Engineering | Design | Planning | Construction Management

River Falls Drainage Assessment

Prepared by

GPI

for

Montgomery County
Department of Transportation

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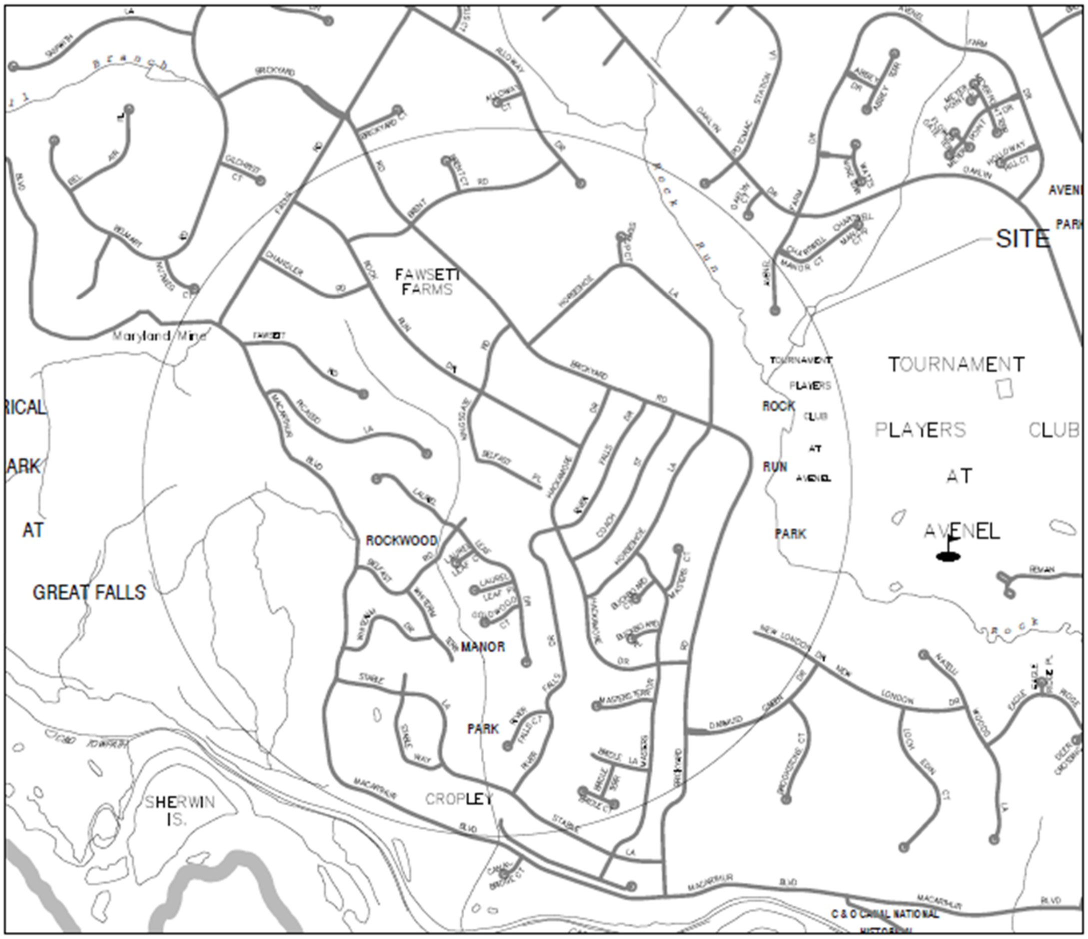

River Falls Neighborhood

VICINITY MAP

Scale: 1” = 2000’

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I. Introduction /Project Description

The Montgomery County Department of Transportation has contracted Greenman-Pedersen, Inc. to provide hydrology and hydraulics analysis for the existing storm drain systems in the River Falls neighborhood of Potomac, MD. The site has been experiencing flooding issues and the purpose of the study is to evaluate existing conditions and assess potential opportunities to minimize flooding within the project study area.

The site is located 2.3 miles west of I-495 and 1.7 miles south of the intersection of River Road (MD-190) and Falls Road. Area of interest is approximately 336 acres.

Two significant drainage issues were identified within the River Falls neighborhood. The first is in the northern section of the neighborhood. A storm drain system outfalls near Brickyard Road, Outfall 1, and flowing into Rock Run. This system extends west through the neighborhood and runs perpendicular to Horseshoe Lane, Coach Street, River Falls Drive, and Hackamore Drive before running along Rock Run Drive, Kingsgate Road, and Brickyard Road. In 1969, the storm drain system was installed where the natural drainage path was originally located. All the drainage in this subwatershed is directed to the storm drain system. Based on the as-built plans and computations, it appears as though the storm drain system was designed in accordance with Montgomery County drainage design standards. At that time, the Montgomery County storm drain design standard was the 10-year storm event. That design standard continues today. Where the system runs perpendicular to the roadways, it crosses through several rights-of-way and between houses with sidewalks. The rights-of-way and storm drain pipes are located at low points in the road with the perpendicular streets rising in elevation on both sides creating a hydrologic valley above the storm drain system. During storm events that exceed the design capacity of the storm drain system, water will flow across the surface, flooding the low points of the streets until rising high enough to flow over the sidewalks within the rights-of-way. This leads to flooding of houses adjacent to the rights-of-way which are near the low points of these streets.

The second area of concern is in the south western portion of the neighborhood where a separate storm drain system outfalls near MacArthur Boulevard, Outfall 7, and receives water from the stream located on property owned by Lorax Forest LLC, upstream of Stable Lane. This stream receives water from overland flow and six outfalls throughout the River Falls neighborhood. Similar to the northern section of the neighborhood, the storm drain system was installed within a natural stream path. According to the as-built plans and computations, it appears as though the storm drain system was designed to satisfy the 10-year storm in accordance with Montgomery County drainage design standards. Frequent flooding has been experienced where the stream enters the storm drain upstream of Stable Lane. Five houses have experienced some level of flooding due to debris from the forested area causing clogging of the system and storms exceeding design capacity between Stable Lane and MacArthur Boulevard. Additional drainage complaints have been received from Hackamore Drive, Masters Drive, and Masters Terrace during severe storm events.

The third area of the neighborhood is the southeastern part where a separate storm drain system outfalls near the intersection of MacArthur Boulevard and Masters Drive, Outfall 8. This section conveys runoff from the southern section of Masters Drive and parts of Bridle Court and Stable Lane to Outfall 8. Frequent flooding has been experienced at the intersection of Masters Drive and Stable Lane.

Complaints were received from seven northern neighborhood property owners through the Montgomery County Department of Transportation (MC DOT) Drainage Assistance Request program with additional complaints received through the County's 311 Request System. In total, it is estimated that 15 houses experienced property damage as did the River Falls Community Center and Pool. In 2019, the Montgomery County DOT performed storm drain improvements to improve the vertical geometry and pipe hydraulics within the system at Stable Lane, in the southern section of the neighborhood. However, even with the improvements, this system will require constant future maintenance by the County's Highway Services because of the woody leafy debris buildup from the approximately 3,100 linear feet of stream channel located upstream of the headwall.

The purpose of the drainage assessment will be, in part, to analyze future frequency of flooding related to this storm drain system and methods for reducing the flooding problem.

II. Sources of Information

- Montgomery County Drainage Design Criteria, November 2013, Rockville, Maryland (revised final June 10, 2014)
- Topographical Survey by Greenman-Pedersen, Inc.
- As-built plans and record drawings.
- Drainage Assistance Request website, Montgomery County, MD
- Web Soil Survey - USDA Natural Resources Conservation Services Soils
- NOAA's National Weather Service Hydrometeorological Design Studies Center Precipitation Frequency Data Server
- Community Collaborative Rain, Hail & Snow Network website: cocorahs.org

III. Project Assumptions

- When inaccessible drainage structures were not able to be field surveyed and record drawings were available, inverts of drainage structures, inlets and manholes, were taken from the as-built plans.
- When inaccessible drainage structures were not able to be field surveyed and there were no as-built plans, the ground slope was assumed for the pipe slope for closed storm drain calculations.
- Inlet spread computations for the existing inlets were not included in this analysis.
- For proposed condition pipe improvements, new pipe sizes were evaluated for the existing pipe slope.

IV. Preliminary Site Assessment

- County's GIS data were utilized in the creation of maps prior to field data collection.
- All available background data and information from previous studies, existing stormwater management facilities, storm drain and conveyance systems including hydrology and hydraulic information, floodplain data, land uses, record plats, property owners, easements and restriction, environmental constraints, road plans, water and sewer utilities etc. were obtained.

V. Field Data Collection

- Site Assessment: Field assessment was performed to confirm the drainage area to the County's inlet. Furthermore, to evaluate various parameters: County assets (storm drain, curb gutter, etc.), drainage patterns, roadside tress, bank/channel erosion, floodplains, occurrence of existing wetlands, locations of upstream and downstream tie-in locations or project limits and a determination outfall and bank/channel stabilization/restoration, limits of ROW, utility easements, and presence of M-NCPPC Parkland.
- Field Survey: The field survey was conducted by Greenman Pedersen, Inc. of all possible drainage structures, pipe network, elevation data, distances and slope lengths of the existing storm drain outfall, the existing drainage conveyance and the receiving waterway were collected. To assess the capacity of closed storm drain system the existing GIS topography base data along with the surveyed information were utilized.
- Wetland and Waterways Identification: Field investigations to identify and qualitatively map the locations of wetland and waterways within the project area was carried out.
- BMP Assessment: A field assessment was performed to identify potential BMP locations. Assessment included finding locations that minimized impacts to existing trees, utilities, driveways, private property, vehicle mobility and location of existing storm drain system.

VI. Wetland and Waterways Identification

Delineation Methodology

The study area was field investigated to identify the location of Waters of the United States (WUS), including watercourses and wetlands. Watercourse and wetland locations were marked on field maps in ArcCollector software utilizing an Eos Arrow 100 GNSS receiver.

Wetlands were identified in accordance with the parameters set forth in the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Eastern Mountains and Piedmont*. These parameters include hydrology, hydric soils, and hydrophytic vegetation. The presence and location of wetlands were determined qualitatively, by making visual observation of the hydrology, soils, and vegetation throughout the study area. No wetland data forms were completed as part of this delineation and no flagging was used to delineate wetland boundaries. If wetlands were found to be present, the location and boundary were drawn on field mapping as observed during the field investigation.

Watercourse locations were identified qualitatively based on the presence of a channel with defined bed and banks. No jurisdictional forms were filled out during this task and no flagging was used to delineate watercourse boundaries. Concrete and grass channels built in upland areas to drain uplands and did not connect to jurisdictional resources were not identified unless indicators of groundwater were present. If a watercourse was found to be present, the location was drawn on field mapping as observed during the field investigation. See Appendix C for mapping and Appendix J for photographs.

Resource Descriptions

Watercourse 1
Watercourse 1 (WC 1) originates from Outfall 2. The channel is perennial and flows in a southwestern direction with a primarily cobble/gravel substrate. Much of the channel is very incised, with signification erosion and instability observed throughout the length of the channel. WC 1 enters a culvert north of Stable Lane, daylighting at Outfall-7 where it flows beyond the study area and converges with another stream.

Watercourse 2
Watercourse 2 (WC 2) originates from Outfall 3. The channel is intermittent and flows in a western direction with a primarily cobble/gravel substrate. Areas of significant bank erosion were observed, primarily at the upstream extent. WC 2 flows to WC 1.

Watercourse 3
Watercourse 3 (WC 3) originates from Outfall 4. Then channel is intermittent and flows in a western direction with a primarily cobble/gravel substrate. Channel is incised with areas of bank erosion observed. WC 3 flows to WC 1.

Watercourse 4
Watercourse 4 (WC 4) originates at a head cut in the forested upland south of WC 3. The channel is ephemeral with a primarily cobble/gravel substrate. WC 4 has developed from a natural drainage pattern in the forested area south of WC 3; a head cut in the drainage pattern marks the beginning of a channel with defined bed and banks that connects directly to WC 3.

Watercourse 5
Watercourse 5 (WC 5) originates from Outfall 9. The channel is intermittent and flows in a western direction with a primarily mud substrate. Manhole-27 was located, but Outfall 9 was not observed. Wetland habitat was observed along the bank of WC 5. WC 5 flows to WC 1.

Watercourse 6
Watercourse 6 (WC 6) originates from Outfall 1. The channel is perennial and flows in a southeastern direction with a primarily cobble/gravel substrate. WC 6 flows beyond the study area.

Watercourse 7
Watercourse 7 (WC 7) originates from Outfall 8 north of MacArthur Boulevard. The channel is intermittent and daylights briefly from Outfall 8 before flowing immediately into a culvert carrying the watercourse under MacArthur Boulevard and out of the study area. The portion of the channel within the study area is primarily concrete.

Wetland 1

Wetland 1 is an emergent wetland located west of WC 1 at the upstream extent. The wetland is positioned at the toe-of-slope in a depression west of WC 1 that drains toward the stream. Soils within the wetland were saturated and were observed to have hydric indicators. *Microstegium vimineum* was the primary vegetation observed.

Wetland 2

Wetland 2 is an emergent wetland located at the downstream extent of WC 1 north of Stable Lane. The wetland is located in the floodplain of WC 1 and receives hydrology from the adjacent stream. Soils were observed to have hydric indicators and vegetation within the wetland included *Microstegium vimineum, Dichanthelium clandestinum, Leersia oryzoides*, and *Polygonum persicaria*.

VII. Hydrology

The study area is comprised of High-Density Residential Areas (R-200), single-family homes with minimum net lot area of 20,000 sq. ft. The soils at the site include Gaila, Glenelg, Elioak, Baile, Brinklow-Blocktown channery, Neshaminy, Elsinboro, Hatboro and Blocktown channery silt loam. See Appendix B for NRCS Soil Report. See table below for hydrologic group and slope range of each soil.

Table 1 – Hydrologic Soil Group and Slope Range

Soil Name	Hydrologic Soil Group	Slope Range
Gaila silt loam	B	3-8%
Glenelg silt loam	B	3-8%
Glenelg silt loam	B	8-15%
Elioak silt loam	C	3-8%
Baile silt loam	C/D	0-3%
Brinklow-Blocktown channery silt loam	C	15-25%
Neshaminy silt loam	B	3-8%
Elsinboro silt loam	B	3-8%
Hatboro silt loam	B/D	0-3%
Blocktown channery silt loam	D	15-25%
Blocktown channery silt loam	D	25-45%

HSG A soils infiltrate rainwater the best, and therefore, the properties of HSG A soils generate the least amount of runoff. HSG D soils have the lowest infiltration rates, and therefore contribute the most runoff. The table below summarizes some of the physical properties of the Hydrologic Soils group:

Table 2 – Physical Properties of Hydrologic Soil Group

Soils Group	Infiltration Rate (in/hr)	Relative Runoff Potential
A	> 0.30	Low
B	0.15 - 0.30	Moderate
C	0.05 - 0.15	High
D	0 - 0.05	Very High

The existing storm drain condition was analyzed for 10-year storm frequency based on the hydrologic criteria for Montgomery County Design Manual (2014). The drainage areas to pertinent study points were delineated and the Rational Method equation (q=CiA) is used for calculating the peak runoff rate. The runoff coefficient "C" is an empirically determined constant and is a measure of fraction of rainfall striking the drainage area that becomes runoff from that drainage area. Depending on the type of landcover the C value varies, for example the impervious surface or tight clay soil will have a high runoff coefficient when compared to well forested land or sandy soil. The design rainfall intensity (i) was calculated using time of concentration for design return period. GIS Topography was used to establish drainage boundaries. GPI defined two points of investigation (POI) for this analysis:

<u>POI #1</u>

The River Falls North storm drain system: This system consists of 10,064 LF of pipe with a 190.76-acre drainage area, 58.41 acres are impervious. POI #1 is located off of Brickyard Road, Outfall 1. See Appendix A for the drainage area map.

Table 3 – Hydrologic Parameters by Sub Area to POI #1

Sub Area	Drainage Area (acres)	Impervious Area (acres)	Tc (hr)
POI #1	190.76	58.41	0.384

<u>POI #2</u>

The River Falls South storm drain system: This system consists of a 9,055 LF of pipe with a 134.77-acre drainage area, 44.84 acres are impervious. POI #2 is located near the west side of MacArthur Boulevard, Outfall 7. See Appendix A for the drainage area map.

Table 4 – Hydrologic Parameters by Sub Area to POI #2

Sub Area	Drainage Area (acres)	Impervious Area (acres)	Tc (hr)
POI #2	134.77	44.84	0.306

POI #3

The River Falls South storm drain system: This system consists of a 1,703 LF of pipe with a 20.18 acre drainage area, 6.70 acres are impervious. POI #3 is located near the intersection of MacArthur Boulevard and Masters Drive, Outfall 8. See Appendix A for the drainage area map.

Table 5 – Hydrologic Parameters by Sub Area to POI #3

Sub Area	Drainage Area (acres)	Impervious Area (acres)	Tc (hr)
POI #3	20.18	6.70	0.190

These storm drain systems was designed and constructed in the late 1960's and early 1970's. The hydrologic design criteria for these systems and the current design criteria is the 10-year storm event.

VIII. Hydraulic Analysis

Existing Storm Drain System

A pipe capacity Excel spreadsheet was used to analyze the hydraulics of the existing storm drain systems. Most of the existing drainage structures were field surveyed, but not all of the structures could be located and/or accessed to record their invert data. Some were paved over, some were field connections, and some were buried. As stated in Section III above, assumptions were made to extrapolate the invert data of pipes. An additional level of effort will be required to excavate these drainage structures to obtain their actual pipe invert elevation. This level of effort exceeded the scope of the project at this time. The closed storm drain analysis was performed to verify the hydraulic capacity of the systems. Given the County's storm drain design standards, the calculations were performed based on the 10-year storm event. Numerous pipes were found to be undersized for the 10-year return period; see tables in Appendix E and mapping in Appendix F.

Design plans and/or computations were not available for all systems within the neighborhood. Part of the storm drain system to POI #2 was provided by the County – Stable Lane to Outfall 7. In comparing the design of the system in 1974, GPI looked at the drainages, runoff coefficients, and time of concentration paths. While the drainage areas and runoff coefficients were similar, there was a greater difference in the time of concentration paths. Since GPI was unable to duplicate the designer's time of concentration paths, there is a difference in discharges in the system.

The hydraulic gradient was checked for three areas where flooding has been the most prevalent. Where the pipe capacity analysis showed that the pipe was undersized, the full flow capacity of the pipe was used in the hydraulic grade line (HGL) computations. The results of the analysis indicated that several sections of storm drain system do not meet the current County standards – the 10-year HGL being no higher than 1 foot above the crown of the pipe and at least one foot below the top of any inlet grate or manhole cover.

Surface Flow and Sump Maps were created for the neighborhood to show where runoff ponds when the storm drain system is filled. The sump data were generated using ESRI ArcGIS Hydrology tools and the 2018 MNCPPC LiDAR Digital Elevation Model (DEM) downloaded from the Maryland iMAP GIS archive. A DEM is a grid of elevation values, also known as a "raster," representing the ground surface topography. Runoff flows from areas of higher elevation to areas of lower elevation and ArcGIS tools can model runoff patterns over the surface by tracing paths from high to low raster values. Sumps are low elevation areas surrounded by ground surfaces of higher elevation preventing surface runoff from escaping. Within sumps, accumulated runoff can only be drained through storm drains, culverts, or other subsurface means. Using ArcGIS, the DEM was "filled" by raising the elevation of all sumps until runoff would continue to pass downhill. Subtracting the filled DEM from the original removed all unfilled areas leaving only those areas where runoff could not drain over the surface.

The program, Autodesk Storm and Sanitary Analysis 2019 was used to run different storm events in the storm drain systems. This program includes a comprehensive modeling package used for analyzing and designing urban drainage systems, stormwater sewers, and sanitary sewers. An analysis on the 25-, 50-, and 100-year storm events was performed using Storm and Sanitary Analysis 2019. Each event resulted in more and more pipe segments reaching capacity, resulting in eventually the entire storm drain system reaching capacity in the model. This result would be consistent because the Montgomery County drainage design standard is the 10-year storm event and the system was design to meeting the 10-year storm event in late 1960's.

As stated previously not all of the storm drain invert information was obtainable. However, if the pipe invert elevation data could be obtained for the lateral storm drain systems that are shown at capacity, we would be able to confirm and revise as necessary our hydraulics storm drain computations and potentially remove those segments from being improved. This situation only effects some of the lateral storm drain systems as they intersect with the main trunk line.

<u>July 2019 Flooding</u>

On July 8, 2019, the River Falls neighborhood experienced a sever storm. Over five (5) inches of rain fell within a short period of time. From the Community Collaborative Rain, Hail & Snow Network, 5.27 inches of rain fall were recorded in Potomac. It was observed by the recorder that most of the rain fell within a 60-minute period; see Appendix D. When comparing this information to NOAA Atlas 14's Point Precipitation Frequency Estimates for the River Falls neighborhood, a storm event with approximately 5 inches of rain fall for a 60-minute duration has less than 0.1% chance of happening each year or a storm larger than 1000-year storm event. The criteria for design of storm drain systems is not based on such a short and intense storm but is based on the 10-year storm (10% chance of storm happening each year) over a period of 24 hours.

IX. Proposed Conditions

<u>Best Management Practices (BMPS)</u>

Stormwater Best Management Practices (BMPs) are practices that provide a level of treatment and /or storage to improve the water quality of watersheds. Stormwater BMPs include physical structures and the use of plants and root systems to soak up rainwater, which stores and treats before entering the local streams. They address three criteria that are critical to managing urban stormwater runoff and reducing flows:

- Volume: Reduce or delay the volume of stormwater that enters the storm drain system.
- Peak discharge: Reduce the peak flow by decreasing the stormwater volume and lengthening the time of concentration.
- Water quality: Improve water quality through volume reduction, filtering and biological and chemical processes.

The topography is gently sloped over most of the study area creating a good environment for various BMP techniques. The BMPs will not only remove the pollutants through vegetative filtering but will also store water in the stone and filtering media thus reducing the volume in the storm drain system. With a potential reduction in impervious area and installing number of BMPs in the watershed this can assist with reducing flooding in the area.

Field investigation identified a potential of 53 BMP locations which can be installed throughout the watershed. For study purposes, a bioswale BMP was selected. The standard size bioswale BMP that was considered was 25-feet (length), 10-feet (width) and 0.5-feet (depth); see Appendix J for BMP Details. The following standard size BMP was modeled in Autodesk Storm and Sanitary Analysis 2019 as a reservoir. The BMP storage, in conjunction with the existing storm drain system, was modeled with this program. The standard method to calculate the storage is just the ponding area within a BMP. The assumed storage volume was 125 cubic feet per BMP. This volume is relatively small to see any kind of reduction in peak discharge. The standard calculation of storage in computing these BMPs does not consider the storage associated with the filter media and stone. Therefore, it is anticipated that the actual storage volume of each facility would be slightly increased if filter media and stone were considered in the calculation. The installation of bioswales should be done in the entire drainage area wherever it is possible to install them in order to obtain the maximum storage and treatment. By constructing BMPs in the upper section of the drainage areas, along Rock Run Drive and Brickyard Road, it will take longer for runoff to enter the storm drain systems and thus reduce the volume in the pipes. See Appendix G for the potential location of BMPs in the project site.

The implementation of bioswale BMPs will provide impervious treatment crediting for the County's NPDES (MS4) Permit compliance. However, they will provide limited runoff storage to reduce the discharge to the storm drain system. In order to have significant reduction in runoff, more traditional stormwater management ponds or underground detention systems would need to be proposed. With the lack of County right-of-way and residential house structures in close proximity to the existing storm drain system, there are limited opportunities to implement traditional stormwater management ponds. Underground detention systems could be an option, but it appears the only suitable location would be under the County roadway. Currently, the County does not accept underground detention systems under their roadways. Proposed Cost to implement 53 Bioswale BMPs' will be $2,067,000.00.

Storm Drain Improvements

The storm drain pipe size improvements can be another method to reduce flooding for the study area. Based on the hydrologic criteria for Montgomery County, the 10-year storm event is used for designing the storm drain system.

The preliminary proposed pipe network for the main trunk has been sized for the 10-year return period. The pipe size was based on the capacity of the water it could carry at the existing pipe slope. See Appendix H for the proposed closed storm drain calculations. The Appendix I has the preliminary cost estimate for upgrading the pipe sizes. Proposed Cost to perform storm drain improvements to bring up to the County's standard will be $3,691,700.00.

Priority for increasing the pipe sizes is as follows:

1. The main trunk for Outfall 1 from Coach Street (EX I-54) to Outfall 1. These pipes are undersized based on HGL and the pipe capacity computations for the 10-year storm event. Water is trapped at the low point in River Falls Drive, Coach Street, and Horseshoe Lane. River Falls Drive has a storm drain system that extends north towards Brickyard Road and has less volume of water ponding at the low point in the roadway. In the next phase of evaluation of the watershed, adding inlets along Coach Street and Horseshoe Lane north towards Brickyard Road will be evaluated. Without upgrading the main trunk between Coach Street and Outfall 1, adding inlets towards Brickyard Road along Coach Street and Horseshoe Lane will only delay the ponding of runoff at the low points in those roads.
2. Pipes for Outfall 2 from Horseshoe Lane to Outfall 2. Runoff is trapped at EX I-79 and EX I-78.
3. Pipes for Outfall 3 from Masters Drive to Outfall 3. Runoff is trapped at EX I-80 and EX I-81A.
4. Pipes for Outfall 8 from Masters Drive to Outfall 8.

In order to address the 25-year, 50-year and 100-year storm events, additional hydraulics modeling will have to occur in future design phases. Because of the site conditions, pipe sizes of the main trunkline would have to increase substantially to rectangular shaped box culverts. As the result of this significant pipe size increase depending on the storm drain targeted design storm, additional right of way, residential housing structures, roadway and utility infrastructure would be impacted. Proposed costs of this level of effort will be significantly more and could be estimated once a preferred alternative was selected. Addition assessment would be required.

Stream and Floodplain Restoration

While this alterative is the least likely alternative to be pursued, it is important to present as an option eliminate flooding of residential community. This alternative would involve reestablishing the remnant stream and floodplain to predevelopment conditions. This would involve removing all residential structures and roadway infrastructure necessary to establish the 100-year floodway. No proposed cost is provided because additional study would be required.

X. Summary

The project site is challenging because the original stream channel and floodway were impacted by storm drain installation and residential houses in the late 1960's. The existing stream channels and floodplains were graded and are no longer present. Stream channels and floodplains offer much more flood storage capacity than a storm drain system. These natural systems are capable of handling higher storm events. The project study area has no opportunities for higher storm events to dissipate across a floodplain because they no longer exist. Residential houses occupy this floodplain and when the storm drain system capacity is exceeded flooding occurs.

The existing storm drain systems do not meet current County's design criteria. Not all existing pipe invert elevation data could be obtained. If the data was obtained, it would be possible to confirm and revise as necessary storm drain computations and potentially remove those segments from being improved. This situation only effects some of the lateral storm drain systems as they intersect with the main trunk line.

The implementation of bioswale BMPs along with the existing storm drain system will only provide a minimal reduction in the runoff volume to the existing storm drain system to pass the 10-year storm event. Bioswale BMPs are effective as water quality treatment, not water quantity treatment. The analysis indicated that approximately 53 bioswale BMP's could be implemented. This treatment credit would support Montgomery County's NPDES MS4 Permit to provide treatment of impervious acres. While their implementation is considered a minor improvement, they will not significantly reduce flooding conditions. The approximate cost for implementing 53 bioswale BMP is $2,106,000.00.

Based on the current Montgomery County Drainage Design Manual, a majority of the existing storm drain pipe segments do not convey the flow for 10-year storm event. The storm drain segments that do pass the 10-year storm event cause a backwater condition and impact the upslope pipe segments. The cost to improve the storm drain pipe segments to conform to the County's Drainage Manual of passing the 10-year storm event is estimated at $3,691,700.00.

The combined solutions of implementing bioswale BMP's and storm drain improvement to pass the 10-year storm event is estimated at $5,758,700.00.

Other alternatives were mentioned in the report, however, additional planning, coordination and evaluation would be necessary to pursue those options.

XI. References

1. "MC Drainage Design Criteria-10th Revised Final", Montgomery County, June 2014.
2. Manning's n for Channels (Chow, 1959)
3. Montgomery County Zoning, March 8, 2022, https://mcatlas.org/zoning/
4. United States Department of Agriculture, NRCS, Web Soil Survey, https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx
5. Autodesk Storm and Sanitary Analysis 2014, User's Guide, March 2013
6. "2011 Maryland Standard and Specifications for Soil Erosion and Sediment Control", 2012 Maryland Department of the Environment.

APPENDICES

APPENDIX A:

DRAINAGE AREA MAP

MONTGOMERY COUNTY ZONING FOR ALL DRAINAGE AREAS IS SINGLE FAMILY (¼ ACRE) - R-200

LEGEND

- - - - -	EX. CONTOURS
— — —	TIME OF CONCENTRATION PATH
———	DRAINAGE AREA BOUNDARY
— — —	SOIL BOUNDARY

PLAN

SCALE: 1" = 300'

Gannett Fleming

GPI GREENMAN-PEDERSEN, INC.

MONTGOMERY COUNTY
DEPARTMENT OF TRANSPORTATION
GAITHERSBURG, MARYLAND

RECOMMENDED FOR APPROVAL

Chief, Transportation Planning and Design Section — Date

APPROVED

Chief, Division of Transportation Engineering — Date

Designed by : ________ Drawn by : ________ Checked by : ________

TASK ORDER 7
DRAINAGE ASSESMENT

RIVER FALLS NORTH
MONTGOMERY COUNTY, MARYLAND

DRAINAGE AREA MAP

SCALE : AS SHOWN

Project No. 2020031.00 — 1 of 1

APPENDIX B:

SOIL REPORT

United States Department of Agriculture

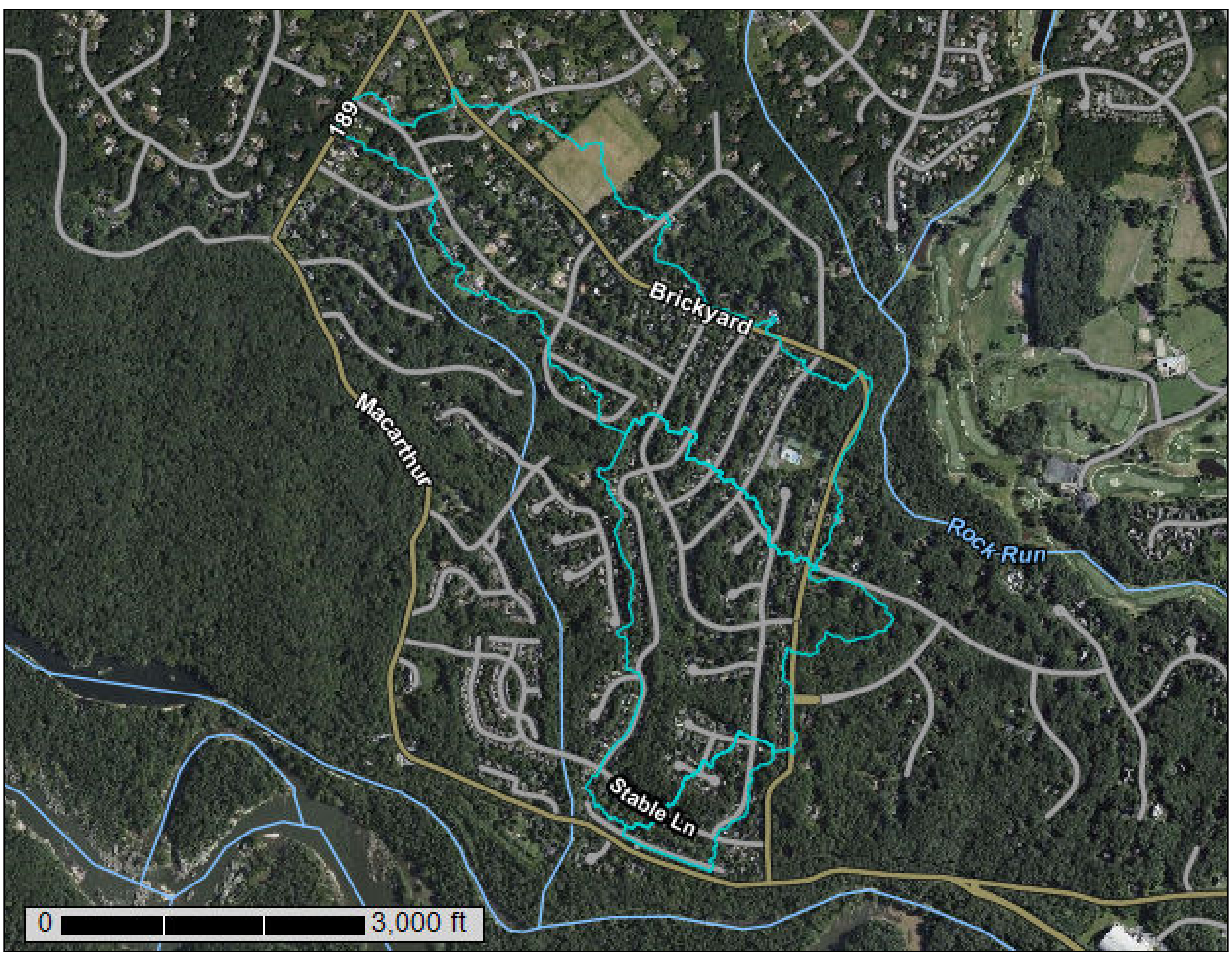
NRCS

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

Montgomery County, Maryland



February 8, 2022

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.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

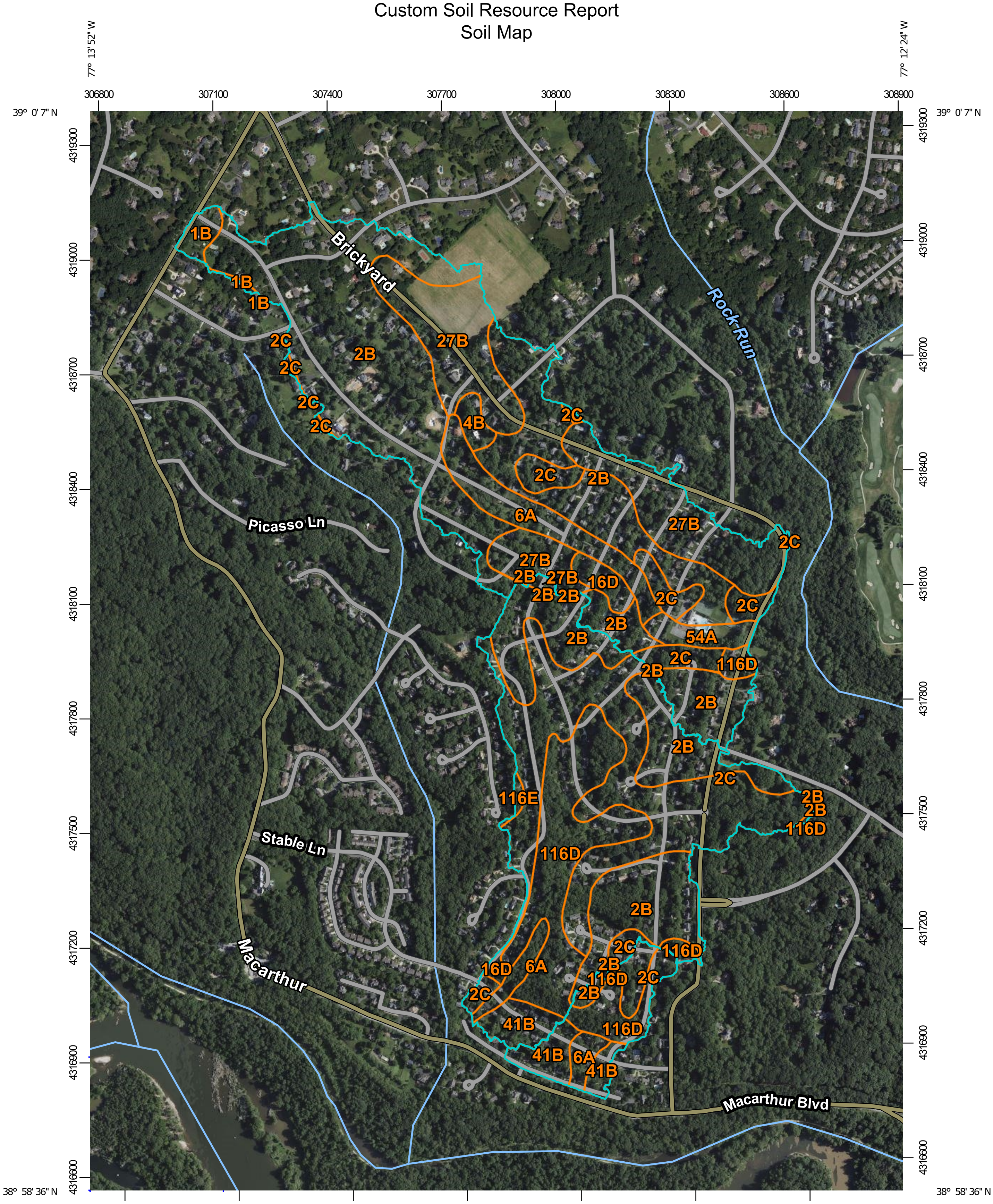
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

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.

Soil Map



Map Scale: 1:13,800 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0, 200, 400, 800, 1200

Feet: 0, 500, 1000, 2000, 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N 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 1:15,800.

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: Montgomery County, Maryland
Survey Area Data: Version 17, Aug 27, 2021

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

Date(s) aerial images were photographed: May 9, 2021—Aug 15, 2021

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

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1B	Gaila silt loam, 3 to 8 percent slopes	2.8	0.8%
2B	Glenelg silt loam, 3 to 8 percent slopes	147.1	43.2%
2C	Glenelg silt loam, 8 to 15 percent slopes	67.3	19.8%
4B	Elioak silt loam, 3 to 8 percent slopes	2.3	0.7%
6A	Baile silt loam, 0 to 3 percent slopes	17.7	5.2%
16D	Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes	3.8	1.1%
27B	Neshaminy silt loam, 3 to 8 percent slopes	46.4	13.6%
41B	Elsinboro silt loam, 3 to 8 percent slopes	10.6	3.1%
54A	Hatboro silt loam, 0 to 3 percent slopes, frequently flooded	4.4	1.3%
116D	Blocktown channery silt loam, 15 to 25 percent slopes, very rocky	37.6	11.0%
116E	Blocktown channery silt loam, 25 to 45 percent slopes, very rocky	0.6	0.2%
Totals for Area of Interest		**340.6**	**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.

Montgomery County, Maryland

1B—Gaila silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: kx7m
Elevation: 100 to 2,000 feet
Mean annual precipitation: 35 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 120 to 255 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Gaila and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Gaila

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 17 inches: sandy clay loam
H3 - 17 to 20 inches: sandy loam
H4 - 20 to 76 inches: loamy sand

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Baile

Percent of map unit: 5 percent
Landform: Flats
Hydric soil rating: Yes

2B—Glenelg silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2v7gr
Elevation: 30 to 1,200 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 150 to 192 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Glenelg and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Glenelg

Setting

Landform: Hillslopes, interfluves
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear
Across-slope shape: Convex, concave, linear
Parent material: Residuum weathered from mica schist

Typical profile

Ap - 0 to 8 inches: silt loam
Bt1 - 8 to 18 inches: clay loam
Bt2 - 18 to 30 inches: clay loam
BCt - 30 to 42 inches: loam
CBt - 42 to 54 inches: loam
C - 54 to 76 inches: channery fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Gaila

Percent of map unit: 10 percent
Landform: Hillslopes, ridges
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Glenville

Percent of map unit: 5 percent
Landform: Drainageways, swales
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

2C—Glenelg silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2tt89
Elevation: 30 to 1,200 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 150 to 192 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Glenelg and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Glenelg

Setting

Landform: Interfluves, hillslopes
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Linear
Across-slope shape: Convex, concave, linear
Parent material: Residuum weathered from mica schist

Typical profile

Ap - 0 to 8 inches: silt loam
Bt1 - 8 to 18 inches: clay loam
Bt2 - 18 to 30 inches: clay loam
BCt - 30 to 42 inches: loam

CBt - 42 to 54 inches: loam
C - 54 to 76 inches: channery fine sandy loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Gaila

Percent of map unit: 10 percent
Landform: Hillslopes, ridges
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Glenville

Percent of map unit: 5 percent
Landform: Drainageways, swales
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

4B—Elioak silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: kx98
Elevation: 300 to 2,000 feet
Mean annual precipitation: 35 to 55 inches
Mean annual air temperature: 45 to 61 degrees F
Frost-free period: 110 to 235 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Elioak and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Elioak

Setting

Landform: Hillslopes, interfluves, flats
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Loamy residuum weathered from phyllite

Typical profile

Ap - 0 to 6 inches: silt loam
E,BE - 6 to 15 inches: silt loam
Bt1,Bt2 - 15 to 42 inches: silty clay loam
C - 42 to 60 inches: silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Glenelg

Percent of map unit: 15 percent
Landform: Hillslopes, interfluves
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

6A—Baile silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: kxb9
Elevation: 250 to 980 feet
Mean annual precipitation: 35 to 50 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 120 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Baile and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Baile

Setting

Landform: Hillslopes, depressions, drainageways, swales
Landform position (three-dimensional): Head slope, base slope
Down-slope shape: Concave
Across-slope shape: Concave, linear

Typical profile

A - 0 to 9 inches: silt loam
Btg - 9 to 32 inches: silty clay loam
Cg - 32 to 65 inches: loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Available water supply, 0 to 60 inches: High (about 10.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: C/D
Hydric soil rating: Yes

Minor Components

Glenville

Percent of map unit: 15 percent

Landform: Drainageways, swales
Landform position (three-dimensional): Head slope, base slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

16D—Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes

Map Unit Setting

National map unit symbol: kx79
Elevation: 300 to 2,000 feet
Mean annual precipitation: 7 to 55 inches
Mean annual air temperature: 45 to 61 degrees F
Frost-free period: 110 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Brinklow and similar soils: 50 percent
Blocktown and similar soils: 30 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Brinklow

Setting

Landform: Knolls
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Gravelly residuum weathered from low base phyllites and schists.

Typical profile

Ap - 0 to 10 inches: channery silt loam
Bt,BC - 10 to 25 inches: channery loam
Cr - 25 to 35 inches: bedrock
R - 35 to 39 inches: bedrock

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 4.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C

Hydric soil rating: No

Description of Blocktown

Setting

Landform: Knolls
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Gravelly residuum weathered from low base phyllites and schists.

Typical profile

Ap - 0 to 6 inches: channery silt loam
Bt - 6 to 17 inches: extremely channery silt loam
Cr - 17 to 21 inches: bedrock
R - 21 to 25 inches: bedrock

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Glenelg

Percent of map unit: 10 percent
Hydric soil rating: No

Baile

Percent of map unit: 5 percent
Landform: Flats
Hydric soil rating: Yes

Occoquan

Percent of map unit: 5 percent
Hydric soil rating: No

27B—Neshaminy silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: kx8d
Elevation: 400 to 1,600 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 155 to 210 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Neshaminy, very deep over gabbro, and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Neshaminy, Very Deep Over Gabbro

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Parent material: Residuum weathered from gabbro

Typical profile

A - 0 to 6 inches: silt loam
BE - 6 to 17 inches: silt loam
Bt1 - 17 to 32 inches: silt loam
Bt2 - 32 to 59 inches: channery silt loam
BC - 59 to 80 inches: very channery loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 60 to 99 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Montalto

Percent of map unit: 10 percent
Hydric soil rating: No

Mount lucas

Percent of map unit: 5 percent
Hydric soil rating: No

41B—Elsinboro silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: kx91
Elevation: 0 to 1,050 feet
Mean annual precipitation: 35 to 55 inches
Mean annual air temperature: 48 to 61 degrees F
Frost-free period: 110 to 235 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Elsinboro and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Elsinboro

Setting

Landform: Terraces
Landform position (three-dimensional): Riser, tread
Down-slope shape: Concave, convex
Across-slope shape: Linear, convex
Parent material: Loamy alluvium derived from phyllite and/or loamy alluvium derived from mica schist and/or loamy alluvium derived from quartzite

Typical profile

Ap - 0 to 9 inches: silt loam
Bt, BC - 9 to 37 inches: silt loam
C1-2 - 37 to 60 inches: silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 60 inches
Frequency of flooding: None
Frequency of ponding: None

Available water supply, 0 to 60 inches: Moderate (about 8.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Delanco

Percent of map unit: 10 percent
Landform: Stream terraces
Landform position (three-dimensional): Riser, tread
Down-slope shape: Linear, concave
Across-slope shape: Convex, linear

Glenelg

Percent of map unit: 5 percent
Landform: Hillslopes, interfluves
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

54A—Hatboro silt loam, 0 to 3 percent slopes, frequently flooded

Map Unit Setting

National map unit symbol: kx9f
Elevation: 200 to 600 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 52 to 57 degrees F
Frost-free period: 180 to 210 days
Farmland classification: Not prime farmland

Map Unit Composition

Hatboro and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hatboro

Setting

Landform: Channels on flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mica bearing loamy alluvium

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 8 inches: silt loam

Bg - 8 to 18 inches: silt loam
Cg - 18 to 66 inches: loam

Properties and qualities
Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 0 to 10 inches
Frequency of flooding: Frequent
Frequency of ponding: Frequent
Available water supply, 0 to 60 inches: Very high (about 12.2 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B/D
Hydric soil rating: Yes

116D—Blocktown channery silt loam, 15 to 25 percent slopes, very rocky

Map Unit Setting
National map unit symbol: kx75
Elevation: 70 to 2,000 feet
Mean annual precipitation: 7 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 120 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition
Blocktown and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Blocktown

Setting
Landform: Knolls
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Gravelly residuum weathered from low base phyllites and schists.

Typical profile
Ap - 0 to 6 inches: channery silt loam
Bt - 6 to 17 inches: extremely channery silt loam
Cr - 17 to 21 inches: bedrock
R - 21 to 25 inches: bedrock

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Brinklow

Percent of map unit: 10 percent
Hydric soil rating: No

Baile

Percent of map unit: 5 percent
Landform: Flats
Hydric soil rating: Yes

116E—Blocktown channery silt loam, 25 to 45 percent slopes, very rocky

Map Unit Setting

National map unit symbol: kx76
Elevation: 50 to 2,000 feet
Mean annual precipitation: 7 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 120 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Blocktown and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Blocktown

Setting

Landform: Knolls
Down-slope shape: Convex
Across-slope shape: Linear

Parent material: Gravelly residuum weathered from low base phyllites and schists.

Typical profile

Ap - 0 to 6 inches: channery silt loam
Bt - 6 to 17 inches: extremely channery silt loam
Cr - 17 to 21 inches: bedrock
R - 21 to 25 inches: bedrock

Properties and qualities

Slope: 25 to 45 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Brinklow

Percent of map unit: 10 percent
Hydric soil rating: No

Baile

Percent of map unit: 5 percent
Landform: Flats
Hydric soil rating: Yes

Soil Information for All Uses

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Hydrologic Soil Group (River Falls)

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

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

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

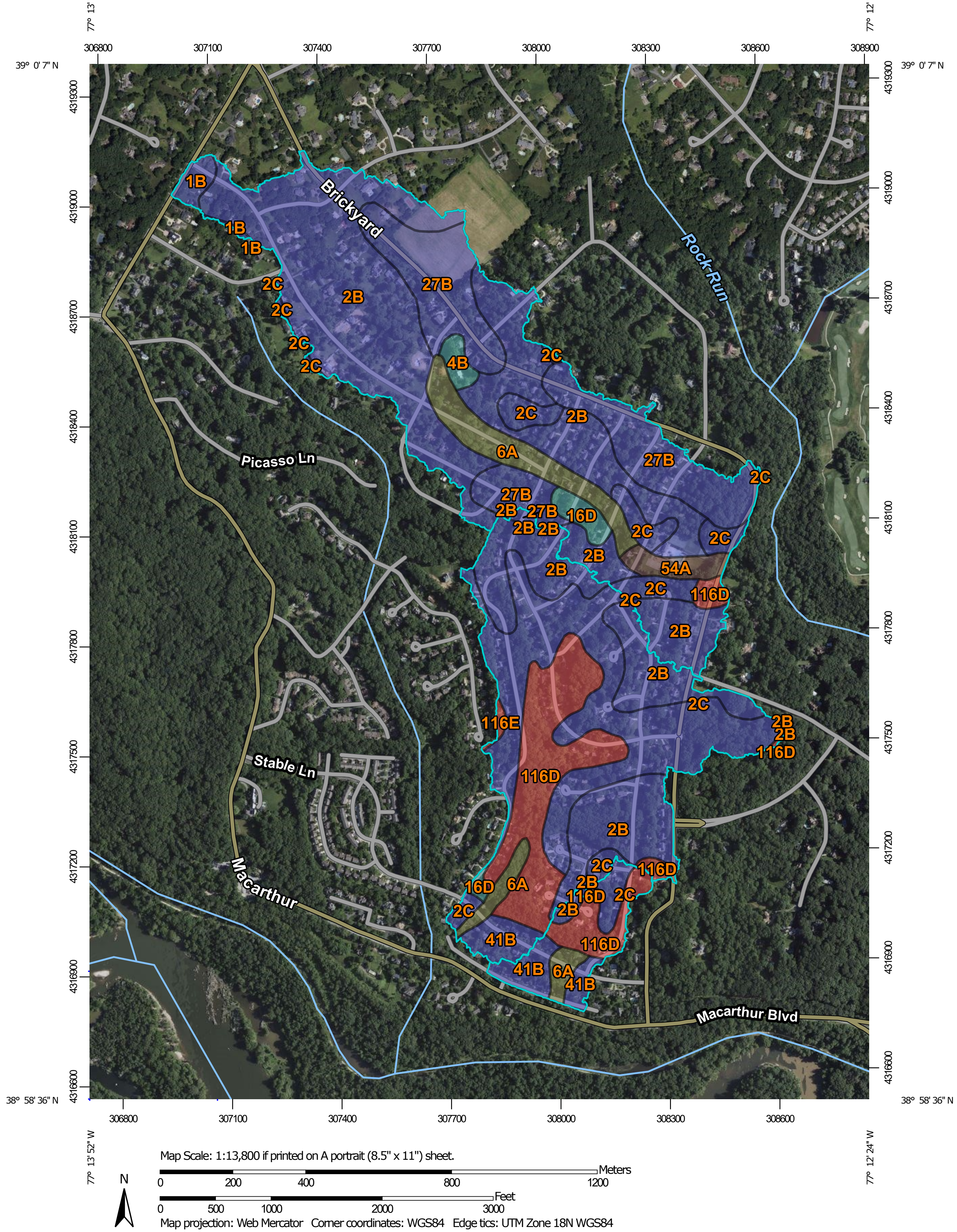
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

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

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

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

Map—Hydrologic Soil Group (River Falls)



MAP LEGEND

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

Soils

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

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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: Montgomery County, Maryland
Survey Area Data: Version 17, Aug 27, 2021

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

Date(s) aerial images were photographed: May 9, 2021—Aug 15, 2021

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.

Table—Hydrologic Soil Group (River Falls)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Gaila silt loam, 3 to 8 percent slopes	B	2.8	0.8%
2B	Glenelg silt loam, 3 to 8 percent slopes	B	147.1	43.2%
2C	Glenelg silt loam, 8 to 15 percent slopes	B	67.3	19.8%
4B	Elioak silt loam, 3 to 8 percent slopes	C	2.3	0.7%
6A	Baile silt loam, 0 to 3 percent slopes	C/D	17.7	5.2%
16D	Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes	C	3.8	1.1%
27B	Neshaminy silt loam, 3 to 8 percent slopes	B	46.4	13.6%
41B	Elsinboro silt loam, 3 to 8 percent slopes	B	10.6	3.1%
54A	Hatboro silt loam, 0 to 3 percent slopes, frequently flooded	B/D	4.4	1.3%
116D	Blocktown channery silt loam, 15 to 25 percent slopes, very rocky	D	37.6	11.0%
116E	Blocktown channery silt loam, 25 to 45 percent slopes, very rocky	D	0.6	0.2%
Totals for Area of Interest			**340.6**	**100.0%**

Rating Options—Hydrologic Soil Group (River Falls)

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

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Glossary

Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the following National Soil Survey Handbook link: "National Soil Survey Handbook."

ABC soil

A soil having an A, a B, and a C horizon.

Ablation till

Loose, relatively permeable earthy material deposited during the downwasting of nearly static glacial ice, either contained within or accumulated on the surface of the glacier.

AC soil

A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

Aeration, soil

The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil

Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvial cone

A semiconical type of alluvial fan having very steep slopes. It is higher, narrower, and steeper than a fan and is composed of coarser and thicker layers of material deposited by a combination of alluvial episodes and (to a much lesser degree) landslides (debris flow). The coarsest materials tend to be concentrated at the apex of the cone.

Alluvial fan

A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes. It is shaped like an open fan or a segment of a cone. The material was deposited by a stream at the place where it issues from a narrow mountain valley or upland valley or where a tributary stream is near or at its junction with the main stream. The fan is steepest near its apex, which points upstream, and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

Alluvium

Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

Alpha,alpha-dipyridyl

A compound that when dissolved in ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction implies reducing conditions and the likely presence of redoximorphic features.

Animal unit month (AUM)

The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

Aquic conditions

Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Argillic horizon

A subsoil horizon characterized by an accumulation of illuvial clay.

Arroyo

The flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed.

Aspect

The direction toward which a slope faces. Also called slope aspect.

Association, soil

A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity)

The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low: 0 to 3
Low: 3 to 6
Moderate: 6 to 9
High: 9 to 12
Very high: More than 12

Backslope

The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

Backswamp

A flood-plain landform. Extensive, marshy or swampy, depressed areas of flood plains between natural levees and valley sides or terraces.

Badland

A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes and narrow interfluves. Badlands develop on surfaces that have little or no vegetative cover overlying unconsolidated or poorly cemented materials (clays, silts, or sandstones) with, in some cases, soluble minerals, such as gypsum or halite.

Bajada

A broad, gently inclined alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically, it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins.

Basal area

The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

Base saturation

The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Base slope (geomorphology)

A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

Bedding plane

A planar or nearly planar bedding surface that visibly separates each successive layer of stratified sediment or rock (of the same or different lithology) from the preceding or following layer; a plane of deposition. It commonly marks a change in the circumstances of deposition and may show a parting, a color difference, a change in particle size, or various combinations of these. The term is commonly applied to any bedding surface, even one that is conspicuously bent or deformed by folding.

Bedding system

A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

Bedrock

The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bedrock-controlled topography

A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

Bench terrace

A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bisequum

Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Blowout (map symbol)

A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand or loose soil or where protective vegetation is disturbed or destroyed. The adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Blowouts are commonly small.

Borrow pit (map symbol)

An open excavation from which soil and underlying material have been removed, usually for construction purposes.

Bottom land

An informal term loosely applied to various portions of a flood plain.

Boulders

Rock fragments larger than 2 feet (60 centimeters) in diameter.

Breaks

A landscape or tract of steep, rough or broken land dissected by ravines and gullies and marking a sudden change in topography.

Breast height

An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

Brush management

Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

Butte

An isolated, generally flat-topped hill or mountain with relatively steep slopes and talus or precipitous cliffs and characterized by summit width that is less than the height of bounding escarpments; commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks.

Cable yarding

A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

Calcareous soil

A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Caliche

A general term for a prominent zone of secondary carbonate accumulation in surficial materials in warm, subhumid to arid areas. Caliche is formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in nonindurated forms to very strong in indurated forms. Other minerals (e.g., carbonates, silicate, and sulfate) may occur as accessory cements. Most petrocalcic horizons and some calcic horizons are caliche.

California bearing ratio (CBR)

The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

Canopy

The leafy crown of trees or shrubs. (See Crown.)

Canyon

A long, deep, narrow valley with high, precipitous walls in an area of high local relief.

Capillary water

Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena

A sequence, or “chain,” of soils on a landscape that formed in similar kinds of parent material and under similar climatic conditions but that have different characteristics as a result of differences in relief and drainage.

Cation

An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity

The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Catsteps

See Terracettes.

Cement rock

Shaly limestone used in the manufacture of cement.

Channery soil material

Soil material that has, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

Chemical treatment

Control of unwanted vegetation through the use of chemicals.

Chiseling

Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Cirque

A steep-walled, semicircular or crescent-shaped, half-bowl-like recess or hollow, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain. It was produced by the erosive activity of a mountain glacier. It commonly contains a small round lake (tarn).

Clay

As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay depletions

See Redoximorphic features.

Clay film

A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Clay spot (map symbol)

A spot where the surface texture is silty clay or clay in areas where the surface layer of the soils in the surrounding map unit is sandy loam, loam, silt loam, or coarser.

Claypan

A dense, compact subsoil layer that contains much more clay than the overlying materials, from which it is separated by a sharply defined boundary. The layer restricts the downward movement of water through the soil. A claypan is commonly hard when dry and plastic and sticky when wet.

Climax plant community

The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse textured soil

Sand or loamy sand.

Cobble (or cobblestone)

A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Cobbly soil material

Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

COLE (coefficient of linear extensibility)

See Linear extensibility.

Colluvium

Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

Complex slope

Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil

A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Concretions

See Redoximorphic features.

Conglomerate

A coarse grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

Conservation cropping system

Growing crops in combination with needed cultural and management practices. In a good conservation cropping system, the soil-improving crops and practices more than offset the effects of the soil-depleting crops and practices. Cropping systems are needed on all tilled soils. Soil-improving practices in a conservation cropping system include the use of rotations that contain grasses and legumes and the return of crop residue to the soil. Other practices include the use of green manure crops of grasses and legumes, proper tillage, adequate fertilization, and weed and pest control.

Conservation tillage

A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil

Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the "Soil Survey Manual."

Contour stripcropping

Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section

The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat)

A type of limnic layer composed predominantly of fecal material derived from aquatic animals.

Corrosion (geomorphology)

A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

Corrosion (soil survey interpretations)

Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Cover crop

A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Crop residue management

Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

Cropping system

Growing crops according to a planned system of rotation and management practices.

Cross-slope farming

Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

Crown

The upper part of a tree or shrub, including the living branches and their foliage.

Cryoturbate

A mass of soil or other unconsolidated earthy material moved or disturbed by frost action. It is typically coarser than the underlying material.

Cuesta

An asymmetric ridge capped by resistant rock layers of slight or moderate dip (commonly less than 15 percent slopes); a type of homocline produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope) that roughly parallels the inclined beds; on the other side, it has a relatively short and steep or clifflike slope (scarp) that cuts through the tilted rocks.

Culmination of the mean annual increment (CMAI)

The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

Cutbanks cave

The walls of excavations tend to cave in or slough.

Decreasers

The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing

Postponing grazing or resting grazing land for a prescribed period.

Delta

A body of alluvium having a surface that is fan shaped and nearly flat; deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, generally a sea or lake.

Dense layer

A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depression, closed (map symbol)

A shallow, saucer-shaped area that is slightly lower on the landscape than the surrounding area and that does not have a natural outlet for surface drainage.

Depth, soil

Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Desert pavement

A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments mantling a desert surface. It forms where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It typically protects the finer grained underlying material from further erosion.

Diatomaceous earth

A geologic deposit of fine, grayish siliceous material composed chiefly or entirely of the remains of diatoms.

Dip slope

A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

Diversion (or diversion terrace)

A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Divided-slope farming

A form of field stripcropping in which crops are grown in a systematic arrangement of two strips, or bands, across the slope to reduce the hazard of water erosion. One strip is in a close-growing crop that provides protection from erosion, and the other strip is in a crop that provides less protection from erosion. This practice is used where slopes are not long enough to permit a full stripcropping pattern to be used.

Drainage class (natural)

Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*. These classes are defined in the "Soil Survey Manual."

Drainage, surface

Runoff, or surface flow of water, from an area.

Drainageway

A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

Draw

A small stream valley that generally is shallower and more open than a ravine or gulch and that has a broader bottom. The present stream channel may appear inadequate to have cut the drainageway that it occupies.

Drift

A general term applied to all mineral material (clay, silt, sand, gravel, and boulders) transported by a glacier and deposited directly by or from the ice or transported by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines and stratified deposits that form outwash plains, eskers, kames, varves, and glaciofluvial sediments. The term is generally applied to Pleistocene glacial deposits in areas that no longer contain glaciers.

Drumlin

A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It commonly has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition.

Duff

A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

Dune

A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand), either barren and capable of movement from place to place or covered and stabilized with vegetation but retaining its characteristic shape.

Earthy fill

See Mine spoil.

Ecological site

An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

Eluviation

The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Endosaturation

A type of saturation of the soil in which all horizons between the upper boundary of saturation and a depth of 2 meters are saturated.

Eolian deposit

Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

Ephemeral stream

A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

Episaturation

A type of saturation indicating a perched water table in a soil in which saturated layers are underlain by one or more unsaturated layers within 2 meters of the surface.

Erosion

The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (accelerated)

Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Erosion (geologic)

Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion pavement

A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion.

Erosion surface

A land surface shaped by the action of erosion, especially by running water.

Escarpment

A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

Escarpment, bedrock (map symbol)

A relatively continuous and steep slope or cliff, produced by erosion or faulting, that breaks the general continuity of more gently sloping land surfaces. Exposed material is hard or soft bedrock.

Escarpment, nonbedrock (map symbol)

A relatively continuous and steep slope or cliff, generally produced by erosion but in some places produced by faulting, that breaks the continuity of more gently sloping land surfaces. Exposed earthy material is nonsoil or very shallow soil.

Esker

A long, narrow, sinuous, steep-sided ridge of stratified sand and gravel deposited as the bed of a stream flowing in an ice tunnel within or below the ice (subglacial) or between ice walls on top of the ice of a wasting glacier and left behind as high ground when the ice melted. Eskers range in length from less than a kilometer to more than 160 kilometers and in height from 3 to 30 meters.

Extrusive rock

Igneous rock derived from deep-seated molten matter (magma) deposited and cooled on the earth's surface.

Fallow

Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fan remnant

A general term for landforms that are the remaining parts of older fan landforms, such as alluvial fans, that have been either dissected or partially buried.

Fertility, soil

The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat)

The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity

The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fill slope

A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil

Sandy clay, silty clay, or clay.

Firebreak

An area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of firefighters and equipment. Designated roads also serve as firebreaks.

First bottom

An obsolete, informal term loosely applied to the lowest flood-plain steps that are subject to regular flooding.

Flaggy soil material

Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

Flagstone

A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

Flood plain

The nearly level plain that borders a stream and is subject to flooding unless protected artificially.

Flood-plain landforms

A variety of constructional and erosional features produced by stream channel migration and flooding. Examples include backswamps, flood-plain splays, meanders, meander belts, meander scrolls, oxbow lakes, and natural levees.

Flood-plain splay

A fan-shaped deposit or other outspread deposit formed where an overloaded stream breaks through a levee (natural or artificial) and deposits its material (commonly coarse grained) on the flood plain.

Flood-plain step

An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. May occur individually or as a series of steps.

Fluvial

Of or pertaining to rivers or streams; produced by stream or river action.

Foothills

A region of steeply sloping hills that fringes a mountain range or high-plateau escarpment. The hills have relief of as much as 1,000 feet (300 meters).

Footslope

The concave surface at the base of a hillslope. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

Forb

Any herbaceous plant not a grass or a sedge.

Forest cover

All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type

A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Fragipan

A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Genesis, soil

The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gilgai

Commonly, a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel with the slope. Typically, the microrelief of clayey soils that shrink and swell considerably with changes in moisture content.

Glaciofluvial deposits

Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur in the form of outwash plains, valley trains, deltas, kames, eskers, and kame terraces.

Glaciolacustrine deposits

Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are bedded or laminated.

Gleyed soil

Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

Graded stripcropping

Growing crops in strips that grade toward a protected waterway.

Grassed waterway

A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel

Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravel pit (map symbol)

An open excavation from which soil and underlying material have been removed and used, without crushing, as a source of sand or gravel.

Gravelly soil material

Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Gravelly spot (map symbol)

A spot where the surface layer has more than 35 percent, by volume, rock fragments that are mostly less than 3 inches in diameter in an area that has less than 15 percent rock fragments.

Green manure crop (agronomy)

A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water

Water filling all the unblocked pores of the material below the water table.

Gully (map symbol)

A small, steep-sided channel caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage whereas a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard bedrock

Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hard to reclaim

Reclamation is difficult after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Hardpan

A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Head slope (geomorphology)

A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

Hemic soil material (mucky peat)

Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

High-residue crops

Such crops as small grain and corn used for grain. If properly managed, residue from these crops can be used to control erosion until the next crop in the rotation is established. These crops return large amounts of organic matter to the soil.

Hill

A generic term for an elevated area of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

Hillslope

A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

Horizon, soil

A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the “Soil Survey Manual.” The major horizons of mineral soil are as follows:

O horizon: An organic layer of fresh and decaying plant residue.

L horizon: A layer of organic and mineral limnic materials, including coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

A horizon: The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon: The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon: The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon: The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon: Soft, consolidated bedrock beneath the soil.

R layer: Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

M layer: A root-limiting subsoil layer consisting of nearly continuous, horizontally oriented, human-manufactured materials.

W layer: A layer of water within or beneath the soil.

Humus

The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups

Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties include depth to a seasonal high water table, the infiltration rate, and depth to a layer that significantly restricts the downward movement of water. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Igneous rock

Rock that was formed by cooling and solidification of magma and that has not been changed appreciably by weathering since its formation. Major varieties include plutonic and volcanic rock (e.g., andesite, basalt, and granite).

Illuviation

The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil

A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers

Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration

The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity

The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate

The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate

The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Very low: Less than 0.2
Low: 0.2 to 0.4
Moderately low: 0.4 to 0.75
Moderate: 0.75 to 1.25
Moderately high: 1.25 to 1.75
High: 1.75 to 2.5
Very high: More than 2.5

Interfluve

A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways.

Interfluve (geomorphology)

A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloping area of a hill; shoulders of backwearing hillslopes can narrow the upland or can merge, resulting in a strongly convex shape.

Intermittent stream

A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Invaders

On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

Iron depletions

See Redoximorphic features.

Irrigation

Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin: Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border: Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding: Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation: Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle): Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow: Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler: Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation: Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding: Water, released at high points, is allowed to flow onto an area without controlled distribution.

Kame

A low mound, knob, hummock, or short irregular ridge composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier; by a supraglacial stream in a low place or hole on the surface of the glacier; or as a ponded deposit on the surface or at the margin of stagnant ice.

Karst (topography)

A kind of topography that formed in limestone, gypsum, or other soluble rocks by dissolution and that is characterized by closed depressions, sinkholes, caves, and underground drainage.

Knoll

A small, low, rounded hill rising above adjacent landforms.

Ksat

See Saturated hydraulic conductivity.

Lacustrine deposit

Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Lake plain

A nearly level surface marking the floor of an extinct lake filled by well sorted, generally fine textured, stratified deposits, commonly containing varves.

Lake terrace

A narrow shelf, partly cut and partly built, produced along a lakeshore in front of a scarp line of low cliffs and later exposed when the water level falls.

Landfill (map symbol)

An area of accumulated waste products of human habitation, either above or below natural ground level.

Landslide

A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones

Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Lava flow (map symbol)

A solidified, commonly lobate body of rock formed through lateral, surface outpouring of molten lava from a vent or fissure.

Leaching

The removal of soluble material from soil or other material by percolating water.

Levee (map symbol)

An embankment that confines or controls water, especially one built along the banks of a river to prevent overflow onto lowlands.

Linear extensibility

Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at $^1/_3$- or $^1/_{10}$-bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Liquid limit

The moisture content at which the soil passes from a plastic to a liquid state.

Loam

Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess

Material transported and deposited by wind and consisting dominantly of silt-sized particles.

Low strength

The soil is not strong enough to support loads.

Low-residue crops

Such crops as corn used for silage, peas, beans, and potatoes. Residue from these crops is not adequate to control erosion until the next crop in the rotation is established. These crops return little organic matter to the soil.

Marl

An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also formed in more saline environments.

Marsh or swamp (map symbol)

A water-saturated, very poorly drained area that is intermittently or permanently covered by water. Sedges, cattails, and rushes are the dominant vegetation in marshes, and trees or shrubs are the dominant vegetation in swamps. Not used in map units where the named soils are poorly drained or very poorly drained.

Mass movement

A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

Masses

See Redoximorphic features.

Meander belt

The zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops.

Meander scar

A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream that impinged upon and undercut the bluff.

Meander scroll

One of a series of long, parallel, close-fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank.

Mechanical treatment

Use of mechanical equipment for seeding, brush management, and other management practices.

Medium textured soil

Very fine sandy loam, loam, silt loam, or silt.

Mesa

A broad, nearly flat topped and commonly isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal rocky material. The summit width is characteristically greater than the height of the bounding escarpments.

Metamorphic rock

Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth’s crust. Nearly all such rocks are crystalline.

Mine or quarry (map symbol)

An open excavation from which soil and underlying material have been removed and in which bedrock is exposed. Also denotes surface openings to underground mines.

Mine spoil

An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. Also called earthy fill.

Mineral soil

Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage

Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area

A kind of map unit that has little or no natural soil and supports little or no vegetation.

Miscellaneous water (map symbol)

Small, constructed bodies of water that are used for industrial, sanitary, or mining applications and that contain water most of the year.

Moderately coarse textured soil

Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil

Clay loam, sandy clay loam, or silty clay loam.

Mollic epipedon

A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

Moraine

In terms of glacial geology, a mound, ridge, or other topographically distinct accumulation of unsorted, unstratified drift, predominantly till, deposited primarily by the direct action of glacial ice in a variety of landforms. Also, a general term for a landform composed mainly of till (except for kame moraines, which are composed mainly of stratified outwash) that has been deposited by a glacier. Some types of moraines are disintegration, end, ground, kame, lateral, recessional, and terminal.

Morphology, soil

The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil

Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Mountain

A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can occur as a single, isolated mass or in a group forming a chain or range. Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

Muck

Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Mucky peat

See Hemic soil material.

Mudstone

A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

Munsell notation

A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Natric horizon

A special kind of argillic horizon that contains enough exchangeable sodium to have an adverse effect on the physical condition of the subsoil.

Neutral soil

A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nodules

See Redoximorphic features.

Nose slope (geomorphology)

A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

Nutrient, plant

Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter

Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low: Less than 0.5 percent
Low: 0.5 to 1.0 percent
Moderately low: 1.0 to 2.0 percent
Moderate: 2.0 to 4.0 percent
High: 4.0 to 8.0 percent
Very high: More than 8.0 percent

Outwash

Stratified and sorted sediments (chiefly sand and gravel) removed or “washed out” from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of a glacier. The coarser material is deposited nearer to the ice.

Outwash plain

An extensive lowland area of coarse textured glaciofluvial material. An outwash plain is commonly smooth; where pitted, it generally is low in relief.

Paleoterrace

An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to, a present-day stream or drainage network.

Pan

A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material

The unconsolidated organic and mineral material in which soil forms.

Peat

Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped

An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedisediment

A layer of sediment, eroded from the shoulder and backslope of an erosional slope, that lies on and is being (or was) transported across a gently sloping erosional surface at the foot of a receding hill or mountain slope.

Pedon

The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation

The movement of water through the soil.

Perennial water (map symbol)

Small, natural or constructed lakes, ponds, or pits that contain water most of the year.

Permafrost

Ground, soil, or rock that remains at or below 0 degrees C for at least 2 years. It is defined on the basis of temperature and is not necessarily frozen.

pH value

A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Phase, soil

A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

Piping

Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Pitting

Pits caused by melting around ice. They form on the soil after plant cover is removed.

Plastic limit

The moisture content at which a soil changes from semisolid to plastic.

Plasticity index

The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plateau (geomorphology)

A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

Playa

The generally dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation and runoff. Playa deposits are fine grained and may or may not have a high water table and saline conditions.

Plinthite

The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other diluents. It commonly appears as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on repeated wetting and drying, especially if it is exposed also to heat from the sun. In a moist soil, plinthite can be cut with a spade. It is a form of laterite.

Plowpan

A compacted layer formed in the soil directly below the plowed layer.

Ponding

Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded

Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Pore linings

See Redoximorphic features.

Potential native plant community

See Climax plant community.

Potential rooting depth (effective rooting depth)

Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

Prescribed burning

Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

Productivity, soil

The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil

A vertical section of the soil extending through all its horizons and into the parent material.

Proper grazing use

Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproduction capacity of the key plants and promotes the accumulation of litter and mulch necessary to conserve soil and water.

Rangeland

Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil

A measure of acidity or alkalinity of a soil, expressed as pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid: Less than 3.5
Extremely acid: 3.5 to 4.4
Very strongly acid: 4.5 to 5.0
Strongly acid: 5.1 to 5.5
Moderately acid: 5.6 to 6.0
Slightly acid: 6.1 to 6.5
Neutral: 6.6 to 7.3
Slightly alkaline: 7.4 to 7.8
Moderately alkaline: 7.9 to 8.4
Strongly alkaline: 8.5 to 9.0
Very strongly alkaline: 9.1 and higher

Red beds

Sedimentary strata that are mainly red and are made up largely of sandstone and shale.

Redoximorphic concentrations

See Redoximorphic features.

Redoximorphic depletions

See Redoximorphic features.

Redoximorphic features

Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:
   - A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*
   - B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*
   - C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.
2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:
   - A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*
   - B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).
3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

Reduced matrix

See Redoximorphic features.

Regolith

All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial, glacial, eolian, lacustrine, and pyroclastic deposits.

Relief

The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

Residuum (residual soil material)

Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

Rill

A very small, steep-sided channel resulting from erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. A rill generally is not an obstacle to wheeled vehicles and is shallow enough to be smoothed over by ordinary tillage.

Riser

The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, steplike landforms, such as successive stream terraces.

Road cut

A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments

Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rock outcrop (map symbol)

An exposure of bedrock at the surface of the earth. Not used where the named soils of the surrounding map unit are shallow over bedrock or where “Rock outcrop” is a named component of the map unit.

Root zone

The part of the soil that can be penetrated by plant roots.

Runoff

The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil

A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Saline spot (map symbol)

An area where the surface layer has an electrical conductivity of 8 mmhos/cm more than the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has an electrical conductivity of 2 mmhos/cm or less.

Sand

As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone

Sedimentary rock containing dominantly sand-sized particles.

Sandy spot (map symbol)

A spot where the surface layer is loamy fine sand or coarser in areas where the surface layer of the named soils in the surrounding map unit is very fine sandy loam or finer.

Sapric soil material (muck)

The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saturated hydraulic conductivity (Ksat)

The ease with which pores of a saturated soil transmit water. Formally, the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy's Law, a law that describes the rate of water movement through porous media. Commonly abbreviated as "Ksat." Terms describing saturated hydraulic conductivity are:

Very high: 100 or more micrometers per second (14.17 or more inches per hour)

High: 10 to 100 micrometers per second (1.417 to 14.17 inches per hour)

Moderately high: 1 to 10 micrometers per second (0.1417 inch to 1.417 inches per hour)

Moderately low: 0.1 to 1 micrometer per second (0.01417 to 0.1417 inch per hour)

Low: 0.01 to 0.1 micrometer per second (0.001417 to 0.01417 inch per hour)

Very low: Less than 0.01 micrometer per second (less than 0.001417 inch per hour).

To convert inches per hour to micrometers per second, multiply inches per hour by 7.0572. To convert micrometers per second to inches per hour, multiply micrometers per second by 0.1417.

Saturation

Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Scarification

The act of abrading, scratching, loosening, crushing, or modifying the surface to increase water absorption or to provide a more tillable soil.

Sedimentary rock

A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

Sequum

A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil

A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Severely eroded spot (map symbol)

An area where, on the average, 75 percent or more of the original surface layer has been lost because of accelerated erosion. Not used in map units in which “severely eroded,” “very severely eroded,” or “gullied” is part of the map unit name.

Shale

Sedimentary rock that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

Sheet erosion

The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Short, steep slope (map symbol)

A narrow area of soil having slopes that are at least two slope classes steeper than the slope class of the surrounding map unit.

Shoulder

The convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

Shrink-swell

The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Shrub-coppice dune

A small, streamlined dune that forms around brush and clump vegetation.

Side slope (geomorphology)

A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

Silica

A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio

The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt

As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone

An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

Similar soils

Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Sinkhole (map symbol)

A closed, circular or elliptical depression, commonly funnel shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, or salt) or by collapse of underlying caves within bedrock. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography.

Site index

A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

Slickensides (pedogenic)

Grooved, striated, and/or glossy (shiny) slip faces on structural peds, such as wedges; produced by shrink-swell processes, most commonly in soils that have a high content of expansive clays.

Slide or slip (map symbol)

A prominent landform scar or ridge caused by fairly recent mass movement or descent of earthy material resulting from failure of earth or rock under shear stress along one or several surfaces.

Slope

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope alluvium

Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

Slow refill

The slow filling of ponds, resulting from restricted water transmission in the soil.

Slow water movement

Restricted downward movement of water through the soil. See Saturated hydraulic conductivity.

Sodic (alkali) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Sodic spot (map symbol)

An area where the surface layer has a sodium adsorption ratio that is at least 10 more than that of the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has a sodium adsorption ratio of 5 or less.

Sodicity

The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of Na^{+} to Ca^{++} + Mg^{++}. The degrees of sodicity and their respective ratios are:

Slight: Less than 13:1

Moderate: 13-30:1

Strong: More than 30:1

Sodium adsorption ratio (SAR)

A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

Soft bedrock

Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil

A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief and by the passage of time.

Soil separates

Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand: 2.0 to 1.0

Coarse sand: 1.0 to 0.5

Medium sand: 0.5 to 0.25

Fine sand: 0.25 to 0.10

Very fine sand: 0.10 to 0.05

Silt: 0.05 to 0.002

Clay: Less than 0.002

Solum

The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Spoil area (map symbol)

A pile of earthy materials, either smoothed or uneven, resulting from human activity.

Stone line

In a vertical cross section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments (commonly a gravel- or cobble-sized lag concentration) that formerly was draped across a topographic surface and was later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface.

Stones

Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony

Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stony spot (map symbol)

A spot where 0.01 to 0.1 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surrounding soil has no surface stones.

Strath terrace

A type of stream terrace; formed as an erosional surface cut on bedrock and thinly mantled with stream deposits (alluvium).

Stream terrace

One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

Stripcropping

Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind erosion and water erosion.

Structure, soil

The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are:

Platy: Flat and laminated
Prismatic: Vertically elongated and having flat tops
Columnar: Vertically elongated and having rounded tops
Angular blocky: Having faces that intersect at sharp angles (planes)
Subangular blocky: Having subrounded and planar faces (no sharp angles)
Granular: Small structural units with curved or very irregular faces

Structureless soil horizons are defined as follows:

Single grained: Entirely noncoherent (each grain by itself), as in loose sand
Massive: Occurring as a coherent mass

Stubble mulch

Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil

Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling

Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum

The part of the soil below the solum.

Subsurface layer

Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summer fallow

The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Summit

The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

Surface layer

The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the “plow layer,” or the “Ap horizon.”

Surface soil

The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Talus

Rock fragments of any size or shape (commonly coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.

Taxadjuncts

Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terminal moraine

An end moraine that marks the farthest advance of a glacier. It typically has the form of a massive arcuate or concentric ridge, or complex of ridges, and is underlain by till and other types of drift.

Terrace (conservation)

An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geomorphology)

A steplike surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

Terracettes

Small, irregular steplike forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock, such as sheep or cattle.

Texture, soil

The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,” “fine,” or “very fine.”

Thin layer

Otherwise suitable soil material that is too thin for the specified use.

Till

Dominantly unsorted and nonstratified drift, generally unconsolidated and deposited directly by a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders; rock fragments of various lithologies are embedded within a finer matrix that can range from clay to sandy loam.

Till plain

An extensive area of level to gently undulating soils underlain predominantly by till and bounded at the distal end by subordinate recessional or end moraines.

Tilth, soil

The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toeslope

The gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

Topsoil

The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements

Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Tread

The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

Tuff

A generic term for any consolidated or cemented deposit that is 50 percent or more volcanic ash.

Upland

An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum.

Valley fill

The unconsolidated sediment deposited by any agent (water, wind, ice, or mass wasting) so as to fill or partly fill a valley.

Variegation

Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve

A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

Very stony spot (map symbol)

A spot where 0.1 to 3.0 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surface of the surrounding soil is covered by less than 0.01 percent stones.

Water bars

Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

Weathering

All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth's surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered material.

Well graded

Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wet spot (map symbol)

A somewhat poorly drained to very poorly drained area that is at least two drainage classes wetter than the named soils in the surrounding map unit.

Wilting point (or permanent wilting point)

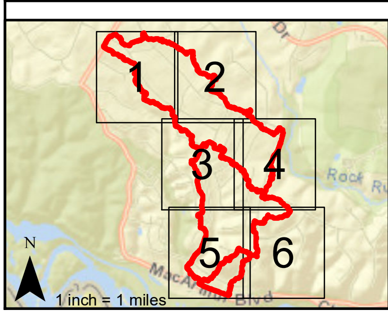
The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Windthrow

The uprooting and tipping over of trees by the wind.

APPENDIX C:

RIVER FALLS WETLAND AND WATERWAY DELINEATION



June 2022

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River Falls Drainage Assessment

Wetland Delineation Resource Map

Potomac
Montgomery County, MD

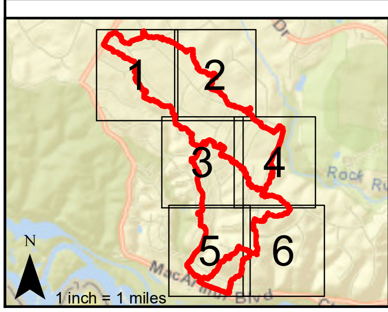
1 inch = 300 feet

Legend

Study Drainage Area

Streams

Wetlands



GPI

June 2022

River Falls Drainage Assessment

Wetland Delineation Resource Map

Potomac
Montgomery County, MD

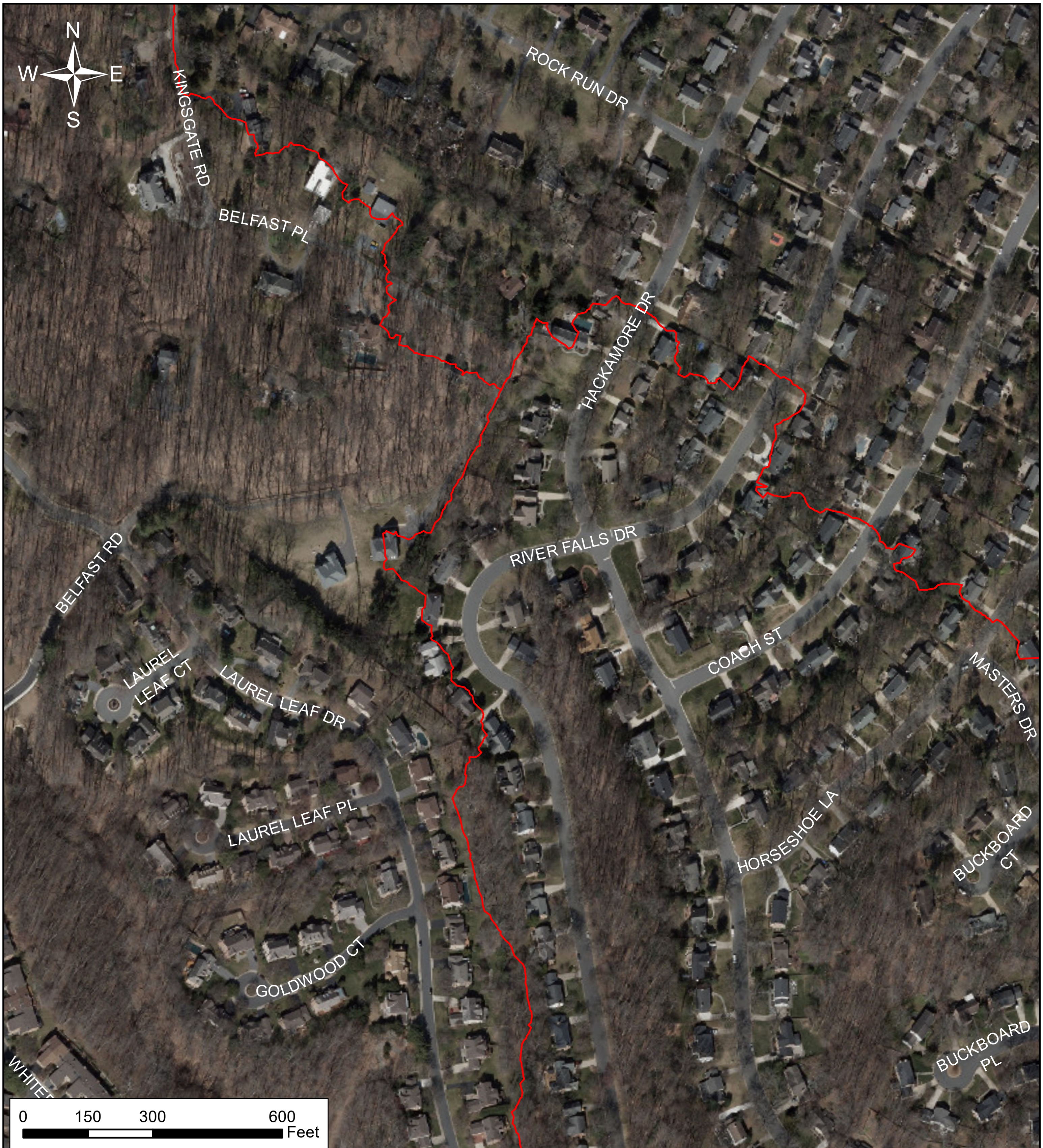
1 inch = 300 feet

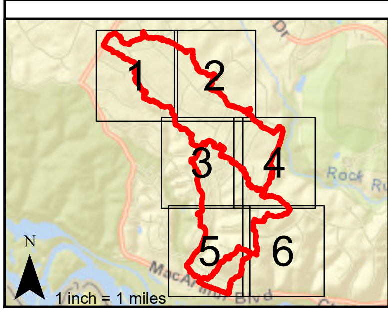
Legend

Study Drainage Area

Streams

Wetlands





June 2022

River Falls Drainage Assessment

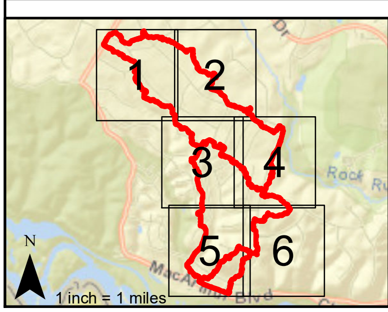
Wetland Delineation Resource Map

Potomac
Montgomery County, MD

1 inch = 300 feet

Legend

- Study Drainage Area
- Streams
- Wetlands



June 2022

Page 4 of 6

River Falls Drainage Assessment

Wetland Delineation Resource Map

Potomac
Montgomery County, MD

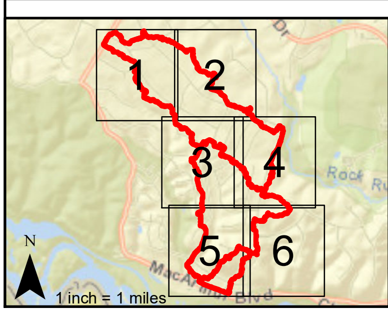
1 inch = 300 feet

Legend

Study Drainage Area

Streams

Wetlands



June 2022

Page 5 of 6

River Falls Drainage Assessment

Wetland Delineation Resource Map

Potomac
Montgomery County, MD

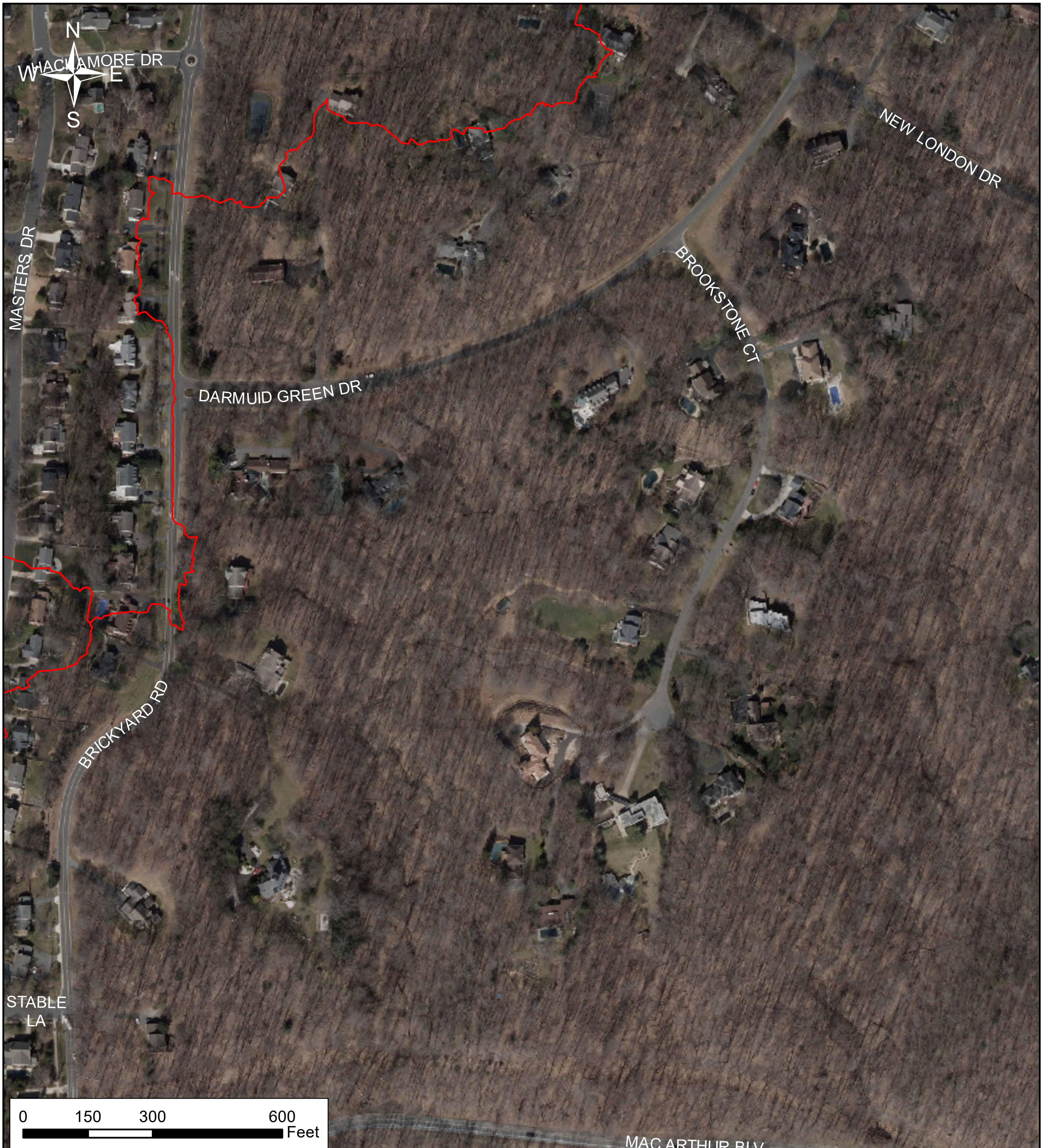
1 inch = 300 feet

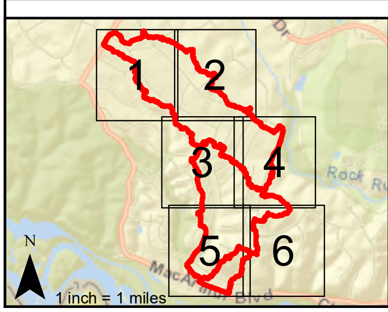
Legend

Study Drainage Area

Streams

Wetlands





GPI

June 2022

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River Falls Drainage Assessment

Wetland Delineation Resource Map

Potomac
Montgomery County, MD

1 inch = 300 feet

Legend

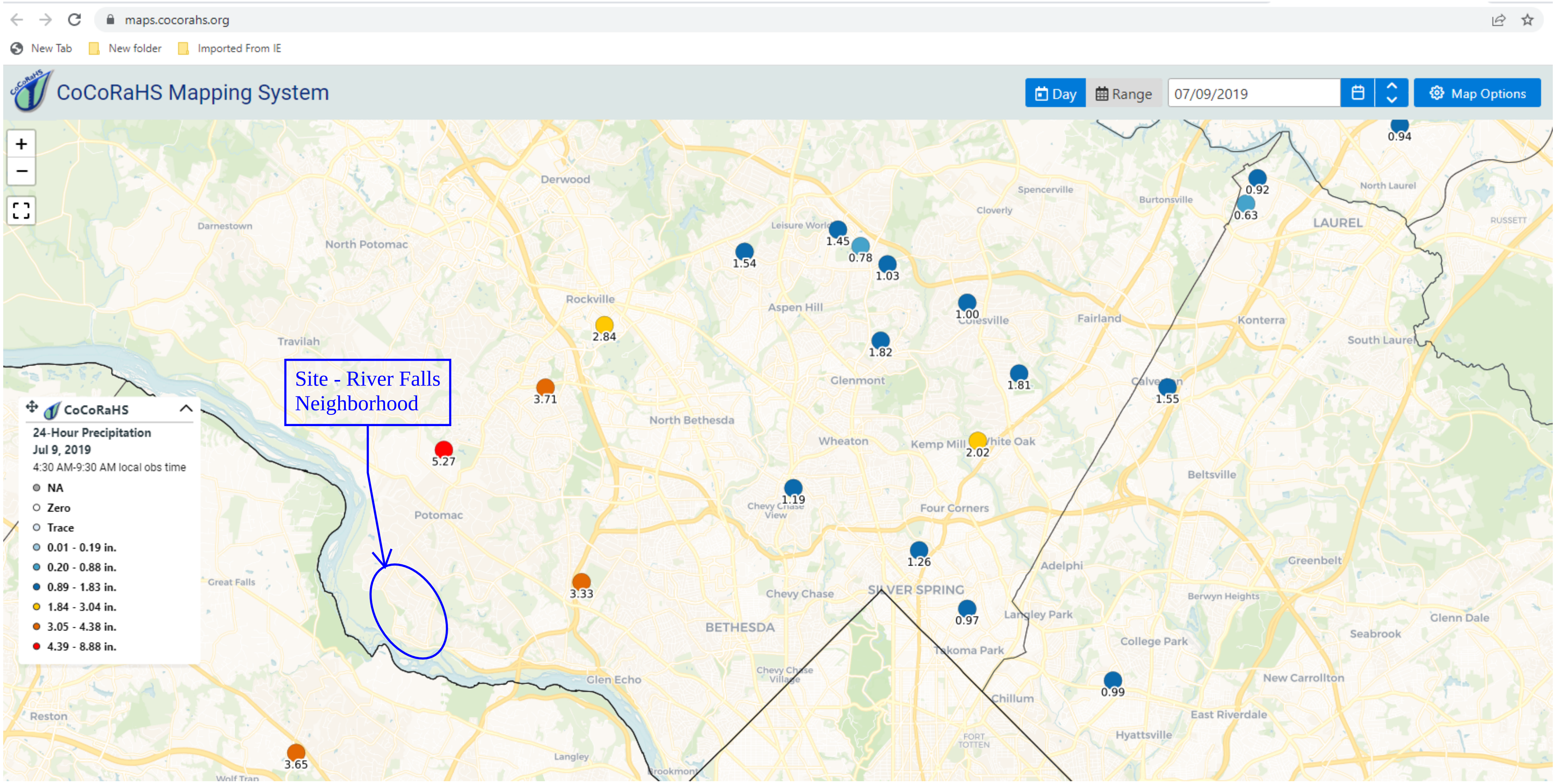
Study Drainage Area

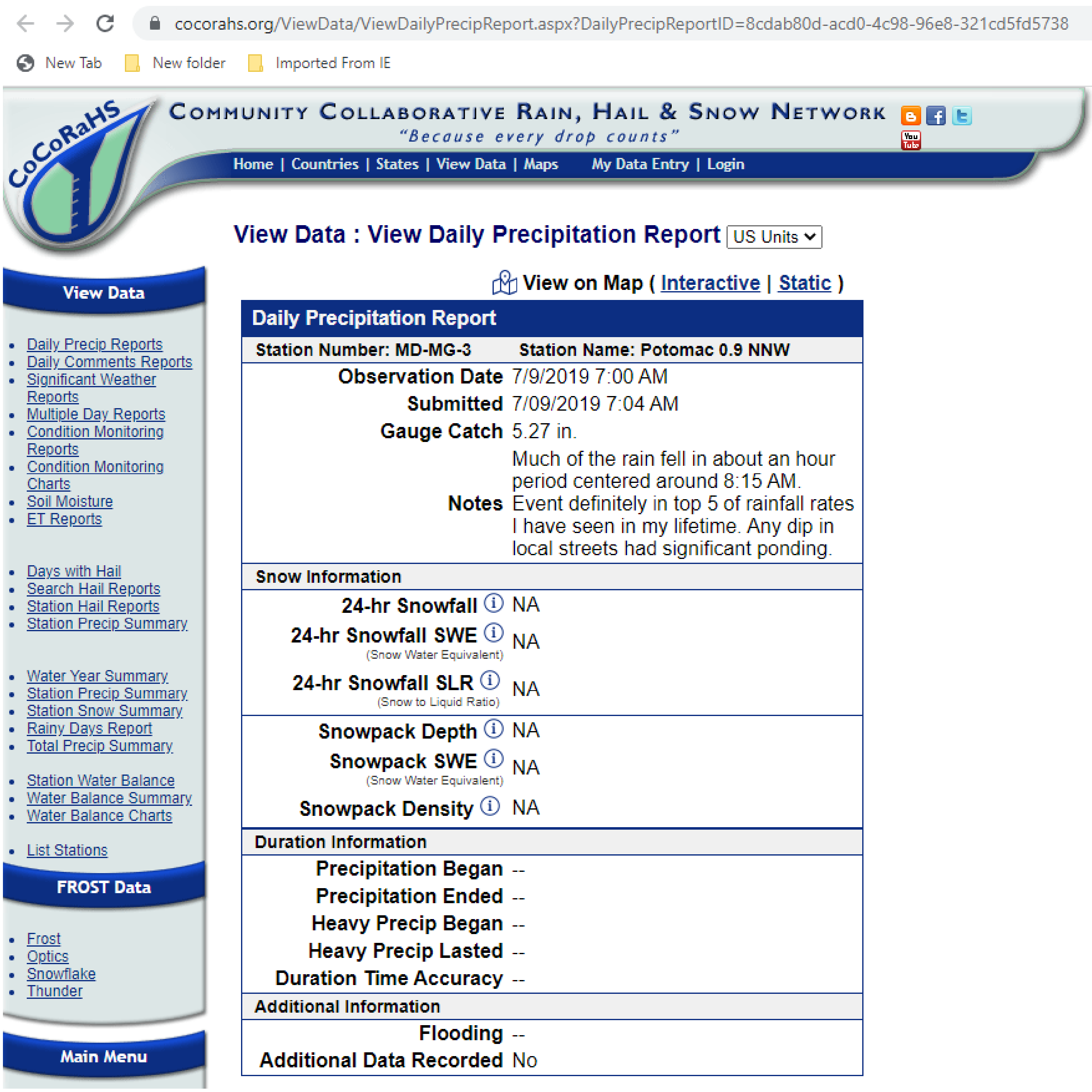
Streams

Wetlands

APPENDIX D:

RAINFALL DATA


maps.cocorahs.org
New Tab
New folder
Imported From IE
CoCoRaHS Mapping System
Day
Range
07/09/2019
Map Options
Site - River Falls
Neighborhood
CoCoRaHS
24-Hour Precipitation
Jul 9, 2019
4:30 AM-9:30 AM local obs time
NA
Zero
Trace
0.01 - 0.19 in.
0.20 - 0.88 in.
0.89 - 1.83 in.
1.84 - 3.04 in.
3.05 - 4.38 in.
4.39 - 8.88 in.
Derwood
Darnestown
North Potomac
Rockville
Travilah
Potomac
Great Falls
Reston
North Bethesda
Aspen Hill
Glenmont
Wheaton
Kemp Mill
Four Corners
Chevy Chase
BETHESDA
SILVER SPRING
Glen Echo
Langley
Spencerville
Cloverly
Burtonsville
Fairland
LAUREL
North Laurel
Konterra
South Laurel
Beltsville
Adelphi
Langley Park
Takoma Park
College Park
Greenbelt
Berwyn Heights
Seabrook
Glenn Dale
New Carrollton
East Riverdale
Hyattsville
Chillum
5.27
3.71
2.84
3.33
3.65
1.54
1.45
0.78
1.03
1.00
1.82
1.81
2.02
1.19
1.26
0.97
0.99
1.55
0.92
0.63
0.94



cocorahs.org/ViewData/ViewDailyPrecipReport.aspx?DailyPrecipReportID=8cdab80d-acd0-4c98-96e8-321cd5fd5738

New Tab | New folder | Imported From IE

Community Collaborative Rain, Hail & Snow Network

"Because every drop counts"

Home | Countries | States | View Data | Maps | My Data Entry | Login

View Data

- Daily Precip Reports
- Daily Comments Reports
- Significant Weather Reports
- Multiple Day Reports
- Condition Monitoring Reports
- Condition Monitoring Charts
- Soil Moisture
- ET Reports

- Days with Hail
- Search Hail Reports
- Station Hail Reports
- Station Precip Summary

- Water Year Summary
- Station Precip Summary
- Station Snow Summary
- Rainy Days Report
- Total Precip Summary

- Station Water Balance
- Water Balance Summary
- Water Balance Charts

- List Stations

FROST Data

- Frost
- Optics
- Snowflake
- Thunder

Main Menu

View Data : View Daily Precipitation Report

US Units

View on Map (Interactive | Static)

Daily Precipitation Report	
Station Number: MD-MG-3	**Station Name: Potomac 0.9 NNW**
Observation Date	7/9/2019 7:00 AM
Submitted	7/09/2019 7:04 AM
Gauge Catch	5.27 in.
Notes	Much of the rain fell in about an hour period centered around 8:15 AM. Event definitely in top 5 of rainfall rates I have seen in my lifetime. Any dip in local streets had significant ponding.
Snow Information	
24-hr Snowfall	NA
24-hr Snowfall SWE (Snow Water Equivalent)	NA
24-hr Snowfall SLR (Snow to Liquid Ratio)	NA
Snowpack Depth	NA
Snowpack SWE (Snow Water Equivalent)	NA
Snowpack Density	NA
Duration Information	
Precipitation Began	--
Precipitation Ended	--
Heavy Precip Began	--
Heavy Precip Lasted	--
Duration Time Accuracy	--
Additional Information	
Flooding	--
Additional Data Recorded	No

Rainfall event took place on 7/8/2019 and was entered into the CoCoRaHS system 7/9/2019. Based on observation, assume 5 inches of rainfall in 60 minutes. Compare to NOAA Atlas 14's Precipitation Frequency Estimates for the River Falls Neighborhood.

NOAA Atlas 14, Volume 2, Version 3
Location name: Potomac, Maryland, USA*
Latitude: 38.9854°, Longitude: -77.2186°
Elevation: 280.46 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

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	0.350 (0.316-0.386)	0.419 (0.379-0.462)	0.499 (0.451-0.551)	0.558 (0.503-0.615)	0.633 (0.566-0.698)	0.689 (0.614-0.760)	0.744 (0.659-0.823)	0.798 (0.702-0.886)	0.868 (0.755-0.968)	0.924 (0.797-1.03)
10-min	0.559 (0.505-0.616)	0.670 (0.607-0.739)	0.799 (0.722-0.882)	0.892 (0.804-0.984)	1.01 (0.902-1.11)	1.10 (0.977-1.21)	1.18 (1.05-1.31)	1.26 (1.11-1.40)	1.37 (1.20-1.53)	1.45 (1.25-1.63)
15-min	0.698 (0.632-0.770)	0.842 (0.763-0.929)	1.01 (0.914-1.12)	1.13 (1.02-1.24)	1.28 (1.14-1.41)	1.39 (1.24-1.53)	1.50 (1.32-1.65)	1.60 (1.40-1.77)	1.73 (1.50-1.93)	1.83 (1.58-2.05)
30-min	0.958 (0.866-1.06)	1.16 (1.05-1.28)	1.44 (1.30-1.59)	1.64 (1.48-1.80)	1.89 (1.69-2.09)	2.09 (1.86-2.31)	2.29 (2.03-2.53)	2.49 (2.19-2.76)	2.75 (2.39-3.07)	2.96 (2.55-3.31)
60-min	1.19 (1.08-1.32)	1.46 (1.32-1.61)	1.84 (1.66-2.03)	2.13 (1.92-2.35)	2.52 (2.26-2.78)	2.83 (2.53-3.13)	3.15 (2.79-3.49)	3.49 (3.07-3.87)	3.95 (3.43-4.40)	4.32 (3.72-4.84)
2-hr	1.40 (1.27-1.55)	1.71 (1.55-1.89)	2.17 (1.96-2.39)	2.53 (2.28-2.78)	3.04 (2.72-3.34)	3.45 (3.08-3.81)	3.90 (3.44-4.30)	4.36 (3.83-4.83)	5.03 (4.36-5.60)	5.59 (4.79-6.24)
3-hr	1.50 (1.36-1.67)	1.83 (1.65-2.03)	2.32 (2.09-2.56)	2.71 (2.43-2.99)	3.27 (2.92-3.61)	3.73 (3.32-4.13)	4.23 (3.72-4.68)	4.76 (4.15-5.28)	5.53 (4.75-6.16)	6.17 (5.24-6.91)
6-hr	1.85 (1.68-2.06)	2.24 (2.03-2.49)	2.83 (2.56-3.14)	3.31 (2.98-3.67)	4.03 (3.59-4.46)	4.64 (4.10-5.14)	5.31 (4.65-5.89)	6.03 (5.23-6.71)	7.10 (6.06-7.95)	8.00 (6.73-9.01)
12-hr	2.25 (2.03-2.52)	2.71 (2.44-3.04)	3.44 (3.09-3.86)	4.07 (3.63-4.55)	5.01 (4.43-5.60)	5.85 (5.12-6.53)	6.77 (5.86-7.58)	7.81 (6.66-8.77)	9.39 (7.84-10.6)	10.8 (8.84-12.2)
24-hr	2.58 (2.35-2.87)	3.12 (2.84-3.47)	4.01 (3.65-4.45)	4.79 (4.34-5.30)	5.99 (5.39-6.59)	7.06 (6.30-7.74)	8.27 (7.31-9.03)	9.65 (8.43-10.5)	11.8 (10.1-12.8)	13.6 (11.5-14.8)
2-day	2.99 (2.72-3.32)	3.62 (3.29-4.02)	4.64 (4.21-5.15)	5.51 (4.99-6.11)	6.82 (6.13-7.54)	7.97 (7.12-8.78)	9.24 (8.19-10.2)	10.7 (9.37-11.7)	12.8 (11.1-14.1)	14.7 (12.5-16.1)
3-day	3.17 (2.88-3.51)	3.83 (3.49-4.25)	4.90 (4.45-5.43)	5.81 (5.27-6.44)	7.20 (6.48-7.94)	8.40 (7.52-9.25)	9.74 (8.64-10.7)	11.2 (9.87-12.3)	13.5 (11.7-14.8)	15.4 (13.2-16.9)
4-day	3.34 (3.05-3.71)	4.04 (3.69-4.48)	5.16 (4.70-5.72)	6.12 (5.56-6.78)	7.57 (6.83-8.35)	8.83 (7.91-9.72)	10.2 (9.08-11.2)	11.8 (10.4-12.9)	14.1 (12.3-15.5)	16.2 (13.8-17.8)
7-day	3.86 (3.54-4.26)	4.66 (4.27-5.13)	5.88 (5.39-6.48)	6.94 (6.33-7.63)	8.51 (7.72-9.33)	9.87 (8.89-10.8)	11.4 (10.2-12.4)	13.0 (11.6-14.2)	15.5 (13.6-17.0)	17.6 (15.2-19.3)
10-day	4.42 (4.06-4.85)	5.31 (4.88-5.83)	6.63 (6.08-7.27)	7.74 (7.08-8.47)	9.35 (8.52-10.2)	10.7 (9.69-11.7)	12.2 (10.9-13.3)	13.7 (12.3-15.0)	16.0 (14.2-17.5)	18.0 (15.7-19.7)
20-day	5.98 (5.55-6.48)	7.11 (6.60-7.70)	8.60 (7.96-9.29)	9.80 (9.06-10.6)	11.5 (10.6-12.4)	12.8 (11.8-13.8)	14.2 (13.0-15.4)	15.7 (14.3-16.9)	17.7 (16.0-19.2)	19.3 (17.3-20.9)
30-day	7.36 (6.86-7.91)	8.70 (8.12-9.36)	10.3 (9.65-11.1)	11.7 (10.9-12.5)	13.5 (12.5-14.5)	15.0 (13.8-16.1)	16.4 (15.2-17.7)	18.0 (16.5-19.3)	20.1 (18.3-21.6)	21.7 (19.6-23.3)
45-day	9.24 (8.67-9.85)	10.9 (10.2-11.6)	12.7 (11.9-13.5)	14.1 (13.3-15.1)	16.0 (15.0-17.0)	17.4 (16.3-18.6)	18.8 (17.5-20.1)	20.2 (18.8-21.5)	22.0 (20.3-23.5)	23.3 (21.5-24.9)
60-day	11.0 (10.3-11.7)	12.9 (12.2-13.7)	14.9 (14.1-15.9)	16.5 (15.5-17.5)	18.4 (17.3-19.6)	19.9 (18.6-21.1)	21.3 (19.9-22.6)	22.6 (21.1-24.1)	24.3 (22.6-25.9)	25.6 (23.7-27.2)

[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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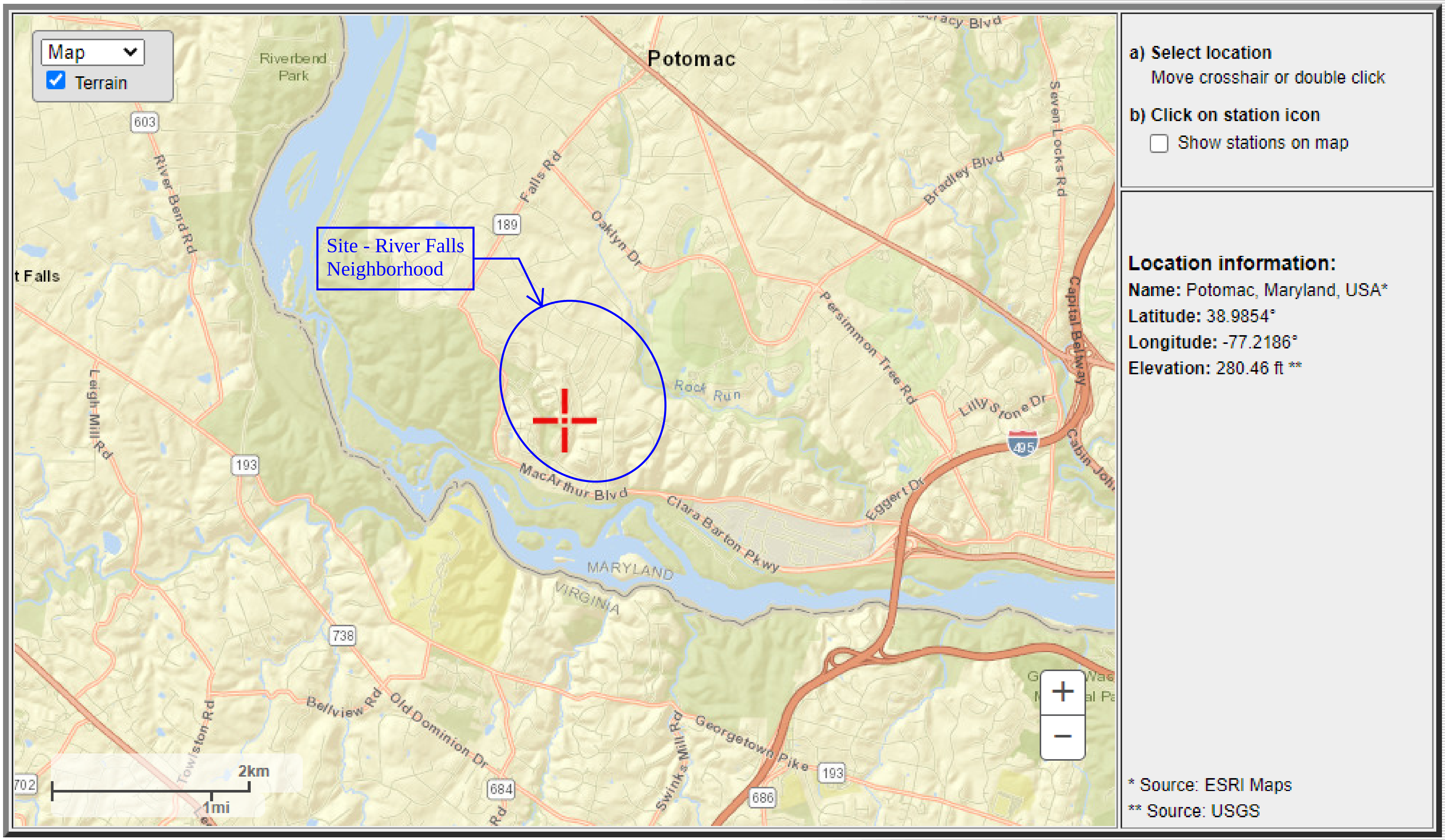
PF graphical


Map
Terrain
Riverbend Park
Potomac
603
River Bend Rd
Falls Rd
189
Oaklyn Dr
Site - River Falls Neighborhood
t Falls
Leigh Mill Rd
193
Rock Run
Persimmon Tree Rd
Bradley Blvd
Seven Locks Rd
Capital Beltway
Lilly Stone Dr
495
MacArthur Blvd
Clara Barton Pkwy
Eggert Dr
MARYLAND
VIRGINIA
738
Bellview Rd
Old Dominion Dr
Towlston Rd
Swinks Mill Rd
Georgetown Pike
684
686
193
702
2km
1mi
a) Select location
Move crosshair or double click
b) Click on station icon
Show stations on map
Location information:
Name: Potomac, Maryland, USA*
Latitude: 38.9854°
Longitude: -77.2186°
Elevation: 280.46 ft **
* Source: ESRI Maps
** Source: USGS

APPENDIX E:

EXISTING CLOSED STORM DRAIN AND

HYDRAULIC GRADE LINE COMPUTATIONS

Project Name: Riverfalls Drainage Assessment
GPI Project No: 2020031.00 Tsk 7
Computation: Storm Drain

Owner/Client: Montgomery County DOT
Calculated By: AS Date: 6/27/2022
Checked By: MMR Date: 6/29/2022

`

Storm Event: 10-Year

Manning's n for RCP 0.013
Manning's n for HDPE 0.010
Manning's n for CMP 0.024

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	Tl pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX I-2	EX I-4		12.12	12.12	0.38	4.60	4.60	14.01	0.05	14.01	5.15	23.71	0.59	**8.42**	27	RCP	6.0	19.1	57.5
EX I-4	EX I-7		5.43	17.55	0.38	2.06	6.67	11.74	0.53	14.06	5.14	34.26	1.23	**1.99**	27	RCP	8.6	12.2	389.7
EX I-7	EX I-9		4.37	26.60	0.36	1.55	10.08	10.23	0.28	14.59	5.06	51.02	1.56	**1.10**	30	RCP	10.4	8.8	148.0
EX I-9	EX I-10		1.60	28.20	0.36	0.57	10.65	10.00	0.74	14.88	5.02	53.49	0.65	**0.55**	36	RCP	7.6	7.0	310.9
EX I-10	EX I-13		1.41	34.22	0.36	0.51	12.84	10.00	0.85	15.62	4.91	63.06	0.90	**0.76**	36	RCP	8.9	8.2	420.7
EX I-13	EX I-16		1.51	41.61	0.38	0.58	15.56	10.00	0.62	16.47	4.80	74.67	1.26	**0.83**	36	RCP	10.6	8.6	321.2
EX I-16	EX MH-1		0.32	41.92	0.46	0.15	15.70	10.00	0.01	17.09	4.72	74.11	1.24	**5.05**	36	RCP	10.5	21.1	18.6
EX MH-1	EX BMH-1		0.00	52.03	0.00	0.00	19.21	0.00	0.22	17.11	4.72	90.68	0.48	**1.40**	42	HDPE	9.4	16.7	217.7
EX BMH-1	EX I-20A		0.00	60.84	0.00	0.00	22.34	0.00	0.44	17.32	4.69	104.78	3.72	**1.37**	42	CMP	10.9	6.6	176.3
EX I-20A	EX BMH-2		1.83	62.67	0.36	0.67	23.01	10.00	0.62	17.77	4.63	106.52	1.89	**1.00**	48	CMP	8.5	7.1	264.2
EX BMH-2	EX I-25		0.00	65.95	0.00	0.00	24.19	0.00	0.27	18.39	4.55	110.07	2.01	**1.18**	48	CMP	8.8	8.3	133.2
EX I-25	EX I-26		2.12	85.88	0.41	0.86	31.82	5.91	0.09	18.66	4.52	143.83	0.60	**1.52**	48	HDPE	11.4	19.3	106.8
EX I-26	EX I-28		2.15	88.03	0.38	0.82	32.64	12.35	0.15	18.75	4.51	147.21	0.63	**1.43**	48	HDPE	11.7	19.0	174.6
EX I-28	EX BMH-3		1.71	92.76	0.38	0.65	34.44	10.00	0.39	18.90	4.49	154.64	1.17	**1.18**	48	RCP	12.3	14.2	328.7
EX BMH-3	EX I-34		0.00	93.77	0.00	0.00	34.80	0.00	0.14	19.29	4.45	154.85	1.17	**1.24**	48	RCP	12.3	14.5	121.5
EX I-34	EX BMH-4		5.52	104.47	0.38	2.09	38.80	9.59	0.25	19.43	4.43	171.89	1.44	**1.00**	48	RCP	13.7	11.4	173.1
EX BMH-4	EX I-40		0.00	113.19	0.00	0.00	42.10	0.00	0.21	19.68	4.41	185.67	1.68	**0.93**	48	RCP	14.8	11.0	137.1
EX I-40	EX I-40A		1.40	120.91	0.38	0.53	44.89	10.00	0.10	19.89	4.38	196.63	1.01	**2.05**	54	RCP	12.4	19.2	112.0
EX I-40A	EX I-44		0.31	122.32	0.48	0.15	45.55	10.00	0.10	19.99	4.37	199.04	0.59	**0.71**	60	RCP	10.1	12.7	78.5
EX I-44	EX I-45		0.88	126.77	0.47	0.41	47.56	10.00	0.61	20.09	4.36	207.36	0.64	**0.42**	60	RCP	10.6	8.6	314.1
EX I-45	EX BMH-5		3.37	130.15	0.41	1.39	48.95	9.86	0.03	20.70	4.29	210.01	0.65	**2.37**	60	RCP	10.7	20.7	33.3
EX BMH-5	EX MH-5		0.00	138.84	0.00	0.00	52.68	0.00	0.29	20.72	4.29	225.99	0.76	**1.73**	60	RCP	11.5	18.6	319.8
EX MH-5	EX I-54		0.00	142.93	0.00	0.00	54.29	0.00	0.10	21.01	4.26	231.26	0.79	**1.24**	60	RCP	11.8	16.4	94.4
EX I-54	EX I-55		4.47	147.40	0.41	1.85	56.14	10.01	0.04	21.11	4.25	238.58	0.84	**1.09**	60	RCP	12.2	15.6	39.4
EX I-55	EX MH-6		5.03	152.43	0.43	2.14	58.28	11.99	0.22	21.15	4.25	247.69	0.55	**0.63**	66	RCP	10.4	12.7	165.8
EX MH-6	EX BMH-6		0.00	152.43	0.00	0.00	58.28	0.00	0.57	21.37	4.22	245.95	0.54	**0.42**	66	RCP	10.4	9.4	318.9
EX BMH-6	EX MH-7		0.00	155.96	0.00	0.00	59.77	0.00	0.07	21.93	4.17	249.23	0.55	**0.45**	66	RCP	10.5	9.2	40.3
EX MH-7	EX BMH-7		0.00	161.99	0.00	0.00	62.36	0.00	0.22	22.01	4.16	259.44	0.60	**1.39**	66	RCP	10.9	17.8	232.9
EX BMH-7	EX I-205B		0.00	166.56	0.00	0.00	64.33	0.00	0.18	22.22	4.14	266.31	0.63	**1.40**	66	RCP	11.2	17.9	191.4
EX I-205B	EX I-201		5.82	173.25	0.39	2.25	66.88	10.93	0.43	22.40	4.12	275.55	0.43	**0.41**	72	RCP	9.7	9.6	246.6
EX I-201	EX BMH-8		12.15	185.40	0.38	4.58	71.46	15.10	0.21	22.83	4.08	291.55	0.48	**0.15**	72	RCP	10.3	5.8	72.5
EX BMH-8	OUTFALL 1		0.00	190.76	0.00	0.00	73.81	0.00	0.23	23.04	4.06	299.68	0.50	**0.15**	72	RCP	10.6	5.8	81.4

Legend

x.xx Actual pipe slope is adequate for flow to pipe

x.xx Actual pipe slope is not adequate for flow to pipe

* Actual velocity from flowmaster

x.xx Pipe slope set to S minimum since pipe has reverse slope

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	TI pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX I-3	EX I-6		1.32	1.32	0.44	0.58	0.58	10.00	1.12	10.00	5.85	3.38	0.27	**1.98**	15	RCP	2.8	6.9	461.2
EX I-6	EX I-7		3.36	4.68	0.38	1.29	1.86	8.41	0.25	11.12	5.64	10.50	1.00	**0.32**	18	RCP	5.9	3.4	50.0
EX I-8	EX I-11		2.10	2.10	0.37	0.79	0.79	8.87	0.20	8.87	6.09	4.79	0.55	**1.17**	15	RCP	3.9	6.2	72.0
EX I-11	EX I-10		2.50	4.60	0.36	0.89	1.68	9.78	0.16	9.78	5.90	9.88	2.35	**1.10**	15	RCP	8.1	5.5	52.5
EX I-12	EX I-14		3.01	3.01	0.37	1.11	1.11	13.16	0.32	13.16	5.28	5.87	0.83	**0.83**	15	RCP	4.8	5.5	104.0
EX I-14	EX I-13		2.87	5.88	0.36	1.02	2.13	11.81	0.10	13.48	5.23	11.16	0.50	**1.92**	21	RCP	4.6	8.9	51.0
EX I-15	EX I-17		1.81	1.81	0.37	0.67	0.67	10.00	0.32	10.00	5.85	3.92	0.37	**0.55**	15	RCP	3.2	4.4	83.5
EX I-17	EX MH-1		0.75	9.35	0.36	0.27	3.51	10.00	0.08	13.23	5.27	18.50	1.37	**4.43**	21	RCP	7.7	14.3	64.5
EX I-37	EX I-36		2.02	2.02	0.38	0.78	0.78	12.55	0.12	12.55	5.39	4.19	0.42	**1.65**	15	RCP	3.4	6.8	50.2
EX I-36	EX I-35		1.35	3.37	0.43	0.58	1.35	10.00	0.33	12.67	5.37	7.27	1.27	**2.61**	15	RCP	5.9	9.2	179.5
EX I-35	EX I-18		1.74	5.11	0.36	0.62	1.98	10.00	0.13	13.00	5.31	10.50	2.66	**3.06**	15	RCP	8.6	10.5	83.4
EX I-18	EX I-17		1.68	6.79	0.35	0.59	2.57	10.00	0.10	13.13	5.29	13.59	4.45	**0.93**	15	RCP	11.1	5.1	29.1
EX I-19	EX MH-1		0.76	0.76	0.46	0.35	0.35	10.00	0.10	10.00	5.85	2.03	0.10	**5.34**	15	RCP	1.7	8.5	49.4
EX I-20	EX BMH-1		8.81	8.81	0.36	3.13	3.13	11.65	0.05	11.65	5.54	17.34	0.18	**3.15**	30	RCP	3.5	12.2	39.0
EX I-21	EX BMH-2		3.27	3.27	0.36	1.18	1.18	12.03	0.04	12.03	5.47	6.48	1.30	**6.60**	18	CMP	3.7	8.0	20.0
EX I-23	EX I-22		8.56	8.56	0.38	3.23	3.23	13.34	0.19	13.34	5.26	17.01	0.22	**0.63**	36	CMP	2.4	4.2	49.2
EX I-22	EX I-25		9.00	17.56	0.38	3.42	6.65	12.71	0.16	13.53	5.23	34.79	0.41	**0.62**	42	CMP	3.6	5.0	46.6
EX I-24	EX I-25		0.25	0.25	0.47	0.12	0.12	10.00	0.22	10.00	5.85	0.69	0.04	**3.20**	15	CMP	0.6	3.4	44.7
EX I-27	EX I-28		3.02	3.02	0.38	1.15	1.15	9.95	0.09	9.95	5.86	6.73	3.72	**2.33**	15	RCP	5.5	8.7	46.0
EX I-29	EX BMH-3		1.01	1.01	0.35	0.36	0.36	10.00	0.35	10.00	5.85	2.09	0.36	**3.51**	15	RCP	1.7	7.4	156.5
EX I-38	EX I-39		4.59	4.59	0.38	1.75	1.75	10.23	0.27	10.23	5.81	10.16	1.41	**0.90**	21	CMP	4.2	3.2	51.1
EX I-39	EX MH-2		1.19	5.79	0.44	0.53	2.28	10.00	0.15	10.50	5.76	13.11	1.56	**1.44**	18	RCP	7.4	7.1	66.0
EX MH-2	EX I-31		0.00	5.79	0.00	0.00	2.28	0.00	0.25	10.65	5.72	13.02	1.54	**4.40**	18	RCP	7.4	13.0	193.2
EX I-31	EX I-32		1.25	7.04	0.35	0.44	2.71	10.00	0.11	10.90	5.68	15.42	2.16	**5.08**	18	RCP	8.7	14.3	97.3
EX I-32	EX I-33		1.09	8.13	0.35	0.38	3.10	10.00	0.30	11.01	5.66	17.52	2.79	**2.20**	18	RCP	9.9	8.8	158.3
EX I-33	EX BMH-4		0.59	8.71	0.35	0.21	3.30	10.00	0.25	11.31	5.60	18.48	3.11	**5.20**	18	RCP	10.5	15.0	224.6
EX I-30	EX I-34		5.19	5.19	0.37	1.91	1.91	10.58	0.06	10.58	5.74	10.98	2.90	**4.49**	15	RCP	8.9	12.4	44.8
EX I-41	EX I-40		6.32	6.32	0.36	2.26	2.26	10.30	0.07	10.30	5.79	13.09	1.56	**2.33**	18	RCP	7.4	10.1	45.5
EX I-41A	EX I-40A		1.10	1.10	0.46	0.51	0.51	10.00	0.07	10.00	5.85	2.96	0.21	**1.95**	15	RCP	2.4	6.6	27.2
EX I-42	EX I-43		2.49	2.49	0.43	1.07	1.07	10.00	0.12	10.00	5.85	6.23	0.93	**0.81**	15	RCP	5.1	5.3	37.3
EX I-43	EX I-44		1.09	3.58	0.49	0.53	1.60	10.00	0.13	10.12	5.83	9.32	0.35	**0.98**	21	RCP	3.9	6.8	54.0
EX I-49	EX I-50		0.66	0.66	0.47	0.31	0.31	10.00	0.21	10.00	5.85	1.84	0.08	**0.88**	15	RCP	1.5	4.3	55.6
EX I-50	EX MH-3		0.44	1.10	0.46	0.20	0.52	10.00	0.00	10.21	5.81	3.01	0.22	**7.80**	15	RCP	2.5	11.3	2.2
EX MH-3	EX I-51		0.00	1.10	0.00	0.00	0.52	0.00	0.18	10.22	5.81	3.01	0.22	**0.60**	15	RCP	2.5	4.3	45.2

Legend

x.xx	Actual pipe slope is adequate for flow to pipe
x.xx	Actual pipe slope is not adequate for flow to pipe
*	Actual velocity from flowmaster
x.xx	Pipe slope set to S minimum since pipe has reverse slope

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	TI pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX I-51	EX I-48		0.13	1.92	0.64	0.08	0.91	7.00	0.54	10.39	5.78	5.25	0.66	**4.78**	15	RCP	4.3	10.7	345.1
EX I-48	EX MH-4		2.24	4.15	0.38	0.86	1.77	10.18	0.18	10.93	5.67	10.01	2.41	**3.83**	15	RCP	8.2	11.4	121.0
EX MH-4	EX I-46		0.00	4.15	0.00	0.00	1.77	0.00	0.28	11.11	5.64	9.96	2.39	**2.47**	15	RCP	8.1	9.4	159.3
EX I-46	EX I-47		2.09	6.24	0.38	0.80	2.57	7.91	0.08	11.39	5.59	14.36	0.83	**1.07**	21	RCP	6.0	7.7	36.4
EX I-47	EX BMH-5		2.45	8.70	0.47	1.16	3.73	8.78	0.10	11.47	5.58	20.79	0.45	**3.15**	27	RCP	5.2	12.9	79.4
EX I-52	EX I-51		0.69	0.69	0.45	0.31	0.31	10.00	0.20	10.00	5.85	1.81	0.08	**1.21**	15	RCP	1.5	4.8	57.0
EX I-53	EX MH-5		4.09	4.09	0.39	1.61	1.61	8.34	0.04	8.34	6.21	9.98	2.40	**6.55**	15	RCP	8.1	14.1	35.8
EX I-56	EX BMH-6		3.53	3.53	0.42	1.49	1.49	10.19	0.06	10.19	5.81	8.64	0.68	**3.18**	18	RCP	4.9	10.4	34.5
EX I-57	EX I-58		2.96	2.96	0.39	1.17	1.17	7.80	0.22	7.80	6.33	7.39	0.50	**0.22**	18	RCP	4.2	2.8	36.8
EX I-58	EX MH-7		3.07	6.03	0.47	1.43	2.60	8.70	0.31	8.70	6.13	15.92	0.27	0.27	27	RCP	4.0	5.3	98.6
EX I-205	EX I-205A		2.84	2.84	0.46	1.29	1.29	9.68	0.18	9.68	5.92	7.67	1.41	**7.52**	15	RCP	6.2	13.9	148.8
EX I-205A	EX BMH-7		1.73	4.57	0.39	0.67	1.96	10.00	0.17	10.00	5.85	11.48	3.17	**2.83**	15	RCP	9.4	8.9	87.7
EX I-205C	EX I-205B		0.87	0.87	0.36	0.31	0.31	10.00	0.45	10.00	5.85	1.81	0.08	**2.16**	15	RCP	1.5	6.0	159.9
EX I-200	EX BMH-8		5.36	5.36	0.44	2.36	2.36	21.73	0.03	21.73	4.19	9.87	0.89	**15.90**	18	RCP	5.6	19.6	37.0

Legend

x.xx Actual pipe slope is adequate for flow to pipe

x.xx Actual pipe slope is not adequate for flow to pipe

* Actual velocity from flowmaster

x.xx Pipe slope set to S minimum since pipe has reverse slope

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	Tl pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX I-62	EX I-61		1.25	1.25	0.44	0.55	0.55	10.00	0.19	10.00	5.85	3.22	0.25	0.25	15	RCP	2.6	3.5	39.0
EX I-61	EX MH-8		2.04	3.29	0.41	0.84	1.39	8.79	0.12	10.19	5.81	8.09	0.60	0.60	18	RCP	4.6	6.1	44.8
EX MH-8	EX I-66		0.00	8.22	0.00	0.00	3.49	0.00	0.20	10.36	5.78	20.16	1.63	**4.42**	21	RCP	8.4	14.5	175.5
EX I-66	EX MH-9		1.34	9.56	0.47	0.63	4.12	10.00	0.12	10.56	5.74	23.66	2.24	**5.22**	21	RCP	9.8	16.0	113.6
EX MH-9	EX I-68		0.00	9.56	0.00	0.00	4.12	0.00	0.09	10.68	5.72	23.57	2.22	**4.08**	21	RCP	9.8	14.6	78.7
EX I-68	EX MH-11		0.44	14.10	0.50	0.22	6.13	10.00	0.14	10.77	5.71	35.00	2.41	**4.54**	24	RCP	11.1	19.5	164.7
EX MH-11	EX I-72		0.00	15.51	0.00	0.00	6.65	0.00	0.30	10.91	5.68	37.78	2.80	**4.46**	24	RCP	12.0	17.3	308.2
EX I-72	EX I-77		0.76	29.24	0.55	0.41	12.87	10.00	0.46	11.21	5.63	72.48	3.14	**1.84**	30	RCP	14.8	11.3	311.9
EX I-77	EX I-79		2.57	38.09	0.47	1.20	16.88	13.46	0.29	13.46	5.24	88.46	1.77	**1.03**	36	RCP	12.5	9.6	165.4
EX I-79	EX I-103A		0.87	43.42	0.57	0.49	19.53	5.00	0.21	13.75	5.19	101.36	2.32	**1.40**	36	RCP	14.3	11.2	138.9
EX I-103A	OUTFALL 2		0.78	53.27	0.47	0.36	24.33	10.00	0.24	13.96	5.16	125.55	1.57	**1.21**	42	RCP	13.0	11.5	166.6
EX I-65	EX I-64		1.24	1.24	0.45	0.56	0.56	10.00	0.11	10.00	5.85	3.26	0.26	**1.11**	15	RCP	2.7	5.5	37.9
EX I-64	EX MH-8		2.08	3.32	0.42	0.88	1.44	10.03	0.24	10.11	5.83	8.38	1.69	**0.70**	15	RCP	6.8	4.4	64.1
EX I-63	EX MH-8		1.62	1.62	0.41	0.66	0.66	10.00	0.11	10.00	5.85	3.85	0.14	**0.94**	18	RCP	2.2	5.4	36.1
EX I-70	EX I-69		1.05	1.05	0.50	0.53	0.53	10.00	0.10	10.00	5.85	3.09	0.23	**1.49**	15	RCP	2.5	5.9	36.9
EX I-69	EX MH-10		2.17	3.22	0.39	0.84	1.37	7.08	0.06	10.10	5.83	8.00	1.54	**1.34**	15	RCP	6.5	6.1	23.2
EX MH-10	EX I-68		0.00	4.09	0.00	0.00	1.79	0.00	0.06	10.17	5.82	10.40	0.98	**2.82**	18	RCP	5.9	10.4	36.5
EX I-67	EX MH-10		0.87	0.87	0.48	0.41	0.41	10.00	0.04	10.00	5.85	2.42	0.14	**6.76**	15	RCP	2.0	9.7	24.7
EX I-99	EX MH-11		1.41	1.41	0.37	0.52	0.52	10.00	0.41	10.00	5.85	3.05	0.22	**0.59**	15	RCP	2.5	4.3	103.5
EX I-75	EX I-76		2.78	2.78	0.43	1.19	1.19	7.71	0.67	7.71	6.35	7.55	1.37	**0.03**	15	RCP	6.1	0.9	36.5
EX I-76	EX MH-12		3.55	6.33	0.46	1.63	2.82	8.22	0.17	8.38	6.20	17.48	7.35	**5.37**	15	RCP	14.2	12.2	124.8
EX MH-12	EX MH-13		0.00	6.33	0.00	0.00	2.82	0.00	0.15	8.55	6.16	17.37	7.26	**4.06**	15	RCP	14.2	10.6	97.9
EX MH-13	EX I-74		0.00	6.33	0.00	0.00	2.82	0.00	0.12	8.70	6.13	17.28	7.19	**3.42**	15	RCP	14.1	9.7	72.3
EX I-74	EX I-72		2.30	11.05	0.47	1.08	5.04	5.47	0.11	10.21	5.81	29.30	1.69	**1.50**	24	RCP	9.3	10.1	65.3
EX I-101	EX I-72		1.92	1.92	0.40	0.76	0.76	10.00	0.29	10.00	5.85	4.47	0.48	**1.13**	15	RCP	3.6	6.2	109.9
EX I-71	EX I-73		0.90	0.90	0.51	0.46	0.46	10.00	0.13	10.00	5.85	2.70	0.18	**0.99**	15	RCP	2.2	5.0	38.4
EX I-73	EX I-74		1.52	2.42	0.45	0.68	1.14	10.00	0.08	10.13	5.83	6.65	1.07	**1.77**	15	RCP	5.4	7.7	37.3
EX I-206	EX I-208		1.40	1.40	0.51	0.71	0.71	10.00	0.26	10.00	5.85	4.14	0.41	**3.44**	15	RCP	3.4	8.9	140.0
EX I-208	EX I-209		0.31	1.71	0.41	0.13	0.83	10.00	0.36	10.26	5.80	4.83	0.56	**8.61**	15	RCP	3.9	12.9	278.0
EX I-209	EX MH-14		3.52	6.29	0.41	1.45	2.81	8.02	0.07	10.62	5.73	16.09	1.04	**5.77**	21	RCP	6.7	15.2	61.8
EX MH-14	EX I-77		0.00	6.29	0.00	0.00	2.81	0.00	0.24	10.69	5.72	16.06	1.03	**2.12**	21	RCP	6.7	10.4	150.7
EX I-207	EX I-209		1.06	1.06	0.50	0.53	0.53	10.00	0.35	10.00	5.85	3.09	0.23	**13.85**	15	RCP	2.5	13.5	280.2
EX I-78	EX I-79		4.45	4.45	0.48	2.16	2.16	5.44	0.11	5.44	6.94	14.96	5.38	**1.13**	15	RCP	12.2	5.6	36.1
EX I-100	EX I-102		2.36	2.36	0.45	1.07	1.07	5.00	0.54	5.00	7.07	7.57	1.38	**3.55**	15	RCP	6.2	10.5	338.9
EX I-102	EX BMH-9		1.19	3.55	0.46	0.54	1.61	10.00	0.45	10.00	5.85	9.45	2.15	**1.27**	15	RCP	7.7	5.9	161.4
EX BMH-9	EX BMH-10		0.00	8.11	0.00	0.00	3.79	0.00	0.04	10.45	5.76	21.81	4.33	**5.56**	18	RCP	12.3	15.8	36.0
EX BMH-10	EX MH-15		0.00	9.07	0.00	0.00	4.44	0.00	0.02	10.49	5.76	25.55	15.71	**29.35**	15	RCP	20.8	31.1	46.0

Legend

x.xx Actual pipe slope is adequate for flow to pipe

x.xx Actual pipe slope is not adequate for flow to pipe

* Actual velocity from flowmaster

x.xx Pipe slope set to S minimum since pipe has reverse slope

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	TI pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX MH-15	EX-103A		0.00	9.07	0.00	0.00	4.44	0.00	0.12	10.52	5.75	25.50	15.66	**10.02**	15	RCP	20.8	16.7	117.8
EX I-106	EX I-105		0.45	0.45	0.66	0.30	0.30	7.00	0.12	7.00	6.52	1.93	0.09	**1.13**	15	RCP	1.6	5.0	37.1
EX I-105	EX BMH-11		2.09	2.53	0.45	0.94	1.24	7.01	0.38	7.12	6.49	8.02	0.59	**0.56**	18	RCP	4.5	4.5	100.6
EX BMH-11	EX BMH-12		0.00	2.53	0.00	0.00	1.24	0.00	0.27	7.50	6.40	7.91	0.57	**0.60**	18	RCP	4.5	5.3	84.8
EX BMH-12	EX I-104		0.00	2.53	0.00	0.00	1.24	0.00	1.31	7.77	6.34	7.83	0.56	**0.27**	18	RCP	4.4	3.1	243.7
EX I-104	EX BMH-9		2.03	4.56	0.46	0.94	2.17	5.71	0.06	9.08	6.04	13.12	1.57	**1.84**	18	RCP	7.4	9.2	33.2
EX I-103	EX BMH-10		0.96	0.96	0.67	0.65	0.65	7.00	0.06	7.00	6.52	4.23	0.43	**3.39**	15	RCP	3.4	8.9	29.5

Legend

x.xx	Actual pipe slope is adequate for flow to pipe
x.xx	Actual pipe slope is not adequate for flow to pipe
*	Actual velocity from flowmaster
x.xx	Pipe slope set to S minimum since pipe has reverse slope

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	TI pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX I-84C	EX MH-16		11.44	11.44	0.40	4.61	4.61	9.76	0.14	9.76	5.90	27.21	2.96	2.23	21	RCP	11.3	9.8	83.4
EX MH-16	EX BMH-11		0.00	12.65	0.00	0.00	5.16	0.00	0.23	10.15	5.82	30.05	3.61	2.22	21	RCP	12.5	9.8	135.0
EX BMH-11	EX I-84		0.00	14.63	0.00	0.00	5.89	0.00	0.23	10.38	5.78	34.03	2.28	1.78	24	RCP	10.8	9.6	135.0
EX I-84	EX MH-17		0.68	17.58	0.48	0.33	7.25	10.00	0.04	10.61	5.73	41.56	3.39	1.76	24	RCP	13.2	9.6	22.8
EX MH-17	EX I-82		0.00	19.16	0.00	0.00	8.00	0.00	0.09	10.65	5.73	45.85	4.13	3.10	24	RCP	14.6	12.7	69.7
EX I-82	EX MH-18		1.63	20.79	0.49	0.81	8.81	10.00	0.22	10.75	5.71	50.30	4.97	4.80	24	RCP	16.0	15.8	209.6
EX MH-18	EX I-80		0.00	20.79	0.00	0.00	8.81	0.00	0.20	10.97	5.67	49.95	4.90	3.53	24	RCP	15.9	13.5	158.6
EX I-80	EX I-81A		1.72	22.52	0.46	0.79	9.60	10.00	0.05	11.16	5.63	54.04	3.06	2.97	27	RCP	13.6	13.4	36.4
EX I-81A	EX I-81		2.48	24.99	0.50	1.24	10.84	6.31	0.11	11.21	5.62	60.92	3.89	4.33	27	RCP	15.3	18.4	124.3
EX I-81	OUTFALL-3		0.45	25.45	0.45	0.20	11.04	10.00	0.07	11.32	5.60	61.85	4.01	7.59	27	RCP	15.6	23.4	100.1
EX I-84B	EX MH-16		0.84	0.84	0.45	0.38	0.38	10.00	0.02	10.00	5.85	2.20	0.12	26.61	15	RCP	1.8	15.4	15.6
EX I-85A	EX MH-16		0.37	0.37	0.48	0.18	0.18	10.00	0.15	10.00	5.85	1.03	0.03	6.80	15	RCP	0.8	7.6	68.9
EX I-84A	EX BMH-11		1.98	1.98	0.37	0.73	0.73	10.00	0.22	10.00	5.85	4.24	0.43	4.07	15	RCP	3.5	10.1	135.0
EX I-86	EX I-85		1.58	1.58	0.43	0.68	0.68	10.00	0.10	10.00	5.85	3.97	0.38	1.61	15	RCP	3.2	6.6	37.8
EX I-85	EX I-84		0.70	2.27	0.51	0.36	1.04	10.00	0.06	10.10	5.83	6.05	0.88	3.28	15	RCP	4.9	9.6	36.6
EX I-83	EX MH-17		1.58	1.58	0.47	0.75	0.75	10.00	0.04	10.00	5.85	4.38	0.17	5.96	18	RCP	2.5	10.8	23.2
EX I-88A	EX MH-19		2.46	2.46	0.42	1.04	1.04	8.27	0.23	8.27	6.22	6.47	1.01	5.45	15	RCP	5.3	11.8	166.0
EX MH-19	EX MH-20		0.00	4.08	0.00	0.00	1.61	0.00	0.41	8.50	6.17	9.91	0.90	1.46	18	RCP	5.6	8.0	193.3
EX MH-20	OUTFALL-4		0.00	8.87	0.00	0.00	3.71	0.00	0.18	10.55	5.75	21.31	1.82	5.10	21	RCP	8.9	15.5	166.5
																`			
EX I-88B	EX MH-19		1.62	1.62	0.35	0.57	0.57	10.00	0.07	10.00	5.85	3.31	0.26	2.91	15	RCP	2.7	7.9	35.0
EX I-89A	EX I-89		1.68	1.68	0.38	0.64	0.64	10.00	0.32	10.00	5.85	3.77	0.34	0.91	15	RCP	3.1	5.3	100.7
EX I-89	EX I-88		1.66	3.34	0.46	0.76	1.40	10.00	0.10	10.32	5.79	8.10	0.60	0.84	18	RCP	4.6	6.1	36.8
EX I-88	EX MH-20		1.46	4.80	0.48	0.70	2.10	10.00	0.13	10.42	5.77	12.12	1.34	2.70	18	RCP	6.9	10.6	84.9
EX I-93	EX I-94		1.96	1.96	0.49	0.96	0.96	10.00	0.25	10.00	5.85	5.64	0.77	12.40	15	RCP	4.6	15.4	233.0
EX I-94	EX I-95		2.04	7.87	0.44	0.90	3.89	8.94	0.10	10.32	5.79	22.51	12.20	8.75	15	RCP	18.3	15.6	97.3
EX I-95	EX BMH-12		0.43	8.30	0.52	0.22	4.11	10.00	0.18	10.43	5.77	23.71	13.54	9.76	15	RCP	19.3	16.4	180.0
EX BMH-12	EX I-96		0.00	8.30	0.00	0.00	4.11	0.00	0.14	10.61	5.74	23.59	13.40	6.76	15	RCP	19.2	13.7	112.8
EX I-96	EX MH-22		1.05	9.92	0.49	0.51	4.95	10.00	0.10	10.75	5.71	28.26	7.27	4.67	18	RCP	16.0	12.8	73.7
EX MH-22	EX I-97		0.00	14.37	0.00	0.00	7.00	0.00	0.36	10.84	5.69	39.86	6.36	2.90	21	RCP	16.6	11.2	245.6
EX I-97	EX MH-23		0.60	15.79	0.49	0.29	7.69	10.00	0.07	11.21	5.62	43.24	3.67	1.78	24	RCP	13.8	9.6	40.5
EX MH-23	EX I-97B		0.00	15.79	0.00	0.00	7.69	0.00	0.11	11.28	5.61	43.16	3.66	2.66	24	RCP	13.7	11.7	78.7
EX I-97B	OUTFALL-8		4.39	20.18	0.38	1.68	9.38	9.36	0.05	11.39	5.59	52.41	2.88	1.67	27	RCP	13.2	10.1	30.0
EX I-92	EX MH-21		1.14	1.14	0.56	0.64	0.64	10.00	0.19	10.00	5.85	3.74	0.34	13.40	15	RCP	3.1	14.1	158.2
EX MH-21	EX I-92A		0.00	1.14	0.00	0.00	0.64	0.00	0.06	10.19	5.81	3.72	0.33	23.46	15	RCP	3.0	17.2	59.4
EX I-92A	EX I-94		1.14	2.28	0.44	0.50	1.14	10.00	0.08	10.25	5.80	6.64	1.06	17.41	15	RCP	5.4	18.2	85.3
EX I-94A	EX I-94		1.59	1.59	0.55	0.88	0.88	10.00	0.07	10.00	5.85	5.12	0.63	4.09	15	RCP	4.2	10.0	39.9
EX I-96A	EX I-96		0.57	0.57	0.57	0.32	0.32	10.00	0.15	10.00	5.85	1.90	0.09	0.79	15	RCP	1.5	4.2	38.2

Legend

x.xx Actual pipe slope is adequate for flow to pipe

x.xx Actual pipe slope is not adequate for flow to pipe

* Actual velocity from flowmaster

x.xx Pipe slope set to S minimum since pipe has reverse slope

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	TI pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX I-98A	EX I-98		2.76	2.76	0.44	1.20	1.20	5.96	0.08	5.96	6.79	8.17	0.61	**1.34**	18	RCP	4.6	7.4	36.7
EX I-98	EX MH-22		1.69	4.45	0.50	0.85	2.06	10.00	0.62	10.00	5.85	12.03	1.32	**0.50**	18	RCP	6.8	4.2	155.6
EX I-97A	EX I-97		0.83	0.83	0.48	0.40	0.40	10.00	0.14	10.00	5.85	2.34	0.13	**0.92**	15	RCP	1.9	4.7	38.1
EX I-87	EX MH-24		2.08	2.08	0.55	1.13	1.13	6.64	0.12	6.64	6.61	7.48	0.51	**18.61**	18	RCP	4.2	19.0	131.9
EX MH-24	OUTFALL-5		0.00	2.08	0.00	0.00	1.13	0.00	0.07	6.76	6.59	7.46	0.51	**1.29**	18	RCP	4.2	7.1	28.8
EX I-90	EX MH-25		3.39	3.39	0.49	1.67	1.67	9.77	0.10	9.77	5.90	9.83	2.32	**16.13**	15	RCP	8.0	19.7	116.8
EX MH-25	EX MH-26		0.00	3.39	0.00	0.00	1.67	0.00	0.05	9.87	5.88	9.79	2.31	**39.47**	15	RCP	8.0	27.2	79.9
EX MH-26	OUTFALL-6		0.00	3.39	0.00	0.00	1.67	0.00	0.05	9.92	5.87	9.78	2.30	**18.78**	15	RCP	8.0	20.8	66.6
EX I-91	EX MH-27		1.27	1.27	0.49	0.62	0.62	10.00	0.28	10.00	5.85	3.65	0.32	**26.30**	15	RCP	3.0	17.8	300.1
EX I-110	EX MH-30		25.39	119.72	0.42	10.74	53.24	17.97	0.17	17.97	4.60	244.90	1.56	**3.39**	54	RCP	15.4	24.5	244.0
EX MH-30	EX MH-31		0.00	124.93	0.00	0.00	55.78	0.00	0.00	18.14	4.58	255.47	1.70	**13.06**	54	RCP	16.1	41.0	11.3
EX MH-31	EX BMH-13		0.00	124.93	0.00	0.00	55.78	0.00	0.03	18.14	4.58	255.47	1.70	**3.88**	54	RCP	16.1	26.0	46.9
EX BMH-13	EX BMH-14		0.00	131.38	0.00	0.00	58.73	0.00	0.12	18.17	4.58	268.97	1.88	**3.88**	54	RCP	16.9	26.3	192.0
EX BMH-14	EX BMH-15		0.00	133.44	0.00	0.00	59.45	0.00	0.05	18.29	4.57	271.68	1.92	**3.88**	54	RCP	17.1	26.4	85.0
EX BMH-15	EX MH-32		0.00	134.77	0.00	0.00	59.96	0.00	0.03	18.35	4.56	273.43	0.67	**1.15**	66	RCP	11.5	16.7	33.0
EX MH-32	OUTFALL-7		0.00	134.77	0.00	0.00	59.96	0.00	0.04	18.38	4.56	273.43	0.67	**1.69**	66	RCP	11.5	19.4	51.9
EX I-107	EX MH-28		3.24	3.24	0.45	1.44	1.44	5.00	0.08	5.00	7.07	10.20	2.51	**10.28**	15	RCP	8.3	16.8	79.9
EX MH-28	EX I-108		0.00	3.24	0.00	0.00	1.44	0.00	0.14	5.08	7.05	10.17	2.49	**9.01**	15	RCP	8.3	16.0	135.7
EX I-108	EX I-109		0.40	3.64	0.52	0.21	1.65	10.00	0.07	10.00	5.85	9.66	0.85	**1.46**	18	RCP	5.5	8.4	36.4
EX I-109	EX MH-29		1.58	5.21	0.56	0.89	2.54	10.00	0.06	10.07	5.84	14.84	0.88	**1.67**	21	RCP	6.2	9.3	33.0
EX MH-29	EX MH-30		0.00	5.21	0.00	0.00	2.54	0.00	0.26	10.13	5.83	14.82	2.00	**4.52**	18	RCP	8.4	13.5	210.6
EX I-111	EX I-112		5.31	5.31	0.45	2.37	2.37	5.31	0.05	5.31	6.98	16.54	2.49	**3.76**	18	RCP	9.4	12.8	36.5
EX I-112	EX BMH-13		1.13	6.44	0.51	0.58	2.95	10.00	0.13	10.00	5.85	17.24	2.71	**3.32**	18	RCP	9.8	12.3	98.0
EX I-113	EX BMH-14		2.06	2.06	0.35	0.72	0.72	15.38	0.08	15.38	4.95	3.57	0.31	**1.00**	15	RCP	2.9	5.4	25.0
EX I-114	EX BMH-15		1.33	1.33	0.39	0.51	0.51	10.00	0.01	10.00	5.85	3.01	0.22	**1.00**	15	RCP	2.5	5.2	4.0

Legend

x.xx	Actual pipe slope is adequate for flow to pipe
x.xx	Actual pipe slope is not adequate for flow to pipe
*	Actual velocity from flowmaster
x.xx	Pipe slope set to S minimum since pipe has reverse slope

10-YEAR Hydraulic Grade Line Computations					LOSS	ELEV.	HGL Above Ground?
STARTING @ Crown of Incoming Pipe at Outfall 1						254.04	
S_f = 0.50% L= 81.38			H_F= S_F L =	0.41	0.41	*254.45*	
Where S_f = friction slope; L: Length of Pipe			Invert of Outgoing Pipe=	248.16			
S_o = 0.15% (actual pipe) slope			Normal Depth (d_n) =	6.00		254.16	
EX I-201			HGL at pipe out =			254.45	
ϕ_1 = 0			V_{in1} /3 (fps) =	1.93			
D(in)= 72		D(in)= 72	K_B = headloss cofficient=	0.15			
Q_{in} (cfs)= 164.02	BMH-8	Q_{out} (cfs)= 164.02	H_{B1} (ft) = K_{B1} $(V_{in1}/3)^2$ /2g =	0.01			
V_{in1} (fps)= 5.8		V_{out} (fps)= 5.8	V_{in2} /3 (fps) =	6.54			
			K_{B2} = headloss cofficient=	1.00			
ϕ_2 = 90			H_{B2} (ft) = K_{B2} $(V_{in2}/3)^2$ /2g =	0.66			
D(in)= 18			Controlling Angle =	90.00			
Q_{in} (cfs)= 9.87			K_B = headloss cofficient=	1.00			
V_{in2} (fps)= 19.6			H_B (ft) = K_B V_{out}^2 /2g =	0.52		254.97	
	EX I-200		Invert of Incoming Pipe=	248.16			
			Normal Depth at Pipe In =	6.00		254.16	
			HGL at pipe in =			254.97	No
S_f = 0.48% L= 72.54			H_F= S_F L =	0.35	0.35	*255.32*	
Where S_f = friction slope; L: Length of Pipe			Invert of Outgoing Pipe=	248.27			
S_o = 0.15% (actual pipe) slope			Normal Depth (d_n) =	6.00		254.27	
EX I-205B			HGL at pipe out =			255.32	
ϕ_1 = 0			K_B = headloss cofficient=	0.50			
D(in)= 72		D(in)= 72	H_B (ft) = K_B V_{out}^2 /2g =	0.26		255.58	
Q_{in} (cfs)= 271.16	EX I-201	Q_{out} (cfs)= 164.02	Invert of Incoming Pipe=	248.53			
V_{in} (fps)= 9.6		V_{out} (fps)= 5.8	Normal Depth at Pipe In =	6.00		254.53	
			HGL at pipe in =			255.58	No
S_f = 0.43% L= 247			H_F= S_F L =	1.05	1.05	*256.63*	
Where S_f = friction slope; L: Length of Pipe			Invert of Outgoing Pipe=	249.54			
S_o = 0.41% (actual pipe) slope			Normal Depth (d_n) =	6.00		255.54	
EX BMH-7			HGL at pipe out =			256.63	
ϕ_1 = 45			V_{in1} /3 (fps) =	5.98			
D(in)= 66		D(in)= 72	K_B = headloss cofficient=	1.10			
Q_{in} (cfs)= 266.31	EX I-205B	Q_{out} (cfs)= 271.16	H_{B1} (ft) = K_{B1} $(V_{in1}/3)^2$ /2g =	0.61			
V_{in1} (fps)= 17.9		V_{out} (fps)= 9.6	V_{in2} /3 (fps) =	1.99			
			K_{B2} = headloss cofficient=	1.50			
ϕ_2 = 90			H_{B2} (ft) = K_{B2} $(V_{in2}/3)^2$ /2g =	0.09			
D(in)= 15			Controlling Angle =	45.00			
Q_{in} (cfs)= 1.81			K_B = headloss cofficient=	1.10			
V_{in2} (fps)= 6.0			H_B (ft) = K_B V_{out}^2 /2g =	1.57		258.20	
	EX I-205C		Invert of Incoming Pipe=	249.88			
			Normal Depth at Pipe In =	3.29		253.17	
			HGL at pipe in =			258.20	YES
S_f = 0.63% L= 191			H_F= S_F L =	1.21	1.21	*259.41*	
Where S_f = friction slope; L: Length of Pipe			Invert of Outgoing Pipe=	252.55			
S_o = 1.40% (actual pipe) slope			Normal Depth (d_n) =	3.29		255.84	
EX MH-7			HGL at pipe out =			259.41	
ϕ_1 = 0			V_{in1} /3 (fps) =	5.92			
D(in)= 66		D(in)= 66	K_B = headloss cofficient=	0.15			
Q_{in} (cfs)= 259.44	EX BMH-7	Q_{out} (cfs)= 266.31	H_{B1} (ft) = K_{B1} $(V_{in1}/3)^2$ /2g =	0.08			
V_{in1} (fps)= 17.8		V_{out} (fps)= 17.9	V_{in2} /3 (fps) =	2.95			
			K_{B2} = headloss cofficient=	1.00			
ϕ_2 = 90			H_{B2} (ft) = K_{B2} $(V_{in2}/3)^2$ /2g =	0.14			
D(in)= 15			Controlling Angle =	90.00			
Q_{in} (cfs)= 11.48			K_B = headloss cofficient=	1.00			
V_{in2} (fps)= 8.9			H_B (ft) = K_B V_{out}^2 /2g =	4.99		264.40	
	EX I-205A		Invert of Incoming Pipe=	252.55			
			Normal Depth at Pipe In =	3.25		255.80	
			HGL at pipe in =			264.40	YES

Legend

- Entry from Storm Drain Computations or FlowMaster (red)
- Entry calculated (black)

10-YEAR Hydraulic Grade Line Computations Continued			LOSS	ELEV.	HGL Above Ground?
S_f = 0.60% L= 233	H_F= S_F L =	1.40	1.40	*265.80*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	255.79			
S_o = 1.39% (actual pipe) slope	Normal Depth (d_n) =	3.25		259.04	
EX BMH-6	HGL at pipe out =			265.80	
ϕ_1 = 0	V_{in1} /3 (fps) =	3.05			
D(in)= 66 → EX MH-7 → D(in)= 66	K_B = headloss cofficient=	0.15			
Q_{in} (cfs)= 217.62 ; Q_{out} (cfs)= 259.44	H_{B1} (ft) = K_{B1} $(V_{in1}/3)^2$ /2g =	0.02			
V_{in1} (fps)= 9.2 ; V_{out} (fps)= 17.8	V_{in2} /3 (fps) =	1.77			
	K_{B2} = headloss cofficient=	1.00			
ϕ_2 = 90	H_{B2} (ft) = K_{B2} $(V_{in2}/3)^2$ /2g =	0.05			
D(in)= 27	Controlling Angle =	90.00			
Q_{in} (cfs)= 15.92	K_B = headloss cofficient=	1.00			
V_{in2} (fps)= 5.3	H_B (ft) = K_B V_{out}^2 /2g =	4.90		270.71	
EX I-58	Invert of Incoming Pipe=	255.90			
	Normal Depth at Pipe In =	5.50		261.40	
	HGL at pipe in =			270.71	YES
S_f = 0.55% L= 40	H_F= S_F L =	0.22	0.22	*270.93*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	256.08			
S_o = 0.45% (actual pipe) slope	Normal Depth (d_n) =	5.50		261.58	
EX MH-6	HGL at pipe out =			270.93	
ϕ_1 = 0	V_{in1} /3 (fps) =	3.13			
D(in)= 66 → EX BMH-6 → D(in)= 66	K_B = headloss cofficient=	0.15			
Q_{in} (cfs)= 222.74 ; Q_{out} (cfs)= 217.62	H_{B1} (ft) = K_{B1} $(V_{in1}/3)^2$ /2g =	0.02			
V_{in1} (fps)= 9.4 ; V_{out} (fps)= 9.2	V_{in2} /3 (fps) =	3.46			
	K_{B2} = headloss cofficient=	1.00			
ϕ_2 = 90	H_{B2} (ft) = K_{B2} $(V_{in2}/3)^2$ /2g =	0.19			
D(in)= 18	Controlling Angle =	90.00			
Q_{in} (cfs)= 8.64	K_B = headloss cofficient=	1.00			
V_{in2} (fps)= 10.4	H_B (ft) = K_B V_{out}^2 /2g =	1.30		272.23	
EX I-56	Invert of Incoming Pipe=	256.08			
	Normal Depth at Pipe In =	5.50		261.58	
	HGL at pipe in =			272.23	YES
S_f = 0.54% L= 319	H_F= S_F L =	1.72	1.72	*273.96*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	257.42			
S_o = 0.42% (actual pipe) slope	Normal Depth (d_n) =	5.50		262.92	
EX I-55	HGL at pipe out =			273.96	
ϕ_1 = 90	K_B = headloss cofficient=	1.00			
D(in)= 66 → EX MH-6 → D(in)= 66	H_B (ft) = K_B V_{out}^2 /2g =	1.37		275.32	
Q_{in} (cfs)= 247.69 ; Q_{out} (cfs)= 222.74	Invert of Incoming Pipe=	257.92			
V_{in} (fps)= 12.7 ; V_{out} (fps)= 9.4	Normal Depth at Pipe In =	4.19		262.11	
	HGL at pipe in =			275.32	YES
S_f = 0.55% L= 166	H_F= S_F L =	0.91	0.91	*276.23*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	258.97			
S_o = 0.63% (actual pipe) slope	Normal Depth (d_n) =	4.19		263.16	
EX I-54	HGL at pipe out =			276.23	
ϕ_1 = 90	K_B = headloss cofficient=	1.50			
D(in)= 60 → EX I-55 → D(in)= 66	H_B (ft) = K_B V_{out}^2 /2g =	3.78		280.01	
Q_{in} (cfs)= 271.90 ; Q_{out} (cfs)= 247.69	Invert of Incoming Pipe=	260.13			
V_{in} (fps)= 13.9 ; V_{out} (fps)= 12.7	Normal Depth at Pipe In =	3.63		263.76	
	HGL at pipe in =			280.01	YES
S_f = 0.84% L= 39	H_F= S_F L =	0.33	0.33	*280.34*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	260.56			
S_o = 1.09% (actual pipe) slope	Normal Depth (d_n) =	3.63		264.19	
EX MH-5	HGL at pipe out =			280.34	
ϕ_1 = 90	K_B = headloss cofficient=	1.50			
D(in)= 60 → EX I-54 → D(in)= 60	H_B (ft) = K_B V_{out}^2 /2g =	4.47		284.81	
Q_{in} (cfs)= 231.26 ; Q_{out} (cfs)= 271.90	Invert of Incoming Pipe=	259.34			
V_{in} (fps)= 16.4 ; V_{out} (fps)= 13.9	Normal Depth at Pipe In =	3.38		262.72	
	HGL at pipe in =			284.81	YES

Legend

- Entry from Storm Drain Computations or FlowMaster (red)
- Entry calculated (black)

10-YEAR Hydraulic Grade Line Computations Continued			LOSS	ELEV.	HGL Above Ground?
S_f = 0.79% L= 94	$H_F = S_F L$ =	0.75	0.75	*285.56*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	260.51			
S_o = 1.24% (actual pipe) slope	Normal Depth (d_n) =	3.38		263.89	
EX BMH-5	HGL at pipe out =			285.56	
ϕ_1 = 90	$V_{in1}/3$ (fps) =	6.21			
D(in)= 60 → EX MH-5 → D(in)= 60	K_B = headloss coefficient=	1.00			
Q_{in} (cfs)= 225.99 → Q_{out} (cfs)= 231.26	H_{B1} (ft) = $K_{B1} (V_{in1}/3)^2 /2g$ =	0.60			
V_{in1} (fps)= 18.6 → V_{out} (fps)= 16.4	$V_{in2}/3$ (fps) =	4.70			
	K_{B2} = headloss coefficient=	0.15			
ϕ_2 = 0	H_{B2} (ft) = $K_{B2} (V_{in2}/3)^2 /2g$ =	0.05			
D(in)= 15	Controlling Angle =	90.00			
Q_{in} (cfs)= 9.98	K_B = headloss coefficient=	1.00			
V_{in2} (fps)= 14.1	H_B (ft) = $K_B V_{out}^2 /2g$ =	4.18		289.74	
EX I-53	Invert of Incoming Pipe=	261.02			
	Normal Depth at Pipe In =	2.97		263.99	
	HGL at pipe in =			289.74	YES
S_f = 0.76% L= 320	$H_F = S_F L$ =	2.42	2.42	*292.16*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	266.54			
S_o = 1.73% (actual pipe) slope	Normal Depth (d_n) =	2.97		269.51	
EX I-45	HGL at pipe out =			292.16	
ϕ_1 = 0	K_B = headloss coefficient=	0.15			
D(in)= 60 → EX BMH-5 → D(in)= 60	H_B (ft) = $K_B V_{out}^2 /2g$ =	0.63		292.79	
Q_{in} (cfs)= 210.01 → Q_{out} (cfs)= 231.26	Invert of Incoming Pipe=	266.63			
V_{in} (fps)= 20.7 → V_{out} (fps)= 16.4	Normal Depth at Pipe In =	2.57		269.20	
	HGL at pipe in =			292.79	YES
S_f = 0.65% L= 33	$H_F = S_F L$ =	0.22	0.22	*293.00*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	267.42			
S_o = 2.37% (actual pipe) slope	Normal Depth (d_n) =	2.57		269.99	
EX I-44	HGL at pipe out =			293.00	
ϕ_1 = 0	K_B = headloss coefficient=	0.50			
D(in)= 60 → EX I-45 → D(in)= 60	H_B (ft) = $K_B V_{out}^2 /2g$ =	3.31		296.32	
Q_{in} (cfs)= 168.78 → Q_{out} (cfs)= 210.01	Invert of Incoming Pipe=	267.96			
V_{in} (fps)= 8.6 → V_{out} (fps)= 20.7	Normal Depth at Pipe In =	5.00		272.96	
	HGL at pipe in =			296.32	YES
S_f = 0.64% L= 314	$H_F = S_F L$ =	2.00	2.00	*298.32*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	269.27			
S_o = 0.42% (actual pipe) slope	Normal Depth (d_n) =	5.00		274.27	
EX I-40A	HGL at pipe out =			298.32	
ϕ_1 = 0	$V_{in1}/3$ (fps) =	3.73			
D(in)= 60 → EX I-44 → D(in)= 60	K_B = headloss coefficient=	0.50			
Q_{in} (cfs)= 219.44 → Q_{out} (cfs)= 168.78	H_{B1} (ft) = $K_{B1} (V_{in1}/3)^2 /2g$ =	0.11			
V_{in1} (fps)= 11.2 → V_{out} (fps)= 8.6	$V_{in2}/3$ (fps) =	2.27			
	K_{B2} = headloss coefficient=	1.50			
ϕ_2 = 90	H_{B2} (ft) = $K_{B2} (V_{in2}/3)^2 /2g$ =	0.12			
D(in)= 21	Controlling Angle =	90.00			
Q_{in} (cfs)= 9.32	K_B = headloss coefficient=	1.50			
V_{in2} (fps)= 6.8	H_B (ft) = $K_B V_{out}^2 /2g$ =	1.72		300.04	
EX I-43	Invert of Incoming Pipe=	269.76			
	Normal Depth at Pipe In =	3.73		273.49	
	HGL at pipe in =			300.04	YES

Legend

- Entry from Storm Drain Computations or FlowMaster (red)
- Entry calculated (black)

10-YEAR Hydraulic Grade Line Computations Continued			LOSS	ELEV.	HGL Above Ground?
S_f = 0.59% L= 78	$H_F = S_F L$ =	0.46	0.46	*300.51*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	270.32			
S_o = 0.71% (actual pipe) slope	Normal Depth (d_n) =	3.73		274.05	
EX I-40	HGL at pipe out =			300.51	
ϕ_1 = 0	V_{in1} /3 (fps) =	6.38			
D(in)= 54 D(in)= 60	K_B = headloss coefficient=	0.50			
Q_{in} (cfs)= 196.63 → EX I-40A Q_{out} (cfs)= 219.44	H_{B1} (ft) = K_{B1} $(V_{in1}/3)^2$ /2g =	0.32			
V_{in1} (fps)= 19.2 V_{out} (fps)= 11.2	V_{in2} /3 (fps) =	2.27			
↑	K_{B2} = headloss coefficient=	1.50			
ϕ_2 = 90	H_{B2} (ft) = K_{B2} $(V_{in2}/3)^2$ /2g =	0.12			
D(in)= 21	Controlling Angle =	0.00			
Q_{in} (cfs)= 9.32	K_B = headloss coefficient=	0.50			
V_{in2} (fps)= 6.8 →	H_B (ft) = K_B V_{out}^2 /2g =	0.97		301.48	
EX I-43	Invert of Incoming Pipe=	270.78			
	Normal Depth at Pipe In =	2.77		273.55	
	HGL at pipe in =			301.48	YES
S_f = 1.01% L= 112	$H_F = S_F L$ =	1.13	1.13	*302.60*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	273.07			
S_o = 2.05% (actual pipe) slope	Normal Depth (d_n) =	2.77		275.84	
EX BMH-4	HGL at pipe out =			302.60	
ϕ_1 = 0	V_{in1} /3 (fps) =	3.67			
D(in)= 48 D(in)= 54	K_B = headloss coefficient=	0.50			
Q_{in} (cfs)= 138.52 → EX I-40 Q_{out} (cfs)= 196.63	H_{B1} (ft) = K_{B1} $(V_{in1}/3)^2$ /2g =	0.10			
V_{in1} (fps)= 11.0 V_{out} (fps)= 19.2	V_{in2} /3 (fps) =	3.37			
↑	K_{B2} = headloss coefficient=	1.50			
ϕ_2 = 90	H_{B2} (ft) = K_{B2} $(V_{in2}/3)^2$ /2g =	0.27			
D(in)= 18	Controlling Angle =	90.00			
Q_{in} (cfs)= 13.09	K_B = headloss coefficient=	1.50			
V_{in2} (fps)= 10.1 →	H_B (ft) = K_B V_{out}^2 /2g =	8.54		311.14	
EX I-41	Invert of Incoming Pipe=	272.74			
	Normal Depth at Pipe In =	4.00		276.74	
	HGL at pipe in =			311.14	YES
S_f = 1.68% L= 137	$H_F = S_F L$ =	2.30	2.30	*313.45*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	274.02			
S_o = 0.93% (actual pipe) slope	Normal Depth (d_n) =	4.00		278.02	
EX I-34	HGL at pipe out =			313.45	
ϕ_1 = 0	V_{in1} /3 (fps) =	3.81			
D(in)= 48 D(in)= 48	K_B = headloss coefficient=	0.15			
Q_{in} (cfs)= 143.64 → EX BMH-4 Q_{out} (cfs)= 138.52	H_{B1} (ft) = K_{B1} $(V_{in1}/3)^2$ /2g =	0.03			
V_{in1} (fps)= 11.4 V_{out} (fps)= 11.0	V_{in2} /3 (fps) =	4.99			
↑	K_{B2} = headloss coefficient=	1.00			
ϕ_2 = 90	H_{B2} (ft) = K_{B2} $(V_{in2}/3)^2$ /2g =	0.39			
D(in)= 18	Controlling Angle =	90.00			
Q_{in} (cfs)= 18.48	K_B = headloss coefficient=	1.00			
V_{in2} (fps)= 15.0 →	H_B (ft) = K_B V_{out}^2 /2g =	1.89		315.33	
EX I-33	Invert of Incoming Pipe=	274.11			
	Normal Depth at Pipe In =	4.00		278.11	
	HGL at pipe in =			315.33	YES
S_f = 1.44% L= 173	$H_F = S_F L$ =	2.49	2.49	*317.83*	
Where S_f = friction slope; L: Length of Pipe	Invert of Outgoing Pipe=	275.84			
S_o = 1.00% (actual pipe) slope	Normal Depth (d_n) =	4.00		279.84	
EX BMH-3	HGL at pipe out =			317.83	
ϕ_1 = 0	K_B = headloss coefficient=	0.15			
D(in)= 48 D(in)= 48	H_B (ft) = K_B V_{out}^2 /2g =	0.30		318.13	
Q_{in} (cfs)= 159.95 → EX I-34 Q_{out} (cfs)= 143.64	Invert of Incoming Pipe=	275.94			
V_{in} (fps)= 12.7 V_{out} (fps)= 11.4	Normal Depth at Pipe In =	3.17		279.11	
	HGL at pipe in =			318.13	YES

Legend

- ■ (red) Entry from Storm Drain Computations or FlowMaster
- ■ (black) Entry calculated

10-YEAR Hydraulic Grade Line Computations				LOSS	ELEV.	
STARTING @ Crown of Incoming Pipe at Outfall 2					213.96	
S_f = 1.57% L= 166.60		$H_F = S_F L$ =	2.61	2.61	*216.57*	
Where S_f = friction slope; L: Length of Pipe		Invert of Outgoing Pipe=	212.48			
S_o = 1.21% (actual pipe) slope		Normal Depth (d_n) =	3.50		215.98	
EX I-79		HGL at pipe out =			216.57	
ϕ_1 = 90		$V_{in1}/3$ (fps) =	3.72			
D(in)= 36	D(in)= 42	K_B = headloss cofficient=	1.50			
Q_{in} (cfs)= 78.91	EX I-103A Q_{out} (cfs)= 110.66	H_{B1} (ft) = K_{B1} $(V_{in1}/3)^2/2g$ =	0.32			
V_{in1} (fps)= 11.2	V_{out} (fps)= 11.5	$V_{in2}/3$ (fps) =	5.55			
		K_{B2} = headloss cofficient=	1.10			
ϕ_2 = 45		H_{B2} (ft) = K_{B2} $(V_{in2}/3)^2/2g$ =	0.53			
D(in)= 15		Controlling Angle =	45.00			
Q_{in} (cfs)= 20.45		K_B = headloss cofficient=	1.10			
V_{in2} (fps)= 16.7		H_B (ft) = $K_B V_{out}^2/2g$ =	2.26		218.83	
	EX MH-15	Invert of Incoming Pipe=	213.43			
		Normal Depth at Pipe In =	3.00		216.43	
		HGL at pipe in =			218.83	No
S_f = 2.32% L= 139		$H_F = S_F L$ =	3.23	3.23	*222.05*	
Where S_f = friction slope; L: Length of Pipe		Invert of Outgoing Pipe=	215.37			
S_o = 1.40% (actual pipe) slope		Normal Depth (d_n) =	3.00		218.37	
EX I-77		HGL at pipe out =			222.05	
ϕ_1 = 90		$V_{in1}/3$ (fps) =	3.19			
D(in)= 36	D(in)= 36	K_B = headloss cofficient=	1.50			
Q_{in} (cfs)= 67.69	EX I-79 Q_{out} (cfs)= 78.91	H_{B1} (ft) = K_{B1} $(V_{in1}/3)^2/2g$ =	0.24			
V_{in1} (fps)= 9.6	V_{out} (fps)= 11.2	$V_{in2}/3$ (fps) =	1.87			
		K_{B2} = headloss cofficient=	0.50			
ϕ_2 = 0		H_{B2} (ft) = K_{B2} $(V_{in2}/3)^2/2g$ =	0.03			
D(in)= 15		Controlling Angle =	90.00			
Q_{in} (cfs)= 6.87		K_B = headloss cofficient=	1.50			
V_{in2} (fps)= 5.6		H_B (ft) = $K_B V_{out}^2/2g$ =	2.90		224.95	
	EX I-78	Invert of Incoming Pipe=	216.57			
		Normal Depth at Pipe In =	3.00		219.57	
		HGL at pipe in =			224.95	YES
S_f = 1.77% L= 165		$H_F = S_F L$ =	2.92	2.92	*227.88*	
Where S_f = friction slope; L: Length of Pipe		Invert of Outgoing Pipe=	218.28			
S_o = 1.03% (actual pipe) slope		Normal Depth (d_n) =	3.00		221.28	
EX I-72		HGL at pipe out =			227.88	
ϕ_1 = 0		$V_{in1}/3$ (fps) =	3.78			
D(in)= 30	D(in)= 36	K_B = headloss cofficient=	0.50			
Q_{in} (cfs)= 55.64	EX I-77 Q_{out} (cfs)= 67.69	H_{B1} (ft) = K_{B1} $(V_{in1}/3)^2/2g$ =	0.11			
V_{in1} (fps)= 11.3	V_{out} (fps)= 9.6	$V_{in2}/3$ (fps) =	3.45			
		K_{B2} = headloss cofficient=	1.50			
ϕ_2 = 90		H_{B2} (ft) = K_{B2} $(V_{in2}/3)^2/2g$ =	0.28			
D(in)= 21		Controlling Angle =	90.00			
Q_{in} (cfs)= 16.06		K_B = headloss cofficient=	1.50			
V_{in2} (fps)= 10.4		H_B (ft) = $K_B V_{out}^2/2g$ =	2.14		230.02	
	EX MH-14	Invert of Incoming Pipe=	220.33			
		Normal Depth at Pipe In =	2.50		222.83	
		HGL at pipe in =			230.02	YES

Legend

- Entry from Storm Drain Computations or FlowMaster (red)
- Entry calculated (black)

10-YEAR Hydraulic Grade Line Computations							LOSS	ELEV.	
STARTING @ Crown of Incoming Pipe at Outfall 3								216.08	
S_f =	4.01%	L=		100	$H_F = S_F L$ =	4.01	4.01	*220.09*	
Where S_f = friction slope; L: Length of Pipe					Invert of Outgoing Pipe=	221.43			
S_o =	7.59%	(actual pipe) slope			Normal Depth (d_n) =	1.42		222.85	
EX I-81A					HGL at pipe out =			222.85	
ϕ_1 =	45				K_B = headloss cofficient=	1.10			
D(in)=	27		D(in)=	27	H_B (ft) = $K_B V_{out}^2/2g$ =	9.34		232.19	
Q_{in} (cfs)=	72.51	EX I-81	Q_{out} (cfs)=	61.85	Invert of Incoming Pipe=	221.87			
V_{in} (fps)=	18.2		V_{out} (fps)=	23.4	Normal Depth at Pipe In =	1.74		223.61	
					HGL at pipe in =			232.19	YES
S_f =	3.89%	L=		124	$H_F = S_F L$ =	4.83	4.83	*237.03*	
Where S_f = friction slope; L: Length of Pipe					Invert of Outgoing Pipe=	227.25			
S_o =	4.33%	(actual pipe) slope			Normal Depth (d_n) =	1.74		228.99	
EX I-80					HGL at pipe out =			237.03	
ϕ_1 =	0				K_B = headloss cofficient=	0.50			
D(in)=	27		D(in)=	27	H_B (ft) = $K_B V_{out}^2/2g$ =	2.58		239.61	
Q_{in} (cfs)=	53.37	EX I-81A	Q_{out} (cfs)=	72.51	Invert of Incoming Pipe=	227.44			
V_{in} (fps)=	13.4		V_{out} (fps)=	18.2	Normal Depth at Pipe In =	2.25		229.69	
					HGL at pipe in =			239.61	YES
S_f =	3.06%	L=		36	$H_F = S_F L$ =	1.11	1.11	*240.72*	
Where S_f = friction slope; L: Length of Pipe					Invert of Outgoing Pipe=	228.52			
S_o =	2.97%	(actual pipe) slope			Normal Depth (d_n) =	2.25		230.77	
EX MH-18					HGL at pipe out =			240.72	
ϕ_1 =	90				K_B = headloss cofficient=	1.50			
D(in)=	24		D(in)=	27	H_B (ft) = $K_B V_{out}^2/2g$ =	4.19		244.92	
Q_{in} (cfs)=	42.50	EX I-80	Q_{out} (cfs)=	53.37	Invert of Incoming Pipe=	229.04			
V_{in} (fps)=	13.5		V_{out} (fps)=	13.4	Normal Depth at Pipe In =	2.00		231.04	
					HGL at pipe in =			244.92	YES
S_f =	4.90%	L=		159	$H_F = S_F L$ =	7.77	7.77	*252.69*	
Where S_f = friction slope; L: Length of Pipe					Invert of Outgoing Pipe=	234.64			
S_o =	3.53%	(actual pipe) slope			Normal Depth (d_n) =	2.00		236.64	
EX I-82					HGL at pipe out =			252.69	
ϕ_1 =	0				K_B = headloss cofficient=	0.15			
D(in)=	24		D(in)=	24	H_B (ft) = $K_B V_{out}^2/2g$ =	0.43		253.12	
Q_{in} (cfs)=	49.56	EX MH-18	Q_{out} (cfs)=	42.50	Invert of Incoming Pipe=	235.64			
V_{in} (fps)=	15.8		V_{out} (fps)=	13.5	Normal Depth at Pipe In =	2.00		237.64	
					HGL at pipe in =			253.12	YES

Legend

- ■ (red) Entry from Storm Drain Computations or FlowMaster
- ■ (black) Entry calculated

Storm Event: 10 Year

H&H SUMMARY TABLE

From	To	Pipe Size (in)	Pipe Type	L (ft)	**Pipe Undersized**	**Pipe inverts Surveyed**	**Comment Section**
EX I-2	EX I-4	27	RCP	57.5	NO	YES	
EX I-4	EX I-7	27	RCP	389.7	NO	YES	
EX I-7	EX I-9	30	RCP	148.0	YES	YES	
EX I-9	EX I-10	36	RCP	310.9	YES	YES	
EX I-10	EX I-13	36	RCP	420.7	YES	YES	
EX I-13	EX I-16	36	RCP	321.2	YES	NO	INLET-16 NOT ACCESSIBLE, INVERT AT I-16 TAKEN FROM AS-BUILT
EX I-16	EX MH-1	36	RCP	18.6	NO	NO	INLET-16 NOT ACCESSIBLE, INVERT AT I-16 TAKEN FROM AS-BUILT
EX MH-1	EX BMH-1	42	HDPE	217.7	NO	NO	BURIED MANHOLE 1, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX BMH-1	EX I-20A	42	CMP	176.3	YES	NO	BURIED MANHOLE 1, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX I-20A	EX BMH-2	48	CMP	264.2	YES	NO	BURIED MANHOLE 2, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX BMH-2	EX I-25	48	CMP	133.2	YES	NO	BURIED MANHOLE 2, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX I-25	EX I-26	48	HDPE	106.8	NO	YES	
EX I-26	EX I-28	48	HDPE	174.6	NO	YES	
EX I-28	EX BMH-3	48	RCP	328.7	NO	NO	BURIED MANHOLE 3, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX BMH-3	EX I-34	48	RCP	121.5	NO	NO	BURIED MANHOLE 3, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX I-34	EX BMH-4	48	RCP	173.1	YES	NO	BURIED MANHOLE 4, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX BMH-4	EX I-40	48	RCP	137.1	YES	NO	BURIED MANHOLE 4, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX I-40	EX I-40A	54	RCP	112.0	NO	YES	
EX I-40A	EX I-44	60	RCP	78.5	NO	YES	
EX I-44	EX I-45	60	RCP	314.1	YES	YES	
EX I-45	EX BMH-5	60	RCP	33.3	NO	NO	BURIED MANHOLE 5, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX BMH-5	EX MH-5	60	RCP	319.8	NO	NO	BURIED MANHOLE 5, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX MH-5	EX I-54	60	RCP	94.4	NO	YES	
EX I-54	EX I-55	60	RCP	39.4	NO	YES	
EX I-55	EX MH-6	66	RCP	165.8	NO	YES	
EX MH-6	EX BMH-6	66	RCP	318.9	YES	NO	BURIED MANHOLE 6, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX BMH-6	EX MH-7	66	RCP	40.3	YES	NO	BURIED MANHOLE 6, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX MH-7	EX BMH-7	66	RCP	232.9	NO	NO	BURIED MANHOLE 7, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX BMH-7	EX I-205B	66	RCP	191.4	NO	NO	BURIED MANHOLE 7, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX I-205B	EX I-201	72	RCP	246.6	YES	YES	
EX I-201	EX BMH-8	72	RCP	72.5	YES	NO	BURIED MANHOLE 8, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX BMH-8	OUTFALL 1	72	RCP	81.4	YES	NO	BURIED MANHOLE 8, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION

From	To	Pipe Size (in)	Pipe Type	L (ft)	**Pipe Undersized**	**Pipe inverts Surveyed**	**Comment Section**
EX I-3	EX I-6	15	RCP	461.2	NO	NO	INLET 6 BURIED, INVERTS TAKEN FROM AS-BUILTS
EX I-6	EX I-7	18	RCP	50.0	YES	NO	INLET 6 BURIED, INVERTS TAKEN FROM AS-BUILTS
EX I-8	EX I-11	15	RCP	72.0	NO	NO	INVERT OUT AT EX. I-11 IS HIGHER THAN PIPE INVERT INTO INLET
EX I-11	EX I-10	15	RCP	52.5	YES	YES	
EX I-12	EX I-14	15	RCP	104.0	YES	NO	INLET 12 BURIED, INVERTS TAKEN FROM AS-BUILTS
EX I-14	EX I-13	21	RCP	51.0	NO	YES	
EX I-15	EX I-17	15	RCP	83.5	NO	YES	
EX I-17	EX MH-1	21	RCP	64.5	NO	YES	
EX I-37	EX I-36	15	RCP	50.2	NO	YES	
EX I-36	EX I-35	15	RCP	179.5	NO	YES	
EX I-35	EX I-18	15	RCP	83.4	NO	YES	
EX I-18	EX I-17	15	RCP	29.1	YES	NO	INVERT OUT AT EX. I-17 IS HIGHER THAN PIPE INVERT INTO INLET
EX I-19	EX MH-1	15	RCP	49.4	NO	YES	
EX I-20	EX BMH-1	30	RCP	39.0	NO	NO	BURIED MANHOLE 1, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX I-21	EX BMH-2	18	CMP	20.0	NO	NO	BURIED MANHOLE 2, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX I-23	EX I-22	36	CMP	49.2	NO	YES	
EX I-22	EX I-25	42	CMP	46.6	NO	YES	
EX I-24	EX I-25	15	CMP	44.7	NO	YES	
EX I-27	EX I-28	15	RCP	46.0	YES	YES	
EX I-29	EX BMH-3	15	RCP	156.5	NO	NO	BURIED MANHOLE 2, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX I-38	EX I-39	21	CMP	51.1	YES	NO	
EX I-39	EX MH-2	18	RCP	66.0	YES	YES	
EX MH-2	EX I-31	18	RCP	193.2	NO	YES	
EX I-31	EX I-32	18	RCP	97.3	NO	YES	
EX I-32	EX I-33	18	RCP	158.3	YES	YES	
EX I-33	EX BMH-4	18	RCP	224.6	NO	YES	
EX I-30	EX I-34	15	RCP	44.8	NO	YES	
EX I-41	EX I-40	18	RCP	45.5	NO	YES	
EX I-41A	EX I-40A	15	RCP	27.2	NO	YES	
EX I-42	EX I-43	15	RCP	37.3	YES	YES	
EX I-43	EX I-44	21	RCP	54.0	NO	YES	

From	To	Pipe Size (in)	Pipe Type	L (ft)	**Pipe Undersized**	**Pipe inverts Surveyed**	**Comment Section**
EX I-49	EX I-50	15	RCP	55.6	NO	YES	
EX I-50	EX MH-3	15	RCP	2.2	NO	YES	
EX MH-3	EX I-51	15	RCP	45.2	NO	YES	
EX I-51	EX I-48	15	RCP	345.1	NO	YES	
EX I-48	EX MH-4	15	RCP	121.0	NO	YES	
EX MH-4	EX I-46	15	RCP	159.3	NO	YES	
EX I-46	EX I-47	21	RCP	36.4	NO	YES	
EX I-47	EX BMH-5	27	RCP	79.4	NO	NO	BURIED MANHOLE 5, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX I-52	EX I-51	15	RCP	57.0	NO	YES	
EX I-53	EX MH-5	15	RCP	35.8	NO	YES	
EX I-56	EX BMH-6	18	RCP	34.5	NO	NO	BURIED MANHOLE 6, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX I-57	EX I-58	18	RCP	36.8	YES	YES	
EX I-58	EX MH-7	27	RCP	98.6	YES	NO	PIPE IS AT A REVERSE SLOPE, ASSUMED MINIMUM SLOPE OF PIPE FOR SIZE AND FLOW
EX I-205	EX I-205A	15	RCP	148.8	NO	YES	
EX I-205A	EX BMH-7	15	RCP	87.7	YES	NO	BURIED MANHOLE 7, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX I-205C	EX I-205B	15	RCP	159.9	NO	YES	
EX I-200	EX BMH-8	18	RCP	37.0	NO	NO	BURIED MANHOLE 8, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION

From	To	Pipe	Pipe	L	**Pipe**	**Pipe inverts**	**Comment**
		Size (in)	Type	(ft)	**Undersized**	**Surveyed**	**Section**
EX I-62	EX I-61	15	RCP	39.0	YES	NO	PIPE IS AT A REVERSE SLOPE, ASSUMED MINIMUM SLOPE OF PIPE FOR SIZE AND FLOW
EX I-61	EX MH-8	18	RCP	44.8	YES	NO	PIPE IS AT A REVERSE SLOPE, ASSUMED MINIMUM SLOPE OF PIPE FOR SIZE AND FLOW
EX MH-8	EX I-66	21	RCP	175.5	NO	YES	
EX I-66	EX MH-9	21	RCP	113.6	NO	YES	
EX MH-9	EX I-68	21	RCP	78.7	NO	YES	
EX I-68	EX MH-11	24	RCP	164.7	NO	YES	
EX MH-11	EX I-72	24	RCP	308.2	NO	YES	
EX I-72	EX I-77	30	RCP	311.9	YES	YES	
EX I-77	EX I-79	36	RCP	165.4	YES	YES	
EX I-79	EX I-103A	36	RCP	138.9	YES	NO	INVERT OUT NOT PROVIDED, INVERTS TAKEN BY SLOPE FROM ASBUILT PLANS
EX I-103A	OUTFALL 2	42	RCP	166.6	YES	YES	
EX I-65	EX I-64	15	RCP	37.9	NO	YES	
EX I-64	EX MH-8	15	RCP	64.1	YES	YES	
EX I-63	EX MH-8	18	RCP	36.1	NO	YES	
EX I-70	EX I-69	15	RCP	36.9	NO	YES	
EX I-69	EX MH-10	15	RCP	23.2	YES		
EX MH-10	EX I-68	18	RCP	36.5	NO	YES	
EX I-67	EX MH-10	15	RCP	24.7	NO	YES	
EX I-99	EX MH-11	15	RCP	103.5	NO	YES	
EX I-75	EX I-76	15	RCP	36.5	YES	YES	
EX I-76	EX MH-12	15	RCP	124.8	YES	YES	
EX MH-12	EX MH-13	15	RCP	97.9	YES	YES	
EX MH-13	EX I-74	15	RCP	72.3	YES	YES	
EX I-74	EX I-72	24	RCP	65.3	YES	YES	
EX I-101	EX I-72	15	RCP	109.9	NO	YES	
EX I-71	EX I-73	15	RCP	38.4	NO	YES	
EX I-73	EX I-74	15	RCP	37.3	NO	YES	
EX I-206	EX I-208	15	RCP	140.0	NO	YES	
EX I-208	EX I-209	15	RCP	278.0	NO	YES	
EX I-209	EX MH-14	21	RCP	61.8	NO	YES	
EX MH-14	EX I-77	21	RCP	150.7	NO	YES	
EX I-207	EX I-209	15	RCP	280.2	NO	YES	
EX I-78	EX I-79	15	RCP	36.1	YES	NO	PIPE HAS REVERSE SLOPE, INVERTS TAKEN BY SLOPE FROM ASBUILT PLANS

From	To	Pipe	Pipe	L	**Pipe**	**Pipe inverts**	**Comment**
		Size (in)	Type	(ft)	**Undersized**	**Surveyed**	**Section**
EX I-100	EX I-102	15	RCP	338.9	NO	YES	
EX I-102	EX BMH-9	15	RCP	161.4	YES	NO	BURIED MANHOLE 9, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX BMH-9	EX BMH-10	18	RCP	36.0	NO	NO	BURIED MANHOLE 9, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX BMH-10	EX MH-15	15	RCP	46.0	NO	NO	BURIED MANHOLE 10, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX MH-15	EX-103A	15	RCP	117.8	YES	YES	
EX I-106	EX I-105	15	RCP	37.1	NO	YES	
EX I-105	EX BMH-11	18	RCP	100.6	YES	NO	BURIED MANHOLE 11, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX BMH-11	EX BMH-12	18	RCP	84.8	NO	NO	BURIED MANHOLE 12, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX BMH-12	EX I-104	18	RCP	243.7	YES	NO	BURIED MANHOLE 12, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX I-104	EX BMH-9	18	RCP	33.2	NO	NO	BURIED MANHOLE 9, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX I-103	EX BMH-10	15	RCP	29.5	NO	NO	BURIED MANHOLE 10, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE

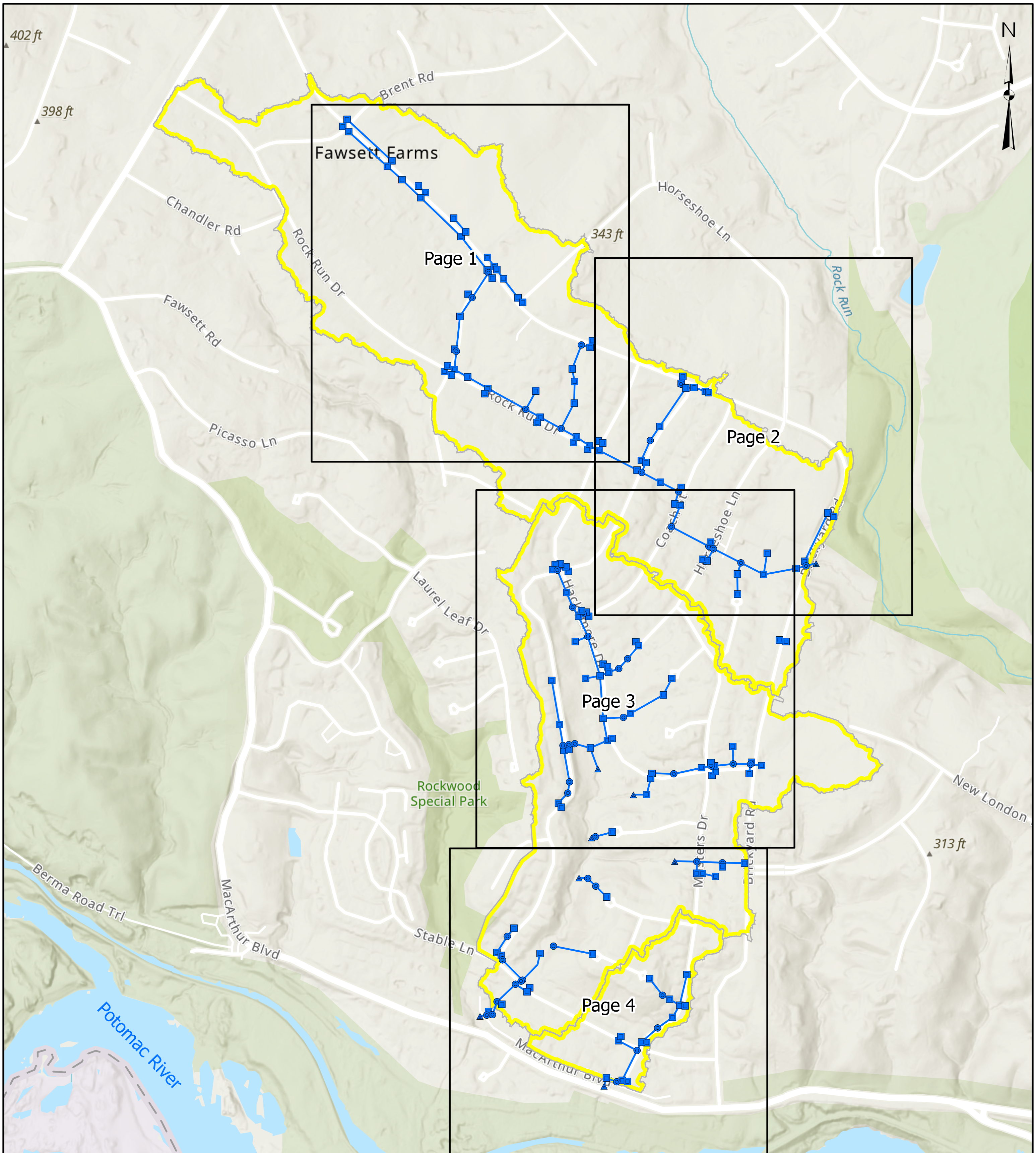
From	To	Pipe Size (in)	Pipe Type	L (ft)	Pipe Undersized	Pipe inverts Surveyed	Comment Section
EX I-84C	EX MH-16	21	RCP	83.4	YES	YES	
EX MH-16	EX BMH-11	21	RCP	135.0	YES	NO	BURIED MANHOLE 11, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX BMH-11	EX I-84	24	RCP	135.0	YES	NO	BURIED MANHOLE 11, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX I-84	EX MH-17	24	RCP	22.8	YES	NO	MANHOLE 17 UNABLE TO OPEN THE LID(ASPHALT), INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX MH-17	EX I-82	24	RCP	69.7	YES	NO	MANHOLE 17 UNABLE TO OPEN THE LID(ASPHALT), INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX I-82	EX MH-18	24	RCP	209.6	YES	YES	
EX MH-18	EX I-80	24	RCP	158.6	YES	YES	
EX I-80	EX I-81A	27	RCP	36.4	YES	YES	
EX I-81A	EX I-81	27	RCP	124.3	NO	YES	
EX I-81	OUTFALL-3	27	RCP	100.1	NO	YES	
EX I-84B	EX MH-16	15	RCP	15.6	NO	YES	
EX I-85A	EX MH-16	15	RCP	68.9	NO	YES	
EX I-84A	EX BMH-11	15	RCP	135.0	NO	NO	BURIED MANHOLE 11, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX I-86	EX I-85	15	RCP	37.8	NO	YES	
EX I-85	EX I-84	15	RCP	36.6	NO	YES	
EX I-83	EX MH-17	18	RCP	23.2	NO	NO	MANHOLE 17 UNABLE TO OPEN THE LID(ASPHALT), INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX I-88A	EX MH-19	15	RCP	166.0	NO	NO	MANHOLE 19 UNABLE TO OPEN THE LID, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX MH-19	EX MH-20	18	RCP	193.3	NO	NO	MANHOLE 19 UNABLE TO OPEN THE LID, INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX MH-20	OUTFALL-4	21	RCP	166.5	NO	NO	
			`				
EX I-88B	EX MH-19	15	RCP	35.0	NO	YES	
EX I-89A	EX I-89	15	RCP	100.7	NO	YES	
EX I-89	EX I-88	18	RCP	36.8	NO	YES	
EX I-88	EX MH-20	18	RCP	84.9	NO	YES	
EX I-93	EX I-94	15	RCP	233.0	NO	YES	
EX I-94	EX I-95	15	RCP	97.3	YES	YES	
EX I-95	EX BMH-12	15	RCP	180.0	YES	NO	BURIED MANHOLE 12, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX BMH-12	EX I-96	15	RCP	112.8	YES	NO	BURIED MANHOLE 12, INVERTS TAKEN BY SURVEY SLOPE ASSUMPTION
EX I-96	EX MH-22	18	RCP	73.7	YES	NO	MANHOLE 22 UNABLE TO OPEN THE LID(ASPHALT), INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX MH-22	EX I-97	21	RCP	245.6	YES	NO	MANHOLE 22 UNABLE TO OPEN THE LID(ASPHALT), INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX I-97	EX MH-23	24	RCP	40.5	YES	YES	
EX MH-23	EX I-97B	24	RCP	78.7	YES	YES	
EX I-97B	OUTFALL-8	27	RCP	30.0	YES	YES	
EX I-92	EX MH-21	15	RCP	158.2	NO	YES	
EX MH-21	EX I-92A	15	RCP	59.4	NO	YES	
EX I-92A	EX I-94	15	RCP	85.3	NO	YES	
EX I-94A	EX I-94	15	RCP	39.9	NO	YES	
EX I-96A	EX I-96	15	RCP	38.2	NO	YES	
EX I-98A	EX I-98	18	RCP	36.7	NO	YES	

From	To	Pipe Size (in)	Pipe Type	L (ft)	**Pipe Undersized**	**Pipe inverts Surveyed**	**Comment Section**
EX I-98	EX MH-22	18	RCP	155.6	YES	NO	MANHOLE 22 UNABLE TO OPEN THE LID(ASPHALT), INVERTS TAKEN FROM MONTGOMERY COUNTY DAR WEBSITE
EX I-97A	EX I-97	15	RCP	38.1	NO	YES	
EX I-87	EX MH-24	18	RCP	131.9	NO	YES	
EX MH-24	OUTFALL-5	18	RCP	28.8	NO	YES	
EX I-90	EX MH-25	15	RCP	116.8	NO	YES	
EX MH-25	EX MH-26	15	RCP	79.9	NO	YES	
EX MH-26	OUTFALL-6	15	RCP	66.6		YES	
EX I-91	EX MH-27	15	RCP	300.1	NO	YES	
EX I-110	EX MH-30	54	RCP	244.0	NO	YES	
EX MH-30	EX MH-31	54	RCP	11.3	NO	YES	
EX MH-31	EX BMH-13	54	RCP	46.9	NO	NO	BURIED MANHOLE 13, INVERTS TAKEN FROM ASBUILT PLAN ELEVATION
EX BMH-13	EX BMH-14	54	RCP	192.0	NO	NO	BURIED MANHOLE 13, INVERTS TAKEN FROM ASBUILT PLAN ELEVATION
EX BMH-14	EX BMH-15	54	RCP	85.0	NO	NO	BURIED MANHOLE 14, INVERTS TAKEN FROM ASBUILT PLAN ELEVATION
EX BMH-15	EX MH-32	66	RCP	33.0	NO	NO	BURIED MANHOLE 15, INVERTS TAKEN FROM ASBUILT PLAN ELEVATION
EX MH-32	OUTFALL-7	66	RCP	51.9	NO	YES	
EX I-107	EX MH-28	15	RCP	79.9	NO	YES	
EX MH-28	EX I-108	15	RCP	135.7	NO	YES	
EX I-108	EX I-109	18	RCP	36.4	NO	YES	
EX I-109	EX MH-29	21	RCP	33.0	NO	YES	
EX MH-29	EX MH-30	18	RCP	210.6	NO	YES	
EX I-111	EX I-112	18	RCP	36.5	NO	YES	
EX I-112	EX BMH-13	18	RCP	98.0	NO	NO	BURIED MANHOLE 13, INVERTS TAKEN FROM ASBUILT PLAN ELEVATION
EX I-113	EX BMH-14	15	RCP	25.0	NO	NO	BURIED MANHOLE 14, INVERTS TAKEN FROM ASBUILT PLAN ELEVATION
EX I-114	EX BMH-15	15	RCP	4.0	NO	NO	BURIED MANHOLE 15, INVERTS TAKEN FROM ASBUILT PLAN ELEVATION

APPENDIX F:

UNDERSIZED PIPE MAPS AND

SURFACE FLOW AND SUMPS MAPS



RIVER FALLS DRAINAGE STUDY

PIPE ANALYSIS MAPS

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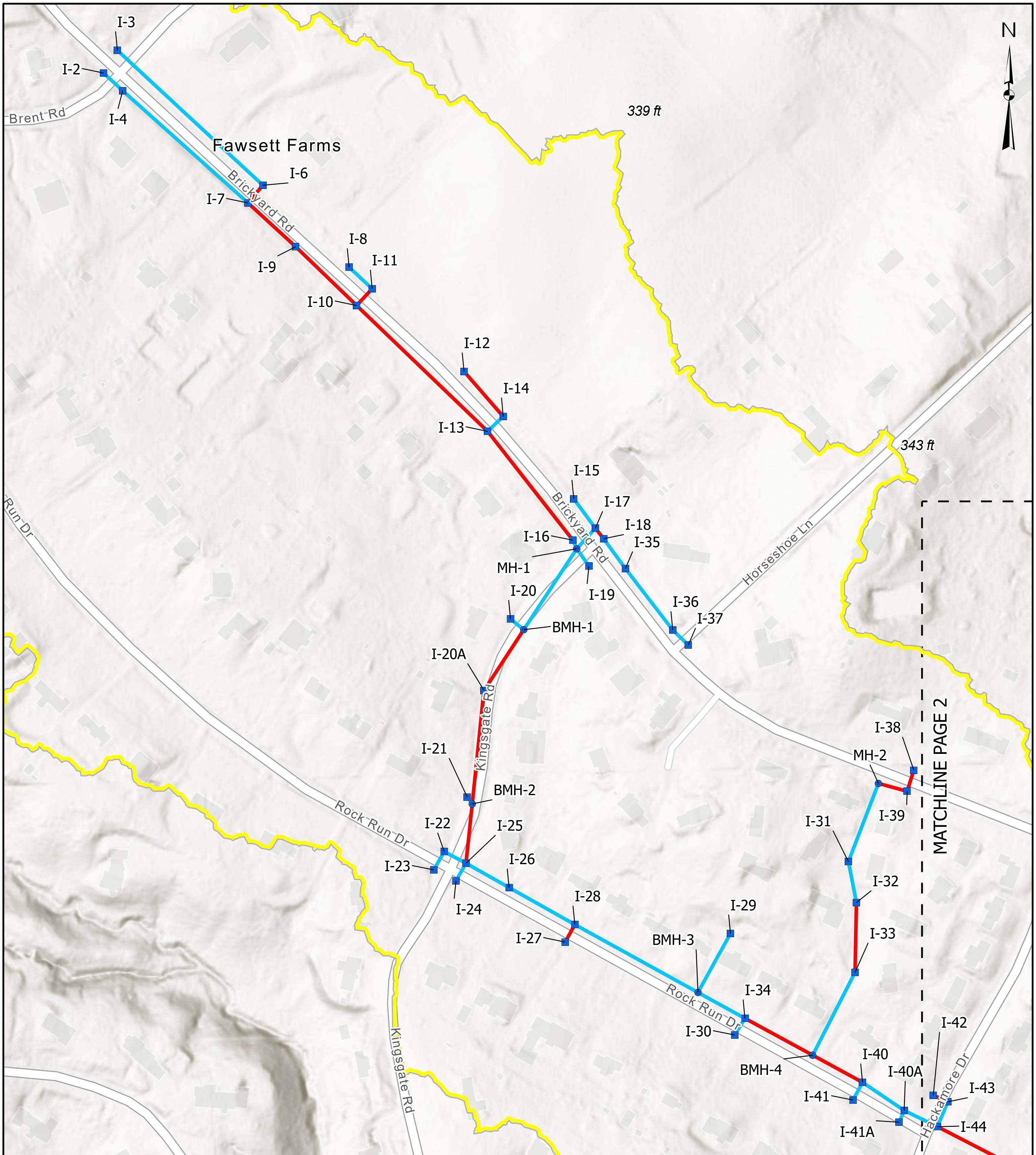

RIVER FALLS DRAINAGE STUDY

PIPE INDIVIDUAL CAPACITY ANALYSIS

Pipes
- Sufficient Capacity
- Undercapacity
- Study Drainage Areas

- Inlet
- Manhole
- Outfall

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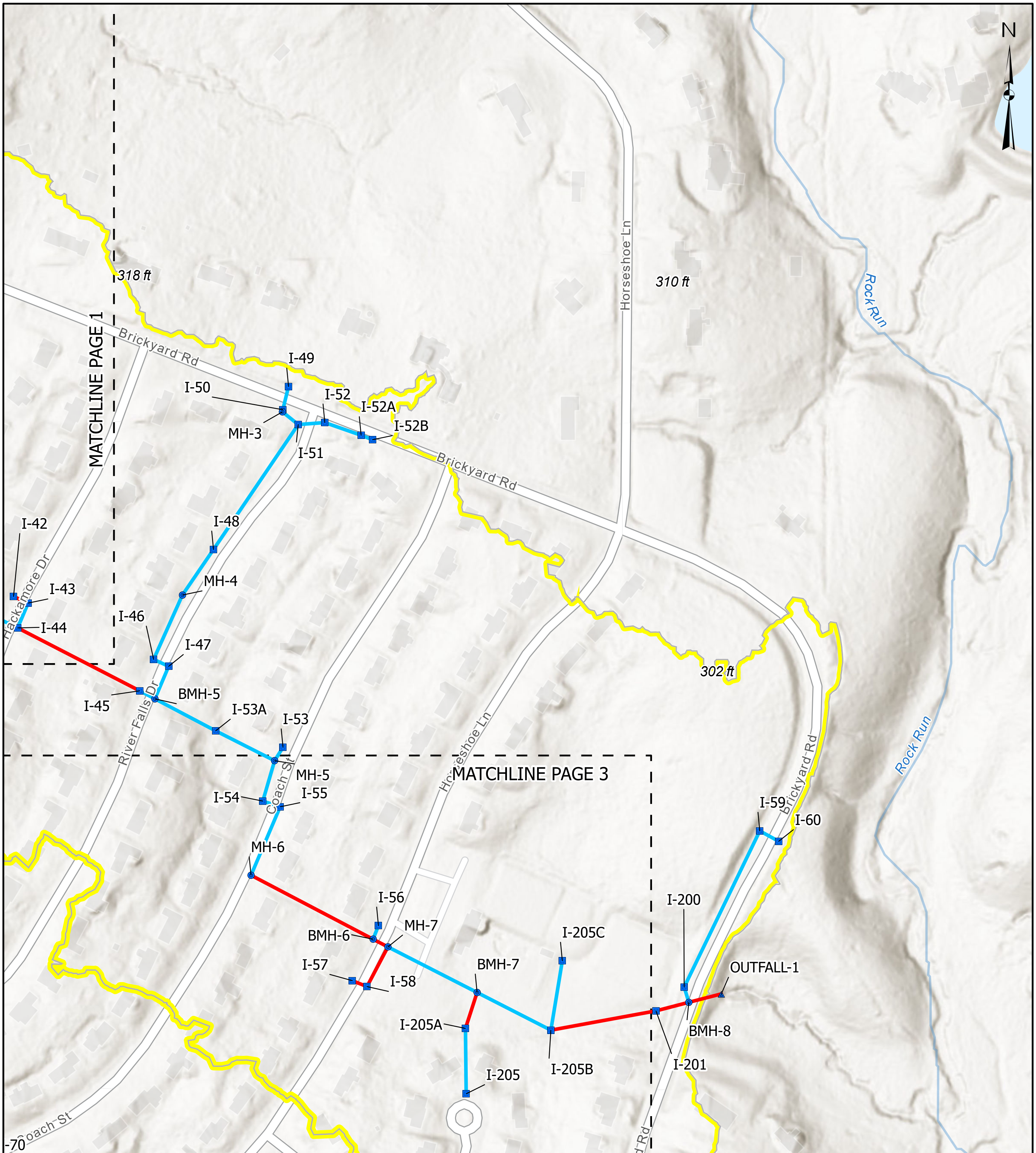

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PIPE INDIVIDUAL CAPACITY ANALYSIS

Pipes

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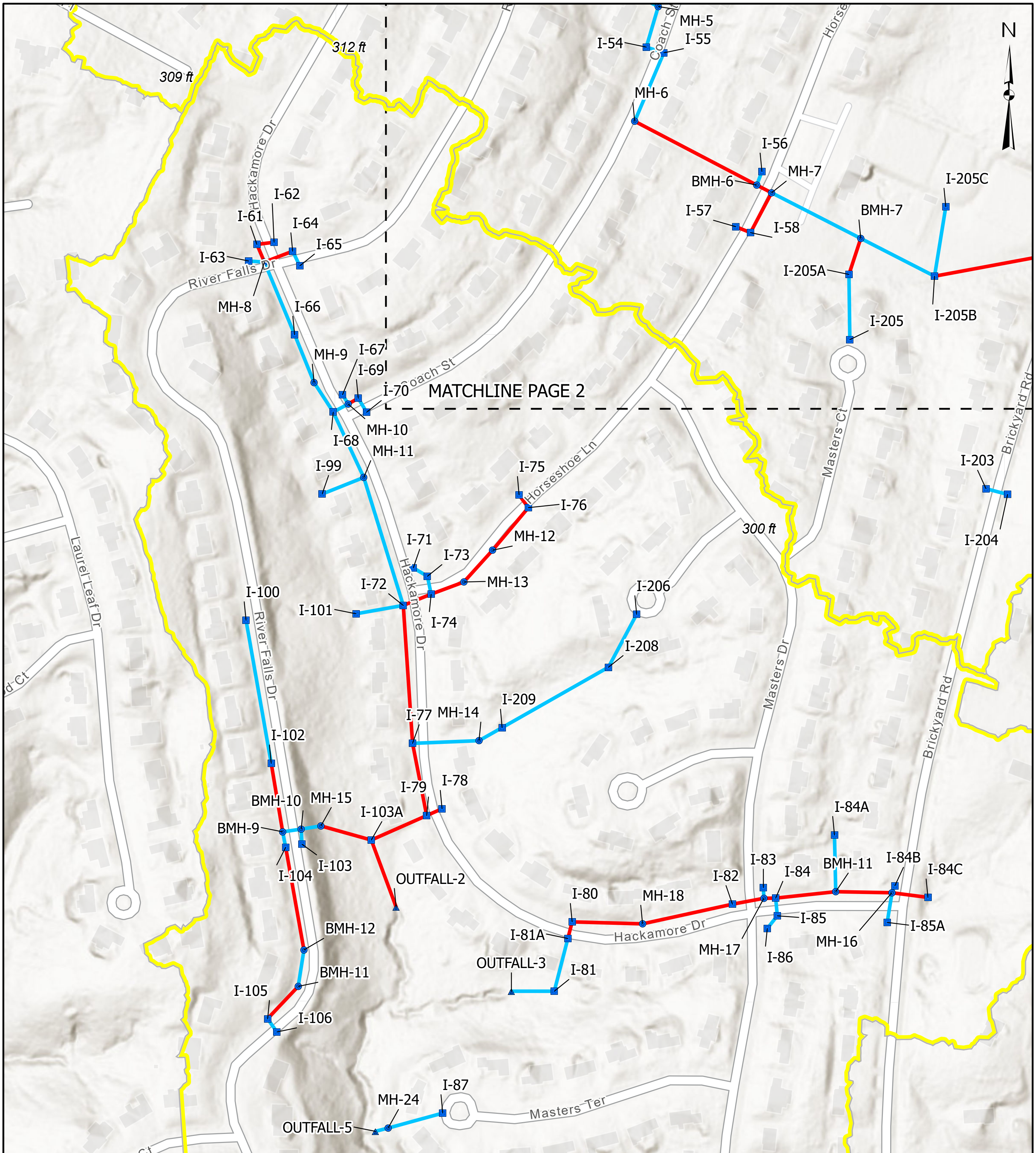

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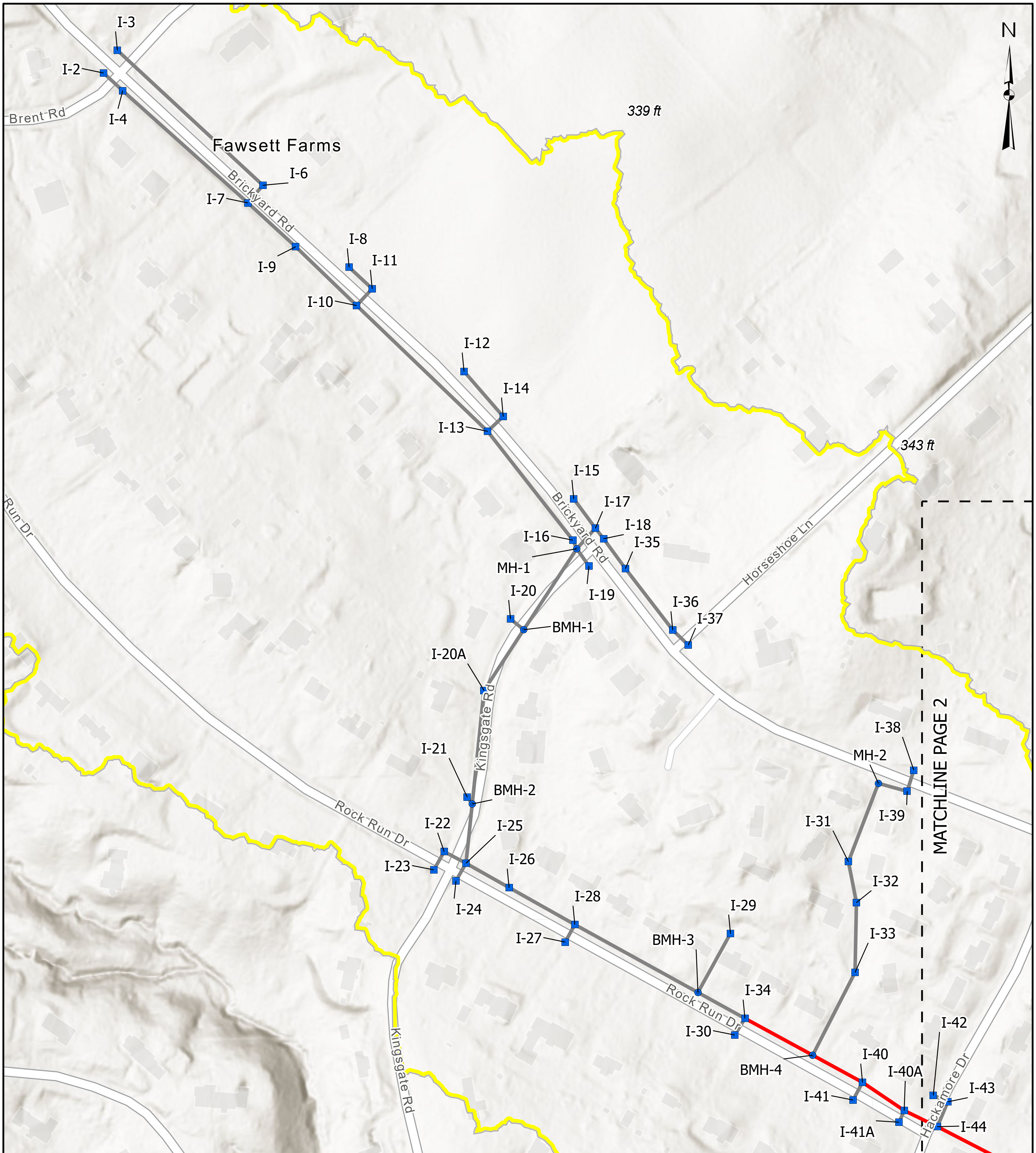

RIVER FALLS DRAINAGE STUDY

HYDRAULIC GRADE LINE (HGL) ANALYSIS

Pipes

- HGL below surface
- HGL above surface
- Not Analyzed

- Study Drainage Areas
- Inlet
- Manhole
- Outfall

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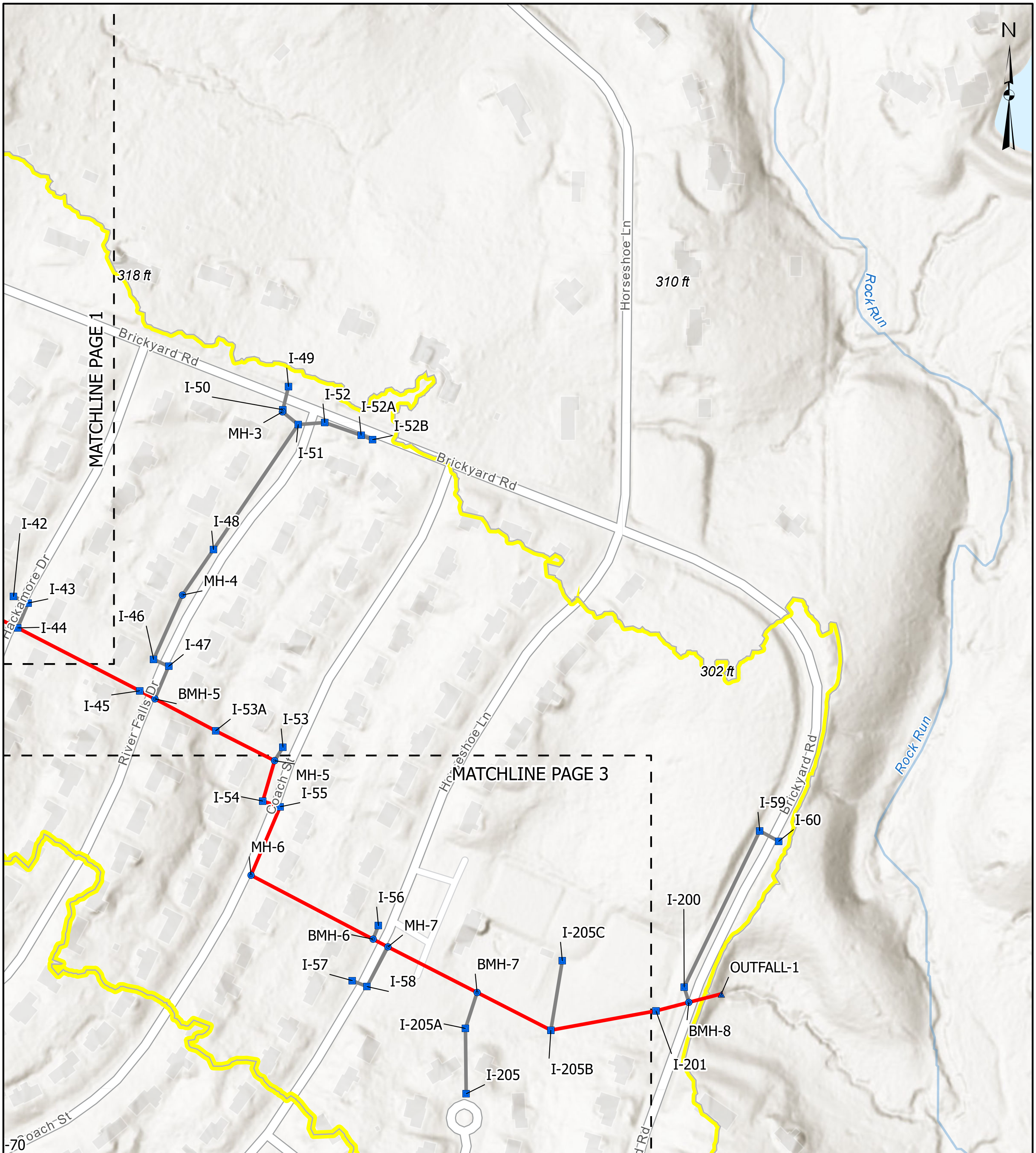

RIVER FALLS DRAINAGE STUDY

HYDRAULIC GRADE LINE (HGL) ANALYSIS

Pipes

- HGL below surface
- HGL above surface
- Not Analyzed

- Study Drainage Areas
- Inlet
- Manhole
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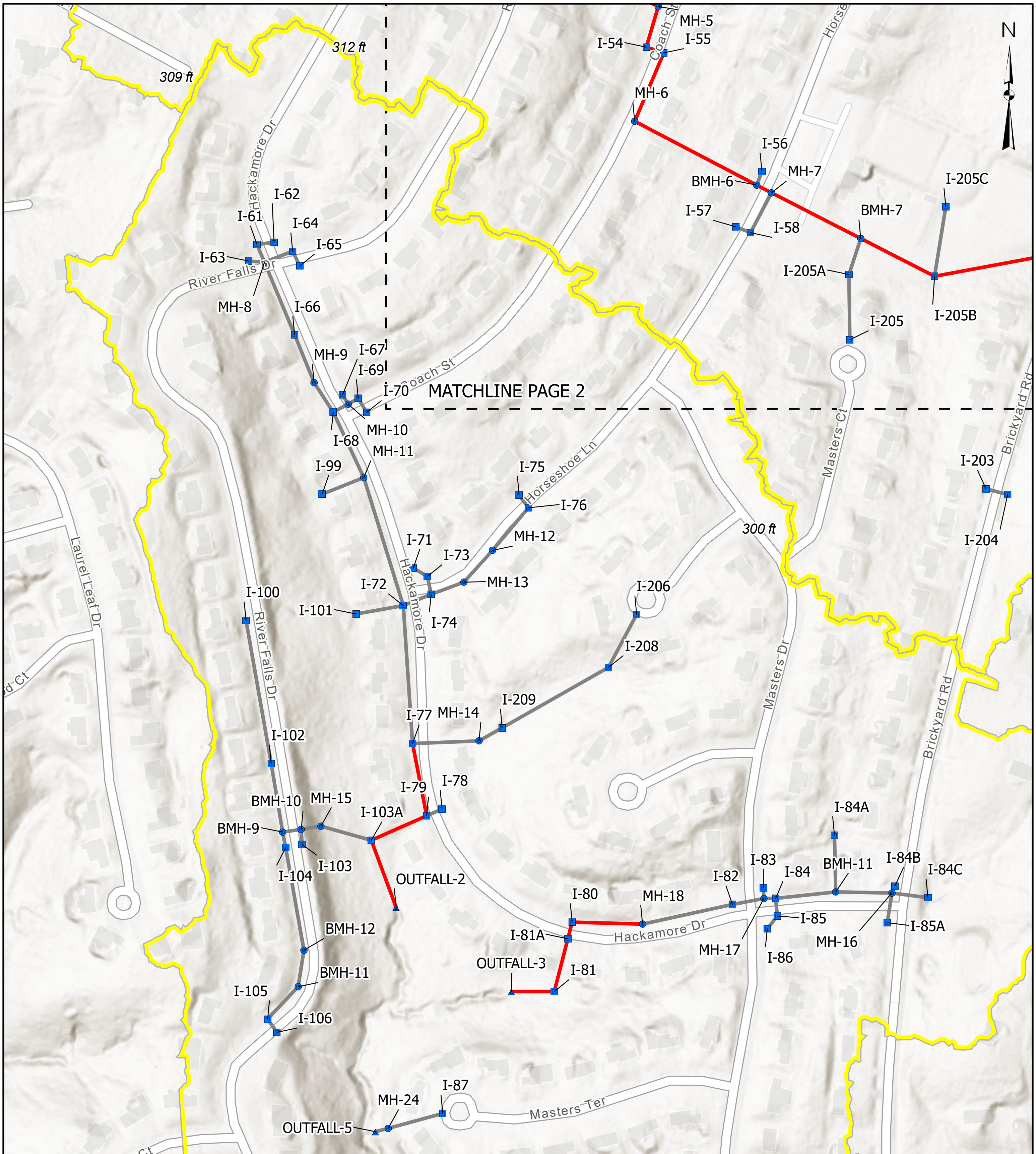

RIVER FALLS DRAINAGE STUDY

HYDRAULIC GRADE LINE (HGL) ANALYSIS

Pipes
- HGL below surface
- HGL above surface
- Not Analyzed

- Study Drainage Areas
- Inlet
- Manhole
- Outfall

GPI

Greenman-Pedersen, Inc.
11000 Broken Land Pkwy, Ste 500
Columbia, MD 21044
410-880-3055 www.gpinet.com

MCDOT

Prepared for:
Montgomery County
Department of Transportation
100 Edison Park Dr., 4th Floor
Gaithersburg, MD 20878

RIVER FALLS DRAINAGE STUDY

HYDRAULIC GRADE LINE (HGL) ANALYSIS

Pipes

- HGL below surface
- HGL above surface
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- Study Drainage Areas
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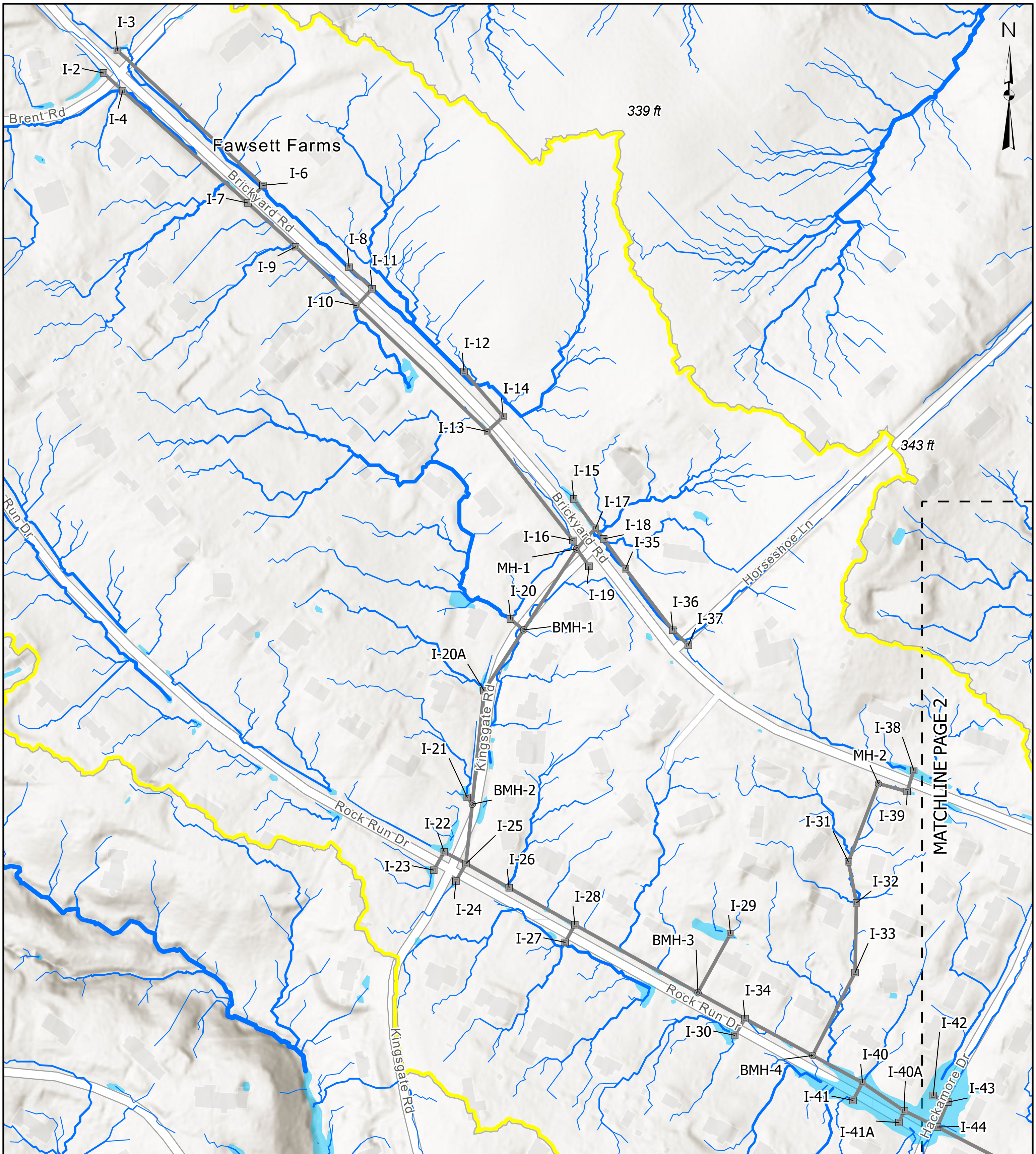

RIVER FALLS DRAINAGE STUDY

SURFACE FLOW AND SUMPS

▪	Inlet
◎	Manhole
▲	Outfall
— (gray line)	Pipe
Yellow outline	Study Drainage Areas
Light blue fill	Sumps (no surface drainage)
Blue line	Surface Flow Accumulation

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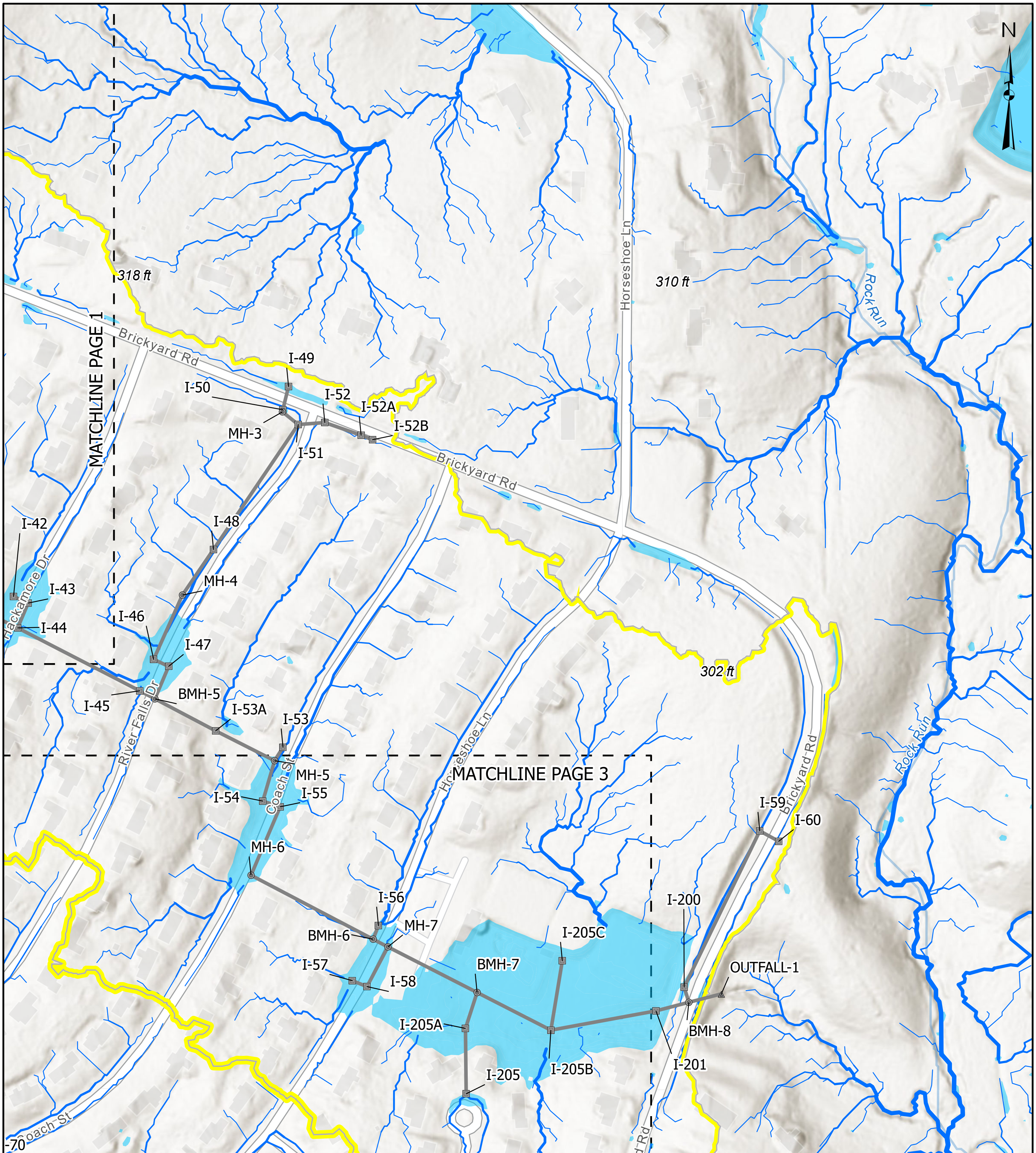

RIVER FALLS DRAINAGE STUDY

SURFACE FLOW AND SUMPS

- Inlet
- Manhole
- Outfall
- Pipe
- Study Drainage Areas
- Sumps (no surface drainage)
- Surface Flow Accumulation

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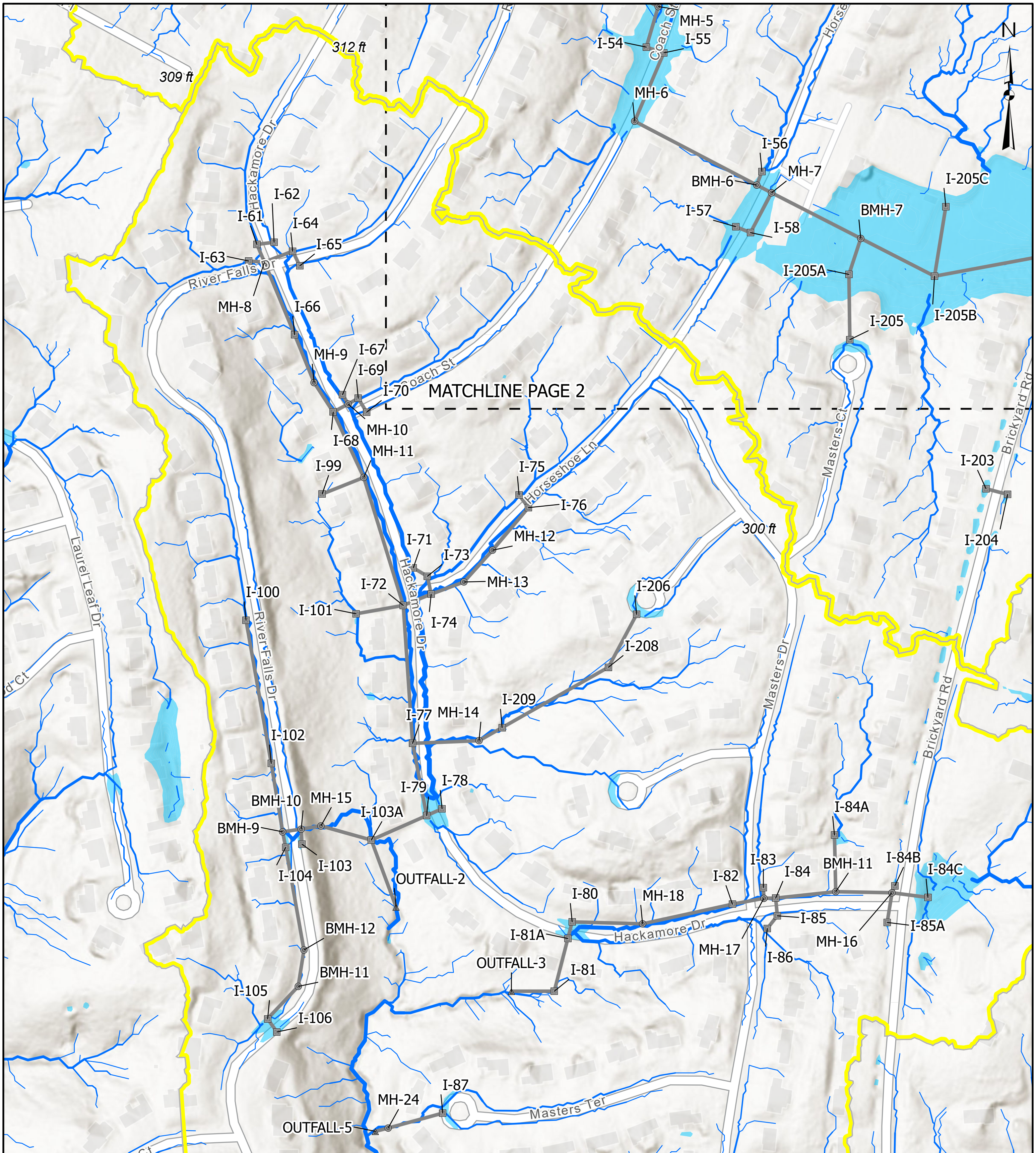

RIVER FALLS DRAINAGE STUDY

SURFACE FLOW AND SUMPS

- Inlet
- Manhole
- Outfall
- Pipe
- Study Drainage Areas
- Sumps (no surface drainage)
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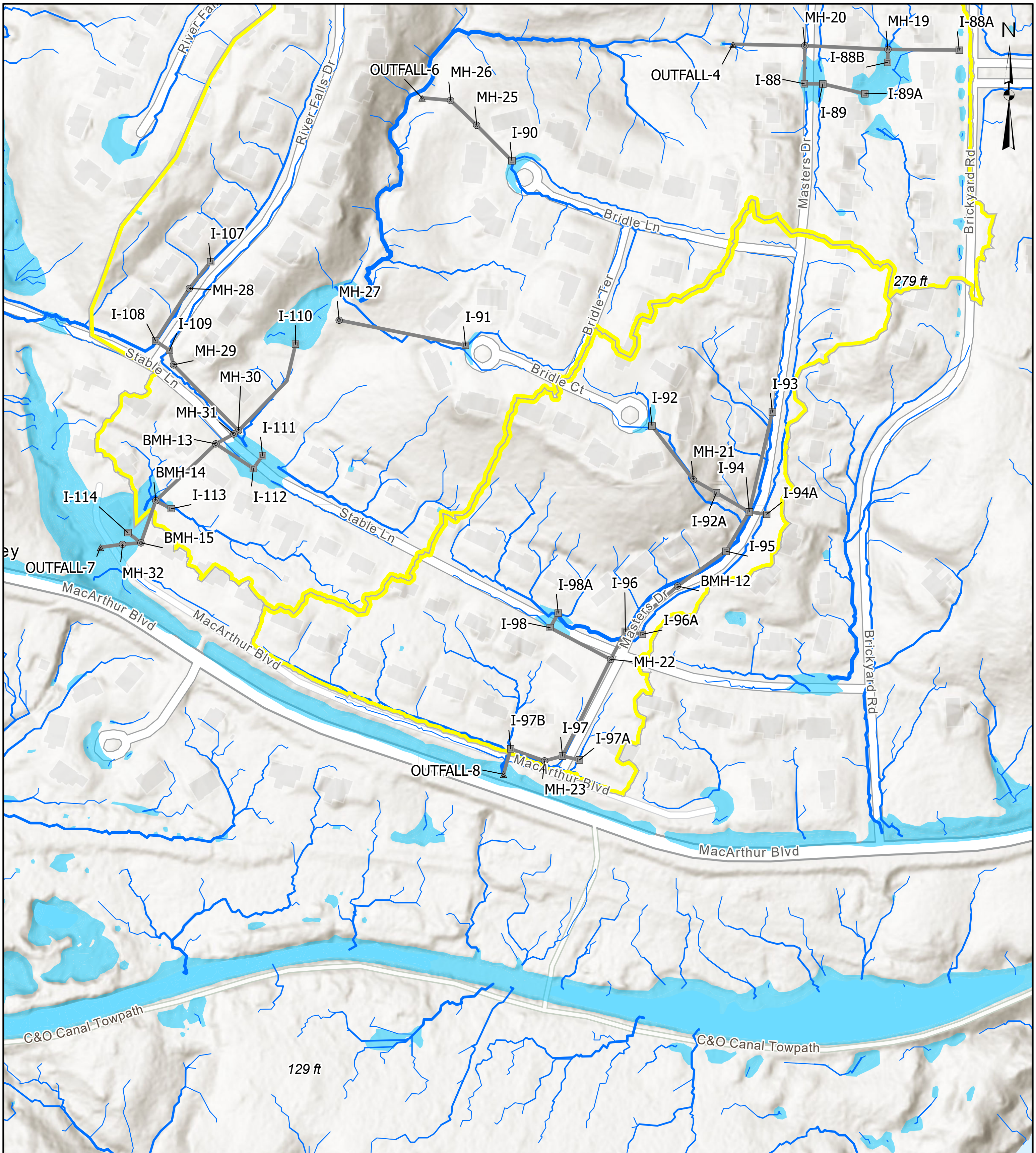

RIVER FALLS DRAINAGE STUDY

SURFACE FLOW AND SUMPS

- Inlet
- Manhole
- Outfall
- Pipe
- Study Drainage Areas
- Sumps (no surface drainage)
- Surface Flow Accumulation

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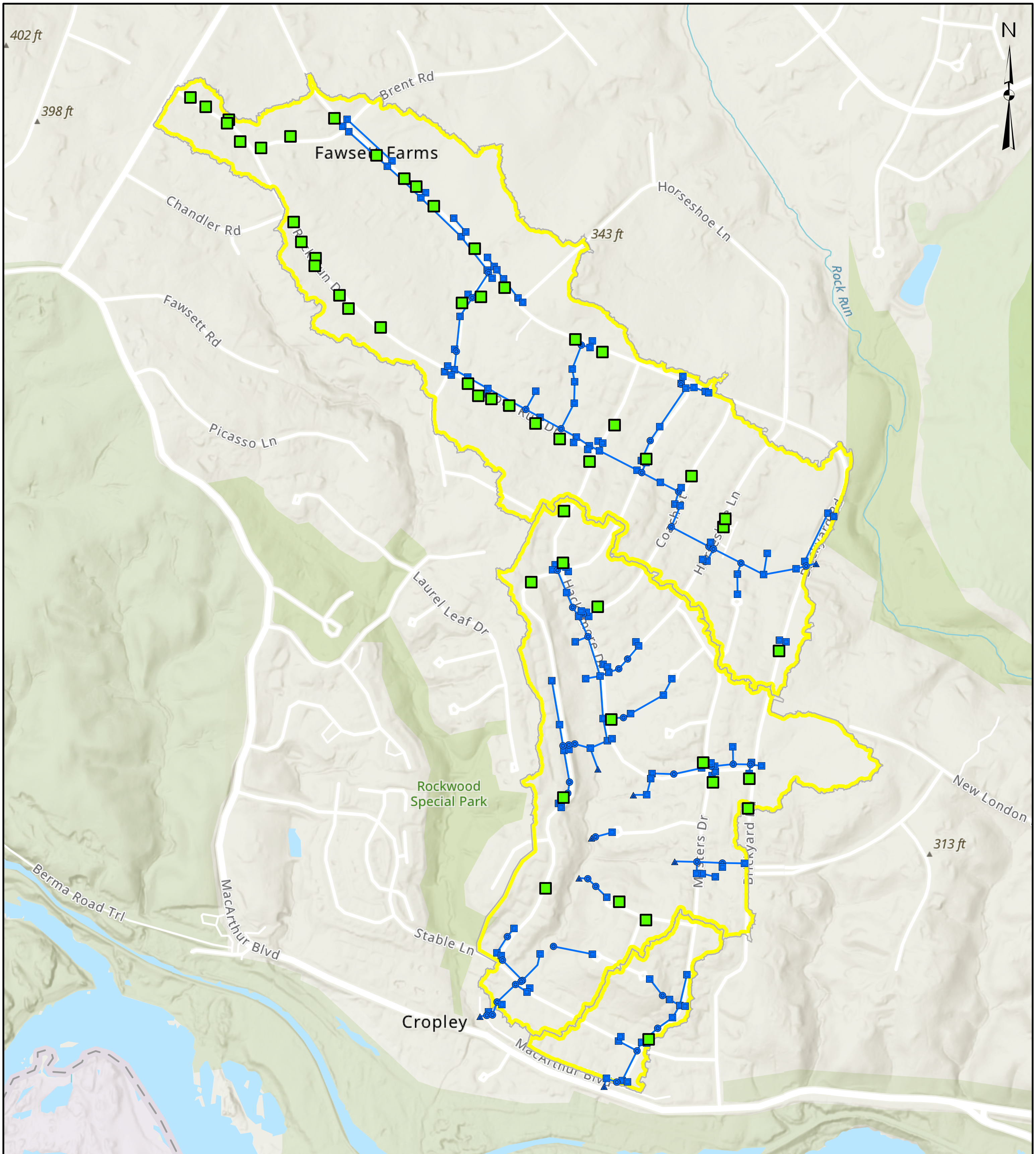
APPENDIX G:

POTENTIAL BMP LOCATION IN THE PROJECT SITE MAPS



RIVER FALLS DRAINAGE STUDY

PROPOSED BMP LOCATIONS

- Proposed BMP
- Study Drainage Areas
- Pipes
- Inlet
- Manhole
- Outfall

GPI

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APPENDIX H:

PROPOSED CLOSED STORM DRAIN COMPUTATIONS

Project Name:	Riverfalls Drainage Assessment	Owner/Client:	Montgomery County DOT		
GPI Project No:	2020031.00 Tsk 7	Calculated By:	AS	Date:	6/27/2022
Computation:	Storm Drain	Checked By:	MMR	Date:	6/29/2022

`

Storm Event: 10-Year

Manning's n for RCP	0.013
Manning's n for HDPE	0.010
Manning's n for CMP	0.024

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	TI pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX I-2	EX I-4		12.12	12.12	0.38	4.60	4.60	14.01	0.05	14.01	5.15	23.71	0.59	**8.42**	27	RCP	6.0	19.1	57.5
EX I-4	EX I-7		5.43	17.55	0.38	2.06	6.67	11.74	0.53	14.06	5.14	34.26	1.23	**1.99**	27	RCP	8.6	12.2	389.7
EX I-7	EX I-9		4.37	26.60	0.36	1.55	10.08	10.23	0.28	14.59	5.06	51.02	0.59	**1.10**	36	RCP	7.2	8.8	148.0
EX I-9	EX I-10		1.60	28.20	0.36	0.57	10.65	10.00	0.74	14.88	5.02	53.49	0.28	**0.55**	42	RCP	5.6	7.0	310.9
EX I-10	EX I-13		1.41	34.22	0.36	0.51	12.84	10.00	0.85	15.62	4.91	63.06	0.40	**0.76**	42	RCP	6.6	8.2	420.7
EX I-13	EX I-16		1.51	41.61	0.38	0.58	15.56	10.00	0.62	16.47	4.80	74.67	0.55	**0.83**	42	RCP	7.8	8.6	321.2
EX I-16	EX MH-1		0.32	41.92	0.46	0.15	15.70	10.00	0.01	17.09	4.72	74.11	0.55	**5.05**	42	RCP	7.7	21.1	18.6
EX MH-1	EX BMH-1		0.00	52.03	0.00	0.00	19.21	0.00	0.22	17.11	4.72	90.68	0.48	**1.40**	42	RCP	9.4	16.7	217.7
EX BMH-1	EX I-20A		0.00	60.84	0.00	0.00	22.34	0.00	0.44	17.32	4.69	104.78	3.72	**1.37**	42	RCP	10.9	6.6	176.3
EX I-20A	EX BMH-2		1.83	62.67	0.36	0.67	23.01	10.00	0.62	17.77	4.63	106.52	1.89	**1.00**	48	RCP	8.5	7.1	264.2
EX BMH-2	EX I-25		0.00	65.95	0.00	0.00	24.19	0.00	0.27	18.39	4.55	110.07	2.01	**1.18**	48	RCP	8.8	8.3	133.2
EX I-25	EX I-26		2.12	85.88	0.41	0.86	31.82	5.91	0.09	18.66	4.52	143.83	0.60	**1.52**	48	HDPE	11.4	19.3	106.8
EX I-26	EX I-28		2.15	88.03	0.38	0.82	32.64	12.35	0.15	18.75	4.51	147.21	0.63	**1.43**	48	HDPE	11.7	19.0	174.6
EX I-28	EX BMH-3		1.71	92.76	0.38	0.65	34.44	10.00	0.39	18.90	4.49	154.64	1.17	**1.18**	48	RCP	12.3	14.2	328.7
EX BMH-3	EX I-34		0.00	93.77	0.00	0.00	34.80	0.00	0.14	19.29	4.45	154.85	1.17	**1.24**	48	RCP	12.3	14.5	121.5
EX I-34	EX BMH-4		5.52	104.47	0.38	2.09	38.80	9.59	0.25	19.43	4.43	171.89	0.77	**1.00**	54	RCP	10.8	11.4	173.1
EX BMH-4	EX I-40		0.00	113.19	0.00	0.00	42.10	0.00	0.21	19.68	4.41	185.67	0.90	**0.93**	54	RCP	11.7	11.0	137.1
EX I-40	EX I-40A		1.40	120.91	0.38	0.53	44.89	10.00	0.10	19.89	4.38	196.63	1.01	**2.05**	54	RCP	12.4	19.2	112.0
EX I-40A	EX I-44		0.31	122.32	0.48	0.15	45.55	10.00	0.10	19.99	4.37	199.04	0.59	**0.71**	60	RCP	10.1	12.7	78.5
EX I-44	EX I-45		0.88	126.77	0.47	0.41	47.56	10.00	0.61	20.09	4.36	207.36	0.38	**0.42**	66	RCP	8.7	8.6	314.1
EX I-45	EX BMH-5		3.37	130.15	0.41	1.39	48.95	9.86	0.03	20.70	4.29	210.01	0.39	**2.37**	66	RCP	8.8	20.7	33.3
EX BMH-5	EX MH-5		0.00	138.84	0.00	0.00	52.68	0.00	0.29	20.72	4.29	225.99	0.46	**1.73**	66	RCP	9.5	18.6	319.8
EX MH-5	EX I-54		0.00	142.93	0.00	0.00	54.29	0.00	0.10	21.01	4.26	231.26	0.48	**1.24**	66	RCP	9.7	16.4	94.4
EX I-54	EX I-55		4.47	147.40	0.41	1.85	56.14	10.01	0.04	21.11	4.25	238.58	0.51	**1.09**	66	RCP	10.0	15.6	39.4
EX I-55	EX MH-6		5.03	152.43	0.43	2.14	58.28	11.99	0.22	21.15	4.25	247.69	0.55	**0.63**	66	RCP	10.4	12.7	165.8
EX MH-6	EX BMH-6		0.00	152.43	0.00	0.00	58.28	0.00	0.57	21.37	4.22	245.95	0.34	**0.42**	72	RCP	8.7	9.4	318.9
EX BMH-6	EX MH-7		0.00	155.96	0.00	0.00	59.77	0.00	0.07	21.93	4.17	249.23	0.35	**0.45**	72	RCP	8.8	9.2	40.3
EX MH-7	EX BMH-7		0.00	161.99	0.00	0.00	62.36	0.00	0.22	22.01	4.16	259.44	0.38	**1.39**	72	RCP	9.2	17.8	232.9
EX BMH-7	EX I-205B		0.00	166.56	0.00	0.00	64.33	0.00	0.18	22.22	4.14	266.31	0.40	**1.40**	72	RCP	9.4	17.9	191.4
EX I-205B	EX I-201		5.82	173.25	0.39	2.25	66.88	10.93	0.43	22.40	4.12	275.55	0.28	**0.41**	78	RCP	8.3	9.6	246.6
EX I-201	EX BMH-8		12.15	185.40	0.38	4.58	71.46	15.10	0.21	22.83	4.08	291.55	0.10	**0.15**	96	RCP	5.8	5.8	72.5
EX BMH-8	OUTFALL 1		0.00	190.76	0.00	0.00	73.81	0.00	0.23	23.04	4.06	299.68	0.11	**0.15**	96	RCP	6.0	5.8	81.4

Legend

x.xx	Actual pipe slope is adequate for flow to pipe
x.xx	Actual pipe slope is not adequate for flow to pipe
*	Actual velocity from flowmaster
x.xx	Pipe slope set to S minimum since pipe has reverse slope
x.xx	Proposed pipe size to convey flow

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	TI pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX I-3	EX I-6		1.32	1.32	0.44	0.58	0.58	10.00	1.12	10.00	5.85	3.38	0.27	**1.98**	15	RCP	2.8	6.9	461.2
EX I-6	EX I-7		3.36	4.68	0.38	1.29	1.86	8.41	0.25	11.12	5.64	10.50	1.00	**0.32**	18	RCP	5.9	3.4	50.0
EX I-8	EX I-11		2.10	2.10	0.37	0.79	0.79	8.87	0.20	8.87	6.09	4.79	0.55	**1.17**	15	RCP	3.9	6.2	72.0
EX I-11	EX I-10		2.50	4.60	0.36	0.89	1.68	9.78	0.16	9.78	5.90	9.88	2.35	**1.10**	15	RCP	8.1	5.5	52.5
EX I-12	EX I-14		3.01	3.01	0.37	1.11	1.11	13.16	0.32	13.16	5.28	5.87	0.83	**0.83**	15	RCP	4.8	5.5	104.0
EX I-14	EX I-13		2.87	5.88	0.36	1.02	2.13	11.81	0.10	13.48	5.23	11.16	0.50	**1.92**	21	RCP	4.6	8.9	51.0
EX I-15	EX I-17		1.81	1.81	0.37	0.67	0.67	10.00	0.32	10.00	5.85	3.92	0.37	**0.55**	15	RCP	3.2	4.4	83.5
EX I-17	EX MH-1		0.75	9.35	0.36	0.27	3.51	10.00	0.08	13.23	5.27	18.50	1.37	**4.43**	21	RCP	7.7	14.3	64.5
EX I-37	EX I-36		2.02	2.02	0.38	0.78	0.78	12.55	0.12	12.55	5.39	4.19	0.42	**1.65**	15	RCP	3.4	6.8	50.2
EX I-36	EX I-35		1.35	3.37	0.43	0.58	1.35	10.00	0.33	12.67	5.37	7.27	1.27	**2.61**	15	RCP	5.9	9.2	179.5
EX I-35	EX I-18		1.74	5.11	0.36	0.62	1.98	10.00	0.13	13.00	5.31	10.50	2.66	**3.06**	15	RCP	8.6	10.5	83.4
EX I-18	EX I-17		1.68	6.79	0.35	0.59	2.57	10.00	0.10	13.13	5.29	13.59	4.45	**0.93**	15	RCP	11.1	5.1	29.1
EX I-19	EX MH-1		0.76	0.76	0.46	0.35	0.35	10.00	0.10	10.00	5.85	2.03	0.10	**5.34**	15	RCP	1.7	8.5	49.4
EX I-20	EX BMH-1		8.81	8.81	0.36	3.13	3.13	11.65	0.05	11.65	5.54	17.34	0.18	**3.15**	30	RCP	3.5	12.2	39.0
EX I-21	EX BMH-2		3.27	3.27	0.36	1.18	1.18	12.03	0.04	12.03	5.47	6.48	1.30	**6.60**	18	CMP	3.7	8.0	20.0
EX I-23	EX I-22		8.56	8.56	0.38	3.23	3.23	13.34	0.19	13.34	5.26	17.01	0.22	**0.63**	36	CMP	2.4	4.2	49.2
EX I-22	EX I-25		9.00	17.56	0.38	3.42	6.65	12.71	0.16	13.53	5.23	34.79	0.41	**0.62**	42	CMP	3.6	5.0	46.6
EX I-24	EX I-25		0.25	0.25	0.47	0.12	0.12	10.00	0.22	10.00	5.85	0.69	0.04	**3.20**	15	CMP	0.6	3.4	44.7
EX I-27	EX I-28		3.02	3.02	0.38	1.15	1.15	9.95	0.09	9.95	5.86	6.73	3.72	**2.33**	15	RCP	5.5	8.7	46.0
EX I-29	EX BMH-3		1.01	1.01	0.35	0.36	0.36	10.00	0.35	10.00	5.85	2.09	0.36	**3.51**	15	RCP	1.7	7.4	156.5
EX I-38	EX I-39		4.59	4.59	0.38	1.75	1.75	10.23	0.27	10.23	5.81	10.16	1.41	**0.90**	21	CMP	4.2	3.2	51.1
EX I-39	EX MH-2		1.19	5.79	0.44	0.53	2.28	10.00	0.15	10.50	5.76	13.11	1.56	**1.44**	18	RCP	7.4	7.1	66.0
EX MH-2	EX I-31		0.00	5.79	0.00	0.00	2.28	0.00	0.25	10.65	5.72	13.02	1.54	**4.40**	18	RCP	7.4	13.0	193.2
EX I-31	EX I-32		1.25	7.04	0.35	0.44	2.71	10.00	0.11	10.90	5.68	15.42	2.16	**5.08**	18	RCP	8.7	14.3	97.3
EX I-32	EX I-33		1.09	8.13	0.35	0.38	3.10	10.00	0.30	11.01	5.66	17.52	2.79	**2.20**	18	RCP	9.9	8.8	158.3
EX I-33	EX BMH-4		0.59	8.71	0.35	0.21	3.30	10.00	0.25	11.31	5.60	18.48	3.11	**5.20**	18	RCP	10.5	15.0	224.6
EX I-30	EX I-34		5.19	5.19	0.37	1.91	1.91	10.58	0.06	10.58	5.74	10.98	2.90	**4.49**	15	RCP	8.9	12.4	44.8
EX I-41	EX I-40		6.32	6.32	0.36	2.26	2.26	10.30	0.07	10.30	5.79	13.09	1.56	**2.33**	18	RCP	7.4	10.1	45.5
EX I-41A	EX I-40A		1.10	1.10	0.46	0.51	0.51	10.00	0.07	10.00	5.85	2.96	0.21	**1.95**	15	RCP	2.4	6.6	27.2
EX I-42	EX I-43		2.49	2.49	0.43	1.07	1.07	10.00	0.12	10.00	5.85	6.23	0.93	**0.81**	15	RCP	5.1	5.3	37.3
EX I-43	EX I-44		1.09	3.58	0.49	0.53	1.60	10.00	0.13	10.12	5.83	9.32	0.35	**0.98**	21	RCP	3.9	6.8	54.0
EX I-49	EX I-50		0.66	0.66	0.47	0.31	0.31	10.00	0.21	10.00	5.85	1.84	0.08	**0.88**	15	RCP	1.5	4.3	55.6
EX I-50	EX MH-3		0.44	1.10	0.46	0.20	0.52	10.00	0.00	10.21	5.81	3.01	0.22	**7.80**	15	RCP	2.5	11.3	2.2
EX MH-3	EX I-51		0.00	1.10	0.00	0.00	0.52	0.00	0.18	10.22	5.81	3.01	0.22	**0.60**	15	RCP	2.5	4.3	45.2

Legend

x.xx	Actual pipe slope is adequate for flow to pipe
x.xx	Actual pipe slope is not adequate for flow to pipe
*	Actual velocity from flowmaster
x.xx	Pipe slope set to S minimum since pipe has reverse slope
x.xx	Proposed pipe size to convey flow

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	TI pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX I-51	EX I-48		0.13	1.92	0.64	0.08	0.91	7.00	0.54	10.39	5.78	5.25	0.66	**4.78**	15	RCP	4.3	10.7	345.1
EX I-48	EX MH-4		2.24	4.15	0.38	0.86	1.77	10.18	0.18	10.93	5.67	10.01	2.41	**3.83**	15	RCP	8.2	11.4	121.0
EX MH-4	EX I-46		0.00	4.15	0.00	0.00	1.77	0.00	0.28	11.11	5.64	9.96	2.39	**2.47**	15	RCP	8.1	9.4	159.3
EX I-46	EX I-47		2.09	6.24	0.38	0.80	2.57	7.91	0.08	11.39	5.59	14.36	0.83	**1.07**	21	RCP	6.0	7.7	36.4
EX I-47	EX BMH-5		2.45	8.70	0.47	1.16	3.73	8.78	0.10	11.47	5.58	20.79	0.45	**3.15**	27	RCP	5.2	12.9	79.4
EX I-52	EX I-51		0.69	0.69	0.45	0.31	0.31	10.00	0.20	10.00	5.85	1.81	0.08	**1.21**	15	RCP	1.5	4.8	57.0
EX I-53	EX MH-5		4.09	4.09	0.39	1.61	1.61	8.34	0.04	8.34	6.21	9.98	2.40	**6.55**	15	RCP	8.1	14.1	35.8
EX I-56	EX BMH-6		3.53	3.53	0.42	1.49	1.49	10.19	0.06	10.19	5.81	8.64	0.68	**3.18**	18	RCP	4.9	10.4	34.5
EX I-57	EX I-58		2.96	2.96	0.39	1.17	1.17	7.80	0.22	7.80	6.33	7.39	0.50	**0.22**	18	RCP	4.2	2.8	36.8
EX I-58	EX MH-7		3.07	6.03	0.47	1.43	2.60	8.70	0.31	8.70	6.13	15.92	0.27	0.27	27	RCP	4.0	5.3	98.6
EX I-205	EX I-205A		2.84	2.84	0.46	1.29	1.29	9.68	0.18	9.68	5.92	7.67	1.41	**7.52**	15	RCP	6.2	13.9	148.8
EX I-205A	EX BMH-7		1.73	4.57	0.39	0.67	1.96	10.00	0.17	10.00	5.85	11.48	3.17	**2.83**	15	RCP	9.4	8.9	87.7
EX I-205C	EX I-205B		0.87	0.87	0.36	0.31	0.31	10.00	0.45	10.00	5.85	1.81	0.08	**2.16**	15	RCP	1.5	6.0	159.9
EX I-200	EX BMH-8		5.36	5.36	0.44	2.36	2.36	21.73	0.03	21.73	4.19	9.87	0.89	**15.90**	18	RCP	5.6	19.6	37.0

Legend

x.xx	Actual pipe slope is adequate for flow to pipe
x.xx	Actual pipe slope is not adequate for flow to pipe
*	Actual velocity from flowmaster
x.xx	Pipe slope set to S minimum since pipe has reverse slope
x.xx	Proposed pipe size to convey flow

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	TI pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX I-62	EX I-61		1.25	1.25	0.44	0.55	0.55	10.00	0.19	10.00	5.85	3.22	0.25	0.25	15	RCP	2.6	3.5	39.0
EX I-61	EX MH-8		2.04	3.29	0.41	0.84	1.39	8.79	0.12	10.19	5.81	8.09	0.60	0.60	18	RCP	4.6	6.1	44.8
EX MH-8	EX I-66		0.00	8.22	0.00	0.00	3.49	0.00	0.20	10.36	5.78	20.16	1.63	**4.42**	21	RCP	8.4	14.5	175.5
EX I-66	EX MH-9		1.34	9.56	0.47	0.63	4.12	10.00	0.12	10.56	5.74	23.66	2.24	**5.22**	21	RCP	9.8	16.0	113.6
EX MH-9	EX I-68		0.00	9.56	0.00	0.00	4.12	0.00	0.09	10.68	5.72	23.57	2.22	**4.08**	21	RCP	9.8	14.6	78.7
EX I-68	EX MH-11		0.44	14.10	0.50	0.22	6.13	10.00	0.14	10.77	5.71	35.00	2.41	**4.54**	24	RCP	11.1	19.5	164.7
EX MH-11	EX I-72		0.00	15.51	0.00	0.00	6.65	0.00	0.30	10.91	5.68	37.78	2.80	**4.46**	24	RCP	12.0	17.3	308.2
EX I-72	EX I-77		0.76	29.24	0.55	0.41	12.87	10.00	0.46	11.21	5.63	72.48	1.19	**1.84**	36	RCP	10.3	11.3	311.9
EX I-77	EX I-79		2.57	38.09	0.47	1.20	16.88	13.46	0.29	13.46	5.24	88.46	0.38	**1.03**	48	RCP	7.0	9.6	165.4
EX I-79	EX I-103A		0.87	43.42	0.57	0.49	19.53	5.00	0.21	13.75	5.19	101.36	0.50	**1.40**	48	RCP	8.1	11.2	138.9
EX I-103A	OUTFALL 2		0.78	53.27	0.47	0.36	24.33	10.00	0.24	13.96	5.16	125.55	0.77	**1.21**	48	RCP	10.0	11.5	166.6
EX I-65	EX I-64		1.24	1.24	0.45	0.56	0.56	10.00	0.11	10.00	5.85	3.26	0.26	**1.11**	15	RCP	2.7	5.5	37.9
EX I-64	EX MH-8		2.08	3.32	0.42	0.88	1.44	10.03	0.24	10.11	5.83	8.38	1.69	**0.70**	15	RCP	6.8	4.4	64.1
EX I-63	EX MH-8		1.62	1.62	0.41	0.66	0.66	10.00	0.11	10.00	5.85	3.85	0.14	**0.94**	18	RCP	2.2	5.4	36.1
EX I-70	EX I-69		1.05	1.05	0.50	0.53	0.53	10.00	0.10	10.00	5.85	3.09	0.23	**1.49**	15	RCP	2.5	5.9	36.9
EX I-69	EX MH-10		2.17	3.22	0.39	0.84	1.37	7.08	0.06	10.10	5.83	8.00	1.54	**1.34**	15	RCP	6.5	6.1	23.2
EX MH-10	EX I-68		0.00	4.09	0.00	0.00	1.79	0.00	0.06	10.17	5.82	10.40	0.98	**2.82**	18	RCP	5.9	10.4	36.5
EX I-67	EX MH-10		0.87	0.87	0.48	0.41	0.41	10.00	0.04	10.00	5.85	2.42	0.14	**6.76**	15	RCP	2.0	9.7	24.7
EX I-99	EX MH-11		1.41	1.41	0.37	0.52	0.52	10.00	0.41	10.00	5.85	3.05	0.22	**0.59**	15	RCP	2.5	4.3	103.5
EX I-75	EX I-76		2.78	2.78	0.43	1.19	1.19	7.71	0.67	7.71	6.35	7.55	1.37	**0.03**	15	RCP	6.1	0.9	36.5
EX I-76	EX MH-12		3.55	6.33	0.46	1.63	2.82	8.22	0.17	8.38	6.20	17.48	2.78	**5.37**	18	RCP	9.9	12.2	124.8
EX MH-12	EX MH-13		0.00	6.33	0.00	0.00	2.82	0.00	0.15	8.55	6.16	17.37	2.75	**4.06**	18	RCP	9.8	10.6	97.9
EX MH-13	EX I-74		0.00	6.33	0.00	0.00	2.82	0.00	0.12	8.70	6.13	17.28	2.72	**3.42**	18	RCP	9.8	9.7	72.3
EX I-74	EX I-72		2.30	11.05	0.47	1.08	5.04	5.47	0.11	10.21	5.81	29.30	0.51	**1.50**	30	RCP	6.0	10.1	65.3
EX I-101	EX I-72		1.92	1.92	0.40	0.76	0.76	10.00	0.29	10.00	5.85	4.47	0.48	**1.13**	15	RCP	3.6	6.2	109.9
EX I-71	EX I-73		0.90	0.90	0.51	0.46	0.46	10.00	0.13	10.00	5.85	2.70	0.18	**0.99**	15	RCP	2.2	5.0	38.4
EX I-73	EX I-74		1.52	2.42	0.45	0.68	1.14	10.00	0.08	10.13	5.83	6.65	1.07	**1.77**	15	RCP	5.4	7.7	37.3
EX I-206	EX I-208		1.40	1.40	0.51	0.71	0.71	10.00	0.26	10.00	5.85	4.14	0.41	**3.44**	15	RCP	3.4	8.9	140.0
EX I-208	EX I-209		0.31	1.71	0.41	0.13	0.83	10.00	0.36	10.26	5.80	4.83	0.56	**8.61**	15	RCP	3.9	12.9	278.0
EX I-209	EX MH-14		3.52	6.29	0.41	1.45	2.81	8.02	0.07	10.62	5.73	16.09	1.04	**5.77**	21	RCP	6.7	15.2	61.8
EX MH-14	EX I-77		0.00	6.29	0.00	0.00	2.81	0.00	0.24	10.69	5.72	16.06	1.03	**2.12**	21	RCP	6.7	10.4	150.7
EX I-207	EX I-209		1.06	1.06	0.50	0.53	0.53	10.00	0.35	10.00	5.85	3.09	0.23	**13.85**	15	RCP	2.5	13.5	280.2
EX I-78	EX I-79		4.45	4.45	0.48	2.16	2.16	5.44	0.11	5.44	6.94	14.96	5.38	**1.13**	15	RCP	12.2	5.6	36.1
EX I-100	EX I-102		2.36	2.36	0.45	1.07	1.07	5.00	0.54	5.00	7.07	7.57	1.38	**3.55**	15	RCP	6.2	10.5	338.9
EX I-102	EX BMH-9		1.19	3.55	0.46	0.54	1.61	10.00	0.45	10.00	5.85	9.45	0.81	**1.27**	18	RCP	5.3	5.9	161.4
EX BMH-9	EX BMH-10		0.00	8.11	0.00	0.00	3.79	0.00	0.04	10.45	5.76	21.81	1.90	**5.56**	21	RCP	9.1	15.8	36.0
EX BMH-10	EX MH-15		0.00	9.07	0.00	0.00	4.44	0.00	0.02	10.49	5.76	25.55	2.61	**29.35**	21	RCP	10.6	31.1	46.0

Legend

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x.xx	Pipe slope set to S minimum since pipe has reverse slope
x.xx	Proposed pipe size to convey flow

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	TI pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX MH-15	EX-103A		0.00	9.07	0.00	0.00	4.44	0.00	0.12	10.52	5.75	25.50	2.60	**10.02**	21	RCP	10.6	16.7	117.8
EX I-106	EX I-105		0.45	0.45	0.66	0.30	0.30	7.00	0.12	7.00	6.52	1.93	0.09	**1.13**	15	RCP	1.6	5.0	37.1
EX I-105	EX BMH-11		2.09	2.53	0.45	0.94	1.24	7.01	0.38	7.12	6.49	8.02	0.26	**0.56**	21	RCP	3.3	4.5	100.6
EX BMH-11	EX BMH-12		0.00	2.53	0.00	0.00	1.24	0.00	0.27	7.50	6.40	7.91	0.25	**0.60**	21	RCP	3.3	5.3	84.8
EX BMH-12	EX I-104		0.00	2.53	0.00	0.00	1.24	0.00	1.31	7.77	6.34	7.83	0.25	**0.27**	21	RCP	3.3	3.1	243.7
EX I-104	EX BMH-9		2.03	4.56	0.46	0.94	2.17	5.71	0.06	9.08	6.04	13.12	0.69	**1.84**	21	RCP	5.5	9.2	33.2
EX I-103	EX BMH-10		0.96	0.96	0.67	0.65	0.65	7.00	0.06	7.00	6.52	4.23	0.43	**3.39**	15	RCP	3.4	8.9	29.5

Legend

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x.xx	Pipe slope set to S minimum since pipe has reverse slope
x.xx	Proposed pipe size to convey flow

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	TI pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX I-84C	EX MH-16		11.44	11.44	0.40	4.61	4.61	9.76	0.14	9.76	5.90	27.21	1.45	**2.23**	24	RCP	8.7	9.8	83.4
EX MH-16	EX BMH-11		0.00	12.65	0.00	0.00	5.16	0.00	0.23	10.15	5.82	30.05	1.77	**2.22**	24	RCP	9.6	9.8	135.0
EX BMH-11	EX I-84		0.00	14.63	0.00	0.00	5.89	0.00	0.23	10.38	5.78	34.03	0.69	**1.78**	30	RCP	6.9	9.6	135.0
EX I-84	EX MH-17		0.68	17.58	0.48	0.33	7.25	10.00	0.04	10.61	5.73	41.56	1.03	**1.76**	30	RCP	8.5	9.6	22.8
EX MH-17	EX I-82		0.00	19.16	0.00	0.00	8.00	0.00	0.09	10.65	5.73	45.85	1.26	**3.10**	30	RCP	9.3	12.7	69.7
EX I-82	EX MH-18		1.63	20.79	0.49	0.81	8.81	10.00	0.22	10.75	5.71	50.30	1.51	**4.80**	30	RCP	10.2	15.8	209.6
EX MH-18	EX I-80		0.00	20.79	0.00	0.00	8.81	0.00	0.20	10.97	5.67	49.95	1.49	**3.53**	30	RCP	10.2	13.5	158.6
EX I-80	EX I-81A		1.72	22.52	0.46	0.79	9.60	10.00	0.05	11.16	5.63	54.04	1.75	**2.97**	30	RCP	11.0	13.4	36.4
EX I-81A	EX I-81		2.48	24.99	0.50	1.24	10.84	6.31	0.11	11.21	5.62	60.92	2.22	**4.33**	30	RCP	12.4	18.4	124.3
EX I-81	OUTFALL-3		0.45	25.45	0.45	0.20	11.04	10.00	0.07	11.32	5.60	61.85	2.29	**7.59**	30	RCP	12.6	23.4	100.1
EX I-84B	EX MH-16		0.84	0.84	0.45	0.38	0.38	10.00	0.02	10.00	5.85	2.20	0.12	**26.61**	15	RCP	1.8	15.4	15.6
EX I-85A	EX MH-16		0.37	0.37	0.48	0.18	0.18	10.00	0.15	10.00	5.85	1.03	0.03	**6.80**	15	RCP	0.8	7.6	68.9
EX I-84A	EX BMH-11		1.98	1.98	0.37	0.73	0.73	10.00	0.22	10.00	5.85	4.24	0.43	**4.07**	15	RCP	3.5	10.1	135.0
EX I-86	EX I-85		1.58	1.58	0.43	0.68	0.68	10.00	0.10	10.00	5.85	3.97	0.38	**1.61**	15	RCP	3.2	6.6	37.8
EX I-85	EX I-84		0.70	2.27	0.51	0.36	1.04	10.00	0.06	10.10	5.83	6.05	0.88	**3.28**	15	RCP	4.9	9.6	36.6
EX I-83	EX MH-17		1.58	1.58	0.47	0.75	0.75	10.00	0.04	10.00	5.85	4.38	0.17	**5.96**	18	RCP	2.5	10.8	23.2
EX I-88A	EX MH-19		2.46	2.46	0.42	1.04	1.04	8.27	0.23	8.27	6.22	6.47	1.01	**5.45**	15	RCP	5.3	11.8	166.0
EX MH-19	EX MH-20		0.00	4.08	0.00	0.00	1.61	0.00	0.41	8.50	6.17	9.91	0.90	**1.46**	18	RCP	5.6	8.0	193.3
EX MH-20	OUTFALL-4		0.00	8.87	0.00	0.00	3.71	0.00	0.18	10.55	5.75	21.31	1.82	**5.10**	21	RCP	8.9	15.5	166.5
EX I-88B	EX MH-19		1.62	1.62	0.35	0.57	0.57	10.00	0.07	10.00	5.85	3.31	0.26	**2.91**	15	RCP	2.7	7.9	35.0
EX I-89A	EX I-89		1.68	1.68	0.38	0.64	0.64	10.00	0.32	10.00	5.85	3.77	0.34	**0.91**	15	RCP	3.1	5.3	100.7
EX I-89	EX I-88		1.66	3.34	0.46	0.76	1.40	10.00	0.10	10.32	5.79	8.10	0.60	**0.84**	18	RCP	4.6	6.1	36.8
EX I-88	EX MH-20		1.46	4.80	0.48	0.70	2.10	10.00	0.13	10.42	5.77	12.12	1.34	**2.70**	18	RCP	6.9	10.6	84.9
EX I-93	EX I-94		1.96	1.96	0.49	0.96	0.96	10.00	0.25	10.00	5.85	5.64	0.77	**12.40**	15	RCP	4.6	15.4	233.0
EX I-94	EX I-95		2.04	7.87	0.44	0.90	3.89	8.94	0.10	10.32	5.79	22.51	4.61	**8.75**	18	RCP	12.7	15.6	97.3
EX I-95	EX BMH-12		0.43	8.30	0.52	0.22	4.11	10.00	0.18	10.43	5.77	23.71	5.12	**9.76**	18	RCP	13.4	16.4	180.0
EX BMH-12	EX I-96		0.00	8.30	0.00	0.00	4.11	0.00	0.14	10.61	5.74	23.59	5.07	**6.76**	18	RCP	13.3	13.7	112.8
EX I-96	EX MH-22		1.05	9.92	0.49	0.51	4.95	10.00	0.10	10.75	5.71	28.26	3.20	**4.67**	21	RCP	11.7	12.8	73.7
EX MH-22	EX I-97		0.00	14.37	0.00	0.00	7.00	0.00	0.36	10.84	5.69	39.86	1.66	**2.90**	27	RCP	10.0	11.2	245.6
EX I-97	EX MH-23		0.60	15.79	0.49	0.29	7.69	10.00	0.07	11.21	5.62	43.24	1.12	**1.78**	30	RCP	8.8	9.6	40.5
EX MH-23	EX I-97B		0.00	15.79	0.00	0.00	7.69	0.00	0.11	11.28	5.61	43.16	1.11	**2.66**	30	RCP	8.8	11.7	78.7
EX I-97B	OUTFALL-8		4.39	20.18	0.38	1.68	9.38	9.36	0.05	11.39	5.59	52.41	1.64	**1.67**	30	RCP	10.7	10.1	30.0
EX I-92	EX MH-21		1.14	1.14	0.56	0.64	0.64	10.00	0.19	10.00	5.85	3.74	0.34	**13.40**	15	RCP	3.1	14.1	158.2
EX MH-21	EX I-92A		0.00	1.14	0.00	0.00	0.64	0.00	0.06	10.19	5.81	3.72	0.33	**23.46**	15	RCP	3.0	17.2	59.4
EX I-92A	EX I-94		1.14	2.28	0.44	0.50	1.14	10.00	0.08	10.25	5.80	6.64	1.06	**17.41**	15	RCP	5.4	18.2	85.3
EX I-94A	EX I-94		1.59	1.59	0.55	0.88	0.88	10.00	0.07	10.00	5.85	5.12	0.63	**4.09**	15	RCP	4.2	10.0	39.9
EX I-96A	EX I-96		0.57	0.57	0.57	0.32	0.32	10.00	0.15	10.00	5.85	1.90	0.09	**0.79**	15	RCP	1.5	4.2	38.2

Legend

- **x.xx** Actual pipe slope is adequate for flow to pipe
- x.xx Actual pipe slope is not adequate for flow to pipe
- * Actual velocity from flowmaster
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- x.xx Proposed pipe size to convey flow

From	To	Remarks	Area (acres)		Coefficient	Inc. AC	Sum of	Tc (min)			Intensity	Peak Q	Slope (%)		Pipe	Pipe	Vel full	*Vel act.	L
			Inc	Total	(C)		AC	Inlet	TI pipe	Total	(in/hr)	(cfs)	Min	Act	Size (in)	Type	(fps)	(fps)	(ft)
EX I-98A	EX I-98		2.76	2.76	0.44	1.20	1.20	5.96	0.08	5.96	6.79	8.17	0.61	**1.34**	18	RCP	4.6	7.4	36.7
EX I-98	EX MH-22		1.69	4.45	0.50	0.85	2.06	10.00	0.62	10.00	5.85	12.03	1.32	**0.50**	18	RCP	6.8	4.2	155.6
EX I-97A	EX I-97		0.83	0.83	0.48	0.40	0.40	10.00	0.14	10.00	5.85	2.34	0.13	**0.92**	15	RCP	1.9	4.7	38.1
EX I-87	EX MH-24		2.08	2.08	0.55	1.13	1.13	6.64	0.12	6.64	6.61	7.48	0.51	**18.61**	18	RCP	4.2	19.0	131.9
EX MH-24	OUTFALL-5		0.00	2.08	0.00	0.00	1.13	0.00	0.07	6.76	6.59	7.46	0.51	**1.29**	18	RCP	4.2	7.1	28.8
EX I-90	EX MH-25		3.39	3.39	0.49	1.67	1.67	9.77	0.10	9.77	5.90	9.83	2.32	**16.13**	15	RCP	8.0	19.7	116.8
EX MH-25	EX MH-26		0.00	3.39	0.00	0.00	1.67	0.00	0.05	9.87	5.88	9.79	2.31	**39.47**	15	RCP	8.0	27.2	79.9
EX MH-26	OUTFALL-6		0.00	3.39	0.00	0.00	1.67	0.00	0.05	9.92	5.87	9.78	2.30	**18.78**	15	RCP	8.0	20.8	66.6
EX I-91	EX MH-27		1.27	1.27	0.49	0.62	0.62	10.00	0.28	10.00	5.85	3.65	0.32	**26.30**	15	RCP	3.0	17.8	300.1
EX I-110	EX MH-30		25.39	119.72	0.42	10.74	53.24	17.97	0.17	17.97	4.60	244.90	1.56	**3.39**	54	RCP	15.4	24.5	244.0
EX MH-30	EX MH-31		0.00	124.93	0.00	0.00	55.78	0.00	0.00	18.14	4.58	255.47	1.70	**13.06**	54	RCP	16.1	41.0	11.3
EX MH-31	EX BMH-13		0.00	124.93	0.00	0.00	55.78	0.00	0.03	18.14	4.58	255.47	1.70	**3.88**	54	RCP	16.1	26.0	46.9
EX BMH-13	EX BMH-14		0.00	131.38	0.00	0.00	58.73	0.00	0.12	18.17	4.58	268.97	1.88	**3.88**	54	RCP	16.9	26.3	192.0
EX BMH-14	EX BMH-15		0.00	133.44	0.00	0.00	59.45	0.00	0.05	18.29	4.57	271.68	1.92	**3.88**	54	RCP	17.1	26.4	85.0
EX BMH-15	EX MH-32		0.00	134.77	0.00	0.00	59.96	0.00	0.03	18.35	4.56	273.43	0.67	**1.15**	66	RCP	11.5	16.7	33.0
EX MH-32	OUTFALL-7		0.00	134.77	0.00	0.00	59.96	0.00	0.04	18.38	4.56	273.43	0.67	**1.69**	66	RCP	11.5	19.4	51.9
EX I-107	EX MH-28		3.24	3.24	0.45	1.44	1.44	5.00	0.08	5.00	7.07	10.20	2.51	**10.28**	15	RCP	8.3	16.8	79.9
EX MH-28	EX I-108		0.00	3.24	0.00	0.00	1.44	0.00	0.14	5.08	7.05	10.17	2.49	**9.01**	15	RCP	8.3	16.0	135.7
EX I-108	EX I-109		0.40	3.64	0.52	0.21	1.65	10.00	0.07	10.00	5.85	9.66	0.85	**1.46**	18	RCP	5.5	8.4	36.4
EX I-109	EX MH-29		1.58	5.21	0.56	0.89	2.54	10.00	0.06	10.07	5.84	14.84	0.88	**1.67**	21	RCP	6.2	9.3	33.0
EX MH-29	EX MH-30		0.00	5.21	0.00	0.00	2.54	0.00	0.26	10.13	5.83	14.82	2.00	**4.52**	18	RCP	8.4	13.5	210.6
EX I-111	EX I-112		5.31	5.31	0.45	2.37	2.37	5.31	0.05	5.31	6.98	16.54	2.49	**3.76**	18	RCP	9.4	12.8	36.5
EX I-112	EX BMH-13		1.13	6.44	0.51	0.58	2.95	10.00	0.13	10.00	5.85	17.24	2.71	**3.32**	18	RCP	9.8	12.3	98.0
EX I-113	EX BMH-14		2.06	2.06	0.35	0.72	0.72	15.38	0.08	15.38	4.95	3.57	0.31	**1.00**	15	RCP	2.9	5.4	25.0
EX I-114	EX BMH-15		1.33	1.33	0.39	0.51	0.51	10.00	0.01	10.00	5.85	3.01	0.22	**1.00**	15	RCP	2.5	5.2	4.0

Legend

x.xx	Actual pipe slope is adequate for flow to pipe
x.xx	Actual pipe slope is not adequate for flow to pipe
*	Actual velocity from flowmaster
x.xx	Pipe slope set to S minimum since pipe has reverse slope
x.xx	Proposed pipe size to convey flow

APPENDIX I:

PROPOSED COST ESTIMATES

MONTGOMERY COUNTY DEPARTMENT OF TRANSPORTATION
DIVISION OF TRANSPORTATION ENGINEERING
WORK ORDER PROPOSAL

BIOSWALES BMP IMPROVEMENTS

ITEM #	ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL COST
1001	BIOSWALES BMP	53	EA	$30,000.00	$1,590,000.00
				SUBTOTAL	$1,590,000.00
				30% CONTINGENCY	$477,000.00
				TOTAL	$2,067,000.00

STORM DRAIN IMPROVEMENTS

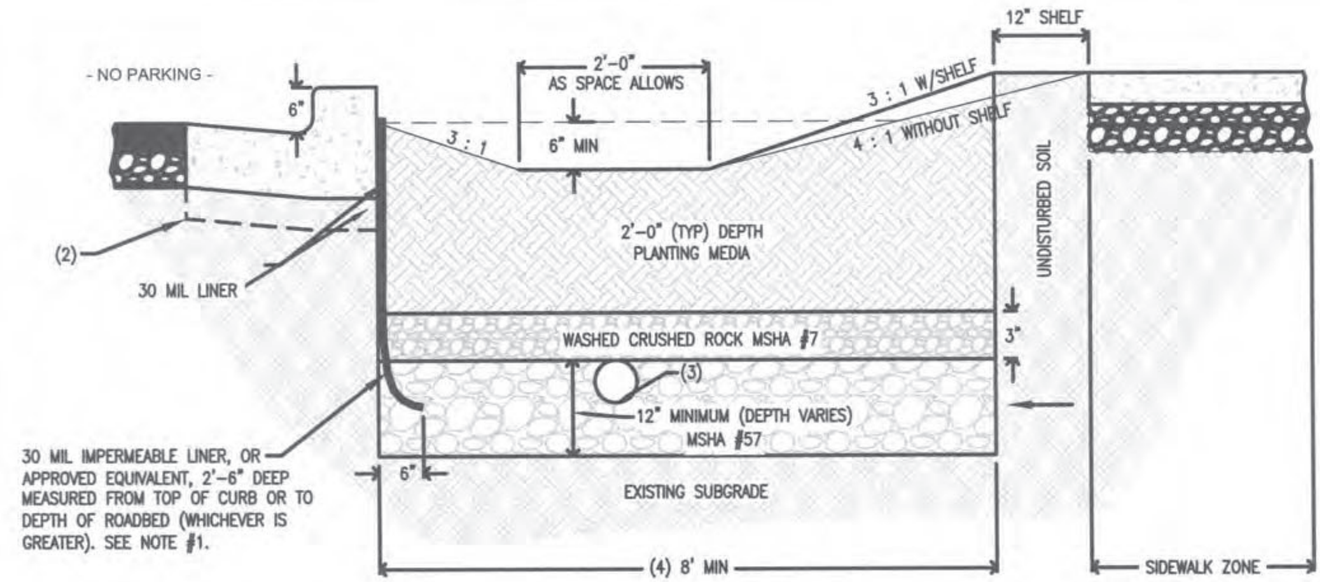
ITEM #	ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL COST
2008	REMOVAL OF EXISTING MASONRY INCLUDING PRECAST STRUCTURES AND ANY SIZE AND ANY TYPE OF PIPE	4636	CY	$20.00	$92,720.00
3001	CLASS 3 EXCAVATION FOR STORM DRAIN AND MISCELLANEOUS CONSTRUCTION: TOTAL DEPTH OF EXCAVATION LESS THAN OR EQUAL TO 4 VERTICAL FEET	9284	CY	$58.00	$538,472.00
3002	CLASS 3 EXCAVTION FOR STORM DRAIN AND MISCELLANEOUS CONSTRUCTION: TOTAL DEPTH OF EXCAVATION GREATER THAN 4 VERTICAL FEET AND LESS THAN OR EQUAL TO 8	6854	CY	$65.00	$445,510.00
3004	SELECTED BACKFILL USING No. 57 AGGREGATE	2956	TONS	$65.00	$192,140.00
3007	CLASS IV OR CLASS V 18 INCH REINFORCED CONCRETE PIPE	849	LF	$58.00	$49,242.00
3008	CLASS IV OR CLASS V 21 INCH REINFORCED CONCRETE PIPE	738	LF	$74.00	$54,612.00
3009	CLASS IV OR CLASS V 24 INCH REINFORCED CONCRETE PIPE	219	LF	$93.00	$20,367.00
3010	CLASS IV OR CLASS V 27 INCH REINFORCED CONCRETE PIPE	246	LF	$72.00	$17,712.00
3011	CLASS IV OR CLASS V 30 INCH REINFORCED CONCRETE PIPE	1076	LF	$83.00	$89,308.00
3013	CLASS IV OR CLASS V 36 INCH REINFORCED CONCRETE PIPE	460	LF	$114.00	$52,440.00
3014	CLASS IV OR CLASS V 42 INCH REINFORCED CONCRETE PIPE	1468	LF	$125.00	$183,500.00
3015	CLASS IV OR CLASS V 48 INCH REINFORCED CONCRETE PIPE	871	LF	$152.00	$132,392.00
3042	NEW PIPE CONNECTIONS TO EXISTING STORM DRAIN STRUCTURES (ANY SIZE, ANY TYPE)	112	EA	$1,650.00	$184,800.00
9001	CLASS IV OR CLASS V 54 INCH REINFORCED CONCRETE PIPE	312	LF	$202.00	$63,024.00
9003	CLASS IV OR CLASS V 66 INCH REINFORCED CONCRETE PIPE	970	LF	$295.00	$286,150.00
9004	CLASS IV OR CLASS V 72 INCH REINFORCED CONCRETE PIPE	785	LF	$336.00	$263,760.00
9005	CLASS IV OR CLASS V 78 INCH REINFORCED CONCRETE PIPE	247	LF	$377.00	$93,119.00
9006	CLASS IV OR CLASS V 96 INCH REINFORCED CONCRETE PIPE	155	LF	$519.00	$80,445.00
				SUBTOTAL	$2,839,713.00
				30% CONTINGENCY	$851,913.90
				TOTAL	$3,691,626.90

STORM DRAIN IMPROVEMENTS WITH BIOSWALES BMP

SUBTOTAL	$4,429,713.00
30% CONTINGENCY	$1,328,913.90
TOTAL	$5,758,626.90

APPENDIX J:

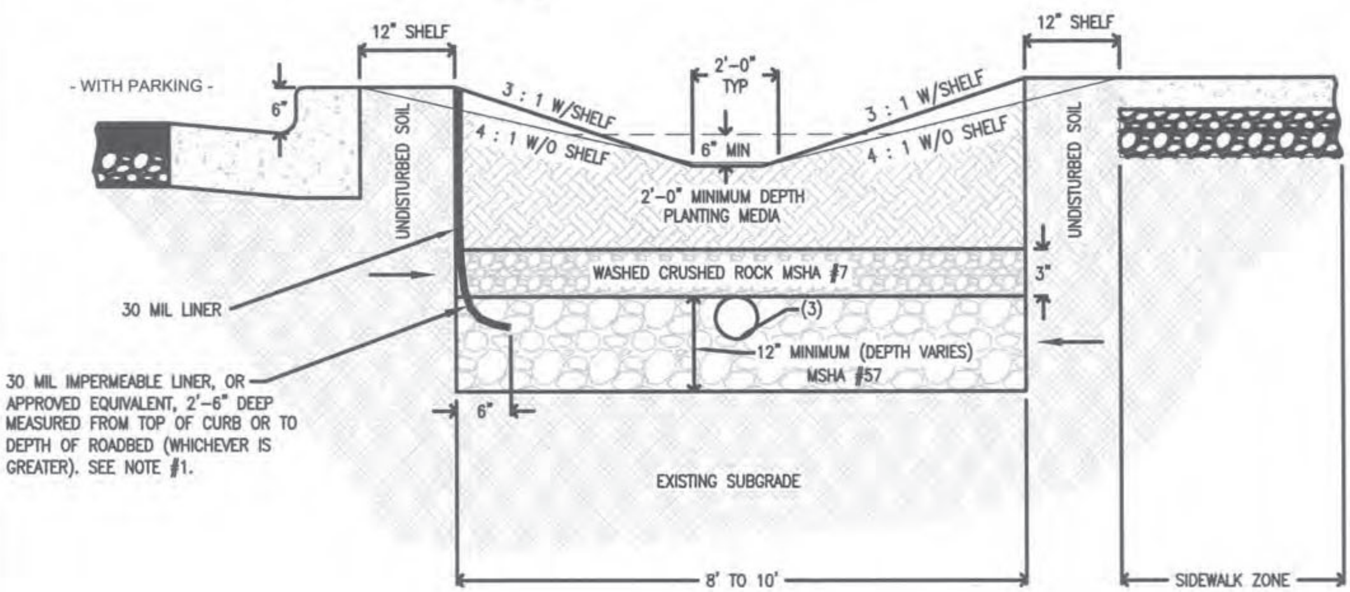
BMP DETAIL



SECTION A-A
SWALE WITHOUT PARKING

NOTES:

1. Liner required when face of new curb is < 2ft from adjacent water line or on secondary collectors and higher street classifications. Liner may be required on local streets with transit routes, higher traffic volumes, or when facility is adjacent to travel lane, at the discretion of the Engineer.
2. Per DOT requirements, either leave existing curb in place or replace curb and gutter per MC-100.01 with 12" thick gutter pan.
3. Per plan, provide either 6" dia. Sch 40 PVC underdrain or a 6" deep gravel drain layer (MSHA #57).
4. See plan for dimensions.



SECTION A-A
SWALE WITH PARKING

FOR PLAN VIEW REFER TO SW-300

- DRAWING NOT TO SCALE -

RIGHT - OF - WAY SWM RETROFIT TYPICAL DETAILS — DRAFT 11-30-2009

Swale Sections

With and without Parking

MONTGOMERY COUNTY MARYLAND 1776

NUMBER

SW-301

APPENDIX K: PHOTOGRAPHS

WC 1, upstream view.

WC 1, downstream view.

WC 2, upstream view.

WC 2, downstream view.

WC 3, upstream view.

WC 3, downstream view.

WC 4, upstream view.

WC 4, downstream view.

WC 5, upstream view.

WC 5, downstream view.

WC 6, upstream view.

WC 6, downstream view.

WC 7, upstream view.

WC 7, downstream view.

Wetland 1.

Wetland 2.

Potential BMP Location.

Potential BMP Location.