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# Stevens Forest to Downtown Columbia Road Shared Use Path

# Basis of Design Report

## Broken Land Parkway to Little Patuxent Parkway

October 2016

Prepared for the Howard County Bureau of Engineering
& Howard County Office of Transportation

PO# 2000016524
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## Contents

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# 1.0 Introduction:

## 1.1 Project Purpose & Need

Completion of the Stevens Forest to Downtown Columbia Trail segment is necessary to support a multi-modal environment, and provide local and regional connectivity. Additionally, the shared use path will encourage more walking and biking, thereby helping to reduce carbon emissions and improve health. This project addresses the need for a low-stress, connected pedestrian and bicycle network in Howard County.

## 1.2 Scope of Work and Project Phasing

This project proposes a bicycle and pedestrian shared-use path connection between Broken Land Parkway and South Entrance Road at Little Patuxent Parkway, as well as on-road bicycle facilities along a portion of Stevens Forest Road form the cul-de-sac to join existing bike lanes at Parallel Lane. The scope of work includes limited preliminary engineering design and limited environmental analysis.

Due to the limited funding available for this phase of the project, and the need for costly preliminary geotechnical investigations and Hydraulics and Hydrology (H&H) Analysis, traditional preliminary engineering activities required to bring the design to the 30% level of completion will not be fully accomplished. The following were completed during the preliminary engineering phase:

- Horizontal and vertical geometric layout of the shared use path and on-road bicycle facilities
- Preliminary analysis of existing drainage conditions, and layout of proposed culverts, drainage systems, and stormwater management facilities
- Preliminary coordination with utility companies, and identification of major utility impacts
- Preliminary analysis of right-of-way impacts
- Preliminary assessment of potential environmental impacts
- Preliminary geotechnical investigation
- Preliminary H&H analysis

Many of these items will require further investigation during the detailed design phase of the project. This report includes recommendations for further investigation and design refinements that will need to be included in the scope of the final design.

Additional funding will be required in order to complete the final design of this project. As such, the timing of the final design phase is currently unknown.

# 2.0 Existing Conditions, Opportunities, & Constraints:

## 2.1 Site Location

As depicted in the location map in Appendix B, the path alignment comprises two distinct segments: a trail segment between Stevens Forest Road and Little Patuxent Parkway in Downtown Columbia, and an on-Road segment along Stevens Forest Road between the cul-de-sac and Parallel Lane. The alignment of the trail segment departs from the roadway to (roughly) parallel the existing sanitary sewer easement for approximately 0.65 miles adjacent to the Little Patuxent River. The alignment passes under the existing bridges at Broken Land Parkway and US-29, along the west edge of an existing wetland area north of US-29, and crosses a tributary of the Little Patuxent River. The alignment then follows an existing abandoned access road east to its intersection with South Entrance Road, and extends north along the west side of south entrance road to intersect with the Downtown Columbia Trail at Little Patuxent Parkway. The portion of the trail segment closest to Little Patuxent Parkway traverses land that is currently being redeveloped. This portion of the trail is subject to realignment, and the project team will continue to coordinate with the adjacent developer to ensure that the pathway is fully coordinated with anticipated roadway reconfiguration to the ensure that the path remains continuous, and connects to the Downtown Columbia Trail.

## 2.2 Environmental Features and Anticipated Permitting Requirements

### *Stream Conditions*

The project study area is within an existing sewer easement that extends along road rights-of-way and residential and commercial properties. A vegetated buffer exists along much of the stream corridor within the study area. The Little Patuxent River is identified in the Maryland Integrated Water Quality Report 303(d) List as being impaired by both Chlorides and Total Suspended Solids from urban runoff and storm sewers. The Little Patuxent River and its tributaries are classified by the Maryland Department of the Environment as Use Class IV-P, protected as recreational trout waters and public water supply. In accordance with the Howard County Code of Ordinances, grading, removal of vegetative cover and trees, paving, and new structures shall not be permitted within 100-feet of streambanks for Use IV streams unless the Department of Planning and Zoning determines those activities are necessary for the construction of the path, disturbance is minimized, no other reasonable alternatives exist, and cost of improvements is not a factor.

### *Stormwater / Erosion Control*

It is anticipated that land disturbance will exceed 5,000 square feet acre; as such, stormwater and erosion control requirements will need to be met under the Maryland Department of the Environment (MDE) and Howard County Grading Permit requirements. An MDE General Permit for Stormwater Associated with

Construction Activity (or Individual Permit) and a NPDES General Construction Permit will be required, along with approval of the erosion and sediment control plan by the Howard County Soil Conservation District. A site-specific soil erosion and sediment control plan must be developed and approved as part of the project design, and a construction general permit obtained as part of the permitting process. This will include, at a minimum, an approved erosion and sediment control plan, approved stormwater management plan, and a pollution prevention plan.

### *Wetlands*

A search of the United States Fish and Wildlife Service's (USFWS) National Wetlands Inventory (NWI) maps and Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps (FIRM) floodplain mapping identified the presence of wetlands, waterways, and floodplains within the project study area. Although a formal wetland and stream delineation was not performed, a review of the Little Patuxent Parallel Interceptor Sewer project plans identified the presence of wetlands and their corresponding wetland buffers at various locations along the path alignment. A formal wetland delineation of the study area should be performed to confirm wetland boundaries and quantify the project impacts. Permits and mitigation for impacts will be required by the US Army Corps of Engineers and the Maryland Department of the Environment. In accordance with the Howard County Code of Ordinances, grading, removal of vegetative cover and trees, paving, and new structures are not permitted within 25 feet of wetlands unless the Department of Planning and Zoning determines that it is necessary for the construction of the path, disturbance is minimized, no other reasonable alternatives exist, and cost of improvements is not a factor.

### *Hydrology & Hydraulics*

The Little Patuxent River watershed was delineated using the GISHydro2000 program (web version) developed at the University of Maryland. This program delineates watershed utilizing 30-m resolution Digital Elevation Model (DEM) and 1:100,000 maps of streams. The total watershed area to the Stevens Forest Road crossing (downstream limit of project) is 29.8 square miles. The watershed was subdivided into seven (7) sub-watersheds to consider the effect of the attenuation provided by Centennial Lake and Wilde Lake. The soils distribution is based on SSURGO data, the existing land use on 2010 Maryland Department of Planning (MDP) data and the ultimate land use on coverage provided within GISHydro2000. The watershed area, land use and soils maps are shown in Appendix C.

Peak discharge estimates for the 2-, 10-, 25-, 50-, 100- and 500-year recurrence intervals were obtained for the Little Patuxent Watershed at the Stevens Forest Road crossing utilizing the NRCS WinTR-20 deterministic hydrologic model.

WinTR-20 parameters were determined based on “Application of Hydrologic Methods in Maryland” (July 2016):

- The watershed is in the Piedmont Region (484 peak factor).
- Use of point-specific Atlas 14 rainfall distributions.
- Use of areal reduction of rainfall depth for spatial distribution over watershed.
- 12-hr distribution for 2-, 10-year storms, 24-hr distribution for remaining storms.
- Antecedent Runoff Condition (ARC) II was used for all studied recurrence intervals as suggested by the Maryland Hydrology Panel.

Basin statistics and sub-watershed distributions for runoff curve numbers are provided in Appendix C. Time-of-concentration was computed using flow path methodology within GISHydro2000. For the two of the sub-watersheds, DA-1 and DA-7, the Velocity Segment Generator tool within GISHydro2000 was applied since the initial times-of concentration were determined to be too long.

**Sub-watershed Parameters.**

| Sub-shed | Area (sq. mi.) | Existing RCN | Ultimate RCN | Tc (hours) |
|---|---|---|---|---|
| DA-1 | 17.9 | 75.4 | 72.8 | 7.0 |
| DA-2 | 3.6 | 72.6 | 67.5 | 4.9 |
| DA-3 | 0.1 | 63.7 | 69.3 | 0.7 |
| DA-4 | 3.3 | 78.4 | 75.0 | 5.0 |
| DA-5 | 1.8 | 79.1 | 76.2 | 3.9 |
| DA-6 | 0.2 | 86.5 | 78.6 | 0.7 |
| DA-7 | 2.9 | 79.7 | 77.9 | 1.2 |

Rainfall depths were obtained from the "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 2, Version 2 and were obtained from GISHydro2000. The table below lists the rainfall durations and depths considering areal reduction for the respective return periods.

**Rainfall Depths for 12/24-hour Storm with Return Periods from 2- to 500-yr.**

| Return Period (years) | 2 | 10 | 25 | 50 | 100 | 500 |
|---|---|---|---|---|---|---|
| Duration (hr) | 12 | 12 | 24 | 24 | 24 | 24 |
| Depth (in) | 2.66 | 4.00 | 5.93 | 6.98 | 8.17 | 11.63 |

Reach routing was done following the procedures established by the USGS WinTR-20 manual. Reach routing was performed for four reaches within the WinTR-20 model. Attenuation in the watershed represents 18% of the total drainage area for two lakes: Centennial Lake (DA-2) and Wilde (DA-5). Lake Kittamuqundi was not included with respect to structure routing since it does store a significant amount of flow during storm events. Stage/storage/discharge rating data for the two lakes was provided by MDE Dam Safety and this data was inserted into WinTR-20 for structure routing purposes. Due to the attenuation, comparison to Fixed Region Tasker intervals as provided by GISHydro2000 and described in "Application of Hydrologic Methods in Maryland" (July 2016), may not be totally valid. However, the Tasker intervals were run to provide some level of comparison for the flows from WinTR-20. FEMA discharges from the effective Flood Insurance Study (FIS) were not provided as a basis for comparison since they are based on the old Fixed Region regression equations and are very conservative.

**WinTR-20 and Fixed Region Discharges.**

| Return Period (years) | Existing WinTR-20 Peak Discharges (cfs) | Fixed Region Peak Discharge (cfs) | | | Ultimate WinTR-20 Peak Discharges (cfs) |
|---|---|---|---|---|---|
| | | - 1 SE | Peak | + 1 SE | |
| **2** | 1,770 | 1,080 | 1,570 | 2,280 | 1,460 |
| **10** | 4,010 | 2,800 | 3,920 | 5,490 | 3,500 |
| **25** | 6,930 | 3,960 | 5,630 | 8,010 | 6,320 |
| **50** | 8,800 | 4,920 | 7,150 | 10,400 | 8,180 |
| **100** | 10,920 | 5,960 | 8,900 | 13,300 | 10,280 |
| **500** | 18,760 | 8,750 | 14,200 | 23,000 | 17,460 |

The RCN values calculated for the ultimate development condition are lower than those for the existing development condition for six of the seven sub-watersheds. This may be due to the conversion of existing agricultural uses under the existing condition to residential land use under ultimate development. Since this would cause the ultimate discharges to be lower than those for existing, the existing development discharges are recommended for use in the hydraulic model.

**Recommended Peak Discharges.**

| Return Period (years) | Recommended Peak Discharge (cfs) |
|---|---|
| **2** | 1,770 |
| **10** | 4,010 |
| **25** | 6,930 |
| **50** | 8,800 |
| **100** | 10,920 |
| **500** | 18,760 |

HEC-RAS Version 5.0.1, dated April 2016, was used for the hydraulic analysis. The computational procedure is generally known as the Standard Step Method. Mixed flow conditions were applied and profiles for the 2-. 10- and 100-year storms were computed to determine whether Code of Maryland (COMAR) regulations were met. The effective FEMA HEC-RAS model for the Little Patuxent River was used as the existing condition from which to develop the proposed condition with the path in place. Due to conceptual nature of this report, no effort was made to revise the existing ground and structure geometry developed by FEMA. The only change to the existing condition that was made was that three additional HEC-RAS sections from a previous KCI hydraulic study (MD 986, South Entrance Road over Little Patuxent River) were added. These sections are numbered 130666, 130481 and 130269. The sections were added in locations where the path was in fill and no FEMA sections were close by to ensure that the impacts of the path were clearly documented in HEC-RAS. These sections were found to be consistent with the FEMA model geometry data with respect to channel invert, channel width and floodplain elevation. The primary impact to Maryland State Highway Administration (SHA) facilities occurs due to the placement of the path in fill adjacent to the south abutment of the US Route 29 Bridges.

With respect to COMAR regulations, 2-, 10- and 100-year water-surface elevation increases are limited to no more than 0.19 foot as a result of the proposed path. This increases occur upstream the NB US Route 29 Bridge and are due to the slightly reduced hydraulic opening with the path under the bridge. Proposed path impacts extend from section 126863 to section 138291 within the HEC-RAS model. There appears to be only one improved private property within or near the 100-year floodplain that could potentially be affected by water-surface elevation increases. This privately owned building is located between Symphony Woods Road and South Entrance Road. The water-surface elevation increases in the vicinity of this building are less than 0.1-foot and coordination with the property owner should not be required. US Route 29 and South Entrance Road can be considered public improved properties and SHA may have to approve the small water-surface elevation increases on US Route 29 so that MDE will issue the Non-tidal Wetlands and Waterways Construction Permit. With respect to shear stress, it appears that there are no changes from existing to proposed conditions that exceed 10 percent. In conclusion, it is likely that this project can obtain a Non-tidal Wetlands and Waterways Construction Permit as long SHA accepts the small water-surface elevation increases on US Route 29.

With respect to the potential for scour at the US Route 29 and Broken Land Parkway Bridges, the hydraulic model shows that the change in bridge opening velocities from existing to proposed conditions for a range of storms, including the 25- through 500-year events, is negligible. In addition, the ratio of bridge flow to approach flow ($Q_2/Q_1$ in the HEC-18 live-bed contraction scour equation) is not expected to change significantly due to the minor amount of fill for the proposed path. The proposed path will be adjacent to the abutments and asphalt paved. The fill slope for the path under both the US Route 29 Bridges and the Broken Land Parkway Bridge should be protected with a minimum of SHA Class II Riprap. Coordination with SHA will be required during the design phase of the project to discuss impacts related to the path being placed under the US Route 29 Bridges with respect to water-surface elevation increases on US Route 29 and potential scour due to the small reduction in hydraulic capacity under the US Route 29 Bridges.

The Federal Emergency Management Agency (FEMA) recently performed a detailed study of Little Patuxent River. The proposed path is shown on Map Number 24027C0155D from the FIS for Howard County, Maryland and Incorporated Areas dated November 6, 2013.

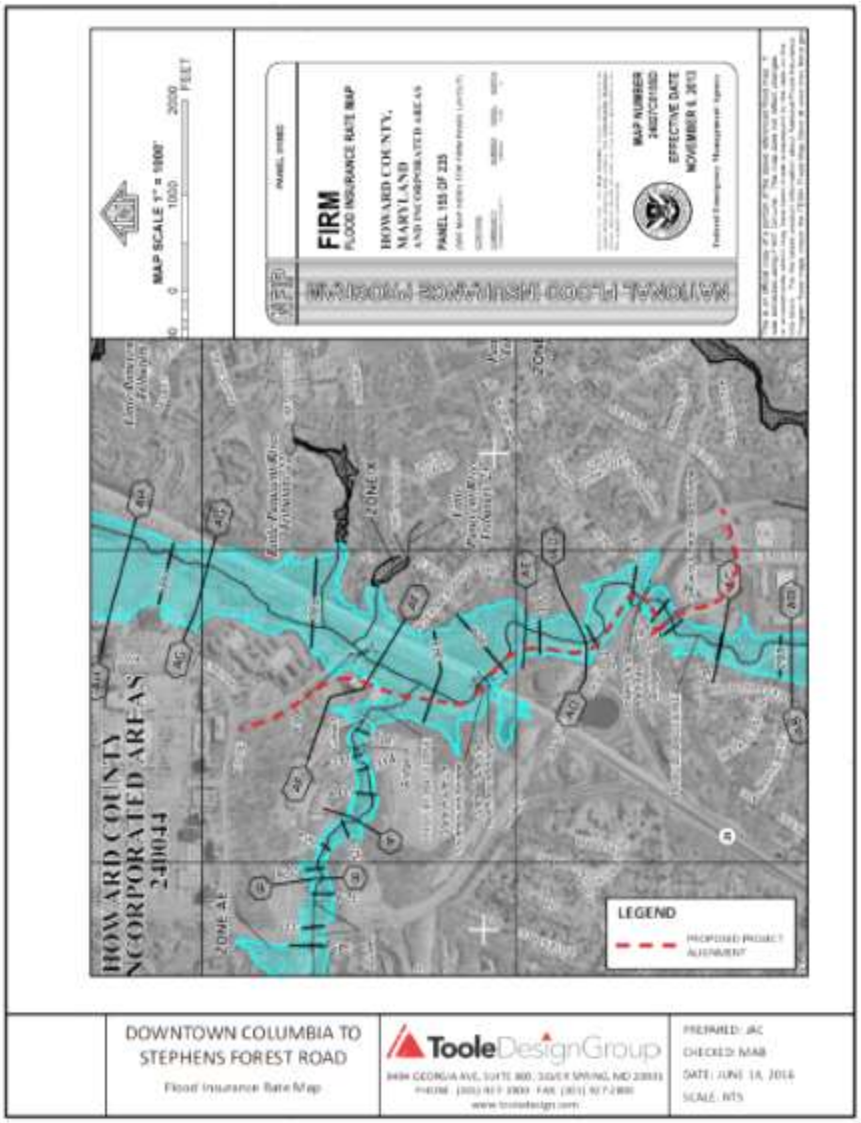


Figure 1. FIRM 24027C0155D at Stevens Forest to Downtown Columbia Road

The Flood Insurance Rate Maps (FIRM) identifies portions of the project area to be within the 100-year floodplain, located within Zone AE (no floodway). Much of the proposed alignment is within this floodplain and the path may need to be closed periodically during high water events. According to the preliminary HEC-RAS model developed for this project, the proposed path results in no water-surface elevations that exceed 1.0 foot and the CLOMR/LOMR review process through FEMA should not be required. However, this should be verified with FEMA during the design phase of the project.

There are two additional proposed bridges for the path that cross small tributaries of the Little Patuxent River, located at proposed path Stations 41+80 and 67+00. Hydrology and hydraulics were not performed for these crossings under this study. However, during the design phase for the proposed path, detailed H&H and scour analyses will be required for these structures for review by MDE Non-tidal Wetlands and Waterways.

Bridge at Station 41+80

This bridge crossing is located directly downstream of a 2-cell 72” RCP culvert under Broken Land Parkway. During the design phase, the DPW should be contacted to obtain plans/studies performed for the existing culvert, if available. A preliminary proposed bridge span of 35 feet has been established for this crossing. Due to the orientation of the existing culvert in relation to the proposed path bridge, one or both of the bridge abutments may be susceptible to scour. This is due to the potential for high velocity storm flow from the nearby culvert. During the design phase, a careful evaluation of potential scour should be performed, especially if the abutment footings are not founded on good quality bedrock. It may be necessary to protect the abutments with SHA Class II Riprap.

Bridge at Station 67+00

This bridge crossing is located on an unnamed tributary of Little Patuxent River that flows from the west. This stream has a detailed FEMA study, including a HEC-RAS model, and is labeled as Stream LPR1. In addition, Biohabitats, Inc. completed a study of the stream (Stream B in their study) in 2015 that may be useful in the design phase of this project. A preliminary proposed bridge span of 50 feet has been established for this crossing. This crossing will require modeling during the design phase to demonstrate that COMAR requirements are being met. Also during the design phase, a careful evaluation of potential scour should be performed for this crossing as well, especially if the abutment footings are not founded on good quality bedrock. It may be necessary to protect the abutments with SHA Class II Riprap.

### *Forest Conservation*

The project is generally located within a sewer easement and is not expected to have significant disturbance to forested land along the Little Patuxent River. A significant portion of this project is within the New Town District, which is exempt from Howard County Forest Conservation requirements. Should the project disturb more than 40,000 square feet outside the New Town District, that segment must comply with Howard County Forest Conservation regulations. A Forest Conservation Plan will document all proposed clearing of forest resources outside the New Town District to determine how much reforestation or afforestation may be required.

### *Threatened and Endangered Species*

The project area is not identified as a Sensitive Species Project Review Area by the Maryland Department of Natural Resources. Additionally, correspondence with the US Fish and Wildlife Service and the MD Department of Natural Resources in July 2016, did not identify any RTE species or habitats within the project study area.

## 2.3 Utilities

Based on available plans from the Little Patuxent Parallel Interceptor project from 2009, portions of the project along Little Patuxent River are located within existing sanitary sewer and telephone utility easements. Additionally, power lines run above portions of the project along Broken Land Parkway, and a natural gas transmission line is present near the US-29 interchange. A design ticket was requested with Miss Utility, and a number of utility companies have either provided record plans, or have indicated they have no facilities within the project area; however a detailed utility survey has not been performed along the project area and additional utilities may be present. The following table summarizes the utility companies contacted, and the response from each:

| Utility Company | Responded? | Comments |
|---|---|---|
| **AT&T** | No | |
| **BGE** | No | |
| **Colonial pipeline** | Yes | Plans received, info added to base map |
| **Fiberlight/ Sunbelt** | No | |
| **Comcast/utiliquest** | No | |
| **Comcast Fiber** | No | |
| **LTC** | Yes | No conflicts |
| **Verizon** | Yes | Plans received, info added to base map |
| **Qwest** | Yes | No conflicts |

It was noted that some of the existing manholes extend above the ground surface; as such, the trail alignment will either need to divert around these manholes or be designed to ramp-up to be level with the top of manhole.

## 3.0 Design Criteria:

### 3.1 Design Guidelines

The primary resources referenced in this basis of design report are as follows:

- AASHTO Guide for the Development of Bicycle Facilities, 2012
- State Highway Administration (SHA), Maryland Department of Transportation, Bicycle Policy & Design Guidelines, 2015
- AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities, 2004
- AASHTO A Policy on Geometric Design of Highways and Streets, 2011
- Manual on Uniform Traffic Control Devices (MUTCD), Federal Highway Administration, 2009
- APBP Bicycle Parking Guidelines, Association of Pedestrian and Bicycle Professionals, 2010
- Proposed Right-of-Way Accessibility Guidelines (PROWAG), US Access Board (Draft), 2011
- International Dark-Sky Association/Illuminating Engineering Society of North America, (IDA/IESNA), Model Lighting Ordinance (MLO), 2011

### 3.2 Shared-Use Path Physical Characteristics

#### *Width and Buffers*

As depicted in Figure 1, the minimum width of a shared use path accommodating traffic in two directions is 10-feet with 2-foot shoulders on each side. In cases of obstructions or low bicycle and pedestrian volumes, an eight foot minimum width can be utilized. Per the SHA Bike Guide, trails less than 10-feet wide will require a design waiver. Wider trails (11' to 14' wide) are recommended for locations that are anticipated to serve a high percentage of pedestrians and a high user volume (i.e. more than 300 users in the peak hour.) Per AASHTO, a minimum of 2-feet of separation is required between the edge of the shared use path and post-mounted signs, landscape plantings, bridge abutments, or other adjacent obstacles; however, the SHA Bike Guide requires a minimum of 3-feet of separation from these features. Additionally, if a shared-use path is installed parallel to a street, consideration should be made to increasing the buffer width to 5-feet between the road and shared-use path.

#### *Vertical Clearance*

The proposed alignment will route the path under three bridges: the two Route 29 bridges and the Broken Land Parkway bridge over Little Patuxent River. A minimum vertical clearance of 10-feet is desirable for adequate vertical shy distances per AASHTO. The SHA Bike Guide indicates a minimum clearance of 8 feet below tree branches, 10 feet recommended, but does not provide a vertical clearance below bridges or other fixed objects. Access by emergency, patrol, and/or maintenance vehicles must also be considered when establishing the design clearance of the structure on the shared use path and as such may be greater than 10 feet.

### *Design Speed and Geometry*

Other elements of the geometric design of the shared use path should be based on design speeds for the average bicyclist. Elements such as sight distance, horizontal curve radii, vertical curve length, and grades must be designed to adequately accommodate a user operating at the design speed. A design speed of 18 mph is adequate for most paths, but special consideration should be given to the terrain where hilly conditions are encountered. Additionally, where pedestrian traffic is expected to be higher, a design speed of 14 mph should be used per AASHTO; however, SHA suggests limiting design speed to 12 mph or lower in urban areas.

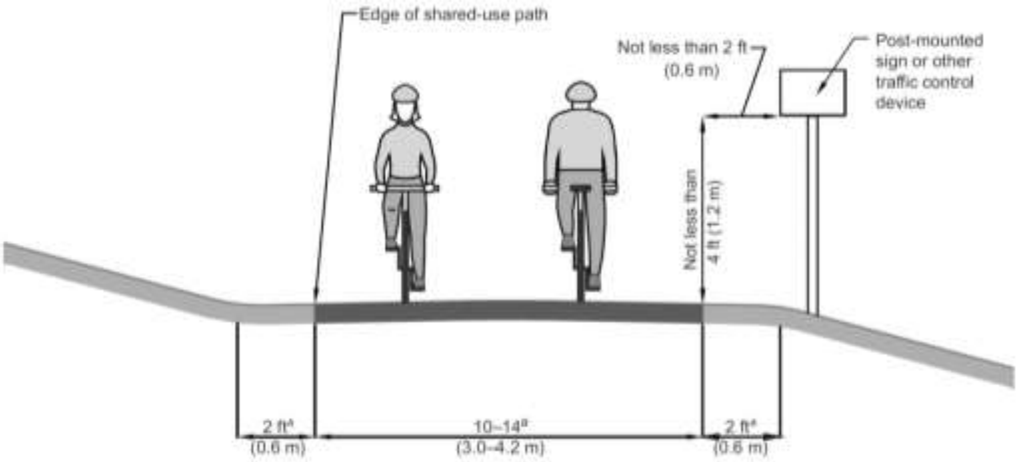


**Figure 1: Typical Cross Section of Two-Way, Shared Use Path on Independent Right-of-Way (Figure 5-2, AASHTO Guide for the Development of Bicycle Facilities, 2012)**

### *Cross Slopes and Grades*

Cross slopes on the shared-use path are recommended between 1% and 2% and should not exceed 2% to maintain ADA compliance. Longitudinal grades should match the roadway grades when installed parallel to a road. Grades on shared-use paths in independent corridors should be kept to a minimum especially on long inclines. Grades greater than 5 percent are undesirable because the ascents are difficult for many path users. Grades on paths in independent rights-of-way should be limited to:

- 5.0 percent maximum for any distance
- 8.3 percent maximum for up to 200 feet
- 10.0 percent maximum for up to 30 feet
- 12.5 percent for up to 10 feet

Additionally, no more than 30 percent of the total path length should have a grade exceeding 8.3 percent. Where grades exceed 5 percent, a resting interval is required at the end of any segment of maximum length as described above.

### *Surface Materials*

Surface materials of a shared-use path should be provided to enable year-round use of the path and minimize maintenance needs. A change in materials should indicate a change in location from the main circulation corridor to an adjacent secondary corridor or amenity area.

Hard, all weather smooth pavement surfaces are recommended for shared-use paths intended for a variety of users (bicyclists, in-line skaters, scooters, pedestrians, and other wheeled users). In general, the primary pathway surface material should be asphalt, which provides a durable all-weather pavement surface.

Shared-use path structural section should be a minimum of 4 inches of asphalt concrete on 4 inches of aggregate base, or as otherwise determined by the engineer of record. Given that this shared use path will also provide utility access to the existing sewer, the designer should identify the types of services vehicles that may occasionally travel on the path and design the pavement section accordingly.

At trailheads, waysides, and other amenity areas, alternate paving materials such as brick/concrete pavers, colored concrete, stamped concrete, unit pavers, pervious concrete, and permeable pavers are recommended to create a focal area for pathway users. All materials should be context sensitive and coordinated throughout the corridor to provide a cohesive network of amenity areas and path segments.

Surface materials that allow water to permeate through and into the ground are recommended where feasible. Pavement section and base material should be evaluated based on geotechnical considerations and should also provide smooth surface conditions for users on wheels.

## 3.3 Shared-Use Path Amenities

The proposed project area is largely within Howard County designated Open Space and as such will provide an inviting natural environment for the future path users. The amenities should accommodate both bicycle and pedestrian users to make their use of the path more accommodating and enjoyable. Amenities may include:

*Benches or Picnic Tables*: seating is an important component of shared use path design to allow users to stop and rest or enjoy the surroundings. While benches allow users to rest, picnic tables allow users to enjoy a meal or gather with friends.

*Water fountains*: If a potable water service is available, water fountains should be considered. If proposed, they must be accessible and should consider models that provide a water source for pets.

*Trash/Recycling Receptacles*: Trash and recycling cans should be proposed at trailheads and at waysides. Note that maintenance vehicles must be able to easily access the locations, so it may not be appropriate to install receptacles at each wayside.

*Bicycle Racks*: Bike racks should be considered at trailheads to allow people to bike to the path, park their bike, and then walk or hike.

*Informational kiosks, maps, and signage:* General information about the shared use path should be provided, including a map, amenities, emergency contact information, hours, trailhead identification, etc. Interpretive signage can also be used along the path at key locations to highlight features (e.g. green infrastructure), natural resources, or other site-specific resources.

*Bollards:* If bollards are used at the trailheads to prevent vehicles from driving on the path, they should contrast visually from the path so that they are visible to users under various lighting conditions. The bollards should be removable to allow emergency and maintenance vehicles to access the path. They should also be spaced to ensure that bicycles with trailers or other wide bikes can easily access the path.

### 3.4 Intersection Design

The proposed shared use path alignment is expected to cross Symphony Woods Road at the northern end. Given that the configuration will be a sidepath at this location, Figure 2 (below) should be used to design this crossing location. Some existing vegetation and signing may require relocation in order to provide adequate sight distance for motorists to see approaching bicyclists and to bicyclists to be able to see vehicles at this intersection.

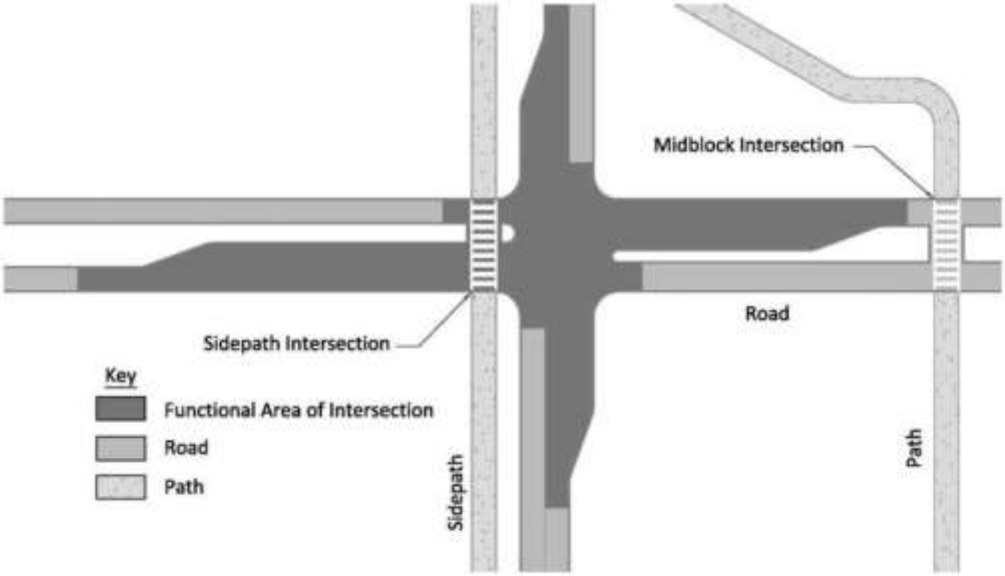


Figure 2: Sidepath Crossing at Intersection and Mid-Block (AASHTO Bike Guide)

The Stevens Forest Road segment will also have intersection crossings. Due to the narrow with of the existing bridge over the Little Patuxent River at this location, this segment will be a combination on on-road shared use path (south of the bridge) and on-road bike lanes. Because the Broken Land Parkway intersection is very wide, green bicycle crossing markings are recommended to guide cyclists to the connecting bike lanes on the far side of the intersection. In addition, bicycle queue boxes are recommended ahead of the stop bar on each side of the intersection to allow cyclists to position themselves ahead of cars for turning maneuvers and to gain a hear start to cross the intersection. High visibility crosswalk markings are also recommended at the location where trail users exit the on-road shared use path, pedestrians are routed to a proposed sidewalk along the east side of Stevens Forest Road, and cyclists to the northbound bike lane. Special consideration is the crosswalk location is required in order to ensure adequate sight lines. High visibility crosswalk marking are also recommended at commercial driveways and at the intersection crossing at Woodside Court.

## 3.5 Lighting

As indicated in the AASHTO Bike Guide, fixed-source lighting can improve visibility along the path and at intersection at night. The installation of lighting should be considered if nighttime usage is permitted. The lighting should be pedestrian-scale using short (12-foot high) poles and should be installed to provide consistent lighting levels along the path. While the AASHTO Bike Guide recommends the use of Metal halide lamps, LED fixtures will be considered consistent with the neighboring Downtown Columbia Trail. All lighting fixtures should be Dark Sky compliant per International Dark Sky Association requirements. Additionally, lighting should be provided under the two roadway underpasses. Due to the length of the undercrossings, it is likely that daytime lighting will also be required at these locations. Existing lighting levels should be reviewed to make a final determination.

## 3.6 Safety and Security

In addition to lighting, the trail design should apply the principals of crime prevention through environmental design, and provide additional enhancements designed to discourage undesirable activities within the project area. Enhancements may include:

- Creating inviting trail spaces to increase trail usage and enhance natural surveillance
- Removal of vegetation and use of small-scale landscape plantings to ensure clear sight lines
- Careful selection of locations for trail waysides and site amenities
- Coordination with police and emergency services to provide mile markers, wayfinding and location identification signage, security cameras, and access points for emergency vehicles
- Carefully selecting locations of lighting to prevent blind spots
- Coordination with County staff to develop and implement a routine maintenance schedule
- Installation of a high water warning system for flood-prone areas of the trail

## 3.7 Structures

The project includes two stream crossings over tributaries of the Little Patuxent River. One location is at Sta. 41+80 and the other at Sta. 67+00. Both crossings are anticipated to be a prefabricated steel pedestrian bridges. The span lengths for the two bridges are 35 feet and 50 feet. The design of both bridges will accommodate vehicular (H-5, 10,000 pounds) live loading to provide access for maintenance vehicles and emergency services. The bridges will be supported by cast-in-place reinforced concrete abutments which may be founded on reinforced concrete drilled shafts.

The site conditions throughout the remainder of the project area are generally flat. Engineered retaining walls are not anticipated based on a desktop review of the project area; however, minimal height segmental retaining walls may be appropriate to limit grading into adjacent properties, such as along Stevens Forest Road.

## 3.8 Typical Sections

The shared-use path should be developed based upon a 10-foot wide, two-way cross-section, as shown in Figure 1 above. This width represents the minimum acceptable width for an unconstrained shared use path. The user volumes are not anticipated to exceed three hundred users in the peak hour period; as such, a wider path is not necessary.

Consistent with the AASHTO Guide for the Development of Bicycle Facilities, a minimum width of 10-feet is recommended for the path width. A minimum of 2-feet of separation is recommended between signs, retaining walls, and shallow swales; a 1-foot to 2-foot separation is recommended between boardwalk or other railings and the path where possible. Three typical cross-sections for the path are provided below as Figures 3 through 5. Figure 4 could be used in the underpass areas based on coordination with SHA regarding acceptable designs within their right-of-way.

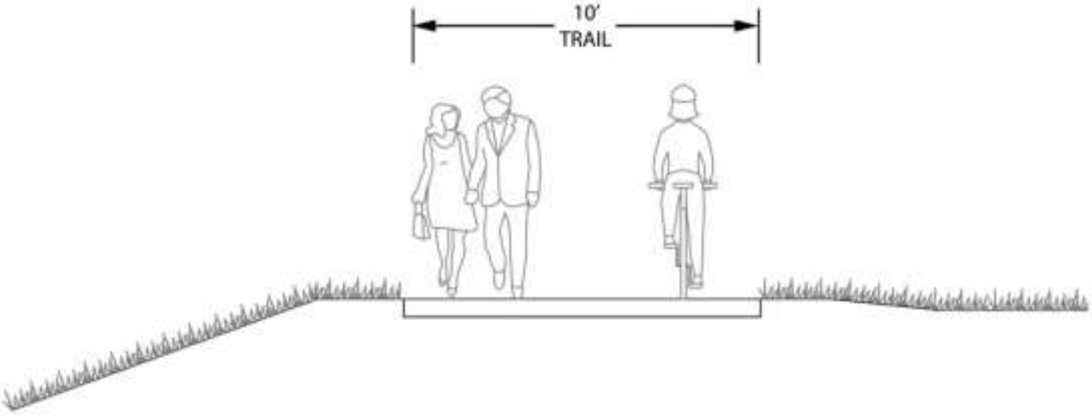


Figure 3: Typical Shared Use Path Cross Section

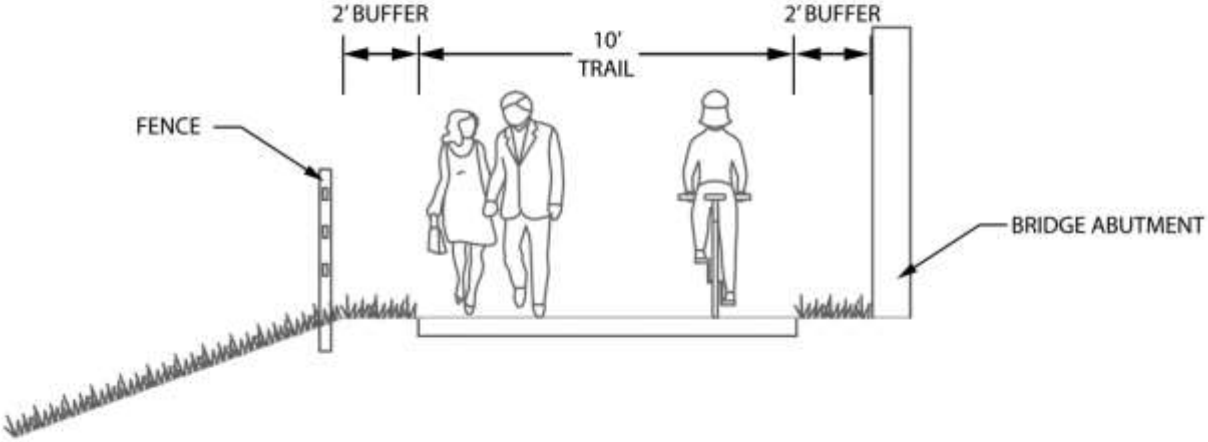


Figure 4: Typical Cross Section showing At-Grade Condition Below Underpass

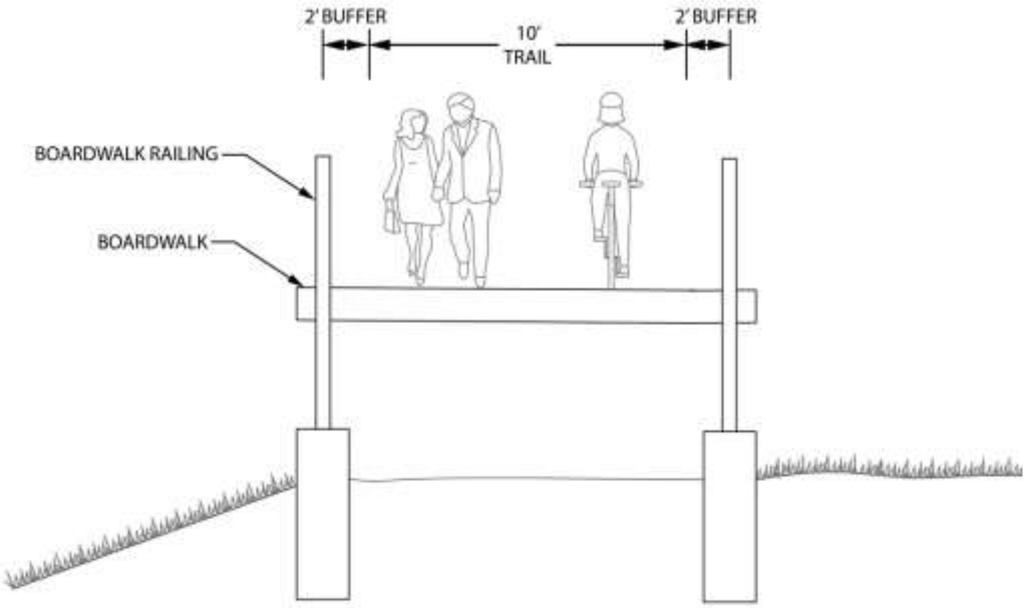


Figure 5: Typical Cross Section showing Boardwalk Design

### 3.9 Right-of-Way

Much of the trail alignment falls within County or SHA rights-of-way, however permanent and temporary construction easements will be required in a number of locations to accommodate construction and future maintenance of trail facilities. In general, criteria for acquiring permanent easements is as follows:

- 3-5 feet beyond the back edge of pavement for sidepaths along roadways (dependent on presence of lighting and fencing/railings along the outside edge)
- 10-15 feet beyond the limits of structures (bridges and retaining walls)

### 3.10 Maintenance

Maintenance should be considered in the design of the shared-use path. Access for both maintenance vehicles and the utility owners along this alignment must be provided along the length of the shared use path, but may not be continuous end-to-end. For example, the design under Route 29 may not accommodate vehicles due to the path width, boardwalk load rating, or vertical clearances. If vehicles are not permitted to travel under this bridge, warning signs, barriers, or other treatments should be utilized to physically prevent vehicles from accessing the bridge.

A maintenance plan should be developed along with the design of the path to ensure that all proposed amenities and path features are understood and located such that they can be easy accessed and maintained. Given that the path is intended to be used for transportation as well as recreation, consideration for snow clearing should also be included in the maintenance plan.

## 4.0 Permit Requirements

Based on the information provided above, the following table summarizes anticipated permit requirements for this project:

| Agency | Permit |
|---|---|
| **US Army Corps of Engineers** | Department of the Army Wetland Permit |
| **Maryland Department of the Environment** | Wetlands and Waterways Permit |
| **Maryland Department of Transportation** | Bikeways Program technical approval |
| **Maryland State Highway Administration** | District Office Permit<br>Memorandum of Agreement for operation and maintenance of the trail<br>Approval of H&H study |
| **Howard County** | Forest Conservation Plan approval for properties outside the New Town zoning district |
| **Howard County** | Site Development Plan (SDP) approval<br>Grading Permit |
| **Utility Companies** | Approval of design plans by impacted utilities |
| | |

## 5.0 Preliminary Cost Estimate

A preliminary cost estimate was prepared based on the 30% design plans. The estimate currently includes a 25% contingency due to the preliminary nature of the design. The estimate will be updated and further refines with subsequent design phases, and the contingency amount will be reduced as more design information becomes available. Because the portion of the trail closest to Little Patuxent Parkway traverses land that is currently being redeveloped and may ultimately be funded or constructed by the developer, the cost estimate includes a separate breakdown for costs related the portion of the trail along South Entrance Road. The preliminary cost estimate is included in Appendix E.

## Appendices

# Appendix A: Photographs

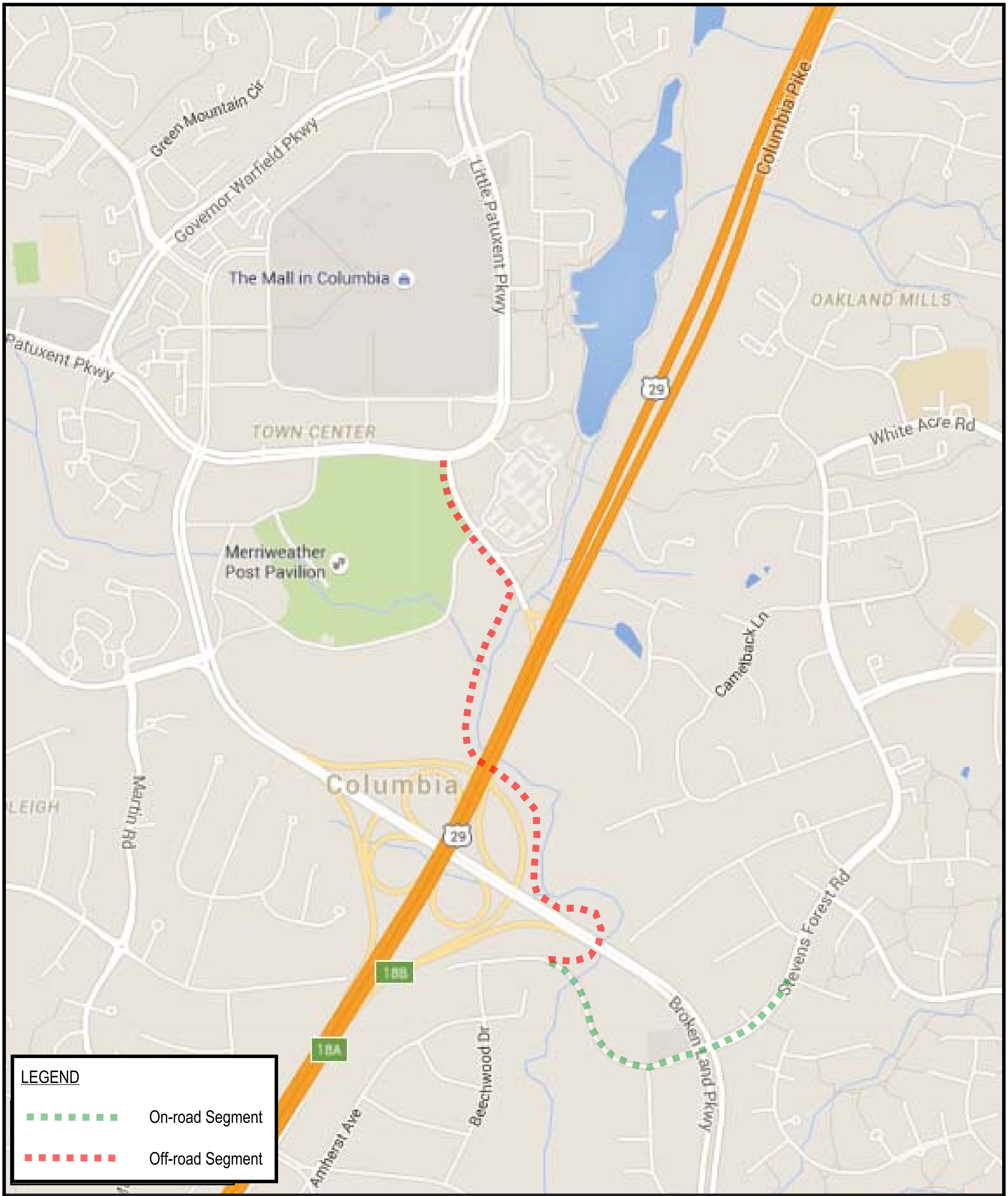
Photo 1: Northbound Columbia Pike Bridge over Little Patuxent River looking South

Photo 2: East of Columbia Pike (Rt 29) Bridge looking West

Photo 3: Little Patuxent River looking west from Columbia Pike (Rt 29)

Photo 4: Looking east toward Columbia Pike (Rt 29) Bridge

# Appendix B: Location Map



# DOWNTOWN COLUMBIA TO STEPHENS FOREST ROAD

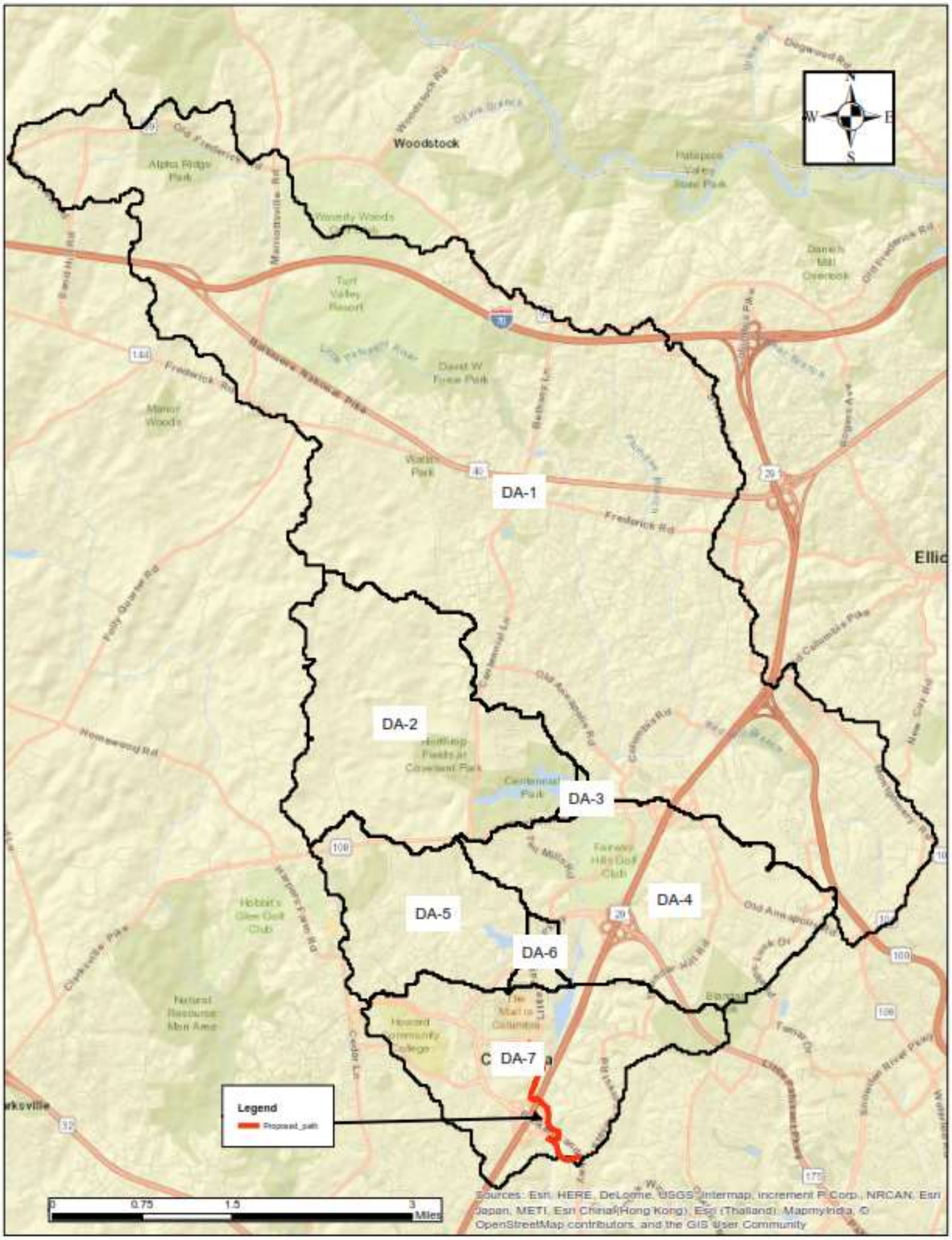
LOCATION MAP

**TooleDesignGroup**

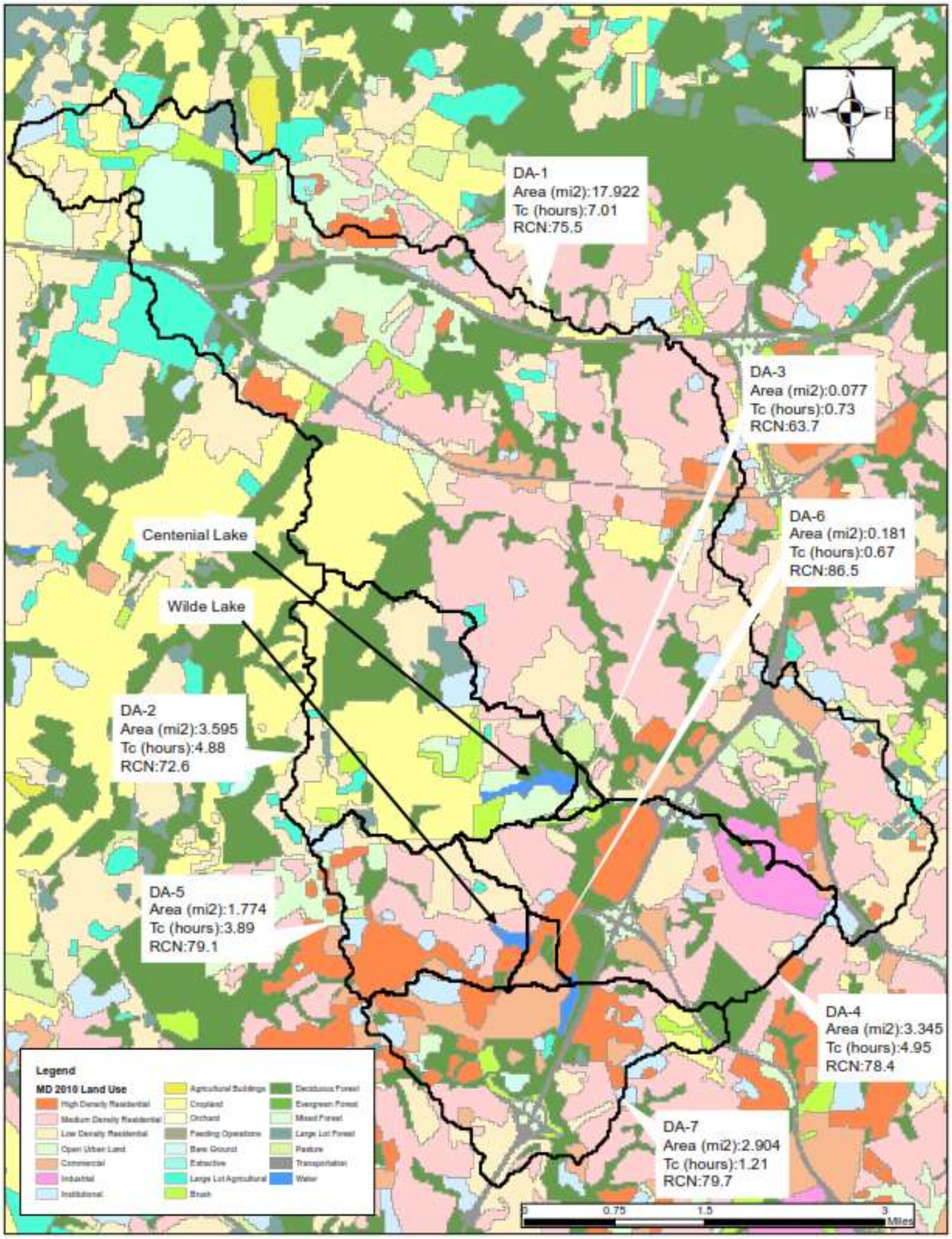
8484 GEORGIA AVE, SUITE 800, SILVER SPRING, MD 20901
PHONE: (301) 927-1900 FAX: (301) 927-2800
www.tooledesign.com

PREPARED: JAC
CHECKED: MAB
DATE: OCTOBER 31, 2016
SCALE: NTS

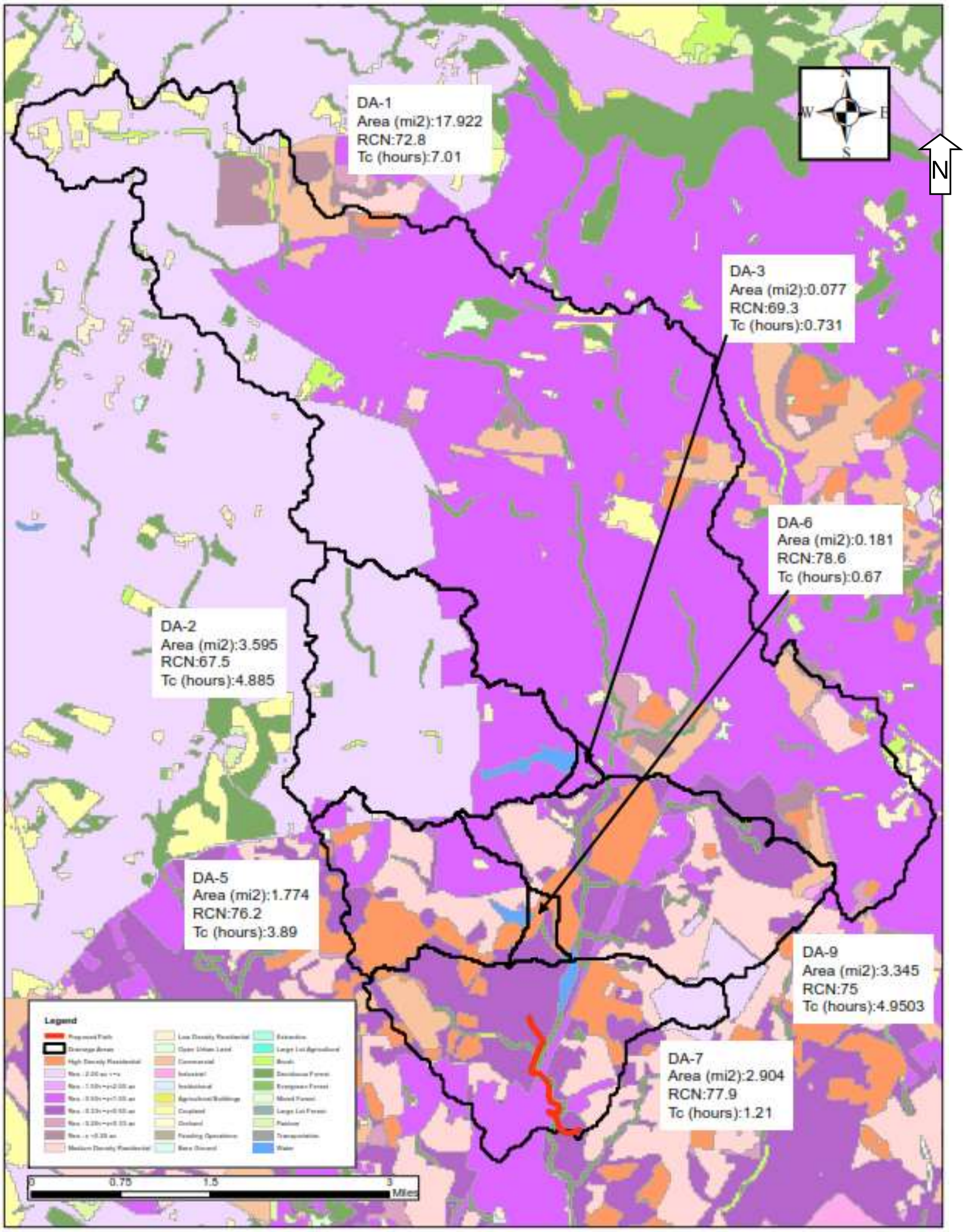
# Appendix C: H&H Computations and 100-Year Floodplain Map



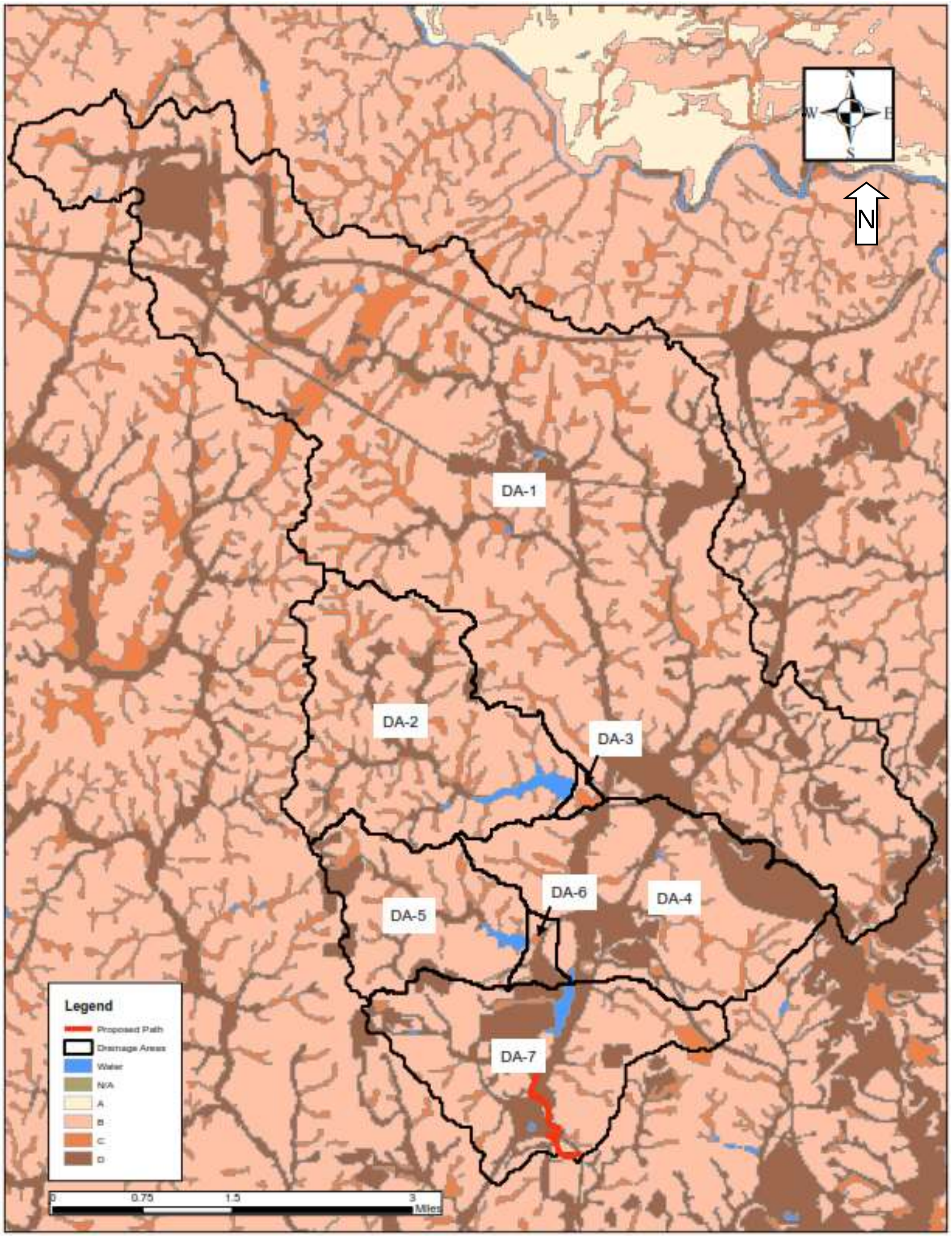
Watershed Area Map.



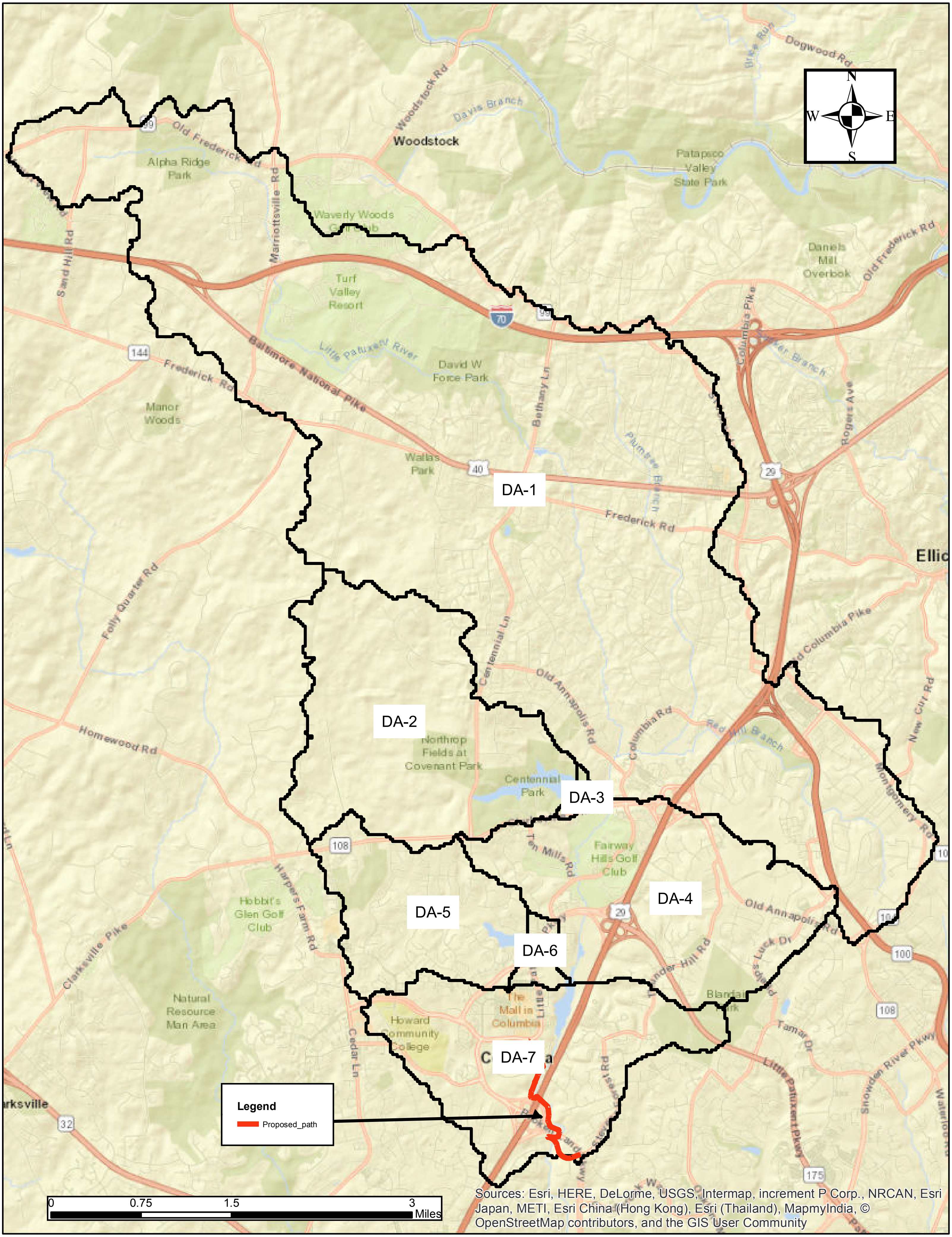
Existing Development Conditions (2010) Land Use.



Ultimate Development Conditions Land Use.



SSURGO Soils by Hydrologic Soil Group.

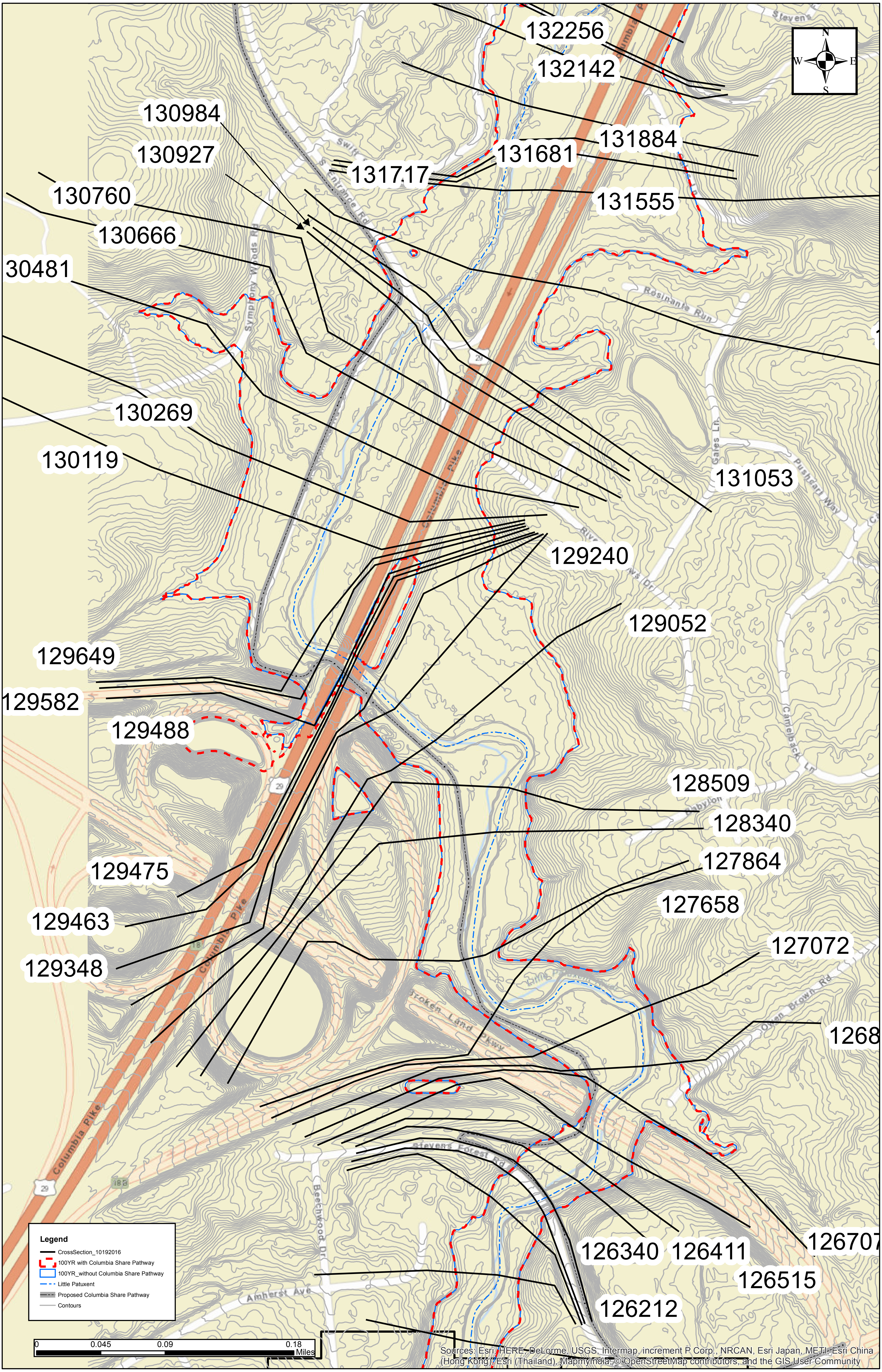


Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

```
Watershed Statistics for:
GISHydro Release Version Date: January 8, 2011
Hydro Extension Version Date:  January 8, 2011
Analysis Date:                 September 15, 2016

Data Selected:
     Quadrangles Used: savage, clarksville, sykesville, ellicott_city
     DEM Coverage: NED DEMs
     Land Use Coverage: 2010 MOP Landuse
     Soil Coverage: SSURGO Soils
     Hydrologic Condition: (see Lookup Table)
     Impose NHD stream Locations: Yes
     Outlet Easting:        412395 m. (MD Stateplane, NAD 1983)
     Outlet Northing:       169949 m. (MD Stateplane, NAD 1983)

Findings:
     Outlet Location:       Piedmont
     Outlet State:          Maryland
     Drainage Area          29.8 square miles
       -Piedmont (100.0% of area)
     Channel Slope:         23.1 feet/mile
     Land Slope:            0.054 ft/ft
     Urban Area:            52.6%
     Impervious Area:       28.4%
 ******************************************************
     URBAN DEVELOPMENT IN WATERSHED EXCEEDS 15%.
     Calculated discharges from USGS Regression
     Equations may not be appropriate.
 ******************************************************
 ******************************************************
     Watershed is within 5km of physiographic
     province boundary.  You should consider
     sensitivity of discharges to region location.
 ******************************************************
     Time of Concentration: 5.9 hours  [W.O. Thomas, Jr. Equation]
     Time of Concentration: 8.1 hours  [From SCS Lag Equation * 1.67]
     Longest Flow Path:     14.10 miles
     Basin Relief:          131.6 feet
     Average CN:            76
     % Forest Cover:        20.4
     % Storage:             0.5
     % Limestone:           0.0
     Selected Soils Data Statistics:
        % A Soils:          0.0
        % B Soils:          66.2
        % C Soils:          12.4
        % D Soils:          20.7
     SSURGO Soils Data Statistics (used in Regression Equations):
        % A Soils:          0.0
        % B Soils:          66.2
        % C Soils:          12.4
        % D Soils:          20.7
     2-Year,24-hour Prec.:  3.21 inches
     Mean Annual Prec.:     44.93 inches
```


132256
132142
130984
131884
131681
130927
131717
131555
130760
130666
30481
130269
130119
131053
129240
129052
129649
129582
129488
128509
128340
127864
129475
127658
129463
127072
129348
1268
126707
126340
126411
126515
126212
Columbia Pike
Stevens
Swift
S Entrance Rd
Symphony Woods Rd
Rosinante Run
Gates Ln
Pushcart Way
River Meadows Dr
Camelback Ln
Babylon
Broken Land Pkwy
Owen Brown Rd
Little Patuxent
Stevens Forest Rd
Beechwood Dr
Amherst Ave
29
18
188
N
S
E
W
Legend
CrossSection_10192016
100YR with Columbia Share Pathway
100YR_without Columbia Share Pathway
Little Patuxent
Proposed Columbia Share Pathway
Contours
0
0.045
0.09
0.18
Miles
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

| Reach | River Sta | Profile | Plan | Q Total | W.S. Elev | E.G. Elev | E.G. Slope | Vel Chnl | Top Width | Change in WSELEV |
|---|---|---|---|---|---|---|---|---|---|---|
| Little Patuxent | 137471 | 2-year | With Pathway | 1240 | 305.96 | 306.02 | 0.000395 | 2.34 | 781.84 | 0 |
| Little Patuxent | 137471 | 2-year | No Pathway | 1240 | 305.96 | 306.02 | 0.000394 | 2.34 | 782.22 | |
| | | | | | | | | | | |
| Little Patuxent | 137429 | | | Culvert | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 137396 | 2-year | With Pathway | 1240 | 305.03 | 305.13 | 0.000635 | 2.84 | 584.61 | 0 |
| Little Patuxent | 137396 | 2-year | No Pathway | 1240 | 305.03 | 305.13 | 0.000635 | 2.84 | 584.6 | |
| | | | | | | | | | | |
| Little Patuxent | 137263 | 2-year | With Pathway | 1240 | 304.9 | 305.01 | 0.0013 | 3.53 | 784.93 | 0 |
| Little Patuxent | 137263 | 2-year | No Pathway | 1240 | 304.9 | 305.01 | 0.0013 | 3.53 | 784.92 | |
| | | | | | | | | | | |
| Little Patuxent | 136811 | 2-year | With Pathway | 1240 | 304.52 | 304.56 | 0.000712 | 2.28 | 638 | 0 |
| Little Patuxent | 136811 | 2-year | No Pathway | 1240 | 304.52 | 304.56 | 0.000712 | 2.28 | 638 | |
| | | | | | | | | | | |
| Little Patuxent | 136278 | 2-year | With Pathway | 1240 | 303.96 | 304.08 | 0.001065 | 3.08 | 283.12 | 0 |
| Little Patuxent | 136278 | 2-year | No Pathway | 1240 | 303.96 | 304.08 | 0.001065 | 3.08 | 283.12 | |
| | | | | | | | | | | |
| Little Patuxent | 135883 | 2-year | With Pathway | 1240 | 303.31 | 303.52 | 0.001964 | 3.91 | 408.44 | 0 |
| Little Patuxent | 135883 | 2-year | No Pathway | 1240 | 303.31 | 303.52 | 0.001964 | 3.91 | 408.44 | |
| | | | | | | | | | | |
| Little Patuxent | 135382 | 2-year | With Pathway | 1240 | 303.22 | 303.23 | 0.000192 | 1.27 | 1336.33 | 0 |
| Little Patuxent | 135382 | 2-year | No Pathway | 1240 | 303.22 | 303.23 | 0.000192 | 1.27 | 1336.29 | |
| | | | | | | | | | | |
| Little Patuxent | 134739 | 2-year | With Pathway | 1770 | 303.05 | 303.07 | 0.000304 | 1.68 | 723.17 | 0 |
| Little Patuxent | 134739 | 2-year | No Pathway | 1770 | 303.05 | 303.07 | 0.000304 | 1.68 | 723.17 | |
| | | | | | | | | | | |
| Little Patuxent | 134223 | 2-year | With Pathway | 1770 | 302.77 | 302.84 | 0.000764 | 2.64 | 788.72 | 0 |
| Little Patuxent | 134223 | 2-year | No Pathway | 1770 | 302.77 | 302.84 | 0.000764 | 2.65 | 788.69 | |
| | | | | | | | | | | |
| Little Patuxent | 133818 | 2-year | With Pathway | 1770 | 302.41 | 302.51 | 0.000841 | 3.11 | 857.69 | 0 |
| Little Patuxent | 133818 | 2-year | No Pathway | 1770 | 302.41 | 302.51 | 0.000842 | 3.11 | 857.68 | |
| | | | | | | | | | | |
| Little Patuxent | 133353 | 2-year | With Pathway | 1770 | 301.76 | 302 | 0.001487 | 4.69 | 599.4 | 0 |
| Little Patuxent | 133353 | 2-year | No Pathway | 1770 | 301.76 | 302 | 0.001492 | 4.69 | 599.38 | |
| | | | | | | | | | | |
| Little Patuxent | 132894 | 2-year | With Pathway | 1770 | 301.24 | 301.43 | 0.001032 | 3.86 | 559.96 | 0 |
| Little Patuxent | 132894 | 2-year | No Pathway | 1770 | 301.24 | 301.42 | 0.001036 | 3.87 | 559.77 | |
| | | | | | | | | | | |
| Little Patuxent | 132387 | 2-year | With Pathway | 1770 | 300.98 | 301.06 | 0.000484 | 2.81 | 357.88 | 0 |
| Little Patuxent | 132387 | 2-year | No Pathway | 1770 | 300.98 | 301.06 | 0.000486 | 2.82 | 357.76 | |
| | | | | | | | | | | |
| Little Patuxent | 132256 | 2-year | With Pathway | 1770 | 300.92 | 300.99 | 0.000525 | 2.63 | 323.4 | 0 |
| Little Patuxent | 132256 | 2-year | No Pathway | 1770 | 300.92 | 300.99 | 0.000527 | 2.63 | 323.33 | |
| | | | | | | | | | | |
| Little Patuxent | 132249 | | | Bridge | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 132244 | 2-year | With Pathway | 1770 | 300.43 | 300.52 | 0.000675 | 3.21 | 320.34 | 0.01 |
| Little Patuxent | 132244 | 2-year | No Pathway | 1770 | 300.42 | 300.51 | 0.000678 | 3.21 | 320.27 | |
| | | | | | | | | | | |
| Little Patuxent | 132142 | 2-year | With Pathway | 1770 | 300.4 | 300.46 | 0.000383 | 2.56 | 331.01 | 0.01 |
| Little Patuxent | 132142 | 2-year | No Pathway | 1770 | 300.39 | 300.45 | 0.000385 | 2.57 | 330.87 | |
| | | | | | | | | | | |
| Little Patuxent | 131884 | 2-year | With Pathway | 1770 | 300.26 | 300.35 | 0.000527 | 2.88 | 345.09 | 0.01 |
| Little Patuxent | 131884 | 2-year | No Pathway | 1770 | 300.25 | 300.34 | 0.000529 | 2.89 | 344.91 | |
| | | | | | | | | | | |

| Reach | River Sta | Profile | Plan | Q Total | W.S. Elev | E.G. Elev | E.G. Slope | Vel Chnl | Top Width | Change in WSELEV |
|---|---|---|---|---|---|---|---|---|---|---|
| Little Patuxent | 131717 | 2-year | With Pathway | 1770 | 300.22 | 300.28 | 0.000249 | 2.43 | 465.69 | 0.01 |
| Little Patuxent | 131717 | 2-year | No Pathway | 1770 | 300.21 | 300.27 | 0.00025 | 2.44 | 465.19 | |
| | | | | | | | | | | |
| Little Patuxent | 131701 | | | Bridge | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 131681 | 2-year | With Pathway | 1770 | 298.77 | 298.95 | 0.000711 | 3.63 | 392.49 | 0.01 |
| Little Patuxent | 131681 | 2-year | No Pathway | 1770 | 298.76 | 298.94 | 0.000713 | 3.64 | 391.79 | |
| | | | | | | | | | | |
| Little Patuxent | 131555 | 2-year | With Pathway | 1770 | 298.65 | 298.81 | 0.001484 | 3.55 | 390.03 | 0.01 |
| Little Patuxent | 131555 | 2-year | No Pathway | 1770 | 298.64 | 298.8 | 0.001493 | 3.55 | 388.31 | |
| | | | | | | | | | | |
| Little Patuxent | 131237 | 2-year | With Pathway | 1770 | 298.2 | 298.33 | 0.001455 | 3.91 | 260.4 | 0.01 |
| Little Patuxent | 131237 | 2-year | No Pathway | 1770 | 298.19 | 298.32 | 0.001467 | 3.92 | 260.28 | |
| | | | | | | | | | | |
| Little Patuxent | 131053 | 2-year | With Pathway | 1770 | 297.65 | 298 | 0.001554 | 4.9 | 93.59 | 0.01 |
| Little Patuxent | 131053 | 2-year | No Pathway | 1770 | 297.64 | 297.99 | 0.001567 | 4.91 | 93.41 | |
| | | | | | | | | | | |
| Little Patuxent | 130984 | 2-year | With Pathway | 1770 | 297.64 | 297.86 | 0.000807 | 3.8 | 86.72 | 0.01 |
| Little Patuxent | 130984 | 2-year | No Pathway | 1770 | 297.63 | 297.85 | 0.000812 | 3.81 | 86.59 | |
| | | | | | | | | | | |
| Little Patuxent | 130953 | | | Culvert | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 130927 | 2-year | With Pathway | 1770 | 296.73 | 296.87 | 0.000612 | 3.03 | 128.66 | 0.01 |
| Little Patuxent | 130927 | 2-year | No Pathway | 1770 | 296.72 | 296.86 | 0.000616 | 3.04 | 128.34 | |
| | | | | | | | | | | |
| Little Patuxent | 130760 | 2-year | With Pathway | 1770 | 296.44 | 296.67 | 0.002067 | 4.16 | 226.35 | 0.02 |
| Little Patuxent | 130760 | 2-year | No Pathway | 1770 | 296.42 | 296.66 | 0.002098 | 4.19 | 226.03 | |
| | | | | | | | | | | |
| Little Patuxent | 130666 | 2-year | With Pathway | 1770 | 296.24 | 296.5 | 0.001743 | 4.59 | 240.87 | 0.02 |
| Little Patuxent | 130666 | 2-year | No Pathway | 1770 | 296.22 | 296.48 | 0.001768 | 4.61 | 238.96 | |
| | | | | | | | | | | |
| Little Patuxent | 130481 | 2-year | With Pathway | 1770 | 296.06 | 296.2 | 0.001198 | 3.62 | 342.64 | 0.03 |
| Little Patuxent | 130481 | 2-year | No Pathway | 1770 | 296.03 | 296.18 | 0.001213 | 3.63 | 341.77 | |
| | | | | | | | | | | |
| Little Patuxent | 130269 | 2-year | With Pathway | 1770 | 295.98 | 296.04 | 0.000389 | 2.32 | 441.83 | 0.02 |
| Little Patuxent | 130269 | 2-year | No Pathway | 1770 | 295.96 | 296.02 | 0.000382 | 2.3 | 441.33 | |
| | | | | | | | | | | |
| Little Patuxent | 130119 | 2-year | With Pathway | 1770 | 295.86 | 295.95 | 0.001058 | 2.99 | 471.24 | 0.02 |
| Little Patuxent | 130119 | 2-year | No Pathway | 1770 | 295.84 | 295.93 | 0.001056 | 2.98 | 470.29 | |
| | | | | | | | | | | |
| Little Patuxent | 129649 | 2-year | With Pathway | 1770 | 294.98 | 295.26 | 0.002319 | 4.86 | 431.17 | 0.05 |
| Little Patuxent | 129649 | 2-year | No Pathway | 1770 | 294.93 | 295.22 | 0.002442 | 4.96 | 430.68 | |
| | | | | | | | | | | |
| Little Patuxent | 129582 | 2-year | With Pathway | 1770 | 294.87 | 295.12 | 0.001366 | 4.16 | 261.91 | 0.05 |
| Little Patuxent | 129582 | 2-year | No Pathway | 1770 | 294.82 | 295.07 | 0.001404 | 4.2 | 252.24 | |
| | | | | | | | | | | |
| Little Patuxent | 129517 | | | Bridge | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 129488 | 2-year | With Pathway | 1770 | 294.82 | 294.95 | 0.000052 | 2.91 | 117.24 | 0 |
| Little Patuxent | 129488 | 2-year | No Pathway | 1770 | 294.82 | 294.92 | 0.000036 | 2.56 | 117.1 | |
| | | | | | | | | | | |
| Little Patuxent | 129475 | 2-year | With Pathway | 1770 | 294.82 | 294.95 | 0.000054 | 2.95 | 126.22 | 0 |
| Little Patuxent | 129475 | 2-year | No Pathway | 1770 | 294.82 | 294.92 | 0.000038 | 2.59 | 126.1 | |
| | | | | | | | | | | |
| Little Patuxent | 129463 | 2-year | With Pathway | 1770 | 294.81 | 294.95 | 0.000056 | 2.98 | 122.91 | 0 |

| Reach | River Sta | Profile | Plan | Q Total | W.S. Elev | E.G. Elev | E.G. Slope | Vel Chnl | Top Width | Change in WSELEV |
|---|---|---|---|---|---|---|---|---|---|---|
| Little Patuxent | 137471 | 10-year | With Pathway | 2890 | 306.75 | 306.91 | 0.001065 | 4.09 | 879.23 | 0 |
| Little Patuxent | 137471 | 10-year | No Pathway | 2890 | 306.75 | 306.91 | 0.001068 | 4.1 | 878.89 | |
| | | | | | | | | | | |
| Little Patuxent | 137429 | | | Culvert | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 137396 | 10-year | With Pathway | 2890 | 306.75 | 306.87 | 0.000821 | 3.69 | 808.08 | 0 |
| Little Patuxent | 137396 | 10-year | No Pathway | 2890 | 306.75 | 306.87 | 0.000821 | 3.69 | 808.12 | |
| | | | | | | | | | | |
| Little Patuxent | 137263 | 10-year | With Pathway | 2890 | 306.66 | 306.72 | 0.000882 | 3.44 | 886.7 | 0 |
| Little Patuxent | 137263 | 10-year | No Pathway | 2890 | 306.66 | 306.72 | 0.000882 | 3.44 | 886.71 | |
| | | | | | | | | | | |
| Little Patuxent | 136811 | 10-year | With Pathway | 2890 | 306.39 | 306.43 | 0.000474 | 2.27 | 706.82 | 0 |
| Little Patuxent | 136811 | 10-year | No Pathway | 2890 | 306.39 | 306.43 | 0.000474 | 2.27 | 706.85 | |
| | | | | | | | | | | |
| Little Patuxent | 136278 | 10-year | With Pathway | 2890 | 305.75 | 305.96 | 0.001586 | 4.5 | 298.4 | 0 |
| Little Patuxent | 136278 | 10-year | No Pathway | 2890 | 305.75 | 305.96 | 0.001585 | 4.5 | 298.4 | |
| | | | | | | | | | | |
| Little Patuxent | 135883 | 10-year | With Pathway | 2890 | 305.12 | 305.31 | 0.001761 | 4.5 | 494.48 | 0 |
| Little Patuxent | 135883 | 10-year | No Pathway | 2890 | 305.12 | 305.32 | 0.001759 | 4.5 | 494.49 | |
| | | | | | | | | | | |
| Little Patuxent | 135382 | 10-year | With Pathway | 2890 | 305.08 | 305.09 | 0.000135 | 1.29 | 1390.5 | 0 |
| Little Patuxent | 135382 | 10-year | No Pathway | 2890 | 305.08 | 305.09 | 0.000135 | 1.29 | 1390.51 | |
| | | | | | | | | | | |
| Little Patuxent | 134739 | 10-year | With Pathway | 4010 | 304.92 | 304.95 | 0.000338 | 2.12 | 755.2 | 0 |
| Little Patuxent | 134739 | 10-year | No Pathway | 4010 | 304.92 | 304.95 | 0.000337 | 2.12 | 755.22 | |
| | | | | | | | | | | |
| Little Patuxent | 134223 | 10-year | With Pathway | 4010 | 304.68 | 304.74 | 0.00055 | 2.71 | 819.69 | -0.01 |
| Little Patuxent | 134223 | 10-year | No Pathway | 4010 | 304.69 | 304.74 | 0.000549 | 2.71 | 819.71 | |
| | | | | | | | | | | |
| Little Patuxent | 133818 | 10-year | With Pathway | 4010 | 304.47 | 304.52 | 0.000508 | 2.87 | 876.65 | 0 |
| Little Patuxent | 133818 | 10-year | No Pathway | 4010 | 304.47 | 304.53 | 0.000507 | 2.87 | 876.67 | |
| | | | | | | | | | | |
| Little Patuxent | 133353 | 10-year | With Pathway | 4010 | 304.13 | 304.24 | 0.000829 | 4.09 | 615.66 | 0 |
| Little Patuxent | 133353 | 10-year | No Pathway | 4010 | 304.13 | 304.24 | 0.000827 | 4.09 | 615.68 | |
| | | | | | | | | | | |
| Little Patuxent | 132894 | 10-year | With Pathway | 4010 | 303.8 | 303.9 | 0.000676 | 3.73 | 628.07 | 0 |
| Little Patuxent | 132894 | 10-year | No Pathway | 4010 | 303.8 | 303.91 | 0.000675 | 3.73 | 628.11 | |
| | | | | | | | | | | |
| Little Patuxent | 132387 | 10-year | With Pathway | 4010 | 303.49 | 303.6 | 0.000621 | 3.72 | 422.8 | 0 |
| Little Patuxent | 132387 | 10-year | No Pathway | 4010 | 303.49 | 303.6 | 0.000619 | 3.72 | 422.91 | |
| | | | | | | | | | | |
| Little Patuxent | 132256 | 10-year | With Pathway | 4010 | 303.39 | 303.51 | 0.000724 | 3.69 | 409.01 | 0 |
| Little Patuxent | 132256 | 10-year | No Pathway | 4010 | 303.39 | 303.51 | 0.000724 | 3.7 | 410.91 | |
| | | | | | | | | | | |
| Little Patuxent | 132249 | | | Bridge | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 132244 | 10-year | With Pathway | 4010 | 302.94 | 303.07 | 0.000858 | 4.24 | 386.12 | -0.01 |
| Little Patuxent | 132244 | 10-year | No Pathway | 4010 | 302.95 | 303.07 | 0.000856 | 4.24 | 386.25 | |
| | | | | | | | | | | |
| Little Patuxent | 132142 | 10-year | With Pathway | 4010 | 302.88 | 302.99 | 0.000595 | 3.73 | 456.01 | -0.01 |
| Little Patuxent | 132142 | 10-year | No Pathway | 4010 | 302.89 | 302.99 | 0.000593 | 3.72 | 456.31 | |
| | | | | | | | | | | |
| Little Patuxent | 131884 | 10-year | With Pathway | 4010 | 302.61 | 302.8 | 0.000956 | 4.53 | 522.18 | 0 |
| Little Patuxent | 131884 | 10-year | No Pathway | 4010 | 302.61 | 302.81 | 0.000953 | 4.53 | 522.34 | |
| | | | | | | | | | | |

| Reach | River Sta | Profile | Plan | Q Total | W.S. Elev | E.G. Elev | E.G. Slope | Vel Chnl | Top Width | Change in WSELEV |
|---|---|---|---|---|---|---|---|---|---|---|
| Little Patuxent | 131717 | 10-year | With Pathway | 4010 | 302.55 | 302.67 | 0.000423 | 3.62 | 677.45 | -0.01 |
| Little Patuxent | 131717 | 10-year | No Pathway | 4010 | 302.56 | 302.68 | 0.000422 | 3.61 | 677.55 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 131701 |  |  | Bridge |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 131681 | 10-year | With Pathway | 4010 | 302.44 | 302.56 | 0.000474 | 3.71 | 708.46 | 0 |
| Little Patuxent | 131681 | 10-year | No Pathway | 4010 | 302.44 | 302.57 | 0.000472 | 3.7 | 709.25 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 131555 | 10-year | With Pathway | 4010 | 302.33 | 302.48 | 0.000827 | 3.71 | 663.75 | -0.01 |
| Little Patuxent | 131555 | 10-year | No Pathway | 4010 | 302.34 | 302.48 | 0.000825 | 3.71 | 664.12 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 131237 | 10-year | With Pathway | 4010 | 302.1 | 302.2 | 0.00083 | 3.86 | 313.33 | -0.01 |
| Little Patuxent | 131237 | 10-year | No Pathway | 4010 | 302.11 | 302.21 | 0.000828 | 3.85 | 313.4 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 131053 | 10-year | With Pathway | 4010 | 301.56 | 301.96 | 0.00119 | 5.81 | 479.01 | -0.01 |
| Little Patuxent | 131053 | 10-year | No Pathway | 4010 | 301.57 | 301.97 | 0.001183 | 5.79 | 479.67 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 130984 | 10-year | With Pathway | 4010 | 301.57 | 301.84 | 0.000687 | 4.64 | 351.83 | -0.01 |
| Little Patuxent | 130984 | 10-year | No Pathway | 4010 | 301.58 | 301.85 | 0.000677 | 4.61 | 352.39 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 130953 |  |  | Culvert |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 130927 | 10-year | With Pathway | 4010 | 299.24 | 299.57 | 0.000974 | 4.73 | 173.28 | -0.04 |
| Little Patuxent | 130927 | 10-year | No Pathway | 4010 | 299.28 | 299.6 | 0.000959 | 4.71 | 173.83 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 130760 | 10-year | With Pathway | 4010 | 299.05 | 299.34 | 0.001826 | 5.07 | 275.78 | -0.05 |
| Little Patuxent | 130760 | 10-year | No Pathway | 4010 | 299.1 | 299.38 | 0.001784 | 5.03 | 276.4 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 130666 | 10-year | With Pathway | 4010 | 298.93 | 299.17 | 0.001579 | 5.29 | 346.8 | -0.04 |
| Little Patuxent | 130666 | 10-year | No Pathway | 4010 | 298.97 | 299.21 | 0.001554 | 5.26 | 347.02 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 130481 | 10-year | With Pathway | 4010 | 298.79 | 298.91 | 0.000933 | 3.94 | 422.36 | -0.05 |
| Little Patuxent | 130481 | 10-year | No Pathway | 4010 | 298.84 | 298.96 | 0.000899 | 3.88 | 423.35 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 130269 | 10-year | With Pathway | 4010 | 298.69 | 298.77 | 0.000422 | 2.91 | 490.01 | -0.06 |
| Little Patuxent | 130269 | 10-year | No Pathway | 4010 | 298.75 | 298.82 | 0.000399 | 2.84 | 490.59 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 130119 | 10-year | With Pathway | 4010 | 298.6 | 298.69 | 0.000742 | 3.28 | 577.11 | -0.06 |
| Little Patuxent | 130119 | 10-year | No Pathway | 4010 | 298.66 | 298.74 | 0.000708 | 3.22 | 578.48 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129649 | 10-year | With Pathway | 4010 | 298.17 | 298.31 | 0.00106 | 4.29 | 572.43 | -0.08 |
| Little Patuxent | 129649 | 10-year | No Pathway | 4010 | 298.25 | 298.38 | 0.001007 | 4.2 | 588.48 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129582 | 10-year | With Pathway | 4010 | 297.53 | 298.08 | 0.002159 | 6.41 | 591.65 | -0.1 |
| Little Patuxent | 129582 | 10-year | No Pathway | 4010 | 297.63 | 298.16 | 0.002085 | 6.33 | 594.32 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129517 |  |  | Bridge |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129488 | 10-year | With Pathway | 4010 | 297.32 | 297.71 | 0.000113 | 4.98 | 237.49 | -0.08 |
| Little Patuxent | 129488 | 10-year | No Pathway | 4010 | 297.4 | 297.71 | 0.000085 | 4.49 | 238.71 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129475 | 10-year | With Pathway | 4010 | 297.31 | 297.7 | 0.000116 | 5.03 | 244.01 | -0.08 |
| Little Patuxent | 129475 | 10-year | No Pathway | 4010 | 297.39 | 297.71 | 0.000087 | 4.53 | 245.66 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129463 | 10-year | With Pathway | 4010 | 297.3 | 297.7 | 0.000119 | 5.07 | 254.8 | -0.08 |

| Reach | River Sta | Profile | Plan | Q Total | W.S. Elev | E.G. Elev | E.G. Slope | Vel Chnl | Top Width | Change in WSELEV |
|---|---|---|---|---|---|---|---|---|---|---|
| Little Patuxent | 129463 | 10-year | No Pathway | 4010 | 297.38 | 297.7 | 0.00009 | 4.57 | 259.19 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129423 |  |  | Bridge |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129348 | 10-year | With Pathway | 4010 | 296.6 | 297.36 | 0.003794 | 7.39 | 640.03 | 0.04 |
| Little Patuxent | 129348 | 10-year | No Pathway | 4010 | 296.56 | 297.33 | 0.003857 | 7.43 | 638.94 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129240 | 10-year | With Pathway | 4010 | 296.76 | 296.84 | 0.000808 | 3.18 | 578.08 | 0.04 |
| Little Patuxent | 129240 | 10-year | No Pathway | 4010 | 296.72 | 296.8 | 0.000822 | 3.2 | 574.48 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129052 | 10-year | With Pathway | 4010 | 296.58 | 296.66 | 0.000745 | 3.11 | 611.43 | 0.04 |
| Little Patuxent | 129052 | 10-year | No Pathway | 4010 | 296.54 | 296.62 | 0.000746 | 3.1 | 610.68 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 128509 | 10-year | With Pathway | 4010 | 295.83 | 296.1 | 0.001753 | 4.88 | 289.88 | 0.01 |
| Little Patuxent | 128509 | 10-year | No Pathway | 4010 | 295.82 | 296.08 | 0.001686 | 4.78 | 289.79 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 128340 | 10-year | With Pathway | 4010 | 295.39 | 295.77 | 0.002011 | 5.33 | 260.01 | -0.01 |
| Little Patuxent | 128340 | 10-year | No Pathway | 4010 | 295.4 | 295.75 | 0.001947 | 5.24 | 260.07 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 127864 | 10-year | With Pathway | 4010 | 294.87 | 295.05 | 0.001011 | 4 | 290.33 | 0.02 |
| Little Patuxent | 127864 | 10-year | No Pathway | 4010 | 294.85 | 295.04 | 0.001044 | 4.06 | 290.22 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 127658 | 10-year | With Pathway | 4010 | 294.15 | 294.67 | 0.003543 | 6.9 | 228.95 | 0.03 |
| Little Patuxent | 127658 | 10-year | No Pathway | 4010 | 294.12 | 294.65 | 0.003621 | 6.96 | 228.76 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 127072 | 10-year | With Pathway | 4010 | 293.67 | 293.8 | 0.000898 | 3.85 | 405.52 | 0.01 |
| Little Patuxent | 127072 | 10-year | No Pathway | 4010 | 293.66 | 293.79 | 0.000872 | 3.79 | 382.91 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126863 | 10-year | With Pathway | 4010 | 293.47 | 293.63 | 0.001031 | 3.8 | 355.05 | 0.02 |
| Little Patuxent | 126863 | 10-year | No Pathway | 4010 | 293.45 | 293.62 | 0.001042 | 3.82 | 354.95 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126707 | 10-year | With Pathway | 4010 | 292.93 | 293.35 | 0.002491 | 6.09 | 311.86 | 0.02 |
| Little Patuxent | 126707 | 10-year | No Pathway | 4010 | 292.91 | 293.34 | 0.002534 | 6.13 | 310.52 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126605 |  |  | Bridge |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126515 | 10-year | With Pathway | 4010 | 292.47 | 292.71 | 0.001082 | 4.64 | 194.64 | 0 |
| Little Patuxent | 126515 | 10-year | No Pathway | 4010 | 292.47 | 292.71 | 0.001096 | 4.67 | 202.01 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126411 | 10-year | With Pathway | 4010 | 292.37 | 292.61 | 0.000928 | 4.42 | 220.65 | 0.01 |
| Little Patuxent | 126411 | 10-year | No Pathway | 4010 | 292.36 | 292.61 | 0.000938 | 4.45 | 235.72 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126340 | 10-year | With Pathway | 4010 | 292.07 | 292.49 | 0.002202 | 6.49 | 228.26 | 0 |
| Little Patuxent | 126340 | 10-year | No Pathway | 4010 | 292.07 | 292.49 | 0.002202 | 6.49 | 228.26 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126212 | 10-year | With Pathway | 4010 | 291.89 | 292.23 | 0.00163 | 5.43 | 207.76 | 0 |
| Little Patuxent | 126212 | 10-year | No Pathway | 4010 | 291.89 | 292.23 | 0.00163 | 5.43 | 207.76 |  |
|  |  |  |  |  |  |  |  |  |  |  |

| Reach | River Sta | Profile | Plan | Q Total | W.S. Elev | E.G. Elev | E.G. Slope | Vel Chnl | Top Width | Change in WSELEV |
|---|---|---|---|---|---|---|---|---|---|---|
| Little Patuxent | 129463 | 2-year | No Pathway | 1770 | 294.81 | 294.92 | 0.000039 | 2.63 | 122.91 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129423 |  |  | Bridge |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129348 | 2-year | With Pathway | 1770 | 294.52 | 294.84 | 0.00221 | 4.65 | 557.21 | 0.03 |
| Little Patuxent | 129348 | 2-year | No Pathway | 1770 | 294.49 | 294.81 | 0.002247 | 4.67 | 556.62 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129240 | 2-year | With Pathway | 1770 | 294.47 | 294.55 | 0.000998 | 2.77 | 514.61 | 0.03 |
| Little Patuxent | 129240 | 2-year | No Pathway | 1770 | 294.44 | 294.52 | 0.001019 | 2.79 | 514.19 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129052 | 2-year | With Pathway | 1770 | 294.27 | 294.34 | 0.000884 | 2.66 | 528.12 | 0.04 |
| Little Patuxent | 129052 | 2-year | No Pathway | 1770 | 294.23 | 294.3 | 0.000901 | 2.68 | 543.03 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 128509 | 2-year | With Pathway | 1770 | 293.58 | 293.75 | 0.001488 | 3.59 | 266.72 | 0 |
| Little Patuxent | 128509 | 2-year | No Pathway | 1770 | 293.58 | 293.73 | 0.001414 | 3.5 | 266.64 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 128340 | 2-year | With Pathway | 1770 | 293.35 | 293.52 | 0.00122 | 3.42 | 224.67 | 0 |
| Little Patuxent | 128340 | 2-year | No Pathway | 1770 | 293.35 | 293.51 | 0.001176 | 3.36 | 224.64 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 127864 | 2-year | With Pathway | 1770 | 293.02 | 293.11 | 0.000587 | 2.61 | 260.12 | 0.01 |
| Little Patuxent | 127864 | 2-year | No Pathway | 1770 | 293.01 | 293.1 | 0.000608 | 2.65 | 259.95 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 127658 | 2-year | With Pathway | 1770 | 292.67 | 292.9 | 0.001848 | 4.34 | 214.3 | 0.02 |
| Little Patuxent | 127658 | 2-year | No Pathway | 1770 | 292.65 | 292.88 | 0.001881 | 4.37 | 214.2 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 127072 | 2-year | With Pathway | 1770 | 292.45 | 292.49 | 0.000373 | 2.25 | 348.22 | 0.03 |
| Little Patuxent | 127072 | 2-year | No Pathway | 1770 | 292.42 | 292.47 | 0.000378 | 2.27 | 347.89 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126863 | 2-year | With Pathway | 1770 | 292.37 | 292.42 | 0.000402 | 2.16 | 319.65 | 0.03 |
| Little Patuxent | 126863 | 2-year | No Pathway | 1770 | 292.34 | 292.4 | 0.00041 | 2.17 | 319.26 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126707 | 2-year | With Pathway | 1770 | 292.21 | 292.33 | 0.000756 | 3.16 | 293.14 | 0.02 |
| Little Patuxent | 126707 | 2-year | No Pathway | 1770 | 292.19 | 292.31 | 0.000772 | 3.19 | 292.47 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126605 |  |  | Bridge |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126515 | 2-year | With Pathway | 1770 | 289.4 | 289.55 | 0.000963 | 3.47 | 157.64 | 0 |
| Little Patuxent | 126515 | 2-year | No Pathway | 1770 | 289.4 | 289.55 | 0.000963 | 3.47 | 157.64 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126411 | 2-year | With Pathway | 1770 | 289.33 | 289.45 | 0.000675 | 3.03 | 125.26 | 0 |
| Little Patuxent | 126411 | 2-year | No Pathway | 1770 | 289.33 | 289.45 | 0.000675 | 3.03 | 125.26 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126340 | 2-year | With Pathway | 1770 | 288.92 | 289.34 | 0.002794 | 5.71 | 150.21 | 0 |
| Little Patuxent | 126340 | 2-year | No Pathway | 1770 | 288.92 | 289.34 | 0.002794 | 5.71 | 150.21 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126212 | 2-year | With Pathway | 1770 | 288.68 | 288.99 | 0.002009 | 4.74 | 124.86 | 0 |
| Little Patuxent | 126212 | 2-year | No Pathway | 1770 | 288.68 | 288.99 | 0.002009 | 4.74 | 124.86 |  |
|  |  |  |  |  |  |  |  |  |  |  |

| Reach | River Sta | Profile | Plan | Q Total | W.S. Elev | E.G. Elev | E.G. Slope | Vel Chnl | Top Width | Change in WSELEV |
|---|---|---|---|---|---|---|---|---|---|---|
| Little Patuxent | 137471 | 10-year | With Pathway | 2890 | 306.75 | 306.91 | 0.001065 | 4.09 | 879.23 | 0 |
| Little Patuxent | 137471 | 10-year | No Pathway | 2890 | 306.75 | 306.91 | 0.001068 | 4.1 | 878.89 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 137429 |  |  | Culvert |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 137396 | 10-year | With Pathway | 2890 | 306.75 | 306.87 | 0.000821 | 3.69 | 808.08 | 0 |
| Little Patuxent | 137396 | 10-year | No Pathway | 2890 | 306.75 | 306.87 | 0.000821 | 3.69 | 808.12 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 137263 | 10-year | With Pathway | 2890 | 306.66 | 306.72 | 0.000882 | 3.44 | 886.7 | 0 |
| Little Patuxent | 137263 | 10-year | No Pathway | 2890 | 306.66 | 306.72 | 0.000882 | 3.44 | 886.71 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 136811 | 10-year | With Pathway | 2890 | 306.39 | 306.43 | 0.000474 | 2.27 | 706.82 | 0 |
| Little Patuxent | 136811 | 10-year | No Pathway | 2890 | 306.39 | 306.43 | 0.000474 | 2.27 | 706.85 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 136278 | 10-year | With Pathway | 2890 | 305.75 | 305.96 | 0.001586 | 4.5 | 298.4 | 0 |
| Little Patuxent | 136278 | 10-year | No Pathway | 2890 | 305.75 | 305.96 | 0.001585 | 4.5 | 298.4 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 135883 | 10-year | With Pathway | 2890 | 305.12 | 305.31 | 0.001761 | 4.5 | 494.48 | 0 |
| Little Patuxent | 135883 | 10-year | No Pathway | 2890 | 305.12 | 305.32 | 0.001759 | 4.5 | 494.49 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 135382 | 10-year | With Pathway | 2890 | 305.08 | 305.09 | 0.000135 | 1.29 | 1390.5 | 0 |
| Little Patuxent | 135382 | 10-year | No Pathway | 2890 | 305.08 | 305.09 | 0.000135 | 1.29 | 1390.51 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 134739 | 10-year | With Pathway | 4010 | 304.92 | 304.95 | 0.000338 | 2.12 | 755.2 | 0 |
| Little Patuxent | 134739 | 10-year | No Pathway | 4010 | 304.92 | 304.95 | 0.000337 | 2.12 | 755.22 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 134223 | 10-year | With Pathway | 4010 | 304.68 | 304.74 | 0.00055 | 2.71 | 819.69 | -0.01 |
| Little Patuxent | 134223 | 10-year | No Pathway | 4010 | 304.69 | 304.74 | 0.000549 | 2.71 | 819.71 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 133818 | 10-year | With Pathway | 4010 | 304.47 | 304.52 | 0.000508 | 2.87 | 876.65 | 0 |
| Little Patuxent | 133818 | 10-year | No Pathway | 4010 | 304.47 | 304.53 | 0.000507 | 2.87 | 876.67 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 133353 | 10-year | With Pathway | 4010 | 304.13 | 304.24 | 0.000829 | 4.09 | 615.66 | 0 |
| Little Patuxent | 133353 | 10-year | No Pathway | 4010 | 304.13 | 304.24 | 0.000827 | 4.09 | 615.68 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 132894 | 10-year | With Pathway | 4010 | 303.8 | 303.9 | 0.000676 | 3.73 | 628.07 | 0 |
| Little Patuxent | 132894 | 10-year | No Pathway | 4010 | 303.8 | 303.91 | 0.000675 | 3.73 | 628.11 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 132387 | 10-year | With Pathway | 4010 | 303.49 | 303.6 | 0.000621 | 3.72 | 422.8 | 0 |
| Little Patuxent | 132387 | 10-year | No Pathway | 4010 | 303.49 | 303.6 | 0.000619 | 3.72 | 422.91 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 132256 | 10-year | With Pathway | 4010 | 303.39 | 303.51 | 0.000724 | 3.69 | 409.01 | 0 |
| Little Patuxent | 132256 | 10-year | No Pathway | 4010 | 303.39 | 303.51 | 0.000724 | 3.7 | 410.91 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 132249 |  |  | Bridge |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 132244 | 10-year | With Pathway | 4010 | 302.94 | 303.07 | 0.000858 | 4.24 | 386.12 | -0.01 |
| Little Patuxent | 132244 | 10-year | No Pathway | 4010 | 302.95 | 303.07 | 0.000856 | 4.24 | 386.25 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 132142 | 10-year | With Pathway | 4010 | 302.88 | 302.99 | 0.000595 | 3.73 | 456.01 | -0.01 |
| Little Patuxent | 132142 | 10-year | No Pathway | 4010 | 302.89 | 302.99 | 0.000593 | 3.72 | 456.31 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 131884 | 10-year | With Pathway | 4010 | 302.61 | 302.8 | 0.000956 | 4.53 | 522.18 | 0 |
| Little Patuxent | 131884 | 10-year | No Pathway | 4010 | 302.61 | 302.81 | 0.000953 | 4.53 | 522.34 |  |
|  |  |  |  |  |  |  |  |  |  |  |

| Reach | River Sta | Profile | Plan | Q Total | W.S. Elev | E.G. Elev | E.G. Slope | Vel Chnl | Top Width | Change in WSELEV |
|---|---|---|---|---|---|---|---|---|---|---|
| Little Patuxent | 131717 | 10-year | With Pathway | 4010 | 302.55 | 302.67 | 0.000423 | 3.62 | 677.45 | -0.01 |
| Little Patuxent | 131717 | 10-year | No Pathway | 4010 | 302.56 | 302.68 | 0.000422 | 3.61 | 677.55 | |
| | | | | | | | | | | |
| Little Patuxent | 131701 | | | Bridge | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 131681 | 10-year | With Pathway | 4010 | 302.44 | 302.56 | 0.000474 | 3.71 | 708.46 | 0 |
| Little Patuxent | 131681 | 10-year | No Pathway | 4010 | 302.44 | 302.57 | 0.000472 | 3.7 | 709.25 | |
| | | | | | | | | | | |
| Little Patuxent | 131555 | 10-year | With Pathway | 4010 | 302.33 | 302.48 | 0.000827 | 3.71 | 663.75 | -0.01 |
| Little Patuxent | 131555 | 10-year | No Pathway | 4010 | 302.34 | 302.48 | 0.000825 | 3.71 | 664.12 | |
| | | | | | | | | | | |
| Little Patuxent | 131237 | 10-year | With Pathway | 4010 | 302.1 | 302.2 | 0.00083 | 3.86 | 313.33 | -0.01 |
| Little Patuxent | 131237 | 10-year | No Pathway | 4010 | 302.11 | 302.21 | 0.000828 | 3.85 | 313.4 | |
| | | | | | | | | | | |
| Little Patuxent | 131053 | 10-year | With Pathway | 4010 | 301.56 | 301.96 | 0.00119 | 5.81 | 479.01 | -0.01 |
| Little Patuxent | 131053 | 10-year | No Pathway | 4010 | 301.57 | 301.97 | 0.001183 | 5.79 | 479.67 | |
| | | | | | | | | | | |
| Little Patuxent | 130984 | 10-year | With Pathway | 4010 | 301.57 | 301.84 | 0.000687 | 4.64 | 351.83 | -0.01 |
| Little Patuxent | 130984 | 10-year | No Pathway | 4010 | 301.58 | 301.85 | 0.000677 | 4.61 | 352.39 | |
| | | | | | | | | | | |
| Little Patuxent | 130953 | | | Culvert | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 130927 | 10-year | With Pathway | 4010 | 299.24 | 299.57 | 0.000974 | 4.73 | 173.28 | -0.04 |
| Little Patuxent | 130927 | 10-year | No Pathway | 4010 | 299.28 | 299.6 | 0.000959 | 4.71 | 173.83 | |
| | | | | | | | | | | |
| Little Patuxent | 130760 | 10-year | With Pathway | 4010 | 299.05 | 299.34 | 0.001826 | 5.07 | 275.78 | -0.05 |
| Little Patuxent | 130760 | 10-year | No Pathway | 4010 | 299.1 | 299.38 | 0.001784 | 5.03 | 276.4 | |
| | | | | | | | | | | |
| Little Patuxent | 130666 | 10-year | With Pathway | 4010 | 298.93 | 299.17 | 0.001579 | 5.29 | 346.8 | -0.04 |
| Little Patuxent | 130666 | 10-year | No Pathway | 4010 | 298.97 | 299.21 | 0.001554 | 5.26 | 347.02 | |
| | | | | | | | | | | |
| Little Patuxent | 130481 | 10-year | With Pathway | 4010 | 298.79 | 298.91 | 0.000933 | 3.94 | 422.36 | -0.05 |
| Little Patuxent | 130481 | 10-year | No Pathway | 4010 | 298.84 | 298.96 | 0.000899 | 3.88 | 423.35 | |
| | | | | | | | | | | |
| Little Patuxent | 130269 | 10-year | With Pathway | 4010 | 298.69 | 298.77 | 0.000422 | 2.91 | 490.01 | -0.06 |
| Little Patuxent | 130269 | 10-year | No Pathway | 4010 | 298.75 | 298.82 | 0.000399 | 2.84 | 490.59 | |
| | | | | | | | | | | |
| Little Patuxent | 130119 | 10-year | With Pathway | 4010 | 298.6 | 298.69 | 0.000742 | 3.28 | 577.11 | -0.06 |
| Little Patuxent | 130119 | 10-year | No Pathway | 4010 | 298.66 | 298.74 | 0.000708 | 3.22 | 578.48 | |
| | | | | | | | | | | |
| Little Patuxent | 129649 | 10-year | With Pathway | 4010 | 298.17 | 298.31 | 0.00106 | 4.29 | 572.43 | -0.08 |
| Little Patuxent | 129649 | 10-year | No Pathway | 4010 | 298.25 | 298.38 | 0.001007 | 4.2 | 588.48 | |
| | | | | | | | | | | |
| Little Patuxent | 129582 | 10-year | With Pathway | 4010 | 297.53 | 298.08 | 0.002159 | 6.41 | 591.65 | -0.1 |
| Little Patuxent | 129582 | 10-year | No Pathway | 4010 | 297.63 | 298.16 | 0.002085 | 6.33 | 594.32 | |
| | | | | | | | | | | |
| Little Patuxent | 129517 | | | Bridge | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 129488 | 10-year | With Pathway | 4010 | 297.32 | 297.71 | 0.000113 | 4.98 | 237.49 | -0.08 |
| Little Patuxent | 129488 | 10-year | No Pathway | 4010 | 297.4 | 297.71 | 0.000085 | 4.49 | 238.71 | |
| | | | | | | | | | | |
| Little Patuxent | 129475 | 10-year | With Pathway | 4010 | 297.31 | 297.7 | 0.000116 | 5.03 | 244.01 | -0.08 |
| Little Patuxent | 129475 | 10-year | No Pathway | 4010 | 297.39 | 297.71 | 0.000087 | 4.53 | 245.66 | |
| | | | | | | | | | | |
| Little Patuxent | 129463 | 10-year | With Pathway | 4010 | 297.3 | 297.7 | 0.000119 | 5.07 | 254.8 | -0.08 |

| Reach | River Sta | Profile | Plan | Q Total | W.S. Elev | E.G. Elev | E.G. Slope | Vel Chnl | Top Width | Change in WSELEV |
|---|---|---|---|---|---|---|---|---|---|---|
| Little Patuxent | 129463 | 10-year | No Pathway | 4010 | 297.38 | 297.7 | 0.00009 | 4.57 | 259.19 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129423 |  |  | Bridge |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129348 | 10-year | With Pathway | 4010 | 296.6 | 297.36 | 0.003794 | 7.39 | 640.03 | 0.04 |
| Little Patuxent | 129348 | 10-year | No Pathway | 4010 | 296.56 | 297.33 | 0.003857 | 7.43 | 638.94 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129240 | 10-year | With Pathway | 4010 | 296.76 | 296.84 | 0.000808 | 3.18 | 578.08 | 0.04 |
| Little Patuxent | 129240 | 10-year | No Pathway | 4010 | 296.72 | 296.8 | 0.000822 | 3.2 | 574.48 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129052 | 10-year | With Pathway | 4010 | 296.58 | 296.66 | 0.000745 | 3.11 | 611.43 | 0.04 |
| Little Patuxent | 129052 | 10-year | No Pathway | 4010 | 296.54 | 296.62 | 0.000746 | 3.1 | 610.68 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 128509 | 10-year | With Pathway | 4010 | 295.83 | 296.1 | 0.001753 | 4.88 | 289.88 | 0.01 |
| Little Patuxent | 128509 | 10-year | No Pathway | 4010 | 295.82 | 296.08 | 0.001686 | 4.78 | 289.79 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 128340 | 10-year | With Pathway | 4010 | 295.39 | 295.77 | 0.002011 | 5.33 | 260.01 | -0.01 |
| Little Patuxent | 128340 | 10-year | No Pathway | 4010 | 295.4 | 295.75 | 0.001947 | 5.24 | 260.07 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 127864 | 10-year | With Pathway | 4010 | 294.87 | 295.05 | 0.001011 | 4 | 290.33 | 0.02 |
| Little Patuxent | 127864 | 10-year | No Pathway | 4010 | 294.85 | 295.04 | 0.001044 | 4.06 | 290.22 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 127658 | 10-year | With Pathway | 4010 | 294.15 | 294.67 | 0.003543 | 6.9 | 228.95 | 0.03 |
| Little Patuxent | 127658 | 10-year | No Pathway | 4010 | 294.12 | 294.65 | 0.003621 | 6.96 | 228.76 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 127072 | 10-year | With Pathway | 4010 | 293.67 | 293.8 | 0.000898 | 3.85 | 405.52 | 0.01 |
| Little Patuxent | 127072 | 10-year | No Pathway | 4010 | 293.66 | 293.79 | 0.000872 | 3.79 | 382.91 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126863 | 10-year | With Pathway | 4010 | 293.47 | 293.63 | 0.001031 | 3.8 | 355.05 | 0.02 |
| Little Patuxent | 126863 | 10-year | No Pathway | 4010 | 293.45 | 293.62 | 0.001042 | 3.82 | 354.95 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126707 | 10-year | With Pathway | 4010 | 292.93 | 293.35 | 0.002491 | 6.09 | 311.86 | 0.02 |
| Little Patuxent | 126707 | 10-year | No Pathway | 4010 | 292.91 | 293.34 | 0.002534 | 6.13 | 310.52 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126605 |  |  | Bridge |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126515 | 10-year | With Pathway | 4010 | 292.47 | 292.71 | 0.001082 | 4.64 | 194.64 | 0 |
| Little Patuxent | 126515 | 10-year | No Pathway | 4010 | 292.47 | 292.71 | 0.001096 | 4.67 | 202.01 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126411 | 10-year | With Pathway | 4010 | 292.37 | 292.61 | 0.000928 | 4.42 | 220.65 | 0.01 |
| Little Patuxent | 126411 | 10-year | No Pathway | 4010 | 292.36 | 292.61 | 0.000938 | 4.45 | 235.72 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126340 | 10-year | With Pathway | 4010 | 292.07 | 292.49 | 0.002202 | 6.49 | 228.26 | 0 |
| Little Patuxent | 126340 | 10-year | No Pathway | 4010 | 292.07 | 292.49 | 0.002202 | 6.49 | 228.26 |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 126212 | 10-year | With Pathway | 4010 | 291.89 | 292.23 | 0.00163 | 5.43 | 207.76 | 0 |
| Little Patuxent | 126212 | 10-year | No Pathway | 4010 | 291.89 | 292.23 | 0.00163 | 5.43 | 207.76 |  |
|  |  |  |  |  |  |  |  |  |  |  |

| Reach | River Sta | Profile | Plan | Q Total | W.S. Elev | E.G. Elev | E.G. Slope | Vel Chnl | Top Width | Change in WSELEV |
|---|---|---|---|---|---|---|---|---|---|---|
| Little Patuxent | 137471 | 100-year | With Pathway | 8,050 | 310.93 | 311.00 | 0.000531 | 3.72 | 1,025.28 | 0.01 |
| Little Patuxent | 137471 | 100-year | No Pathway | 8,050 | 310.92 | 310.99 | 0.000533 | 3.73 | 1,025.01 | |
| | | | | | | | | | | |
| Little Patuxent | 137429 | | | Culvert | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 137396 | 100-year | With Pathway | 8,050 | 310.88 | 310.95 | 0.000506 | 3.69 | 962.77 | 0.01 |
| Little Patuxent | 137396 | 100-year | No Pathway | 8,050 | 310.87 | 310.94 | 0.000509 | 3.70 | 962.15 | |
| | | | | | | | | | | |
| Little Patuxent | 137263 | 100-year | With Pathway | 8,050 | 310.83 | 310.87 | 0.00046 | 3.29 | 967.85 | 0.01 |
| Little Patuxent | 137263 | 100-year | No Pathway | 8,050 | 310.82 | 310.86 | 0.000463 | 3.29 | 967.72 | |
| | | | | | | | | | | |
| Little Patuxent | 136811 | 100-year | With Pathway | 8,050 | 310.68 | 310.71 | 0.000269 | 2.33 | 839.54 | 0.02 |
| Little Patuxent | 136811 | 100-year | No Pathway | 8,050 | 310.66 | 310.70 | 0.000271 | 2.33 | 839.27 | |
| | | | | | | | | | | |
| Little Patuxent | 136278 | 100-year | With Pathway | 8,050 | 310.02 | 310.37 | 0.001702 | 6.28 | 337.59 | 0.01 |
| Little Patuxent | 136278 | 100-year | No Pathway | 8,050 | 310.01 | 310.35 | 0.001713 | 6.29 | 337.35 | |
| | | | | | | | | | | |
| Little Patuxent | 135883 | 100-year | With Pathway | 8,050 | 309.76 | 309.87 | 0.000794 | 4.21 | 669.90 | 0.02 |
| Little Patuxent | 135883 | 100-year | No Pathway | 8,050 | 309.74 | 309.85 | 0.000801 | 4.22 | 669.45 | |
| | | | | | | | | | | |
| Little Patuxent | 135382 | 100-year | With Pathway | 8,050 | 309.75 | 309.76 | 0.00007 | 1.29 | 1,413.29 | 0.02 |
| Little Patuxent | 135382 | 100-year | No Pathway | 8,050 | 309.73 | 309.74 | 0.000071 | 1.29 | 1,413.13 | |
| | | | | | | | | | | |
| Little Patuxent | 134739 | 100-year | With Pathway | 10,920 | 309.62 | 309.67 | 0.000258 | 2.54 | 786.12 | 0.02 |
| Little Patuxent | 134739 | 100-year | No Pathway | 10,920 | 309.60 | 309.65 | 0.00026 | 2.54 | 786.01 | |
| | | | | | | | | | | |
| Little Patuxent | 134223 | 100-year | With Pathway | 10,920 | 309.48 | 309.53 | 0.00029 | 2.70 | 861.90 | 0.02 |
| Little Patuxent | 134223 | 100-year | No Pathway | 10,920 | 309.46 | 309.51 | 0.000292 | 2.71 | 861.72 | |
| | | | | | | | | | | |
| Little Patuxent | 133818 | 100-year | With Pathway | 10,920 | 309.38 | 309.42 | 0.000254 | 2.71 | 911.56 | 0.03 |
| Little Patuxent | 133818 | 100-year | No Pathway | 10,920 | 309.35 | 309.40 | 0.000256 | 2.72 | 911.46 | |
| | | | | | | | | | | |
| Little Patuxent | 133353 | 100-year | With Pathway | 10,920 | 309.19 | 309.27 | 0.000464 | 3.91 | 665.30 | 0.03 |
| Little Patuxent | 133353 | 100-year | No Pathway | 10,920 | 309.16 | 309.25 | 0.000468 | 3.92 | 665.00 | |
| | | | | | | | | | | |
| Little Patuxent | 132894 | 100-year | With Pathway | 10,920 | 308.99 | 309.08 | 0.000421 | 3.82 | 817.25 | 0.02 |
| Little Patuxent | 132894 | 100-year | No Pathway | 10,920 | 308.97 | 309.05 | 0.000426 | 3.83 | 816.35 | |
| | | | | | | | | | | |
| Little Patuxent | 132387 | 100-year | With Pathway | 10,920 | 308.70 | 308.84 | 0.000617 | 4.71 | 591.24 | 0.03 |
| Little Patuxent | 132387 | 100-year | No Pathway | 10,920 | 308.67 | 308.81 | 0.000624 | 4.73 | 591.07 | |
| | | | | | | | | | | |
| Little Patuxent | 132256 | 100-year | With Pathway | 10,920 | 308.55 | 308.74 | 0.000801 | 5.09 | 582.30 | 0.03 |
| Little Patuxent | 132256 | 100-year | No Pathway | 10,920 | 308.52 | 308.71 | 0.00081 | 5.11 | 582.00 | |
| | | | | | | | | | | |
| Little Patuxent | 132249 | | | Bridge | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 132244 | 100-year | With Pathway | 10,920 | 308.18 | 308.35 | 0.000911 | 5.59 | 599.40 | 0.03 |
| Little Patuxent | 132244 | 100-year | No Pathway | 10,920 | 308.15 | 308.32 | 0.000922 | 5.62 | 599.14 | |
| | | | | | | | | | | |
| Little Patuxent | 132142 | 100-year | With Pathway | 10,920 | 308.08 | 308.26 | 0.000788 | 5.45 | 706.66 | 0.03 |
| Little Patuxent | 132142 | 100-year | No Pathway | 10,920 | 308.05 | 308.23 | 0.000798 | 5.48 | 706.47 | |
| | | | | | | | | | | |
| Little Patuxent | 131884 | 100-year | With Pathway | 10,920 | 307.69 | 308.02 | 0.001227 | 6.57 | 681.24 | 0.04 |
| Little Patuxent | 131884 | 100-year | No Pathway | 10,920 | 307.65 | 307.99 | 0.001249 | 6.62 | 680.76 | |
| | | | | | | | | | | |

| Reach | River Sta | Profile | Plan | Q Total | W.S. Elev | E.G. Elev | E.G. Slope | Vel Chnl | Top Width | Change in WSELEV |
|---|---|---|---|---|---|---|---|---|---|---|
| Little Patuxent | 131717 | 100-year | With Pathway | 10,920 | 307.69 | 307.82 | 0.000409 | 4.44 | 893.41 | 0.04 |
| Little Patuxent | 131717 | 100-year | No Pathway | 10,920 | 307.65 | 307.78 | 0.000418 | 4.48 | 893.00 | |
| | | | | | | | | | | |
| Little Patuxent | 131701 | | | Bridge | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 131681 | 100-year | With Pathway | 10,920 | 307.63 | 307.76 | 0.000448 | 4.51 | 936.89 | 0.05 |
| Little Patuxent | 131681 | 100-year | No Pathway | 10,920 | 307.58 | 307.72 | 0.000458 | 4.56 | 936.54 | |
| | | | | | | | | | | |
| Little Patuxent | 131555 | 100-year | With Pathway | 10,920 | 307.38 | 307.64 | 0.001036 | 5.54 | 953.27 | 0.05 |
| Little Patuxent | 131555 | 100-year | No Pathway | 10,920 | 307.33 | 307.60 | 0.001067 | 5.61 | 952.46 | |
| | | | | | | | | | | |
| Little Patuxent | 131237 | 100-year | With Pathway | 10,920 | 307.05 | 307.25 | 0.001376 | 6.27 | 671.96 | 0.07 |
| Little Patuxent | 131237 | 100-year | No Pathway | 10,920 | 306.98 | 307.19 | 0.001416 | 6.34 | 671.35 | |
| | | | | | | | | | | |
| Little Patuxent | 131053 | 100-year | With Pathway | 10,920 | 306.81 | 307.05 | 0.000658 | 5.64 | 774.61 | 0.07 |
| Little Patuxent | 131053 | 100-year | No Pathway | 10,920 | 306.74 | 306.98 | 0.000661 | 5.63 | 769.32 | |
| | | | | | | | | | | |
| Little Patuxent | 130984 | 100-year | With Pathway | 10,920 | 306.72 | 307.00 | 0.000597 | 5.54 | 687.56 | 0.08 |
| Little Patuxent | 130984 | 100-year | No Pathway | 10,920 | 306.64 | 306.93 | 0.000611 | 5.58 | 685.90 | |
| | | | | | | | | | | |
| Little Patuxent | 130953 | | | Culvert | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 130927 | 100-year | With Pathway | 10,920 | 306.59 | 306.87 | 0.000518 | 5.10 | 646.19 | 0.08 |
| Little Patuxent | 130927 | 100-year | No Pathway | 10,920 | 306.51 | 306.81 | 0.000532 | 5.15 | 643.92 | |
| | | | | | | | | | | |
| Little Patuxent | 130760 | 100-year | With Pathway | 10,920 | 306.52 | 306.75 | 0.000776 | 5.11 | 607.38 | 0.08 |
| Little Patuxent | 130760 | 100-year | No Pathway | 10,920 | 306.44 | 306.68 | 0.000798 | 5.16 | 597.77 | |
| | | | | | | | | | | |
| Little Patuxent | 130666 | 100-year | With Pathway | 10,920 | 306.49 | 306.66 | 0.000715 | 5.08 | 626.43 | 0.08 |
| Little Patuxent | 130666 | 100-year | No Pathway | 10,920 | 306.41 | 306.59 | 0.00074 | 5.15 | 625.40 | |
| | | | | | | | | | | |
| Little Patuxent | 130481 | 100-year | With Pathway | 10,920 | 306.44 | 306.53 | 0.000416 | 3.83 | 652.79 | 0.07 |
| Little Patuxent | 130481 | 100-year | No Pathway | 10,920 | 306.37 | 306.46 | 0.000424 | 3.86 | 651.69 | |
| | | | | | | | | | | |
| Little Patuxent | 130269 | 100-year | With Pathway | 10,920 | 306.39 | 306.46 | 0.00024 | 3.10 | 938.81 | 0.08 |
| Little Patuxent | 130269 | 100-year | No Pathway | 10,920 | 306.31 | 306.38 | 0.000242 | 3.11 | 931.22 | |
| | | | | | | | | | | |
| Little Patuxent | 130119 | 100-year | With Pathway | 10,920 | 306.34 | 306.42 | 0.000345 | 3.46 | 958.08 | 0.08 |
| Little Patuxent | 130119 | 100-year | No Pathway | 10,920 | 306.26 | 306.34 | 0.00035 | 3.48 | 949.80 | |
| | | | | | | | | | | |
| Little Patuxent | 129649 | 100-year | With Pathway | 10,920 | 306.17 | 306.26 | 0.000376 | 3.82 | 976.53 | 0.08 |
| Little Patuxent | 129649 | 100-year | No Pathway | 10,920 | 306.09 | 306.18 | 0.000376 | 3.80 | 965.62 | |
| | | | | | | | | | | |
| Little Patuxent | 129582 | 100-year | With Pathway | 10,920 | 306.12 | 306.23 | 0.000355 | 3.91 | 989.59 | 0.08 |
| Little Patuxent | 129582 | 100-year | No Pathway | 10,920 | 306.04 | 306.15 | 0.000363 | 3.94 | 981.65 | |
| | | | | | | | | | | |
| Little Patuxent | 129517 | | | Bridge | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 129488 | 100-year | With Pathway | 10,920 | 304.09 | 305.11 | 0.000182 | 8.13 | 588.26 | 0.19 |
| Little Patuxent | 129488 | 100-year | No Pathway | 10,920 | 303.90 | 304.83 | 0.000162 | 7.75 | 504.14 | |
| | | | | | | | | | | |
| Little Patuxent | 129475 | 100-year | With Pathway | 10,920 | 304.06 | 305.11 | 0.000185 | 8.19 | 424.98 | 0.18 |
| Little Patuxent | 129475 | 100-year | No Pathway | 10,920 | 303.88 | 304.82 | 0.000165 | 7.80 | 411.65 | |
| | | | | | | | | | | |
| Little Patuxent | 129463 | 100-year | With Pathway | 10,920 | 304.04 | 305.10 | 0.000189 | 8.25 | 388.50 | 0.18 |

| Reach | River Sta | Profile | Plan | Q Total | W.S. Elev | E.G. Elev | E.G. Slope | Vel Chnl | Top Width | Change in WSELEV |
|---|---|---|---|---|---|---|---|---|---|---|
| Little Patuxent | 129463 | 100-year | No Pathway | 10,920 | 303.86 | 304.82 | 0.000169 | 7.86 | 384.70 | |
| | | | | | | | | | | |
| Little Patuxent | 129423 | | | Bridge | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 129348 | 100-year | With Pathway | 10,920 | 300.85 | 302.88 | 0.006047 | 12.31 | 772.24 | 0.03 |
| Little Patuxent | 129348 | 100-year | No Pathway | 10,920 | 300.82 | 302.86 | 0.006086 | 12.33 | 771.58 | |
| | | | | | | | | | | |
| Little Patuxent | 129240 | 100-year | With Pathway | 10,920 | 301.63 | 301.74 | 0.000615 | 3.88 | 696.93 | 0.02 |
| Little Patuxent | 129240 | 100-year | No Pathway | 10,920 | 301.61 | 301.71 | 0.000618 | 3.89 | 696.52 | |
| | | | | | | | | | | |
| Little Patuxent | 129052 | 100-year | With Pathway | 10,920 | 301.50 | 301.59 | 0.000556 | 3.75 | 804.09 | 0.02 |
| Little Patuxent | 129052 | 100-year | No Pathway | 10,920 | 301.48 | 301.57 | 0.000553 | 3.73 | 803.72 | |
| | | | | | | | | | | |
| Little Patuxent | 128509 | 100-year | With Pathway | 10,920 | 300.70 | 301.14 | 0.001745 | 6.70 | 346.80 | 0 |
| Little Patuxent | 128509 | 100-year | No Pathway | 10,920 | 300.70 | 301.13 | 0.001697 | 6.61 | 346.84 | |
| | | | | | | | | | | |
| Little Patuxent | 128340 | 100-year | With Pathway | 10,920 | 300.00 | 300.75 | 0.002512 | 8.03 | 324.95 | -0.02 |
| Little Patuxent | 128340 | 100-year | No Pathway | 10,920 | 300.02 | 300.74 | 0.002448 | 7.93 | 325.14 | |
| | | | | | | | | | | |
| Little Patuxent | 127864 | 100-year | With Pathway | 10,920 | 299.55 | 299.87 | 0.001079 | 5.49 | 322.76 | -0.01 |
| Little Patuxent | 127864 | 100-year | No Pathway | 10,920 | 299.56 | 299.88 | 0.001094 | 5.53 | 322.79 | |
| | | | | | | | | | | |
| Little Patuxent | 127658 | 100-year | With Pathway | 10,920 | 298.68 | 299.45 | 0.003444 | 9.19 | 262.36 | 0 |
| Little Patuxent | 127658 | 100-year | No Pathway | 10,920 | 298.68 | 299.46 | 0.003446 | 9.20 | 262.38 | |
| | | | | | | | | | | |
| Little Patuxent | 127072 | 100-year | With Pathway | 10,920 | 298.57 | 298.73 | 0.000646 | 4.35 | 441.81 | 0 |
| Little Patuxent | 127072 | 100-year | No Pathway | 10,920 | 298.57 | 298.72 | 0.000655 | 4.38 | 441.80 | |
| | | | | | | | | | | |
| Little Patuxent | 126863 | 100-year | With Pathway | 10,920 | 298.40 | 298.60 | 0.00079 | 4.57 | 397.71 | 0.01 |
| Little Patuxent | 126863 | 100-year | No Pathway | 10,920 | 298.39 | 298.60 | 0.000791 | 4.57 | 397.70 | |
| | | | | | | | | | | |
| Little Patuxent | 126707 | 100-year | With Pathway | 10,920 | 297.82 | 298.36 | 0.001995 | 7.39 | 704.24 | 0 |
| Little Patuxent | 126707 | 100-year | No Pathway | 10,920 | 297.82 | 298.36 | 0.002003 | 7.40 | 704.16 | |
| | | | | | | | | | | |
| Little Patuxent | 126605 | | | Bridge | | | | | | |
| | | | | | | | | | | |
| Little Patuxent | 126515 | 100-year | With Pathway | 10,920 | 297.12 | 297.63 | 0.001531 | 7.06 | 343.44 | -0.02 |
| Little Patuxent | 126515 | 100-year | No Pathway | 10,920 | 297.14 | 297.64 | 0.001516 | 7.04 | 343.66 | |
| | | | | | | | | | | |
| Little Patuxent | 126411 | 100-year | With Pathway | 10,920 | 296.99 | 297.48 | 0.001336 | 6.72 | 264.15 | -0.03 |
| Little Patuxent | 126411 | 100-year | No Pathway | 10,920 | 297.02 | 297.48 | 0.00127 | 6.56 | 286.87 | |
| | | | | | | | | | | |
| Little Patuxent | 126340 | 100-year | With Pathway | 10,920 | 296.77 | 297.34 | 0.002204 | 8.35 | 283.35 | 0 |
| Little Patuxent | 126340 | 100-year | No Pathway | 10,920 | 296.77 | 297.34 | 0.002204 | 8.35 | 283.35 | |
| | | | | | | | | | | |
| Little Patuxent | 126212 | 100-year | With Pathway | 10,920 | 296.57 | 297.12 | 0.001712 | 7.11 | 227.29 | 0 |
| Little Patuxent | 126212 | 100-year | No Pathway | 10,920 | 296.57 | 297.12 | 0.001712 | 7.11 | 227.29 | |
| | | | | | | | | | | |

| Reach | River Sta | Profile | Plan | Q Total | Min Ch El | Vel Chnl | Shear Total | Percent Change in Velocity in Channel | Percent Change in Shear Stress |
|---|---|---|---|---|---|---|---|---|---|
| | | | | (cfs) | (ft) | (ft/s) | (lb/sq ft) | | |
| Little Patuxent | 137471 | 2-year | With Pathway | 1240 | 297.58 | 2.34 | 0.04 | 0.0% | 0.0% |
| Little Patuxent | 137471 | 2-year | No Pathway | 1240 | 297.58 | 2.34 | 0.04 | | |
| | | | | | | | | | |
| Little Patuxent | 137429 | | | Culvert | | | | | |
| | | | | | | | | | |
| Little Patuxent | 137396 | 2-year | With Pathway | 1240 | 297.28 | 2.84 | 0.06 | 0.0% | 0.0% |
| Little Patuxent | 137396 | 2-year | No Pathway | 1240 | 297.28 | 2.84 | 0.06 | | |
| | | | | | | | | | |
| Little Patuxent | 137263 | 2-year | With Pathway | 1240 | 296.98 | 3.53 | 0.11 | 0.0% | 0.0% |
| Little Patuxent | 137263 | 2-year | No Pathway | 1240 | 296.98 | 3.53 | 0.11 | | |
| | | | | | | | | | |
| Little Patuxent | 136811 | 2-year | With Pathway | 1240 | 296.88 | 2.28 | 0.08 | 0.0% | 0.0% |
| Little Patuxent | 136811 | 2-year | No Pathway | 1240 | 296.88 | 2.28 | 0.08 | | |
| | | | | | | | | | |
| Little Patuxent | 136278 | 2-year | With Pathway | 1240 | 296.58 | 3.08 | 0.17 | 0.0% | 0.0% |
| Little Patuxent | 136278 | 2-year | No Pathway | 1240 | 296.58 | 3.08 | 0.17 | | |
| | | | | | | | | | |
| Little Patuxent | 135883 | 2-year | With Pathway | 1240 | 296.28 | 3.91 | 0.15 | 0.0% | 0.0% |
| Little Patuxent | 135883 | 2-year | No Pathway | 1240 | 296.28 | 3.91 | 0.15 | | |
| | | | | | | | | | |
| Little Patuxent | 135382 | 2-year | With Pathway | 1240 | 295.28 | 1.27 | 0.02 | 0.0% | 0.0% |
| Little Patuxent | 135382 | 2-year | No Pathway | 1240 | 295.28 | 1.27 | 0.02 | | |
| | | | | | | | | | |
| Little Patuxent | 134739 | 2-year | With Pathway | 1770 | 294.78 | 1.68 | 0.05 | 0.0% | 0.0% |
| Little Patuxent | 134739 | 2-year | No Pathway | 1770 | 294.78 | 1.68 | 0.05 | | |
| | | | | | | | | | |
| Little Patuxent | 134223 | 2-year | With Pathway | 1770 | 294.48 | 2.64 | 0.08 | -0.4% | 0.0% |
| Little Patuxent | 134223 | 2-year | No Pathway | 1770 | 294.48 | 2.65 | 0.08 | | |
| | | | | | | | | | |
| Little Patuxent | 133818 | 2-year | With Pathway | 1770 | 293.98 | 3.11 | 0.08 | 0.0% | 0.0% |
| Little Patuxent | 133818 | 2-year | No Pathway | 1770 | 293.98 | 3.11 | 0.08 | | |
| | | | | | | | | | |
| Little Patuxent | 133353 | 2-year | With Pathway | 1770 | 292.28 | 4.69 | 0.13 | 0.0% | 0.0% |
| Little Patuxent | 133353 | 2-year | No Pathway | 1770 | 292.28 | 4.69 | 0.13 | | |
| | | | | | | | | | |
| Little Patuxent | 132894 | 2-year | With Pathway | 1770 | 291.01 | 3.86 | 0.1 | -0.3% | 0.0% |
| Little Patuxent | 132894 | 2-year | No Pathway | 1770 | 291.01 | 3.87 | 0.1 | | |
| | | | | | | | | | |
| Little Patuxent | 132387 | 2-year | With Pathway | 1770 | 289.78 | 2.81 | 0.11 | -0.4% | 0.0% |
| Little Patuxent | 132387 | 2-year | No Pathway | 1770 | 289.78 | 2.82 | 0.11 | | |
| | | | | | | | | | |
| Little Patuxent | 132256 | 2-year | With Pathway | 1770 | 289.77 | 2.63 | 0.13 | 0.0% | 0.0% |
| Little Patuxent | 132256 | 2-year | No Pathway | 1770 | 289.77 | 2.63 | 0.13 | | |
| | | | | | | | | | |
| Little Patuxent | 132249 | | | Bridge | | | | | |

| Reach | River Sta | Profile | Plan | Q Total | Min Ch El | Vel Chnl | Shear Total | Percent Change in Velocity in Channel | Percent Change in Shear Stress |
|---|---|---|---|---|---|---|---|---|---|
| | | | | (cfs) | (ft) | (ft/s) | (lb/sq ft) | | |
| | | | | | | | | | |
| Little Patuxent | 132244 | 2-year | With Pathway | 1770 | 289.76 | 3.21 | 0.16 | 0.0% | 0.0% |
| Little Patuxent | 132244 | 2-year | No Pathway | 1770 | 289.76 | 3.21 | 0.16 | | |
| | | | | | | | | | |
| Little Patuxent | 132142 | 2-year | With Pathway | 1770 | 289.7 | 2.56 | 0.11 | -0.4% | 0.0% |
| Little Patuxent | 132142 | 2-year | No Pathway | 1770 | 289.7 | 2.57 | 0.11 | | |
| | | | | | | | | | |
| Little Patuxent | 131884 | 2-year | With Pathway | 1770 | 289.58 | 2.88 | 0.14 | -0.3% | 0.0% |
| Little Patuxent | 131884 | 2-year | No Pathway | 1770 | 289.58 | 2.89 | 0.14 | | |
| | | | | | | | | | |
| Little Patuxent | 131717 | 2-year | With Pathway | 1770 | 289.38 | 2.43 | 0.06 | -0.4% | 0.0% |
| Little Patuxent | 131717 | 2-year | No Pathway | 1770 | 289.38 | 2.44 | 0.06 | | |
| | | | | | | | | | |
| Little Patuxent | 131701 | | | Bridge | | | | | |
| | | | | | | | | | |
| Little Patuxent | 131681 | 2-year | With Pathway | 1770 | 289.28 | 3.63 | 0.13 | -0.3% | 0.0% |
| Little Patuxent | 131681 | 2-year | No Pathway | 1770 | 289.28 | 3.64 | 0.13 | | |
| | | | | | | | | | |
| Little Patuxent | 131555 | 2-year | With Pathway | 1770 | 289.2 | 3.55 | 0.29 | 0.0% | 0.0% |
| Little Patuxent | 131555 | 2-year | No Pathway | 1770 | 289.2 | 3.55 | 0.29 | | |
| | | | | | | | | | |
| Little Patuxent | 131237 | 2-year | With Pathway | 1770 | 289.28 | 3.91 | 0.31 | -0.3% | 0.0% |
| Little Patuxent | 131237 | 2-year | No Pathway | 1770 | 289.28 | 3.92 | 0.31 | | |
| | | | | | | | | | |
| Little Patuxent | 131053 | 2-year | With Pathway | 1770 | 289.28 | 4.9 | 0.42 | -0.2% | -2.3% |
| Little Patuxent | 131053 | 2-year | No Pathway | 1770 | 289.28 | 4.91 | 0.43 | | |
| | | | | | | | | | |
| Little Patuxent | 130984 | 2-year | With Pathway | 1770 | 289.98 | 3.8 | 0.33 | -0.3% | 0.0% |
| Little Patuxent | 130984 | 2-year | No Pathway | 1770 | 289.98 | 3.81 | 0.33 | | |
| | | | | | | | | | |
| Little Patuxent | 130953 | | | Culvert | | | | | |
| | | | | | | | | | |
| Little Patuxent | 130927 | 2-year | With Pathway | 1770 | 289.78 | 3.03 | 0.18 | -0.3% | 0.0% |
| Little Patuxent | 130927 | 2-year | No Pathway | 1770 | 289.78 | 3.04 | 0.18 | | |
| | | | | | | | | | |
| Little Patuxent | 130760 | 2-year | With Pathway | 1770 | 288.94 | 4.16 | 0.34 | -0.7% | 0.0% |
| Little Patuxent | 130760 | 2-year | No Pathway | 1770 | 288.94 | 4.19 | 0.34 | | |
| | | | | | | | | | |
| Little Patuxent | 130666 | 2-year | With Pathway | 1770 | 286.38 | 4.59 | 0.29 | -0.4% | 0.0% |
| Little Patuxent | 130666 | 2-year | No Pathway | 1770 | 286.38 | 4.61 | 0.29 | | |
| | | | | | | | | | |
| Little Patuxent | 130481 | 2-year | With Pathway | 1770 | 286.68 | 3.62 | 0.19 | -0.3% | 0.0% |
| Little Patuxent | 130481 | 2-year | No Pathway | 1770 | 286.68 | 3.63 | 0.19 | | |
| | | | | | | | | | |
| Little Patuxent | 130269 | 2-year | With Pathway | 1770 | 284.18 | 2.32 | 0.07 | 0.9% | 0.0% |

| Reach | River Sta | Profile | Plan | Q Total | Min Ch El | Vel Chnl | Shear Total | Percent Change in Velocity in Channel | Percent Change in Shear Stress |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | (cfs) | (ft) | (ft/s) | (lb/sq ft) |  |  |
| Little Patuxent | 130269 | 2-year | No Pathway | 1770 | 284.18 | 2.3 | 0.07 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 130119 | 2-year | With Pathway | 1770 | 288.28 | 2.99 | 0.18 | 0.3% | 0.0% |
| Little Patuxent | 130119 | 2-year | No Pathway | 1770 | 288.28 | 2.98 | 0.18 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129649 | 2-year | With Pathway | 1770 | 286.58 | 4.86 | 0.28 | -2.0% | -3.4% |
| Little Patuxent | 129649 | 2-year | No Pathway | 1770 | 286.58 | 4.96 | 0.29 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129582 | 2-year | With Pathway | 1770 | 286.08 | 4.16 | 0.43 | -1.0% | -2.3% |
| Little Patuxent | 129582 | 2-year | No Pathway | 1770 | 286.08 | 4.2 | 0.44 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129517 |  |  | Bridge |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129488 | 2-year | With Pathway | 1770 | 286.08 | 2.91 | 0.02 | 13.7% | 0.0% |
| Little Patuxent | 129488 | 2-year | No Pathway | 1770 | 286.08 | 2.56 | 0.02 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129475 | 2-year | With Pathway | 1770 | 286.18 | 2.95 | 0.02 | 13.9% | 0.0% |
| Little Patuxent | 129475 | 2-year | No Pathway | 1770 | 286.18 | 2.59 | 0.02 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129463 | 2-year | With Pathway | 1770 | 286.28 | 2.98 | 0.02 | 13.3% | 0.0% |
| Little Patuxent | 129463 | 2-year | No Pathway | 1770 | 286.28 | 2.63 | 0.02 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129423 |  |  | Bridge |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129348 | 2-year | With Pathway | 1770 | 286.28 | 4.65 | 0.6 | -0.4% | 0.0% |
| Little Patuxent | 129348 | 2-year | No Pathway | 1770 | 286.28 | 4.67 | 0.6 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129240 | 2-year | With Pathway | 1770 | 286.11 | 2.77 | 0.15 | -0.7% | 0.0% |
| Little Patuxent | 129240 | 2-year | No Pathway | 1770 | 286.11 | 2.79 | 0.15 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 129052 | 2-year | With Pathway | 1770 | 285.69 | 2.66 | 0.14 | -0.7% | 0.0% |
| Little Patuxent | 129052 | 2-year | No Pathway | 1770 | 285.69 | 2.68 | 0.14 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 128509 | 2-year | With Pathway | 1770 | 285.39 | 3.59 | 0.26 | 2.6% | 0.0% |
| Little Patuxent | 128509 | 2-year | No Pathway | 1770 | 285.39 | 3.5 | 0.26 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 128340 | 2-year | With Pathway | 1770 | 285.18 | 3.42 | 0.25 | 1.8% | 0.0% |
| Little Patuxent | 128340 | 2-year | No Pathway | 1770 | 285.18 | 3.36 | 0.25 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 127864 | 2-year | With Pathway | 1770 | 284.28 | 2.61 | 0.13 | -1.5% | 0.0% |
| Little Patuxent | 127864 | 2-year | No Pathway | 1770 | 284.28 | 2.65 | 0.13 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Little Patuxent | 127658 | 2-year | With Pathway | 1770 | 283.96 | 4.34 | 0.35 | -0.7% | -2.8% |
| Little Patuxent | 127658 | 2-year | No Pathway | 1770 | 283.96 | 4.37 | 0.36 |  |  |
|  |  |  |  |  |  |  |  |  |  |

| Reach | River Sta | Profile | Plan | Q Total | Min Ch El | Vel Chnl | Shear Total | Percent Change in Velocity in Channel | Percent Change in Shear Stress |
|---|---|---|---|---|---|---|---|---|---|
| | | | | (cfs) | (ft) | (ft/s) | (lb/sq ft) | | |
| Little Patuxent | 127072 | 2-year | With Pathway | 1770 | 283.3 | 2.25 | 0.08 | -0.9% | -11.1% |
| Little Patuxent | 127072 | 2-year | No Pathway | 1770 | 283.3 | 2.27 | 0.09 | | |
| | | | | | | | | | |
| Little Patuxent | 126863 | 2-year | With Pathway | 1770 | 283.08 | 2.16 | 0.09 | -0.5% | 0.0% |
| Little Patuxent | 126863 | 2-year | No Pathway | 1770 | 283.08 | 2.17 | 0.09 | | |
| | | | | | | | | | |
| Little Patuxent | 126707 | 2-year | With Pathway | 1770 | 282.58 | 3.16 | 0.17 | -0.9% | 0.0% |
| Little Patuxent | 126707 | 2-year | No Pathway | 1770 | 282.58 | 3.19 | 0.17 | | |
| | | | | | | | | | |
| Little Patuxent | 126605 | | | Bridge | | | | | |
| | | | | | | | | | |
| Little Patuxent | 126515 | 2-year | With Pathway | 1770 | 281.38 | 3.47 | 0.26 | 0.0% | 0.0% |
| Little Patuxent | 126515 | 2-year | No Pathway | 1770 | 281.38 | 3.47 | 0.26 | | |
| | | | | | | | | | |
| Little Patuxent | 126411 | 2-year | With Pathway | 1770 | 280.8 | 3.03 | 0.23 | 0.0% | 0.0% |
| Little Patuxent | 126411 | 2-year | No Pathway | 1770 | 280.8 | 3.03 | 0.23 | | |
| | | | | | | | | | |
| Little Patuxent | 126340 | 2-year | With Pathway | 1770 | 280.34 | 5.71 | 0.48 | 0.0% | 0.0% |
| Little Patuxent | 126340 | 2-year | No Pathway | 1770 | 280.34 | 5.71 | 0.48 | | |
| | | | | | | | | | |
| Little Patuxent | 126212 | 2-year | With Pathway | 1770 | 280.18 | 4.74 | 0.46 | 0.0% | 0.0% |
| Little Patuxent | 126212 | 2-year | No Pathway | 1770 | 280.18 | 4.74 | 0.46 | | |
| | | | | | | | | | |

| Reach | River Sta | Profile | Plan | Q Total | Min Ch El | Vel Chnl | Shear Total | Percent Change in Velocity in Channel | Percent Change in Shear Stress |
|---|---|---|---|---|---|---|---|---|---|
| | | | | (cfs) | (ft) | (ft/s) | (lb/sq ft) | | |
| Little Patuxent | 137471 | 10-year | With Pathway | 2890 | 297.58 | 4.09 | 0.15 | -0.2% | 0.0% |
| Little Patuxent | 137471 | 10-year | No Pathway | 2890 | 297.58 | 4.1 | 0.15 | | |
| | | | | | | | | | |
| Little Patuxent | 137429 | | | Culvert | | | | | |
| | | | | | | | | | |
| Little Patuxent | 137396 | 10-year | With Pathway | 2890 | 297.28 | 3.69 | 0.14 | 0.0% | 0.0% |
| Little Patuxent | 137396 | 10-year | No Pathway | 2890 | 297.28 | 3.69 | 0.14 | | |
| | | | | | | | | | |
| Little Patuxent | 137263 | 10-year | With Pathway | 2890 | 296.98 | 3.44 | 0.16 | 0.0% | 0.0% |
| Little Patuxent | 137263 | 10-year | No Pathway | 2890 | 296.98 | 3.44 | 0.16 | | |
| | | | | | | | | | |
| Little Patuxent | 136811 | 10-year | With Pathway | 2890 | 296.88 | 2.27 | 0.1 | 0.0% | 0.0% |
| Little Patuxent | 136811 | 10-year | No Pathway | 2890 | 296.88 | 2.27 | 0.1 | | |
| | | | | | | | | | |
| Little Patuxent | 136278 | 10-year | With Pathway | 2890 | 296.58 | 4.5 | 0.41 | 0.0% | 0.0% |
| Little Patuxent | 136278 | 10-year | No Pathway | 2890 | 296.58 | 4.5 | 0.41 | | |
| | | | | | | | | | |
| Little Patuxent | 135883 | 10-year | With Pathway | 2890 | 296.28 | 4.5 | 0.3 | 0.0% | 0.0% |
| Little Patuxent | 135883 | 10-year | No Pathway | 2890 | 296.28 | 4.5 | 0.3 | | |
| | | | | | | | | | |
| Little Patuxent | 135382 | 10-year | With Pathway | 2890 | 295.28 | 1.29 | 0.03 | 0.0% | 0.0% |
| Little Patuxent | 135382 | 10-year | No Pathway | 2890 | 295.28 | 1.29 | 0.03 | | |
| | | | | | | | | | |
| Little Patuxent | 134739 | 10-year | With Pathway | 4010 | 294.78 | 2.12 | 0.09 | 0.0% | 0.0% |
| Little Patuxent | 134739 | 10-year | No Pathway | 4010 | 294.78 | 2.12 | 0.09 | | |
| | | | | | | | | | |
| Little Patuxent | 134223 | 10-year | With Pathway | 4010 | 294.48 | 2.71 | 0.12 | 0.0% | 0.0% |
| Little Patuxent | 134223 | 10-year | No Pathway | 4010 | 294.48 | 2.71 | 0.12 | | |
| | | | | | | | | | |
| Little Patuxent | 133818 | 10-year | With Pathway | 4010 | 293.98 | 2.87 | 0.11 | 0.0% | 0.0% |
| Little Patuxent | 133818 | 10-year | No Pathway | 4010 | 293.98 | 2.87 | 0.11 | | |
| | | | | | | | | | |
| Little Patuxent | 133353 | 10-year | With Pathway | 4010 | 292.28 | 4.09 | 0.19 | 0.0% | 0.0% |
| Little Patuxent | 133353 | 10-year | No Pathway | 4010 | 292.28 | 4.09 | 0.19 | | |
| | | | | | | | | | |
| Little Patuxent | 132894 | 10-year | With Pathway | 4010 | 291.01 | 3.73 | 0.16 | 0.0% | 0.0% |
| Little Patuxent | 132894 | 10-year | No Pathway | 4010 | 291.01 | 3.73 | 0.16 | | |
| | | | | | | | | | |
| Little Patuxent | 132387 | 10-year | With Pathway | 4010 | 289.78 | 3.72 | 0.2 | 0.0% | 0.0% |
| Little Patuxent | 132387 | 10-year | No Pathway | 4010 | 289.78 | 3.72 | 0.2 | | |
| | | | | | | | | | |
| Little Patuxent | 132256 | 10-year | With Pathway | 4010 | 289.77 | 3.69 | 0.23 | -0.3% | 0.0% |
| Little Patuxent | 132256 | 10-year | No Pathway | 4010 | 289.77 | 3.7 | 0.23 | | |
| | | | | | | | | | |
| Little Patuxent | 132249 | | | Bridge | | | | | |

| Reach | River Sta | Profile | Plan | Q Total | Min Ch El | Vel Chnl | Shear Total | Percent Change in Velocity in Channel | Percent Change in Shear Stress |
|---|---|---|---|---|---|---|---|---|---|
| | | | | (cfs) | (ft) | (ft/s) | (lb/sq ft) | | |
| | | | | | | | | | |
| Little Patuxent | 132244 | 10-year | With Pathway | 4010 | 289.76 | 4.24 | 0.28 | 0.0% | 0.0% |
| Little Patuxent | 132244 | 10-year | No Pathway | 4010 | 289.76 | 4.24 | 0.28 | | |
| | | | | | | | | | |
| Little Patuxent | 132142 | 10-year | With Pathway | 4010 | 289.7 | 3.73 | 0.2 | 0.3% | 0.0% |
| Little Patuxent | 132142 | 10-year | No Pathway | 4010 | 289.7 | 3.72 | 0.2 | | |
| | | | | | | | | | |
| Little Patuxent | 131884 | 10-year | With Pathway | 4010 | 289.58 | 4.53 | 0.28 | 0.0% | 0.0% |
| Little Patuxent | 131884 | 10-year | No Pathway | 4010 | 289.58 | 4.53 | 0.28 | | |
| | | | | | | | | | |
| Little Patuxent | 131717 | 10-year | With Pathway | 4010 | 289.38 | 3.62 | 0.11 | 0.3% | 0.0% |
| Little Patuxent | 131717 | 10-year | No Pathway | 4010 | 289.38 | 3.61 | 0.11 | | |
| | | | | | | | | | |
| Little Patuxent | 131701 | | | Bridge | | | | | |
| | | | | | | | | | |
| Little Patuxent | 131681 | 10-year | With Pathway | 4010 | 289.28 | 3.71 | 0.13 | 0.3% | 8.3% |
| Little Patuxent | 131681 | 10-year | No Pathway | 4010 | 289.28 | 3.7 | 0.12 | | |
| | | | | | | | | | |
| Little Patuxent | 131555 | 10-year | With Pathway | 4010 | 289.2 | 3.71 | 0.24 | 0.0% | 0.0% |
| Little Patuxent | 131555 | 10-year | No Pathway | 4010 | 289.2 | 3.71 | 0.24 | | |
| | | | | | | | | | |
| Little Patuxent | 131237 | 10-year | With Pathway | 4010 | 289.28 | 3.86 | 0.33 | 0.3% | 3.1% |
| Little Patuxent | 131237 | 10-year | No Pathway | 4010 | 289.28 | 3.85 | 0.32 | | |
| | | | | | | | | | |
| Little Patuxent | 131053 | 10-year | With Pathway | 4010 | 289.28 | 5.81 | 0.23 | 0.3% | 0.0% |
| Little Patuxent | 131053 | 10-year | No Pathway | 4010 | 289.28 | 5.79 | 0.23 | | |
| | | | | | | | | | |
| Little Patuxent | 130984 | 10-year | With Pathway | 4010 | 289.98 | 4.64 | 0.19 | 0.7% | 5.6% |
| Little Patuxent | 130984 | 10-year | No Pathway | 4010 | 289.98 | 4.61 | 0.18 | | |
| | | | | | | | | | |
| Little Patuxent | 130953 | | | Culvert | | | | | |
| | | | | | | | | | |
| Little Patuxent | 130927 | 10-year | With Pathway | 4010 | 289.78 | 4.73 | 0.34 | 0.4% | 0.0% |
| Little Patuxent | 130927 | 10-year | No Pathway | 4010 | 289.78 | 4.71 | 0.34 | | |
| | | | | | | | | | |
| Little Patuxent | 130760 | 10-year | With Pathway | 4010 | 288.94 | 5.07 | 0.51 | 0.8% | 2.0% |
| Little Patuxent | 130760 | 10-year | No Pathway | 4010 | 288.94 | 5.03 | 0.5 | | |
| | | | | | | | | | |
| Little Patuxent | 130666 | 10-year | With Pathway | 4010 | 286.38 | 5.29 | 0.42 | 0.6% | 2.4% |
| Little Patuxent | 130666 | 10-year | No Pathway | 4010 | 286.38 | 5.26 | 0.41 | | |
| | | | | | | | | | |
| Little Patuxent | 130481 | 10-year | With Pathway | 4010 | 286.68 | 3.94 | 0.27 | 1.5% | 3.8% |
| Little Patuxent | 130481 | 10-year | No Pathway | 4010 | 286.68 | 3.88 | 0.26 | | |
| | | | | | | | | | |
| Little Patuxent | 130269 | 10-year | With Pathway | 4010 | 284.18 | 2.91 | 0.14 | 2.5% | 7.7% |

| Reach | River Sta | Profile | Plan | Q Total | Min Ch El | Vel Chnl | Shear Total | Percent Change in Velocity in Channel | Percent Change in Shear Stress |
|---|---|---|---|---|---|---|---|---|---|
| | | | | (cfs) | (ft) | (ft/s) | (lb/sq ft) | | |
| Little Patuxent | 130269 | 10-year | No Pathway | 4010 | 284.18 | 2.84 | 0.13 | | |
| | | | | | | | | | |
| Little Patuxent | 130119 | 10-year | With Pathway | 4010 | 288.28 | 3.28 | 0.23 | 1.9% | 4.5% |
| Little Patuxent | 130119 | 10-year | No Pathway | 4010 | 288.28 | 3.22 | 0.22 | | |
| | | | | | | | | | |
| Little Patuxent | 129649 | 10-year | With Pathway | 4010 | 286.58 | 4.29 | 0.29 | 2.1% | 7.4% |
| Little Patuxent | 129649 | 10-year | No Pathway | 4010 | 286.58 | 4.2 | 0.27 | | |
| | | | | | | | | | |
| Little Patuxent | 129582 | 10-year | With Pathway | 4010 | 286.08 | 6.41 | 1.04 | 1.3% | 3.0% |
| Little Patuxent | 129582 | 10-year | No Pathway | 4010 | 286.08 | 6.33 | 1.01 | | |
| | | | | | | | | | |
| Little Patuxent | 129517 | | | Bridge | | | | | |
| | | | | | | | | | |
| Little Patuxent | 129488 | 10-year | With Pathway | 4010 | 286.08 | 4.98 | 0.06 | 10.9% | 20.0% |
| Little Patuxent | 129488 | 10-year | No Pathway | 4010 | 286.08 | 4.49 | 0.05 | | |
| | | | | | | | | | |
| Little Patuxent | 129475 | 10-year | With Pathway | 4010 | 286.18 | 5.03 | 0.06 | 11.0% | 20.0% |
| Little Patuxent | 129475 | 10-year | No Pathway | 4010 | 286.18 | 4.53 | 0.05 | | |
| | | | | | | | | | |
| Little Patuxent | 129463 | 10-year | With Pathway | 4010 | 286.28 | 5.07 | 0.06 | 10.9% | 20.0% |
| Little Patuxent | 129463 | 10-year | No Pathway | 4010 | 286.28 | 4.57 | 0.05 | | |
| | | | | | | | | | |
| Little Patuxent | 129423 | | | Bridge | | | | | |
| | | | | | | | | | |
| Little Patuxent | 129348 | 10-year | With Pathway | 4010 | 286.28 | 7.39 | 1.51 | -0.5% | -1.3% |
| Little Patuxent | 129348 | 10-year | No Pathway | 4010 | 286.28 | 7.43 | 1.53 | | |
| | | | | | | | | | |
| Little Patuxent | 129240 | 10-year | With Pathway | 4010 | 286.11 | 3.18 | 0.22 | -0.6% | 0.0% |
| Little Patuxent | 129240 | 10-year | No Pathway | 4010 | 286.11 | 3.2 | 0.22 | | |
| | | | | | | | | | |
| Little Patuxent | 129052 | 10-year | With Pathway | 4010 | 285.69 | 3.11 | 0.2 | 0.3% | 0.0% |
| Little Patuxent | 129052 | 10-year | No Pathway | 4010 | 285.69 | 3.1 | 0.2 | | |
| | | | | | | | | | |
| Little Patuxent | 128509 | 10-year | With Pathway | 4010 | 285.39 | 4.88 | 0.52 | 2.1% | 2.0% |
| Little Patuxent | 128509 | 10-year | No Pathway | 4010 | 285.39 | 4.78 | 0.51 | | |
| | | | | | | | | | |
| Little Patuxent | 128340 | 10-year | With Pathway | 4010 | 285.18 | 5.33 | 0.59 | 1.7% | 0.0% |
| Little Patuxent | 128340 | 10-year | No Pathway | 4010 | 285.18 | 5.24 | 0.59 | | |
| | | | | | | | | | |
| Little Patuxent | 127864 | 10-year | With Pathway | 4010 | 284.28 | 4 | 0.31 | -1.5% | -3.1% |
| Little Patuxent | 127864 | 10-year | No Pathway | 4010 | 284.28 | 4.06 | 0.32 | | |
| | | | | | | | | | |
| Little Patuxent | 127658 | 10-year | With Pathway | 4010 | 283.96 | 6.9 | 0.95 | -0.9% | -1.0% |
| Little Patuxent | 127658 | 10-year | No Pathway | 4010 | 283.96 | 6.96 | 0.96 | | |
| | | | | | | | | | |

| Reach | River Sta | Profile | Plan | Q Total | Min Ch El | Vel Chnl | Shear Total | Percent Change in Velocity in Channel | Percent Change in Shear Stress |
|---|---|---|---|---|---|---|---|---|---|
| | | | | (cfs) | (ft) | (ft/s) | (lb/sq ft) | | |
| Little Patuxent | 127072 | 10-year | With Pathway | 4010 | 283.3 | 3.85 | 0.24 | 1.6% | 0.0% |
| Little Patuxent | 127072 | 10-year | No Pathway | 4010 | 283.3 | 3.79 | 0.24 | | |
| | | | | | | | | | |
| Little Patuxent | 126863 | 10-year | With Pathway | 4010 | 283.08 | 3.8 | 0.27 | -0.5% | -3.6% |
| Little Patuxent | 126863 | 10-year | No Pathway | 4010 | 283.08 | 3.82 | 0.28 | | |
| | | | | | | | | | |
| Little Patuxent | 126707 | 10-year | With Pathway | 4010 | 282.58 | 6.09 | 0.65 | -0.7% | -1.5% |
| Little Patuxent | 126707 | 10-year | No Pathway | 4010 | 282.58 | 6.13 | 0.66 | | |
| | | | | | | | | | |
| Little Patuxent | 126605 | | | Bridge | | | | | |
| | | | | | | | | | |
| Little Patuxent | 126515 | 10-year | With Pathway | 4010 | 281.38 | 4.64 | 0.42 | -0.6% | 2.4% |
| Little Patuxent | 126515 | 10-year | No Pathway | 4010 | 281.38 | 4.67 | 0.41 | | |
| | | | | | | | | | |
| Little Patuxent | 126411 | 10-year | With Pathway | 4010 | 280.8 | 4.42 | 0.33 | -0.7% | 6.5% |
| Little Patuxent | 126411 | 10-year | No Pathway | 4010 | 280.8 | 4.45 | 0.31 | | |
| | | | | | | | | | |
| Little Patuxent | 126340 | 10-year | With Pathway | 4010 | 280.34 | 6.49 | 0.61 | 0.0% | 0.0% |
| Little Patuxent | 126340 | 10-year | No Pathway | 4010 | 280.34 | 6.49 | 0.61 | | |
| | | | | | | | | | |
| Little Patuxent | 126212 | 10-year | With Pathway | 4010 | 280.18 | 5.43 | 0.51 | 0.0% | 0.0% |
| Little Patuxent | 126212 | 10-year | No Pathway | 4010 | 280.18 | 5.43 | 0.51 | | |
| | | | | | | | | | |

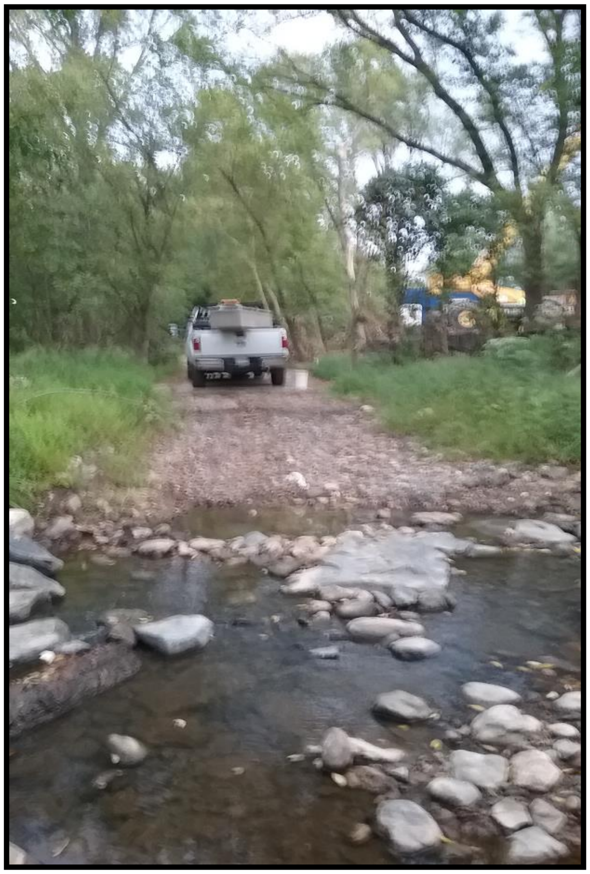
# Appendix D: Geotechnical Report

# Basis of Design Geotechnical Engineering Report

## Downtown Columbia to Stevens Forest Road Shared Use Path

## Howard County, Maryland

*KCI Project No. 17133314.98*



**Prepared For**
*Howard County Department of Public Work*

**Prepared By**
*KCI Technologies, Inc.*
*October 2016*

KCI
TECHNOLOGIES

936 Ridgebrook Road
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Direct Dial (410) 891-1743

October 26, 2016

Howard County Department of Public Works
DPW Capital Projects Administration
9250 Bendix Road
Columbia, MD 21045

Attention: Mr. Kris Singleton

Subject: Basis of Design Geotechnical Engineering Report
***Downtown Columbia to Stevens Forest Road Shared Use Path***
Stormwater and Watershed Management Evaluation/Design/Build Services
Howard County, Maryland
Consulting Services Agreement CA 23-2013
*KCI Project No. 17133314.98*

Greetings Mr. Singleton:

KCI Technologies, Inc. (KCI) has completed the requested preliminary subsurface explorations and geotechnical engineering services as part of the Basis of Design (or concept design) for the proposed Downtown Columbia to Stephens Forest Road Shared Use Path Project in Columbia, Howard County, Maryland.

The attached report presents our review of the project information, a description of the site and subsurface conditions encountered, geotechnical evaluations for the concept bridge structures and pavement structure for the proposed project. The Appendices to the report contain site and boring location plan, the results of our field and laboratory testing, and preliminary foundation analyses.

KCI appreciates the opportunity to provide geotechnical engineering services for this project. Please contact us if you have any questions regarding the information presented.

Sincerely,

**KCI TECHNOLOGIES, INC.**

Charbel Khoury, PhD, PE
Senior Project Engineer

for Tomasz Labuda, PE, PG
Geo-Environmental Regional Practice Leader

KOFI B. ACHEAMPONG
33722

Kofi B. Acheampong, PhD, PE, ENV SP
Chief Geotechnical Engineer

**"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND, LICENSE NO.: 33722 EXPIRATION DATE: 12/18/16 "**

## TABLE OF CONTENTS

# 1.0 INTRODUCTION

## 1.1 GENERAL

This is the preliminary geotechnical engineering report for Concept Design Phase submission as part of the Basis of Design Report for the proposed Downtown Columbia to Stephens Forest Road Shared Use Path Project in Columbia, Howard County, Maryland. A Site Location Map is shown in Figure 1 (Appendix A).

At the request of Howard County Bureau of Engineering and the Howard County Office of Transportation, KCI is part of a design team with team with a sub-consultant and other consultants under contract directly to Howard County. Toole Design Group, LLC (TDG) is responsible for overall project management, civil design, public/stakeholder involvement, and landscape design. While KCI is tasked to provide concept Hydraulics & Hydrology (H&H) design, Structural design, geotechnical evaluations and analysis, and environmental analysis.

This report presents our review of the project information, a description of the site and subsurface conditions encountered, geotechnical evaluations for the concept design of two bridge structures and pavement structure for the proposed improvements.

## 1.2 PROJECT INFORMATION

Our understanding of the project is based upon information provided by and discussions with the Client, and TDG. In addition, we have reviewed conceptual drawings prepared by TDG, and performed several site visits. The project involves design and construction of a paved bicycle and pedestrian shared-use path connection between Broken Land Parkway and South Entrance Road at Little Patuxent Parkway, and paralleling the former road bed and sanitary sewer alignment within the cleared zone of the sanitary sewer easement. The proposed improvements will also include on-road bicycle facilities along a portion of Stevens Forest Road from the cul-de-sac to connect the trail just south of Broken Land Parkway.

The proposed construction requires concept engineering and plan development for two bridge structures and relatively low height retaining walls as part of the proposed Patuxent Branch Trail Extension in Columbia, Maryland. The originally planned elevated boardwalk over wetland areas has been eliminated due to the cost considerations. Proposed low height retaining walls will not require geotechnical evaluations. The proposed bridge structures include:

**Bridge at Culvert Station 41+80**: This bridge crossing is located directly downstream of a 2-cell 72" RCP culvert under Broken Land Parkway. During the design phase, the DPW should be contacted to obtain plans/studies performed for the existing culvert, if available. A preliminary proposed bridge span of 35 feet and 10-foot travel wide has been established for this crossing. Due to the orientation of the existing culvert in relation to the proposed path bridge, one or both of the bridge abutments may be susceptible to scour. This is due to the potential for high velocity storm water flow from the nearby culvert. During the design phase, a detailed evaluation of the impacts of potential scour on the bridge abutments, foundations and other substructures with estimated scour depths should be performed.

**Bridge at Stream (Station 67+00):** This bridge crossing is located on an unnamed tributary of Little Patuxent River that flows from the west. This stream has a detailed FEMA study, including a HEC-RAS model, and is labeled as Stream LPR1. In addition, Biohabitats, Inc. completed a study of the stream

(Stream B in their 2015 study) that may be useful in the design phase of this project. A preliminary proposed bridge span of 50 feet and 10-foot travel width has been established for this crossing. During the design phase, a detailed evaluation of the impacts of potential scour on bridge abutments, foundations and other substructures with estimated scour depths should be performed for this crossing as well.

### 1.3 SCOPE OF SERVICES

The purpose of this preliminary geotechnical subsurface explorations was to obtain site-specific subsurface data along designated sections of the proposed shared use path alignment including the bridge structure locations. The scope of services for this subsurface investigations study included the following:

- A brief review and description of the field and laboratory test procedures and results;
- A brief review of the area and site geologic conditions;
- A review of subsurface conditions encountered at test boring locations with soil types and physical properties, and depths to groundwater (if encountered).
- Identify principal geotechnical issues that will impact proposed construction;
- Pavement recommendations;
- Foundation recommendations including foundation types, allowable bearing capacity and settlements for the concept design;
- General construction recommendations including re-use of on-site soils and potential excavation difficulties, and temporary groundwater control.

Assessments of site environmental conditions for the presence or absence of pollutants in the soil, rock, surface water, or groundwater of the site were beyond the proposed objectives of our exploration.

## 2.0 SITE DESCRIPTION AND REVIEW OF EXISTING SUBSURFACE DATA

### 2.1 GENERAL

The subsurface conditions discussed below are based on our review of existing subsurface information including published geologic and soil mappings and the 2008 subsurface explorations performed by others.

### 2.2 EXISTING SITE CONDITIONS

KCI conducted site reconnaissance on July 21, 2016 to mark boring locations and on September 15 and 16, 2016 during drilling operations to observe and document existing site surface conditions. We used the information gathered during our site visits to help us interpret the subsurface data, and to detect conditions that could affect our evaluations and recommendations.

The project is located in Columbia, Maryland, at the center of Howard County. The proposed shared use path alignment is located along the right bank of Little Patuxent River between South Entrance Road and Broken Land Parkway within the flood plains and associated wetlands. The path alignment begins at the intersection of Stevens Forest Road and Broken Land Parkway, and travels southward toward the cul-de-sac. Just before it reaches the cul-de-sac, the trail alignment departs from the roadway to (roughly) parallel the existing sanitary sewer easement for approximately 0.65 miles adjacent to the Little Patuxent River. The alignment passes under the existing bridges at Broken Land Parkway and US-29, along the west edge of an existing wetland area north of Route US-29, and crosses a tributary of the Little Patuxent River. The alignment then follows an existing abandoned access road east to its intersection with South Entrance Road, and extends north along the west side of south entrance road to intersect with the Downtown Columbia Trail at Little Patuxent Parkway.

The most northern leg of the path follows an existing asphalt paved trail. The asphalt cover ends at the stream crossing at Station 67+00 where a bridge is planned to carry the path across the stream. The central section of the proposed path travels is parallel to the existing sanitary sewer. The second stream crossing is located at Station 41+80 where a second bridge is planned to carry the path. The south eastern portion of the proposed path includes on-road section along the Stevens Forest Road.

Generally, the path alignment is flat with a relatively steep slope directly west and south (right river bank and road embankments). During our visit, we observed large rock boulders (greater than two feet in diameter) were scattered along the stream crossings. We did not observe evidence of unstable ground conditions at the site.

## 2.3 GEOLOGIC SETTING

Based on the Physiographic Map of Maryland (2008) the project site is mapped in the Piedmont Physiographic Province. In addition, based on the Physiographic Provinces and their Subdivisions in Maryland (2001), the proposed sites are located within the Upland Section of the Piedmont. Our review of the Geologic Map of Howard County (1993) indicates that the project sites are located in the eastern part of the Piedmont where bedrock consists of schist, gneiss, gabbro, and other highly metamorphosed sedimentary and igneous rocks of probable volcanic origin.

The Geologic Map of Howard County (1993) indicates that the specific geologic units within the proposed project area include Guilford Granite, Oella Formation, and the Baltimore Gneiss (bgn). The ***Guilford Granite*** of the Silurian (a member of Paleozoic geological age Granitic Series), typically consists of gray and tan, uniform, massive, fine to medium grained, quartz Granite. The Granitic Series protrude through the Oella Formation (or Lower Pelitic Schist) which may be present at the site.

The ***Oella Formation*** of the Cambrian Age era, a member of the Lower Pelitic Schist, and formerly mapped as oligoclase facies of the Wissahickon Formation and the Glenarm Supergroup, typically consists of gray, medium-grained, biotite-plagioclase-muscovite-quartz Schist interlayered with fine-grained, biotite-plagioclase-quartz Gneiss. The primary rock type for the Lower Pelitic Schist is quartz-feldspar schist.

The ***Baltimore Gneiss*** belongs to the Precambrain geologic era. Granitic gneiss, with swirling leucosomes and irregular biotite-rich restite layers, is the dominant lithology or primary rock type and constitutes approximately 75 to 80 percent of the exposed rocks. The remaining 20 to 25 percent comprises hornblende-biotite gneiss, amphibolite is widespread but subordinate with or without pyroxene, and pegmatite. Granitic gneiss is composed of quartz, plagioclase, biotite, feldspar and microcline. Minor and accessory minerals are garnet, muscovite, magnetite, ilmenite, sphene, apatite, and zircon

The surface materials within the Little Patuxent River consists of Alluvium comprising of boulders, gravel, and sand fractions with silt and clay matrix. The residual materials derived from in-situ weathering of the underlying crystalline and often micaceous bedrock consist mainly of silty sand. Residual soils typically form a profile characterized by a change from soil to completely weathered rock to decomposed rock and to bedrock with increasing depths below the ground surface. Artificial fill is also present at the site in the vicinity of buried utility lines and roadway embankments and other site developments.

According to the Natural Resources Conservation Service (NRCS) Web Soil Survey mapping for Howard County, the site soils are predominately mapped as part of the Codorus and Hatboro silt complex. The site soils typically consist of dipped, flood plain, moderately well drained, silt loams, gravelly silt loam and very gravelly silt loam.

## 2.4 REVIEW OF EXISTING SUBSURFACE EXPLORATION DATA

We have reviewed the Geotechnical Report for the Little Patuxent Parallel Sewer Contract 9 prepared by EBA Engineering, Inc. for Dewberry (dated June 2008) for the sewer pipeline project which extended from the south side of Broken Land Parkway to South Entrance Road in Columbia, Maryland. This sewer pipeline alignment followed Little Patuxent River and incorporates sections of the proposed Shared Use Path project.

The subsurface data provided in the report included 16 Standard Penetration Test (SPT) borings, numbered B09-01 through B09-16; and 12 auger probes along the sewer alignment. Boring were advanced to depths of about 2 to 19 feet below ground surface. In general, the subsurface conditions encountered along the sewer alignment included five major strata:

- ***Stratum I – Existing Fill***: About 3 to 12 feet thick fill materials consisting of heterogeneous mixture of loose to very dense, Silty Sand, Clayey Sand and poorly graded Gravel; and soft to very stiff Sandy Silt, and including topsoil/rootmat. Cobbles, boulders, asphalt and wood fragments were also present within the fill. The in-situ moisture contents of selected samples ranged from 22 to 34 percent.

- ***Stratum II – Alluvium Soils:*** Encountered below topsoil or fill to depths of 5 to 14 feet. It consisted of moist to wet, loose to very dense, poorly graded GRAVEL (GP), Silty GRAVEL (GM), poorly graded SAND (SP), Silty SAND (SM); and soft to stiff Sandy SILT (ML) and Sandy Elastic SILT (MH). Cobbles and boulders were encountered in the mix. The natural moisture contents of selected samples ranged from 6 to 43 percent; liquid limits range from 30 to 58 percent, and plasticity indices ranged from non-plastic to 26 percent.

- ***Stratum III – Residual Soils***: Based on site location, residual soils were encountered below topsoil, fill, and/or alluvium stratum. Residual soils included moist to wet, medium dense to very dense Silty SAND (SM/SC) and Rock fragments (GP/GM); and medium stiff to hard Sandy SILT and CLAY (ML/CL). Relic zones of intact rock, characterized by cobbles and boulder-sized rock fragments, frequently occurred within this stratum. Depth stop the bottom of this stratum reportedly ranged from 2.5 to over 16 feet. The natural moisture contents of selected samples ranged from 5 to 16 percent.

- ***Stratum IV – Decomposed Rock***: Reportedly encountered under the alluvium and residual soils consisted of dry ro moist, very dense Rock Fragment with Silt and Sand (GM, GP); and Silty to Clayey SAND with rock fragments (SM/SC). The depths to the bottom of this layer ranged from about 10 to over 15 feet. The natural moisture contents of selected samples ranged from 5 to 26 percent. The pH of selected samples ranged from 4.8 to 9.4, indicative of corrosive environment.

- ***Stratum V – Bedrock***: Bedrock was encountered below the Alluvium and Decomposed Rock and cores advanced 3.5 to 5.5 feet into rock. The bedrock consisted of light gray and pink, moderately hard to hard, moderately weathered to slightly weathered GRANITE. The core sample recovery ranged from 52 to 95 percent, and RQD ranged from 41 to 70 percent.

  Lab Uniaxial compressive strength tests performed on intact rock cores ranged from 7,750 to 23, 200 psi.

- ***Groundwater and Cave-in Conditions*****:** Short-term groundwater levels encountered during and after completion of drilling ranged from near surface (0) to 6 feet deep. Borehole cave-in occurred at depths of about 1.5 to 8 feet below ground surface in each boring after removing the augers.

Note that the existing subsurface data is used for informational purposes only and to determine general trends in the subsurface profiles, especially where is subsurface data gaps. KCI's geotechnical and foundation design recommendations are based primarily on the results of the 2016 subsurface explorations.

# 3.0 SUBSURFACE CONDITIONS

## 3.1 SUBSURFACE EXPLORATION

KCI's subcontractor Free State Drilling Inc., drilled six test borings at the site using an All-Terrain Vehicle (ATV) mounted drill rig on September 15 and 16, 2016. The explorations were performed in general accordance with procedures presented in Appendix B. We designated the borings as B-1 through B-6. We drilled the borings to depths indicated in Table 3-1 below. We have shown the approximate boring locations on Figure 2 (Appendix A) and the boring logs in Appendix B.

**Standard Penetration Test (SPT) Borings** - We performed SPT borings in accordance with ASTM D 1586 using Hollow Stem Auger (HSA) procedures. The SPT method consisted of advancing a 2-inch diameter sampling spoon to a depth of 18 inches by driving it with an automated 140-pound hammer falling 30 inches. The values reported on the boring logs are the blows required to advance three successive 6-inch increments. The first 6-inch increment is considered as seating. The sum of the number of blows for the second and third increments is the SPT "N" value.

SPT N-values can be used to provide a qualitative indication of the in-place relative density of cohesionless soils. In a less reliable way, N-values also provide an indication of consistency for cohesive soils. The indications of relative density and consistency are qualitative, since many factors can significantly affect N-values and prevent direct correlations, including differences among drill crews, drill rigs, drilling procedures, and hammer-rod-sampler assemblies.

**Soil Sampling**: KCI obtained soil samples at 2.5-foot intervals to a depth of 10 feet bgs and then at every 5 feet below the top 10 feet to boring termination depths thereafter at each location. Soil samples extracted from a split spoon sampler were visually classified in the field and then placed and sealed in glass jars and transported to the laboratory for testing. A KCI geotechnical engineer visually classified the recovered soil samples in general accordance with ASTM D 2488 Standard Practice for Description and Identification of Soils. Soil samples were classified with respect to texture based on the Unified Soil Classification System (USCS) in accordance with ASTM D 2487. The sampling sequence and associated jar samples for each boring may be referenced from the Boring Logs in Appendix B.

**Rock Coring**: KCI obtained 5-foot NX size rock cores at borings B-1, B4, and B-5 following auger refusals. Extracted rock cores were visually classified in the field and transported in wooden boxes to the laboratory for evaluation and storage. A detailed description of the rock core is presented on the logs in addition to Core Recovery and Rock Quality Designation (RQD). Recovery is defined as the length of core obtained, expressed as a percentage of the total cored length. Recovery provides an indication of the competency and continuity of the rock mass. The RQD is defined as the total length of cored pieces 4-inches or greater in length, expressed as a percentage of the total length cored. The RQD provides an indication of the integrity of the rock mass and relative extent of seams, jointing, and bedding planes.

**Bulk Soil Sampling:** We obtained bulk samples within the upper five feet of borings B-2 and B-4. We collected auger cuttings brought to the surface by HSA and placed them in water-resistant plastic bags for testing. The sample locations are indicated on the appropriate boring logs or on the appropriate laboratory test results figure.

**Table 3-1: Summary of As-Drilled Test Borings**

| Boring No. | Boring Depth (ft) | Groundwater Depth During Drilling (ft) | Approximate Cave-in Depth After Completion (ft) | Approximate Depth to Top of Weathered Rock (ft) | Approximate Depth to Top of Rock (ft) |
|---|---|---|---|---|---|
| B-1 | 17.2 | 4.5 | 8.1 | 12.0 | 12.1 |
| B-2 | 9.3 | DRY | 8.1 | 8.5 | --- |
| B-3 | 28.8 | 6.0 | 19.5 | 13.5 | --- |
| B-4 | 22.6 | 7.9 | 14.5 | 13.5 | 17.5 |
| B-5 | 19.9 | 2.1 | 3.2 | 13.5 | 15.0 |
| B-6 | 10 | 9.5 | 6.3 | --- | --- |

### 3.2 SUBSURFACE PROFILES

The subsurface conditions encountered at each boring location is shown on the test boring logs in Appendix B. A generalized subsurface profiles are attached as Figures 3A and 3B in Appendix A. The boring logs and subsurface profiles represent our interpretation of the subsurface conditions based on visual examination of field samples by a KCI geotechnical engineer and our laboratory tests of soil samples. The lines designating the interfaces between various strata represent the approximate interface locations. The actual transitions between strata may be gradual.

In general, the test borings at the project site encountered four soil strata within the boring termination depths. The subsurface conditions encountered are described below in order of increasing depth:

***Asphalt***: 5 inch thick asphalt layer was present at the B-6 location.

***Topsoil:*** 3 to 7 inch thick layer of topsoil was encountered in borings B-3, B-4, and B-5.

***Stratum I – Existing Fill:*** We encountered existing Fill up to about 3.5 feet at borings B-1 and B-2. Stratum I soils typically consisted of damp, Silty SAND (SM) with traces of Gravel. The SPT N-values ranged from 9 to 14 blows per foot (bpf), indicating loose to medium dense relative densities. We anticipate that the existing Fill along the path alignment is associated with previous construction of the sewer and gas line.

***Stratum II – Natural Soils (SM/SW, ML, CL):*** We encountered Stratum II natural soils in eavh boring below existing Fill material or the existing ground surface. These soils extended to a depth ranging between 8.5 and 13.5 feet below the existing ground surface (bgs). These soils typically consisted of moist to wet, brown and gray, Well Graded SAND (SW), Silty SAND (SM), Sandy SILT (ML), SILT (ML), and Lean CLAY (CL), with varying amounts of mica and Gravel. The SPT N-values ranged from 3 bpf to 50 bpf, indicating very loose to dense relative densities for granular soils, and very soft to hard consistency for cohesive soils. The samples we tested indicate slight plasticity with moisture contents ranging between 5 and 40 percent.

***Stratum III – Completely Weathered Rock (Micaceous Silty SAND):*** Below the natural soils, we encountered residual soils (Completely Weathered Rock) from about 8.5 feet 28 feet bgs. We sampled these soils as moist to wet, brown, gray, tan, micaceous, Silty SAND (SM) with varying amounts of rock fragments. The SPT-N value were greater than 100 bpf (characterized by spoon refusal, i.e. 50/4", 50/5", etc.) indicating very dense compactness.

***Stratum IV – BEDROCK:*** We encountered Bedrock in borings B-1, B-4 and B-5 below Stratum III to the boring termination depths. We sampled the extracted rock cores as gray, moderately to slightly weathered, moderately to extremely fractured, MICA SCHIST and GRANITE BEDROCK. Core recovery ranged from 60 to 100 percent. The RQD ranged between 33 to 55 percent.

### 3.3 GROUNDWATER AND CAVE-IN DEPTH CONDITIONS

We monitored short-term ground water levels in the test borings during the period of fieldwork. Table above provides a summary of ground water conditions and cave-in depths encountered. Generally, the groundwater was recorded between 2 and 9.5 feet below the existing ground surface.

Borings caved-in after drilling at various depths ranging from about 3 to 20 feet bgs. Cave-in may be due typically to collapse of loose and soft soils after removing the augers at the completion of drilling. However, in granular soils, cave-in depths could also be indicative of the presence of saturated soil conditions arising from perched-water conditions.

Note that, fluctuations of the groundwater levels and/or perched water may occur due to variations in in-situ soil types, precipitation, evaporation, soil capillary, construction activity impacting ground conditions and surface runoff, and other site-specific factors not present at the time of drilling.

### 3.4 LABORATORY TESTING RESULTS

KCI's subcontractor, Jay Kay Testing, performed the geotechnical laboratory tests in general accordance with ASTM standards to confirm visual classification and determine soil physical properties. Test results are presented in Appendix C and consisted of the following:

| **LABORATORY TEST** | **NO. OF TESTS** |
|---|---|
| • Moisture Content Determination (ASTM D 2216) | 15 |
| • Grain-Size Determination (ASTM D 1140) | 3 |
| • Atterberg Limits (Liquid and Plastic Limits) (ASTM D 4318) | 3 |
| • Standard Proctor (AASHTO T-99) | 2 |
| • California Bearing Ratio (CBR AASHTO T-193) | 2 |

**Index Test Results**: Tables 3-2 and 3-3 below presents a summary of the moisture contents, Atterberg limits, CBR, moisture-density relationship, and soil classification (USCS).

**Table 3-2: Summary of Soil Gradation and Index Test Results**

| BORING/ SAMPLE | DEPTH (ft) | DESCRIPTION | LL (%) | PI (%) | NMC (%) | Fines (%) | USCS |
|---|---|---|---|---|---|---|---|
| B-2/BULK | 1.0-5.0 | Brown Silty SAND | 31 | 8 | -- | 32 | SM |
| B-4/BULK | 1.0-5.0 | Brown Silty SAND | 28 | NP | -- | 27 | SM |
| B-3/S-2 | 3.5-5.0 | Brown SILT | 41 | 15 | 39.4 | 92 | ML |

**NOTES**: **PI**: Plasticity Index Limit; **LL**: Liquid Limit; **NP** = Non-Plastic; **NMC**: Natural Moisture Content; **USCS**: Unified Soil Classification System – Laboratory classification results in UPPER CASE. All other classifications are visual.

In general, the laboratory test results indicate that site soils typically are non-plastic to medium plastic with high fine contents (typically greater than 30 percent by weight passing the US No. 200 sieve size). The results are consistent with the visual observations.

**Moisture-Density Tests:** We performed moisture-density tests on selected bulk samples in accordance with ASTM D 698 to determine compaction characteristics, consisting of the maximum dry density and optimum moisture content. A summary of test results is shown in Table 3-3 below.

**California Bearing Ratio (CBR) Test**: We performed CBR tests on a selected bulk samples in general accordance with AASHTO T-193. The results of the moisture-density test is used to compact the test samples to the desired density and moisture content for the laboratory California Bearing Ratio test. The CBR test is a punching shear test and is a comparative measure of the shearing resistance of a soil. It provides data that is a semi-empirical index of the strength and deflection characteristics of soil that has been correlated with pavement performance to establish design curves. A summary of the test results is shown in Table 3-3 below. The detailed test results are presented in Appendix C.

**Table 3-3: Summary of Moisture Density Relationship**

| Boring No. | Sample No. | Sample Depth (ft) | Proctor Test | | USCS | CBR (%) | Swell (%) |
|---|---|---|---|---|---|---|---|
| | | | MDD (pcf) | OMC (%) | | | |
| B-2 | BULK | 1.0-5.0 | 122.2 | 11.2 | SM | 5.1 | 0.55 |
| B-4 | BULK | 1.0-5.0 | 116.2 | 13.8 | SM | 4.7 | 0.20 |

OMC = Optimum Moisture Content ; MDD = Maximum Dry Density

# 4.0 GEOTECHNICAL EVALUATIONS AND RECOMMENDATIONS

## 4.1 GEOTECHNICAL ISSUES

We have based our evaluations on the site observations, subsurface conditions encountered, laboratory testing results, our geotechnical analyses and experiences with similar subsurface conditions. We have identified the following major geotechnical issues:

- Shallow Depths to Bedrock
- Loose/Soft Soils
- Presence of Floodplain and Wetlands
- Scour Effects
- Existing Utilities

**Shallow Depths to Bedrock:** We encountered Bedrock below soils at depths between 12.0 and 17.5 feet bgs, with top of rock occurring between approximate El. 278.5 and El. 284. The RQD within the top 5-foot in the vicinity of the proposed bridges varied between 53 and 55 percent, indicating fair rock mass quality. The bedrock encountered at boring B-4 (within the eliminated boardwalk) exhibited highly fractured conditions with RQD of 32 percent. We anticipate that varying drilling conditions will be encountered into bedrock during installation of foundation elements. We recommend that the Contractor be prepared to drill into bedrock (rock sockets) in the bridge areas where deep foundations are required. In addition, temporary casing may be required to be seated into the top of rock as necessary to facilitate installation of the rock socket. Twisting of casing into the rock should be anticipated to seat the casing in the rock.

**Loose/Soft Soils:** We encountered saturated, loose micaceous silty Sand (SM) and soft micaceous Silt and Clay (ML/CL) within the proposed asphalt trail and bridge areas.

Loose micaceous silty Sand and soft micaceous Silt and Clay soils will typically have low bearing capacity and subjected to long-term (or consolidation) settlements and excessive non-uniform settlements under new loads. These micaceous soils are also prone to disturbance when exposed with significant strength degradation. During construction, we recommend that loose/soft and/or disturbed soils at pavement subgrade level be undercut a minimum of 1 to 2 feet below subgrade and replaced with compacted structural backfill (e.g., No 57 stone aggregate) prior to construction.

**Presence of Floodplain and Wetlands:** Due the presence of adjacent streams, floodplain and wetlands, high groundwater conditions are anticipated at the project site. In addition, based on our subsurface exploration, we encountered groundwater levels during drilling at depths between 2 and 8 feet, between approximate El. 286 and El. 293. Due to the poor drainage characteristics of the in-situ micaceous soils and the potential for disturbance, the Contractor should provide adequate drainage and dewatering measures to control surficial water and groundwater within the construction site.

**Scour Effects:** Due to the potential for high velocity storm water flow, the scour will impact the in-situ soil conditions and subsurface profiles at the bridge substructures. The proposed bridge foundations should be designed to account for the impact of scour to provide adequate foundation embedment depths and ensure long-term stability. Therefore, we recommend detailed scour analyses be performed during the design phase of the project.

**Existing Utilities:** Buried utility lines can interfere with the proposed construction at the project site. Therefore, we recommend that all active existing utilities on site be identified during the design phase and located prior to initiating construction and protected during construction.

## 4.2 BRIDGE FOUNDATION RECOMMENDATIONS

We have evaluated foundation bearing strata and feasible foundation options based on the in-situ subsurface conditions at the site and the provided structural loadings.

**Bearing Strata:** Foundation bearing capacities can be derived mainly from the Weathered Rock and Schist and Granite BEDROCK Strata.

**Foundation Types:** Due to a loose/soft soils and anticipated scour impact, shallow footings will not be feasible. Therefore, deep foundation consisting of drilled shaft or micro piles will be required to support the proposed bridge structures. Due to shallow depths to bedrock these deep foundations will require rock socket. For this concept design phase, we provided deep foundation recommendations for drilled shaft support only due to unknown scour depths. Alternative analyses for the micro-piles foundation should be part of the final design based on estimated scour depths.

We have provided below a summary of our estimated design soil parameters and deep foundation design capacities based on the foundation loads provided.

**Foundation Loads:** Foundations loads were provided to us by the Structural Engineer as summarized in the Table 4-1 below.

**Table 4-1: Foundation Loads Provided by the Structural Engineer**

| Bridge | Maximum Axial Load (lb/ft) | Lateral Load (lb/ft) | Moment (lb-ft / ft) |
|---|---|---|---|
| At STA. 41+80 | 3,500 | 200 | 1,150 |
| At STA. 67+00 | 6,000 | 320 | 1,950 |
| Notes: Loads are per linear foot of abutment length. | | | |

For an approximate 10-foot width abutment for each bridge supported on two drilled shafts we estimated the following loads per shaft.

*Bridge at Station 41+80:*

- Axial Load: Vmax = 17.5 kips;
- Lateral Load: H = 1.0 kip;
- Moment = 5.75 kips-ft.

*Bridge at Station 67+00:*

- Axial Load: Vmax = 30.0 kips;
- Lateral Load: H = 1.6 kips;
- Moment = 9.75 kips-ft.

**Design Soil and Foundation Parameters**: Based on the subsurface conditions encountered and laboratory test results, we recommend the following design soil parameters be used for foundation analyses as summarized in Table 4-2 below:

**Table 4-2: Summary of Design Soil/Rock Parameters for Bridge Foundations**

| In-situ Soil Stratum | Est. Stratum Depth (ft) | Effective Unit Weight $\gamma$ (pcf) | Effective Friction Angle $\phi$ (deg) | Uniaxial Compressive Strength $q_u$ (psi) | Lateral Subgrade Modulus $k_h$ (pci) | Strain Modulus $\varepsilon_{50}$ |
|---|---|---|---|---|---|---|
| Sand (SM), ML and or CL * | 0 to 12 | 62.4 | 28 | --- | 25 | --- |
| Completely Weathered Rock (CWR) | 12 to 13.5 | 67.6 | 34 | --- | 100 | --- |
| Bedrock | Below 13.5 | 77.6 | --- | 3,000 | --- | --- |
| * Due to the assumed scour depth, this stratum was not used in our analyses. | | | | | | |

**Drilled Shaft Axial Capacity Analyses**: Drilled shafts capacity evaluations are based on FHWA, and AASHTO recommended design procedures (*Drilled Shafts*: *Construction Procedures and LRFD Design Methods, FHWA Publication No. FHWA-NHI-10-016, FHWA GEC 010, May 2010*). Foundation design parameters are based on in-situ subsurface conditions and laboratory testing data, and our experiences with similar soil types.

Based on the encountered subsurface conditions, specifically within the proposed bridge structures, we estimated the top of bedrock as El. 278.5 feet. We performed axial capacity analyses for a 36-in diameter drilled shaft with 24-inch diameter rock socket embedded a minimum of 5 feet into Bedrock.

In general, axial capacity is based on either side shear on the wall of the rock socket or end-bearing resistances below the tip of the drilled shaft, or a combination of both. The end bearing of the drilled shaft is ignored to limit foundation displacement. The allowable capacity is based on a factor of safety 2.5. We assumed 3,500 psi concrete strength. The design axial capacities per drilled shaft are as follows:

- Estimated Ultimate Unit Side Friction $f_s$ = ***12,000*** psf
- Allowable Axial Capacity (Design Unit Side Friction Resistance) = **4,800 psf**

Therefore, for a 2-foot diameter rock socket, the **Allowable Axial Capacity is 30 Kips/LF** of socket depth. We anticipate shaft settlements to be less than 0.5-inch.

**Drilled Shaft Lateral Capacity Analyses:** We have performed lateral capacity analyses using LPILE 2013 (Ensoft, Inc.) software which is based on soil-structure interaction analyses with the applied structural loads.

Based on the encountered loose/soft saturated soils, we have assumed depth of scour to top of weathered rock stratum at approximate El. 281 feet. We have performed lateral capacity evaluations for imposed lateral loads at the top of drilled shafts under free head conditions. We have assumed 3,500 psi concrete strength in our analysis and approximately 1 percent steel reinforcement area. Results of lateral analyses are presented in Appendix D.

Our analyses indicate that lateral loading controls the drilled shaft rock socket design with a minimum 5-foot depth into bedrock. For final design, the structural capacity of foundations should be evaluated by the Structural Engineer using details such as amount of steel reinforcement and concrete compressive strengths to confirm that axial, shear and moment capacities meet the loading demands.

**Installation of Drilled Shaft Foundations:** Drilled Shafts should be installed to the minimum embedment depths satisfying structural loads and deflection criteria. We recommend that drilled shafts be installed in accordance with the project specifications, the latest MDSHA *Standard Specifications for Construction and Materials (2008), and Howard County Standard Specifications for Construction*.

Based on anticipated high groundwater conditions temporary steel casing will be required during drilled shafts installation. We recommend that quality control and quality assurance procedures should be implemented to ensure that construction tolerances and the structural integrity of the constructed piles meet project requirements. In addition, temporary casing may be required to be seated into the top of rock as necessary to facilitate installation of the rock socket. Twisting of casing into the rock should be anticipated to seat the casing in the rock. The bottom of the drilled shaft should be cleaned of loose/soft and unsuitable materials using appropriate measures and methods prior to placing steel and concrete.

## 4.3 PAVEMENT RECOMMENDATIONS

### 4.3.1 Subgrade Conditions

Based on the project information, we anticipate that portions of the asphalt trail will require cut into existing subgrade (Cut Area) and other sections will require fills up to 6 feet across the site (Fill Area). We anticipate the presence of loose/soft soils within the proposed asphalt trail. When such soil conditions are encountered we recommend to be densified in place and/or undercut a minimum of 1 to 2 feet below subgrade level and replaced with compacted structural backfill (e.g., No 57 stone aggregate) prior to pavement placement.

### 4.3.2 Pavement Section

We understand that the asphalt trail extends approximately 1.5 miles. We have performed two CBR tests on representative bulk samples obtained from borings B-2 and B-4. Laboratory CBR average value is about 5 percent. The presence of gravel and rock fragments in various area of the site may have resulted in high CBR values, which could not be representative of the actual behavior of the onsite micaceous soils. Therefore, we recommend that a CBR value of 3 be used for the design of pavement.

At the time of this report, we were not provided with traffic design data for the trail; however, we understand that the trail will be used for full range of activities from walking to biking with full sized vehicles periodically accessing the trail for maintenance and emergencies purposes. Therefore, our analyses and recommendations are based on our experiences with similar projects and anticipated general traffic loading conditions.

For concept design, we have provided a summary of the minimum recommended pavement section in Table 4-3. However, final pavement section should be determined based on actual traffic data and the sequence of grading and availability of on-site or off-site backfill materials during construction.

**Table 4-3: Proposed Minimum Pavement Layer Thicknesses (in)**

| | |
|---|---|
| HMA Superpave - Surface Course (9.5 mm PG 64-22) | 2.0 |
| HMA Superpave - Base Course (19.0 mm PG 64-22) | 3.0 |
| Graded Aggregate Base – GAB (4-in layers) | 4.0 |

Due to high groundwater conditions, localized pavement underdrains may be required.

# 5.0 CONSTRUCTION RECOMMENDATIONS

## 5.1 GENERAL SITE AND SUBGRADE PREPARATION

Site preparation should be conducted in accordance with Howard County Standards. The Contractor should locate/identify and take precautions to protect below grade existing utility such as electrical lines, water, sewer, gas, and stormwater mains and utility substructures services, within the vicinity of the project site, prior to installation of the drilled shaft foundations and proposed construction.

Debris, stumps, vegetation and root systems, topsoil and organic materials should be removed from the construction area. We recommend that, prior to placing foundations, new fill or concrete, the exposed subgrade be proof-rolled with appropriate construction equipment. The intent is to detect unsuitable soil conditions which may be present. If unsuitable conditions are encountered at the subgrade level, they should be undercut and replaced with compacted fill or No. 57 stone aggregate.

## 5.2 FILL MATERIALS, PLACEMENT AND COMPACTION

The selection of fill materials used as compacted fill, and the methods of placement, compaction and field density testing should be in accordance with the project requirements/specifications, Howard County Standards and the latest edition of MDSHA *Standard Specifications for Construction and Materials*.
Borrow and select fill may come from off-site sources. Imported materials should have a Unified Soils Classification of GW, GP, GM, GC, SW, SP, SM, having fines content less than 15 percent, liquid limits less than 40 and plastic indices less than 10. Particles larger than six inches in diameter should not be included in the compacted fill.

A majority of the on-site soils may not be suitable for use as structural fill due to the micaceous nature, medium plasticity and high fines content. Thus, only limited portions of on-site soils classified as SM or more granular with fines content less than 35 percent are considered suitable for re-use as structural fill. Re-use of on-site materials as structural backfill will require additional laboratory testing, on-site evaluation and approval by the geotechnical engineer before placement. On-site fill material placement and compaction will require significant quality control and quality assurance during construction. Following excavation and removal, some of the existing fill may be re-used in non-structural areas or as top-soil.

We recommend that compacted fills be constructed by spreading acceptable soil in loose layers not more than eight inches thick. The soils used along the proposed path, around structures, or for replacement in any undercut areas should be compacted in maximum 8-inch loose lifts to at least 95 percent of Modified Proctor ASTM 1557 or 98 percent of Standard Proctor (ASTM D698). The upper 12 inches of fill beneath pavements should be compacted to 95 percent of Modified Proctor. In non-structural areas, the fill should be compacted to 90 percent of Modified Proctor (or 92 percent of Standard Proctor) maximum dry density. The moisture content of fill soils should be maintained within two percentage points of the optimum moisture content determined from density tests.

We recommend the fill placement and compaction be observed and documented by a geotechnical engineer or his representative. Deviations, either from specifications or good construction practice, should be brought to the attention of the concerned authority, along with appropriate recommendations. Field density tests should be performed as needed to verify that the specified degree of compaction is being achieved. Any areas that do not meet the compaction specifications should be re-compacted to meet the project specifications and compliance.

## 5.3 CONSTRUCTION WATER CONTROLS

We encountered shallow groundwater conditions during our subsurface explorations. In addition, perched (or trapped) water conditions may also be encountered at shallow depths. Also, due to the micaceous nature of on-site soils, such soils have the potential to trap water and are prone to disturbance and strength degradation when exposed to prolonged moisture and adverse construction conditions. Therefore, the Contractor should provide adequate drainage and dewatering measures to control surficial water, perched and groundwater within the construction site. Dewatering can be handled with ditching, sumps, and pumping. Run-off from adjacent areas should be diverted away from the excavation to prevent ponding of water in the excavation. Dewatering activities should be in accordance with Howard County Standards and the latest edition of MDSHA *Standard Specifications for Construction and Materials.*

## 6.0 GEOTECHNICAL LIMITATIONS

General

1. This report has been prepared to aid in the evaluation for the proposed construction described in this report. Adequate recommendations have been provided to serve as a basis for concept design. The opinions, conclusions, and recommendations contained in this report are based upon our professional judgment and generally accepted principles of geotechnical engineering. Inherent to these are the assumptions that the earthwork construction should be monitored and tested under the guidance of a geotechnical engineer licensed in the State of Maryland or his representative.

Explorations

2. The analyses and recommendations provided are, of necessity, based on project information available at the time of the actual writing of this report, including existing site, surface and subsurface conditions that existed at the time the exploratory borings were drilled. Further assumption has been made that the limited exploratory borings, in relation to both the lateral extent of the site and to depth, are representative of general conditions across the site.

   The nature and extent of variations between these explorations may not become evident until further explorations and construction. If variations from anticipated conditions then appear evident, it will be necessary to revise the recommendations in this report.

3. The generalized soil profiles described in the text and indicated on the subsurface profiles logs are intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples; actual soil transitions are probably more erratic. Refer to boring profiles log for specific information at the boring profile log.

4. Groundwater level readings have been made in the drill hole at times and under conditions stated on the boring profile log. We did not encounter groundwater during drilling. These data have been reviewed and interpretations have been made in this report. Fluctuations in the level of the ground water may occur due to variations in rainfall, temperature, and other factors occurring since the time measurements were made.

Review

5. This report has been prepared based on plans and description of the proposed construction cited herein. In the event that any changes in the nature, design or location of the proposed project are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing by KCI.

Uses of Report

6. This report has been prepared for the exclusive use of Howard County Department of Public Works and other members of the design team for specific application to the proposed **Columbia Shared Use Path.** Our professional services have been performed in accordance with generally accepted geotechnical engineering principles and practices; no other warranty, expressed or implied, is made. KCI assumes no responsibility for interpretations made by others on the work performed by KCI.

7. This report is for concept design purposes only and is not sufficient to prepare an accurate bid. Contractors wishing a copy of the report may secure it with the understanding that its scope is limited to design considerations only. We recommend that this report be made available in its entirety including attachments and appendices to contractors for informational purposes only.

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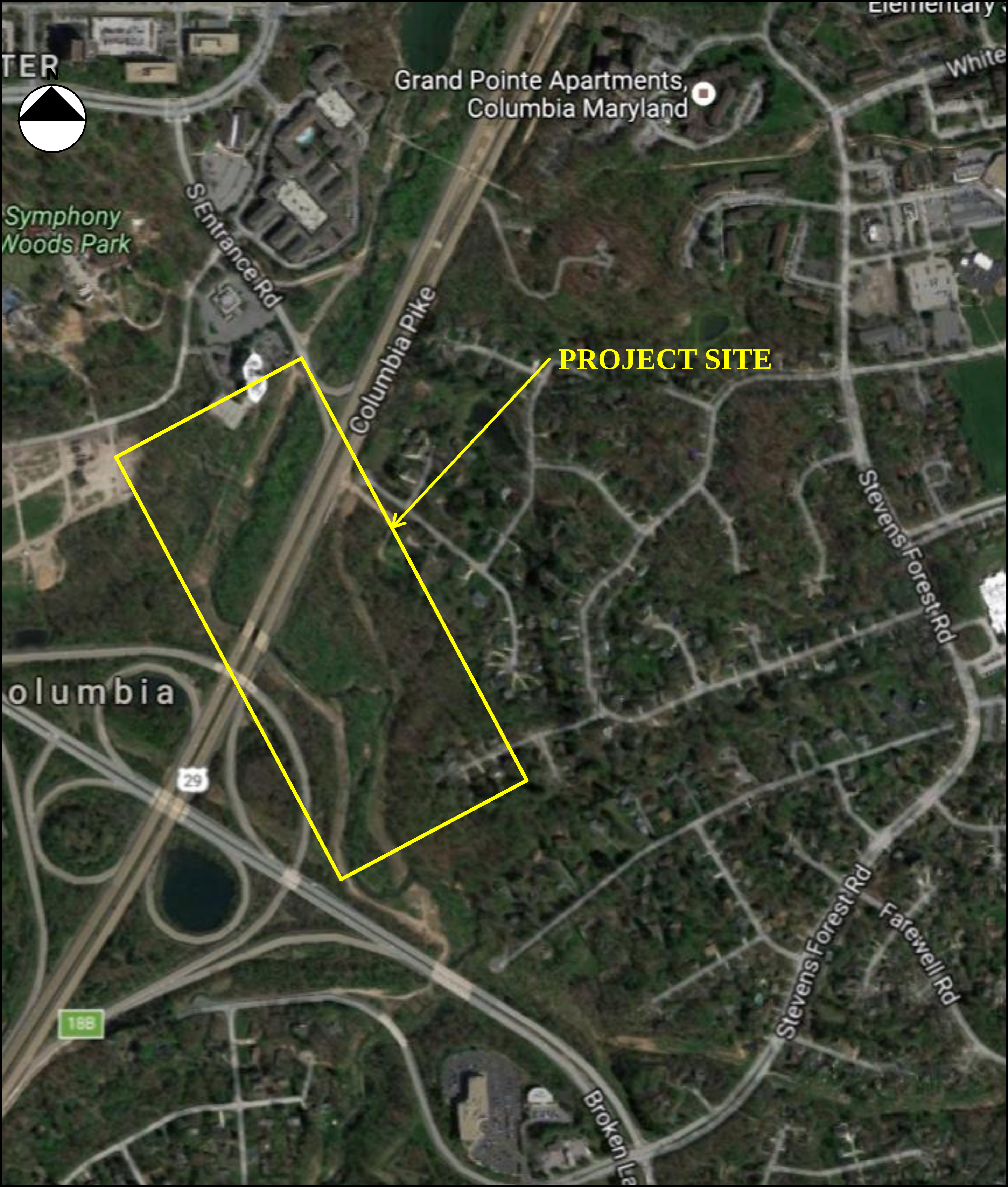
# FIGURES



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Sparks, MD 21152
410-316-7800 | Fax 410-316-7817

**SITE VICINITY MAP**

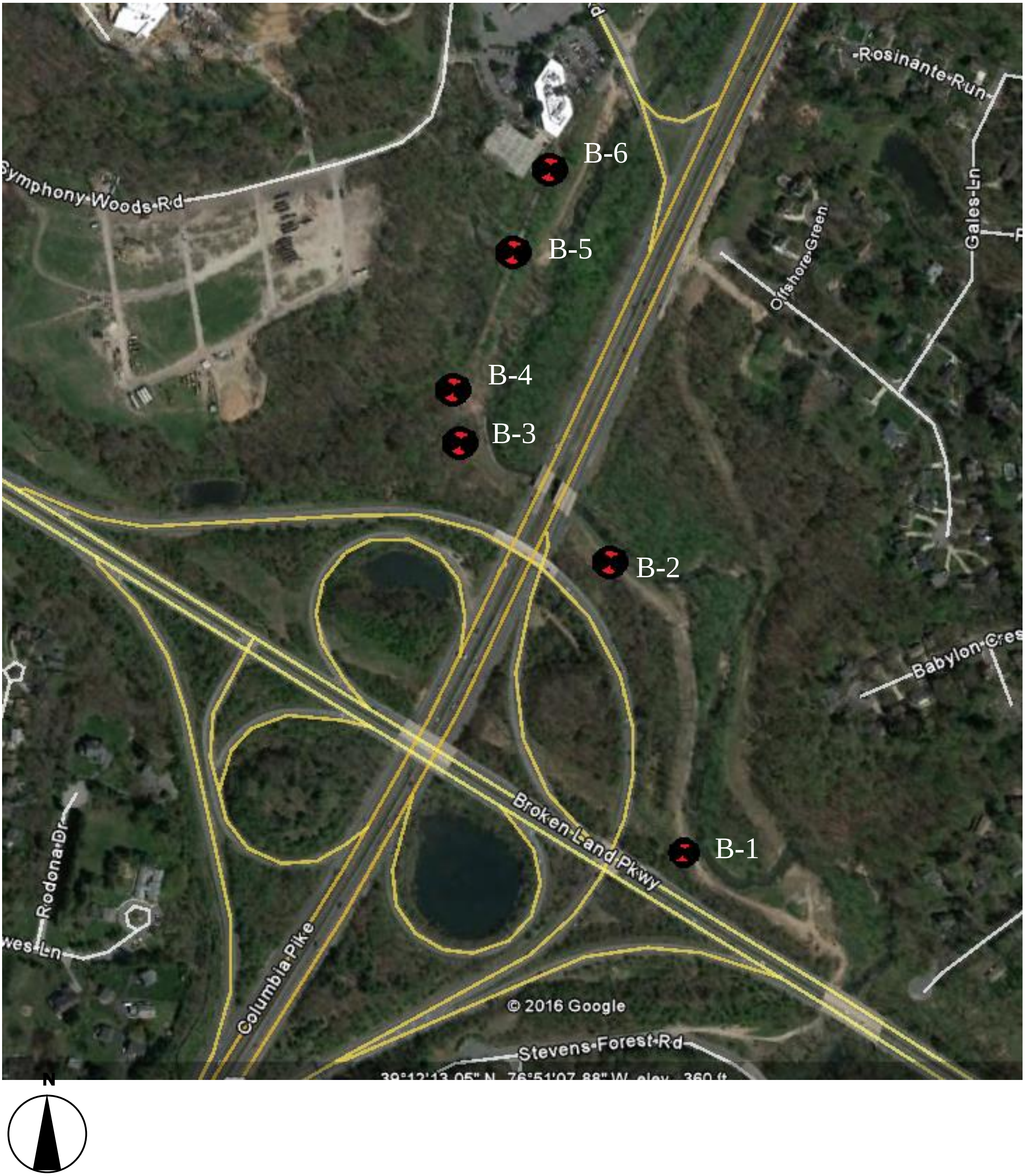
**COLUMBIA SHARED USE PATH**

**COLUMBIA, HOWARD COUNTY, MD**

Figure No.

**1**

| DRAWN BY | APPROVED BY | SCALE | DATE | KCI PROJECT NUMBER |
|---|---|---|---|---|
| SD | TL | NTS | October 2016 | 17133314.98 |



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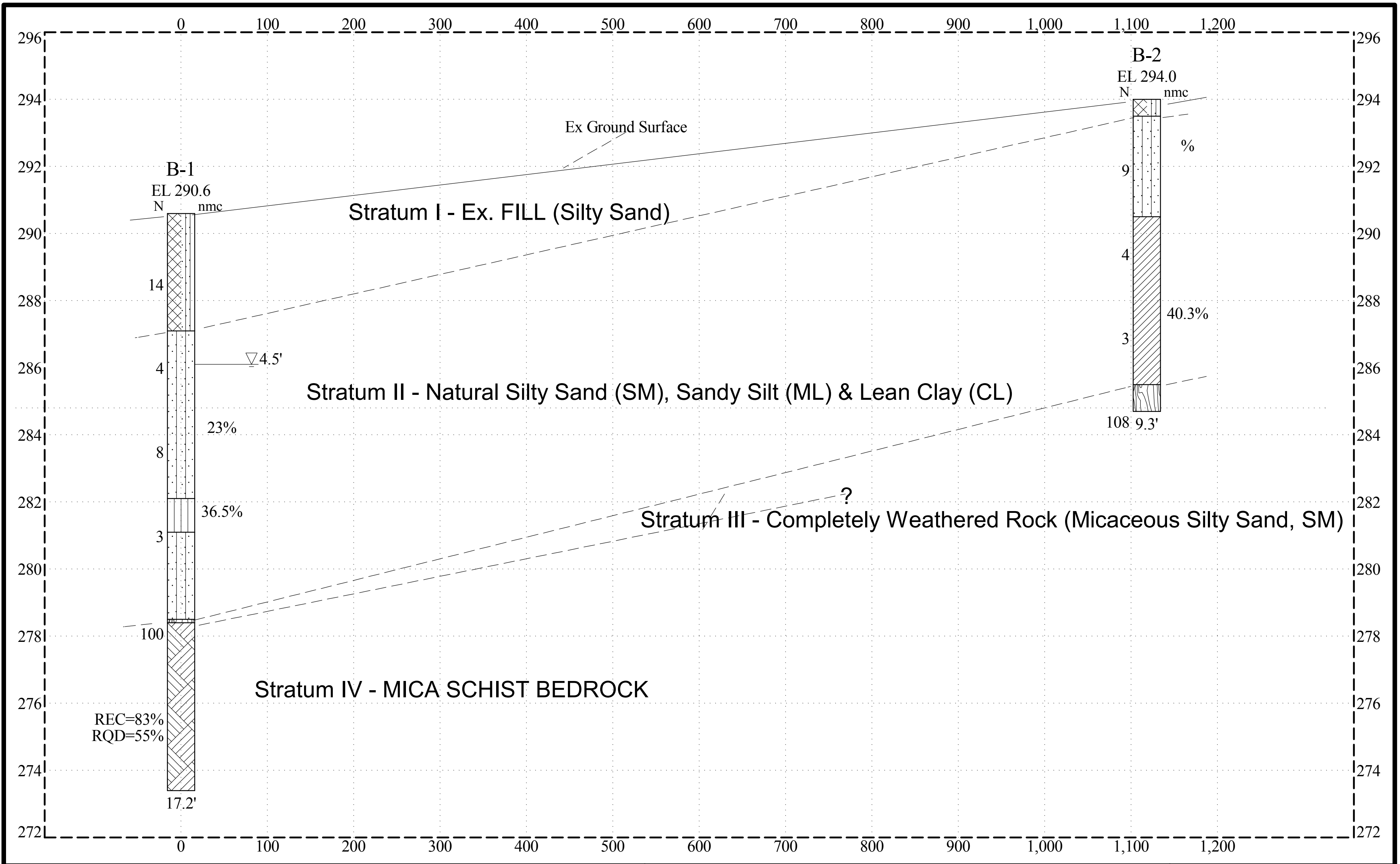
# BORING LOCATION PLAN

COLUMBIA SHARED USE PATH
HOWARD COUNTY, MARYLAND

FIGURE NO.
2

| DRAWN BY | APPROVED BY | SCALE | DATE | KCI PROJECT NO. |
|---|---|---|---|---|
| LSG | CK | NTS | October 2016 | 17133314.98 |



USCS SOIL KEY

| | | | |
|---|---|---|---|
| GW | SW | ML | OL |
| GP | SP | MH | OH |
| GM | SM | CL | FILL |
| GC | SC | CH | SANDSTONE |

Title: SUBSURFACE PROFILE - BRIDGE @ CULVERT

Columbia Shared Use Bike Path

Figure No.

3A

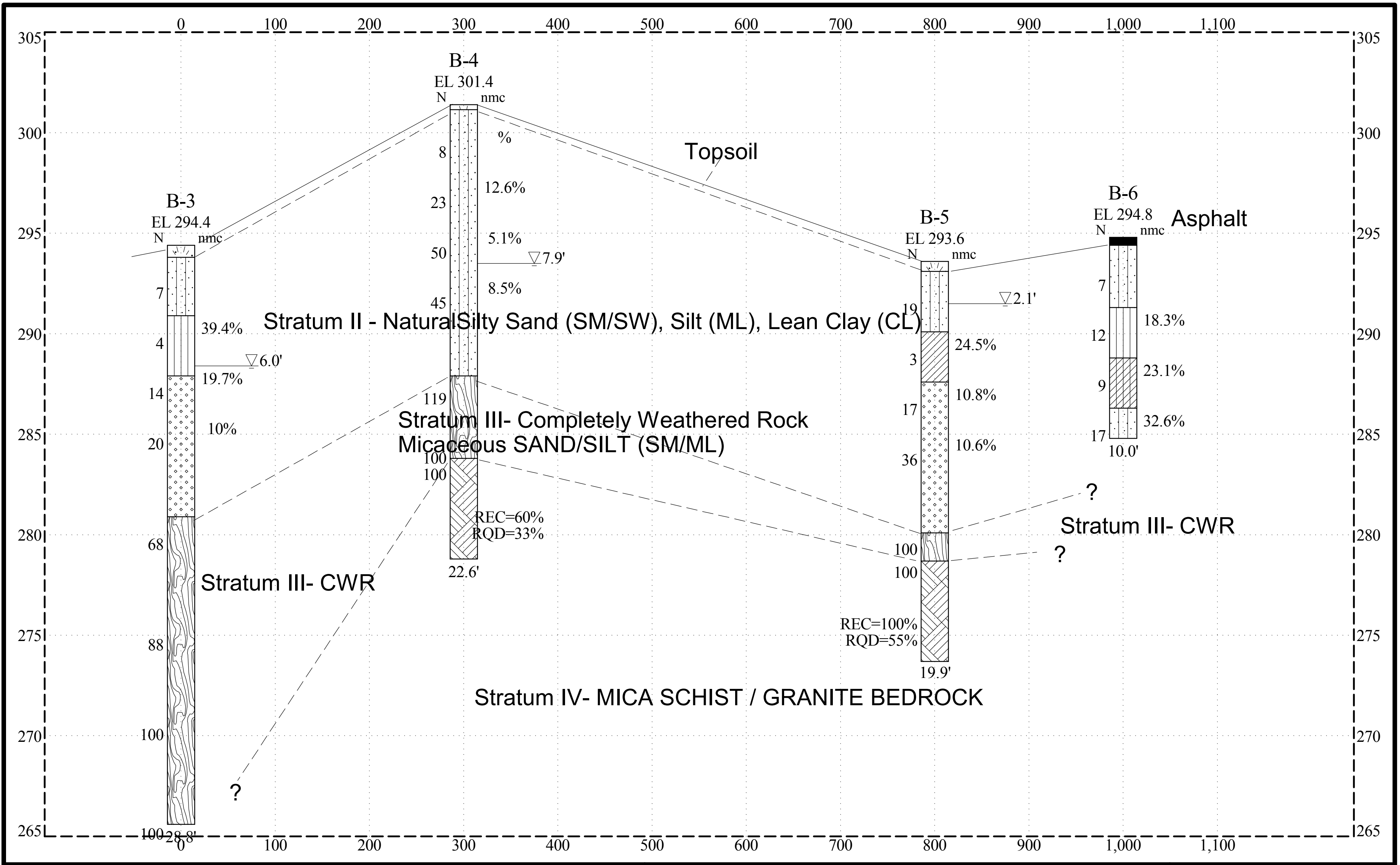
Drawn: LSG

Approved: KBA

Date: 10/26/16

KCI Job No. 17133314.98

KCI 8.5X11 PLOG FENCE/LOGO/SOIL KEY FINAL LOGS.GPJ MD SHA REVISED TEMPLATE.GDT 10/26/16



USCS SOIL KEY

GW
GP
GM
GC
SW
SP
SM
SC
ML
MH
CL
CH
OL
OH
FILL
SANDSTONE

Title:
# SUBSURFACE PROFILE

Columbia Shared Use Bike Path

Figure No.

3B

Drawn: LSG

Approved: KBA

Date: 10/26/16

KCI Job No. 17133314.98

KCI 8.5X11 PLOG FENCE/LOGO/SOIL KEY FINAL LOGS.GPJ MD SHA REVISED TEMPLATE.GDT 10/26/16

# TEST BORING LOGS

KCI TECHNOLOGIES

PROJECT **Columbia Shared Use Bike Path**

PROJECT NO. **17133314.98**

Surface Elevation **290.6 (ft)**

# TEST BORING LOG

# B-1

SHEET 1 OF 1

| Driller: | Method: | Casing Length: | Date Begun: |
|---|---|---|---|
| **FSD, Inc.** | **HSA** | **12.1 ft** | **9/16/2016** |
| KCI Representative: | Hammer Type: | Casing Diameter: | Date Completed: |
| **SD** | **Automatic** | **3.25"** | **9/16/2016** |

## Groundwater Levels (feet)

0 hour: 4.5 ▽

24 hours: ________

## SOIL CLASSIFICATION AND REMARKS

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

FILL Sampled As: Damp, gray, brown, medium dense, Silty fine SAND, trace Gravel (SM)

Moist to wet, gray, very loose to loose, Silty fine to medium SAND (SM)

Wet, dark gray, very soft, micaceous, Sandy SILT (ML)

Wet, gray, very loose, Silty fine to medium SAND (SM)

Completely Weathered Rock Sampled As: Wet, gray, tan, very dense, Silty fine to medium SAND, some rock fragments (SM)

BEDROCK Core Sampled As: Gray, competent, fair quality, moderately hard to hard, moderately weathered to slightly weathered, moderately fractured, Mica SCHIST

Boring terminated at 17.2 ft. bgs

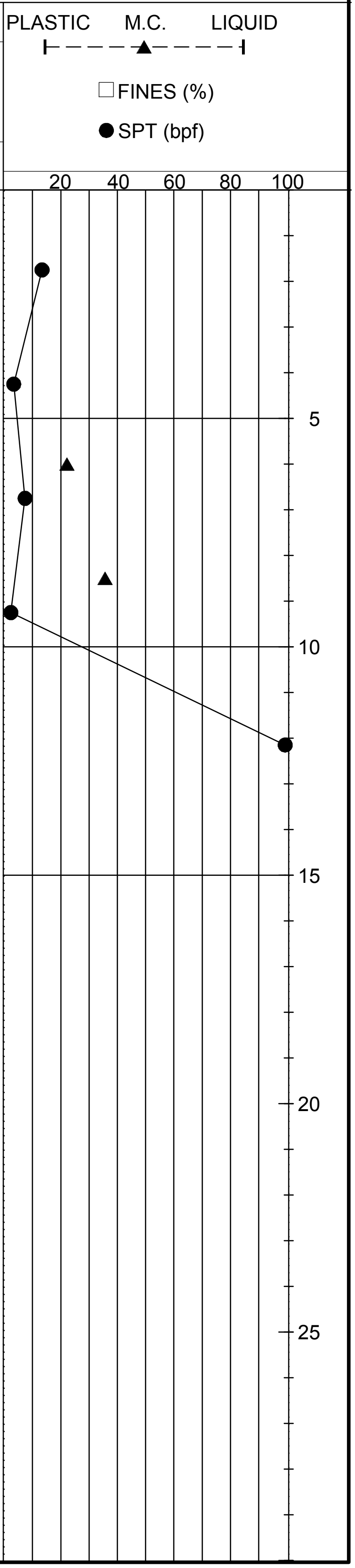
Notes:
1) We encountered groundwater in augers at 6.5 feet bgs during drilling; and 4.5 feet bgs at completion of drilling.
2) Borehole caved-in at 8.1 feet bgs.
3) Borehole backfilled with auger cuttings upon completion.

## SAMPLES

| IDNET | N-COUNT (1st 6" 2nd 6" 3rd 6" 4th 6")<br>REC<br>RQD |
|---|---|
| S-1 | 6-8-6<br>N = 14<br>REC=18" |
| S-2 | 1-2-2<br>N = 4<br>REC=16" |
| S-3 | 2-4-4<br>N = 8<br>REC=14" |
| S-4 | 1-0-3<br>N = 3<br>REC=18" |
| S-5 | -50/1"<br>N = 100<br>REC=1" |
| R-1 | REC=83%<br>%RQD=55 |

DEPTH (ft): 5, 10, 15, 20, 25

ELEV (ft): 290, 285, 280, 275, 270, 265



KCI TECHNOLOGIES

PROJECT **Columbia Shared Use Bike Path**

PROJECT NO. **17133314.98**

Surface Elevation **294 (ft)**

# TEST BORING LOG

# B-2

SHEET 1 OF 1

| | | | |
|---|---|---|---|
| Driller:<br>**FSD, Inc.** | Method:<br>**HSA** | Casing Length:<br>**8.5 ft** | Date Begun: **9/16/2016** |
| KCI Representative:<br>**SD** | Hammer Type:<br>**Automatic** | Casing Diameter:<br>**3.25"** | Date Completed: **9/16/2016** |

**Groundwater Levels (feet)**

0 hour: _______

24 hours: _______

SOIL CLASSIFICATION AND REMARKS

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

Fill Sampled As: Damp, brown, loose, Silty fine SAND, trace Gravel (SM)

Damp, dark green, loose, Silty fine SAND, little Gravel and rock fragments (SM)

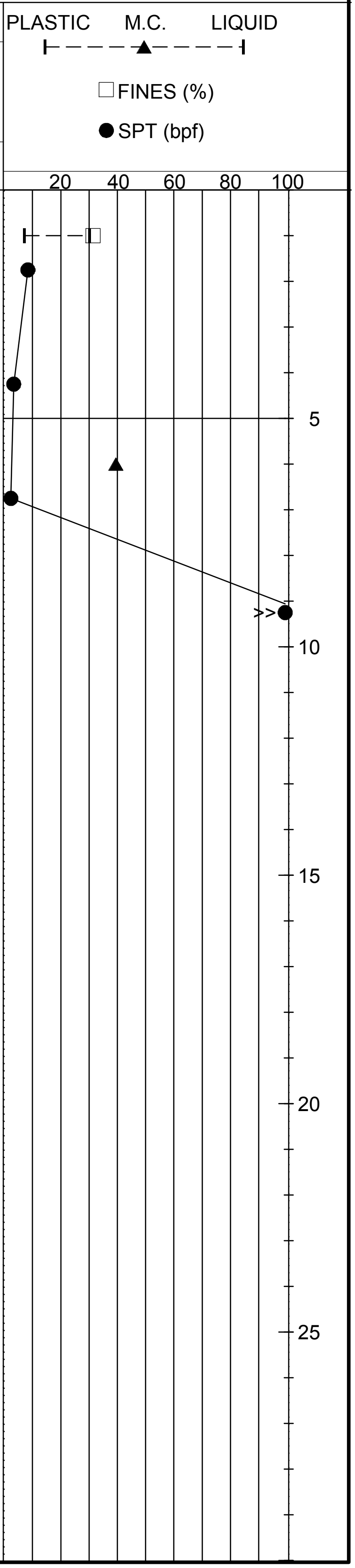
Moist, gray, soft, micaceous, Lean CLAY (CL)

Completely Weathered Rock Sampled As: Moist, gray, brown, tan, very dense, micaceous, Silty SAND, some rock fragments (SM)

Boring terminated at 9.3 ft. bgs

Notes:
1) We did not encounter groundwater during or after completion of drilling.
2) Borehole caved-in at 8.1 feet bgs
3) Borehole backfilled with auger cuttings upon completion.
4) Bulk sample taken from 1-5 feet bgs.

| DEPTH (ft) | ELEV (ft) | IDNET | TYPE | PID (ppm) | N-COUNT 1st 6" 2nd 6" 3rd 6" 4th 6"<br>REC RQD |
|---|---|---|---|---|---|
| 1.5–3 | | S-1 | ☒ | | 10-5-4<br>N = 9<br>REC=5" |
| 4–5.5 | 290 | S-2 | ☒ | | 1-2-2<br>N = 4<br>REC=17" |
| 6.5–8 | | S-3 | ☒ | | 1-1-2<br>N = 3<br>REC=16" |
| 9–10.5 | 285 | S-4 | ☒ | | 4-8-50/4"<br>N = 108<br>REC=9" |



# TEST BORING LOG

# B-3

PROJECT **Columbia Shared Use Bike Path**
PROJECT NO. **17133314.98**
Surface Elevation **294.4 (ft)**

SHEET 1 OF 1

| | | | |
|---|---|---|---|
| Driller: **FSD, Inc.** | Method: **HSA** | Casing Length: **28.5 ft** | Date Begun: **9/15/2016** |
| KCI Representative: **SD** | Hammer Type: **Automatic** | Casing Diameter: **3.25"** | Date Completed: **9/15/2016** |

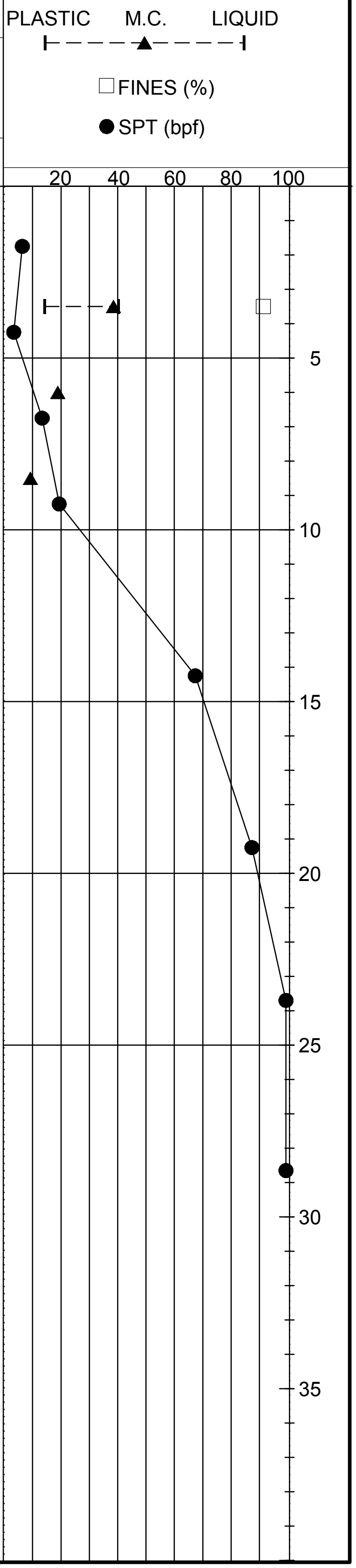
**Groundwater Levels (feet)**
0 hour: 6 ▽
24 hours: ________

SOIL CLASSIFICATION AND REMARKS

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

| DEPTH (ft) | SOIL CLASSIFICATION AND REMARKS | ELEV (ft) | IDNET | N-COUNT / REC |
|---|---|---|---|---|
| | 7" Topsoil | | | |
| | Moist, brown, loose, Silty fine SAND, trace Gravel (SM) | | S-1 | 2-3-4<br>N = 7<br>REC=10" |
| 5 | Moist, dark green, soft, SILT (ML) | 290 | S-2 | 2-2-2<br>N = 4<br>REC=18" |
| ▽ | Wet, gray, medium dense, fine to coarse, Well-Graded SAND, trace Quartz and Gravel (SW) | | S-3 | 4-6-8<br>N = 14<br>REC=15" |
| 10 | | 285 | S-4 | 6-8-12<br>N = 20<br>REC=12" |
| 15 | Completely Weathered Rock Sampled As: Moist, brown, tan, very dense, micaceous, Silty fine SAND (SM) | 280 | S-5 | 13-28-40<br>N = 68<br>REC=16" |
| 20 | | 275 | S-6 | 25-43-45<br>N = 88<br>REC=16" |
| 25 | | 270 | S-7 | -50/5"<br>N = 100<br>REC=5" |
| 30 | Boring terminated at 28.8 ft. bgs | 265 | S-8 | -50/4"<br>N = 100<br>REC=4" |
| 35 | | 260 | | |
| | | 255 | | |

Notes:
1) We encountered groundwater in augers at 6.5 feet bgs during drilling; and at 6 feet bgs after completion of drilling.
2) Borehole caved-in at 19.5 feet bgs.
3) Borehole backfilled with auger cuttings upon completion.



KCI TECHNOLOGIES

PROJECT **Columbia Shared Use Bike Path**
PROJECT NO. **17133314.98**
Surface Elevation **301.4 (ft)**

# TEST BORING LOG
## B-4

SHEET 1 OF 1

| | | | |
|---|---|---|---|
| Driller: **FSD, Inc.** | Method: **HSA** | Casing Length: **17.6 ft** | Date Begun: **9/15/2016** |
| KCI Representative: **SD** | Hammer Type: **Automatic** | Casing Diameter: **3.25"** | Date Completed: **9/15/2016** |

**Groundwater Levels (feet)**
0 hour: 7.9 ▽
24 hours: ________

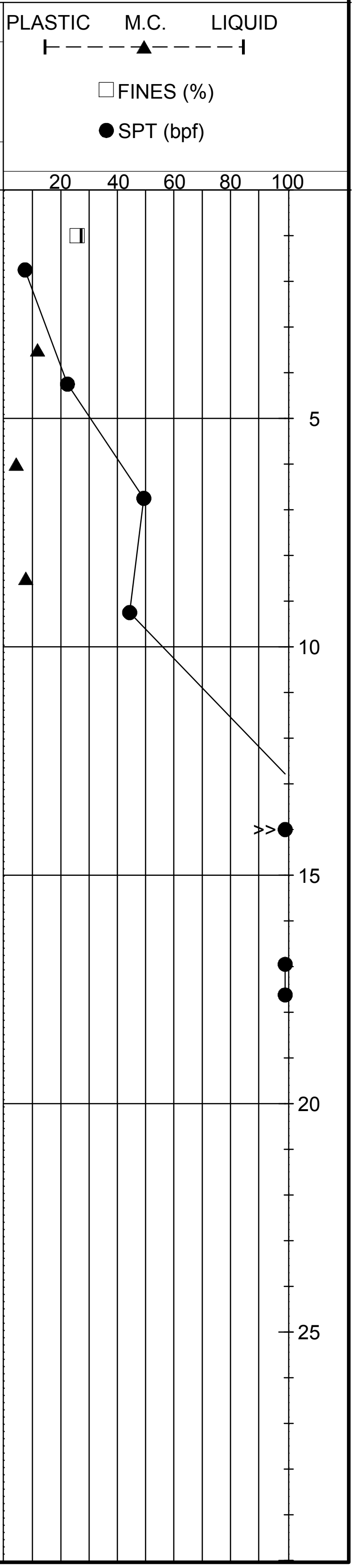
SOIL CLASSIFICATION AND REMARKS

SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

| DEPTH (ft) | SOIL CLASSIFICATION AND REMARKS | ELEV (ft) |
|---|---|---|
| 0 | 3" Topsoil | 301.4 |
| | Moist, brown, loose to dense, micaceous, Silty fine SAND (SM) | |
| 13.5 | Completely Weathered Rock Sampled As: Moist, gray, white, hard, micaceous, Sandy SILT (ML) | |
| 17.6 | BEDROCK Core Sampled As: Gray, incompetent, poor quality, moderately hard to hard, moderately weathered to slightly weathered, extremely fractured, Mica SCHIST | |
| 22.6 | Boring terminated at 22.6 ft. bgs | |

| IDNET | N-COUNT (1st 6" / 2nd 6" / 3rd 6" / 4th 6")<br>REC RQD |
|---|---|
| S-1 | 4-4-4<br>N = 8<br>REC=16" |
| S-2 | 7-12-11<br>N = 23<br>REC=18" |
| S-3 | 32-50<br>N = 50<br>REC=10" |
| S-4 | 12-16-29<br>N = 45<br>REC=17" |
| S-5 | 21-19-50/1"<br>N = 119<br>REC=11" |
| S-6 | 39-50/5"<br>N = 100<br>REC=10" |
| S-7 | -50/.5"<br>N = 100<br>REC=0" |
| R-1 | REC=60%<br>%RQD=33 |

Notes:
1) We encountered groundwater at 7.9 feet bgs at completion of drilling.
2) Borehole caved-in at 14.5 feet bgs.
3) Bulk sample taken from 1-5 feet bgs.
4) Borehole backfilled upon completion.



KCI TECHNOLOGIES

PROJECT **Columbia Shared Use Bike Path**
PROJECT NO. **17133314.98**
Surface Elevation **293.6 (ft)**

# TEST BORING LOG
# B-5

SHEET 1 OF 1

| Driller: | Method: | Casing Length: | Date Begun: |
|---|---|---|---|
| **FSD, Inc.** | **HSA** | **14.8 ft** | **9/15/2016** |
| KCI Representative: | Hammer Type: | Casing Diameter: | Date Completed: |
| **SD** | **Automatic** | **3.25"** | **9/15/2016** |

**Groundwater Levels (feet)**
0 hour: 2.1 ▽
24 hours: ________

SOIL CLASSIFICATION AND REMARKS

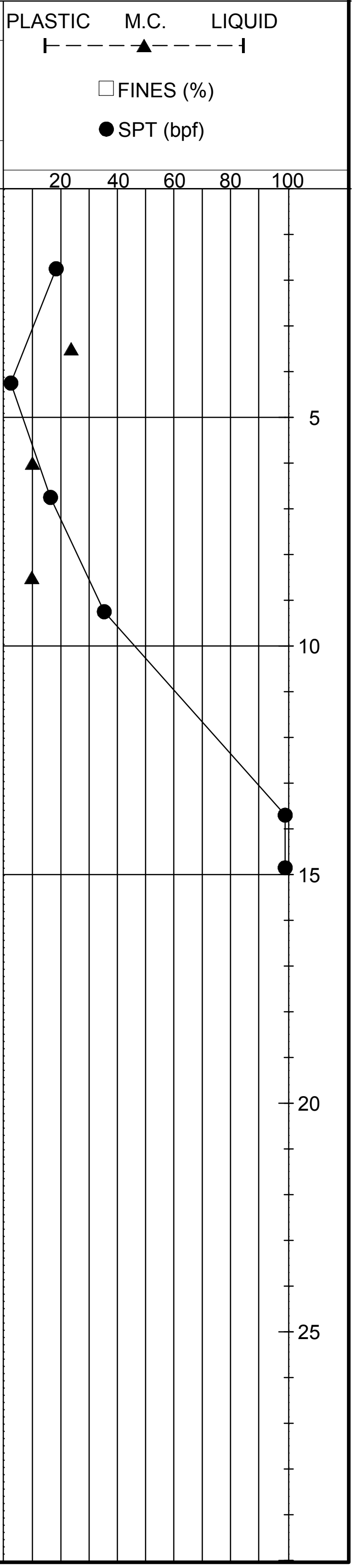
SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.

| SOIL CLASSIFICATION AND REMARKS | IDNET | N-COUNT<br>REC<br>RQD |
|---|---|---|
| 6" Topsoil | | |
| Moist, gray, medium dense, Silty fine SAND, little rock fragments (SM) | S-1 | 3-6-13<br>N = 19<br>REC=14" |
| Moist, gray, soft, micaceous, Lean CLAY (CL) | S-2 | 1-1-2<br>N = 3<br>REC=8" |
| Wet, brown, gray, medium dense to dense, fine to medium Well-Graded SAND, little to trace Gravel (SW) | S-3 | 6-7-10<br>N = 17<br>REC=13" |
| -Soil color changes to brown and tan | S-4 | 9-21-15<br>N = 36<br>REC=14" |
| Completely Weathered Rock Sampled As: Moist, black, tan, brown, very dense, micaceous, Silty fine to medium SAND and rock fragments (SM) | S-5 | -50/5"<br>N = 100<br>REC=5" |
| | S-6 | -50/1.5"<br>N = 100<br>REC=1" |
| BEDROCK Core Sampled As: Gray and pink, continuous, fair quality, moderately hard to hard, moderately weathered to slightly weathered, moderately fractured, GRANITE and Mica SCHIST | R-1 | REC=100%<br>%RQD=55 |

DEPTH (ft): 5, 10, 15, 20, 25
ELEV (ft): 290, 285, 280, 275, 270, 265

Boring terminated at 19.9 ft. bgs

Notes:
1) We encountered groundwater at 7 feet bgs during drilling and 2.1 feet bgs at completion.
2) Borehole caved-in at 3.2 feet bgs.
3) Borehole backfilled with auger cuttings upon completion.



KCI TECHNOLOGIES

PROJECT **Columbia Shared Use Bike Path**

PROJECT NO. **17133314.98**

Surface Elevation **294.8 (ft)**

# TEST BORING LOG
# B-6

SHEET 1 OF 1

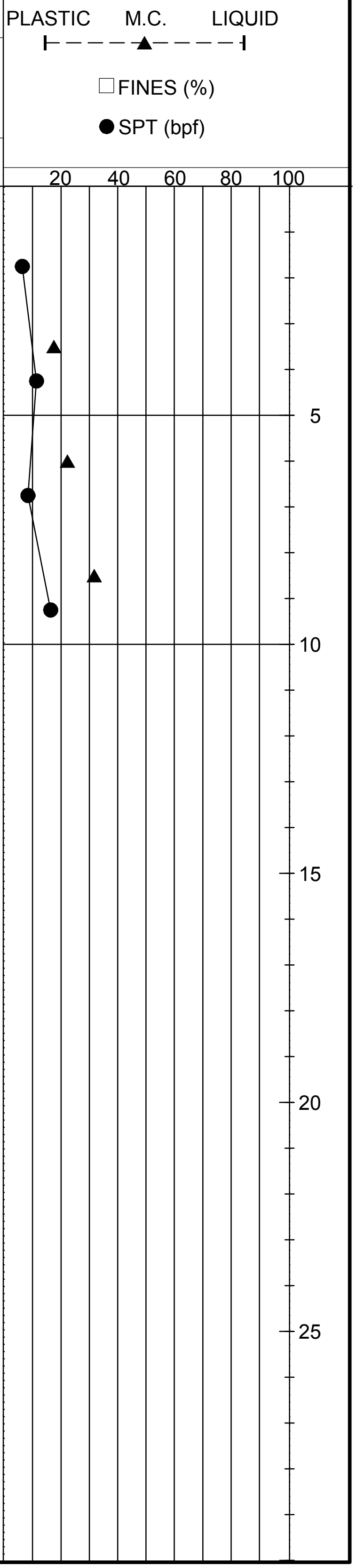
| Driller: | Method: | Casing Length: | |
|---|---|---|---|
| **FSD, Inc.** | **HSA** | **8.5 ft** | Date Begun: **9/15/2016** |
| KCI Representative: | Hammer Type: | Casing Diameter: | |
| **SD** | **Automatic** | **3.25"** | Date Completed: **9/15/2016** |

**Groundwater Levels (feet)**

0 hour: _______

24 hours: _______

| DEPTH (ft) | SOIL CLASSIFICATION AND REMARKS<br>SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW. | LITHOLOGY | ELEV (ft) | IDNET | TYPE | PID (ppm) | N-COUNT 1st 6" 2nd 6" 3rd 6" 4th 6"<br>REC RQD |
|---|---|---|---|---|---|---|---|
| | 5" Asphalt | | | | | | |
| | Moist, gray, loose, Silty fine SAND (SM) | | | S-1 | ☒ | | 7-5-2<br>N = 7<br>REC=13" |
| 5 | Moist, brown, stiff, Sandy SILT (ML) | | 290 | S-2 | ☒ | | 2-5-7<br>N = 12<br>REC=18" |
| | Moist, gray, brown, stiff, Clayey SILT (CL-ML) | | | S-3 | ☒ | | 3-4-5<br>N = 9<br>REC=18" |
| 10 | Moist to wet, gray, brown, medium dense, Silty fine SAND, some rock fragments (SM) | | 285 | S-4 | ☒ | | 2-1-16<br>N = 17<br>REC=12" |
| | Boring terminated at 10 ft. bgs | | | | | | |
| 15 | Notes:<br>1) We encountered groundwater at 9.5 feet bgs during drilling.<br>2) Borehole caved-in at 6.3 feet bgs.<br>3) Borehole backfilled with auger cutting and asphalt patched prior to leaving the site. | | 280 | | | | |
| 20 | | | 275 | | | | |
| 25 | | | 270 | | | | |
| | | | 265 | | | | |



# USCS SOIL CLASSIFICATION CHART

| MAJOR DIVISIONS | | | SYMBOLS | | TYPICAL DESCRIPTIONS |
|---|---|---|---|---|---|
| | | | GRAPH | LETTER | |
| COARSE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE | GRAVEL AND GRAVELLY SOILS<br>MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE | CLEAN GRAVELS<br>(LITTLE OR NO FINES) | ● | GW | WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES |
| | | | ○ | GP | POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES |
| | | GRAVELS WITH FINES<br>(APPRECIABLE AMOUNT OF FINES) | ○ | GM | SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES |
| | | | ▨ | GC | CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES |
| | SAND AND SANDY SOILS<br>MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE | CLEAN SANDS<br>(LITTLE OR NO FINES) | ⁘ | SW | WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES |
| | | | ∴ | SP | POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES |
| | | SANDS WITH FINES<br>(APPRECIABLE AMOUNT OF FINES) | ⁘ | SM | SILTY SANDS, SAND - SILT MIXTURES |
| | | | ▨ | SC | CLAYEY SANDS, SAND - CLAY MIXTURES |
| FINE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE | SILTS AND CLAYS | LIQUID LIMIT LESS THAN 50 | ▥ | ML | INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY |
| | | | ▨ | CL | INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS |
| | | | ☰ | OL | ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY |
| | SILTS AND CLAYS | LIQUID LIMIT GREATER THAN 50 | ▥ | MH | INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS |
| | | | ▨ | CH | INORGANIC CLAYS OF HIGH PLASTICITY |
| | | | ≈ | OH | ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS |
| HIGHLY ORGANIC SOILS | | | ⩛ | PT | PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS |

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

USCS LEGEND 2/7/13

# FIELD CLASSIFICATION SYSTEM FOR SOIL EXPLORATION

## NON-COHESIVE SOILS
(Sand, Gravel, and Combinations)

Density

| | |
|---|---|
| Very Loose | - 4 blows/ft. or less |
| Loose | - 5 to 10 blows/ft. |
| Medium Dense | - 11 to 30 blows/ft. |
| Dense | - 31 to 50 blows/ft. |
| Very Dense | - 51 blows/ft. or more |

Relative Proportions

| Descriptive Term | Percent |
|---|---|
| Trace | 1 to 10 |
| Little | 11 to 20 |
| Some | 21 to 35 |
| And | 35 to 50 |

Particle Size Identification

| | | |
|---|---|---|
| Boulders | | - 12 inch diameter or more |
| Cobbles | | - 12 to 3 inch diameter |
| Gravel | -Coarse | - 3 to 0.75 inch diameter |
| | Fine | - 0.75 to 0.19 inch diameter |
| Sand | -Coarse | - 4.75 to 2 mm diameter<br>(dia. of pencil lead) |
| | Medium | - 2 to 0.425 mm diameter<br>(dia. of broom straw) |
| | Fine | - 0.425 to 0.075 mm diameter<br>(dia. of human hair) |
| Fines | -Silt & Clay | - less than 0.075 mm diameter<br>(Cannot see particles) |

## COHESIVE SOILS
(Clay, Silt, and Combinations)

Consistency

| | |
|---|---|
| Very Soft | - 2 blows/ft. or less |
| Soft | - 3 to 4 blows/ft. |
| Medium Stiff | - 5 to 8 blows/ft. |
| Stiff | - 9 to 15 blows/ft. |
| Very Stiff | - 16 to 30 blows/ft. |
| Hard | - 31 blows/ft. or more |

Plasticity

| Degree of Plasticity | Plasticity Index |
|---|---|
| None to Slight | 0 - 4 |
| Slight | 5 - 7 |
| Medium | 8 - 22 |
| High to Very High | over 22 |

Classification on Records of Soil Exploration are made by visual inspection of samples and laboratory testing.

Standard Penetration Test

- Driving a 2.0" - O.D., 1 3/8" - I.D. sampler a distance of 1.0 foot into undisturbed soil with a 140-pound hammer free falling a distance of 30.0 inches. It is required to drive the spoon 6.0 inches to seat into undistured soil, then perform the test. The number of hammer blows for seating and making the test are recorded each 6.0 inches of penetration on the Record of Soil Exploration (Example: 6-8-9). The standard penetration test result can be obtained by adding the last two figures. (i.e. 8+9=17 blows/ft.) (ASTM D-1586).

Strata Changes

- In the column "Soil Descriptions" on the Record of Soil Exploration the horizontal lines represent estimated strata changes.

Ground Water

- Observations were made at the times indicated. Porosity of soil strata, weather conditions, site topography, etc. may cause changes in the water levels indicated on the Record of Soil Exploration.

KCI
TECHNOLOGIES

FIELD CLASSIFICATION SYSTEM
FOR SOIL EXPLORATION

Figure No.
GENERAL

Drawn: DPC
Approved: KO-A
Date: GENERAL
KCI Job No. GENERAL

# FIELD CLASSIFICATION SYSTEM FOR ROCK EXPLORATION

| | |
|---|---|
| Saprolite: | A transitional material between soil and rock retains the relic structure of the parent rock and exhibits penetration resistance between 60 blows per foot and 100 blows per 2-inches of penetration. |
| RQD: | Rock Quality Designation; Ratio of the core lengths greater than four inches to the total length of the run. |

| Description | Percentage Core Recovered | RQD Rock Quality Description | Description of Rock Quality |
|---|---|---|---|
| Incompetent | Less than 40 | 0 - 25 | very poor |
| Competent | 40 - 70 | 25 - 50 | poor |
| Fairly Competent | 70 - 80 | 50 - 75 | fair |
| Fairly Continous | 80 - 90 | 75 - 90 | good |
| Countinous | 90 - 100 | 90 - 100 | excellent |

**FIELD HARDNESS:** ( A measure of resistance to scratching or abrasion)

| | |
|---|---|
| Very Hard | Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick. |
| Hard | Can be scratched with knife or pick only with difficulty. Hard blow of a hammer required to detach hand specimen. |
| Moderately Hard | Can be scratched with knife or pick. Gouges or grooves to 1/4-in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow. |
| Medium | Can be grooved or gouged 1/16-in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick. |
| Soft | Can be gouged or grooved readily with knife or pick point. Can be excavated in chips and pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure. |
| Very Soft | Can be carved with knife. Can be excavated with point of pick. Pieces 1-inch or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail. |

**WEATHERING:** (The action of the elements in altering the color, texture, and compostion of the rock)

| | |
|---|---|
| Very slightly | Rock generally fresh, joint stained, some joints may contain thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline. |
| Slightly | Rock generally fresh, joints stained, and discoloration extends into rock up to 1-inch. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer. |
| Moderately | Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some may be decomposed to clay. Rock has dull sound under hammer and has a significant loss of strength compared with fresh rock. |
| Severely | All rock except quartz discolored or stained. Rock "fabric" clear and evident but reduced in strength to strong soil. In granitoid rocks all feldspars kaolinized to some extent. Some fragments of strong rock usually left. |
| Very severely | All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining. |
| Completely | All rock completely altered to soil-like material. |

**ROCK FRACTURE FREQUENCY:** (Any break in a rock whether or not it has undergone relative displacement)

| Description | Spacing Between Fractures |
|---|---|
| Extremely fractured | Less than 1-inch |
| Moderately fractured | 1-inch to 4-inches |
| Slightly fractured | 4-inches to 8-inches |
| Sound | More than 8-inches |

Note: Fracture frequency terms are generalized to describe the average condition of the rock obtained from the core run. Portions of the rock within the run described may vary from the generalized descriptions. Where a core break appears to be due to drilling and not to natural causes, it has not been considered as a break for accessing fracture frequency. Frequency shown on Record of Soil Exploration represents condition of core as removed from the core barrel.

**JOINTS, BEDDING, AND FOLIATION:**

| Joints | Bedding & Foliation | Spacing |
|---|---|---|
| Very close | Very thin | Less than 2-inches |
| Close | Thin | 2-inches - 1-foot |
| Moderately close | Medium | 1-foot - 3-feet |
| Wide | Thick | 3-feet - 10-feet |
| Very wide | Very thick | More than 10-feet |

Note: Refers to perpendicular distance between discontinuities.

| Attitude | Attitude (degrees) |
|---|---|
| Horizontal | 0 to 5 |
| Shallow to low angle | 5 to 35 |
| Moderately dipping | 35 to 55 |
| Steep or high angle | 55 to 85 |
| Vertical | 85 to 90 |

KCI TECHNOLOGIES

FIELD CLASSIFICATION SYSTEM
FOR ROCK EXPLORATION

Figure No. GENERAL

Drawn: DPC
Approved: KO-A
Date: GENERAL
KCI Job No. GENERAL

# FIELD EXPLORATORY PROCEDURES

The general field procedures employed by KCI are summarized in ASTM specification D 420 entitled "Investigating and Sampling Soils and Rocks for Engineering Purposes". This recommended practice lists recognized methods for determining soil and rock distribution and ground water conditions. These methods include geophysical and in-situ borings.

Borings are advanced to obtain subsurface samples using one of several techniques depending upon the site and subsurface conditions. These techniques are:

1. Continuous hollow-stem augers;
2. Wash borings using roller cone or drag bits (mud or water);
3. Continuous flight augers (ASTM D 1452);
4. Continuous sampling using a Tripod-mounted drill rig.

The standard penetration test (SPT) borings are performed in accordance with ASTM D 1586. The SPT method consisted of advancing a two-inch outside diameter sampling spoon to a depth of 18 inches by driving it with a 140-pound hammer falling 30 inches. The values reported on the boring logs are the blows required to advance three successive six-inch increments. The first six-inch increment is considered as seating. The sum of the number of blows for the second and third increments is the "N" value. The "N" value is used to determine the relative density of the soil. KCI obtained soil samples using the SPT method and sampling was performed at two and half-foot intervals to a depth of ten feet bgs and every five feet thereafter to boring terminations depth. Representative soil samples are obtained during these tests and used to classify the soils encountered. We place the recovered representative soil samples in six-inch glass jars and transport them to the laboratory for testing.

These drilling methods are not capable of penetrating through material designated as "refusal materials." Refusal may result from hard cemented soil, soft watered rock, coarse gravel or boulders, thin rock seams, or the upper surface of sound continuous rock. Core drilling procedures are required to determine the character and continuity of refusal materials.

The Driller reports the subsurface conditions encountered during drilling on a field test boring record. The record contains information concerning the boring method, samples attempted and recovered, indications of the presence of various materials such as coarse gravel, cobbles, etc., and observation of ground water. It also contains the driller's interpretation of the soil conditions between samples. Therefore, these boring records contain both factual and interpretive information.

A geotechnical engineer reviews the soils and rock samples plus the field boring records. The engineer classifies the soils in general accordance with the procedures outlined in ASTM Specification D 2488 and prepares the final boring records, which are the basis for all evaluations and recommendations.

The final test boring records represent our interpretation of the contents of the field records based on the results of the engineering examination and tests of the field samples. These records depict subsurface conditions at the specific locations and at the particular time when drilled. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the subsurface soil and ground water conditions at these boring locations. The lines designating the interface between soil or refusal materials on the records and on profiles represent approximate boundaries. The actual transition between materials may be gradual. The final Test Boring Records are included in Appendix B.

# LABORATORY TESTING RESULTS

# Appendix C

## SUMMARY OF LABORATORY TESTING

# COLUMBIA SHARED BIKE PATH

**PROJECT NO.** 17133314.98

**SAMPLES:** 17

**REPORT:** 10/03/16

**SAMPLE DATE** -

**LOCATION:** -

**REMARKS:** -

**JAY KAY TESTING, INC.**
5233 Lehman Road, Suite 110
Spring Grove, PA 17362
Phone: (410) 259-5101

| BORING | SAMPLE | DEPTH | MC % | OM % | LL | PL | PI | % FINES | USCS |
|---|---|---|---|---|---|---|---|---|---|
| B-1 | S-3 | 6.0-7.5 | 23.0 | - | - | - | - | - | - |
| B-1 | S-4 | 8.5-10.0 | 36.5 | - | - | - | - | - | - |
| B-2 | Bulk | 1.0-5.0 | - | - | 31 | 23 | 8 | 32.2 | SM |
| B-2 | S-3 | 6.0-7.5 | 40.3 | - | - | - | - | - | - |
| B-3 | S-2 | 3.5-5.0 | 39.4 | - | 41 | 26 | 15 | 92.2 | ML |
| B-3 | S-3 | 6.0-7.5 | 19.7 | - | - | - | - | - | - |
| B-3 | S-4 | 8.5-10.0 | 10.0 | - | - | - | - | - | - |
| B-4 | Bulk | 1.0-5.0 | - | - | 28 | NP | NP | 26.6 | SM |
| B-4 | S-2 | 3.5-5.0 | 12.6 | - | - | - | - | - | - |
| B-4 | S-3 | 6.0-7.5 | 5.1 | - | - | - | - | - | - |
| B-4 | S-4 | 8.5-10.0 | 8.5 | - | - | - | - | - | - |
| B-5 | S-2 | 3.5-5.0 | 24.5 | - | - | - | - | - | - |
| B-5 | S-3 | 6.0-7.5 | 10.8 | - | - | - | - | - | - |
| B-5 | S-4 | 8.5-10.0 | 10.6 | - | - | - | - | - | - |
| B-6 | S-2 | 3.5-5.0 | 18.3 | - | - | - | - | - | - |
| B-6 | S-3 | 6.0-7.5 | 23.1 | - | - | - | - | - | - |
| B-6 | S-4 | 8.5-10.0 | 32.6 | - | - | - | - | - | - |

Jay Kay Testing, Inc. (AASHTO-Accredited)

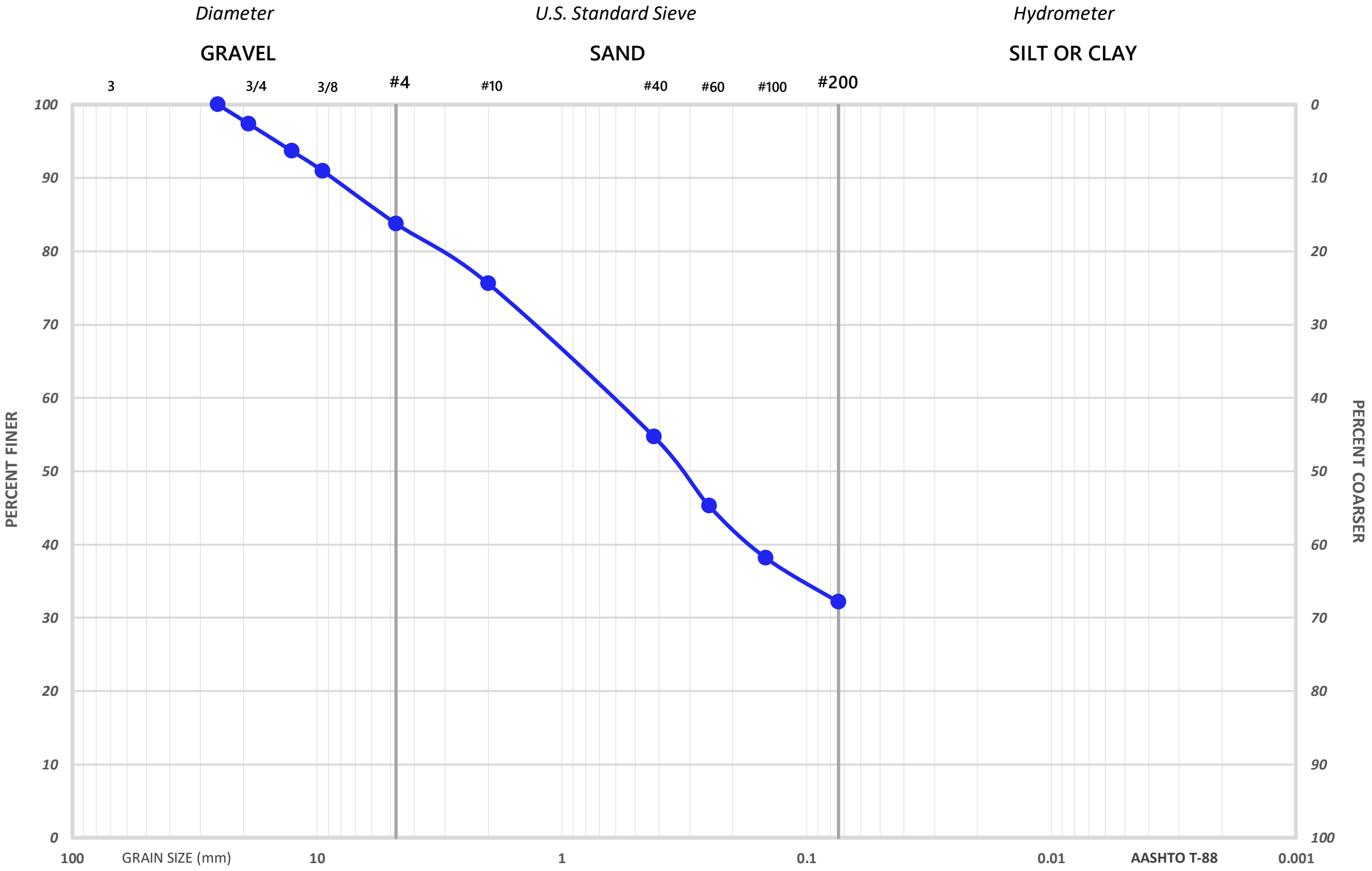
10/03/16 TESTED BY: JMK REVIEWED BY: TL

## COLUMBIA SHARED BIKE PATH

Boring: **B-2**
Sample: **Bulk**
Depth: **1.0-5.0'**

Project No.: 17133314.98
Sample Date: -
Location: -

**JAY KAY TESTING, INC.**
5233 Lehman Road, Suite 110
Spring Grove, PA 17362
Phone: (410) 259-5101



### GRAIN SIZE ANALYSIS

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Diameter* | 75.0 | 50.8 | 37.5 | 25.4 | 19.0 | 12.7 | 9.51 | 4.75 | 2.0 | 0.42 | 0.25 | 0.147 | 0.074 |
| *Sieve Size* | 3" | 2" | 1.5" | 1" | 3/4" | 1/2" | 3/8" | #4 | #10 | #40 | #60 | #100 | **# 200** |
| *% Passing* | - | - | - | 100.0 | 97.4 | 93.7 | 91.0 | 83.8 | 75.6 | 54.7 | 45.3 | 38.2 | **32.2** |

| % GRAVEL | % SAND | *Coarse Gravel* | *Fine Gravel* | *Coarse Sand* | *Medium Sand* | *Fine Sand* | CC | CU |
|---|---|---|---|---|---|---|---|---|
| **16.2** | **51.6** | 2.6 | 13.6 | 8.2 | 20.9 | 22.5 | - | - |

| | | | |
|---|---|---|---|
| Moisture Content | - | Organic Content | - |
| pH | - | Other | - |

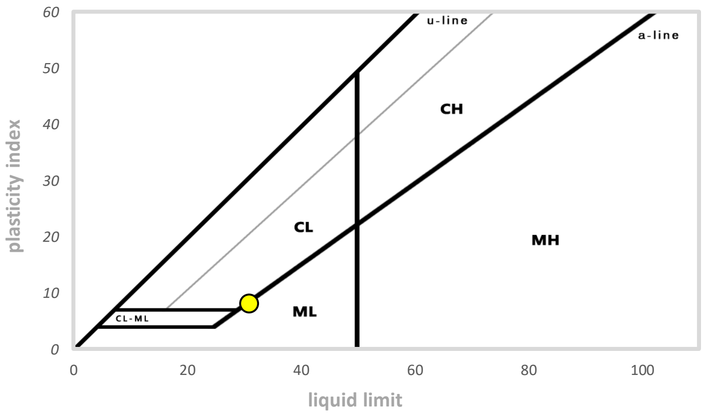
### ATTERBERG LIMITS

| | |
|---|---|
| Liquid Limit | 31 |
| Plastic Limit | 23 |
| Plasticity Index | 8 |

### CLASSIFICATION

| | |
|---|---|
| AASHTO | A-2-4 |
| USCS | SM |

AASHTO T-89/T-90



### SOIL DESCRIPTION

Dark green silty SAND with gravel and rock

10/03/16 TESTED BY: JMK REVIEWED BY: TL

**COLUMBIA SHARED BIKE PATH**

Boring: **B-3**
Sample: **S-2**
Depth: **3.5-5.0'**

Project No.: 17133314.98
Sample Date: -
Location: -

**JAY KAY TESTING, INC.**
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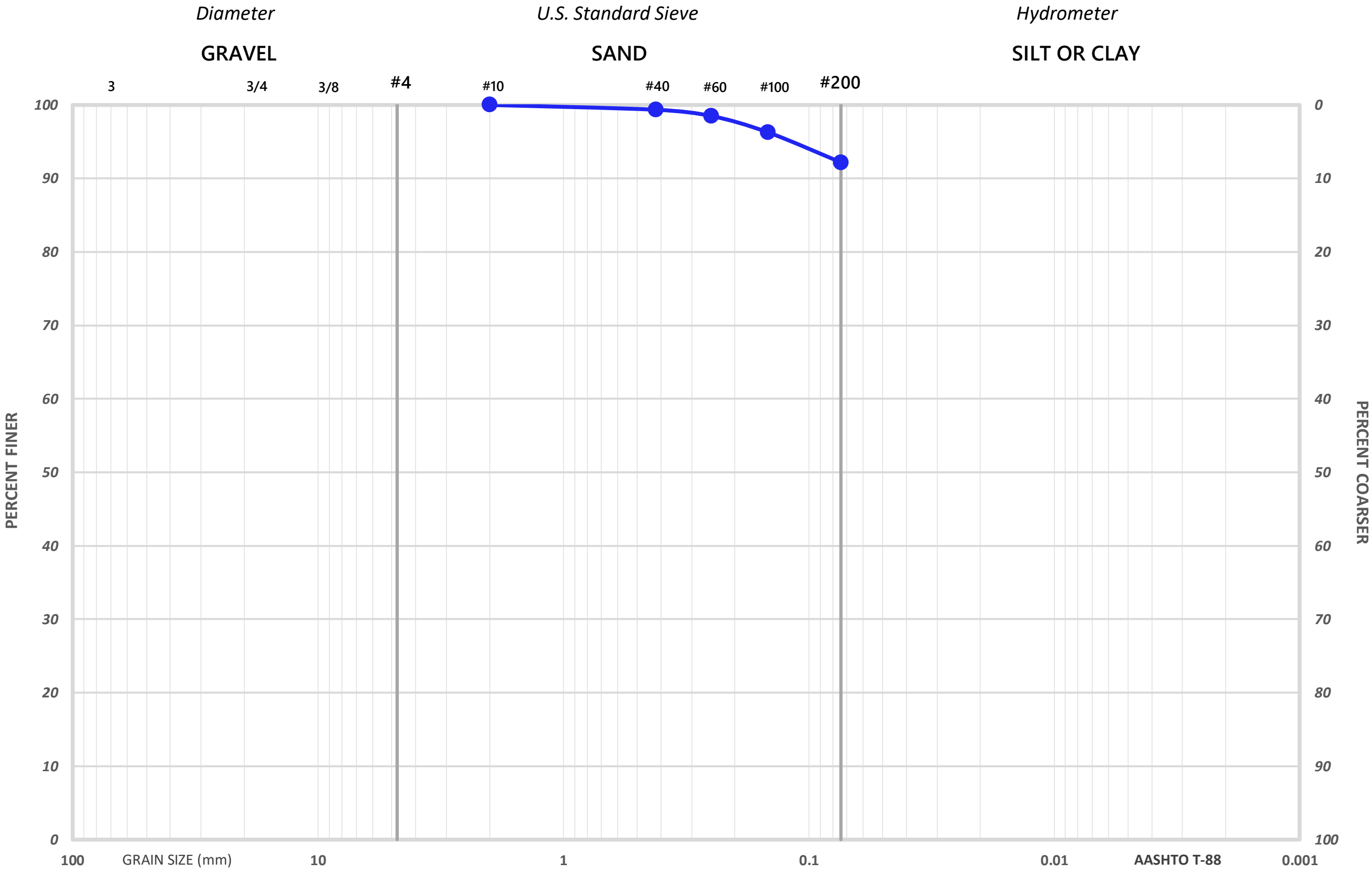
Spring Grove, PA 17362
Phone: (410) 259-5101



## GRAIN SIZE ANALYSIS

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Diameter* | 75.0 | 50.8 | 37.5 | 25.4 | 19.0 | 12.7 | 9.51 | 4.75 | 2.0 | 0.42 | 0.25 | 0.147 | 0.074 |
| *Sieve Size* | 3" | 2" | 1.5" | 1" | 3/4" | 1/2" | 3/8" | #4 | #10 | #40 | #60 | #100 | **# 200** |
| *% Passing* | - | - | - | - | - | - | - | - | 100.0 | 99.3 | 98.5 | 96.3 | **92.2** |

| % GRAVEL | % SAND | *Coarse Gravel* | *Fine Gravel* | *Coarse Sand* | *Medium Sand* | *Fine Sand* | CC | CU |
|---|---|---|---|---|---|---|---|---|
| - | **7.8** | - | - | - | 0.7 | 7.1 | - | - |

| | |
|---|---|
| Moisture Content | 39.4 |
| pH | - |
| Organic Content | - |
| Other | - |

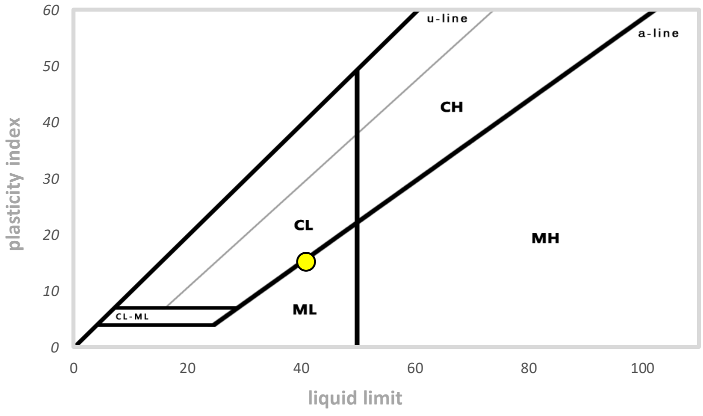
## ATTERBERG LIMITS

| | |
|---|---|
| Liquid Limit | 41 |
| Plastic Limit | 26 |
| Plasticity Index | 15 |

## CLASSIFICATION

| | |
|---|---|
| AASHTO | A-7-6 |
| USCS | ML |

AASHTO T-89/T-90



## SOIL DESCRIPTION

Dark green SILT

10/03/16

TESTED BY: JMK

REVIEWED BY: TL

# COLUMBIA SHARED BIKE PATH

| | | | | |
|---|---|---|---|---|
| Boring: | **B-4** | Project No.: | 17133314.98 | |
| Sample: | **Bulk** | Sample Date: | - | |
| Depth: | **1.0-5.0'** | Location: | - | |

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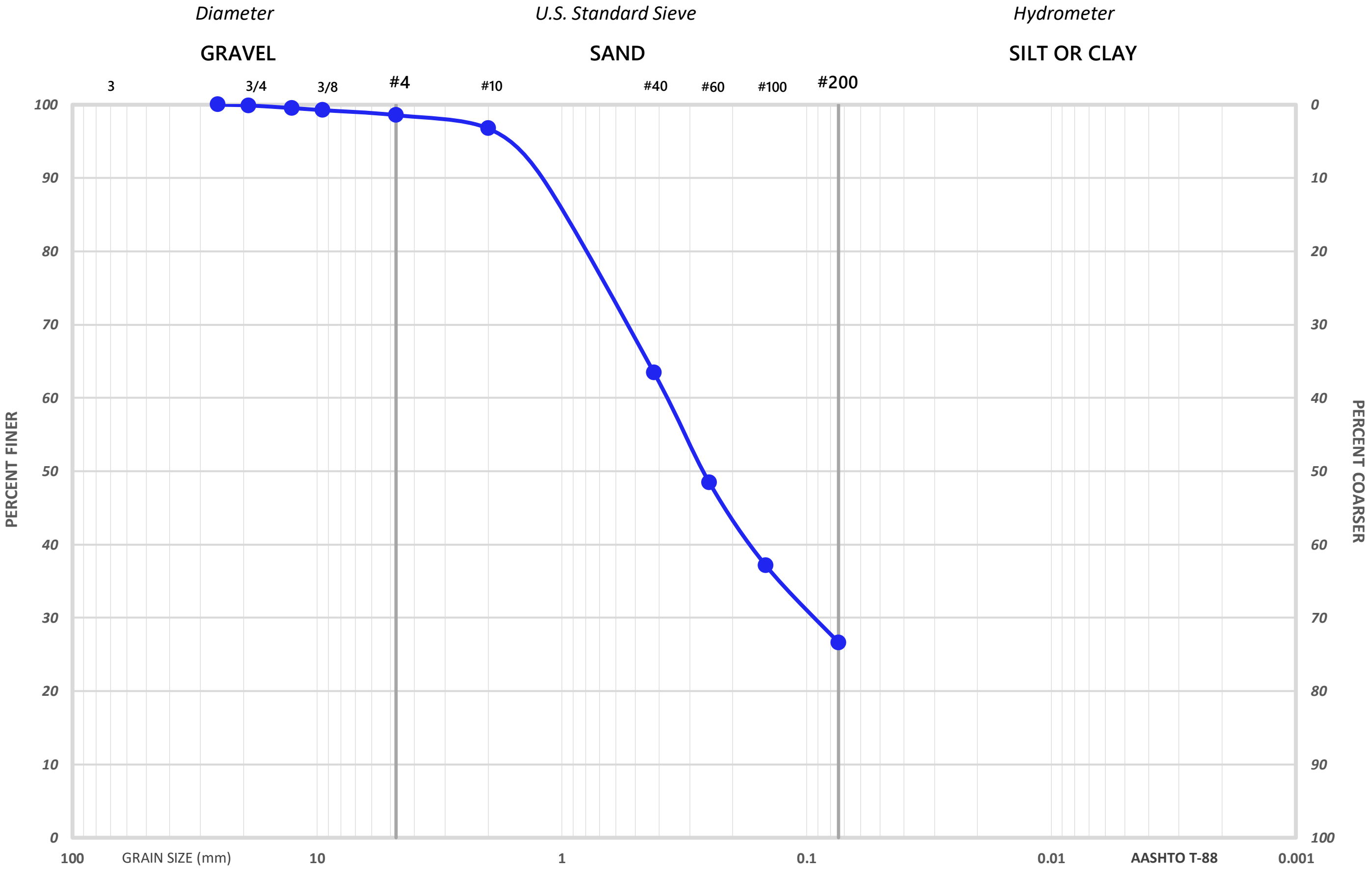


## GRAIN SIZE ANALYSIS

| *Diameter* | 75.0 | 50.8 | 37.5 | 25.4 | 19.0 | 12.7 | 9.51 | 4.75 | 2.0 | 0.42 | 0.25 | 0.147 | 0.074 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sieve Size* | 3" | 2" | 1.5" | 1" | 3/4" | 1/2" | 3/8" | #4 | #10 | #40 | #60 | #100 | **# 200** |
| *% Passing* | - | - | - | 100.0 | 99.9 | 99.5 | 99.3 | 98.6 | 96.8 | 63.4 | 48.5 | 37.2 | **26.6** |

| % GRAVEL | % SAND | *Coarse Gravel* | *Fine Gravel* | *Coarse Sand* | *Medium Sand* | *Fine Sand* | CC | CU |
|---|---|---|---|---|---|---|---|---|
| **1.4** | **72.0** | 0.1 | 1.3 | 1.8 | 33.4 | 36.8 | - | - |

| | | | |
|---|---|---|---|
| Moisture Content | - | Organic Content | - |
| pH | - | Other | - |

## ATTERBERG LIMITS

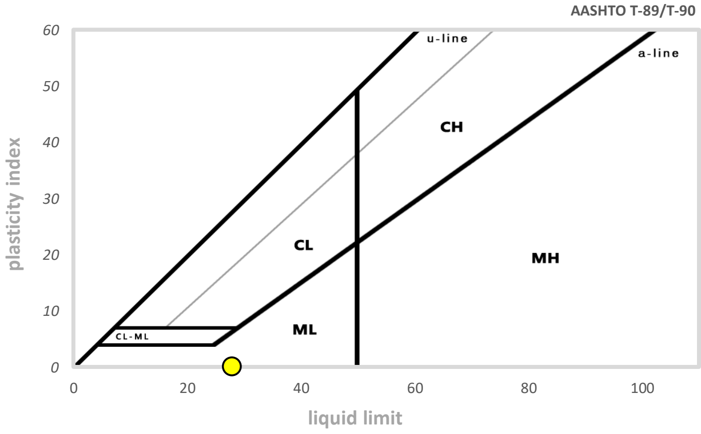
| | |
|---|---|
| Liquid Limit | 28 |
| Plastic Limit | NP |
| Plasticity Index | NP |

## CLASSIFICATION

| | |
|---|---|
| AASHTO | A-2-4 |
| USCS | SM |

## SOIL DESCRIPTION

Brown silty SAND



10/03/16 TESTED BY: JMK REVIEWED BY: TL

**COLUMBIA SHARED BIKE PATH**

| | | | |
|---|---|---|---|
| Boring: | **B-2** | Project No.: | 17133314.98 |
| Sample: | **Bulk** | Sample Date: | - |
| Depth: | **1.0-5.0'** | Location: | - |

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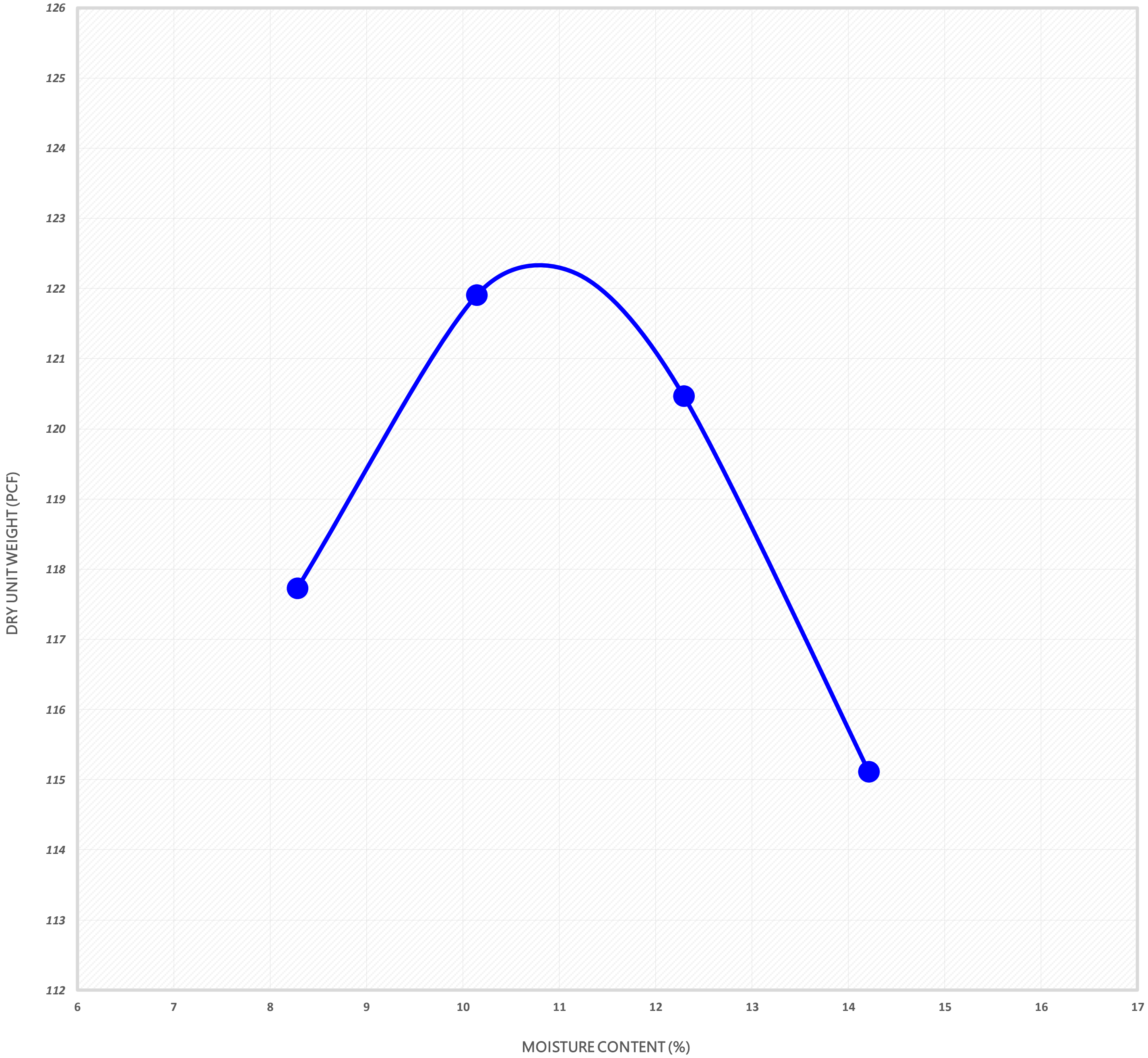
Phone: (410) 259-5101

## STANDARD PROCTOR TEST RESULTS

TEST METHOD: AASHTO T-99 (C)

| MAXIMUM DRY UNIT WEIGHT | OPTIMUM MOISTURE CONTENT |
|---|---|
| 122.2 | 11.2 |
| PCF | % |



| MC | LL | PL | PI | USCS | AASHTO | FINES | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| - | 31 | 23 | 8 | SM | A-2-4 | 32.2 | Dark green silty SAND with gravel and rock |

10/03/16 TESTED BY: JMK REVIEWED BY: TL

**COLUMBIA SHARED BIKE PATH**

Boring: **B-4**
Sample: **Bulk**
Depth: **1.0-5.0'**

Project No.: 17133314.98
Sample Date: -
Location: -

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Phone: (410) 259-5101

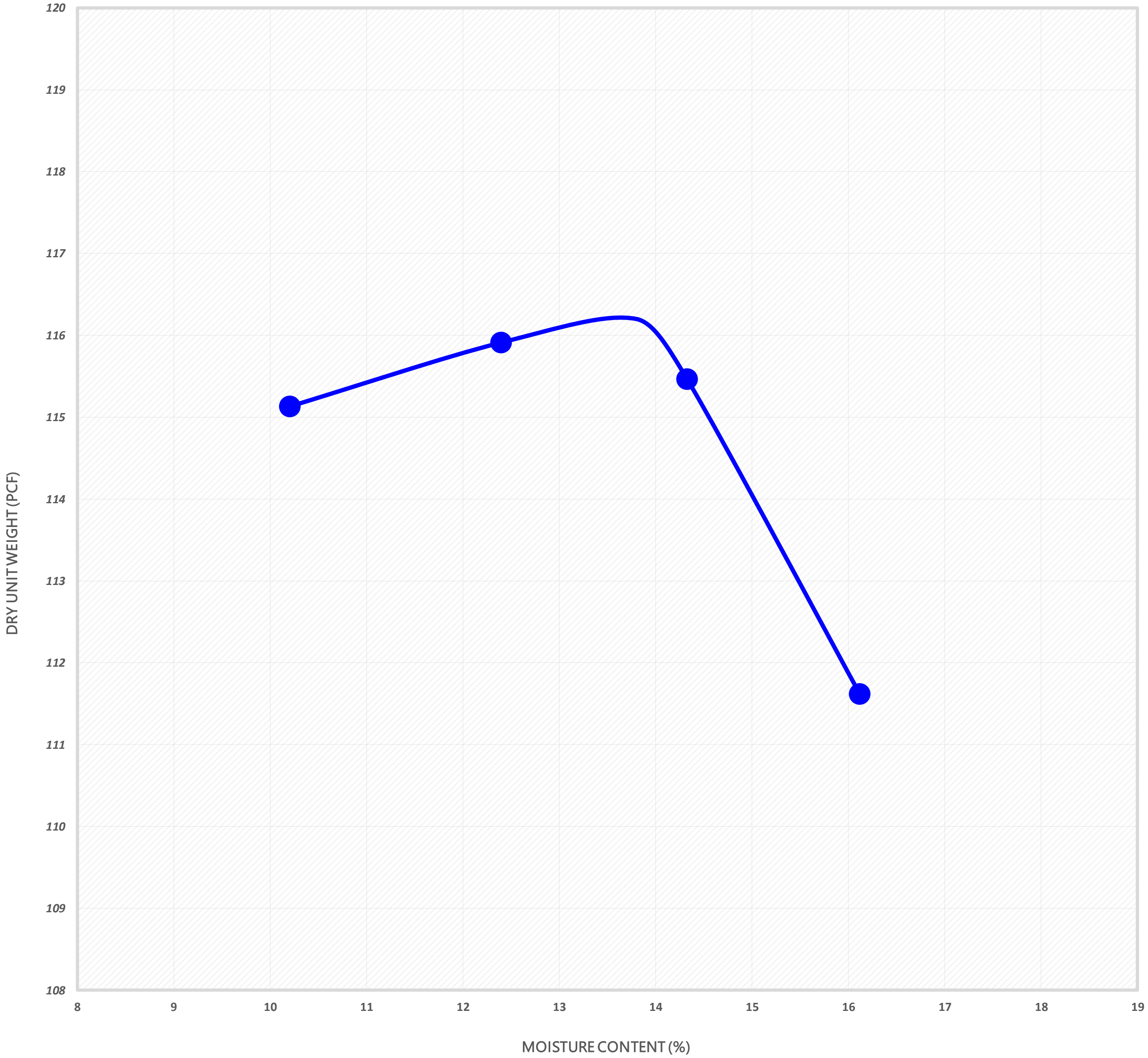
---

## STANDARD PROCTOR TEST RESULTS

TEST METHOD: AASHTO T-99 (C)

MAXIMUM DRY UNIT WEIGHT
116.2
PCF

OPTIMUM MOISTURE CONTENT
13.8
%



| MC | LL | PL | PI | USCS | AASHTO | FINES | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| - | 28 | NP | NP | SM | A-2-4 | 26.6 | Brown silty SAND |

10/03/16 TESTED BY: JMK REVIEWED BY: TL

**COLUMBIA SHARED BIKE PATH**

Boring: **B-2**
Sample: **Bulk**
Depth: **1.0-5.0'**

Project No.: 17133314.98
Sample Date: -
Location: -

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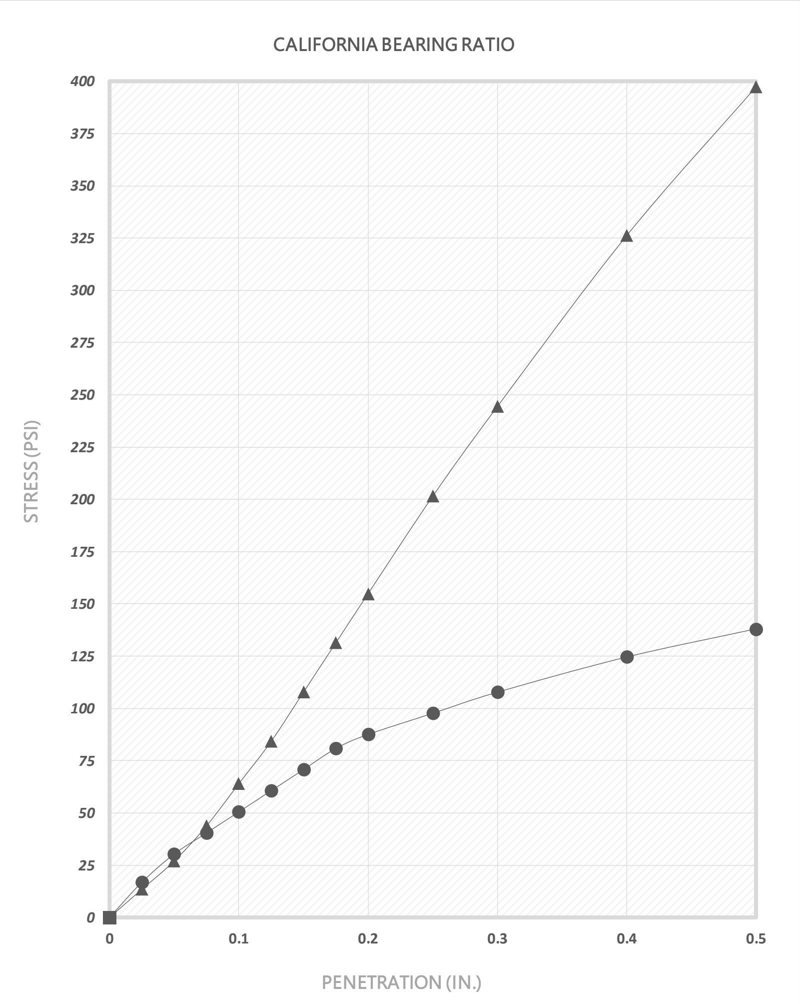
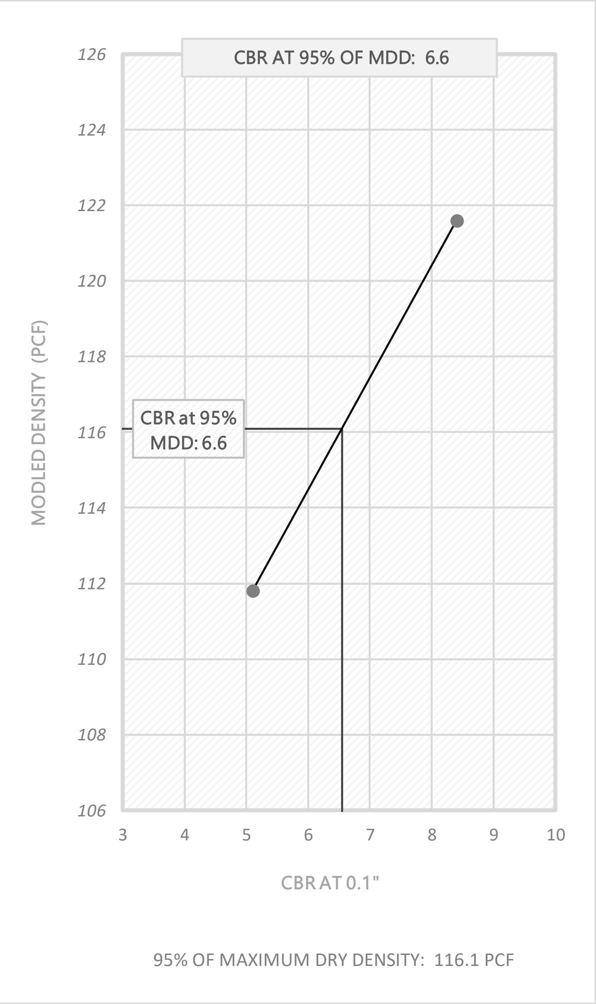
Spring Grove, PA 17362
Phone: (410) 259-5101

## CALIFORNIA BEARING RATIO TEST RESULTS

| | AS MOLDED | | | AFTER SOAK | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Compaction | Density | Moisture | Compaction | Density | Moisture | CBR at 0.1" | CBR at 0.2" | Blows | Swell |
| ● | 91.5 | 111.8 | 11.0 | 91.0 | 111.2 | 15.2 | 5.1 | 5.8 | 15 | 0.66 |
| ▲ | 99.5 | 121.6 | 11.4 | 99.4 | 121.4 | 12.0 | 8.4* | 11.9* | 56 | 0.55 |
| ■ | - | - | - | - | - | - | - | - | - | - |
| | % | PCF | % | % | PCF | % | * DENOTES CORRECTED VALUE | | # | % |

| MAXIMUM DRY DENSITY | OPTIMUM MOISTURE CONTENT | COMPACTION METHOD | CBR METHOD | SURCHARGE |
|---|---|---|---|---|
| 122.2 PCF | 11.2 % | AASHTO T-99 (C) | AASHTO T-193 | 75 PSF |





95% OF MAXIMUM DRY DENSITY: 116.1 PCF

| MC | LL | PL | PI | USCS | AASHTO | FINES | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| - | 31 | 23 | 8 | SM | A-2-4 | 32.2 | Dark green silty SAND with gravel and rock |

10/03/16 TESTED BY: JMK REVIEWED BY: TL

**COLUMBIA SHARED BIKE PATH**

| | | | |
|---|---|---|---|
| Boring: | **B-2** | Project No.: | 17133314.98 |
| Sample: | **Bulk** | Sample Date: | - |
| Depth: | **1.0-5.0'** | Location: | - |

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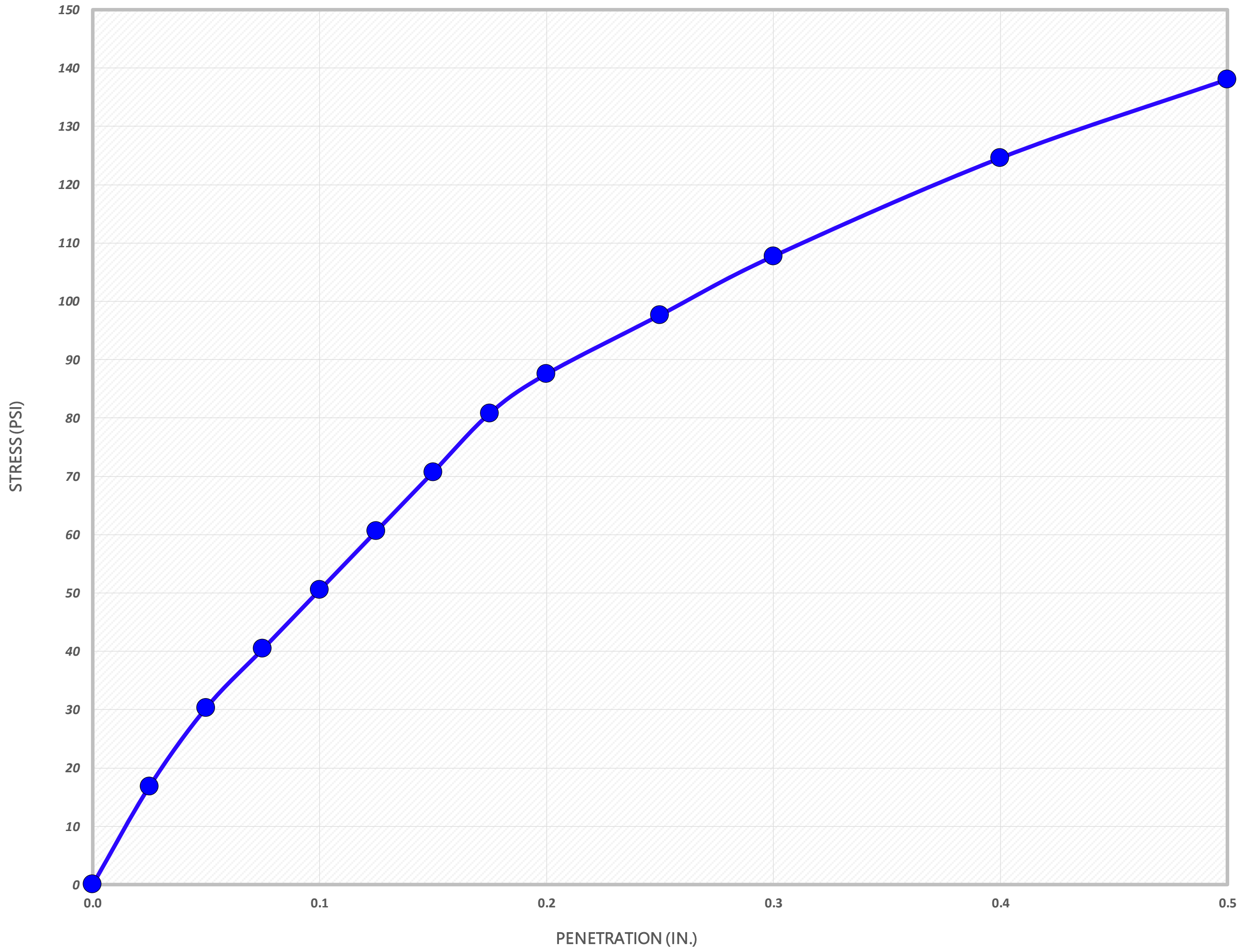
Spring Grove, PA 17362
Phone: (410) 259-5101

## CALIFORNIA BEARING RATIO TEST RESULTS

| CBR AT 0.1" | CBR AT 0.2" |
|---|---|
| 5.1 | 5.8 |

| | **Dry Unit Weight** | **Moisture Content** | **Compaction** | **Swell** | **Surcharge** |
|---|---|---|---|---|---|
| As Molded | 111.8 | 11.0 | 91.5 | - | 75 |
| After Soak | 111.2 | 15.2 | 91.0 | 0.66 | 75 |
| | **PCF** | **%** | **%** | **%** | **PSF** |

METHOD: AASHTO T-193, COMPACTION: AASHTO T-99 (C)



| MC | LL | PL | PI | USCS | AASHTO | FINES | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| - | 31 | 23 | 8 | SM | A-2-4 | 32.2 | Dark green silty SAND with gravel and rock |

10/03/16 TESTED BY: JMK REVIEWED BY: TL

**COLUMBIA SHARED BIKE PATH**

Boring: **B-2**
Sample: **Bulk**
Depth: **1.0-5.0'**

Project No.: 17133314.98
Sample Date: -
Location: -

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---

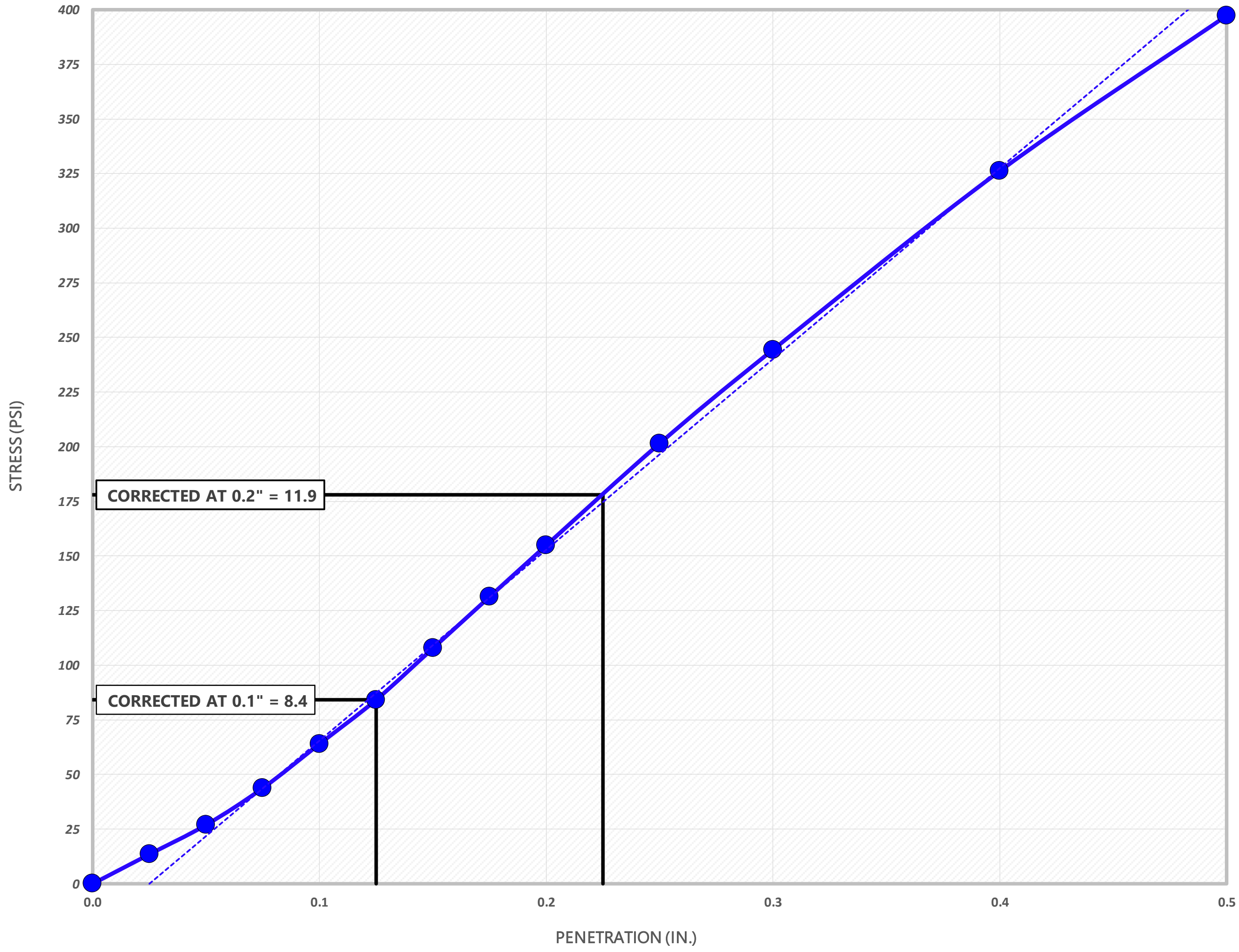
## CALIFORNIA BEARING RATIO TEST RESULTS

CORRECTED CBR AT 0.1"
8.4

CORRECTED CBR AT 0.2"
11.9

| | Dry Unit Weight | Moisture Content | Compaction | Swell | Surcharge |
|---|---|---|---|---|---|
| As Molded | 121.6 | 11.4 | 99.5 | - | 75 |
| After Soak | 121.4 | 12.0 | 99.4 | 0.55 | 75 |
| | PCF | % | % | % | PSF |

METHOD: AASHTO T-193, COMPACTION: AASHTO T-99 (C)



| MC | LL | PL | PI | USCS | AASHTO | FINES | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| - | 31 | 23 | 8 | SM | A-2-4 | 32.2 | Dark green silty SAND with gravel and rock |

10/03/16 TESTED BY: JMK REVIEWED BY: TL

**COLUMBIA SHARED BIKE PATH**

Boring: **B-4**
Sample: **Bulk**
Depth: **1.0-5.0'**

Project No.: 17133314.98
Sample Date: -
Location: -

**JAY KAY TESTING, INC.**
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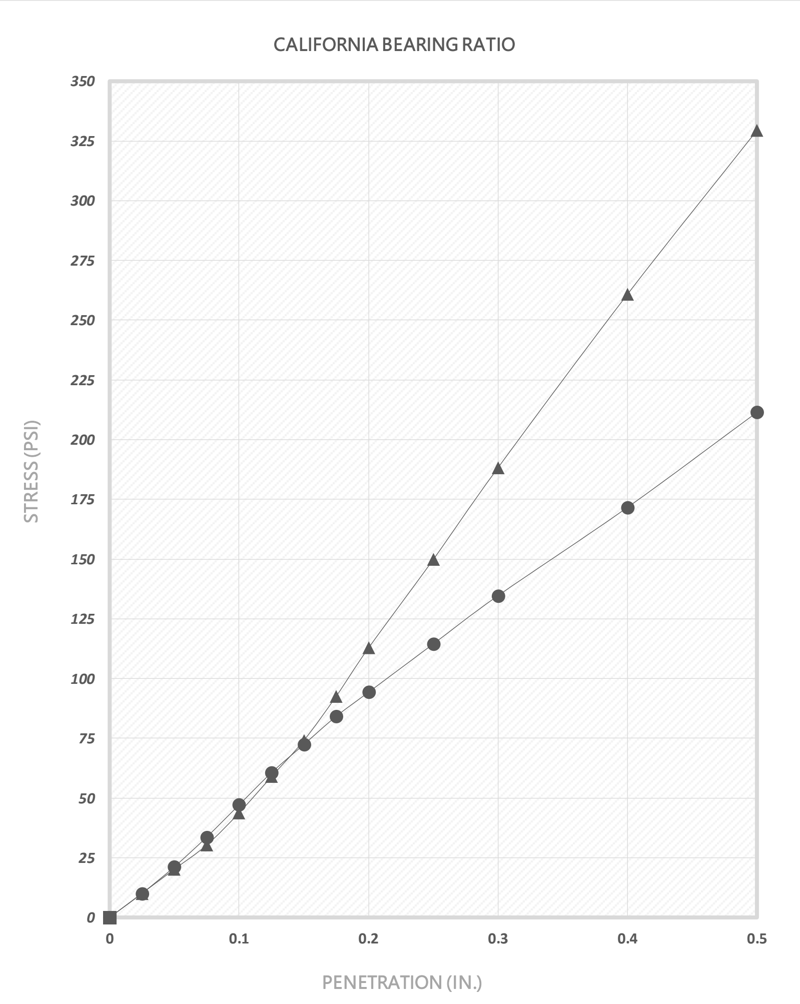
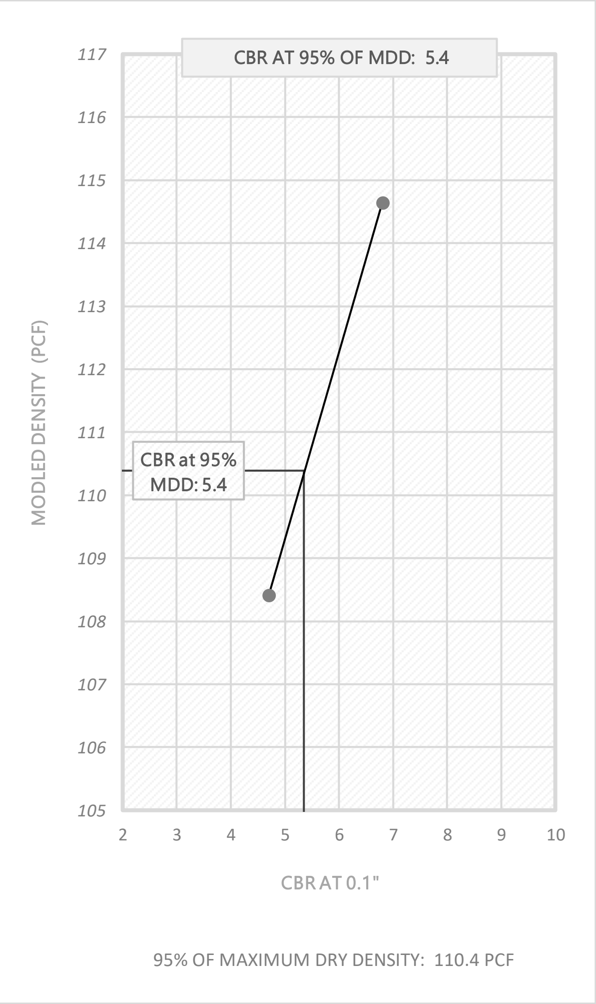
Spring Grove, PA 17362
Phone: (410) 259-5101

# CALIFORNIA BEARING RATIO TEST RESULTS

| | AS MOLDED | | | AFTER SOAK | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Compaction | Density | Moisture | Compaction | Density | Moisture | CBR at 0.1" | CBR at 0.2" | Blows | Swell |
| ● | 93.3 | 108.4 | 13.7 | 93.6 | 108.8 | 16.2 | 4.7 | 6.3 | 15 | 0.17 |
| ▲ | 98.7 | 114.6 | 13.8 | 99.3 | 115.4 | 14.1 | 6.8* | 9.5* | 56 | -0.02 |
| ■ | - | - | - | - | - | - | - | - | - | - |
| | % | PCF | % | % | PCF | % | * DENOTES CORRECTED VALUE | | # | % |

| MAXIMUM DRY DENSITY | OPTIMUM MOISTURE CONTENT | COMPACTION METHOD | CBR METHOD | SURCHARGE |
|---|---|---|---|---|
| 116.2 PCF | 13.8 % | AASHTO T-99 (C) | AASHTO T-193 | 75 PSF |





95% OF MAXIMUM DRY DENSITY: 110.4 PCF

| MC | LL | PL | PI | USCS | AASHTO | FINES | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| - | 28 | NP | NP | SM | A-2-4 | 26.6 | Brown silty SAND |

10/03/16 TESTED BY: JMK REVIEWED BY: TL

**COLUMBIA SHARED BIKE PATH**

| | | | |
|---|---|---|---|
| Boring: | **B-4** | Project No.: | 17133314.98 |
| Sample: | **Bulk** | Sample Date: | - |
| Depth: | **1.0-5.0'** | Location: | - |

**JAY KAY TESTING, INC.**
5233 Lehman Road, Suite 110
Spring Grove, PA 17362
Phone: (410) 259-5101

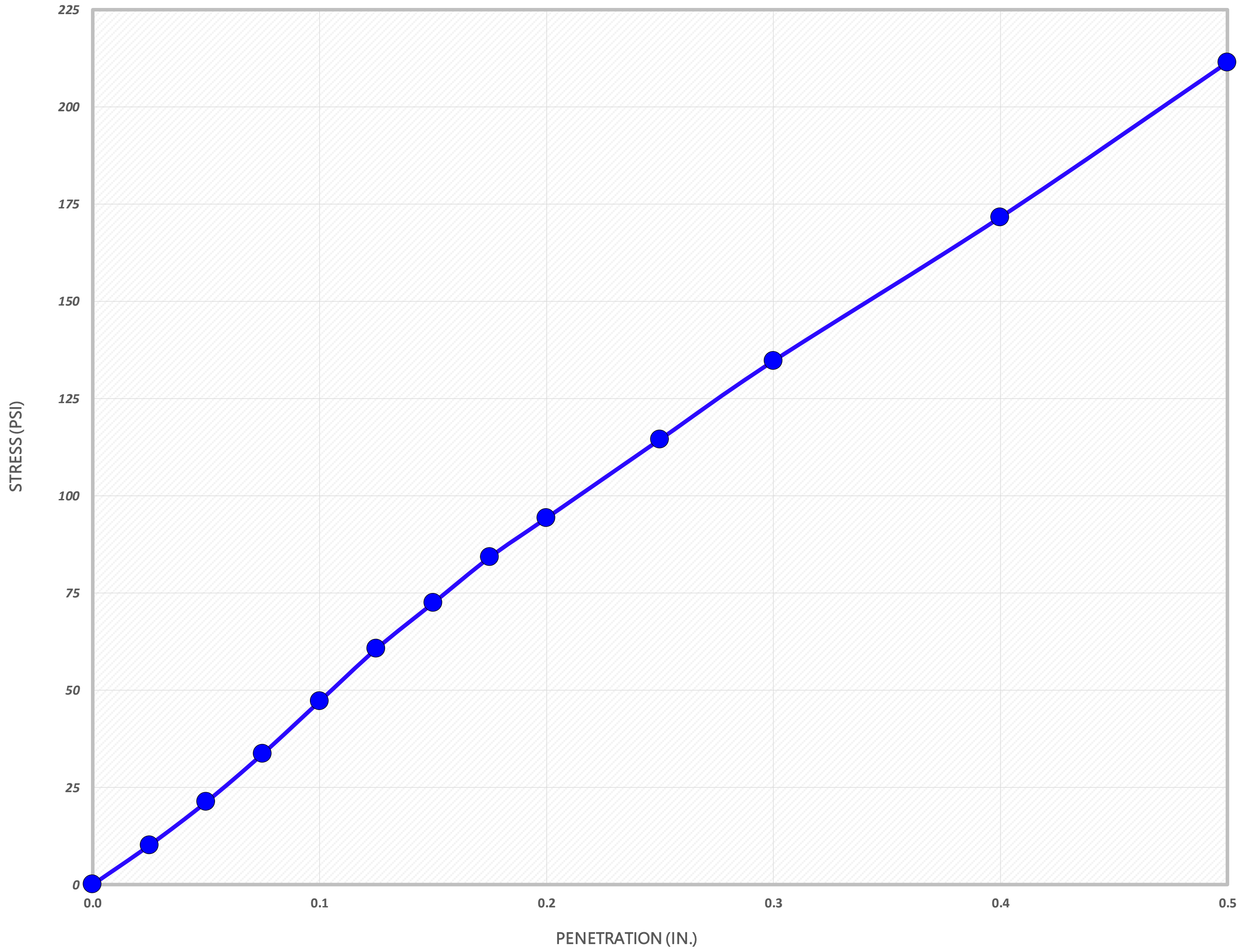
---

## CALIFORNIA BEARING RATIO TEST RESULTS

| CBR AT 0.1" | CBR AT 0.2" |
|---|---|
| 4.7 | 6.3 |

| | Dry Unit Weight | Moisture Content | Compaction | Swell | Surcharge |
|---|---|---|---|---|---|
| As Molded | 108.4 | 13.7 | 93.3 | - | 75 |
| After Soak | 108.8 | 16.2 | 93.6 | 0.17 | 75 |
| | **PCF** | **%** | **%** | **%** | **PSF** |

METHOD: AASHTO T-193, COMPACTION: AASHTO T-99 (C)



| MC | LL | PL | PI | USCS | AASHTO | FINES | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| - | 28 | NP | NP | SM | A-2-4 | 26.6 | Brown silty SAND |

10/03/16 TESTED BY: JMK REVIEWED BY: TL

**COLUMBIA SHARED BIKE PATH**

| | | | | |
|---|---|---|---|---|
| Boring: | **B-4** | Project No.: | 17133314.98 | |
| Sample: | **Bulk** | Sample Date: | - | |
| Depth: | **1.0-5.0'** | Location: | - | |

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Spring Grove, PA 17362
Phone: (410) 259-5101

---

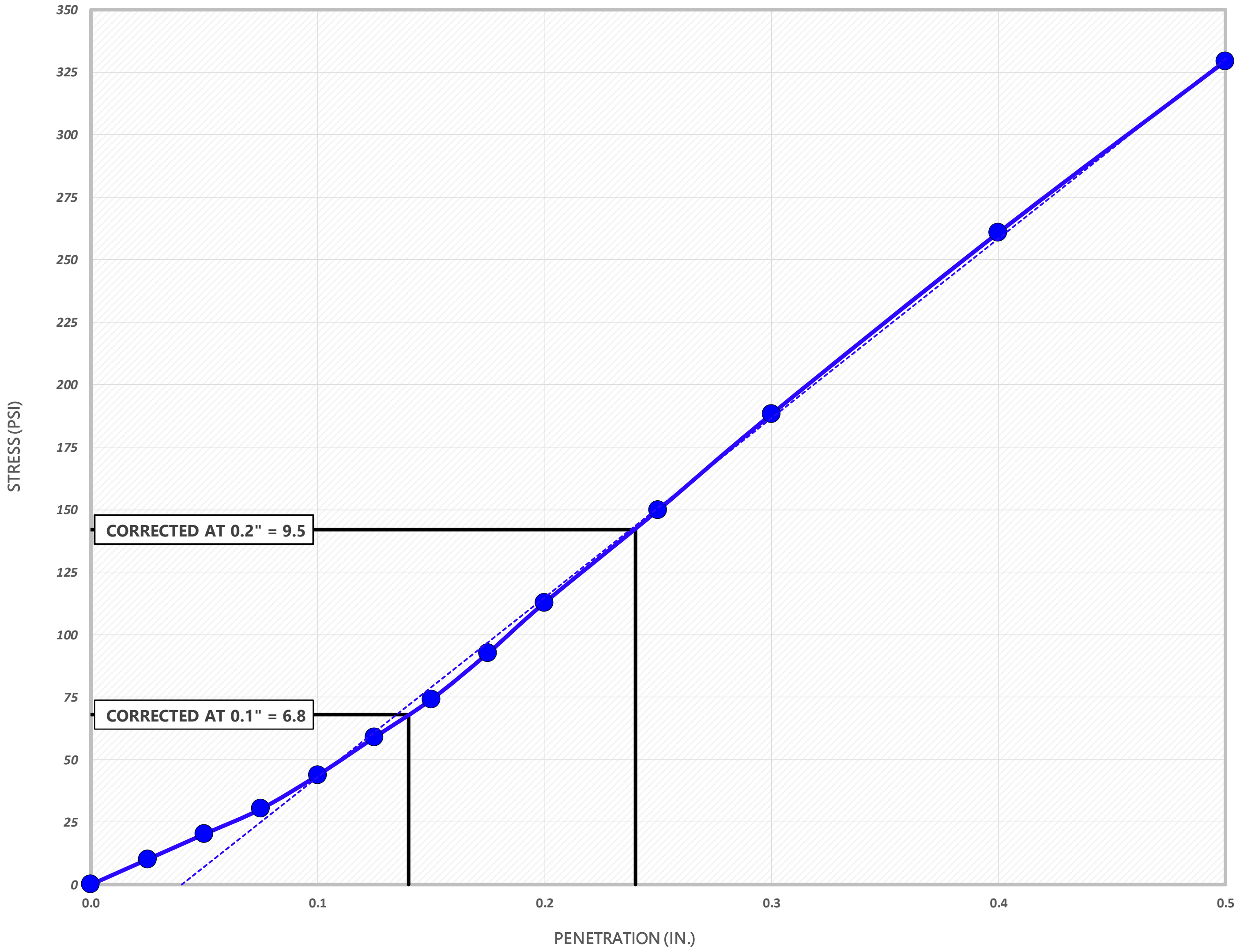
## CALIFORNIA BEARING RATIO TEST RESULTS

CORRECTED CBR AT 0.1"
6.8

CORRECTED CBR AT 0.2"
9.5

| | Dry Unit Weight | Moisture Content | Compaction | Swell | Surcharge |
|---|---|---|---|---|---|
| As Molded | 114.6 | 13.8 | 98.7 | - | 75 |
| After Soak | 115.4 | 14.1 | 99.3 | -0.02 | 75 |
| | PCF | % | % | % | PSF |

METHOD: AASHTO T-193, COMPACTION: AASHTO T-99 (C)



| MC | LL | PL | PI | USCS | AASHTO | FINES | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| - | 28 | NP | NP | SM | A-2-4 | 26.6 | Brown silty SAND |

10/03/16 TESTED BY: JMK REVIEWED BY: TL

# LABORATORY TESTING PROCEDURES

**Natural Moisture Content -** The natural moisture content (NMC) of selected samples was determined in accordance with ASTM D 2216. The moisture content of the soil is the ratio, expressed as a percentage, of the weight of water in a given mass of soil to the weight of the soil particles. The laboratory test results are summarized in Table 3-2 of the report.

**Percent Fines -** The percentage of fine-grained particles present in selected samples was determined by passing the samples through a No. 200 mesh sieve. The percent by weight passing the sieve is the percentage of fines or portion of the sample in the silt and clay size range. This test was conducted in accordance with ASTM D 1140. The results are shown on the attached Grain Size Distribution sheets.

**Grain Size Distribution -** Grain size tests were performed on representative soil samples washed over a U. S. standard No. 200 sieve to remove the fines. The samples were then dried and sieved through a standard set of nested sieves. This test was performed in general accordance with ASTM D 422. The results are presented as percent finer by weight versus particle size curves on the attached Grain Size Distribution sheets.

**Atterberg Limits -** Representative samples of the site soils were selected for Atterberg Limits testing to determine their soil plasticity characteristics. The soil's Plasticity Index (PI) is representative of this characteristic and is bracketed by the Liquid Limit (LL) and the Plastic Limit (PL). These characteristics are determined in accordance with ASTM D 4318. The LL is the moisture content at which the soil will flow as a heavy viscous fluid. The PL is the moisture content at which the soil begins to lose its plasticity. The data obtained are presented on the attached Grain Size Distribution sheets and summarized in Table 3-2 of this report.

Certain soils swell and shrink with increases and decreases in soil moisture. The PI is related to this potential volume change ability. When such volume changes occur in soils confined beneath foundations, floor slabs and pavements, structural deformations can be produced. Past experience has shown that soils having a PI of less than 30 are only slightly susceptible to volume changes. Soils having a PI greater than 50 are generally very susceptible to this volume changes. Soils with a PI between these limits have moderate volume change potential.

**Moisture-Density Relationship Test** - The moisture-density relationship of the selected soil sample was determined in general accordance with ASTM D 698 (Standard Proctor). The test method is generally performed as follows:

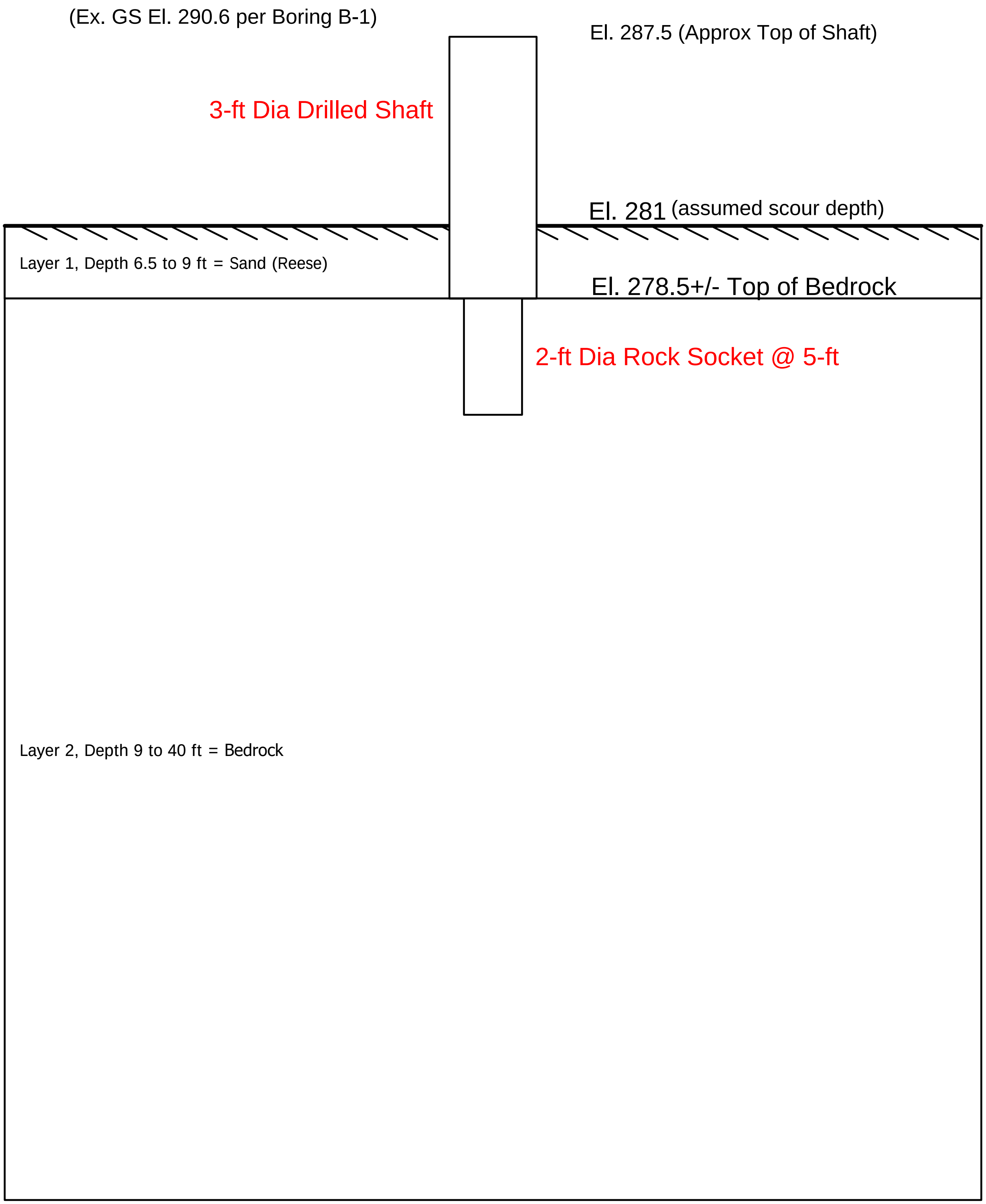
1. Mix water with soil to a selected water content.
2. Place the soil into a mold of given dimensions. The soil is placed in three equally thick layers, with each layer compacted by 25 blows of a 5.5-lb rammer dropped from of distance of 12 inches.
3. Determine the resulting dry unit weight of the soil sample.
4. Repeat the above procedure for a sufficient number of water contents to establish a relationship between dry unit weight and the water content for the soil.

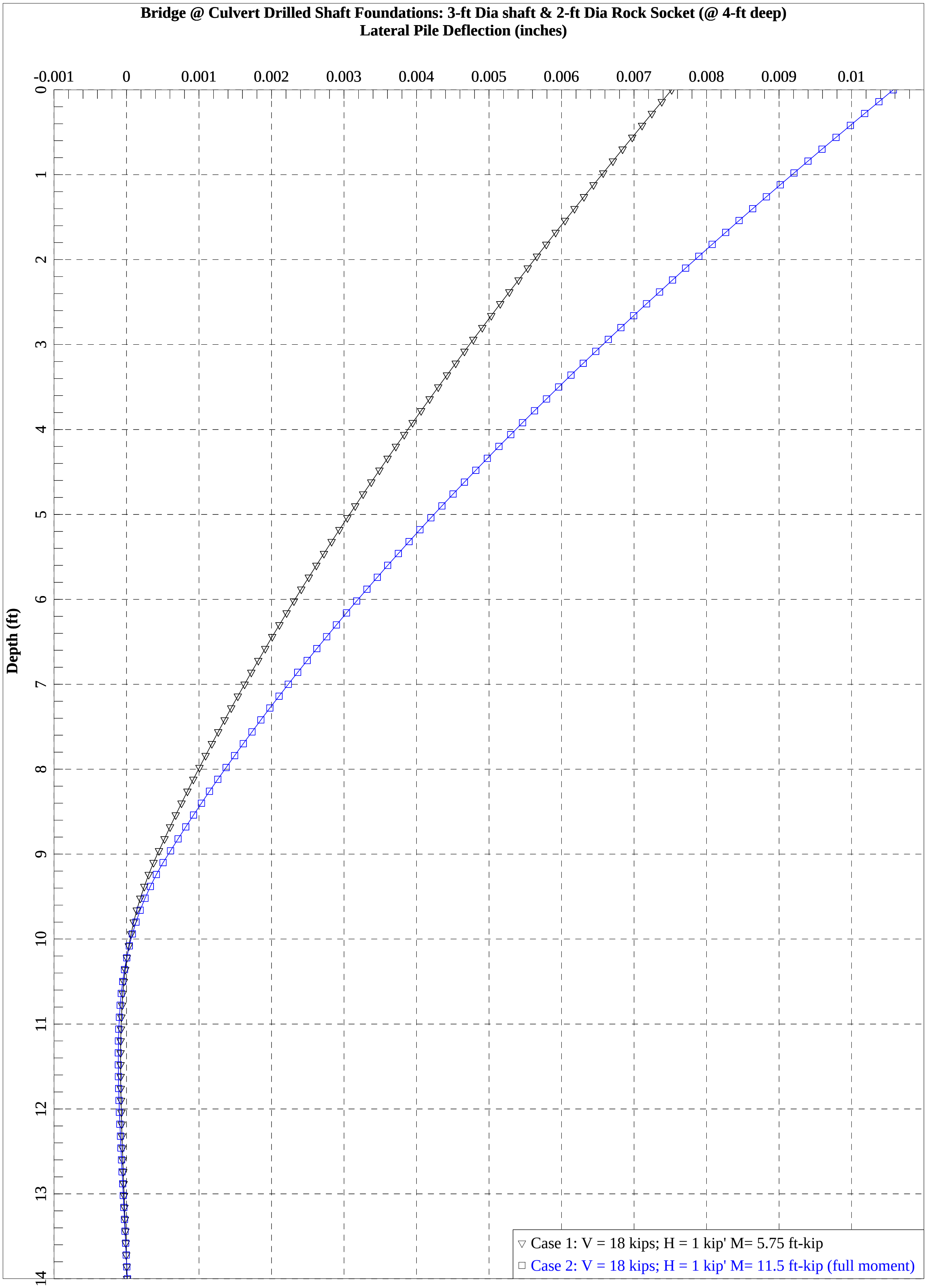
A graph of dry unit weight and water content, called “compaction curve”, is plotted. The values of optimum water content and standard maximum dry unit weight are determined from the compaction curve. The results are summarized in the Table 3-3 of this report.

# FOUNDATION ANALYSES

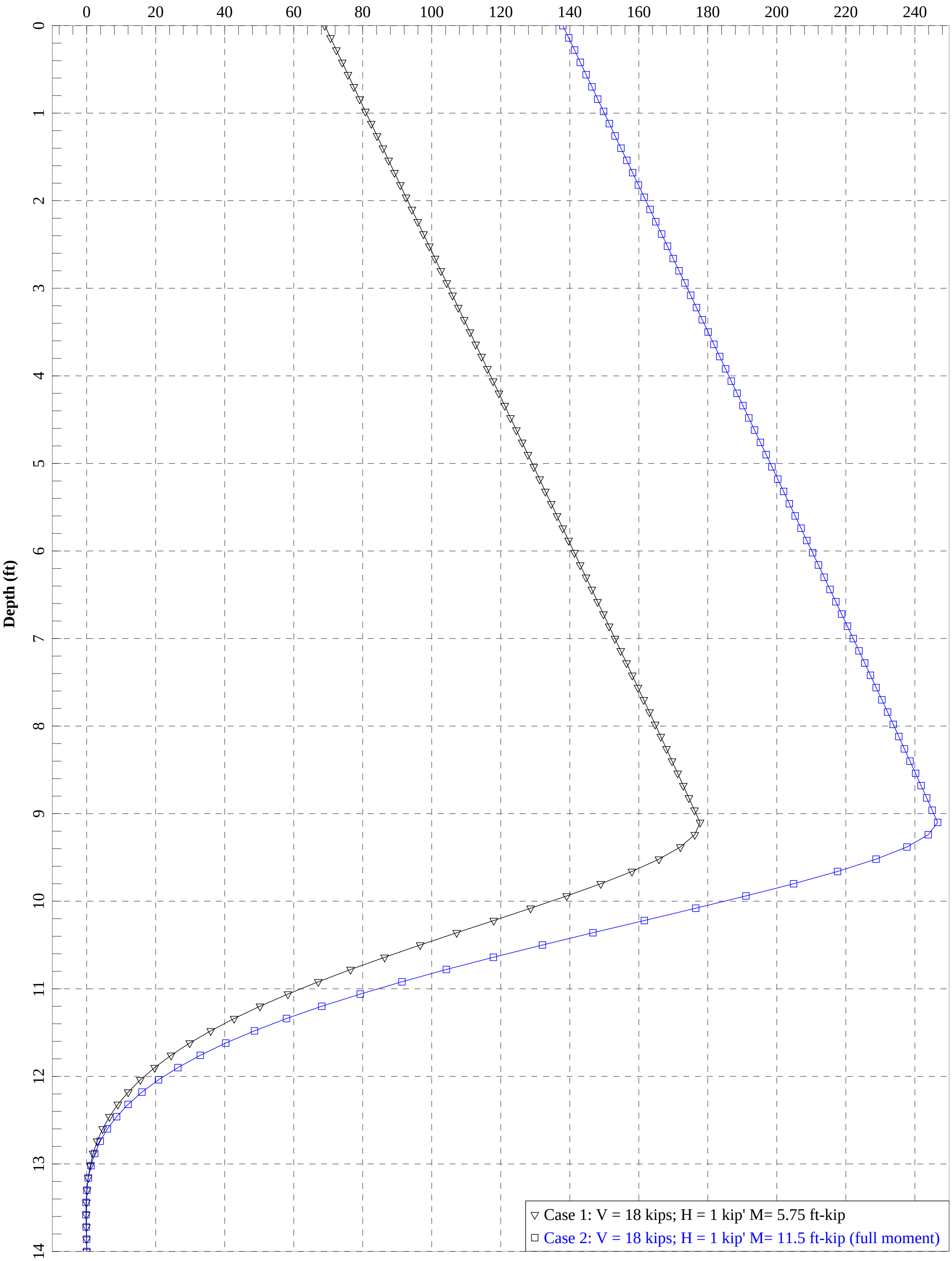
# Appendix D

## Bridge @ STA 41+80 Culvert - Drilled Shaft Foundations

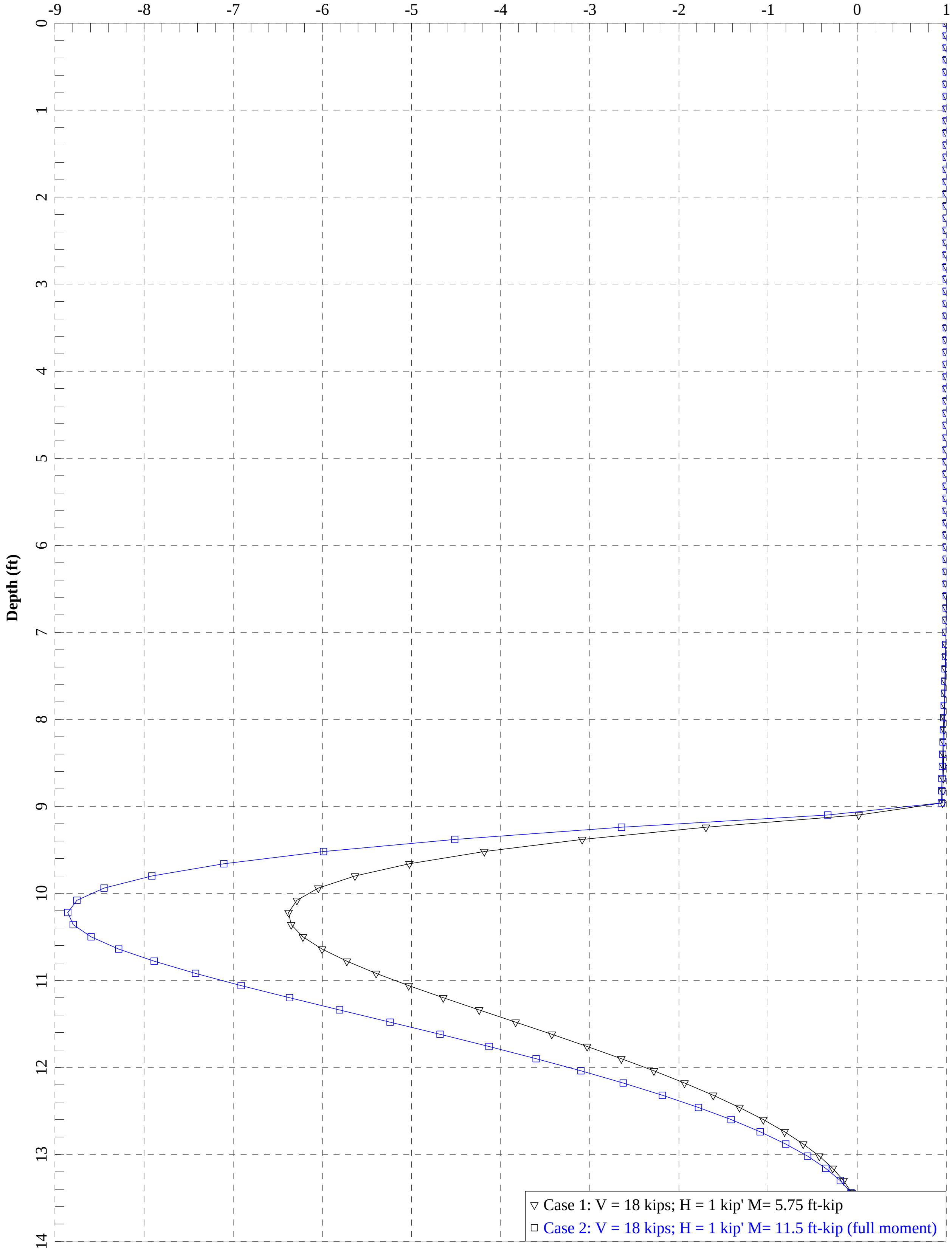



Bridge @ Culvert Drilled Shaft Foundations: 3-ft Dia shaft & 2-ft Dia Rock Socket (@ 4-ft deep)
Lateral Pile Deflection (inches)
-0.001
0
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009
0.01
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
▽ Case 1: V = 18 kips; H = 1 kip' M= 5.75 ft-kip
□ Case 2: V = 18 kips; H = 1 kip' M= 11.5 ft-kip (full moment)

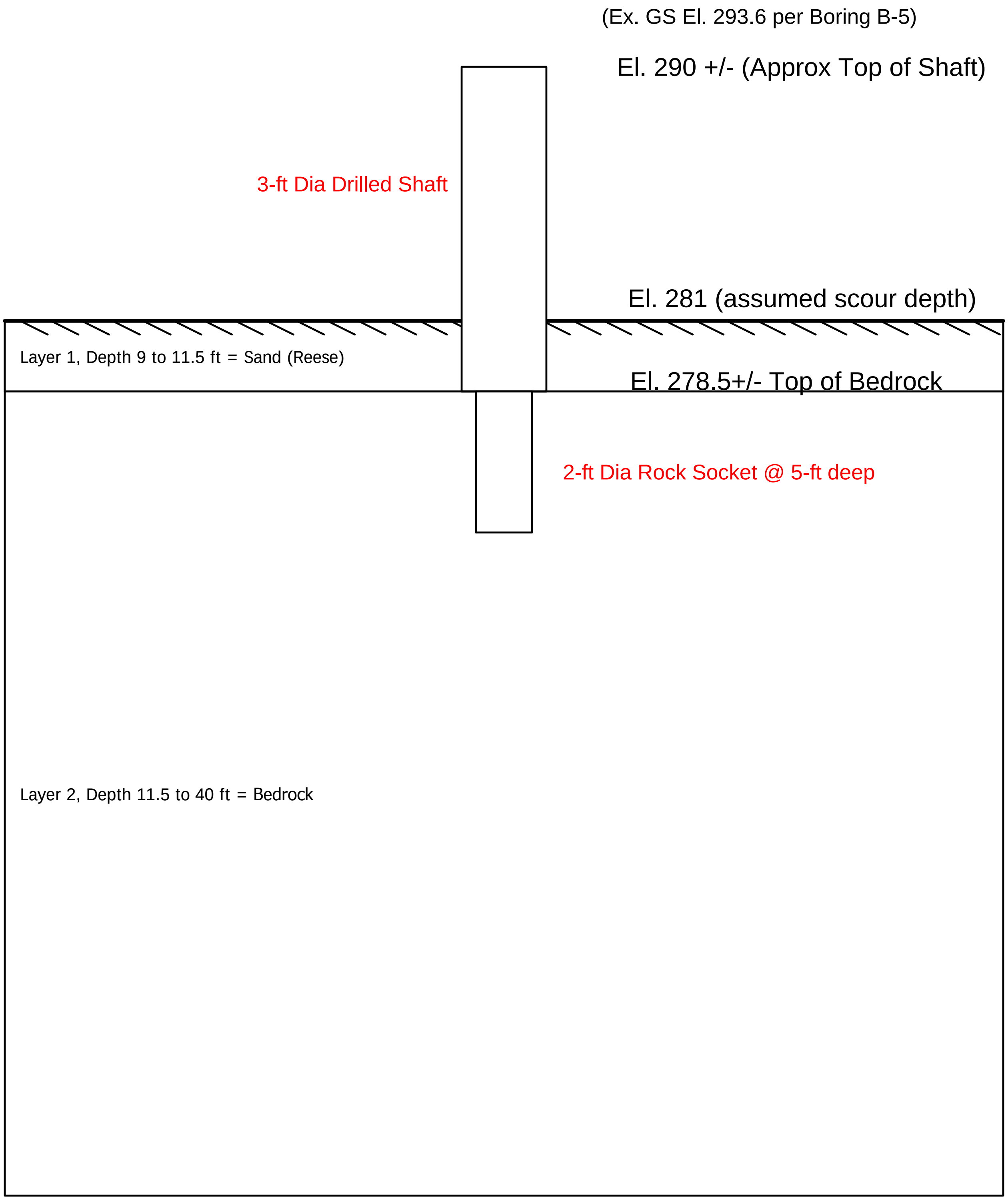
## Bridge @ Culvert Drilled Shaft Foundations: 3-ft Dia shaft & 2-ft Dia Rock Socket (@ 4-ft deep)
## Bending Moment (in-kips)

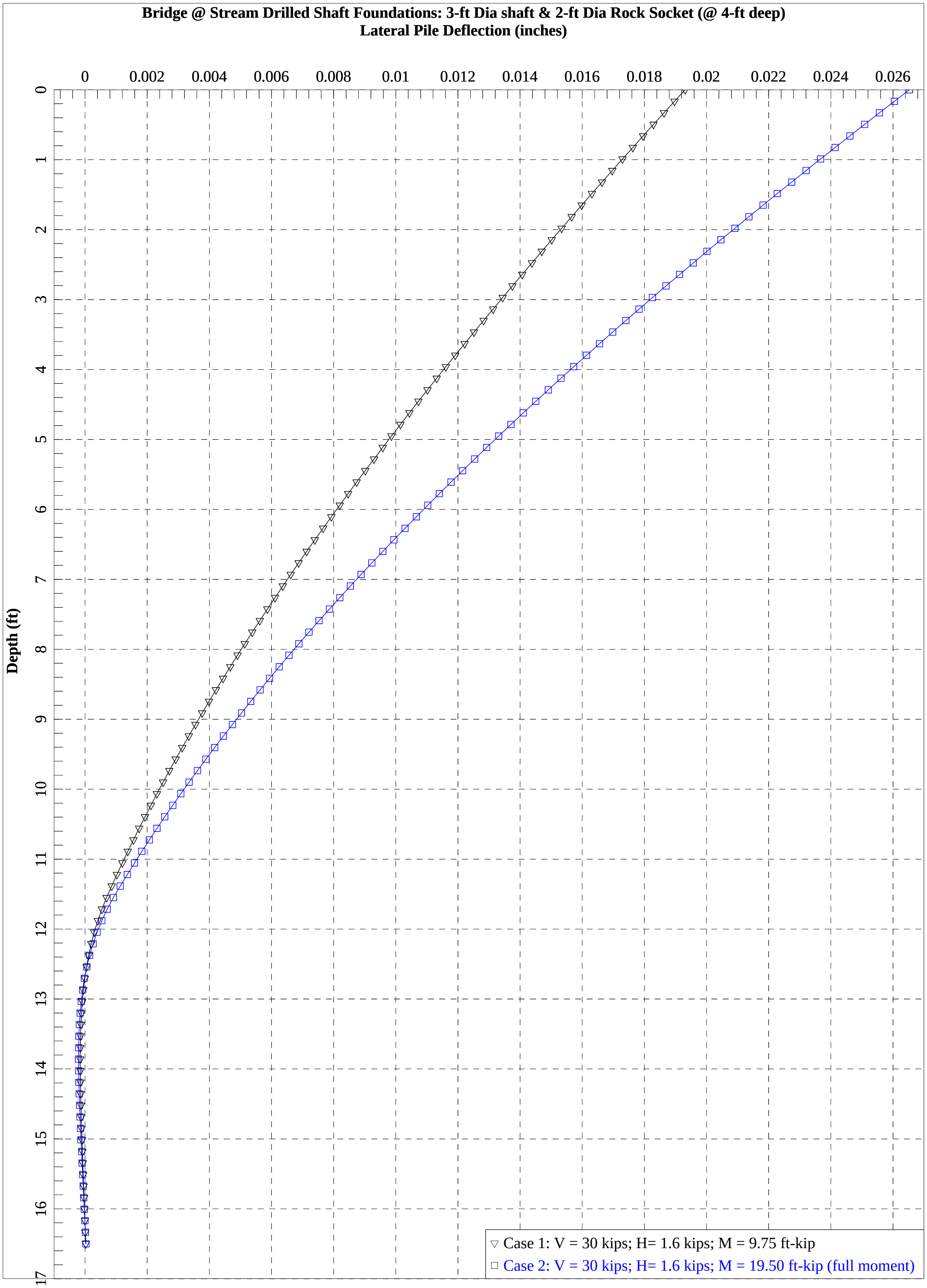


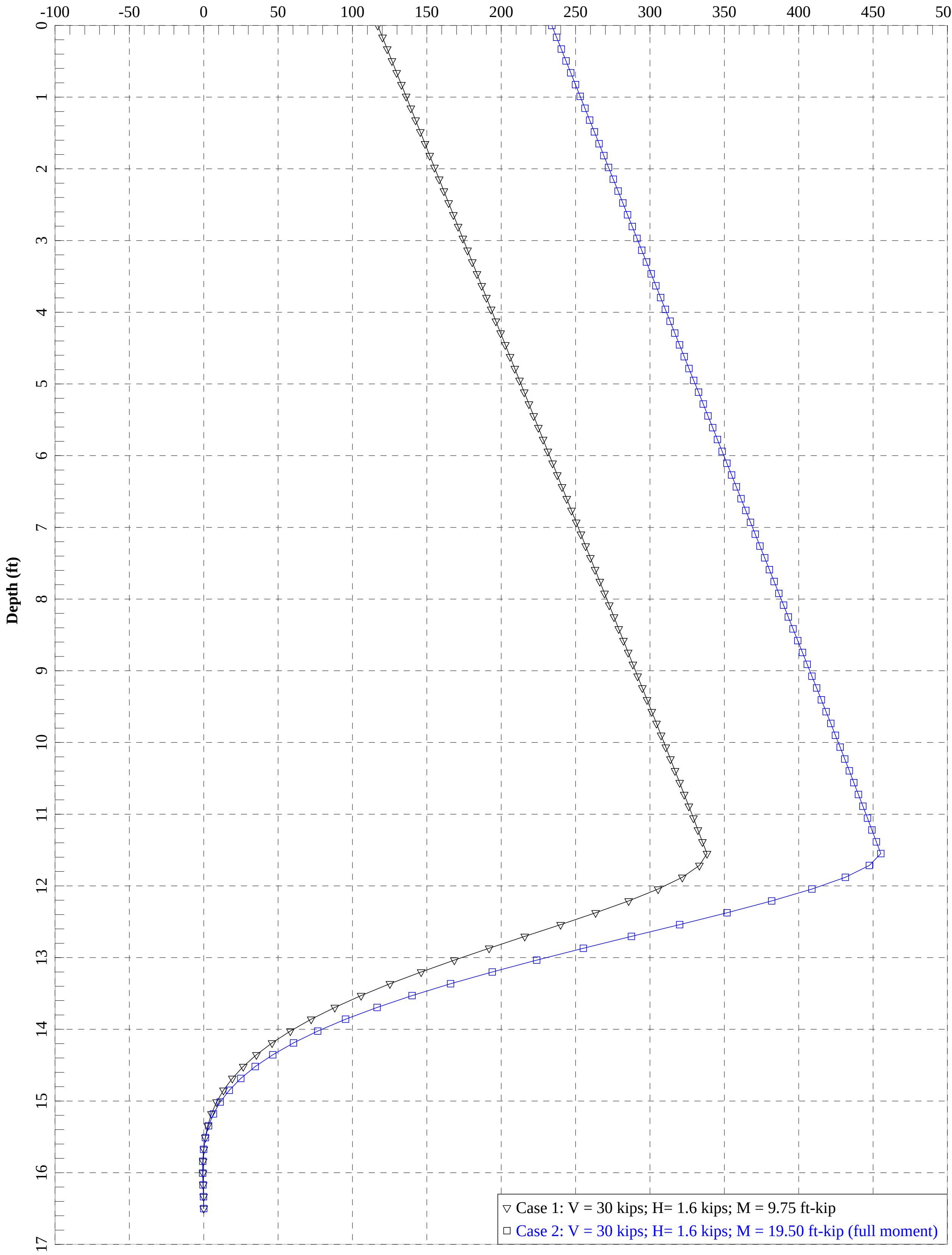
## Bridge @ Culvert Drilled Shaft Foundations: 3-ft Dia shaft & 2-ft Dia Rock Socket (@ 4-ft deep)
## Shear Force (kips)



# Bridge @ STA 67+00 Stream - Drilled Shaft Foundations

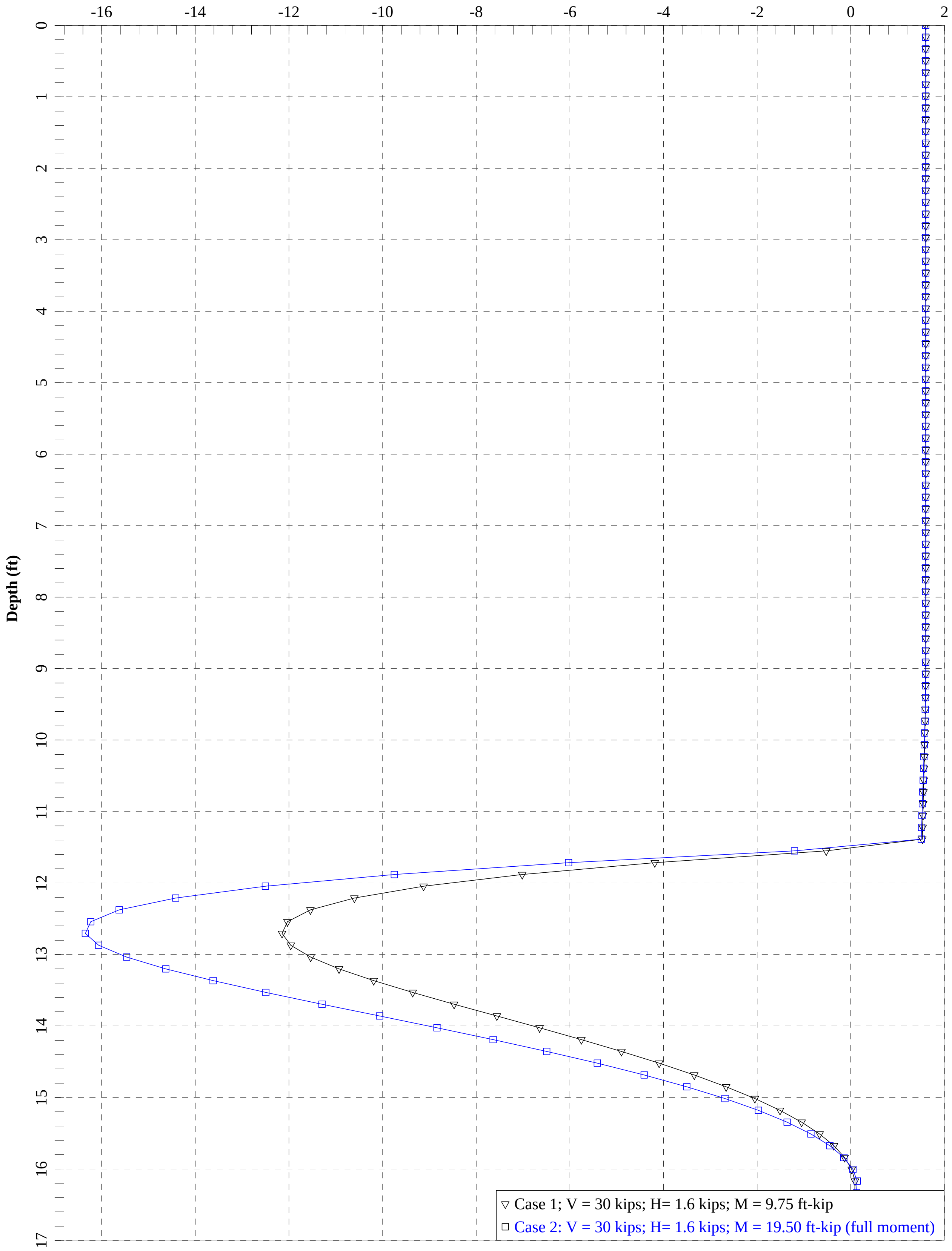



Bridge @ Stream Drilled Shaft Foundations: 3-ft Dia shaft & 2-ft Dia Rock Socket (@ 4-ft deep)
Lateral Pile Deflection (inches)
0
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
0.018
0.02
0.022
0.024
0.026
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
▽ Case 1: V = 30 kips; H= 1.6 kips; M = 9.75 ft-kip
□ Case 2: V = 30 kips; H= 1.6 kips; M = 19.50 ft-kip (full moment)

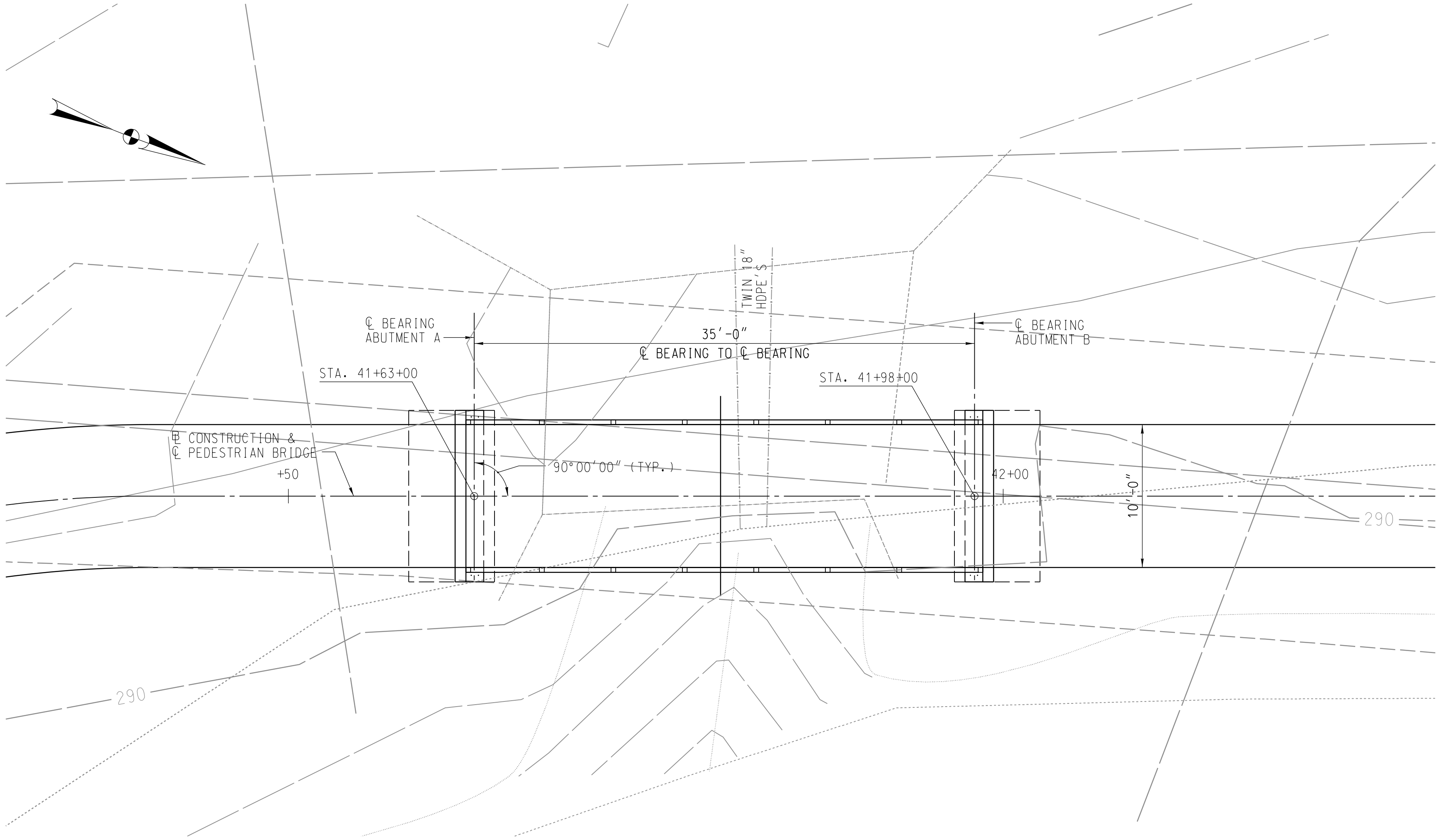


**Bridge @ Stream Drilled Shaft Foundations: 3-ft Dia shaft & 2-ft Dia Rock Socket (@ 4-ft deep)**
**Bending Moment (in-kips)**

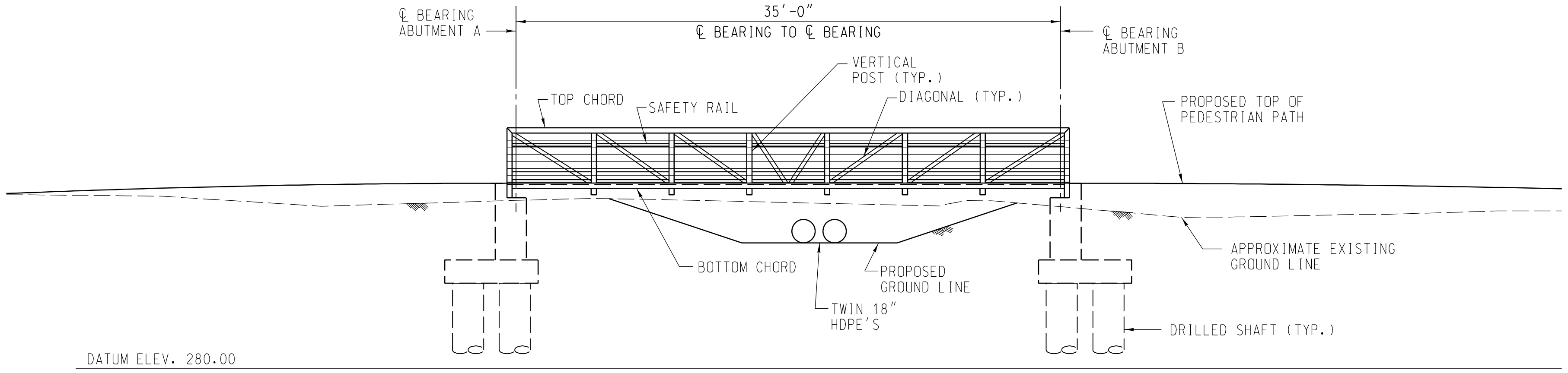
**Bridge @ Stream Drilled Shaft Foundations: 3-ft Dia shaft & 2-ft Dia Rock Socket (@ 4-ft deep)**
**Shear Force (kips)**



# Appendix E: Structural Drawings



PLAN
SCALE: 3/16" = 1'-0"



ELEVATION
SCALE: 3/16" = 1'-0"

GENERAL NOTES

| | |
|---|---|
| SPECIFICATIONS: | HOWARD COUNTY VOLUME IV DESIGN MANUAL STANDARD SPECIFICATIONS AND DETAILS FOR CONSTRUCTION |
| | SHA SPECIFICATIONS DATED JULY 2008<br>REVISIONS THEREOF AND ADDITIONS THERETO AND SPECIAL PROVISIONS FOR MATERIALS AND CONSTRUCTION |
| | AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS DATED 2014 FOR DESIGN INCLUDING 2015 INTERIMS |
| | AASHTO LRFD GUIDE SPECIFICATIONS FOR THE DESIGN OF PEDESTRIAN BRIDGES DATED DECEMBER 2009 INCLUDING 2015 INTERIMS |
| LOADING: | PEDESTRIAN LIVE LOAD OF 90 POUNDS / SQUARE FOOT OF DECK<br>VEHICULAR LOAD H5 (10,000 POUND VEHICLE) |
| CONCRETE DESIGN: | LOAD AND RESISTANCE FACTOR DESIGN METHOD<br>$f'c = 3000$ PSI |
| REINFORCING STEEL DESIGN: | $fy = 60{,}000$ PSI |
| CONCRETE: | ALL CONCRETE SHALL BE MIX NO. 3 (3500 PSI) |
| REINFORCING STEEL: | REINFORCING STEEL SHALL CONFORM TO ASTM A615, GRADE 60 |
| | <u>ONLY GRADE 60 CAN BE USED FOR THIS PROJECT</u> |
| | ALL SPLICES, NOT SHOWN, SHALL BE LAPPED AS PER BAR LAP CHARTS. MINIMUM COVER FOR ANY BAR SHALL BE 2" UNLESS OTHERWISE NOTED, WITH THE EXCEPTION OF BARS AT THE BOTTOM AND SIDES OF ALL FOOTINGS WHICH SHALL HAVE 3" MINIMUM COVER. |
| KEYS: | ALL CONCRETE CONSTRUCTION KEYS ARE NOMINAL SIZE. |

APPROVED
PLANNING BOARD OF HOWARD COUNTY

DATE: ____________________

HOWARD COUNTY DEPARTMENT OF PLANNING & ZONING

CHIEF, DEVELOPMENT ENGINEERING DIVISION ______ DATE ______
CHIEF, DIVISION OF LAND DEVELOPMENT ______ DATE ______
DIRECTOR ______ DATE ______

PROFESSIONAL CERTIFICATION

I HEREBY CERTIFY THAT THESE PLANS
WERE PREPARED OR APPROVED BY
ME, AND THAT I AM A DULY LICENSED
PROFESSIONAL ENGINEER UNDER THE
LAWS OF THE STATE OF MARYLAND,
LICENSE NO. ________,
EXPIRATION DATE: ____________.

DSGN
DR
CHK
APVD

| NO. | DATE | REVISION | BY | APVD |
|---|---|---|---|---|

ToolеDesignGroup
8484 GEORGIA AVENUE, SUITE 800 SILVER SPRING, MD 20910
PHONE: (301) 927-1900 FAX: (301) 927-2800
www.tooledesign.com
PLANNING | ENGINEERING | LANDSCAPE ARCHITECTURE

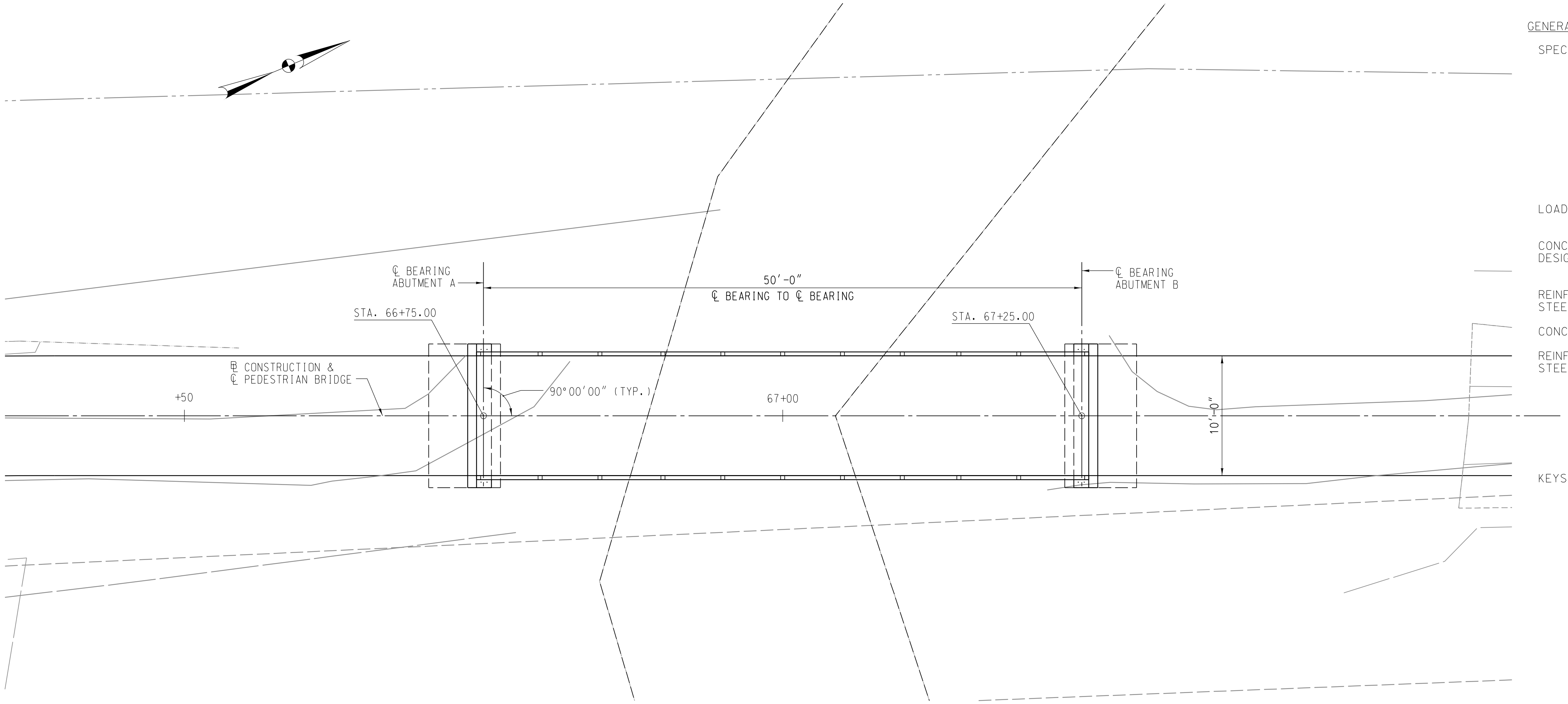
REUSE OF DOCUMENTS
ALL DRAWINGS ARE INSTRUMENTS OF PROFESSIONAL SERVICE FOR THIS PROJECT. REUSE OR ALTERATION WITHOUT TDG'S WRITTEN PERMISSION IS AT THE USER'S SOLE RISK.

BAR SHOWN BELOW IS ONE INCH ON ORIGINAL DRAWING. IF BAR DOES NOT MEASURE ONE INCH, ADJUST SCALES ACCORDINGLY.
0" 1"

DOWNTOWN COLUMBIA TO STEVENS FOREST
SHARED USE PATH
DEPARTMENT OF PUBLIC WORKS
HOWARD COUNTY, MARYLAND

35' PEDESTRIAN BRIDGE
GENERAL PLAN AND ELEVATION

SHEET
DWG
DATE OCT 2016
PROJECT 5409.04



PLAN
SCALE: 3/16" = 1'-0"

## GENERAL NOTES

| | |
|---|---|
| SPECIFICATIONS: | HOWARD COUNTY VOLUME IV DESIGN MANUAL STANDARD SPECIFICATIONS AND DETAILS FOR CONSTRUCTION<br>SHA SPECIFICATIONS DATED JULY 2008 REVISIONS THEREOF AND ADDITIONS THERETO AND SPECIAL PROVISIONS FOR MATERIALS AND CONSTRUCTION<br>AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS DATED 2014 FOR DESIGN INCLUDING 2015 INTERIMS<br>AASHTO LRFD GUIDE SPECIFICATIONS FOR THE DESIGN OF PEDESTRIAN BRIDGES DATED DECEMBER 2009 INCLUDING 2015 INTERIMS |
| LOADING: | PEDESTRIAN LIVE LOAD OF 90 POUNDS / SQUARE FOOT OF DECK<br>VEHICULAR LOAD H5 (10,000 POUND VEHICLE) |
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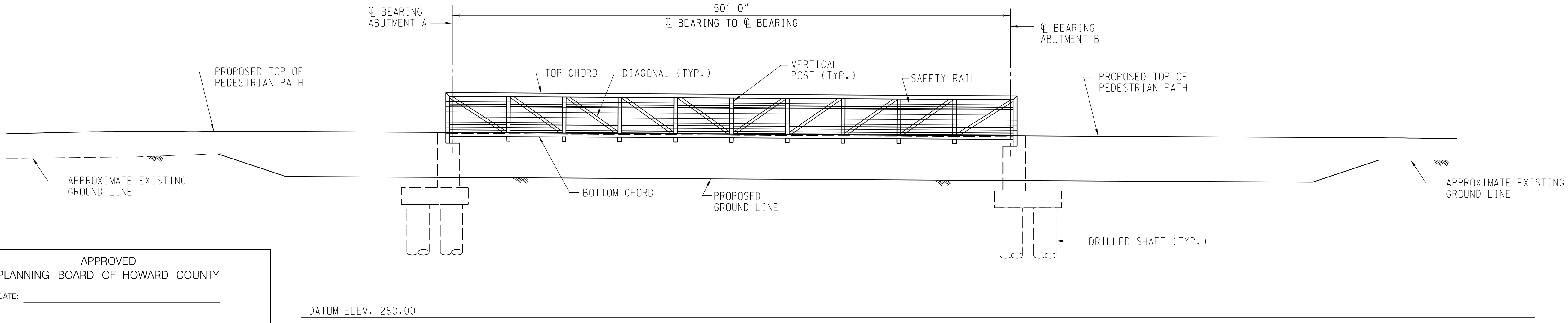
| KEYS: | ALL CONCRETE CONSTRUCTION KEYS ARE NOMINAL SIZE. |



ELEVATION
SCALE: 3/16" = 1'-0"

APPROVED
PLANNING BOARD OF HOWARD COUNTY

DATE: ____________________

HOWARD COUNTY DEPARTMENT OF PLANNING & ZONING

CHIEF, DEVELOPMENT ENGINEERING DIVISION — DATE

CHIEF, DIVISION OF LAND DEVELOPMENT — DATE

DIRECTOR — DATE

PROFESSIONAL CERTIFICATION

I HEREBY CERTIFY THAT THESE PLANS
WERE PREPARED OR APPROVED BY
ME, AND THAT I AM A DULY LICENSED
PROFESSIONAL ENGINEER UNDER THE
LAWS OF THE STATE OF MARYLAND,
LICENSE NO. ________,
EXPIRATION DATE: ____________.

| | | | | | |
|---|---|---|---|---|---|
| DSGN | | | | | |
| DR | | | | | |
| CHK | | | | | |
| APVD | NO. | DATE | REVISION | BY | APVD |

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BAR SHOWN BELOW IS ONE INCH ON ORIGINAL DRAWING. IF BAR DOES NOT MEASURE ONE INCH, ADJUST SCALES ACCORDINGLY.
0" ▬ 1"

DOWNTOWN COLUMBIA TO STEVENS FOREST
SHARED USE PATH
DEPARTMENT OF PUBLIC WORKS
HOWARD COUNTY, MARYLAND

50' PEDESTRIAN BRIDGE
GENERAL PLAN AND ELEVATION

| | |
|---|---|
| SHEET | |
| DWG | |
| DATE | OCT 2016 |
| PROJECT | 5409.04 |

# Appendix F: Preliminary Cost Estimate

**Downtown Columbia to Stevens Forest Trail**
**Preliminary Engineering Cost Estimate**
**10/25/2016**

Trail Length: 5600 lf (1.06 mi)
On-Road Length: 3100 lf (0.59 mi)

| **Item** | **Qty** | **Units** | ***Unit Price** | **Total Price** |
|---|---|---|---|---|
| **Pavment Marking** | | | | |
| 5/6" Solid White/Yellow Paint | 650 | LF | $4.00 | $ 2,600 |
| 5/6" Dashed White Paint | 1,060 | LF | $4.00 | $ 4,200 |
| 5/6" Solid White/Yellow Thermoplastic | 14,880 | LF | $5.00 | $ 74,400 |
| 5/6" Dashed White Thermoplastic | 460 | LF | $5.00 | $ 2,300 |
| Thermoplastic Pavement Marking Legend (ROAD XING) | 6 | EA | $400.00 | $ 2,400 |
| Thermoplastic Arrow Markings | 12 | | $100.00 | $ 1,200 |
| 10' Crosswalk Striping (2' Wide) | 600 | LF | $10.00 | $ 6,000 |
| Stop Bar (2' Wide) | 80 | LF | $10.00 | $ 800 |
| 8" Solid White Rumble Strip (Thermoplastic) | 180 | LF | $6.50 | $ 1,200 |
| Thermoplastic Pavement Marking Symbol | 20 | EA | $250.00 | $ 5,000 |
| Green Epoxy Pavement Marking | 2,630 | SF | $10.00 | $ 26,300 |
| | | | | |
| **Bridges** | | | | |
| **35' long Pedestrian Bridge** | | | | |
| Maintenance of Stream Flow | 1 | LS | $15,000.00 | $ 15,000 |
| Class 3 Excavation | 95 | CY | $65.00 | $ 6,175 |
| Footing Concrete | 40 | CY | $500.00 | $ 20,000 |
| Substructure Concrete for Bridge | 35 | CY | $1,000.00 | $ 35,000 |
| Drilled Shafts 36 Inch Diameter | 60 | LF | $200.00 | $ 12,000 |
| Rock Sockets 24 Inch Diameter | 40 | LF | $600.00 | $ 24,000 |
| Prefabricated Pedestrian Bridge | 1 | LS | $66,500.00 | $ 66,500 |
| | | | | |
| **50' long Pedestrian Bridge** | | | | |
| Maintenance of Stream Flow | 1 | LS | $15,000.00 | $ 15,000 |
| Class 3 Excavation | 120 | CY | $65.00 | $ 7,800 |
| Footing Concrete | 40 | CY | $500.00 | $ 20,000 |
| Substructure Concrete for Bridge | 45 | CY | $1,000.00 | $ 45,000 |
| Drilled Shafts 36 Inch Diameter | 80 | LF | $200.00 | $ 16,000 |
| Rock Sockets 24 Inch Diameter | 40 | LF | $600.00 | $ 24,000 |
| Prefabricated Pedestrian Bridge | 1 | LS | $131,250.00 | $ 131,250 |
| | | | | |
| **Sitework** | | | | |
| Clearing & Grubbing | 1 | LS | $10,000.00 | $ 10,000 |
| Class 1 Excavation | 3,200 | CY | $25.00 | $ 80,000 |
| Concrete Curb | 1,150 | LF | $35.00 | $ 40,300 |
| Aggregate Base Course | 1,360 | CY | $60.00 | $ 81,600 |
| Base Course - 25.0 mm Asphalt | 845 | TONS | $76.00 | $ 64,200 |
| Intermediate Course - 12.5 mm Pervious Asphalt | 265 | TONS | $75.00 | $ 19,900 |
| Surface Course - 9.5 mm Asphalt | 540 | TONS | $76.00 | $ 41,000 |
| Riprap for Scour Protection | 418 | SY | $130.00 | $ 54,300 |
| RCP Culvert | 10 | EA | $500.00 | $ 5,000 |
| 3" Underdrain pipe (for trail) | 1,050 | LF | $6.00 | $ 6,300 |
| Geotextile Class "C" Filter Cloth | 1,400 | SY | $3.00 | $ 4,200 |
| Bioretention Area | 2 | EA | $10,000.00 | $ 20,000 |
| Top Soil-Furnished and Placed | 1,500 | SY | $4.00 | $ 6,000 |

| | | | | |
|---|---|---|---|---|
| Trail Signage | 40 | EA | $250.00 | $ 10,000 |
| Wayfinding Signage | 4 | EA | $1,000.00 | $ 4,000 |
| Wayside Rest Area | 2 | EA | $15,000.00 | $ 30,000 |
| Trail Lighting | 41 | EA | $8,000.00 | $ 328,000 |
| Wetland Mitigation | 0.75 | AC | $40,000.00 | $ 30,000 |
| | | | | |
| **High Water Warning System** | | | | |
| Sensor Assembly | 2 | EA | $6,670.00 | $ 13,340 |
| Sign Assembly with Flashing Beacon | 4 | EA | $6,265.00 | $ 25,060 |
| Heavy Duty Pole Assembly | 6 | EACH | $475.00 | $ 2,850 |
| Electrical Work | 1 | LS | $10,000.00 | $ 10,000 |
| Field Assembly and Sensor Mounting | 1 | LS | $10,000.00 | $ 10,000 |
| Furnish and Install 1-2" Galvnized Conduit | 100 | LF | $62.00 | $ 6,200 |
| Furnish and Install Heavy-Duty Pole Foundation | 6 | EACH | $1,800.00 | $ 10,800 |
| Furnish and Install Ground Rod | 6 | EACH | $200.00 | $ 1,200 |
| Onsite Support | 1 | LS | $1,800.00 | $ 1,800 |
| 3-year Wireless Service ($40/month/unit) | 6 | EACH | $1,440.00 | $ 8,640 |
| | | | **Subtotal** | $ 1,489,000 |
| | | | | |
| | | | | |
| Drainage & E&S (4%) | 1 | LS | $ 59,600 | $ 59,600 |
| Maintenance of Traffic (2%) | 1 | LS | $ 29,800 | $ 29,800 |
| Landscaping (5%) | 1 | LS | $ 74,500 | $ 74,500 |
| Utility Relocation (5%) | 1 | LS | $ 74,500 | $ 74,500 |
| Temporary Construction / Mobilizaton (5%) | 1 | LS | $ 74,500 | $ 74,500 |
| | | | **Subtotal** | $ 313,000 |
| | | | | |
| | | | Construction Contingency (25%) | $ 451,000 |
| | | | **Subtotal** | $ 451,000 |
| | | | | |
| Inspection (10%) | 1 | LS | $ 225,000 | $ 225,000 |
| Engineering / Permitting (25%) | 1 | LS | $ 563,300 | $ 563,300 |
| | | | **Subtotal** | $ 788,000 |
| | | | | |
| | | | **Total Estimated Construction Cost** | $ 3,041,000 |

* Unit prices are based on historical bid pricing from MD SHA and Estimator's Judgment.

Right-of-Way costs are not included in this estimate.

**Downtown Columbia to Stevens Forest Trail**
**Preliminary Engineering Cost Estimate - Potential Developer Funded Portion**
**10/25/2016**

Trail Length: 1250 lf (0.24 mi)

| Item | Qty | Units | *Unit Price | Total Price |
|---|---|---|---|---|
| **Pavment Marking** | | | | |
| 5/6" Solid White/Yellow Paint | 500 | LF | $4.00 | $ 2,000 |
| 5/6" Dashed White Paint | 750 | LF | $4.00 | $ 3,000 |
| 5/6" Solid White/Yellow Thermoplastic | - | LF | $5.00 | $ - |
| 5/6" Dashed White Thermoplastic | - | LF | $5.00 | $ - |
| Thermoplastic Pavement Marking Legend (ROAD XING) | 4 | EA | $400.00 | $ 1,600 |
| Thermoplastic Arrow Markings | - | | $100.00 | $ - |
| 10' Crosswalk Striping (2' Wide) | 320 | LF | $10.00 | $ 3,200 |
| Stop Bar (2' Wide) | - | LF | $10.00 | $ - |
| 8" Solid White Rumble Strip (Thermoplastic) | 150 | LF | $6.50 | $ 1,000 |
| Thermoplastic Pavement Marking Symbol | - | EA | $250.00 | $ - |
| Green Epoxy Pavement Marking | - | SF | $10.00 | $ - |
| | | | | |
| **Bridges** | | | | |
| **35' long Pedestrian Bridge** | | | | |
| Maintenance of Stream Flow | - | LS | $15,000.00 | $ - |
| Class 3 Excavation | - | CY | $65.00 | $ - |
| Footing Concrete | - | CY | $500.00 | $ - |
| Substructure Concrete for Bridge | - | CY | $1,000.00 | $ - |
| Drilled Shafts 36 Inch Diameter | - | LF | $200.00 | $ - |
| Rock Sockets 24 Inch Diameter | - | LF | $600.00 | $ - |
| Prefabricated Pedestrian Bridge | - | LS | $66,500.00 | $ - |
| | | | | |
| **50' long Pedestrian Bridge** | | | | |
| Maintenance of Stream Flow | - | LS | $15,000.00 | $ - |
| Class 3 Excavation | - | CY | $65.00 | $ - |
| Footing Concrete | - | CY | $500.00 | $ - |
| Substructure Concrete for Bridge | - | CY | $1,000.00 | $ - |
| Drilled Shafts 36 Inch Diameter | - | LF | $200.00 | $ - |
| Rock Sockets 24 Inch Diameter | - | LF | $600.00 | $ - |
| Prefabricated Pedestrian Bridge | - | LS | $131,250.00 | $ - |
| | | | | |
| **Sitework** | | | | |
| Clearing & Grubbing | - | LS | $10,000.00 | $ - |
| Class 1 Excavation | 680 | CY | $25.00 | $ 17,000 |
| Concrete Curb | - | LF | $35.00 | $ - |
| Aggregate Base Course | 370 | CY | $60.00 | $ 22,200 |
| Base Course - 25.0 mm Asphalt | - | TONS | $76.00 | $ - |
| Intermediate Course - 12.5 mm Pervious Asphalt | 140 | TONS | $75.00 | $ 10,500 |
| Surface Course - 9.5 mm Asphalt | 175 | TONS | $76.00 | $ 13,300 |
| RCP Culvert | - | EA | $500.00 | $ - |
| 3" Underdrain pipe (for trail) | 550 | LF | $6.00 | $ 3,300 |
| Geotextile Class "C" Filter Cloth | 735 | SY | $3.00 | $ 2,200 |
| Bioretention Area | - | EA | $10,000.00 | $ - |
| Top Soil-Furnished and Placed | 280 | SY | $4.00 | $ 1,100 |
| Trail Signage | 6 | EA | $250.00 | $ 1,500 |

| | | | | |
|---|---|---|---|---|
| Wayfinding Signage | - | EA | $1,000.00 | $ - |
| Wayside Rest Area | - | EA | $15,000.00 | $ - |
| Trail Lighting | 20 | EA | $8,000.00 | $ 160,000 |
| Wetland Mitigation | - | AC | $40,000.00 | $ - |
| | | | | |
| **High Water Warning System** | | | | |
| Sensor Assembly | - | EA | $6,670.00 | $ - |
| Sign Assembly with Flashing Beacon | - | EA | $6,265.00 | $ - |
| Heavy Duty Pole Assembly | - | EACH | $475.00 | $ - |
| Electrical Work | - | LS | $10,000.00 | $ - |
| Field Assembly and Sensor Mounting | - | LS | $10,000.00 | $ - |
| Furnish and Install 1-2" Galvnized Conduit | - | LF | $62.00 | $ - |
| Furnish and Install Heavy-Duty Pole Foundation | - | EACH | $1,800.00 | $ - |
| Furnish and Install Ground Rod | - | EACH | $200.00 | $ - |
| Onsite Support | - | LS | $1,800.00 | $ - |
| 3-year Wireless Service ($40/month/unit) | - | EACH | $1,440.00 | $ - |
| | | | **Subtotal** | $ 242,000 |
| | | | | |
| | | | | |
| Drainage & E&S (4%) | 1 | LS | $ 9,700 | $ 9,700 |
| Maintenance of Traffic (2%) | 1 | LS | $ 4,800 | $ 4,800 |
| Landscaping (5%) | 1 | LS | $ 12,100 | $ 12,100 |
| Utility Relocation (5%) | 1 | LS | $ 12,100 | $ 12,100 |
| Temporary Construction / Mobilizaton (5%) | 1 | LS | $ 12,100 | $ 12,100 |
| | | | **Subtotal** | $ 51,000 |
| | | | | |
| Construction Contingency (25%) | | | | $ 73,000 |
| **Subtotal** | | | | $ 73,000 |
| | | | | |
| Inspection (10%) | 1 | LS | $ 37,000 | $ 37,000 |
| Engineering / Permitting (25%) | 1 | LS | $ 91,500 | $ 91,500 |
| **Subtotal** | | | | $ 129,000 |
| | | | | |
| **Total Estimated Construction Cost** | | | | $ 495,000 |

* Unit prices are based on historical bid pricing from MD SHA and Estimator's Judgment.
Right-of-Way costs are not included in this estimate.