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December 10, 2021

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SUBJECT: **Findings for the Bank Erosion Hazard Index and Near Bank Stress Analysis**
Chosewood Park
Atlanta, Fulton County, Georgia

Ms. Arbeiter,

Pond & Company's Environment + Water Resources team (Pond) completed Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) analyses for the Chosewood Park property (Park) on November 18, 2021. These technical studies are associated with evaluating the existing condition of streams located on the Park property. This report has been prepared to inform the Park proponents of the streambank dynamics and their contribution to downstream sediment migration, stability, and safety/visual quality based on the intended adjacent use. The BEHI evaluation inventories streambank characteristics such as geometry, root cover, root depth, root density, streambank angle, streambank surface protection, and soil composition. Additionally, the NBS evaluation inventories the stream pattern, profile, streambank characteristics and forces which contribute to streambank erosion. Numerical field measurements are converted using a scaling factor to correspond with stability risk ratings. Erodibility (i.e. BEHI) and streambank forces (i.e. NBS) are ranked on a scale from very low to extreme, with extreme corresponding to conditions with the greatest streambank instability and erosion potential. Together, BEHI and NBS provide a predictive model for streambank erosion and downstream sediment migration.

INTRODUCTION AND PROPERTY OVERVIEW

During the November 18th field visit, Pond's team of environmental scientists and water resource engineers identified three streams (unnamed tributaries to Entrenchment Creek) located within the environmental survey boundary (see Figure 2 – Project Overview Map; **Attachment A**). The streams located within the Park footprint are associated with a drainage basin approximately 65 acres (~0.1 square miles) in size. Existing conditions data provided by the U.S. Geological Survey indicate the drainage area consists of 21.3% impervious surface area and the elevation averages 979 feet above mean sea level (AMSL) with a maximum elevation of 1027 feet AMSL. The drainage area and Park property are located within the Piedmont/Ridge and Valley Region (Region 1) of Georgia with an average precipitation totaling ~52 inches per year. Topography within the drainage area and on the Park property is highly variable and consists of a mean basin slope of ~11%, based on the headwaters and outlet elevation of the drainage area (see USGS StreamStats Report; **Attachment D**). Drainage enters the Park via four drainage paths. Stream 1 consists of two culverted drainages, both of which are perched above the stream channel. One of the drainages at the headwaters of Stream 1 has bypassed its relict culvert structure. Stream 2 enters the Park property via multiple culverted drainages into a stream reach where previous attempts to be stabilize the channel with rip rap protection have occurred. Stream 3 enters the Park property as an open channel. Multiple sanitary sewer structures, culverts, and headwalls are located along and adjacent to Streams 1-3 (see Photograph log; **Attachment B**) within the park property. These existing structures are locations of accelerated streambank erosion and pose a risk of future structure failure if not addressed.

Land use upstream of the Park is primarily residential, with mixed commercial and light industrial land use in the vicinity surrounding the Park's drainage basin. The Park property is largely undeveloped, consisting primarily of mixed pine-hardwood forest along the streams in the southern portion of the property. Much of the property consists of sparse understory; however, sections of the streambank and adjacent areas are overcome with kudzu (*Pueraria montana)* and English ivy (*Hedera helix*) as well as other invasive species. Invasive species provide little stabilization or surface protection and outcompete native species better suited to provide stream stability and instream habitat. During the field visit, various groups of white-tailed deer (*Odocoileus virginianus*) were observed in the park. As Chosewood Park is densely forested and surrounded by urbanized and developing areas, it serves as a refuge for wildlife and connects area wildlife via the forested corridor toward the northeast of the Park boundary to Entrenchment Creek and its floodplain.

BEHI AND NBS FINDINGS

As noted in the attached figures (see Figures 3 & 4; **Attachment A**) the BEHI evaluation for Streams 1-3 identified primarily moderate, high, and very high-risk ratings along the surveyed stream reaches. The greatest contributing factors to the moderate to very high-risk ratings were low root density, high streambank angle, low surface protection, and streambank height as compared to the bankfull (i.e., typical portion of channel accessed by flow) height. Stream reaches within tight meander bends and at locations of converging flows exhibited increased BEHI ratings. Additionally, stream reaches characterized with low radius meander bends are subject to greater forces during storm events and typically result in greater channel bank instability and erosive soil loss. The streambank substrate is primarily clay loam with some sand intermixed which is beneficial for the system and helps the streambank soil to bind to itself and vegetation. Only slight amounts of sediment deposition were observed in the channel itself, indicating there is likely little upstream sediment contribution and the system is transporting a majority of the sediment loss from the streambanks downstream to other surface waters. Overall, the streambanks along all three streams exhibited near vertical slopes and were highly entrenched. **Figure 1** (below) provides a graphical depiction of streambank characteristics associated with the BEHI evaluation.

The NBS evaluation for Streams 1-3 identified primarily high, very high, and extreme risk ratings. The stream reaches associated with moderate to high NBS risk ratings were associated with areas that were more attached to a floodplain shelf with relief from flood flows during storm events. Many areas were identified as very high or extreme risk as these reaches were highly entrenched with tight meander bends and consisted of head cuts and steep slopes. Typically, stream reaches which are highly entrenched and consist of erosional gullies and converging flows in confined systems are of very high to extreme risk as it relates to the NBS evaluation. Much of the evaluated stream system, due to erosional streambank losses and downcutting in stream channel elevation, have resulted in confined conditions. **Figure 2** (below) provides a graphical depiction of various geomorphic channel cross-sections and their associated NBS risk rating. Refer to **Attachment B** for photos of the various streams associated with this evaluation.

Together NBS and BEHI analyses provide a predictive model for potential streambank erosion. Moreover, the unit rate of erosion (tons/year/foot) provides an estimate for erosive losses at any given point along Streams 1-3. Based on the observations and computations associated with the NBS and BEHI analyses, the predicted sediment loss of Stream 1 is approximately 711 tons of streambank material per year with an average unit erosion rate of 0.55 tons of streambank material per year per linear foot. Stream 2 is predicted to contribute 602 tons of material per year with a unit erosion rate of 2.17 tons of material per year per linear foot. Stream 3 is predicted to contribute 402 tons of material per year with a unit erosion rate of 1.26 tons of material per year per linear foot. These values provide a rough estimate of the potential downstream sediment migration. As the system transports sediment downstream, and approaches Entrenchment Creek and its floodplain, sediment is likely to deposit in the larger system and potentially result in downstream degradation. As flow and sediment from Streams 1-3 move downstream and enter into Entrenchment Creek, energy dissipates over its floodplain, and sediment will fall out of suspension. A summary of the observed BEHI and NBS observations and erosion predictions are provided as attachments (see Figure 5; **Attachment A & C**).

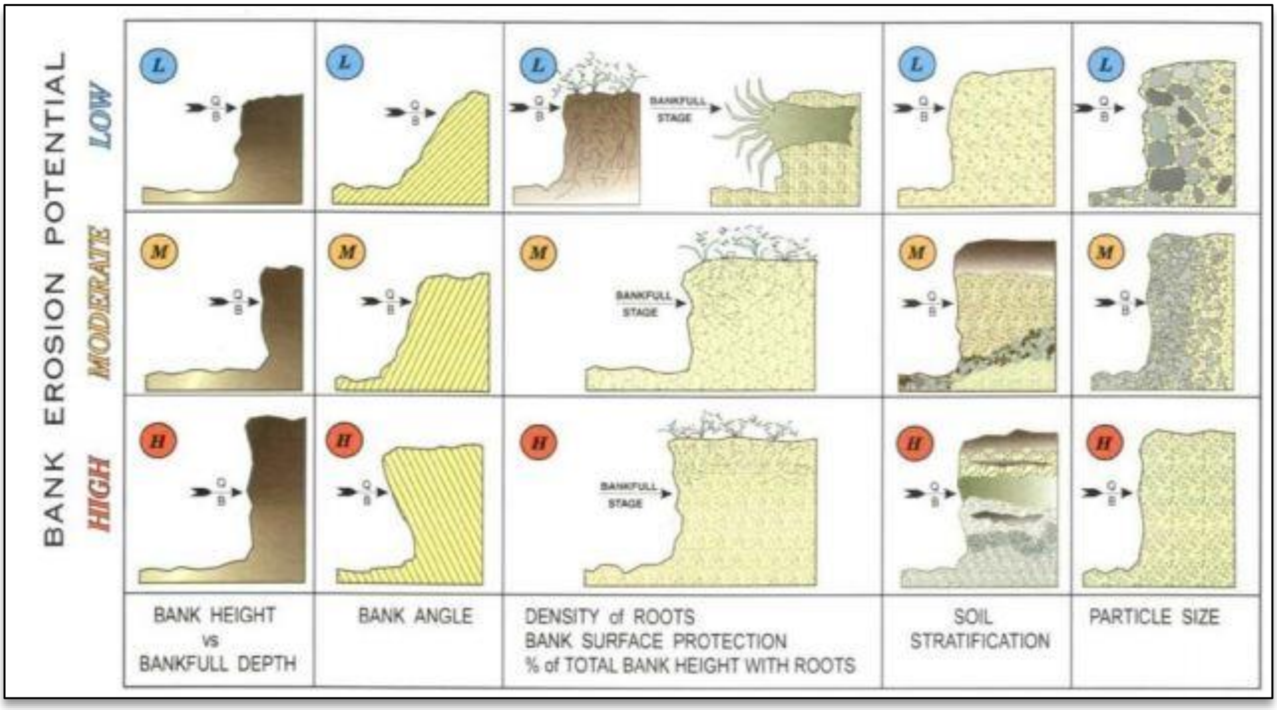

Figure 1. *Rosgen Streambank BEHI Erodibility Factors   Source: Wildland Hydrology*

<u>Near Bank Stress (NBS)</u> is a visual assessment of the amount of stress the channel flow is exhibiting in the near bank area of the channel (see diagram). NBS is highest at the outside of a very tight meander bend and lowest in a straight section with uniform channel dimension.

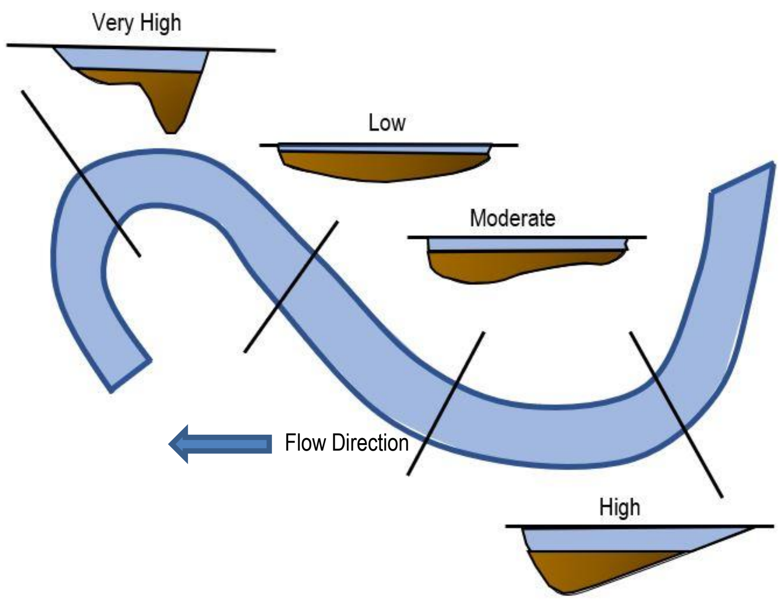

Figure 2. *Channel Geometry and Near streambank Stress Classification   Source: NCSU RC101*

CLASSIFICATION, VISUAL APPEARANCE, AND OBSERVATIONS

According to the *Rosgen Classification of Natural Rivers*, the streams located in the Park would classify as G4 (Stream 1), G5 (Stream 2), and G3 (Stream 3) consisting of highly entrenched, confined, and moderately sinuous systems with gravel, sand, and cobble substrates. The stream system consists primarily of alluvial substrates and detritus transported from upstream and from the adjacent riparian buffer. Leaf litter, woody debris, and larger rocky material (assumably placed for stabilization) provide some habitat diversity. The stream pattern primarily consists of riffles and pools, with few well-developed glides or runs. Stream systems in the Piedmont region with moderate slopes benefit from appropriately formed riffle, pool, glide, and run sequences from a habitat and stream stability standpoint. The streams located on the property are poorly attached to their floodplain (non-existent in most reaches). During high flows the floodwaters are unable to escape the channel and streambank into a floodplain, which concentrates stream energy on its streambanks, accelerating erosion. Large amounts of trash were observed along the length of the survey reach.

Due to the existing and unstable conditions of the evaluated streams located within the park property, consideration and planning should occur before attracting patrons to areas near these features. Many of the streambank heights are in excess of 15 feet and pose a potential risk of injury for those unaware of the existing stream conditions. Additionally, stabilization measures to address actively eroding channel banks and unstable stream conditions, should be considered during the evaluation and planning associated with any proposed bridge structure or pedestrian crossings across the evaluated stream features.

Based on Pond's preliminary analysis, any fixed structure installed across the evaluated stream systems could result in structure failure if the proper measures are not implemented to stabilize the stream at the crossing location. As discussed, there are multiple sanitary sewer crossings and culvert outlets located along the surveyed reaches. These structures have severely eroded streambanks at the location of their crossings and should be considered as future development is expected to further exacerbate the erosional losses.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

The findings from the BEHI and NBS analysis are not uncommon of streams in a highly urbanized setting. The three streams present within Chosewood Park have experienced downcutting, undercutting, and mass wasting of soil from the streambanks evaluated within its borders. Existing impervious surfaces within the watershed are contributing to flashy flow conditions during storm events. As the watershed continues to be developed, trees are removed, and impervious surfaces are introduced, it is expected that less stormwater will infiltrate into the soil or be utilized by trees and will runoff into the drainages of the Park. Changes in watershed characteristics, such as increased impervious surface area and reduced vegetation, often result in further degradation of the streams, unless future development within the watershed were to appropriately account for stormwater management and retention needs.

Streams, even in natural settings are in a constant dynamic equilibrium, meaning they are constantly adjusting in and out of stability and instability. Typically, streams in pristine settings will migrate across their floodplains through geologic time. Erosion, sedimentation, and deposition are natural processes as well. Streams transport sediment and deposit material downstream, which is the driving force for their geomorphology. However, streams, often those in urban settings, can enter a stage of disequilibrium where excessive erosion, streambank collapse, down cutting, over widening or narrowing occurs resulting in a loss of floodplain connection. This loss of floodplain connection often results in continued channel instability until a new floodplain can be established a lower elevation and an equilibrium can be achieved. With consideration of planned development in the watershed, a proposed increase in impervious surface area, and tree removal, the streams at Chosewood Park would be a candidate for stream restoration/stabilization. Prior to final determination of the recommended restoration/stabilization method, review of the engineering design plans and associated stormwater management measures for the surrounding developments would be necessary. This analysis would inform project proponents of whether a particular stream or multiple streams would need to be restored or stabilized. Stream restoration/stabilization practices consider the stressors that are adversely affecting the stream channel and utilizing natural channel design and bioengineering principles seek to restore equilibrium to the destabilized stream creating a channel that does not aggrade or degrade overtime.

Based on Pond's current understanding of the existing conditions and proposed development in the watershed, Priority III restoration, as defined by Rosgen, would be recommended. Priority III stream restoration involves excavation of the existing channel to modify its stream type. As discussed, the streams evaluated within the Park can be characterized as G stream types (i.e. incised, confined, unstable). We would recommend restoring the stream as a B stream type. This restoration would involve establishing a three-stage river system consisting of an appropriately sized inner berm, bankfull channel, and flood-prone area. This three-stage river system would provide relief during rain events and floods to dissipate energy within the channel to the flood-prone area (**Figure 3**). Below are the primary advantages of Priority III restoration:

- Reduces the amount of land needed to return the stream to a stable form
- Developments next to river need not be relocated due to flooding potential
- Decreased flood stage for the same magnitude storm
- Improves aquatic habitat
- Includes the establishment or restoration of the stream buffer with native species

Priority I and II restoration (reconstruct the stream system and establish a floodplain) would not be a practical solution due to the existing topography and need to connect the system to an outlet (upstream) and inlet (downstream) culvert. The development of a true floodplain would require extensive grading and would be difficult to achieve the required slope.

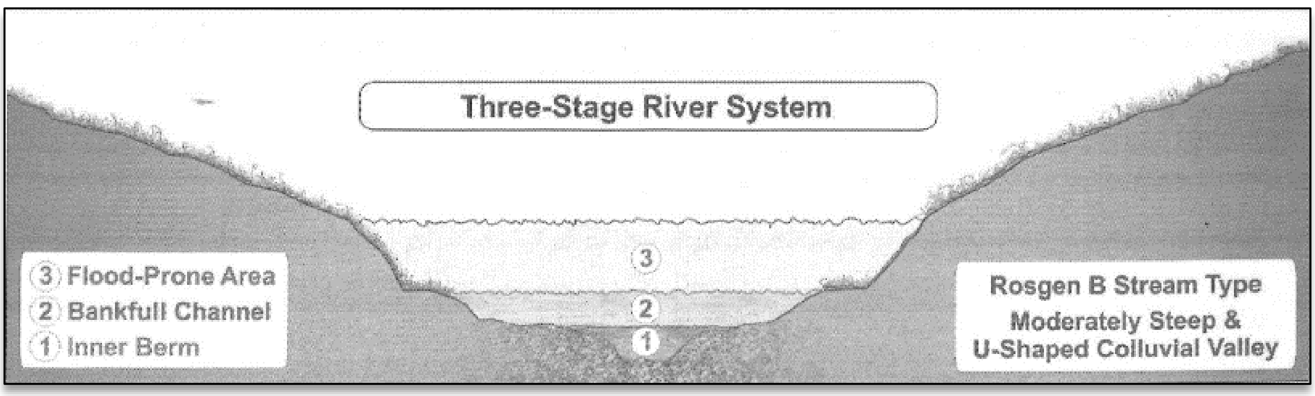

Figure 3. *Rosgen Priority III three-stage river system* *Source: Wildland Hydrology*

Priority IV restoration (stabilization in place) is the least preferred restoration option as it can be extremely costly and is not as aesthetically pleasing for a public park when utilized over an entire stream system. Small sections of Priority IV restoration would likely be needed where existing structures cannot be relocated. Priority IV restoration at sanitary sewer crossings, proposed bridge crossings, and culvert inlets/outlets, would provide the needed additional protection for structures. An example of a stabilization system utilized for Priority IV restoration is the Envirolok Geobag system. Below are a few photos of the Envirolok Geobag product implemented on a much larger stream system.

In addition to restoration/stabilization of the streams at Chosewood Park, downstream daylighting of the drainage between the northern property boundary and the culverted stream outlet near Entrenchment Creek would provide added flexibility to complete more extensive restoration, habitat improvements, and provide a broader flood-prone area or even reattach the degraded stream to its relict floodplain. More extensive restoration downstream through daylighting and restoration of the unnamed tributaries to Entrenchment Creek would provide the opportunity for greater riparian buffer establishment/restoration to establish a wildlife connection corridor between the Park, Entrenchment Creek, and its floodplain.

Figure 4. *Geobag system installation*

Figure 5. *Geobag system after installation with added toe rock protection*

Figure 6. *Geobag system fully stabilized and vegetated*

Figure 7. *Geobag system fully stabilized and vegetated*

CONCLUSIONS

Our team has collected the field measurements necessary for these two evaluations and produced figures, with reference photos, depicting our findings. We hope this information will aid in informing the team of the existing stream conditions and provide a basis for discussion as the Friends of Chosewood Park look towards next steps in informing Atlanta Housing and adjacent developers of the risk for future development without consideration of tree removal or impervious surface additions to the watershed. Once the Friends of Chosewood Park have determined their preference in accomplishing the goals of Chosewood Park and the surrounding community, an evaluation of the environmental permitting and design necessary to complete restoration, stabilization, wildlife connection, and stream daylighting, as discussed in our recommendations, should be evaluated. This study and report of findings does not constitute a delineation of Waters of the U.S. A delineation of jurisdictional streams and wetlands should be completed to inform future design and permitting ahead of development. We look forward to your review of this report of our findings. If you have any questions or require additional information, please do not hesitate to reach out to myself or Will Rector.

Sincerely,

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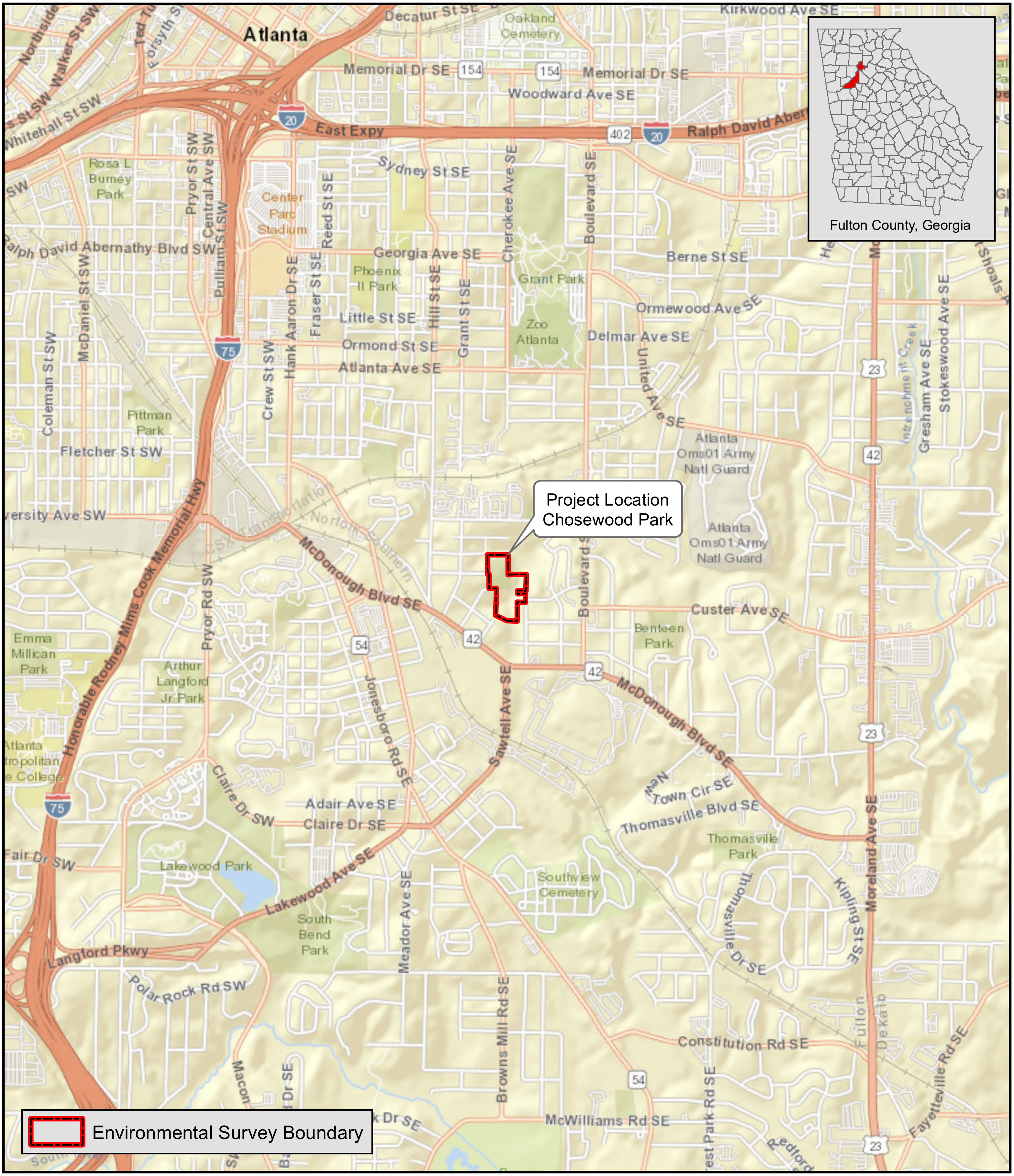
REFERENCES:

North Carolina State University. Course Instruction Materials for River Course 101 – Stream Morphology Assessment.
Rosgen, Dave. A Classification of Natural Rivers. Catena. 1994.
Rosgen, Dave. A Geomorphological Approach to Restoration of Incised Rivers. Preceedings of the Conference on Management of Landscapes Disturbed by Channel Incision, Oxford, MS. 1997.
U.S. Geological Survey. StreamStats. https://streamstats.usgs.gov/ss/. Accessed December 2021.
Wildland Hydrology. Course Instruction Materials for Level I – Applied Fluvial Geomorphology. 2020

ATTACHMENTS:

Attachment A: Project Figures
Attachment B: Photograph Log
Attachment C: BEHI and NBS Calculation Summary Tables
Attachment D: U.S. Geological Survey StreamStats Report

ATTACHMENT A: PROJECT FIGURES



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

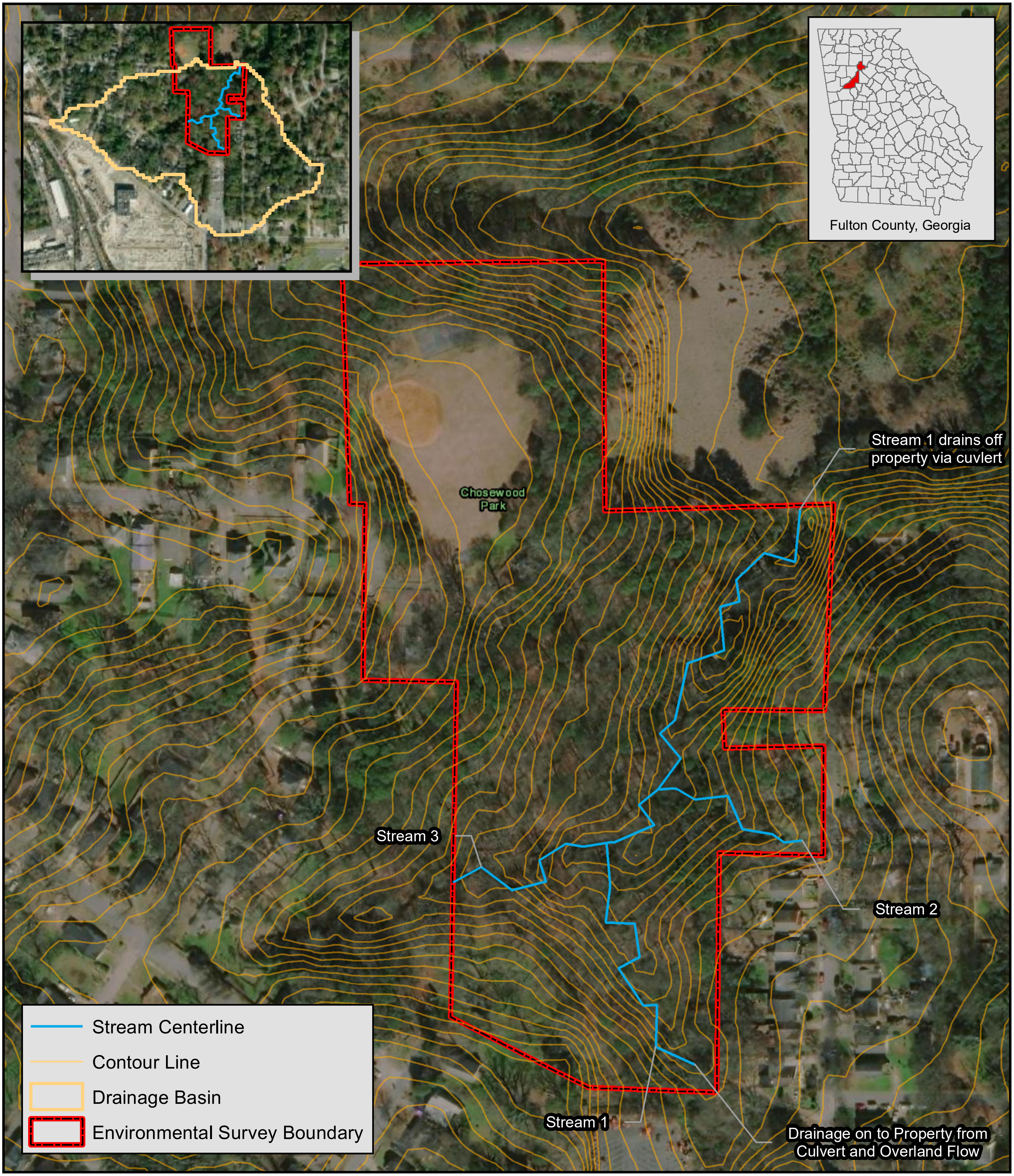
Figure 1
Project Location Map

Chosewood Park - BEHI & NBS Stream Assessment
Atlanta, Fulton County, Georgia
December 2021

0 1,250 2,500 Feet

0 435 870 Meters

1 in = 2,500 ft



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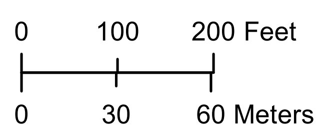
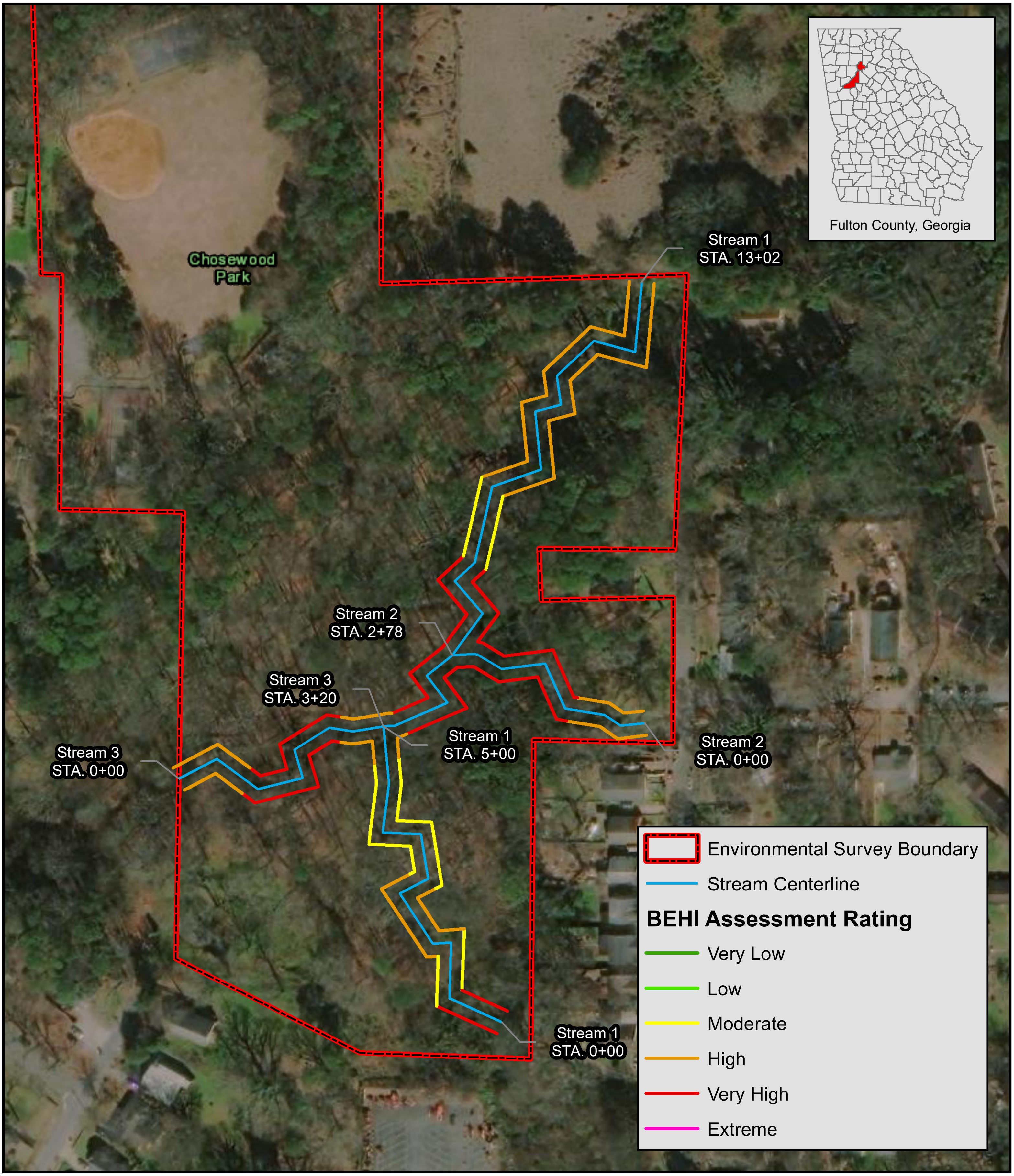
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS

Figure 2
Project Overview Map

Chosewood Park - BEHI & NBS Stream Assessment
Atlanta, Fulton County, Georgia
December 2021



1 in = 200 ft



Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN,

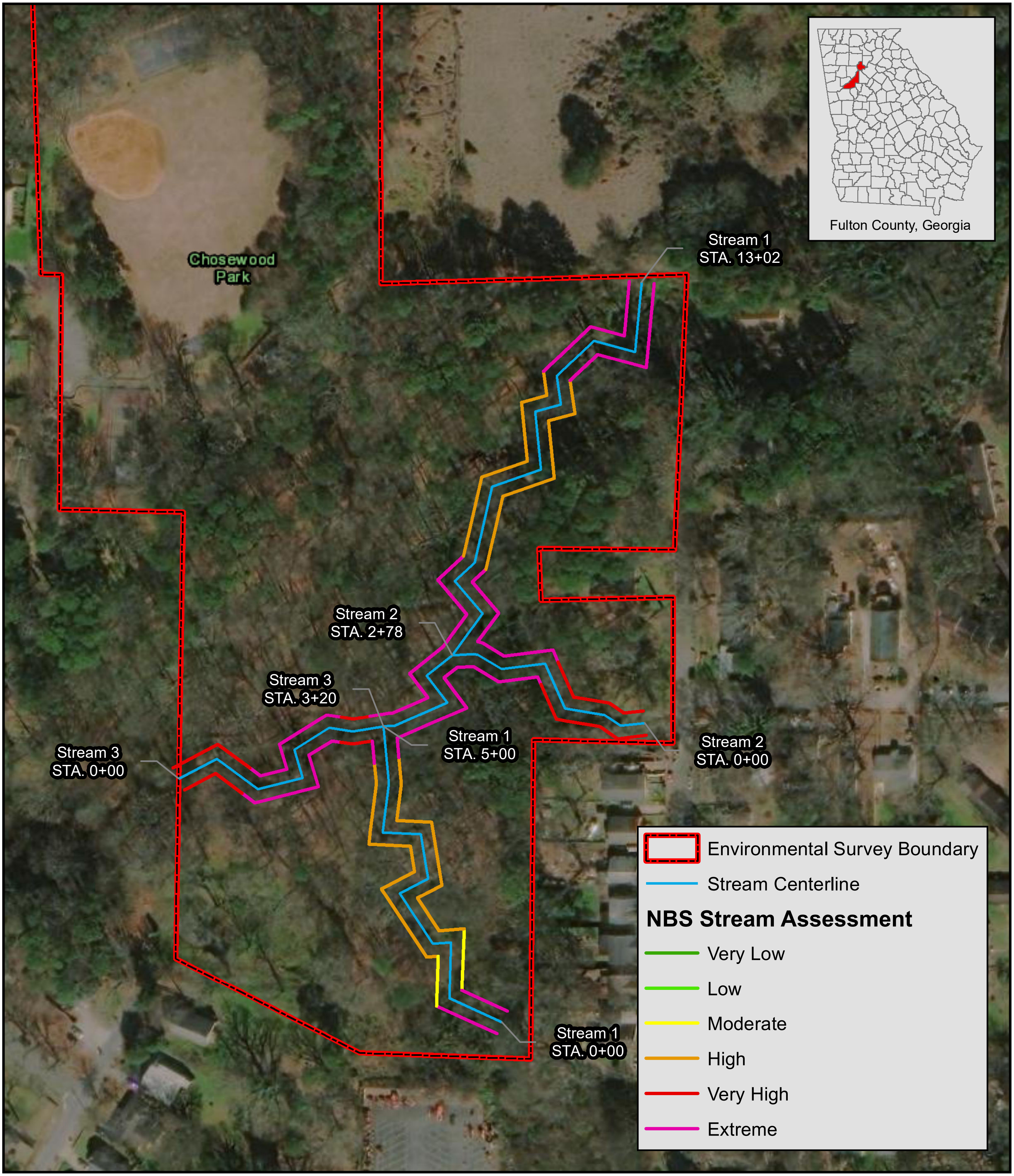
Figure 3
Bank Erosion Hazard Index Map

Chosewood Park - BEHI & NBS Stream Assessment
Atlanta, Fulton County, Georgia
December 2021

POND

0 75 150 Feet
0 25 50 Meters

1 in = 150 ft



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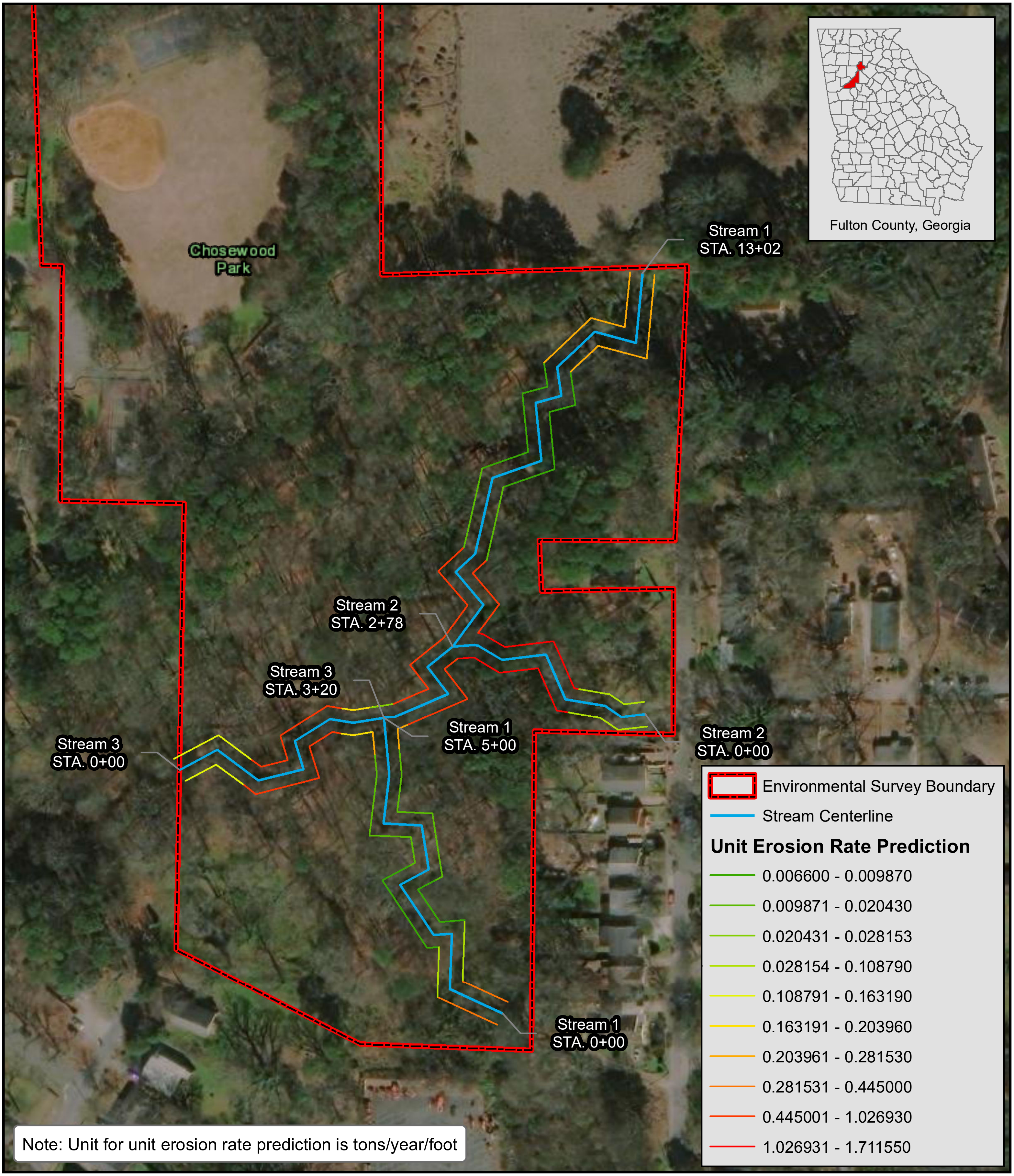
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN,

Figure 4
Near Bank Stress Map

Chosewood Park - BEHI & NBS Stream Assessment
Atlanta, Fulton County, Georgia
December 2021

0 75 150 Feet
0 25 50 Meters
1 in = 150 ft

POND



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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN,

Figure 5
Erosion Prediction Map

Chosewood Park - BEHI & NBS Stream Assessment
Atlanta, Fulton County, Georgia
December 2021

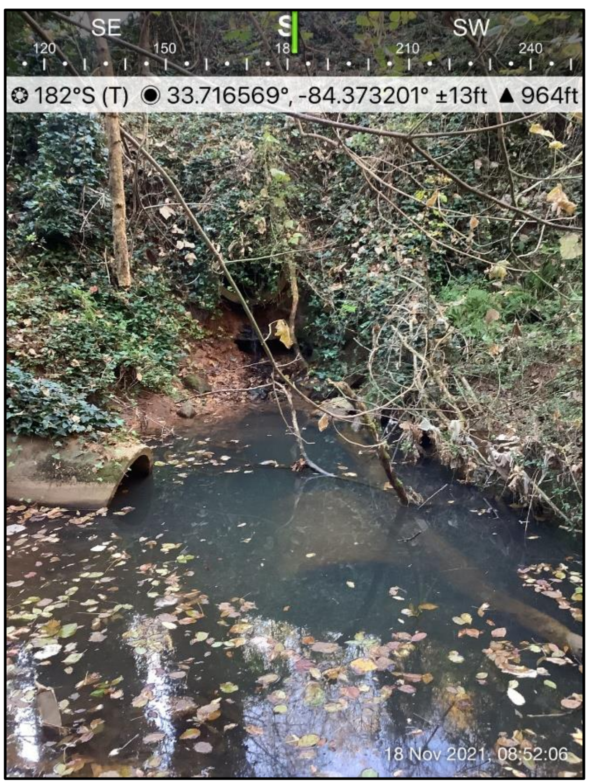
POND

0 75 150 Feet
0 25 50 Meters
1 in = 150 ft

ATTACHMENT B: PHOTOGRAPH LOG

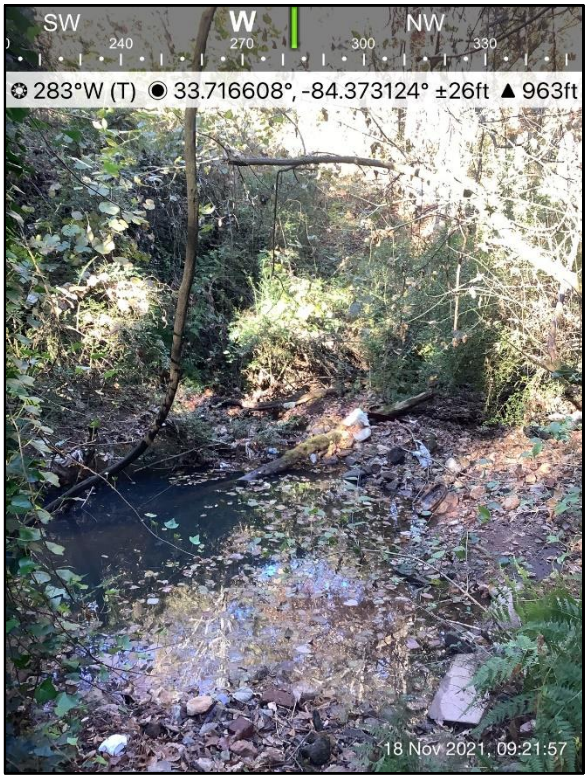
Photograph 1: Erosional drainage feature adjacent to abandoned culvert structure looking upstream along Stream 1

Photograph 2: Erosional drainage feature adjacent to abandoned culvert structure looking upstream along Stream 1

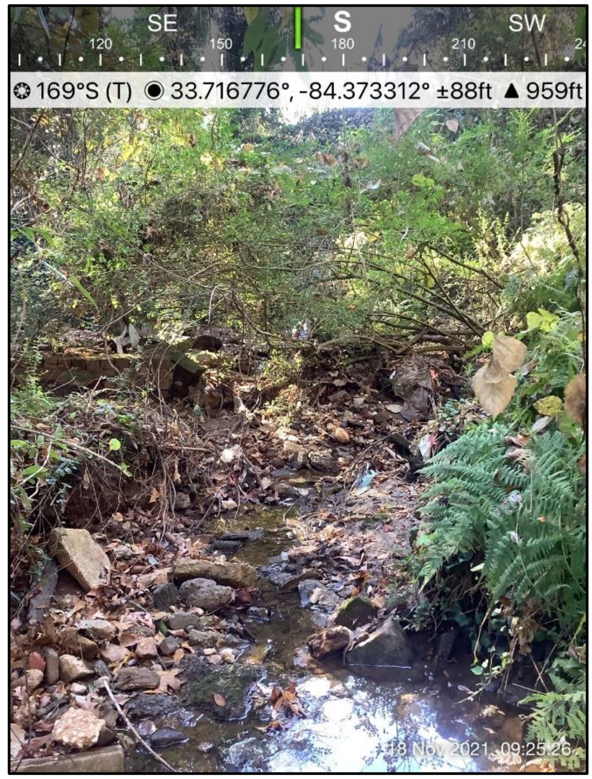


Photograph 3: Primary culvert structure draining to Stream 1 looking upstream at erosional plunge pool and relic culvert structure in the foreground

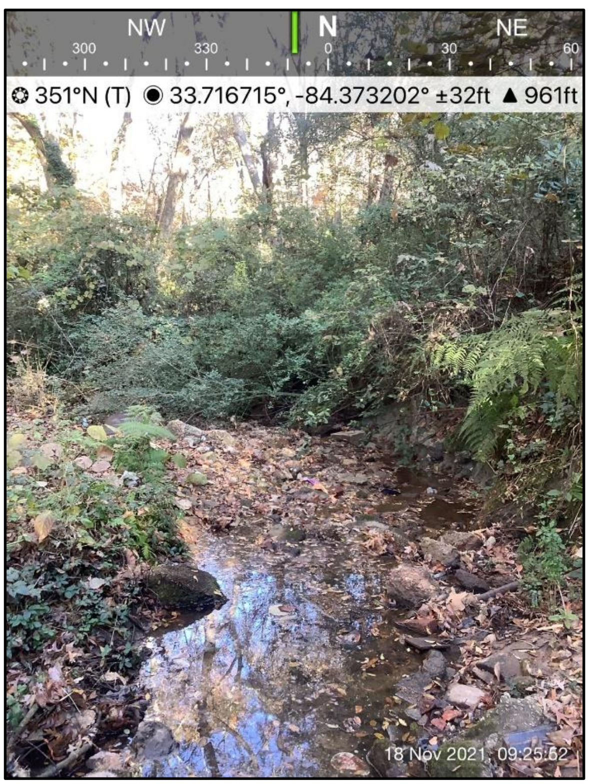
Photograph 4: Non-functional culvert structure for drainage shown in photographs 1-3



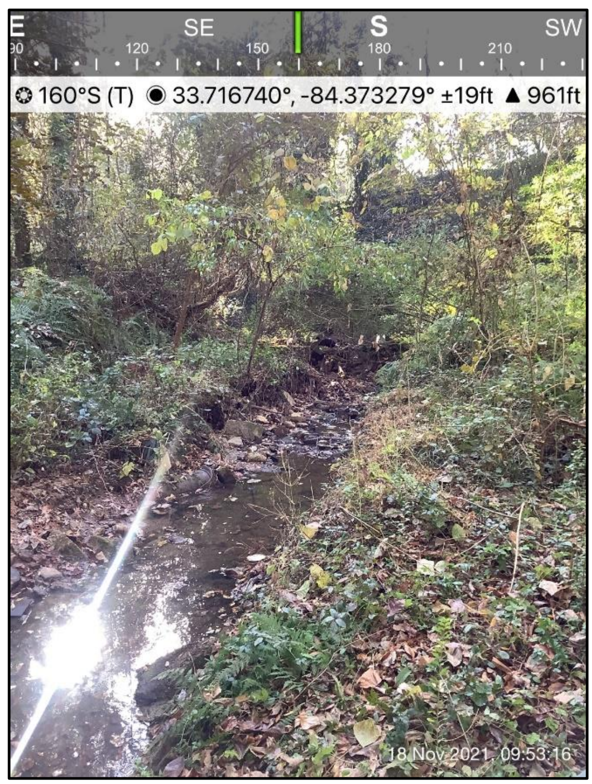
Photograph 5: Plunge pool feature from outlet of primary culvert drainage structure along Stream 1 looking downstream



Photograph 6: Stream 1 looking upstream at approx. Sta. 0+80



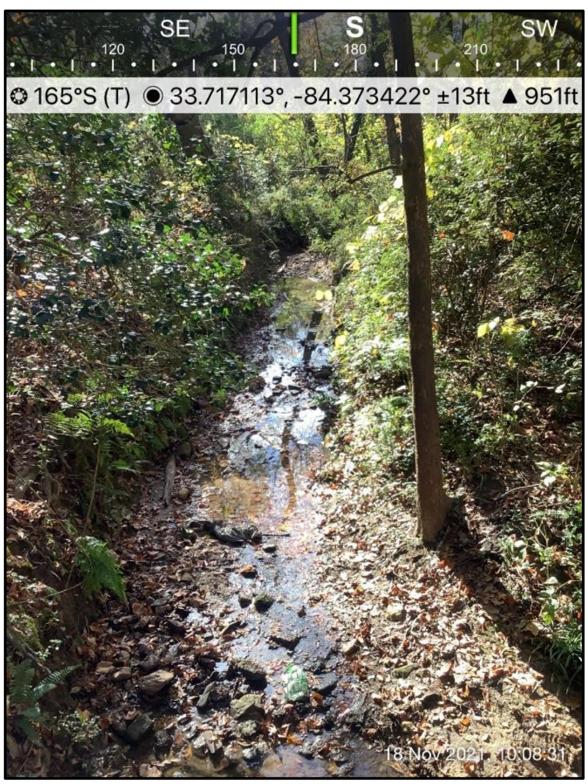
Photograph 7: Stream 1 looking downstream at approx. Sta. 1+40



Photograph 8: Stream 1 looking upstream at approx. Sta. 1+70

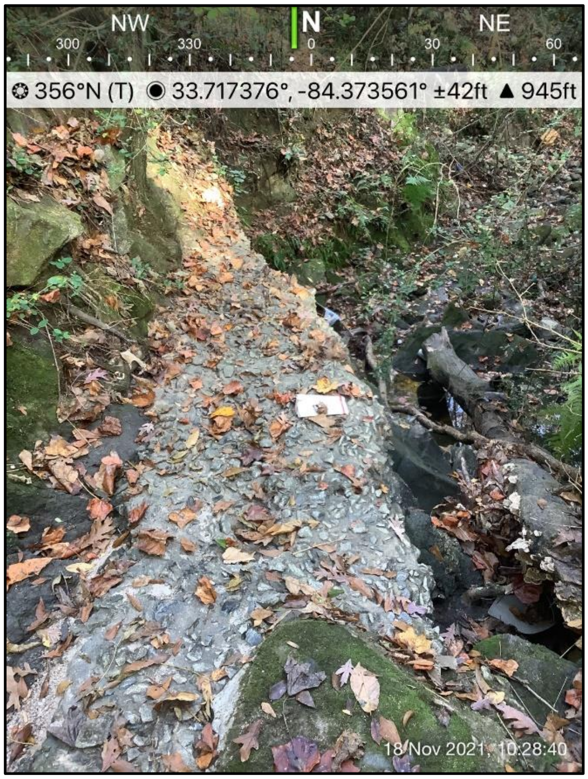
Photograph 9: Stream 1 looking at left bank at approx. Sta. 2+00

Photograph 10: Stream 1 looking at left bank at approx. Sta. 2+20

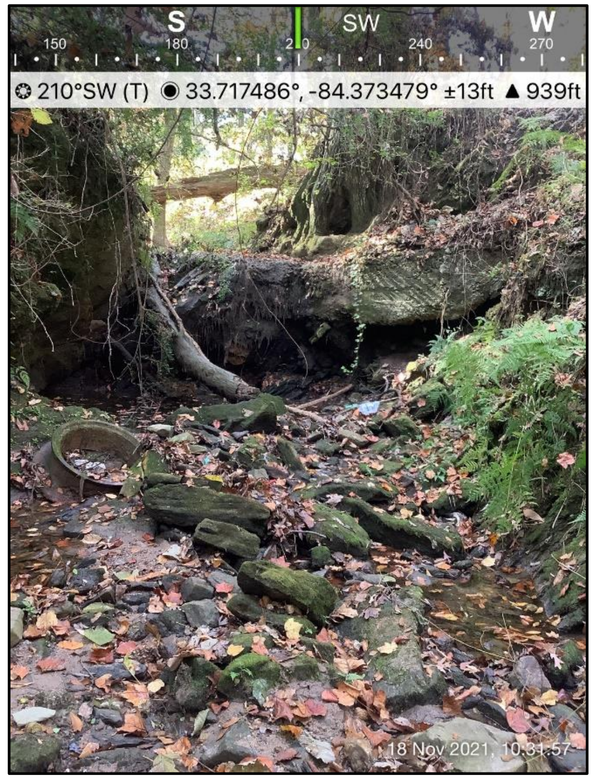


Photograph 11: Stream 1 looking upstream at approx. Sta. 3+40

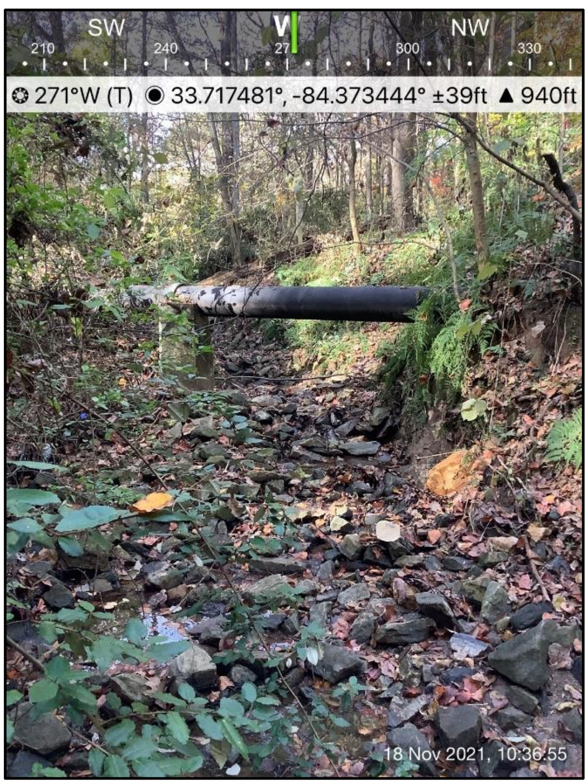
Photograph 12: Stream 1 looking downstream at approx. Sta. 4+20



Photograph 13: Concrete pipe protection over sanitary sewer line at large headcut along Stream 1 at approx. Sta. 4+70



Photograph 14: Large headcut along Stream 1 near confluence with Stream 3 and sanitary sewer crossing at approx. Sta. 5+00

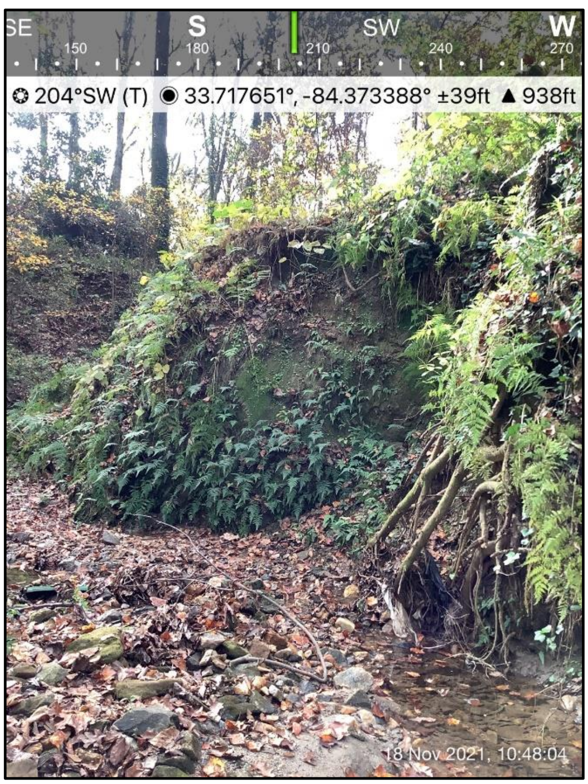


Photograph 15: Sanitary sewer crossing near confluence of Stream 1 and Stream 3 at approx. Sta. 5+00

Photograph 16: Stream 1 looking upstream at actively eroding stream bank at approx. Sta. 5+60

Photograph 17: Stream 1 looking downstream at erosional stream bank at approx. Sta. 5+70

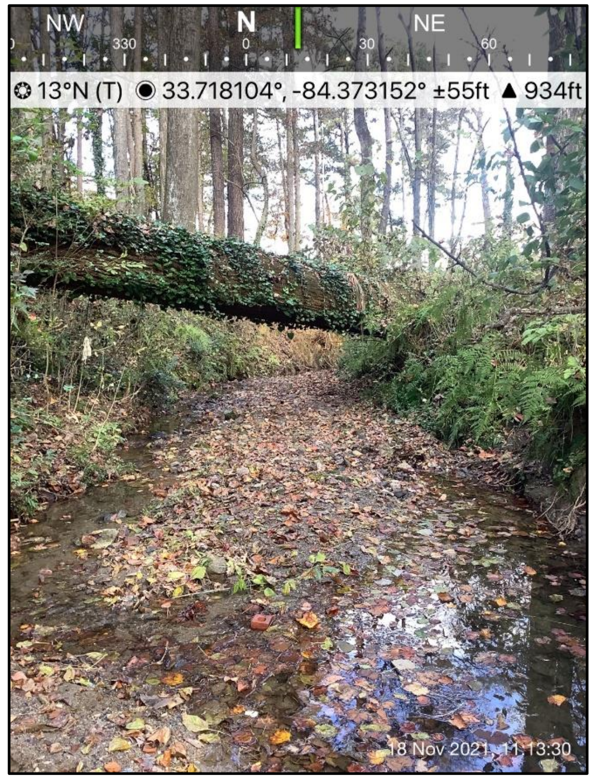
Photograph 18: Stream 1 looking downstream near confluence with Stream 2 at approx. Sta. 6+60



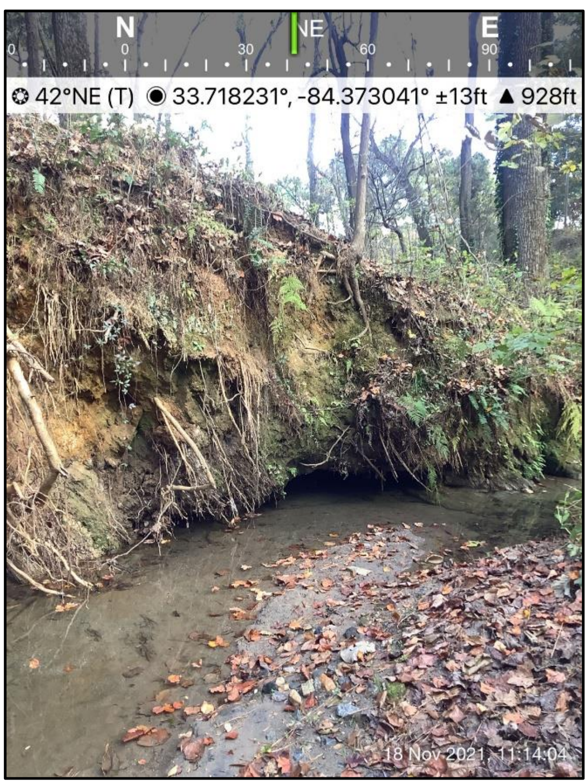
Photograph 19: Stream 1 looking upstream near confluence with Stream 2 at approx. Sta. 6+60

Photograph 20: Stream 1 looking downstream at undercut bank with active erosion at approx. Sta. 7+00

Photograph 21: Stream 1 looking downstream at sanitary sewer crossing at approx. Sta. 7+40



Photograph 22: Stream 1 looking downstream at approx. Sta. 8+40



Photograph 23: Stream 1 looking downstream at actively eroding left bank at approx. Sta. 9+00

Photograph 24: Stream 1 looking downstream at approx. Sta. 9+60

Photograph 25: Stream 1 looking at left bank at approx. Sta. 10+90

Photograph 26: Stream 1 looking downstream at approx. Sta. 11+00

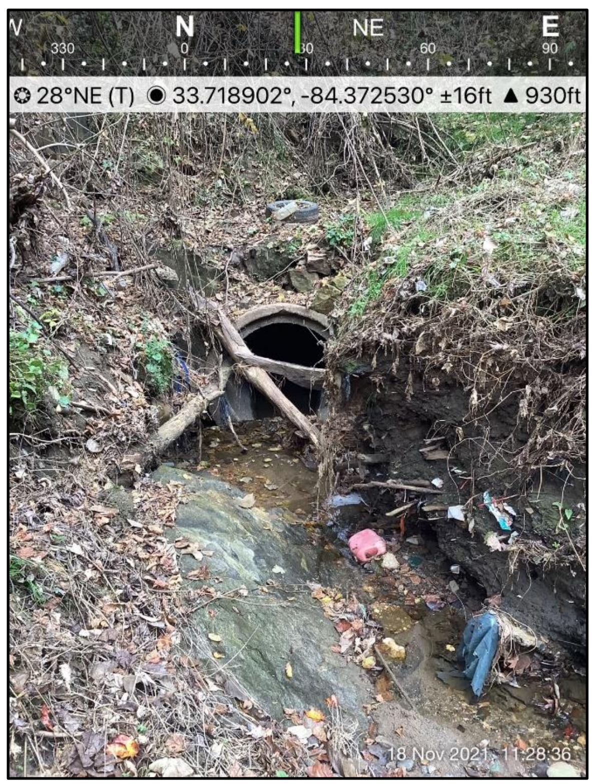
Photograph 27: Stream 1 looking downstream at approx. Sta. 11+10

Photograph 28: Stream 1 looking upstream at sanitary sewer crossing

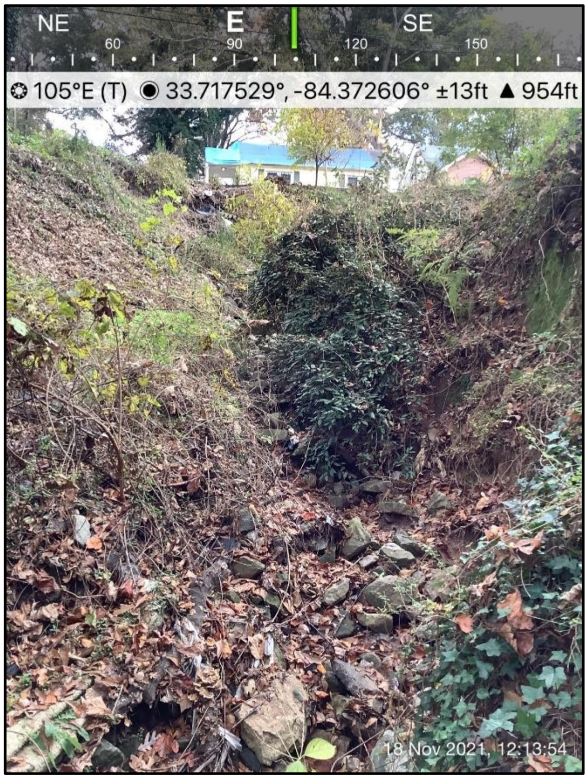
Photograph 29: Stream 1 looking downstream at failing headwall and culvert outlet in right bank at approx. Sta. 12+40

Photograph 30: Stream 1 looking downstream at approx. Sta. 12+50

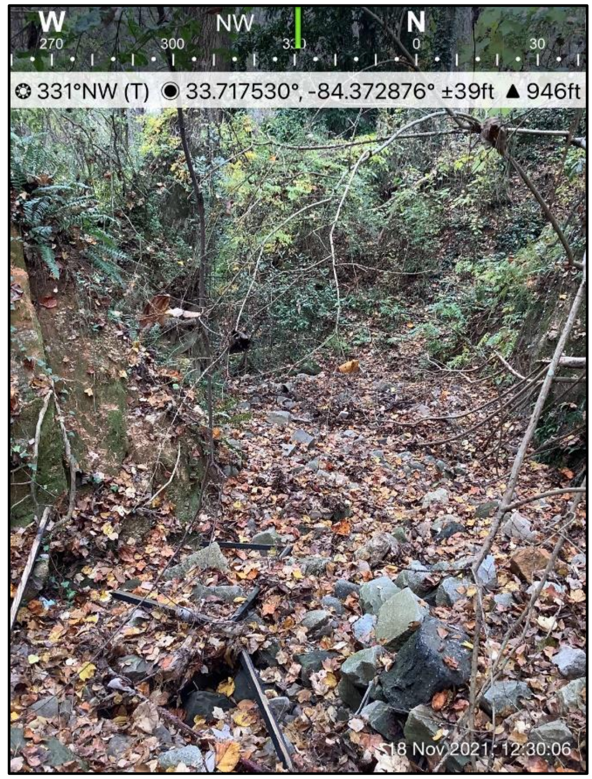
Photograph 31: Stream 1 looking upstream at approx. Sta. 12+80



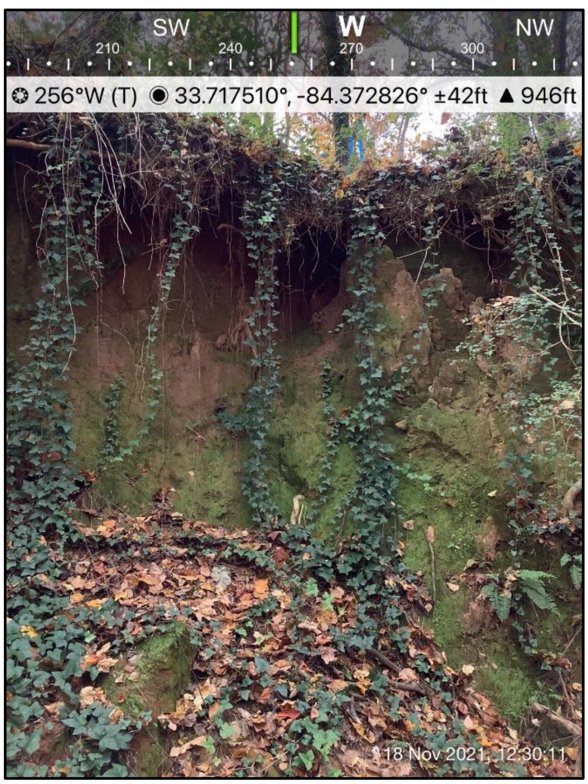
Photograph 32: Stream 1 looking downstream at culvert inlet near property line at approx. Sta. 13+00



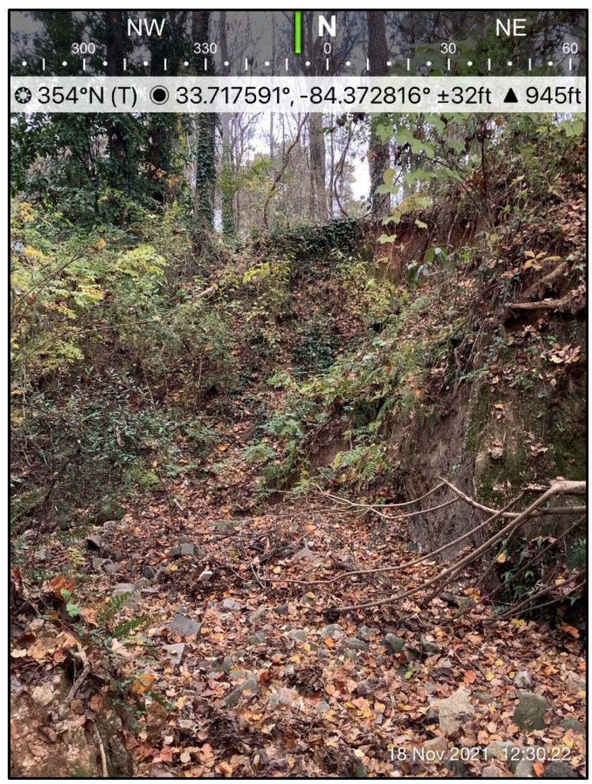
Photograph 33: Stream 2 looking upstream toward culvert outlets near property line at approx. Sta. 0+30



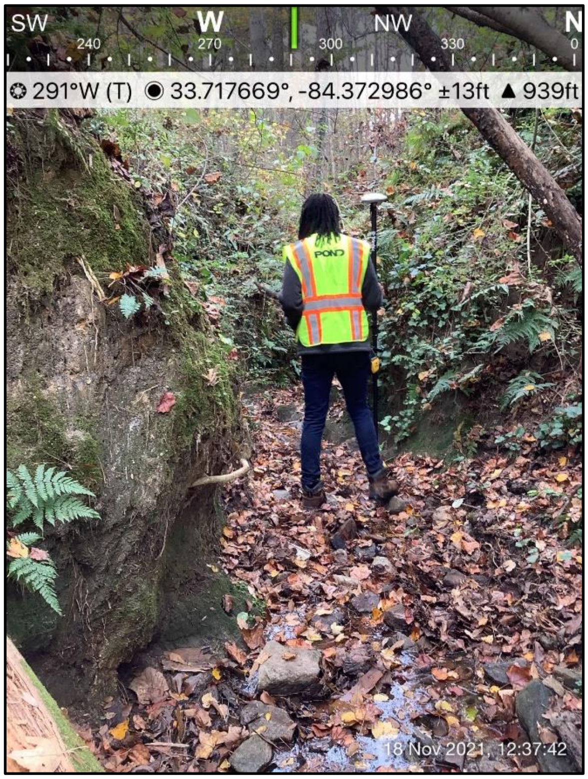
Photograph 34: Stream 2 looking downstream at approx. Sta. 1+10



Photograph 35: Stream 2 looking at left bank at approx. Sta. 1+10

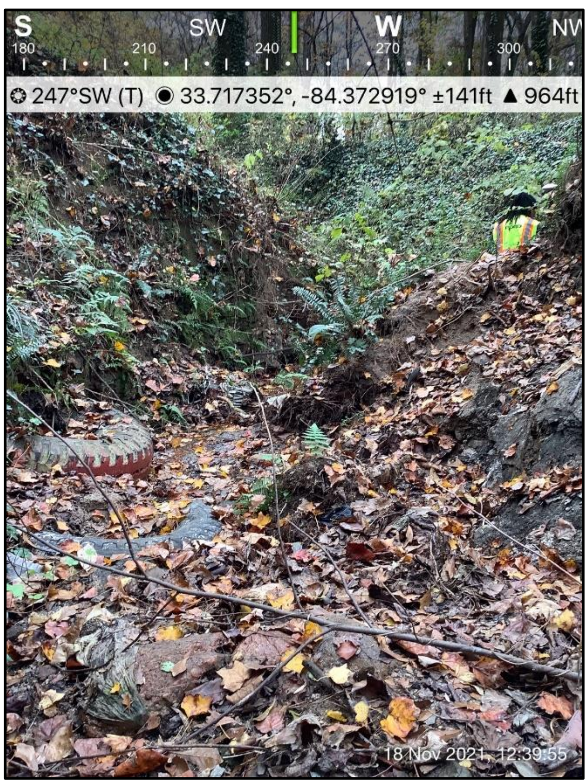


Photograph 36: Stream 2 looking downstream at approx. Sta. 1+30



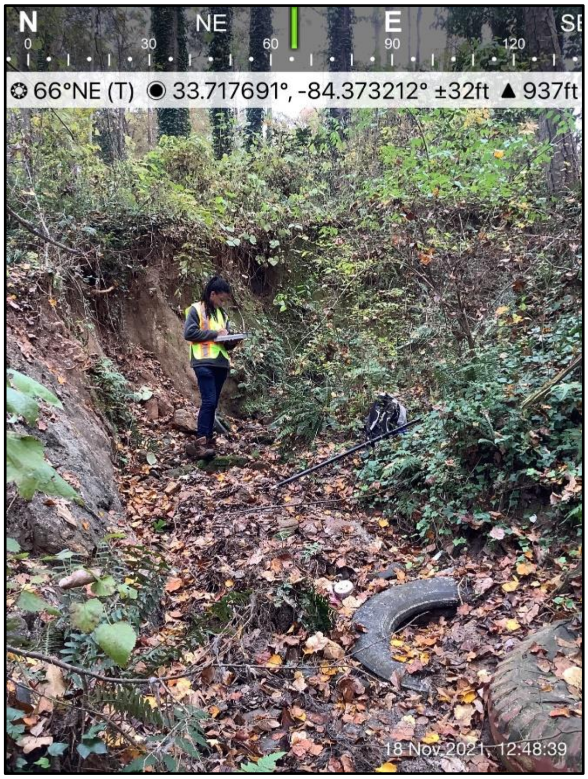
Photograph 37: Stream 2 looking downstream at approx. Sta. 2+30

Photograph 38: Stream 2 looking downstream at approx. Sta. 2+40



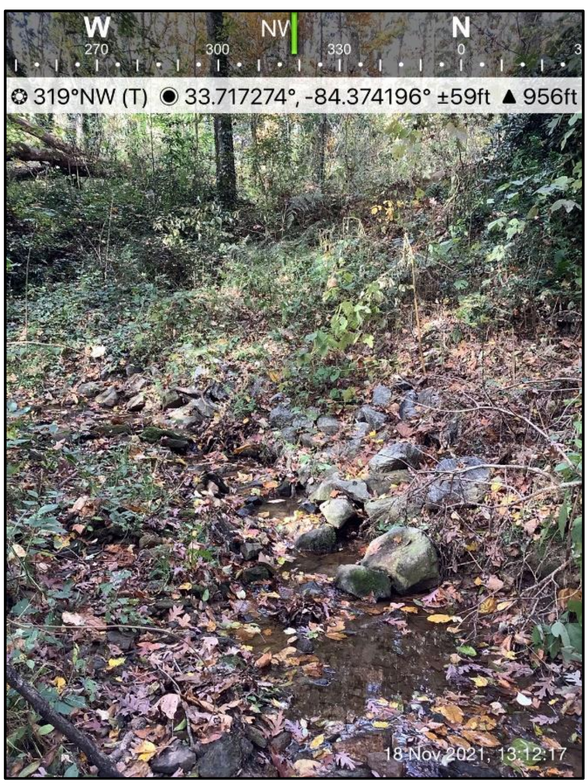
Photograph 39: Stream 2 looking downstream at approx. Sta. 2+50

Photograph 40: Stream 2 looking at left bank at approx. Sta. 2+60

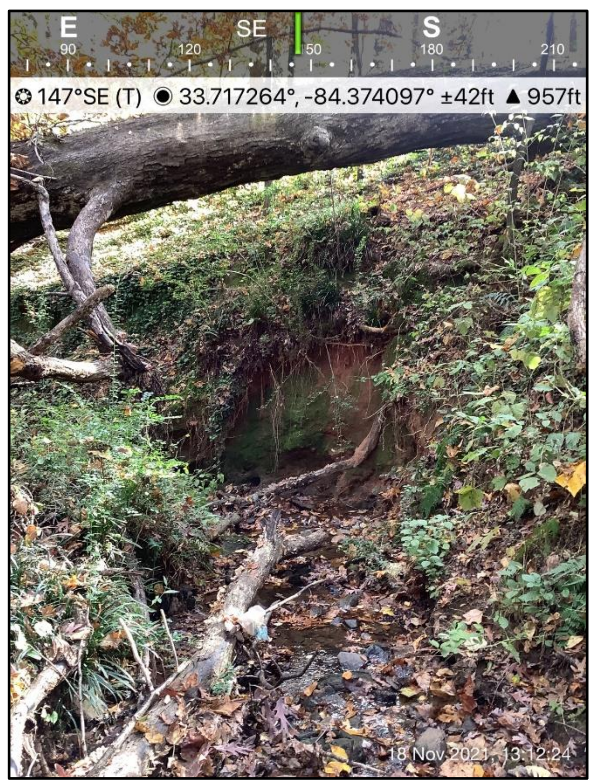


Photograph 41: Stream 2 looking upstream near confluence with Stream 1 at approx. Sta. 2+78

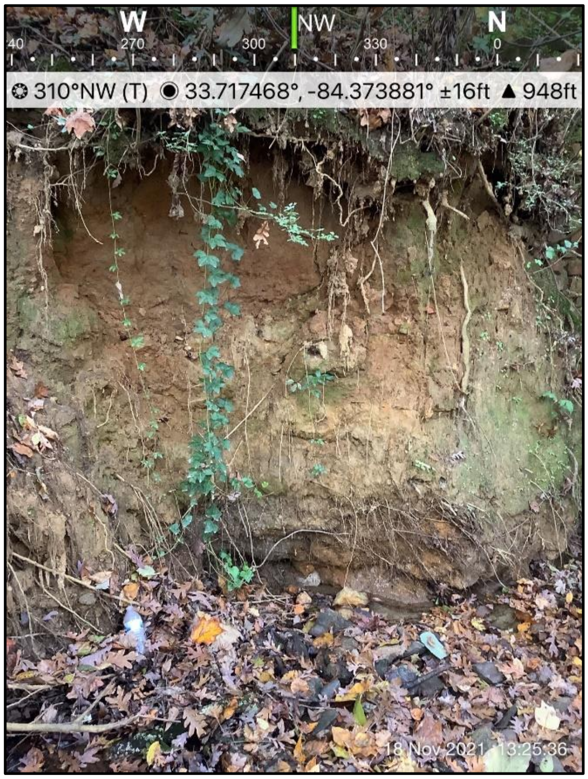
Photograph 42: Stream 3 looking upstream near property line at approx. Sta. 0+00



Photograph 43: Stream 3 looking downstream at approx. Sta. 0+20

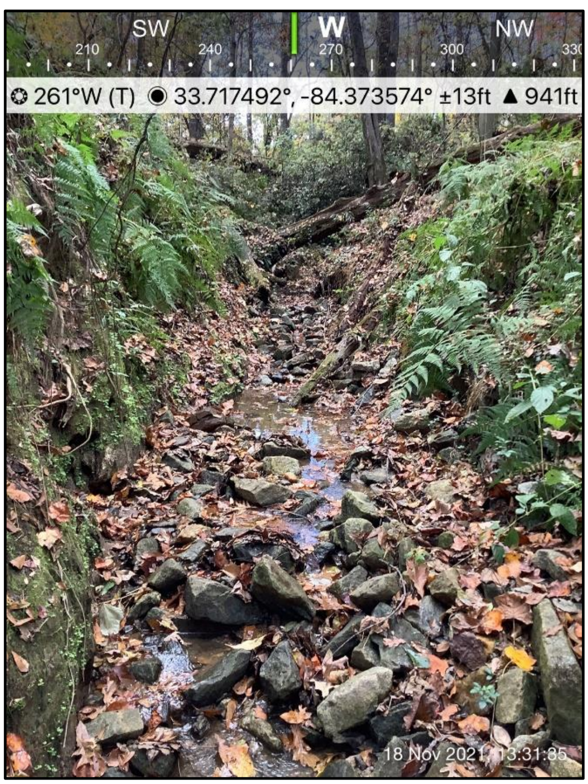


Photograph 44: Stream 3 looking downstream at approx. Sta. 1+00



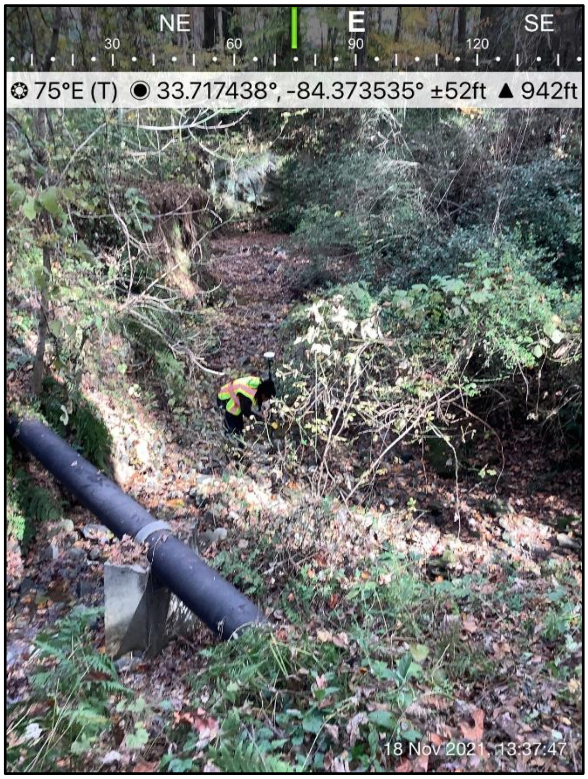
Photograph 45: Stream 3 looking at left bank at approx. Sta. 2+10

Photograph 46: Stream 3 looking downstream at sanitary sewer crossing near Sta. 2+20

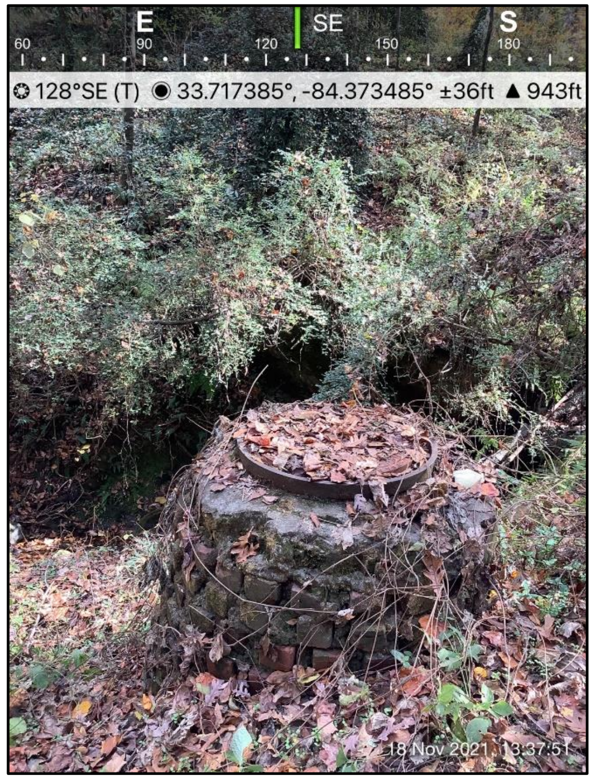


Photograph 47: Stream 3 looking upstream at approx. Sta. 2+80

Photograph 48: Stream 3 looking downstream at sanitary sewer crossing near confluence with Stream 1 (approx. Sta. 3+10)



Photograph 49: Looking from top of bank at confluence of Stream 1 and Stream 3



Photograph 50: Sanitary sewer structure adjacent to Stream 1 and Stream 3

ATTACHMENT C: BEHI AND NBS CALCULATION SUMMARY TABLES

Worksheet 3-13. Annual streambank erosion estimates for various study reaches.

Streambank Erosion Prediction

Stream: **Stream 1** Location: **Chosewood Park**

Graph Used: **NCSU Piedmont Curve** Total Stream Length (ft): **1302** Date: **11/18/2021**

Observers: **Alex Darr, Mani Walcott** Landscape Type: C-AL-AD Stream Type: **G4**

(1) Station (ft)	(2) BEHI Rating (Worksheet 3-11) (adjective)	(3) NBS Rating (Worksheet 3-12) (adjective)	(4) Bank Erosion Rate (Figure 3-9 or 3-10) (ft/yr)	(5) Length of Bank (ft)	(6) Study Bank Height (ft)	(7) Erosion Subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Unit Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. **0**	**Very High**	**Extreme**	**1.4219**	**140.00**	**7**	**1293.93**	**0.44500**
2. **70**	**Moderate**	**Moderate**	**0.4070**	**100.00**	**4**	**162.80**	**0.07839**
3. **120**	**High**	**High**	**0.0205**	**280.00**	**7**	**38.38**	**0.00660**
4. **260**	**Moderate**	**High**	**0.1061**	**240.00**	**4**	**91.67**	**0.01839**
5. **380**	**Moderate**	**High**	**0.1061**	**160.00**	**4**	**67.90**	**0.02043**
6. **460**	**High**	**Extreme**	**0.3898**	**120.00**	**15**	**701.66**	**0.28153**
7. **520**	**Very High**	**Extreme**	**1.4219**	**220.00**	**12**	**3753.82**	**0.82154**
8. **630**	**Very High**	**Extreme**	**1.4219**	**360.00**	**12**	**6142.61**	**0.82154**
9. **810**	**Moderate**	**High**	**0.1061**	**180.00**	**4**	**76.39**	**0.02043**
10. **900**	**High**	**High**	**0.0205**	**400.00**	**10**	**82.00**	**0.00987**
11. **1100**	**High**	**Extreme**	**0.3898**	**404.00**	**15**	**2362.19**	**0.28152**
12. **1302**							
13.							
14.							
15.							

Sum erosion subtotals in Column (7) for each BEHI/NBS combination	**Total Erosion (ft^3/yr)**	**14773.35**
Convert erosion in ft^3/yr to yds^3/yr {divide *Total Erosion (ft^3/yr)* by 27}	**Total Erosion (yds^3/yr)**	**547.16**
Convert erosion in yds^3/yr to tons/yr {multiply *Total Erosion (yds^3/yr)* by 1.3}	**Total Erosion (tons/yr)**	**711.31**
Calculate erosion per unit length of channel {divide *Total Erosion (tons/yr)* by *Total Stream Length (ft)* surveyed}	**Unit Erosion Rate (tons/yr/ft)**	**0.54632**

Worksheet 3-13. Annual streambank erosion estimates for various study reaches.

Streambank Erosion Prediction

Stream:	**Stream 2**			Location: **Chosewood Park**			
Graph Used:	**NCSU Piedmont Curve**		Total Stream Length (ft):		**278**		Date: **11/18/2021**
Observers:	**Alex Darr, Mani Walcott**			Landscape Type:	C-AL-AD	Stream Type: **G5**	

(1) Station (ft)	(2) BEHI Rating (Worksheet 3-11) (adjective)	(3) NBS Rating (Worksheet 3-12) (adjective)	(4) Bank Erosion Rate (Figure 3-9 or 3-10) (ft/yr)	(5) Length of Bank (ft)	(6) Study Bank Height (ft)	(7) Erosion Subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Unit Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. **0**	**High**	**Very High**	**0.2824**	**170.00**	**8.00**	**384.12**	**0.10879**
2. **85**	**Very High**	**Very High**	**1.1391**	**224.00**	**25.00**	**6378.96**	**1.37114**
3. **197**	**Very High**	**Extreme**	**1.4219**	**162.00**	**25.0**	**5758.70**	**1.71155**
4. **278**							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**12521.77**	
Convert erosion in ft^3/yr to yds^3/yr {divide *Total Erosion (ft^3/yr)* by 27}					**Total Erosion (yds^3/yr)**	**463.77**	
Convert erosion in yds^3/yr to tons/yr {multiply *Total Erosion (yds^3/yr)* by 1.3}					**Total Erosion (tons/yr)**	**602.90**	
Calculate erosion per unit length of channel {divide *Total Erosion (tons/yr)* by *Total Stream Length (ft)* surveyed}					**Unit Erosion Rate (tons/yr/ft)**	**2.16871**	

Worksheet 3-13. Annual streambank erosion estimates for various study reaches.

Streambank Erosion Prediction

Stream: **Stream 3** Location: **Chosewood Park**

Graph Used: **NCSU Piedmont Curve** Total Stream Length (ft): **320** Date: **11/18/2021**

Observers: **Alex Darr, Mani Walcott** Landscape Type: C-AL-D Stream Type: **G3**

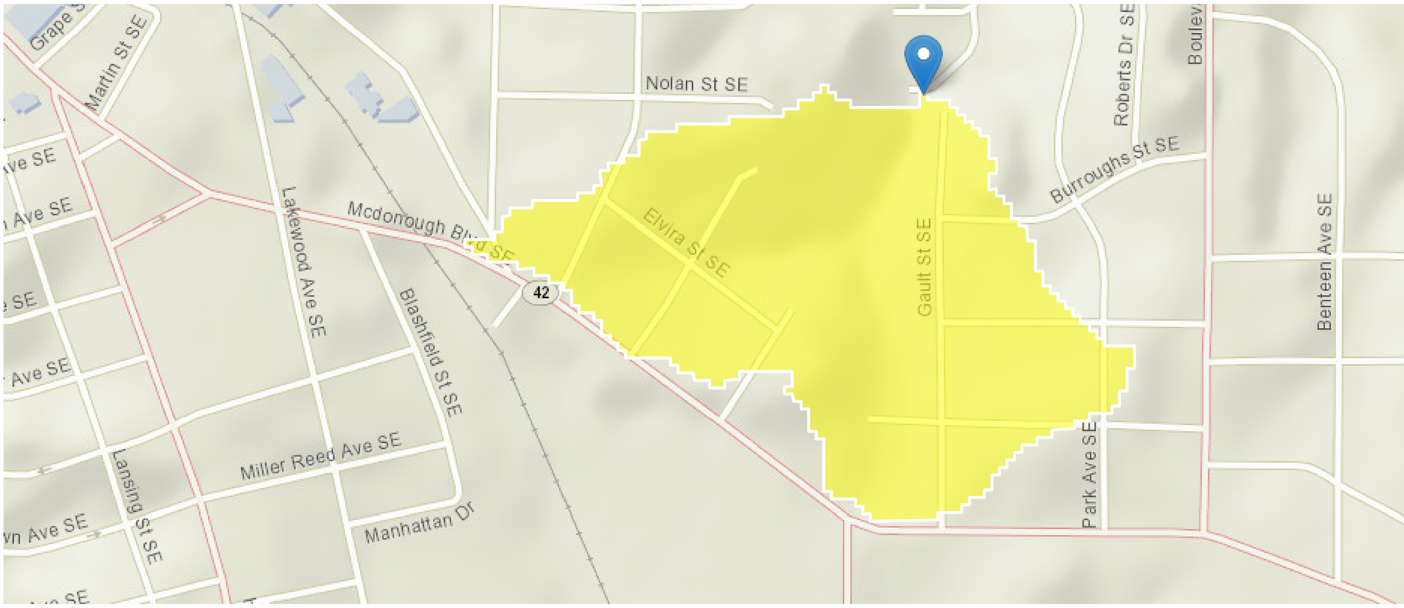
(1) Station (ft)	(2) BEHI Rating (Worksheet 3-11) (adjective)	(3) NBS Rating (Worksheet 3-12) (adjective)	(4) Bank Erosion Rate (Figure 3-9 or 3-10) (ft/yr)	(5) Length of Bank (ft)	(6) Study Bank Height (ft)	(7) Erosion Subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Unit Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. 0	High	Very High	0.2824	200.00	12.00	677.86	0.16319
2. 100	Very High	Extreme	1.4219	340.00	15.00	7251.69	1.02693
3. 270	High	Very High	0.2824	100.00	15.00	423.60	0.20396
4. 320							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							

Sum erosion subtotals in Column (7) for each BEHI/NBS combination	Total Erosion (ft^3/yr)	8353.15
Convert erosion in ft^3/yr to yds^3/yr {divide *Total Erosion (ft^3/yr)* by 27}	Total Erosion (yds^3/yr)	309.38
Convert erosion in yds^3/yr to tons/yr {multiply *Total Erosion (yds^3/yr)* by 1.3}	Total Erosion (tons/yr)	402.19
Calculate erosion per unit length of channel {divide *Total Erosion (tons/yr)* by *Total Stream Length (ft)* surveyed}	Unit Erosion Rate (tons/yr/ft)	1.25684

ATTACHMENT D: U.S. GEOLOGICAL SURVEY STREAMSTATS REPORT

Chosewood Park BEHI & NBS Study

Region ID: GA
Workspace ID: GA20211116144933662000
Clicked Point (Latitude, Longitude): 33.71903, -84.37259
Time: 2021-11-16 09:49:58 -0500



Friends of Chosewood Park, Atlanta, Georgia

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.1	square miles
PRECPRIS00	Basin average mean annual precipitation for 1971 to 2000 from PRISM	51.8	inches
PCTREG1	Percentage of drainage area located in Region 1 - Piedmont / Ridge and Valley	100	percent
PCTREG2	Percentage of drainage area located in Region 2 - Blue Ridge	0	percent
PCTREG3	Percentage of drainage area located in Region 3 - Sandhills	0	percent
PCTREG4	Percentage of drainage area located in Region 4 - Coastal Plains	0	percent
PCTREG5	Percentage of drainage area located in Region 5 - Lower Tifton Uplands	0	percent
LC06IMP	Percentage of impervious area determined from NLCD 2006 impervious dataset	19.2	percent
RRMEAN	Relief ratio defined as (ELEV-MINBELEV)/(ELEVMAX-MINBELEV)	0.599	dimensionless
BSLDEM10M	Mean basin slope computed from 10 m DEM	10.606	percent
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	239	feet per mi
ELEV	Mean Basin Elevation	979	feet
ELEVMAX	Maximum basin elevation	1027	feet
GWHEAD	Mean basin elevation minus minimum basin elevation	72.3	feet
I24H100Y	Maximum 24-hour precipitation that occurs on average once in 100 years	7.55	inches

Parameter Code	Parameter Description	Value	Unit
I24H10Y	Maximum 24-hour precipitation that occurs on average once in 10 years	5.05	inches
I24H25Y	Maximum 24-hour precipitation that occurs on average once in 25 years	5.98	inches
I24H50Y	Maximum 24-hour precipitation that occurs on average once in 50 years	6.74	inches
LC06AGRI	Percent agriculture computed as total of grass, pasture, and crops, NLCD classes 71, 81 and 82	0	percent
LC06DEV	Percentage of land-use from NLCD 2006 classes 21-24	87.415	percent
LC06FOREST	Percentage of forest from NLCD 2006 classes 41-43	11.946	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	88.2	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	21.3	percent
MINBELEV	Minimum basin elevation	907	feet
RELIEF	Maximum - minimum elevation	121	feet

Peak-Flow Statistics Parameters [Region 1 rural under 1 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.1	square miles	0.1	1
LC06IMP	Percent Impervious NLCD2006	19.2	percent	0	47.9

Peak-Flow Statistics Flow Report [Region 1 rural under 1 sqmi 2014 5030]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	ASEp
50-percent AEP flood	57.4	ft^3/s	30.2	109	31.9
20-percent AEP flood	79.9	ft^3/s	47.5	134	25.4
10-percent AEP flood	94	ft^3/s	57	155	25
4-percent AEP flood	110	ft^3/s	63.6	190	27
2-percent AEP flood	121	ft^3/s	66.9	219	29.3
1-percent AEP flood	132	ft^3/s	68.8	253	32.1
0.5-percent AEP flood	141	ft^3/s	69.6	286	35.1
0.2-percent AEP flood	160	ft^3/s	75	341	37.5

Peak-Flow Statistics Citations

Feaster, T.D., Gotvald, A.J., and Weaver, J.C.,2014, Methods for estimating the magnitude and frequency of floods for urban and small, rural streams in Georgia, South Carolina, and North Carolina, 2011 (ver. 1.1, March 2014): U.S. Geological Survey Scientific Investigations Report 2014–5030, 104 p. (http://pubs.usgs.gov/sir/2014/5030/)

Annual Flow Statistics Parameters [N Georgia mean flow 2017 5001]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.1	square miles	1.67	576
PRECPRIS00	Mean Annual Precip PRISM 1971 2000	51.8	inches	47.6	81.6

Annual Flow Statistics Disclaimers [N Georgia mean flow 2017 5001]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Annual Flow Statistics Flow Report [N Georgia mean flow 2017 5001]

Statistic	Value	Unit
Mean Annual Flow	0.115	ft^3/s

Annual Flow Statistics Citations

Gotvald, A.J.,2017, Methods for estimating selected low-flow frequency statistics and mean annual flow for ungaged locations on streams in North Georgia: U.S. Geological Survey Scientific Investigations Report 2017–5001, 25 p. (https://doi.org/10.3133/sir20175001)

Low-Flow Statistics Parameters [N Georgia low flow 2017 5001]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.1	square miles	1.67	576
PRECPRIS00	Mean Annual Precip PRISM 1971 2000	51.8	inches	47.6	81.6
RRMEAN	Relief Ratio Mean	0.599	dimensionless	0.146	0.607

Low-Flow Statistics Disclaimers [N Georgia low flow 2017 5001]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Low-Flow Statistics Flow Report [N Georgia low flow 2017 5001]

Statistic	Value	Unit
1 Day 10 Year Low Flow	0.000808	ft^3/s
7 Day 10 Year Low Flow	0.00114	ft^3/s

Low-Flow Statistics Citations

Gotvald, A.J.,2017, Methods for estimating selected low-flow frequency statistics and mean annual flow for ungaged locations on streams in North Georgia: U.S. Geological Survey Scientific Investigations Report 2017–5001, 25 p. (https://doi.org/10.3133/sir20175001)

Monthly Flow Statistics Parameters [N Georgia low flow 2017 5001]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.1	square miles	1.67	576
PRECPRIS00	Mean Annual Precip PRISM 1971 2000	51.8	inches	47.6	81.6
RRMEAN	Relief Ratio Mean	0.599	dimensionless	0.146	0.607

Monthly Flow Statistics Disclaimers [N Georgia low flow 2017 5001]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Monthly Flow Statistics Flow Report [N Georgia low flow 2017 5001]

Statistic	Value	Unit

Statistic	Value	Unit
Jan 7 Day 10 Year Low Flow	0.0262	ft^3/s
Feb 7 Day 10 Year Low Flow	0.0397	ft^3/s
Mar 7 Day 10 Year Low Flow	0.0449	ft^3/s
Apr 7 Day 10 Year Low Flow	0.0328	ft^3/s
May 7 Day 10 Year Low Flow	0.017	ft^3/s
Jun 7 Day 10 Year Low Flow	0.00894	ft^3/s
Jul 7 Day 10 Year Low Flow	0.00395	ft^3/s
Aug 7 Day 10 Year Low Flow	0.00202	ft^3/s
Sep 7 Day 10 Year Low Flow	0.00142	ft^3/s
Oct 7 Day 10 Year Low Flow	0.00192	ft^3/s
Nov 7 Day 10 Year Low Flow	0.00865	ft^3/s
Dec 7 Day 10 Year Low Flow	0.0153	ft^3/s

Monthly Flow Statistics Citations

Gotvald, A.J.,2017, Methods for estimating selected low-flow frequency statistics and mean annual flow for ungaged locations on streams in North Georgia: U.S. Geological Survey Scientific Investigations Report 2017–5001, 25 p. (https://doi.org/10.3133/sir20175001)

Bankfull Statistics Parameters [Appalachian Highlands D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.1	square miles	0.07722	940.1535

Bankfull Statistics Parameters [Piedmont P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.1	square miles	0.289575	939.99906

Bankfull Statistics Parameters [USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.1	square miles	0.07722	59927.7393

Bankfull Statistics Flow Report [Appalachian Highlands D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	5.84	ft
Bieger_D_channel_depth	0.579	ft
Bieger_D_channel_cross_sectional_area	3.41	ft^2

Bankfull Statistics Disclaimers [Piedmont P Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Bankfull Statistics Flow Report [Piedmont P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	5.36	ft

Statistic	Value	Unit
Bieger_P_channel_depth	0.561	ft
Bieger_P_channel_cross_sectional_area	2.77	ft^2

Bankfull Statistics Flow Report [USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	5.51	ft
Bieger_USA_channel_depth	0.738	ft
Bieger_USA_channel_cross_sectional_area	4.93	ft^2

Bankfull Statistics Flow Report [Area-Averaged]

Statistic	Value	Unit
Bieger_D_channel_width	5.84	ft
Bieger_D_channel_depth	0.579	ft
Bieger_D_channel_cross_sectional_area	3.41	ft^2
Bieger_P_channel_width	5.36	ft
Bieger_P_channel_depth	0.561	ft
Bieger_P_channel_cross_sectional_area	2.77	ft^2
Bieger_USA_channel_width	5.51	ft
Bieger_USA_channel_depth	0.738	ft
Bieger_USA_channel_cross_sectional_area	4.93	ft^2

Bankfull Statistics Citations

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub/1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF&utm_campaign=PDFCoverPages)

Urban Peak-Flow Statistics Parameters [Region 1 Urban under 3 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.1	square miles	0.1	3
LC06IMP	Percent Impervious NLCD2006	19.2	percent	0	47.9

Urban Peak-Flow Statistics Flow Report [Region 1 Urban under 3 sqmi 2014 5030]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	ASEp
Urban 50-percent AEP flood	57.4	ft^3/s	30.2	109	31.9
Urban 20-Percent AEP flood	79.9	ft^3/s	47.5	134	25.4
Urban 10-percent AEP flood	94	ft^3/s	57	155	25
Urban 4-percent AEP flood	110	ft^3/s	63.6	190	27
Urban 2-percent AEP flood	121	ft^3/s	66.9	219	29.3
Urban 1-percent AEP flood	132	ft^3/s	68.8	253	32.1

Statistic	Value	Unit	PII	Plu	ASEp
Urban 0.5-percent AEP flood	141	ft^3/s	69.6	286	35.1
Urban 0.2-percent AEP flood	160	ft^3/s	75	341	37.5

Urban Peak-Flow Statistics Citations

Feaster, T.D., Gotvald, A.J., and Weaver, J.C.,2014, Methods for estimating the magnitude and frequency of floods for urban and small, rural streams in Georgia, South Carolina, and North Carolina, 2011 (ver. 1.1, March 2014): U.S. Geological Survey Scientific Investigations Report 2014–5030, 104 p. (http://pubs.usgs.gov/sir/2014/5030/)

Rural Peak-Flow Statistics Parameters [Region 1 Urban over 3 sqmi 2014 5030]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.1	square miles	3	436
LC06IMP	Percent Impervious NLCD2006	19.2	percent	0	47.9

Rural Peak-Flow Statistics Flow Report [Region 1 Urban over 3 sqmi 2014 5030]

Statistic	Value	Unit

Rural Peak-Flow Statistics Citations

Application Version: 4.6.2
StreamStats Services Version: 1.2.22
NSS Services Version: 2.1.2