOSED GRADES MEET EXISTING ARE NOT ACCEPTABLE. GRADING SHALL BE APPROVED BY THE OWNER'S REPRESENTATIVE PRIOR TO THE ADDITION OF THE TOPSOIL LAYER.
8. SEE DRAWINGS C-230 AND C-231 FOR STORMWATER PROFILE DRAWINGS.

ADA NOTES

1. ALL A… RUCTED TO MEET, AT A MINIMUM, THE MORE STRINGENT OF: (A) THE REQU… 2101 ET SEQ. AND 42 U.S.C. § 4151 ET SEQ.); AND (B) ANY APPLICABLE LOCAL AND STATE… WHEN THESE PLANS WERE COMPLETED.
2. THE C… ACCURACY, COMPLIANCE, AND CONSISTENCY WITH INDUSTRY GUIDELINES.
3. THE C… TION OF ACCESSIBLE (ADA) COMPONENTS AND ACCESSIBLE ROUTES FOR THE SITE… SPACES, PUBLIC TRANSPORTATION, PEDESTRIAN ACCESS, AND INTER-BUILDING ACCE… E ACCESSIBLE GUIDELINES AND REQUIREMENTS WHICH INCLUDE, BUT ARE NOT LIMITE…
   - 3.1. ACCESSIBLE PARKING SPACES AND ACCESS AISLE SLOPES MUST NOT EXCEED 1:50 (2.0%) IN ANY DIRECTION.
   - 3.2. PATH OF TRAVEL ALONG ACCESSIBLE ROUTE MUST PROVIDE A 48-INCHES MINIMUM WIDTH. UNOBSTRUCTED WIDTH OF TRAVEL (CAR OVERHANGS AND/OR H… 50 (2.0%) IN C… PATH OF TR… EL AT A SL…
   - 3.3. AC… IBLE RA… AT CHANGE DI… AMP MUST BE…
   - 3.4. AC… LEVEL LA… AT THE TOP, FL…
   - 3.5. DO… BE SL… ONG, EX… -2009 AND OT…
   - 3.6. W… M EXISTING DO… NT OF JU… TELY NO… WHAT IS SH… D BY THE BA…
   - 3.7. TH… OR IS OR… CES. CO…
4. IT IS S… G CODE PRIOR…

SCS Unit Hydrograph Method, Curve Number

Catchment Number	Total Area (ft²)	Impervious Area C = 98 (ft²)	Turfed Area C = 74 (ft²)	Composite Curve Number
Post-Development				
1001	6173.79	3613.33	2560.46	88.0
1002	1364.16	1364.16	0.00	98.0
1003	839.80	839.80	0.00	98.0
1004	3471.16	3471.16	0.00	98.0
1005/1006	3826.35	1405.11	2421.24	82.8
1007	559.04	0.00	559.04	74.0
1008	482.76	15.01	467.75	74.7
1009	1297.69	1287.97	9.72	97.8
1010	1116.29	1116.29	0.00	98.0
Fire Station 5	8003.63	8003.63	0.00	98.0
Offsite 1	11129.11	1029.62	10099.49	76.2
Offsite 2	6372.55	4041.11	2331.44	89.2
∑	44636.33			

STOR…

STRUCTURE NAME	GRATE / RIM ELEVATION	PIPE			
1000.JB	995.28	1000-… INV IN…			0.5%
1001.AI	995.50	1001-… INV IN… 1001-1002, 12" INV IN =991.71 BIO UNDERDRAIN 1.1, 6" INV IN =992.00 BIO UNDERDRAIN 1.2, 6" INV IN =992.00	1000-1001, 12" INV OUT =991.21	N: 977891.22 E: 2818408.30	30" AREA INLET W/ DOME GRATE, SEE NOTE 2 REF: C-401; 1 / C-530, 5 / C-531 & 1-2 / C-532
1002.CI	996.63	1002-1003, 12" INV IN =992.06	1001-1002, 12" INV OUT =991.86	N: 977907.48 E: 2818409.02	2'X3' CURB INLET REF: 1 / C-530 & 1-2 / C-531
1003.CI	996.60	1003-1004, 12" INV IN =992.73	1002-1003, 12" INV OUT =992.53	N: 977947.03 E: 2818380.76	2'X3' CURB INLET REF: 1 / C-530 & 1-2 / C-531
1004.CI	1000.18		1003-1004, 12" INV OUT =996.00	N: 978032.84 E: 2818384.29	2'X3' CURB INLET REF: 1 / C-530 & 1-2 / C-531
1005.AI	997.86	1005-1006, 12" INV IN =993.66 BIO UNDERDRAIN 2.1, 6" INV IN =994.03 BIO UNDERDRAIN 2.2, 6" INV IN =994.03	1001-1005, 12" INV OUT =993.16	N: 977890.08 E: 2818526.60	24" AREA INLET W/ DOME GRATE, SEE NOTE 2 REF: C-401;1 / C-530 & 2, 3, 5 / C-531
1006.JB	999.40	1006-1007, 12" INV IN =994.21	1005-1006, 12" INV OUT =994.01	N: 977922.79 E: 2818532.99	24" DRAIN BASIN W/ SOLID COVER REF: 1 / C-530 & 2,4, & 5 / C-531
1007.AI	1001.95	1007-1008, 12" INV IN =995.19	1006-1007, 12" INV OUT =994.99	N: 977963.78 E: 2818534.70	24" AREA INLET W/ DOME GRATE REF:1 / C-530 & 2, 3, & 5 / C-531
1008.AI	1002.09	1008-1009, 12" INV IN =995.90	1007-1008, 12" INV OUT =995.70	N: 977991.06 E: 2818535.81	24" AREA INLET W/ DOME GRATE REF: 1 / C-530 & 2, 3, & 5 / C-531
1009.AI	1001.95	1009-1010, 12" INV IN =996.62	1008-1009, 12" INV OUT =996.42	N: 978018.84 E: 2818531.05	STANDARD DOUBLE GRATE INLET REF: 2 / C-530
1010.AI	1001.93	1010-FS5, 6" INV IN =997.09	1009-1010, 12" INV OUT =996.89	N: 978034.78 E: 2818531.72	STANDARD DOUBLE GRATE INLET REF: 2 / C-530
EX CI	989.93	EX CI-1000, 15" INV IN =986.38		N: 977866.28 E: 2818263.15	EXISTING CURB INLET, SEE NOTE 3 REF: 3-4 / C-530

BIO UNDERDRAIN 1.1	32.74 L.F. OF PERFORATED 6" PVC @ 0.5%
EX CI-1000	133.81 LF OF 15" HDPE @ 3.16%
1000-1001	31.21 LF OF 12" HDPP @ 1.00%
1001-1002	14.52 LF OF 12" HDPP @ 1.00%
1001-1005	116.32 LF OF 12" HDPP @ 1.25%
1002-1003	47.13 LF OF 12" HDPP @ 1.00%
1003-1004	84.45 LF OF 12" HDPP @ 3.88%
1005-1006	31.33 LF OF 12" HDPP @ 1.12%
1006-1007	39.03 LF OF 12" HDPP @ 2.00%
1007-1008	25.31 LF OF 12" HDPP @ 2.00%
1008-1009	26.08 LF OF 12" HDPP @ 2.00%
1009-1010	13.70 LF OF 12" HDPP @ 2.00%
1010-FS5	23.28 LF OF 6" HDPE @ 1.13%

NOTES

1. CONTRACTOR TO REUSE EXISTING MANHOLE, IF POSSIBLE. SEE C-102. GROUT AND REPAIR EXISTING PIPE PENETRATIONS NO LONGER NECESSARY PER CITY OF LEE'S SUMMIT, MO STANDARDS. NOTIFY ENGINEER IF STRUCTURE IS UNABLE TO BE REUSED. EXISTING INVERT ELEVATION OUT ASSUMED BASED ON LINEAR INTERPOLATION. CONTRACTOR TO FIELD VERIFY AND CONTACT ENGINEER IF DISCREPANCY EXISTS.
2. BIORETENTION BASIN OUTLET CONTROL STRUCTURE. SEE C-401.
3. THIS STRUCTURE HAS ADDITIONAL EXISTING PIPES NOT SHOWN IN THIS STRUCTURE TABLE.

1 GRADING & DRAINAGE PLAN

1" = 20'-0"

GRAPHIC SCALE 20' (0, 20', 40')

N

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100% CONSTRUCTION DOCUMENT DRAWINGS

FIRE STATION #5
CITY OF LEE'S SUMMIT

801 MISSOURI HIGHWAY 150
LEE'S SUMMIT, MISSOURI 64082

REVISIONS:

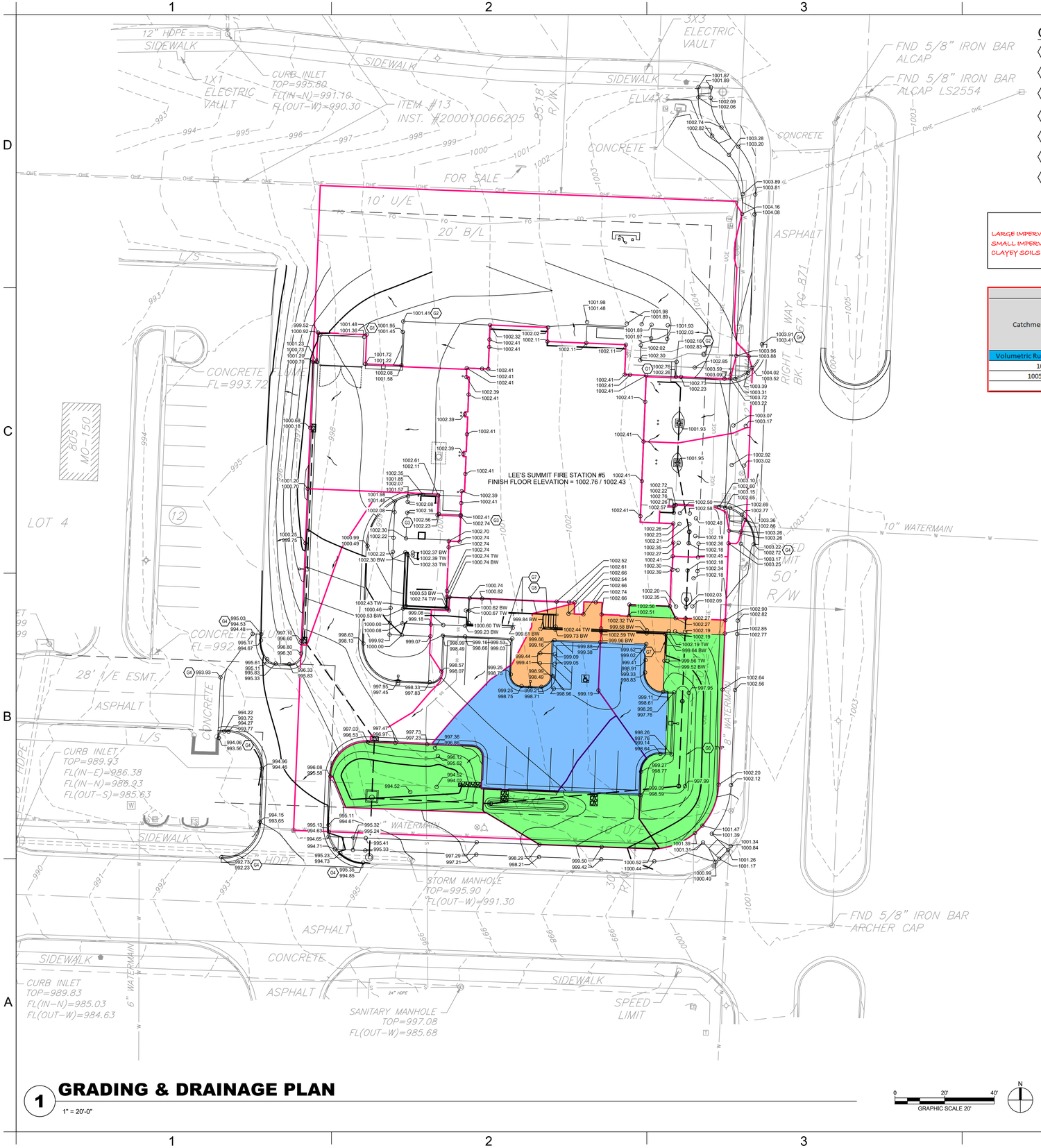
#	Description	Date

DERICK HOLMES - CIVIL ENGINEER
MO# PE-2022005196

PROJECT NO:	18225R21001
DATE:	10.26.2022
DRAWN BY:	SJB
CHK'D BY:	DMH

GRADING & DRAINAGE PLAN

C-104



GRADING & DRAINAGE KEYNOTES:

- G1 TRANSITION FROM 6" CURB TO FLUSH CURB
- G2 FLUSH CURB
- G3 4" CURB
- G4 (+/-) MATCH EXISTING ELEVATION. NOTIFY ENGINEER IF SIGNIFICANT DISCREPANCY EXISTS.
- G5 CONCRETE STEPS REF: C-502
- G6 SEE DRAWINGS LTR-LTR FOR STORMWATER PROFILE DRAWINGS
- G7 RETAINING WALL REF: C-502

LEGEND

LARGE IMPERVIOUS AREAS
SMALL IMPERVIOUS AREAS
CLAYEY SOILS (HSG-C AND D)

GENERAL GRADING & DRAINAGE NOTES:

1. CONTRACTOR SHALL OBTAIN A COPY OF THE GEOTECHNICAL REPORT BEFORE STARTING CONSTRUCTION.
2. ALL PROPOSED CONTOUR LINES AND SPOT ELEVATIONS SHOWN ARE FINISH GROUND ELEVATIONS. CONTRACTOR SHALL ACCOUNT FOR PAVEMENT DEPTHS, BUILDING PADS, TOPSOIL, ETC. WHEN GRADING THE SITE.
3. ALL DISTURBED AREAS THAT ARE NOT TO BE PAVED (GREEN SPACES) SHALL BE FINISH GRADED WITH A MINIMUM OF SIX INCHES OF TOPSOIL.
4. ALL EXCAVATIONS AND EMBANKMENTS SHALL COMPLY WITH THE RECOMMENDATIONS PROVIDED BY THE GEOTECHNICAL ENGINEER.
5. FINISHED GRADES SHALL NOT BE STEEPER THAN 3:1, UNLESS NOTED OTHERWISE ON THE PLANS.
6. ALL SITE WORK FOR THIS PROJECT IS CONSIDERED "UNCLASSIFIED". THE TERM "UNCLASSIFIED" EXCAVATION SHALL BE DEFINED AS MEANING THE CONTRACTOR BEARS THE ENTIRE RISK OF THE SOIL QUANTITIES AND/OR TYPE (E.G. ROCK, CLAY, PEAT, SILT, SHALE, ETC.) ENCOUNTERED EITHER ABOVE OR BELOW PROPOSED SUBGRADES. IN THE EVENT IT BECOMES NECESSARY FOR UNSUITABLE SOIL TO BE HANDLED, REMOVED FROM THE SITE, OR FOR SUITABLE MATERIAL TO BE IMPORTED TO THE SITE, THE CONTRACTOR SHALL BEAR THE ENTIRE COST OF SUCH ADDITIONAL WORK. "UNSUITABLE" SOIL ALSO INCLUDES SATURATED SOILS THAT MAY NEED REPLACING AND/OR TREATING IN ORDER TO MEET SCHEDULE DATES. THIS DEFINITION OF "UNCLASSIFIED" SUPERCEDES ANY CONTRARY DEFINITIONS OR STATEMENTS WHICH MAY BE CONTAINED IN SPECIFICATIONS, PLANS, OR OTHER DOCUMENTS.
7. CONTRACTOR SHALL FIELD VERIFY ALL EXISTING ELEVATIONS OF CONNECTION POINTS AS SHOWN ON GRADING PLANS. NOTIFY ENGINEER IF

Fire Station 5

Catchment Number	Total Area (ft²)	Pitched Roofs and Large Impervious Areas (Large Parking Lots) Rv = 0.98 (ft²)	Small Impervious Areas and Narrow Streets Rv = 0.75 (ft²)	Clayey Soils HSG-C and D Rv = 0.23 (ft²)	Composite Volumetric Coefficient	WQv = 1.37 * Rv (in)	WQv = (1.37 * Rv) * A (ft³)
Volumetric Runoff Coefficient							
1001	6173.79	3613.33	0.00	2560.46	0.67	0.92	471.50
1005/1006	4113.73	1266.98	138.13	2708.62	0.48	0.66	224.71
∑	10287.52	4880.31	138.13	5269.08	0.59	0.81	696.21

ACCESSIBILITY RULES AND REGULATIONS. THE CONTRACTOR SHALL BE RESPONSIBLE TO KNOW AND UNDERSTAND ALL CURRENT ACCESSIBILITY REGULATIONS AS THEY PERTAIN TO THE CONSTRUCTION OF ACCESSIBLE SITE FEATURES.

2. ALL NEW CONCRETE SIDEWALK PAVEMENT SHALL BE INSTALLED WITH A MAXIMUM 5% RUNNING SLOPE AND A MAXIMUM 2% CROSS SLOPE.
3. SURFACES OF ALL NEW CONCRETE PAVEMENT PATHWAYS SHALL BE SMOOTH AND EVEN WITH NO ABRUPT CHANGES IN ELEVATION OF 1/4" OR GREATER AS REQUIRED BY THE ACCESSIBILITY DESIGN REGULATIONS.

LEGEND

- 1289.00 — SPOT ELEVATION
- 1289.00 / 1288.50 — TOP OF CURB ELEVATION / FLOWLINE ELEVATION
- 1289.00 TW / 1279.00 BW — TOP OF RETAINING WALL / BOTTOM OF RETAINING WALL
- 430 — PROPOSED MAJOR CONTOUR
- 429 — PROPOSED MINOR CONTOUR
- 430 — EXISTING CONTOUR
- FLOWLINE ARROW
- PROPOSED STORM SEWER
- PROPOSED CURB INLET
- PROPOSED STORMWATER JUNCTION BOX
- PROPOSED AREA INLET

1 **GRADING & DRAINAGE PLAN**

1" = 20'-0"

0 20' 40'
GRAPHIC SCALE 20'

N

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100% DESIGN DEVELOPMENT DRAWINGS

REVISIONS:

#	Description	Date

CHECK SET

ANGIE MORGAN - CIVIL ENGINEER
MO# PE-2010031541

PROJECT NO:	18225R21001
DATE:	01.20.2022
DRAWN BY:	DMH
CHK'D BY:	ALM

GRADING & DRAINAGE PLAN

C-104

APPENDIX B.2
1-YR, 24-HR STORM EVENT SSA REPORT

Project Description

File Name	18225R21001_FS5_R0_220309.SPF
Description	Site_Design\Regatta_FS5\Calculations\Stormwater\Working Files\Analysis\CAD Files\18225R21001_FS5_Post-

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	00:00:00	0:00:00
End Analysis On	00:00:00	0:00:00
Start Reporting On	00:00:00	0:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	5	seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	12
Nodes	16
Junctions	4
Outfalls	3
Flow Diversions	0
Inlets	7
Storage Nodes	2
Links	15
Channels	2
Pipes	11
Pumps	0
Orifices	2
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
49		Time Series	100-YR, 24-HR	Cumulative	inches				0.00	

Subbasin Summary

SN	Subbasin ID	Area (ac)	Peak Rate Factor	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	{Site 1}.1001	0.14	484.00	88.00	9.16	7.70	1.09	0.30	0 00:05:00
2	{Site 1}.1002	0.03	484.00	98.00	9.16	8.91	0.28	0.07	0 00:05:00
3	{Site 1}.1003	0.02	484.00	98.00	9.16	8.89	0.17	0.04	0 00:05:00
4	{Site 1}.1004	0.08	484.00	98.00	9.16	8.92	0.70	0.17	0 00:05:00
5	{Site 1}.1005/1006	0.09	484.00	82.80	9.16	7.06	0.62	0.18	0 00:05:00
6	{Site 1}.1007	0.01	484.00	74.00	9.16	5.88	0.08	0.02	0 00:05:00
7	{Site 1}.1008	0.01	484.00	74.70	9.16	5.97	0.07	0.02	0 00:05:00
8	{Site 1}.1009	0.03	484.00	97.80	9.16	8.89	0.27	0.07	0 00:05:00
9	{Site 1}.1010	0.03	484.00	98.00	9.16	8.91	0.23	0.06	0 00:05:00
10	{Site 1}.Fire Station 5	0.18	484.00	98.00	9.16	8.92	1.63	0.41	0 00:05:00
11	{Site 1}.Offsite 1	0.26	484.00	76.20	9.16	6.25	1.59	0.49	0 00:05:00
12	{Site 1}.Offsite 2	0.15	484.00	88.70	9.16	7.79	1.14	0.32	0 00:05:00

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	1000.JB	Junction	990.60	995.43	0.00	6.00	0.00	1.36	991.24	0.00	4.19	0 00:00	0.00	0.00
2	1001.AI	Junction	991.21	995.50	0.00	0.00	10.00	1.36	991.97	0.00	3.53	0 00:00	0.00	0.00
3	1005.AI	Junction	993.16	997.86	0.00	0.00	10.00	0.77	993.89	0.00	3.97	0 00:00	0.00	0.00
4	1006.AI	Junction	994.01	998.08	0.00	0.00	10.00	0.59	994.41	0.00	3.67	0 00:00	0.00	0.00
5	Out-01	Outfall	997.00					0.49	997.00					
6	Out-02	Outfall	995.00					0.32	995.00					
7	Out-03	Outfall	986.38					1.36	989.93					
8	Biofiltration_1	Storage Node	994.75	996.04	0.00		0.00	0.30	995.56				0.00	0.00
9	Biofiltration_2	Storage Node	997.28	998.22	0.00		0.00	0.18	997.90				0.00	0.00

Link Summary

SN	Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length	Inlet Invert Elevation	Outlet Invert Elevation	Average Slope	Diameter or Height	Manning's Roughness	Peak Flow	Design Flow Capacity	Peak Flow/ Design Flow Ratio	Peak Flow Velocity	Peak Flow Depth	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged	Reported Condition
					(ft)	(ft)	(ft)	(%)	(in)		(cfs)	(cfs)		(ft/sec)	(ft)		(min)	
1	1000-1001	Pipe	1001.AI	1000.JB	31.21	991.21	990.90	0.9900	15.000	0.0100	1.36	8.37	0.16	5.01	0.34	0.27	0.00	Calculated
2	1001-1002	Pipe	1002.CI	1001.AI	14.52	991.86	991.71	1.0300	12.000	0.0100	0.28	5.01	0.06	3.45	0.16	0.16	0.00	Calculated
3	1001-1005	Pipe	1005.AI	1001.AI	116.31	993.16	991.71	1.2500	12.000	0.0100	0.77	5.17	0.15	4.76	0.26	0.26	0.00	Calculated
4	1002-1003	Pipe	1003.CI	1002.CI	47.13	992.53	992.06	1.0000	12.000	0.0100	0.21	4.72	0.05	3.06	0.14	0.14	0.00	Calculated
5	1003-1004	Pipe	1004.CI	1003.CI	84.45	996.00	992.73	3.8700	12.000	0.0100	0.17	9.11	0.02	4.51	0.10	0.10	0.00	Calculated
6	1005-1006	Pipe	1006.AI	1005.AI	31.33	994.01	993.66	1.1200	12.000	0.0100	0.59	4.90	0.12	4.20	0.23	0.23	0.00	Calculated
7	1006-1007	Pipe	1007.AI	1006.AI	39.09	994.99	994.21	2.0000	12.000	0.0100	0.59	6.58	0.09	5.20	0.20	0.20	0.00	Calculated
8	1007-1008	Pipe	1008.AI	1007.AI	25.31	995.70	995.19	2.0200	12.000	0.0100	0.57	6.64	0.09	5.17	0.20	0.20	0.00	Calculated
9	1008-1009	Pipe	1009.AI	1008.AI	26.08	996.42	995.90	1.9900	12.000	0.0100	0.54	6.66	0.08	5.13	0.19	0.19	0.00	Calculated
10	1009-1010	Pipe	1010.AI	1009.AI	13.70	996.89	996.62	1.9700	12.000	0.0100	0.47	6.85	0.07	5.01	0.18	0.18	0.00	Calculated
11	Out-03-1000	Pipe	1000.JB	Out-03	133.81	990.60	986.38	3.1500	15.000	0.0100	1.36	14.91	0.09	7.59	0.25	0.20	0.00	Calculated
12	BP_Out-02_1003	Channel	1003.CI	Out-02	44.84	996.60	995.00	3.5700	12.000	0.0130	0.00	86.27	0.00	0.00	0.00	0.00	0.00	
13	BP_Out-03-1002	Channel	1002.CI	Out-03	163.87	996.63	989.93	4.0900	12.000	0.0130	0.00	92.35	0.00	0.00	0.00	0.00	0.00	
14	Orifice-BF1	Orifice	Biofiltration_1	1001.AI		994.75	991.21		25.750		0.30							
15	Orifice-BF2	Orifice	Biofiltration_2	1005.AI		997.28	993.16		25.750		0.18							

Inlet Summary

SN	Element ID	Inlet Manufacturer	Manufacturer Part Number	Inlet Location	Number of Inlets	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Initial Water Elevation (ft)	Ponded Area (ft^2)	Peak Flow (cfs)	Peak Flow Intercepted by Inlet (cfs)	Peak Flow Bypassing Inlet (cfs)	Inlet Efficiency during Peak Flow (%)	Allowable Spread (ft)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)
1	1002.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	991.88	996.63	0.00	N/A	0.07	0.00	0.00	0.00	7.00	0.25	996.76
2	1003.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	992.55	996.60	0.00	N/A	0.04	0.00	0.00	0.00	7.00	0.76	996.64
3	1004.CI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	996.00	1000.18	0.00	10.00	0.17	N/A	N/A	N/A	7.00	1.10	1000.20
4	1007.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	995.00	1001.95	0.00	10.00	0.02	N/A	N/A	N/A	7.00	0.35	1001.96
5	1008.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	995.71	1002.09	0.00	10.00	0.02	N/A	N/A	N/A	7.00	0.35	1002.10
6	1009.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	996.44	1001.95	0.00	10.00	0.07	N/A	N/A	N/A	7.00	0.00	1001.97
7	1010.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	996.92	1001.93	0.00	10.00	0.47	N/A	N/A	N/A	7.00	0.00	1001.99

Junction Input

SN	Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft^2)	Minimum Pipe Cover (in)
1	1000.JB	990.60	995.43	4.83	0.00	-990.60	6.00	-989.43	0.00	0.00
2	1001.AI	991.21	995.50	4.29	0.00	-991.21	0.00	-995.50	10.00	0.00
3	1005.AI	993.16	997.86	4.70	0.00	-993.16	0.00	-997.86	10.00	0.00
4	1006.AI	994.01	998.08	4.07	0.00	-994.01	0.00	-998.08	10.00	0.00

Junction Results

SN	Element ID	Peak Inflow (cfs)	Peak Lateral Inflow (cfs)	Max HGL Elevation Attained (ft)	Max HGL Depth Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Max HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	1000.JB	1.36	0.00	991.24	0.64	0.00	4.19	991.01	0.41	0 12:01	0 00:00	0.00	0.00
2	1001.AI	1.36	0.00	991.97	0.76	0.00	3.53	991.80	0.59	0 12:01	0 00:00	0.00	0.00
3	1005.AI	0.77	0.00	993.89	0.73	0.00	3.97	993.74	0.58	0 12:00	0 00:00	0.00	0.00
4	1006.AI	0.59	0.00	994.41	0.40	0.00	3.67	994.28	0.27	0 12:00	0 00:00	0.00	0.00

Channel Input

SN	Element ID	Length (ft)	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Total Drop (ft)	Average Slope (%)	Shape	Height (ft)	Width (ft)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	Flap Gate
1	BP_Out-02_1003	44.84	996.60	4.05	995.00	0.00	1.60	3.5700	Rectangular	1.000	5.000	0.0130	0.5000	0.5000	0.0000	0.00	No
2	BP_Out-03-1002	163.87	996.63	4.75	989.93	3.55	6.70	4.0900	Rectangular	1.000	5.000	0.0130	0.5000	0.5000	0.0000	0.00	No

Channel Results

SN	Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged (min)	Froude Number	Reported Condition
1	BP_Out-02_1003	0.00	0 12:05	86.27	0.00	0.00		0.00	0.00	0.00		
2	BP_Out-03-1002	0.00	0 00:00	92.35	0.00	0.00		0.00	0.00	0.00		

Pipe Input

SN	Element ID	Length (ft)	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Average Slope (%)	Pipe Diameter or Height (in)	Pipe Width (in)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	No. of Barrels
1	1000-1001	31.21	991.21	0.00	990.90	0.30	0.9900	15.000	15.000	0.0100	0.5000	0.4000	0.0000	0.00	1
2	1001-1002	14.52	991.86	-0.02	991.71	0.50	1.0300	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
3	1001-1005	116.31	993.16	0.00	991.71	0.50	1.2500	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
4	1002-1003	47.13	992.53	-0.02	992.06	0.18	1.0000	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
5	1003-1004	84.45	996.00	0.00	992.73	0.18	3.8700	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
6	1005-1006	31.33	994.01	0.00	993.66	0.50	1.1200	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
7	1006-1007	39.09	994.99	-0.01	994.21	0.20	2.0000	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
8	1007-1008	25.31	995.70	-0.01	995.19	0.19	2.0200	12.000	12.000	0.0100	0.5000	0.1500	0.0000	0.00	1
9	1008-1009	26.08	996.42	-0.02	995.90	0.19	1.9900	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
10	1009-1010	13.70	996.89	-0.03	996.62	0.18	1.9700	12.000	12.000	0.0100	0.5000	0.1500	0.0000	0.00	1
11	Out-03-1000	133.81	990.60	0.00	986.38	0.00	3.1500	15.000	15.000	0.0100	0.5000	0.5000	0.0000	0.00	1

Pipe Results

SN	Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged (min)	Froude Number	Reported Condition
1	1000-1001	1.36	0 12:01	8.37	0.16	5.01	0.10	0.34	0.27	0.00		Calculated
2	1001-1002	0.28	0 12:00	5.01	0.06	3.45	0.07	0.16	0.16	0.00		Calculated
3	1001-1005	0.77	0 12:01	5.17	0.15	4.76	0.41	0.26	0.26	0.00		Calculated
4	1002-1003	0.21	0 12:00	4.72	0.05	3.06	0.26	0.14	0.14	0.00		Calculated
5	1003-1004	0.17	0 12:00	9.11	0.02	4.51	0.31	0.10	0.10	0.00		Calculated
6	1005-1006	0.59	0 12:00	4.90	0.12	4.20	0.12	0.23	0.23	0.00		Calculated
7	1006-1007	0.59	0 12:00	6.58	0.09	5.20	0.13	0.20	0.20	0.00		Calculated
8	1007-1008	0.57	0 11:56	6.64	0.09	5.17	0.08	0.20	0.20	0.00		Calculated
9	1008-1009	0.54	0 11:20	6.66	0.08	5.13	0.08	0.19	0.19	0.00		Calculated
10	1009-1010	0.47	0 11:20	6.85	0.07	5.01	0.05	0.18	0.18	0.00		Calculated
11	Out-03-1000	1.36	0 12:01	14.91	0.09	7.59	0.29	0.25	0.20	0.00		Calculated

Inlet Input

SN	Element ID	Inlet Manufacturer	Manufacturer Part Number	Inlet Location	Number of Inlets	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Inlet Depth (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Ponded Area (ft^2)	Grate Clogging Factor (%)
1	1002.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	991.88	996.63	4.75	0.00	0.00	N/A	0.00
2	1003.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	992.55	996.60	4.05	0.00	0.00	N/A	0.00
3	1004.CI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	996.00	1000.18	4.18	0.00	0.00	10.00	0.00
4	1007.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	995.00	1001.95	6.95	0.00	0.00	10.00	0.00
5	1008.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	995.71	1002.09	6.38	0.00	0.00	10.00	0.00
6	1009.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	996.44	1001.95	5.51	0.00	0.00	10.00	0.00
7	1010.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	996.92	1001.93	5.01	0.00	0.00	10.00	0.00

Roadway & Gutter Input

SN	Element ID	Roadway Longitudinal Slope (ft/ft)	Roadway Cross Slope (ft/ft)	Roadway Manning's Roughness	Gutter Cross Slope (ft/ft)	Gutter Width (ft)	Gutter Depression (in)	Allowable Spread (ft)
1	1002.CI	0.0400	0.0200	0.0130	0.5208	16.00	0.0410	7.00
2	1003.CI	0.0800	0.0200	0.0130	0.0521	16.00	0.0410	7.00
3	1004.CI	N/A	0.0200					
4	1007.AI	N/A	0.0200					
5	1008.AI	N/A	0.0200					
6	1009.AI	N/A	0.0200	0.0160	0.0620	2.00	0.0656	7.00
7	1010.AI	N/A	0.0200	0.0160	0.0620	2.00	0.0656	7.00

Inlet Results

SN	Element ID	Peak Flow (cfs)	Peak Lateral Inflow (cfs)	Peak Flow Intercepted by Inlet (cfs)	Peak Flow Bypassing Inlet (cfs)	Inlet Efficiency during Peak Flow (%)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)	Max Gutter Water Depth during Peak Flow (ft)	Time of Max Depth Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	1002.CI	0.07	0.07	0.00	0.00	0.00	0.25	996.76	0.13	0 12:00	0.00	0.00
2	1003.CI	0.04	0.04	0.00	0.00	0.00	0.76	996.64	0.04	0 12:00	0.00	0.00
3	1004.CI	0.17	0.17	N/A	N/A	N/A	1.10	1000.20	0.02	0 11:45	0.00	0.00
4	1007.AI	0.02	0.02	N/A	N/A	N/A	0.35	1001.96	0.01	0 11:56	0.00	0.00
5	1008.AI	0.02	0.02	N/A	N/A	N/A	0.35	1002.10	0.01	0 11:20	0.00	0.00
6	1009.AI	0.07	0.07	N/A	N/A	N/A	0.00	1001.97	0.02	0 11:20	0.00	0.00
7	1010.AI	0.47	0.47	N/A	N/A	N/A	0.00	1001.99	0.06	0 11:19	0.00	0.00

Storage Nodes

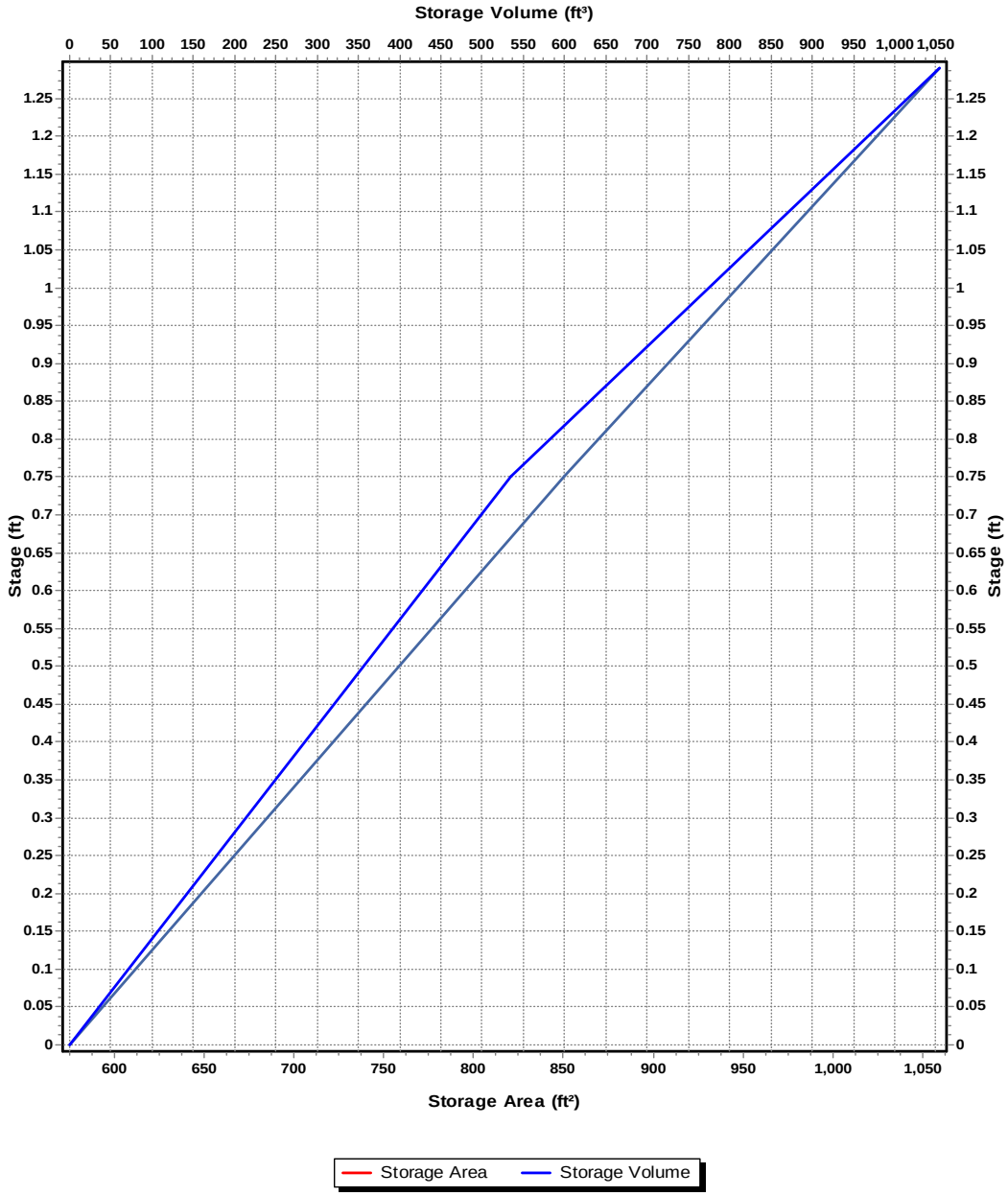
Storage Node : Biofiltration_1

Storage Area Volume Curves

Storage Curve : Storage_BF1

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	575.25	0
0.75	850.64	534.71
1.29	1059.37	1054.33

Storage Area Volume Curves



Storage Node : Biofiltration_1 (continued)

Output Summary Results

Peak Inflow (cfs)	0.3
Peak Lateral Inflow (cfs)	0.3
Peak Outflow (cfs)	0.3
Peak Exfiltration Flow Rate (cfm)	0
Max HGL Elevation Attained (ft)	995.56
Max HGL Depth Attained (ft)	0.81
Average HGL Elevation Attained (ft)	995.24
Average HGL Depth Attained (ft)	0.49
Time of Max HGL Occurrence (days hh:mm)	0 12:05
Total Exfiltration Volume (1000-ft³)	0
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0

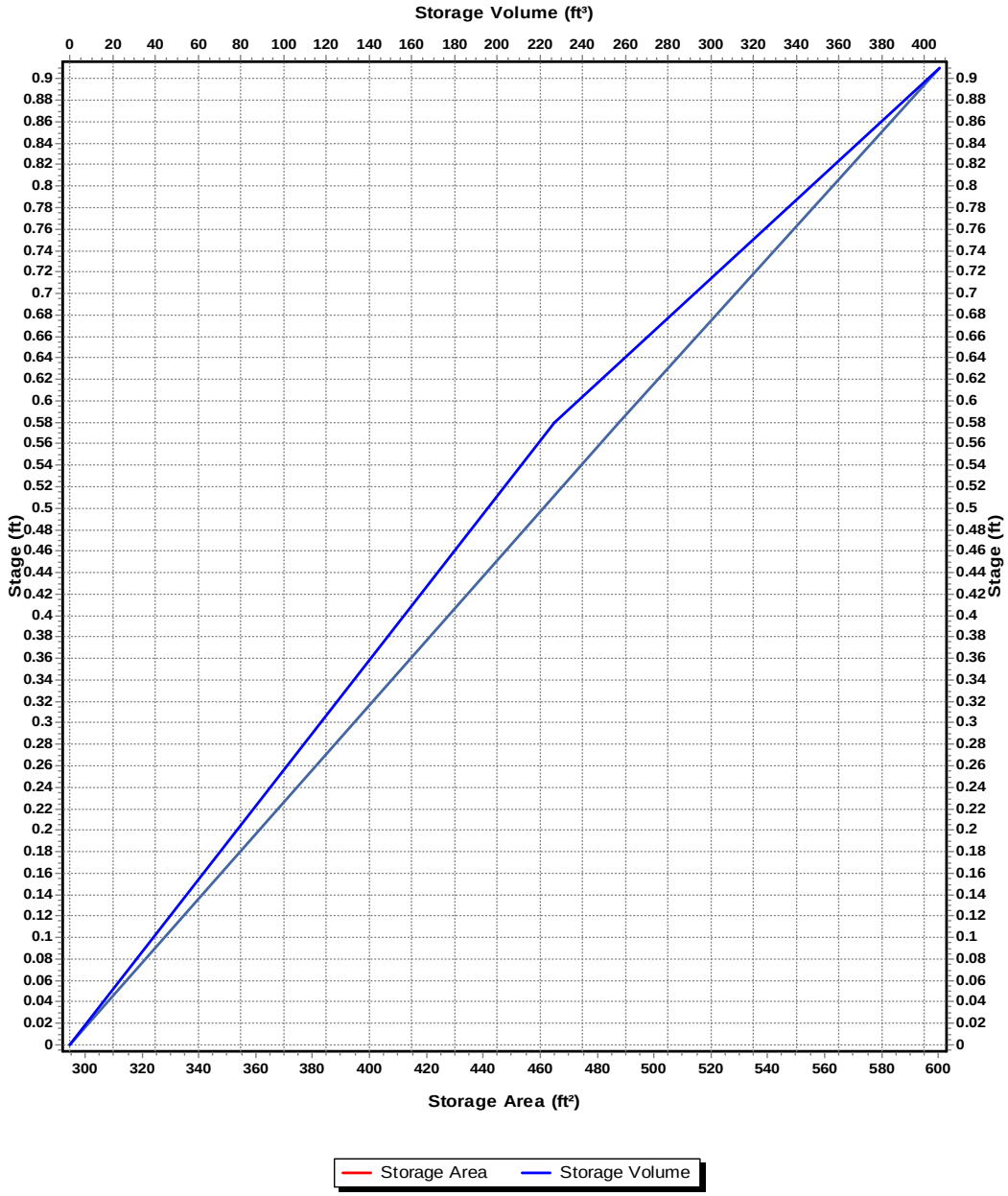
Storage Node : Biofiltration_2

Storage Area Volume Curves

Storage Curve : Storage_BF2

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	294.55	0
0.58	487.73	226.86
0.91	600.42	407.21

Storage Area Volume Curves



Storage Node : Biofiltration_2 (continued)

Output Summary Results

Peak Inflow (cfs)	0.18
Peak Lateral Inflow (cfs)	0.18
Peak Outflow (cfs)	0.18
Peak Exfiltration Flow Rate (cfm)	0
Max HGL Elevation Attained (ft)	997.9
Max HGL Depth Attained (ft)	0.62
Average HGL Elevation Attained (ft)	997.66
Average HGL Depth Attained (ft)	0.38
Time of Max HGL Occurrence (days hh:mm)	0 12:05
Total Exfiltration Volume (1000-ft³)	0
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0

APPENDIX B.3
10-YR, 24-HR STORM EVENT SSA REPORT

Project Description

File Name	18225R21001_FS5_R0_220309.SPF
Description	Site_Design\Regatta_FS5\Calculations\Stormwater\Working Files\Analysis\CAD Files\18225R21001_FS5_Post-

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	00:00:00	0:00:00
End Analysis On	00:00:00	0:00:00
Start Reporting On	00:00:00	0:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	5	seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	12
Nodes	16
Junctions	4
Outfalls	3
Flow Diversions	0
Inlets	7
Storage Nodes	2
Links	15
Channels	2
Pipes	11
Pumps	0
Orifices	2
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
49		Time Series	100-YR, 24-HR	Cumulative	inches				0.00	

Subbasin Summary

SN	Subbasin ID	Area (ac)	Peak Rate Factor	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	{Site 1}.1001	0.14	484.00	88.00	9.16	7.70	1.09	0.30	0 00:05:00
2	{Site 1}.1002	0.03	484.00	98.00	9.16	8.91	0.28	0.07	0 00:05:00
3	{Site 1}.1003	0.02	484.00	98.00	9.16	8.89	0.17	0.04	0 00:05:00
4	{Site 1}.1004	0.08	484.00	98.00	9.16	8.92	0.70	0.17	0 00:05:00
5	{Site 1}.1005/1006	0.09	484.00	82.80	9.16	7.06	0.62	0.18	0 00:05:00
6	{Site 1}.1007	0.01	484.00	74.00	9.16	5.88	0.08	0.02	0 00:05:00
7	{Site 1}.1008	0.01	484.00	74.70	9.16	5.97	0.07	0.02	0 00:05:00
8	{Site 1}.1009	0.03	484.00	97.80	9.16	8.89	0.27	0.07	0 00:05:00
9	{Site 1}.1010	0.03	484.00	98.00	9.16	8.91	0.23	0.06	0 00:05:00
10	{Site 1}.Fire Station 5	0.18	484.00	98.00	9.16	8.92	1.63	0.41	0 00:05:00
11	{Site 1}.Offsite 1	0.26	484.00	76.20	9.16	6.25	1.59	0.49	0 00:05:00
12	{Site 1}.Offsite 2	0.15	484.00	88.70	9.16	7.79	1.14	0.32	0 00:05:00

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	1000.JB	Junction	990.60	995.43	0.00	6.00	0.00	1.36	991.24	0.00	4.19	0 00:00	0.00	0.00
2	1001.AI	Junction	991.21	995.50	0.00	0.00	10.00	1.36	991.97	0.00	3.53	0 00:00	0.00	0.00
3	1005.AI	Junction	993.16	997.86	0.00	0.00	10.00	0.77	993.89	0.00	3.97	0 00:00	0.00	0.00
4	1006.AI	Junction	994.01	998.08	0.00	0.00	10.00	0.59	994.41	0.00	3.67	0 00:00	0.00	0.00
5	Out-01	Outfall	997.00					0.49	997.00					
6	Out-02	Outfall	995.00					0.32	995.00					
7	Out-03	Outfall	986.38					1.36	989.93					
8	Biofiltration_1	Storage Node	994.75	996.04	0.00		0.00	0.30	995.56				0.00	0.00
9	Biofiltration_2	Storage Node	997.28	998.22	0.00		0.00	0.18	997.90				0.00	0.00

Link Summary

SN	Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length	Inlet Invert Elevation	Outlet Invert Elevation	Average Slope	Diameter or Height	Manning's Roughness	Peak Flow	Design Flow Capacity	Peak Flow/ Design Flow Ratio	Peak Flow Velocity	Peak Flow Depth	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged	Reported Condition
					(ft)	(ft)	(ft)	(%)	(in)		(cfs)	(cfs)		(ft/sec)	(ft)		(min)	
1	1000-1001	Pipe	1001.AI	1000.JB	31.21	991.21	990.90	0.9900	15.000	0.0100	1.36	8.37	0.16	5.01	0.34	0.27	0.00	Calculated
2	1001-1002	Pipe	1002.CI	1001.AI	14.52	991.86	991.71	1.0300	12.000	0.0100	0.28	5.01	0.06	3.45	0.16	0.16	0.00	Calculated
3	1001-1005	Pipe	1005.AI	1001.AI	116.31	993.16	991.71	1.2500	12.000	0.0100	0.77	5.17	0.15	4.76	0.26	0.26	0.00	Calculated
4	1002-1003	Pipe	1003.CI	1002.CI	47.13	992.53	992.06	1.0000	12.000	0.0100	0.21	4.72	0.05	3.06	0.14	0.14	0.00	Calculated
5	1003-1004	Pipe	1004.CI	1003.CI	84.45	996.00	992.73	3.8700	12.000	0.0100	0.17	9.11	0.02	4.51	0.10	0.10	0.00	Calculated
6	1005-1006	Pipe	1006.AI	1005.AI	31.33	994.01	993.66	1.1200	12.000	0.0100	0.59	4.90	0.12	4.20	0.23	0.23	0.00	Calculated
7	1006-1007	Pipe	1007.AI	1006.AI	39.09	994.99	994.21	2.0000	12.000	0.0100	0.59	6.58	0.09	5.20	0.20	0.20	0.00	Calculated
8	1007-1008	Pipe	1008.AI	1007.AI	25.31	995.70	995.19	2.0200	12.000	0.0100	0.57	6.64	0.09	5.17	0.20	0.20	0.00	Calculated
9	1008-1009	Pipe	1009.AI	1008.AI	26.08	996.42	995.90	1.9900	12.000	0.0100	0.54	6.66	0.08	5.13	0.19	0.19	0.00	Calculated
10	1009-1010	Pipe	1010.AI	1009.AI	13.70	996.89	996.62	1.9700	12.000	0.0100	0.47	6.85	0.07	5.01	0.18	0.18	0.00	Calculated
11	Out-03-1000	Pipe	1000.JB	Out-03	133.81	990.60	986.38	3.1500	15.000	0.0100	1.36	14.91	0.09	7.59	0.25	0.20	0.00	Calculated
12	BP_Out-02_1003	Channel	1003.CI	Out-02	44.84	996.60	995.00	3.5700	12.000	0.0130	0.00	86.27	0.00	0.00	0.00	0.00	0.00	
13	BP_Out-03-1002	Channel	1002.CI	Out-03	163.87	996.63	989.93	4.0900	12.000	0.0130	0.00	92.35	0.00	0.00	0.00	0.00	0.00	
14	Orifice-BF1	Orifice	Biofiltration_1	1001.AI		994.75	991.21		25.750		0.30							
15	Orifice-BF2	Orifice	Biofiltration_2	1005.AI		997.28	993.16		25.750		0.18							

Inlet Summary

SN	Element ID	Inlet Manufacturer	Manufacturer Part Number	Inlet Location	Number of Inlets	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Initial Water Elevation (ft)	Ponded Area (ft^2)	Peak Flow (cfs)	Peak Flow Intercepted by Inlet (cfs)	Peak Flow Bypassing Inlet (cfs)	Inlet Efficiency during Peak Flow (%)	Allowable Spread (ft)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)
1	1002.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	991.88	996.63	0.00	N/A	0.07	0.00	0.00	0.00	7.00	0.25	996.76
2	1003.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	992.55	996.60	0.00	N/A	0.04	0.00	0.00	0.00	7.00	0.76	996.64
3	1004.CI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	996.00	1000.18	0.00	10.00	0.17	N/A	N/A	N/A	7.00	1.10	1000.20
4	1007.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	995.00	1001.95	0.00	10.00	0.02	N/A	N/A	N/A	7.00	0.35	1001.96
5	1008.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	995.71	1002.09	0.00	10.00	0.02	N/A	N/A	N/A	7.00	0.35	1002.10
6	1009.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	996.44	1001.95	0.00	10.00	0.07	N/A	N/A	N/A	7.00	0.00	1001.97
7	1010.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	996.92	1001.93	0.00	10.00	0.47	N/A	N/A	N/A	7.00	0.00	1001.99

Junction Input

SN	Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft^2)	Minimum Pipe Cover (in)
1	1000.JB	990.60	995.43	4.83	0.00	-990.60	6.00	-989.43	0.00	0.00
2	1001.AI	991.21	995.50	4.29	0.00	-991.21	0.00	-995.50	10.00	0.00
3	1005.AI	993.16	997.86	4.70	0.00	-993.16	0.00	-997.86	10.00	0.00
4	1006.AI	994.01	998.08	4.07	0.00	-994.01	0.00	-998.08	10.00	0.00

Junction Results

SN	Element ID	Peak Inflow (cfs)	Peak Lateral Inflow (cfs)	Max HGL Elevation Attained (ft)	Max HGL Depth Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Max HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	1000.JB	1.36	0.00	991.24	0.64	0.00	4.19	991.01	0.41	0 12:01	0 00:00	0.00	0.00
2	1001.AI	1.36	0.00	991.97	0.76	0.00	3.53	991.80	0.59	0 12:01	0 00:00	0.00	0.00
3	1005.AI	0.77	0.00	993.89	0.73	0.00	3.97	993.74	0.58	0 12:00	0 00:00	0.00	0.00
4	1006.AI	0.59	0.00	994.41	0.40	0.00	3.67	994.28	0.27	0 12:00	0 00:00	0.00	0.00

Channel Input

SN	Element ID	Length (ft)	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Total Drop (ft)	Average Slope (%)	Shape	Height (ft)	Width (ft)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	Flap Gate
1	BP_Out-02_1003	44.84	996.60	4.05	995.00	0.00	1.60	3.5700	Rectangular	1.000	5.000	0.0130	0.5000	0.5000	0.0000	0.00	No
2	BP_Out-03-1002	163.87	996.63	4.75	989.93	3.55	6.70	4.0900	Rectangular	1.000	5.000	0.0130	0.5000	0.5000	0.0000	0.00	No

Channel Results

SN	Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged (min)	Froude Number	Reported Condition
1	BP_Out-02_1003	0.00	0 12:05	86.27	0.00	0.00		0.00	0.00	0.00		
2	BP_Out-03-1002	0.00	0 00:00	92.35	0.00	0.00		0.00	0.00	0.00		

Pipe Input

SN	Element ID	Length (ft)	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Average Slope (%)	Pipe Diameter or Height (in)	Pipe Width (in)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	No. of Barrels
1	1000-1001	31.21	991.21	0.00	990.90	0.30	0.9900	15.000	15.000	0.0100	0.5000	0.4000	0.0000	0.00	1
2	1001-1002	14.52	991.86	-0.02	991.71	0.50	1.0300	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
3	1001-1005	116.31	993.16	0.00	991.71	0.50	1.2500	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
4	1002-1003	47.13	992.53	-0.02	992.06	0.18	1.0000	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
5	1003-1004	84.45	996.00	0.00	992.73	0.18	3.8700	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
6	1005-1006	31.33	994.01	0.00	993.66	0.50	1.1200	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
7	1006-1007	39.09	994.99	-0.01	994.21	0.20	2.0000	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
8	1007-1008	25.31	995.70	-0.01	995.19	0.19	2.0200	12.000	12.000	0.0100	0.5000	0.1500	0.0000	0.00	1
9	1008-1009	26.08	996.42	-0.02	995.90	0.19	1.9900	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
10	1009-1010	13.70	996.89	-0.03	996.62	0.18	1.9700	12.000	12.000	0.0100	0.5000	0.1500	0.0000	0.00	1
11	Out-03-1000	133.81	990.60	0.00	986.38	0.00	3.1500	15.000	15.000	0.0100	0.5000	0.5000	0.0000	0.00	1

Pipe Results

SN	Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged (min)	Froude Number	Reported Condition
1	1000-1001	1.36	0 12:01	8.37	0.16	5.01	0.10	0.34	0.27	0.00		Calculated
2	1001-1002	0.28	0 12:00	5.01	0.06	3.45	0.07	0.16	0.16	0.00		Calculated
3	1001-1005	0.77	0 12:01	5.17	0.15	4.76	0.41	0.26	0.26	0.00		Calculated
4	1002-1003	0.21	0 12:00	4.72	0.05	3.06	0.26	0.14	0.14	0.00		Calculated
5	1003-1004	0.17	0 12:00	9.11	0.02	4.51	0.31	0.10	0.10	0.00		Calculated
6	1005-1006	0.59	0 12:00	4.90	0.12	4.20	0.12	0.23	0.23	0.00		Calculated
7	1006-1007	0.59	0 12:00	6.58	0.09	5.20	0.13	0.20	0.20	0.00		Calculated
8	1007-1008	0.57	0 11:56	6.64	0.09	5.17	0.08	0.20	0.20	0.00		Calculated
9	1008-1009	0.54	0 11:20	6.66	0.08	5.13	0.08	0.19	0.19	0.00		Calculated
10	1009-1010	0.47	0 11:20	6.85	0.07	5.01	0.05	0.18	0.18	0.00		Calculated
11	Out-03-1000	1.36	0 12:01	14.91	0.09	7.59	0.29	0.25	0.20	0.00		Calculated

Inlet Input

SN	Element ID	Inlet Manufacturer	Manufacturer Part Number	Inlet Location	Number of Inlets	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Inlet Depth (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Ponded Area (ft^2)	Grate Clogging Factor (%)
1	1002.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	991.88	996.63	4.75	0.00	0.00	N/A	0.00
2	1003.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	992.55	996.60	4.05	0.00	0.00	N/A	0.00
3	1004.CI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	996.00	1000.18	4.18	0.00	0.00	10.00	0.00
4	1007.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	995.00	1001.95	6.95	0.00	0.00	10.00	0.00
5	1008.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	995.71	1002.09	6.38	0.00	0.00	10.00	0.00
6	1009.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	996.44	1001.95	5.51	0.00	0.00	10.00	0.00
7	1010.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	996.92	1001.93	5.01	0.00	0.00	10.00	0.00

Roadway & Gutter Input

SN	Element ID	Roadway Longitudinal Slope (ft/ft)	Roadway Cross Slope (ft/ft)	Roadway Manning's Roughness	Gutter Cross Slope (ft/ft)	Gutter Width (ft)	Gutter Depression (in)	Allowable Spread (ft)
1	1002.CI	0.0400	0.0200	0.0130	0.5208	16.00	0.0410	7.00
2	1003.CI	0.0800	0.0200	0.0130	0.0521	16.00	0.0410	7.00
3	1004.CI	N/A	0.0200					
4	1007.AI	N/A	0.0200					
5	1008.AI	N/A	0.0200					
6	1009.AI	N/A	0.0200	0.0160	0.0620	2.00	0.0656	7.00
7	1010.AI	N/A	0.0200	0.0160	0.0620	2.00	0.0656	7.00

Inlet Results

SN	Element ID	Peak Flow (cfs)	Peak Lateral Inflow (cfs)	Peak Flow Intercepted by Inlet (cfs)	Peak Flow Bypassing Inlet (cfs)	Inlet Efficiency during Peak Flow (%)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)	Max Gutter Water Depth during Peak Flow (ft)	Time of Max Depth Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	1002.CI	0.07	0.07	0.00	0.00	0.00	0.25	996.76	0.13	0 12:00	0.00	0.00
2	1003.CI	0.04	0.04	0.00	0.00	0.00	0.76	996.64	0.04	0 12:00	0.00	0.00
3	1004.CI	0.17	0.17	N/A	N/A	N/A	1.10	1000.20	0.02	0 11:45	0.00	0.00
4	1007.AI	0.02	0.02	N/A	N/A	N/A	0.35	1001.96	0.01	0 11:56	0.00	0.00
5	1008.AI	0.02	0.02	N/A	N/A	N/A	0.35	1002.10	0.01	0 11:20	0.00	0.00
6	1009.AI	0.07	0.07	N/A	N/A	N/A	0.00	1001.97	0.02	0 11:20	0.00	0.00
7	1010.AI	0.47	0.47	N/A	N/A	N/A	0.00	1001.99	0.06	0 11:19	0.00	0.00

Storage Nodes

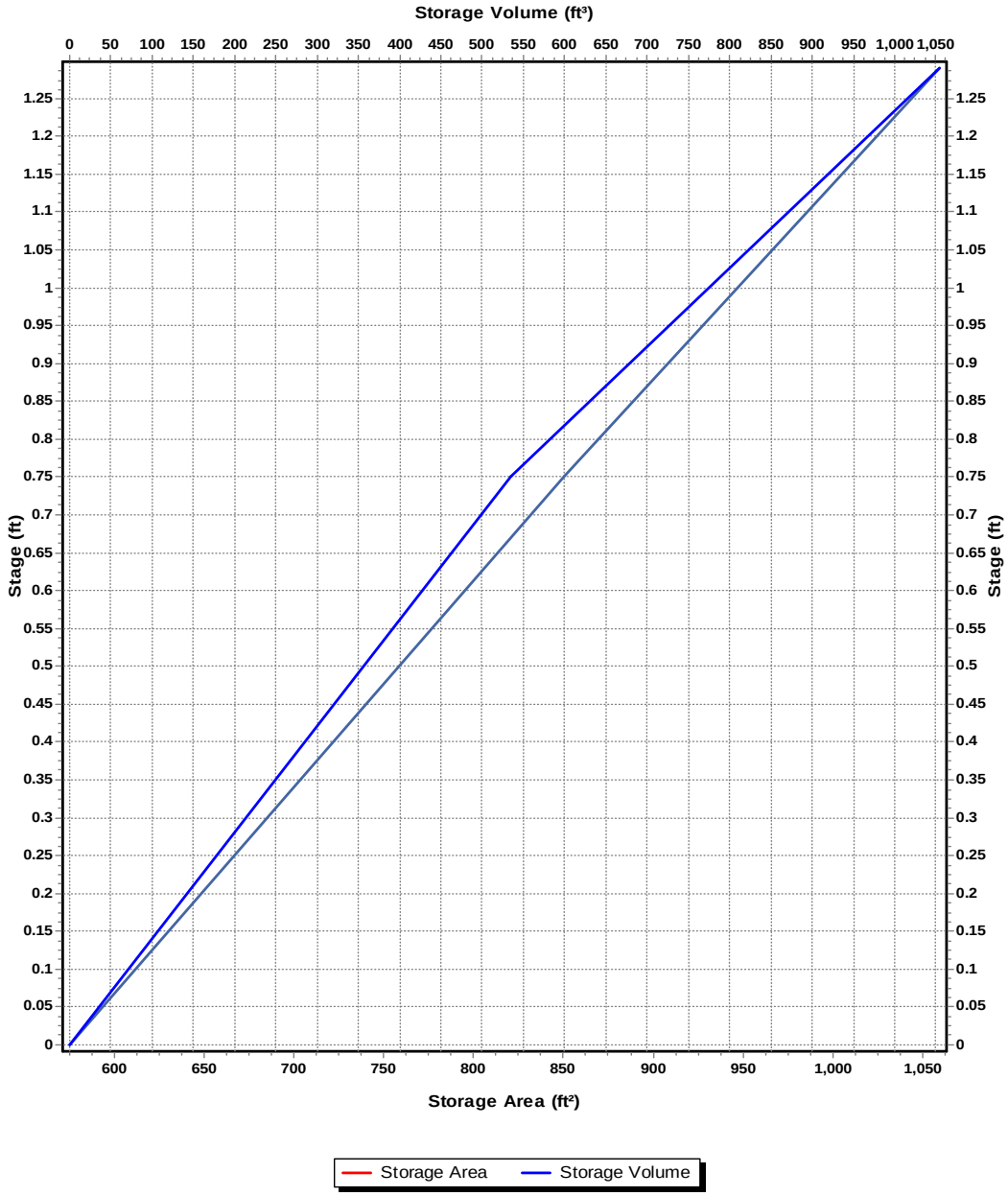
Storage Node : Biofiltration_1

Storage Area Volume Curves

Storage Curve : Storage_BF1

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	575.25	0
0.75	850.64	534.71
1.29	1059.37	1054.33

Storage Area Volume Curves



Storage Node : Biofiltration_1 (continued)

Output Summary Results

Peak Inflow (cfs)	0.3
Peak Lateral Inflow (cfs)	0.3
Peak Outflow (cfs)	0.3
Peak Exfiltration Flow Rate (cfm)	0
Max HGL Elevation Attained (ft)	995.56
Max HGL Depth Attained (ft)	0.81
Average HGL Elevation Attained (ft)	995.24
Average HGL Depth Attained (ft)	0.49
Time of Max HGL Occurrence (days hh:mm)	0 12:05
Total Exfiltration Volume (1000-ft³)	0
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0

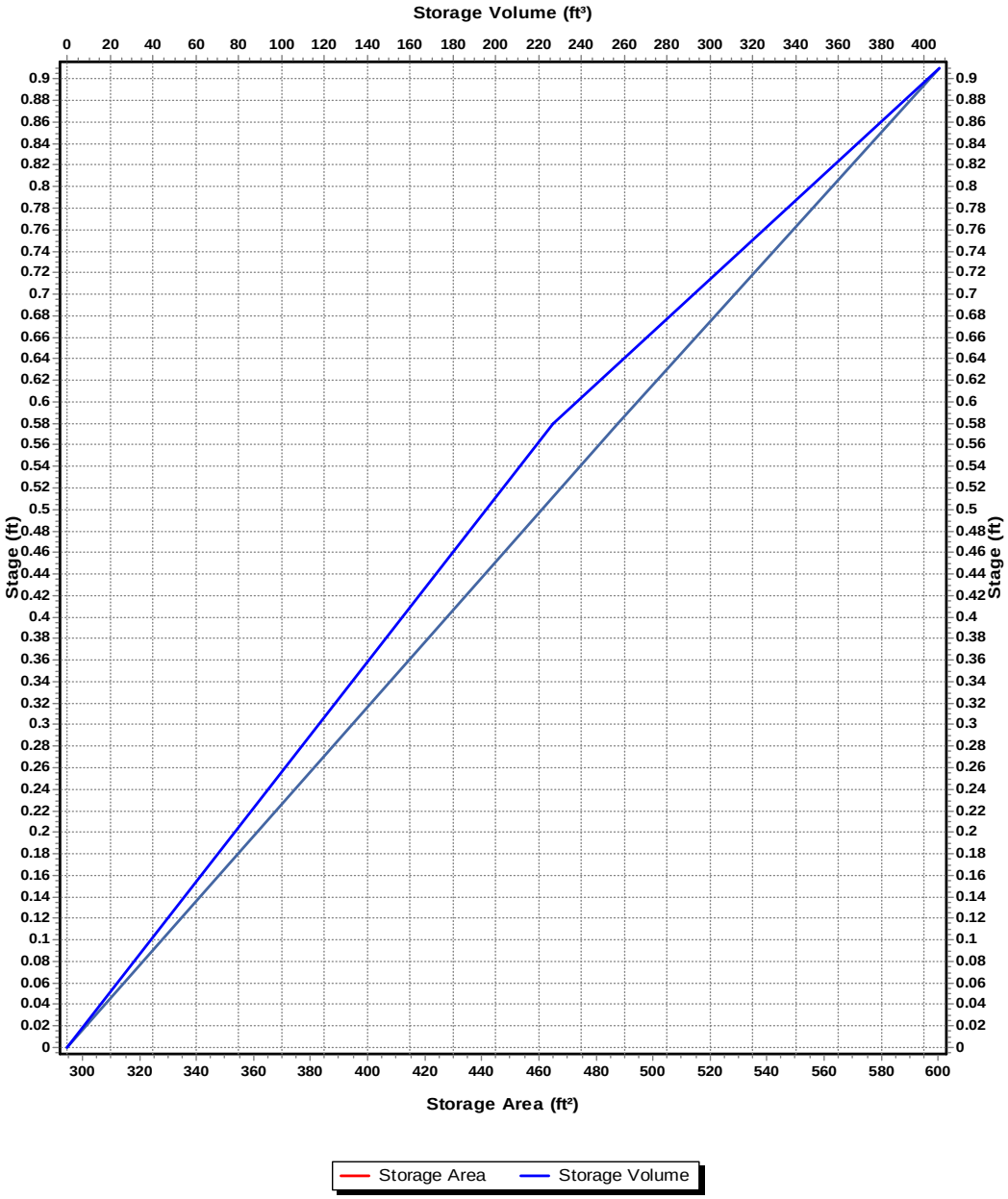
Storage Node : Biofiltration_2

Storage Area Volume Curves

Storage Curve : Storage_BF2

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	294.55	0
0.58	487.73	226.86
0.91	600.42	407.21

Storage Area Volume Curves



Storage Node : Biofiltration_2 (continued)

Output Summary Results

Peak Inflow (cfs)	0.18
Peak Lateral Inflow (cfs)	0.18
Peak Outflow (cfs)	0.18
Peak Exfiltration Flow Rate (cfm)	0
Max HGL Elevation Attained (ft)	997.9
Max HGL Depth Attained (ft)	0.62
Average HGL Elevation Attained (ft)	997.66
Average HGL Depth Attained (ft)	0.38
Time of Max HGL Occurrence (days hh:mm)	0 12:05
Total Exfiltration Volume (1000-ft³)	0
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0

APPENDIX B.4
100-YR, 24-HR STORM EVENT SSA REPORT

Project Description

File Name	18225R21001_FS5_R0_220309.SPF
Description	Site_Design\Regatta_FS5\Calculations\Stormwater\Working Files\Analysis\CAD Files\18225R21001_FS5_Post-

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	00:00:00	0:00:00
End Analysis On	00:00:00	0:00:00
Start Reporting On	00:00:00	0:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	5	seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	12
Nodes	16
Junctions	4
Outfalls	3
Flow Diversions	0
Inlets	7
Storage Nodes	2
Links	15
Channels	2
Pipes	11
Pumps	0
Orifices	2
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
49		Time Series	100-YR, 24-HR	Cumulative	inches				0.00	

Subbasin Summary

SN	Subbasin ID	Area (ac)	Peak Rate Factor	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	{Site 1}.1001	0.14	484.00	88.00	9.16	7.70	1.09	0.30	0 00:05:00
2	{Site 1}.1002	0.03	484.00	98.00	9.16	8.91	0.28	0.07	0 00:05:00
3	{Site 1}.1003	0.02	484.00	98.00	9.16	8.89	0.17	0.04	0 00:05:00
4	{Site 1}.1004	0.08	484.00	98.00	9.16	8.92	0.70	0.17	0 00:05:00
5	{Site 1}.1005/1006	0.09	484.00	82.80	9.16	7.06	0.62	0.18	0 00:05:00
6	{Site 1}.1007	0.01	484.00	74.00	9.16	5.88	0.08	0.02	0 00:05:00
7	{Site 1}.1008	0.01	484.00	74.70	9.16	5.97	0.07	0.02	0 00:05:00
8	{Site 1}.1009	0.03	484.00	97.80	9.16	8.89	0.27	0.07	0 00:05:00
9	{Site 1}.1010	0.03	484.00	98.00	9.16	8.91	0.23	0.06	0 00:05:00
10	{Site 1}.Fire Station 5	0.18	484.00	98.00	9.16	8.92	1.63	0.41	0 00:05:00
11	{Site 1}.Offsite 1	0.26	484.00	76.20	9.16	6.25	1.59	0.49	0 00:05:00
12	{Site 1}.Offsite 2	0.15	484.00	88.70	9.16	7.79	1.14	0.32	0 00:05:00

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft²)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	1000.JB	Junction	990.60	995.43	0.00	6.00	0.00	1.36	991.24	0.00	4.19	0 00:00	0.00	0.00
2	1001.AI	Junction	991.21	995.50	0.00	0.00	10.00	1.36	991.97	0.00	3.53	0 00:00	0.00	0.00
3	1005.AI	Junction	993.16	997.86	0.00	0.00	10.00	0.77	993.89	0.00	3.97	0 00:00	0.00	0.00
4	1006.AI	Junction	994.01	998.08	0.00	0.00	10.00	0.59	994.41	0.00	3.67	0 00:00	0.00	0.00
5	Out-01	Outfall	997.00					0.49	997.00					
6	Out-02	Outfall	995.00					0.32	995.00					
7	Out-03	Outfall	986.38					1.36	989.93					
8	Biofiltration_1	Storage Node	994.75	996.04	0.00		0.00	0.30	995.56				0.00	0.00
9	Biofiltration_2	Storage Node	997.28	998.22	0.00		0.00	0.18	997.90				0.00	0.00

Link Summary

SN	Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length	Inlet Invert Elevation	Outlet Invert Elevation	Average Slope	Diameter or Height	Manning's Roughness	Peak Flow	Design Flow Capacity	Peak Flow/ Design Flow Ratio	Peak Flow Velocity	Peak Flow Depth	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged	Reported Condition
					(ft)	(ft)	(ft)	(%)	(in)		(cfs)	(cfs)		(ft/sec)	(ft)		(min)	
1	1000-1001	Pipe	1001.AI	1000.JB	31.21	991.21	990.90	0.9900	15.000	0.0100	1.36	8.37	0.16	5.01	0.34	0.27	0.00	Calculated
2	1001-1002	Pipe	1002.CI	1001.AI	14.52	991.86	991.71	1.0300	12.000	0.0100	0.28	5.01	0.06	3.45	0.16	0.16	0.00	Calculated
3	1001-1005	Pipe	1005.AI	1001.AI	116.31	993.16	991.71	1.2500	12.000	0.0100	0.77	5.17	0.15	4.76	0.26	0.26	0.00	Calculated
4	1002-1003	Pipe	1003.CI	1002.CI	47.13	992.53	992.06	1.0000	12.000	0.0100	0.21	4.72	0.05	3.06	0.14	0.14	0.00	Calculated
5	1003-1004	Pipe	1004.CI	1003.CI	84.45	996.00	992.73	3.8700	12.000	0.0100	0.17	9.11	0.02	4.51	0.10	0.10	0.00	Calculated
6	1005-1006	Pipe	1006.AI	1005.AI	31.33	994.01	993.66	1.1200	12.000	0.0100	0.59	4.90	0.12	4.20	0.23	0.23	0.00	Calculated
7	1006-1007	Pipe	1007.AI	1006.AI	39.09	994.99	994.21	2.0000	12.000	0.0100	0.59	6.58	0.09	5.20	0.20	0.20	0.00	Calculated
8	1007-1008	Pipe	1008.AI	1007.AI	25.31	995.70	995.19	2.0200	12.000	0.0100	0.57	6.64	0.09	5.17	0.20	0.20	0.00	Calculated
9	1008-1009	Pipe	1009.AI	1008.AI	26.08	996.42	995.90	1.9900	12.000	0.0100	0.54	6.66	0.08	5.13	0.19	0.19	0.00	Calculated
10	1009-1010	Pipe	1010.AI	1009.AI	13.70	996.89	996.62	1.9700	12.000	0.0100	0.47	6.85	0.07	5.01	0.18	0.18	0.00	Calculated
11	Out-03-1000	Pipe	1000.JB	Out-03	133.81	990.60	986.38	3.1500	15.000	0.0100	1.36	14.91	0.09	7.59	0.25	0.20	0.00	Calculated
12	BP_Out-02_1003	Channel	1003.CI	Out-02	44.84	996.60	995.00	3.5700	12.000	0.0130	0.00	86.27	0.00	0.00	0.00	0.00	0.00	
13	BP_Out-03-1002	Channel	1002.CI	Out-03	163.87	996.63	989.93	4.0900	12.000	0.0130	0.00	92.35	0.00	0.00	0.00	0.00	0.00	
14	Orifice-BF1	Orifice	Biofiltration_1	1001.AI		994.75	991.21		25.750		0.30							
15	Orifice-BF2	Orifice	Biofiltration_2	1005.AI		997.28	993.16		25.750		0.18							

Inlet Summary

SN	Element ID	Inlet Manufacturer	Manufacturer Part Number	Inlet Location	Number of Inlets	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Initial Water Elevation (ft)	Ponded Area (ft^2)	Peak Flow (cfs)	Peak Flow Intercepted by Inlet (cfs)	Peak Flow Bypassing Inlet (cfs)	Inlet Efficiency during Peak Flow (%)	Allowable Spread (ft)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)
1	1002.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	991.88	996.63	0.00	N/A	0.07	0.00	0.00	0.00	7.00	0.25	996.76
2	1003.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	992.55	996.60	0.00	N/A	0.04	0.00	0.00	0.00	7.00	0.76	996.64
3	1004.CI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	996.00	1000.18	0.00	10.00	0.17	N/A	N/A	N/A	7.00	1.10	1000.20
4	1007.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	995.00	1001.95	0.00	10.00	0.02	N/A	N/A	N/A	7.00	0.35	1001.96
5	1008.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	995.71	1002.09	0.00	10.00	0.02	N/A	N/A	N/A	7.00	0.35	1002.10
6	1009.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	996.44	1001.95	0.00	10.00	0.07	N/A	N/A	N/A	7.00	0.00	1001.97
7	1010.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	996.92	1001.93	0.00	10.00	0.47	N/A	N/A	N/A	7.00	0.00	1001.99

Junction Input

SN	Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft^2)	Minimum Pipe Cover (in)
1	1000.JB	990.60	995.43	4.83	0.00	-990.60	6.00	-989.43	0.00	0.00
2	1001.AI	991.21	995.50	4.29	0.00	-991.21	0.00	-995.50	10.00	0.00
3	1005.AI	993.16	997.86	4.70	0.00	-993.16	0.00	-997.86	10.00	0.00
4	1006.AI	994.01	998.08	4.07	0.00	-994.01	0.00	-998.08	10.00	0.00

Junction Results

SN	Element ID	Peak Inflow (cfs)	Peak Lateral Inflow (cfs)	Max HGL Elevation Attained (ft)	Max HGL Depth Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Max HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	1000.JB	1.36	0.00	991.24	0.64	0.00	4.19	991.01	0.41	0 12:01	0 00:00	0.00	0.00
2	1001.AI	1.36	0.00	991.97	0.76	0.00	3.53	991.80	0.59	0 12:01	0 00:00	0.00	0.00
3	1005.AI	0.77	0.00	993.89	0.73	0.00	3.97	993.74	0.58	0 12:00	0 00:00	0.00	0.00
4	1006.AI	0.59	0.00	994.41	0.40	0.00	3.67	994.28	0.27	0 12:00	0 00:00	0.00	0.00

1001.AI UNDRAIN
ELEVATION = 992.00

1005.AI UNDERDRAIN
ELEVATION = 994.03

Channel Input

SN	Element ID	Length (ft)	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Total Drop (ft)	Average Slope (%)	Shape	Height (ft)	Width (ft)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	Flap Gate
1	BP_Out-02_1003	44.84	996.60	4.05	995.00	0.00	1.60	3.5700	Rectangular	1.000	5.000	0.0130	0.5000	0.5000	0.0000	0.00	No
2	BP_Out-03-1002	163.87	996.63	4.75	989.93	3.55	6.70	4.0900	Rectangular	1.000	5.000	0.0130	0.5000	0.5000	0.0000	0.00	No

Channel Results

SN	Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged (min)	Froude Number	Reported Condition
1	BP_Out-02_1003	0.00	0 12:05	86.27	0.00	0.00		0.00	0.00	0.00		
2	BP_Out-03-1002	0.00	0 00:00	92.35	0.00	0.00		0.00	0.00	0.00		

Pipe Input

SN	Element ID	Length (ft)	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Average Slope (%)	Pipe Diameter or Height (in)	Pipe Width (in)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	No. of Barrels
1	1000-1001	31.21	991.21	0.00	990.90	0.30	0.9900	15.000	15.000	0.0100	0.5000	0.4000	0.0000	0.00	1
2	1001-1002	14.52	991.86	-0.02	991.71	0.50	1.0300	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
3	1001-1005	116.31	993.16	0.00	991.71	0.50	1.2500	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
4	1002-1003	47.13	992.53	-0.02	992.06	0.18	1.0000	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
5	1003-1004	84.45	996.00	0.00	992.73	0.18	3.8700	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
6	1005-1006	31.33	994.01	0.00	993.66	0.50	1.1200	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
7	1006-1007	39.09	994.99	-0.01	994.21	0.20	2.0000	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
8	1007-1008	25.31	995.70	-0.01	995.19	0.19	2.0200	12.000	12.000	0.0100	0.5000	0.1500	0.0000	0.00	1
9	1008-1009	26.08	996.42	-0.02	995.90	0.19	1.9900	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
10	1009-1010	13.70	996.89	-0.03	996.62	0.18	1.9700	12.000	12.000	0.0100	0.5000	0.1500	0.0000	0.00	1
11	Out-03-1000	133.81	990.60	0.00	986.38	0.00	3.1500	15.000	15.000	0.0100	0.5000	0.5000	0.0000	0.00	1

Pipe Results

SN	Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged (min)	Froude Number	Reported Condition
1	1000-1001	1.36	0 12:01	8.37	0.16	5.01	0.10	0.34	0.27	0.00		Calculated
2	1001-1002	0.28	0 12:00	5.01	0.06	3.45	0.07	0.16	0.16	0.00		Calculated
3	1001-1005	0.77	0 12:01	5.17	0.15	4.76	0.41	0.26	0.26	0.00		Calculated
4	1002-1003	0.21	0 12:00	4.72	0.05	3.06	0.26	0.14	0.14	0.00		Calculated
5	1003-1004	0.17	0 12:00	9.11	0.02	4.51	0.31	0.10	0.10	0.00		Calculated
6	1005-1006	0.59	0 12:00	4.90	0.12	4.20	0.12	0.23	0.23	0.00		Calculated
7	1006-1007	0.59	0 12:00	6.58	0.09	5.20	0.13	0.20	0.20	0.00		Calculated
8	1007-1008	0.57	0 11:56	6.64	0.09	5.17	0.08	0.20	0.20	0.00		Calculated
9	1008-1009	0.54	0 11:20	6.66	0.08	5.13	0.08	0.19	0.19	0.00		Calculated
10	1009-1010	0.47	0 11:20	6.85	0.07	5.01	0.05	0.18	0.18	0.00		Calculated
11	Out-03-1000	1.36	0 12:01	14.91	0.09	7.59	0.29	0.25	0.20	0.00		Calculated

Inlet Input

SN	Element ID	Inlet Manufacturer	Manufacturer Part Number	Inlet Location	Number of Inlets	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Inlet Depth (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Ponded Area (ft^2)	Grate Clogging Factor (%)
1	1002.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	991.88	996.63	4.75	0.00	0.00	N/A	0.00
2	1003.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	992.55	996.60	4.05	0.00	0.00	N/A	0.00
3	1004.CI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	996.00	1000.18	4.18	0.00	0.00	10.00	0.00
4	1007.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	995.00	1001.95	6.95	0.00	0.00	10.00	0.00
5	1008.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	995.71	1002.09	6.38	0.00	0.00	10.00	0.00
6	1009.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	996.44	1001.95	5.51	0.00	0.00	10.00	0.00
7	1010.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	996.92	1001.93	5.01	0.00	0.00	10.00	0.00

Roadway & Gutter Input

SN	Element ID	Roadway Longitudinal Slope (ft/ft)	Roadway Cross Slope (ft/ft)	Roadway Manning's Roughness	Gutter Cross Slope (ft/ft)	Gutter Width (ft)	Gutter Depression (in)	Allowable Spread (ft)
1	1002.CI	0.0400	0.0200	0.0130	0.5208	16.00	0.0410	7.00
2	1003.CI	0.0800	0.0200	0.0130	0.0521	16.00	0.0410	7.00
3	1004.CI	N/A	0.0200					
4	1007.AI	N/A	0.0200					
5	1008.AI	N/A	0.0200					
6	1009.AI	N/A	0.0200	0.0160	0.0620	2.00	0.0656	7.00
7	1010.AI	N/A	0.0200	0.0160	0.0620	2.00	0.0656	7.00

Inlet Results

SN	Element ID	Peak Flow (cfs)	Peak Lateral Inflow (cfs)	Peak Flow Intercepted by Inlet (cfs)	Peak Flow Bypassing Inlet (cfs)	Inlet Efficiency during Peak Flow (%)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)	Max Gutter Water Depth during Peak Flow (ft)	Time of Max Depth Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	1002.CI	0.07	0.07	0.00	0.00	0.00	0.25	996.76	0.13	0 12:00	0.00	0.00
2	1003.CI	0.04	0.04	0.00	0.00	0.00	0.76	996.64	0.04	0 12:00	0.00	0.00
3	1004.CI	0.17	0.17	N/A	N/A	N/A	1.10	1000.20	0.02	0 11:45	0.00	0.00
4	1007.AI	0.02	0.02	N/A	N/A	N/A	0.35	1001.96	0.01	0 11:56	0.00	0.00
5	1008.AI	0.02	0.02	N/A	N/A	N/A	0.35	1002.10	0.01	0 11:20	0.00	0.00
6	1009.AI	0.07	0.07	N/A	N/A	N/A	0.00	1001.97	0.02	0 11:20	0.00	0.00
7	1010.AI	0.47	0.47	N/A	N/A	N/A	0.00	1001.99	0.06	0 11:19	0.00	0.00

Storage Nodes

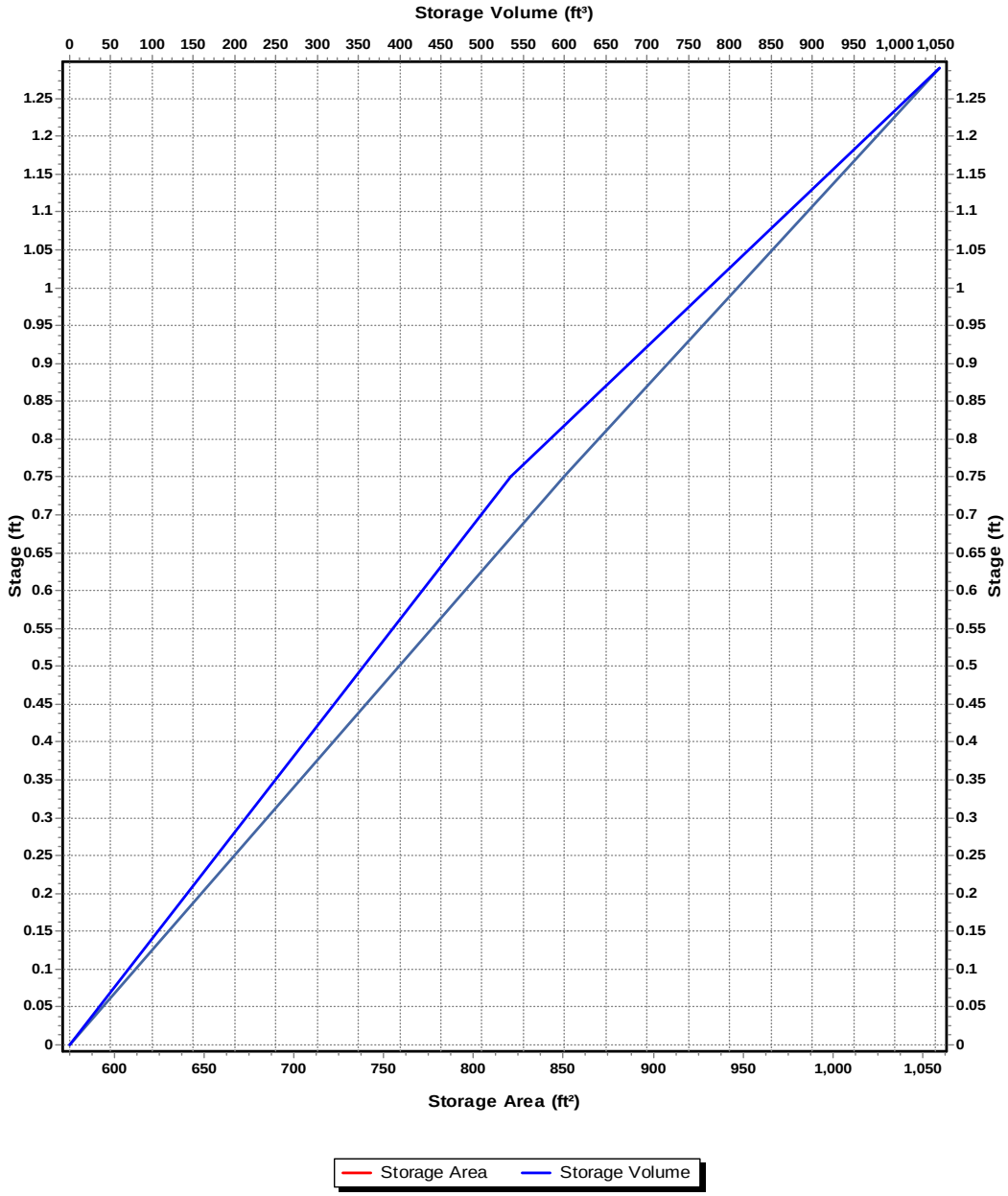
Storage Node : Biofiltration_1

Storage Area Volume Curves

Storage Curve : Storage_BF1

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	575.25	0
0.75	850.64	534.71
1.29	1059.37	1054.33

Storage Area Volume Curves



Storage Node : Biofiltration_1 (continued)

Output Summary Results

Peak Inflow (cfs)	0.3
Peak Lateral Inflow (cfs)	0.3
Peak Outflow (cfs)	0.3
Peak Exfiltration Flow Rate (cfm)	0
Max HGL Elevation Attained (ft)	995.56
Max HGL Depth Attained (ft)	0.81
Average HGL Elevation Attained (ft)	995.24
Average HGL Depth Attained (ft)	0.49
Time of Max HGL Occurrence (days hh:mm)	0 12:05
Total Exfiltration Volume (1000-ft³)	0
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0

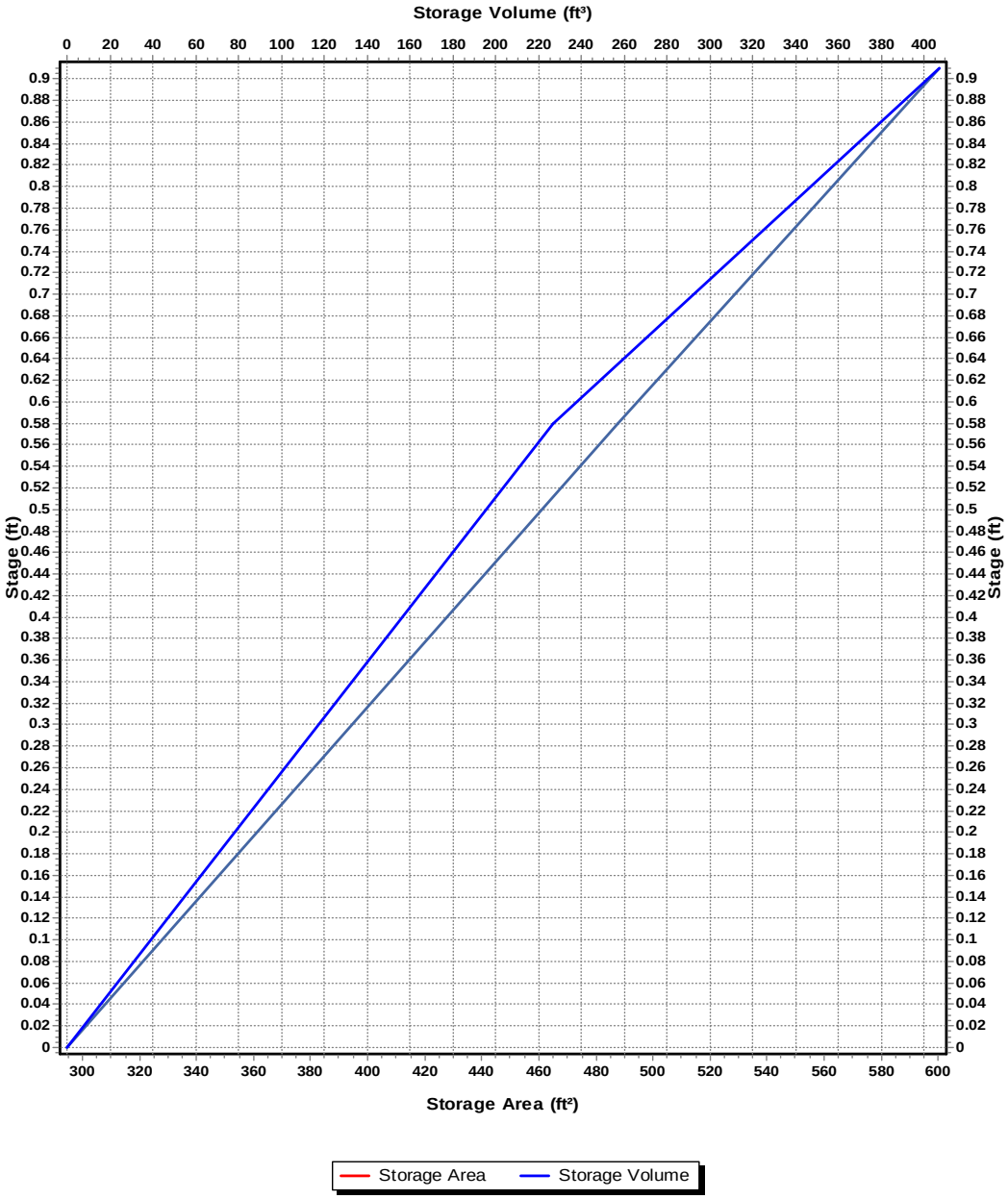
Storage Node : Biofiltration_2

Storage Area Volume Curves

Storage Curve : Storage_BF2

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	294.55	0
0.58	487.73	226.86
0.91	600.42	407.21

Storage Area Volume Curves



Storage Node : Biofiltration_2 (continued)

Output Summary Results

Peak Inflow (cfs)	0.18
Peak Lateral Inflow (cfs)	0.18
Peak Outflow (cfs)	0.18
Peak Exfiltration Flow Rate (cfm)	0
Max HGL Elevation Attained (ft)	997.9
Max HGL Depth Attained (ft)	0.62
Average HGL Elevation Attained (ft)	997.66
Average HGL Depth Attained (ft)	0.38
Time of Max HGL Occurrence (days hh:mm)	0 12:05
Total Exfiltration Volume (1000-ft³)	0
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0

APPENDIX B.5
WATER QUALITY VOLUME ANALYSIS

1. Calculate the WQv utilizing the *Small Storm Hydrology Method* (MARC BMP Manual 6.3).

$WQv = P \times Weighted\ Rv$

Where:

$WQv = Water\ Quality\ Volume\ (in)$

$P = rainfall\ event\ in\ inches\ (the\ Water\ Quality\ Sotrm\ of\ 1.37\ inches)$

$$Weighted\ Rv = \frac{\sum(Rv1 \times Ac1) + (Rv2 \times Ac2) + \cdots (Rvi * Aci)}{Total\ Acreage}$$

$Rvi = Volumetric\ runoff\ coefficient\ for\ cover\ type\ i$

$Aci = Area\ of\ cover\ type\ i\ (acres)$

$Total\ Acreage = Total\ area\ of\ the\ drainage\ area\ (acres)$

TABLE 6.1
Volumetric Coefficients For Urban Runoff for Directly Connected Impervious Areas (Claytor and Schueler 1996)

Rainfall (inches)	Flat roofs and large unpaved parking lots	Pitched roofs and large impervious areas (large parking lots)	Small impervious areas and narrow streets	Silty soils HSG-B	Clayey soils HSG-C and D
0.75	0.82	0.97	0.66	0.11	0.20
1.00	0.84	0.97	0.70	0.11	0.21
1.25	0.86	0.98	0.74	0.13	0.22
1.37	**0.87**	**0.98**	**0.75**	**0.14**	**0.23**
1.50	0.88	0.99	0.77	0.15	0.24

TABLE 6.2
Reduction Factors To Volumetric Runoff Coefficients for Disconnected Impervious Surfaces (Claytor and Schueler 1996)

Rainfall (inches)	Strip commercial and shopping center	Medium-to-high-density residential with paved alleys	Medium-to-high-density residential without alleys	Low-density residential
0.75	0.99	0.27	0.21	0.20
1.00	0.99	0.38	0.22	0.21
1.25	0.99	0.48	0.22	0.22
1.37	**0.99**	**0.53**	**0.23**	**0.23**
1.50	0.99	0.59	0.24	0.24

Note:

To use the reduction factors for disconnected impervious surfaces listed above, the impervious area uphill from a pervious area (a cover type that allows stormwater to infiltrate) should be less than one-half the area of the pervious surface, and the flow path through the pervious area should be at least twice the impervious surface flow path. For example, a 10-foot wide sidewalk would be a "disconnected impervious surface" if separated from the conveyance system by a 20-foot grassed strip or other pervious cover.

Fire Station 5							
Catchment Number	Total Area (ft^2)	Pitched Roofs and Large Impervious Areas (Large Parking Lots) Rv = 0.98 (ft^2)	Small Impervious Areas and Narrow Streets Rv = 0.75 (ft^2)	Clayey Soils HSG-C and D Rv = 0.23 (ft^2)	Composite Volumetric Coefficient	WQv = 1.37 * Rv (in)	WQv = (1.37 * Rv) * A (ft^3)
Volumetric Runoff Coefficient							
1001	**6173.79**	**3613.33**	**0.00**	**2560.46**	**0.67**	**0.92**	**471.50**
1005/1006	**4113.73**	**1266.98**	138.13	**2708.62**	**0.48**	**0.66**	**224.71**
∑	**10287.52**	**4880.31**	**138.13**	**5269.08**	**0.59**	**0.81**	**696.21**

	Bioretention #1	Bioretention #2
Available Freeboard (in)	**6.48**	**3.92**
Ponding Height (in)	**9.00**	**7.00**
Top of Bank	996.04	998.19
WQv Elevation (ft)	995.50	997.86
Top of Rock Elevation (ft)	**994.75**	997.28
Top of Bioretention Soil Mixture (BSM) (ft)	**994.50**	**997.03**
Bottom of Bioretention Soil Mixture (BSM) (ft)	992.00	**994.03**

Biofiltration #1				Biofiltration #2			
Contour Elevation (ft)	Depth (ft)	Contour Area (ft^2)	Volume (ft^3)	Contour Elevation (ft)	Depth (ft)	Contour Area (ft^2)	Volume (ft^3)
994.75	**0.00**	575.25	0.00	997.28	**0.00**	294.55	0.00
995.50	**0.75**	850.65	534.71	997.86	**0.58**	487.71	226.86
996.04	**1.29**	1073.87	1054.33	998.19	**0.91**	605.33	407.21
Check Volume Provided > WQv			OK				OK

Bioretention Calculations:

Basin ID	Bioretention #1	Bioretention #2
Water Quality Volume, WQv (ft^3)	**471.50**	**224.71**
Planting Bed Soil Depth, d_f (ft)	**2.50**	**3.00**
Coefficient of Permeability, k (ft/day)	2.00	2.00
Maximum Ponding Height, h_{max} (ft)	**0.75**	**0.58**
Average Height of Water Above Bioretention Bed, h_{avg} $h_{avg} = h_{max}/2$ (ft)	**0.38**	**0.29**
Time Required for WQv to Filter through Planting Soil Bed, t_f (days)	1.00	1.00
Required Filter Bed Surface Area, A_f $A_f = (WQv*d_f)/(k*t_f*(h_{avg}+d_f))$ (ft^2)	205.00	102.40
Filter Surface Bed Provided (ft^2)	575.25	294.55
Check Is Af < Provided.	OK	OK

APPENDIX C
TECHNICAL REFERENCES

APPENDIX C.1

SECTION 5600 – STORM DRAINAGE SYSTEMS & FACILITIES, CITY OF LEE'S SUMMIT, MO DESIGN CRITERIA

SECTION 5600 - STORM DRAINAGE SYSTEMS & FACILITIES
CITY OF LEE'S SUMMIT, MISSOURI
DESIGN CRITERIA

This is Lee's Summit, Missouri's supplement to Section 5600 of the Kansas City Metropolitan Chapter of APWA Design Criteria, current edition. The following additions, deletions and/or revisions are adopted as a part of Section 5600 for use within Lee's Summit, Missouri.

5601.5 System Types and Applications, Under A. General Guidelines:
DELETE the fourth paragraph and REPLACE it with the following:

The engineered drainage system shall begin where the tributary area reaches 2 acres.

Table 5601-1: Level of Service for Street Crossings
CHANGE Minimum Design Storm Capacity for Arterial Streets to the following:
"1%".

CHANGE Minimum Design Storm Capacity for Collector Streets to the following:
"2%".

ADD the following note at the bottom of Table 5601-1:
"Water backing up onto adjacent properties for 1% storm capacity will require an inundation (drainage) easement."

5601.5.A.4.a Default Strategy: Comprehensive Protection
Delete this section in its entirety and insert the following:

"The City has adopted the Default Strategy: Comprehensive Protection method. Under this strategy, peak runoff control will be required for the 1%, 10%, and 50% annual chance storm event. Peak runoff control is required where there are known downstream flooding problems or where an increase in the peak runoff from a development has the potential to create flooding of property, structures, stormwater infrastructure, roads, bridges, and dams. Under this strategy, volumetric and/or extended detention control of the 90% mean annual event storm event shall be provided for broad protection of the receiving system, including channel erosion protection and flood peak reductions over a range of return periods. Volumetric and/or extended detention control of the 90% mean annual event storm shall be implemented for all sites unless otherwise exempt by Section 5601.3. Performance standards and sizing criteria are provided in Section 5608."

5601.8.A. Protection of Property
ADD the following subparagraphs 3 and 4.

3. Master Drainage Plans

To address level of service issues on an individual building lot basis, the Developer shall submit a Master Drainage Plan with the engineering plans for each development. The plan shall cover all

portions of the development whether it is to be developed as single or multiple final plats, and shall cover all areas outside of the existing or proposed public rights-of-way. All lots must be graded in accordance with the approved Master Drainage Plan to the extent that swales, channels, diversion berms and grading activities are provided to establish the overall drainage patterns. The Master Drainage Plan is not intended to replace good lot grading practices during construction, but rather to establish overall drainage patterns for each lot and the development as a whole. Information on the plan shall include, but not be limited to, the following.

- ***a. Overall drainage map, including off-site tributary areas contributing to the runoff in the development.***
- ***b. Existing and proposed contours at two-foot or smaller contour intervals.***
- ***c. Property boundary, lot lines and numbers, and streets.***
- ***d. Location(s) of all existing and proposed swales and channels, either natural or improved, along with design flows, typical sections, details, upstream and downstream elevations, and approximate slope.***
- ***e. Limits of regulatory floodplain, where applicable.***
- ***f. Limits of 1% storm water surface elevation for all swales and channels not within regulatory floodplain.***
- ***g. Required buffer zones for natural streams.***
- ***h. The elevation of the minimum, or lowest, building opening elevation (MBOE) for each lot. If a lot is adjacent to or contains a designated swale or channel, the MBOE must be set at the 1% water surface elevation plus two feet. If there is significant change in elevation along a swale or channel, as determined by the City Engineer, multiple MBOEs may be required for different sides of the building.***
- ***i. Lots where walkout basements and daylight basement plans will be allowed.***
- ***j. Finished elevations at all corners of each lot with a minimum of four elevations per lot.***

4. The Developer shall include on the plats for the development covered by the Master Drainage Plan, a restriction that the individual lot owner(s) shall not change or obstruct the overall drainage flow lines or paths on the lots, as shown on the Master Drainage Plan, unless specific application is made and approved by the City Engineer.

Section 5603.1 Hydraulic Calculation for Pipes, Culverts, and Open Channels
Add the following:
"Enclosed systems will use the open channel, or gravity, flow design method for the appropriate design storm."

5604.1.B Inlet Design - Type
REVISE the dimension for opening length as follows:

Opening length, inside 4.0 ft (min), 8.0 ft. (max)

5604.1.C Inlet Design – Design Method
REVISE references to Figures 5604-37 and 5604-38 ***to Figures 5604-19 and 5604-21 respectively.***

ADD the following sentences to the paragraph:
Figures 5604-2 through 5604-19 apply to a curb inlet with a 10-inch throat opening height, similar to Standard Drawing CI-2. For curb inlets with different opening heights, specific design calculations must be submitted.

5604.1 Inlet Design
Add the following as Paragraph D:
D. Location: Curb inlets shall not be located in the radius of two intersecting streets. Maximum spacing of inlets shall be 400 feet.

Section 5608.7.B Additional Requirements, Underground Storage
Add the following:
"Underground detention systems typically allow some storage volume for voids in open-graded aggregate backfill around the storage chambers. Industry standard assumes the aggregate has 40% voids in the aggregate; the City will allow up to 30% voids in the aggregate. Storage in aggregate voids may be further reduced based on design conditions, maintenance programs, site conditions, etc. The Design Engineer will provide a maintenance program for underground detention systems to ensure the system will continue to function as intended."

Table 5603-1
Add the following under Closed Conduits

High Density Polyethylene Pipe (HDPE)	0.010

Section 5605.7.E Culverts, Bridges, and Above Grade Crossings
Delete the last sentence and replace with the following:

"Culverts shall be designed so the headwater to opening dimension ratio (i.e., generally referred to as HW/D) is no greater than 1.5 for the 4% design storm. All other design parameters, including the requirement that the 1% water surface elevation within the unregulated, non-special flood hazard area remain unchanged on adjacent properties unless appropriate easements are obtained, shall apply."

Section 5605.10 Floodplain Fills
Delete the entire paragraph and replace with the following:

"Fills placed within areas designated as special flood hazard areas by the Federal Emergency Management Agency (FEMA) shall comply with the City of Lee's Summit Unified Development Ordinance (UDO) "Floodplain Overlay District". Fills placed outside these limits shall not cause a rise in the 1% water surface elevation beyond the limits controlled by the developer or owner, unless appropriate easements have been obtained from adjacent property owners."

APPENDIX C.2
SELECT PAGES, APWA SECTION 5600

DIVISION V

SECTION 5600

STORM DRAINAGE SYSTEMS & FACILITIES

(February 16, 2011)

[DMH 4.20.2021] - ALL ADDITIONS, DELETIONS, AND REVISIONS TO THIS DOCUMENT ARE PER CITY OF LEE'S SUMMIT DESIGN CRITERIA, REVISED JULY 2020

DIVISION V

DESIGN CRITERIA

SECTION 5600 STORM DRAINAGE SYSTEMS & FACILITIES

SECTION 5601 ADMINISTRATIVE

5601.1 Introduction

These criteria provide uniform procedures for designing and checking the design of storm drainage systems under the rainfall and land characteristics typical of the Kansas City Metropolitan Area. This manual generally focuses on water quantity concerns including: conveyance, flow rates, and construction design parameters of stormwater systems. For an in-depth discussion of water quality design standards and Best Management Practices (BMPs) for the Kansas City Metropolitan area see the "Mid-America Regional Council and American Public Works Association; Manual for Best Management Practices for Stormwater Quality".

Federal law requires that "Waters of the United States may be disturbed only after permission is received from the City/County and permitted by the U.S. Army Corps of Engineers, if applicable. A jurisdictional determination by the U.S. Army Corps of Engineers shall be obtained prior to beginning design." Besides federal guidelines, specific criteria have been developed and are applicable to the types of drainage systems and facilities ordinarily encountered in local urban and suburban areas. Other special situations may be encountered that require added criteria or more complex technology than included herein such as maintaining or improving water quality. Any design procedure conforming to current accepted engineering practice may be used for the design of storm drainage systems in lieu of the computation methods presented in this manual, providing equivalent results are obtained and have been approved by the City/County Engineer. Drainage systems for all developments shall be designed assuming ultimate or built-out land-use conditions. The decision flowchart in Figure 5601-1, "Guide to Stormwater Management for Site Development", shall be used to determine the appropriate runoff controls (see end of this section).

5601.2 Definitions

Best Management Practice (BMP): Stormwater management practice used to prevent or control the discharge of pollutants to water of the U.S. BMPs may include structural or non-structural solutions, a schedule of activities, prohibition of practices, maintenance procedures, or other management practices. For a comprehensive discussion on BMPs refer to the "Mid-America Regional Council and American Public Works Association; Manual for Best Management Practices for Stormwater Quality".

City/County: The municipality or body having jurisdiction and authority to govern.

City/County Engineer: The municipal or county public works official or body having jurisdiction and authority to review and approve plans and designs for storm drainage systems.

Channel Lining: Includes any type of material used to stabilize the banks or bed of an engineered channel.

Design Storm: The combination of rainfall depth, duration, and distribution of a hypothetical rainfall event with a given likelihood of occurring in any year.

Detention Facility: A storm water management facility controlling storm water runoff from a site or watershed. The allowable runoff specified for detention facilities in Section 5608 is intended to manage maximum storm water release rates to minimize flooding and downstream erosion.

Detention Storage: The volume occupied by water above the level of the principal spillway crest during operation of a stormwater detention facility.

5601.3 General Requirements and Applicability

The design shall be accomplished under the direction of a Registered Professional Engineer qualified in the field of stormwater design. The design shall be based on land use in the tributary area as zoned, actually developed, or indicated by an adopted future land use plan, whichever basis produces the greatest runoff.

This design criterion shall apply to all development, including subdivision, which alters the surface of the land to create additional impervious surfaces, including, but not limited to, pavement, buildings, and structures with the following exceptions:

A. Redevelopment, Expansion, Renovation, Repair and Maintenance Activities Listed Below

1. Additions to, improvements, and repair of existing single-family and duplex dwellings.
2. Remodeling, repair, replacement, or other improvements to any existing structure or facility and appurtenances that does not cause an increased area of impervious surface on the site.
3. Remodeling, repair, replacement or other improvements to any existing structure or facility and appurtenances on sites smaller than two acres that does not cause an increased area of impervious surface on the site in excess of 10 percent of that previously existing.
4. Remodeling, repair, replacement, or other improvements to any existing structure or facility and appurtenances that does not cause an increased area of impervious surface on the site in excess of 10 percent of that previously existing, provided the total impervious area of the site is less than 5,000 square feet. (See "Site Planning for Urban Stream Protection" provided by the "Center for Watershed Protection" for a discussion on imperviousness and its effect on watershed health; http://www.cwp.org/SPSP/TOC.htm).

B. New Construction Meeting the Following Criteria

1. Construction of any one new single family or duplex dwelling unit, irrespective of the site area on which the structure may be situated, provided the total impervious area of the site is less than 5,000 square feet.
2. Construction of any buildings, structures, and/or appurtenant service roads, drives, and walks on a site having previously provided stormwater management, as defined in Section 5601.5 A4 as part of a larger unit of development, OR a site previously relieved of stormwater management requirements.

5601.4 Existing Drainage System

Existing drainage system component pipes, structures, and appurtenances within the project limits may be retained as elements of an improved system providing:

- They are in sound structural condition.
- Their hydraulic capacity, including surcharge, is equal to or greater than the capacity required by these criteria.
- Easements exist or are dedicated to allow operation and maintenance.

Discharge from an existing upstream storm drainage system shall be computed assuming its capacity is adequate to meet the performance criteria listed in Section 5601.8. The computed discharge shall be used to design the new downstream system even if the actual capacity of the existing upstream system is less.

5601.5 System Types and Applications

A. General Guidelines: Natural channels are to be preserved to the maximum extent practicable as site conditions permit. Design standards for natural channels are addressed in Section 5605. Engineered channels, the next highest priority system component, shall be designated and coordinated with the design

of building lots and streets in accordance with the design criteria and performance standards addressed in section 5607.

To the maximum extent possible, drainage systems, street layout and grades, lot patterns and placement of curbs, inlets and site drainage, and overflow swales shall be concurrently designed in accordance with the design criteria and performance standards set forth in this document. Curb and gutter may be omitted or modified where approved by the City/County Engineer and deemed feasible in conjunction with other stormwater management practices including water quality BMPs.

Enclosed conveyance systems consisting of inlets, conduits, and manholes may be used to convey stormwater runoff where site conditions and open space requirements will not permit the use of natural or engineered channels. Where used, such systems must be designed in accordance with design criteria and performance standards addressed in section 5606.

Generally, a drainage system is engineered and constructed when the drainage area exceeds 2 acres.

1. **Open Systems:** Where feasible, open systems consisting of open or engineered channels shall be used if all of the following design criteria and the conditions of Section 5601.8 are met:
   - **a.** The channel slope is less than or equal to 5 percent or where appropriate armoring techniques are used to prevent erosion.
   - **b.** The 50% storm velocity is less than or equal to 5 feet per second (fps) or where appropriate armoring techniques are used to prevent erosion.
   - **c.** When 60 feet or farther away from top of bank to any existing or proposed habitable building, regardless of system design capacity.
2. **Enclosed Systems:** Enclosed systems consisting of underground pipes, culverts, and similar underground structures shall be used to convey stormwater at all locations whenever one of the following design criteria and the conditions of 5601.8 are met:
   - **a.** Where natural channels or open systems are not feasible per the requirements set forth in Section 5605 and Section 5601.5-A1
   - **b.** Within the right-of-way of streets with curbs, regardless of system design capacity.
3. **Overflow Systems:** Each conveyance element of the stormwater drainage system (whether open, enclosed, or detention) shall include an overflow element. Overflow systems shall:
   - **a.** Be designed to route downstream any amount of the 1% storm exceeding the in-system design capacity specified in Section 5601.8.
   - **b.** Include streets, engineered channels, redundant piping, spillways, parking lots, drives or combinations thereof.
   - **c.** Limit the maximum water surface elevation generated by the 1% storm as specified in Section 5601.8.
   - **d.** Conform to local standards regarding dedicated easements and/or restricted uses for overflow systems; consult with the local authority for requirements.
   - **e.** Be limited to the natural drainage basins, unless overflows transferred out of a natural drainage basin (e.g. a thoroughfare straight-graded through a drainage basin with a sump in another drainage basin) are added to the overflows in the receiving drainage basin and the combined overflow still meets the criteria at 5601.5 A 3C
4. **Stormwater Management:** New development or redevelopment as defined in Section 5601.2 shall incorporate stormwater management measures to control runoff from the site. Allowable runoff from a site may be limited by the need to minimize downstream flood damage, prevent erosion, and/or

"The City has adopted the Default Strategy: Comprehensive Protection method. Under this strategy, peak runoff control will be required for the 1%, 10%, and 50% annual chance storm event. Peak runoff control is required where there are known downstream flooding problems or where an increase in the peak runoff from a development has the potential to create flooding of property, structures, stormwater infrastructure, roads, bridges, and dams. Under this strategy, volumetric and/or extended detention control of the 90% mean annual event storm event shall be provided for broad protection of the receiving system, including channel erosion protection and flood peak reductions over a range of return periods. Volumetric and/or extended detention control of the 90% mean annual event storm shall be implemented for all sites unless otherwise exempt by Section 5601.3. Performance standards and sizing criteria are provided in Section 5608."

minimize impacts to the ecology and water quality of the downstream drainage system. It is recognized for site-level runoff controls to be effective, consistent application across a watershed is necessary to realize measurable benefits along the downstream system. This section presents four site runoff control strategies that can be applied to sites within a watershed based on watershed protection goals and identified problems. The City/County or local authority shall pre-determine which strategy is to be applied within its watersheds or subsheds. If watershed control strategies are not defined by the local authority, the default strategy for new development shall be the Comprehensive Protection strategy.

a. Default Strategy: Comprehensive Protection

Under this strategy, peak runoff control is provided for the 1%, 10% and 50% chance storms and volumetric and/or extended detention control of the 90% mean annual event storm for broad protection of the receiving system, including channel erosion protection and flood peak reductions over a range of return periods. This strategy shall be the default strategy unless otherwise designated or approved by the local authority. Performance standards and sizing criteria are provided in Section 5608.

b. Reduced Control Strategies

1) **Frequent Event Control for Stream Erosion Protection:** This strategy provides runoff control for the 10% and 50% chance storms and volumetric and/or extended detention control of the 90% mean annual event storm in order to protect downstream channels from erosion. This strategy is appropriate for largely undeveloped watersheds containing natural streams where downstream flooding of existing structures is not present and would not occur under future upstream full-development conditions.

2) **Extreme Flood Event Control Only:** Under this strategy, detention is provided solely to reduce peak runoff rates for the 10% and 1% storm events. Over-detention of the peak release rates at the discharge point (i.e. requiring the post-development rate to be less than the pre-development rate) is used to ensure a cumulative benefit for a reasonable distance downstream. If known flooding occurs downstream in flood events more frequent than the 10% event, the local authority may require control of these events.

   This strategy is not effective at protecting stream channels and banks from erosion. It is most applicable in certain redevelopment and in-fill situations where flooding problems are known, existing downstream stream conditions are already poor, and economic barriers to redevelopment preclude more extensive control.

3) **Special Locally-Defined Strategies:** The City/County may develop alternative strategies that are tailored to the unique circumstances of their watersheds. Such strategies may apply globally to the City/County or only to certain designated areas. The City/County will identify each alternative strategy with a unique descriptor and publish the requirements for each.

   Such alternative strategies may involve increased or decreased allowable release rates, relaxed or more stringent controls for certain storm return intervals, reliance on infiltration or low-impact development practices for added volume control, planning and open space controls, and/or special requirements to participate in regional control facilities instead of development-scale facilities.

   Stormwater management for site development may include structural facilities and/or non-structural solutions. Where runoff controls are required, low-impact development practices or, off-site control of runoff in addition to or instead of the standard wet or dry bottom basins may be used.

5601.6 Waivers

The Developer may submit a study by a registered professional engineer that quantifies the problems and demonstrates that a waiver (exemption) of the requirement to provide stormwater management is appropriate. The City/County Engineer may waive requirements to address *unique* conditions or constraints:

A. Stormwater Management Facilities: Stormwater management facilities may be waived and/or release rates other than those permitted by Section 5608 when supported by a developer's Drainage Study performed in accordance with Section 5609 and approved by the City/County Engineer.

B. Overflow Channels: In previously developed areas, requirements to provide for 1% storm conveyance may be reduced by the City/County Engineer in circumstances where flood protection for the 1% storm is not reasonably attainable due to the location of damageable improvements with respect to the drainage system and where non-attainment is supported by an approved Drainage Study.

5601.7 Other Requirements

Rules and regulations of other agencies also pertain to drainage systems which may or may not complement these criteria. When conflicts are encountered, the more stringent criteria shall govern.

The following agencies have jurisdiction over streams and/or drainage systems and often require permits. Other regulations, permits and requirements may not be limited to these agencies.

- Federal Emergency Management Agency.
- U.S. Army Corps of Engineers.
- Missouri Department of Natural Resources.
- Kansas Department of Agriculture – Division of Water Resources.
- Kansas Department of Health and Environment
- Municipal Ordinances.

5601.8 Levels of Service

Drainage systems shall be designed to meet all levels of service described below. In addition, natural streams include requirements specified in Section 5605.

A storm drainage system shall be provided that is capable of conveying the peak discharge generated by the 1% storm. If the in-system capacity established in this section is less the 1% storm peak discharge, then an overflow system as specified in Section 5601.5 -A-3 may provide the additional system capacity.

A. Protection of Property

1. Property not reserved or designed for conveying storm water shall be protected from frequent inundation**:**

a. When the total drainage area is less than 2 acres, protection may be provided by following good lot grading practices or by one of the conveyances described below.

b. When the total drainage area is 2 acres or more, one of the following conveyances must be used to convey the 10% storm:

1) Pipe system conveying the design storm under a regime of pressure flow with no overflow at inlets or manholes, or

2) An engineered open channel conveying the 10% storm at bank full

3) A street gutter

4) A natural stream

a. Master Drainage Plans
To address level of service issues on an individual building lot basis, the Developer shall submit a Master Drainage Plan with the engineering plans for each development. The plan shall cover all portions of the development whether it is to be developed as single or multiple final plats, and shall cover all areas outside of the existing or proposed public rights-of-way. All lots must be graded in accordance with the approved Master Drainage Plan to the extent that swales, channels, diversion berms and grading activities are provided to establish the overall drainage patterns. The Master Drainage Plan is not intended to replace good lot grading practices during construction, but rather to establish overall drainage patterns for each lot and the development as a whole. The plan shall include, but not be limited to, the following.
a. Overall drainage map, including off-site tributary areas contributing to the runoff in the development.
b. Existing and proposed contours at two-foot or smaller contour intervals.
c. Property boundary, lot lines and numbers, and streets.

d. Location(s) of all existing and proposed swales and channels, either natural or improved, along with design flows, typical sections, details, upstream and downstream elevations, and approximate slope.
e. Limits of regulatory floodplain, where applicable.
f. Limits of 1% storm water surface elevation for all swales and channels not within regulatory floodplain.
g. Required buffer zones for natural streams.
h. The elevation of the minimum, or lowest, building opening elevation (MBOE) for each lot. If a lot is adjacent to or contains a designated swale or channel, the MBOE must be set at the 1% water surface elevation plus two feet. If there is significant change in elevation along a swale or channel, as determined by the City Engineer, multiple MBOEs may be required for different sides of the building.
i. Lots where walkout basements and daylight basement plans will be allowed.
j. Finished elevations at all corners of each lot with a minimum of four elevations per lot.

4. The Developer shall include on the plats for the development covered by the Master Drainage Plan, a restriction that the individual lot owner(s) shall not change or obstruct the overall drainage flow lines or paths on the lots, as shown on the Master Drainage Plan, unless specific application is made and approved by the City Engineer.

2. Buildings shall be protected from infrequent flooding by:

a. Providing a minimum of one-foot freeboard above the 1% storm stage, at any point along the drainage system, for openings in a building. For lakes and detention basins the 1% storm stage will be the water surface of flow through the emergency spillway.

b. Flood-proofing a building below the 1% storm water surface elevation plus one foot of freeboard, in accordance with the current edition of the International Building Code or as required by the City/County.

c. Non habitable accessory buildings are sometimes provided less protection by local City/County ordinances or policies. Consult the local authority for exceptions.

B. Protection for Streets

1. Gutter Spread: Water spread in streets shall meet the requirements in Section 5604.2 for the 10% design storm. These values are intended to establish a standard of accessibility for the widths (classes) of roadways listed during the 10% storm. When the local jurisdiction requires a higher standard for curb inlets, the conveyance system connected to the roadway must also meet that higher standard. If the roadway conveyance system connects to an underground system with lesser capacity, the system must be constructed to allow the discharge of that excess capacity into the overflow system.

2. Street Crossings: Concentrated flow not conveyed in the gutter system, shall be conveyed under streets to prevent vehicles from being swept from the roadway in infrequent storms. These crossings may be bridges, culverts or underground systems. A common practice is to construct the low point in the roadway so that it does not fall on the bridge or culvert. This practice protects the structure from damage in an overflow condition, but does not change this requirement. Crossings will be designed to completely convey flood flows without street overtopping in accordance with Table 5601-1.

Table 5601-1: Level of Service for Street Crossings

Street Classification	Min. Design Storm Capacity
Arterial	2% 1%
Collector	4% 2%
Residential	10%
Residential with open channel downstream	4%

* Water backing up onto adjacent properties for 1% storm capacity will require an inundation (drainage) easement.

Further, concentrated flow in excess of the minimum design storm may only overtop the roadway if the following conditions are met:

a. The span of the structure opening is less than 20 feet.

b. The peak stormwater runoff from the 1% storm is 250 cfs or less unless a guard fence is installed on the downstream side of the roadway.

Such overflow depths at low points in roadways during the 1% storm will be limited to 7 inches measured at the high point in the roadway cross section; except that it also shall not exceed 14 inches at the deepest point in the roadway cross section. Depths may be limited where necessary by reverse grading the downstream right of way area, by lengthening the vertical curve of the roadway, by reducing roadway crown, or by other similar means. Roadway overtopping depths shall be determined by integrating the broad crested weir formula across the roadway profile. Each incremental flow can be determined by using the formula:

$$q = C \cdot l \cdot h^{2/3}$$

Where:

q = the flow for an increment of profile length (width of flow)

l = the incremental width

C = a flow coefficient that shall not exceed 3.0

h = the average depth of flow at each increment

The total flow Q is the sum of the incremental flows. Depth determinations can be made through an iterative process where successive depths are chosen; Q is calculated for each depth and then compared to the known Q at the overtopping point.

Overflow protection criteria provides additional accessibility criteria at major stream crossings for emergency personnel, and provides the public with protection against injury and property damage.

C. Downstream Impacts

1. The negative impacts of development on flooding problems in the downstream system shall be mitigated through detention as specified in Section 5601.5-A-4, or through other means approved by the City/County.

a. Impacts on natural channels are regulated in Section 5605.

b. Communities that have adopted the recommended "Manual of Best Management Practices (BMPs) for Stormwater Quality" should also mitigate the negative impact of development on natural channels through the installation of water quality BMPs and closely adhere to practices specified in Section 5605 on natural channels.

D. Adjoining Property: State and Federal regulations often establish requirements for a storm drainage project that impacts adjoining property, especially when a project causes a rise in water surface elevations. In addition to all Federal and State regulations the following shall be met:

1. Drainageways not designated a Special Flood Hazard Area (FEMA 1% Floodplain): Construction of a storm drainage system, including grading and filling within a natural drainage way, requires agreement from adjoining property owners if the work will cause a rise in the water surface elevation on the adjoining property for the 1% storm. Agreement shall be considered granted by recording a document which reserves the affected property for inundation during the 1% storm, or by other means approved by the City/County.

2. Drainageways designated a Special Flood Hazard Areas (FEMA 1% Floodplain) and City/County participates in the National Flood Insurance Program: When impacting adjoining properties, refer to the local community's adopted Floodplain Management Ordinance for any requirements, in addition to all current FEMA regulation.

SECTION 5602 HYDROLOGY

5602.1 Scope

This section sets forth the hydrologic parameters to be used for computations involving the definition of runoff mass and peak rates to be accommodated by the storm drainage system. The methods to be used for calculating runoff mass and peak rates are intended for the design of drainage systems. Refer to the "Mid-America Regional Council and American Public Works Association; Manual for Best Management Practices for Stormwater Quality" for design methods and calculations of runoff water quality.

5602.2 Computation Methods for Runoff

Runoff rates to be accommodated by each element of the proposed storm drainage system shall be calculated using the criteria of this section for land use runoff factors, rainfall, and system time. The following methods of computations are allowed:

A. Watersheds Less than 200 Acres: The Rational Method may be used to calculate peak rates of runoff to elements of enclosed and open channel systems, including inlets, when the total upstream area tributary to the point of consideration is less than 200 acres. The Rational Method is defined as follows:

$$Q = K \cdot C \cdot i \cdot A$$

Where:

Q = Peak rate of runoff to system in cfs

C = Runoff coefficient as determined in accordance with Paragraph 5602.3

i = Rainfall intensity in inches per hour as determined in accordance with Paragraph 5602.6

K = Dimensionless coefficient to account for antecedent precipitation as follows, except the product of C·K shall not exceed 1.0. See Table 5602-1.

Table 5602-1: Antecedent Coefficient

Design Storm	K
10% and more frequent	1.0
4%	1.1
2%	1.2
1%	1.25

B. Baseline Unit Hydrograph Method: The following computer implementations of the unit hydrograph method are acceptable for all watersheds:

- SCS Technical Release No. 55 "Urban Hydrology for Small Watersheds", 2nd Edition, June 1986.
- 2. SCS Technical Release No. 20 "Project Formulation - Hydrology", 2nd Edition, May 1983.
- 3. U.S. Army Corps of Engineers, Hydrologic Engineering Center - "HEC-1Flood Hydrograph Package".
- 4. U.S. Army Corps of Engineers, Hydrologic Engineering Center - "HEC-HMS Hydrologic Modeling System", current version.

Copies of the above publications and micro-computer programs based thereon are available for purchase through National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

Table 5602-2 Documented Extreme Stream Flows in Kansas City Area and Surrounding Region

ID No.	USGS Station Number	Station Name	Contributing Drainage Area (sq. miles)	Date of Max. Discharge	Max. Recorded Discharge (cfs)	Max. Discharge per Basin Area (cfs/acre)	Period of Record (Water Yr.)	References
45.	--	Stratton Creek near Washta, Iowa	1.9	9-Aug-61	11,000	9.0	--	2
46.	--	West Fork Big Blue River trib. near York, Nebr.	6.9	9-Jul-50	23,000	5.2	--	2
47.	08057140	Cottonwood Creek at Forest Lane, Dallas, Tx.	8.5	28-Apr-66	17,600	3.2	1962-78	5,7
48.	--	Ranch Creek near Halley, Okla.	17.1	4-Sep-40	32,400	3.0	--	2

References Cited:

1. Alexander and Wilson. Technique for Estimating the 2-to 500-Year Flood Discharges on Unregulated Streams in Rural Missouri. USGS WRIR 95-4231. 1995
2. Crippen and Bue. Maximum Floodflows in the Conterminous United States. USGS WSP 1887. 1977.
3. Hauth. Floods in Kansas City, Missouri and Kansas, September 12-13, 1977. USGS Prof. Paper 1169. 1981.
4. Rasmussen and Perry. Estimate of Peak Streamflows for Unregulated Rural Streams in Kansas. USGS WRIR 00-4079. 2000.
5. Sauer et al. Flood Characteristics of Urban Watersheds in the United States. USGS WSP 2207. 1983.
6. USGS. Kansas-Missouri - Floods of July 1951. USGS WSP 1139. 1952.
7. USGS. Surface-Water Data for the Nation. Peak flow database at http://waterdata.usgs.gov/nwis/sw. Queried January 2003.

5602.3 Runoff Coefficients

A. Basis of Curve Number Coefficients: All Curve Number coefficients in this section are values for Hydrologic Group "C" soils. For soils in other Hydrologic Groups, equivalent SCS Curve Numbers can be found in SCS Technical Release No. 55. No soil disturbed by construction shall be assigned a Hydrologic Group classification of 'A' or 'B'.

B. Standard Land Use/Zoning Classifications: Runoff Coefficients relative to development, undeveloped land and land use shall have the values indicated in Table 5602-3.

Table 5602-3: Runoff Parameters

Land Use / Zoning	Average Percent Impervious	Average Percent Pervious	Rational Method "C"	SCS Curve Number
Business				
Downtown Area	95	5	0.87	97
Neighborhood Areas	85	15	0.81	94
Residential				
Single Family Areas	35	65	0.51	82
Multifamily Areas	60	40	0.66	88
Churches & Schools	75	25	0.75	92

Table 5602-3: Runoff Parameters

Land Use / Zoning	Average Percent Impervious	Average Percent Pervious	Rational Method "C"	SCS Curve Number
Industrial				
Light Areas	60	40	0.66	88
Heavy Areas	80	20	0.78	93
Parks, Cemeteries	10	90	0.36	76
Railroad Yard Areas	25	75	0.45	80
Undeveloped Areas	0	100	0.30	74
All Surfaces				
Impervious: Asphalt, Concrete, Roofs, etc.	100	0	0.90	98
Turfed	0	100	0.30	74
Wet Detention Basins	100	0	0.90	98

C. Rational Method "C" for Non-Standard Land Use/Zoning Classifications: The "C" value can be calculated from any type of land use and known percent impervious surface from the following equation:

$$C = 0.3 + 0.6 \cdot I$$

Where:

I = percent impervious divided by 100

D. Un-zoned, but Master Planned Areas: Areas whose future land use is defined by an adopted land use plan shall be assigned runoff coefficients for the land use indicated on such plan.

E. Agricultural and Unplanned Areas

1. **Existing Conditions**: For purposes of determination of development impact, undeveloped areas whose current land use is agriculture (crops, pasture, meadow) shall be assigned a maximum of 0% impervious surface or a maximum Curve Number equivalent to good condition pasture, grassland or range (C=0.30, CN=74).
2. **Proposed Conditions:** Undeveloped areas designated as agricultural or those areas for which no specific land use is indicated shall be assigned a minimum of 35% impervious surface for purposes of the design of storm drainage systems (C=0.51, CN = 82).

F. Composite Coefficients: As an alternative to the above coefficients and for areas not listed above (office parks, shopping centers, trailer parks, etc.), a composite runoff coefficient based on the actual percentages of pervious and impervious surfaces shall be used.

5602.4 Rainfall Mass

The U.S. Soil Conservation Service (SCS) Type 2 twenty-four hour rainfall distribution shall be used for all computations that employ the use of rainfall mass. That rainfall distribution is reproduced in Table 5602-4.

Table 5602-4: Rainfall Mass

TOTAL RAINFALL DEPTH ACQUIRED FROM NOAA POINT PRECIPITATION FREQUENCY TABLES

Time in Hours	Accumulated Rainfall in Percent of 24-hour Rainfall
0.0	0.00
2.0	2.20
4.0	4.80
6.0	8.00
8.0	12.00
9.0	14.70
9.5	16.30
10.0	18.10
10.5	20.40
11.0	23.50
11.5	28.30
11.75	38.70
12.0	66.30
12.5	73.50
13.0	77.20
13.5	79.90
14.0	82.00
16.0	88.00
20.0	95.20
24.0	100.00

5602.5 Unit Hydrographs

The SCS Dimensionless Unit Hydrograph (either curvilinear or triangular) shall be the basis for computation of runoff hydrographs.

5602.6 Rainfall Intensity

Rainfall intensity shall be determined from Figure 5602-1 or Table 5602-5 using a calculated Time of Concentration.

Table 5602-5: Design Aide for Calculating Rainfall Intensity Kansas City Metropolitan Area

Return Period	Equation 1 $5 \leq T_c \leq 15$	Equation 2 $15 < T_c \leq 60$
2 yr.	$i = \frac{119}{T_c + 17}$	$i = \frac{134}{T_c + 21.4}$
5 yr.	$i = \frac{154}{T_c + 18.8}$	$i = \frac{182}{T_c + 25}$

Table 5602-5: Design Aide for Calculating Rainfall Intensity Kansas City Metropolitan Area

Return Period	Equation 1 $5 \leq T_c \leq 15$	Equation 2 $15 < T_c \leq 60$
10 yr.	$i = \frac{175}{T_c + 18.8}$	$i = \frac{214}{T_c + 26.7}$
25 yr.	$i = \frac{203}{T_c + 18.8}$	$i = \frac{262}{T_c + 28.8}$
50 yr.	$i = \frac{233}{T_c + 19.8}$	$i = \frac{296}{T_c + 29.6}$
100 yr.	$i = \frac{256}{T_c + 19.8}$	$i = \frac{331}{T_c + 30}$

5602.7 Time of Concentration and Lag Time

Time of Concentration (T_C) is equal to the overland flow time to the most upstream inlet or other point of entry to the system, Inlet Time (T_I), plus the time for flow in the system to travel to the point under consideration, Travel Time (T_T).

$$T_C = T_I + T_T$$

A. Inlet Time: T_I shall be calculated by the following formula or determined graphically from Figure 5602-2, but shall not be less than 5.0 minutes nor greater than 15.0 minutes:

$$T_I = 1.8 \cdot (1.1 - C) \cdot \frac{D^{1/2}}{S^{1/3}}$$

Where:

T_I = Inlet Time in minutes

C = Rational Method Runoff Coefficient as determined in accordance with paragraph 5602.3

D = Overland flow distance parallel to slope in feet (100 feet shall be the maximum distance used for overland flow)

S = Slope of tributary area surface perpendicular to contour in percent.

"Enclosed systems will use the open channel, or gravity, flow design method for the appropriate design storm."

SECTION 5603 HYDRAULICS

5603.1 Hydraulic Calculations for Pipes, Culverts, and Open Channels

A. Gravity versus Pressure Flow for Enclosed Systems: Two design philosophies exist for sizing storm drains under the steady uniform flow assumption. The first is referred to as open channel, or gravity flow design, in which the water surface within the conduit remains open to atmospheric pressure. Pressure flow design, on the other hand, requires that the flow in the conduit be at a pressure greater than atmospheric. For a given flow rate, design based on open channel flow requires larger conduit sizes than those sized based on pressure flow. While it may be more expensive to construct storm drainage systems designed based on open channel flow, this design procedure provides a margin of safety by providing additional headroom in the conduit to accommodate an increase in flow above the design discharge. Under most ordinary conditions, it is recommended that storm drains be sized based on a gravity flow criteria at full flow or near full. Pressure flow design may be justified in certain instances. As hydraulic calculations are performed, frequent verification of the existence of the desired flow condition should be made.

Storm drainage systems can often alternate between pressure and open channel flow conditions from one section to another (U.S. Department of Transportation Federal Highway Administration, 1996).

For gravity flow conditions, Manning's formula shall be used as described below.

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

Where:

Q = Discharge, cubic feet per second

A = Cross sectional area of flow, square feet

n = Manning's roughness coefficient (see Table 5603-1)

R = Hydraulic radius, feet

$$R = \frac{A}{P}$$

S = Slope in feet per foot

P = Wetted perimeter in feet

In closed conduits flowing under pressure flow, the energy grade line (EGL) will be above the crown of the pipe. In this case, the Bernoulli equation shall be used to calculate pipe capacity:

$$\frac{p_1}{\gamma} + \frac{{V_1}^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{{V_2}^2}{2g} + z_2 + h_f + h_m$$

Where:

$\frac{p_1}{\gamma}$ = pressure head in the upstream system segment, feet

$\frac{{V_1}^2}{2g}$ = velocity head in the upstream system segment, feet

z_1 = elevation of the system invert in the upstream system segment, feet

$\frac{p_2}{\gamma}$ = pressure head in the upstream system segment, feet

$\frac{{V_2}^2}{2g}$ = velocity head in the upstream system segment, feet

z_2 = elevation of the system invert in the upstream system segment, feet

h_f = friction loss in the downstream system segment in feet

h_m = minor system losses in the downstream segment in feet

Pipe friction losses, h_f, may be calculated the friction slope method.

B. Friction Slope Method

This derivation of Manning's equation is from (FHWA, 1996).

$$h_f = S_f L$$

$$S_f = \frac{(Q \cdot n)^2}{\left(1.486\, A \cdot R^{\frac{2}{3}}\right)^2}$$

S_f = friction slope, feet/foot (which is also the slope of the HGL)

Minor losses, h_m, shall be calculated by:

$$h_m = k \cdot \frac{v^2}{2g}$$

Where:

k = Coefficient as shown in Table 5603-2

A step-by-step procedure for manual calculation of the EGL using the energy loss method is presented in Section 7.5 of (FHWA, 1996). For most drainage systems, computer methods such as HYDRA, StormCAD, CulvertMaster, or SWMM are the most efficient means of evaluating the EGL and designing the system elements.

Table 5603-1: Manning's Roughness Coefficient

Type of Channel	n
Closed Conduits	
Reinforced Concrete Pipe (RCPs)	0.013
Reinforced Concrete Elliptical Pipe	0.013
Corrugated Metal Pipe (CMPs):	
2⅔ x ½in. Annular or Helical Corrugations unpaved - plain	0.024
2⅔ x ½in. Annular or Helical Corrugations paved invert	0.021
3x1 in. Annular or Helical Corrugations unpaved - plain	0.027
3x1 in. Annular or Helical Corrugations paved invert	0.023
6x2 in. Corrugations unpaved - plain	0.033
6x2 in. Corrugations paved invert	0.028
24" diameter and smaller with Helical Corrugations.*	0.020
Vitrified Clay Pipe	0.013
Asbestos Cement Pipe	0.012
High Density Polyethylene Pipe (HDPE)	0.010
Open Channels (Lined)	
Gabions	0.025
Concrete	
Trowel Finish	0.013

Table 5603-1: Manning's Roughness Coefficient

Type of Channel	n
Float Finish	0.015
Unfinished	0.017
Concrete, bottom float finished, with sides of	
Dressed Stone	0.017
Random Stone	0.020
Cement Rubble masonry	0.025
Dry Rubble or Riprap	0.030
Gravel bottom, side of	
Random Stone	0.023
Riprap	0.033
Grass (Sod)	0.030
Riprap	0.035
Grouted Riprap	0.030
Open Channels (Unlined) Excavated or Dredged	
Earth, straight and uniform	0.027
Earth, winding and sluggish	0.035
Channels, not maintained, weeds & brush uncut	0.090
Natural Stream	
Clean stream, straight	0.030
Stream with pools, sluggish reaches, heavy underbrush	0.100
Flood Plains	
Grass, no brush	0.030
With some brush	0.090
Street Curbing	0.014

*Allowed only when the pipe length between structures is at least 20 pipe diameters.

Table 5603-2: Head Loss Coefficients

Condition	k
Manhole, junction boxes and inlets with shaped inverts:	
Thru flow	0.15
Junction	0.40
Contraction transition	0.10
Expansion transition	0.20
90 degree bend	0.40
45 degree and less bends	0.30
Culvert Inlets:	
Pipe, Concrete	
Projecting from fill, socket end (grove end)	0.20

Table 5603-2: Head Loss Coefficients

Condition	k
Projecting from fill, sq. cut end	0.50
Headwall or headwall and wingwalls	
Socket end of pipe (groove end)	0.20
Square edge	0.50
Round (radius=1/12D)	0.20
Mitered to conform to fill slope	0.70
Standard end section	0.50
Beveled edges, 33.7º or 45º bevels	0.20
Side or slope-tapered inlet	0.20
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.90
Headwall or headwall and wingwalls square edge	0.50
Mitered to conform to fill slope, paved or unpaved slope	0.70
Standard end section	0.50
Beveled edges, 33.7º or 45º bevels	0.20
Side or slope-tapered inlet	0.20
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square edged on 3 edges	0.50
Rounded on 3 edges to radius of 1/12 barrel dim. or beveled edges on 3 sides	0.20
Wingwalls at 30º to 75º to barrel	
Square edged at crown	0.40
Crown edge rounded to radius of 1/12 barrel dimension or beveled top edge	0.20
Wingwalls at 10º to 25º to barrel - square edged at crown	0.50
Wingwalls parallel (extension of sides) - square edged at crown	0.70
Side or slope-tapered inlet	0.20

Note: When 50 percent or more of the discharge enters the structure from the surface, "k" shall be 1.0.

C. Culverts: Classified as having either entrance or outlet control. Either the inlet opening (entrance control), or friction loss within the culvert or backwater from the downstream system (outlet control) will control the discharge capacity.

1. **Entrance Control:** Entrance control occurs when the culvert is hydraulically short (when the culvert is not flowing full) and steep. Flow at the entrance would be critical as the water falls over the brink. If the tailwater covers the culvert completely (i.e., a submerged exit), the culvert will be full at that point, even though the inlet control forces the culvert to be only partially full at the inlet. The transition from partially full to full occurs in a hydraulic jump, the location of which depends on the flow resistance and water levels. If the flow resistance is very high, or if the headwater and tailwater levels are high

SECTION 5604 INLETS, MANHOLES AND JUNCTION BOXES

5604.1 Inlet Design

A. Type: Only curb opening inlets shall be used on public streets, except as approved by the City/County Engineer.

B. Configuration: These minimum dimensions (shown in Table 5604-1 and illustrated by Figure 5604-1) apply to either the lazy-back or steep-face type curbs:

Table 5604-1: Inlet Configuration Dimensions

Description	Dimension
Opening length, inside	4.0 ft (min), 8.0 ft. (max)
Width, perpendicular to curb line, inside	3.0 ft (min)
Setback curb line to face	1.0 ft (min)
Opening, clear height	6.0 in. (min)
Gutter depression at inlet	6 ¼ in. (min)
Gutter transition length	
(a) Both sides in sump and upstream side on slopes	5.0 ft (min)
(b) Downstream on slopes	3.0 ft (min)

5604.1.C Inlet Design – Design Method - - > [DMH 4.20.2021] I couldn't find these references.
REVISE references to Figures 5604-37 and 5604-38 to Figures 5604-19 and 5604-21 respectively.

C. Design Method: Inlets should be designed using the methods prescribed in Section 5604.8 and/or Figures 5604-2 through 5604-19. Note that the Theoretical Captured Discharge (right side of chart) is the design capacity, 80 percent clogging factor should not be used for inlets on grade, unless deemed necessary by the engineer. Figures 5604-2 through 5604-19 describe inlet efficiency as a function of street slope (See Figure 5604-3 for design example) and in most cases will require the designer to add bypassed flow to the next downstream inlet. Figure 5604-21 describes inlet capacity for sump regions using HEC-22 equation 4-31a. Inlet capacity for sump regions shall be rated at 80 percent of the theoretical capacity to allow for partial obstruction and clogging. "Type CG-2 Curb" and Type CG-1 Curb", as indicated on these figures, refers to the lazy-back and steep-face style curbs, respectively.

Figures 5604-2 through 5604-19 apply to a curb inlet with a 10-inch throat opening height, similar to Standard Drawing CI-2. For curb inlets with different opening heights, specific design calculations must be submitted.

5604.2 Gutter Flow

D. Location: Curb inlets shall not be located in the radius of two intersecting streets. Maximum spacing of inlets shall be 400 feet.

Inlets shall be located to limit the width of flow in street gutters at the time of peak discharge for the design storm specified in 5601.8 B to the limits indicated in Table 5604-2.

Table 5604-2: Gutter Spread Criteria

Back to Back of Curb Street Width (feet)	Maximum Allowable Spread in Each Outside Curb Lane from Back of Curb* (feet)
28 or Less	12.0
Over 28 to 36	12.0
Over 36	12.0
Divided Roadways	As above for each direction roadway

* spread may exceed these limits within 50 feet of a sump inlet.

In addition to the inlet spacing requirements for limiting width of flow, inlets shall be locate to limit gutter flow from crossing the street centerline at the time of peak discharge for the design storm to the limits shown in Table 5604-3.

Table 5604-3: Inlet Bypass Spread Criteria

Condition Causing Flow Crossing Street Centerline	**Maximum Discharge** (cfs)
Sump at intersection return*	1.0
Transitions to superelevation	1.0
Sump at midblock	Not Allowed
Overflow of non-gutter flow	Per 5601.8.B

* For new development, inlets at intersections shall be positioned outside the curb return.

5604.3 Gutter Capacity

Izzard's Formula shall be used to determine gutter capacity (see Figure 5604-20 for graphical solution):

$$Q = \frac{0.56z \cdot S^{1/2} \cdot D^{8/3}}{n}$$

Where:

Q = The gutter capacity in cubic feet per second

z = The reciprocal of the average cross-slope, including gutter section, in feet per foot

S = The longitudinal street grade in feet per foot

D = The depth of flow at curb face in feet

n = Manning's "n" (see Table 5603-1)

5604.4 Freeboard Requirements

Any opening which surface water is intended to enter (or may backflow from) the system shall be 0.5 feet or more above the hydraulic grade line in the inlet during the design storm, specified in Section 5601.8, where such calculation must include minor losses.

5604.5 Inverts and Pipes

The crown(s) of pipe(s) entering a drainage structure shall be at or above the crown of the pipe exiting from the structure and provide a minimum fall of the invert in the structure of 0.2 feet for straight flow through the structure or 0.5 feet fall for all other types of flow (bends more than 22.5 deflection angle, multiple lines entering, enlargement transition, etc.) through the structure. The desirable minimum fall across the invert is 0.5 feet. Alternatively, the crowns of the pipes may be at or above the EGL of normal flow at design frequency.

The maximum spacing between manholes shall be 500 feet.

5604.6 Loading Conditions for Structures

Loading shall be in accordance with Section 5710.3.

5604.7 Street Grade on Vertical Curves

The following formula shall be used to determine the street grade (S_x) at any point on a vertical curve using plus for grades ascending forward and minus for grades descending forward, in feet per foot.

$$S_x = S_1 + \frac{x \cdot (S_2 - S_1)}{L}$$

Where:

S_x = the street grade on a vertical curve at point x, in feet per foot

S_1 = the street grade at the PC of a vertical curve, in feet per foot

S_2 = the street grade at the PT of a vertical curve, in feet per foot

x = the distance measured from the PC to point x on a vertical curve, in feet

L = the total length of a vertical curve, in feet

5604.8 Curb Inlet Intercept Equations[1]

A. For any given set of conditions (curb type, inlet length, street grade and cross-slope), the relationship between the captured discharge and the total discharge can be approximated satisfactorily by an equation

$$Q_c = \begin{cases} Q_t \quad for\ Q_t \le Q_o \\ Q_o + (Q_a - Q_o)\left\{1 - \exp\left[-\left(\frac{Q_t - Q_o}{Q_a - Q_o}\right)\right]\right\} for\ Q_t > Q_o \end{cases}$$

of the form:

Q_o and Q_a are constants. The constant Q_o represents the largest discharge that is captured completely, and the constant Q_a represents the upper limit on the captured discharge, which is approached asymptotically with increasing total discharge. For a particular curb type and street cross-slope, Q_o and Q_a vary with inlet length (L_o) and street grade (S_o) according to the formulas

$$Q_o = (a + b \cdot L_o)(S_o)^x$$

$$Q_a = (c + d \cdot L_o)(S_o)^x$$

Where a, b, c, d and x are constants. Table 5604-4 shows these constants in U.S. customary units.

Table 5604-4: Values of Coefficients and Exponent

Curb Type	Sx,%	a	b	c	d	x
CG-1 (B)	2	1.0	0	3.2	1.7	-0.5
CG-1 (B)	4	1.5	0.5	2.6	1.9	-0.5
CG-2 (A)	2	-0.4	0.1	3.5	0.8	-0.7
CG-2 (A)	4	-0.3	0.3	4.3	2.5	-0.8

B. Appendix A provides a Microsoft Visual Basic function that can be added to a Microsoft Excel (97 or later) worksheet or template for inlet intercept calculations.

[1] "Hydraulic Performance of Set-Back Curb Inlets", McEnroe et al., University of Kansas, 1998.

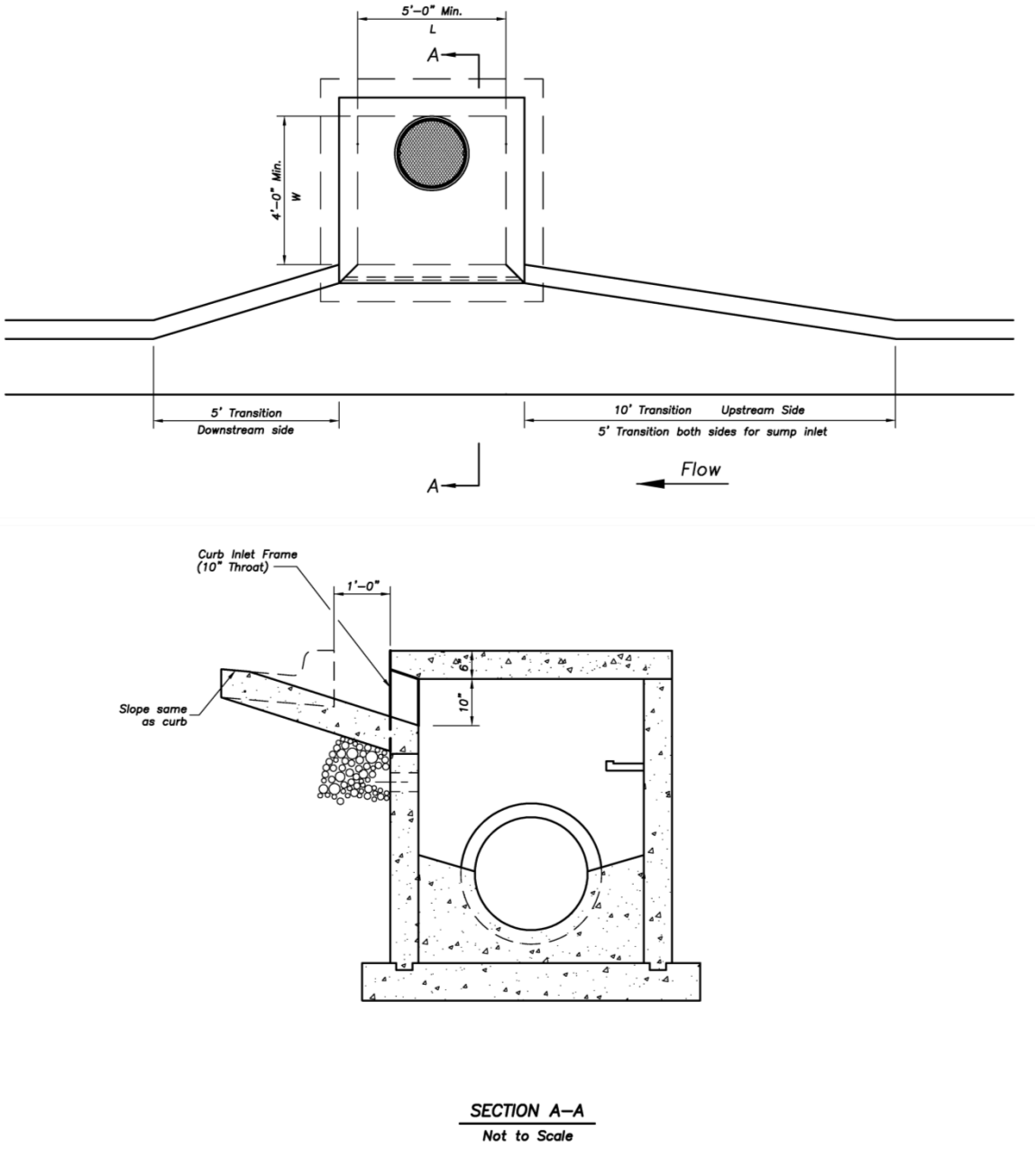


Figure 5604-1: Curb Inlet (10' Throat) Minimum Hydraulic Dimensions

SECTION 5606 ENCLOSED PIPE SYSTEMS

5606.1 Easements

Permanent easements shall be dedicated to the City/County for operation and maintenance of the storm drainage facilities. Easement width shall not be less than 15 feet, or the outside width of the pipe or conveyance structure plus 10 feet; whichever is greater. Easements shall be centered on the pipe.

A. Permanent: The City/County Engineer may require wider easements when other utilities are located within the same easement and/or when the depth of cover is greater than 4 feet.

B. Temporary: Temporary construction easements of sufficient width to provide access for construction shall be acquired when the proposed work is located in areas developed prior to construction.

5606.2 Capacity

Capacity shall be determined in accordance with Section 5603. Minimum design pipe size shall be 15-inch in diameter. For partially full pipe flow, Figure 5606-1 can be used to obtain hydraulic parameters of the flow.

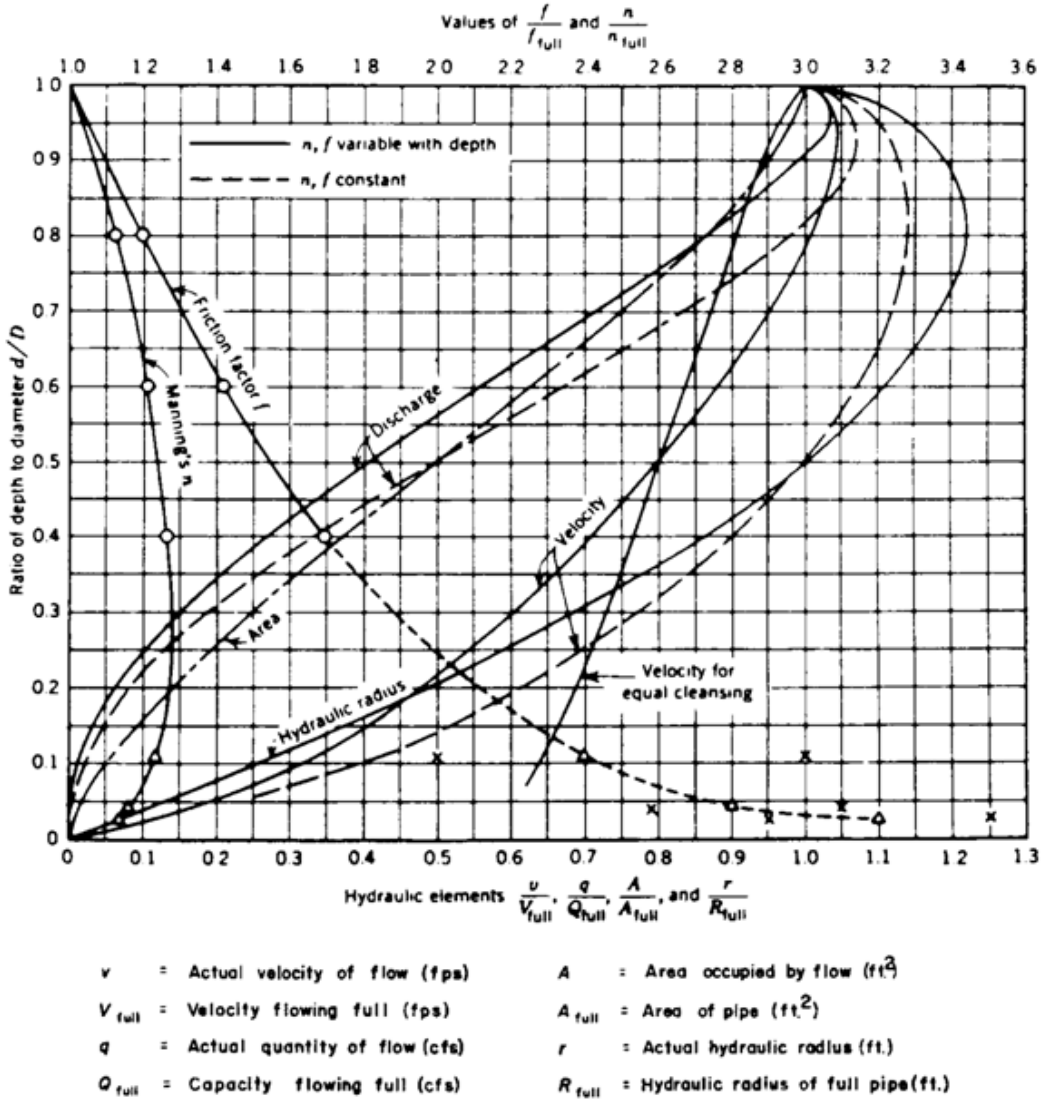


Figure 5606-1: Hydraulic Elements of Circular Conduits

5606.3 Pressure Flow

After considering the discussion presented in Section 5603.1 A, an enclosed system may be designed to operate with pressure flow, for the design storms specified in Section 5601.8, if all the following conditions are met:

A. The Hydraulic Grade Line (HGL) must be 0.5 feet below any openings to the ground or street at all locations.

B. Watertight joints capable of withstanding the internal surcharge pressure are used in the construction.

C. Appropriate energy losses for bends, transitions, manholes, inlets, and outlets, are used in computing the HGL.

D. Energy methods (Bernoulli's equation) must be used for the computations.

5606.4 Energy Dissipation:

The outfall, as defined in Section 5605.6, of all enclosed systems shall include energy dissipation sufficient to transition outlet flows to velocities and applied shear stresses consistent with the normal flow conditions in the receiving channel for the range of flows up to and including the 1% storm. Calculations, at a minimum, should include the 100%, the 10% and the 1% storms.

Energy dissipation for lateral outflows to natural streams and edge of buffer outfalls to riparian buffers shall follow the guidance in Section 5605.6. Effective energy dissipating structures shall be provided if necessary to meet the requirements stated in Tables 5605-2 and 5606-1. Examples of energy dissipating structures are:

- Check Dams
- Level Spreaders
- Hydraulic Jump Basins
- Impact Baffle Basins
- Plunge Pool and Plunge Basin
- Slotted-Grating or Slotted Bucket Dissipaters
- Stilling Basins
- Rock Revetment
- Internal Pipe Rings

Grade control shall be provided downstream of the dissipator or shall be constructed integrally with it.

The suitability of each method is site dependent and subject to approval by the City/County Engineer. Table 5606-1 lists methods and applicability.

Table 5606-1: Energy Dissipation Counter Measures

	Functional Applications		Suitable Environment			
Counter Measure	Vertical Control	Horizontal Control	Dam Outlets	Small Culverts	Large Culvert	References
Check Dam	X	O	X	X	X	2, 6
Level Spreaders	X	X	O	X	O	1
Hydraulic Jump Basins	X	X	X	X	X	1, 3
Impact Baffle Basins	X	X	X	X	X	1
Plunge Pool & Plunge	X	O	X	X	X	1

Table 5606-1: Energy Dissipation Counter Measures

Counter Measure	Functional Applications		Suitable Environment			
	Vertical Control	Horizontal Control	Dam Outlets	Small Culverts	Large Culvert	References
Basin						
Slotted-Grating or Slotted Bucket Dissipators	X	X	X	O	X	1
Stilling Basins	X	O	X	X	X	1, 2, 3, 4, 5, 6
Rock Revetment	X	X	X	X	X	1, 2, 6
Internal Pipe Rings	X	O	N/A	X	N/A	

LEGEND

X = Suitable Countermeasure

0 = Marginal Countermeasure

REFERENCES

1. Design of Small Dams 1987 United States Department of Interior
2. HEC 23
3. Hydraulic Design of Stilling Basins and Energy Dissipaters
4. HEC-14 FHWA Hydraulic Design of Energy Dissipaters for Culverts and Channels
5. U.S. Army Corps ff Engineers, 1994 Hydraulic Design of Flood Control Channels
6. Hydraulic Design Series (HDS-6)

NOTE: Other means may be used for Energy Dissipation and Stream Stability by designers as accepted by the local governing agency.

Energy dissipaters shall be designed according to the criteria and procedures defined in professionally acceptable references. Several such references include:

- United States. Department of the Interior. Bureau of Reclamation. Design of Small Dams. 1987 ed. Denver: GPO, 1987.
- United States. Department of the Interior. Bureau of Reclamation. A Water Resource Technical Publication. Engineering Monograph No. 25. Hydraulic Design of Stilling Basins and Energy Dissipaters. 1978 ed. GPO, 1978.
- Federal Highway Administration (FHA), 1983. Hydraulic Design of Energy Dissipaters for Culverts and Channels, Hydraulic Engineering Circular (HEC) No. 14.
- US Army Corps of Engineers, 1994. Hydraulic Design of Flood Control Channels, US Army Corps of Engineers Engineer Manual EM 1110-2-1601.
- Bridge Scour and Stream Instability Countermeasures Experience, Selection, and Design Guidance (Latest Edition), National Highway Institute, HEC No. 23.
- River Engineering for Highway Encroachments, Highways in the River Environment, U.S. Department of Transportation, Federal Highway Administration, Publication No. FHWA NHI 01-004, December 2001.

5606.5 Velocity within the System

The velocity within the system shall be between 3 and 20 feet per second.

5606.6 Loading

A. Cover: Minimum depth of cover shall be 18 inches.

B. Minimum Loading Conditions:

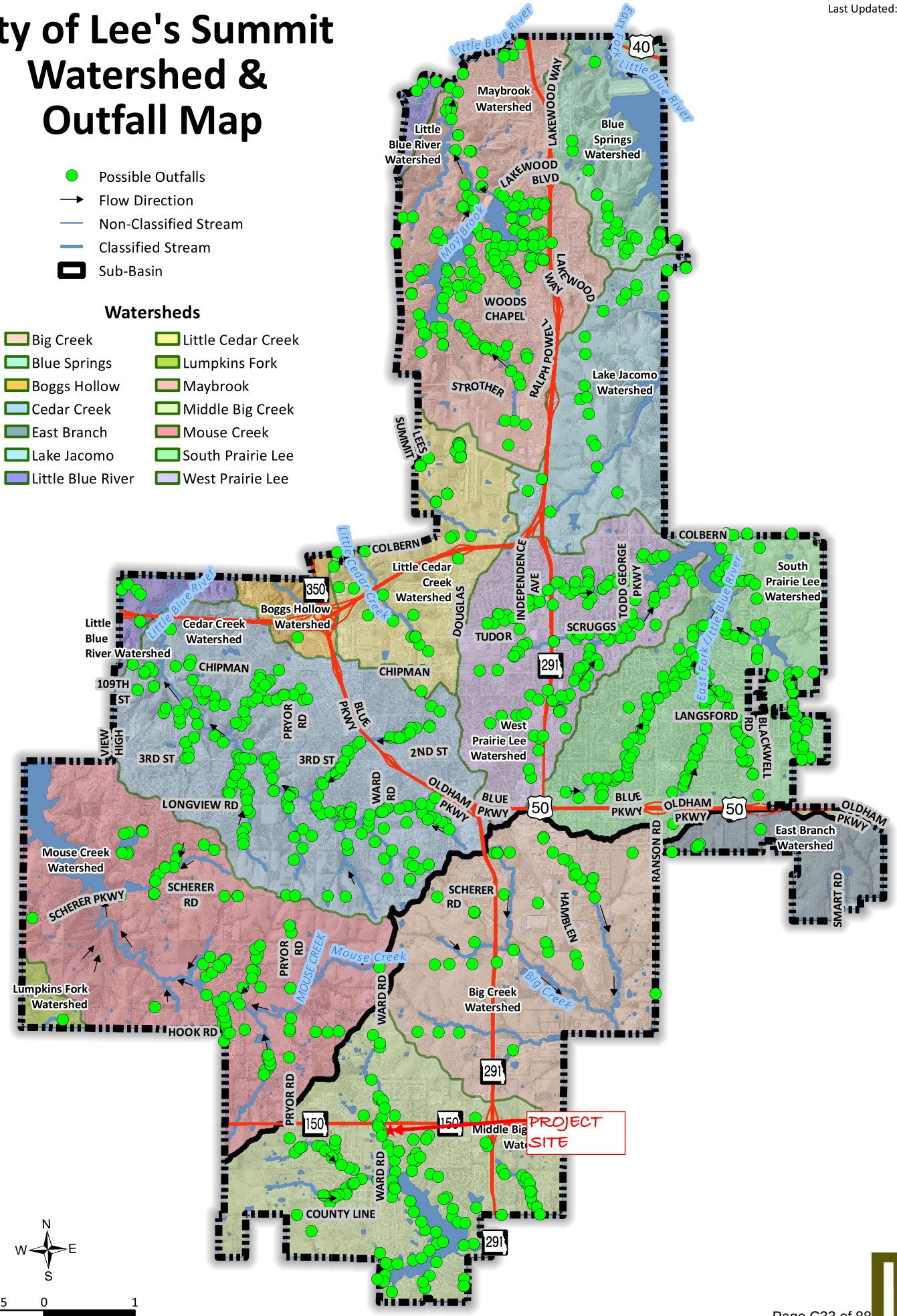
1. Live load: H-20.
2. Unit Weight of soil cover: 120 lbs/ft^3.
3. Rigid pipes shall be bedded and backfilled to provide a minimum factor of safety of 1.5 at the 0.01-inch crack loading condition.

APPENDIX C.3

CITY OF LEE'S SUMMIT WATERSHED & OUTFALL MAP

City of Lee's Summit Watershed & Outfall Map

Last Updated: March 2021



APPENDIX C.4
NOAA POINT PRECIPITATION DATA

NOAA Atlas 14, Volume 8, Version 2
Location name: Lees Summit, Missouri, USA*
Latitude: 38.8526°, Longitude: -94.3954°
Elevation: 1003.06 ft**
* source: ESRI Maps
** source: USGS

NOTE: 24-HR RAINFALL DEPTHS HIGHLIGHTED WERE DISTRIBUTED PER TABLE 5602-4 IN APPENDIX C.2 TO CREATE THE DESIGN STORMS FOR THIS PROJECT.

POINT PRECIPITATION FREQUENCY ESTIMATES

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

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.412 (0.329-0.518)	0.483 (0.385-0.607)	0.600 (0.476-0.756)	0.698 (0.551-0.882)	0.834 (0.637-1.08)	0.941 (0.702-1.24)	1.05 (0.757-1.41)	1.16 (0.803-1.59)	1.31 (0.872-1.84)	1.42 (0.923-2.02)
10-min	0.604 (0.481-0.759)	0.708 (0.563-0.889)	0.879 (0.697-1.11)	1.02 (0.806-1.29)	1.22 (0.933-1.59)	1.38 (1.03-1.81)	1.53 (1.11-2.06)	1.70 (1.18-2.33)	1.91 (1.28-2.69)	2.08 (1.35-2.96)
15-min	0.736 (0.587-0.925)	0.863 (0.687-1.09)	1.07 (0.850-1.35)	1.25 (0.983-1.58)	1.49 (1.14-1.94)	1.68 (1.25-2.21)	1.87 (1.35-2.51)	2.07 (1.43-2.84)	2.33 (1.56-3.28)	2.53 (1.65-3.61)
30-min	1.02 (0.812-1.28)	1.20 (0.956-1.51)	1.50 (1.19-1.89)	1.75 (1.38-2.21)	2.10 (1.60-2.72)	2.36 (1.77-3.11)	2.64 (1.90-3.54)	2.91 (2.02-4.00)	3.28 (2.19-4.61)	3.56 (2.32-5.08)
60-min	1.34 (1.06-1.68)	1.57 (1.25-1.97)	1.96 (1.55-2.47)	2.29 (1.80-2.89)	2.75 (2.10-3.58)	3.12 (2.33-4.11)	3.50 (2.53-4.70)	3.88 (2.70-5.34)	4.41 (2.95-6.21)	4.82 (3.14-6.87)
2-hr	1.65 (1.33-2.06)	1.94 (1.55-2.41)	2.41 (1.93-3.02)	2.82 (2.24-3.54)	3.41 (2.63-4.41)	3.88 (2.92-5.07)	4.36 (3.17-5.82)	4.86 (3.40-6.64)	5.54 (3.74-7.76)	6.07 (3.99-8.60)
3-hr	1.87 (1.51-2.32)	2.19 (1.76-2.71)	2.73 (2.19-3.39)	3.20 (2.55-3.99)	3.88 (3.01-5.01)	4.43 (3.36-5.78)	5.00 (3.66-6.66)	5.60 (3.94-7.64)	6.43 (4.36-8.99)	7.09 (4.68-10.0)
6-hr	2.25 (1.83-2.77)	2.65 (2.15-3.26)	3.33 (2.69-4.11)	3.93 (3.16-4.87)	4.81 (3.77-6.18)	5.53 (4.22-7.18)	6.28 (4.64-8.33)	7.08 (5.03-9.61)	8.20 (5.60-11.4)	9.08 (6.04-12.7)
12-hr	2.64 (2.16-3.22)	3.15 (2.57-3.84)	4.01 (3.27-4.91)	4.78 (3.87-5.87)	5.90 (4.65-7.52)	6.81 (5.24-8.77)	7.77 (5.78-10.2)	8.79 (6.28-11.8)	10.2 (7.03-14.1)	11.3 (7.59-15.8)
24-hr	3.09 (2.55-3.74)	3.68 (3.03-4.46)	4.71 (3.86-5.71)	5.61 (4.58-6.83)	6.94 (5.51-8.78)	8.02 (6.22-10.3)	9.16 (6.87-12.0)	10.4 (7.48-13.9)	12.1 (8.38-16.5)	13.4 (9.06-18.6)
2-day	3.65 (3.03-4.38)	4.27 (3.54-5.13)	5.36 (4.43-6.45)	6.33 (5.20-7.64)	7.76 (6.22-9.76)	8.94 (6.99-11.4)	10.2 (7.71-13.2)	11.5 (8.38-15.3)	13.4 (9.38-18.2)	14.9 (10.1-20.5)
3-day	4.04 (3.37-4.82)	4.67 (3.89-5.58)	5.77 (4.79-6.91)	6.75 (5.57-8.11)	8.20 (6.60-10.2)	9.39 (7.38-11.9)	10.7 (8.10-13.8)	12.0 (8.77-15.9)	13.9 (9.78-18.9)	15.4 (10.5-21.1)
4-day	4.37 (3.65-5.19)	5.00 (4.18-5.95)	6.11 (5.09-7.28)	7.09 (5.87-8.49)	8.54 (6.89-10.6)	9.73 (7.67-12.2)	11.0 (8.37-14.1)	12.3 (9.03-16.3)	14.2 (10.0-19.2)	15.7 (10.8-21.4)
7-day	5.16 (4.34-6.10)	5.84 (4.91-6.90)	7.00 (5.86-8.29)	8.00 (6.67-9.52)	9.45 (7.66-11.6)	10.6 (8.41-13.2)	11.8 (9.07-15.1)	13.1 (9.66-17.1)	14.9 (10.6-20.0)	16.3 (11.2-22.1)
10-day	5.86 (4.95-6.88)	6.60 (5.57-7.77)	7.85 (6.60-9.25)	8.91 (7.45-10.5)	10.4 (8.45-12.7)	11.6 (9.20-14.3)	12.8 (9.84-16.2)	14.1 (10.4-18.3)	15.8 (11.2-21.0)	17.1 (11.8-23.1)
20-day	7.83 (6.66-9.11)	8.82 (7.50-10.3)	10.4 (8.84-12.2)	11.8 (9.90-13.8)	13.5 (11.0-16.3)	14.9 (11.9-18.2)	16.2 (12.5-20.3)	17.6 (13.0-22.5)	19.3 (13.8-25.5)	20.6 (14.4-27.7)
30-day	9.47 (8.10-11.0)	10.7 (9.12-12.4)	12.6 (10.7-14.7)	14.2 (12.0-16.5)	16.2 (13.2-19.4)	17.7 (14.2-21.5)	19.2 (14.9-23.8)	20.6 (15.3-26.3)	22.4 (16.1-29.4)	23.7 (16.6-31.7)
45-day	11.6 (9.93-13.3)	13.0 (11.2-15.1)	15.4 (13.1-17.8)	17.2 (14.6-19.9)	19.5 (16.0-23.1)	21.2 (17.0-25.5)	22.8 (17.7-28.1)	24.3 (18.2-30.8)	26.2 (18.9-34.1)	27.4 (19.4-36.6)
60-day	13.4 (11.5-15.4)	15.1 (13.0-17.3)	17.7 (15.2-20.4)	19.7 (16.8-22.8)	22.3 (18.3-26.3)	24.1 (19.4-28.9)	25.8 (20.1-31.7)	27.4 (20.5-34.5)	29.2 (21.1-37.9)	30.4 (21.5-40.4)

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

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

Please refer to NOAA Atlas 14 document for more information.

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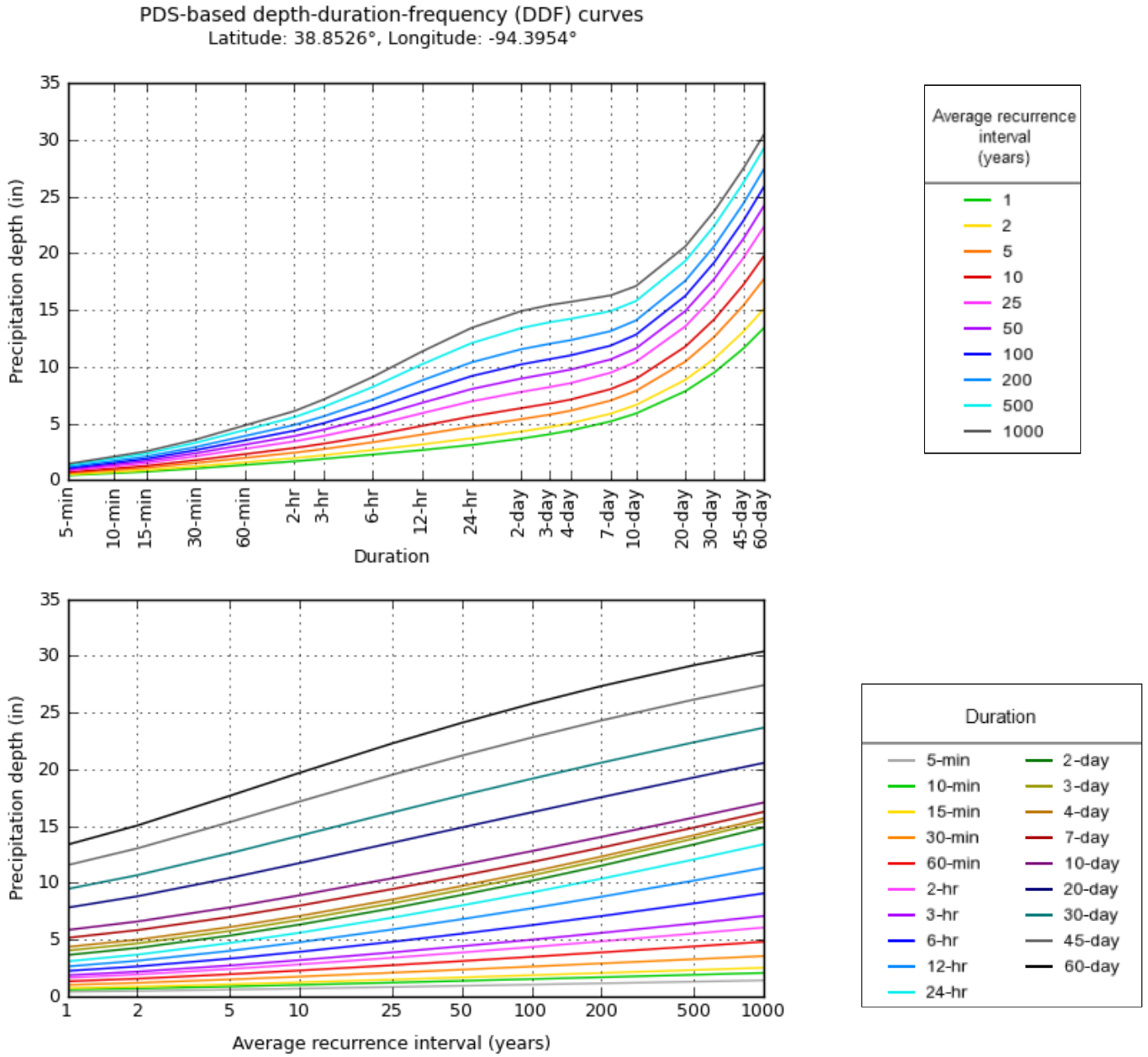
PF graphical



NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Tue Jan 4 18:13:29 2022

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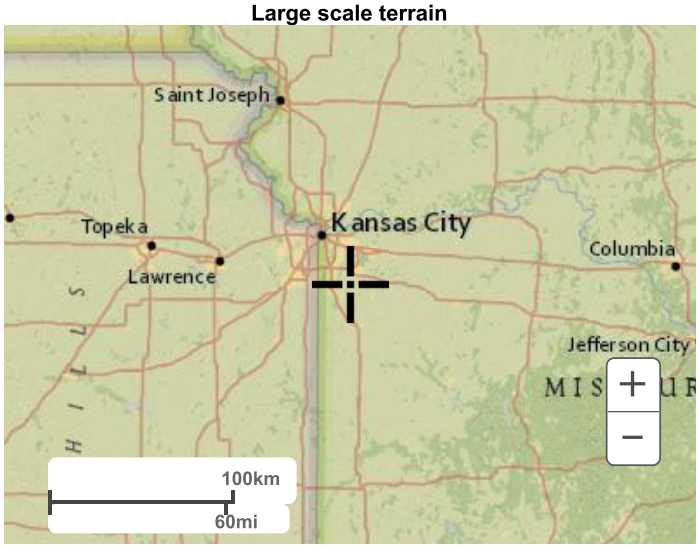
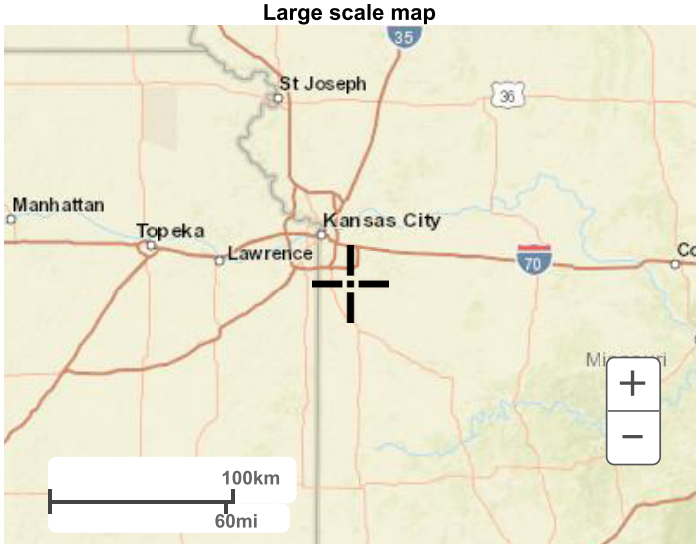
Maps & aerials

Small scale terrain

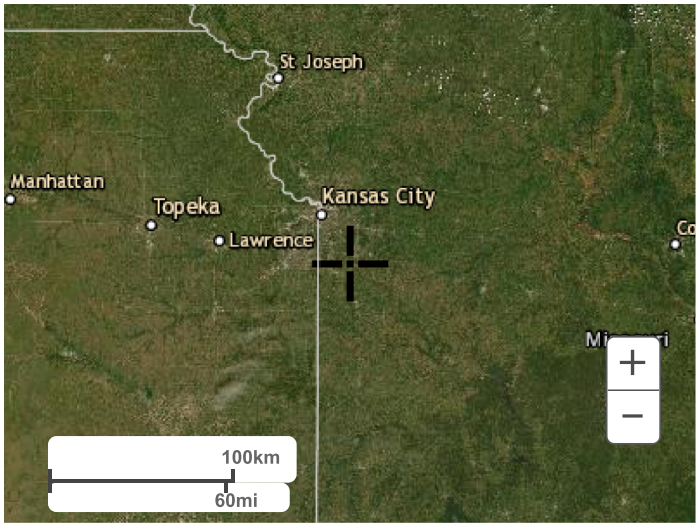
Large scale terrain



Large scale map



Large scale aerial



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX C.5
SELECT PAGES, NRCS WEB SOIL SURVEY

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Jackson County, Missouri

Fire Station 5

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

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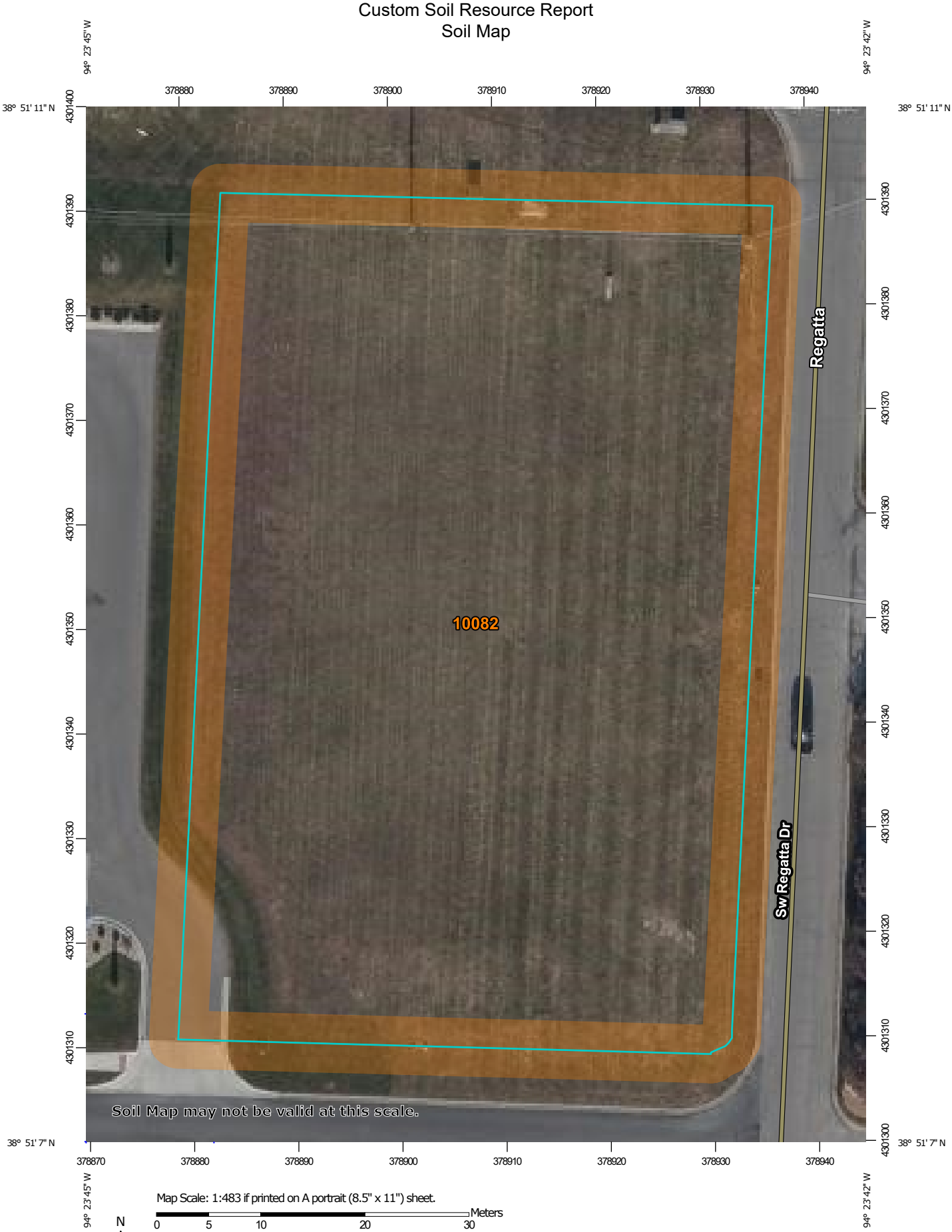
Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.



Map Scale: 1:483 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 5 10 20 30

Feet
0 20 40 80 120

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

MAP LEGEND

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

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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

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

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Jackson County, Missouri
Survey Area Data: Version 24, Aug 31, 2022

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

Date(s) aerial images were photographed: Sep 6, 2019—Nov 16, 2019

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Note: Actual acreage in AOI = 1.0

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
10082	Arisburg-Urban land complex, 1 to 5 percent slopes	1.1	100.0%
Totals for Area of Interest		**1.1**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Jackson County, Missouri

10082—Arisburg-Urban land complex, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: 2w7ld
Elevation: 750 to 1,130 feet
Mean annual precipitation: 39 to 45 inches
Mean annual air temperature: 50 to 55 degrees F
Frost-free period: 177 to 220 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Arisburg and similar soils: 61 percent
Urban land: 30 percent
Minor components: 9 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Arisburg

Setting

Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loess

Typical profile

Ap - 0 to 6 inches: silt loam
A - 6 to 13 inches: silt loam
Bt - 13 to 19 inches: silty clay loam
Btg - 19 to 56 inches: silty clay loam
BCg - 56 to 79 inches: silty clay loam

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 11.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: R107XB007MO - Loess Upland Prairie
Hydric soil rating: No

Description of Urban Land

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Minor Components

Sampsel

Percent of map unit: 3 percent
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Concave
Ecological site: R109XY010MO - Interbedded Sedimentary Upland Savanna
Hydric soil rating: Yes

Greenton

Percent of map unit: 3 percent
Landform: Hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R109XY002MO - Loess Upland Prairie
Hydric soil rating: No

Sharpsburg

Percent of map unit: 3 percent
Landform: Ridges
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R109XY002MO - Loess Upland Prairie
Hydric soil rating: No

APPENDIX C.6

RAINTREE LAKE VILLAGE AMENDMENT TO CERTIFICATION CONCERNING DECLARATION OF COVENANTS, CONDITIONS AND RESTRICTIONS

(The above space is reserved for Recorder's Certification.)

TITLE OF DOCUMENT:	AMENDMENT TO CERTIFICATION CONCERNING DECLARATION OF COVENANTS, CONDITIONS AND RESTRICTIONS
DATE OF DOCUMENT:	June 6, 2021
GRANTOR:	RAINTREE LAKE PROPERTY OWNERS ASSOCIATION, INC.
GRANTOR'S MAILING ADDRESS:	825 SW Raintree Drive, Lee's Summit, MO 64062
GRANTEE:	CITY OF LEE'S SUMMIT, MISSOURI
GRANTEE'S MAILING ADDRESS:	220 SE Green Street Lee's Summit, Missouri 64063 Attention: City Clerk
RETURN DOCUMENTS TO:	David Bushek Lee's Summit City Hall 220 SE Green Street Lee's Summit, Missouri 64063
LEGAL DESCRIPTION:	Lot 5, RAINTREE LAKE VILLAGE, a subdivision of land in Lee's Summit, Jackson County, Missouri, according the recorded plat thereof.

This cover page is attached solely for the purpose of complying with the requirements stated in §§59.310.2; 59.313.2 Revised Missouri Statutes.

AMENDMENT TO CERTIFICATION CONCERNING
DECLARATION OF COVENANTS, CONDITIONS AND RESTRICTIONS

THIS AMENDMENT TO CERTIFICATION CONCERNING DECLARATION OF COVENANTS, CONDITIONS AND RESTRICTIONS (the "**Amendment**") is made on ~~May~~ JUNE 6, 2021, by the Raintree Lake Property Owners Association, Inc., a Missouri not-for-profit corporation ("**Raintree**").

Raintree executed a document titled "Certification Concerning Declaration of Covenants, Conditions and Restrictions" on November 4, 2013 (the "**Certification**"), which was recorded on November 14, 2013 as Instrument Number 2013E0118167, a copy of which is attached hereto as **Exhibit A**. A document titled the Development Guidelines for Lots 4 & 5 (the "**Lot 4 & 5 Development Guidelines**") was attached to the Certification and serve as restrictions on development that may occur on Lots 4 and 5 of the plat entitled Raintree Lake Village, a subdivision in Lee's Summit, Jackson County, Missouri. Raintree now desires to amend the Certification and the Lot 4 & 5 Development Guidelines as they are applicable to Lot 5 of the plat of Raintree Lake Village.

The Certification is hereby amended as follows:

The Lot 4 & 5 Development Guidelines are hereby amended by adding the following provision to the end of the Guidelines:

l. Notwithstanding anything to the contrary as set forth in these Development Guidelines, the following shall apply to the construction of any public facility on Lot 5, including a fire station and all appurtenances thereto:

i. The construction of any public facility on Lot 5 by the City of Lee's Summit, and all appurtenances thereto, shall not be subject to the Development Guidelines set forth above. The following provisions shall apply to the construction of a public facility on Lot 5:

a. A bio-swale or equivalent stormwater feature that is designed to concentrate and convey stormwater runoff, remove debris and pollution, and increase infiltration capabilities at the site, as approved by the City Engineer, shall be constructed on the site. This feature will be sized to treat the Water Quality Volume (WQv, 1.37"/24-hour rainfall), per American Public Works Association (APWA) Section 5600, for the site's parking lot runoff. Treating the WQv will increase infiltration and reduce the amount of stormwater discharged into the existing detention basin.

b. All signage will be mounted on the structure in compliance with the City's sign regulations. The construction of a fire station will not be accompanied by a free-standing monument sign, and any signage for a fire station will be on the building.

ii. The plans for any public facility to be constructed on Lot 5 by the City of Lee's Summit shall be presented to the Raintree Lake Property Owners Association Architectural Review Board for review and comment pursuant to the Guidelines for Architectural

Control as approved by the Board of Directors of Raintree on February 13, 2018, and as may be amended from time to time.

ii. Any public facilities which are constructed on Lot 5 shall be subject to all applicable development and permitting requirements of the City of Lee's Summit, Missouri.

This Amendment shall be effective for and apply to the following property:

Lot 5, RAINTREE LAKE VILLAGE, a subdivision of land in Lee's Summit, Jackson County, Missouri, according the recorded plat thereof.

IN WITNESS WHEREOF, Raintree has executed this Amendment as of the day and year above written.

Raintree Lake Property Owners Association, Inc.

Daniel Merrick, President

ACKNOWLEDGMENT

STATE OF MISSOURI)
) **SS.**
COUNTY OF JACKSON)

On this 6th day of June, 2021, before me, the undersigned, a Notary Public, personally appeared Dan Merrick, to me known to be the persons described in and who executed the foregoing instrument, and acknowledged that he executed the same as the President of the Raintree Lake Property Owners Association, Inc.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my notarial seal the day and year last above written.

Rachelle J Vandiver
Notary Public in and for said State

[SEAL]

NOTARY PUBLIC NOTARY SEAL STATE OF MISSOURI

RACHELLE J. VANDIVER
My Commission Expires
June 27, 2024
Jackson County
Commission #12380291

My commission expires: _____

EXHIBIT A

CERTIFICATION CONCERNING
DECLARATION OF COVENANTS, CONDITIONS AND RESTRICTIONS

[Attached]

ELECTRONICALLY RECORDED
JACKSON COUNTY, MISSOURI
11/14/2013 03:36:51 PM
CERT FEE: $ 36.00 6 Pages
INSTRUMENT NUMBER:
2013E0118167

WHEN RECORDED RETURN TO:

Ms. Rachelle M. Biondo
White Goss Bowers March Schulte & Weisenfels,
a Professional Corporation
4510 Belleview Avenue, Suite 300
Kansas City, Missouri 64111-3538

Title of Document:	Certification Concerning Declaration of Covenants, Conditions and Restrictions
Date of Document:	November 4, 2013
Grantor(s):	Raintree Lake Property Owners Association, Inc.
Grantee(s):	Raintree Lake Property Owners Association, Inc.
Grantee(s) Mailing Address:	9400 Reeds Road, Suite 100 Overland Park, KS 66207
Legal Description:	See Exhibit A
Reference Book and Page(s):	Document I-167323, Document I-584739, and Document I-641018

PLEASE RETURN DOCUMENT TO:

First American Title Insurance Company
National Commercial Services
911 Main, Suite 2500, Kansas City, MO 64105
Attention: Karen Koehler
FILE NO. 1004116

Recorded Electronically
ID 20132011816?
County Jackson Co. MO
Date 11-14-13 Time 3:30:51 pm
Simplifile.com 800.460.5657

WHEN RECORDED RETURN TO:

Ms. Rachelle M. Biondo
White Goss Bowers March Schulte & Weisenfels,
a Professional Corporation
4510 Belleview Avenue, Suite 300
Kansas City, Missouri 64111-3538

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Legal Description:	See Exhibit A
Reference Book and Page(s):	Document I-167323, Document I-584739, and Document I-641018

PLEASE RETURN DOCUMENT TO:

First American Title Insurance Company
National Commercial Services
911 Main, Suite 2500, Kansas City, MO 64105
Attention: Karen Keehler
FILE NO. 606476

CERTIFICATION CONCERNING DECLARATION OF COVENANTS, CONDITIONS & RESTRICTIONS

Raintree Lake Property Owners Association, Inc., a Missouri not-for-profit corporation ("Raintree"), the Association under that certain Declaration of Covenants, Conditions & Restrictions dated September 24, 1973, and recorded as Document I-167323 in the Office of the Recorder of Deeds for Jackson County, Missouri (the "Recorder's Office"), as amended by that certain Amendment to Declaration of Covenants, Conditions and Restrictions dated May 21, 1984 and recorded as Document I-584739 in the Recorder's Office, and that Certain Declaration of Annexation dated July 23, 1985 and recorded as Document I-641018 in the Recorder's Office (the "Declaration"), which encumbers certain real property described therein, located in Jackson County, Missouri, which includes the Property legally described on Exhibit A (the "Property"), hereby makes this Certification Concerning Declaration of Covenants, Conditions & Restrictions (the "Certification") as of the 4th day of ~~October~~ November, 2013, with respect to the certain rights and obligations pertaining to the future development of Property under the Declaration. All capitalized terms not otherwise defined herein shall have the meaning as defined in the Declaration.

Raintree hereby states and agrees as follows with respect to the Declaration:

1. Pursuant to Article VII of the Declaration, the Architectural Review Board has the authority to regulate the external design, appearance, use, location, and maintenance of the Properties & Improvements subject to the Declaration.

2. Raintree hereby promulgates and adopts the Development Guidelines, attached hereto as Exhibit B, which shall apply to any proposed future development of the Property and shall be the sole criteria and guidelines applicable to the Property by Raintree and/or the Architectural Review Board, pursuant to the Declaration.

3. Raintree acknowledges that any future development of the Property shall be subject to all applicable development and permitting requirements of the City of Lee's Summit, Missouri.

Raintree Property Owners Association, Inc.,
a Missouri not-for-profit corporation

By: _____
Name: Brian L West
Its: President

STATE OF Missouri)
) ss.
COUNTY OF Jackson)

On this 4 day of November, 2013, before me, a Notary Public, personally appeared Brian L. West, known to me to be the person described in and who executed the foregoing instrument, and acknowledged that he executed the same as his free act and deed as President, of Raintree Property Owners Association, Inc., a Missouri not-for-profit corporation, and said Brian L. West acknowledged execution of the foregoing instrument to be the free act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last above written.

Rachelle J. Vandiver
Notary Public
Rachelle J. Vandiver

My commission expires:

6-27-2016

RACHELLE J. VANDIVER
Notary Public - Notary Seal
State of Missouri
Commissioned for Jackson County
My Commission Expires: June 27, 2016
Commission Number: 12380291

EXHIBIT A

Legal Description

LOTS 4 and 5, RAINTREE LAKE VILLAGE, a subdivision of land in Lee's Summit, Jackson County, Missouri, according the recorded plat thereof.

EXHIBIT B

Development Guidelines

RAINTREE LAKE VILLAGE | DEVELOPMENT GUIDELINES – LOTS 4 & 5

a. The maximum building footprint of any one Building on Lots 4 & 5, Raintree Lake Village ("Property") shall not exceed Eight Thousand Five Hundred (8,500) square feet if Lots 4 & 5 are developed together and re-platted as one lot. The maximum building footprint of any Building located on each of Lots 4 & 5 shall not exceed Four Thousand Five Hundred (4,500) square feet each, if the lots are developed separately.

b. All Buildings on the Property shall not exceed twenty-four (24) feet in height, as measured from the mean finished elevation of the parking area of the Property. Architectural features such as parapet walls, mechanical equipment, penthouses and screens to hide mechanical equipment shall not exceed twenty-six (26) feet in height. All Buildings shall be single one-story structures.

c. All Buildings on the Property shall meet the following architectural standards:

   i. Minimum of one hundred percent (100%) of the total frontal (street elevation) of the Building shall be one or more of the following materials: stucco, brick, stone, rock or other masonry product;

   ii. Exterior colors of the Building shall be neutral tones, with the exception of the prototypical signage of the end-user and accent colors used in Tenant specific trade dress, which may be colorful in nature and is an element of end-user's brand identity; and

   iii. The Property shall have an enclosed dumpster pad to store trash dumpsters. Such enclosure shall be architecturally similar to Building in color and exterior finishes using masonry materials, and shall be constructed with steel gates painted to match the building structures. The location of the trash dumpster shall be located in an area of the development as to screen the enclosure from Regatta Drive located somewhere behind the rear building line.

d. All Buildings on the Property shall be self-parked and shall comply with the following minimum parking requirements:

   i. Four (4) parking space for each one thousand (1,000) square feet of floor area of the Building for retail and other general uses unless more restrictive use is defined in paragraph d(ii-iii);

ii. Five (5) parking space for each one thousand (1,000) square feet of floor area of the Building for fast-food restaurant use or fast casual restaurant concepts; or

iii. Ten (10) parking spaces for each one thousand (1,000) square feet of floor area of the Building for full-service, sit-down restaurants serving alcohol.

e. Each Lot 4 & Lot 5 shall be allowed a freestanding monument sign, not to exceed a size permitted by the City of Lee's Summit sign ordinance; however, in the event the lots are developed together, only one (1) free standing monument sign shall be permitted, subject to the City's sign ordinance.

f. All screening shall be composed of: a.) masonry, or b.) living screen scrubs planted to create a hedge or visual screen within two (2) growing seasons. All screening on Regatta Drive shall be living screen material to soften the impact between the commercial development and the residential housing located in proximity to Regatta Drive. The developer of the Property shall use landscape berms and live screening composed of eight (8) feet evergreen trees to the south of the main entrance off Regatta Drive into the commercial development parcel.

g. A bio-swale shall be constructed along the perimeter of the site to pre-treat the initial flush of the parking lot runoff. The bio-swale will discharge into a downstream "Defender" to further separate grit and other pollutants from the parking lot runoff. The bio-swale will provide onsite retention reducing the amount of storm water discharged into the existing detention basin.

h. In the event a convenience store is constructed, the gas canopy rainwater shall be harvested and stored in a cistern and used specifically for landscaping irrigation.

i. Subject to the City of Lee's Summit's approval, the Developer shall post "No Truck Traffic" signs on Regatta Drive, which will be enforced with its tenants and customers. Access for ingress and egress shall be limited to SW Lemans Lane. The developer of the Property shall seek City approval to post such signage and the City shall have the final determination as to the flow of delivery truck traffic.

j. Provided that the developer of the Property meets the criteria as set out above, Raintree Lake Property Owners Association, Inc. ("RLPOA") and the RLPOA Architectural Review Board ("ARB") will approve the Developer's plans and shall execute a written certification in recordable form to the developer of the Property that RLPOA and the ARB have approved the project.

k. Notwithstanding the foregoing, all Site and Building Plans are subject to review, revision, and approval by the City of Lee's Summit, Missouri ("City"), prior to the issuance of any building permits. Furthermore, the use of the Property shall be governed by the current zoning ordinances previously adopted by the City.

APPENDIX C.7
SELECT PAGES, MARC BMP MANUAL

BMP

Manual of Best Management Practices For Stormwater Quality

october 2012

AMERICAN PUBLIC WORKS ASSOCIATION
APWA
Kansas City Metro Chapter

Clean Water. Healthy Life.
Regional Water Quality Education Program

MARC
Mid-America Regional Council

8.4 BIORETENTION

Source: City of Lenexa, Kansas

Targeted Constituents

Sediment	◒
Nutrients	●
Trash	●
Metals	●
Bacteria	●
Oil and Grease	●
Organics	●

Legend (Removal Effectiveness)

High	Medium	Low
●	◒	○

Source: California Stormwater Quality Association, 2003

8.4.1 Description

Bioretention is a best management practice (BMP) that filters, uptakes, and infiltrates stormwater runoff by way of the natural chemical, biological, and physical properties of plants, microbes, and soils (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002) (CDM, 1989, 2001). The practice gets its name from the ability of the biomass within a small landscaped basin to retain the water quality volume (WQv) and remove nutrients and other pollutants from stormwater runoff (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002). The runoff's velocity is reduced by passing the runoff over or through a pretreatment device and subsequently distributing it evenly along a ponding area (Urban Drainage and Flood Control District - Denver, Colorado, 2005). The WQv is allowed to infiltrate into the surrounding soil naturally or be collected by an underdrain system that discharges to the storm sewer system or directly to receiving water. Runoff in excess of the water quality storm is passed through or around the facility via an overflow structure.

Bioretention controls runoff close to the source. Unlike end-of-pipe BMPs, bioretention facilities are typically shallow depressions located in upland areas. The strategic, uniform distribution of bioretention facilities across a development site results in smaller, more manageable subwatersheds, and thus, will help in controlling runoff close to the source where it is generated to promote recharge. This is beneficial in that it reduces the amount of runoff that must be managed further downstream, thus reducing the cost and land area required for large regional BMPs (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002).

8.4.2 General Application

Bioretention typically treats stormwater that has run over impervious surfaces at commercial, residential, and industrial areas (Urban Drainage and Flood Control District - Denver, Colorado, 2005). For example, bioretention is an ideal BMP to be used in median strips, parking lot islands, and landscaped swales. These areas can be designed or modified so that runoff is either diverted directly into the bioretention area or conveyed into the bioretention area by a curb and gutter collection system (Urban Drainage and Flood Control District - Denver, Colorado, 2005) (Office of Water, EPA, 1999).

Bioretention is usually most effective when used upland from inlets that receive sheet flow from graded areas. Bioretention can also be applied effectively where runoff is collected from impervious areas and discharged to a

bioretention cell. To maximize treatment effectiveness, the site must be graded in such a way that minimizes erosive conditions as sheet flow is conveyed to the treatment area. Locations where a bioretention area can be readily incorporated into the site plan without further environmental damage are preferred. Furthermore, to effectively minimize sediment loading in the treatment area, bioretention only should be used in stabilized tributary areas (Urban Drainage and Flood Control District - Denver, Colorado, 2005) (Office of Water, EPA, 1999).

8.4.3 Advantages

- Bioretention facilities use minimal land area (1 to 15 percent of total tributary area) and can therefore be sited in locations that are unsuitable for other BMPs.
- Bioretention is easily incorporated in a BMP treatment train.
- Bioretention reduces peak runoff rate and volume from a site for small frequent storms and may reduce the total volume that must be managed further downstream (depending on the amount of retention).
- Bioretention has one of the highest nutrient and pollutant removal efficiencies of any BMP.
- Properly designed and maintained bioretention provides aesthetic enhancement. When aesthetic features are incorporated into bioretention designs, they encourage environmental stewardship and community pride. (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002).
- When constructed in areas with porous native soil, bioretention facilities can contribute to groundwater recharge.
- By intercepting runoff in bioretention areas near the source, the amount of the stormwater management infrastructure may be reduced, resulting in significant cost savings in site work (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002) (CDM, 2001).Bioretention facilities reduce the temperature of water discharged from the overall system (CDM, 2001).

8.4.4 Disadvantages

- Bioretention should not be installed until the entire tributary area has been stabilized; otherwise, silt from unstabilized areas can clog the bioretention facility.
- Bioretention is not a suitable BMP at locations where the wet season water table is within 1 to 2 feet of the ground surface and where the surrounding soil stratum is unstable. Too shallow of a water table can prevent runoff from draining completely through the bioretention soil mixture (CDM, 1989, 2001).
- Bioretention is not recommended for upland areas with slopes greater than 20 percent; otherwise, clogging may be a problem, particularly if the area receives runoff with high sediment loads. If clogging occurs, unclogging can be difficult (Office of Water, EPA, 1999).
- Bioretention is not recommended for areas where mature tree removal would be required (Office of Water, EPA, 1999). Existing trees should be incorporated into the bioretention facility where applicable.
- Flood control features are not easily incorporated into bioretention.
- Bioretention is most effective for tributary areas of less than 4 acres.
- Bioretention requires a specific soil matrix to provide a minimum saturated vertical hydraulic conductivity (See Appendix A for specification).
- Bioretention may not effectively remove pollutants immediately after construction. Pollutant removal efficiency increases as vegetation becomes established.

8.4.5 Design Requirements and Considerations

Design specifications for bioretention facilities are given in Appendix A.

One of the unique qualities of bioretention is the flexibility of design themes that a designer may employ when integrating into the site. Making multi-functional use of existing site constraints, bioretention can blend nicely with buffers, landscape berms, and environmental setback areas (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002). Additionally, the layout of the bioretention area is determined after site constraints such as location of utilities, underlying soils, existing vegetation, and runoff are considered (Office of Water, EPA, 1999) (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002). Figure 8.5 illustrates the composition of a sample bioretention facility. The following guidelines are to be considered when designing bioretention facilities:

- Bioretention facilities shall not be constructed within stream buffers or in areas adjacent to streams where sediment may be deposited during flood events.
- Bioretention facilities shall not be constructed until all tributary areas are permanently stabilized against erosion and sedimentation. Any discharge of sediment to the cell will require reconstruction of the cell to restore its defined performance.
- The bioretention facility shall be designed to capture the WQv. The WQv should filter through the facility's planting soil bed in 1 to 3 days.
- Recommended minimum dimensions are 15 feet wide by 40 feet long, although the preferred dimensions are 25 feet wide by 50 feet long, allowing enough space for a dense, randomly distributed area of plants and shrubs to become established while decreasing the chances of concentrated flow. Essentially, any facilities wider than 20 feet shall be twice as long as they are wide (Urban Drainage and Flood Control District - Denver, Colorado, 2005).
- The tributary area for a bioretention area shall be less than 4 acres. Multiple bioretention areas may be required for larger tributary areas (Office of Water, EPA, 1999). Inflow velocities to bioretention facilities shall be reduced to below erosive levels (generally 3 feet per second) upstream of the facility.

8.4.5.1 Excavation

- The bioretention facility can be excavated before final stabilization of the tributary area; however, the bioretention soil mixture and underdrain system shall not be placed until the entire tributary area has been stabilized. Any sediment from construction operations deposited in the bioretention facility shall be completely removed from the facility after all vegetation, including landscaping within the tributary area to the bioretention facility, has been established. The excavation limits shall then be final graded to the dimensions, side slopes, and final elevations as specified in the construction.
- Low ground-contact pressure equipment, such as excavators and backhoes, is preferred on bioretention facilities to minimize disturbance to established areas around the perimeter of the cell. No heavy equipment shall operate within the perimeter of a bioretention facility during underdrain placement, backfilling, planting, or mulching of the facility.
- Bioretention facility side slopes shall be excavated at 4:1 or flatter.

8.4.5.2 Underdrain or Outlet

The underdrain increases the ability of the soil to drain quickly and in so doing keeps the soil at an adequate aerobic state, allowing plants to flourish. The use of an underdrain system to provide a discharge point precludes the need for extensive geotechnical investigation. Underdrains are configured in many different ways and typically include a gravel/stone "blanket" encompassing a horizontal, perforated discharge pipe. An aggregate can be used to protect

the underdrain from clogging (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002).

- Design the underdrain system with the following components: a 4-inch minimum perforated pipe system with an 8-inch gravel bed. Filter fabric shall be placed on top of the gravel bed to impede soil migration from the planting soil bed, and the filter fabric shall be secured against movement/displacement during construction. The pipe shall have perforations between 0.25 and 0.375 inches diameter, spaced at 6-inch centers, with a minimum of 4 holes per row. The pipe(s) shall be placed with one header and several branches or several headers with a 20' spacing between headers or branches. Maintain a minimum grade of 0.5 percent. See specification in Appendix A for additional underdrain system design criteria.
- Provide at least one cleanout per run and every 50 feet or less.
- Connect the underdrain system to the conventional stormwater management system, or daylight it to a suitable nonerosive outfall.
- A cap with an orifice or an in-line orifice fitting shall be provided at or near the discharge point of the underdrain system to permit a 40-hr drawdown time for the WQv.

After placing the underdrain and aggregate and before placing the bioretention soil mixture (BSM), the bottom of the excavation shall be rototilled to a minimum depth of 6 inches to alleviate any compaction of the facility bottom. Any ponded water shall be removed from the bottom of the facility, and the soil shall be friable before rototilling. The rototilling shall not be done where the soil supports the aggregate bed underneath the underdrain.

8.4.5.3 Overflow

The overflow component of the bioretention system consists of the gravel underdrain system, an aggregate overflow curtain drain, and a high-flow overflow structure (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002). In a residential setting, overflow usually does not present a problem for two reasons: (1) the tributary area and facility capacity are relatively small, and (2) the system is located within grassy areas that provide a safe, nonerosive surface for any overflow conditions that may arise. Additionally, residential bioretention facilities are typically designed off line and already incorporate a safe overland flow path. In commercial or industrial settings, design for overflow is more critical. Often, facilities in commercial settings are incorporated into the parking lot landscape islands. The paved surfaces flowing to the facilities can generate large quantities of runoff. Designers are required to provide a safe discharge point (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002).

- Bioretention can be designed to be off line or on line of the existing stormwater management system (Office of Water, EPA, 1999). If the system is off line, design the overflow to convey peak discharge of the WQv and set it above the shallow ponding limit. If the facility is on line, design the high flow overflow as a conventional stormwater control structure or channel. Connect the overflow structure to the site stormwater management system, or outfall to a suitable nonerosive location.
- The high flow overflow system is usually a yard drain catch basin, but any number of conventional management practices may be used, including an open vegetated or stabilized channel.
- Bioretention facilities shall be designed so that runoff flows from storm events greater than the water quality event, up to and including the 1 percent event, safely pass through or around the facility. If the 1 percent event is to pass through the facility, the maximum velocity shall be kept below 3 feet per second to avoid erosion of the soil matrix. If facilities are designed with a bypass, it shall be designed to safely pass runoff flows from events up to and including the 1 percent event. At a minimum, all facility embankments shall be protected from failure during the 1 percent event.

8.4.5.4 Aggregate

An aggregate, which provides a greater porosity and is less likely to clog, is preferred (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002).

It is recommended to have an aggregate layer around the perforated pipe to facilitate drainage. Refer to the specification in Appendix A.

8.4.5.5 Sand Bed

The sand bed is an optional feature that underlies the planting soil bed and allows water to drain from the planting soil bed into the surrounding soil. It provides additional filtration and allows aeration of the planting soil bed (Office of Water, EPA, 1999).

8.4.5.6 Planting Soil Bed

The soil characteristics are critical for the proper operation of the bioretention facility. The planting soil, called the BSM, provides the water and nutrients for the plants to sustain growth (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002). The BSM is a mixture of organic mulch, planting soil, and sand. To enhance nutrient uptake, the soil must have a combination of chemical and physical properties to support a diverse microbial community.

- The planting soil shall have a minimum depth of approximately 2.5 feet to provide adequate moisture capacity and to create space for the root system of the plants. Root balls of many trees will require additional depths (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002). Planting soil shall be 4 inches deeper than the bottom of the largest root ball and a maximum of 4 feet altogether. Planting soil depths greater than 4 feet may require additional construction practices, such as shoring measures (Urban Drainage and Flood Control District - Denver, Colorado, 2005) (Office of Water, EPA, 1999).
- The BSM shall be free of stones, stumps, roots, or other weedy material over 1 inch in diameter, excluding the mulch. Brush or seeds from noxious weeds shall not be present in the solids. Refer to the specification in Appendix A.

8.4.5.7 Organic or Mulch Layer

The organic layer (mulch) protects the soil bed from erosion, retains moisture in the plant zone, provides a medium for biological growth and decomposition of organic matter, and filters pollutants (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002).

- Following placement of any trees and shrubs, the ground cover and/or mulch shall be established at an appropriate depth during the establishment period. Ground cover such as grasses or legumes can be planted at the beginning of the growing season (Urban Drainage and Flood Control District - Denver, Colorado, 2005). Mulching shall be complete within 24 hours after the trees and shrubs are planted to reduce the potential of silt accumulation on the surface (Urban Drainage and Flood Control District - Denver, Colorado, 2005).
- Pine mulch and wood chips are not acceptable in the mulch layer because they are displaced during storm events (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002). Grass clippings are not allowed in the mulch layer. Refer to the specification in Appendix A.

8.4.5.8 Plant Materials

The role of plant species in the bioretention concept is to bind nutrients and other pollutants by plant uptake, to remove water through evapotranspiration, and to create pathways for infiltration through root development and plant

growth. Root growth provides a media that fosters bacteriologic growth, which in turn develops a healthy soil structure. Proper selection and installation of plant material is key to the success of the bioretention system.

- The designer should assess aesthetics, site layout, natural function, and maintenance requirements when selecting and placing plant species (Office of Water, EPA, 1999).
- Native grasses and other various local ground covers can be incorporated into a bioretention planting scheme. Trees and shrubs are also beneficial in wider facilities (minimum of 15 to 20 feet) because they create shade. Shade helps reduce runoff temperature and can be seen as an amenity in applications such as parking lots.
- See specification in Appendix A for appropriate plant materials.

8.4.5.9 Ponding Area

The ponding area provides temporary surface storage of stormwater runoff before it filters through the soil bed and facilitates the evaporation of a portion of the runoff (Office of Water, EPA, 1999) (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002). The ponding area (A_p) is the actual footprint of the Bioretention cell. Settling of the particulates occurs in the ponding area and provides an element of pretreatment. Ponding design depths shall be kept to a minimum to reduce hydraulic overload of in situ soils/soil medium and to maximize the surface area to facility depth ratio (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002). The ponding area shall have a maximum depth of 12 inches. However, a depth of 3 to 4 inches is preferable (Urban Drainage and Flood Control District - Denver, Colorado, 2005).

8.4.5.10 Pretreatment

The best method of capturing and treating runoff is to allow the water to sheetflow into the facility over grassed areas to reduce inflow velocity and to reduce the load of coarse sediment entering the bioretention area (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002). When site constraints or space limitations impede sheetflow, flow entrances shall be created that reduce the velocity of the water. Possible Pretreatment alternatives include:

- Vegetated Pretreatment Strip. Runoff enters the bioretention area as sheet flow through the vegetated pretreatment strip, which can be planted with native grass or turf-forming grass. The filter strip reduces incoming runoff velocity and filters particulates from the runoff (Office of Water, EPA, 1999). Several factors determine the length in the direction of flow of the vegetated pretreatment strip, including size and imperviousness of the tributary area and filter strip slope. If a vegetated pretreatment strip is used, its length shall be 10 feet at a minimum. See Table 8.2 for vegetated pretreatment strip sizing guidelines.
- Vegetated Pretreatment Channel. For sites where concentrated or channelized runoff enters the bioretention system, such as through a slotted curb opening, a vegetated channel with an aggregate is the preferred pretreatment method. This channel can also be planted with native grass or turf-forming grass. The length in the direction of flow of the vegetated pretreatment channel depends on the tributary area, land use, and channel slope. When a vegetated channel is used, the minimum length shall be 25 feet. See Table 8.3 for vegetated channel sizing guidelines.
- In the case of parking lot landscape islands, curb cuts protected with energy dissipaters such as landscape stone or surge stone can be used. It is important to note that entrances of this type will tend to become obstructed with sediment and trash that settles out at lower velocities. This is not a problem as long as routine parking lot maintenance is performed (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002).
- Baffle boxes or other pretreatment devices can be used as a pretreatment to flow entering a bioretention facility from a piped system. This form of pretreatment serves to settle out solids and slow the velocity of

flow. Cisterns placed at the bottoms of roof downspouts can be used to slow the velocity of runoff coming from rooftops and direct it to landscaped swale.

8.4.6 Maintenance and Inspections

By design, bioretention capitalizes on the deep root systems and wide moister tolerance of native vegetation to absorb and treat stormwater. Native vegetation commonly takes a minimum of three years for proper establishment after which the plants can work effectively with little maintenance for many years. Neglected bioretention facilities, by contrast, can present continual and costly maintenance issues, as well as fall short of design expectations for stormwater management. Proper maintenance will increase the expected life span of the facility and will improve aesthetics (Programs & Planning Division, Department of Environmental Resources, Prince George's County, MD, Revised 2002).

Planting design for bioretention cells should be carefully considered and guildance from a registered landscape architect is strongly recommended. Appropriately selected plants provide a critical functional component of the system by aiding in the reduction of fertilizer, pesticide, and water use, as well as minimizing standing water issues. Additionally, stands of native grasses and flowers in bioretention cells can provide valuable year-long visual interest and precious habitat islands for birds, butterflies, and other wildlife. Bioretention system components should blend over time through plant and root growth, organic decomposition, and the development of a natural soil horizon. These biologic and physical processes will lengthen the facility's lifespan and reduce the need for extensive maintenance (Urban Drainage and Flood Control District – Denver, Colorado, 2005).

The primary maintenance requirement for bioretention areas is that of frequent inspection (monthly) and repair or replacement of functional components. Generally, this involves routine periodic maintenance similar to that required of a landscaped area or conventional stormwater utility. Plants that are appropriate for the site, climatic, and watering conditions should be selected for use in the bioretention cell and maintained for the life of the facility. Shrubs and trees may be incorporated into the planting design for bioretention cells, but herbaceous species such as native grasses and flowers provide the best filtration and pollutant removal through dense, fibrous root systems.

Bioretention cells are very sensitive to sedimentation from the contributing drainage area or adjacent land uses. Any sediment observed migratin into the cell should be removed immediately to prevent clogging of the soil matrix. Inpsections of the drainage area include securing open dumpster lids, sweeping parking lots or impervious surfaces to remove sand and silt, and maintaining adjacent vegetation. Plant debris should be removed periodically to prevent surface clogging and outlet obstructions. Routine inspections for areas of standing water and corrective measures to restore proper infiltration rates are necessary. In addition, bioretention areas receiving sediment impacts are more susceptible to invasion by aggressive plant species such as cattails, which increase the chances of water standing and subsequent vector production if not routinely maintained (Urban Drainage and Flood Control District - Denver, Colorado, 2005). Properly maintained bioretention cells will promptly infiltrate stormwater and should not be a vector concern.

TABLE 8.3 Bioretention Cell Typical Maintenance Activities		
Activity		Frequency
Establishment *(1-3yrs)*		
	Watering plants *(plug and container plants in drought)*	1" per week as needed
	Weed control *(string-trim, mechanical removal, foliar herbicide)*	Monthly
	Remove litter and debris *(trash, leaves, mower discharge, sand)*	Monthly
	Monitor & repair erosion *(stabilize soil, replace plants, secure edging)*	Monthly
	Check for standing water *(longer than design, any puddles, saturated soils)*	Monthly
	Add mulch *(moisture & weed control, 3" or less, dispose properly)*	Annually
	Inspect drainage area *(parking lot sweeping, open dumpsters, etc)*	Annually
	Replace dead plants *(use design species/size, maintain density)*	Annually, as needed
Maintenance *(3+yrs, establishment activities may carry over, as needed)*		
	Vegetation cleanup (*string trim, prescribed burn, prune)*	Annually, spring or fall
	Evaluate plant composition (*woody invasion, grass/flower ratio, "right plant, right place")*	Annually
	Sediment removal(*pretreatment structures: forebay, swales)*	Annually
	Address animal damage *(Canada geese, muskrats, deer rubs)*	Annually
	Verify structural component function *(area inlet, valve lube, underdrains, outlet protection)*	Annually
Bioretention cell		
	Evaluate soils for nutrients, physical make-up	Annually
	Fortify edging material/adjacent landscape beds	Annually

Typical maintenance activities are outlined to provide a basis for scheduling and planning work but should not be considered wholly comprehensive or definitive. Activities and frequencies will vary depending on site conditions and expectations related to adjacent land use. Some activities shown may continue through the establishment and maintenance phases. It's important to use adaptive management based on the goals of the practice and to integrate evaluation and assessment into a long-term maintenance plan.

8.4.7 Design Example

Below is a bioretention facility design example. These procedures follow the steps outlined in the Design Procedure Form: Bioretention, Main Worksheet. When using the worksheet in electronic form, manually enter values in green.

Example: Design a bioretention facility to treat runoff from the water quality rainfall event for the Kansas City Metropolitan Area (1.37 inches) coming off a ½-acre paved parking lot.

I. Basin Water Quality Storage Volume

Step 1 - Enter the tributary area to the bioretention facility (A_T).

Step 2 - Calculate the WQv using the methodology in Section 6 of this manual.

IIa. Pretreatment

Step 1 - Specify the type of inflow to the facility as either sheetflow or concentrated/channelized flow.

Step 2 - Specify the type of pretreatment to use (vegetated filter strip, vegetated channel or other pretreatment device).

Step 3 - Proceed to Part IIb, IIc, or IId for design guidance on different pretreatment options.

IIb. Vegetated Pretreatment Strip

Step 1 - Specify the type of land cover of the contributing area to the facility.

Step 2 - Enter the maximum inflow approach length ($L_{approach}$). This is the maximum length that runoff will flow across the parking lot before hitting the bioretention facility.

Step 3 - Enter the average slope of the vegetated filter strip (S_{f5}). This slope should not exceed 6 percent.

Step 4 - Determine the minimum required length for the filter strip (L_{fs}) from Table 8.2.

IIc. Vegetated Pretreatment Channel

Step 1 - Enter the percent imperviousness of the contributing area to the facility (% imp).

Step 2 - Enter the average slope of the vegetated channel (S_{vc}). This slope should not exceed 6 percent.

Step 3 - Determine the minimum required length for the vegetated channel (L_{vc}) from Table 8.3.

IId. Other Pretreatment Devices

Other methods of pretreatment may be used upstream of a bioretention facility to settle out suspended solids and reduce runoff velocity. Several proprietary devices are available that will achieve these results. Most of these devices are installed below ground and accept inflow from a piped stormwater management system or from surface sheetflow via drop inlets. These devices should be selected and sized based on site-specific conditions for each project and according to manufacturer instructions.

III. Planting Soil Bed and Ponding Area

Step 1 - Enter the planting soil bed depth (d_f). This depth can range from 2.5 feet to 4 feet. Soil bed depths greater than 4 feet may require additional construction practices such as shoring measures.

Step 2 - Enter the coefficient of permeability for the soil bed (k). The soil bed mixture should be tested before construction of the facility to ensure that it meets the desired permeability. This value should be at least 1 ft/day.

Step 3 - Enter the maximum ponding depth in the facility (h_{max}). This depth should be between 3 and 12 inches.

Step 4 - Calculate the average height of water above the bioretention bed (h_{avg}) as half the depth set in Step 3.

$H_{avg} = H_{max}/2$

Step 5 - Enter the time required for the WQv to filter through the planting soil bed (t_f). A time of 3 days is recommended.

Step 6 - Calculate the required filter bed surface area (A_f). See equation derivation on the Variable Dictionary sheet of the Bioretention Design Procedure Form.

$A_f = (WQv * d_f)/[k * t_f * (h + d_f)]$

Step 7 - Calculate the approximate filter bed length (L_f). Optimally the facility will be twice as long as it is wide. The facility length should be at least 40 feet.

Step 8 - Calculate the approximate filter bed width (W_f). This dimension should be approximately half the filter bed length, and should be at least 15 feet.

Step 9 - Calculate the Ponding Area (A_p).

IV. Underdrain

Step 1 - Set the underdrain pipe diameter (D_U). This value should be at least 4 inches.

Step 2 - Determine the depth of the gravel blanket (Z_{gravel}) around the underdrain pipe. This depth should be no less than 8 inches and should be at least 2 inches greater than the underdrain pipe diameter.

Step 3 - Set underdrain perforation diameter to 0.375 inches.

Step 4 - Set the longitudinal center-to-center underdrain perforation spacing (S_{perf}) as 6 inches.

Step 5 - Set the number of perforations per row (n_{perf}) (around the circumference of the underdrain pipe). This number should be at least 4.

Step 6 - Set the underdrain collector pipe spacing (Su) center-to-center. This distance should be 20 feet.

Step 7 -Ensure that the grade for all underdrain pipes (G_{pipe}) is at least 0.5 percent.

Step 8 -Ensure that one cleanout is provided at the end of each pipe run.

Step 9 - Determine the design head on the orifice at or near the outfall (h_o), equal to one half of the sum of the planting soil depth (d_f) and the maximum ponding depth in the facility (h_{max}).

Step 10 – Determine the average rate of flow to drain the WQv in 40 hrs, equal to the WQv divided by 144000.

Step 11 – Determine the orifice area at the outfall using the orifice equation, $Q= 0.6A (2gh_o)^{0.5}$.

V. Overflow

The bioretention overflow shall be designed to safely pass runoff flows from events up to and including the 1 percent event unless the facility is designed with a bypass around the facility for larger storm events. If the 1-percent event is to pass through the facility, the maximum velocity shall be kept below 3 feet per second to avoid erosion of the soil matrix. If facilities are designed with a bypass, it shall be designed to safely pass runoff flows from events up to and including the 1 percent event. The overflow can be designed as a vegetated or stabilized channel or a yard inlet catch basin. Vegetated or stabilized channel overflows shall be designed using one of the methods presented in APWA Section 5603 and shall conform to the design criteria presented in APWA Section 5607. Methods presented in APWA Section 5604 shall be used for overflow inlet design.

VI. Vegetation

Enter a description of the mix and density of vegetation that will be planted in the bioretention facility. Follow guidance given in Appendix A of this manual. It is beneficial to plant variable types and species of plants in a

bioretention facility. Such variability prevents single-species susceptibility to disease and insect infestation and provides a more aesthetic appearance. Native species should be used because they are more likely to thrive in the local climate. A minimum of three native species of shrubs and three native species of plants is recommended. Plants should also be selected for their ability to withstand extended dry conditions (which are likely to occur in parking lot island bioretention facilities) and periodic inundation.

TABLE 8.4
Vegetated Pretreatment Strip Sizing Guidance

Parameter	Impervious Parking Lots				Residential Lawns				Notes
Maximum Inflow Approach Length (feet)	35		75		75		150		
Filter Strip Slope	≤2%	≥2%	≤2%	≥2%	≤2%	≥2%	≤2%	≥2%	Maximum Slope = 6%
Filter Strip Minimum Length (feet)	10	15	20	25	10	12	15	18	

TABLE 8.5
Vegetated Pretreatment Channel Sizing Guidance for a 1.0-Acre Tributary Area

Parameter	≤33% Impervious		Between 34% and 66% Impervious		≥67% Impervious		Notes
Channel Slope	≤2%	≥2%	≤2%	≥2%	≤2%	≥2%	Maximum Slope = 6%
Grass Channel Minimum Length (feet)	25	40	30	45	35	50	Assumes bottom width is 2 feet

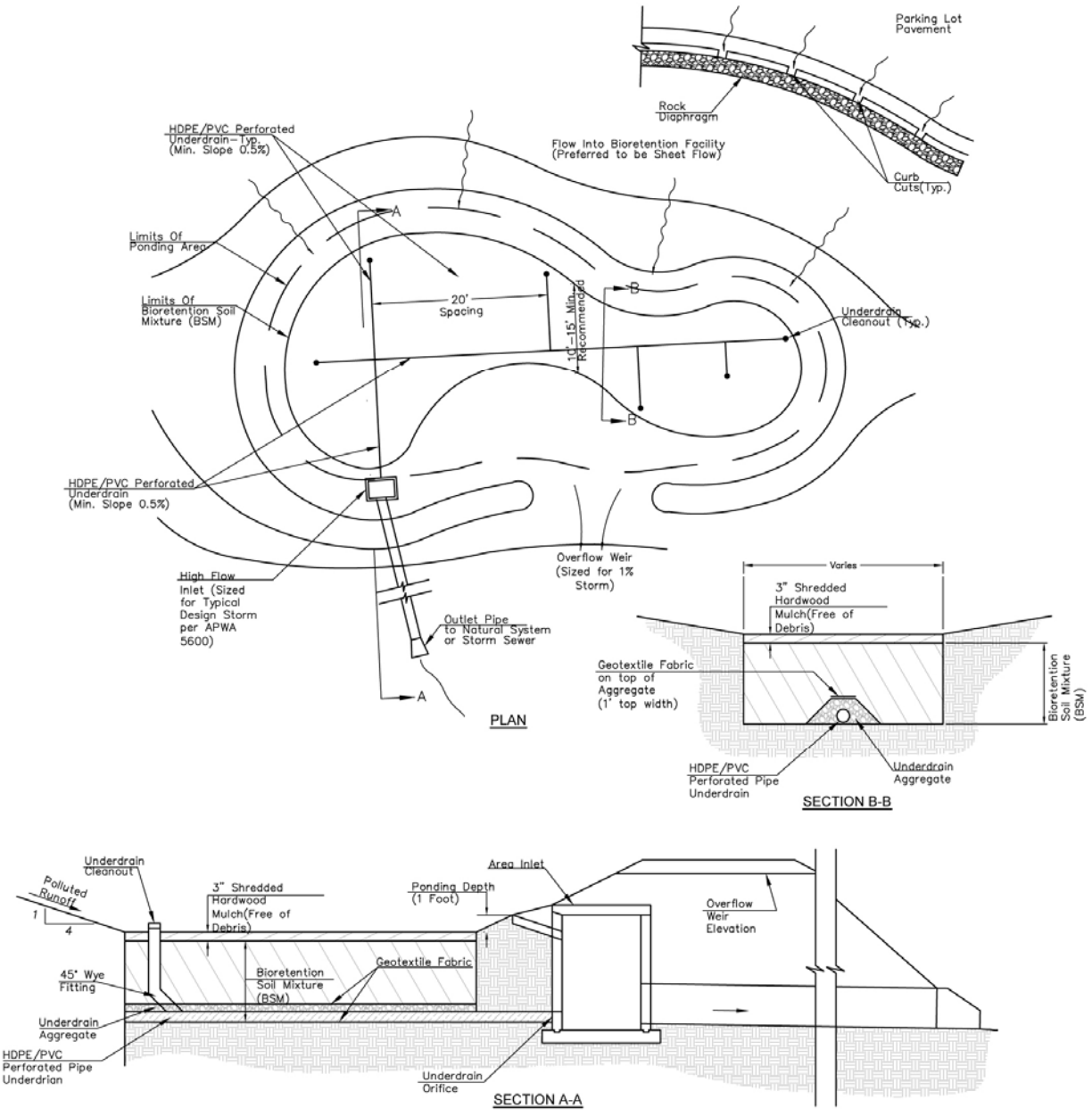

FIGURE 8.5 - Bioretention Plan and Profile

Design Procedure Form: Bioretention
Main Worksheet

Designer: _____
Checked By: _____
Company: _____
Date: _____
Project: _____
Location: _____

III. Planting Soil Bed and Ponding Area

Step 1) Planting bed soil depth, d_f (ft) (d_f should be between 2.5 feet and 4 feet).	d_f (ft) =	3
Step 2) Coefficient of permeability for planting soil bed, k (ft/day) (k should be at least 1 ft/ day)	k (ft/ day) =	1.3
Step 3) Maximum ponding depth, h_{max} (ft) (h_{max} should be between 0.25 ft and 1.0 ft).	h_{max} (ft) =	1
Step 4) Average height of water above bioretention bed, havg (ft) $h_{avg} = h_{max}/2$	h_{avg} (ft) =	0.5
Step 5) Time required for WQv to filter through the planting soil bed, t_f (days) (t_f of 1 to 3 days is recommended)	t_f (days) =	2
Step 6) Required filter bed surface area, A_f (ft^2) $A_f = (WQv*d_f)/[k*t_f*(h_{avg}+df)]$	A_f (ft^2) =	785
Step 7) Approximate filter bed length, L_f (ft), assuming a length to width ratio of 2:1 (L_f should be at least 40 ft)	L_f (ft) =	40
Step 8) Approximate filter bed width, W_f (ft), assuming a length to width ratio of 2:1 (W_f should be at least 15 feet, and optimally half of L_f)	W_f (ft) =	20
Step 9) Required Ponding Area, A_p (sf) $Ap = WQv/h_{max}$	Ap (ft^2) =	2380

Design Procedure Form: Bioretention
Main Worksheet

Designer: _____
Checked By: _____
Company: _____
Date: _____
Project: _____
Location: _____

IV. Underdrain		
Step 1) Underdrain pipe diameter, D_U (in) (D_U should be at least 4 inches)	D_U (in) =	6
Step 2) Depth of gravel blanket, Z_{gravel} (in.) (Z_{gravel} should be at least 8 inches, and at least 2 inches greater than D_U)	Z_{gravel} (in) =	8
Step 3) Set underdrain perforation diameters to 0.375 inches.	D_{perf} (in) =	0.375
Step 4) Longitudinal center-to-center underdrain perforation spacing, S_{perf} (in)	S_{perf} (in) =	6
Step 5) Number of perforations per row (around circumference of underdrain), n_{perf} (n_{perf} should be at least 4)	n_{perf} =	5
Step 6) Underdrain collector spacing (approximately 20') SU (ft)	S_U (ft) =	20
Step 7) Pipe grade, Gpipe (%), for main pipe and transverse collector pipes (G_{pipe} should be at least 0.5%)	G_{pipe} (%) =	0.5
Step 8) Providing at least one cleanout per pipe run? (Yes or No)		Yes
Step 9) Determine design head (ho) on orifice, ho = (df + hmax)/2	ho (ft) =	2
Step 10) Determine Average flow rate, Qavg = WQv/144,000	Qavg (cfs) =	0.017
Step 11) Determine orifice area Ao = Qavg/(0.6*(2*g*ho)^0.5)	Ao (ft^2) =	0.0025
	Ao (in^2) =	0.36

V. Overflow

The bioretention overflow shall be designed to safely pass runoff flows from events up to and including the 1 percent event unless the facility is designed with a bypass around the facility for larger storm events. If the 1-percent event is to pass through the facility, the maximum velocity shall be kept below 3 feet per second to avoid erosion of the soil matrix. If facilities are designed with a bypass, it shall be designed to safely pass runoff flows from events up to and including the 1 percent event. The overflow shall be designed as a vegetated or stabilized channel of a yard inlet catch basin. Vegetated or stabilized channels shall be designed using one of the methods presented in APWA Section 5603 and shall conform to the design criteria presented in APWA Section 5607. Methods presented in APWA Section 5604 shall be used for inlet design.

Design Procedure Form: Bioretention
Main Worksheet

Designer: _____
Checked By: _____
Company: _____
Date: _____
Project: _____
Location: _____

V. Vegetation

Describe mix and density of vegetation to be placed in the bioretention facility. Follow specifications given under Plant Materials in Appendix A. It is beneficial to plant variable types and species of plants in a bioretention facility. Such variability prevents single-species susceptibility to disease and insect infestation and provides a more aesthetic appearance. Native species should be used because they are more likely to thrive in the local climate. A minimum of three native species is recommended. Plants should also be selected for their ability to withstand extended dry conditions (which are likely to occur in parking lot island bioretention facilities) and periodic inundation.

Design Procedure Form: Bioretention
Main Worksheet

Designer: _____
Checked By: _____
Company: _____
Date: _____
Project: _____
Location: _____

I. Water Quality Volume	
Step 1) Tributary area to bioretention area, A_T (ac)	A_T (ac) =
Step 2) Calculate WQv using methodology in Section 6	WQv (cu-ft) =
IIa. Pretreatment	
Step 1) Specify type of inflow to Bioretention facility: Type 1 = sheet flow Type 2 = concentrated or channelized	Inflow type =
Step 2) Pretreatment	
Step 3) Proceed to Part IIb, IIc, or IId for design guidance on different pretreatment options	
IIb. Vegetated Pretreatment Strip	
Step 1) Type of land cover of contributing area: Type 1 = Impervious (i.e., parking lot) Type 2 = Pervious (i.e., residential lawn)	Land cover type =
Step 2) Maximum inflow approach length, $L_{approach}$ (ft)	$L_{approach}$ (ft) =
Step 3) Average slope of pretreatment strip, S_{fs} (%) (Maximum slope of 6%)	S_{fs} (%) =
Step 4) Vegetated pretreatment strip minimum length, L_{fs} (ft), from Table 8.2	L_{fs} (ft) =
IIc. Vegetated Pretreatment Channel	
Step 1) Percent imperviousness of contributing area, % imp	% imp =
Step 2) Average slope of vegetated channel, S_{vc} (%) (Maximum slope of 6%)	S_{vc} (%) =
Step 3) Vegetated pretreatment channel minimum length, L_{vc} (ft), from Table 8.3	L_{vc} (ft) =
IId. Other Pretreatment Devices	
Other methods of pretreatment may be utilized upstream of a bioretention facility to settle out suspended solids and reduce runoff velocity. Several proprietary devices are available that will achieve these results. Most such devices install below ground and accept inflow from a piped stormwater management system or from surface sheet flow via drop inlets. These devices should be selected and sized based on site-specific conditions for each project.	

Design Procedure Form: Bioretention
Main Worksheet

Designer: _____
Checked By: _____
Company: _____
Date: _____
Project: _____
Location: _____

III. Planting Soil Bed and Ponding Area

Step 1) Planting bed soil depth, d_f (ft) — d_f (ft) =
(d_f should be between 2.5 feet and 4 feet).

Step 2) Coefficient of permeability for planting soil bed, k (ft/day) — k (ft/ day) =
(k should be at least 1 ft/ day)

Step 3) Maximum ponding depth, h_{max} (ft) — h_{max} (ft) =
(h_{max} should be between 0.25 ft and 1.0 ft).

Step 4) Average height of water above bioretention bed, havg (ft) — h_{avg} (ft) =
$h_{avg} = h_{max}/2$

Step 5) Time required for WQv to filter through the planting soil bed, t_f (days) — t_f (days) =
(t_f of 1 to 3 days is recommended)

Step 6) Required filter bed surface area, A_f (ft^2) — A_f (ft^2) =
$A_f = (WQv*d_f)/[k*t_f*(h_{avg}+df)]$

Step 7) Approximate filter bed length, L_f (ft), assuming a length to width ratio of 2:1 — L_f (ft) =
(L_f should be at least 40 ft)

Step 8) Approximate filter bed width, W_f (ft), assuming a length to width ratio of 2:1 — W_f (ft) =
(W_f should be at least 15 feet, and optimally half of L_f)

Step 9) Required Ponding Area, A_p (sf) — Ap (ft^2) =
$Ap = WQv/h_{max}$

Design Procedure Form: Bioretention
Main Worksheet

Designer: _____
Checked By: _____
Company: _____
Date: _____
Project: _____
Location: _____

IV. Underdrain

Step 1) Underdrain pipe diameter, D_U (in) (D_U should be at least 4 inches)	D_U (in) =
Step 2) Depth of gravel blanket, Z_{gravel} (in.) (Z_{gravel} should be at least 8 inches, and at least 2 inches greater than D_U)	Z_{gravel} (in) =
Step 3) Set underdrain perforation diameters to 0.375 inches.	D_{perf} (in) =
Step 4) Longitudinal center-to-center underdrain perforation spacing, S_{perf} (in)	S_{perf} (in) =
Step 5) Number of perforations per row (around circumference of underdrain), n_{perf} (n_{perf} should be at least 4)	n_{perf} =
Step 6) Underdrain collector spacing (approximately 20') SU (ft)	S_U (ft) =
Step 7) Pipe grade, Gpipe (%), for main pipe and transverse collector pipes (G_{pipe} should be at least 0.5%)	G_{pipe} (%) =
Step 8) Providing at least one cleanout per pipe run? (Yes or No)	
Step 9) Determine design head (ho) on orifice, ho = (df + hmax)/2	ho (ft) = _____
Step 10) Determine Average flow rate, Qavg = WQv/144,000	Qavg (cfs) = _____
Step 11) Determine orifice area Ao = Qavg/(0.6*(2*g*ho)^0.5)	Ao (ft^2) = _____ Ao (in^2) =

V. Overflow

The bioretention overflow shall be designed to safely pass runoff flows from events up to and including the 1 percent event unless the facility is designed with a bypass around the facility for larger storm events. If the 1-percent event is to pass through the facility, the maximum velocity shall be kept below 3 feet per second to avoid erosion of the soil matrix. If facilities are designed with a bypass, it shall be designed to safely pass runoff flows from events up to and including the 1 percent event. The overflow shall be designed as a vegetated or stabilized channel of a yard inlet catch basin. Vegetated or stabilized channels shall be designed using one of the methods presented in APWA Section 5603 and shall conform to the design criteria presented in APWA Section 5607. Methods presented in APWA Section 5604 shall be used for inlet design.

Design Procedure Form: Bioretention
Main Worksheet

Designer: _____
Checked By: _____
Company: _____
Date: _____
Project: _____
Location: _____

V. Vegetation

Describe mix and density of vegetation to be placed in the bioretention facility. Follow specifications given under Plant Materials in Appendix A. It is beneficial to plant variable types and species of plants in a bioretention facility. Such variability prevents single-species susceptibility to disease and insect infestation and provides a more aesthetic appearance. Native species should be used because they are more likely to thrive in the local climate. A minimum of three native species is recommended. Plants should also be selected for their ability to withstand extended dry conditions (which are likely to occur in parking lot island bioretention facilities) and periodic inundation.

Variable Dictionary

Variable	Units	Definition
A_f	ft^2	Required filter bed surface area
A_T	ac	Tributary area to Bioretention Facility
d_f	ft	Planting bed soil depth
D_{perf}	in	Underdrain perforation diameter
D_U	in	Underdrain pipe diameter
G_{pipe}	%	Pipe grade for main pipe and transverse collector pipes
h_{avg}	ft	Average ponding depth above soil bed
h_{max}	ft	Maximum ponding depth above soil bed
k	ft/day	Coefficient of permeability for planting soil bed
$L_{approach}$	ft	maximum inflow approach length to bioretention facility
L_f	ft	Approximate filter bed length
L_{fs}	ft	Minimum length of vegetated filter strip
L_{vc}	ft	Minimum length of vegetated channel
n_{perf}	none	Number of perforations per row (around circumference of underdrain pipe)
n_{pipe}	none	Number of underdrain transverse collector pipes
% Imp	%	Percent imperviousness of contributing area
S_{fs}	%	Average slope of vegetated filter strip
S_{perf}	in	Longitudinal center-to-center underdrain perforation spacing
S_U	ft	Underdrain transverse collector pipe spacing, center-to-center
S_{vc}	%	Average slope of vegetated channel
t_f	days	Time required for the WQv to filter through the planting soil bed
W_f	ft	Approximate filter bed width
WQv	ac-ft	Water quality volume
Z_{gravel}	in	Depth of gravel blanket

Part IIIb, Step 6) Required filter bed surface area equation derivation

$WQv = Q * t$ (Volume = Flow Rate * Time)

$Q = k * i * A$ (Darcy's Law)

$WQv = k * i * A * t$ (Substitute in Darcy parameters for Q)

$i = \Delta h/H = (h_{avg} + d_f)/d_f$ (Darcy hydraulic gradient)

$WQv = k * [(h_{avg} + d_f)/d_f] * A_f * t_f$ (Substitute in hydraulic gradient terms)

$A_f = (WQv * d_f)/[k * t_f * (h_{avg} + d_f)]$ (Rewrite to solve for A_f)

WQv = water quality volume in (ac-ft)
d_f = planting bed soil depth in (ft)
k = coefficient of permeability for planting soil bed in (ft/day)
t_f = time required for WQv to filter through the planting soil bed in (days)
h_{avg} = average ponding depth above planting soil bed in (ft)

B. Stockpiled materials shall meet the following requirements:

1. Be selectively placed on a stable site within the construction area;
2. Be protected from contaminants and unnecessary compaction that would interfere with revegetation;
3. Be protected from wind and water erosion through prompt establishment and maintenance of an effective, quick growing vegetative cover or through other measures provided in the approved water pollution control plan; and
4. Not be moved until required for redistribution unless approved by the Engineer.

C. Where long-term stockpiling of materials is required, and where such stockpiling would be detrimental to the quality or quantity of those materials, the Engineer may approve the temporary distribution of the soil materials to an approved site within the construction area.

1. Such action will not permanently diminish the capability of the topsoil of the host site.
2. The material will be distributed in a condition more suitable for redistribution than if stockpiled.

D. Redistribution

1. Topsoil materials removed shall be redistributed in a manner that--
   a. Achieves an approximately uniform, stable thickness consistent with the approved restoration plan, finished grading, and surface-water drainage systems;
   b. Prevents excess compaction of the materials; and
   c. Protects the materials from wind and water erosion before and after seeding and planting.
2. Before redistribution of the material removed, the regraded land shall be scarified to reduce potential slippage of the redistributed material and to promote root penetration. Such treatment may be conducted after the material is replaced if no harm will be caused to the redistributed material and reestablished vegetation.
3. The Engineer may choose not to require the redistribution of topsoil or topsoil substitutes on the final embankments if it determines that--
   a. Placement of topsoil or topsoil substitutes on such embankments will result in greater sedimentation than would otherwise occur, or
   b. Such embankments will be stabilized by other approved means.

9002.6 Vegetation

Vegetation shall be established on all exposed surfaces. Plantings shall be as shown in the plans and as specified.

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SECTION 9003 BIORETENTION FACILITIES

9003.1 Description

Bioretention facilities are small landscaped basins intended to provide water quality management by filtering stormwater runoff before release into storm drain systems. This work shall consist of installing bioretention facilities as specified in the Contract Documents, including all materials, equipment, labor and services required to perform the work.

9003.2 Materials

A. Bioretention Soil Mixture: The Bioretention Soil Mixture (BSM) is a mixture of planting soil, compost, and sand consisting of the following:

Item	Composition By Volume	Reference
Planting Soil	30%	See below.
Organic Compost	20%	See below.
Sand	50%	ASTM C33 Fine Aggregate

B. Planting Soil: The USDA textural classification of the Planting Soil for the BSM shall be LOAMY SAND OR SANDY LOAM. The Planting Soil shall be the best available on site material or furnished. Additionally, the Planting Soil shall be tested and meet the following criteria or as approved by the Engineer:

Item	Percent By Weight	Test Method
Sand (2.0 – 0.050 mm)	50 – 85%	AASHTO T88
Silt (0.050 – 0.002 mm)	0 – 50%	AASHTO T88
Clay (less than 0.002 mm)	2 – 5%	AASHTO T88
Organic Matter	3 – 10%	AASHTO T194

The textural analysis for the Planting Soil shall be as follows:

ASTM E11 Sieve Size	Minimum Percent Passing By Weight
2 in.	100
No. 4	90
No. 10	80

At least 45 days prior to the start of construction of bioretention facilities, the Contractor shall submit the source and testing results of the Planting Soil for the BSM to the Engineer for approval. No time extensions will be granted should the proposed Planting Soil fail to meet the minimum requirements stated above. Once a stockpile of the Planting Soil has been sampled, no material shall be added to the stockpile.

C. Organic Compost: Compost is a homogeneous and friable mixture of partially decomposed organic matter, with or without soil, resulting from composting, which is a managed process of bio-oxidation of a solid heterogeneous organic substrate including a thermophilic phase.

Compost is deemed acceptable if it meets 2 of the following requirements:

1. C/N ratio <= 25;
2. Oxygen uptake rate <= 150 mg O_2/kg volatile solids per hour; and
3. Compost must not contain more than 1 percent foreign matter. Foreign matter is defined as: "Any matter over a 2 mm dimension that results from human intervention and having organic or inorganic constituents such as metal, glass and synthetic polymers (e.g. plastic and rubber) that may be present in the compost but excluding mineral soils, woody material and rocks."
4. Foreign matter less than 1 percent by weight must not exceed 12.5 mm in any dimension.

D. The Bioretention Soil Mixture (BSM) shall be a uniform mix, free of plant residue, stones, stumps, roots or other similar objects larger than two inches excluding mulch. No other materials or substances shall be mixed or dumped within the bioretention area that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations.

1. The Bioretention Soil Mixture shall be tested and meet the following criteria:

Item	Criteria	Test Method
Corrected pH	5.5 – 7.5	ASTM D4972
Magnesium	Minimum 32 ppm	*
Phosphorus (Phosphate - P_2O_5)	not to exceed 60 ppm plant available phosphorus	*
Potassium (K_2O)	Minimum 78 ppm	*
Soluble Salts	Not to exceed 500 ppm	*

* Use authorized soil test procedures.

2. Should the pH fall outside of the acceptable range, it may be modified with lime (to raise) or ammonium sulfate (to lower). The lime or ammonium sulfate must be mixed uniformly into the BSM prior to use in bioretention facilities.
3. Should the BSM not meet the minimum requirement for magnesium, it may be modified with magnesium sulfate. Likewise, should the BSM not meet the minimum requirement for potassium, it may be modified with potash. Magnesium sulfate and potash must be mixed uniformly into the BSM prior to use in bioretention facilities.
4. Planting soil and/or BSM that fails to meet the minimum requirements shall be replaced at the Contractor's expense. Mixing of the corrective additives to the BSM is incidental and shall be at the Contractor's expense.
5. Mixing of the BSM to a homogeneous consistency shall be done to the satisfaction of the Engineer. Upon approval of all requirements and testing above, the BSM shall be stockpiled, and no material shall be added to the BSM in the stockpile or during transport to the bioretention facility.

E. Other Materials

Material	Specification
No. 57 Aggregate	ASTM D448
No. 7 Aggregate	ASTM D448
4-inch HDPE Plastic Pipe Underdrain	AASHTO M252
Geotextile Fabric	AASHTO M288
Mulch, 2x Shredded Hardwood Bark	See below
Water	See below.
Lime	ASTM C25
Ammonium Sulfate	See below.
Magnesium Sulfate	See below.
Potash	See below.

1. Shredded Hardwood Mulch: Shredded hardwood mulch shall be aged a minimum of 6 months and consist of the bark and wood (50/50) from hardwood trees which has been milled and screened to a maximum 4 in. particle size and provide a uniform texture free from sawdust, clay, soil, foreign materials, and any artificially introduced chemical compounds that would be detrimental to plant or animal life.

2. Aggregate: No. 7 and No. 57 Aggregate shall be double-washed to reduce suspended solids and potential for clogging. The aggregate shall be placed as shown in the Contract Drawings.

3. Water: Water used in the planting, establishing, or caring for vegetation shall be free from any substance that is injurious to plant life.

4. Lime: Lime shall contain not less than 85 percent calcium and magnesium carbonates. Dolomitic (magnesium) lime shall contain at least 10 percent magnesium as magnesium oxide and 85 percent calcium and magnesium carbonates. Lime shall conform to the following gradation:

Sieve Size	Minimum Percent Passing By Weight
No. 10	100
No. 20	98
No. 100	50

5. Ammonium Sulfate: Ammonium sulfate shall be a constituent of an approved horticultural product produced as a fertilizer for supplying nitrogen and as a soil acidifier.

6. Magnesium Sulfate: Magnesium sulfate shall be a constituent of an approved horticultural product produced as a fertilizer.

7. Potash: Potash (potassium oxide) shall be a constituent of an approved horticultural product produced as a fertilizer.

9003.3 Construction

Bioretention facilities shall not be constructed until all contributing drainage areas are permanently stabilized against erosion and sedimentation as shown on the Contract Plans and to the satisfaction of the Engineer. Any discharge of sediment that affects the performance of the cell will require reconstruction of the cell to restore its defined performance. No heavy equipment shall operate within the perimeter of a bioretention facility during underdrain placement, backfilling, planting, or mulching of the facility.

A. Excavation: If the bioretention facility is to be used as a sediment basin the bioretention facility shall be excavated to the dimensions, side slopes, and *1 foot above* the bottom of the Bioretention Soil Mixture elevations shown on the Contract Plans. Any sediment from construction operations deposited in the bioretention facility shall be completely removed from the facility after all vegetation, including landscaping within the drainage area of the bioretention facility, has been established. The excavation limits shall then be final graded to the dimensions, side slopes, and ***final*** elevations shown on the Contract Plans. Excavators and backhoes, operating on the ground adjacent to the bioretention facility, shall be used to excavate the facility if possible. low ground-contact pressure equipment or, if approved by the engineer, by excavators and/or backhoes operating on the ground adjacent to the bioretention facility. Low ground-contact pressure equipment is preferred on bioretention facilities to minimize disturbance to established areas around perimeter of cell. No heavy equipment shall be used within the perimeter of the bioretention facility before, during, or after the placement of the BSM.

   Excavated materials shall be removed from the bioretention facility site. Excavated materials shall be used or disposed of in conformance with the project specifications.

B. Roto-tilling: After placing the underdrain and aggregate and before the BSM, the bottom of the excavation shall be roto-tilled to a minimum depth of 6 inches to alleviate any compaction of the facility bottom. Any substitute method for roto-tilling must be approved by the Engineer prior to use. Any ponded water shall be removed from the bottom of the facility and the soil shall be friable before roto-tilling. The roto-tilling shall not be done where the soil supports the aggregate bed underneath the "Underdrain for Bioretention". (See "Underdrain for Bioretention" specifications below.)

C. Underdrain for bioretention: The underdrain system, aggregate bed, and geotextile fabric shall be placed according to dimensions shown on the Contract Plans.

D. Observation wells/cleanouts of 4-inch non-perforated HDPE pipe shall be placed vertically in the bioretention facility as shown on the Contract Plans. The wells/cleanouts shall be connected to the perforated underdrain with the appropriate manufactured connections as shown on the Contract Plans. The wells/cleanouts shall extend 6 inches above the top elevation of the bioretention facility mulch, and shall be capped with a screw cap.

E. Placement of the Bioretention Soil Mixture: The Bioretention Soil Mixture (BSM) shall be placed and graded using low ground-contact pressure equipment or, if approved by the engineer, by excavators and/or backhoes operating on the ground adjacent to the bioretention facility. Low ground-contact pressure equipment is preferred on bioretention facilities to minimize disturbance to established areas around perimeter of cell. No heavy equipment shall be used within the perimeter of the bioretention facility before, during, or after the placement of the BSM. The BSM shall be placed in horizontal layers not to exceed 12 inches for the entire area of the bioretention facility. The BSM shall be saturated over the entire area of the bioretention facility after each lift of BSM is placed until water flows from the underdrain to lightly consolidate the BSM mixture. Water for saturation shall be applied by spraying or sprinkling in a manner to avoid separation of the BSM components. Saturation of each lift shall be performed in the presence of the Engineer. If the BSM becomes contaminated during the construction of the facility, the contaminated material shall be removed and replaced with uncontaminated material at the Contractor's expense. Final grading of the BSM shall be performed after a 24-hour settling period. Upon final grading the surface of the BSM shall be roto-tilled to a depth of 6". Final elevations shall be within 2 inches of elevations shown on the Contract Plans.

F. Mulching: Once grading is complete, the entire bioretention facility shall be mulched to a uniform thickness of 3 inches. Mulching shall be complete within 24 hours to reduce the potential of silt accumulation on the surface. Well aged shredded hardwood bark mulch is the only acceptable mulch. Mulching shall be done immediately after grading to reduce potential of any silt accumulation on the surface.

G. Plant Installation: Trees, shrubs, and other plant materials specified for Bioretention Facilities shall be planted as specified in the Contract Plans and applicable landscaping standards with the exception that pesticides, herbicides, and fertilizer shall not be applied during planting under any circumstances. Furthermore, pesticides, fertilizer, and any other soil amendments shall not be applied to the bioretention facility during landscape construction, plant establishment, or maintenance.

9003.4 Method of Measurement

Bioretention Facilities will be measured by the square foot and will be paid for at the Contract Unit Price.

9003.5 Basis of Payment

The payment will be full compensation for all material, labor, equipment, tools, and incidentals necessary to satisfactorily complete the work. Biological Plantings will be paid for separately under other items of the contract.