City Council

190 Church St., NE
Cleveland, TN 37312
www.clevelandtn.gov

AGENDA ITEM MEMORANDUM

TO: Mayor and City Council

FROM: Christopher Broom

DATE: 8/9/2021

RE: 2020-2021 TDEC Annual Report

SUMMARY:

Every year the Stormwater Division follows the requirements of the Tennessee Department of Environment and Conservation (TDEC) permit issued on April 3, 2017. In the permit the City outlines the measures it will take to meet the requirements of TDEC. These requirements are broken into five areas called Best Management Practices (BMP's). Those BMP's are listed below:

1) Public Education and Public Participation
2) Illicit Discharge Detection and Elimination
3) Construction Site Runoff Program
4) Post-Construction Stormwater Management Program
5) Municipal Pollution Prevention and Good Housekeeping

These requirements are the same year to year except for how many illicit discharges were reported, plans were reviewed, permanent stormwater management facilities were inspected, maintenance agreements were received, and enforcement actions were taken by the Stormwater Division. During the permit year July 1, 2020, to June 30, 2021, the stormwater staff has documented the following:

a) Nine (9) illicit discharges were reported.
b) Seventy-two (72) plans reviewed and approved.
c) One hundred sixty-three (163) permanent stormwater management facilities were inspected.
d) Twenty-four (24) stormwater maintenance agreements were received.
e) Sixteen (16) notices of violation were issued.
f) Zero (0) civil penalties were issued.

The City of Cleveland Stormwater Division received coverage under the current TDEC permit (expires September 30, 2021). The Stormwater Division was designated as a Qualified Local Program (QLP) by TDEC in 2017 and fully implemented the program in 2018. This designation allows Cleveland to issue permits on behalf of TDEC.

COMMITTEE FINDINGS:

No Committee or Board action

FISCAL ANALYSIS:

RECOMMENDATION:

City staff recommends approval.

NOTICE OF PUBLIC HEARING
CLEVELAND CITY COUNCIL TO HEAR PUBLIC COMMENTS CONCERING THE STORMWATER DIVISION ANNUAL REPORT

The City of Cleveland, Tennessee will hold a public hearing on Monday, August 23, 2021, 3 o'clock pm (local time) in their regular meeting place, the 2nd floor council meeting room, Cleveland Municipal Building, 190 Church Street NE to hear public comments concerning the Stormwater Division's annual report to Tennessee Department of Environment and Conservation (TDEC) Division of Water Pollution Control.

Attn: Legal Ad Dept.
Please run one time on or before Friday, August 13, 2021. Bill the City of Cleveland, Accounts Payable, Attn: Lavinia Johnson. Thanks.

Tennessee Department of Environment and Conservation
Division of Water Resources
William R. Snodgrass Tennessee Tower,
312 Rosa L. Parks Avenue, 11th Floor, Nashville, Tennessee 37243
1-888-891-8332 (TDEC)

Phase II Small Municipal Separate Storm Sewer System (MS4) Annual Report

1. MS4 Information

Name of MS4: City of Cleveland	MS4 Permit Number: TNS075213	
Contact Person: Christopher Broom	Email Address: cbroom@clevelandtn.gov	
Telephone: (423) 479-1913	MS4 Program Web Address: www.clevelandtn.gov/stormwater	
Mailing Address: 185 2nd Street NE		
City: Cleveland	State: TN	ZIP code: 37311

What is the current population of your MS4? 55,000

What is the reporting period for this annual report? July1 2020 to June 30 2021

2. Discharges to Waterbodies with Unavailable Parameters or Exceptional Tennessee Waters (Section 3.1)

A. Does your MS4 discharge into waters with unavailable parameters (previously referred to as impaired) for pathogens, nutrients, siltation or other parameters related to stormwater runoff from urbanized areas as listed on TN's most current 303(d) list and/or according to the on-line state GIS mapping tool (tdeconline.tn.gov/dwr/)? If yes, attach a list. ☒ Yes ☐ No

B. Are there established and approved TMDLs (http://www.tn.gov/environment/article/wr-ws-tennessees-total-maximum-daily-load-tmdl-program) with waste load allocations for MS4 discharges in your jurisdiction? If yes, attach a list. ☒ Yes ☐ No

C. Does your MS4 discharge to any Exceptional Tennessee Waters (ETWs - http://environment-online.tn.gov:8080/pls/enf_reports/f?p=9034:34304:4880790061142)? If yes, attach a list. ☒ Yes ☐ No

D. Are you implementing specific Best Management Practices (BMPs) to control pollutant discharges to waterbodies with unavailable parameters or ETWs? If yes, describe the specific practices: The City of Cleveland has been designated as a Qualifing Local Program (QLP) for its efforts to monitor construction site activities. The City also provides information to homeowners on how to improve water quality through the distribution of flyers, brochures, and public outreach events. ☒ Yes ☐ No

3. Public Education/Outreach and Involvement/Participation (Sections 4.2.1 and 4.2.2)

A. Have you developed a Public Information and Education plan (PIE)? ☒ Yes ☐ No

B. Is your public education program targeting specific pollutants and sources, such as Hot Spots? If yes, describe the specific pollutants and/or sources targeted by your public education program: Siltation Sourse, Leaf dumping in storm drains, Construction Site Runoff, Stream Buffers ☒ Yes ☐ No

C. Do you have a webpage dedicated to your stormwater program? If yes, provide a link/URL: www.clevelandtn.gov/stormwater ☒ Yes ☐ No

D. Summarize how you advertise and publicize your public education, outreach, involvement and participation opportunities: notices are run in the Cleveland Daily Banner and posted on the City's website and social media

E. Summarize the public education, outreach, involvement and participation activities you completed during this reporting period: Stream cleanups, household hazardous waste collection, community outreach events, student outreach, and Project Wet teacher education (planned, but cannceled due to COVID 19)

F. Summarize any specific successful outcome(s) (e.g., citizen involvement, pollutant reduction, water quality improvement, etc.) fully or partially attributable to your public education and participation program during this reporting period: Stream cleanups, household hazardous waste collection are successful at educating the public and removing trash and pollutants. Project Wet is successful at integrating water quality into the classroom

4. Illicit Discharge Detection and Elimination (Section 4.2.3)

A. Have you developed and do you continue to update a storm sewer system map that shows the location of system outfalls where the municipal storm sewer system discharges into waters of the state or conveyances owned or operated by another MS4? ☒ Yes ☐ No

B. If yes, does the map include inputs into the storm sewer collection system, such as the inlets, catch basins, drop structures or other defined contributing points to the sewershed of that outfall, and general direction of stormwater flow? ☒Yes ☐ No

C. How many outfalls have you identified in your storm sewer system? 1,043

D. Do you have an ordinance, or other regulatory mechanism, that prohibits non-stormwater discharges into your storm sewer system? ☒Yes ☐ No

E. Have you implemented a plan to detect, identify and eliminate non-stormwater discharges, including illegal disposal, throughout the storm sewer system? If yes, provide a summary: Twenty-five percent of the outfalls are inspected yearly. The city uses complaint tracking software to track illicit discharges. ☒ Yes ☐ No

F. How many illicit discharge related complaints were received this reporting period? 9

G. How many illicit discharge investigations were performed this reporting period? 9

H. Of those investigations performed, how many resulted in valid illicit discharges that were addressed and/or eliminated? 6

5. Construction Site Stormwater Runoff Pollutant Control (Section 4.2.4)

A. Do you have an ordinance or other regulatory mechanism requiring:

Construction site operators to implement appropriate erosion prevention and sediment control BMPs consistent with those described in the TDEC EPSC Handbook? ☒ Yes ☐ No

Construction site operators to control wastes such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste? ☒ Yes ☐ No

Design storm and special conditions for unavailable parameters waters or Exceptional Tennessee Waters consistent with those of the current Tennessee Construction General Permit (TNR100000)? ☒ Yes ☐ No

B. Do you have specific procedures for construction site plan (including erosion prevention and sediment BMPs) review and approval? ☒ Yes ☐ No

C. Do you have sanctions to enforce compliance? ☒ Yes ☐ No

D. Do you hold pre-construction meetings with operators of priority construction activities and inspect priority construction sites at least monthly? ☒ Yes ☐ No

E. How many construction sites disturbing at least one acre or greater were active in your jurisdiction this reporting period? 94

F. How many active priority and non-priority construction sites were inspected this reporting period? 129

G. How many construction related complaints were received this reporting period? 2

6. Permanent Stormwater Management at New Development and Redevelopment Projects (Section 4.2.5)

A. Do you have a regulatory mechanism (e.g. ordinance) requiring permanent stormwater pollutant removal for development and redevelopment projects? ☒ Yes ☐ No
If no, have you submitted an Implementation Plan to the Division? ☐ Yes ☐ No

B. Do you have an ordinance or other regulatory mechanism requiring:

Site plan review and approval of new and re-development projects? ☒ Yes ☐ No

A process to ensure stormwater control measures (SCMs) are properly installed and maintained? ☒ Yes ☐ No

Permanent water quality riparian buffers? If yes, specify requirements: The buffer is based on drainage area. Less than 1 square mile the buffer is 30 feet. Greater than 1 square the buffer is 60 feet. ☒ Yes ☐ No

C. What is the threshold for development and redevelopment project plans plan review (e.g., all projects, projects disturbing greater than one acre, etc.)? One acre disturbed and/or part of larger plan or any commercial with a drive thru

D. How many development and redevelopment project plans were reviewed for this reporting period? 104

E. How many development and redevelopment project plans were approved? 72

F. How many permanent stormwater related complaints were received this reporting period? 0

G. How many enforcement actions were taken to address improper installation or maintenance? 2

H. Do you have a system to inventory and track the status of all public and private SCMs installed on development and redevelopment projects? ☒ Yes ☐ No

I. Does your program include an off-site stormwater mitigation or payment into public stormwater fund? If yes, specify. If water quality and/or quantity cannot be addressed on site, then the developer has the option to pay into the stormwater mitigation bank. Factors that are considered include cost of construction and maintenance. ☒ Yes ☐ No

7. Stormwater Management for Municipal Operations (Section 4.2.6)

A. As applicable, have stormwater related operation and maintenance plans that include information related to maintenance activities, schedules and the proper disposal of waste from structural and non-structural stormwater controls been developed and implemented at the following municipal operations:

Streets, roads, highways? ☒ Yes ☐ No

Municipal parking lots? ☒ Yes ☐ No

Maintenance and storage yards? ☒ Yes ☐ No

Fleet or maintenance shops with outdoor storage areas? ☒ Yes ☐ No

Salt and storage locations? ☒ Yes ☐ No

Snow disposal areas? ☒ Yes ☐ No

Waste disposal, storage, and transfer stations? ☒ Yes ☐ No

B. Do you have a training program for employees responsible for municipal operations at facilities within the jurisdiction that handle, generate and/or store materials which constitute a potential pollutant of concern for MS4s? ☒ Yes ☐ No

If yes, are new applicable employees trained within six months, and existing applicable employees trained and/or retrained within the permit term? ☒ Yes ☐ No

8. Reviewing and Updating Stormwater Management Programs (Section 4.4)

A. Describe any revisions to your program implemented during this reporting period including but not limited to:

Modifications or replacement of an ineffective activity/control measure. 0

Changes to the program as required by the division to satisfy permit requirements. 0

Information (e.g. additional acreage, outfalls, BMPs) on newly annexed areas and any resulting updates to your program. The City annexed 79.75 acres during this reporting period.

B. In preparation for this annual report, have you performed an overall assessment of your stormwater management program effectiveness? If yes, summarize the assessment results, and any modifications and improvements scheduled to be implemented in the next reporting period. Staff uses the TDEC MS4 Audit Worksheet ☒ Yes ☐ No

9. Enforcement Response Plan (Section 4.5)

A. Have you implemented an enforcement response plan that includes progressive enforcement actions to address non-compliance, and allows the maximum penalties specified in TCA 68-221-1106? If no, explain. ______ ☒ Yes ☐ No

B. As applicable, identify which of the following types of enforcement actions (or their equivalent) were used during this reporting period; indicate the number of actions, the minimum measure (e.g., construction, illicit discharge, permanent stormwater management), and note those for which you do not have authority:

Action	Construction	Permanent Stormwater	Illicit Discharge	In Your ERP?	
Verbal warnings	#292	#0	#4	☒ Yes	☐ No
Written notices	#15	#10	#1	☒ Yes	☐ No
Citations with administrative penalties	#0	#0	#0	☒ Yes	☐ No
Stop work orders	#8	#0	#0	☒ Yes	☐ No
Withholding of plan approvals or other authorizations	#11	#2	#0	☒ Yes	☐ No
Additional Measures	#0	#0	#0	Describe: N/A	

C. Do you track instances of non-compliance and related enforcement documentation? ☒ Yes ☐ No

D. What were the most common types of non-compliance instances documented during this reporting period? No Erosion Controls, Mud Tracking, and BMP's not installed according to plan

10. Monitoring, Recordkeeping and reporting (Section 5)

A. Summarize any analytical monitoring activities (e.g., planning, collection, evaluation of results) performed during this reporting period. TMSP permit testing, TMDL, Stream Surveys, Microbiological Sampling

B. Summarize any non-analytical monitoring activities (e.g., planning, collection, evaluation of results) performed during this reporting period. Outfall inspections

C. If applicable, are monitoring records for activities performed during this reporting period submitted with this report. ☐ Yes ☒ No

11. Certification

This report must be signed by a ranking elected official or by a duly authorized representative of that person. See signatory requirements in sub-part 6.7.2 of the permit.

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Kevin Brooks, Mayor
Printed Name and Title

Signature

8-23-2021
Date

Annual reports must be submitted by September 30 of each calendar year (Section 5.4) to the appropriate Environmental Field Office (EFO), identified in the table below:

EFO	Street Address	City	Zip Code	Telephone
Chattanooga	1301 Riverfront Pkwy, Suite 206	Chattanooga	37402	(423) 634-5745
Columbia	1421 Hampshire Pike	Columbia	38401	(931) 380-3371
Cookeville	1221 South Willow Ave.	Cookeville	38506	(931) 520-6688
Jackson	1625 Hollywood Drive	Jackson	38305	(731) 512-1300
Johnson City	2305 Silverdale Road	Johnson City	37601	(423) 854-5400
Knoxville	3711 Middlebrook Pike	Knoxville	37921	(865) 594-6035
Memphis	8383 Wolf Lake Drive	Bartlett	38133	(901) 371-3000
Nashville	711 R S Gass Boulevard	Nashville	37216	(615) 687-7000

Attachments

Attachment "A": List of Waters with Unavailable Parameters

Attachment "B": List of TMDL's

Attachment "C": List of Exceptional Tennessee Waters

Attachment "D": Stormwater Division Organizational Chart

Attachment "E": Biological Stream Sampling

Attachment "F": Stream Surveys

Attachment “A”: List of Waters with Unavailable Parameters

Waters with Unavailable Parameters	
Waterbody Name	**Waterbody ID**
Candies Creek	TN06020002005_2000
South Mouse Creek	TN06020002009_2000
South Mouse Creek	TN06020002009_1000
Woolen Mill Branch	TN06020002009_0300
Fillauer Creek	TN06020002009_0200
Little Chatata Creek	TN06020002012_0200

Attachment “B”: List of TMDL’s

Total Maximum Daily Load (TMDL) For Pathogens		
Waterbody Name	**Waterbody ID**	**TMDL (% Red.)**
South Mouse Creek	TN06020002009_2000	>92.4
Woolen Mill Branch	TN06020002009_0300	>92.4
Fillauer Creek	TN06020002009_0200	>92.4
Little Chatata Creek	TN06020002012_0200	87.2

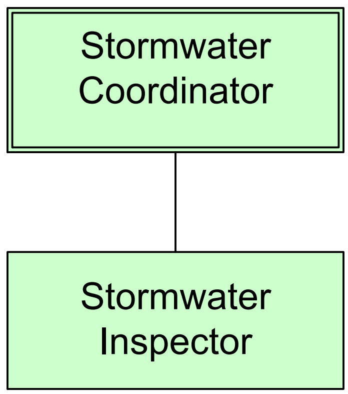
Total Maximum Daily Load (TMDL) For Siltation and Habitat Alteration				
Waterbody Name	**Waterbody ID**	**TMDL (Required Overall Load Reduction) %**	**WLA (MS4s and Construction SW) %**	**LA (Nonpoint Sources) %**
Candies Creek	TN06020002005_2000	50.1	52.6	52.6
South Mouse Creek	TN06020002009_2000	43.1	46	46
Woolen Mill Branch	TN06020002009_0300	43.1	46	46
Fillauer Creek	TN06020002009_0200	43.1	46	46
Little Chatata Creek	TN06020002012_0200	51.2	53.6	53.6

Attachment “C”: List of Exceptional Tennessee Waters

Exceptional Tennessee Waters	
Waterbody Name	**Waterbody ID**
Spring Branch	TN06020002005_0410

Attachment "D": Stormwater Division Organizational Chart

Stormwater Management



Attachment "E": Biological Stream Sampling

(Copy of report available upon request)

2020 Biological Stream Sampling
City of Cleveland MS4
Bradley County, Tennessee
S&ME Project No. 4143-19-208

PREPARED FOR:

City of Cleveland
Development and Engineering Services,
Stormwater Division
P.O. Box 1519
190 Church Street, NE
Cleveland, Tennessee 37311

PREPARED BY:

S&ME, Inc.
6515 Nightingale Lane
Knoxville, Tennessee 37909

August 31, 2020

August 31, 2020

City of Cleveland
Development and Engineering Services, Stormwater Division
P.O. Box 1519
190 Church St. NE
Cleveland, Tennessee 37311

Attention: Mr. Chris Broom, Stormwater Program Manager

Reference: **2020 Biological Stream Sampling Report**
City of Cleveland MS4
Bradley County, Tennessee
S&ME Project No. 4143-19-208

Dear Chris,

S&ME, Inc. (S&ME) has completed the 2020 biological stream sampling event for the City of Cleveland (the City). The City is required to perform biological monitoring services in order to meet Total Maximum Daily Load (TMDL) and the National Pollutant Discharge Elimination System (NPDES) General Permit for Discharges from Small Municipal Separate Storm Sewer Systems (MS4) requirements. S&ME completed a biological stream sampling event for the City on Woolen Mill Branch on July 8, 2020 in general accordance with S&ME Proposal No. 41-1900510, dated October 31, 2019 and signed on November 18, 2019, as a response to the City's request for a proposal. This report presents the assessment procedures, findings, and conclusions of the biological sampling event. Please note that this report has been prepared for your files, and we will not submit the results to TDEC without your request and approval.

S&ME appreciates the opportunity to provide you with TMDL and MS4 monitoring services. If you have any questions, please feel free to contact us.

Sincerely,

S&ME, Inc.

Sarah Rowe

Sarah A. Rowe, PWS, QHP
Project Scientist

Elizabeth M. Porter

Elizabeth M. Porter, PG, PMP
Vice President

Table of Contents

List of Tables

Appendices

1.0 Project Summary

The City of Cleveland (City) operates a regulated small municipal separate storm sewer system (MS4) and is obligated to satisfy certain water quality requirements of the Clean Water Act (CWA). These requirements include analytical monitoring of streams within the MS4 jurisdiction, comprised of bacteriological sampling for streams with unavailable parameters for pathogens and biological sampling/habitat assessment for streams with unavailable parameters for siltation, habitat alteration, and/or nutrients.

S&ME understands that the City is now a Tennessee MS4 Qualifying Local Program (QLP), and macroinvertebrate samples are only required on 303(d)-listed streams impaired from nutrients in the City's jurisdiction. According to the City and the Tennessee Department of Environment and Conservation (TDEC) Division of Water Resources (DWR) Public Data Viewer, the only stream listed due to nutrients is Woolen Mill Branch, which includes two tributaries. As requested, S&ME submitted two proposed sampling locations to Mr. Chip Walton (TDEC biologist) for his review and approval (one on each tributary of Woolen Mill Branch, slightly upstream from the two-tributary confluence), and Mr. Walton responded that only one location needs to be sampled. He indicated that both locations could be evaluated for appropriate habitat, and the location with the best habitat would be the only location sampled. This approach was approved by Mr. Walton in an email dated December 18, 2019. Therefore, sampling per the TDEC *Quality System Standard Operating Procedure (QSSOP) for Macroinvertebrate Stream Surveys*, revised August 2017, was performed on only one location on Woolen Mill Branch, on the easternmost tributary since the western tributary was dry at the time of the site visit.

The following table (Table 1) lists the monitoring location sampled; the location is also shown in the Sample Location Map (Appendix A, Figure 1). This report includes the results of the biological stream sampling event that S&ME completed in 2020 per the City's MS4 requirements.

Table 1 –Monitoring Location

Stream Name	Monitoring Location ID	Longitude	Latitude
Woolen Mill Branch	WMILL001.4BR	-84.874378	35.152475

2.0 Habitat Assessment

According to the QSSOP a habitat assessment is to be conducted at each site where a benthic sample is collected. The purpose of the habitat assessment is to evaluate the integrity of the physical stream habitat at each sampling station. A habitat assessment of the biological sampling station was performed at the time of sampling using the habitat data sheets located in Appendix B of the QSSOP. The habitat assessment procedure for Moderate to High Gradient Streams was used since the location is located within ecoregion 67g (Southern Shale Valleys) in a riffle stream.

Ten separate habitat parameters that are related to overall aquatic life use were evaluated by two S&ME biologists. The ten parameters include epifaunal substrate/available cover, embeddedness of riffles, velocity/depth combinations, sediment deposition, channel flow status, channel alteration, frequency of re-oxygenation zones, bank stability, bank vegetative protection, and riparian vegetative zone width. Each parameter was given a score based on a scale of 0 to 20, with 20 being the highest attainable score and 0 being the poorest score. Scores are divided into four categories (optimal, suboptimal, marginal, and poor), with a range of five scores possible in each category. A maximum of 200 points is possible.

The following narrative provides a detailed description of each parameter to illustrate physical site conditions. The resulting scores are shown in Table 2. A completed Stream Survey Field Sheet, Habitat Assessment Field Sheet, and the Habitat Assessment Guidelines are located in Appendices B and D. Representative photographs are located on Figure 2, Appendix A.

1. **Epifaunal Substrate / Available Cover**—This parameter accounts for the relative quantity and variety of natural structures in the stream that could provide stable habitat for macroinvertebrates and fish, including cobble riffles, large rocks, fallen trees, logs, branches, and undercut banks. A wide variety of submerged structures provides different niches, which in turn increases diversity.

2. **Embeddedness of Riffles**—Observations of embeddedness are taken in the upstream portions of riffles and cobble substrate areas to estimate the percent that rocks and snags are covered in silt, sand, or mud of the stream bottom, thereby reducing the amount of surface area available to biota.

3. **Velocity / Depth Regime**—The occurrence of a variety of velocity and depth regimes allows for greater habitat diversity and the stream's ability to maintain a stable aquatic environment.

4. **Sediment Deposition**—The amount of sediment that has accumulated within the stream channel, including that of bar formation or areas where pools have begun to fill in, is estimated for this parameter. Heavy deposits of fine material in bars and within pools is an indicator of a constantly changing environment that further decreases habitat.

5. **Channel Flow Status**—The amount of water filling the channel directly affects the amount of suitable substrate for macroinvertebrates and other aquatic fauna.

6. **Channel Alteration**—Channel alteration (such as riprap, channelization, bridges, dams, etc.) plays a large factor in the health of instream habitat since it can directly result in loss of habitat (e.g. dredging). It can also negatively affect stream habitat quality due to accelerated flooding, increased erosion, and scouring.

7. **Frequency of Riffles, Bends, or Other Oxygenation Zones**—Riffles are usually sources of higher oxygenated waters and provide high-quality habitat, while bends help prevent excessive erosion and flooding.

8. **Bank Stability**—This parameter evaluates whether the banks are stable or have a high potential for erosion during flooding. Eroded banks add to the problem of sediment deposition and embeddedness and are usually exacerbated by a lack of quality riparian vegetation.

9. **Bank Vegetative Protective**—Quality, abundant native vegetation along the streambanks provides bank stability, helps control instream scouring, uptakes nutrients, acts as a food source, and provides stream shading.

10. **Riparian Vegetative Zone Width**—This parameter accounts for the width of natural vegetation from the edge of the stream bank out through the riparian zone (approximately 18 meters). A poor riparian zone includes impacts due to parking lots, roads, fields, lawns, agricultural pastures, and buildings.

Table 2 – Habitat Assessment Scores

Habitat Assessment Parameters	WMILL001.4BR
	Score
1. Epifaunal Substrate/ Available Cover	7
2. Embeddedness of Riffles	11
3. Velocity / Depth Regime	6
4. Sediment Deposition	6
5. Channel Flow Status	14
6. Channel Alteration	8
7. Frequency of Re-oxygenation Zones	14
8. Bank Stability	10
9. Vegetative Protective	8
10. Riparian Zone Width	3
HABITAT SCORE	**87**
Date	**7/8/2020**
Ecoregion /Drainage Area	**67g / 0.9 mi^2**
HABITAT ASSESSMENT GUIDELINES	**Below**

According to the TDEC *QSSOP Habitat Assessment Guidelines* (Appendix D), between the months of July and December, streams with a drainage area of less than 2.5 square miles must achieve a habitat score of at least 129 in ecoregion 67g to be considered not impaired. The Woolen Mill Branch sampling site fell into the Impaired category for habitat conditions with a score of 87.

3.0 Water Chemistries

Water chemistries and corresponding flow measurements were taken at the sampling location one time, immediately prior to the macroinvertebrate sampling event. The field measurements evaluated included water temperature (°C), dissolved oxygen (D.O. measured in mg/l), pH (S.U.), and conductivity (µs/cm). Flow measurements are presented in cubic feet per second (cfs). The resulting values are shown in Table 3.

Table 3 – Water Quality Measurements

Monitoring Location ID	Sampling Date / Time	Water Temp (°C)	D.O. (mg/L)	pH (S.U.)	Conductivity (µS /cm)	Stream Flow (CFS)
WMILL001.4BR	7/8/2020 / 11:15	21.6	9.1	7.8	320	0.9

The TDEC Water Quality Control Board (TWQC) DWPC has issued a *General Water Quality Criteria (Chapter 1200-4-3)* (Criteria) for the state of Tennessee. This Criteria is meant to be used to determine the permissible conditions of waters with respect to pollution for the specific water uses. In this report, the data collected for the sampling site has been compared to water values that will support fish and aquatic life (Chapter 1200-4-3-.03-3).

Water temperature is important for stream health since it is directly related to the amount of oxygen that can be dissolved in the stream. Colder water can hold more oxygen than warm water; therefore, certain species of fish and macroinvertebrates that have high oxygen demands live in colder temperature habitats. According to the TDEC Criteria, the temperature of Tennessee streams shall not exceed 30.5ºC to support fish and aquatic life. The sampling site possessed a temperature lower than 30.5 ºC.

The D.O. level in streams is related to the temperature of the water and the amount of flow within the system. D.O. levels are normally high in areas of fast water flow such as riffles and are normally low in stagnant or backwater areas such as in ponds or lakes. According to the Criteria, D.O. shall not be less than 5.0 mg/l in non-trout streams and in streams in ecoregions other than 73a and 66. The sampling site possessed a D.O. higher than 5.0 mg/l.

The pH of streams determines the solubility and biological availability of chemical constituents such as nutrients (e.g. phosphorus, nitrogen, carbon) and heavy metals (e.g. lead, cadmium, copper). According to the Criteria, pH values shall not be outside the range of 6.0 to 9.0 in wadable streams. The sampling site exhibited a pH level within the allowable range.

Conductivity is a measurement of the ability of water to conduct an electrical current and can be directly affected by sources of ions such as soil, bedrock, human and animal waste, fertilizers, pesticides, herbicides, and road salt. Although appropriate conductivity values are not included in the Criteria, most streams range between 50 to 1,500 µs/cm, and the EPA website for conductivity monitoring[1] states that streams supporting good mixed fisheries have a range between 150 and 500 µs/cm. Conductivity outside this range may be unsuitable for certain species of fish or macroinvertebrates. The sampling location possessed a conductivity within the range for supporting diverse aquatic life.

Stream flow is the volume of water that moves over a designated point over a fixed period of time and is usually expressed in cubic feet per second (cfs). Flow is directly related to the seasons and the immediate environment (e.g. storm events, drought conditions) and therefore, the amount of flow was not given an exact number in the Criteria. The Criteria states only that flow shall support the fish and aquatic life criteria. The sampling site possessed an adequate amount of flow to support fish and aquatic life with a flow of 0.9 cfs.

4.0 Macroinvertebrate Sampling & Biometric Analysis

According to the TDEC QSSOP, biometric analysis can be used to calculate a value representing some aspect of a biological population's structure, function, or other measurable characteristic that changes in a predictable way

[1] U.S. EPA Water Monitoring and Assessment, Section 5.9 Conductivity (water.epa.gov/type/rsl/monitoring/vms59.cfm)

with increasing human influence. A macroinvertebrate index has been developed by TDEC for use in semi-quantitative macroinvertebrate surveys, which is based on ecoregional reference data and calibrated by bioregion.

A semi-quantitative single habitat macroinvertebrate sample was collected at the sampling location and was conducted in accordance with the *Tennessee Water Quality Criteria for Streams Classified for Fish and Aquatic Life* per Rule 12020-4-3.03(k) and TDEC's *QSSOP*. The biological survey was to be performed by a qualified biologist during low flow/high temperature conditions (i.e., summer/early fall) 2020.

The biological survey was performed by two S&ME biologists using the Semi-Quantitative Riffle Kick (SQKICK) method of using two one-meter square riffle kicks using a 500-micron mesh net per station. One kick was collected at the upstream portion of the riffle, and one kick was taken at the downstream portion of the riffle. The composite sample from both kicks would provide species from a higher velocity and a lower velocity habitat. The kick samples were composited into one bag and preserved with 80% ethanol. The sample was then shipped to Pennington & Associates, Inc. (Pennington) laboratory in Cookeville, Tennessee for taxonomic analysis.

Upon receipt of the sample, Pennington reduced the composite collection into 200+/- 20% subsamples, following the protocols detailed in Protocol I of the *QSSOP*. The laboratory identified the organisms and calculated the Tennessee Macroinvertebrate Index (TMI) score following Protocols J and K of the QSSOP. Scoring each of the following seven biometrics for the subsample was performed, which includes taxa richness (TR), insect orders *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT) richness, percent EPT abundance (excluding *Cheumatopsyche* spp.), *Chironomidae* and *Oligochaeta* abundance (Percent OC), North Carolina biotic index (NCBI), percent of Tennessee nutrient tolerant taxa (Percent TNutol), and percent contribution of organisms that build fixed retreats or have adaptations to attach to surfaces in flowing water (Percent Clingers). The laboratory results submitted by Pennington on August 18, 2020 are presented in Appendix C. Results from the analysis are shown in Appendix C and Table 4.

The TMI score for the sampling location was compared to the Index Score Rating for Tennessee bioregion 67g according to the drainage class. The target TMI for streams within bioregion 67g is 32. According to the biometric analysis, the Woolen Mill Branch sample scored below the target TMI of 32 with a score of 22, indicating impairment to the biological community.

Table 4 – Macroinvertebrate TMI Values

WMILL001.4BR		
Metric	Value	Score
TR	22	4
EPT Richness	5	2
%EPT – Cheum	7.62%	0
%OC	6.73%	6
NCBI	4.90	6
% Clingers - Cheum	24.66%	2
%TNUTOL	72.20%	2
Date	7/8/2020	
Ecoregion / Drainage Area	**67g / 0.9 mi^2**	
TMI Score	**22**	

5.0 Conclusions

S&ME, Inc. (S&ME) has completed the biological sampling / habitat assessment for the City of Cleveland MS4 in accordance with the guidelines detailed in the City's MS4 permit. Results of the 2020 sampling event can be summarized as follows:

Habitat Assessment

According to the habitat assessment performed at the Woolen Mill Branch sampling location, the site falls into the Impaired category for habitat conditions. The low score is primarily due to the lack of a healthy and diverse riparian buffer zone, high sediment loads in the areas where the habitat was assessed, lack of substrate and stable habitat within the channel, and unstable highly eroding areas along the streambanks.

Water Chemistries

Water chemistries were collected at the sampling station and included testing for temperature, D.O., pH, conductivity, and stream flow. The Woolen Mill Branch sampling location scored within the ranges adequate for supporting fish and aquatic life according to the TDEC DWPC *General Water Quality Criteria*.

Macroinvertebrate Sampling and Biometric Analysis

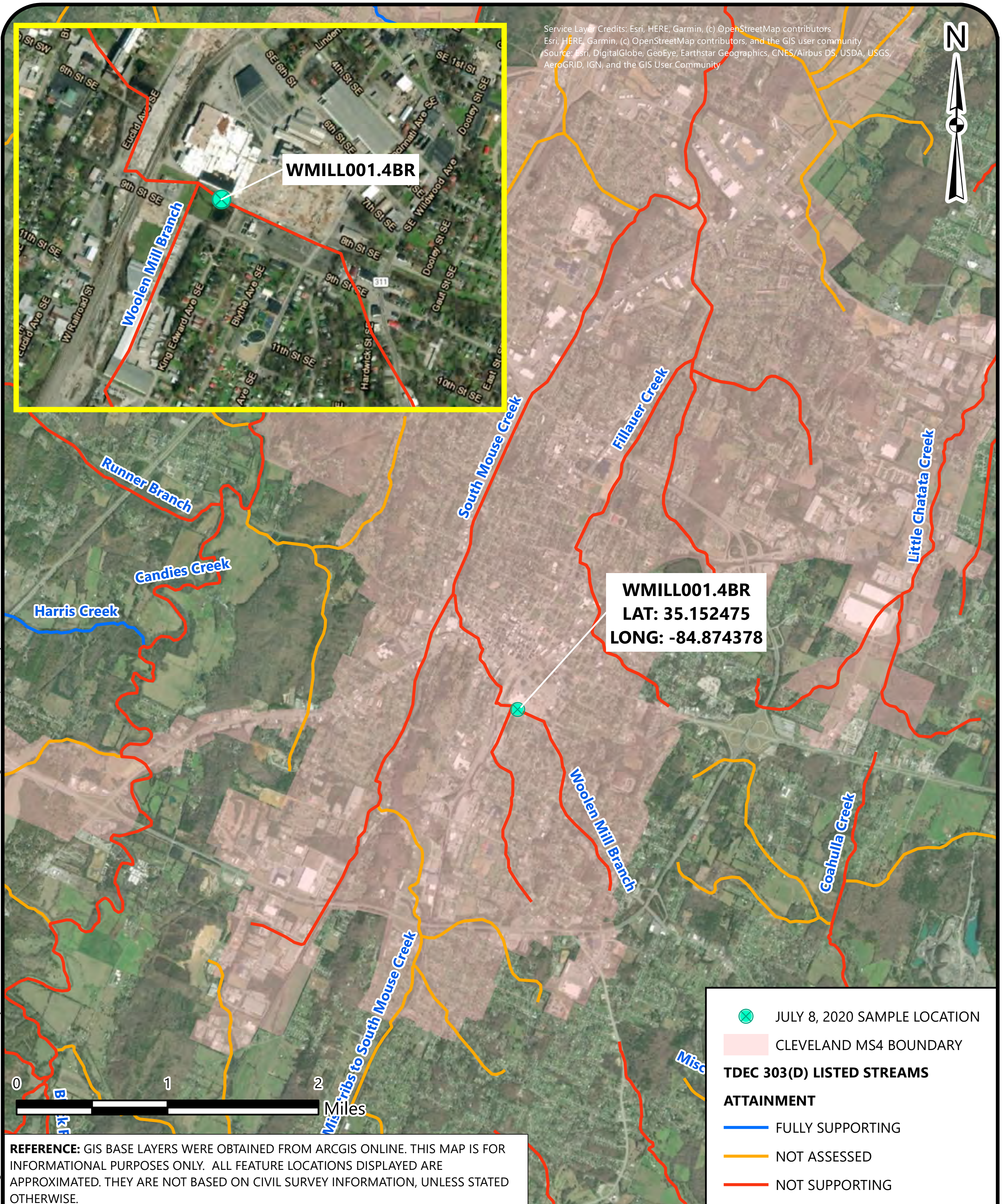
According to the biometric analysis, the Woolen Mill Branch sample scored below the target TMI 32 with a score of 22, indicating impairment to the biological community. The low score for the stream could indicate further degradation within the overall watershed. However, since the biological sampling is performed only once in five years, other discrete factors that may have occurred a short time before the sampling was performed could also influence the score. These include events such as weather influences (e.g., heavy storm flows, droughts), possible sewage or chlorinated water releases from wastewater treatment facilities, and/or water treatment plants, or potentially leaking pipes within the county's infrastructure. Other point and non-point source pollutants that may enter the creeks upstream from the sampling site, such as illicit discharges, roadway runoff, agriculture, pesticides and herbicides, and toxic hazardous wastes from households or businesses could also have negatively affected the macroinvertebrate community prior to sampling. Continued monitoring of the stream will provide further data to assist in evaluating the overall health of the stream and its watershed.

APPENDICES

APPENDIX A—FIGURES

Figure 1 - Sample Location Map

Figure 2 - Representative Photographs



Drawing Path: R:_GIS PROJECTS\2019_Projects\4143-19-208_Cleveland_MS4\MS4_Monitoring_Locations.mxd plotted by Srowe 07-21-2020

SAMPLE LOCATION MAP

2020 BIOLOGICAL STREAM SAMPLING REPORT
CITY OF CLEVELAND MS4
CLEVELAND, BRADLEY COUNTY, TENNESSEE

SCALE:	1 " = 4,500 '
DATE:	7-21-20
PROJECT NUMBER:	4143-19-208
FIGURE NO.	1

Date: 7/8/2020

Photographer: Sarah A. Rowe

1	**Location / Orientation**	WMILL001.4BR, facing upstream.
	Remarks	Macroinvertebrate sampling location on Woolen Mill Branch.

Date: 7/8/2020

Photographer: Sarah A. Rowe

2	**Location / Orientation**	WMILL001.4BR, facing downstream.
	Remarks	Macroinvertebrate sampling location on Woolen Mill Branch.

APPENDIX B—TDEC QSSOP DATA SHEETS

WPC Stream Survey Field Sheets

Habitat Assessment Field Sheets

STREAM SURVEY INFORMATION

DWR Station ID: WMILL001.4BR	**Samplers:** SRowe + JRowe
Monitoring Location Name: Woolen Mill Branch	**Date:** 7/8/2020 **Time:** 1115
Monitoring Location: 200ft DS of crossing	**Organization:** S+ME **Drainage Area:** 0.9 mi²
County: Bradley	Ecoregion: 67g u/s ECO: —
Latitude: 35.158475	HUC: 0602002404 WS Grp: —
Longitude: -84.874378	WBID: — Field Log #: —

Project Name: ☐ Watershed ☐ 303(d) ☐ Antideg ☐ ECO ☐ FECO **Other:** MS4

Project ID: TNPR

Activity Type: ☒ Sample ☐ QC Sample ☒ Habitat ☐ QC habitat ☐ QC ID

Sample Status: ☒ Collected ☐ Seasonally Dry ☐ Frequently Dry ☐ No Channel ☐ Too Deep (Not Wadeable) ☐ Too Deep (Temporary) ☐ Permanent Barrier ☐ Fenced ☐ Landowner Denial: ☐ Temporary Barrier ☐ Posted Plan to revisit? ☐ Yes ☐ No

Flow Conditions: ☐ Dry ☐ Isolated Pools ☐ Stagnant ☐ Low ☒ Moderate ☐ High ☐ Bankful ☐ Flooding

Sample	Collected?	Comment	Sample	Collected?	Comment
Biorecon			Periphyton		
SQKICK	✓		Other		
SQBANK	/		Describe Other Sample:		

Chemicals/Bacteria: ☒ None ☐ Routine ☐ Nutrient ☐ Metals ☐ *E. coli* ☐ Organics ☐ Other________

Field Parameters: Meter(s) Used: /

pH (su)	7.8		Dissolved Oxygen %	/	
Conductivity (umhos)	320		Turbidity (NTU)	/	
Temperature (C°)	21.6		TDS (mg/L)	/	
Dissolved Oxygen (ppm = mg/L)	9.1		Flow (cfs)	0.9	

Meter Problems? /

Photos Taken? ☐ No ☒ Yes: Description: ________

Previous 48 hours precipitation: ☐ Unknown ☐ None ☐ Slight ☐ Moderate ☐ Heavy ☐ Flooding

Air Temperature (°F) 92

Physical Characteristics & Light Penetration:

Gradient (sample reach): ☐ Flat ☐ Low ☒ Moderate ☐ High ☐ Cascades

Average Stream Width: ☐ Very Small (<1.5yd) ☐ Small (1.5-3yd) ☒ Med. (3-10yd) ☐ Large (10-25yd) ☐ Very Large (>25yd)

Maximum Stream Depth: ☐ Shallow (<0.3yd) ☒ Medium (0.3-0.6yd) ☐ Deep (0.6 – 1yd) ☐ Very Deep(>1yd)

% Canopy Cover Estimated for Reach: 40%

% Canopy Cover Measured (mid-reach): / u/s + / d/s + / LDB + / RDB = Total/384*100 ___

Channel Characteristics:

Bank Height: 2 (yd.) High Water Mark: 1 (yd.)

Bank Slope LDB: ☐ Deeply incised ☐ Bluff/Wall ☒ Undercut ☐ Sloughing ☐ Steep terrain ☐ Gentle Slope

Bank Slope RDB: ☐ Deeply incised ☐ Bluff/Wall ☐ Undercut ☒ Sloughing ☐ Steep terrain ☐ Gentle Slope

Manmade Modification: ☐ None ☐ Rip-Rap ☒ Cement ☐ Gabions ☒ Channelized ☐ Dam ☐ Dredging ☐ Bridge ☐ ATV

Stream Characteristics:

Sediment Deposits: ☐ None ☐ Slight ☒ Moderate ☐ Excessive ☐ Blanket

Sediment Type: ☐ None ☒ Sand ☒ Silt ☐ Mud ☐ Clay ☐ Sludge ☐ Mn Precipitant ☐ Orange Flocculent

Turbidity: ☒ Clear ☐ Slightly Turbid ☐ Muddy ☐ Milky ☐ Tannic ☐ Planktonic Algae ☐ Dyed

Foam/Surface Sheen: ☒ None ☐ Nutrient ☐ Surfactant ☐ Bacteria

Algae: ☐ None ☐ Slight ☒ Moderate ☐ High ☐ Choking **Type:** ☒ Diatoms ☐ Green ☐ Filamentous ☐ Blue-green

TDEC-DWR Stream Survey Field Sheet (Back)

DWR Station ID: WMILL001.4BR **Date:** 7/8/2020 **Assessors:** S Rowe + J Rowe

Dominate Substrate: (More than 25%) Check all that apply

Riffle	Run	Pool
☐ Boulders (>10")	☐ Boulders (>10")	☐ Boulders (>10")
☒ Cobble (2.5-10")	☒ Cobble (2.5-10")	☐ Cobble (2.5-10")
☒ Gravel (0.1-2.5")	☒ Gravel (0.1-2.5")	☒ Gravel (0.1-2.5")
☐ Bedrock	☐ Bedrock	☐ Bedrock
☐ Sand	☐ Sand	☒ Sand
☐ Silt (not gritty)	☐ Silt (not gritty)	☒ Silt (not gritty)
☐ Clay (Slick)	☐ Clay (Slick)	☐ Clay (Slick)

Surrounding Land Uses (list additional land uses under comments)

☐ Forest	☐ Grazing	☒ Stormwater	☐ STP/WWTP	☒ Construction / Demolition
☐ Wetland	☐ Row Crops	☒ Urban	☒ Industry	☐ Impoundment
☐ Park	☐ CAFO/Dairy	☐ Commercial	☐ Mining/Dredging	☐ ATV/OHV
☐ Hay/Fields	☐ Logging	☐ Residential	☒ Road/Hwy/RR	☐ Golf Course

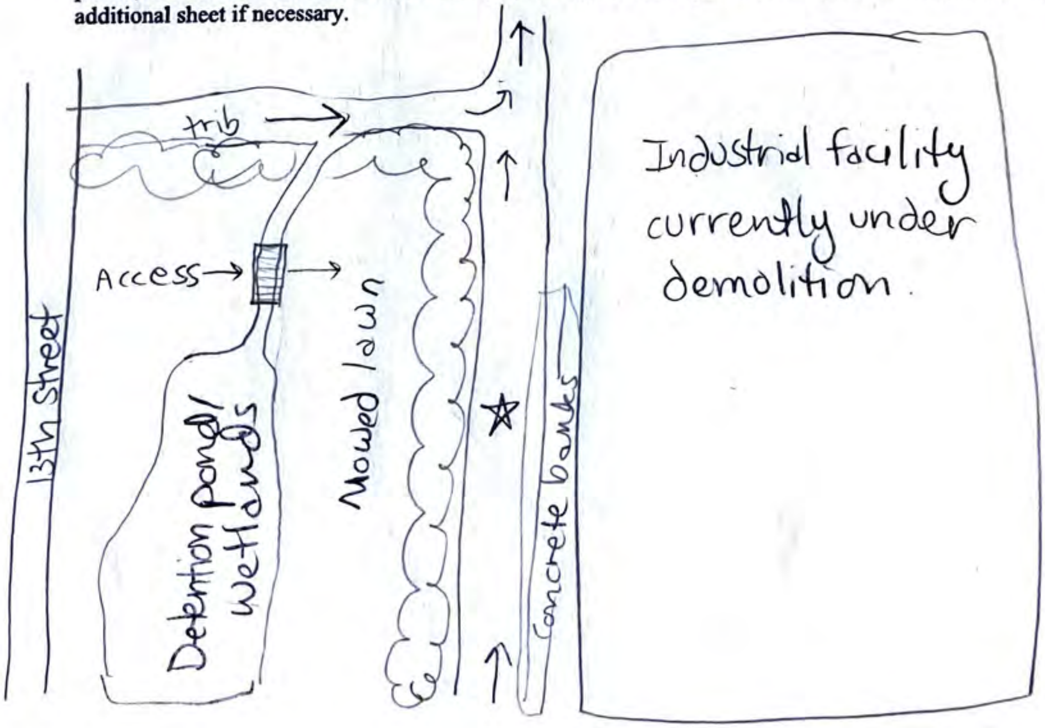
Sta	dep	vel
RB 9.5	0	0
9	0.1	0
8.5	0.1	0.8
7.5	0.2	1.2
6.5	0.3	0.8
5.5	0.32	1.4
4.5	0.1	0.05
4	0	0

Observed Human Disturbance to Stream: Blank (not observed) S (Slight) M (Moderate) H (High)

Riparian Loss	H	Logging		Industry		ATV/OHV	
Channelization	H	Urban	H	Mining/ Dredging		Golf Course	
Active Grazing		Commercial		Road/Hwy/RR	M	Garbage/Trash	
Row Crops		Residential		Construction	S	Landfill	
CAFO/Dairy		STP/WWTP		Impoundment		Water Withdrawal	

Other Stream Information and Stressors:

Stream Sketch: (include road name or landmark, flow direction, reach distance, distance from bridge or road, sampling points, tributaries, outfalls, livestock access, riparian, potential impacts, north arrow, immediate land use, buildings, etc.) Use additional sheet if necessary.



HABITAT ASSESSMENT FIELD SHEET- MODERATE TO HIGH GRADIENT STREAMS (FRONT)
(See Protocol E for detailed descriptions and rank information)

STATION ID: WMILL001.4BR		HABITAT ASSESSED BY: S Rowe + J Rowe	
STREAM NAME: Woolen Mill Branch		DATE: 7/8/2020	TIME: 1115
STATION LOCATION: 200ft DS of crossing		ECOREGION: 67g	QC: Consensus Duplicate
WBID/HUC: 06020002 1404	GROUP: 6	ASSOCIATED LOG #:	

	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Over 70% of stream reach has natural stable habitat suitable for colonization by fish and/or macroinvertebrates. Four or more productive habitats are present.	Natural stable habitat covers 40-70% of stream reach. Three or more productive habitats present. (If near 70% and more than 3 go to optimal.)	Natural stable habitat covers 20 -40% of stream reach or only 1-2 productive habitats present. (If near 40% and more than 2 go to suboptimal.)	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comments				
2.Embeddedness of Riffles	Gravel, cobble, and boulders 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space. If near 25% drop to suboptimal if riffle not layered cobble.	Gravel, cobble and boulders 25-50% surrounded by fine sediment. Niches in bottom layers of cobble compromised. If near 50% & riffles not layered cobble drop to marginal.	Gravel, cobble, and boulder s are 50-75% surrounded by fine sediment. Niche space in middle layers of cobble is starting to fill with fine sediment.	Gravel, cobble, and boulders are more than 75% surrounded by fine sediment. Niche space is reduced to a single layer or is absent.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comments				
3. Velocity/ Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing score lower). If slow-deep missing score 15.	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime. Others regimes too small or infrequent to support aquatic populations.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comments	Fast shallow + slow shallow			
4. Sediment Deposition	Sediment deposition affects less than 5% of stream bottom in quiet areas. New deposition on islands and point bars is absent or minimal.	Sediment deposition affects 5-30% of stream bottom. Slight deposition in pool or slow areas. Some new deposition on islands and point bars. Move to marginal if build-up approaches 30%.	Sediment deposition affects 30-50% of stream bottom. Sediment deposits at obstruction, constrictions and bends. Moderate pool deposition.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comments				
5. Channel Flow Status. .	Water reaches base of both lower banks and streambed is covered by water throughout reach. Minimal productive habitat is exposed.	Water covers > 75% of streambed or 25% of productive habitat is exposed.	Water covers 25-75% of streambed and/or productive habitat is mostly exposed.	Very little water in channel and mostly present as standing pools. Little or no productive habitat due to lack of water.
SCORE 14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comments				

44

HABITAT ASSESSMENT FIELD SHEET- MODERATE TO HIGH GRADIENT STREAMS (BACK)

Station ID WMILL001.4BR Date 7/8/2020 Initials SRowe

	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization, dredging rock removal or 4-wheel activity (past or present) absent or minimal; natural meander pattern. NO artificial structures in reach. Upstream or downstream structures do not affect reach.	Channelization, dredging or 4-wheel activity up to 40%. Channel has stabilized. If larger reach, channelization is historic and stable. Artificial structures in or out of reach do not affect natural flow patterns.	Channelization, dredging or 4-wheel activity 40-80% (or less that has not stabilized.) Artificial structures in or out of reach may have slight affect.	Over 80% of reach channelized, dredged or affected by 4-wheelers. Instream habitat greatly altered or removed. Artificial structures have greatly affected flow pattern.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comments				
7. Frequency of re-oxygenation zones. Use frequency of riffle or bends for category. Rank by quality.	Occurrence of re-oxygenation zones relatively frequent; ratio of distance between areas divided by average stream width <7:1.	Occurrence of re-oxygenation zones infrequent; distance between areas divided by average stream width is 7 - 15.	Occasional re-oxygenation area. The distance between areas divided by average stream width is over 15 and up to 25.	Generally all flat water or flat bedrock; little opportunity for re-oxygenation. Distance between areas divided by average stream width >25.
SCORE 14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Comments				
8. Bank Stability (score each bank) Determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. If approaching 30% score marginal if banks steep.	Moderately unstable; 30-60 % of bank in reach has areas of erosion; high erosion potential during floods, If approaching 60% score poor if banks steep.	Unstable; many eroded area; raw areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 4 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 6 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Comments	Concrete protection on RB.			
9. Vegetative Protective (score each bank) includes vegetation from top of bank to base of bank. Determine left or right side by facing downstream	More than 90% of the bank covered by undisturbed vegetation. All 4 classes (mature trees, understory trees, shrubs, groundcover) are represented and allowed to grow naturally. All plants are native.	70-90% of the bank covered by undisturbed vegetation. One class may not be well represented. Disruption evident but not effecting full plant growth. Non-natives are rare (< 30%)	50-70% of the bank covered by undisturbed vegetation. Two classes of vegetation may not be well represented. Non-native vegetation may be common (30-50%).	Less than 50% of the bank covered by undisturbed vegetation or more than 2 classes are not well represented or most vegetation has been cropped. Non-native vegetation may dominate (> 50%)
SCORE 6 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 2 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Comments				
10. Riparian Vegetative Zone Width (score each bank.) Zone begins at top of bank.	Average width of riparian zone > 18 meters. Unpaved footpaths may score 9 if run-off potential is negligible.	Average width of riparian zone 12-18 meters. Score high if areas < 18 meters are small or are minimally disturbed.	Average width of riparian zone 6-11 meters. Score high if areas less than 12 meters are small or are minimally disturbed.	Average width of riparian zone <6 meters. Score high if areas less than 6 meters are small or are minimally disturbed.
SCORE 2 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 1 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
43 **Comments**				

Total Score 87 **Comparison to Ecoregion Guidelines (circle): ABOVE or BELOW**

If score is below guidelines , result of (circle): Natural Conditions or Human Disturbance

Describe

APPENDIX C—PENNINGTON LABORATORY RESULTS

Taxa List and Biometric Results

PAI ID NO				53927
STATION				Woolen Mill Br.
DATE				7/8/2020
FRACTION				
SPECIES	T.V.	F.F.G.	CL	
PLATYHELMINTHES				
Turbellaria		P		
Tricladida		P		
Planariidae	6.3	O		
Girardia sp.	7.1	P		9
NEMATODA	6	CG		2
MOLLUSCA				
Bivalvia				
Veneroida				
Sphaeriidae	6.9	FC		
Pisidium sp.	6.6	FC		8
Gastropoda				
Mesogastropoda				
Pleuroceridae	6			
Elimia sp.	2.7	SC		70
ARTHROPODA				
Arachnoidea				
Acariformes	5.5			
Hygrobatidae	5.5			
Hygrobates sp.	5.5	-		4
Sperchontidae	5.5			
Sperchon sp.	5.5	-		2
Insecta				
Ephemeroptera				
Baetidae	6	CG		
Baetis sp.	6	CG		6
Heptageniidae	3	SC	CL	1
Trichoptera				
Hydropsychidae	4.1	FC	CL	
Cheumatopsyche sp.	6.6	FC	CL	60
Hydropsyche sp.	4.3	FC	CL	7
Philopotamidae	2.2	FC	CL	
Chimarra sp.	3.3	FC	CL	3
Coleoptera				
Elmidae	4.41	CG	CL	
Oulimnius sp.	1.9	CG	CL	8
Stenelmis sp.	5.60	SC	CL	27
Diptera				
Chironomidae				
Ablabesmyia sp.	7.1	P		1

PAI ID NO				**53927**
STATION				**Woolen Mill Br.**
DATE				**7/8/2020**
FRACTION				
SPECIES	**T.V.**	**F.F.G.**	**CL**	
Cricotopus sp.	**7.44**		CL	3
Diplocladius sp.	**8**	**CG**		1
Nanocladius sp.	**7.4**	**CG**		1
Polypedilum sp.	**6.1**	**SH**		1
Potthastia sp.	**5.4**	**CG**		1
Rheotanytarsus sp.	**6.5**	**FC**	CL	5
Synorthocladius sp.	**4.2**	**CG**		2
Tipulidae	**5.3**	**SH**		
Antocha sp.	**4.4**	**CG**	CL	1
TOTAL NO. OF ORGANISMS				**223**
TOTAL NO. OF TAXA				**22**
EPT				**5**
%OC				**6.73%**
%EPT-CHEUM				**7.62%**
NCBI				**4.90**
%TNUTOL				**72.20%**
% CLINGERS-CHEUM				**24.66%**

APPENDIX D—REFERENCE GUIDES FROM THE QSSOP

Habitat Assessment Guidelines Table

Biocriteria Tables

Table 2: Habitat Assessment Guidelines

Values listed below are considered to meet regional guidelines. Guidelines are based on 75% of median reference value, adjusted up to lowest habitat score passing TMI in each ecoregion.

Ecoregion	Habitat Type	Streams > 2.5 sq. mile drainage		Headwater Streams ≤ 2.5 sq. mile drainage	
		Jan-June	July-Dec	Jan-June	July-Dec
65abei	Low Grad.	109	≥ 98	>107	≥ 111
65j	High Grad.	≥ 148	≥ 169	≥ 152	≥ 157
66d	High Grad.	≥ 157	≥ 158	≥ 146	≥ 157
66e	High Grad.	≥ 158	≥ 152	≥ 143	≥ 148
66f	High Grad.	≥ 135	≥ 136	≥ 148	≥ 140
66g	High Grad.	≥ 140	≥ 140	≥ 150	≥ 124
66j	High Grad.	≥ 145	≥ 139	≥ 115	≥ 132
67f	High Grad.	≥ 131	≥ 128	≥ 133	≥ 123
67g	High Grad.	≥ 106	≥ 103	≥ 136	≥ 129
67h	High Grad.	≥ 156	≥ 148	≥ 125	≥ 146
67i	High Grad.	≥ 114	≥ 117	≥ 114	≥ 117
68a	High Grad.	≥ 135	≥ 145	≥ 139	≥ 128
68b	High Grad.	≥ 124	≥ 129	≥ 137	≥ 143
68c	High Grad.	≥ 131	≥ 124	≥ 163	≥ 155
69d	High Grad.	≥ 133	≥ 123	≥ 134	≥ 123
69e	High Grad.	≥ 127	≥ 122	≥ 151	≥ 136
71e	High Grad.	≥ 113	≥ 114	≥ 145	≥ 130
71f	High Grad.	≥ 126	≥ 123	≥ 129	≥ 126
71g	High Grad.	≥ 126	≥ 128	≥ 119	≥ 149
71h	High Grad.	≥ 115	≥ 114	≥ 132	≥ 123
71i	High Grad.	≥ 112	≥ 99	≥ 113	≥ 114
71i	Low Grad.	≥ 106	≥ 114	NA	NA
73a	Low Grad.	≥ 118	≥ 118	≥ 106	≥ 106
74a	High Grad.	≥ 124	≥ 122	≥ 108	≥ 116
74b	Low Grad.	≥ 108	≥ 108	≥ 134	≥ 113

Bioregion: 67fghi Season: January – June Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 32	22 – 32	11 – 21	< 11
EPT Richness (EPT)	> 10	7– 10	4 – 6	< 4
% EPT-Cheum	> 49.2	32.8 – 49.2	16.4 – 32.7	< 16.4
% OC	< 27.7	27.7 – 51.7	51.8 – 75.9	> 75.9
NCBI	< 4.82	4.82 – 6.54	6.55 – 8.27	> 8.27
% Clingers-Cheum	> 50.6	33.8– 50.6	16.9 – 33.7	< 16.9
% TNutol	< 28.0	28.0 – 51.9	52.0 – 76.0	> 76.0

Bioregion: 67fghi Season: July-December Target TMI = 32 Scoring calibrated to 160-240 organism sample			Headwater Method = SQKICK Drainage ≤ 2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 29	20 – 29	10 – 19	< 10
EPT Richness (EPT)	> 11	8 – 11	4 – 7	< 4
% EPT-Cheum	> 43.4	29.0 – 43.4	14.5 – 28.9	< 14.5
% OC	< 28.7	28.7 – 52.4	52.5 – 76.2	> 76.2
NCBI	< 5.05	5.05 – 6.69	6.70 – 8.35	> 8.35
% Clingers-Cheum	> 53.3	35.6 – 53.3	17.8 – 35.5	< 17.8
% TNutol	< 28.4	28.4 – 52.2	52.3 –76.1	> 76.1

Bioregion: 67fghi Season: January – June Target TMI = 32 Scoring calibrated to 160-240 organism sample			Method = **SQBANK** Drainage >2.5 sq miles Genus Level Identification	
Metric	6	4	2	0
Taxa Richness (TR)	> 28	20 – 28	10 – 19	< 10
EPT Richness (EPT)	> 6	5 – 6	2 – 4	< 2
% EPT-Cheum	> 25.9	17.4 – 25.9	8.7 – 17.3	< 8.7
% OC	< 50.0	50.0 – 66.6	66.7 – 83.3	> 83.3
NCBI	< 6.67	6.67 – 7.77	7.78 – 8.89	> 8.89
% Clingers	> 20.1	13.5 – 20.1	6.7 – 13.4	< 6.7
% TNutol	< 45.1	45.1 – 63.3	63.4 – 81.7	> 81.7

Attachment “F”: Stream Surveys

(Copy of report available upon request)

HIGH DEFINITION STREAM SURVEY TO SUPPORT STORMWATER MANAGEMENT - CLEVELAND, TN

Prepared for Christopher Broom,
Stormwater Coordinator, City of Cleveland

May 26, 2021

TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

Prepared by: James Parham, Ph.D., Dane Shuman, M.S., Emy Parham, M.A., and Brett Connell, M.S.

149 Hedgelawn Drive
Hendersonville, TN 37075
615.461.0010

www.TruttaSolutions.com

info@TruttaSolutions.com

Table of Contents

List of Figures

List of Tables

Appendices

Executive Summary

The High Definition Stream Survey (HDSS) approach was used to perform a stream corridor assessment within the municipality of Cleveland, TN. Field data was collected on 28 miles (45.05 km) of streams during 20-23 May 2019. Portions of eight streams were sampled to determine the existing conditions of the streambed, streambanks, and riparian corridors and to document the locations of discrete point features (e.g., pipe, outfalls, fish barriers, etc.). The HDSS system utilized a locational receiver, video cameras and sonar to record the survey data, which was later visually classified as fully functional, functional, slightly impaired, impaired, or non-functional for the entire survey area. Additionally, a modification type (unmodified, modified, or highly modified) was also determined. Both function and modification were used to define the condition of the streambed, streambanks, and riparian areas at nearly every meter along the stream corridor. Stream discharge from the nearest USGS gauging station suggests that local discharge levels were low and slightly falling during the survey.

Overall (all streams combined), streambed function was equally split between functional (48%) and slightly impaired (48%), with no streambeds classified as fully functional. Streambed modification was dominated by the unmodified category (97%). Streambank function was slightly impaired for both the left (46%) and right (44%) followed by impaired (>25%) then functional (>21%). Left streambank modification was dominated (90%) by unmodified with just over 6% highly modified and 4% modified, while the right streambank showed a similar trend. Overall, left riparian was fully functional (38%) followed by slightly impaired (29%), functional (22%), and impaired (9%). Fully Functional was the dominant functional category representing 37% of the right riparian followed by slightly impaired (32%), functional (21%), and impaired (6%). Additionally, 2,115 discrete features were observed in all the streams sampled, with the majority being classified as other followed by sediment. Pipe and road impacts were observed 304 and 263 times, respectively.

Within each tributary, Woolen Mills Branch (20%) Fillauer Creeks (5%) and Little Chatata Creek (3%) had the greatest percentage of impaired streambed sections. Little Chatata Creek was the only tributary to have non-functional streambeds (6%). Spring Branch had 100% of its streambeds categorized as functional followed by Little Chatata (59%), South Mouse (48%), Candies Creeks (47%), and Woolen Mills Branch (46%). Bigsby Creek had the highest percentage of streambank classified as non-functional with both the left and right banks at 33% and 38% of the left bank along Little South Mouse Creek was also classified as non-functional. Little Chatata and South Mouse Creeks were the only streams to have fully functional classifications on both the left and right banks. Both the left and right riparian areas of Woolen Mill Branch (36%) and South Mouse Creek (4%) had the highest percentage non-functional within the individual streams, while Little South Mouse Creek (100%) Spring Branch (78%) and Candies Creek (75%) had the highest percentage of fully functional riparian areas.

The value of this project is not this report, but the videos and spatial data provided with the report. The images in the report are general in nature and cover a long stream segment and may not be directly suitable for answering specific management questions. However, the continuous 1m resolution data linked to high resolution video of the river corridor allows detailed inspection of instream conditions to support numerous different management decisions. Overall, the functional stream corridor conditions within the City of Cleveland were surprisingly good. Over 76% of the stream length surveys were in fully functional or functional condition and less than 3% of the stream length were in the impaired or non-functional categories.

Introduction

The City of Cleveland is located in Bradley County, TN in the southeastern area of the state. Several streams flow within the city limits including Candies Creek, South Mouse Creek and Little Chatata Creek and their tributaries. As part of its municipal responsibilities under the Tennessee phase II Municipal Separate Storm Sewer System (MS4) general stormwater permit, Cleveland has a goal of minimizing stormwater runoff. As part of the permit compliance process and to protect its citizens for various water pollution issues, the city is interested in documenting the riparian, streambank and channel conditions along the streams within the city's boundaries (Figure 1).

To accomplish this, Trutta Environmental Solutions, LLC. (TRUTTA) used our High Definition Stream Survey (HDSS) method to collect and classify the stream corridor data. In general, the HDSS approach follows a standardized series of steps which rapidly and systematically collects and processes large amounts of river condition information. The longitudinal HDSS survey collected information on riparian, streambank, streambed and discrete features to allow us to complete a Stream Corridor Assessment (SCA) for Cleveland streams.

Objectives

This project focused on the following objectives:

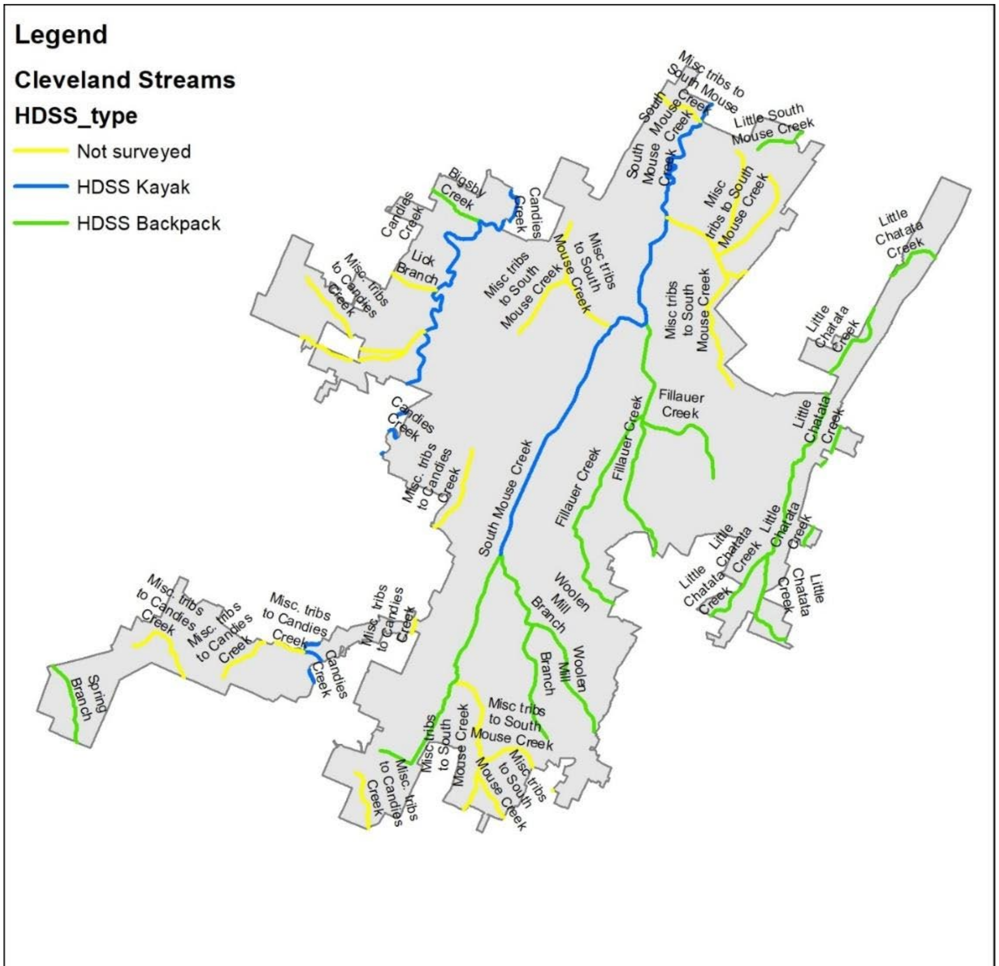
- Collect stream channel and instream habitat information to support MS4 permit compliance on 4.8 miles of Candies Creek, 0.7 miles of Bigsby Creek, 1.0 miles of Spring Branch, 10.3 miles of South Mouse Creek, 6.8 miles of Fillauer Branch. 3.9 miles of Woolen Mill Branch and 6.5 miles of Little Chatata Creek.

- Document at least 60% of the stream miles documented by HDSS video and 30% with HDSS still imagery.

- Use high-resolution, geo-referenced longitudinal video or still imagery to classify the extent, location, severity, and correctability of:

    - Channel alteration,
    - Left and right bank erosion susceptibility,
    - Exposed pipes,
    - Pipe outfalls,
    - Fish barriers,
    - In/Near stream construction,
    - Trash dumping, and
    - Other unique problem areas.

- Create GIS layers for classified results listed above,
- Document management issues found within each stream by creating site reports for Top 20 worst locations within the streams with estimates of correctability, access, and relative cost.



CYCLE	WATER_NAME	ATTAINMENT	L_miles
2016	Little South Mouse Creek	Not Supporting	0.547917
2016	Bigsby Creek	Fully Supporting	0.660038
2016	Candies Creek	Not Supporting	4.782577
2016	South Mouse Creek	Not Supporting	3.381062
2016	Little Chatata Creek	Not Supporting	6.51326
2016	Misc. tribs to Candies Creek	Not Assessed	6.648676
2016	Woolen Mill Branch	Not Supporting	3.903789
2016	Fillauer Creek	Not Supporting	6.790343
2016	Misc tribs to South Mouse Creek	Not Assessed	10.99186
2016	Spring Branch	Fully Supporting	0.963447
2016	Lick Branch	Not Assessed	0.535796
2016	South Mouse Creek	Not Supporting	6.334851

Figure 1: Map and data table for streams within the city limits provided by the City of Cleveland. Blue lines were preliminarily assessed as kayak surveys, green lines were backpack surveys, and yellow lines were segments not to be surveyed.

Methods

High Definition Stream Survey (HDSS)

The High-Definition Stream Survey (HDSS) is a method to rapidly assess the physical and/or biological components in and along the stream corridor to identify and prioritize the areas of greatest need for restoration or conservation. This assessment provides continuous 1-meter longitudinal resolution output documenting the conditions present in and along a river or stream corridor (Figure 2). This continuous georeferenced high-resolution data is easily used for small scale (i.e., microhabitat) to broad scale (i.e., watershed) analyses or any spatial level in between. The results of the HDSS allow planners to make informed management decisions supported by well documented evidence to select actions that directly influence their desired outcomes.

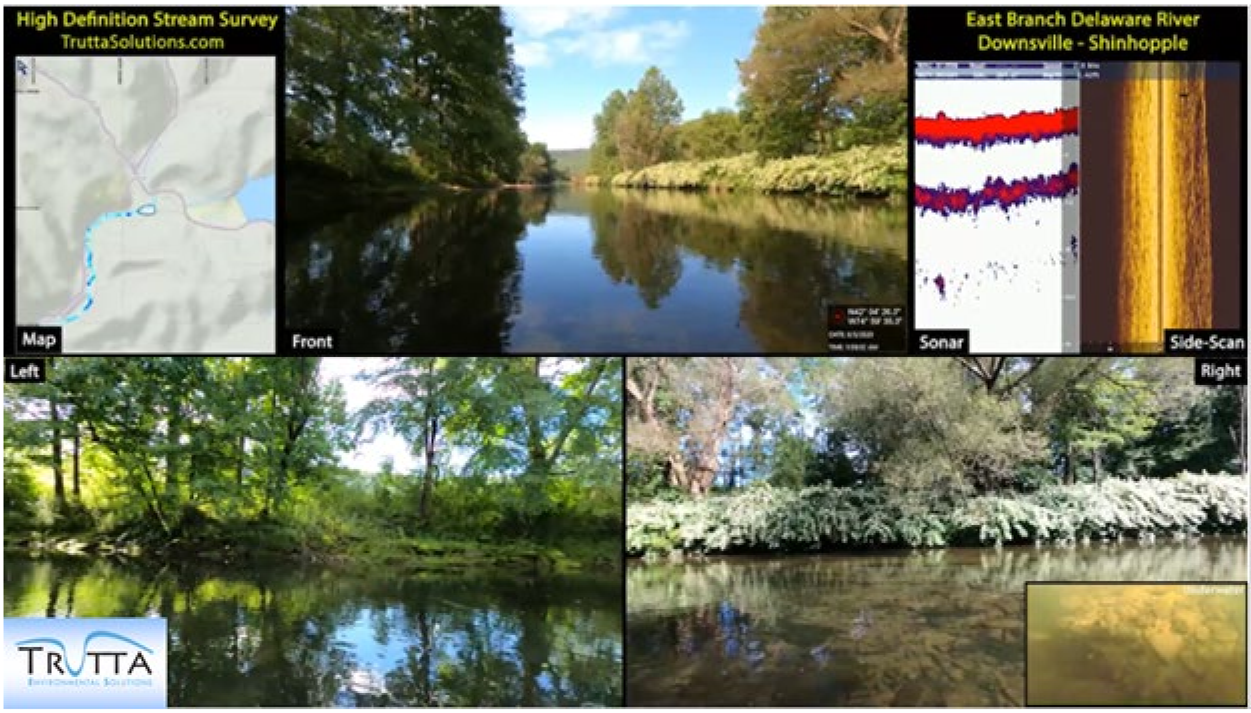


Figure 2: Example of the HDSS StreamView video output showing the stream corridor conditions both above and below water. This example is from the Delaware River in New York.

HDSS was designed to overcome numerous problems associated with traditional stream survey methods. Many techniques have been developed to assess physical and biological conditions within the stream, but they have been primarily focused on detailed descriptions of short stream segments (100 to 250m) or related landcover to streams at the watershed level. Neither of these scales of inquiry fit many of the important life history requirements of the organisms living in stream systems (Figure 3, Fausch et al., 2002). Systemwide assessment protocols generally select specific sites within the stream or stream corridor of interest and then average those samples with the intent of describing the system's condition as a whole. Unfortunately, these approaches suffer from the lack of statistical power as in most cases only a tiny fraction of the overall stream miles is sampled, thus the conditions observed at the sample sites may or may not be indicative of the overall health of the system. HDSS utilizes the opposite conceptual framework. With HDSS, we cover many miles of streams with a consistent spatial resolution which allows the data to easily be scaled from small microhabitat to basin to multi-watershed regional assessments.

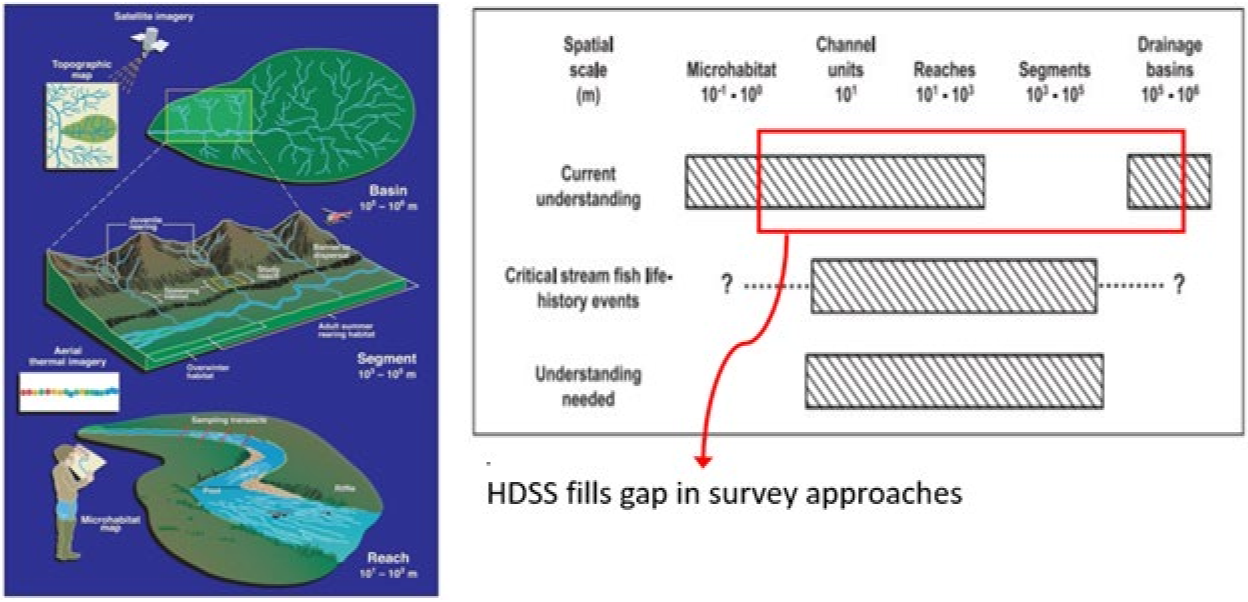


Figure 3: Important scales of survey information and the lack of a good approach to document long stretches of stream corridor information that is now filled by HDSS. Figure adapted from Fausch et al. 2002.

From beginning to end, HDSS is designed to improve upon the shortcomings of traditional survey approaches and address the needs of a wide range of water resource issues. Because of the improvements to the HDSS design, the result supports the application of an Integrated Planning Framework (Figure 4). This framework allows a single survey to be used by multiple partners to accomplish their unique individual goals and the group's overall goals. HDSS provides the data to support decisions concerning infrastructure, water quantity, water quality, habitat, outreach and the stream corridor.

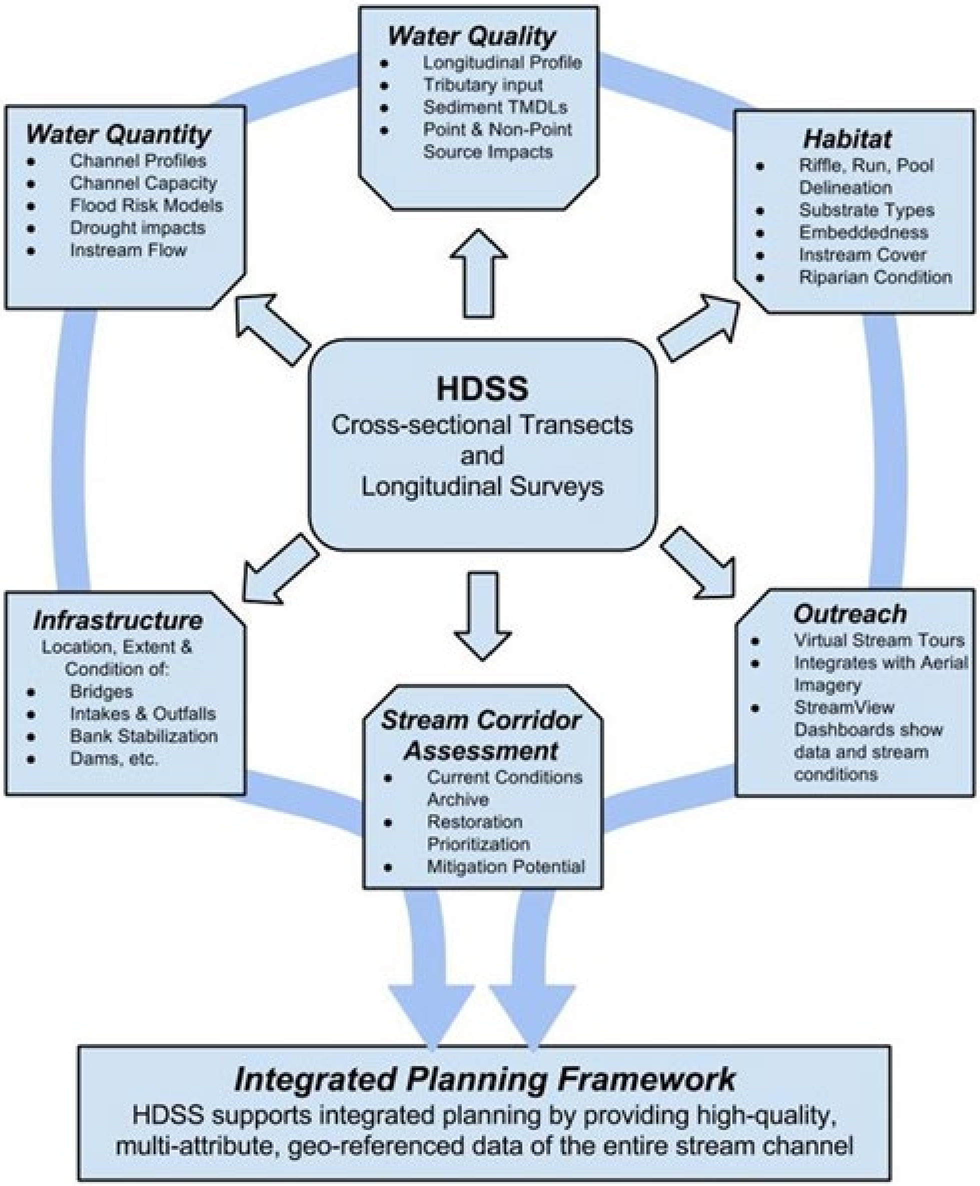


Figure 4: Integrated planning framework.

For the streams within the municipality of Cleveland, TN, an HDSS stream corridor assessment was performed to determine the function and modifications within the stream corridor and identify the areas in greatest need of management action. The HDSS survey is the end result of a series of steps that HDSS data undergoes ending with a continuous rating for the rivers or streams. These steps begin with project initiation, followed by data collection using the HDSS platforms and selected hardware, data processing, data classification and data analysis and results (Figure 5). These steps allow for the assimilation and discernment of data in and adjacent to the stream corridor.

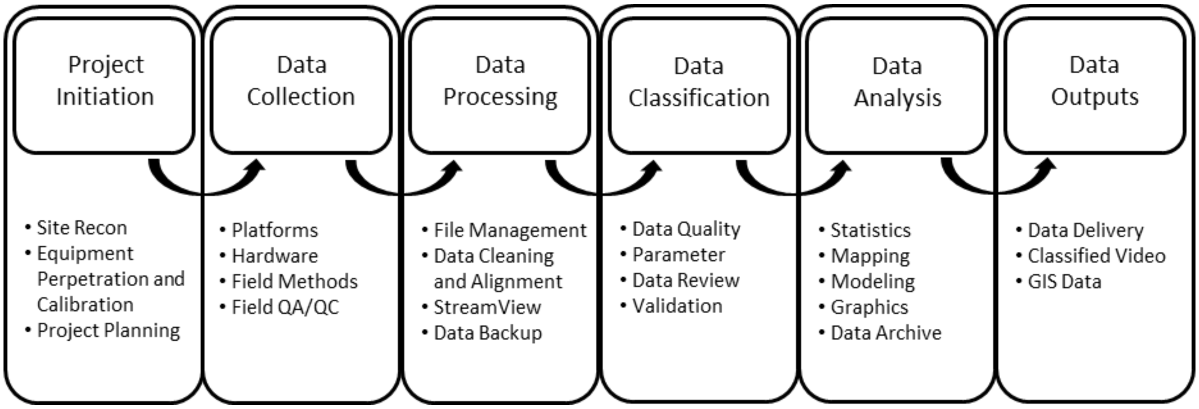


Figure 5: The standardized HDSS project flow chart.

Stream Corridor Assessment

For this assessment, the goal was the development of a HDSS Stream corridor assessment. The HDSS stream corridor assessment framework consists of six fundamental elements: streambed, right and left streambank, right and left riparian area and discrete features (Figure 6). This framework is similar to the Platts et al. (1983) definition of the riparian zone, with the exception of discrete features. Continuous data include the streambed, left and right streambanks, and left and right riparian areas while discrete point features are point locations of anthropogenic or environmental importance. When combined, these six elements define the location, extent, and condition of issues within the stream corridor to aid in planning and effective management. Additionally, each element can be used independently to identify and target specific management actions.

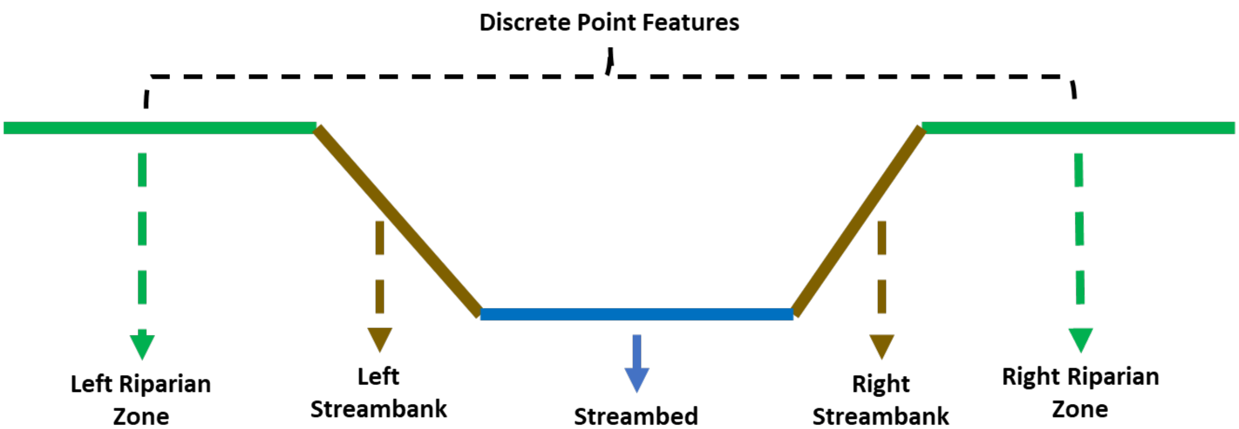


Figure 6: Elements of the Stream Corridor Assessment evaluated using the high-definition stream survey technique. Discrete features are located within the corridor and can affect the stream form and function, most often along the streambanks or streambed.

Project Initiation

A reconnaissance of the streams was conducted to determine the existing conditions within the streams. This was done using GIS and in coordination with the managers from the City of Cleveland. The primary conditions of interest were channel width and depth, water clarity, and physical topography around and near the stream corridor. A review of the project's objectives was then completed. Using both the information from the site reconnaissance and project's goals, the appropriate hardware and platforms for data collection were confirmed. Data collection methods were then later matched to the appropriate data classification method allowing HDSS to address the project's goals.

Prior to field data collection, the GPS receivers, video cameras and sonar were tested and calibrated to local conditions according to the manufacturer's specifications. Instruments with internal GPS receivers (both video cameras and sonar) were initiated approximately 15 minutes prior to field data collection allowing for satellite acquisition to increase accuracy and precision. Sonar units were tested and calibrated to ensure accurate depth and temperature readings. Data collection platforms (i.e., boats and backpacks) were also inspected each day prior to use and batteries were fully charged. Coordination with the City of Cleveland was conducted to ensure that entry and exit access points were obtained and appropriate to the sampling locations. The City of Cleveland also made a public service announcement concerning all activities within the stream and provided guidance on stream access.

Data Collection

Backpack and boat-mounted data platforms were used to record the data. Hardware used on both platforms include a mapping-grade locational receiver, and video camera, while the boat platform also had sonar (Table 1). Video cameras and sonar had internal locational receivers that included latitude, longitude and time. When using the backpack mounted platform, the surveyor walked upstream attempting to follow the thalweg of the stream, while the boat-mounted platform traveled downstream, parallel to the streamflow, in or near the thalweg of the channel.

In addition to the standard HDSS survey, a tablet/photographic survey was conducted in areas where the standard HDSS platforms and methods were constrained. During a photographic survey, images are taken of the most important features observed. Examples where a photographic survey may be used include streams that are primarily underground and rarely daylight for intermittent viewing in highly urbanized or industrial areas; streams with limited access due to property ownership; streams not safe to sample due to animals and/or chemical presence; and/or streams without a clearly defined channel. The photographic survey provided an indication of the potential severity within the stream segment. For the tablet/photographic survey, we still used video although the imagery needed to be fit to the stream in the GIS system. For example, an image may have been collected from a road crossing that looked upstream for 100m. Within the GIS, the information associated with the stream corridor would be mapped to the appropriate stream segment. Therefore, it is important to realize that unlike the boat and backpack surveys, the tablet/photographic video tracks do not relate *exactly* to the time and location of the GIS data.

Table 1: Hardware used on the data collection platforms.

Collector Type	Make	Model	Enabled Features	Rate	Company
Primary Locational Receiver	Garmin	GPSMap 64	WAAS	1 Hz	Garmin International, Inc., Olathe, KS
Video Camera	Garmin	Virb XE	GPS, Image Stabilization	30 fps	Garmin International, Inc., Olathe, KS
Sonar	Humminbird	Helix 9 G2N	Chirp	400 Hz	Johnson Outdoors Inc., Racine, WI

Data Processing

During data processing, the raw data from the locational receiver, video camera and sonar were cleaned, aligned, and then archived. First, data were individually obtained from the locational receiver, video camera and sonar (hardware) at the end of each field day. The individual ("daily") files were then merged according to the hardware type to create a complete dataset for each hardware type. These hardware type datasets were then cleaned, and the cleaned dataset was imported into a database and merged. This ensured that the foundational HDSS data were correct and properly aligned in space and time.

Next, software was used to review and clean raw sonar data. The software utilized an algorithm to highlight potential anomalous depth readings. Anomalous readings were visually inspected and kept or removed (Figure 7). Most removed anomalous readings were likely the result of backscatter from a leaf or other debris floating in the water column or difficulty tracking the correct bottom return. These are observed as a shallow depth reading (such as 1 ft deep) with deep water (10 ft) immediately on all sides. Most retained anomalous readings were associated with steep drop-offs near the river bluffs. In these situations, shallow and deep depths were correctly found in close proximity.

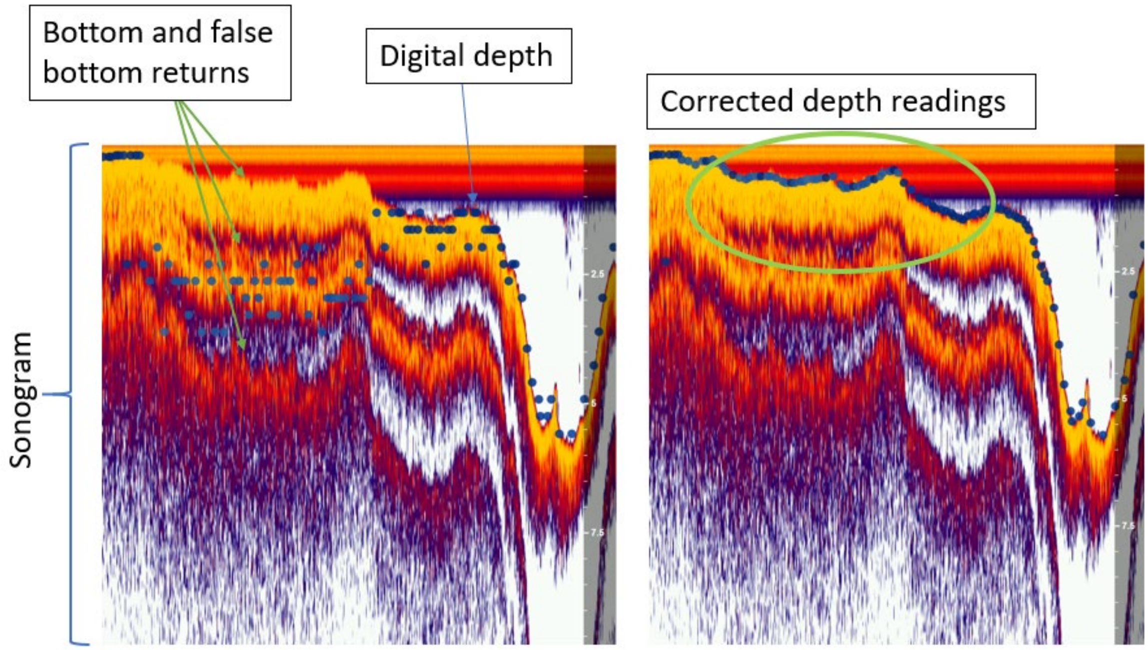


Figure 7: An example of an anomalous depth reading, highlighted in green, collected by the Humminbird Helix 9 G2N sonar.

Locational data was visually inspected for outliers by mapping data from the primary locational receiver to existing National Hydrography Dataset (NHD) GIS layers. Data that appeared to be outside the stream corridor were further reviewed to ensure accuracy. In most cases, anomalies between the field data and existing NHD GIS data layer were due to existing NHD layers not being up-to-date with current channel locations. To allow future classified data to be compared at a single location, cleaned data were mapped to the nearest point along a centerline so the classified data could be referenced to a single point on the river. Each point in the survey was spatially associated with the nearest locational point. From this relationship, points were plotted (approximately equal to 1 m) for each parameter by their defined category classification (Figure 8).

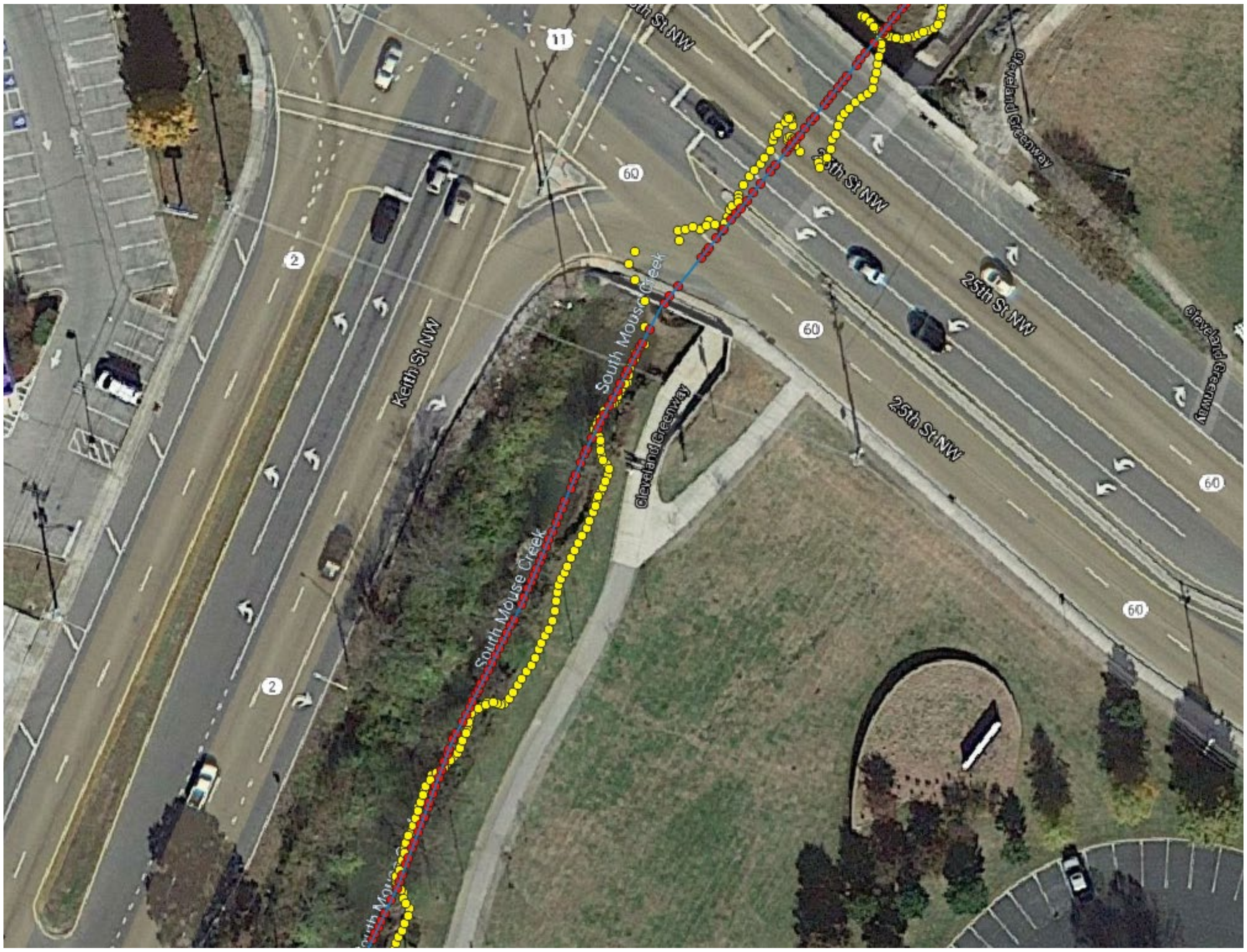


Figure 8: An example of original survey points (yellow) mapped to the stream centerline (blue) and the resulting points moved to the centerline (red).

Geo-referenced video was combined with the locational and sonar data such that each data point is associated with Coordinated Universal Time (UTC) and coordinate information. The individual files were assembled to form a single, georeferenced, continuous video tracklog (i.e., StreamView; Figure 9), referenced to a common location and time. This StreamView video allows for visual classification using HDSS video coder software which allowed an appropriate score to be applied to each second of the video and associated GPS location. This tracklog also provided the format for baseline information for non-visual (algometric) data classification.

Figure 9: Example of StreamView dashboard for data collected from the kayak (left) and backpack (right) platforms.

Data Classification

Data were identified and classified using a standard set of criteria. Visual classifications and software algorithms were used to classify the parameters of interest. Visual classifications for the streambed, streambanks and discrete point features were conducted using HDSS video coder software while viewing the StreamView videos. Each parameter visually classified was independently observed and scored, requiring multiple viewings of the video. To avoid observer reliability error due to different observers, all scoring of streambed, streambank, and discrete point feature conditions were performed by a single experienced classifier. An algorithm was used to classify both the left and riparian areas. After classification, every GPS point had an associated collection time, latitude, and longitude for the parameter of interest.

Data Quality Classification

Data quality classification occurred prior to the visual classification of parameters of interest. During the data quality classification, the video quality and suitability were defined for classification of right and left streambanks, streambed, and discrete point features. Additionally, it defined how the data can be used to deliver specific parameters during analysis. The continuous video file was classified into one of 12 categories (Table 2).

Table 2: Data location and type with respective definitions used during Data Quality classification.

Data Location or Type	Definition
Good data	Video allows for analysis
Restricted data	All video data obstructed limiting analysis.
Right bank obscured	View of right bank obstructed limiting analysis.
Left bank obscured	View of left bank obstructed limiting analysis.
Left bank and streambed obscured	View of left bank and streambed obstructed limiting analysis.
Right bank and streambed obscured	View of left bank and streambed obstructed limiting analysis.

Dragging	Kayak is dragging on in-channel obstacles requiring the navigator to exit the kayak to continue, often over shallow riffles or debris jams.
Transect	Video where cross-sectional transects were performed.
Underground	Channel goes underground, inaccessible by foot or kayak.
Off-channel	Video identifies a water management related structure (e.g., detention pond, terracing).
Revisit	Video needs additional review by field staff or others for clarification.
Photo survey	Video will be used for photographic description due to safety and difficulty of survey.

Streambed Function and Modification

The two elements of function and modification were classified for the streambed. Streambed function was classified and used as a measure of disturbance to the streambed and potential impacts on stream function and stability during high and low flow events. Streambed modification was classified and used as a measure of anthropogenic influence to the streambed. Streambed function and modification were independently viewed and classified during the classification process.

Function of the streambed was rated on a scale from 1 (fully functional) to 5 (non-functional; Figure 10) based on conditions during the survey. The primary characteristics used to classify streambed function included a visual integration of habitat heterogeneity (i.e., water depth and velocities, substrate types, and instream cover), channel shape (e.g., appropriate channel sinuosity and width), and sedimentation. Streambed modification was identified as unmodified (i.e., no human influence), modified (e.g., riprap, gabion baskets, or other highly porous, permeable material) or highly modified (e.g., concrete channel or other non-porous material; Figure 11).

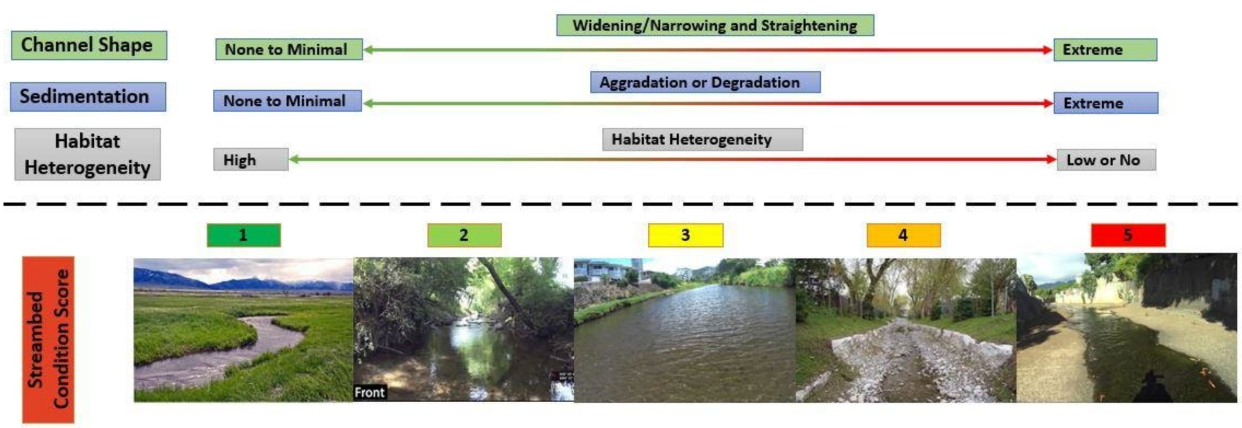


Figure 10: Streambed function scoring criteria that is visually integrated to provide an overall streambed function score (above) and examples of each of the five categories (below) ranging from 1-5, with 1 being the best and 5 being the worst.

Unmodified Modified Highly Modified

Type Score	Type Class	Description
1	Unmodified	Little to no human modification. No obvious erosion control measures have been implemented.
2	Modified	Obvious signs of human modification such as placement of erosion control measures. Measures implemented allow for surface water and ground interaction (e.g., riprap, gabion baskets, etc.)
3	Highly Modified	Obvious signs of intensive human modification to control erosion and discharge. Measures implemented do not allow for surface water and ground interaction (e.g., poured concrete or other highly impermeable surface)

Figure 11: Examples of streambed modification identifying native, modified, and highly modified streambeds (above) and streambed modification scores, classes, and descriptions (lower).

Streambank Function and Modification

Streambanks are defined as the sloping lands that contain the stream under normal flows. The method used to score streambank function consisted of the two elements of function and modification. Streambank function scores reflect the potential for streambank erosion or streambank failure, while streambank modification is used as a measure of anthropogenic influence along the streambank. The functional score consists of five levels ranging from fully functional (1) to non-functional (5; Figure 12; Figure 13. Streambank modification is identified as unmodified (i.e., no human influence), modified (e.g., riprap, gabion baskets, concrete blankets, or other highly porous, permeable material) or highly modified (e.g., concrete channel or other non-porous material; Figure 14). These two elements of function and modification were individually classified for both the left and right streambank. Both function and modification were continuously assessed individually for both the left and right banks along the entire sampling area by a single experienced classifier.

Left and right streambank function and modification were visually assessed from the high-definition video for both sides of the river. The method used to score function is similar to BESI developed by Connell et al. (2019) for landscape scale assessments of streambank erosion susceptibility. Streambank function is a visual integration of streambank angle, height, surface protection, and vegetated diversity. Compared to the BEHI method developed by Rogen (2001), our method utilizes a riparian condition parameter, similar to Sass and Keane (2012), as a surrogate for root depth and density and data were viewed on high-definition video captured from the HDSS system. Video has been used with success to determine streambank erosion rates (Hensley and Ayers 2018) and areas susceptible to erosion (Connell et al. 2019). The major advantages of this method over traditional erosion assessments are the reduction of field time, cost and uncertainty when extrapolating data to represent the entire river.

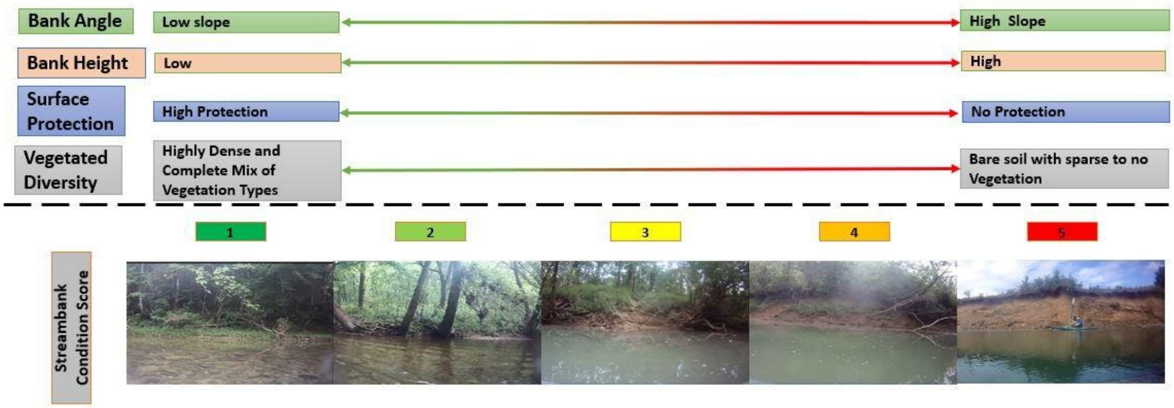


Figure 12: Streambank scoring criteria that is visually integrated to provide an overall streambank function score (above) and examples of each of the five categories (below) ranging from 1-5, with 1 being the best and 5 being the worst.

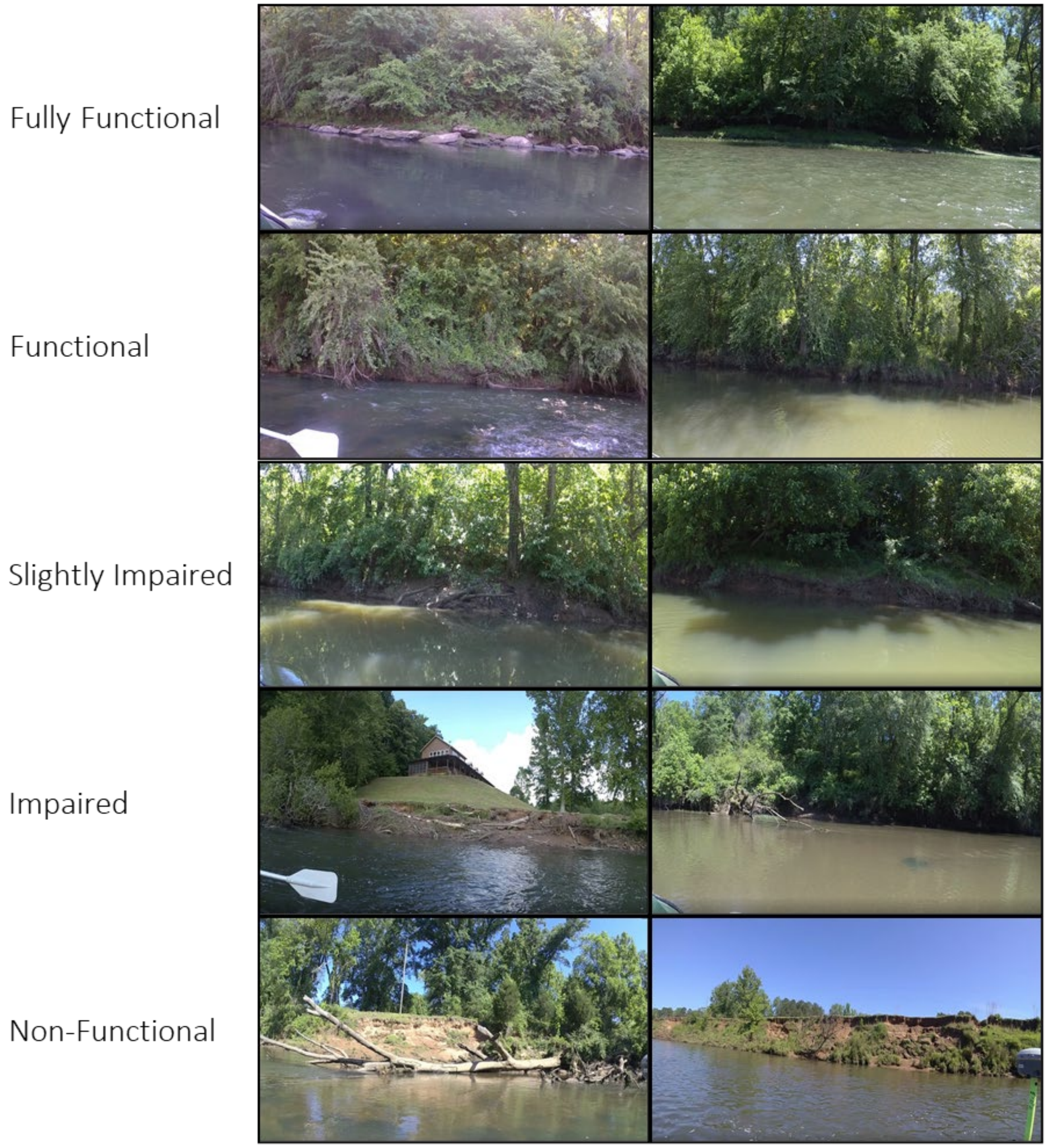


Figure 13: Examples of the five streambank impairment classification levels.

Type Score	Type Class	Description
1	Unmodified	Little to no human modification. No obvious erosion control measures have been implemented.
2	Modified	Obvious signs of human modification such as placement of erosion control measures. Measures implemented allow for surface water and ground interaction (e.g., riprap, concrete blanket, gabion baskets, etc.)
3	Highly Modified	Obvious signs of intensive human modification to control erosion and discharge. Measures implemented do not allow for surface water and ground interaction (e.g., poured concrete or other highly impermeable surface)

Unmodified Modified Highly Modified

Figure 14: Examples of streambank modification identifying unmodified, modified, and highly modified streambanks (above) and streambank modification scores, classes, and descriptions (below).

Riparian Function

The riparian area encompasses that portion of the terrestrial landscape from the top of the bank outward 30 m (100 ft). Riparian function score reflects the potential for the riparian area to provide food and shelter for aquatic organisms, increase filtration of overland flows, increase infiltration to reduce overland flows and stabilize the streambank. Riparian function score also reflects the level of anthropogenic influence along the riparian zone. The functional score consisted of five levels ranging from fully functional (1) to non-functional (5; Figure 15) and could also be viewed as a range from little (i.e., little to no human influence), to moderate (e.g., agricultural, ranching, timber harvest) to high (e.g., urbanized; Figure 15) levels of human modification. Riparian function was continuously assessed individually for both the left and right banks along the entire sampling area.

Left and right riparian function was assessed by importing GIS land use coverages and then integrating them with the HDSS data for continuous riparian classification. Function was scored based on the visual integration of vegetative functional complexity where a decrease in the range of plant types and sizes decreased the vegetative function (Figure 15) .

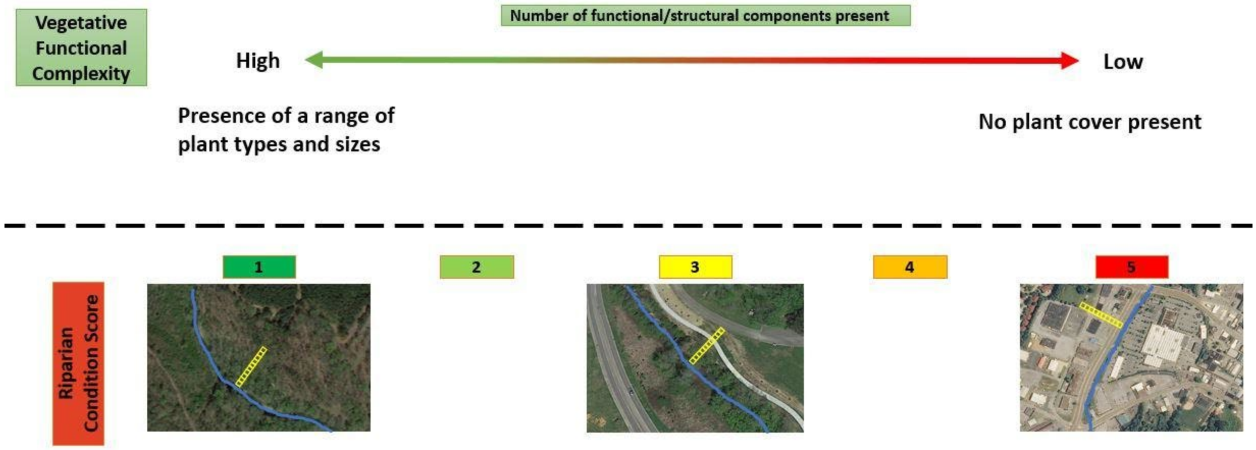


Figure 15: Riparian area scoring criteria that is visually integrated to provide an overall riparian function score (above) and examples of three of the five categories (below) ranging from 1-5, with 1 being the best and 5 being the worst.

The riparian data was based on the 2016 National Landcover Database (NLCD; USGS). The riparian areas were compared with 2020 aerial imagery (ESRI Satellite images) to account for changes in riparian conditions between 2016 and 2020. The NLCD raster data was resampled to 3m resolution to improve the resolution of the NLCD within specific riparian areas (Figure 16). A 30 m buffer was applied to the stream centerline and individual polygons were created for the left and right riparian areas for each meter of the stream (Figure 17). The average of the classified landcover (fully functional to non-functional) was collected for each riparian polygon and rounded to the nearest integer value. This resulted in a single score (1 to 5) that represented the function and modification of the riparian area.

Figure 16: An example of the riparian data and 30m buffer zone created along the stream centerline. The example image is from South Mouse Creek just downstream of the intersection of Keith St NW and 25th St NW.

Figure 17: Example of the right and left riparian polygons created for each meter of the stream centerlines. The example image is from South Mouse Creek just downstream of the intersection of Keith St NW and 25th St NW.

Discrete Point Features

Discrete point features are unique manmade or natural features that may affect the physical and biological function of the stream corridor. Discrete point features were identified and classified based on the three elements of type, condition and location similar to Yetman (2001). Feature type identifies what the feature is, condition identifies the effect that the feature is having on stream function and its susceptibility to damage and location identifies where the feature was within the stream corridor.

Each discrete point feature type was arranged into one of four categories that include: pipes, road crossings, sedimentation or other. Discrete point feature types categorized as pipes include exposed pipe, intake, manhole stack, and outfall (Figure 18), while road crossings types include culvert, overhead bridge and low water crossing concrete or dirt (Figure 19). Sedimentation types include excess fines, in-channel bars, vegetated islands and in-channel vegetation (Figure 20). The “other” category includes the types such as large woody debris, debris jams, fish barriers, in-coming channels, trash, livestock, construction in/near stream and side channel present (Figure 21). Table 3 identifies the discrete point feature types and provides a brief description. Condition was rated on a scale from 1 (minor) to 3 (severe). The condition of each discrete feature was scored based on the visual integration of one or more components to determine the level of impact relative to other problems in the same type (Table 4; Figure 22). Location of each discrete feature was identified as being within the left, right, or both banks, in-channel, or overall (Table 5).

Table 3: List of potentially identifiable discrete features and their brief descriptions.

	Discrete Feature	Description
Pipes	Exposed Pipe	Pipes along the stream's banks or on bed that have become exposed, or pipes built over a stream that could be affected by occasional high flows.
	Intake	Any pipes or small manmade channels that remove discharge from the stream
	Manhole Stack	Prefabricated or constructed pit to access utilities below grade.
	Outfalls	Any pipes or small manmade channels that discharge into the stream
Road Crossings	Culvert	A structure that can allows water to flow under a road, railroad, trail, or similar obstruction from one side to the other side. Typically embedded (surrounded by soil) constructed of metal, concrete, or plastic.
	Overhead bridge	A structure carrying a pathway, roadway, or railway over a waterway, typically spanning greater than 6.5m (or 20ft).
	Low water crossing dirt	Stream crossing of natural bed material, often rocky or bedrock cross, at or slightly above the elevation of the streambed without pipes
	Low water crossing concrete	Stream crossing of improved, reinforced roadbed, often with concrete planks, slabs, or asphalt, at or slightly above the elevation of the streambed without pipes.
Sedimentation	Excess fines	Large accumulations of fine sediment on the bottom of the stream
	In-channel bars	Exposed ridge-like accumulation of sand, gravel, or other alluvial material formed in a channel, along the banks, or at the mouth of a stream at an elevation lower than the floodplain.
	Vegetated Island	Discrete parcels of land surrounded by water within the stream channel that are relatively stable. Additionally, the elevation of an island has a point that is ≥ to the floodplain.
	In-channel Vegetation	Clump or cluster of emergent or submergent vegetation, more than a few plants, that has the potential to reduce base flows and assist in bar development or indicate a depositional area.
Other	Large Woody Debris	Woody debris retards current velocity, adds structure, and increases the volume of usable habitat for some fish in small streams during periods of low flow (Lisle, 1986). LWD is counted inside the wetted width of the channel and has a diameter greater than six inches.
	Debris/Log Jam	Accumulation of debris in a channel that may cause ponding of water or alluvial deposition upstream from the accumulation.
	Fish Barriers	Physical barriers in streams and rivers are any structure or habitat condition that creates a potential obstacle to fish migration (Bain and

		Stevenson 1999) such as waterfalls, cascades, culverts, exposed pipes, log or debris jams, beaver dams, and artificial constructed dams.
	In-coming Channel	Is a confluence or where the channel being surveyed meets another stream channel.
	Trash	Areas where trash is concentrated due to dumping or aggregation by currents. Not to be confused with garbage or litter.
	Livestock	Livestock are in the stream or near the stream and access is not limited.
	Construction in/near channel	Construction site or activities in or near that do or can influence the stream.

Figure 18: List of potentially identifiable discrete features and their brief descriptions.

Figure 19: Examples of road crossings discrete point features often classified: A-culvert, B- overhead bridge, C- low water crossing dirt, D- low water crossing concrete.

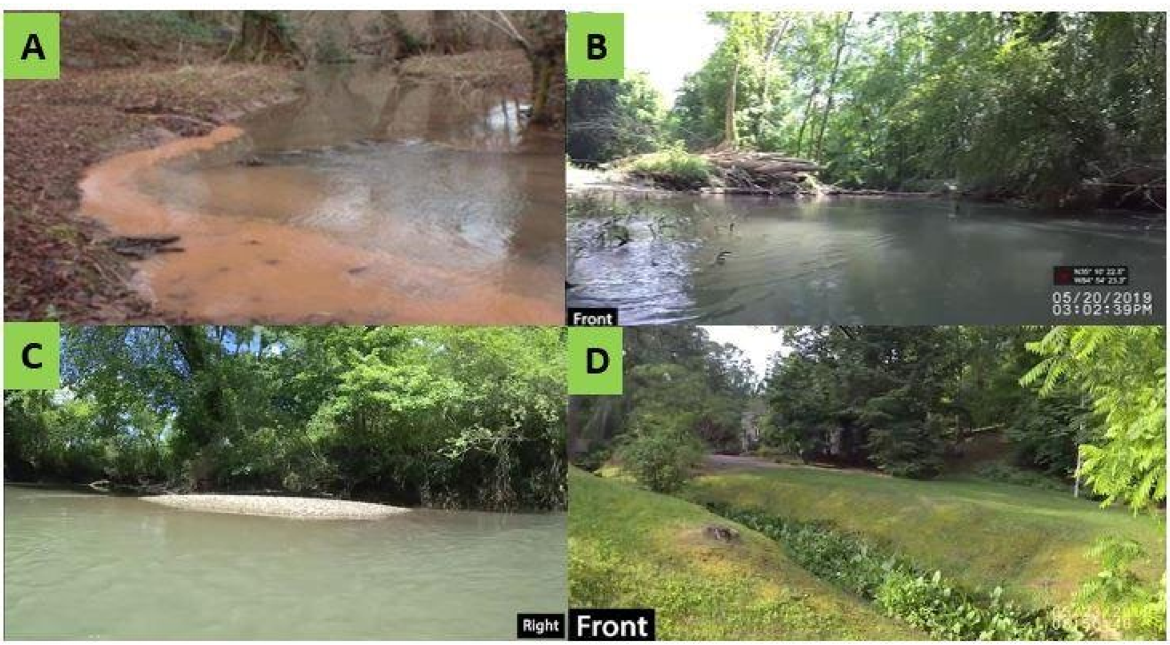


Figure 20: Examples of sedimentation discrete point features often classified: A-excess fines, B- in-channel Island, C- bars, D- in-channel vegetation.

Figure 21: Examples of Other discrete point features often classified: A-large woody debris, B- debris jam, C- fish barrier, D- in-coming channel, E- trash, F- livestock, and G- In/near channel construction.

Table 4: Parameters visually integrated to determine the severity score for discrete point features. List of discrete point features and their respective condition criteria.

Discrete Feature		Parameter	Condition		
			Minor	Moderate	Severe
Pipes	Exposed Pipe	Diameter of Pipe	Large		
			Small		
		Location	On Bottom or partially exposed	Hanging	
		Condition of Pipe	Not leaking or broken		Leaking or broken
				Bent	
	Intake	Pipe size	Small (< 2 inches; residential)	Medium (>2 but ≤ 4 inches; agricultural)	Large (>4 inches; municipal or commercial)
	Manhole Stack	Location/exposure	On bank or off-channel	At edges wetted width	Within or near center of channel
		Erosion to stream	No effect	Slight	Significant
	Outfalls	Color or odor	No	Slight	Strong
		Affecting stream biota	No	Localized	Far reaching
		Erosion to stream	No effect	Slight	Significant
Road Crossings	Culvert or Overhead bridge	Upstream blockage	Little to no debris on upstream end	Debris has accumulated on the upstream end	Total blockage at upstream end
		Erosion to stream	No effect	Slight	Significant
	Low water crossing dirt	Indication of use	Rare use (overgrown two track)	Moderate use	Heavily use (well defined)
	Low water crossing concrete	Indication of use	Rare use (residential single property owner)	Moderate use (often public lands)	Heavily use (arterial road)
Sedimentation	Excess fines	Depth	< 1 inch	1-2 inches	> 2 inches
		Length	< 2 x wetted width	15-50 x wetted width	> 50 x wetted width
	In-channel bars	Width	< 25% of channel width affected	> 25% but < 75% of channel affected	≥ 75% of channel width affected
		Length	< 2 x wetted width	3–9 x wetted width	> 10 x wetted width
	Vegetated Island	Width	≤ 25% of channel affected	> 25% but < 75% of channel affected	≥ 75% of channel width affected
		Length	< 15 x wetted width	15-50 x wetted width	> 50 x wetted width

Table 4 (continued): Table of parameters visually integrated to determine the severity score for discrete point features.

Discrete Feature		Parameter	Condition		
			Minor	Moderate	Severe
	In-channel Vegetation	Width	≤ 25% of channel affected	> 25% but < 75% of channel affected	≥ 75% of channel width affected
		Length	< 2 x wetted width	3–9 x wetted width	> 10 x wetted width
		Density	Not Dense	Dense	
General	Large Woody Debris	Number of pieces	< 3	> 3 but ≤ 7	> 8
	Debris/Log Jam	Width	≤ 90% of channel affected	100% of channel affected	
		Flow	Very limited flow	Highly restricted	
	Fish Barriers	Water velocity over barrier	Slow	Moderate	Fast
		Height	< 4 inches	>4 inches but < 12 inches	> 12 inches
		Width	≤ 90% of channel affected	100% of channel affected	
	In-coming Channel	Width	≤ 25% the width of stream/ river being sampled	> 25% but < 75% of the width of stream/ river being sampled	≥ 75% of the width of stream/ river being sampled
	Trash	Method of collection	Stream pick-up	Small equipment or intense labor required	Heavy machinery required
	Livestock access	BMP	In place and adequate	In place but inadequate or failing	None implemented
	Construction in/near channel	Erosion control measures	In place and adequate	In place and inadequate	None
		Project size	Minor road or single house	Major road or commercial	

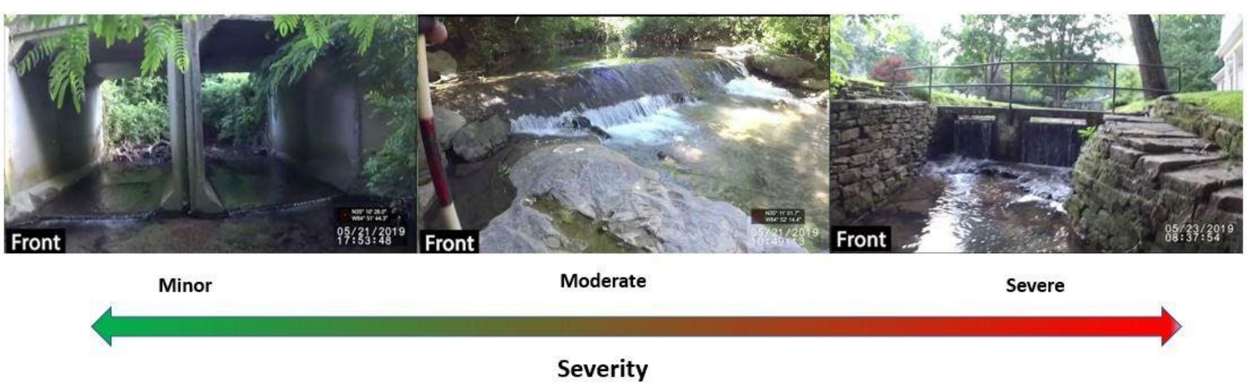


Figure 22: Example of severity rating for discrete point features (e.g., fish barriers).

Table 5: Locations where discrete point features could be observed and their brief description.

Location	Description
Left Bank	Within ¼ of the streams total wetted width of the left bank
Right Bank	Within ¼ of the streams total wetted width of the right bank
In-channel	Between the areas for left and right bank listed above
Both Banks	Occurs only at both left and right banks
Overall	Occurs on left and right banks and in-channel

Stream Corridor Functional and Modification Rating

All individual elements of the stream corridor (streambed, left streambank, right streambank, left riparian, and right riparian) were combined to provide a single rating for the stream corridor function and the extent of modification. At each meter of the stream corridor there was a single 5 -code representing the cross-sectional values of the stream corridor. For example, a code of 53224 would represent the cross-sectional scores of 5=left riparian, 3=left streambank, 2=streambed, 2=right streambank, and 4=right riparian. Given the 5 possible functional scores for the 5 different elements of the stream corridor, there were 3125 possible combinations (5^5=3125). The 3125 possible combinations were grouped into 16 similar classes of similarity of restoration effort and those 16 different restoration groups were further grouped into five categories representing the overall function of the stream corridor using the same 1=fully functional to 5=non-functional scoring system from the individual functional assessments (Table 6).

Stream corridor modification was based on the modification scores of the streambed, left streambank, and right streambank as these were clear indicators of past management effort. Similar to the individual modification scoring systems, stream corridor modification rating scores represented the extent of modification present and ranged from unmodified to highly modified.

Relative Restoration Cost

In addition to the stream corridor functional and modification rating, we estimated the relative cost to restore each element of the stream corridor and combined those to create an overall relative cost for each of the 16 restoration groups. These relative costs were based on the difficulty of typical management actions. For example, it is easier and thus less expensive to plant trees in a riparian area than it is to restore a failing streambank. Therefore, the relative cost of the riparian restoration was lower than the cost of the streambank restoration. These relative costs are very general and should be used with further site exploration from the video before basing a cost on this estimate alone.

Functional Uplift

After the classification was complete for each meter of stream, continuous stream sections with the same rating were given a unique ID. The segment rating ID allowed the length, starting and ending points and overall functional uplift to be calculated for each segment. These segments were then ordered by the maximum amount of functional uplift available with respect to the segment length (uplift/m) which allowed segments with the highest potential uplift to be considered first for management actions. The multivariable rating, modification and uplift scores provided an indication of the location, extent, and range of conditions management action.

Table 6: Stream corridor restoration and rating groups.

Group Code	Group Name	Group Cost	Count	Rating	Rating Name
1	All5	324	32	5	5:Non-functional
2	Any4	300	240	5	5:Non-functional
3	Both Banks & Channel	300	72	4	4: Impaired
4	Riparian Bank & Channel	172	144	4	4: Impaired
5	Mix3	170	504	4	4: Impaired
6	Streambank & Stream Channel	160	216	3	3: Slightly Impaired
7	Both StreamBanks	140	108	3	3: Slightly Impaired
8	Riparian & Streambank	82	216	3	3: Slightly Impaired
9	Both Riparians	30	108	3	3: Slightly Impaired
10	Mix2	74	432	3	3: Slightly Impaired
11	SC Only	90	162	2	2: Functional
12	Single Streambank	20	324	2	2: Functional
13	Single Riparian	10	324	2	2: Functional
14	Slightly Impaired	37	121	2	2: Functional
15	Near Functional	0	90	1	1: Fully Functional
16	Functional	0	32	1	1: Fully Functional

Results

A total of approximately 45.05 km (28.0 miles) of streams were sampled using HDSS during 20-23 May 2019 (Table 7). The HDSS boat (kayak), backpack and tablet platforms were all utilized due to the varying stream sizes and access issues. The boat platform was used exclusively on 17.59 km, while the backpack platform was used on 24.54 km of Cleveland streams. A total of 2.91 km of streams were documented using the tablet/photographic survey approach. Twenty-four StreamView Video Tracks were created for the different stream segments during this project (Table 8). The tablet/photographic approach was used on four of the video tracks (408, 409, 410, 411) as we were not able to consistently stay within the stream corridor (Figure 23). Images from the videos were used to estimate channel conditions where possible. The StreamView videos can be referenced to the GIS data by their track number and date and time of collection making it possible to relate the classified data to the stream videos.

Table 7: Length of streams surveyed within the City of Cleveland for this project.

Stream	length (m)	Length (miles)
Bigsby Creek	775	0.5
Candies Creek	10,510	6.5
Fillauer Branch	7,445	4.6
Little Chatata Creek	8,181	5.1
Little South Mouse Creek	121	0.1
South Mouse Creek	14,190	8.8
Spring Branch	759	0.5
Woolen Mill Branch	3,065	1.9
Total	45,046	28.0

Table 8: Video Tracks, Streams, Stream Segments, Lengths, Platform, and start and end times for the HDSS output.

Video Track	Stream Name	Stream Segment Code	length (m)	Platform	Start time	End Time
101	South Mouse Creek	SMC_M1	7,082	boat	2019-05-20T11:19:00	2019-05-20T13:23:28
103	Candies Creek	Candies Creek	5,026	boat	2019-05-20T15:00:32	2019-05-20T16:11:21
104	Candies Creek	Candies Creek	5,484	boat	2019-05-20T16:18:22	2019-05-20T17:47:31
201	South Mouse Creek	SMC_M1	2,280	backpack	2019-05-21T10:15:10	2019-05-21T11:55:13
202	South Mouse Creek	SMC_M1	2,930	backpack	2019-05-21T12:02:22	2019-05-21T13:44:55
203	South Mouse Creek	SMC_M1	1,020	backpack	2019-05-21T14:19:19	2019-05-21T14:52:50
204	South Mouse Creek	SMC_T2	878	backpack	2019-05-21T15:11:16	2019-05-21T15:35:42
205	Fillauer Branch	FB_M1	4,288	backpack	2019-05-21T16:18:37	2019-05-21T18:16:42
301	Fillauer Branch	FB_T1	667	backpack	2019-05-22T09:00:35	2019-05-22T09:23:51
302	Little Chatata Creek	LCC_M3	2,675	backpack	2019-05-22T10:28:24	2019-05-22T12:15:17
303	Little Chatata Creek	LCC_M3	1,866	backpack	2019-05-22T13:05:20	2019-05-22T14:19:34
304	Little Chatata Creek	LCC_M1	3,018	backpack	2019-05-22T14:59:30	2019-05-22T16:39:33
305	Little Chatata Creek	LCC_M1	622	backpack	2019-05-22T16:54:08	2019-05-22T17:15:57
401	Fillauer Branch	FB_M1	895	backpack	2019-05-23T08:14:49	2019-05-23T08:51:16
402	Fillauer Branch	FB_T2	830	backpack	2019-05-23T09:17:56	2019-05-23T09:49:33
403	Fillauer Branch	FB_T2	526	backpack	2019-05-23T10:29:42	2019-05-23T10:43:44
404	Woolen Mill Branch	WMB_M1	391	backpack	2019-05-21T12:26:44	2019-05-23T11:28:08
405	Bigsby Creek	Bigsby Creek	775	backpack	2019-05-23T14:59:15	2019-05-23T15:20:21
406	Little South Mouse Creek	LSMC1	121	backpack	2019-05-23T16:01:26	2019-05-23T16:05:33
407	Spring Branch	Spring Branch	759	backpack	2019-05-23T16:54:55	2019-05-23T17:12:28
408	Woolen Mill Branch	WMB_T4	1,080	tablet	used for images	used for images
409	Woolen Mill Branch	WMB_M1	1,427	tablet	used for images	used for images
410	Woolen Mill Branch	WMB_T1	167	tablet	used for images	used for images
411	Fillauer Branch	FB_T1	239	tablet	used for images	used for images

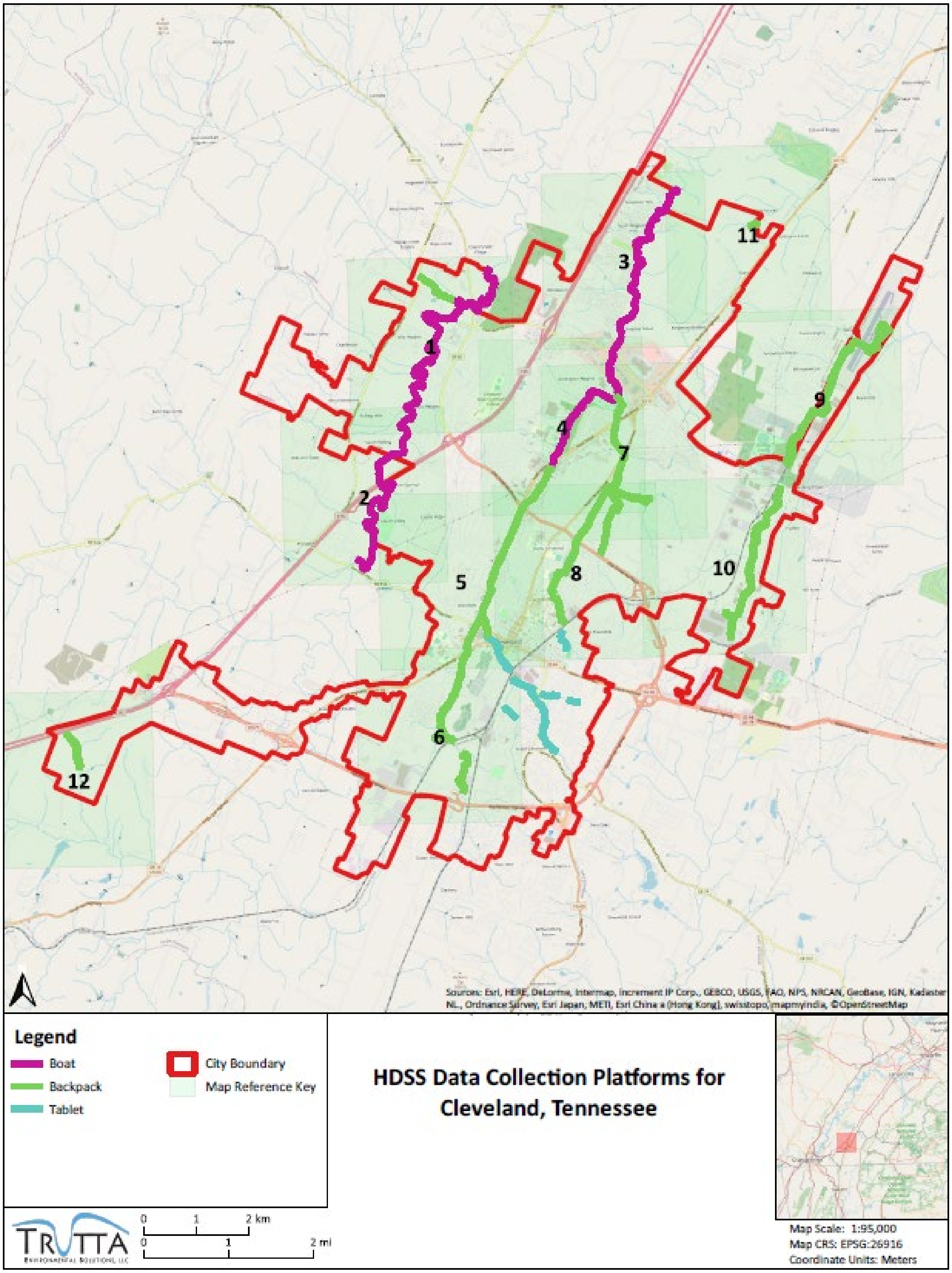


Figure 23: Locations of the different types of platforms (boat, backpack, tablet) used during the HDSS project.

Local Flow Conditions

The HDSS survey for the stream was completed during the period beginning on 20 May 2019 and ending on 23 May 2019. To understand the local flow conditions during the pre- and post- survey period, we consulted the USGS gage data for the nearest appropriate gage. For this project, the nearest appropriate gage was site number: 03565500 - OOSTANAULA CREEK NEAR SANFORD, TN. Mean daily discharge was calculated by summing the instantaneous data observations, recorded and reported by the USGS every 15 minutes, from 00:00 to 23:45 each day and then dividing it by the total number of recorded observations during that period. The data for the following discharge plots were retrieved from the USGS website. While this gage is not on any of the surveyed streams, it is on a nearby stream which also flows into the Hiwassee River like streams in Cleveland, TN and thus was the most appropriate gage to describe general flow conditions (Figure 24).

In general, the stream discharge was low and slightly falling during the surveys which was observed in both the short-term and long-term discharge plots (Figure 25; Figure 26). The data for the following discharge plots were retrieved from the USGS website. Mean daily discharge ranged between 86 cfs and 97.5 cfs during our survey dates.

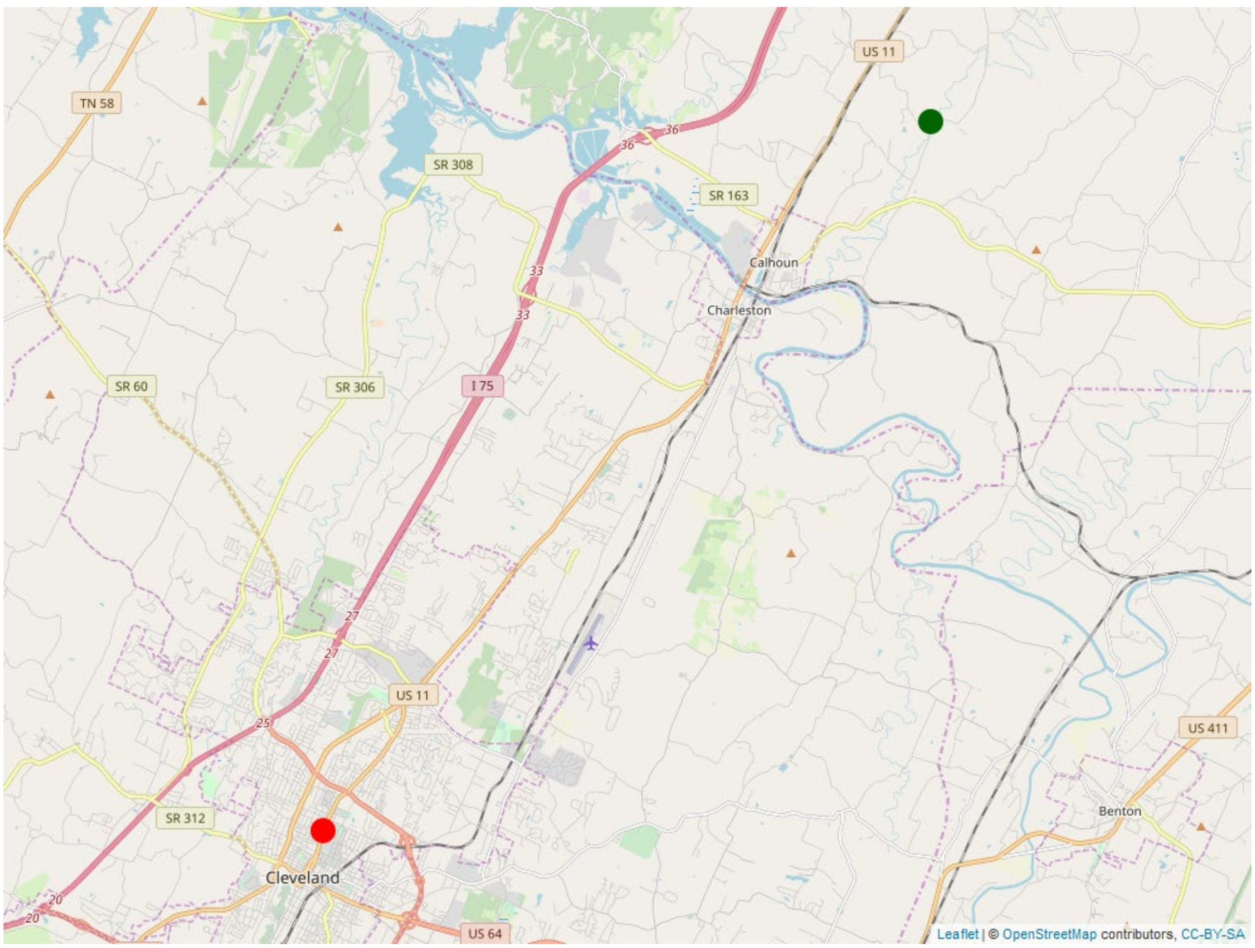


Figure 24: Map of USGS Stream Gage location (dark green dot) relative to the city of Cleveland, TN (Red dot).

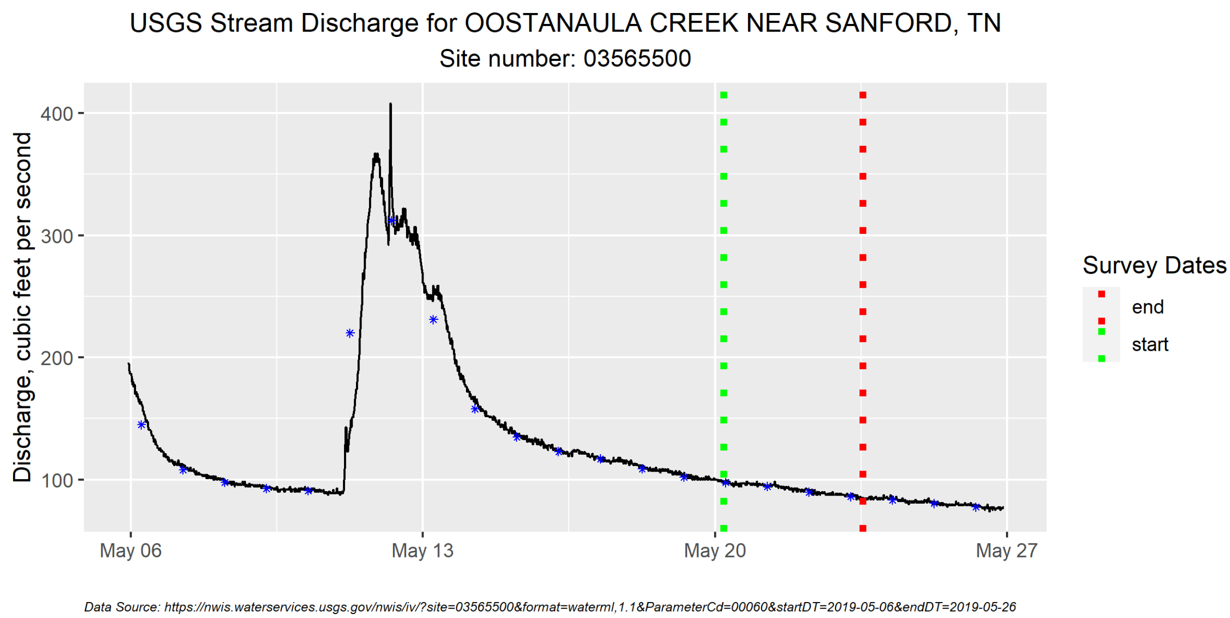


Figure 25: 21-day stream discharge, 14 days prior and 3 days post sampling event, for USGS Site Number: 03565500, the nearest USGS site in the survey area. Blue stars represent mean daily discharge, the green vertical dashed line is survey beginning and red vertical dashed line is survey end.

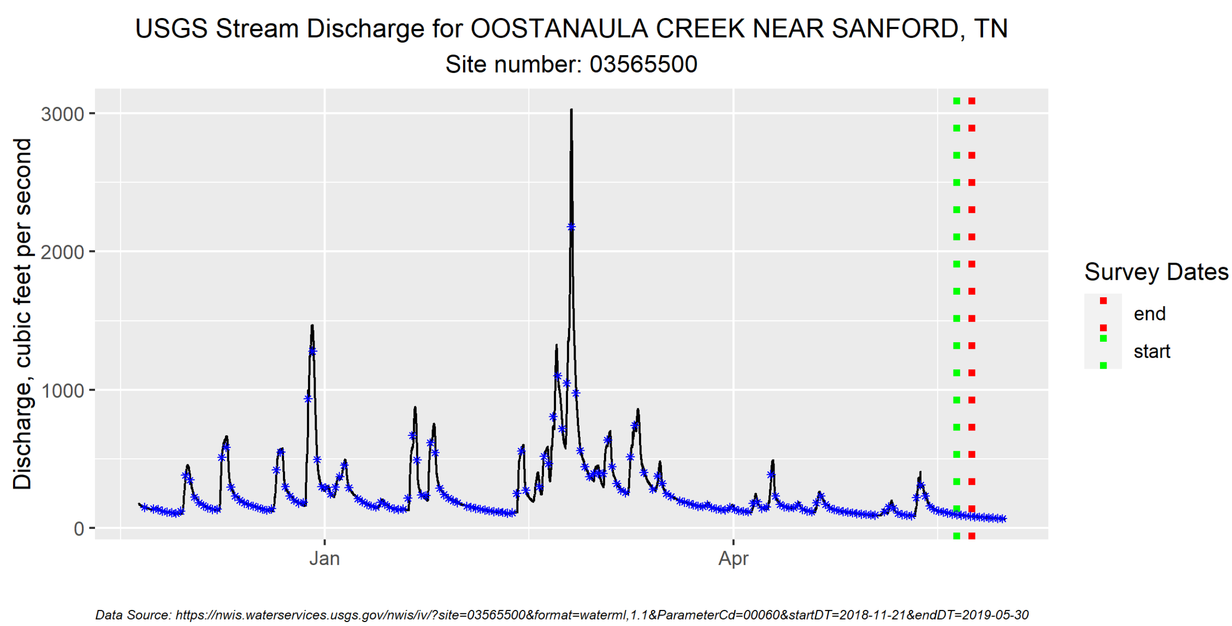


Figure 26: 190-day stream discharge, 180 days prior and 7 days post sampling event, for USGS Site Number: 03565500, the nearest USGS site in the survey area. Blue stars represent mean daily discharge, the green vertical dashed line is survey beginning and red vertical dashed line is survey end.

Weather Conditions

During 20-23 May 2019, the local weather conditions were warm and dry with high temperatures in the upper 80s to lower 90s and low temperatures ranging from low 60s to low 70s. No precipitation was recorded during the survey, and none was forecasted the week prior to the survey

Data Quality

A total of 12 comments were noted in all surveys. All comments required confirmation of discrete features such as partially hidden culverts and exposed pipes. Only two comments remained in the final data that identified the beginning and ending of a chain-linked fence that ran parallel in the streambed. Revisits that remained in the dataset were used to identify the additional locations to be used in the photographic survey.

The total number of stream meters observations can and do vary among classifications due to the observer's ability to identify the required elements (i.e., data quality classification). For example, if the observer leaves the stream channel due to depth and traverses along left riparian area with observations only of the right streambank and streambed then the left streambank is not visible for classification and therefore, the number of observations is not equal between streambanks. Figure 27 shows the distribution of the data quality classification where the good classification is the majority of the observations.

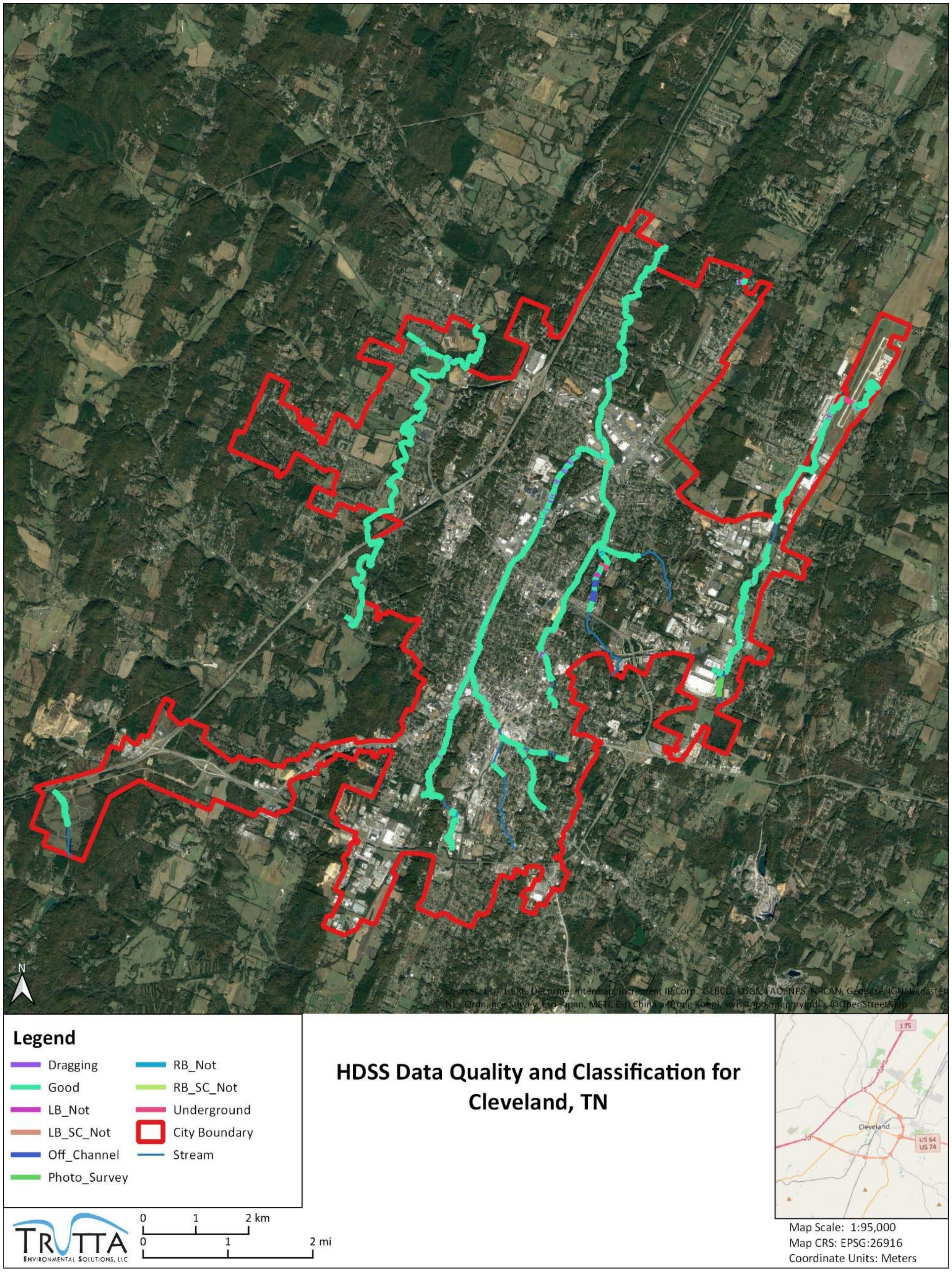


Figure 27:Data quality and classification types for the HDSS project.

Streambed Function and Modification

Of all the streams that were surveyed with HDSS, 96% of the streambeds analyzed were functional or slightly impaired (Table 9), while 3% were impaired and 1% were non-functional. No stream exhibited a fully functional rating for streambed. Streambed function varied among streams (Figure 28) with one stream exhibiting a range between functional to non-functional. Three streams exhibited three functional rating values between functional to impaired (Table 9), one stream with two rating values (functional to slightly impaired) and three streams had a single rating value (functional or slightly impaired). Woolen Mills Branch and Little Chatata Creek were the most compromised streams with ≥ 9% of the streams classified as impaired or non-functional, while Spring Branch was the least impaired being classified 100% functional. Four streams had impaired segments; however, they represented ≤ 20% of each stream.

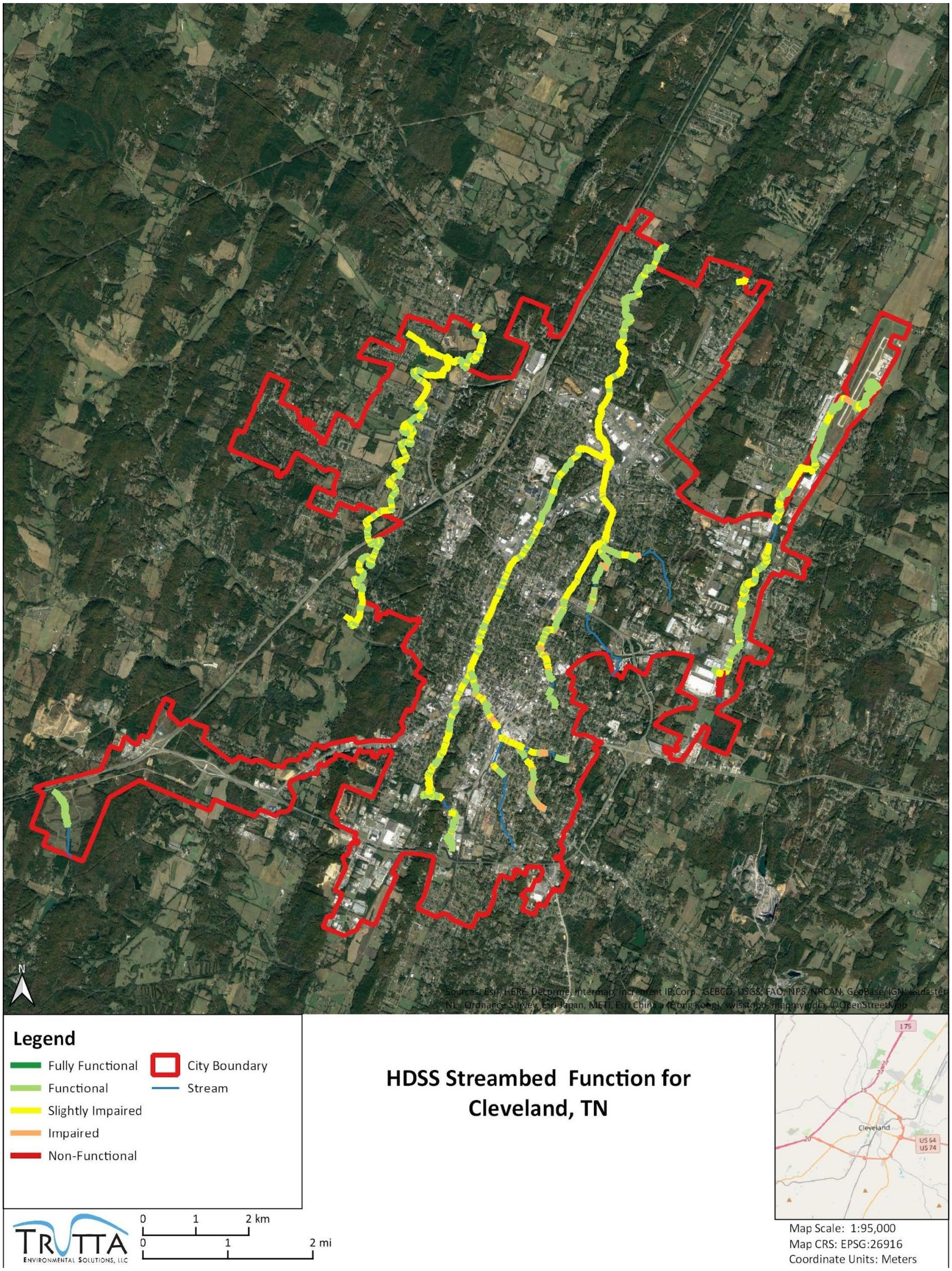


Figure 28: Streambed function for Cleveland, TN.

Table 9: Streambed function determined with the HDSS for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sampled during 20-23 May 2019. N represents the length (m) of stream in the category. If percentages do not sum to 100, it is the result of rounding errors.

	1: Fully Functional		2: Functional		3: Slighty Impaired		4: Impaired		5: Non-Functional		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Bigsby Creek	-	-	-	-	813	100	-	-	-	-	813	100
Candies Creek	-	-	4,959	47	5,513	53	-	-	-	-	10,472	100
Fillauer Branch	-	-	2,832	39	4,066	56	399	5	-	-	7,297	100
Little Chatata Creek	-	-	4,862	59	2,628	32	208	3	475	6	8,173	100
Little South Mouse Creek	-	-	-	-	121	100	-	-	-	-	121	100
South Mouse Creek	-	-	6,846	48	7,324	52	20	0	-	-	14,190	100
Spring Branch	-	-	759	100	-	-	-	-	-	-	759	100
Wollen Mill Branch	-	-	1,412	46	1,031	34	622	20	-	-	3,065	100
Total	-	-	21,670	48	21,496	48	1,249	3	475	1	44,890	100

Figure 29: Examples of functional (left), slightly impaired (middle), and impaired (fight) streambeds classified on Fillauer Creek (Track 401) sampled during 23 May 2019.

Overall, in the streambed modification category, "unmodified streambed" dominated, representing slightly over 97% of the eight creeks sampled (Table 10; Figure 30). Modified streambeds represented 1% of all streams combined, while highly modified represented 3%. Streambed modification varied only slightly among and within the stream reaches sampled (Figure 31). Ninety-four percent or more of the streambed in all streams were unmodified, with the exception of Woolen Mill Branch (76%). Woolen Mill Branch, Fillauer Creek, and Little Chatata Creek had the greatest proportion of highly modified streambeds representing up to 21% of stream surveyed.

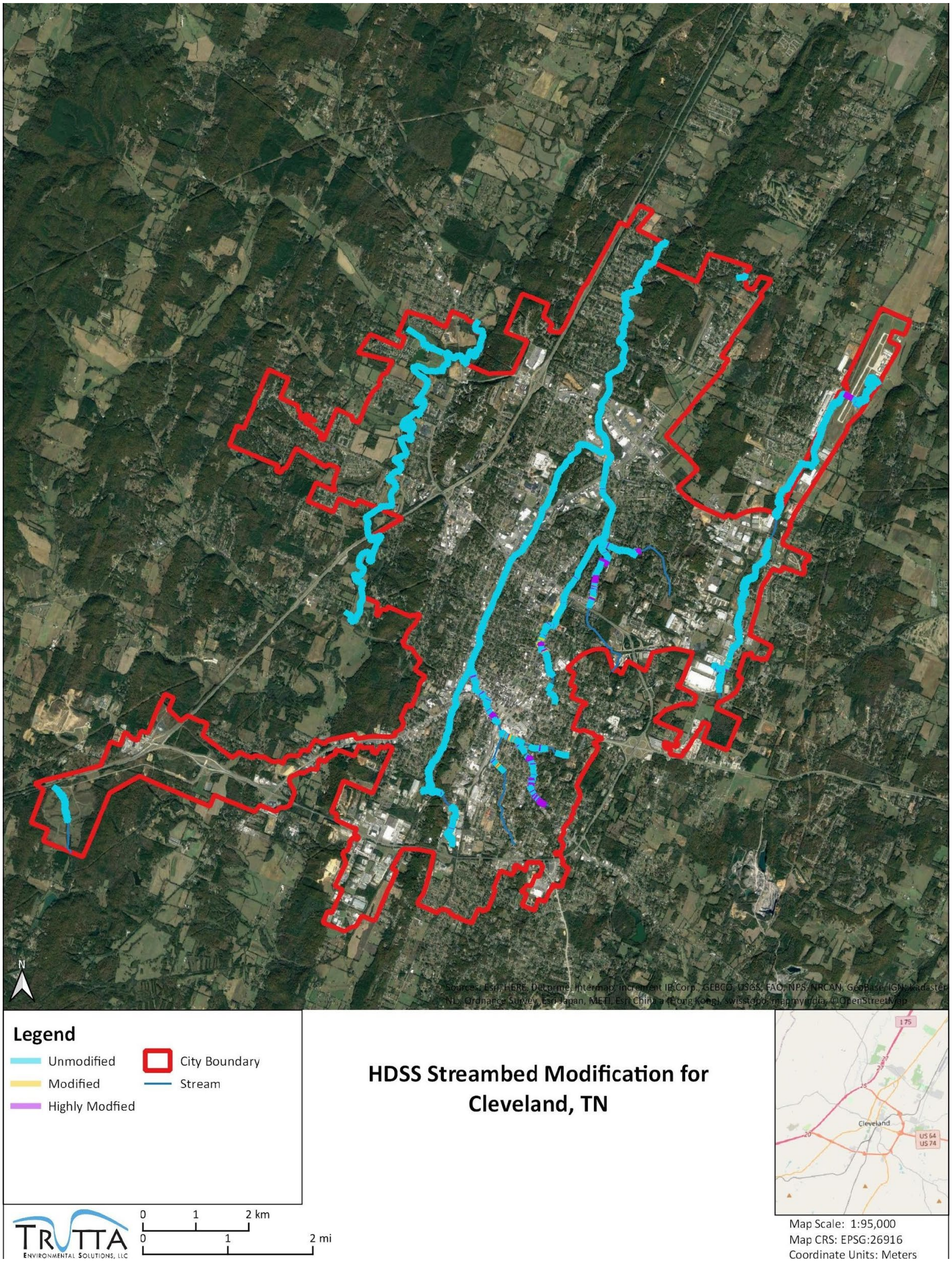


Figure 30: Streambed modification for Cleveland, TN.

Table 10: Streambed modification determined with the HDSS for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sampled during 20-23 May 2019. N represents the length (m) of stream in the category. If percentages do not sum to 100, it is the result of rounding errors.

	Unmodified		Modified		Highly_modified		Total	
	N	%	N	%	N	%	N	%
Bigsby Creek	813	100					813	100
Candies Creek	10,472	100					10,472	100
Fillauer Branch	6,827	94	99	1	371	5	7,297	100
Little Chatata Creek	7,938	97	27	0	208	3	8,173	100
Little South Mouse Creek	121	100					121	100
South Mouse Creek	14,170	100			20	0	14,190	100
Spring Branch	759	100					759	100
Woolen Mill Branch	2,316	76	116	4	633	21	3,065	100
Total	43,416	97	242	1	1,232	3	44,890	100

Figure 31: Examples of unmodified (left), modified (center), and highly modified (right) streambeds on Little Chatata Creek (Track 304) sampled during 22 May 2019.

Right Streambank Function and Modification

The total percentage of all right streambank functions combined was predominately slightly impaired (44%), followed by impaired (28%), and functional (21%), whereas 6% were non-functional and 1% were fully functional (Figure 32; Table 11). Individually, all streams sampled had slightly impaired, impaired and non-functional right streambank sections classified. The majority of Little South Mouse Creek (62%) and Spring Branch (62%) were classified as impaired, while the majority of Woolen Mill Branch (60%) was functional. Candies Creek, Fillauer Creek, Little Chatata Creek and South Mouse Creek had the majority of the stream classified as slightly impaired (Figure 33). The greatest percentage of non-functional streambank was classified in Bigsby Creek (33%), Spring Branch (11%), and Fillauer Creek (10%) while the greatest number of observations classified as fully functional occurred along South Mouse Creek followed by Little Chatata Creek.

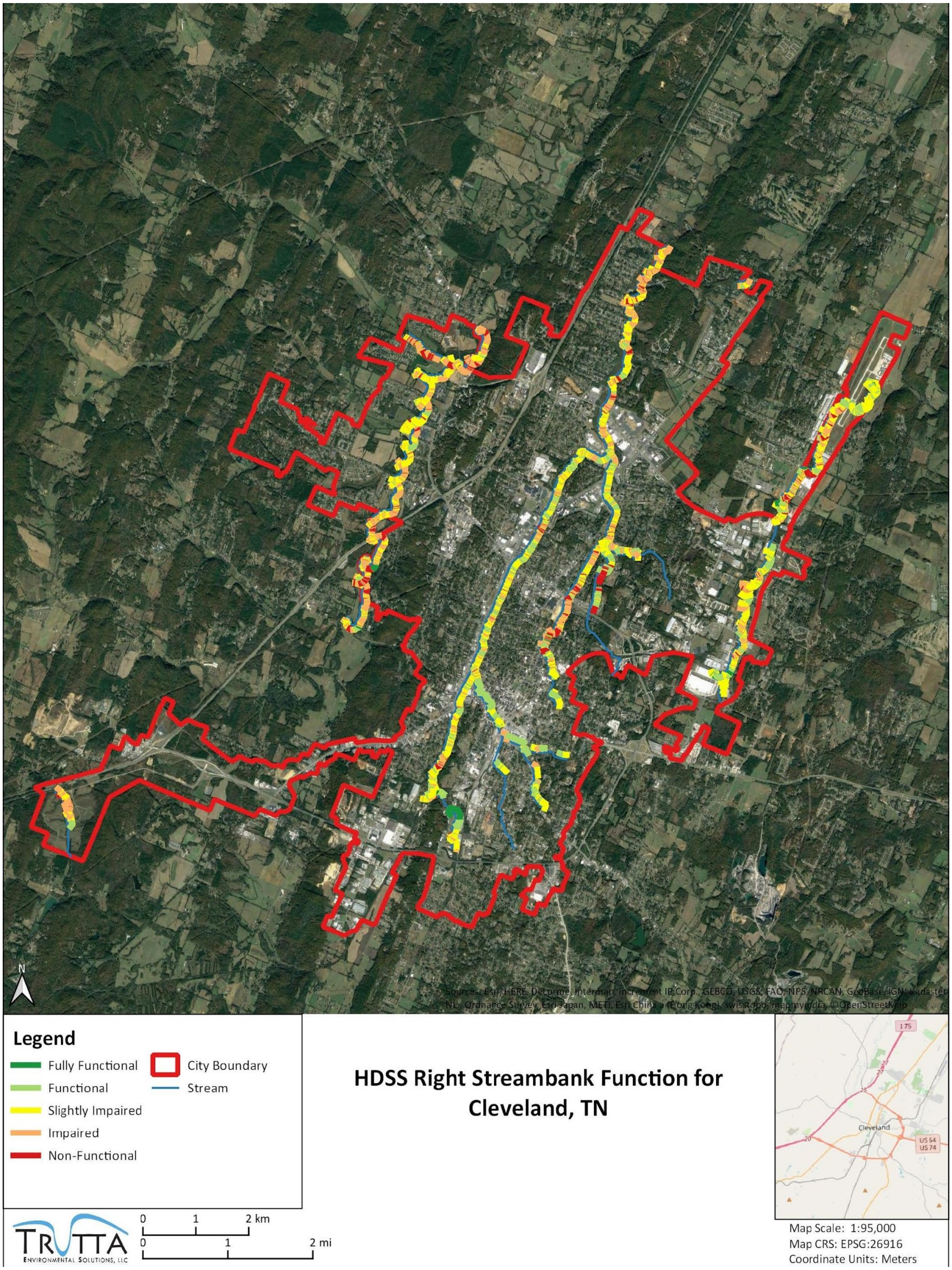


Figure 32: Right streambank function for Cleveland, TN.

Table 11: Right streambank function determined with the HDSS for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sample during 20-23 May 2019. N represents the length (m) of stream in the category. If percentages do not sum to 100, it is the result of rounding errors.

	1: Fully Functional		2: Functional		3: Slighty Impaired		4: Impaired		5: Non-Functional		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Bigsby Creek					232	29	296	38	259	33	787	100
Candies Creek	82	1	905	9	4,699	45	4,196	40	589	6	10,471	100
Fillauer Branch	28	0	2,032	28	2,559	35	1,916	26	762	10	7,297	100
Little Chatata Creek	201	2	1,621	20	4,378	54	1,673	20	302	4	8,175	100
Little South Mouse Creek			12	12	21	20	64	62	7	7	104	100
South Mouse Creek	227	2	2,850	20	6,739	48	3,741	26	630	4	14,187	100
Spring Branch			10	1	201	26	467	62	81	11	759	100
Woolen Mill Branch			1,783	60	834	28	338	11	21	1	2,976	100
Total	538	1	9,213	21	19,663	44	12,691	28	2,651	6	44,756	100

Figure 33: Examples of fully functional, (left) slightly impaired (middle) and non-functional (right) streambank function for the right streambank on Candies Creek (Track 103) sampled during 20 May 2019. Note fully functional streambank is rock outcropping.

Overall, for all streams combined, 90% of right streambank modification was classified as unmodified (Figure 34; Table 12). Individually, the right streambanks of all streams were dominated (≥85%) by unmodified, with Woolen Mill Branch being the only exception. The right streambed in Woolen Mill Branch was primarily classified as highly modified (Figure 35).

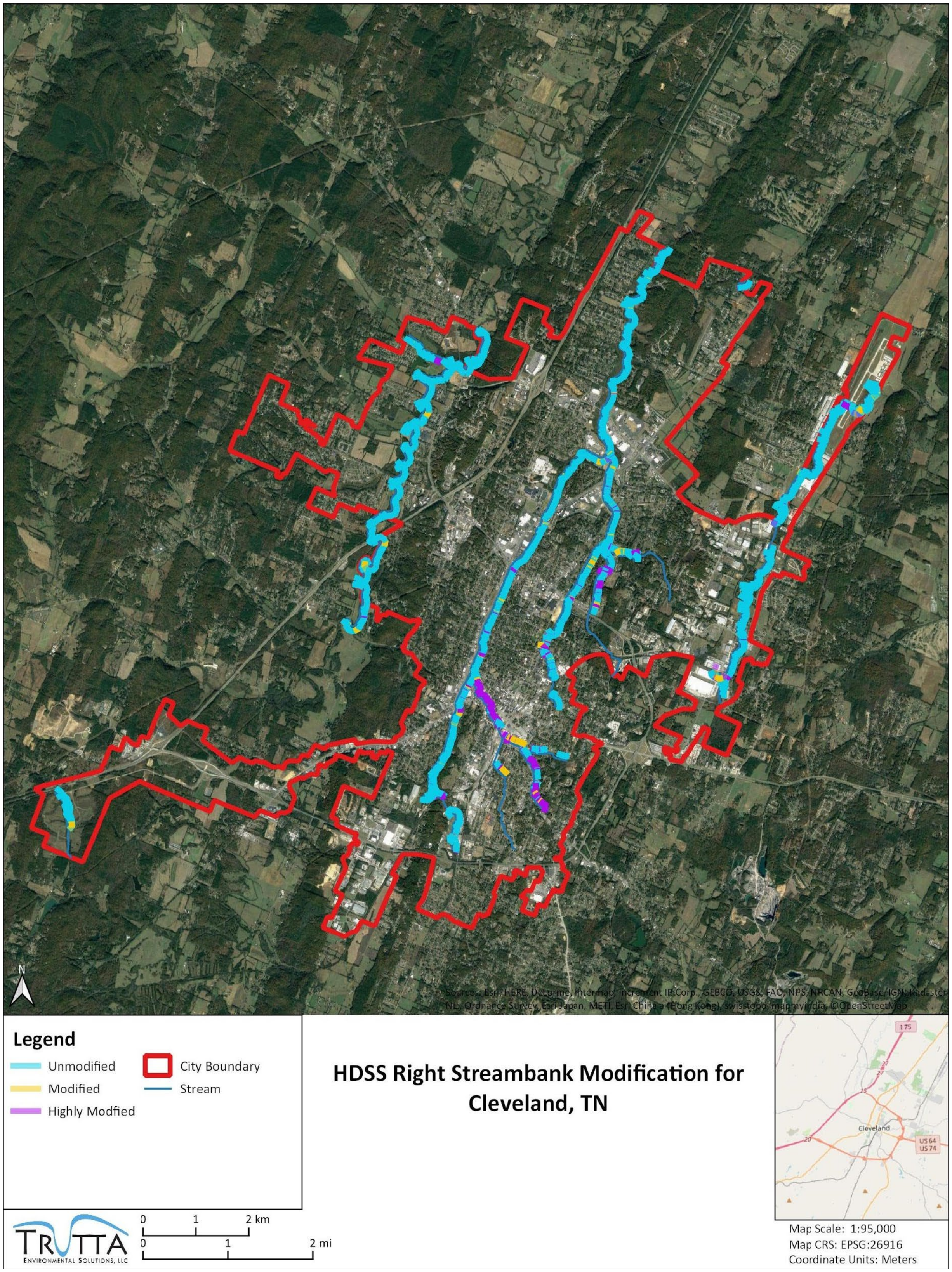


Figure 34: Right streambank modification for Cleveland, TN.

Table 12: Right streambank modification determined with the HDSS for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sample during 20-23 May 2019. N represents the length (m) of stream in the category. If percentages do not sum to 100, it is the result of rounding errors.

	Unmodified		Modified		Highly_modified		Total	
	N	%	N	%	N	%	N	%
Bigsby Creek	768	98	19	2			787	100
Candies Creek	10,317	99	127	1	27	0	10,471	100
Fillauer Branch	6,233	85	437	6	627	9	7,297	100
Little Chatata Creek	7,784	95	108	1	283	3	8,175	100
Little South Mouse Creek	104	100					104	100
South Mouse Creek	13,531	95	304	2	352	2	14,187	100
Spring Branch	749	99	10	1			759	100
Woolen Mill Branch	989	33	495	17	1,492	50	2,976	100
Total	40,475	90	1,500	3	2,781	6	44,756	100

Figure 35: Examples of unmodified (left), modified (center), and highly modified (right) right streambanks modification on Woolen Mill Branch (Track 404) sampled 23 May 2019.

Left Streambank Function and Modification

The percentage of left streambanks for all streams sampled were classified as predominantly slightly impaired followed by impaired and functional (Figure 36; Table 13). Fully functional was the least classified category, followed by non-functional when all streams were combined. Individually, half of the streams sampled had a majority of their left streambank classified as slightly impaired. Bigsby Creek, Little South Mouse Creek, and Spring Branch had a majority classified as impaired and had the greatest proportion of non-functional left streambank classified (Figure 37). Woolen Mill Branch was the only stream to have a majority of the reach classified as functional. Fully functional left streambanks were only observed in two streams in a relatively small proportion.

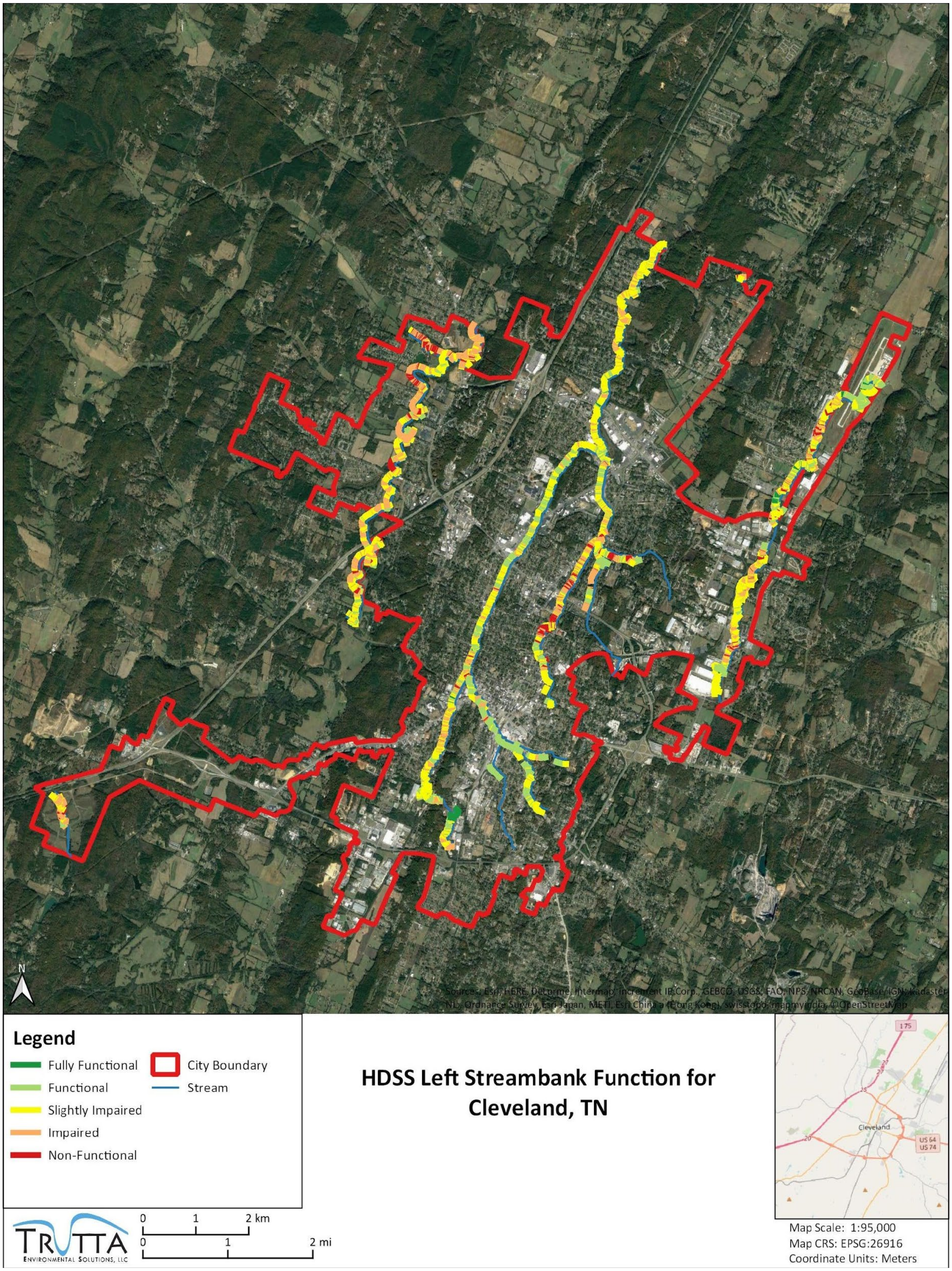
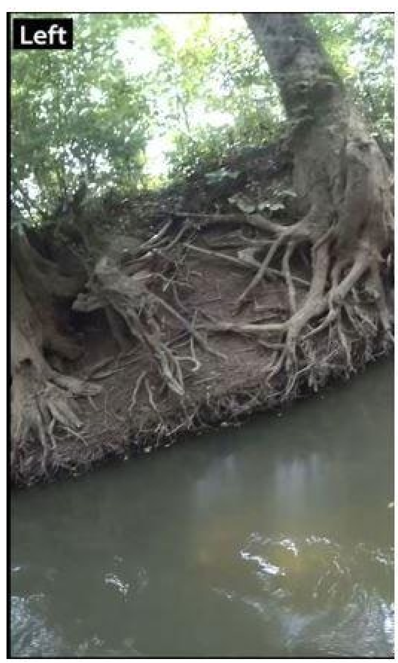


Figure 36: Left streambank function for Cleveland, TN.

Table 13: Left streambank function determined with the HDSS for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sample during 20-23 May 2019. N represents the length (m) of stream in the category. If percentages do not sum to 100, it is the result of rounding errors.

	1: Fully Functional		2: Functional		3: Slighty Impaired		4: Impaired		5: Non-Functional		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Bigsby Creek					189	23	358	44	266	33	813	100
Candies Creek			849	8	4,811	46	4,357	42	454	4	10,471	100
Fillauer Branch			1,791	25	2,733	37	1,949	27	824	11	7,297	100
Little Chatata Creek	214	3	1,971	24	3,958	48	1,587	19	445	5	8,175	100
Little South Mouse Creek					13	13	51	49	40	38	104	100
South Mouse Creek	257	2	3,249	23	8,154	57	2,426	17	101	1	14,187	100
Spring Branch			16	2	166	22	467	62	110	14	759	100
Woolen Mill Branch			1,963	64	794	26	224	7	84	3	3,065	100
Total	471	1	9,839	22	20,818	46	11,419	25	2,324	5	44,871	100



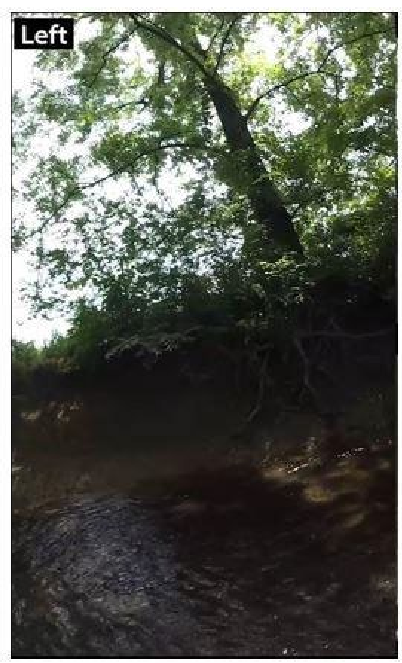


Figure 37: Examples of slightly impaired (left), impaired (middle), and non-functional (right) streambank function for the left streambank on Bigsby Creek (Track 405). Note: streambanks in the impaired and non-functional have a greater bank angle than slightly impaired.

Left streambank modification overall for all streams combined was similar to the right streambank with 90% of left streambanks classified as unmodified, followed by highly modified (6%) and modified (4%;Figure 38; Table 14). Individually, the left streambanks of all streams were similar to the right streambank, dominated by unmodified classification. Unlike the right streambank however, a large portion of the left stream bank of Woolen Mill Branch was classified as highly modified (36%) and unmodified (19%). For examples of streambank modification please see Figure 35 above.

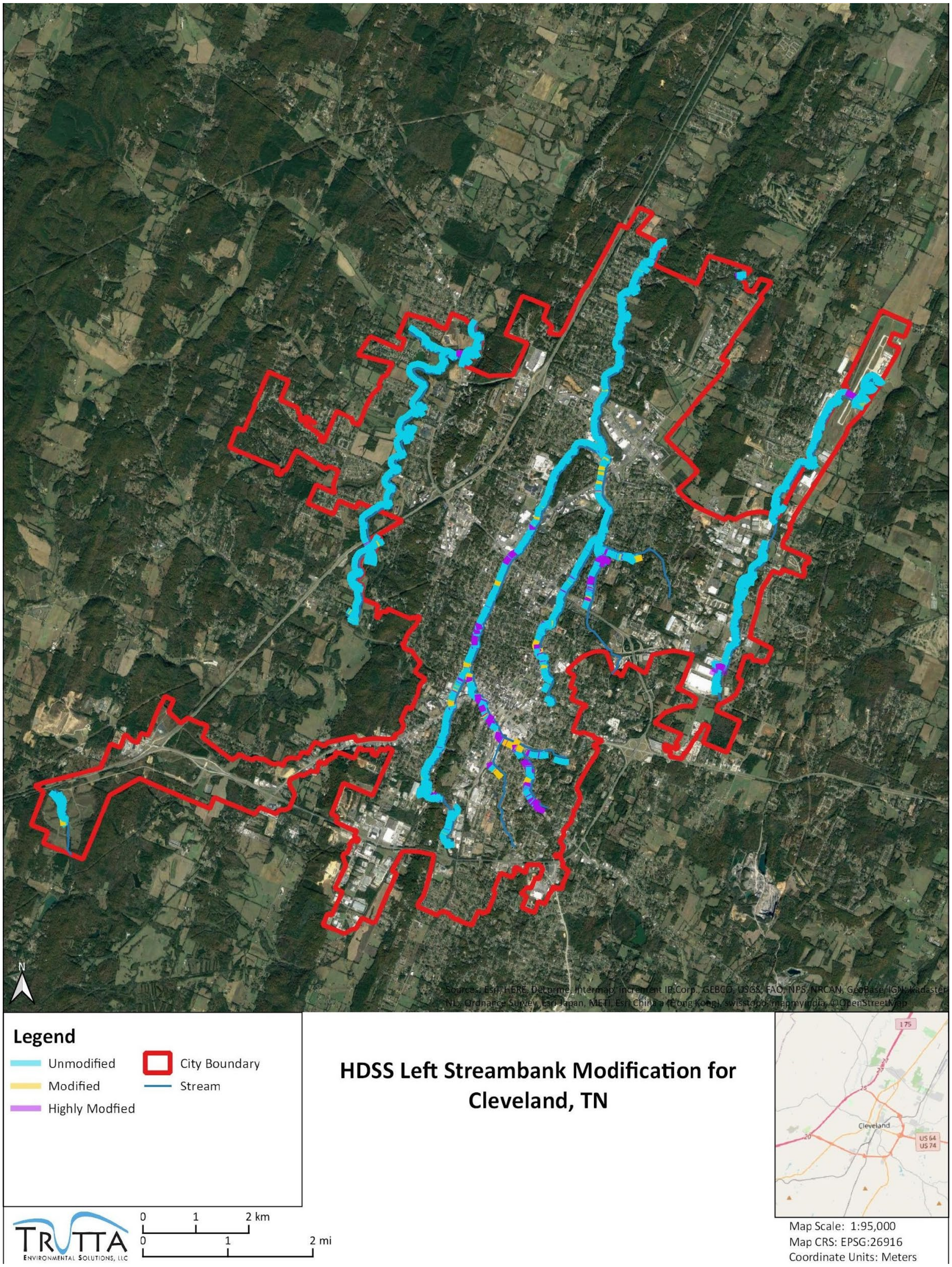


Figure 38: Left streambank modification for Cleveland, TN.

Table 14: Left streambank modification determined with the HDSS for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sample during 20-23 May 2019. N represents the length (m) of stream in the category. If percentages do not sum to 100, it is the result of rounding errors.

	Unmodified		Modified		Highly_modified		Total	
	N	%	N	%	N	%	N	%
Bigsby Creek	809	100	4	0			813	100
Candies Creek	10,306	98	64	1	101	1	10,471	100
Fillauer Branch	6,345	87	401	5	551	8	7,297	100
Little Chatata Creek	7,809	96	106	1	260	3	8,175	100
Little South Mouse Creek	104	100					104	100
South Mouse Creek	13,054	92	511	4	622	4	14,187	100
Spring Branch	740	97	19	3			759	100
Woolen Mill Branch	1,390	45	570	19	1,105	36	3,065	100
Total	40,557	90	1,675	4	2,639	6	44,871	100

Right Riparian Function

Overall, for all streams, 58% of the right riparian area sampled in Cleveland were classified as fully functional and functional (Figure 39; Table 15), while 32% were slightly impaired. The non-functional classification of riparian area represented the lowest total stream proportion (4%), followed by impaired (6%). Among functional categories within individual streams, fully functional represented the greatest proportion in Candies Creek, Spring Branch, and South Mouse Creek, while Bigsby Creek, Fillauer Creek (Figure 40), and Little South Mouse Creek had ≥52% of the stream classified as slightly impaired. Additionally, 36% of right riparian for Woolen Mill Branch was classified as non-functional.

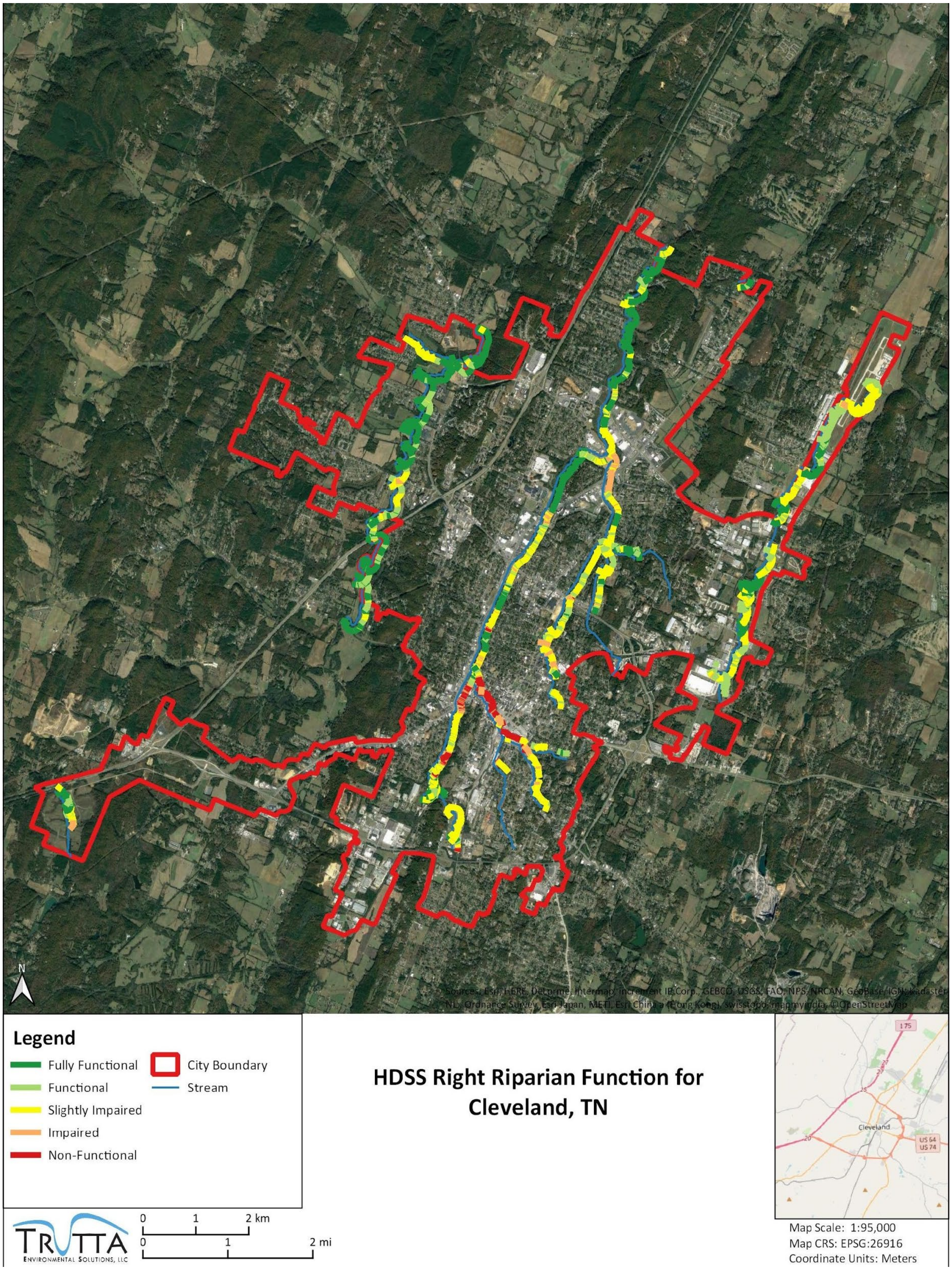


Figure 39: Right riparian function for Cleveland, TN.

Table 15: Right riparian function for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sample during 20-23 May 2019. N represents the length (m) of stream in the category. If percentages do not sum to 100, it is the result of rounding errors.

	1: Fully Functional		2: Functional		3: Slighty Impaired		4: Impaired		5: Non-Functional		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Bigsby Creek	38	5	4	0	771	95					813	100
Candies Creek	7,810	75	1,702	16	860	8	100	1			10,472	100
Fillauer Branch	784	11	1,656	22	3,842	52	1,136	15	27	0	7,445	100
Little Chatata Creek	1,757	21	3,189	39	2,987	37	245	3			8,178	100
Little South Mouse Creek	41	34	6	5	74	61					121	100
South Mouse Creek	5,925	42	2,475	17	4,395	31	796	6	596	4	14,187	100
Spring Branch	334	44	175	23	236	31	13	2			758	100
Woolen Mill Branch	163	5	203	7	1,181	39	401	13	1,117	36	3,065	100
Total	16,852	37	9,410	21	14,346	32	2,691	6	1,740	4	45,039	100

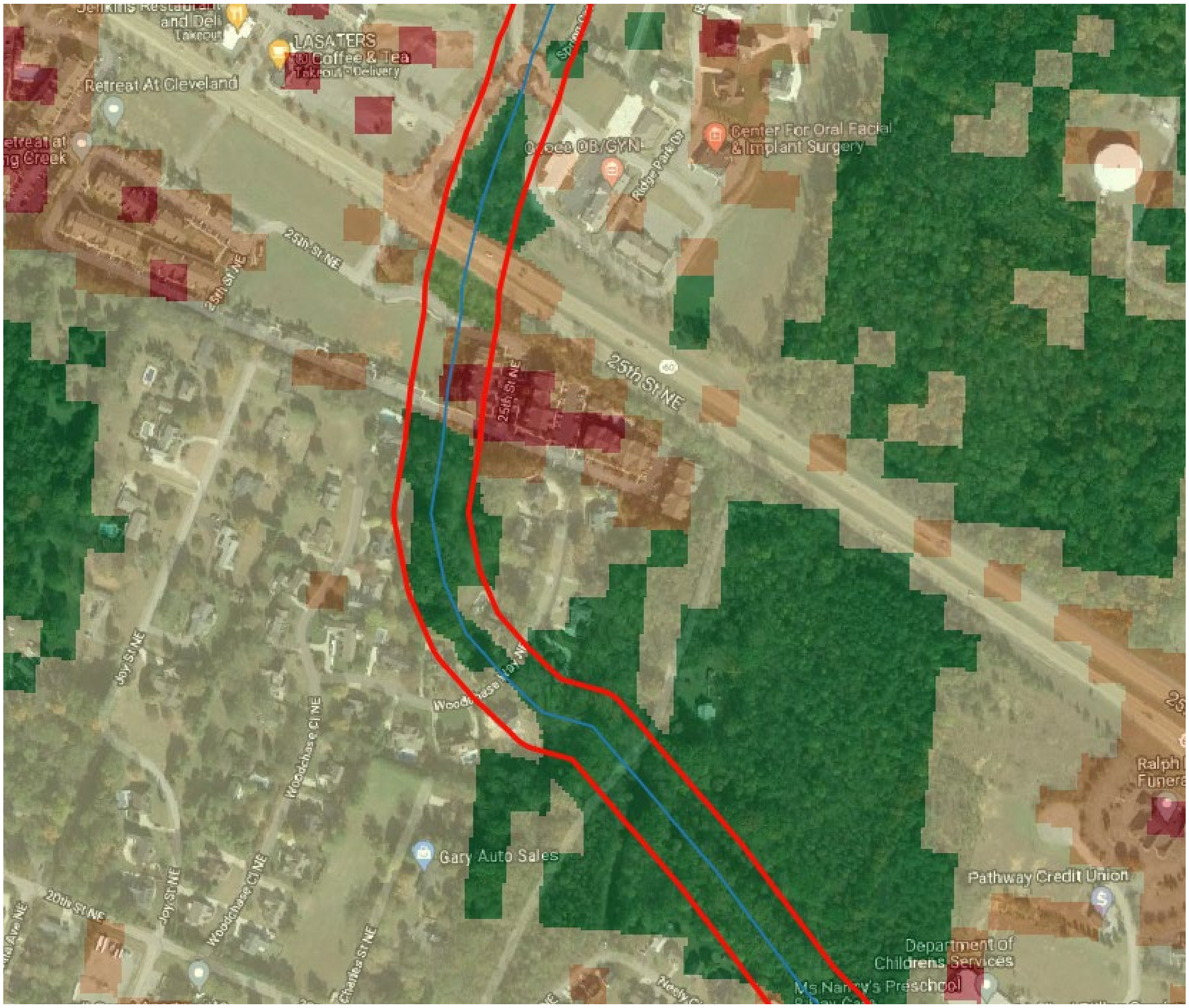


Figure 40: Examples of fully functional (dark green), slightly impaired (pink), and non-functional (red) riparian function for the riparian areas on Fillauer Creek.

Left Riparian Function

Similar to overall right riparian function, 60% of the left riparian area sampled combined was classified as fully functional and functional, while 39% were slightly impaired. Again, like the right riparian, the non-functional category represented the fewest total observations of all categories, followed by impaired. All streams had a portion of the left riparian area classified as fully functional, ranging from 6-100% of the individual stream's surveyed length. Among categories within individual streams, left riparian areas of all streams were influenced by at least three or more different functional rating categories (Figure 41;Table 16), with Little South Mouse Creek being the exception. Little South Mouse Creek, Spring Branch, and Candies Creek had the highest proportion of fully functional left riparian, respectively, while Woolen Mill Branch had the highest proportion of non-functional left riparian. For examples of riparian function please see Figure 15 above.

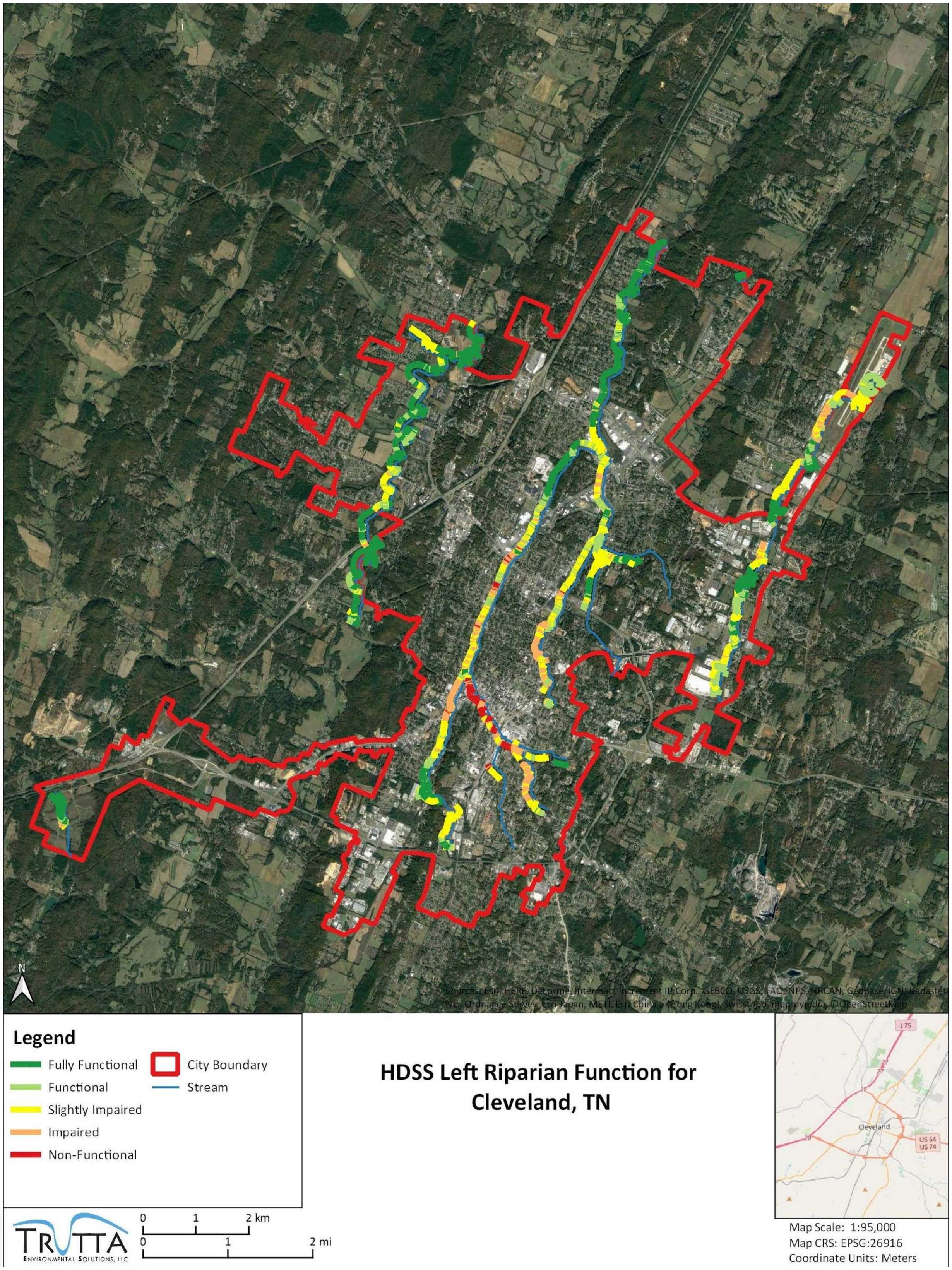


Figure 41: Left riparian function for Cleveland, TN.

Table 16: Left riparian function for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sample during 20-23 May 2019. N represents the length (m) of stream in the category. If percentages do not sum to 100, it is the result of rounding errors.

	1: Fully Functional		2: Functional		3: Slighty Impaired		4: Impaired		5: Non-Functional		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Bigsby Creek	111	14	4	0	698	86					813	100
Candies Creek	7,641	73	2,082	20	658	6	91	1			10,472	100
Fillauer Branch	863	12	2,138	29	3,560	48	852	11	32	0	7,445	100
Little Chatata Creek	1,978	24	2,542	31	3,122	38	538	7			8,180	100
Little South Mouse Creek	121	100									121	100
South Mouse Creek	5,701	40	2,879	20	3,944	28	1,505	11	159	1	14,188	100
Spring Branch	594	78	28	4	135	18	2	0			759	100
Woolen Mill Branch	196	6	179	6	895	29	1,016	33	779	25	3,065	100
Total	17,205	38	9,852	22	13,012	29	4,004	9	970	2	45,043	100

Stream Corridor Rating

The stream corridor rating score for all streams ranged from fully functional to the non-functional categories (Table 17 and Figure 42) and results showed less than 1% of the streams sampled had a classification of non-functional, while 77% were classified as either fully functional (6%) or functional (71%). Not surprisingly, the most urban stream , Woolen Mill Branch, had more than double the percent of the stream corridor length classified as slightly impaired or impaired (53%) than the average of all the streams (23%). Interestingly, two of the more rural streams had more than 50% of the stream length classified as slightly impaired (Bigsby Creek at 63% and Spring Branch at 51%) in contrast to another rural stream, Little Chatata Creek at only 13% in the slightly impaired or impaired categories. A generally better riparian condition along Little Chatata Creek likely accounted for the overall better stream corridor condition. Additionally, the stream detention pond and restoration projects near the Whirlpool factory and the airport along Little Chatata Creek may have contributed to the improved rating. The two largest streams, Candies Creek and South Mouse Creek, were generally in functional condition. Candies Creek has some issues and the presence of extensive large woody debris and debris jams in the creek (see next section) indicated that streambank erosion was actively occurring. South Mouse Creek appears to have active management occurring on the stream as much of the stream has a greenway along its banks through town. The overall stream corridor rating for South Mouse Creek was very good considering its highly developed watershed.

When considering the amount of modification to the stream corridor, the large majority of the Cleveland streams were unmodified (87%) (Table 18 and Figure 43). As expected Woolen Mill Branch and to a lesser extent, Fillauer Creek had higher rates of modification than any other creeks. These stream segments flow through urban and suburban areas and past modifications to control stormwater flow were evident.

Table 17: Stream corridor functional rating scores for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sample during August 2019. N represents the length (m) of stream in the category. If percentages do not sum to 100, it is the result of rounding errors.

	1: Fully Functional		2: Functional		3: Slightly Impaired		4: Impaired		5:Non-functional		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Bigsby Creek			286	37	489	63					775	100
Candies Creek	393	4	8,036	76	2,017	19	37	0	27	0	10,510	100
Fillauer Branch	378	5	4,606	62	2,185	29	224	3	52	1	7,445	100
Little Chatata Creek	830	10	6,265	77	895	11	191	2			8,181	100
Little South Mouse Creek			59	49	62	51					121	100
South Mouse Creek	1,150	8	10,946	77	1,760	12	299	2	35	0	14,190	100
Spring Branch			325	43	434	57					759	100
Woolen Mill Branch	157	5	1,279	42	1,223	40	388	13	18	1	3,065	100
Total	2,908	6	31,802	71	9,065	20	1,139	3	132	0	45,046	100

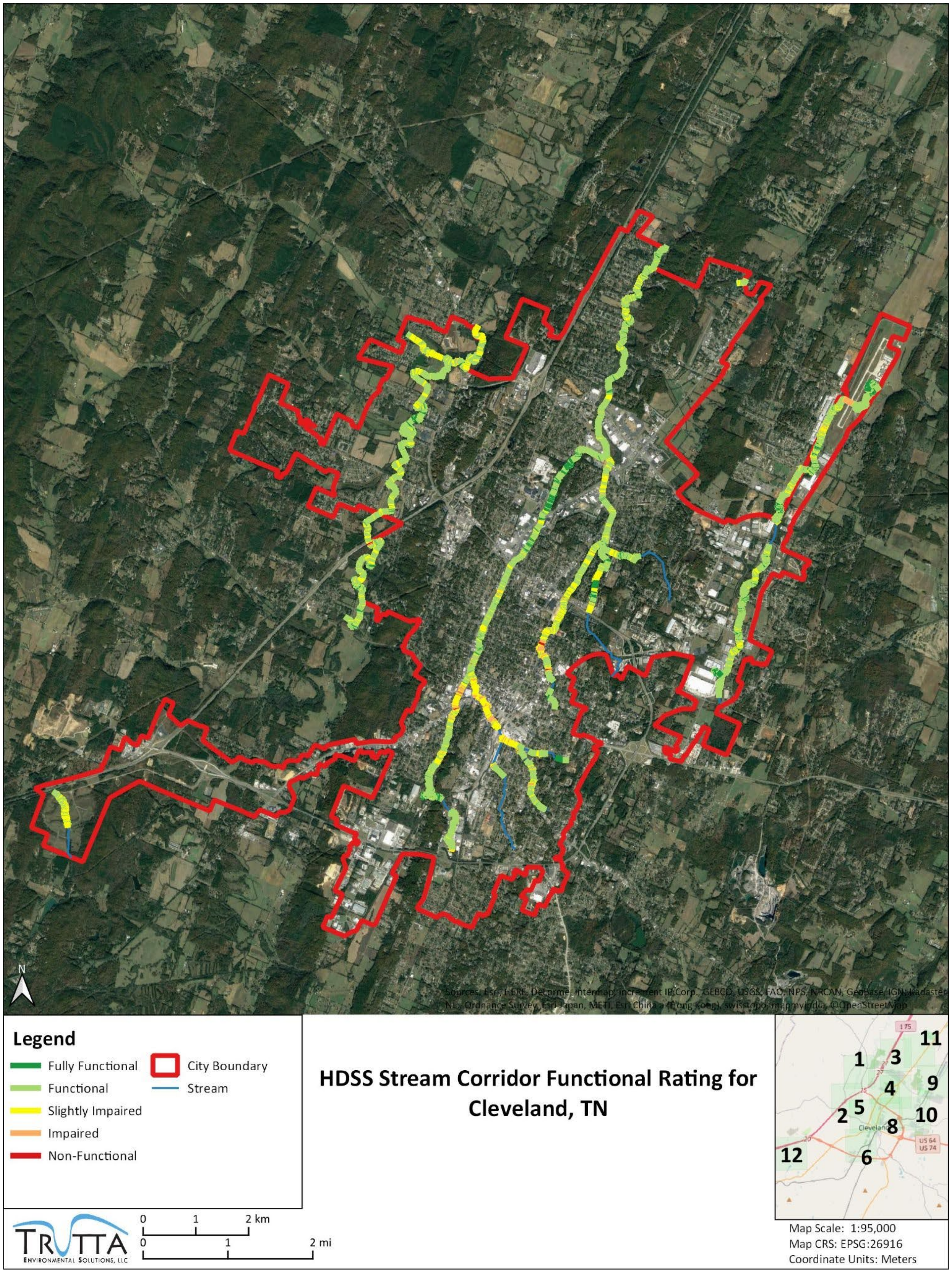


Figure 42: Stream corridor functional rating for the streams in Cleveland, TN.

Table 18: Stream corridor modification rating scores the for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sample during August 2019. N represents the length (m) of stream in the category. If percentages do not sum to 100, it is the result of rounding errors.

	1:Unmodified		2:Modified		3:Highly_modified		Total	
	N	%	N	%	N	%	N	%
Bigsby Creek	726	94	49	6			775	100
Candies Creek	10,202	97	307	3	1	0	10,510	100
Fillauer Branch	6,012	81	948	13	485	7	7,445	100
Little Chatata Creek	7,696	94	246	3	239	3	8,181	100
Little South Mouse Creek	104	86			17	14	121	100
South Mouse Creek	12,733	90	1,206	8	251	2	14,190	100
Spring Branch	740	97	19	3			759	100
Woolen Mill Branch	837	27	1,127	37	1,101	36	3,065	100
Total	39,050	87	3,902	9	2,094	5	45,046	100

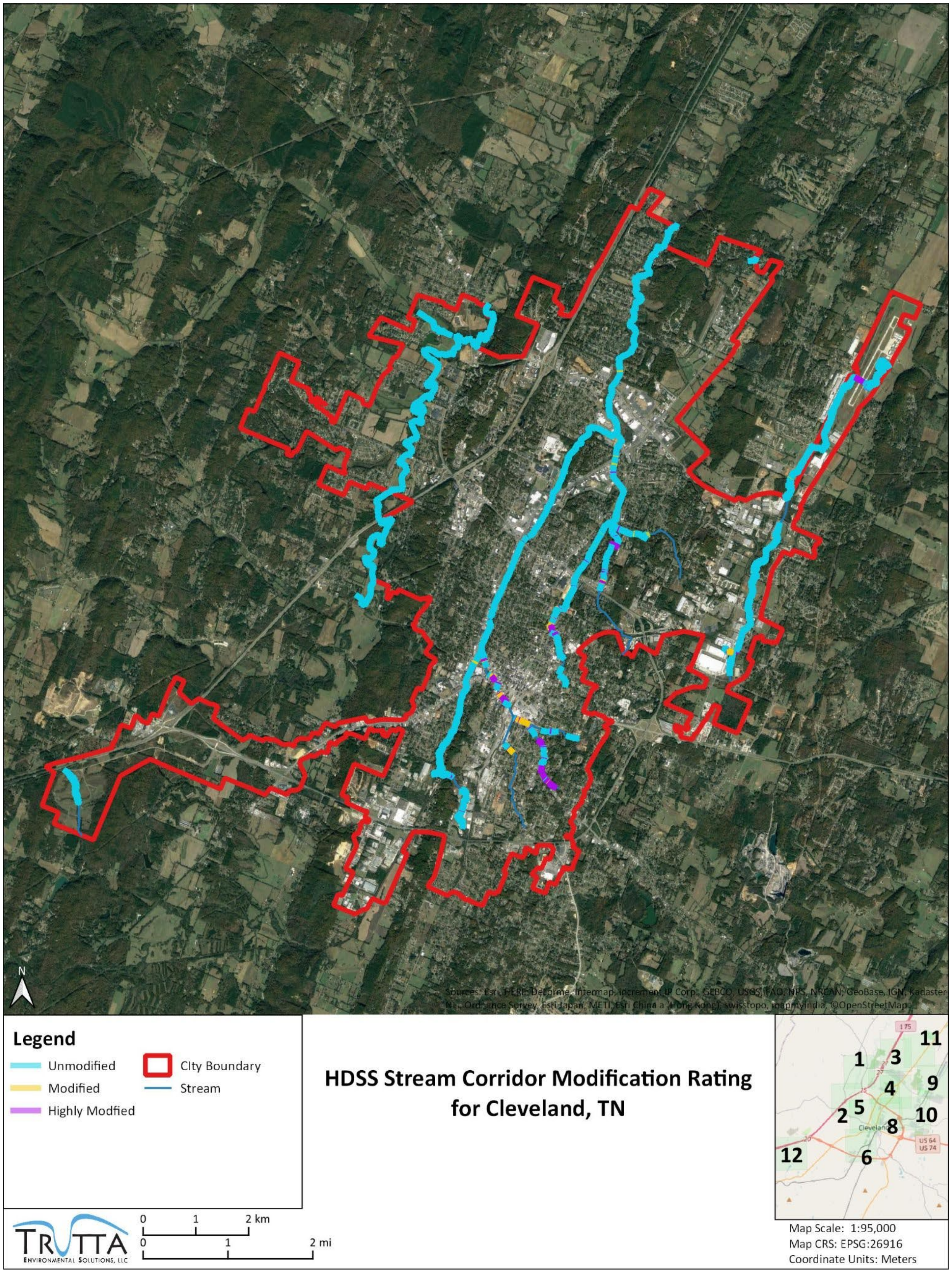


Figure 43: Stream corridor modification rating for the streams in Cleveland, TN.

Discrete Features

Overall, 2,115 discrete features were observed in all the streams sampled (Figure 44), with the majority being classified as “other” followed by sediment (Table 19). However, all four types were observed (Figure 45). Pipe and road impacts were observed 304 and 263 times, respectively. The greatest number of discrete features were observed in South Mouse Creek followed by Candies Creek and Fillauer Creek, while the fewest were observed in Little South Mouse Creek.

The highest percentage of discrete point features observed by category varied among streams. Streams with >50% of the discrete point features observed in the Sediment category include: Bigsby Creek, Little Chatata Creek, Little South Mouse Creek and Spring Branch where in-channel bars were the dominant type (Table 20). Candies Creek and South Mouse Creek had the greatest percentage of discrete features in the “other” category, dominated by large woody debris. Pipes were the dominant discrete point feature along Fillauer Creek, primarily consisting of outfalls. Little South Mouse Creek and Spring Branch had no observed pipe related observations. Road crossings were the dominant feature observed along Woolen Mills Branch, consisting primarily of culverts. Multiple discrete observations were also observed and identified at a single location (Figure 46).

Table 19: Count and percentage by categories of discrete point features for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sample during 20-23 May 2019. N represents the number of points in stream in the category. If percentages do not sum to 100 it is the result of rounding errors.

	Other		Pipe Impact		Road Impact		Sediment		Total	
	N	%	N	%	N	%	N	%	N	%
Bigsby Creek	18	38	3	6	1	2	25	53	47	100
Candies Creek	514	87	6	1	20	3	50	8	590	100
Fillauer Creek	83	24	105	30	71	20	91	26	350	100
Little Chatata Creek	108	35	21	7	20	7	156	51	305	100
Little South Mouse Creek	3	33			2	22	4	44	9	100
South Mouse Creek	212	35	123	20	78	13	188	31	601	100
Spring Branch	20	28			1	1	51	71	72	100
Wollen Mill Branch	14	10	46	33	70	50	11	8	141	100
Total	972	46	304	14	263	12	576	27	2115	100

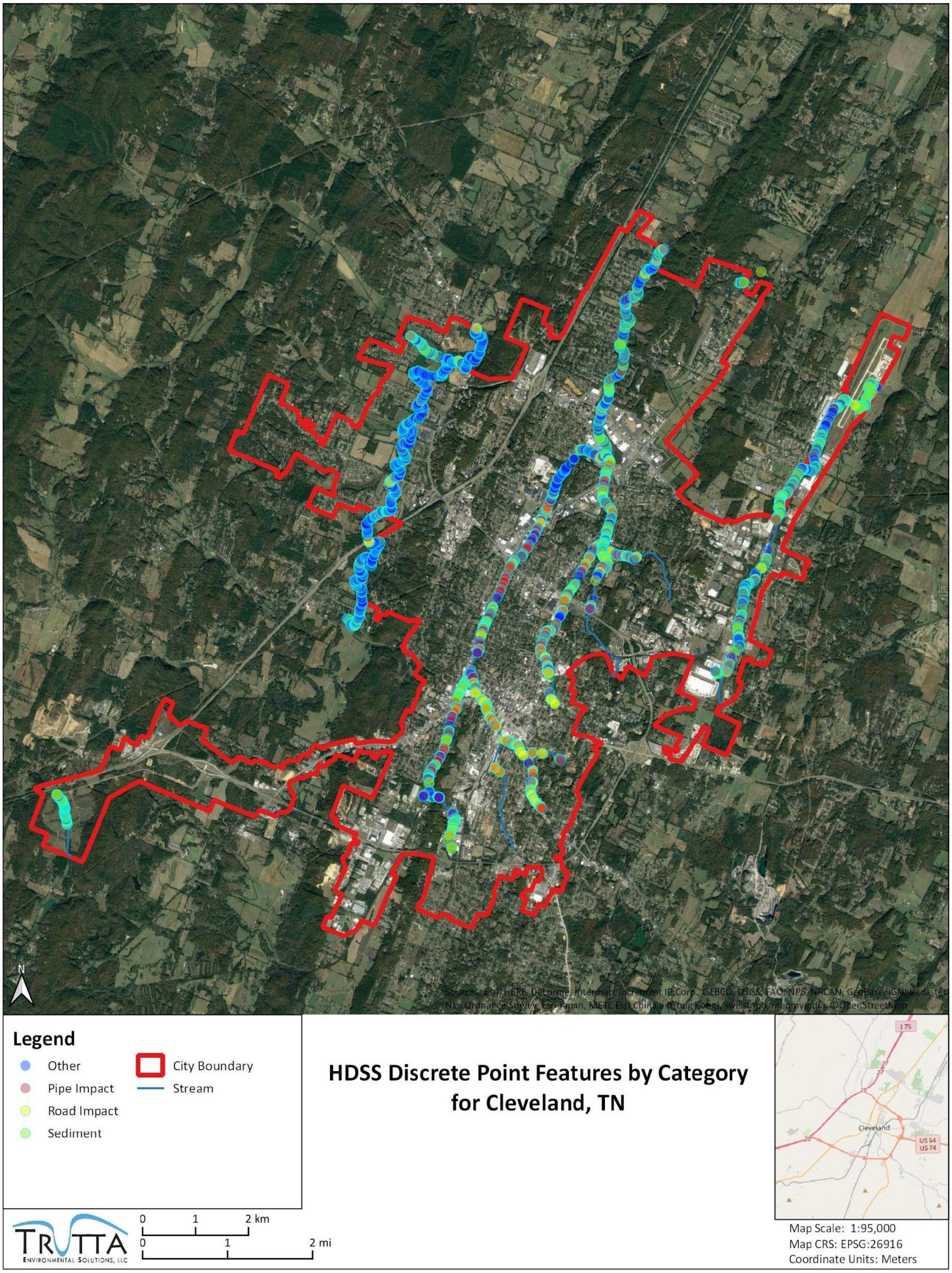


Figure 44: Discrete point features for Cleveland, TN.

Table 20: Count of type within categories for discrete point features along Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sample during 20-23 May 2019. N represents the number of points in stream in the category. If percentages do not sum to 100 it is the result of rounding errors.

	Other					Pipe Impact				Road Impact				Sediment			Total
	Debris Jam	Fence	Fish Barrier	Incoming Channel	Large Woody Debris	Exposed Pipe	Intake	Manhole Stack	Outfall	Concrete Low Water	Culvert	Dirt Low Water Crossing	Overhead Bridge	In Channel Bars	In Channel Vegetation	Vegetated Islands	
Bigsby Creek				2	16				3				1	25			47
Candies Creek	6		1	19	488	1			5				20	31	15	4	590
Fillauer Creek	2	2	13	14	52	24	1	4	76		59	1	11	64	27		350
Little Chatata Creek	8		2	25	73	8		1	12		8	8	4	106	50		305
Little South Mouse Creek					3						2			4			9
South Mouse Creek	4		18	33	157	22	2	3	96	5	45		28	105	77	6	601
Spring Branch	1			2	17						1			51			72
Wollen Mill Branch	1	2	4	4	3	14		1	31		67		3	6	5		141
Total	22	4	38	99	809	69	3	9	223	5	182	9	67	392	174	10	2115

Figure 45: Examples of the four most common discrete features observed which include: outfall (top left; South Mouse Creek, track 101); in-channel vegetation (top right; South Mouse Creek, track 201); large woody debris (bottom left; Candies Creek, track 103); and in-channel bar (bottom right; Spring Branch, track 407).

Figure 46: Image of multiple discrete features at a single location which included: road culvert, exposed pipe, debris jam, and fish barrier.

A total of 70 severely rated discrete features were observed in seven of the eight streams sampled (Table 21; Table 22). Most severe rated discrete point features observed were in the sediment category, followed by the "other" and pipe categories. The most observed severely rated type was in-channel bars with 23 locations observed, followed by large woody debris and in-channel vegetation each with 18 observations. Severely rated large woody debris accounted for 2% of the total large woody debris observed, while in-channel bars accounted for nearly 6% and in-channel vegetation accounted for 10% of the total observations for each type.

The number of observed severely rated discrete features ranged from 0-18 among the streams sampled (Table 21; Table 22). Candies Creek, Fillauer Creek, Little Chatata and South Mouse had the greatest number of severely rated features with 18, 15, 14 and 13, respectively. Streams with the fewest were Little South Mouse Creek (n=1), Bigsby Creek (n=3), and Spring Branch (n=6), while Woolen Mills Branch had zero.

The number of severely rated discrete features by type also varied among streams (Table 21; Table 22). Large woody debris was the dominant severely rated feature in Candies Creek. Fillauer Creek, Little Chatata Creek, South Mouse Creek, Bigsby Creek and Spring Branch had the greatest percent of severe rated observations within the sediment category. Specifically, in-channel vegetation was dominant in Fillauer Creek and in-channel bars were dominant in Little Chatata, Bigsby Creek and Spring Branch, while South Mouse was nearly equally split between the two types. Examples of a few of the severely rated discrete features and examples of the rating scale are provided in Figure 47, Figure 48, Figure 49, Figure 50, Figure 51 and Figure 52.

Table 21: Count of severely rated discrete features by type within category for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sample during 20-23 May 2019.

	Other			Pipe Impact		Sediment			Total
	Debris Jam	Fish Barrier	Large Woody Debris	Exposed Pipe	Outfall	In Channel Bars	In Channel Vegetation	Vegetated Islands	
Bigsby Creek			1			2			3
Candies Creek	2		14			1		1	18
Fillauer Creek		3		1		1	10		15
Little Chatata Creek			1			9	4		14
Little South Mouse Creek						1			1
South Mouse Creek	1				2	5	4	1	13
Spring Branch			2			4			6
Total	3	3	18	1	2	23	18	2	70

Table 22: List of streams, track number, date, and time of discrete features with a rating of severe, for Bigsby, Candies, Fillauer, Little Chatata, Little South Mouse, and South Mouse creeks and Spring and Woolen Mill branches, in Cleveland, TN sample during 20-23 May 2019.

Stream Name	Track	Date and Time	Severity Rating	Point Type
South Mouse Creek	101	2019/05/20 13:02:44.000	Severe	Vegetated Islands
Candies Creek	103	2019/05/20 15:05:41.000	Severe	Large Woody Debris
Candies Creek	103	2019/05/20 15:32:41.000	Severe	Large Woody Debris
Candies Creek	103	2019/05/20 15:32:51.000	Severe	Large Woody Debris
Candies Creek	103	2019/05/20 15:47:21.000	Severe	Large Woody Debris
Candies Creek	103	2019/05/20 15:51:55.000	Severe	Vegetated Islands
Candies Creek	103	2019/05/20 15:52:09.000	Severe	Large Woody Debris
Candies Creek	103	2019/05/20 15:56:05.000	Severe	Large Woody Debris
Candies Creek	103	2019/05/20 16:10:09.000	Severe	Large Woody Debris
Candies Creek	103	2019/05/20 16:11:20.000	Severe	Debris Jam

Candies Creek	104	2019/05/20 16:21:57.000	Severe	Large Woody Debris
Candies Creek	104	2019/05/20 16:31:13.000	Severe	Large Woody Debris
Candies Creek	104	2019/05/20 16:41:07.000	Severe	In Channel Bars
Candies Creek	104	2019/05/20 17:03:43.000	Severe	Large Woody Debris
Candies Creek	104	2019/05/20 17:09:21.000	Severe	Large Woody Debris
Candies Creek	104	2019/05/20 17:13:23.000	Severe	Large Woody Debris
Candies Creek	104	2019/05/20 17:19:03.000	Severe	Large Woody Debris
Candies Creek	104	2019/05/20 17:19:43.000	Severe	Large Woody Debris
Candies Creek	104	2019/05/20 17:24:07.000	Severe	Debris Jam
South Mouse Creek	201	2019/05/21 10:57:51.000	Severe	In Channel Vegetation
South Mouse Creek	202	2019/05/21 12:32:44.000	Severe	In Channel Vegetation
South Mouse Creek	202	2019/05/21 12:33:10.000	Severe	In Channel Bars
South Mouse Creek	202	2019/05/21 12:33:28.000	Severe	In Channel Vegetation
South Mouse Creek	202	2019/05/21 13:22:47.000	Severe	In Channel Vegetation
South Mouse Creek	202	2019/05/21 13:22:53.000	Severe	In Channel Bars
South Mouse Creek	202	2019/05/21 13:36:35.000	Severe	Debris Jam
South Mouse Creek	202	2019/05/21 13:43:50.000	Severe	In Channel Bars
South Mouse Creek	203	2019/05/21 14:43:24.000	Severe	Outfall
South Mouse Creek	203	2019/05/21 14:43:24.000	Severe	Outfall
South Mouse Creek	204	2019/05/21 15:26:35.000	Severe	In Channel Bars
South Mouse Creek	204	2019/05/21 15:27:39.000	Severe	In Channel Bars
Fillauer Creek	205	2019/05/21 17:42:05.000	Severe	In Channel Bars

Fillauer Creek	205	2019/05/21 18:04:47.000	Severe	Exposed Pipe
Fillauer Creek	301	2019/05/22 09:17:37.000	Severe	Fish Barrier
Little Chatata Creek	302	2019/05/22 10:39:58.000	Severe	In Channel Vegetation
Little Chatata Creek	302	2019/05/22 10:42:11.000	Severe	In Channel Vegetation
Little Chatata Creek	302	2019/05/22 10:55:27.000	Severe	In Channel Vegetation
Little Chatata Creek	302	2019/05/22 10:57:47.000	Severe	In Channel Vegetation
Little Chatata Creek	303	2019/05/22 14:12:15.000	Severe	In Channel Bars
Little Chatata Creek	303	2019/05/22 14:16:07.000	Severe	In Channel Bars
Little Chatata Creek	303	2019/05/22 14:16:40.000	Severe	In Channel Bars
Little Chatata Creek	304	2019/05/22 15:41:25.000	Severe	In Channel Bars
Little Chatata Creek	304	2019/05/22 15:49:21.000	Severe	Large Woody Debris
Little Chatata Creek	304	2019/05/22 16:16:43.000	Severe	In Channel Bars
Little Chatata Creek	304	2019/05/22 16:34:35.000	Severe	In Channel Bars
Little Chatata Creek	305	2019/05/22 16:55:38.000	Severe	In Channel Bars
Little Chatata Creek	305	2019/05/22 16:56:04.000	Severe	In Channel Bars
Little Chatata Creek	305	2019/05/22 16:56:31.000	Severe	In Channel Bars
Fillauer Creek	401	2019/05/23 08:38:09.000	Severe	Fish Barrier
Fillauer Creek	401	2019/05/23 08:50:47.000	Severe	In Channel Vegetation
Fillauer Creek	401	2019/05/23 08:51:15.000	Severe	Fish Barrier
Fillauer Creek	402	2019/05/23 09:18:15.000	Severe	In Channel Vegetation
Fillauer Creek	402	2019/05/23 09:18:30.000	Severe	In Channel Vegetation

Fillauer Creek	402	2019/05/23 09:20:42.000	Severe	In Channel Vegetation
Fillauer Creek	402	2019/05/23 09:21:33.000	Severe	In Channel Vegetation
Fillauer Creek	402	2019/05/23 09:24:14.000	Severe	In Channel Vegetation
Fillauer Creek	402	2019/05/23 09:26:03.000	Severe	In Channel Vegetation
Fillauer Creek	402	2019/05/23 09:28:21.000	Severe	In Channel Vegetation
Fillauer Creek	402	2019/05/23 09:29:01.000	Severe	In Channel Vegetation
Fillauer Creek	402	2019/05/23 09:30:31.000	Severe	In Channel Vegetation
Bigsby Creek	405	2019/05/23 15:10:37.000	Severe	In Channel Bars
Bigsby Creek	405	2019/05/23 15:15:51.000	Severe	In Channel Bars
Bigsby Creek	405	2019/05/23 15:19:51.000	Severe	Large Woody Debris
Little South Mouse Creek	406	2019/05/23 16:04:14.000	Severe	In Channel Bars
Spring Branch	407	2019/05/23 17:02:07.000	Severe	Large Woody Debris
Spring Branch	407	2019/05/23 17:05:05.000	Severe	In Channel Bars
Spring Branch	407	2019/05/23 17:06:10.000	Severe	In Channel Bars
Spring Branch	407	2019/05/23 17:06:41.000	Severe	In Channel Bars
Spring Branch	407	2019/05/23 17:08:07.000	Severe	Large Woody Debris
Spring Branch	407	2019/05/23 17:08:49.000	Severe	In Channel Bars

Figure 47: Examples of severity rating scale for in-channel bars observed which include minor (left; South Mouse Creek, track 204), moderate (center; South Mouse Creek, track 101), and severe (right; Little Chatata Creek, track 303) sampled 20-22 May 2019.

Figure 48: Examples of severe rated in-channel bars observed in Bigsby Creek (left; track 405); Little Chatata Creek (center; track 304); and Spring Branch (right, track 407) sampled during 22-23 May 2019.

Figure 49: Examples of severity rating scale for large woody debris observed in Candies Creek (track 103) which include minor (left), moderate (center), and severe (right) sampled during 21 May 2019.

Figure 50: Examples of severe rated large woody debris observed in Candies Creek track 103 (left); track 104 (center); and track 103 (right) sampled 20 May 2019.

Figure 51: Examples of severity rating score for in-channel vegetation observed which include minor (left; Little Chatata Creek, track 302), moderate (center; South Mouse Creek, track 202); and severe (right; South Mouse Creek, track 202) 21-22 May 2019.

Figure 52: Examples of severe rating for in-channel vegetation observed in South Mouse Creek, (left; track 202), Fillauer Creek (center; track 401); and Little Chatata Creek (right; track 302) sampled 21-23 May 2019.

Selection of Sites in Need of Restoration

One goal of this project was to select the top 20 sites in need of management action. This proved more difficult than expected. The difficulty is not due to lack of data or potential sites, rather it is due to the numerous ways the top 20 sites could be selected. For example, they could be selected based on a mix of discrete problem points and continuous problem areas or the sites could be stratified to include each stream. Providing a list of the top 20 sites with each stream does not account for the large differences in stream length surveyed among streams. To generate a list of sites in need of restoration, we chose to select stream segments at least 10m in length with a functional rating of slightly impaired to non-functional. These segments were then stratified into sites by modification level. Within each list, the sites were then ordered by potential uplift/m within the stream segment. It is important to realize that other classification systems could be applied, producing different results from those presented here.

The results of this classification contained 188 unmodified sites, 30 modified sites, and 30 highly modified sites. We provided these sites in a spreadsheet along with every rated stream segment so that each site could be inspected or ranked on different criteria. In addition to rating these 248 stream segments, we have provided the starting and ending location within the stream to relate to the GIS data and the video track and starting time and ending time related to the StreamView Videos of the surveys. Thus, the 248 continuous sites and the 70 severe point locations discussed in the previous section provide over 300 different locations that could be improved with management actions.

To show the utility of the HDSS data and classification system, we built a small database application to store the 248 continuous sites selected using our criteria and linked images from the videos to the sites. The following five sites, all occurring within the top 10 of the selected sites, show the different types of issues that can be documented with this approach (Figure 53, Figure 54, Figure 55, Figure 56 and Figure 57).

In the first site (Figure a), there were failing streambanks, low riparian cover and a poor quality streambed. Interestingly, immediately upstream of the image, the streambank had riprap applied to slow erosion. It appears that the riprap was not stable and was being washed downstream. In the second site (Figure b), there was a streambank failure immediately downstream of a road culvert. Stormwater exiting the culvert is undercutting the far streambank. Streambank stabilization would be appropriate at this location. At the next site (Figure c), an outfall was likely causing streambank erosion. This site located on South Mouse Creek was not visible from any road or trail and was a good example of how a complete survey can find stormwater related problems in otherwise hidden areas. The fourth site (Figure 56), was in a highly observable location. Here, South Mouse Creek showed poor overall stream function with too much fine sediment in the streambed, failing streambanks and little riparian cover. The remediation action may be more difficult as the stream is located between a shopping mall parking lot and a major road. Potentially a grade control structure and some additional shoreline stabilization would be helpful at this location. Finally at site five (Figure e), a failing retaining wall was observed. While erosion was not excessive at this location, the streambank and additional retaining walls likely will continue to fail if the site is not repaired.

The use of different selection criteria would allow stormwater managers to inspect sites that meet multiple management goals. For example, if a large restoration project was planned, sites longer than 100m may be considered or if small, routine maintenance was planned, sites from 2- 5m long may be chosen so that a two-person team could complete the project in 1 day. The HDSS video, GIS data and consistent classification systems can provide strong support for site selection for stormwater management.

Potential Restoration Sites: Unmodified Group

General Site Information

Stream	Fillauer Branch	Site Rating ID	1077
Stream Segment	FB_T1	HDSS Platform	Backpack

StreamView Video Information

Track	205		
Starting MeterID	36372	Starting Date/Time	2019-05-21T18:16:30
Ending MeterID	36407	Ending Date/Time	2019-05-21T18:16:42

Site Scoring

Uplift / m	8.9
Length (m)	36
Uplift Total	320
Relative Uplift Cost	33.8
Restoration Group	Any4
Modification Group	1:Unmodified

Figure 53: Site 1077 on Fillauer Creek showed failing streambanks and poor riparian cover.

General Site Information

Stream	Fillauer Branch	Site Rating ID	1093
Stream Segment	FB_T1	HDSS Platform	Backpack

StreamView Video Information

Track	301		
Starting MeterID	36634	Starting Date/Time	2019-05-22T09:05:17
Ending MeterID	36651	Ending Date/Time	2019-05-22T09:05:33

Site Scoring

Uplift / m	7.6
Length (m)	18
Uplift Total	136
Relative Uplift Cost	22.8
Restoration Group	Mix3
Modification Group	1:Unmodified

Figure 54: Site 1093 on Fillauer Creek showed failing streambanks downstream of a road culvert.

General Site Information

Stream	South Mouse Creek	Site Rating ID	2413
Stream Segment	SMC_M1	HDSS Platform	Backpack

StreamView Video Information

Track	202		
Starting MeterID	15305	Starting Date/Time	2019-05-21T13:30:18
Ending MeterID	15316	Ending Date/Time	2019-05-21T13:30:36

Site Scoring

Uplift / m	7
Length (m)	12
Uplift Total	84
Relative Uplift Cost	24.3
Restoration Group	Mix3
Modification Group	1:Unmodified

Figure 55: Site 2413 on South Mouse Creek showed an outfall on the left bank and high erosion on the right bank across from the outfall.

General Site Information

Stream	South Mouse Creek	Site Rating ID	2571
Stream Segment	SMC_M1	HDSS Platform	Backpack

StreamView Video Information

Track	202		
Starting MeterID	16584	Starting Date/Time	2019-05-21T12:34:26
Ending MeterID	16616	Ending Date/Time	2019-05-21T12:36:09

Site Scoring

Uplift / m	6.6

Length (m)	33
Uplift Total	219
Relative Uplift Cost	25.8
Restoration Group	Mix3
Modification Group	1:Unmodified

Figure 56: Site 2571 on South Mouse Creek showed poor overall stream function with too much fine sediment in the streambed, failing streambanks and little riparian cover.

General Site Information

Stream	Woolen Mill Branch	Site Rating ID	3225
Stream Segment	WMB_M1	HDSS Platform	Tablet/Photo

StreamView Video Information

Track	409		
Starting MeterID	30515	Starting Date/Time	2019-05-20T12:39:01
Ending MeterID	30532	Ending Date/Time	2019-05-20T12:39:26

Site Scoring

Uplift / m	8.1

Length (m)	18
Uplift Total	146
Relative Uplift Cost	21
Restoration Group	Mix3
Modification Group	2:Modified

Figure 57: Site 3225 on Woolen Mill Branch showed a failing retaining wall with the potential for high erosion at the failure site.

Discussion

The High Definition Stream Survey (HDSS) approach proved to be a rapid method to collect a wide range of data pertaining to stream conditions within the City of Cleveland, TN. We surveyed 45.1 km and collected data about the riparian areas, stream banks and the stream bottom and documented over 2000 different point features within the streams. This data and StreamView video should be useful to city stormwater managers for a broad range of river management issues.

Overall, the functional stream conditions within the City of Cleveland were surprisingly good. Over 76% of the stream length surveys were in fully functional or functional condition and less than 3% of the stream length were in the imparied or non-functional categories. Although it runs through much of the city, South Mouse Creek is in the best condition of all Cleveland streams. Over 85% of South Mouse Creek was categorized as functional or better. In contrast, Woolen Mill Branch was in the most degraded condition of all Cleveland streams with over 50% of the stream being categorized as slightly imparied to non-functional. Woolen Mill Branch is located in the most developed area of Cleveland and stream segments reflect extensive modification and associated loss of function.

The most common stormwater impairment observed in Cleveland streams was the eroded streambanks and the presence of too much fine sediment in the streambed. Pipe impacts were most common in the more urbanized stream areas like Woolen Mill Branch anc Fillauer Creek. The more rural creeks, Bigsby, Little Chatata, and Spring Branch, had much higher occurrences of sediment impacts observed in the streams. The sediment was likely from agricultural sources and not primarily from eroding streambanks as while some streambank problems were observed they were not extensive throughout the streams. We observed numerous modifications to the stream corridor to decrease stormwater impacts and while there are still problem areas to address, past management efforts were having a positive impact.

When comparing the HDSS results to previous stormwater reports for the City of Cleveland, we were not able to make direct comparisons due to differences in methodology. The TMDL Siltation and Habitat Alteration and Benthic Monitoring Report (TMDL report; S&ME 2012) was designed to assess the impacts of TMDLs on the biological community and habitat conditions within the stream. This TMDL report used accepted standardized methods (TDEC 2017) to determine the physical and biological impacts to the stream. However, the sampling strategy, limited random sampling with use of convenience sampling (e.g., sampling at road crossing due to convenience), likely overestimated the negative impacts since the majority of samples were taken in the vicinity or immediately downstream of road crossings. Stream habitats are often modified to support road infrastructure and stormwater outfalls, which are routed along these roads increasing the frequency and magnitude of discharge during rainfall events that degrade local and downstream habitat. These conditions are negatively viewed in most habitat evaluations but only represent a small fraction of the conditions within the reach or stream. Differentiating between localized and reach scale or stream-wide impacts is not the original intended purpose of the TMDL report (S&ME 2012); however, management actions are currently guided by habitat conditions and benthic monitoring in habitats that often represents ≤ 1% of the actual condition of the stream.

The overestimation of negative impacts would be minimized using the HDSS technique in conjunction with biological monitoring. HDSS data allows for the stratification of biological sampling based on HDSS habitat condition ratings allowing for biological sampling to be conducted in proportion to the habitat conditions present within the stream corridor. This stratified sampling strategy for macroinvertebrates/biota, where HDSS data guides biological monitoring sample collection, would help increase accuracy and reduce variability of the estimates allowing for a more representative sample to be obtained. HDSS data would also allow for additional stratification if required. Biological sampling could be easily conducted in conjunction with standard HDSS survey since biological data is already collected for nearly the entire stream.

The HDSS video is exceptionally useful in providing a baseline documentation of conditions throughout the streams found within the City of Cleveland, TN. If future surveys are completed, comparison with this survey completed in 2019 would allow for the direct comparison of the changes in river conditions between surveys. This repeated approach would allow changes in the river corridor conditions to be accurately documented. As a result of the StreamView video, direct site-by-site comparisons could be made with the new survey. Even if the classifications presented here were not carried out in a similar way by the new survey observer, the StreamView video can easily be rescored to meet new or different classification systems. Part of the difficulty of using past traditional survey data (such as the S&ME 2012 Report) to compare with new survey results is that it is difficult to collect and analyze data with the same process. The HDSS approach attempts to minimize this problem by allowing future surveyors to view the conditions and compare the scoring results with any new survey. The StreamView video can also be completely reanalyzed by different observers or with different scoring systems to produce novel results. The ability to review the video of the survey conditions allows the results to be further validated, updated, or changed as future observers require.

Finally, use of the HDSS video allows for a wide range of interested viewers to see the conditions throughout the river. It is unlikely that most river managers, public officials, decision-makers or other interested parties will have time to spend boating or hiking all the segments of the Cleveland streams to look for problem areas. With the HDSS video, it is easy to review the instream conditions and view specific problem areas. The availability of this video should help inform decision making throughout the river as issues can be identified and addressed using a comparative prioritization scheme.

The HDSS method provides resource managers with an integrated suite of stream corridor information to support effective decision-making. We collected continuous geo-referenced imagery of instream, streambank, and discrete point data over a long segment of streams. Using the HDSS approach, we delivered to managers and stakeholders more data at lower cost as compared to traditional methods. The HDSS platform allowed us to provide data-rich, 1-meter resolution GIS layers representing numerous instream and streambank parameters. These parameters can be combined in informative ways to create powerful decision-support tools allowing for a new holistic approach to river and stream management.

The value of this project is not this report, but the videos and spatial data provided with the report. The images in the report are general in nature and cover a long stream segment and may not be directly suitable for answering specific management questions. However, the continuous 1m resolution data linked to high resolution video of the river corridor allows detailed inspection of instream conditions to support numerous different management decisions. For example, data from other HDSS river survey projects have been used to estimate fish habitat, site drinking water intakes, determine stormwater management plans or quantify different project impact assessments. All of these issues and more are supported with the provided data from this survey.

Deliverables

The StreamView videos for the Cleveland Streams were provided via file transfer protocol with the report.

All GIS and Tabular Data that supported the maps and graphics in this report were submitted via electronic file transfer with the report. These files included:

· Cleveland_GeneralInfoTables.xlsx – Spreadsheet data with Track, Length and Platform Table data.

· Cleveland_PivotTablesFinal1.xlsx – Spreadsheet data associated with Pivot Tables for univariate analyses for riparian, streambank, streambed and point data.

· Cleveland_PivotTablesRating2.xlsx – Spreadsheet data associated with Pivot Tables for analyses for combined stream corridor function rating and modification data.

· Cleveland_ContinuousProblemSites.xlsx – Spreadsheet data associated with the continuous stream corridor potential restoration sites.

· ClevelandSeverePoints.xlsx – Spreadsheet data associated with the results of the point data classified in the “severe” category for further review.

· ClevelandStream_05212021.shp – GIS file with function and modification results for continuous variable of left riparian, left streambank, streambed, right streambank, and right riparian for each meter of the surveys. In UTM Zone 16 N.

· CClevelandPoints_05212021.shp – GIS file with discrete point information and condition for each point observed during the surveys. In UTM Zone 16 N.

· ClevelandRatings_05212021.shp – GIS file with stream corridor ratings, cost and modification for each meter of the surveys. In UTM Zone 16 N.

References

Bain, M.B., and N.J. Stevenson, editors. 1999. Aquatic habitat assessment common methods. American Fisheries Society, Bethesda, Maryland.

Connell, B., P. Ayers, A. Ludwig, K. Neff, and J. Parham. 2019. Georeferenced Video Mapping to Classify Streambank Erosion Susceptibility. Journal of Spatial Hydrology 15(2).

Hensley, K.J. and P.D. Ayers. 2018. Estimating Streambank Erosion Rates with a GPS-Based Video Mapping System. Journal of the American Water Resources Association. 54:6.

Hill, A.R. 1996. Nitrate Removal in Stream Riparian Zones. Journal of Environmental Quality. 25:743-755.

Kaufmann, P.R., P. Levine, E.G. Robison, C. Seeliger, and D.V. Peck. 1999. Quantifying Physical Habitat in Wadeable Streams. EPA/620/R-99/003. U.S. Environmental Protection Agency, Washington, D.C.

Lisle, T.E. 1986. Effects of Woody Debris on Anadromous Salmonid Habitat, Prince of Wales Island, Southeast Alaska. North American Journal of Fisheries Management. 6:538-550.

Naiman, R.J., and H. Decamps, 1997. The ecology of interfaces: riparian zones. Annual Review of Ecology and Systematics. 28:621-658.

Patten, D.T. 1998. Riparian ecosystems of semi-arid North America: diversity and human impact. Wetlands 18:498-512.

Platts, W.S.; W.F. Megahan, G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. Gen. Tech. Rep. INT-138. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 70p.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO. 353pp.

S&ME. 2012. 2011 TMDL siltation / habitat alteration benthic monitoring report City of Cleveland, Cleveland Tennessee S&ME Project No. 1437-11-325. Prepared for-City of Cleveland, Public Works Department, Division of Stormwater. pp 99.

Sass, C.K. and T.D. Keane. 2012. Application of Rosgen's BANCS Model for NE Kansas and the Development of Predictive Streambank Erosion Curves. Journal of the American Water Resources Association. 48:4 774–87.

Simon, A. 1995. Adjustments and recovery of unstable alluvial channels: identification and approaches for engineering management. Earth Surface Processes and Landforms 20: 611-628.

Somerville, D.E. 2010. Stream Assessment and Mitigation Protocols: A Review of Commonalities and Differences, May 4, 2010, Prepared for the U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds (Contract No. GS-00F0032M). Washington, D.C.

Tabacchi, E., D.L. Correll, R. Hauer, G. Pinay, A. Planty-Tabacchi, and R.T. Wissmar. 1998. Development, maintenance and role of riparian vegetation in river landscape. Freshwater Biology. 40:497-516.

Tennessee Department of Environment and Conservation. 2017. Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys. Control number DWR-PAS-P-01-QSSOP-081117.

Wilber D.H. and D.G. Clarke. 2001. Biological Effects of Suspended Sediments: A Review of Suspended Sediment Impacts on Fish and Shellfish with Relation to Dredging Activities in Estuaries. North American Journal of Fisheries Management. 21:4.

Yetman, K.T. 2001. Stream Corridor Assessment Survey. Watershed Restoration Division Chesapeake & Coastal Watershed Services Maryland Dept. of Natural Resources Annapolis, MD.

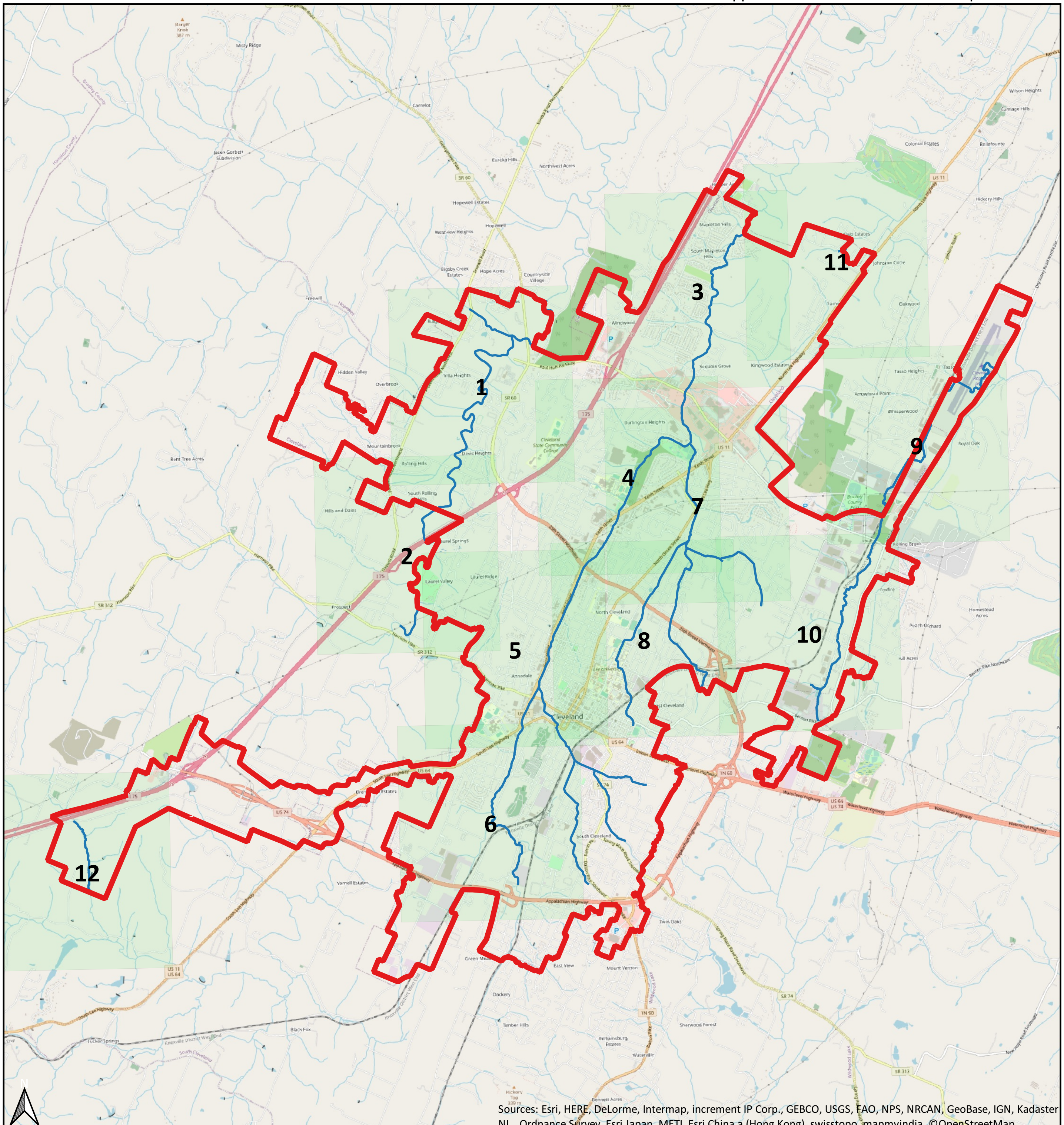
Appendix 1
Overview Maps

1a: Overview Map

1b: HDSS StreamView Video Track Groups HDSS Data Collection Platforms

1c: HDSS Data Collection Platforms

1d: HDSS Data Quality and Use Classification



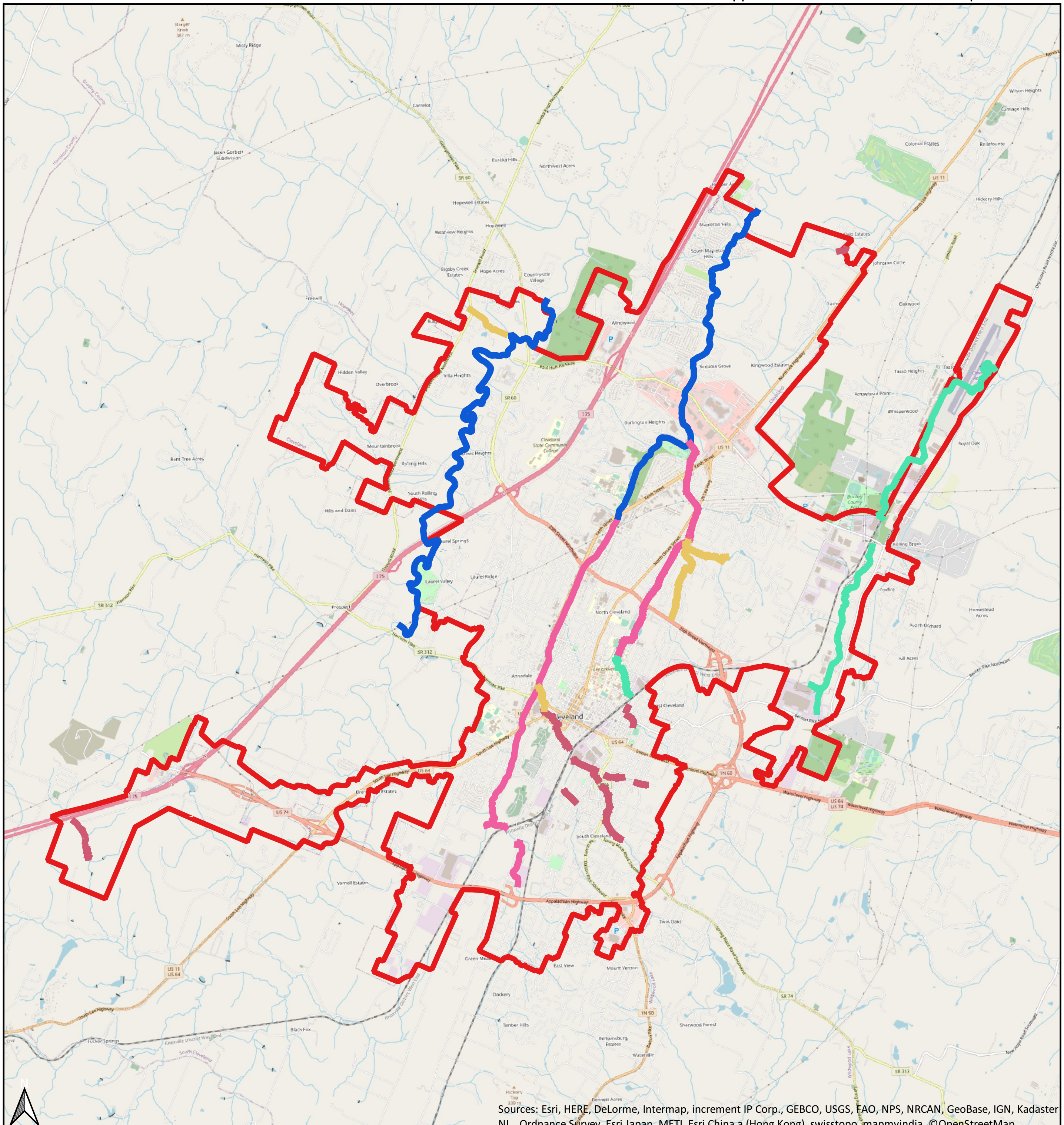
Legend

- City Boundary
- Streams
- Map Reference Key

Map Guide for Cleveland, Tennessee

0 1 2 km
0 1 2 mi

Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- 101-104
- 201-205
- 301-305
- 401-405
- 406-411
- City Boundary

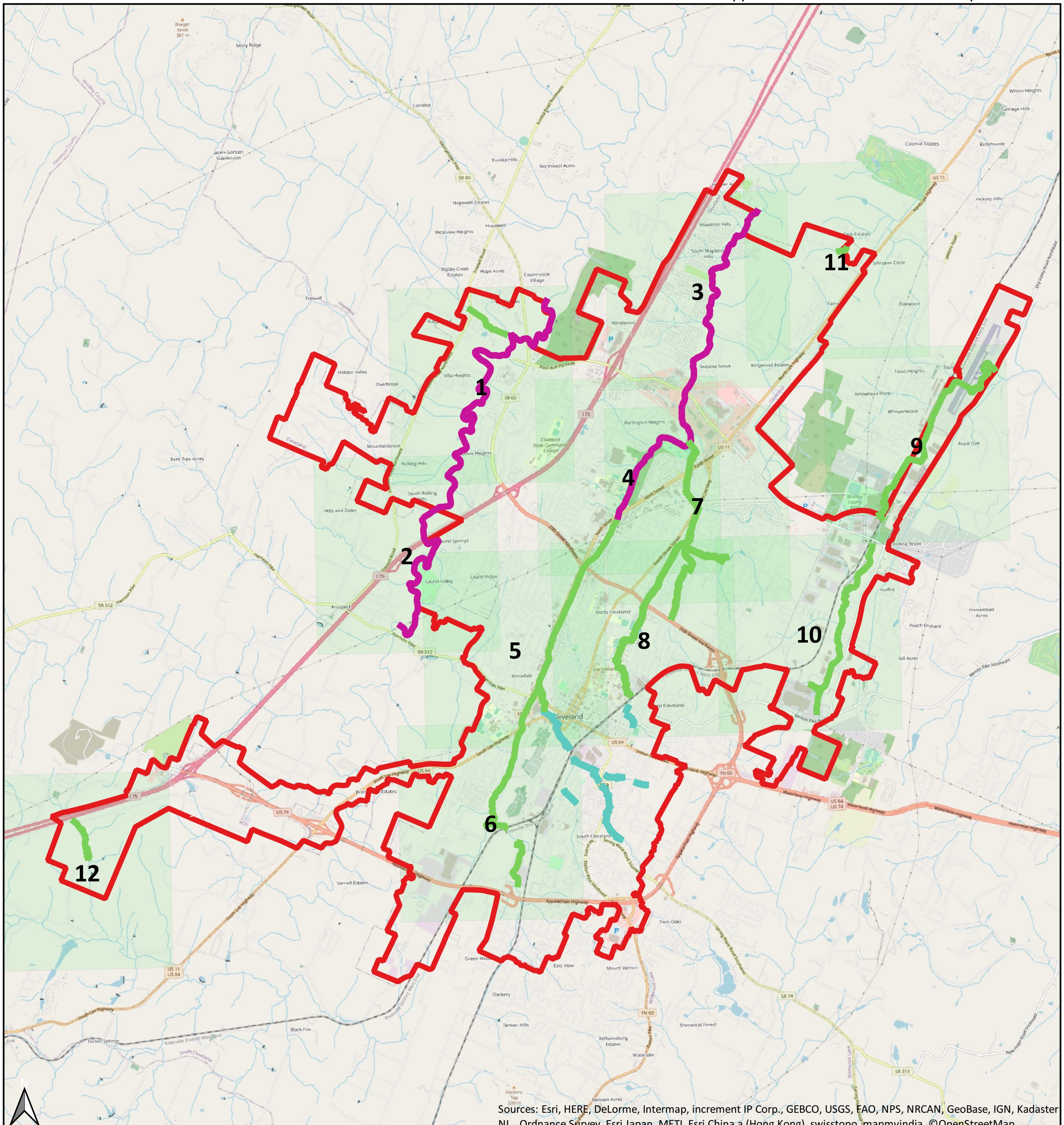
HDSS StreamView Video Track Groups for Cleveland, Tennessee

TRUTTA Environmental Solutions, LLC

0 1 2 km

0 1 2 mi

Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Boat
- Backpack
- Tablet
- City Boundary
- Map Reference Key

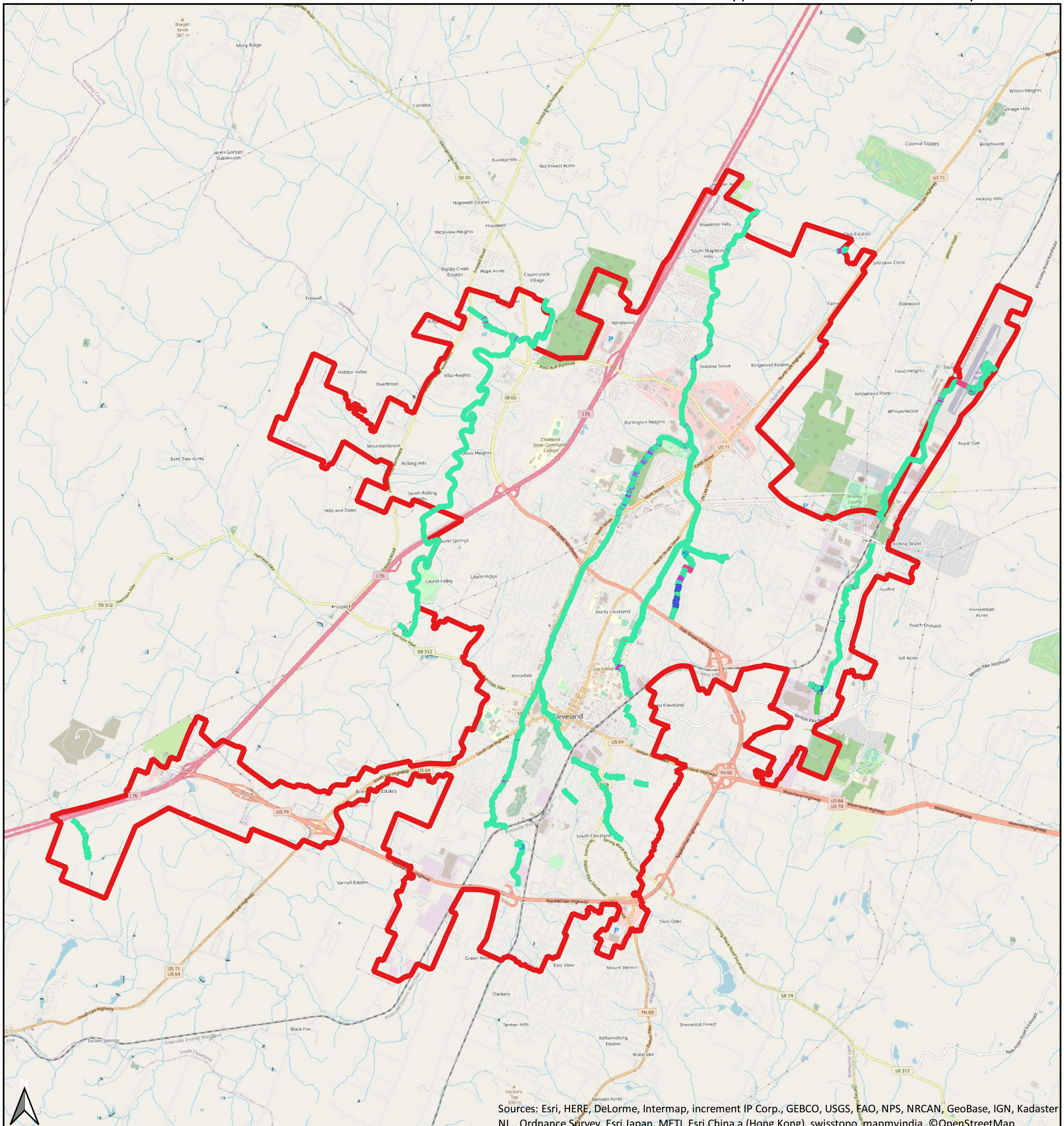
HDSS Data Collection Platforms for Cleveland, Tennessee

0 1 2 km

0 1 2 mi

TRUTTA Environmental Solutions, LLC

Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Dragging
- Good
- LB_Not
- LB_SC_Not
- Off_Channel
- Photo_Survey
- RB_Not
- RB_SC_Not
- Underground
- City Boundary

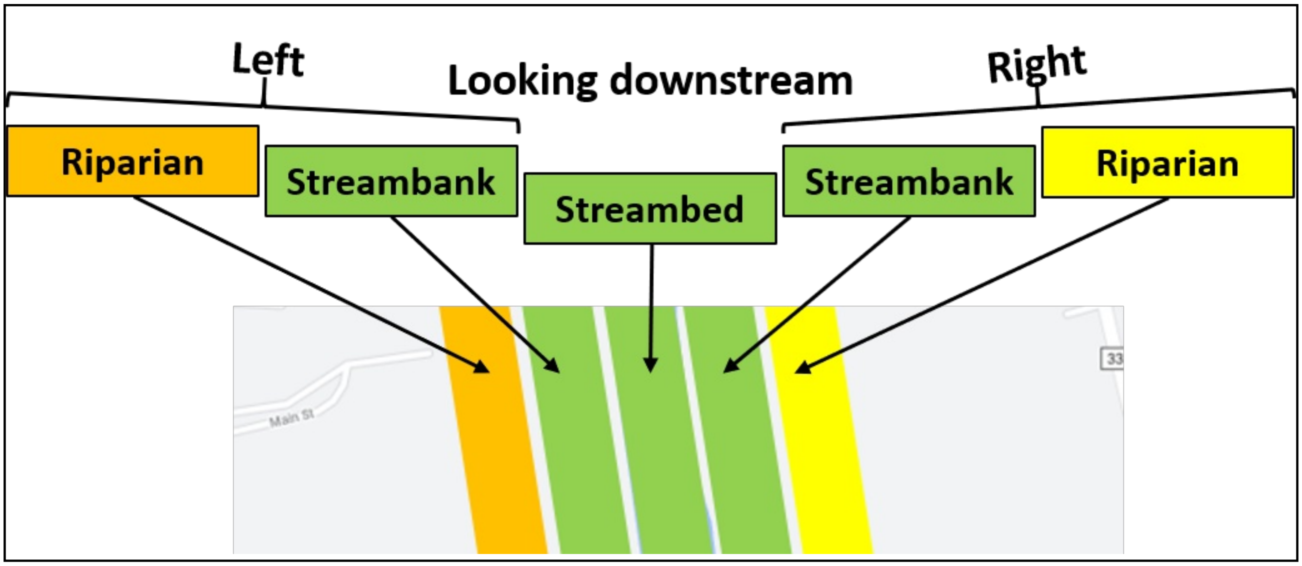
HDSS Data Quality and Use Classification for Cleveland, Tennessee

0 1 2 km
0 1 2 mi

Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Appendix 2:
Streambed, Streambank, and Riparian Function

Cross-section of the stream corridor. Left and right sides of the corridor are determined when looking downstream.

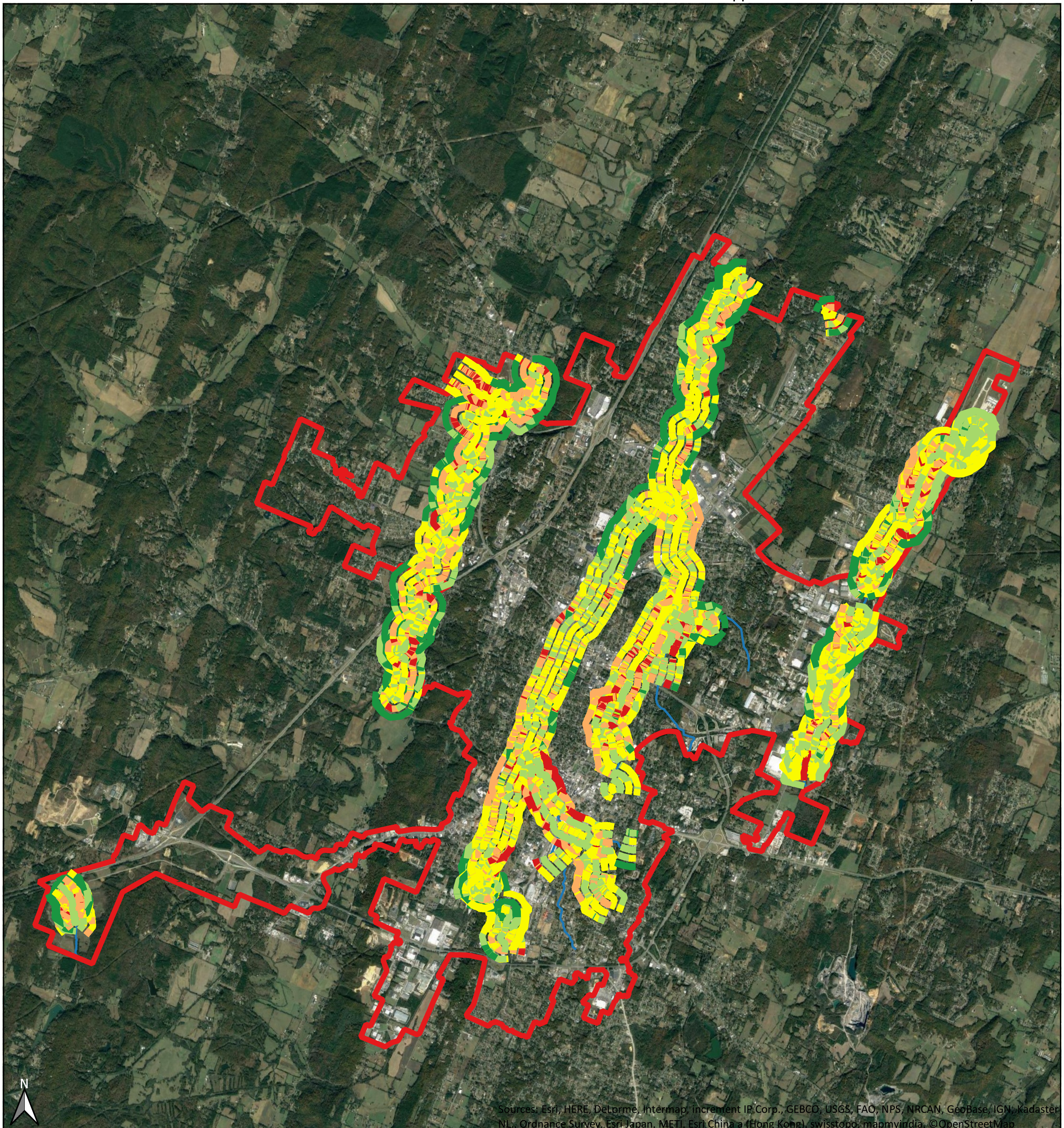


Streambed and streambank function were visually assessed and integrated into a single functional score, utilizing the high definition video, based on the gernal summary for the paramerters listed below. The streambed and each streambank were viewed independently during the classification process. Ripairan function was assessed using landcover to assess vegetated diversity.

	Streambed			Streambanks				Riparian
	Widening or Narrowing and Straightening	Aggregation or Degradation	Habitat Heterogeneity	Bank Angle	Bank Height	Surface Protection	Vegetated Diversity	Vegetative Functional Complexity
Fully Functional	None to minimal	None to minimal	High	Low Slope	Low	High	High	High
Functional								
Slightly Impaired								
Impaired								
Non-Functional	Extreme	Extreme	Low to none	High slope	High	Low	Bare soil	Low

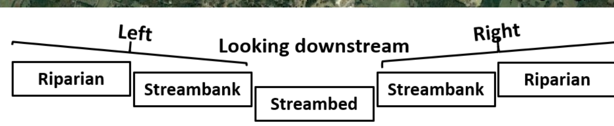
*The Functional rating scores are a visual integration of the categories, based on the reviewer's experience and expertise.

TRUTTA
Environmental Solutions, LLC

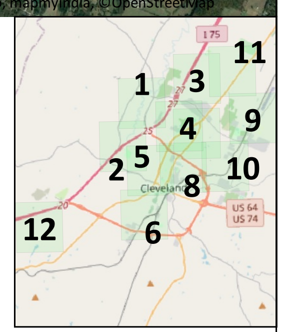


Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream



HDSS Streambed, Streambank, and Riparian Function for Cleveland, TN

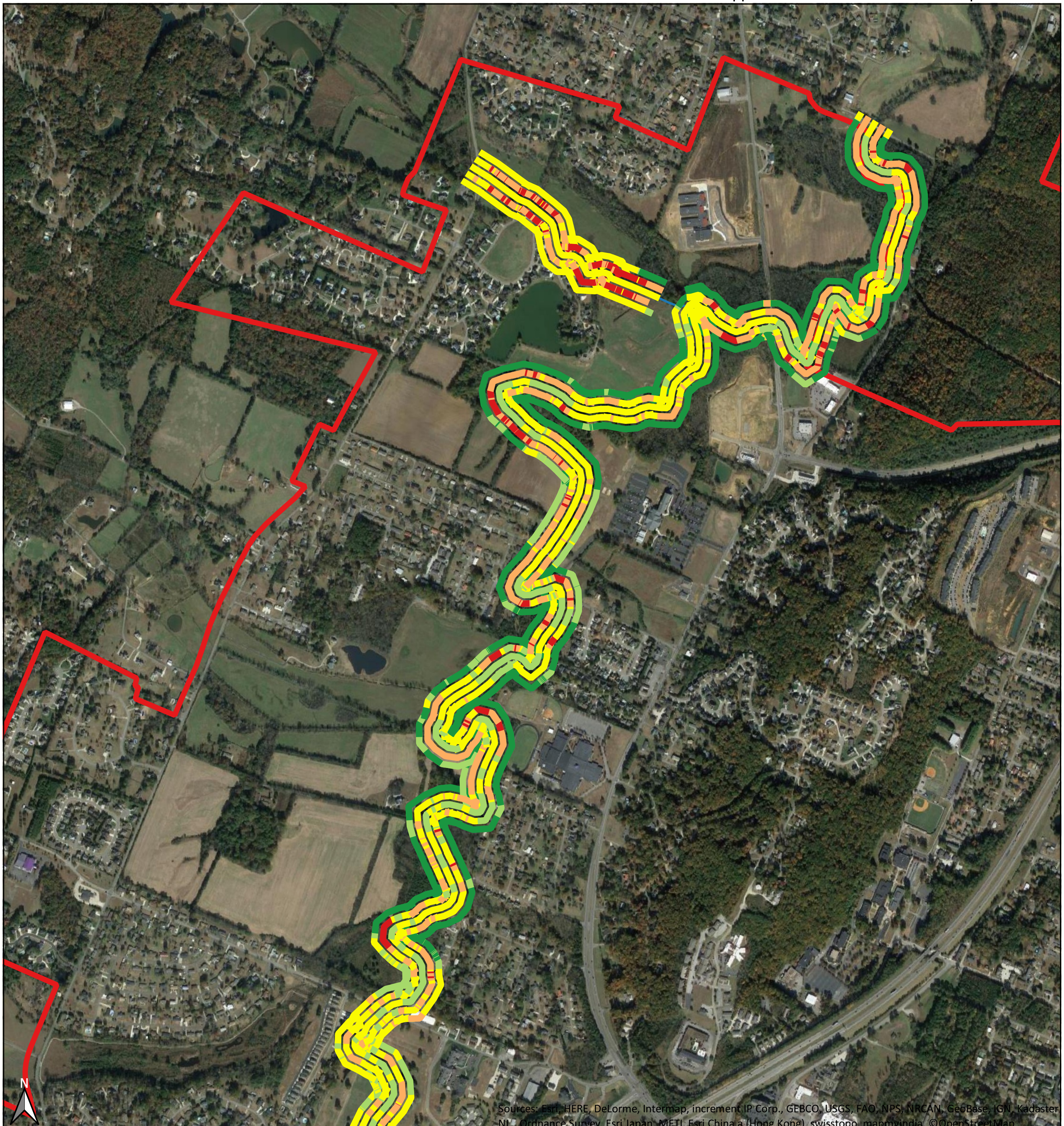


TRUTTA Environmental Solutions, LLC

0 1 2 km

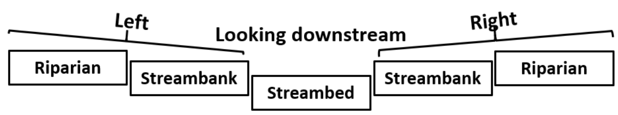
0 1 2 mi

Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters

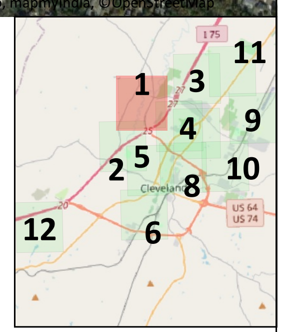


Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream



HDSS Streambed, Streambank, and Riparian Function for the Candies and Bigsby Creeks: Map 1

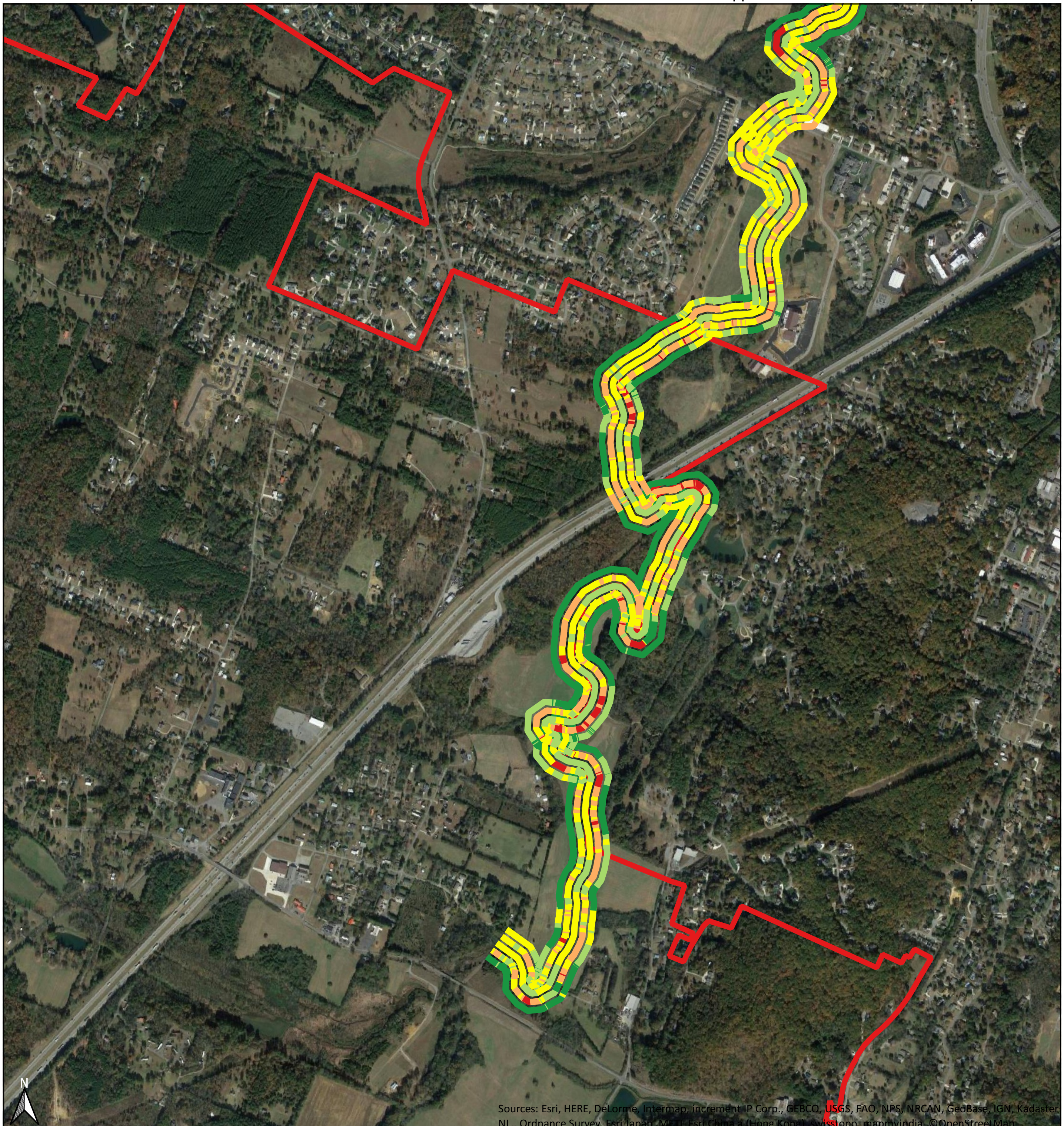


TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km

0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



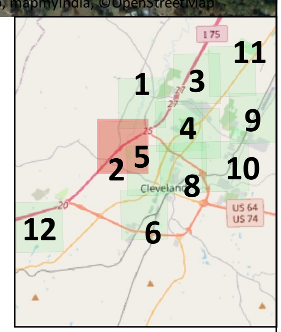
Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

Left — Looking downstream — Right

Riparian	Streambank	Streambed	Streambank	Riparian

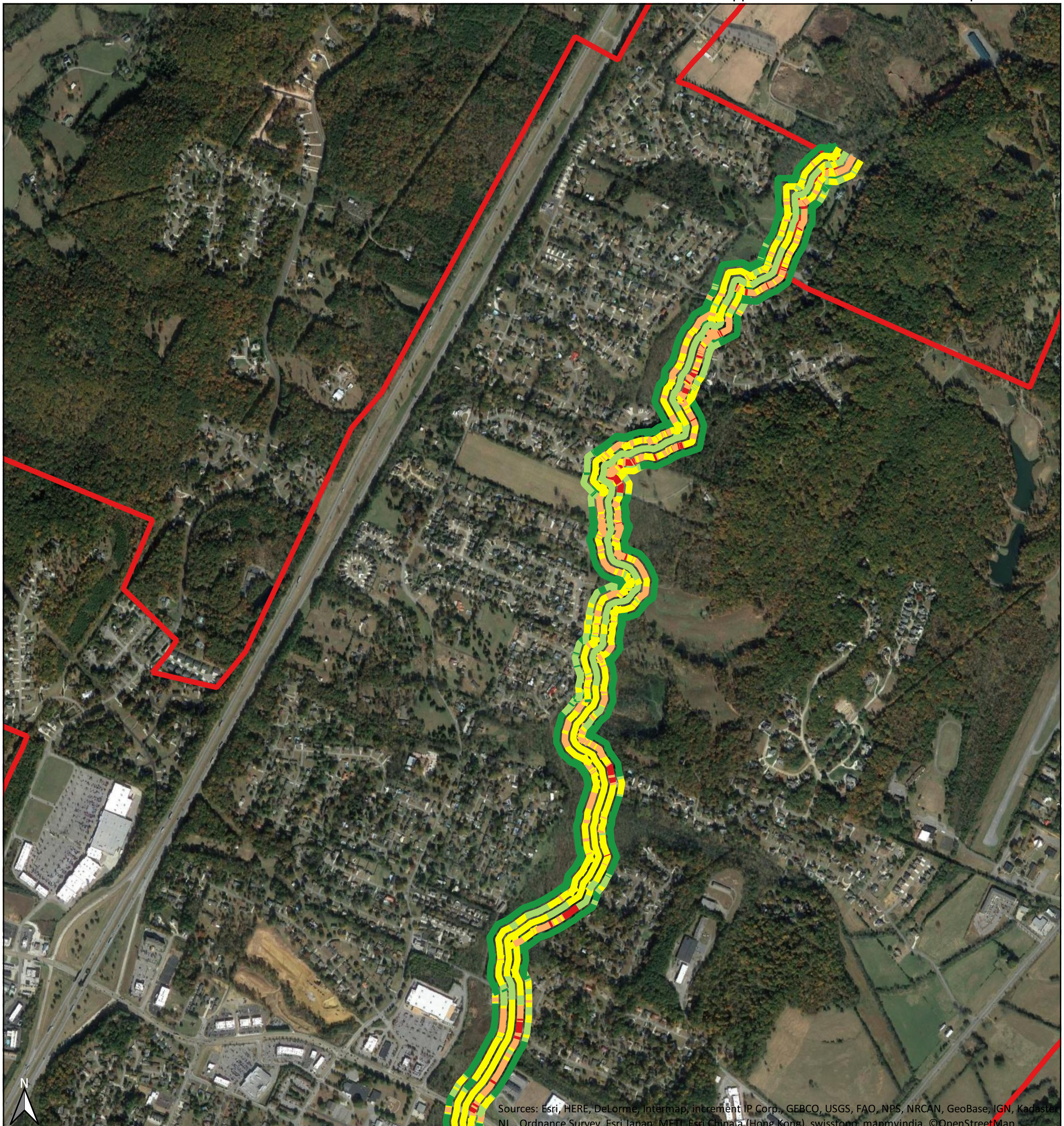
HDSS Streambed, Streambank, and Riparian Function for the Candies Creek: Map 2



0 0.3 0.6 km

0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

Left — Looking downstream — Right

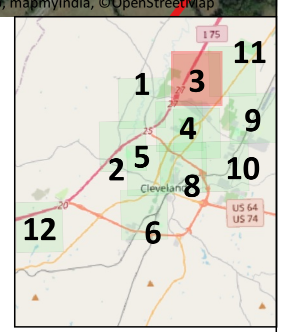
Riparian | Streambank | Streambed | Streambank | Riparian

HDSS Streambed, Streambank, and Riparian Function for the South Mouse Creek: Map 3

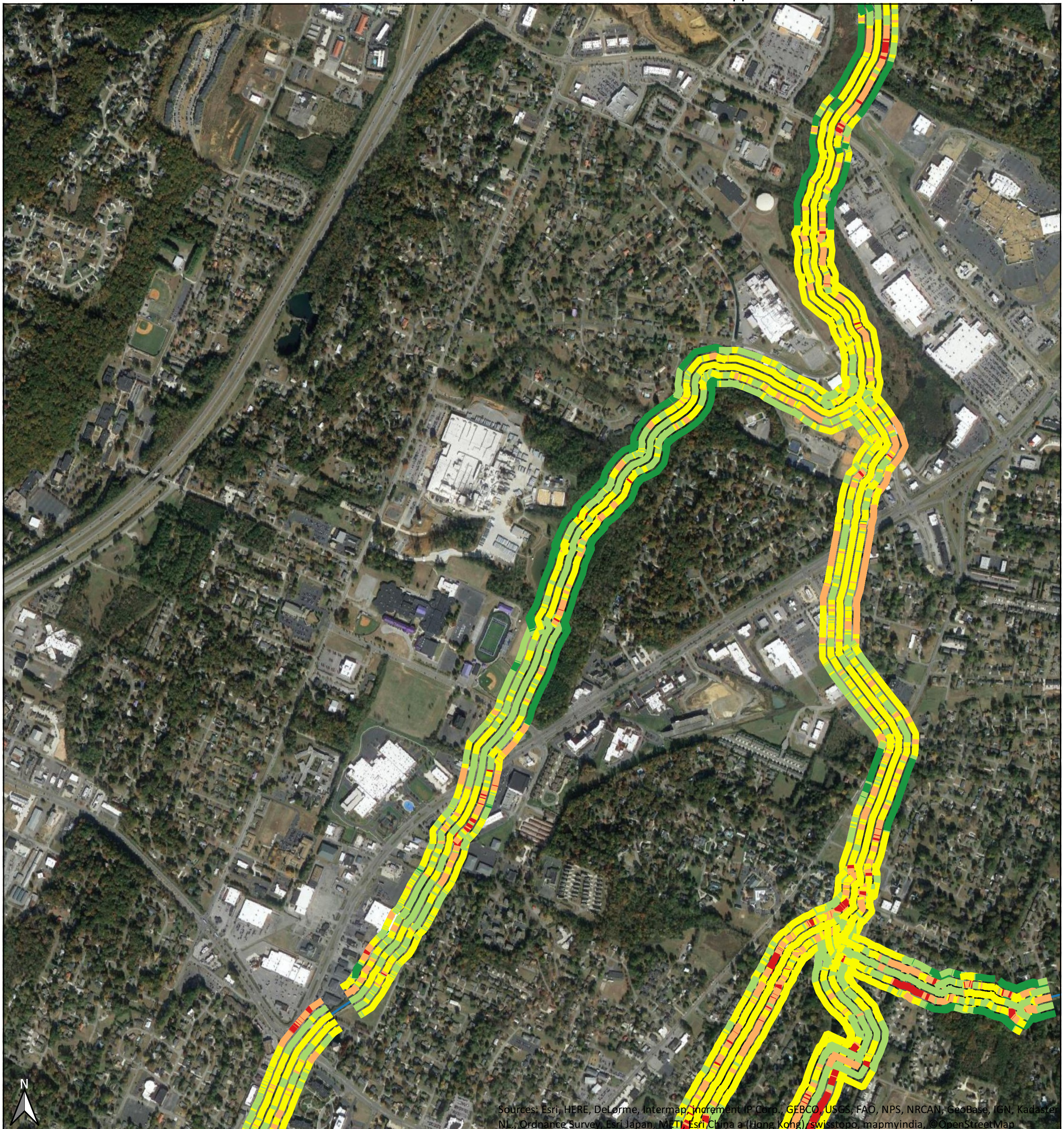
TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km

0 0.2 0.4 mi



Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



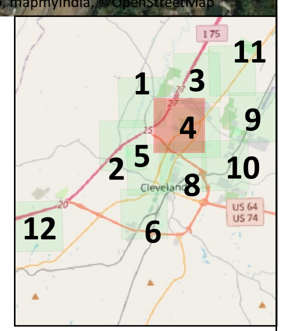
Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

Left — Looking downstream — Right

Riparian	Streambank	Streambed	Streambank	Riparian

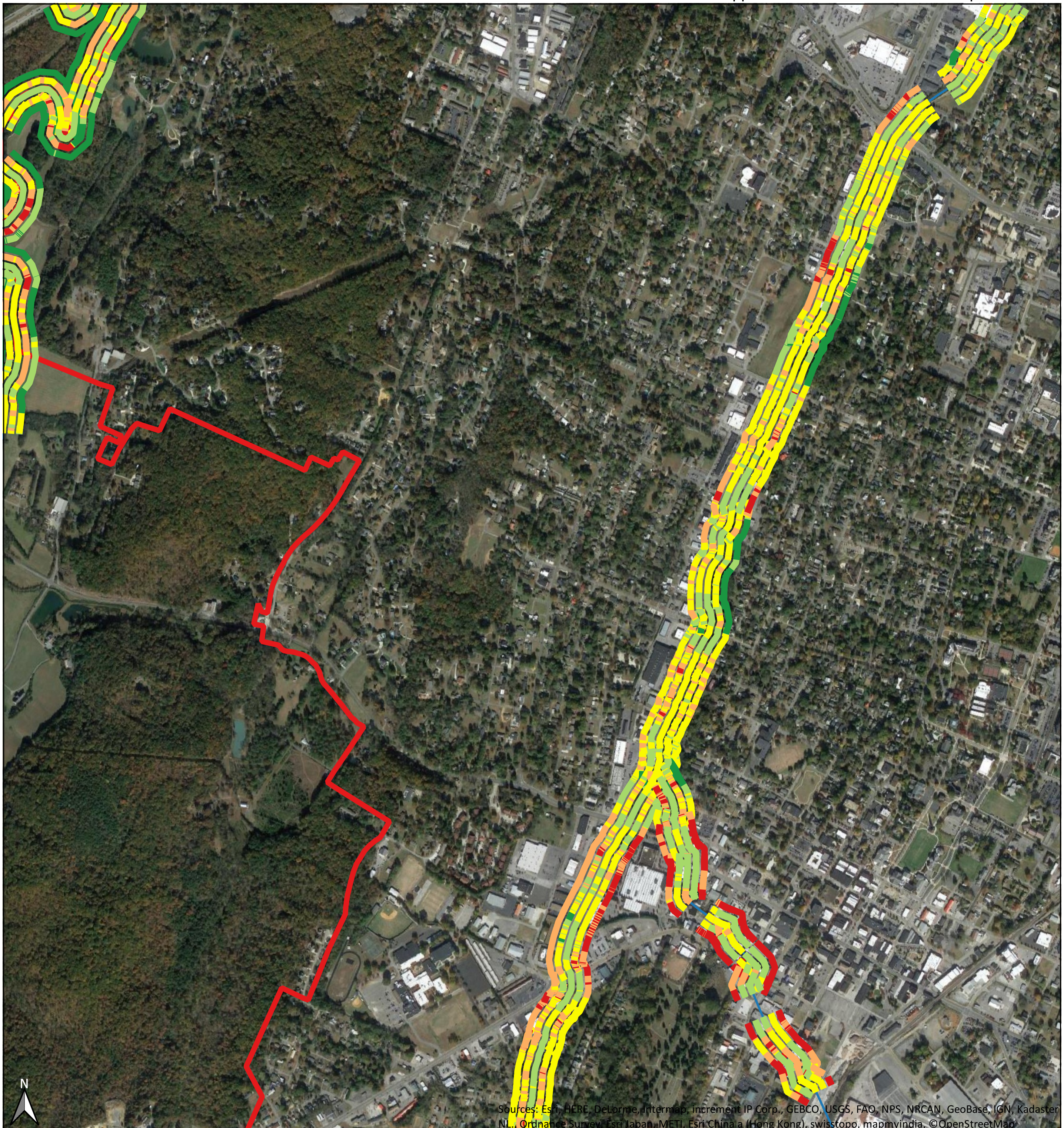
HDSS Streambed, Streambank, and Riparian Function for the South Mouse Creek: Map 4



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



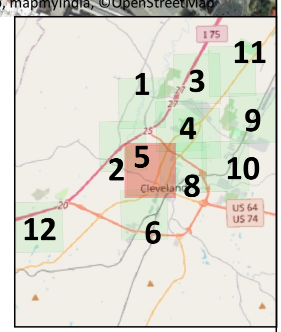
Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

Left — Looking downstream — Right

Riparian	Streambank	Streambed	Streambank	Riparian

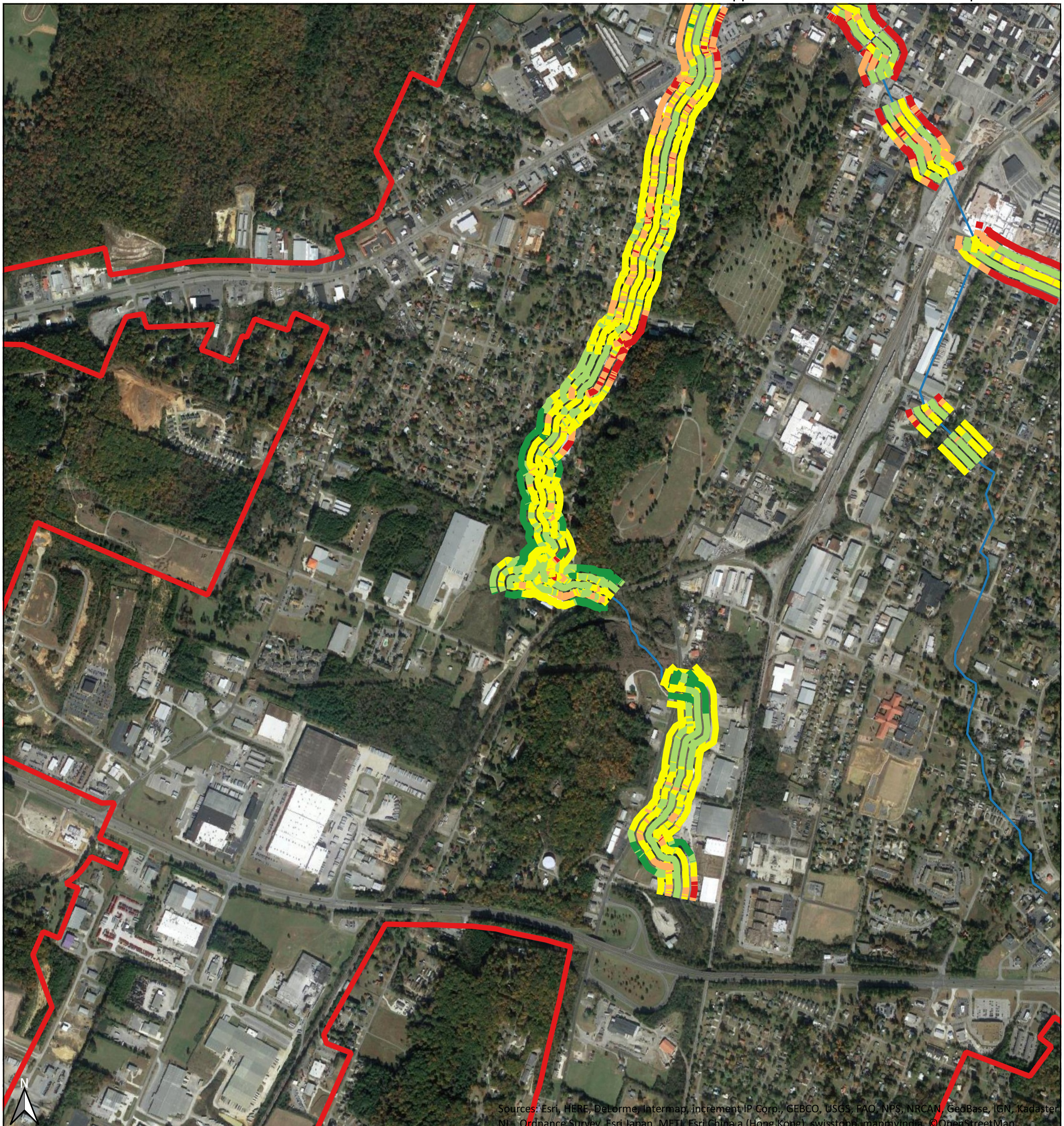
HDSS Streambed, Streambank, and Riparian Function for the South Mouse Creek & Woolen Mill Branch: Map 5



0 0.3 0.6 km
0 0.2 0.4 mi

TRUTTA Environmental Solutions, LLC

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



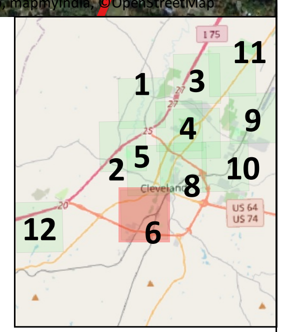
Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

Left | Looking downstream | Right

Riparian | Streambank | Streambed | Streambank | Riparian

HDSS Streambed, Streambank, and Riparian Function for the South Mouse Creek: Map 6

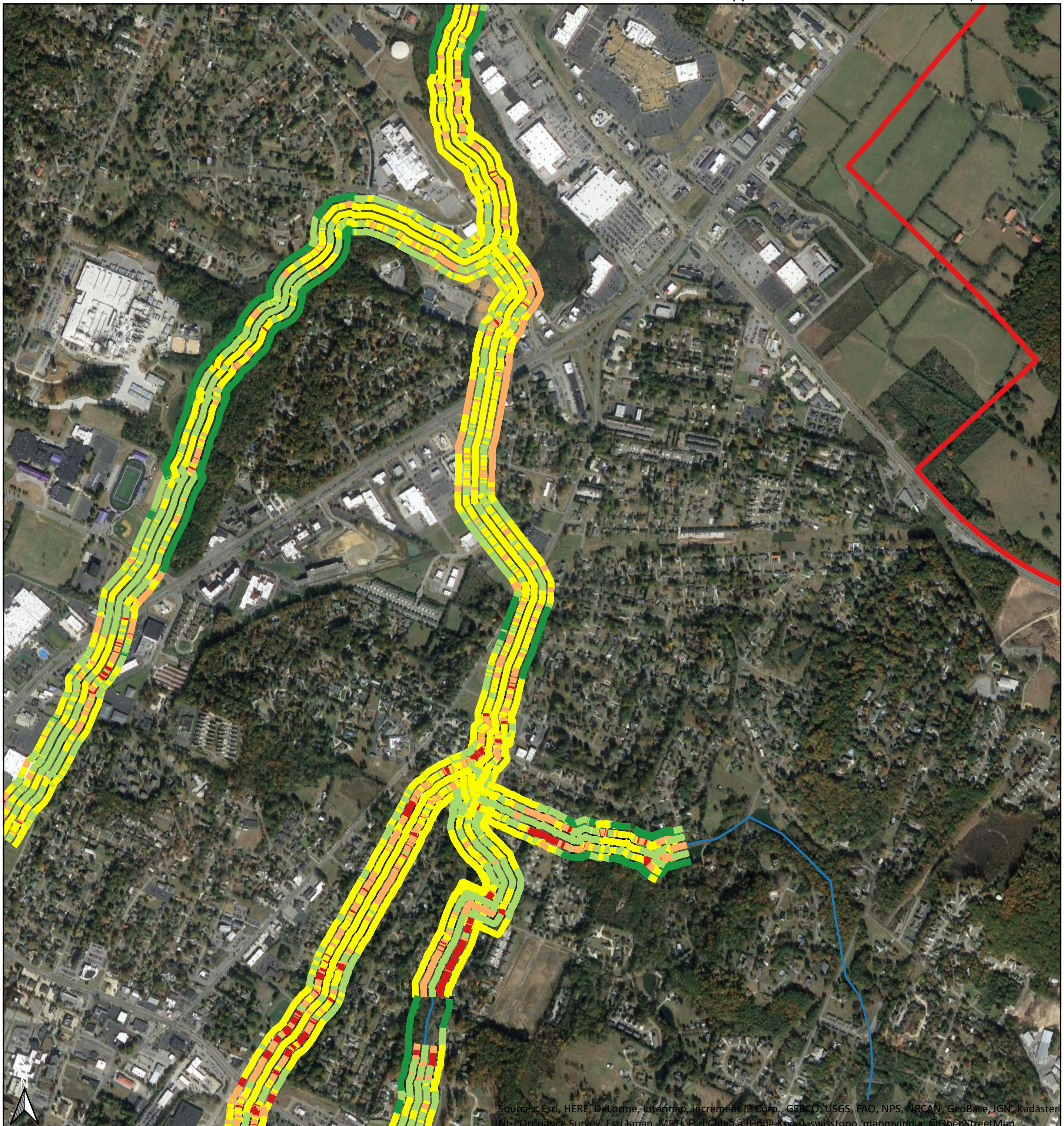


TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km

0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

Left — Looking downstream — Right

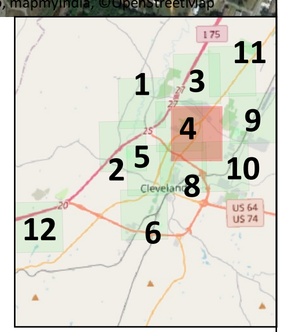
Riparian	Streambank	Streambed	Streambank	Riparian

HDSS Streambed, Streambank, and Riparian Function for the Fillauer Creek: Map 7

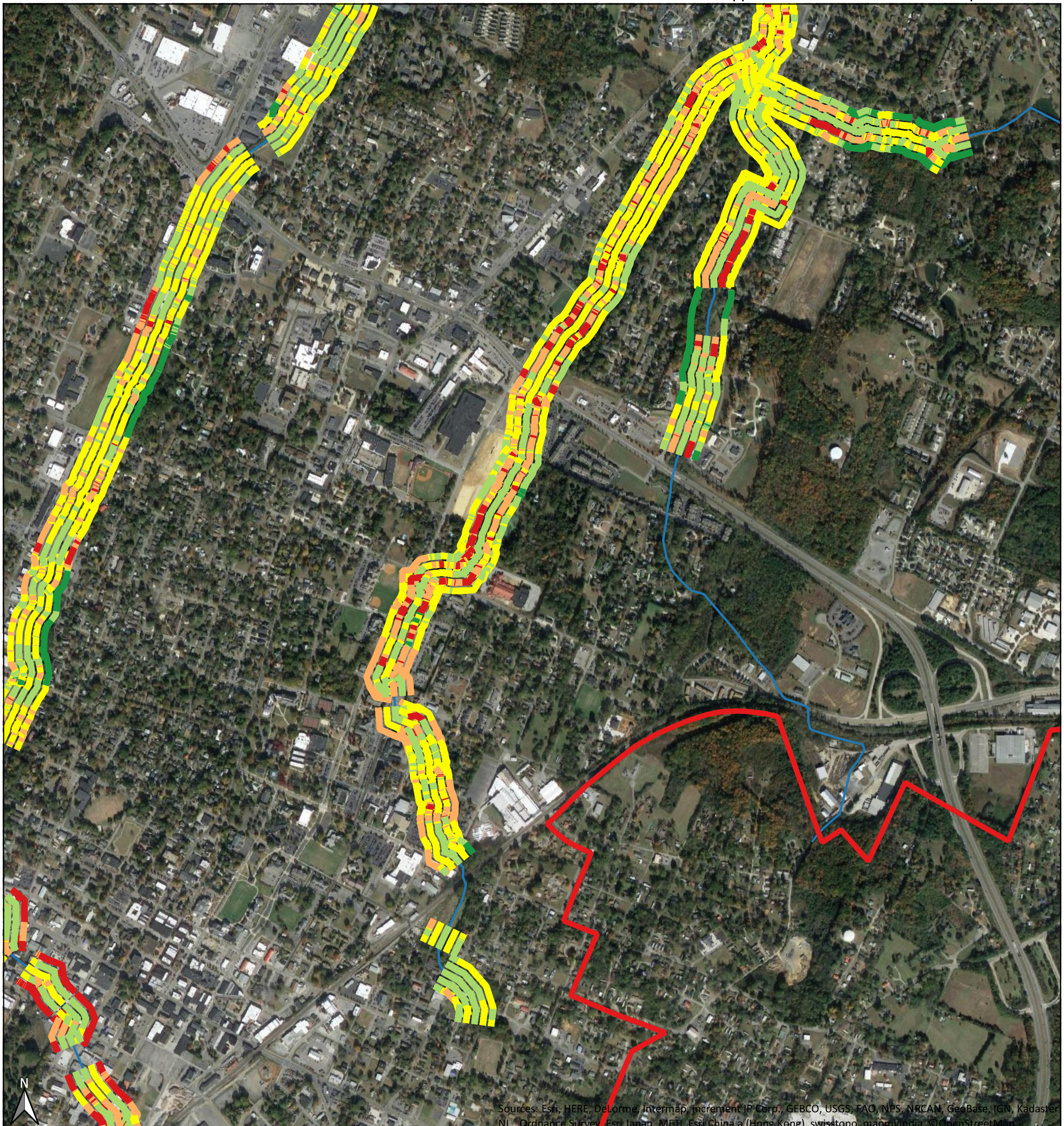
TRUTTA Environmental Solutions, LLC

0 — 0.3 — 0.6 km

0 — 0.2 — 0.4 mi

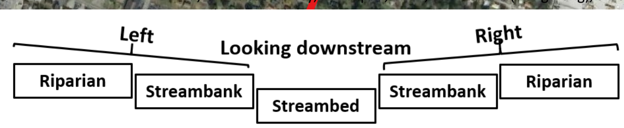


Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

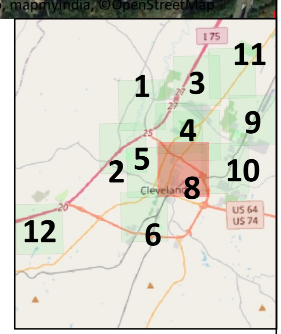


Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream



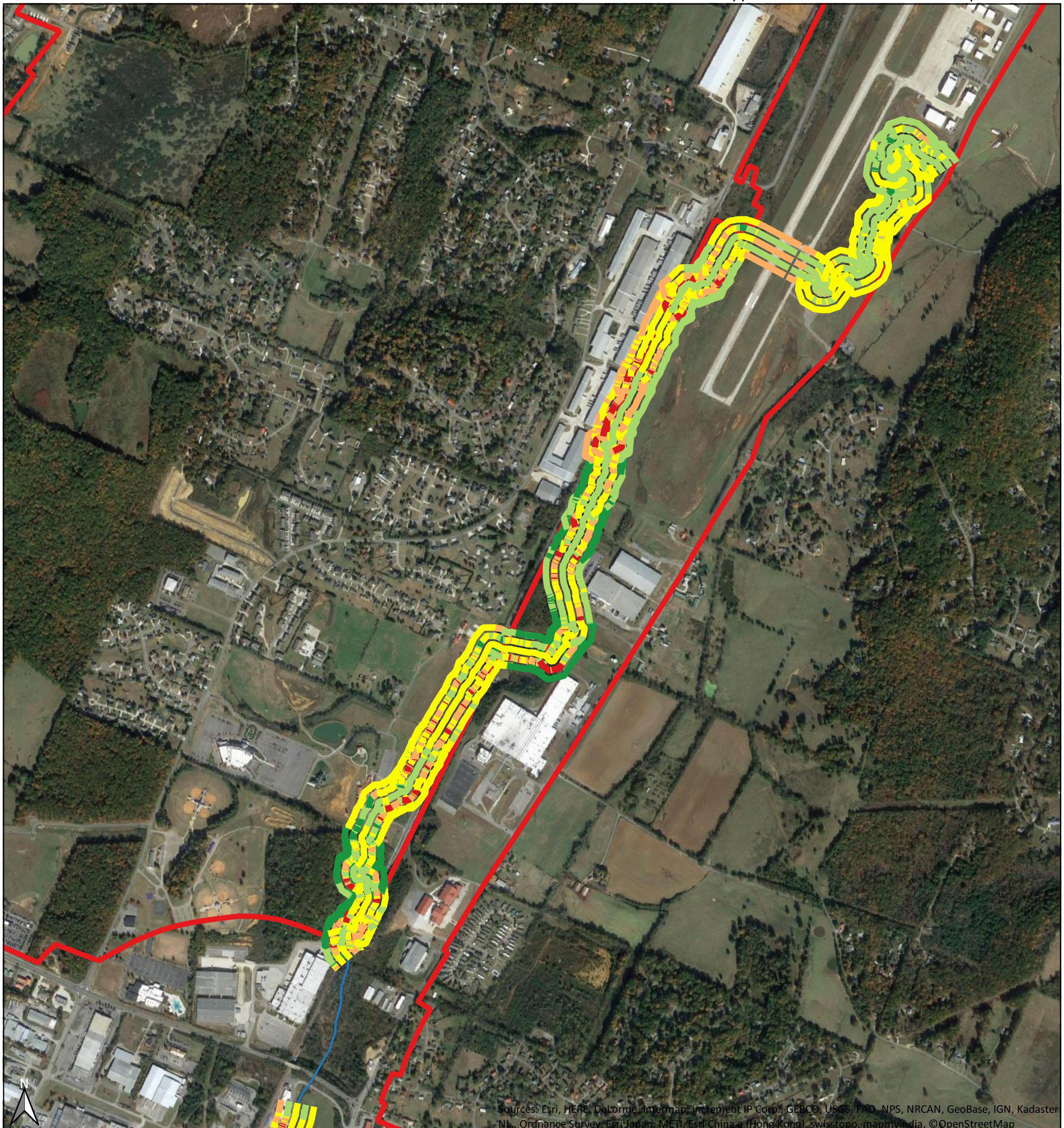
HDSS Streambed, Streambank, and Riparian Function for the Fillauer Creek: Map 8



TRUTTA Environmental Solutions, LLC

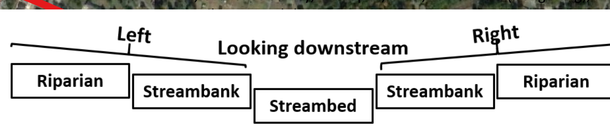
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

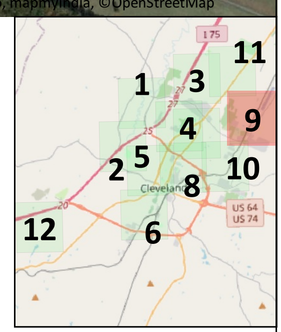


Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream



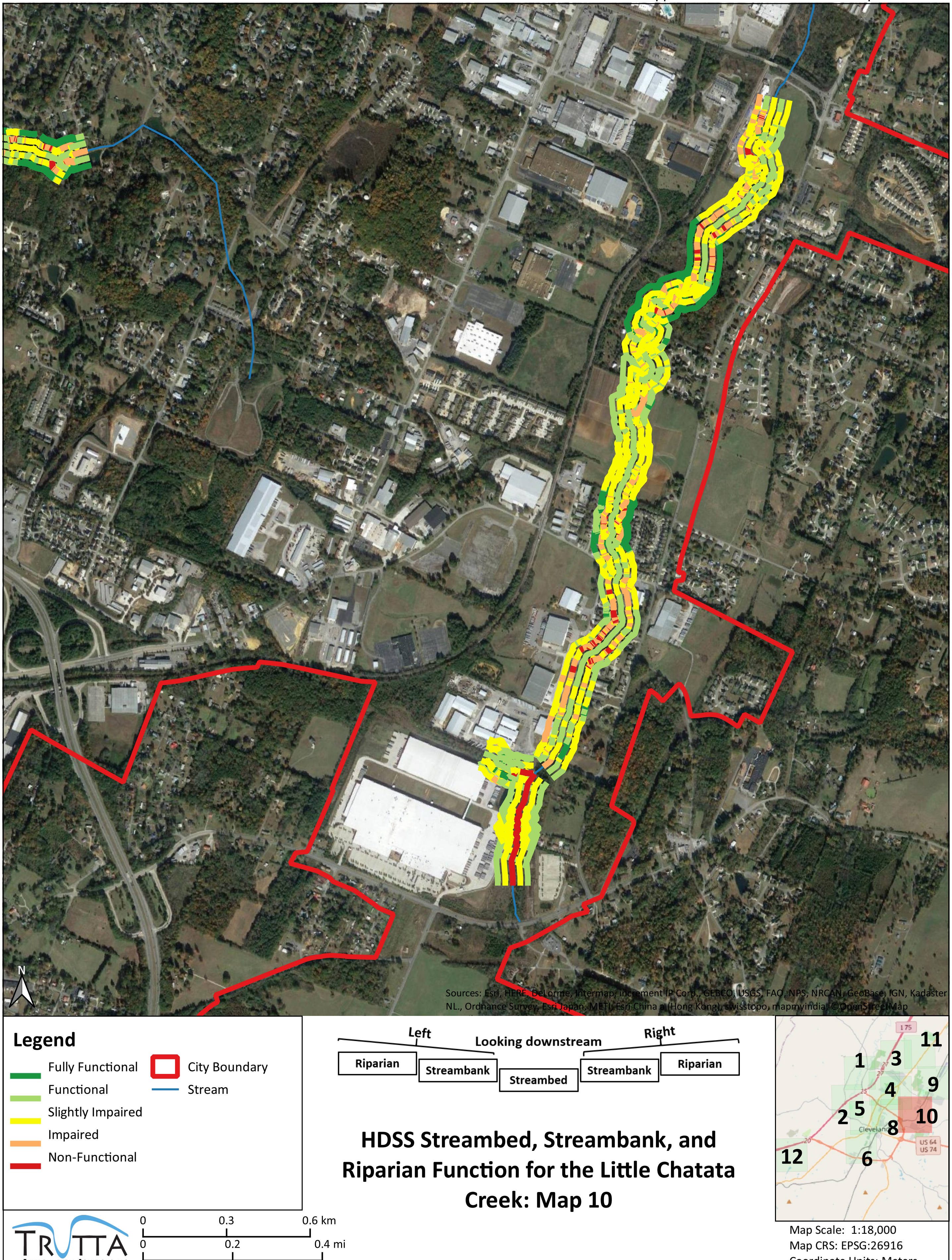
HDSS Streambed, Streambank, and Riparian Function for the Little Chatata Creek: Map 9



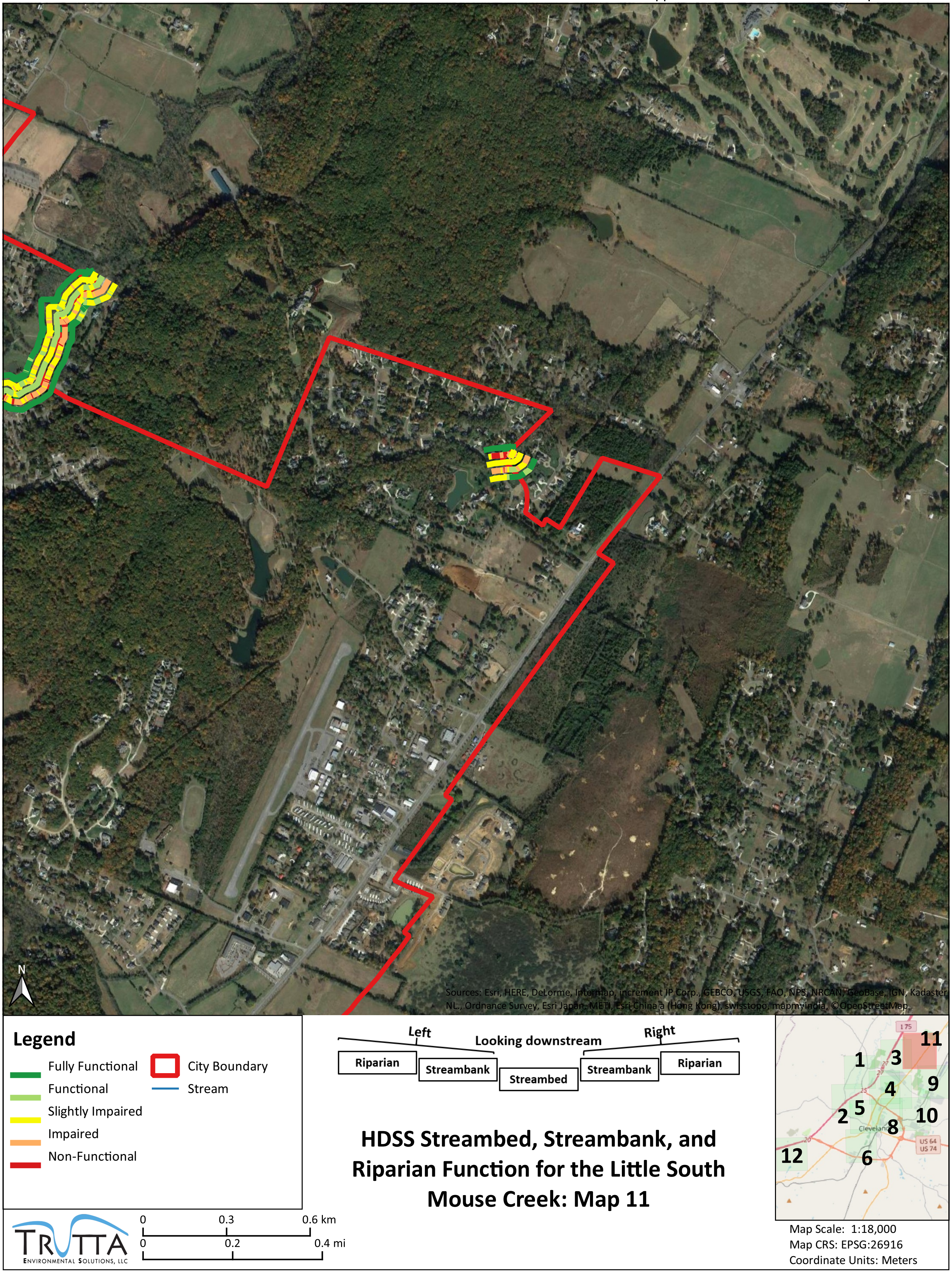
TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

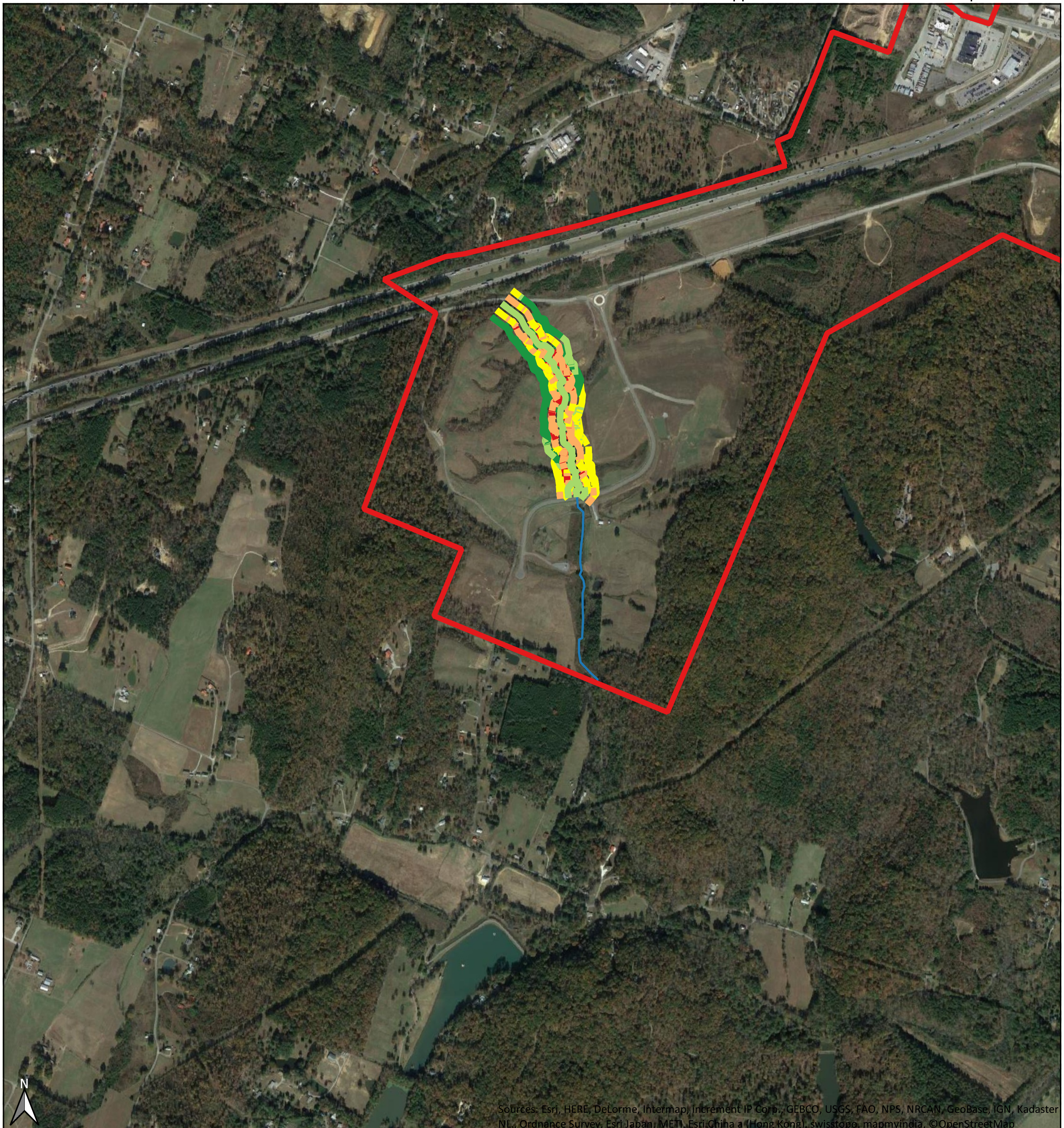


HDSS Streambed, Streambank, and Riparian Function for the Little Chatata Creek: Map 10



HDSS Streambed, Streambank, and Riparian Function for the Little South Mouse Creek: Map 11

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



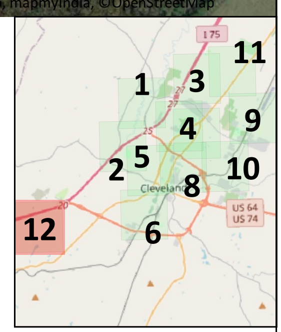
Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

Left — Looking downstream — Right

Riparian | Streambank | Streambed | Streambank | Riparian

HDSS Streambed, Streambank, and Riparian Function for the Spring Branch: Map 12



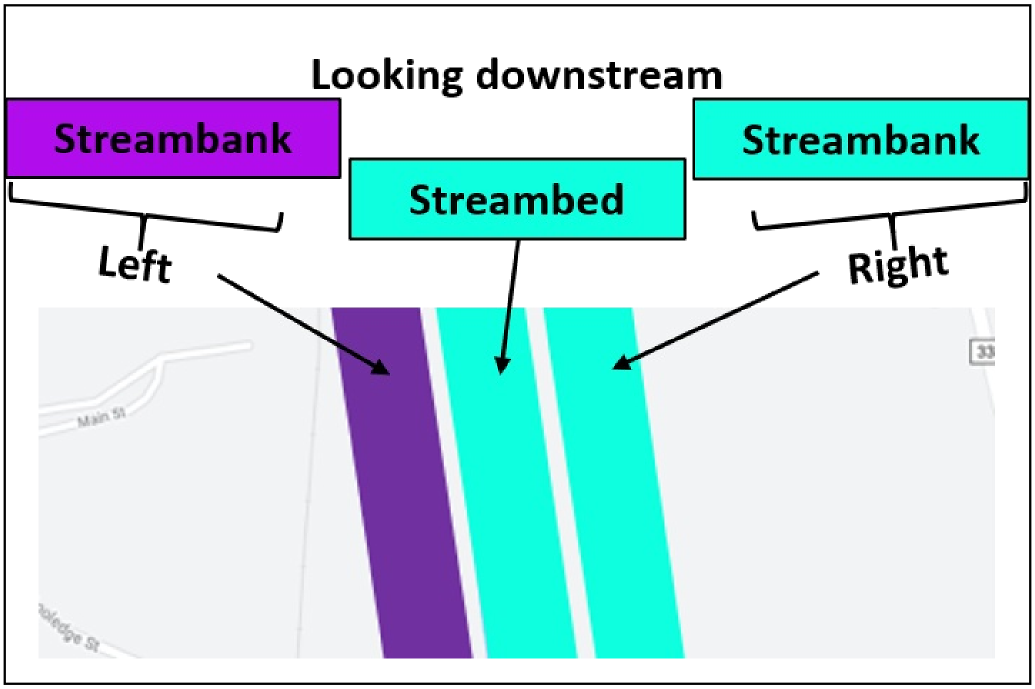
TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

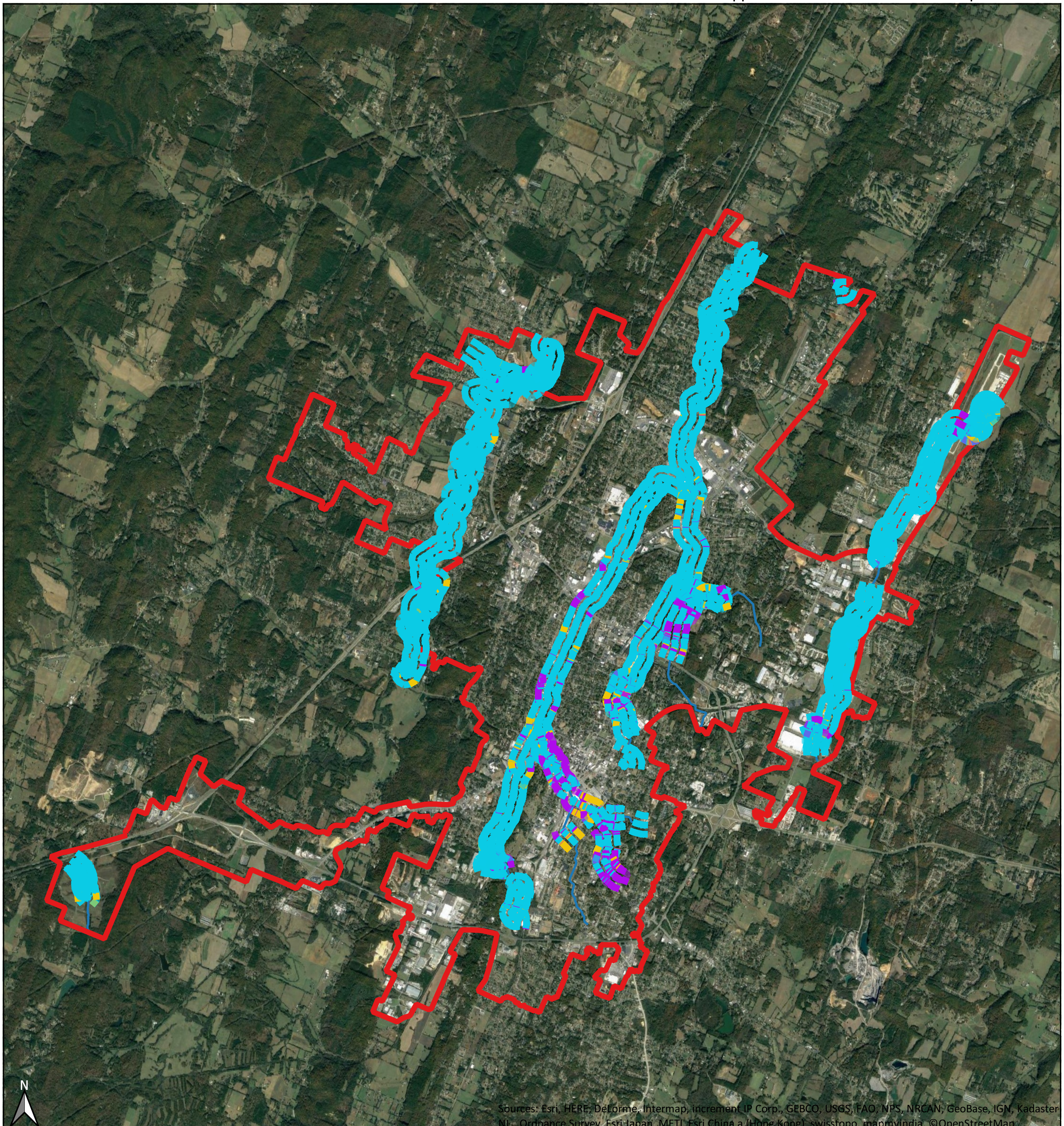
Appendix 3:
City of Cleveland- Streambed and Streambank Modification

Cross-section of the stream corridor. Left and right sides of the corridor are determined when looking downstream.



Streambed and streambank modification were visually assessed utilizing the high definition video ,based on the gernal summary for the paramerters listed below. The streambed and each streambank were viewed independently during the classification process.

Unmodified	**Little to no human modification.**
Modified	**Obvious signs of human modification such a placement of erosion control measures that allows for surface and ground water interactions (e.g., rip-rap, gabion baskets, etc.)**
Highly Modified	**Intensive human modification to control erosion and discharge that does not allow for surface and ground water interaction (e.g., poured concrete or other highly impermeable surface).**



Legend

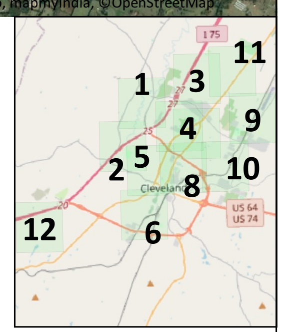
- Unmodified
- Modified
- Highly Modified
- City Boundary
- Stream

Looking downstream

Streambank | Streambed | Streambank

Left | | Right

HDSS Streambed and Streambank Modification for Cleveland, TN

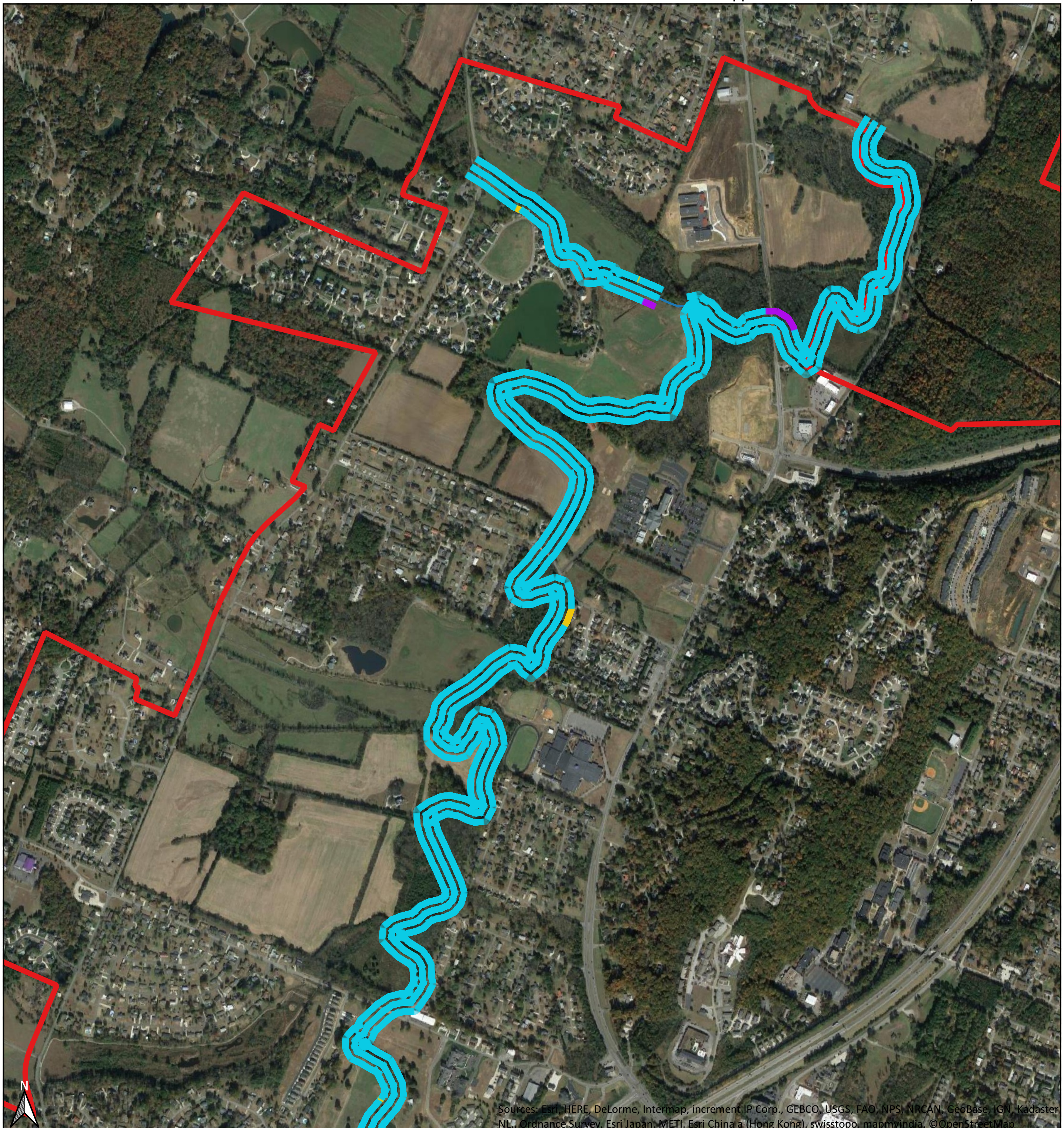


TRUTTA Environmental Solutions, LLC

0 1 2 km

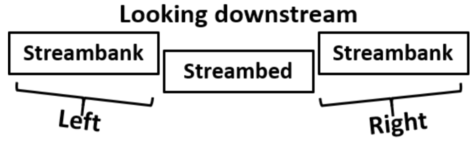
0 1 2 mi

Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters

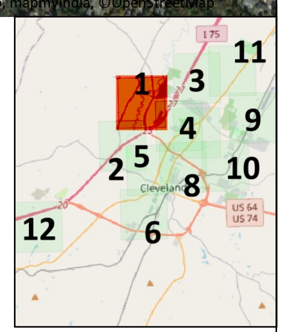


Legend

- Unmodified
- Modified
- Highly Modified
- City Boundary
- Stream



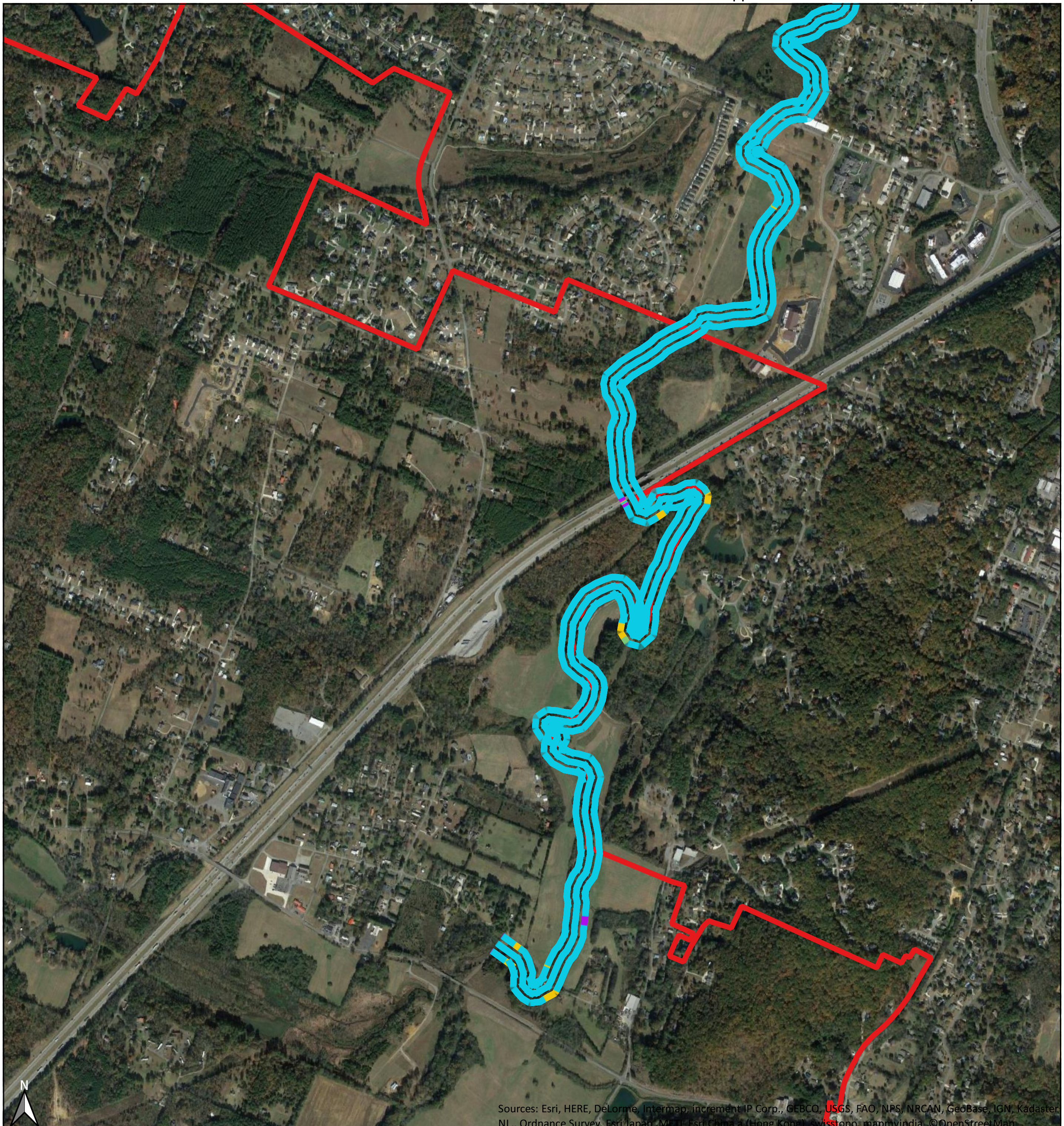
HDSS Streambed and Streambank Modifications for the Candies and Bigsby Creeks: Map 1



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



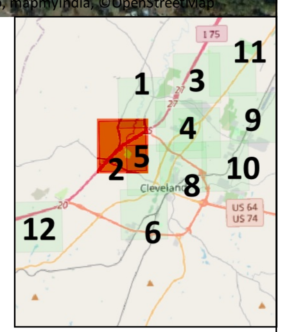
Legend

- Unmodified
- Modified
- Highly Modified
- City Boundary
- Stream

Looking downstream

Streambank	Streambed	Streambank
Left		Right

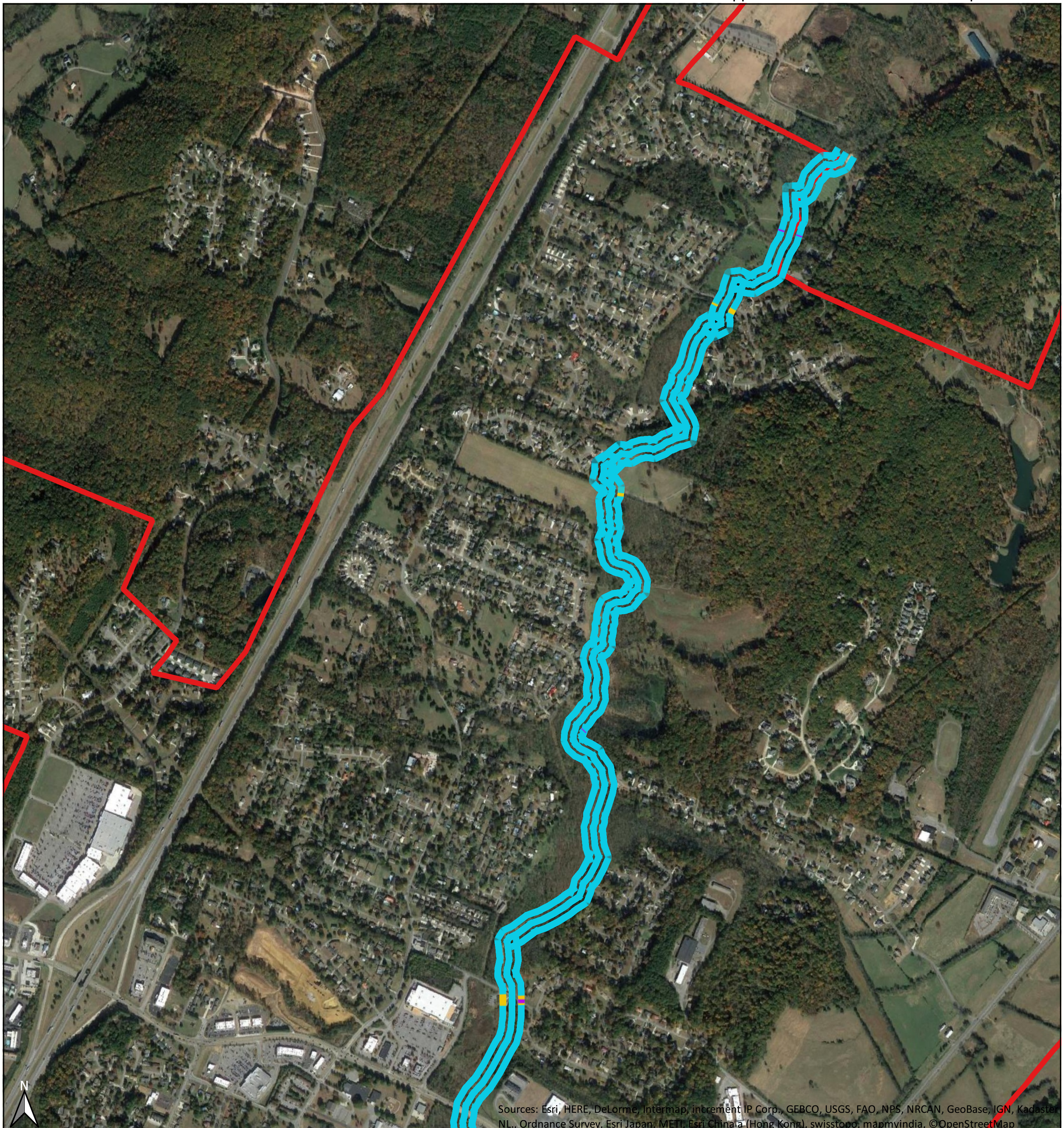
HDSS Streambed and Streambank Modifications for the Candies Creek: Map 2



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

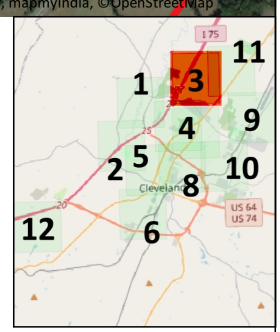
- Unmodified
- Modified
- Highly Modified
- City Boundary
- Stream

Looking downstream

Streambank | Streambed | Streambank

Left | | Right

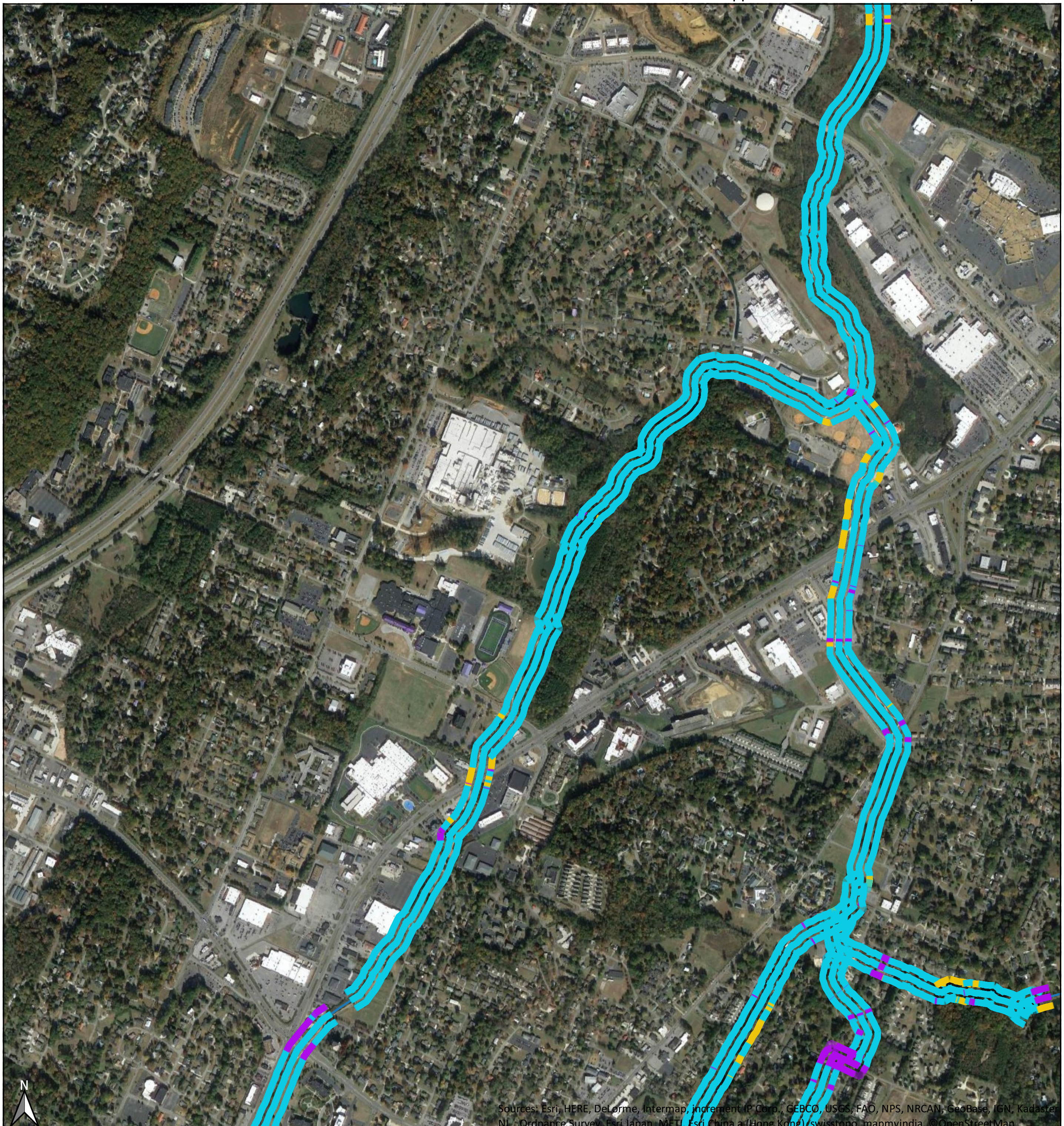
HDSS Streambed and Streambank Modifications for the South Mouse Creek: Map 3



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Unmodified
- Modified
- Highly Modified
- City Boundary
- Stream

Looking downstream

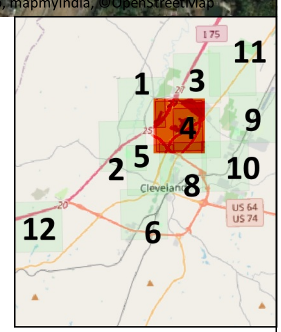
Streambank | Streambed | Streambank

Left | | Right

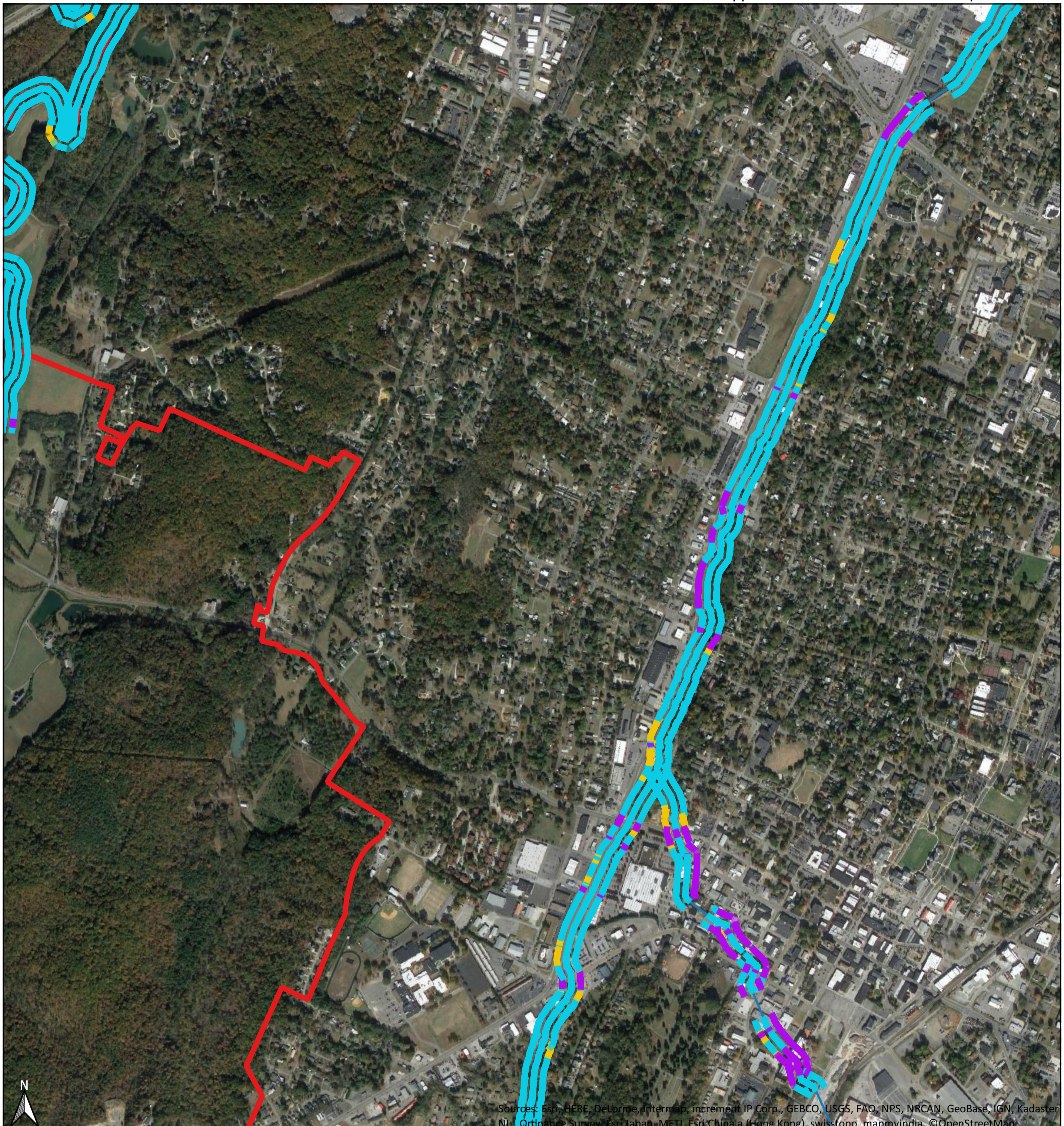
HDSS Streambed and Streambank Modifications for the South Mouse Creek: Map 4

0 0.3 0.6 km

0 0.2 0.4 mi



Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



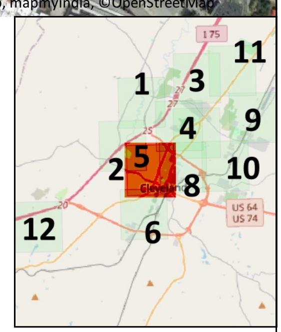
Legend

- Unmodified
- Modified
- Highly Modified
- City Boundary
- Stream

Looking downstream

Streambank	Streambed	Streambank
Left		Right

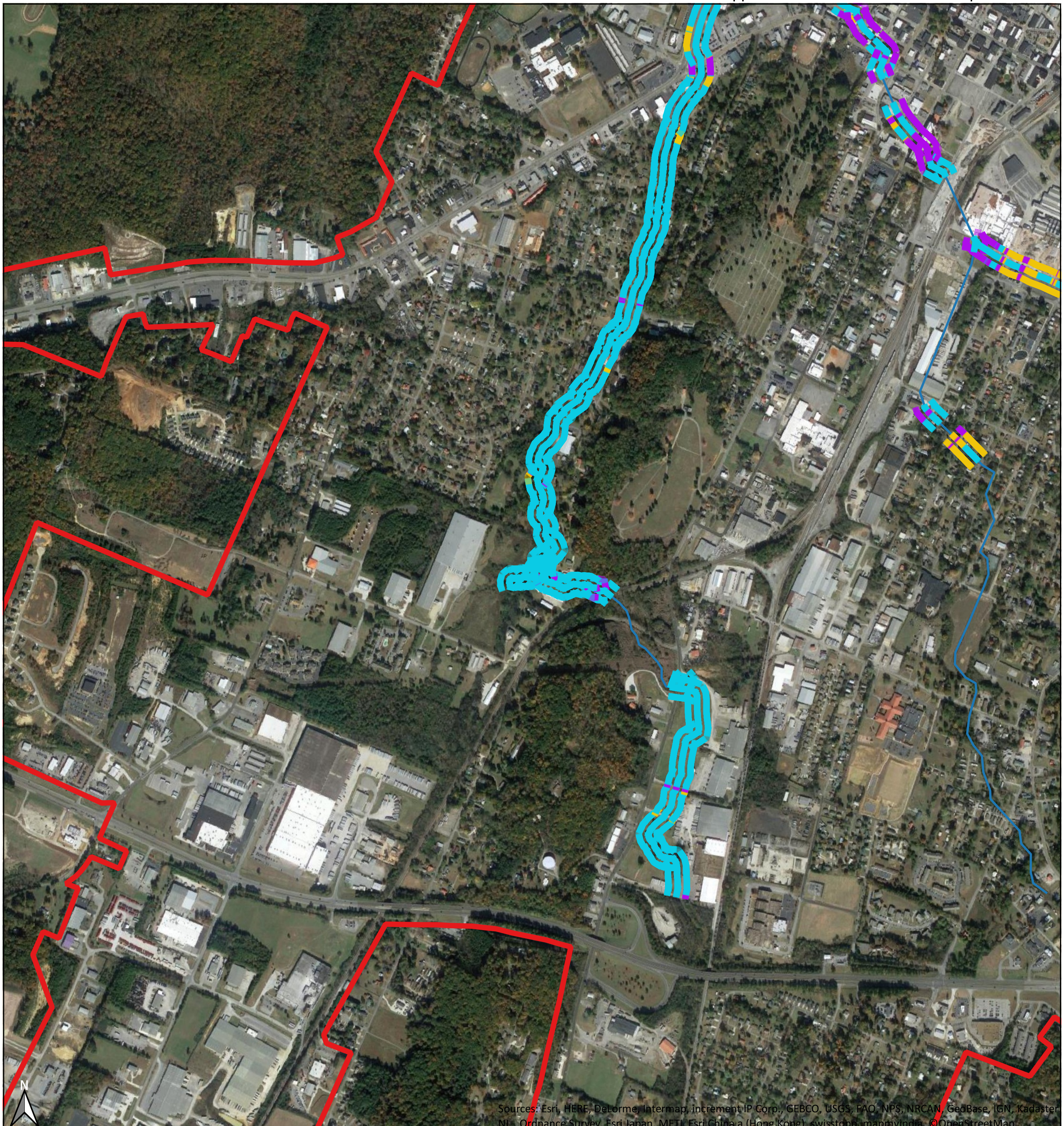
HDSS Streambed and Streambank Modifications for the South Mouse Creek & Woolen Mill Branch: Map 5



0 0.3 0.6 km

0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

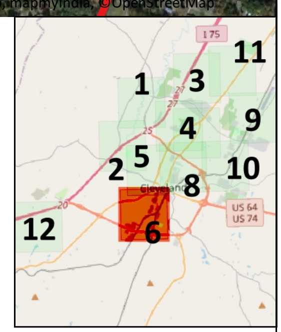
- Unmodified
- Modified
- Highly Modified
- City Boundary
- Stream

Looking downstream

Streambank | Streambed | Streambank

Left | Right

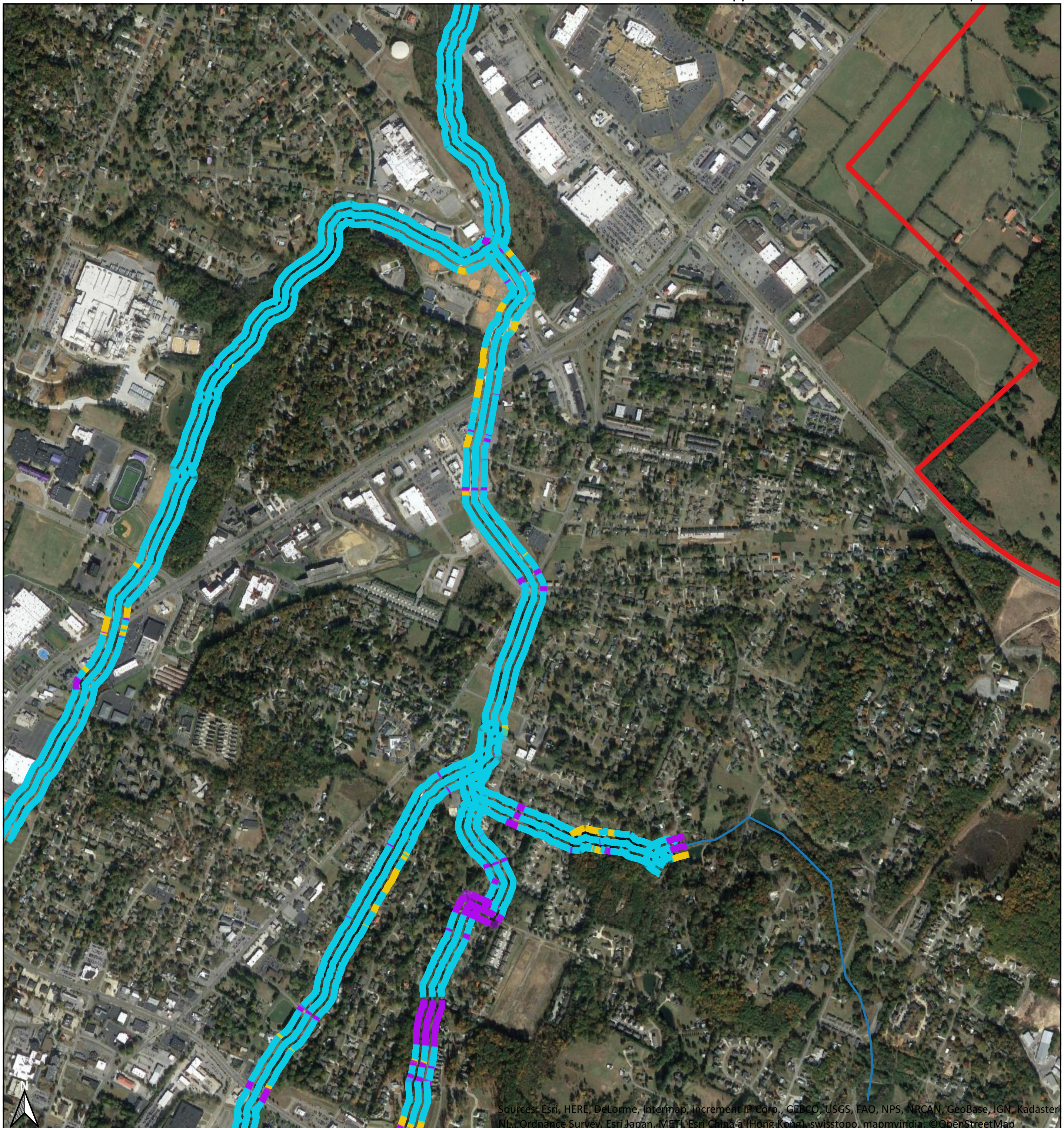
HDSS Streambed and Streambank Modifications for the South Mouse Creek: Map 6



TRUTTA Environmental Solutions, LLC

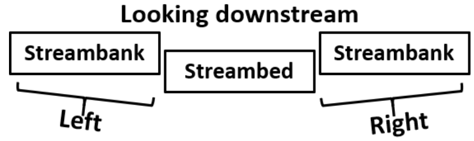
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

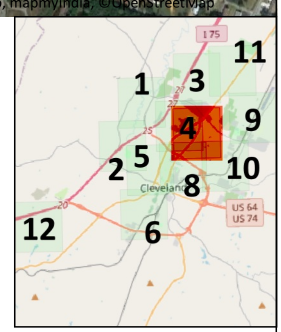


Legend

- Unmodified
- Modified
- Highly Modified
- City Boundary
- Stream



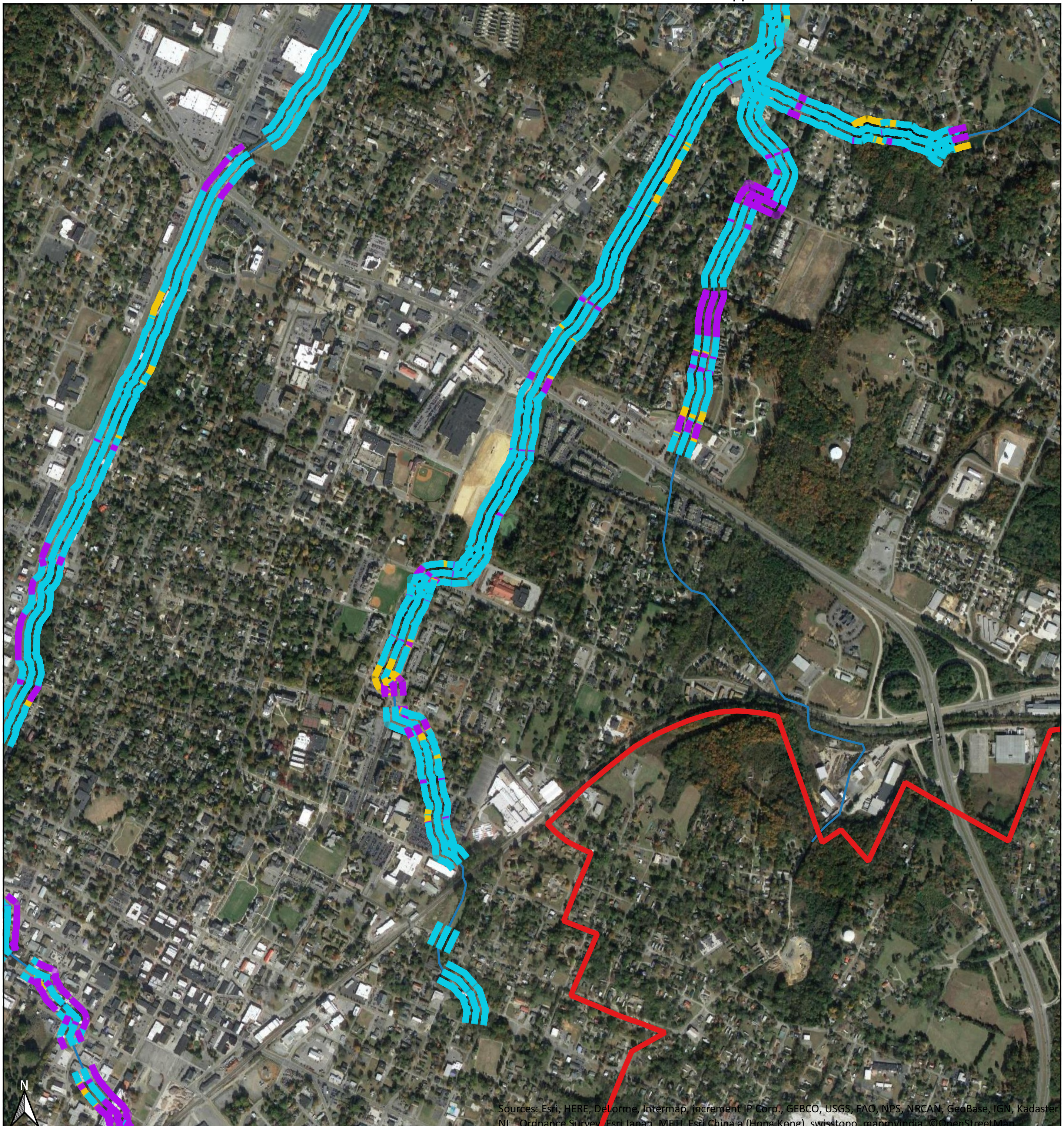
HDSS Streambed and Streambank Modifications for the Fillauer Creek: Map 7



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

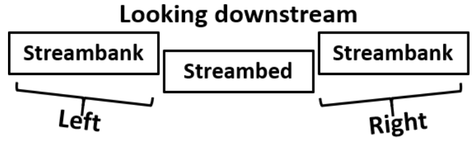
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



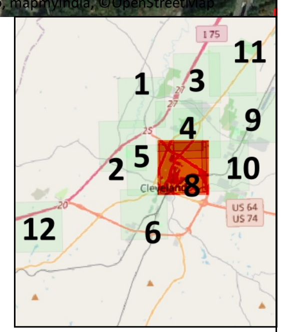
Legend

- Unmodified
- Modified
- Highly Modified
- City Boundary
- Stream

Looking downstream

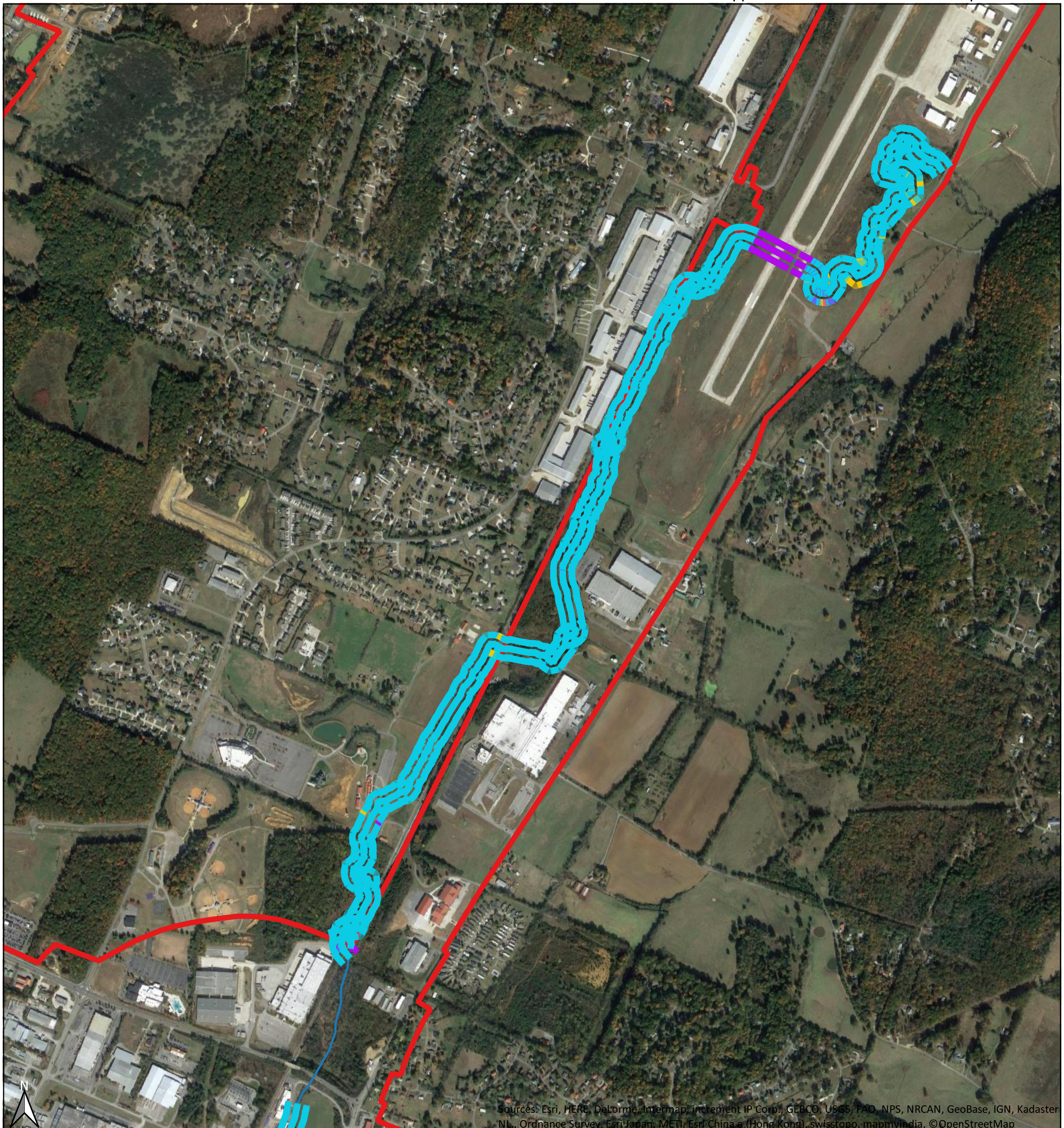


HDSS Streambed and Streambank Modifications for the Fillauer Creek: Map 8



0 0.3 0.6 km
0 0.2 0.4 mi

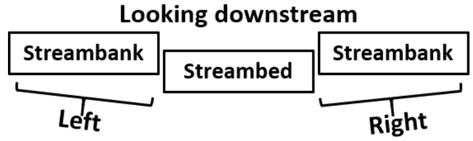
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



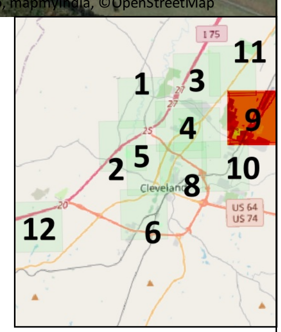
Legend

- Unmodified
- Modified
- Highly Modified
- City Boundary
- Stream

Looking downstream

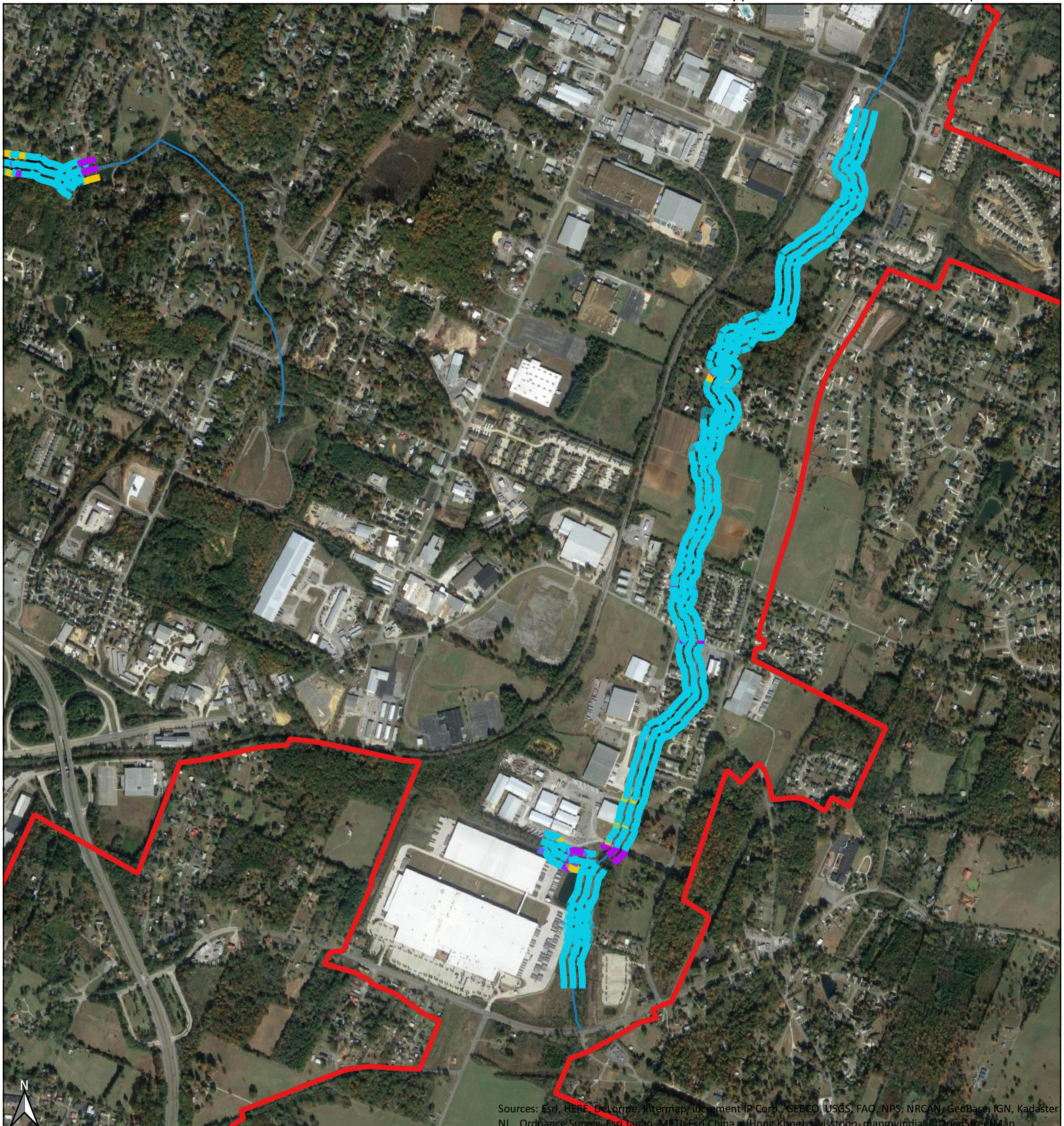


HDSS Streambed and Streambank Modifications for the Little Chatata Creek: Map 9



0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

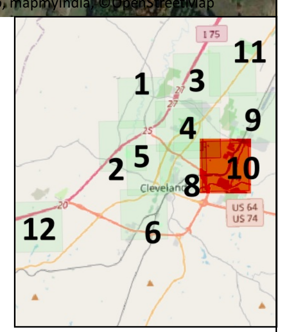
- Unmodified
- Modified
- Highly Modified
- City Boundary
- Stream

Looking downstream

Streambank | Streambed | Streambank

Left | Right

HDSS Streambed and Streambank Modifications for the Little Chatata Creek: Map 10

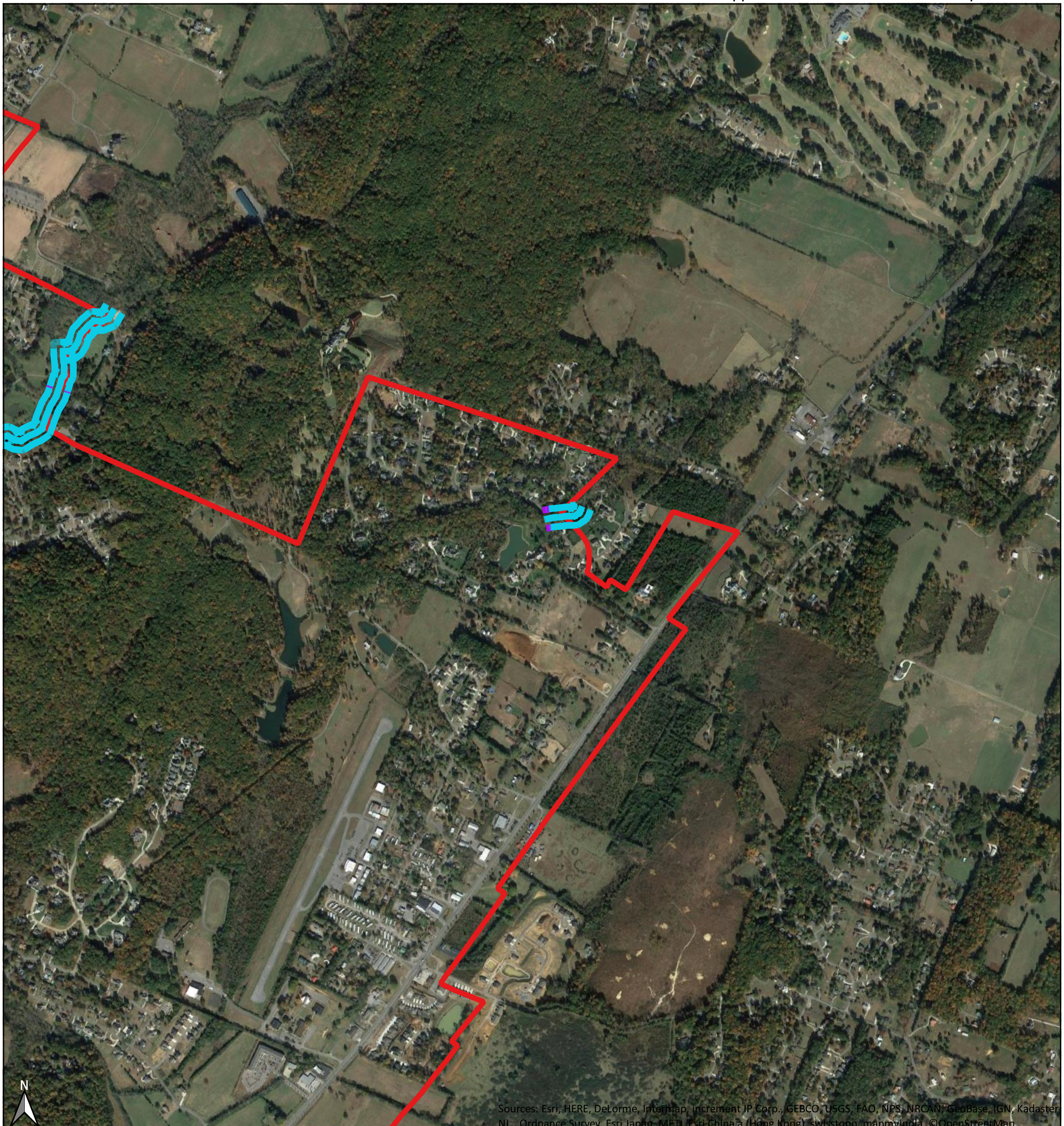


0 0.3 0.6 km

0 0.2 0.4 mi

TRUTTA Environmental Solutions, LLC

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

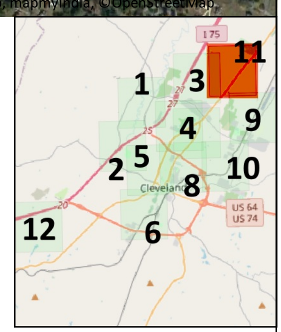
- Unmodified
- Modified
- Highly Modified
- City Boundary
- Stream

Looking downstream

Streambank | Streambed | Streambank

Left | Right

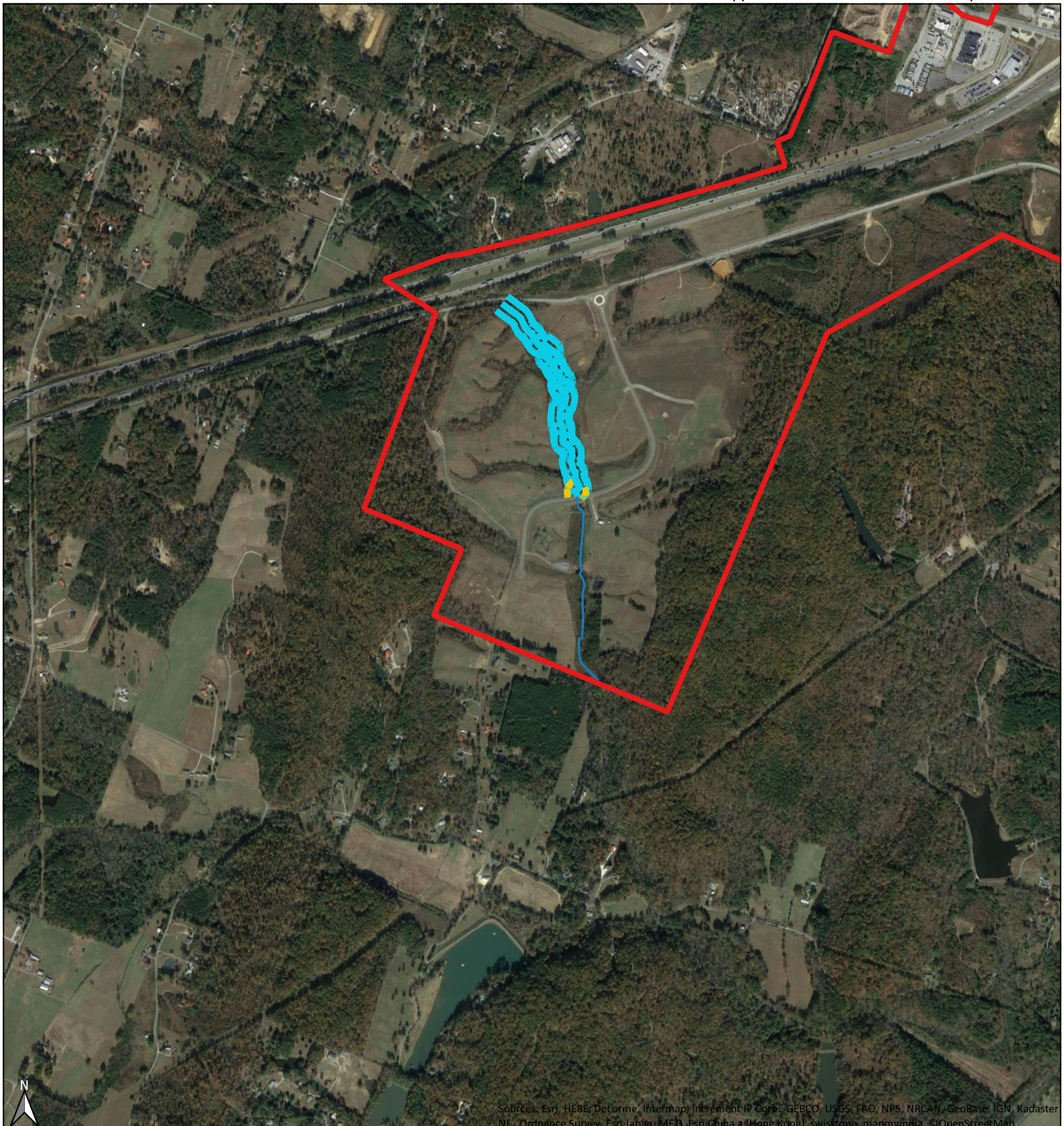
HDSS Streambed and Streambank Modifications for the Little South Mouse Creek: Map 11



0 0.3 0.6 km

0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

Unmodified
Modified
Highly Modified
City Boundary
Stream

Looking downstream

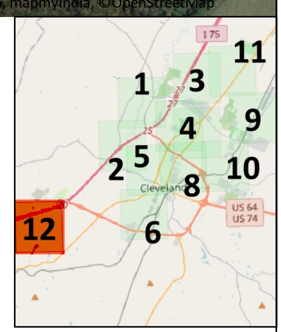
Streambank | Streambed | Streambank

Left | Right

HDSS Streambed and Streambank Modifications for the Spring Branch: Map 12

TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi



Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Appendix 4

Discrete Point Features

4a: Discrete Point Features (Pipe Impact, Sedimentation, Road Crossings, and Other)

4b: Pipe Impact Discrete Point Features by Category

4c: Road Impact Discrete Point Features by Category

4d: Sedimentation Discrete Point Features by Category

4e: Other Discrete Point Features by Category

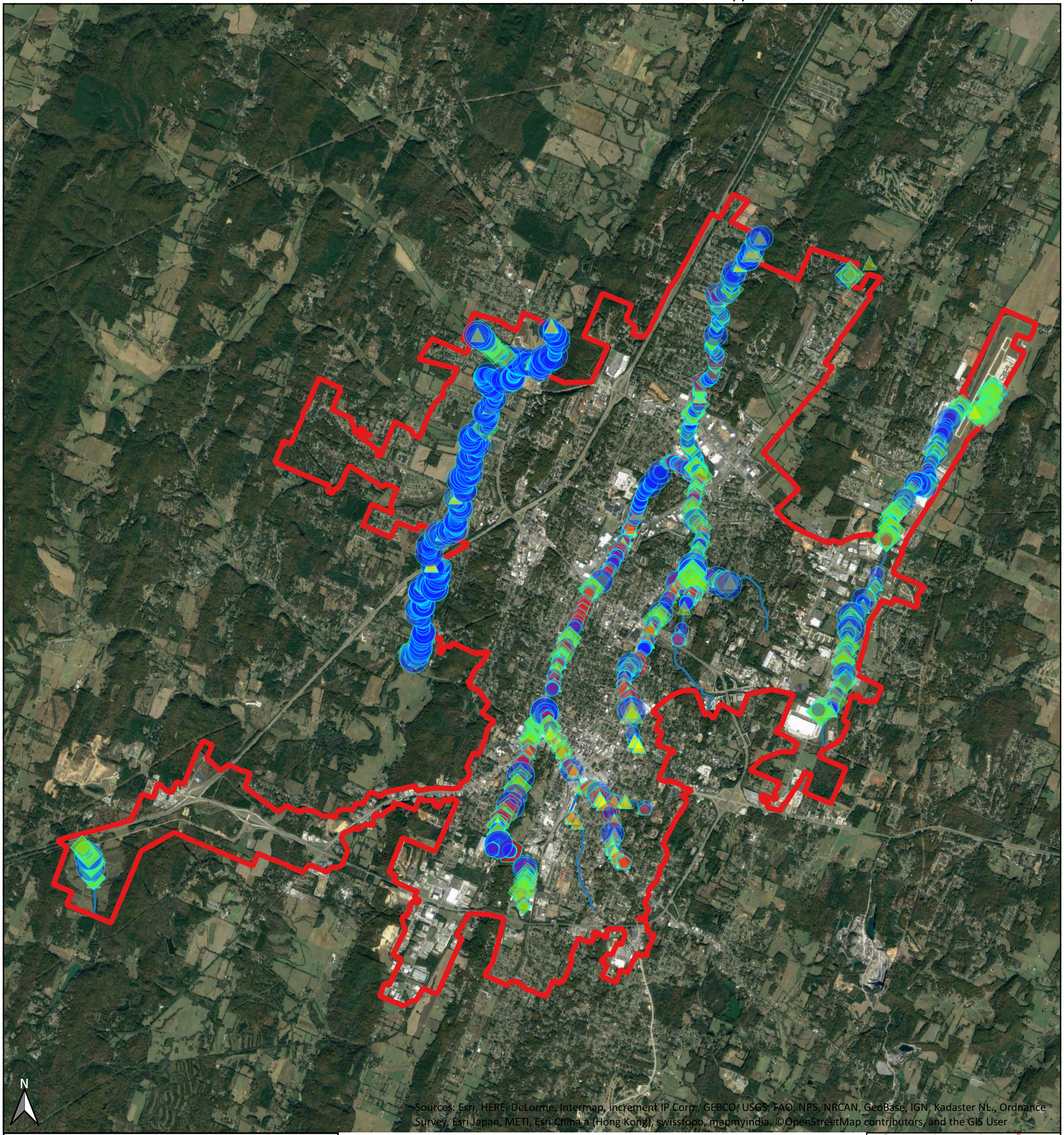
4f: Large Woody Debris Discrete Point Features

Created on: May 2021

TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

Appendix 4a:
Discrete Point Features by Type (Pipe Impacts, Sedimentation, Road Crossings, and Other)

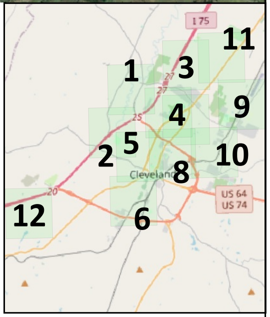
Example images of discrete point features types commonly observed which includes pipes (exposed pipe; A), road crossings (culvert; B), sedimentation (in-channel bars; C), and other (trash; D).



Legend

- Other
- Pipe Impact
- Road Impact
- Sediment
- City Boundary
- Stream
- Severe
- Moderate
- Minor

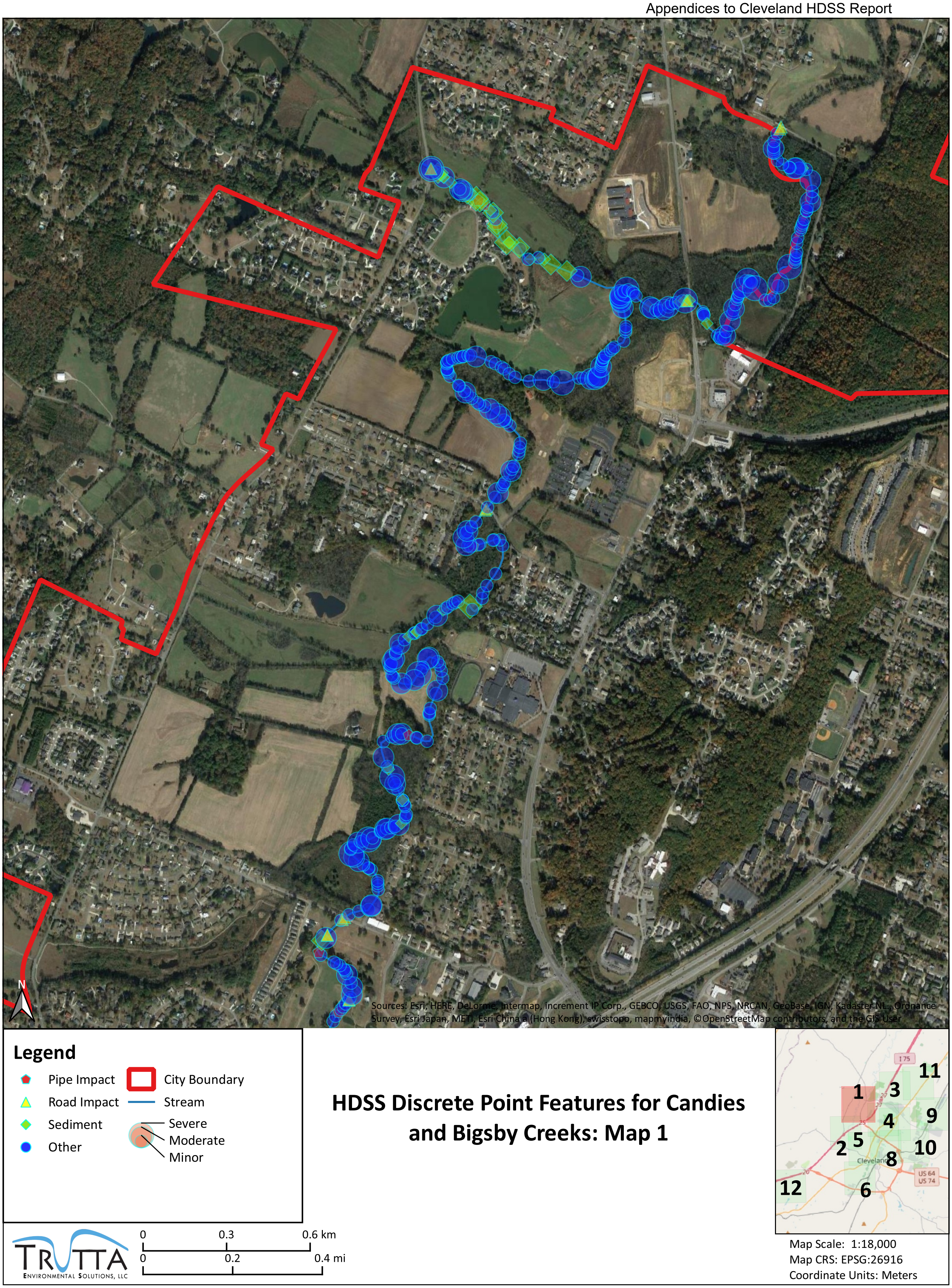
HDSS Discrete Point Features for Cleveland, TN



0 1 2 km
0 1 2 mi

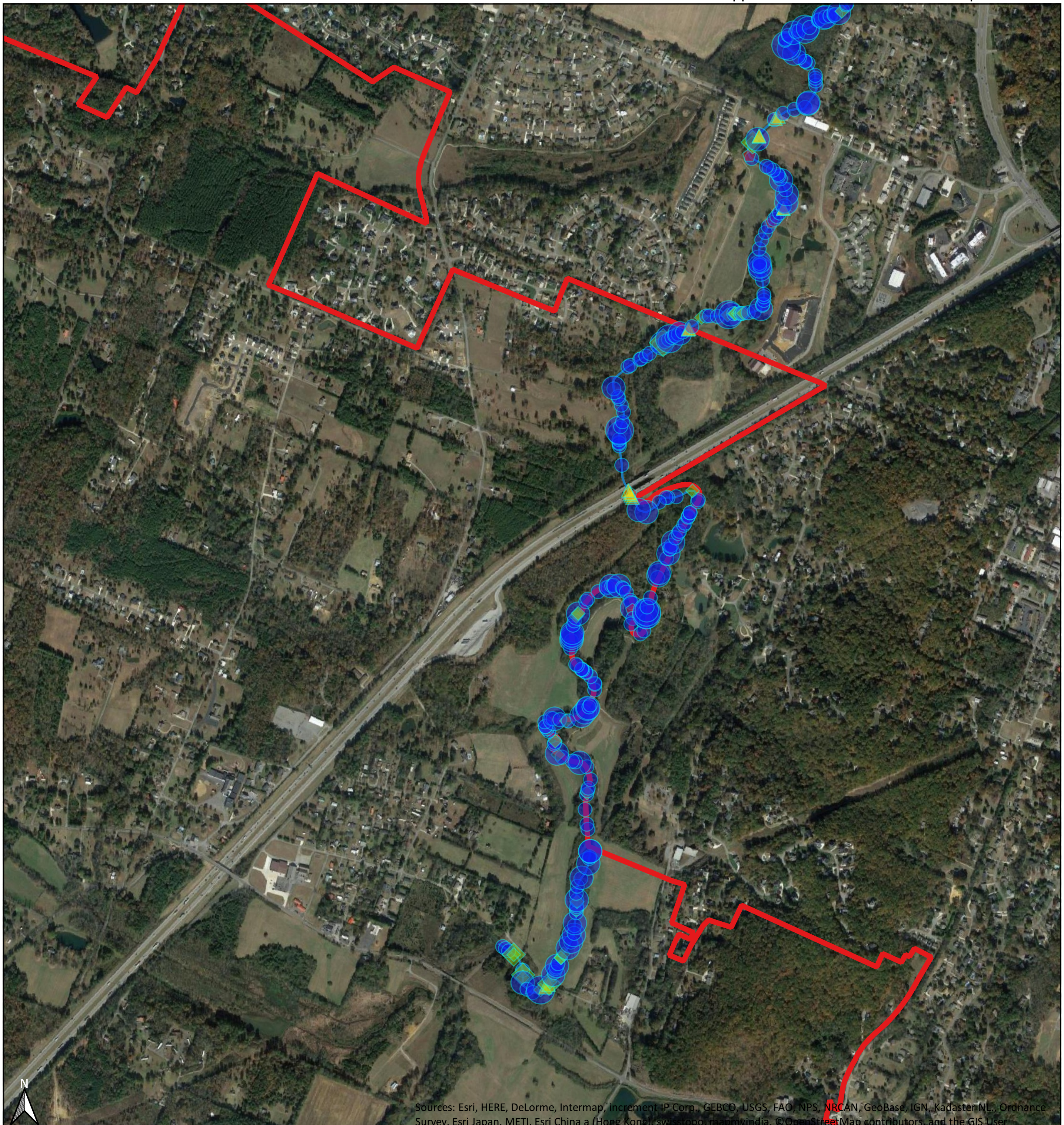
TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters



HDSS Discrete Point Features for Candies and Bigsby Creeks: Map 1

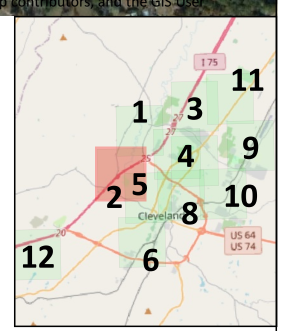
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Pipe Impact
- Road Impact
- Sediment
- Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

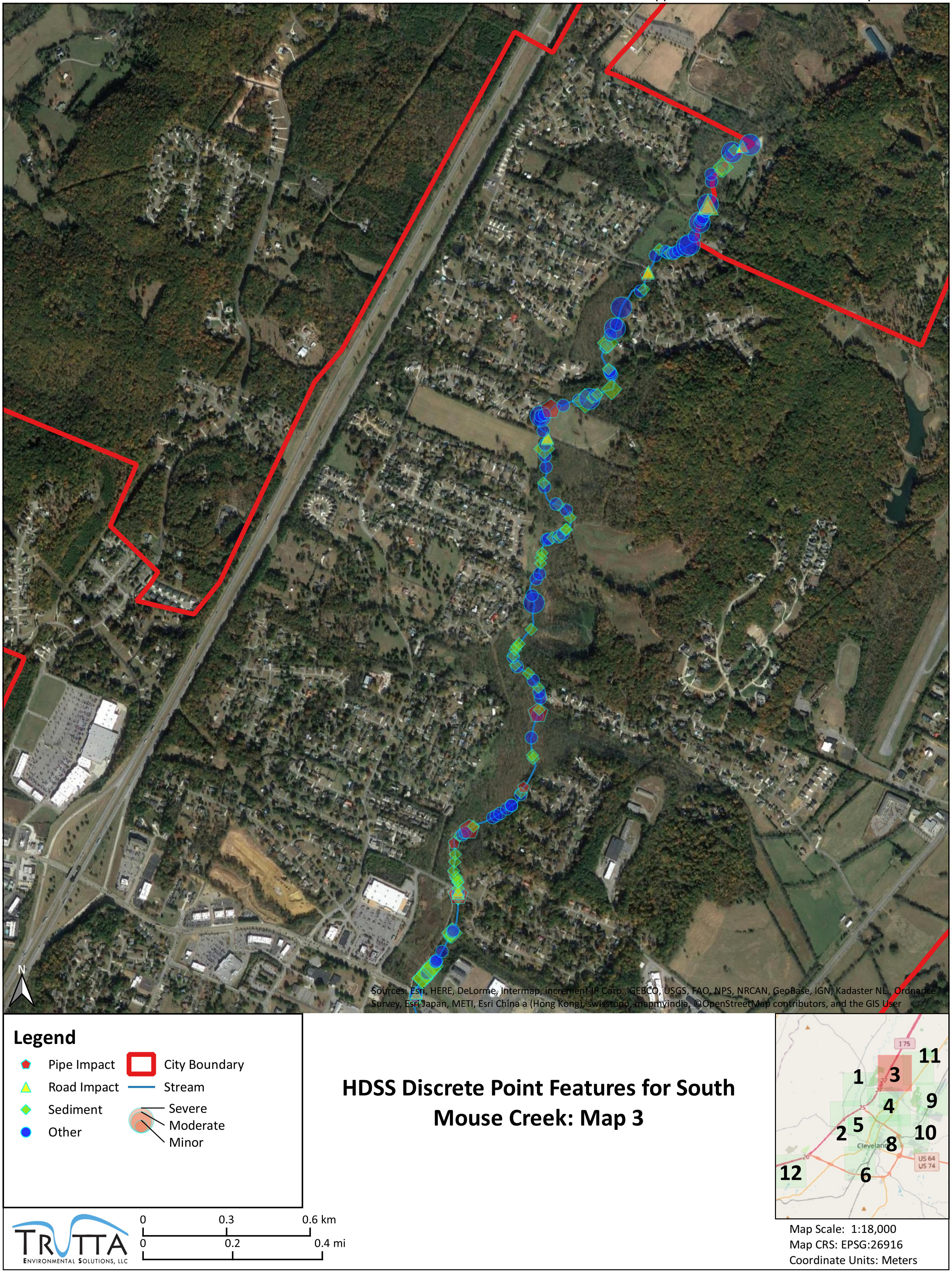
HDSS Discrete Point Features for Candies Creek: Map 2



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

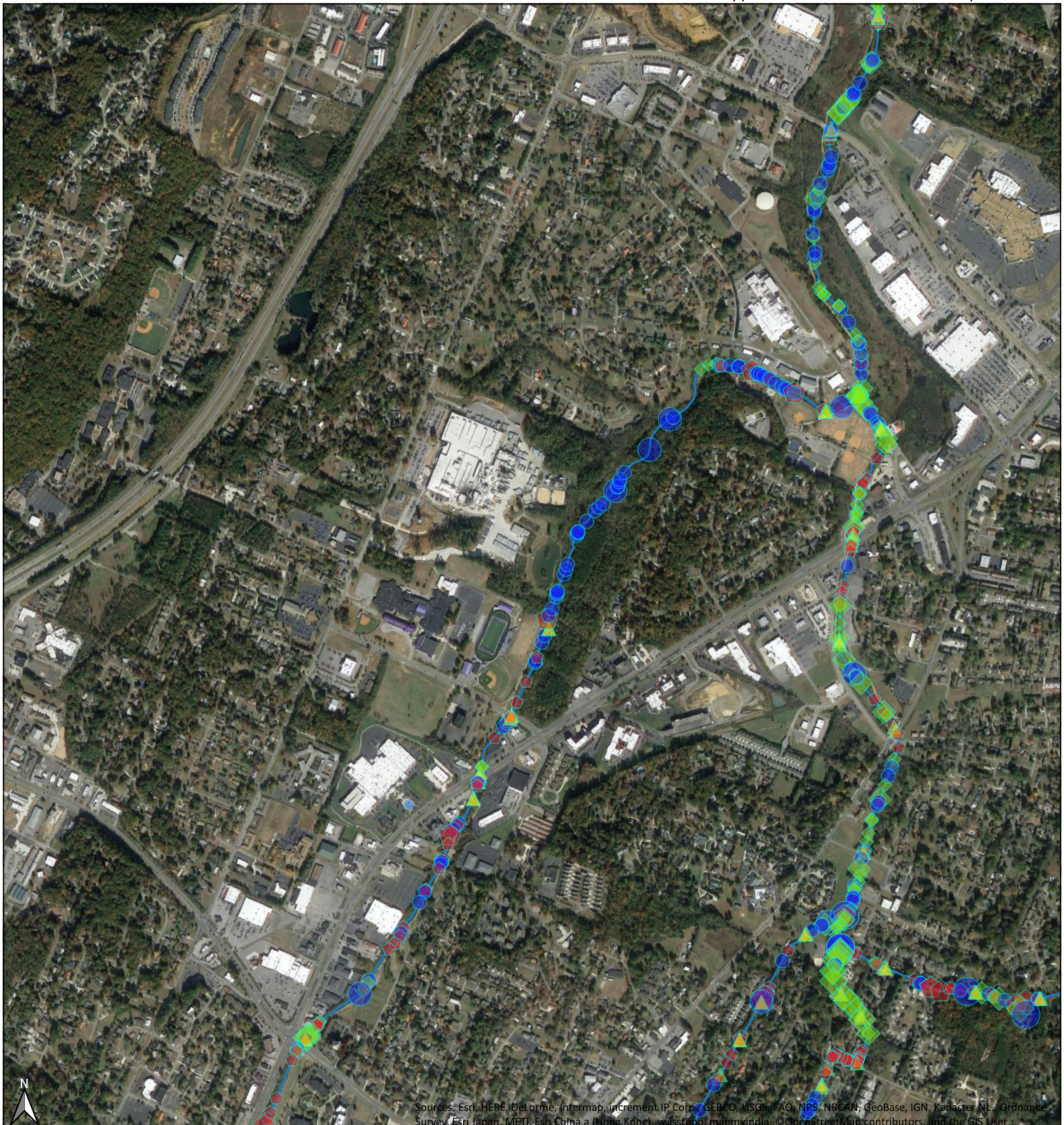
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



HDSS Discrete Point Features for South Mouse Creek: Map 3

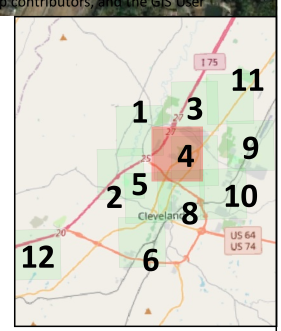
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Pipe Impact
- Road Impact
- Sediment
- Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

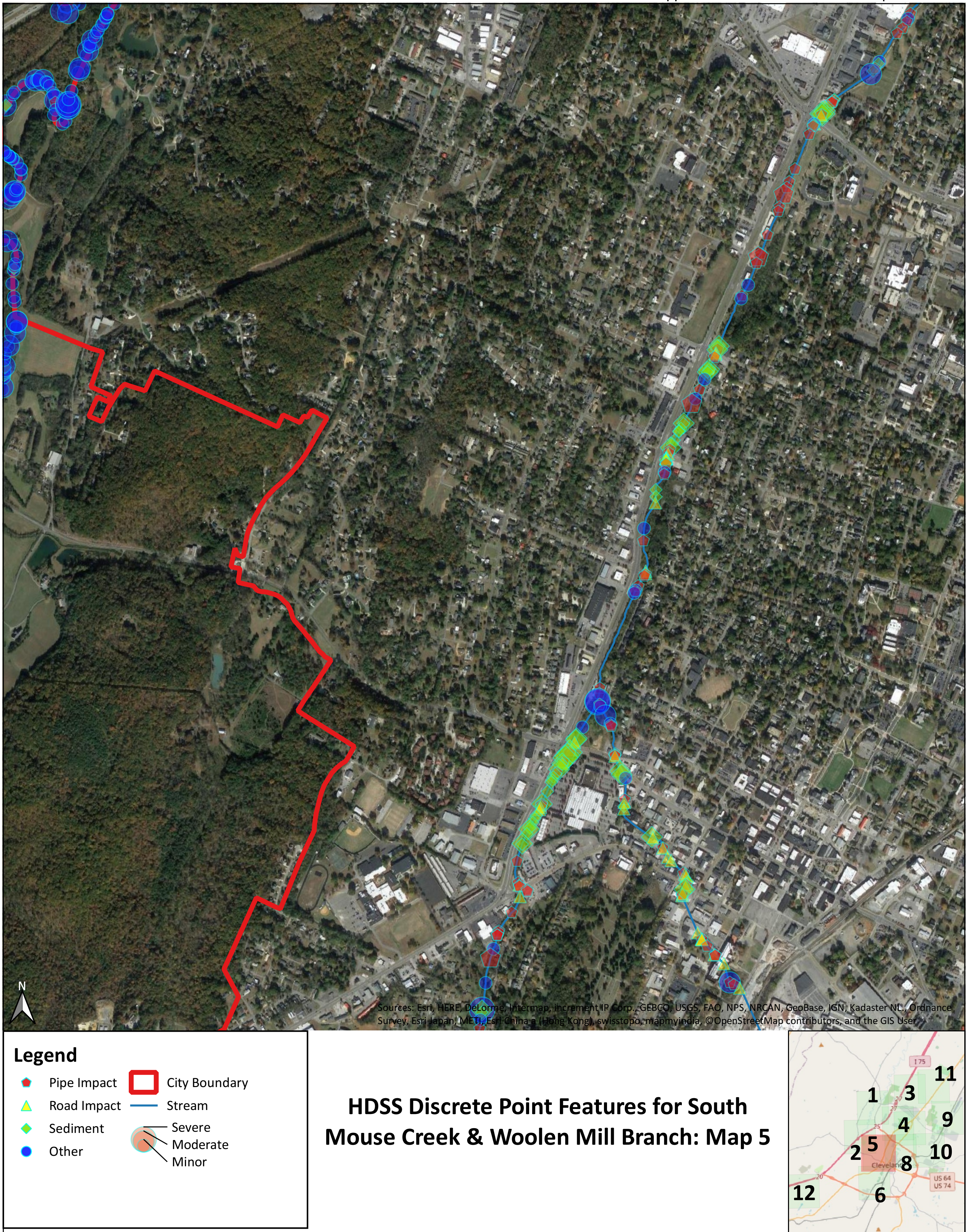
HDSS Discrete Point Features for South Mouse Creek: Map 4



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

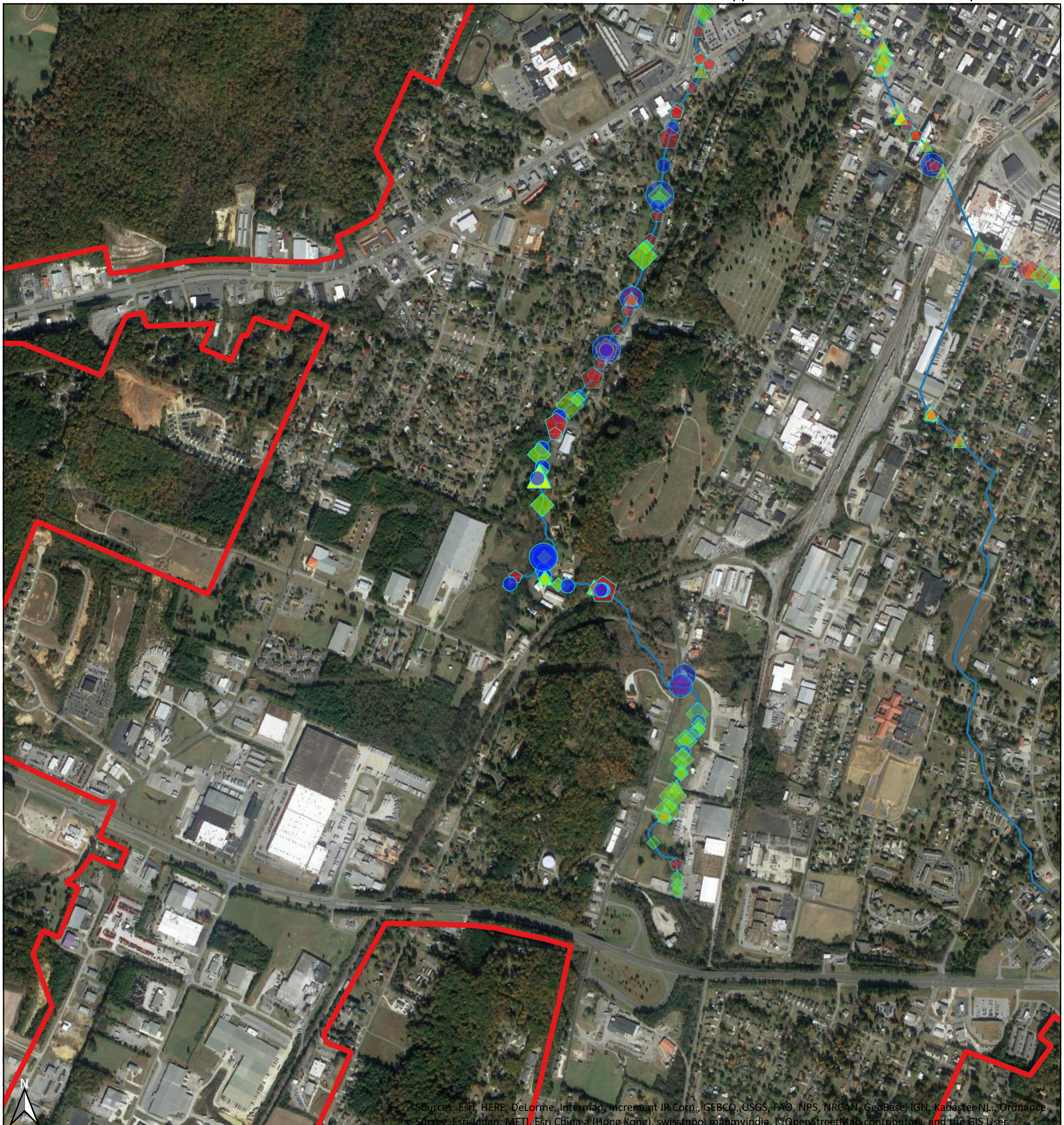
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



HDSS Discrete Point Features for South Mouse Creek & Woolen Mill Branch: Map 5

TRUTTA Environmental Solutions, LLC

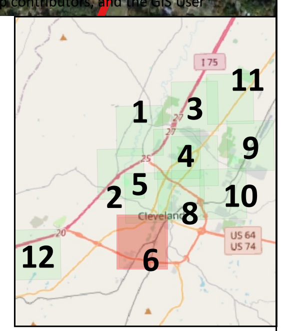
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Pipe Impact
- Road Impact
- Sediment
- Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Discrete Point Features for South Mouse Creek: Map 6



TRUTTA Environmental Solutions, LLC

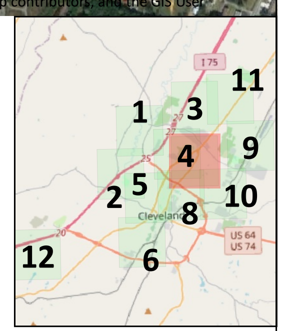
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Pipe Impact
- Road Impact
- Sediment
- Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

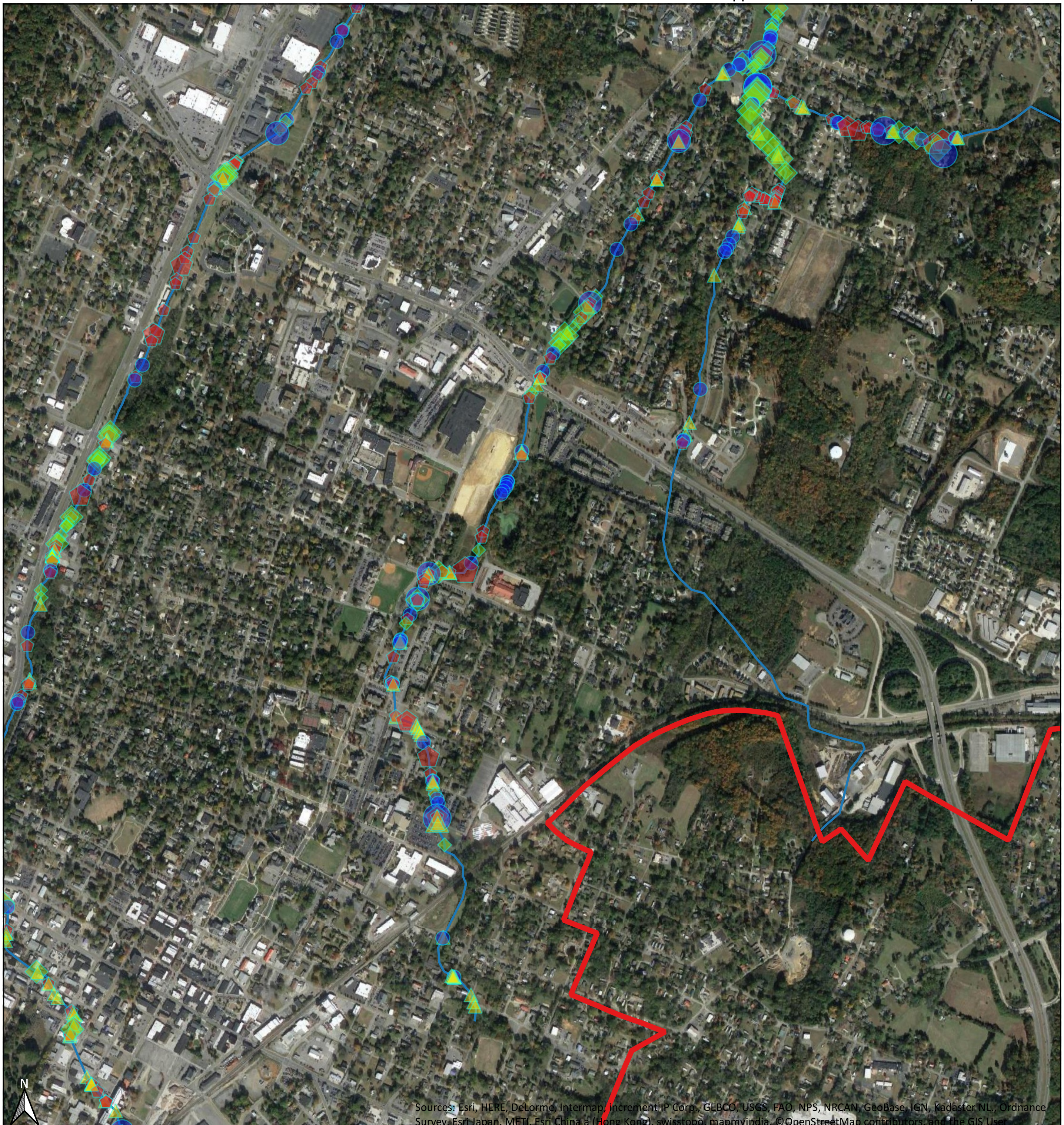
HDSS Discrete Point Features for Fillauer Creek: Map 7



0 0.3 0.6 km

0 0.2 0.4 mi

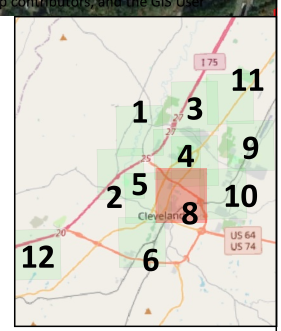
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Pipe Impact
- Road Impact
- Sediment
- Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Discrete Point Features for Fillauer Creek: Map 8

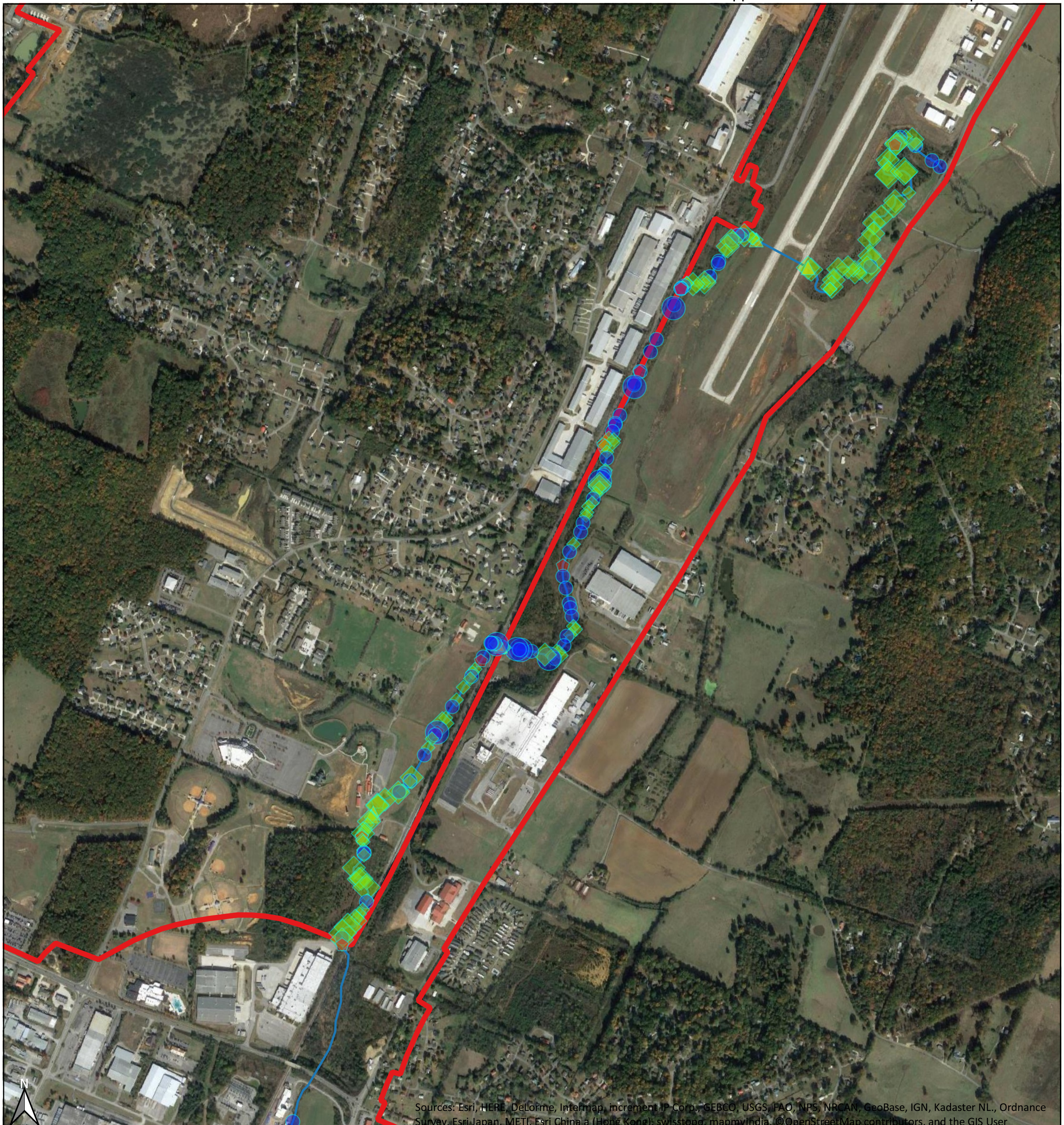


0 0.3 0.6 km

0 0.2 0.4 mi

TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

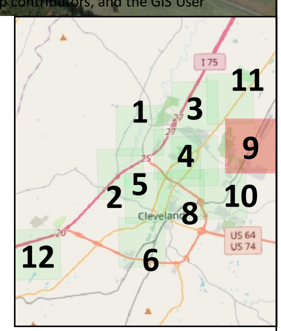
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Pipe Impact
- Road Impact
- Sediment
- Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

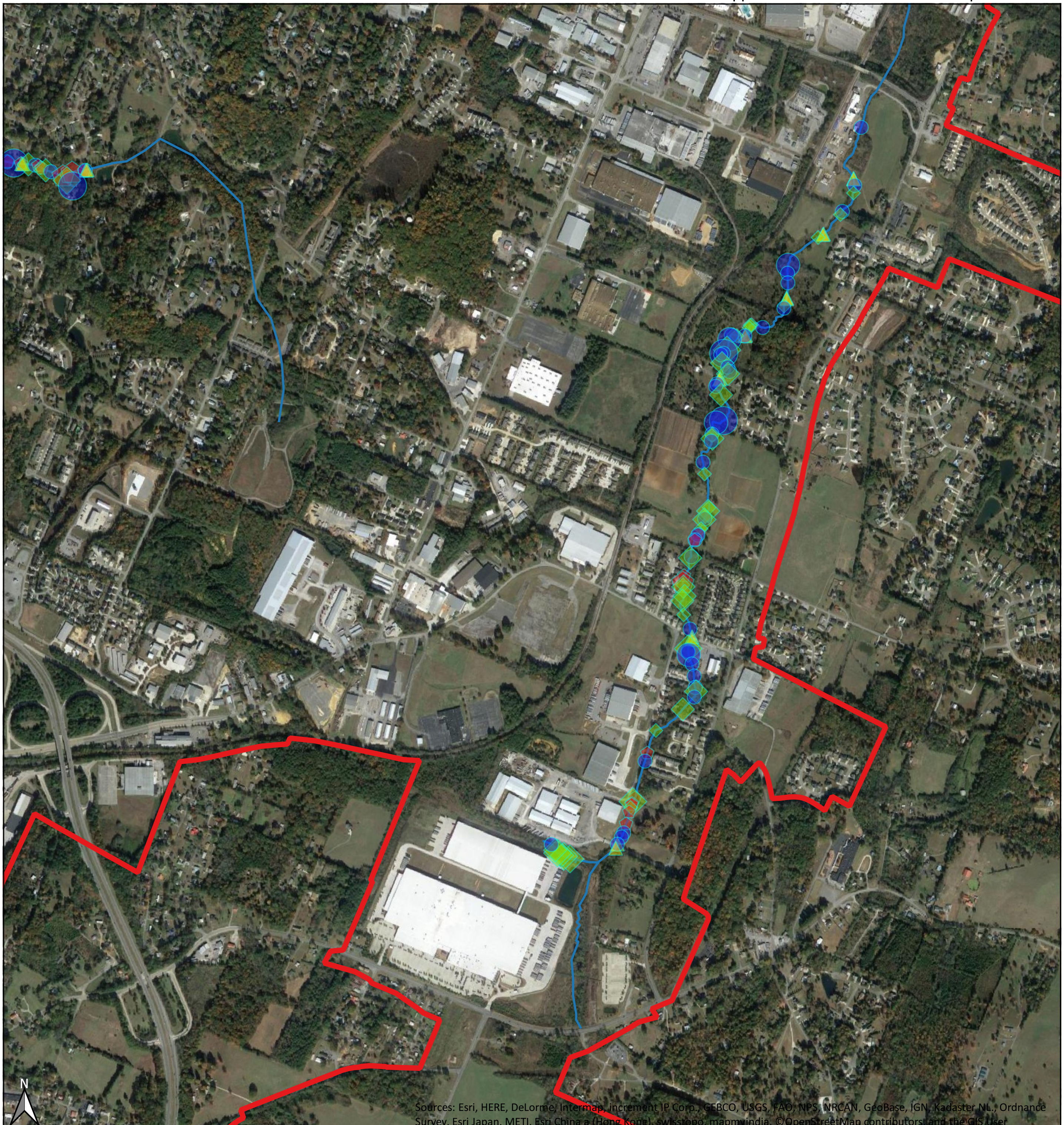
HDSS Discrete Point Features for Little Chatata Creek: Map 9



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

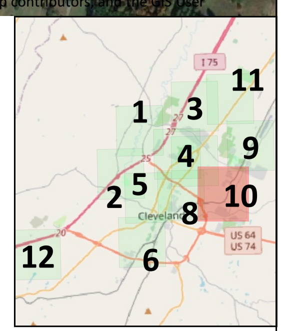
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

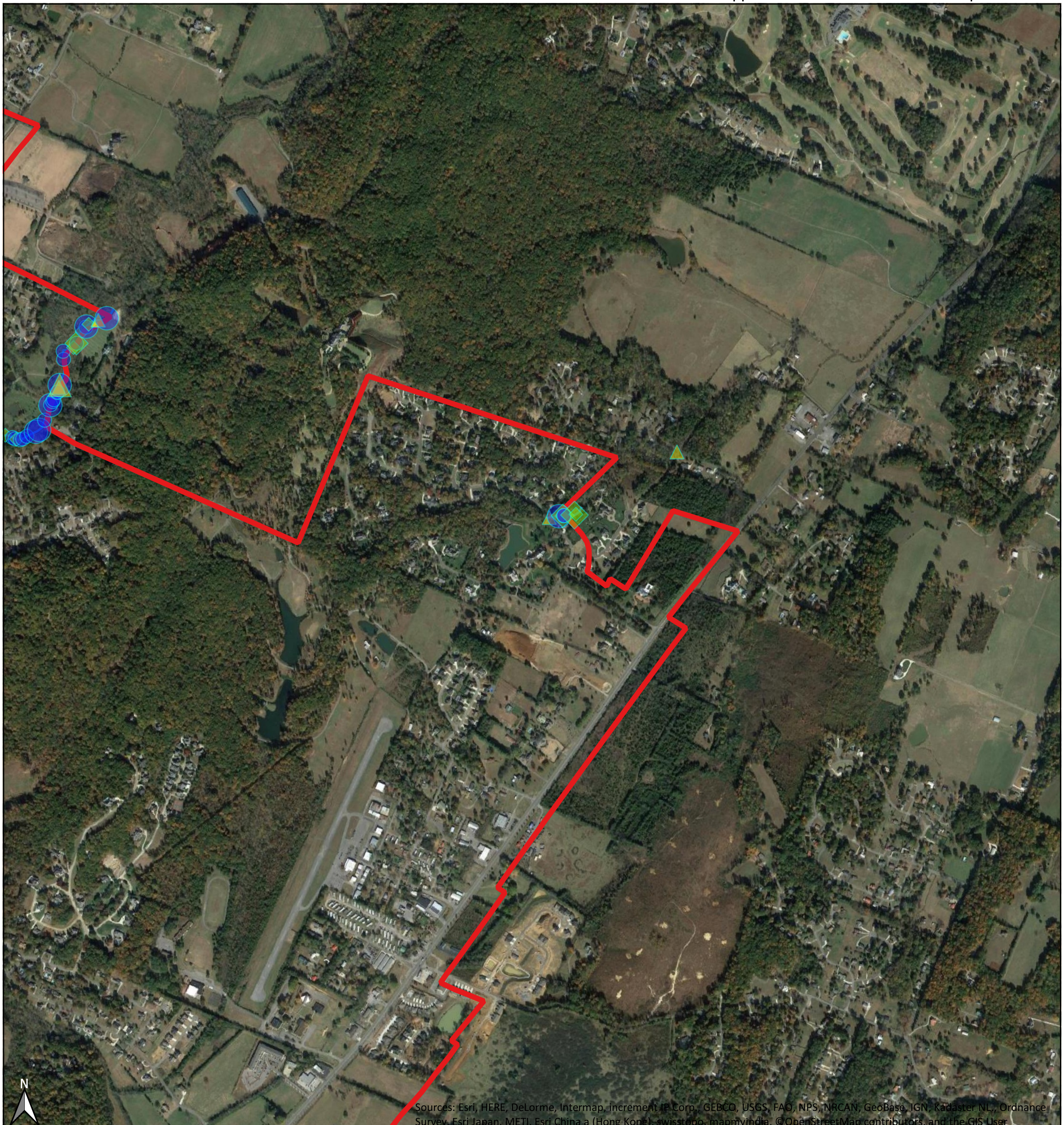
- Pipe Impact
- Road Impact
- Sediment
- Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Discrete Point Features for Little Chatata Creek: Map 10



0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

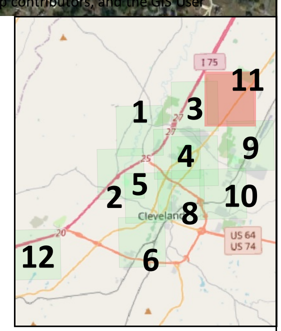


Legend

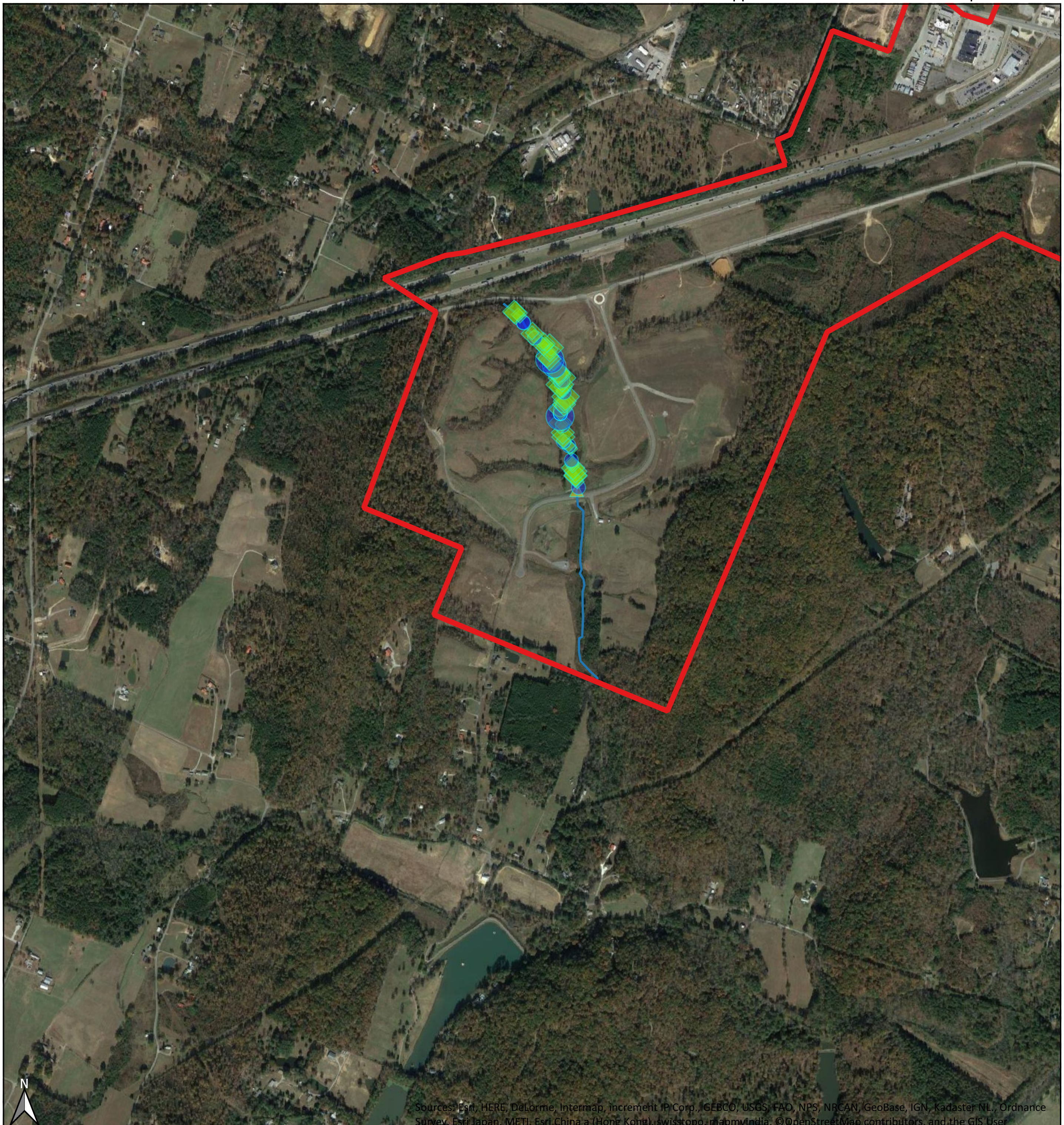
- Pipe Impact
- Road Impact
- Sediment
- Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

0 0.3 0.6 km
0 0.2 0.4 mi

HDSS Discrete Point Features for Little South Mouse Creek: Map 11



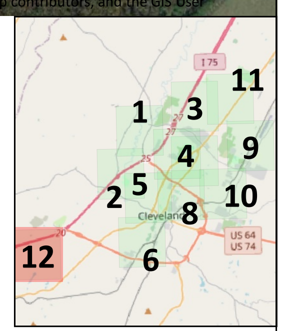
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Pipe Impact
- Road Impact
- Sediment
- Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Discrete Point Features for Spring Branch: Map 12



0 0.3 0.6 km

0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Appendix 4b:
Pipe Discrete Point Features

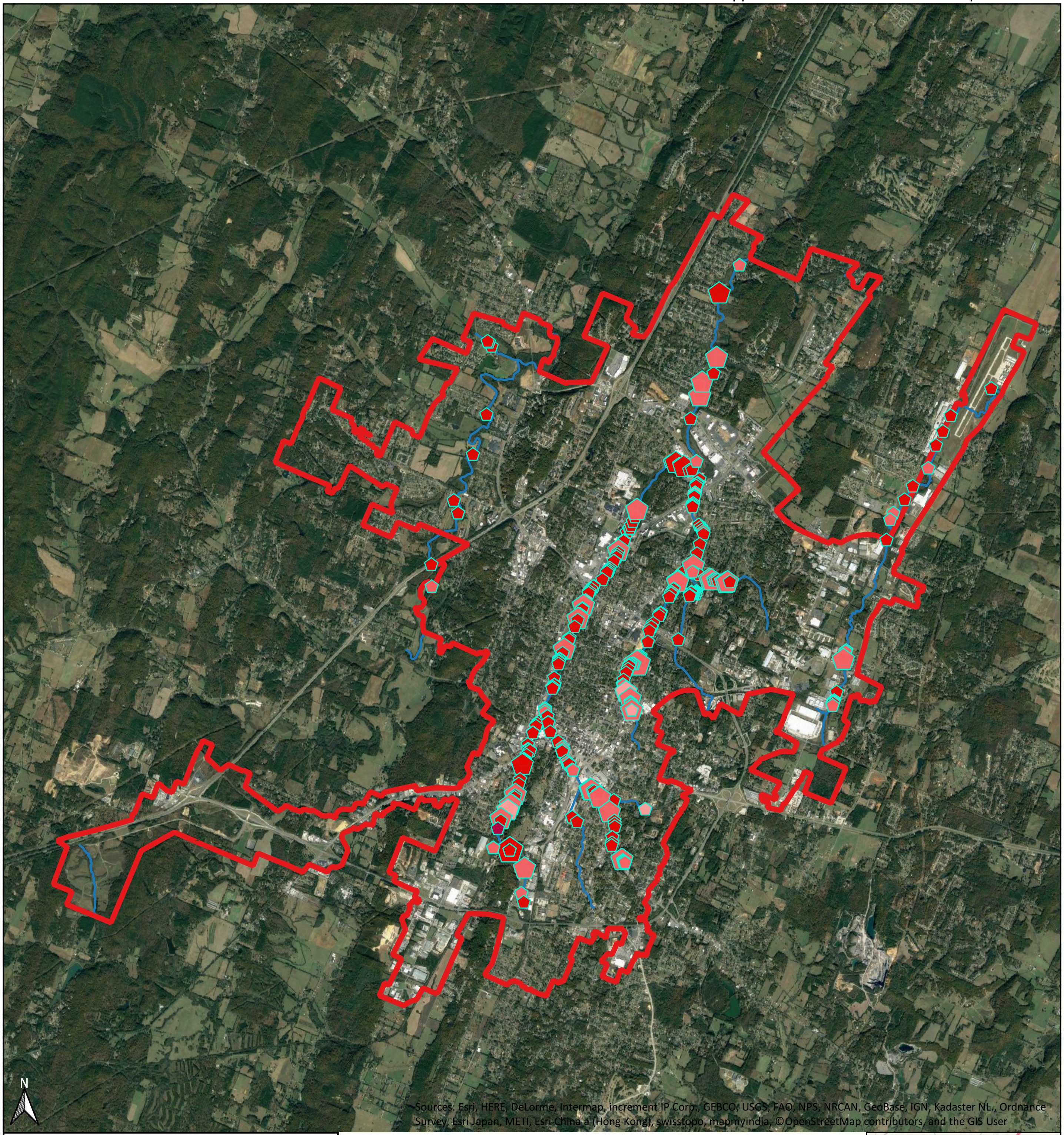
Example images of pipe discrete point features which includes exposed pipes (A), intakes (B), manhole stacks (C), and outfalls (D).

Appendix 4b: Pipe Impact Discrete Point Features

Pipe discrete point feature severity rating criteria by category.

Discrete Feature		Parameter	Severity		
Type	Category		Minor	Moderate	Severe
Pipe	Exposed Pipe	Diameter of Pipe	Large		
			Small		
		Location	On Bottom or partially exposed	Hanging	
		Condition of Pipe	Not leaking or broken		Leaking or broken
				Bent	
	Intake	Pipe size	Small (< 2 inches; residential)	Medium (>2 but ≤ 4 inches; agricultural)	Large (>4 inches; municipal or commercial)
	Manhole Stack	Location/ exposure	On bank or off-channel	At edges wetted width	Within or near center of channel
		Erosion to stream	No effect	Slight	Significant
	Outfalls	Color or odor	No	Slight	Strong
		Affecting stream biota	No	Localized	Far reaching
		Erosion to stream	No effect	Slight	Significant

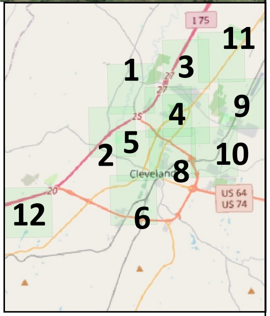
TRUTTA Environmental Solutions, LLC



Legend

- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Pipe Impact Discrete Point Features for Cleveland, TN



0 1 2 km

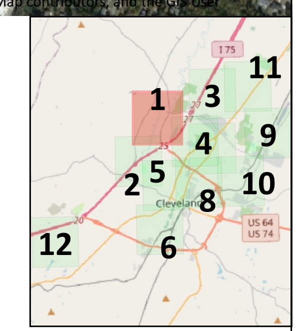
0 1 2 mi

Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

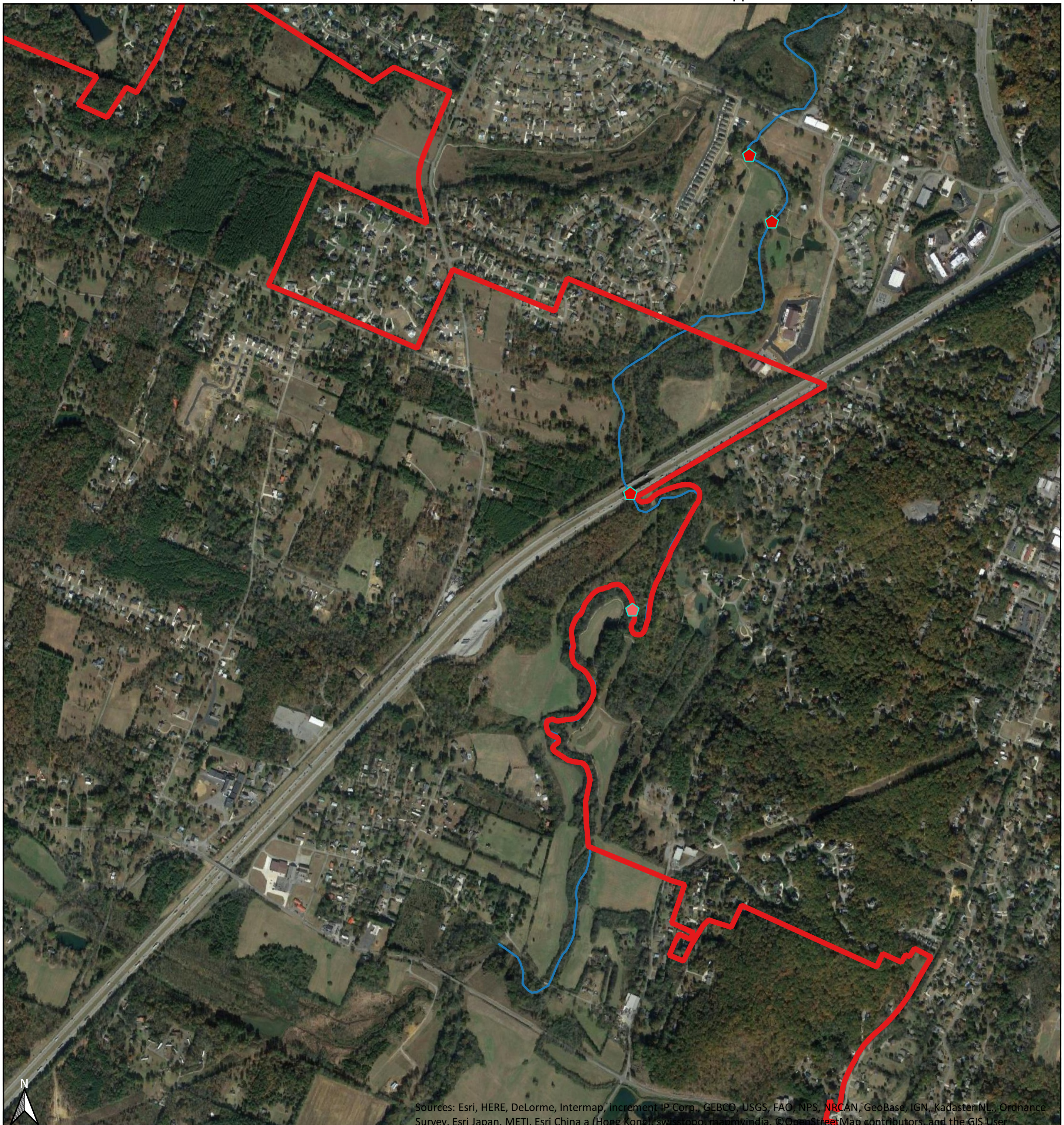
HDSS Pipe Impact Discrete Point Features for Candies and Bigsby Creeks: Map 1



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

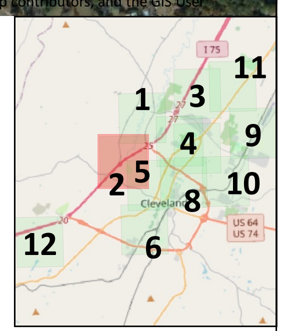
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

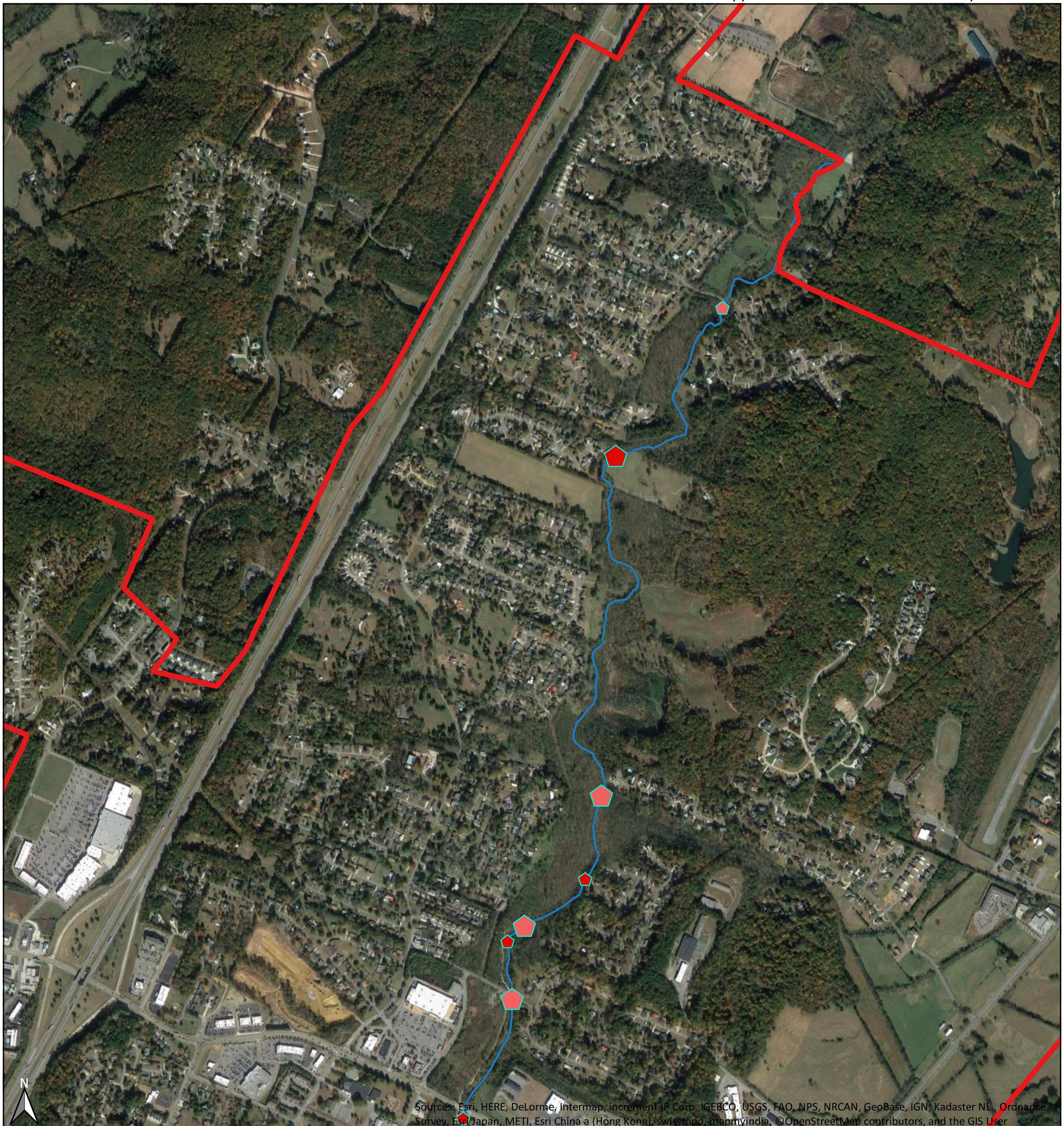
HDSS Pipe Impact Discrete Point Features for Candies Creek: Map 2



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

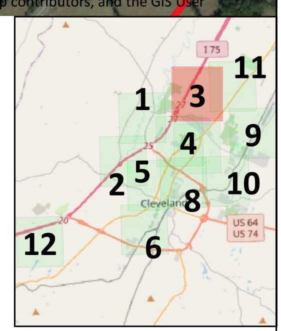
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

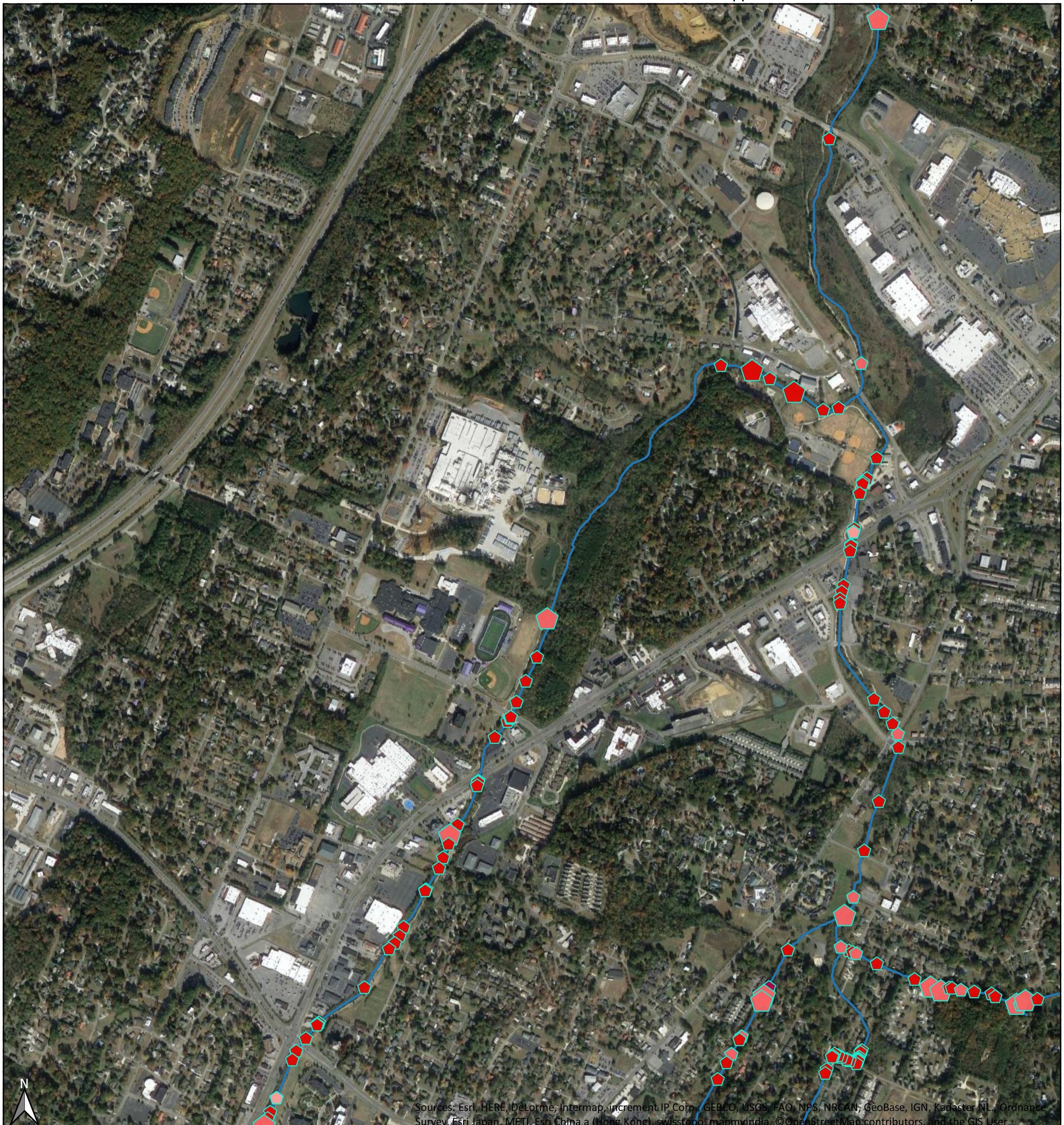
HDSS Pipe Impact Discrete Point Features for South Mouse Creek: Map 3



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

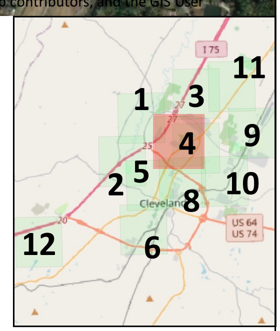
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

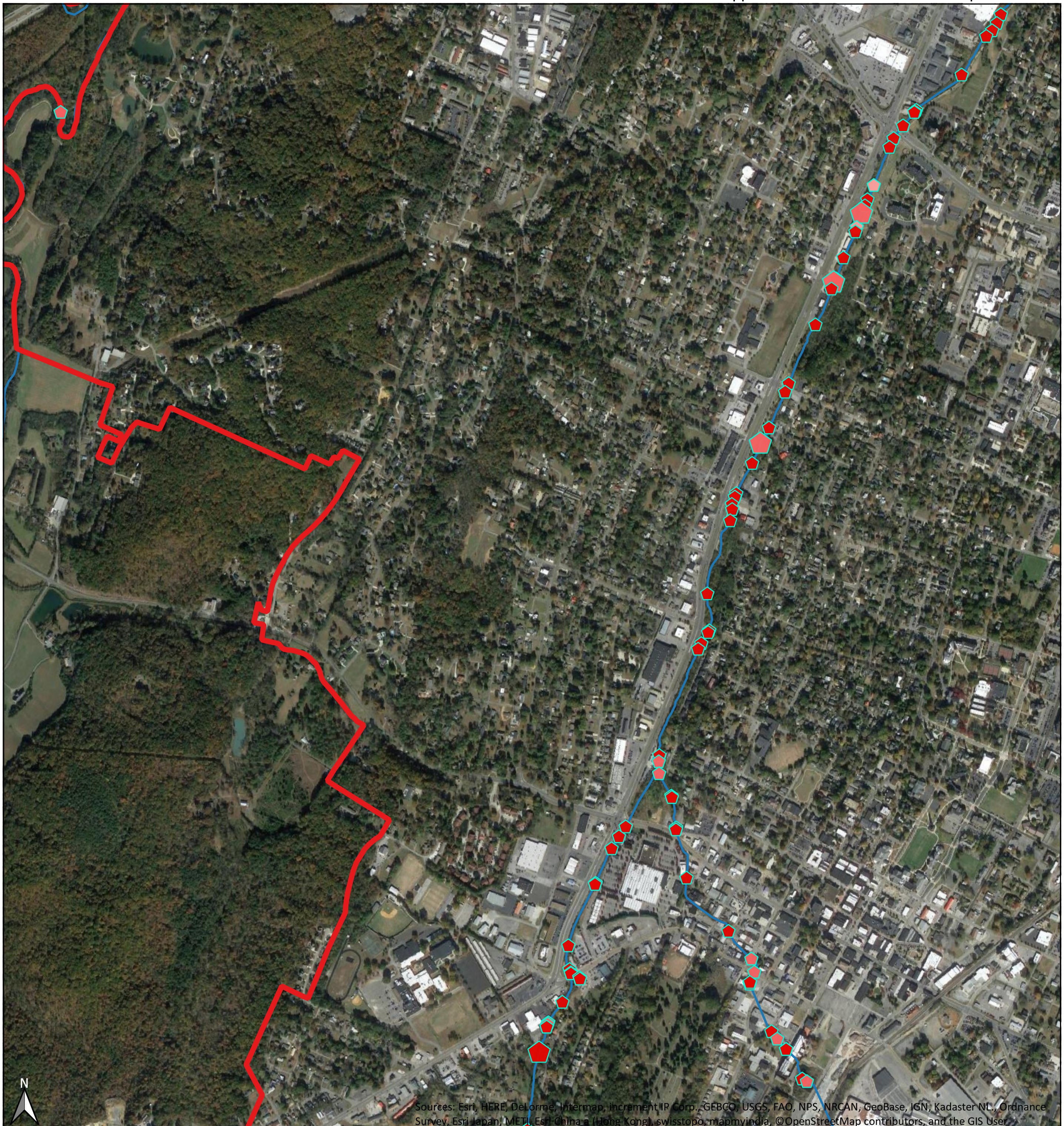
HDSS Pipe Impact Discrete Point Features for South Mouse Creek: Map 4



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

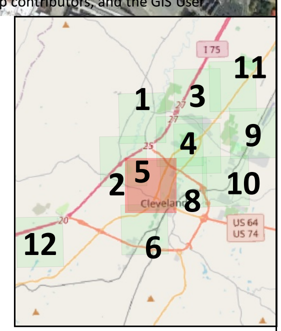
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Pipe Impact Discrete Point Features for South Mouse Creek & Woolen Mill Branch: Map 5



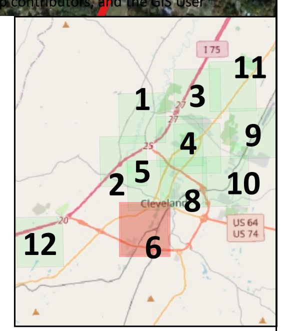
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Pipe Impact Discrete Point Features for South Mouse Creek: Map 6



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

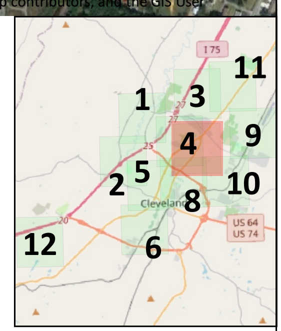
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

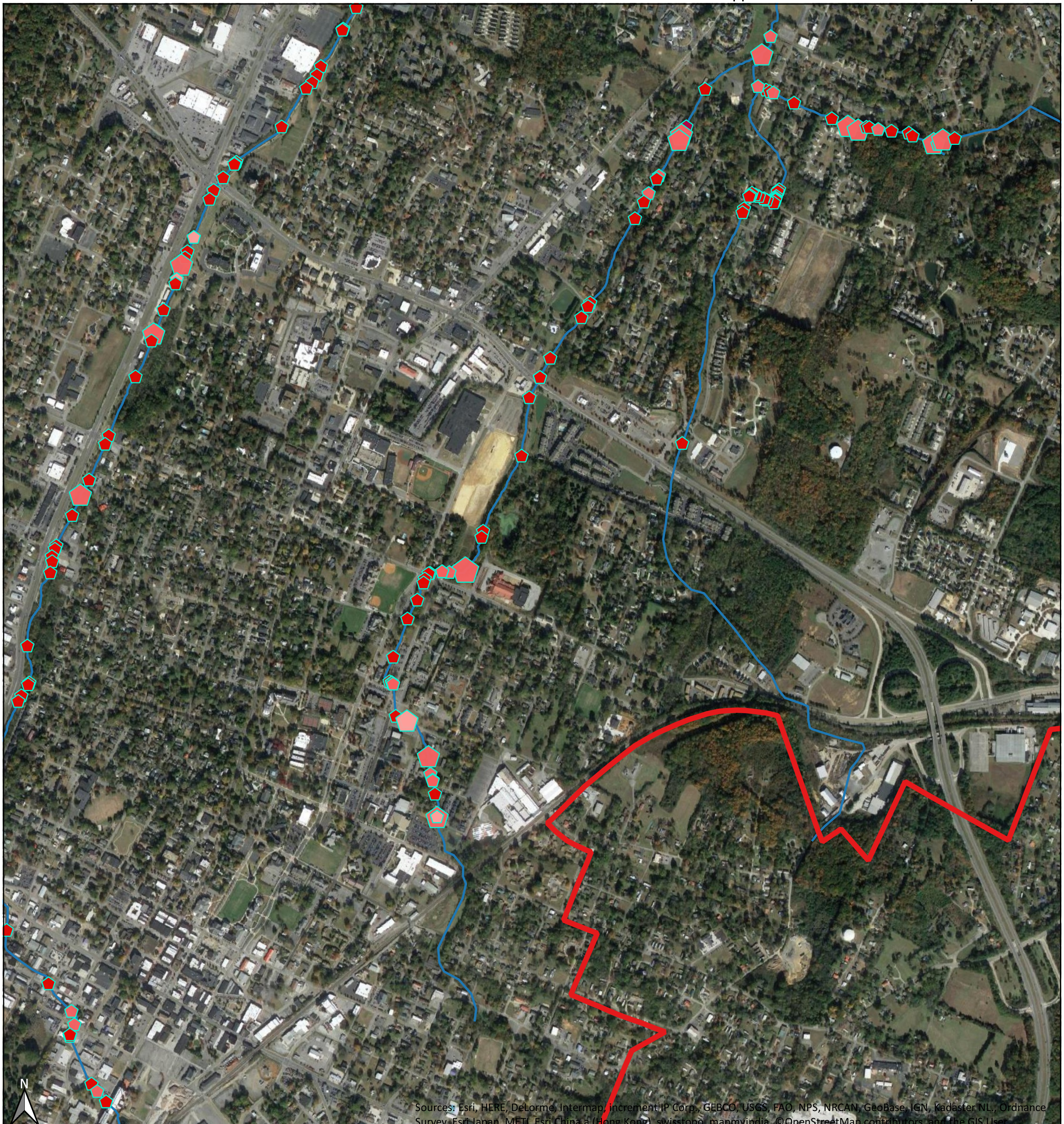
HDSS Pipe Impact Discrete Point Features for Fillauer Creek: Map 7



TRUTTA
Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

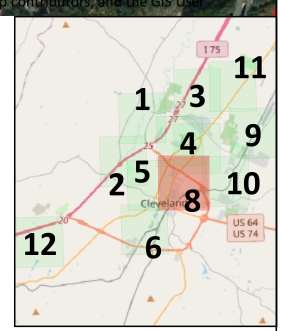
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

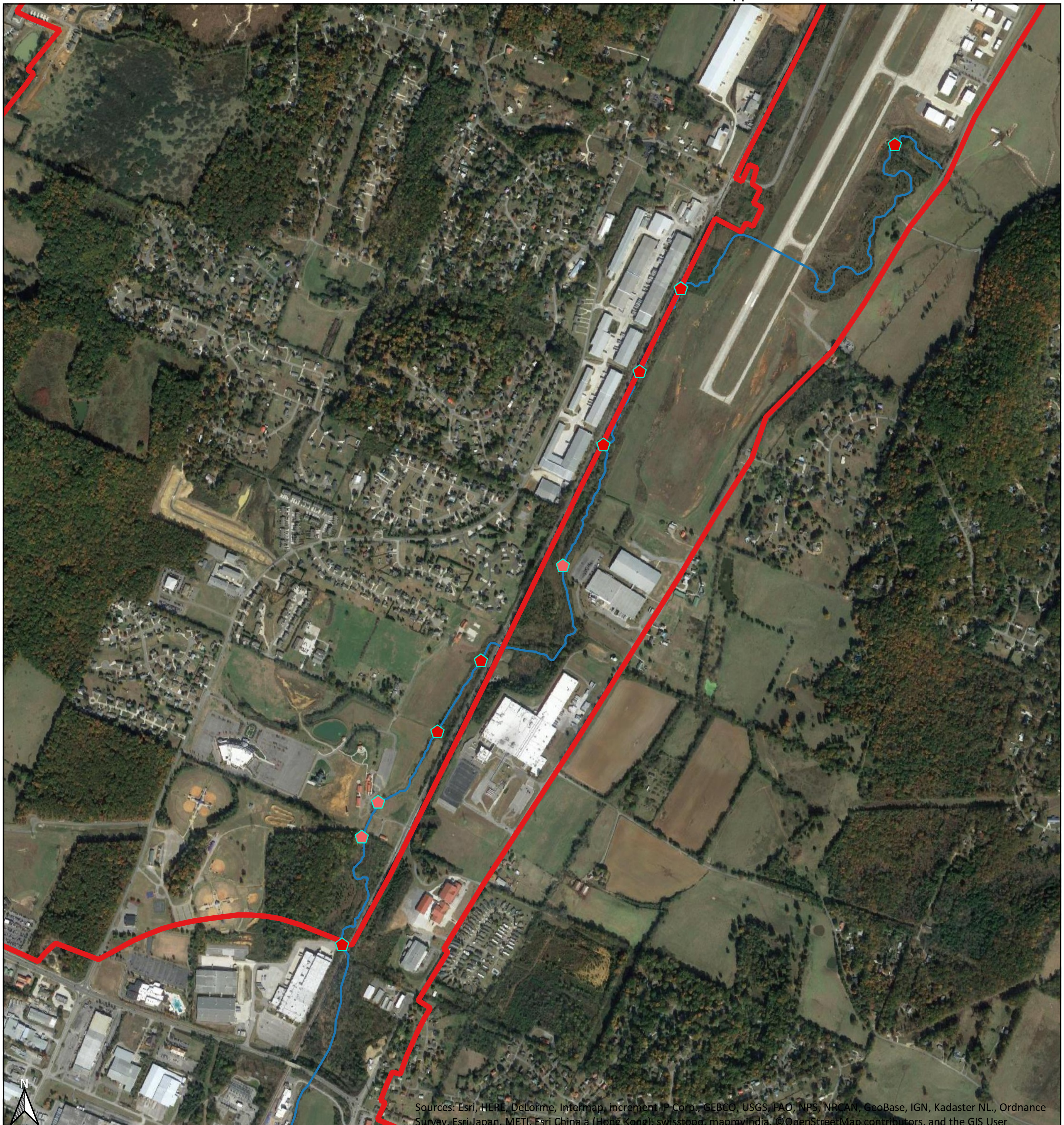
HDSS Pipe Impact Discrete Point Features for Fillauer Creek: Map 8



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

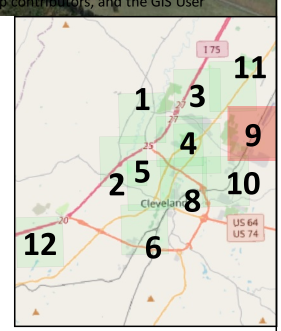
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Pipe Impact Discrete Point Features for Little Chatata Creek: Map 9



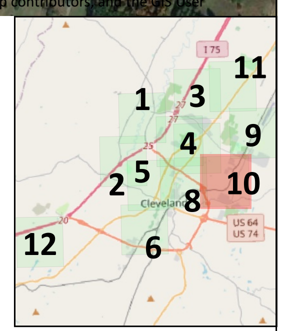
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Pipe Impact Discrete Point Features for Little Chatata Creek: Map 10



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

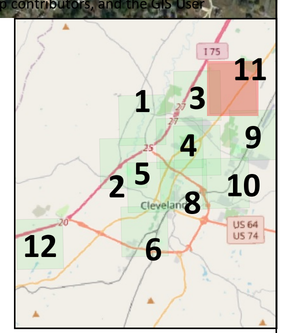
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

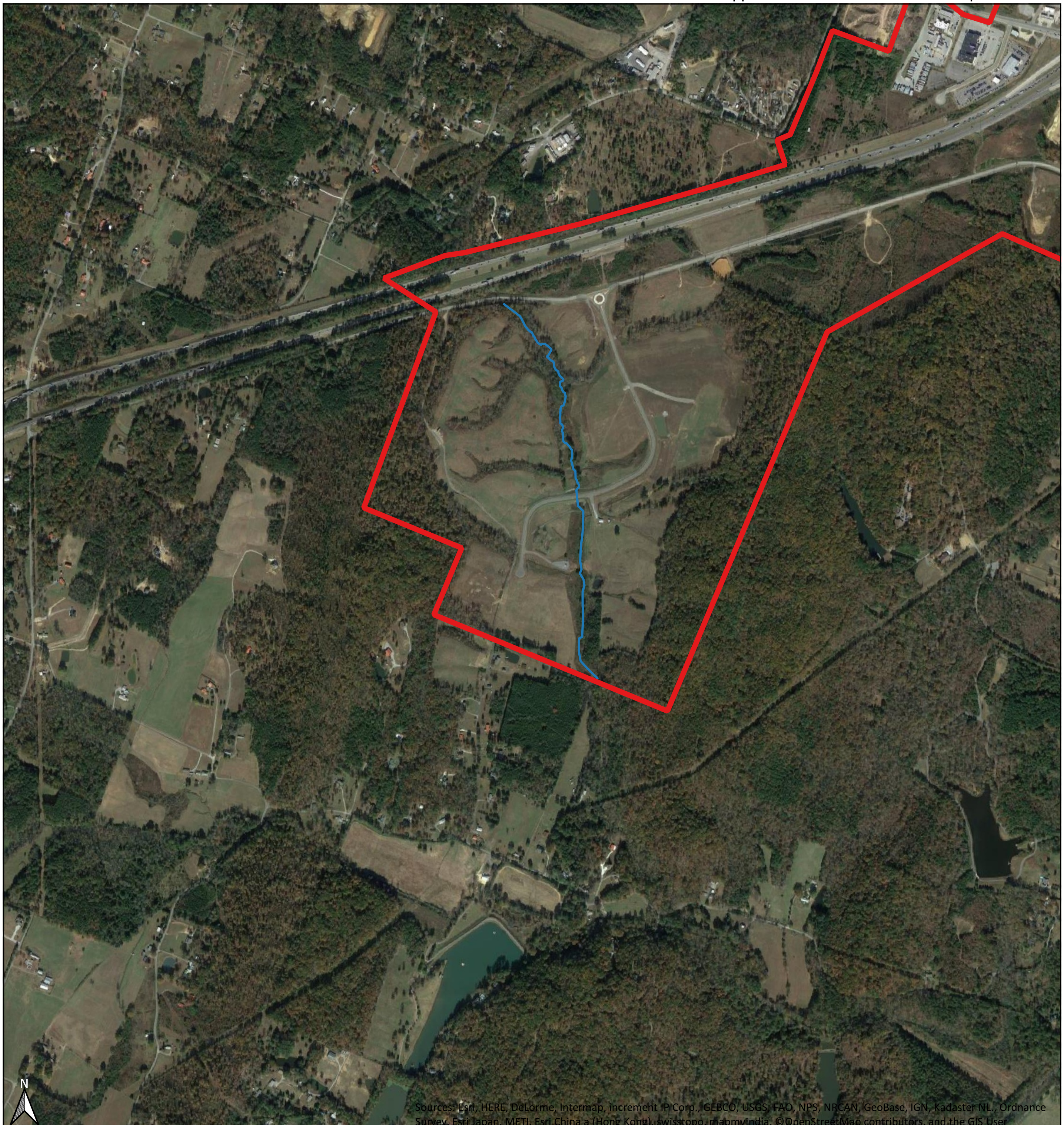
- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Pipe Impact Discrete Point Features for Little South Mouse Creek: Map 11



0 0.3 0.6 km
0 0.2 0.4 mi

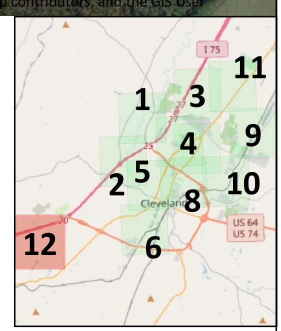
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Exposed Pipe
- Intake
- Manhole Stack
- Outfall
- Pipe Other
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Pipe Impact Discrete Point Features for Spring Branch: Map 12



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

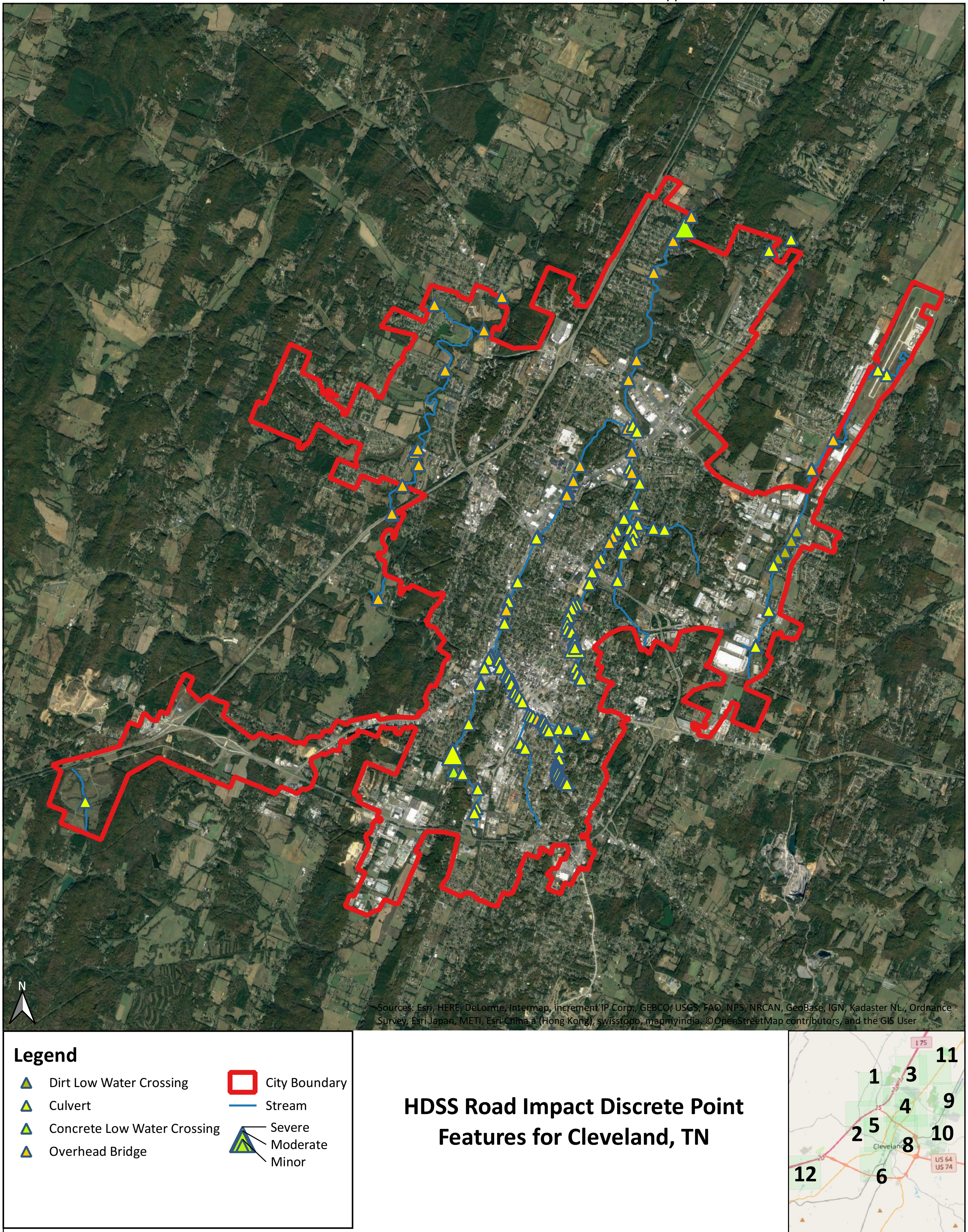
Appendix 4c:
Road Crossing Discrete Point Features

Example images of road crossing discrete point feature cateories commonly observed which includes culvert (A), overhead bridge (B), low water crossing dirt (C), and low water crossing concrete (D).

Appendix 4c:
Road Impact Discrete Point Features

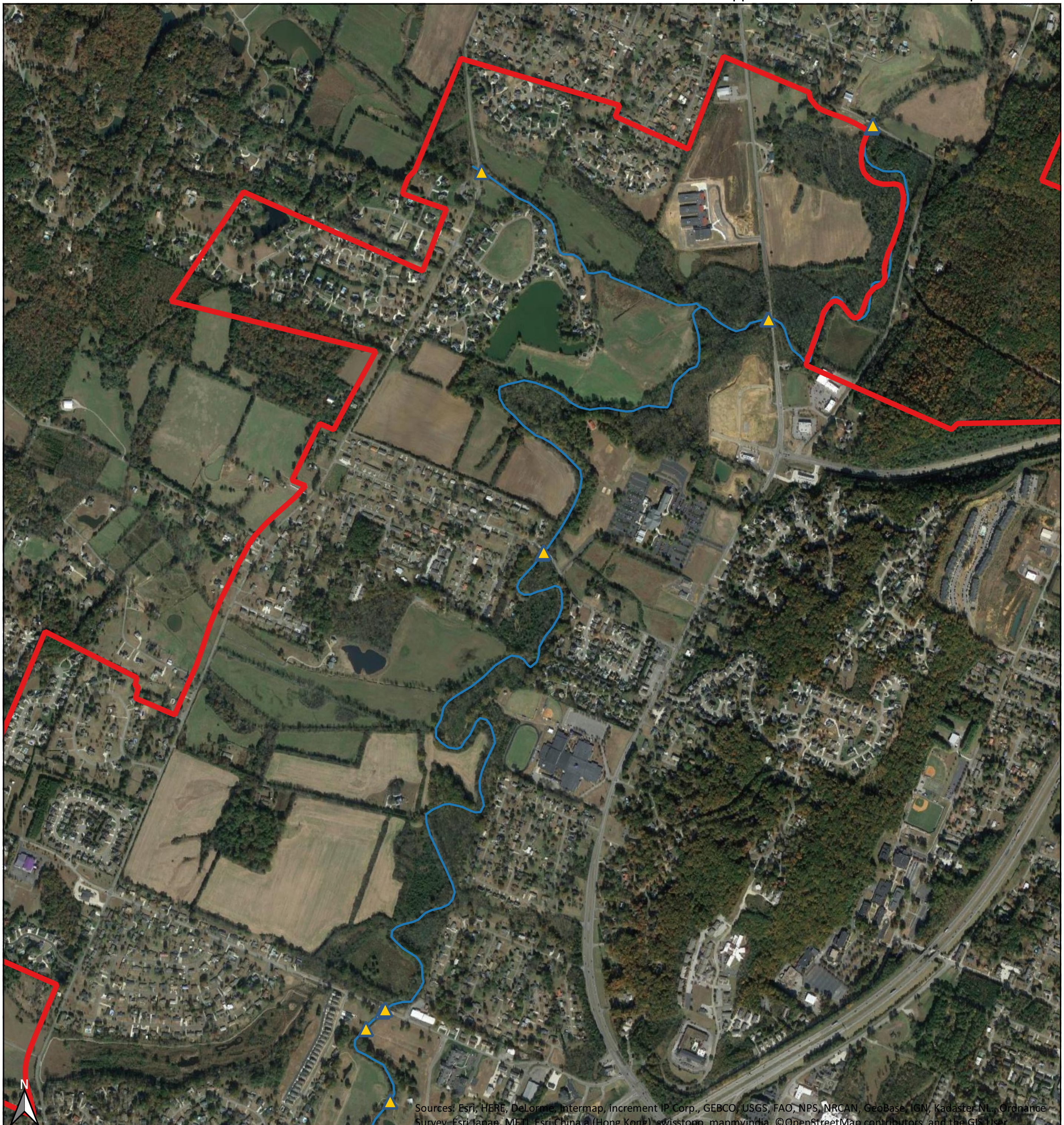
Road crossing discrete point feature seveeirty ranking criteria by category.

Discrete Feature		Parameter	Severity		
Type	Category		Minor	Moderate	Severe
Road Crossing	Culvert or Overhead bridge	Upstream blockage	Little to no debris on upstream end	Debris has accumulated on the upstream end	Total blockage at upstream end
		Erosion to stream	No effect	Slight	Significant
	Low water crossing dirt	Indication of use	Rare use (overgrown two track)	Moderate use	Heavily use (well defined)
	Low water crossing concrete	Indication of use	Rare use (residential single property owner)	Moderate use (often public lands)	Heavily use (arterial road)



HDSS Road Impact Discrete Point Features for Cleveland, TN

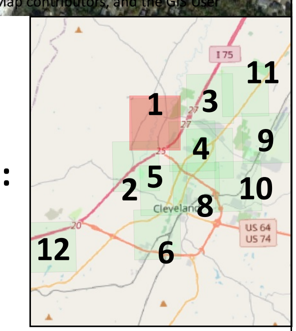
Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Dirt Low Water Crossing
- Culvert
- Concrete Low Water Crossing
- Overhead Bridge
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Road Impact Discrete Point Features for Candies and Bigsby Creeks: Map 1

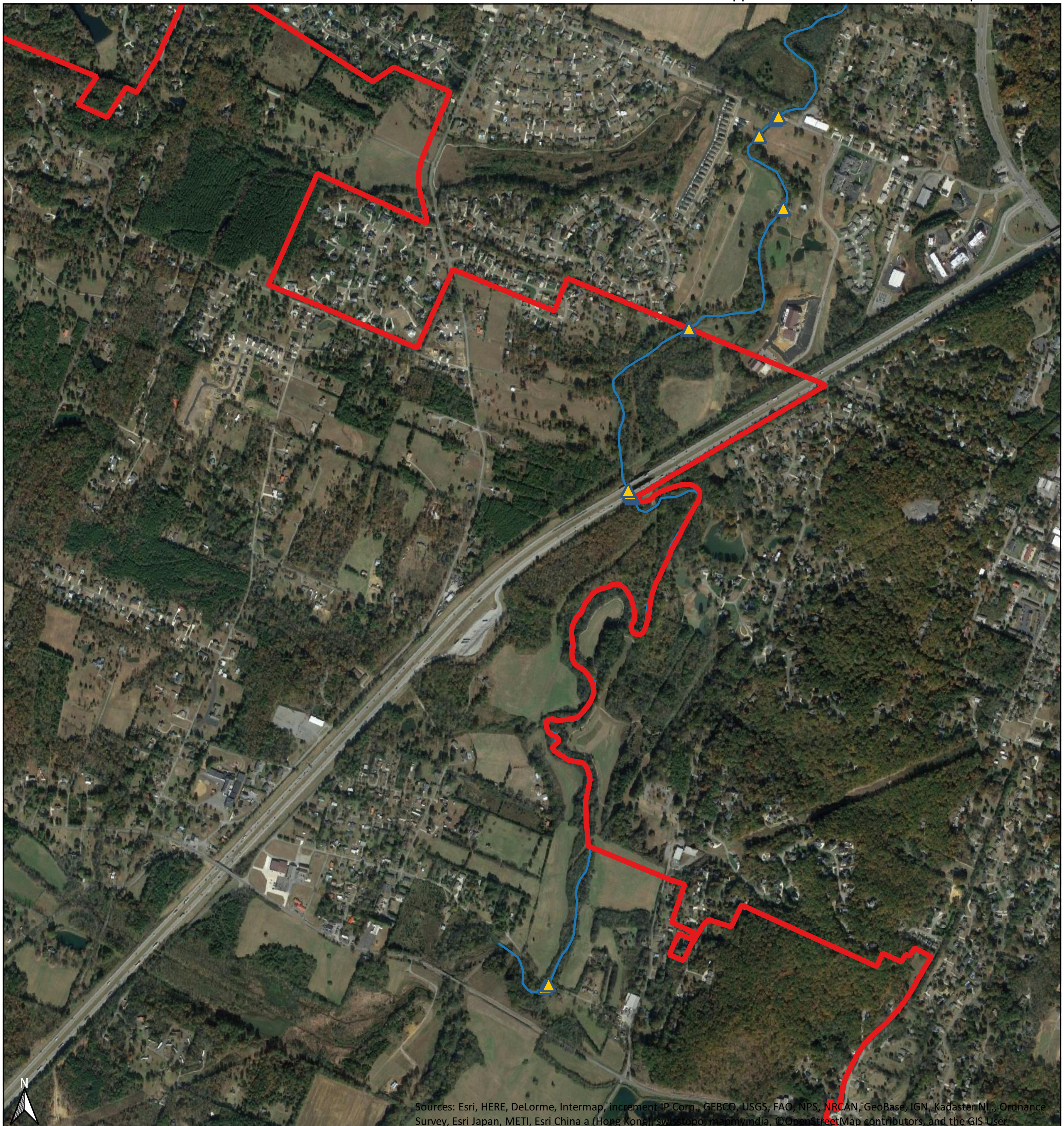


0 0.3 0.6 km

0 0.2 0.4 mi

TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

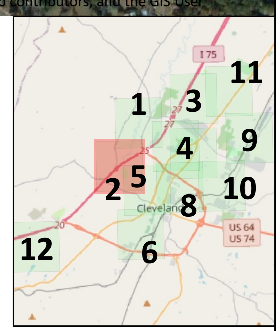
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Dirt Low Water Crossing
- Culvert
- Concrete Low Water Crossing
- Overhead Bridge
- City Boundary
- Stream
- Severe
- Moderate
- Minor

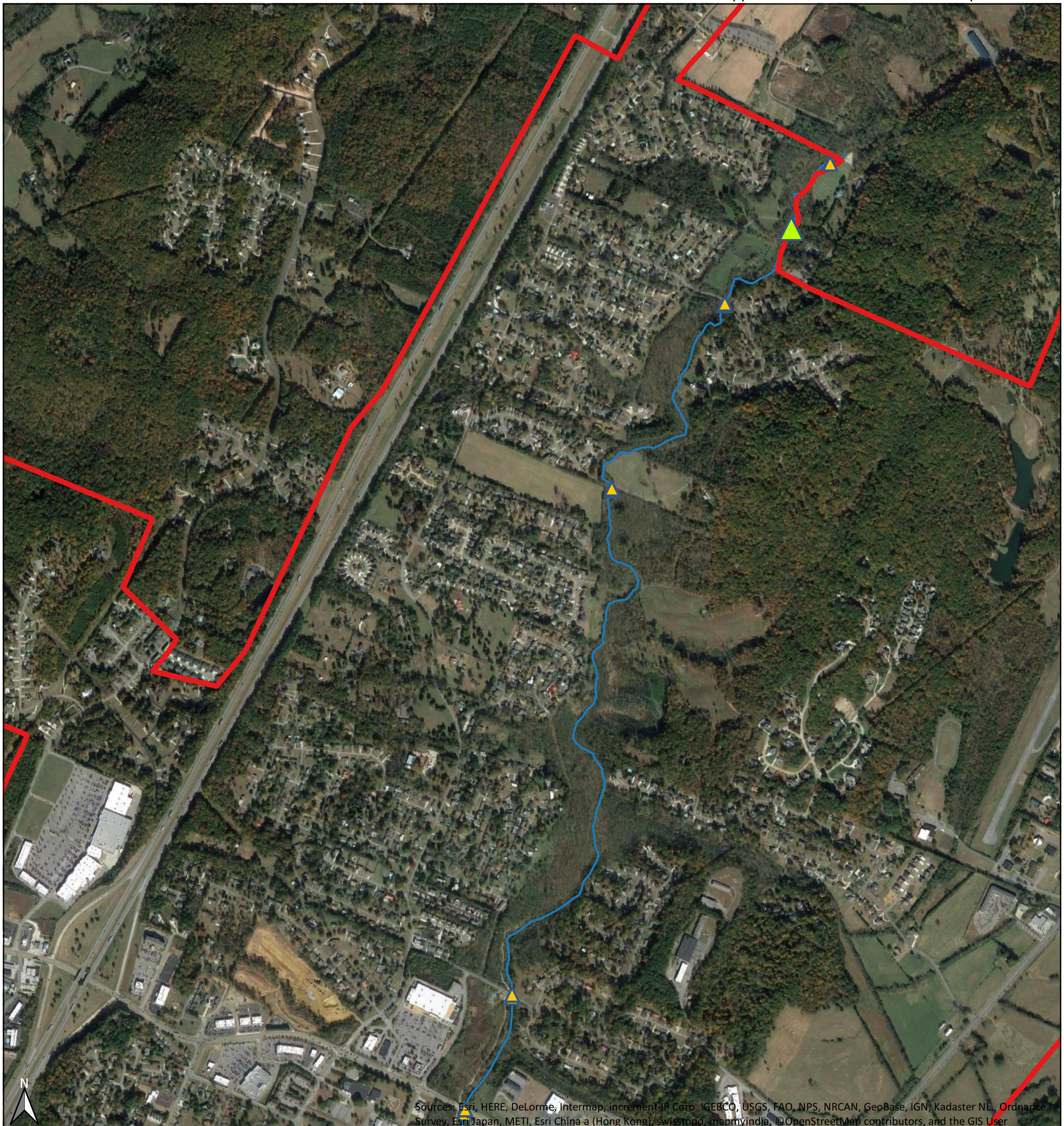
HDSS Road Impact Discrete Point Features for Candies Creek: Map 2



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

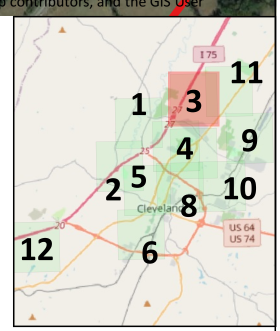
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Dirt Low Water Crossing
- Culvert
- Concrete Low Water Crossing
- Overhead Bridge
- City Boundary
- Stream
- Severe
- Moderate
- Minor

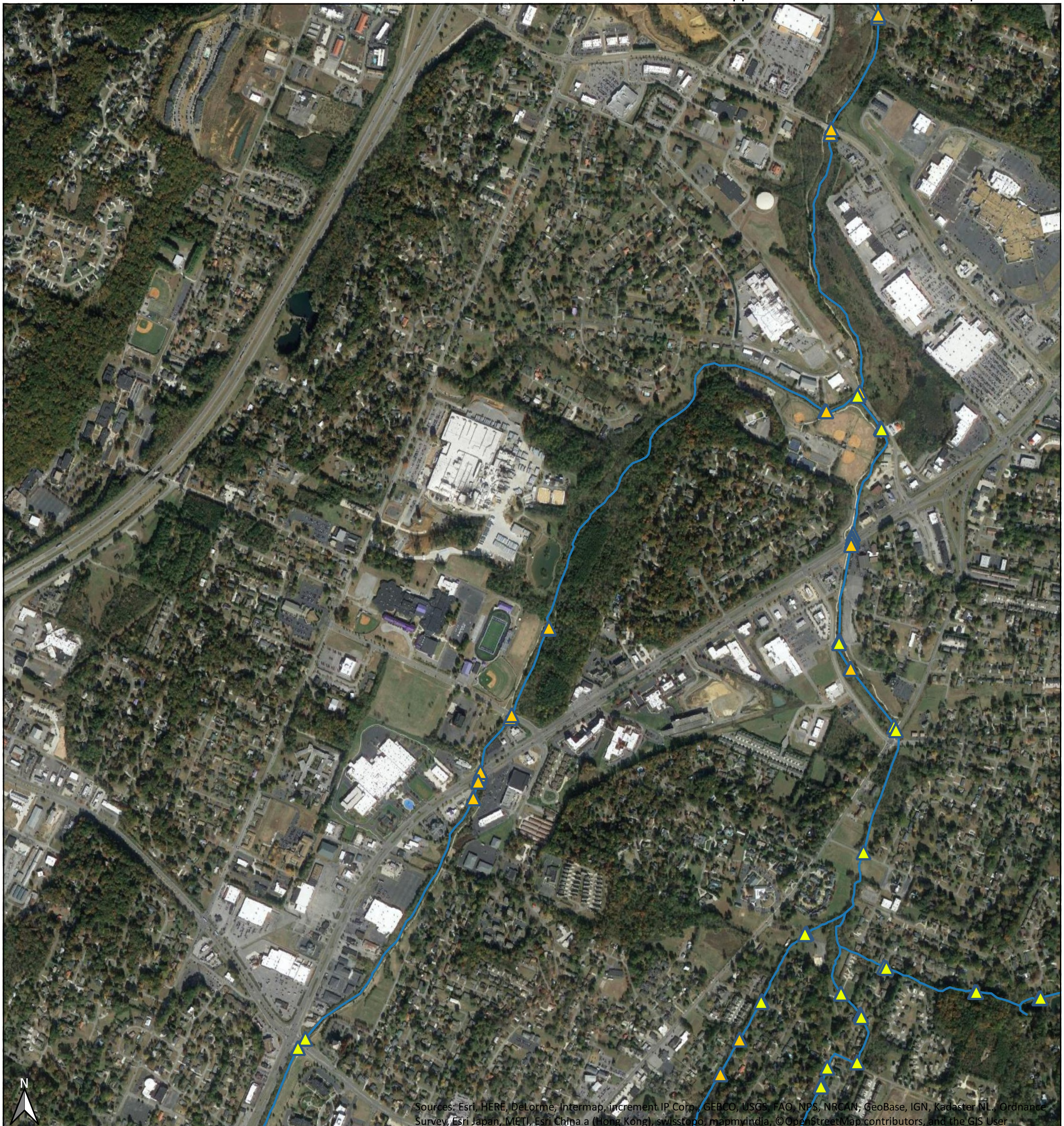
HDSS Road Impact Discrete Point Features for South Mouse Creek: Map 3



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

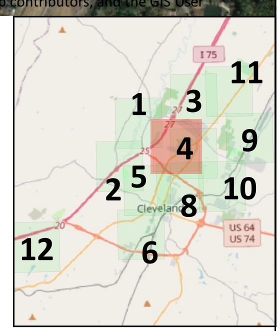
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Dirt Low Water Crossing
- Culvert
- Concrete Low Water Crossing
- Overhead Bridge
- City Boundary
- Stream
- Severe
- Moderate
- Minor

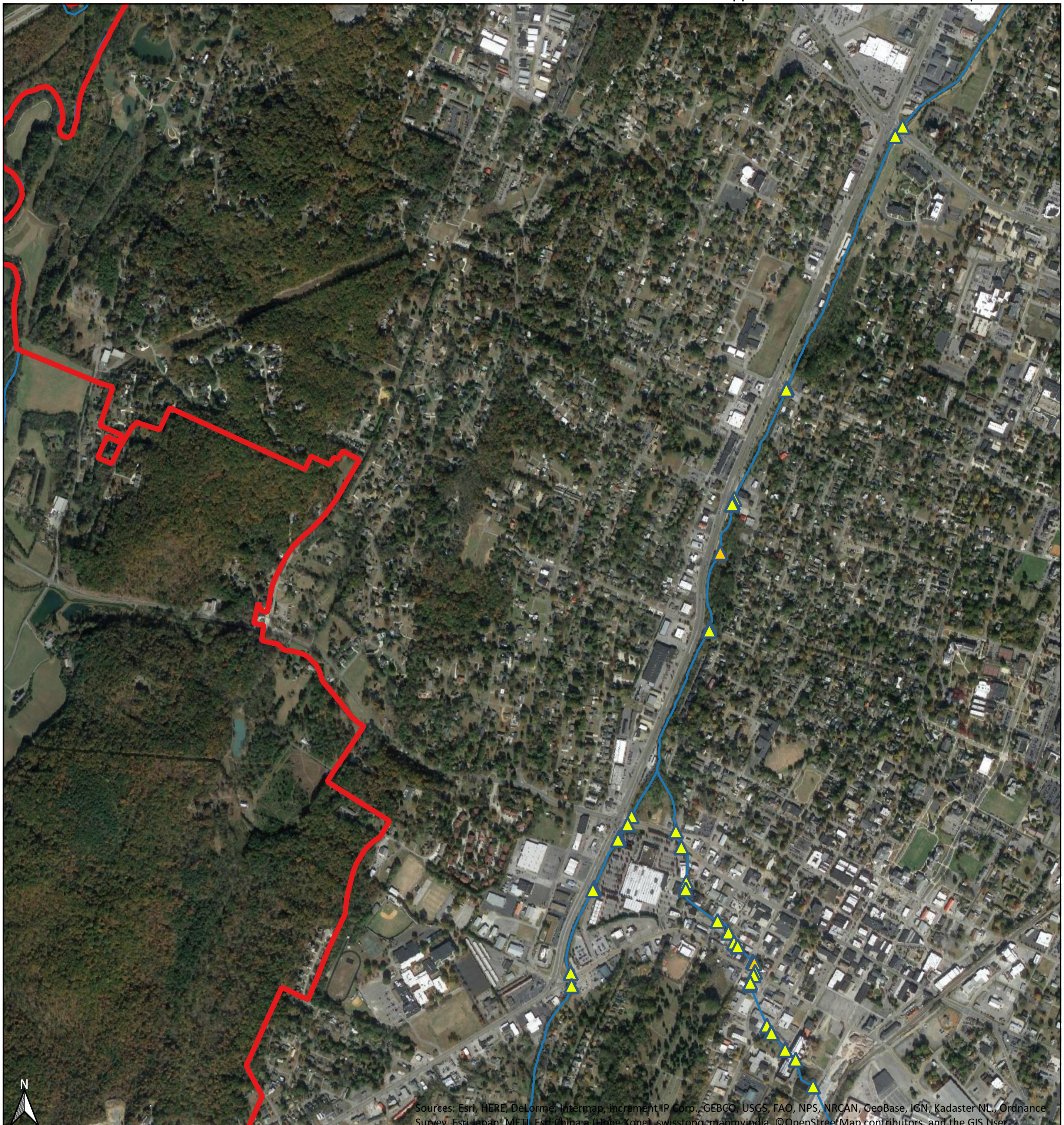
HDSS Road Impact Discrete Point Features for South Mouse Creek: Map 4



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

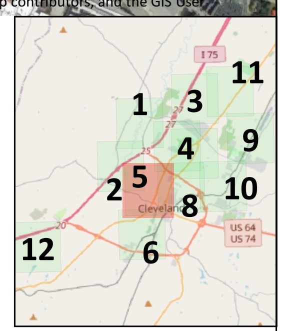
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Dirt Low Water Crossing
- Culvert
- Concrete Low Water Crossing
- Overhead Bridge
- City Boundary
- Stream
- Severe
- Moderate
- Minor

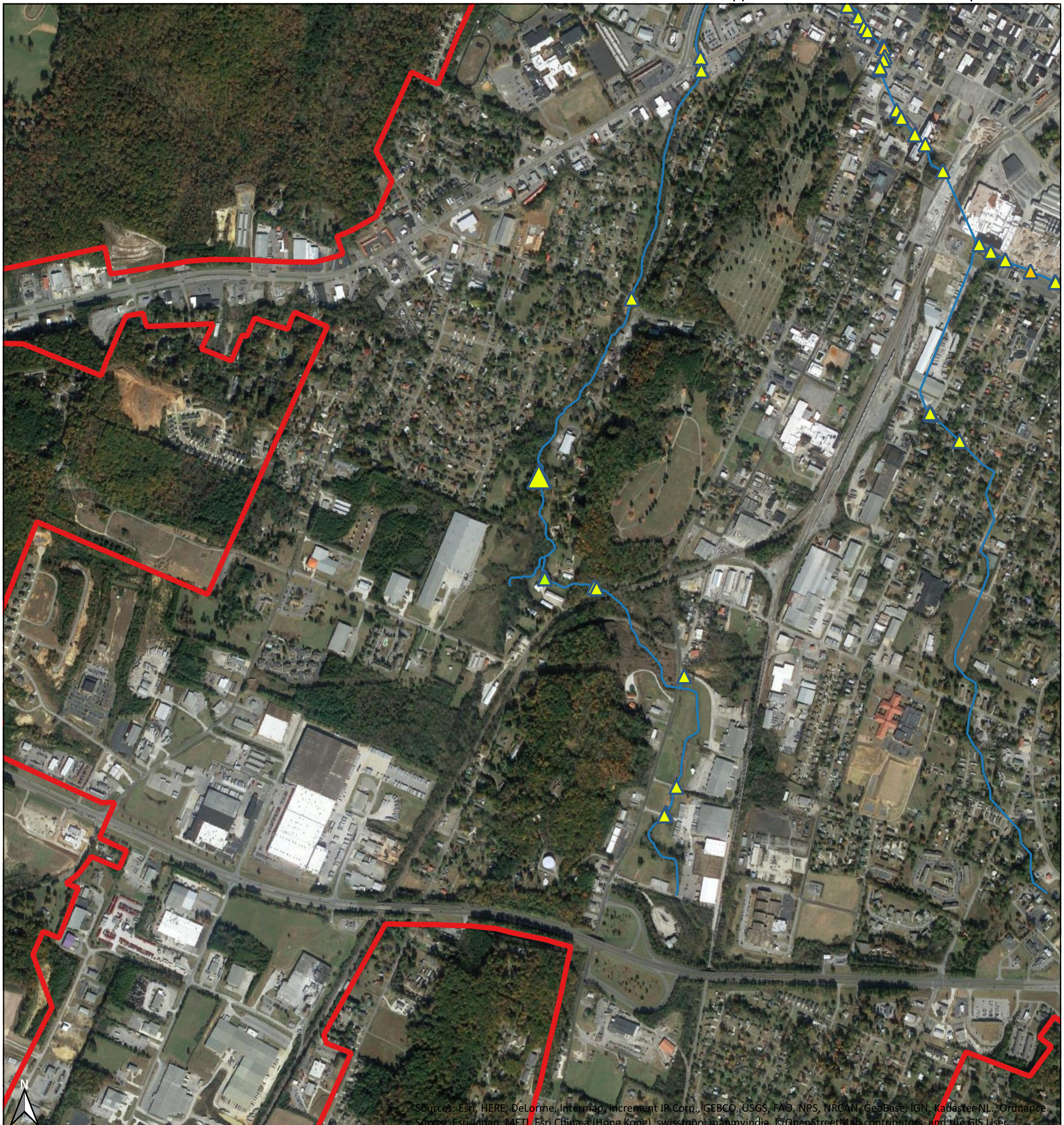
HDSS Road Impact Discrete Point Features for South Mouse Creek & Woolen Mill Branch: Map 5



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

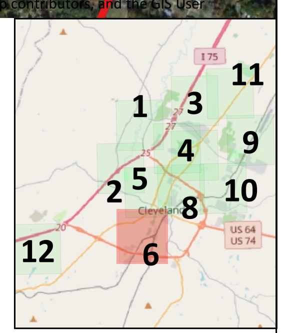
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Dirt Low Water Crossing
- Culvert
- Concrete Low Water Crossing
- Overhead Bridge
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Road Impact Discrete Point Features for South Mouse Creek: Map 6



0 0.3 0.6 km

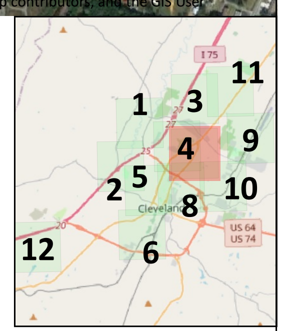
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Dirt Low Water Crossing
- Culvert
- Concrete Low Water Crossing
- Overhead Bridge
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Road Impact Discrete Point Features for Fillauer Creek: Map 7



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

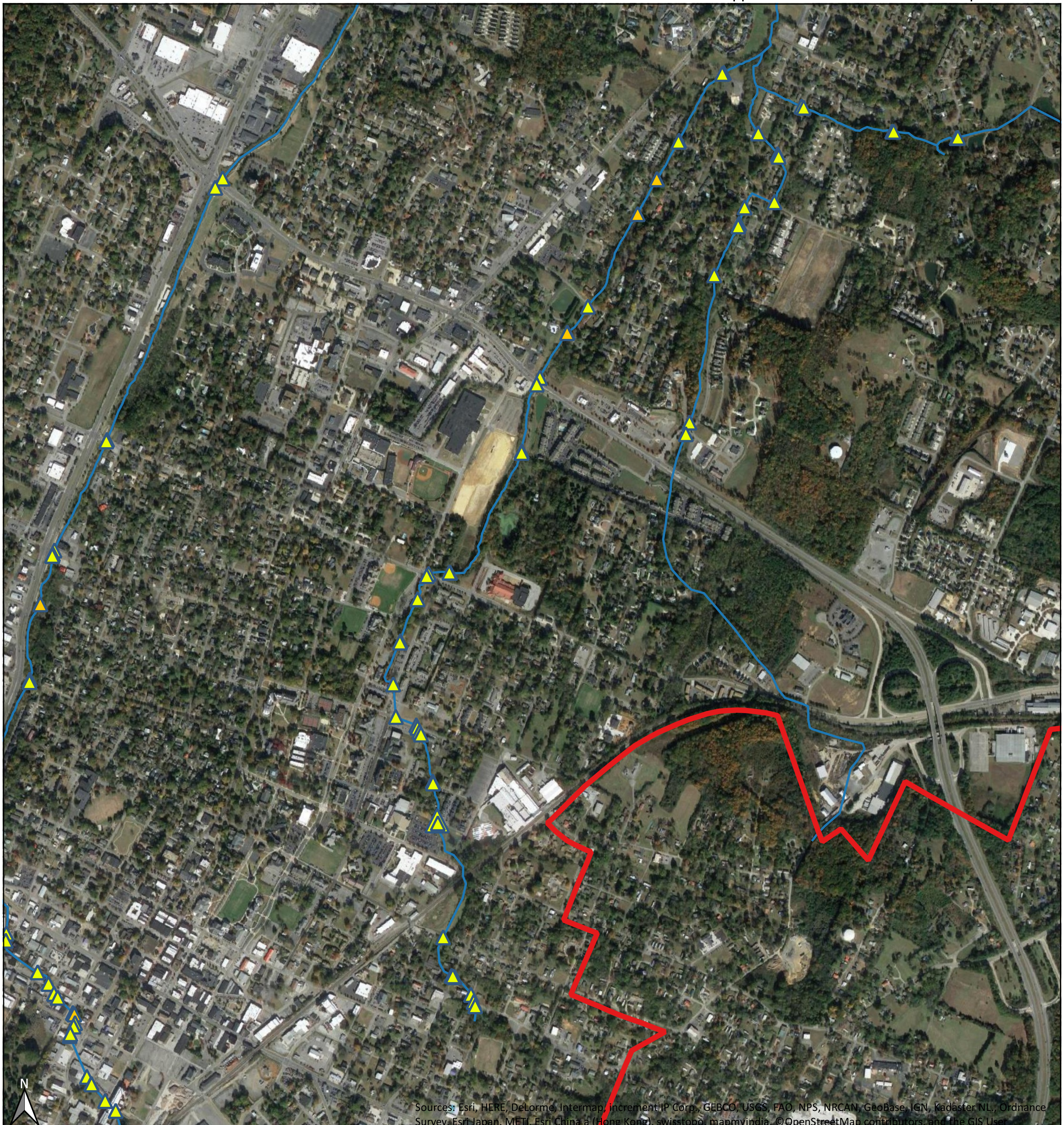
0 0.3 0.6 km

0 0.2 0.4 mi

Map Scale: 1:18,000

Map CRS: EPSG:26916

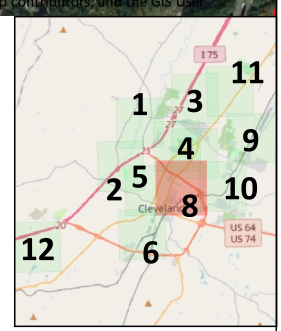
Coordinate Units: Meters



Legend

- Dirt Low Water Crossing
- Culvert
- Concrete Low Water Crossing
- Overhead Bridge
- City Boundary
- Stream
- Severe
- Moderate
- Minor

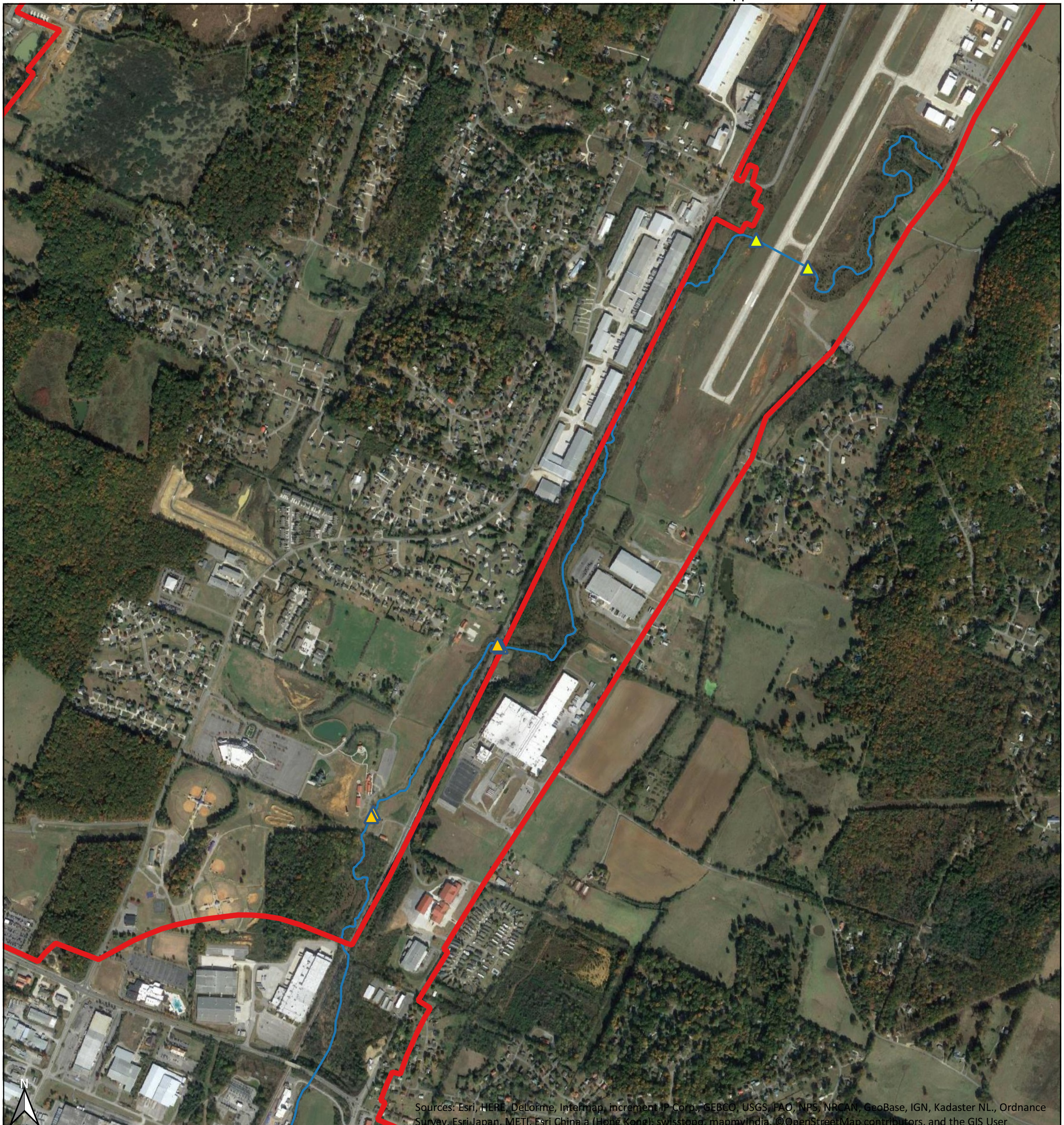
HDSS Road Impact Discrete Point Features for Fillauer Creek: Map 8



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

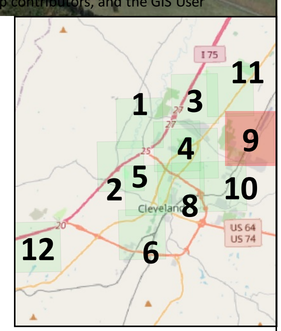
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Dirt Low Water Crossing
- Culvert
- Concrete Low Water Crossing
- Overhead Bridge
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Road Impact Discrete Point Features for Little Chatata Creek: Map 9



0 0.3 0.6 km

0 0.2 0.4 mi

TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

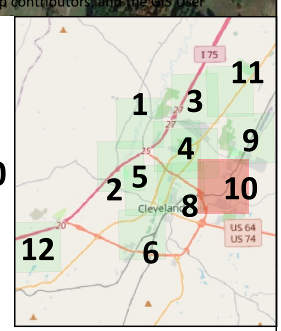
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Dirt Low Water Crossing
- Culvert
- Concrete Low Water Crossing
- Overhead Bridge
- City Boundary
- Stream
- Severe
- Moderate
- Minor

0 0.3 0.6 km
0 0.2 0.4 mi

HDSS Road Impact Discrete Point Features for Little Chatata Creek: Map 10

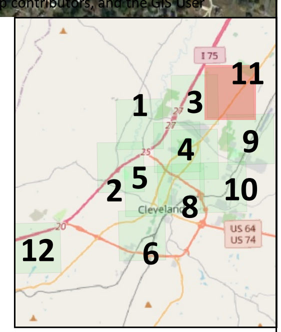


Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Dirt Low Water Crossing
- Culvert
- Concrete Low Water Crossing
- Overhead Bridge
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Road Impact Discrete Point Features for Little South Mouse Creek: Map 11

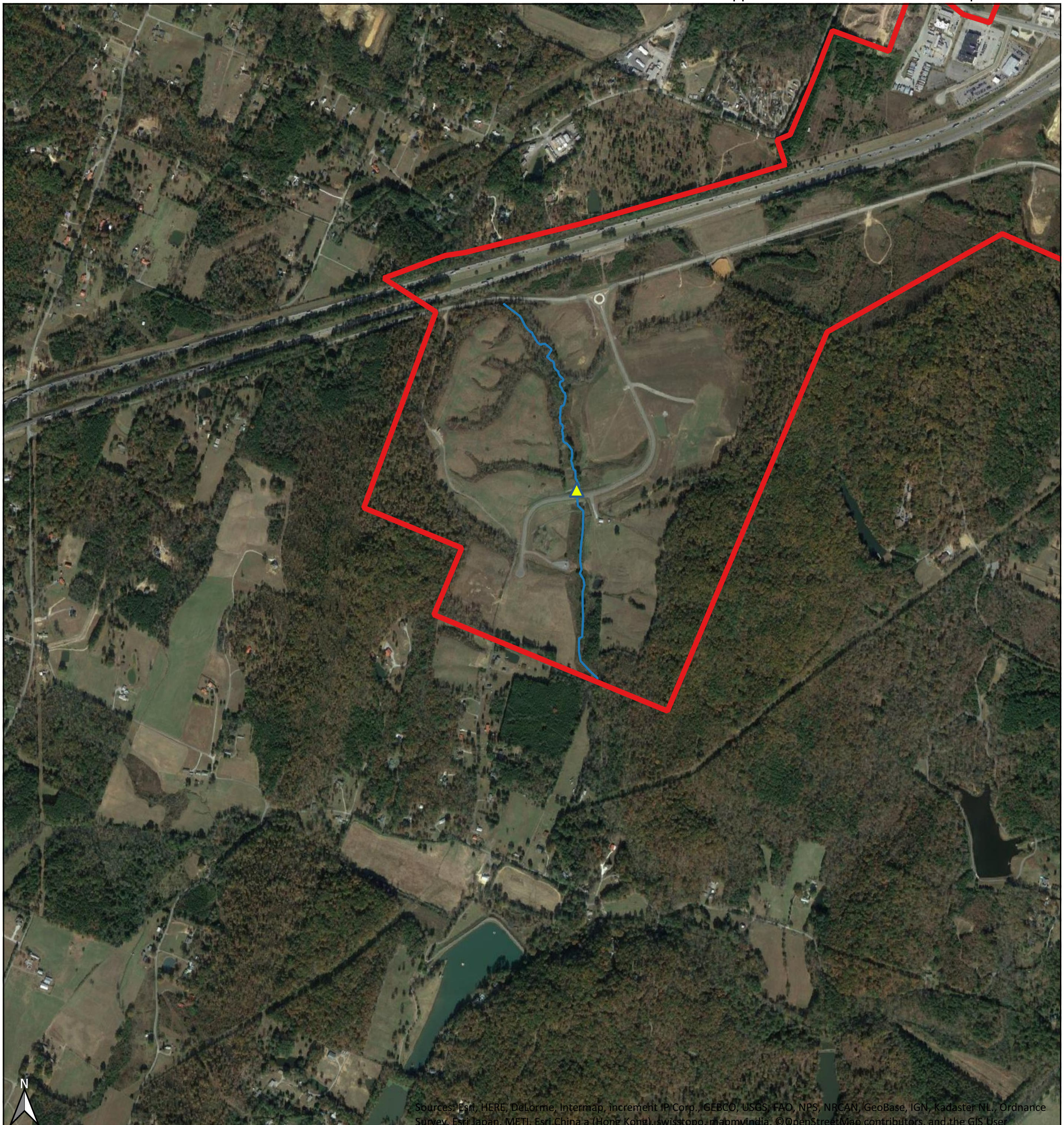


TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km

0 0.2 0.4 mi

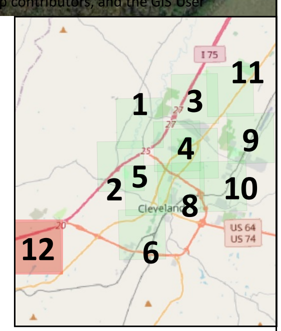
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Dirt Low Water Crossing
- Culvert
- Concrete Low Water Crossing
- Overhead Bridge
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Road Impact Discrete Point Features for Spring Branch: Map 12



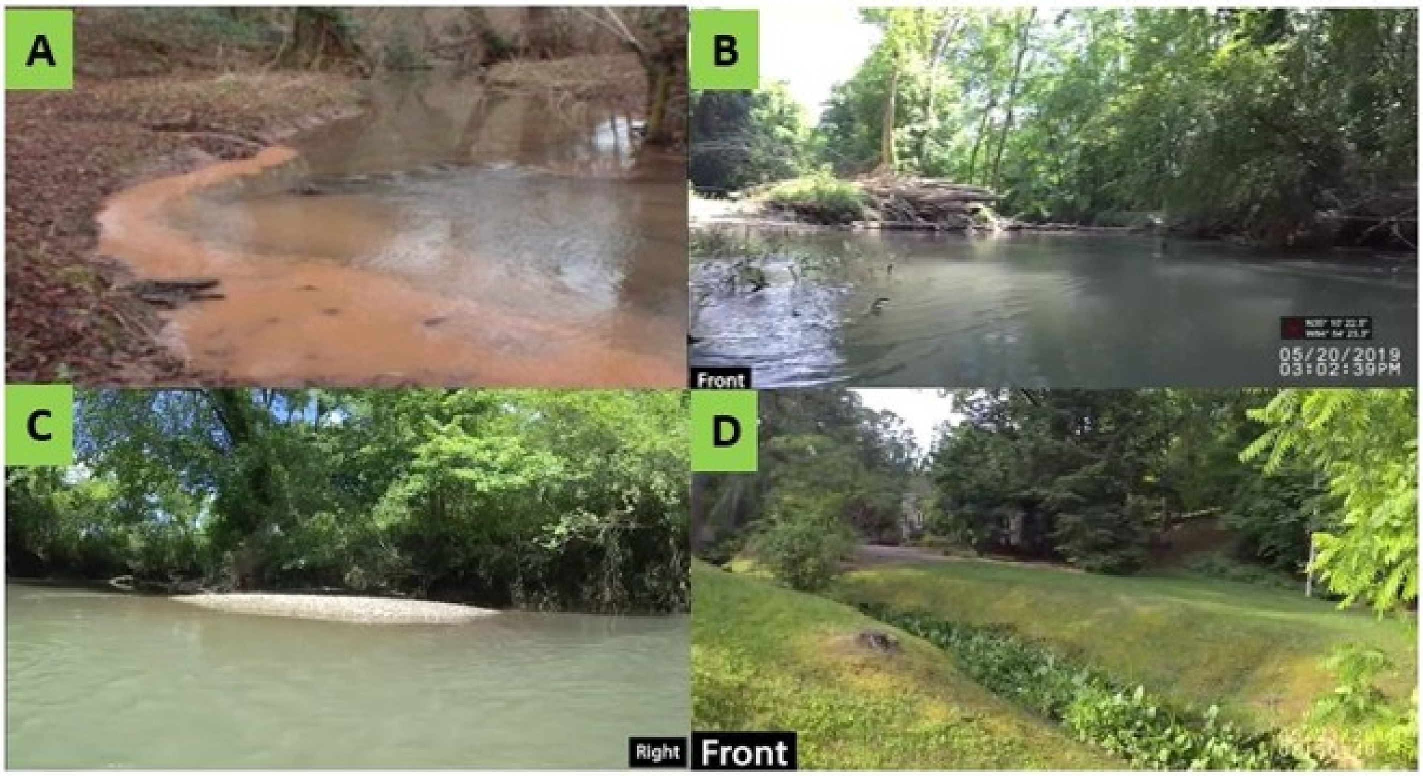
TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Appendix 4d:
Sedimentation Discrete Point Features

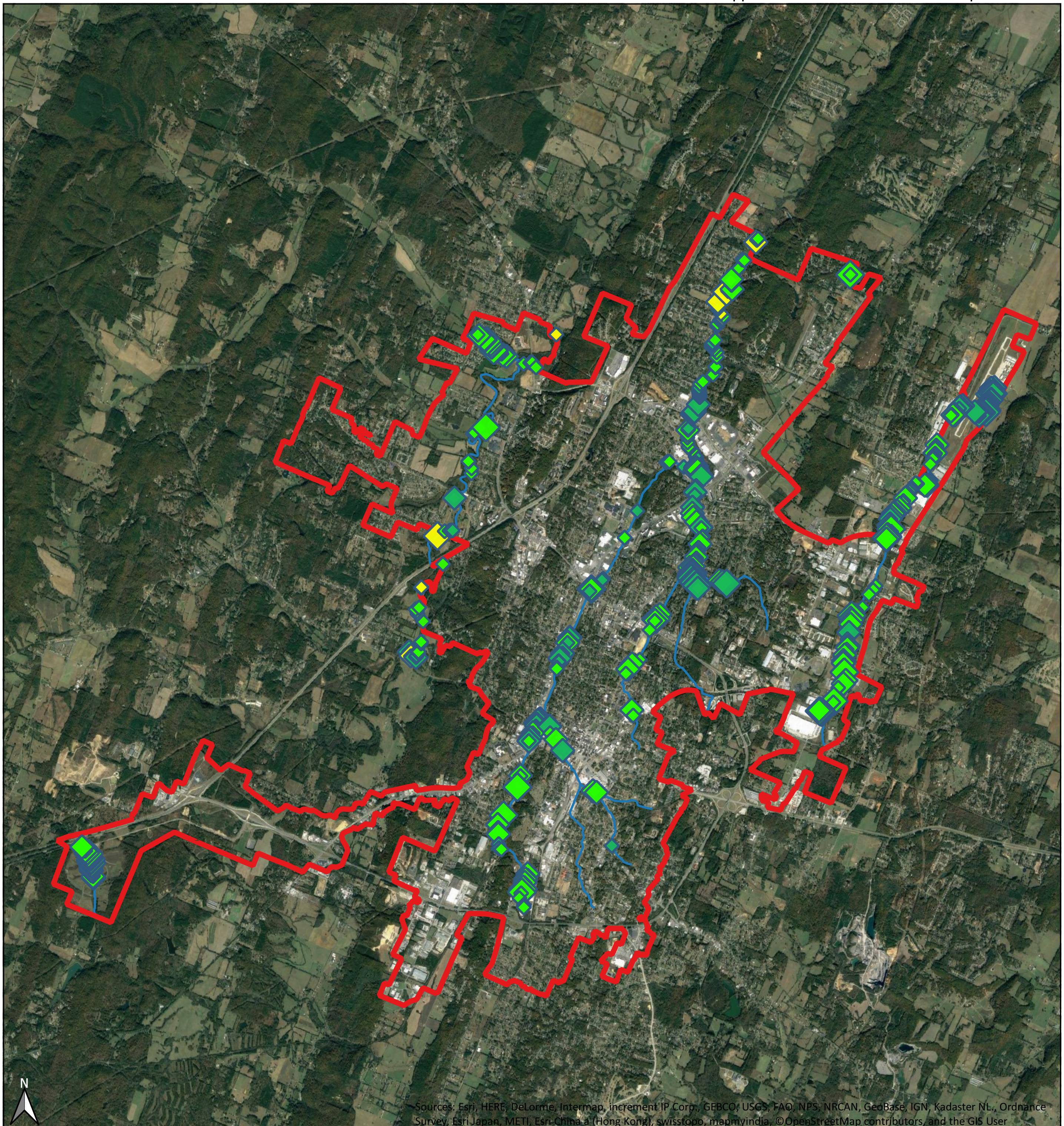
Example images of sedimentation discrete point feature categories commonly observed which includes excess fine sediment (A), vegetated islands (B), in-channel bars (C), and in-channel vegetation (D).



Appendix 4d:
Sedimentation Discrete Point Features

Sedimentation discrete point feature severity ranking criteria by category.

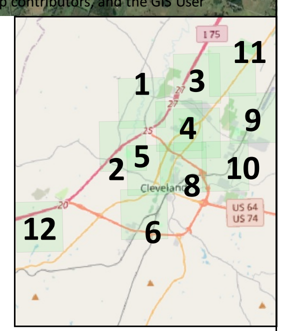
Discrete Feature		Parameter	Severity		
Type	Category		Minor	Moderate	Severe
Sedimentation	Excess fines	Depth	< 1 inch	>1- <2 inches	>2 inches
		Length	< 2 x wetted width	15-50 x wetted width	> 50 x wetted width
	In-channel bars	Width	< 25% of channel width affected	> 25% but < 75% of channel affected	≥ 75% of channel width affected
		Length	< 2 x wetted width	3–9 x wetted width	> 10 x wetted width
	Vegetated Island	Width	≤ 25% of channel affected	> 25% but < 75% of channel affected	≥ 75% of channel width affected
		Length	< 15 x wetted width	15-50 x wetted width	> 50 x wetted width
	In-channel Vegetation	Width	≤ 25% of channel affected	> 25% but < 75% of channel affected	≥ 75% of channel width affected
		Length	< 2 x wetted width	3–9 x wetted width	> 10 x wetted width
		Density	Not Dense	Dense	



Legend

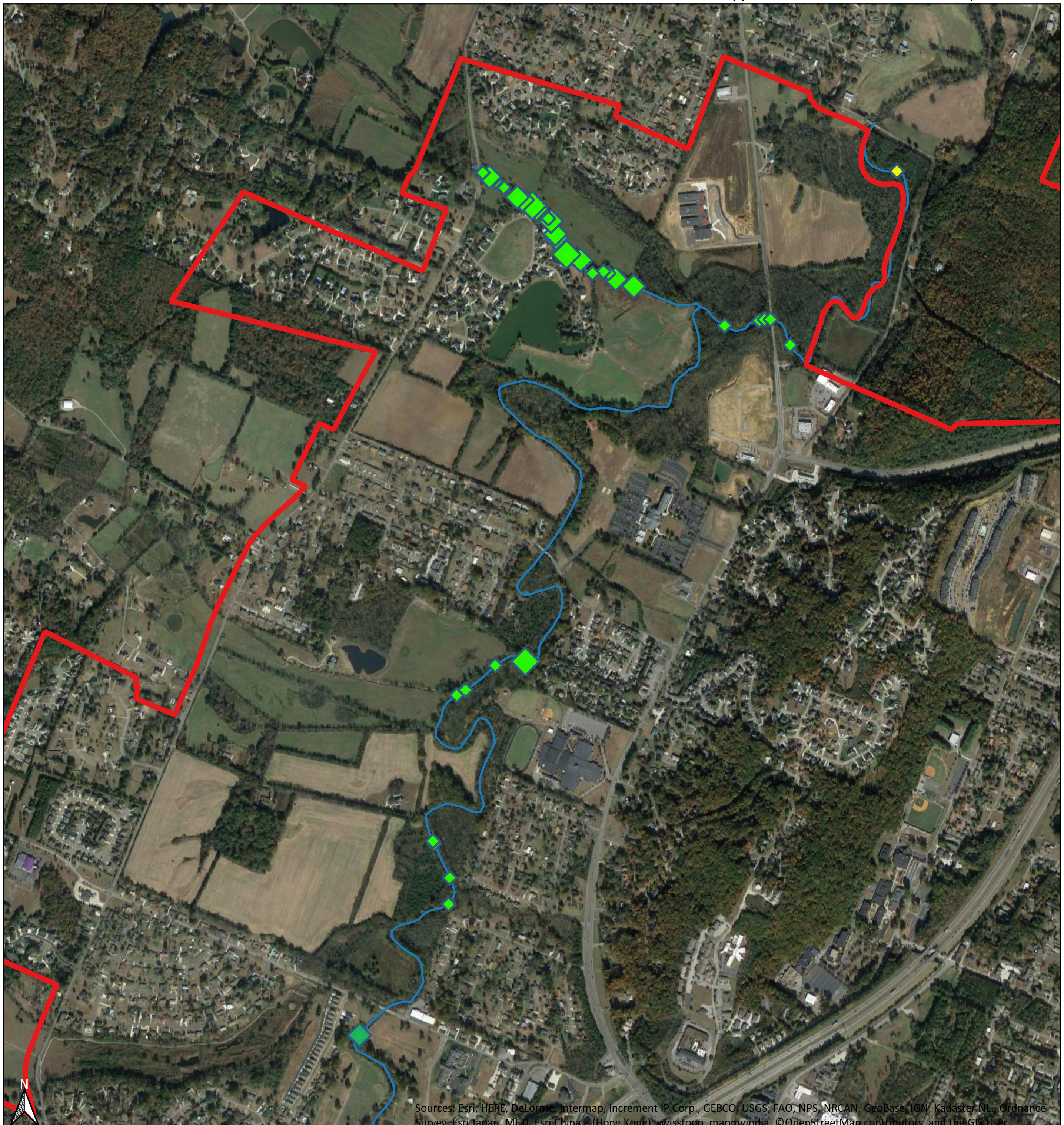
- In Channel Bars
- Vegetated Islands
- In-Channel Vegetation
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Sedimentation Discrete Point Features for Cleveland, TN



0 1 2 km
0 1 2 mi

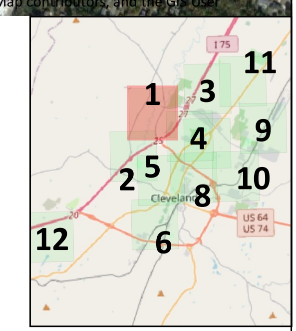
Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- In Channel Bars
- Vegetated Islands
- In-Channel Vegetation
- City Boundary
- Stream
- Severe
- Moderate
- Minor

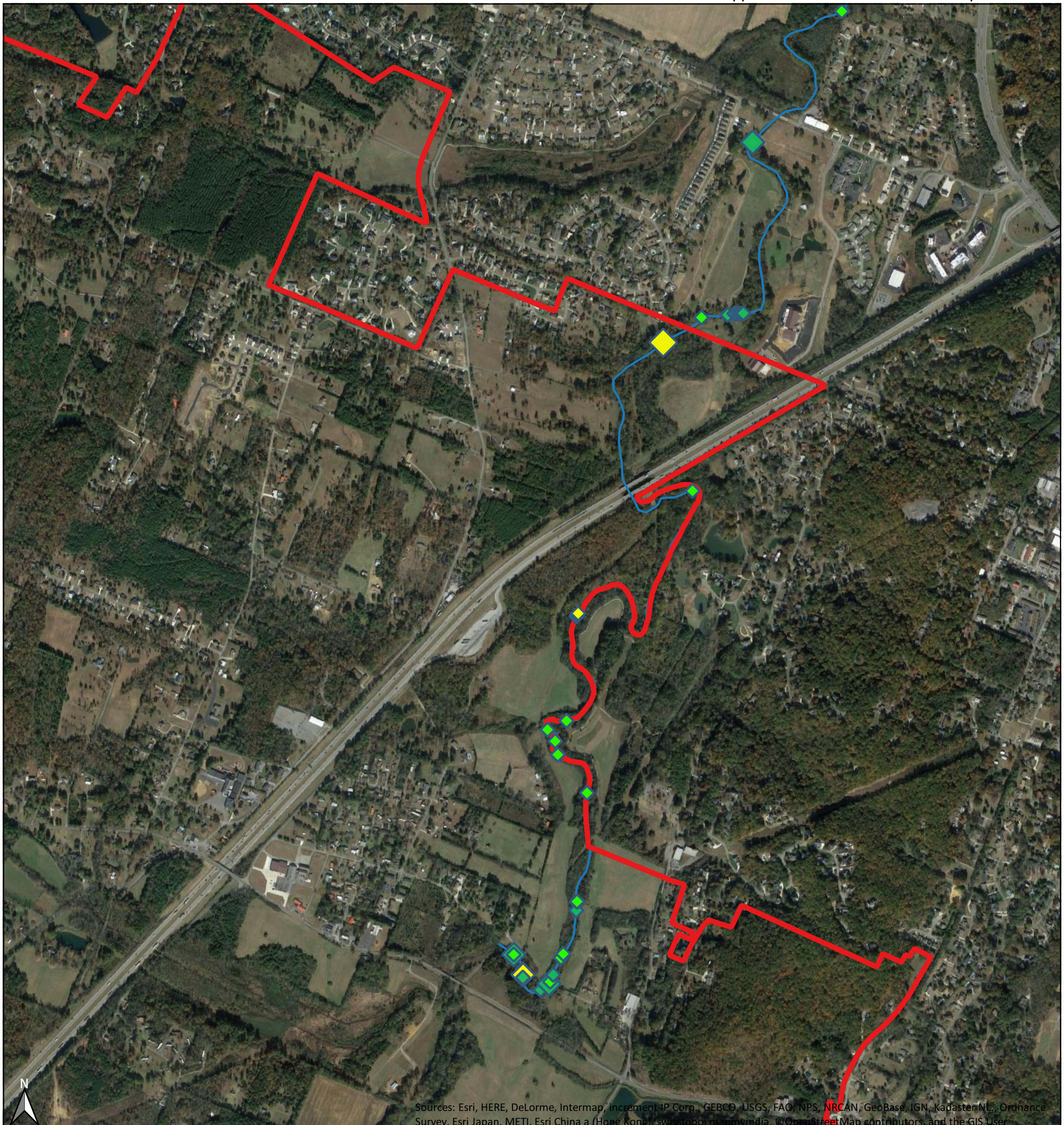
HDSS Sedimentation Discrete Point Features for Candies and Bigsby Creeks: Map 1



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

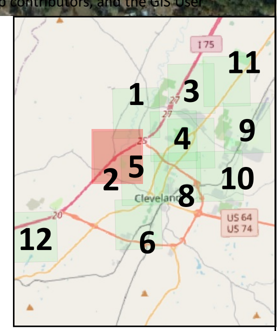
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- In Channel Bars
- Vegetated Islands
- In-Channel Vegetation
- City Boundary
- Stream
- Severe
- Moderate
- Minor

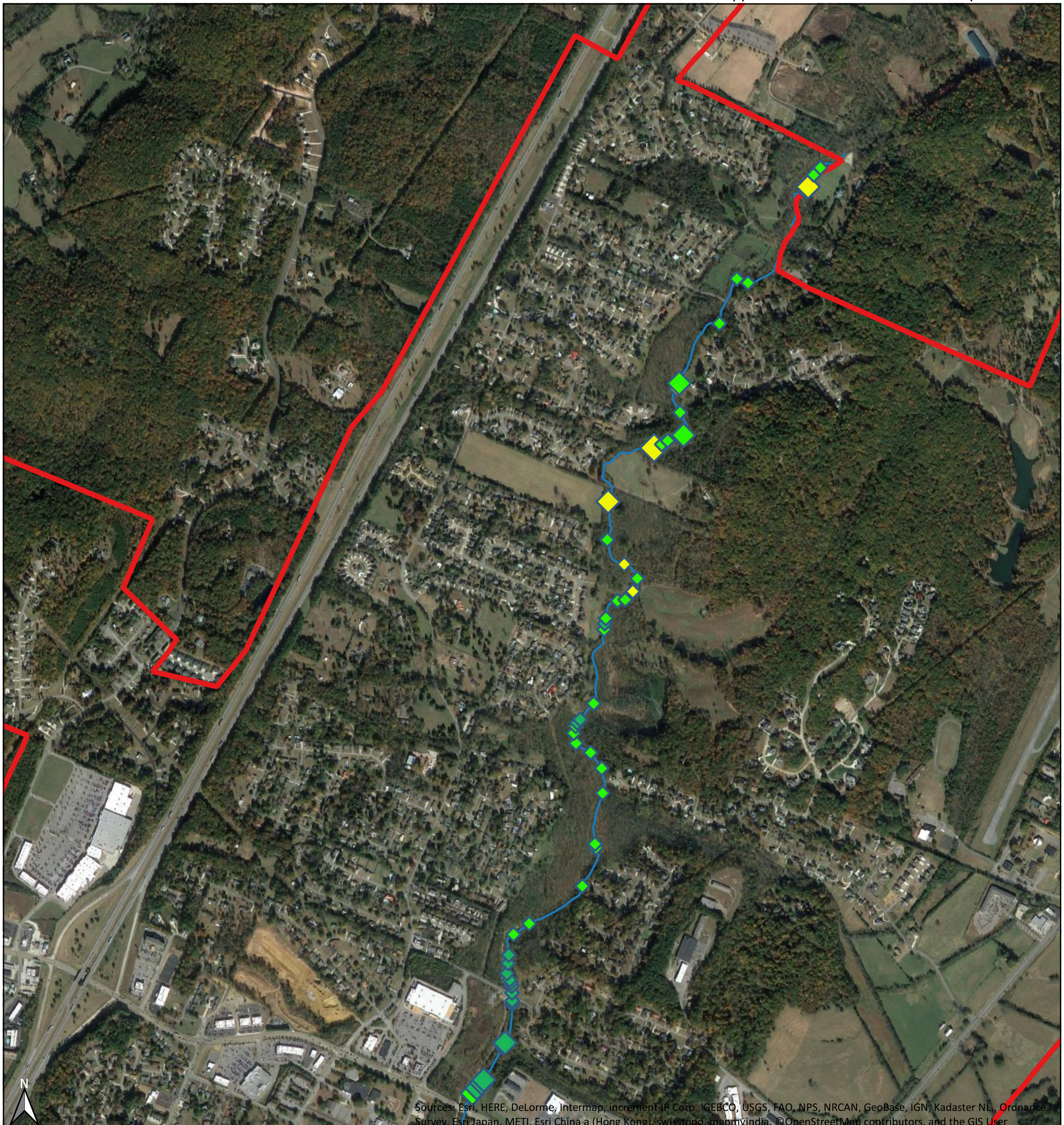
HDSS Sedimentation Discrete Point Features for Candies Creek: Map 2



0 0.3 0.6 km

0 0.2 0.4 mi

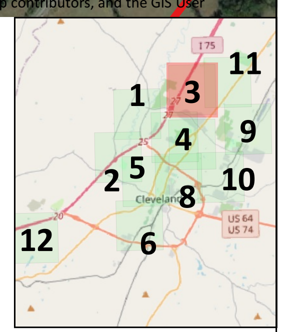
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- In Channel Bars
- Vegetated Islands
- In-Channel Vegetation
- City Boundary
- Stream
- Severe
- Moderate
- Minor

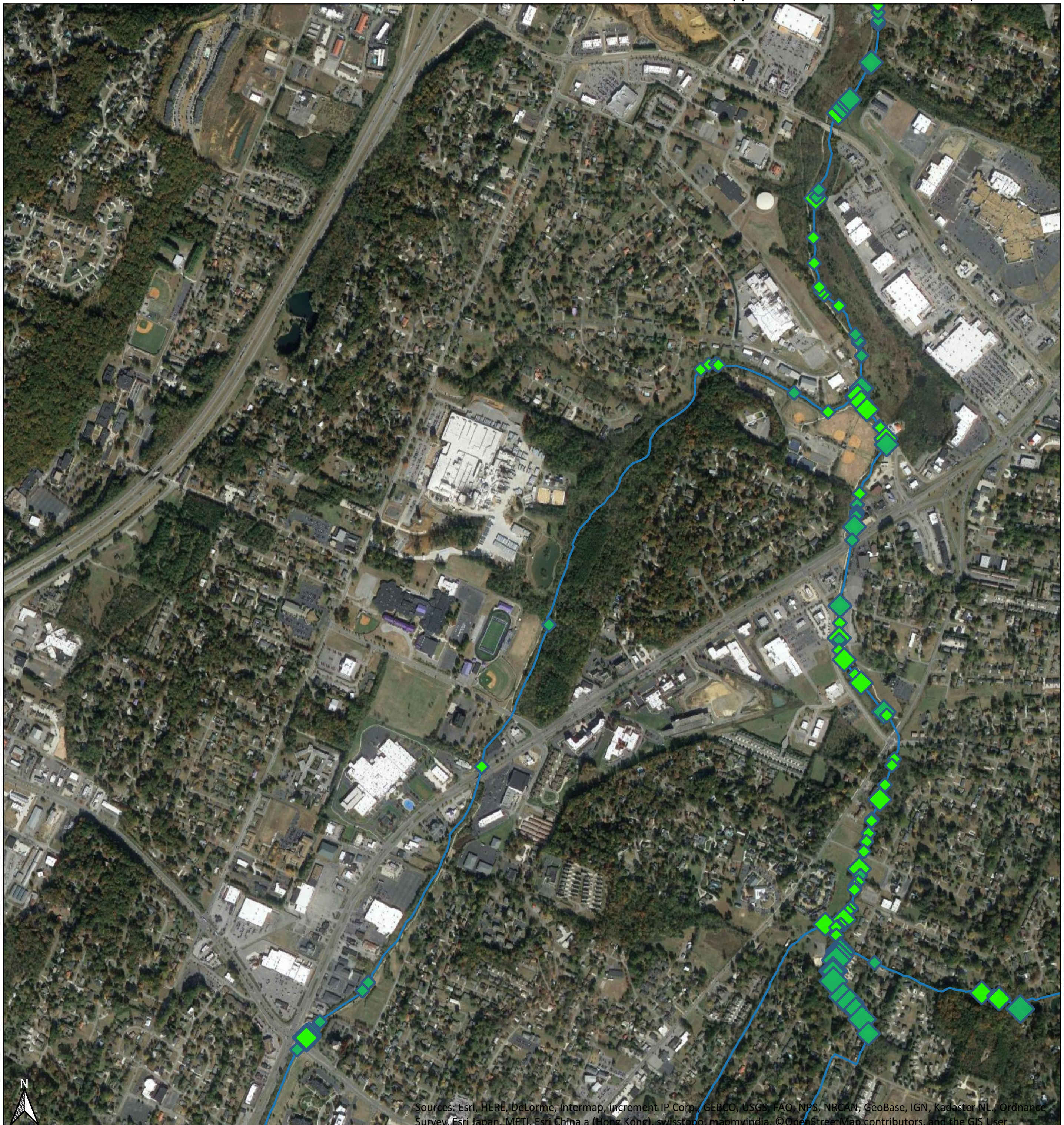
HDSS Sedimentation Discrete Point Features for South Mouse Creek: Map 3



0 0.3 0.6 km

0 0.2 0.4 mi

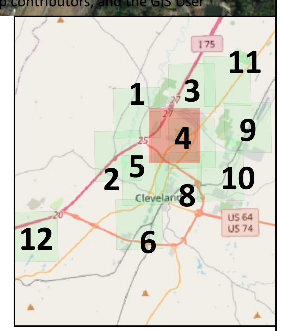
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

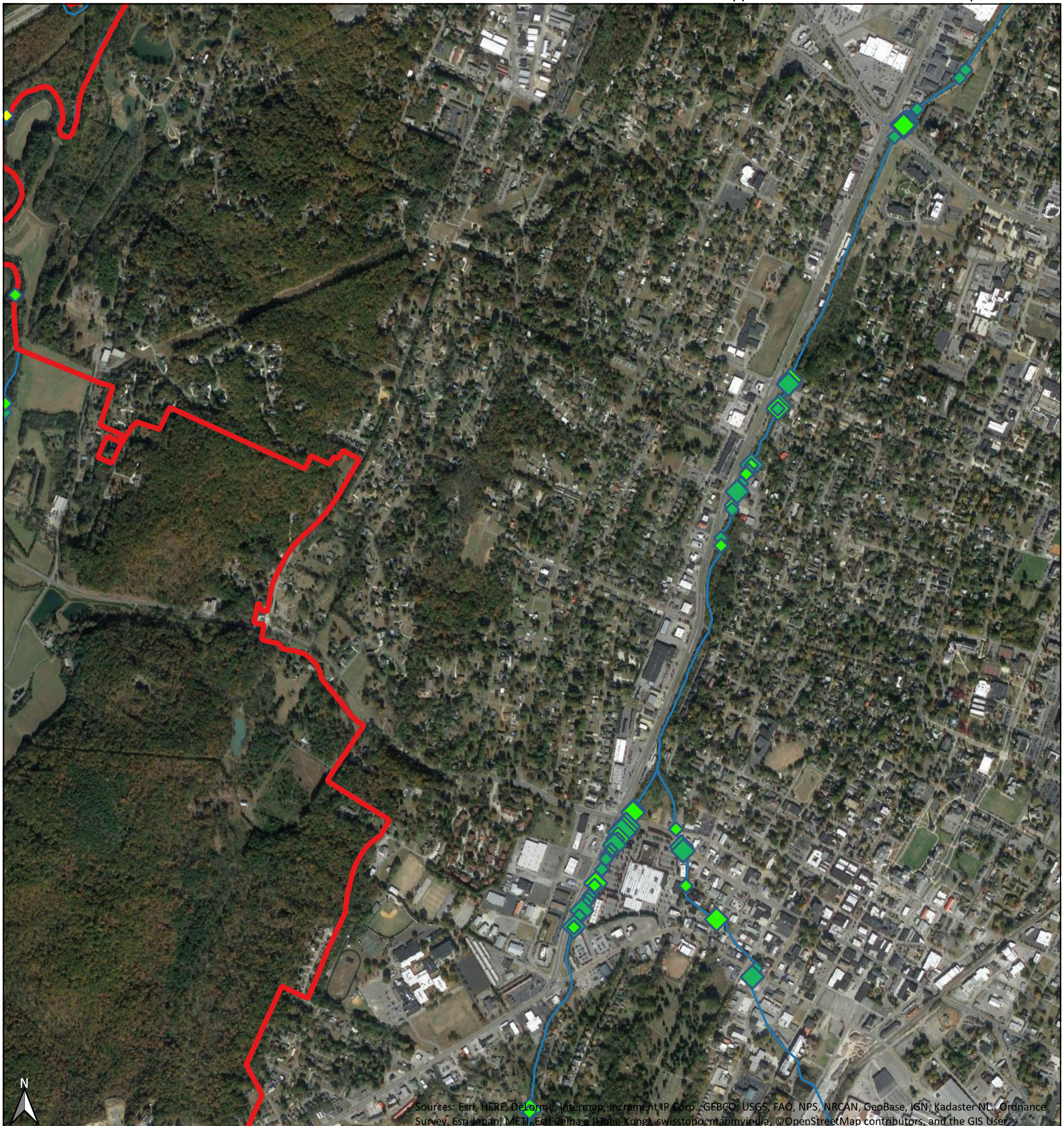
- In Channel Bars
- Vegetated Islands
- In-Channel Vegetation
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Sedimentation Discrete Point Features for South Mouse Creek: Map 4



0 0.3 0.6 km
0 0.2 0.4 mi

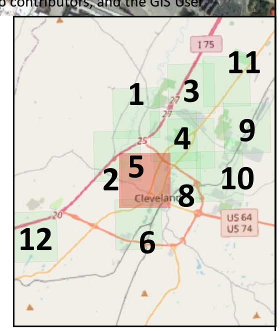
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

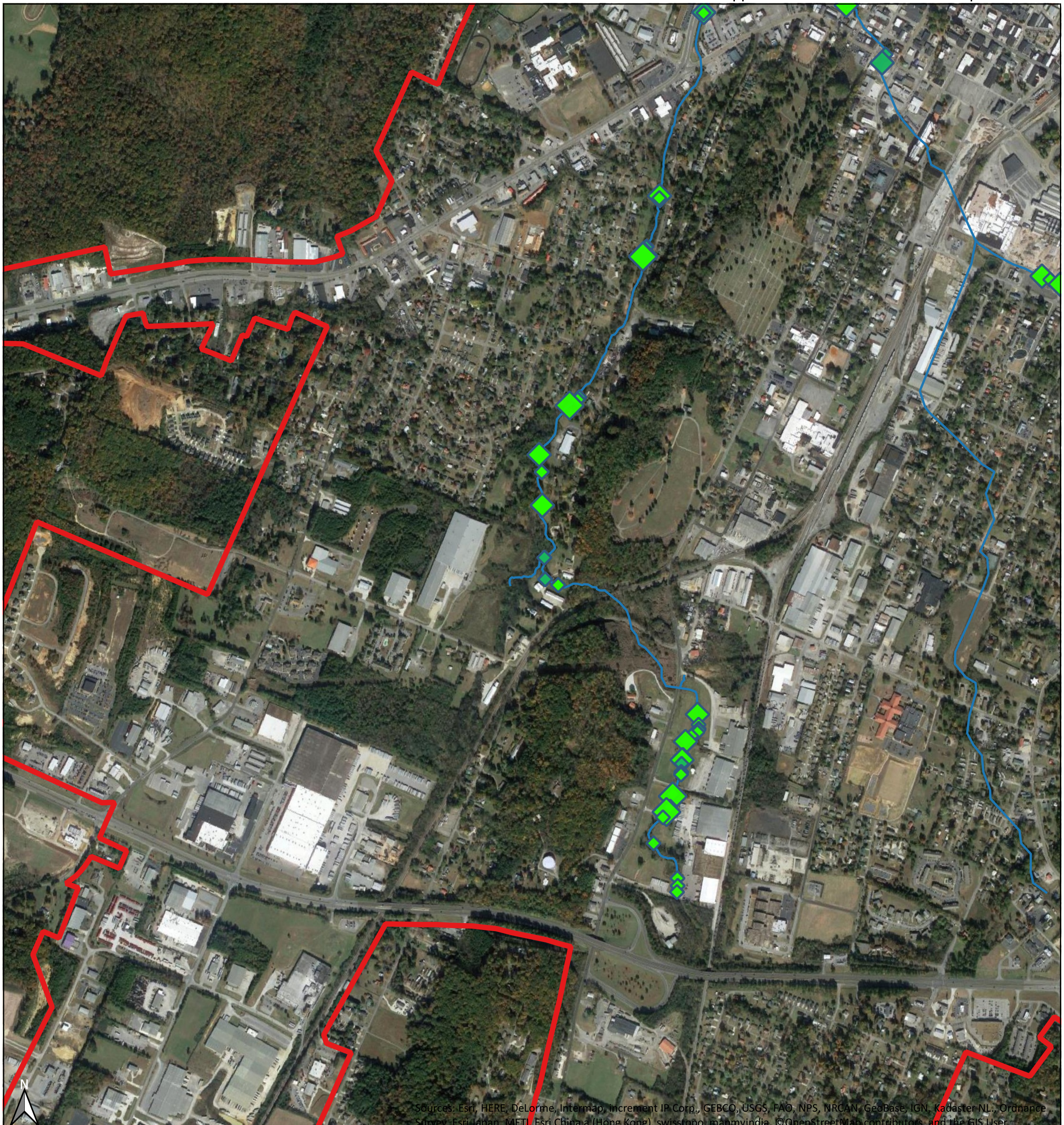
- In Channel Bars
- Vegetated Islands
- In-Channel Vegetation
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Sedimentation Discrete Point Features for South Mouse Creek & Woolen Mill Branch: Map 5



0 0.3 0.6 km
0 0.2 0.4 mi

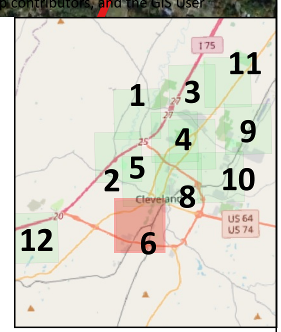
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- In Channel Bars
- Vegetated Islands
- In-Channel Vegetation
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Sedimentation Discrete Point Features for South Mouse Creek: Map 6



0 0.3 0.6 km

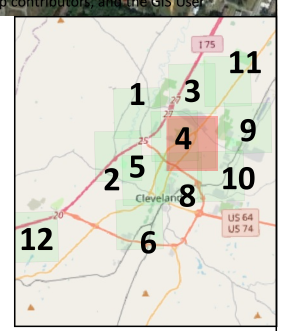
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- In Channel Bars
- Vegetated Islands
- In-Channel Vegetation
- City Boundary
- Stream
- Severe
- Moderate
- Minor

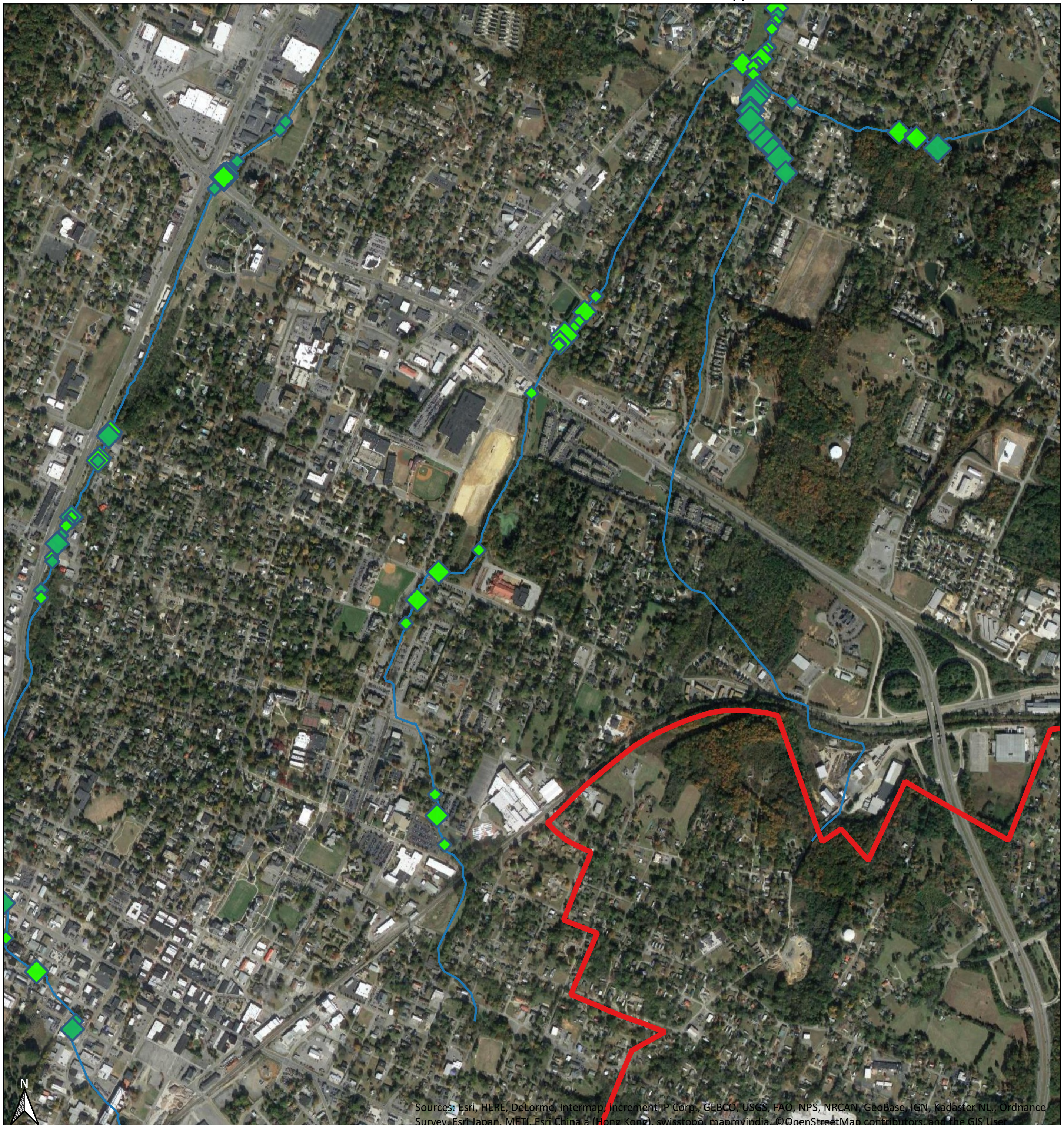
HDSS Sedimentation Discrete Point Features for Fillauer Creek: Map 7



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

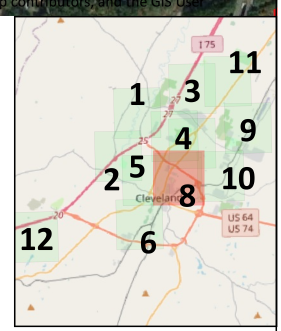
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- In Channel Bars
- Vegetated Islands
- In-Channel Vegetation
- City Boundary
- Stream
- Severe
- Moderate
- Minor

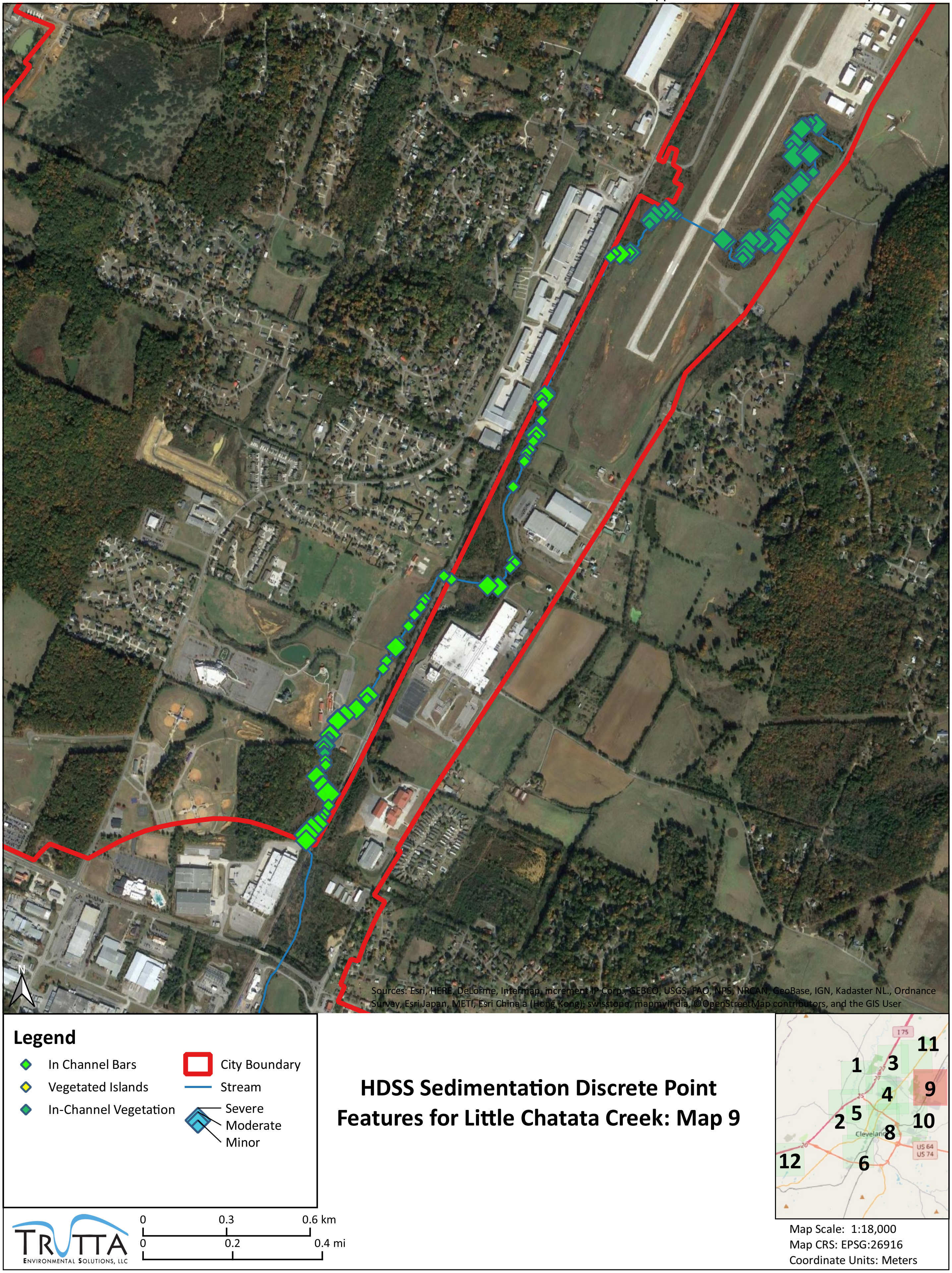
HDSS Sedimentation Discrete Point Features for Fillauer Creek: Map 8



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

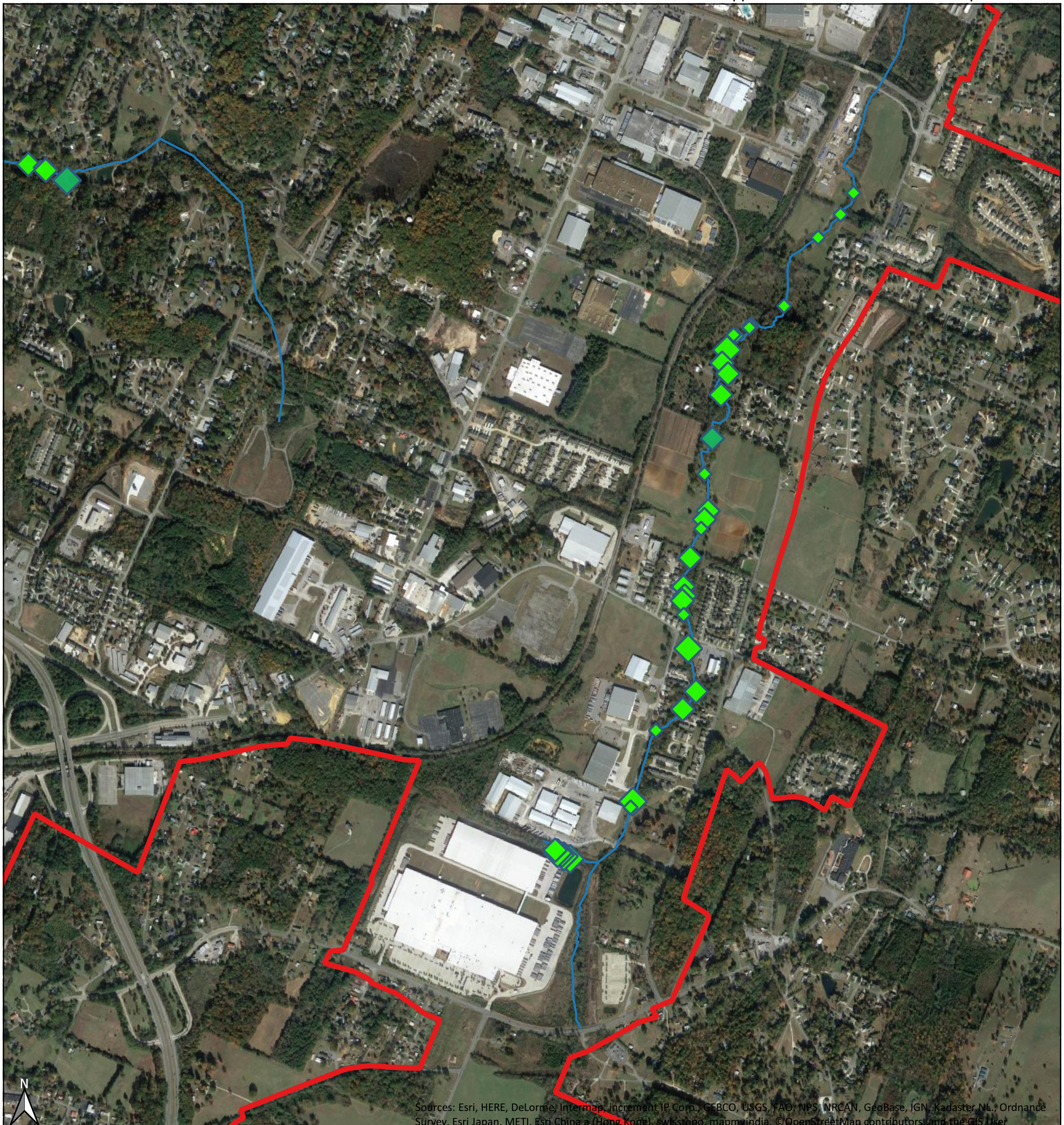
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



HDSS Sedimentation Discrete Point Features for Little Chatata Creek: Map 9

TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

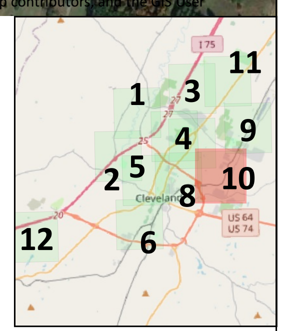
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- In Channel Bars
- Vegetated Islands
- In-Channel Vegetation
- City Boundary
- Stream
- Severe
- Moderate
- Minor

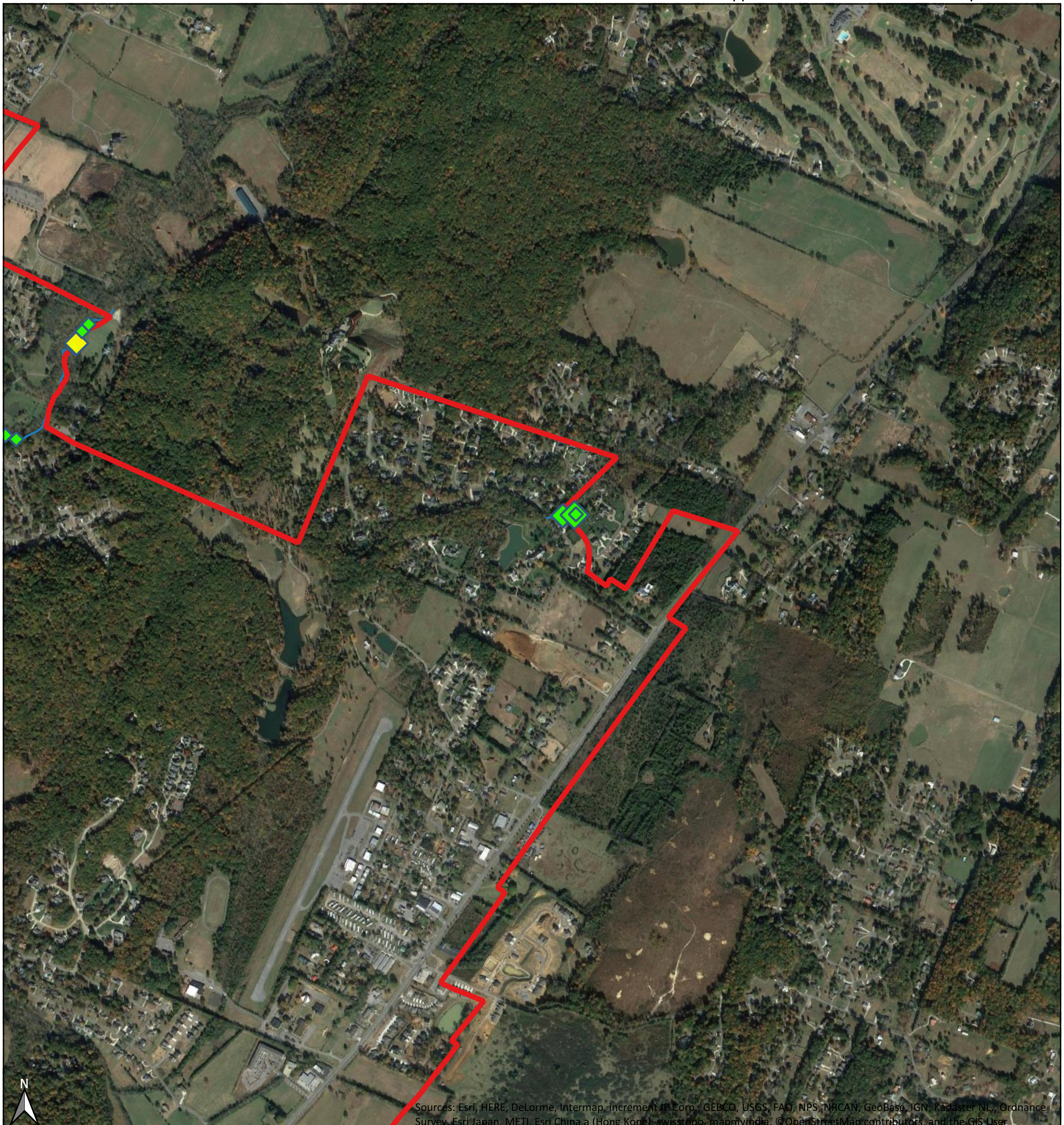
HDSS Sedimentation Discrete Point Features for Little Chatata Creek: Map 10



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

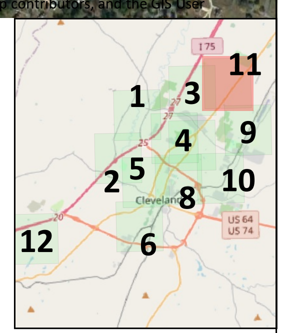
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- In Channel Bars
- Vegetated Islands
- In-Channel Vegetation
- City Boundary
- Stream
- Severe
- Moderate
- Minor

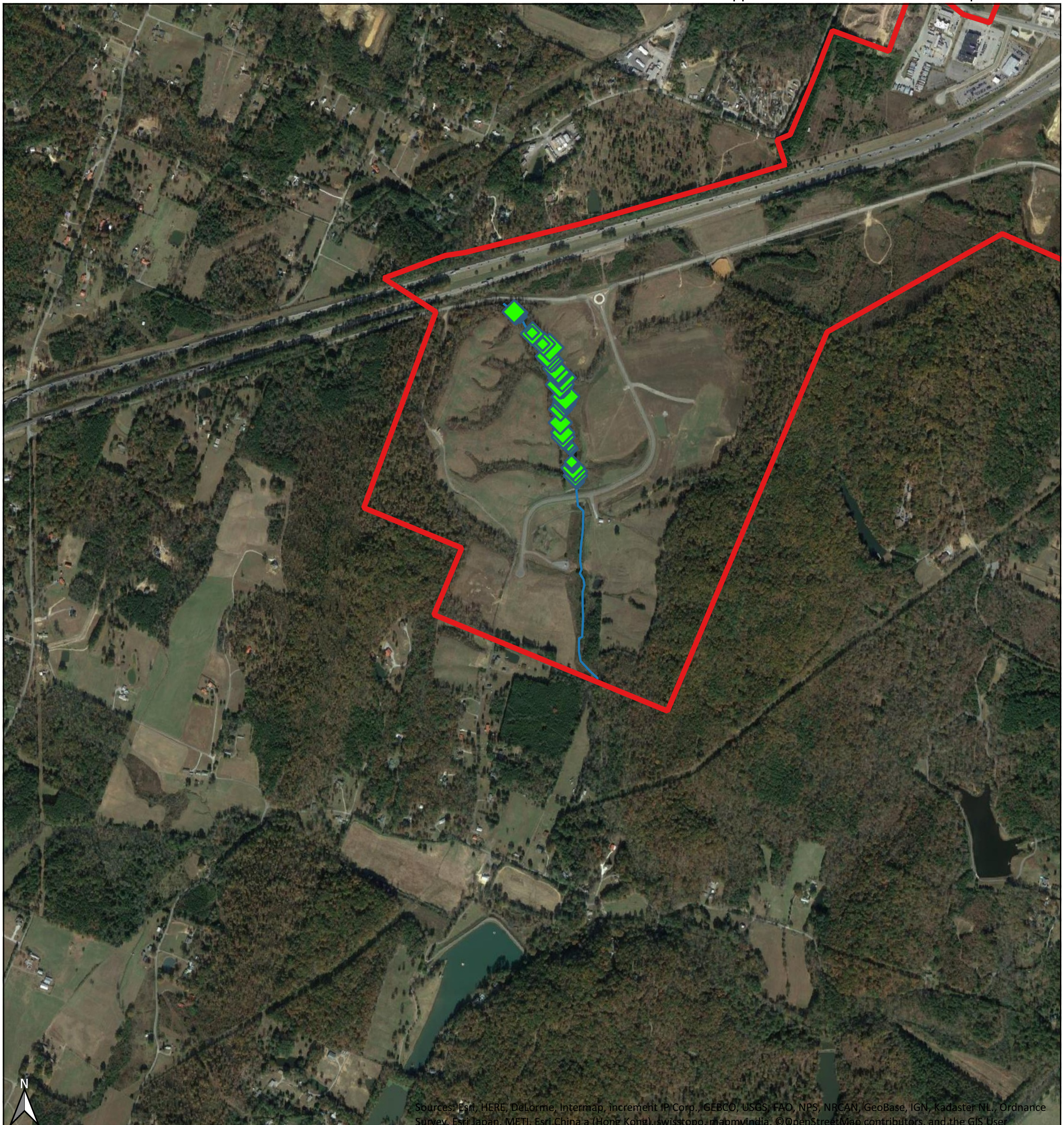
HDSS Sedimentation Discrete Point Features for Little South Mouse Creek: Map 11



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

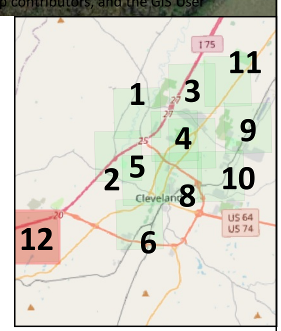
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- In Channel Bars
- Vegetated Islands
- In-Channel Vegetation
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Sedimentation Discrete Point Features for Spring Branch: Map 12



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km

0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

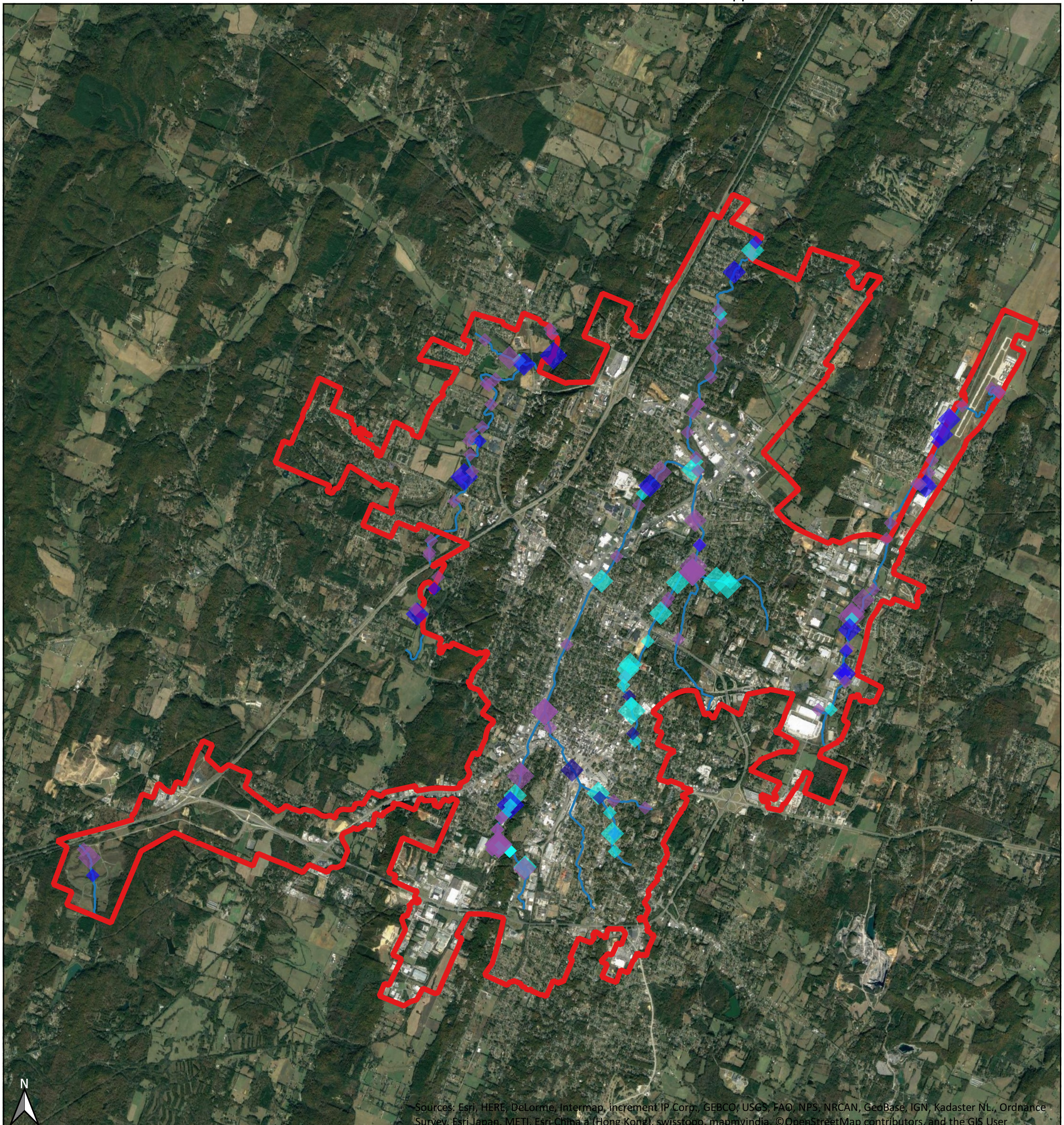
Appendix 4e:
Other Discrete Point Features

Example images of other discrete point feature categories commonly observed which includes in-coming channel (A), trash (B), livestock (C), construction on/near shore (D), large woody debris (E), debris jam (F), and fish barrier (G).

Appendix 4e:
Other Discrete Point Features

Other discrete point feature severity ranking criteria by category.

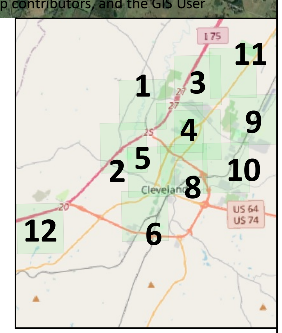
Discrete Feature		Parameter	Severity		
Type	Category		Minor	Moderate	Severe
General	Large Woody Debris	Number of pieces	< 3	> 3 but ≤ 7	> 8
	Debris/Log Jam	Width	≤ 90% of channel affected	100% of channel affected	
		Flow	Very limited flow	Highly restricted	
	Fish Barriers	Water velocity over barrier	Slow	Moderate	Fast
		Height of drop	< 4 inches	>4 but < 12 inches	> 12 inches
		Width	≤ 90% of channel affected	100% of channel affected	
	In-coming Channel	% of width of stream sampled	≤ 25%	> 25% but < 75%	≥ 75%
	Trash	Collection method	Community stream pickup	Small equipment or intense labor	Heavy machinery required
	Livestock	BMP implemented	In place and adequate	In place but inadequate	None implemented
	Construction in/near channel	Erosion control measures	In place and adequate	In place and inadequate	None
		Project size	Minor road or single house	Major road or commercial	



Legend

- Fish Barrier
- In-comming Channel
- Debris Jam
- Fence
- City Boundary
- Stream
- Severe
- Moderate
- Minor

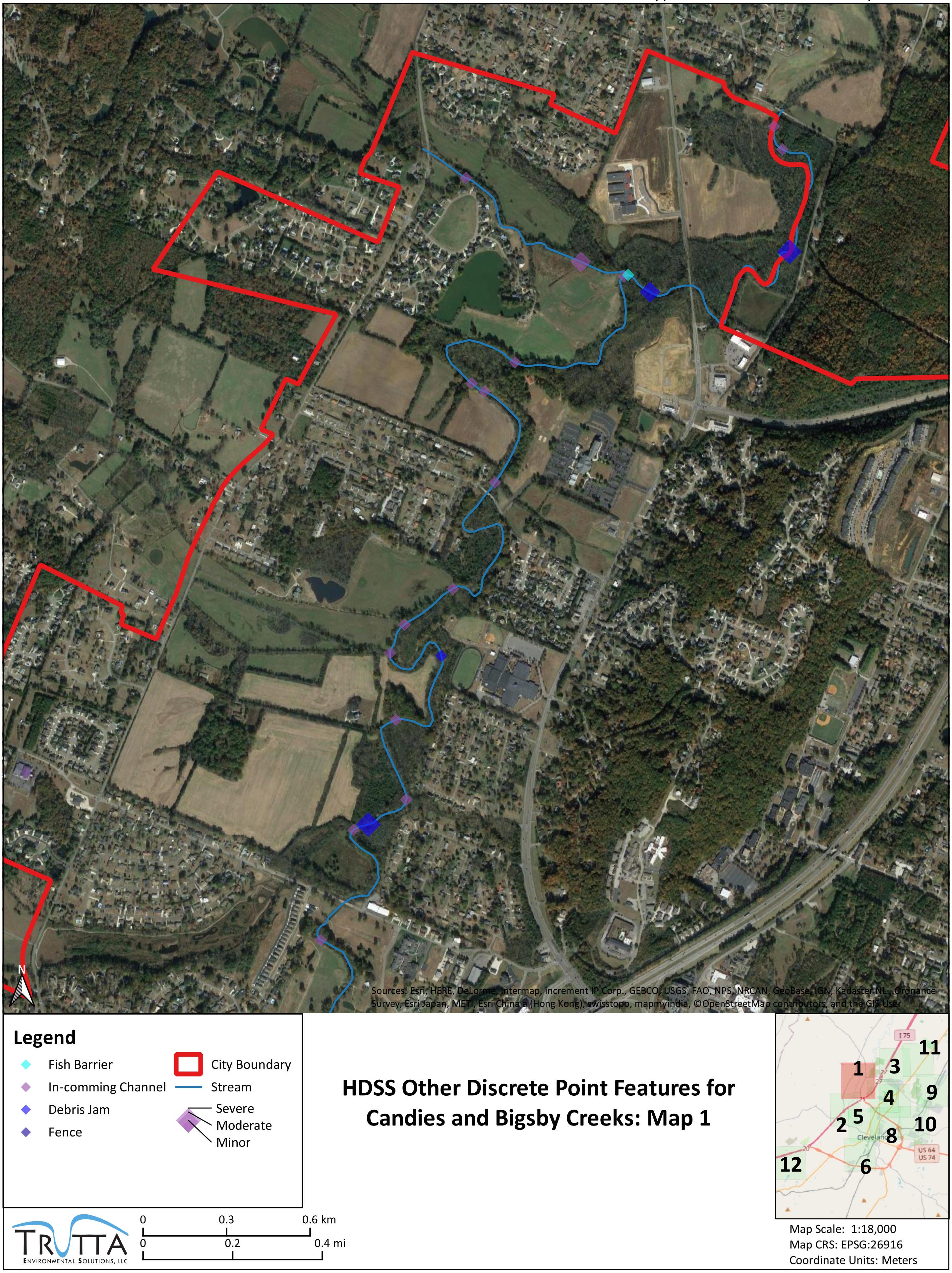
HDSS Other Discrete Point Features for Cleveland, TN

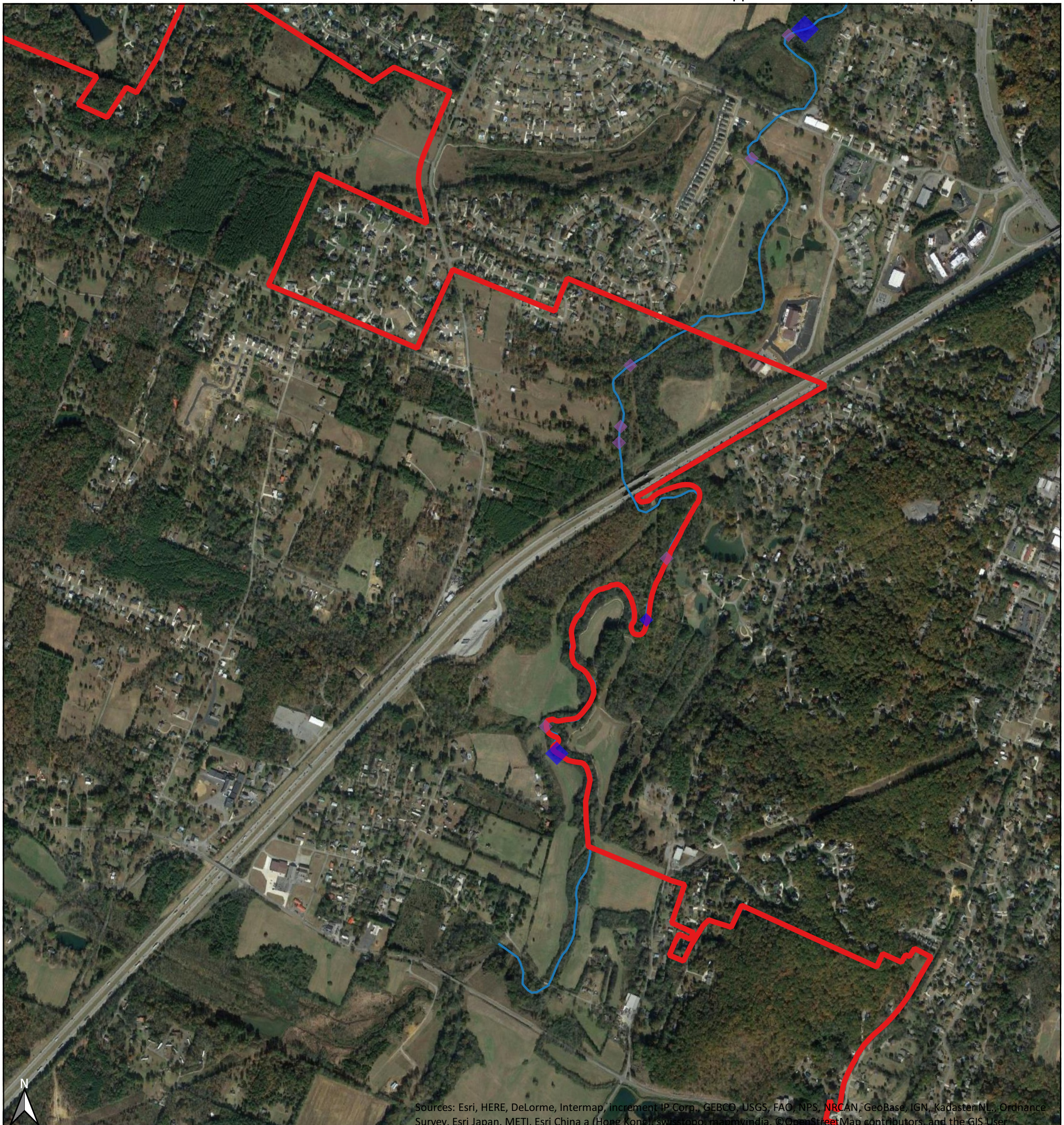


TRUTTA Environmental Solutions, LLC

0 1 2 km
0 1 2 mi

Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters

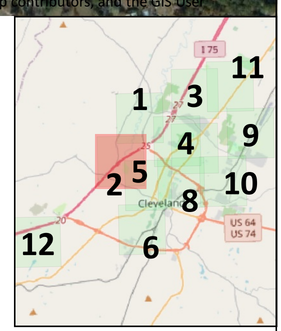

N
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, mapmyindia, © OpenStreetMap contributors, and the GIS User
Legend
Fish Barrier
In-comming Channel
Debris Jam
Fence
City Boundary
Stream
Severe
Moderate
Minor
HDSS Other Discrete Point Features for Candies and Bigsby Creeks: Map 1
1
2
3
4
5
6
8
9
10
11
12
Cleveland
0
0.3
0.6 km
0
0.2
0.4 mi
TRUTTA ENVIRONMENTAL SOLUTIONS, LLC
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fish Barrier
- In-comming Channel
- Debris Jam
- Fence
- City Boundary
- Stream
- Severe
- Moderate
- Minor

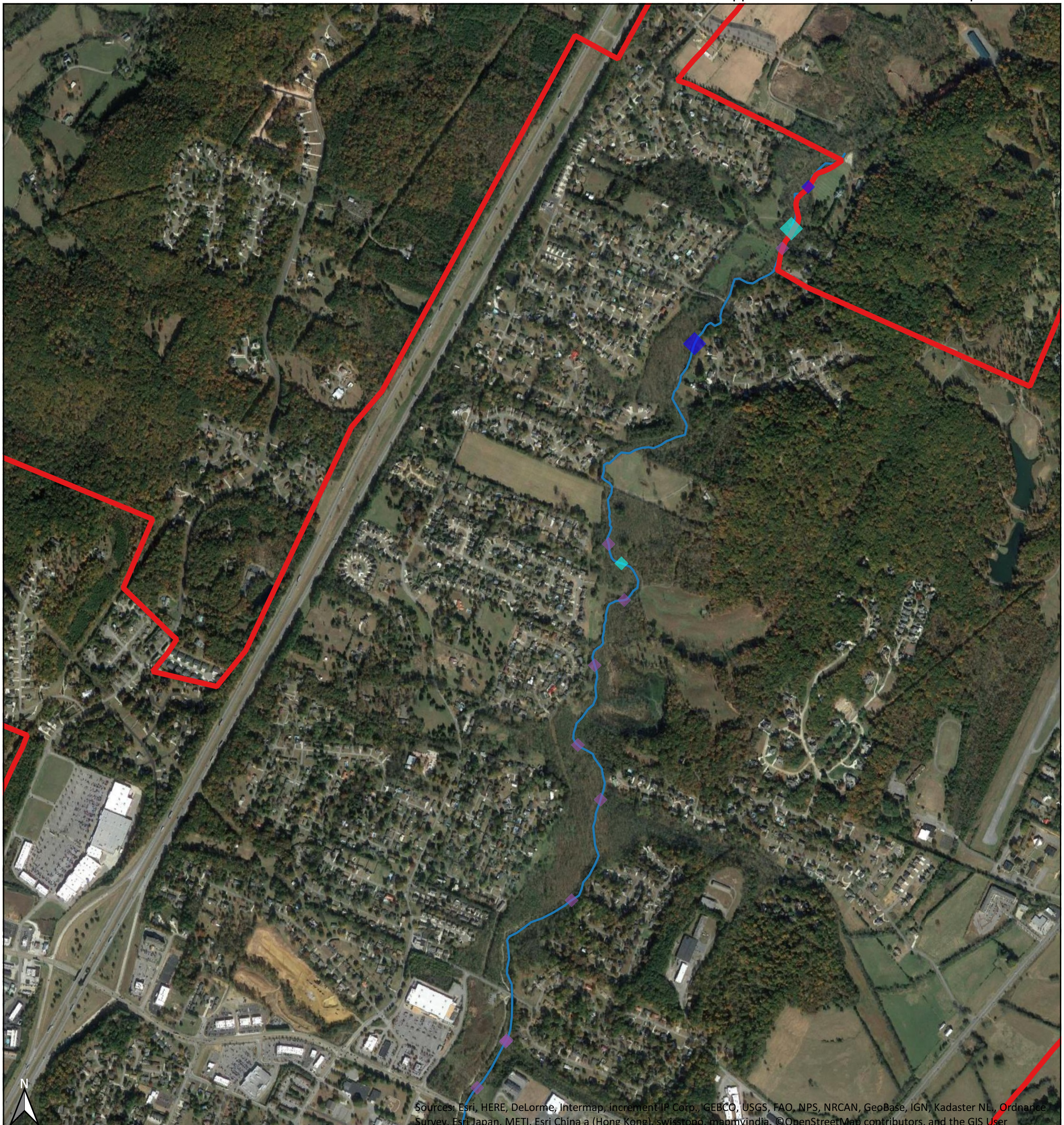
HDSS Other Discrete Point Features for Candies Creek: Map 2



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

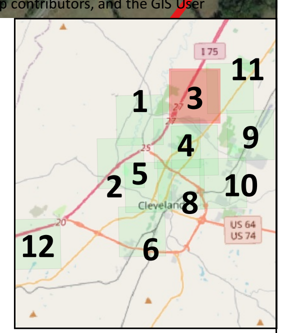
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fish Barrier
- In-comming Channel
- Debris Jam
- Fence
- City Boundary
- Stream
- Severe
- Moderate
- Minor

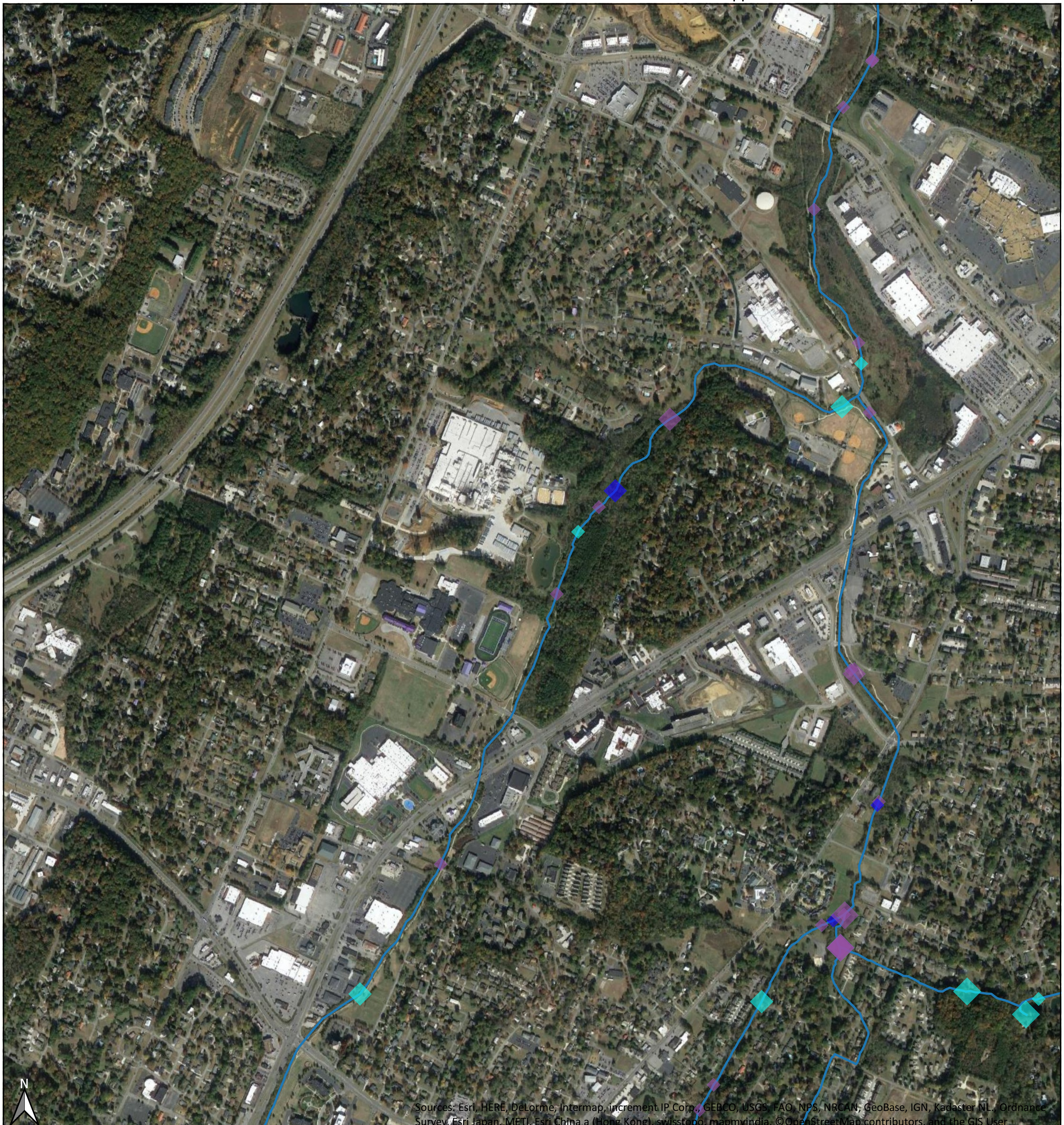
HDSS Other Discrete Point Features for South Mouse Creek: Map 3



0 0.3 0.6 km

0 0.2 0.4 mi

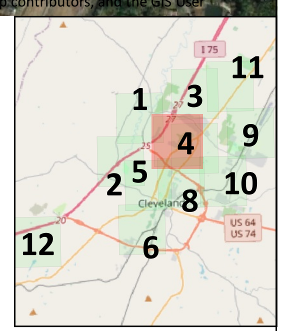
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fish Barrier
- In-comming Channel
- Debris Jam
- Fence
- City Boundary
- Stream
- Severe
- Moderate
- Minor

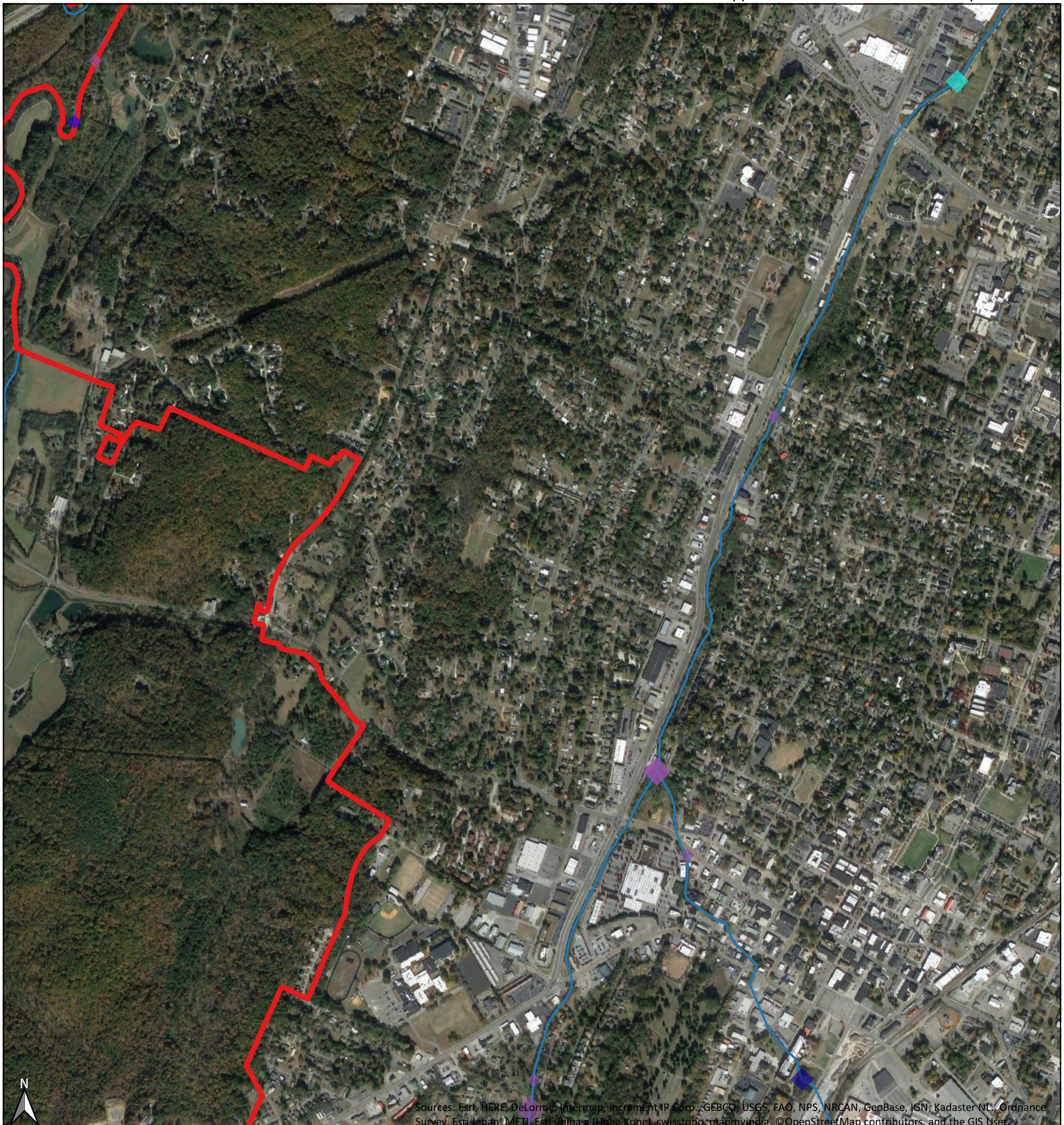
HDSS Other Discrete Point Features for South Mouse Creek: Map 4



0 0.3 0.6 km

0 0.2 0.4 mi

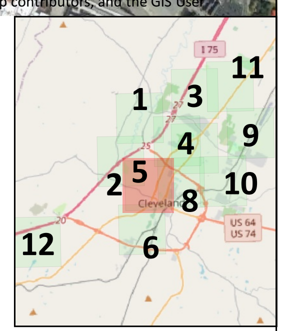
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fish Barrier
- In-comming Channel
- Debris Jam
- Fence
- City Boundary
- Stream
- Severe
- Moderate
- Minor

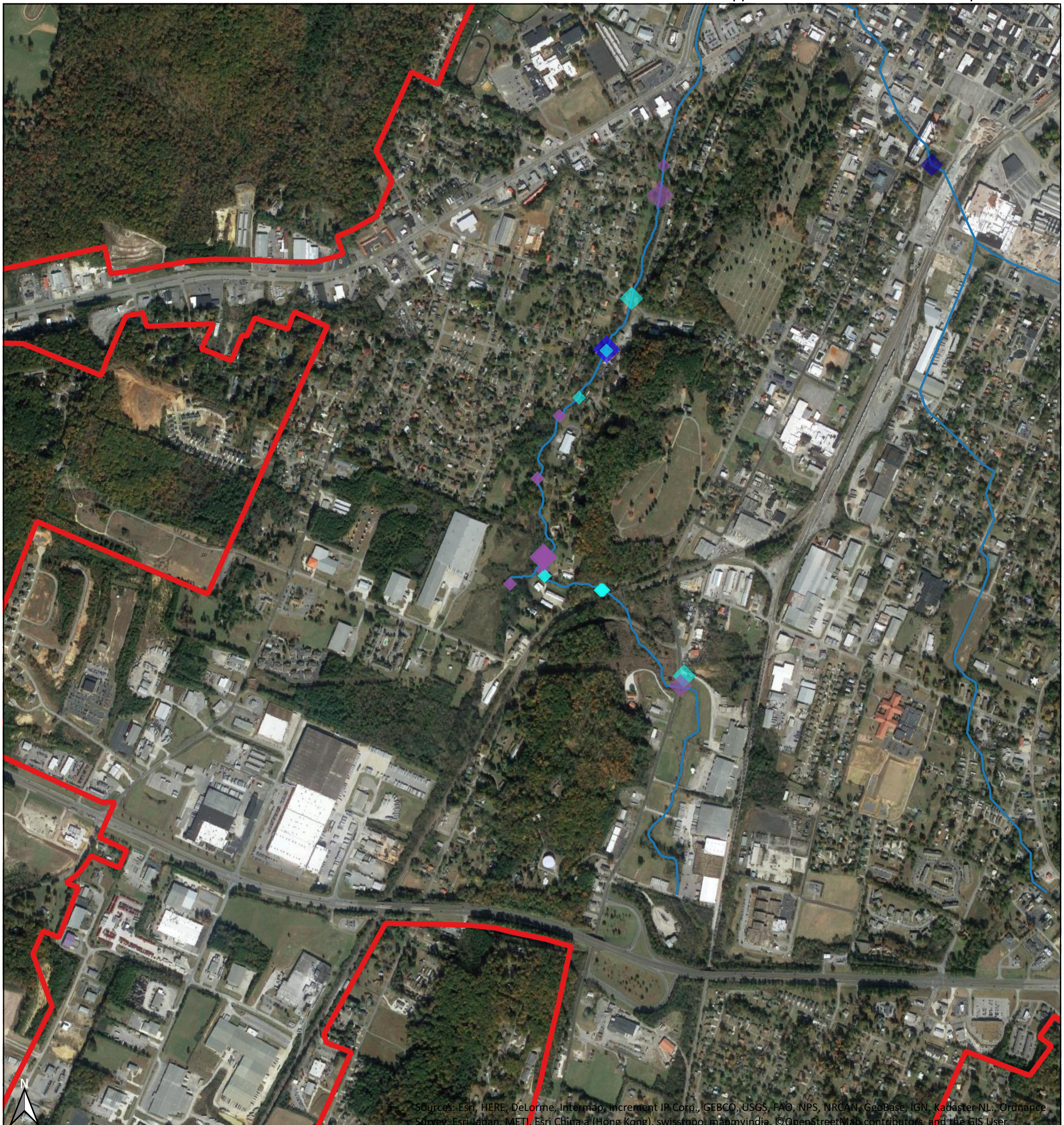
HDSS Other Discrete Point Features for South Mouse Creek & Woolen Mill Branch: Map 5



0 0.3 0.6 km

0 0.2 0.4 mi

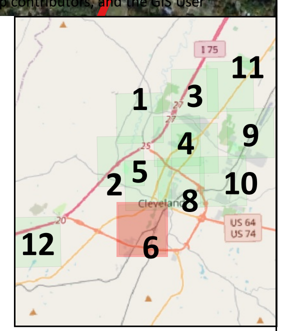
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fish Barrier
- In-comming Channel
- Debris Jam
- Fence
- City Boundary
- Stream
- Severe
- Moderate
- Minor

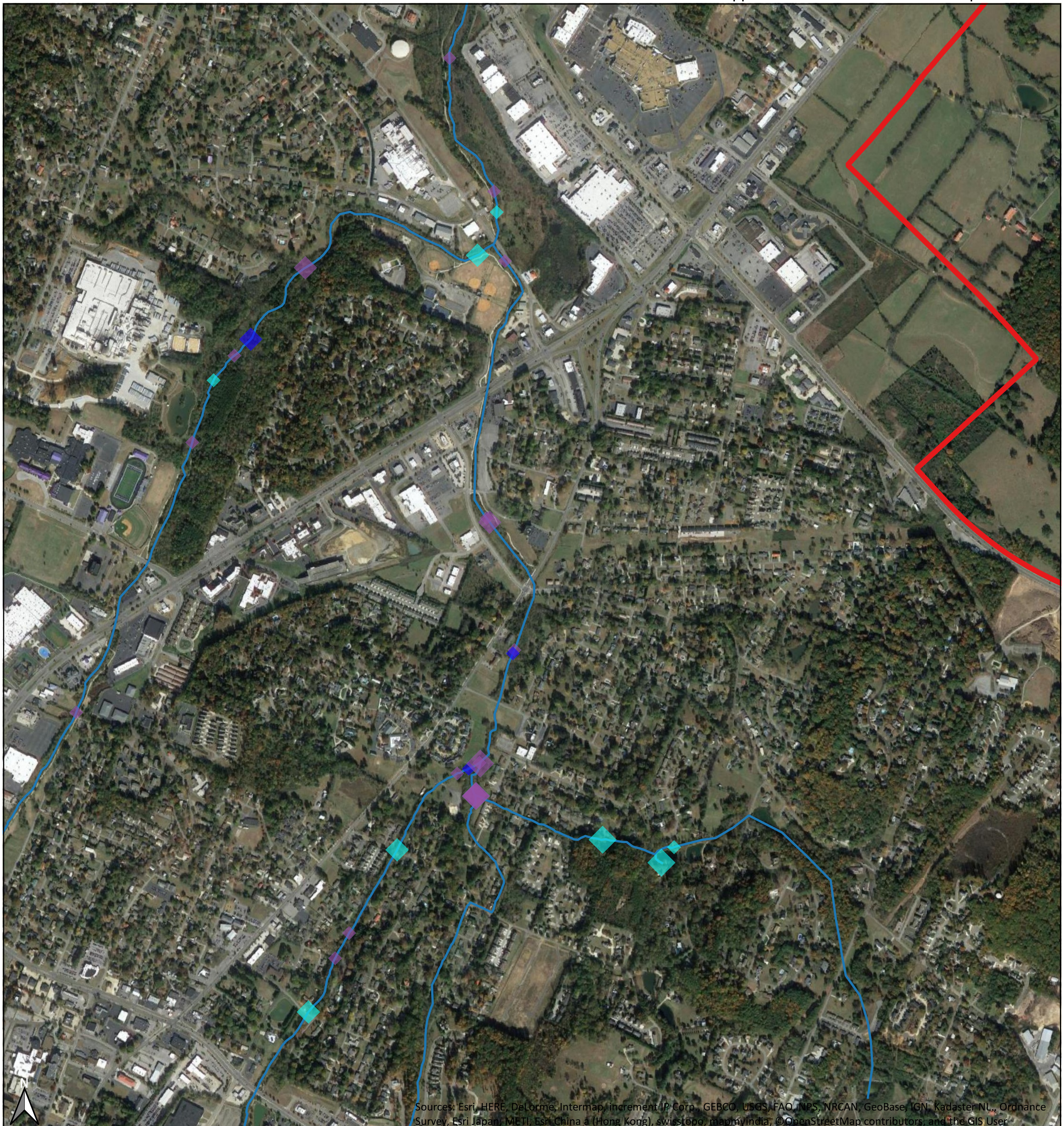
HDSS Other Discrete Point Features for South Mouse Creek: Map 6



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

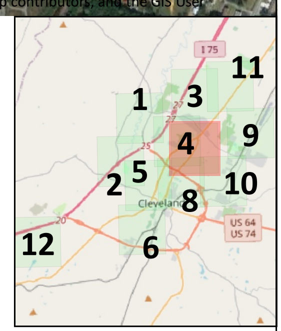
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fish Barrier
- In-comming Channel
- Debris Jam
- Fence
- City Boundary
- Stream
- Severe
- Moderate
- Minor

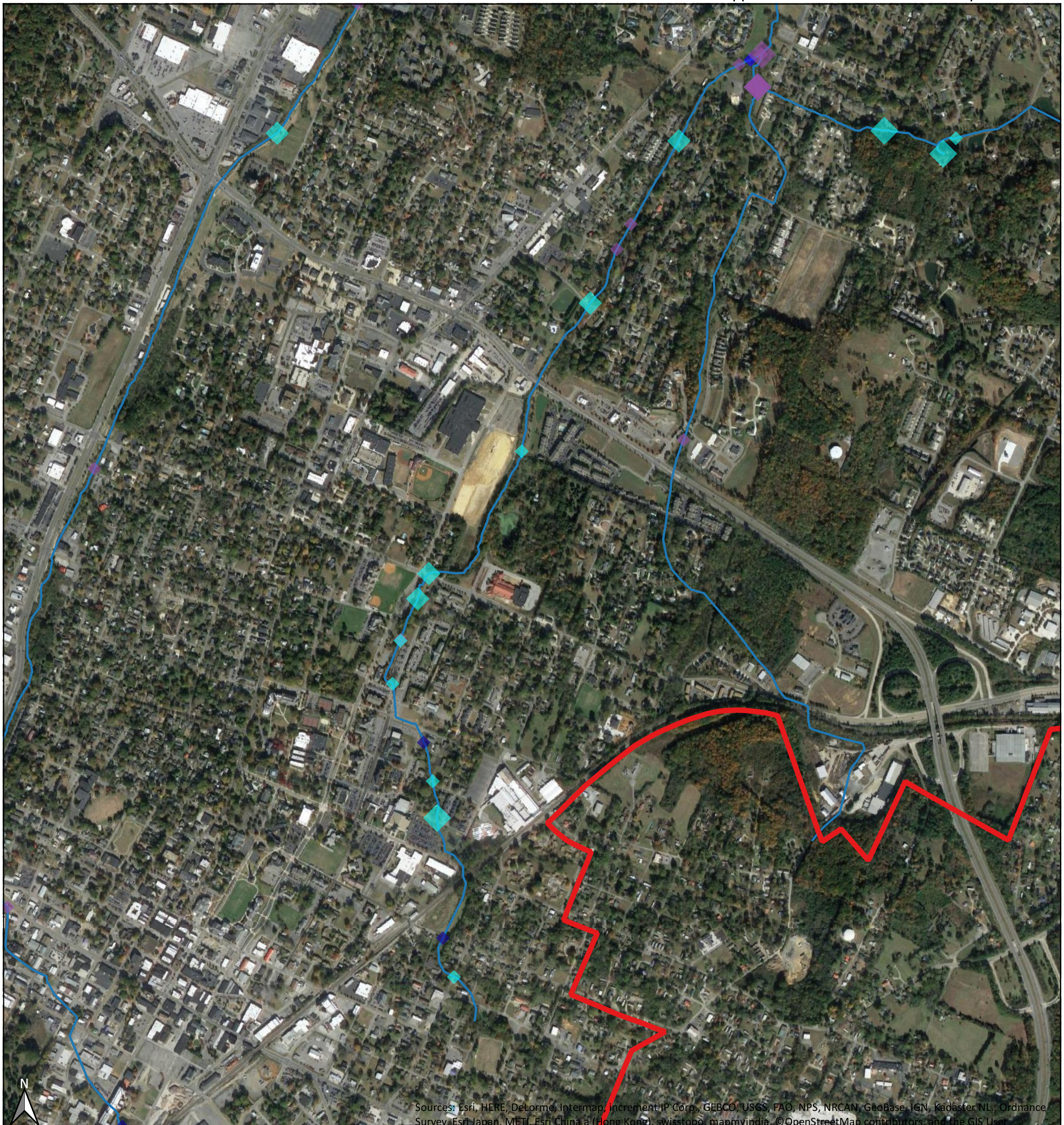
HDSS Other Discrete Point Features for Fillauer Creek: Map 7



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

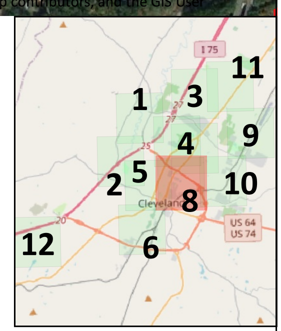
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fish Barrier
- In-comming Channel
- Debris Jam
- Fence
- City Boundary
- Stream
- Severe / Moderate / Minor

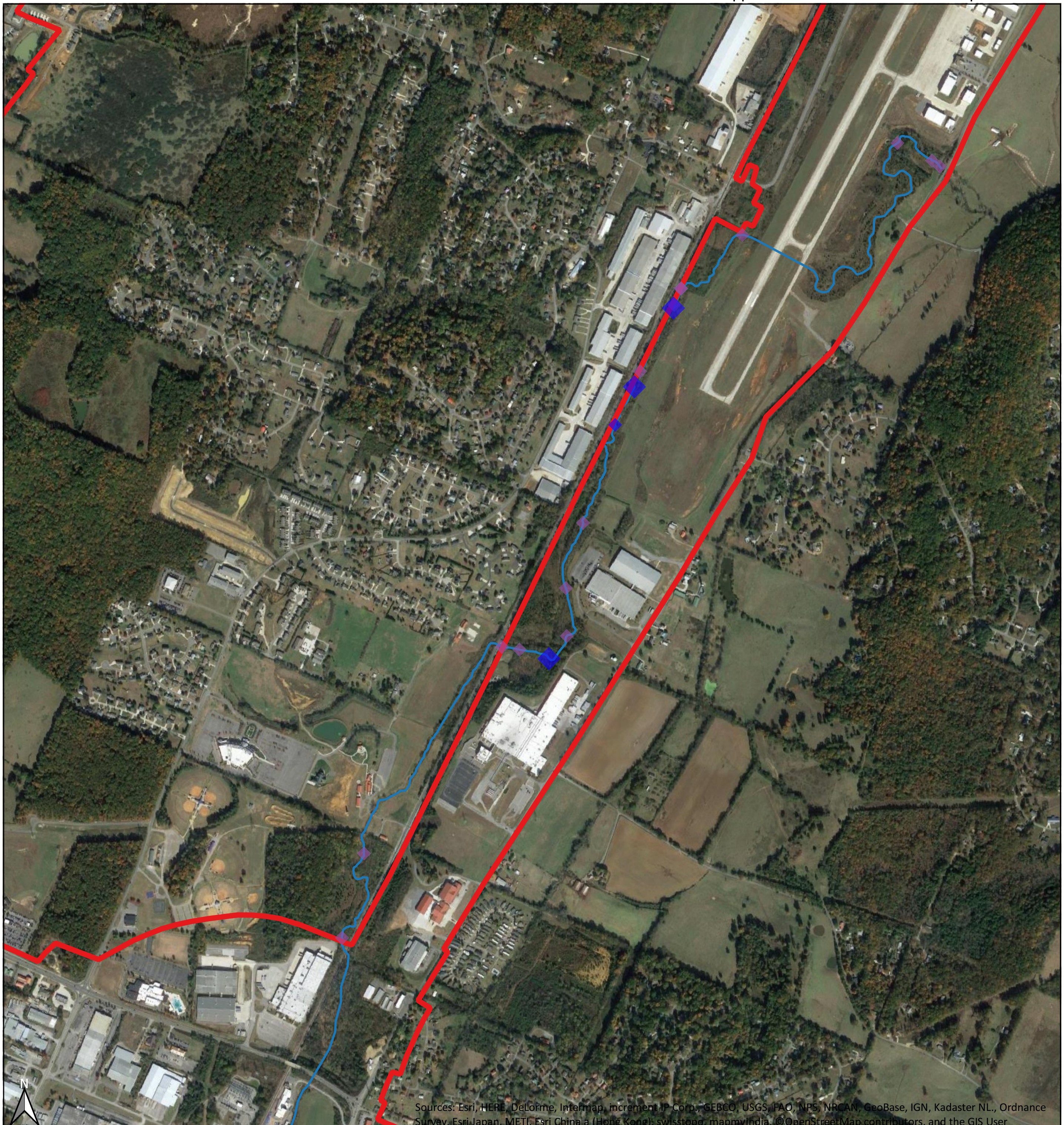
HDSS Other Discrete Point Features for Fillauer Creek: Map 8



0 0.3 0.6 km
0 0.2 0.4 mi

TRUTTA Environmental Solutions, LLC

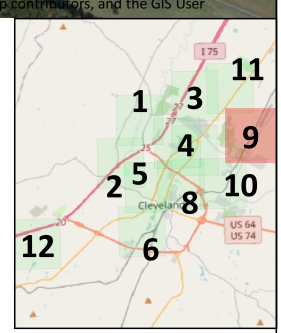
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fish Barrier
- In-comming Channel
- Debris Jam
- Fence
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Other Discrete Point Features for Little Chatata Creek: Map 9

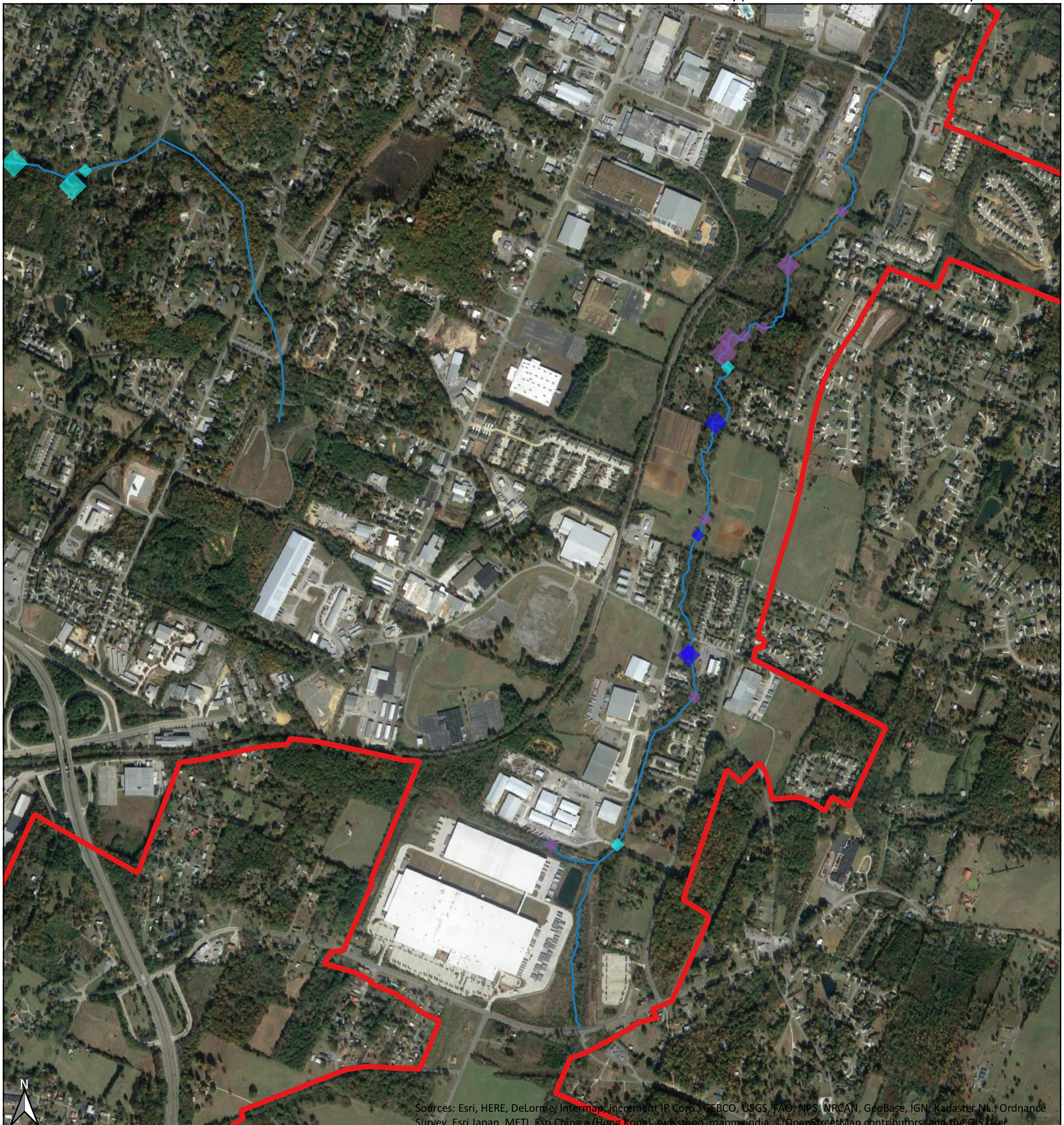


TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km

0 0.2 0.4 mi

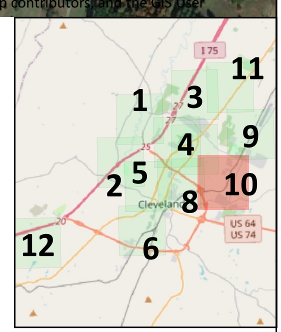
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fish Barrier
- In-comming Channel
- Debris Jam
- Fence
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Other Discrete Point Features for Little Chatata Creek: Map 10



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

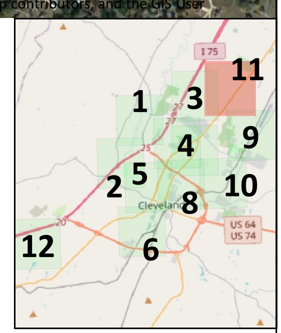
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Fish Barrier
- In-comming Channel
- Debris Jam
- Fence
- City Boundary
- Stream
- Severe
- Moderate
- Minor

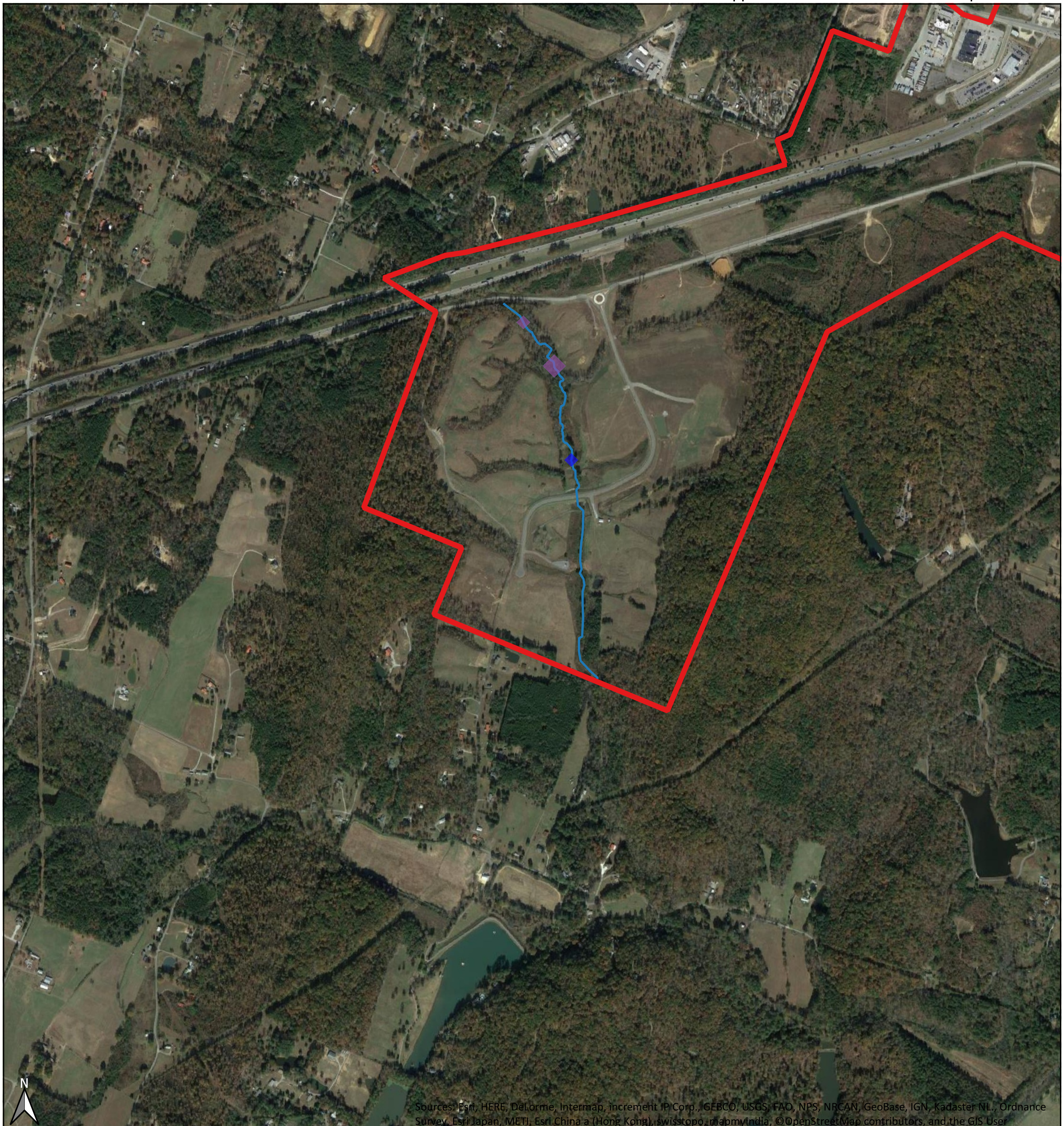
HDSS Other Discrete Point Features for Little South Mouse Creek: Map 11



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

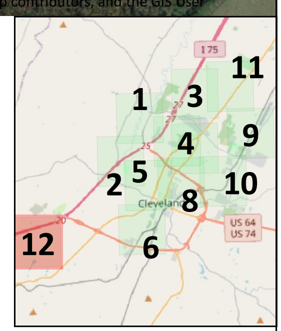
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fish Barrier
- In-comming Channel
- Debris Jam
- Fence
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Other Discrete Point Features for Spring Branch: Map 12



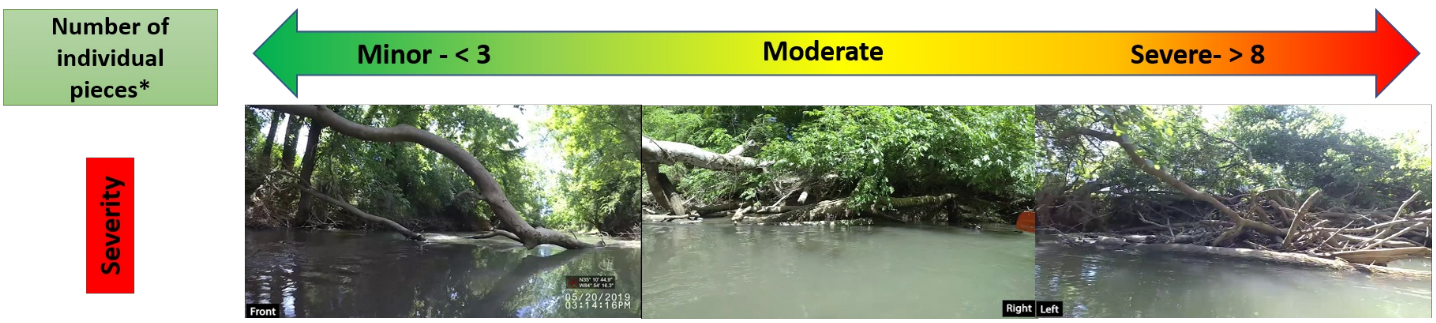
TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

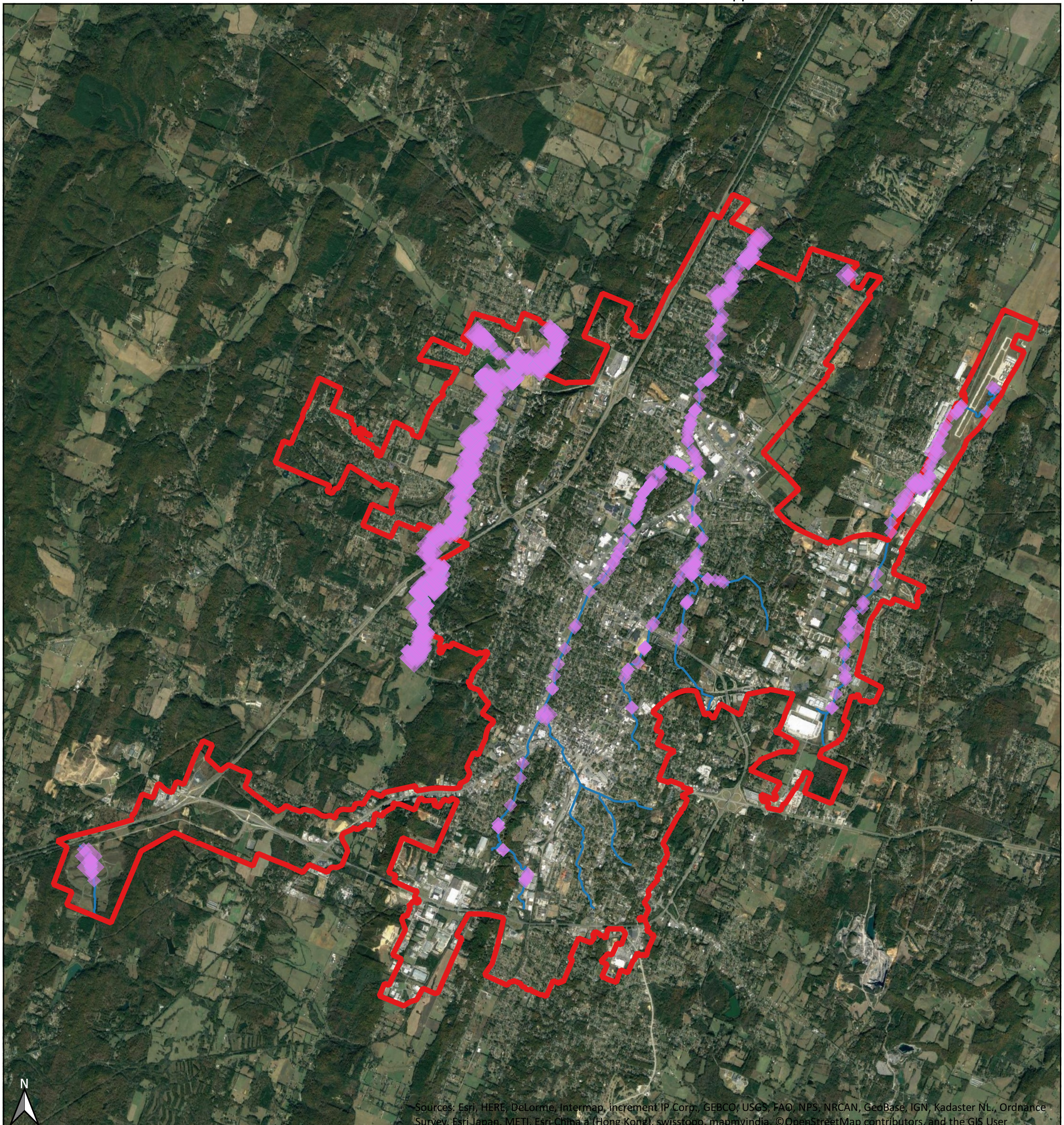
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Appendix 4f:
Large Woody Debris Discrete Point Features

Due to the large amount of large woody debris, an individual set of maps were generated to help understand area of concern.

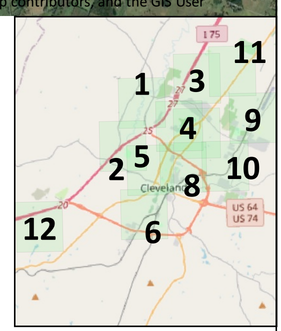




Legend

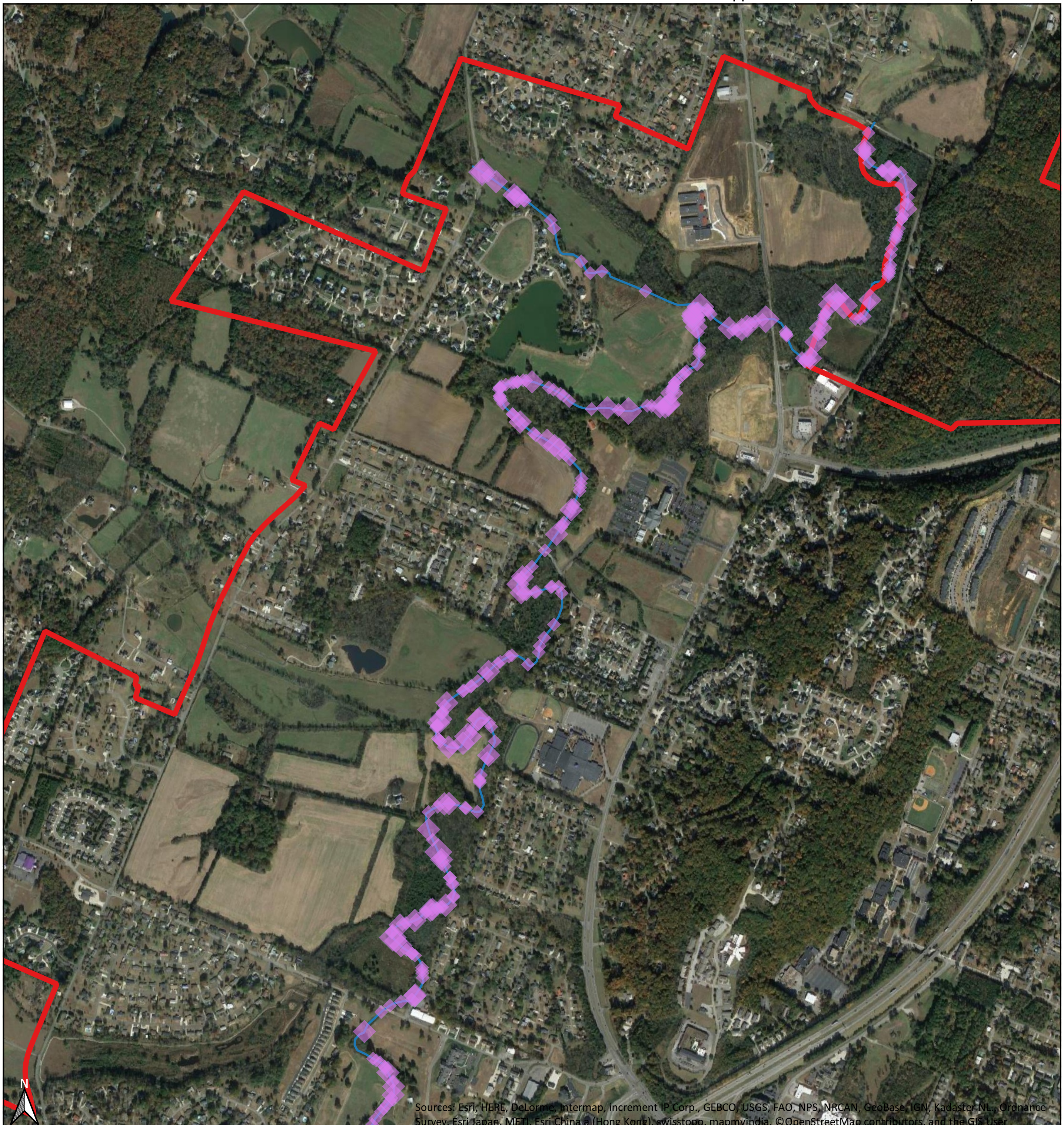
- Large Woody Debris
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Large Woody Debris Features for Cleveland, TN



0 1 2 km
0 1 2 mi

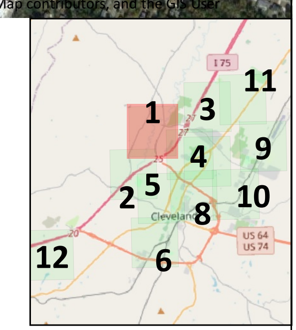
Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

Large Woody Debris
City Boundary
Stream
Severe
Moderate
Minor

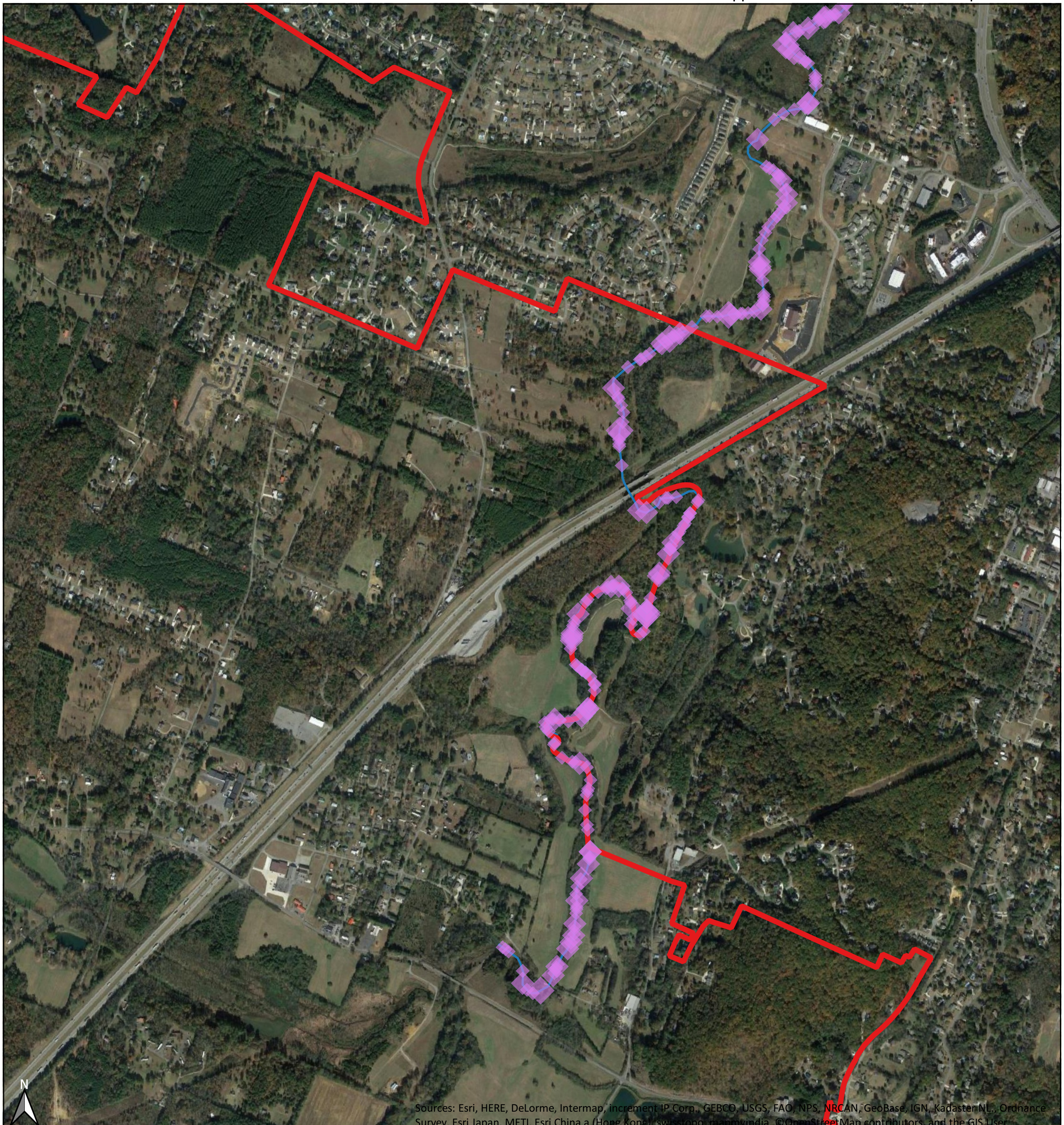
HDSS Large Woody Debris Discrete Point Features for Candies and Bigsby Creeks: Map 1



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

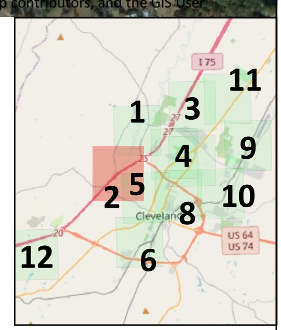
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Large Woody Debris
- City Boundary
- Stream
- Severe
- Moderate
- Minor

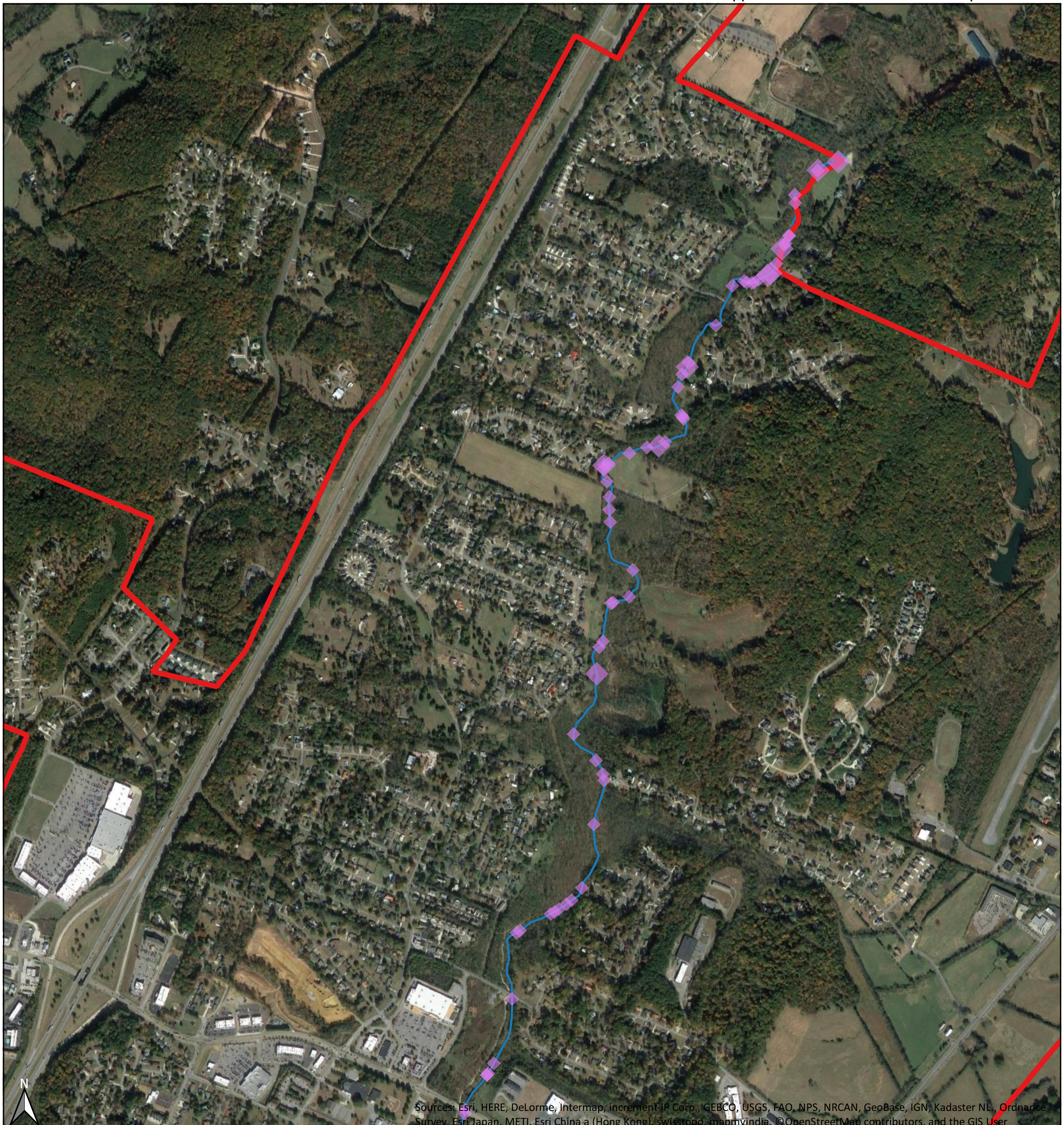
HDSS Large Woody Debris Discrete Point Features for Candies Creek: Map 2



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

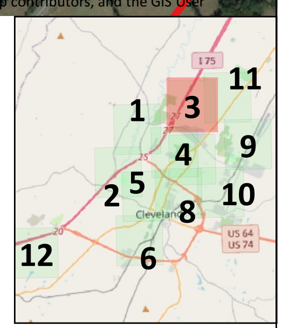
Large Woody Debris

City Boundary

Stream

Severe
Moderate
Minor

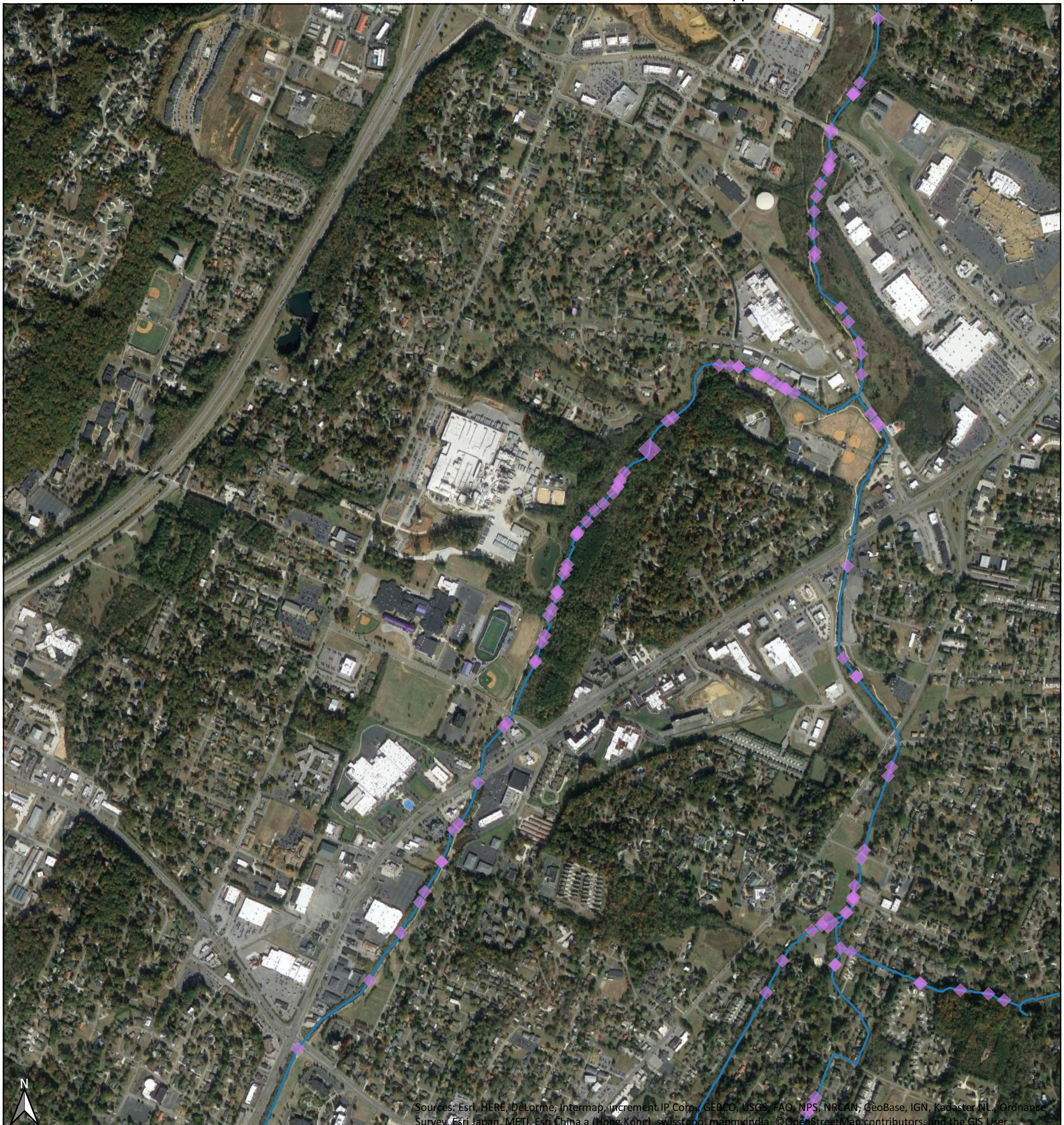
HDSS Large Woody Debris Discrete Point Features for South Mouse Creek: Map 3



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

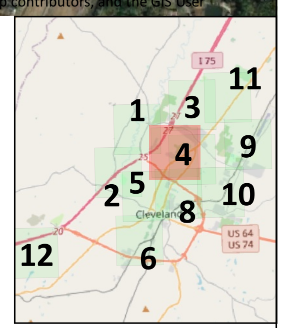
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Large Woody Debris
- City Boundary
- Stream
- Severe
- Moderate
- Minor

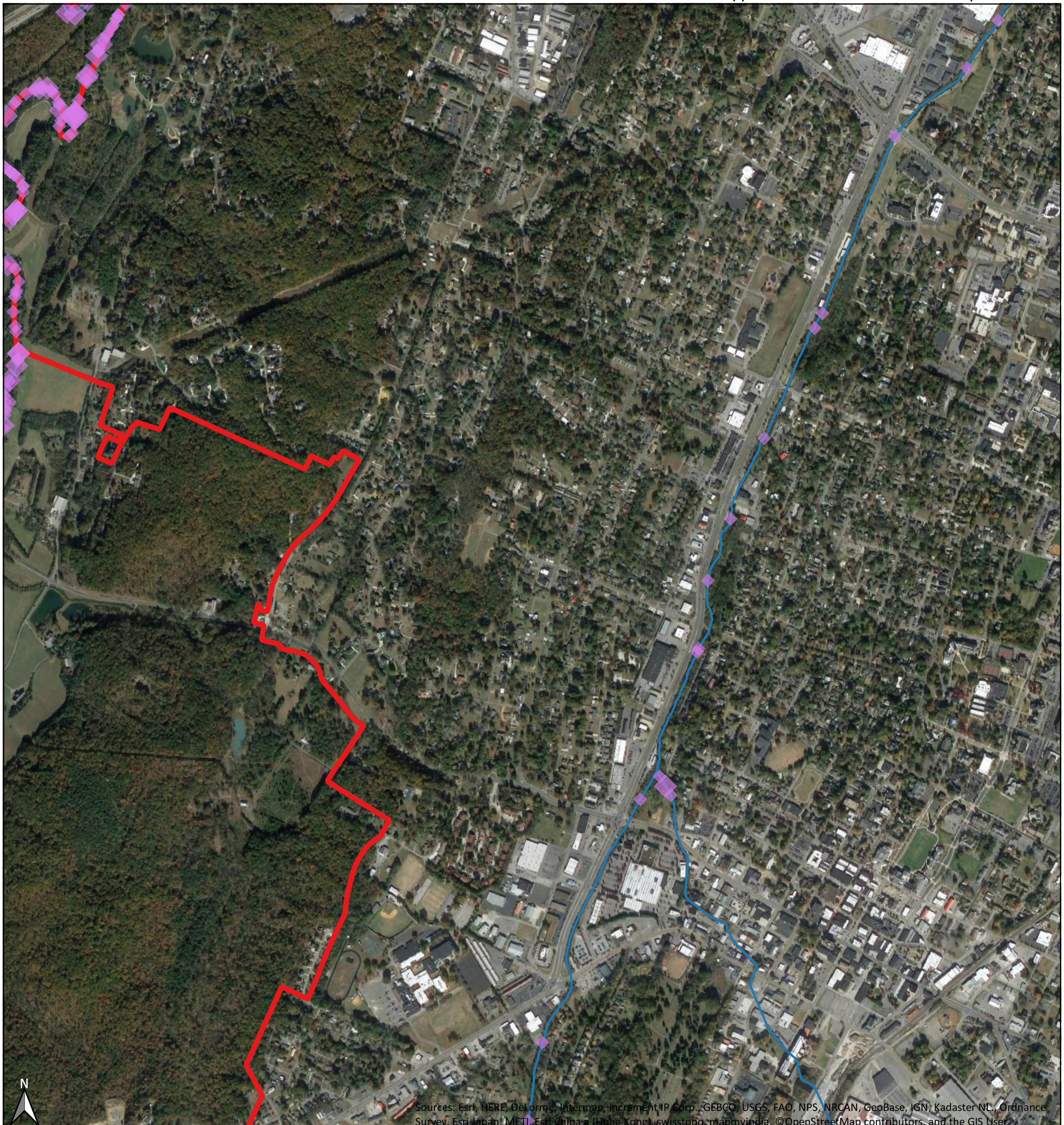
HDSS Large Woody Debris Discrete Point Features for South Mouse Creek: Map 4



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

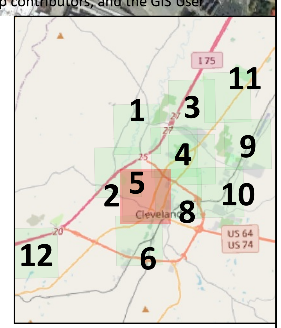
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Large Woody Debris
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Large Woody Debris Discrete Point Features for South Mouse Creek & Woolen Mill Branch: Map 5



TRUTTA Environmental Solutions, LLC

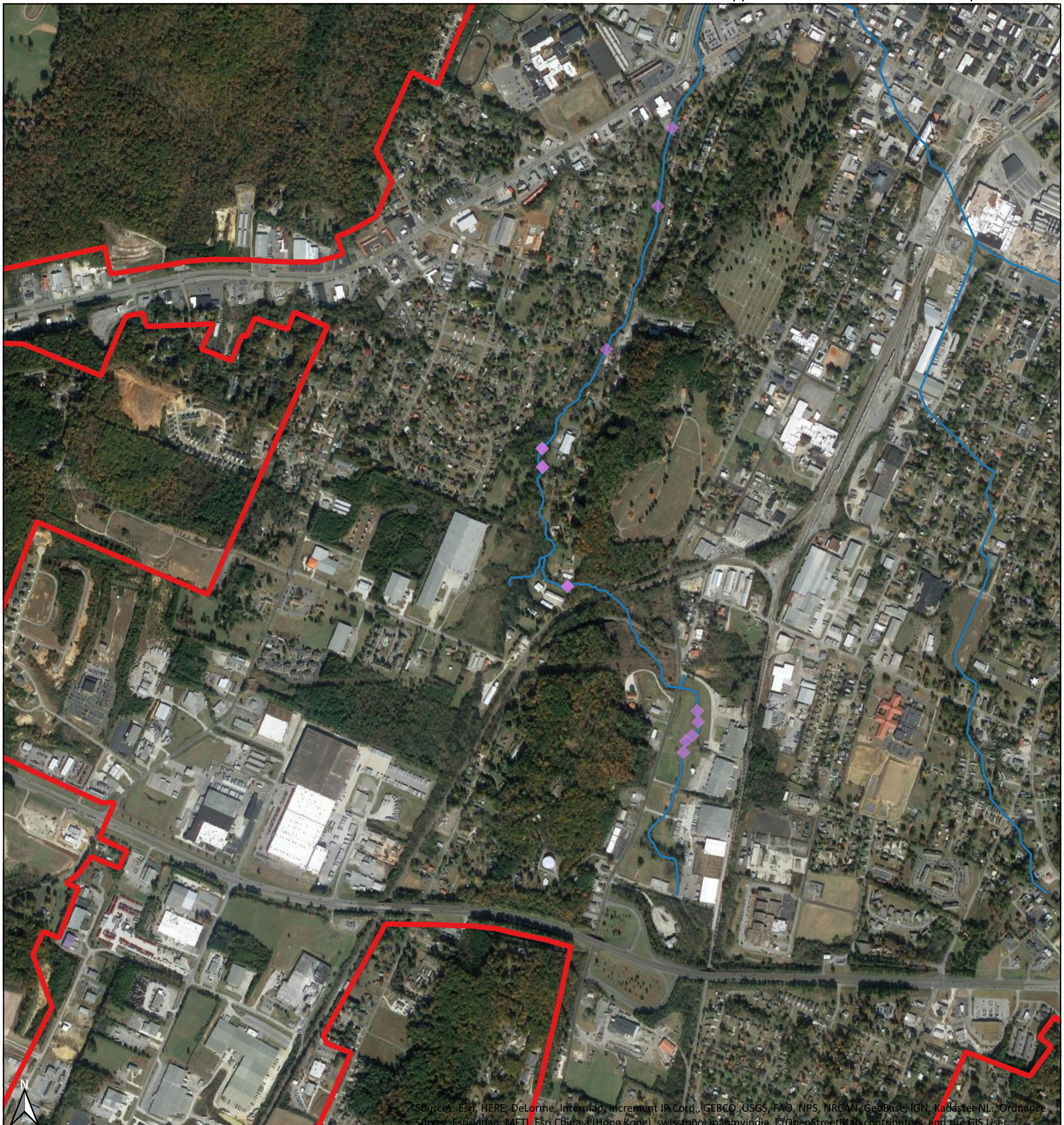
0 0.3 0.6 km

0 0.2 0.4 mi

Map Scale: 1:18,000

Map CRS: EPSG:26916

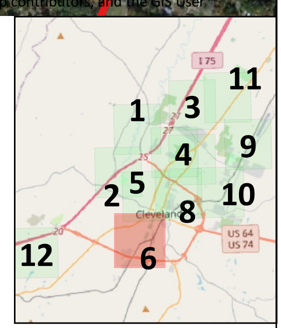
Coordinate Units: Meters



Legend

Large Woody Debris
City Boundary
Stream
Severe
Moderate
Minor

HDSS Large Woody Debris Discrete Point Features for South Mouse Creek: Map 6



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

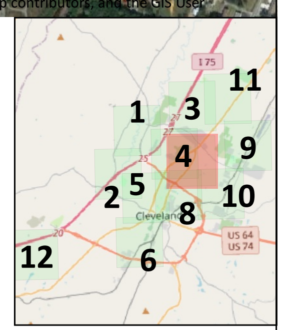
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Large Woody Debris
- City Boundary
- Stream
- Severe
- Moderate
- Minor

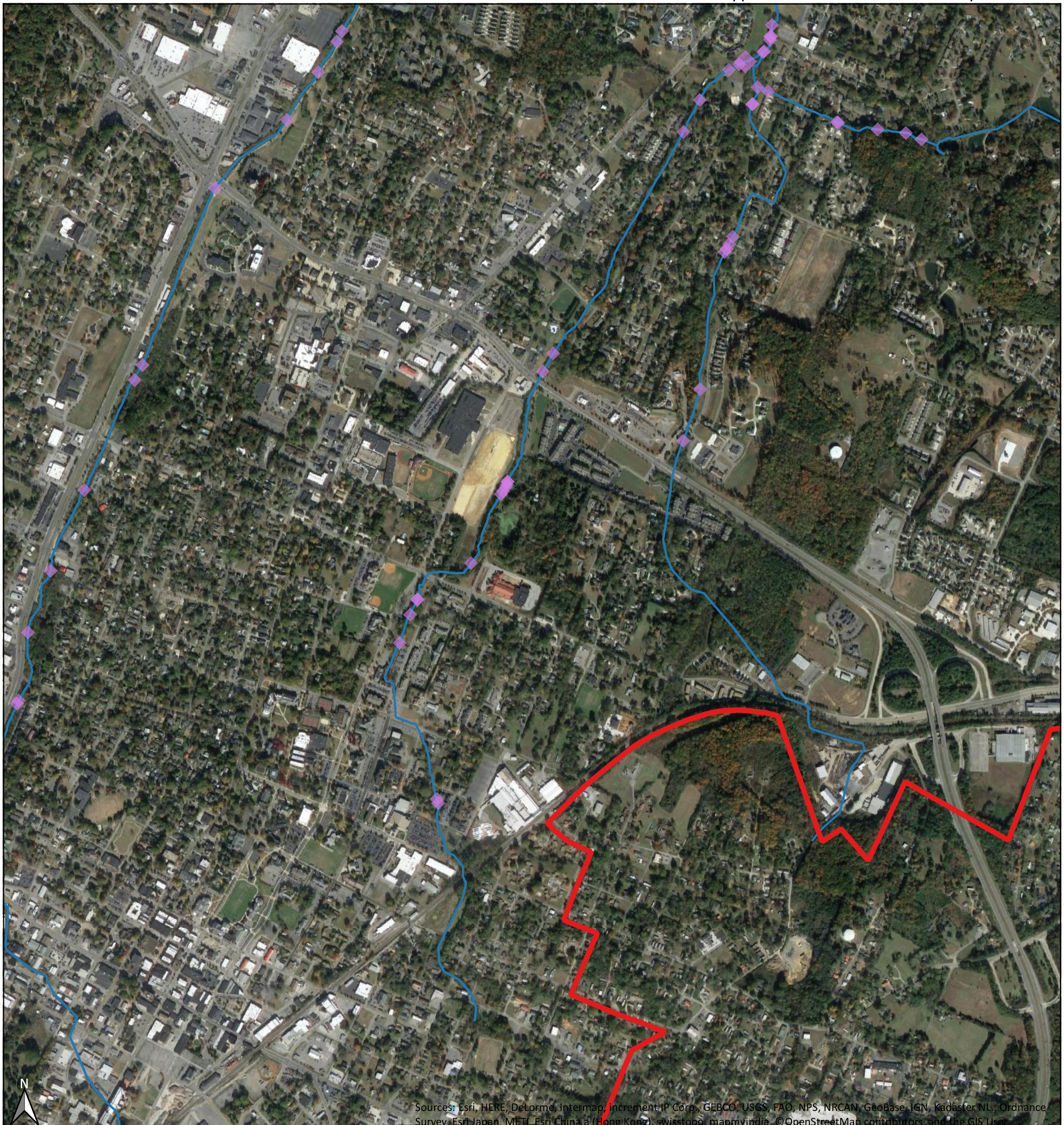
HDSS Large Woody Debris Discrete Point Features for Fillauer Creek: Map 7



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

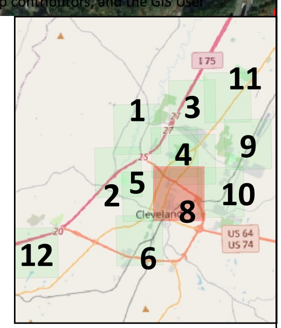
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Large Woody Debris
- City Boundary
- Stream
- Severe
- Moderate
- Minor

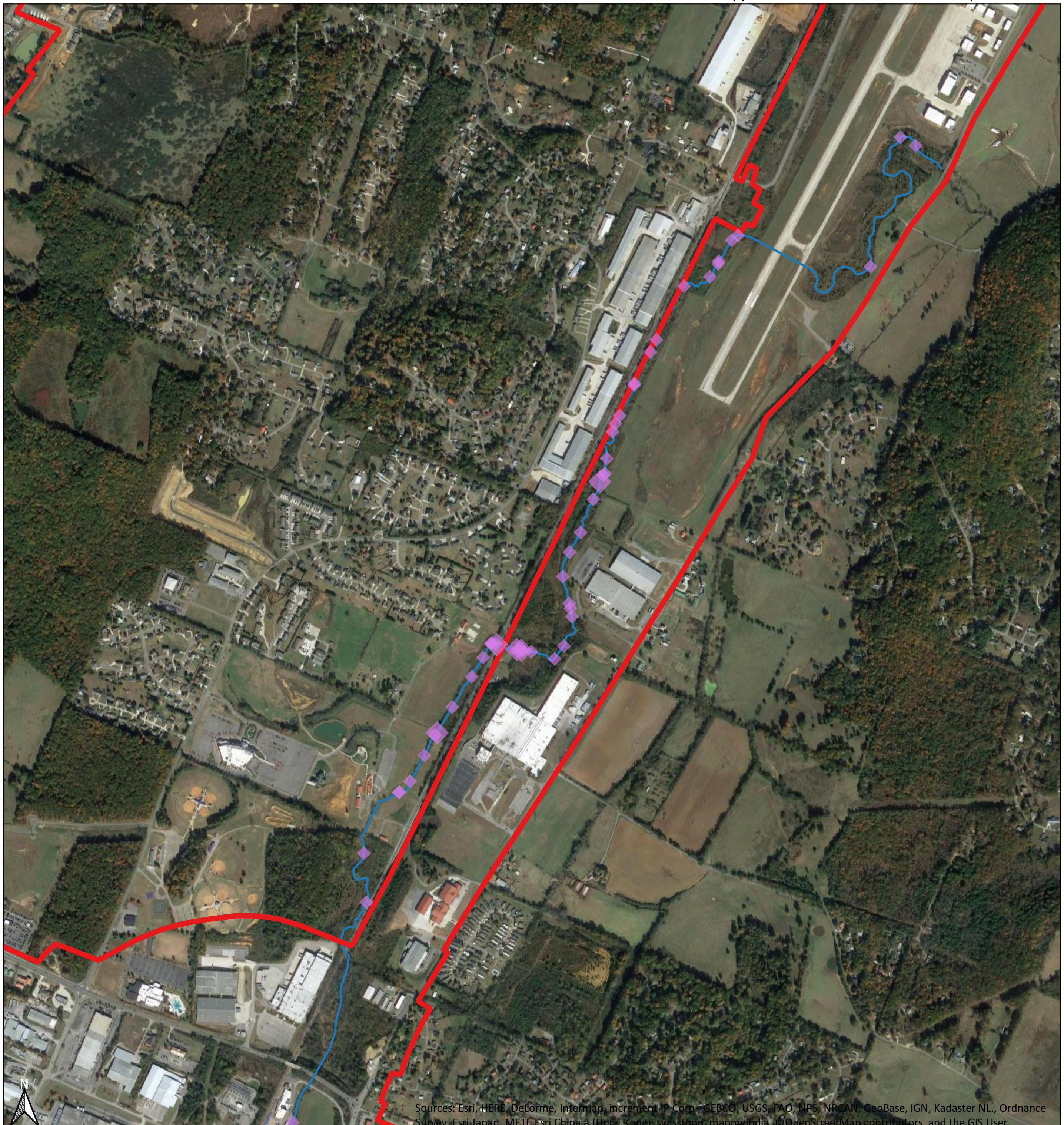
HDSS Large Woody Debris Discrete Point Features for Fillauer Creek: Map 8



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

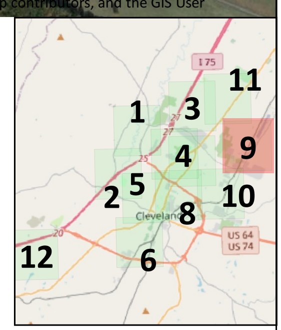
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Large Woody Debris
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Large Woody Debris Discrete Point Features for Little Chatata Creek: Map 9



TRUTTA Environmental Solutions, LLC

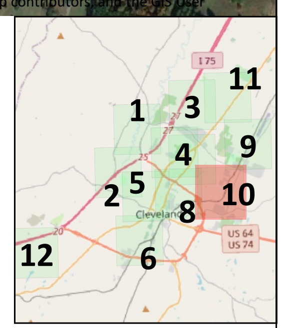
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

Large Woody Debris
City Boundary
Stream
Severe
Moderate
Minor

HDSS Large Woody Debris Discrete Point Features for Little Chatata Creek: Map 10



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

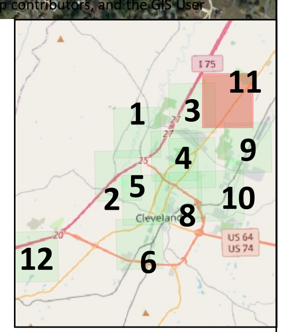
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Large Woody Debris
- City Boundary
- Stream
- Severe / Moderate / Minor

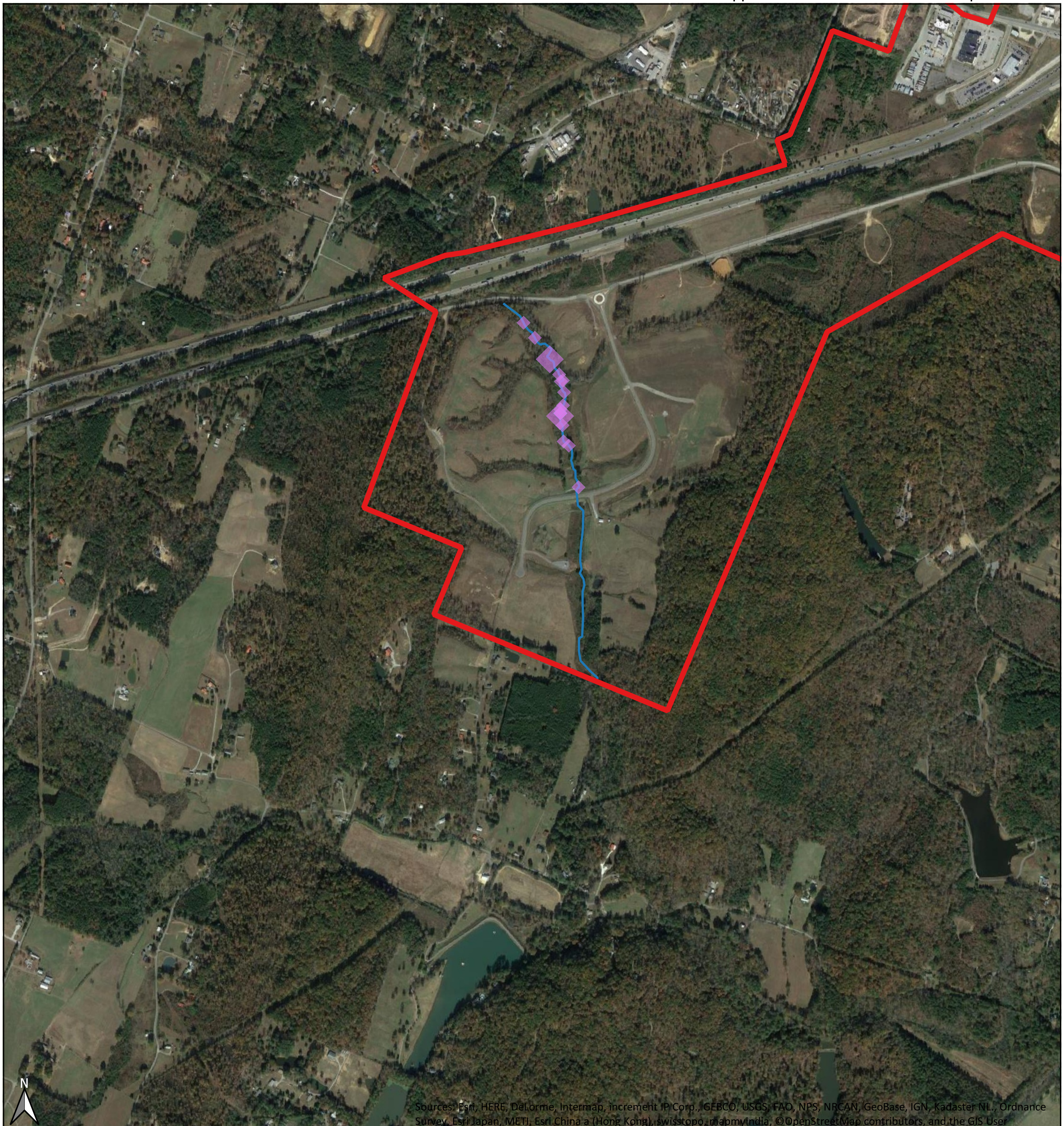
HDSS Large Woody Debris Discrete Point Features for Little South Mouse Creek: Map 11



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

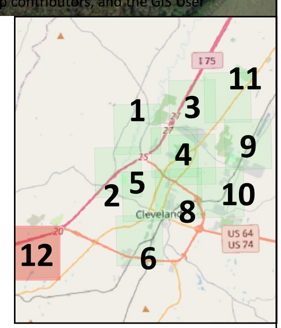
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Large Woody Debris
- City Boundary
- Stream
- Severe
- Moderate
- Minor

HDSS Large Woody Debris Discrete Point Features for Spring Branch: Map 12



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

End of Appendix 4

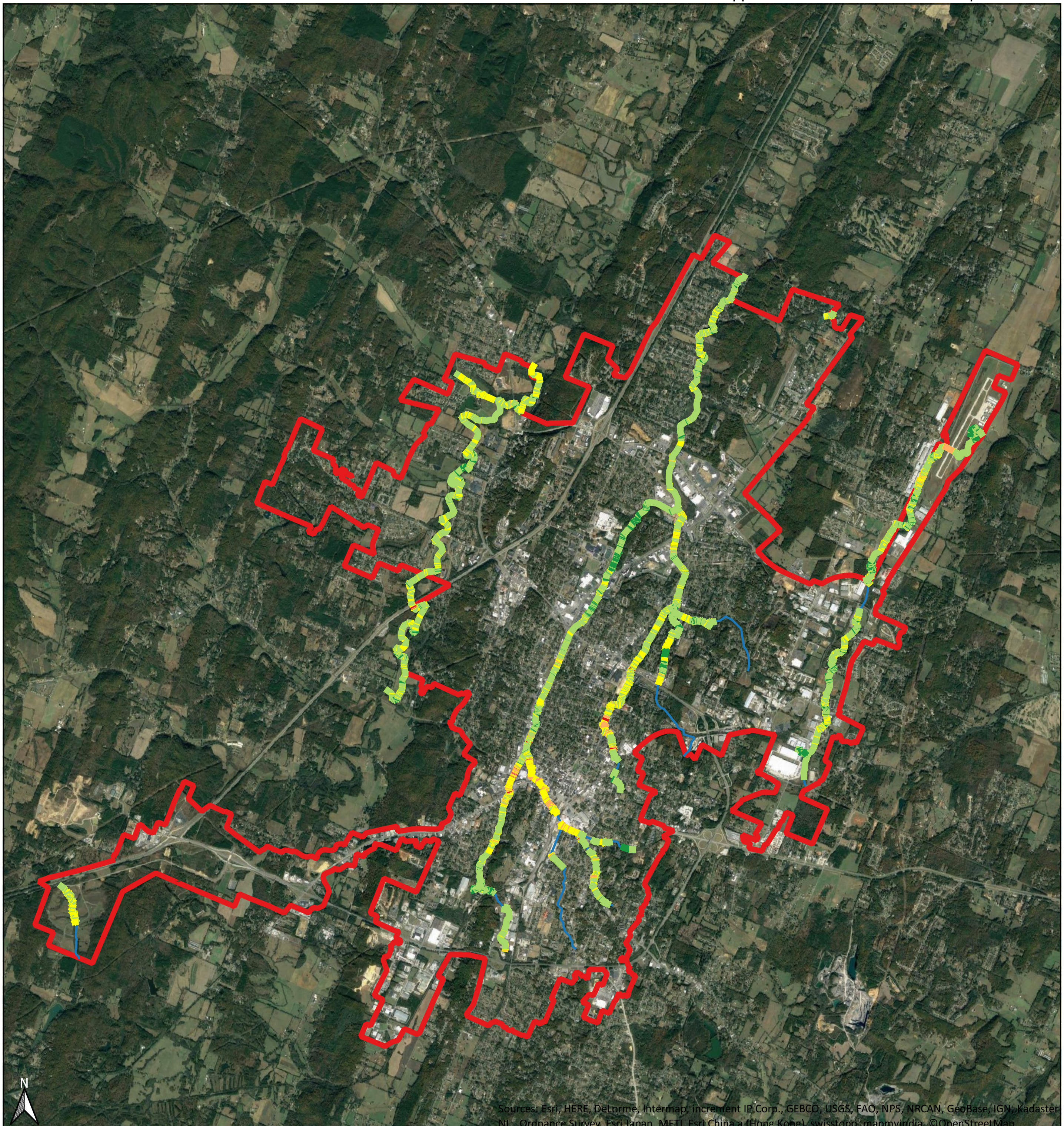
Discrete Point Features

Created on: May 2021

ENVIRONMENTAL SOLUTIONS, LLC

Appendix 5

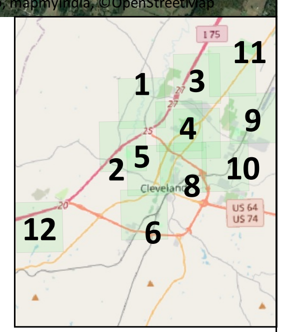
HDSS Stream Corridor Functional and Modification Ratings



Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

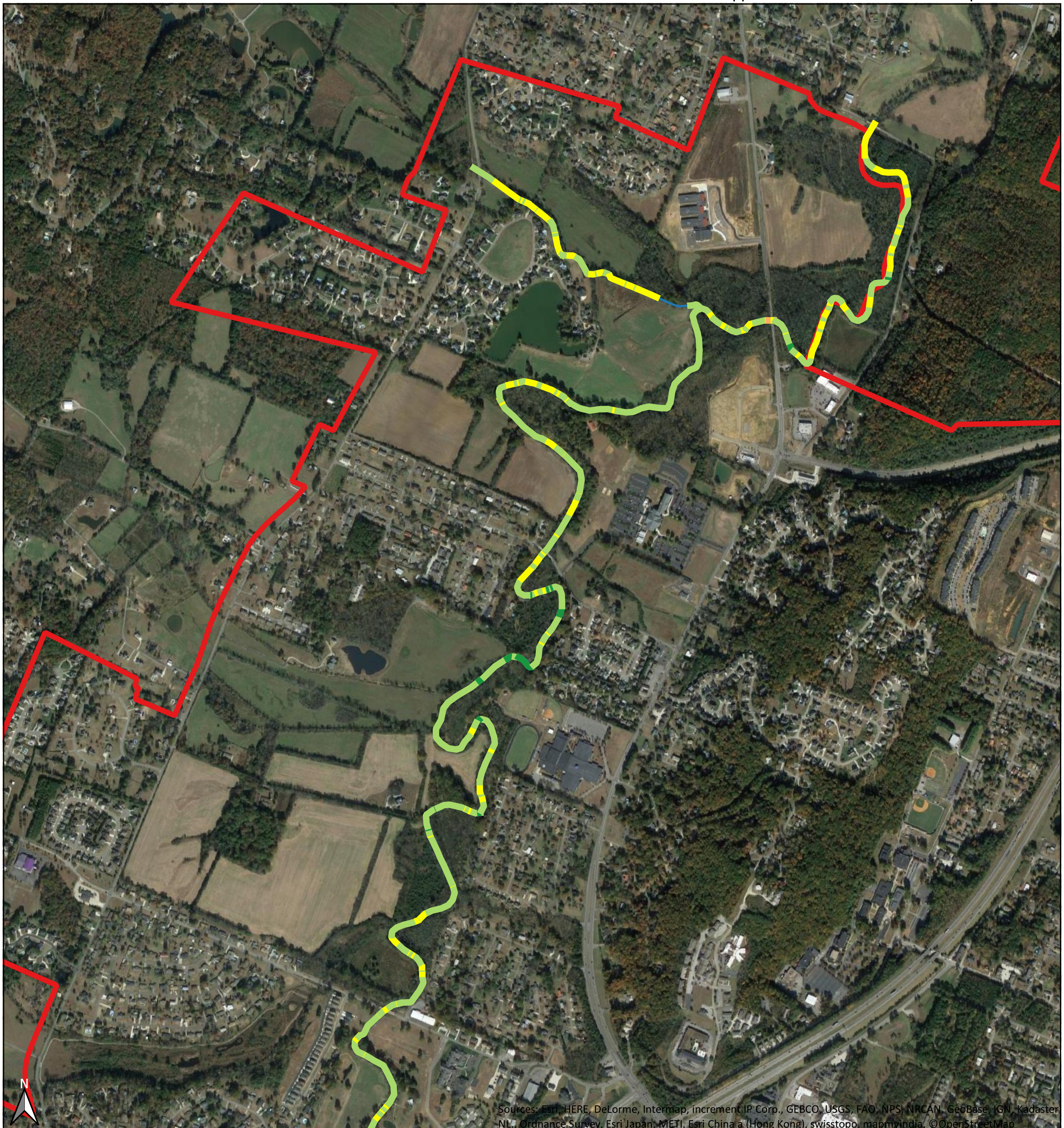
HDSS Stream Corridor Functional Rating for Cleveland, TN



0 1 2 km

0 1 2 mi

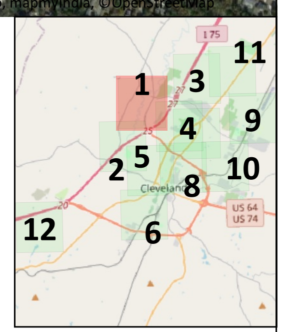
Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

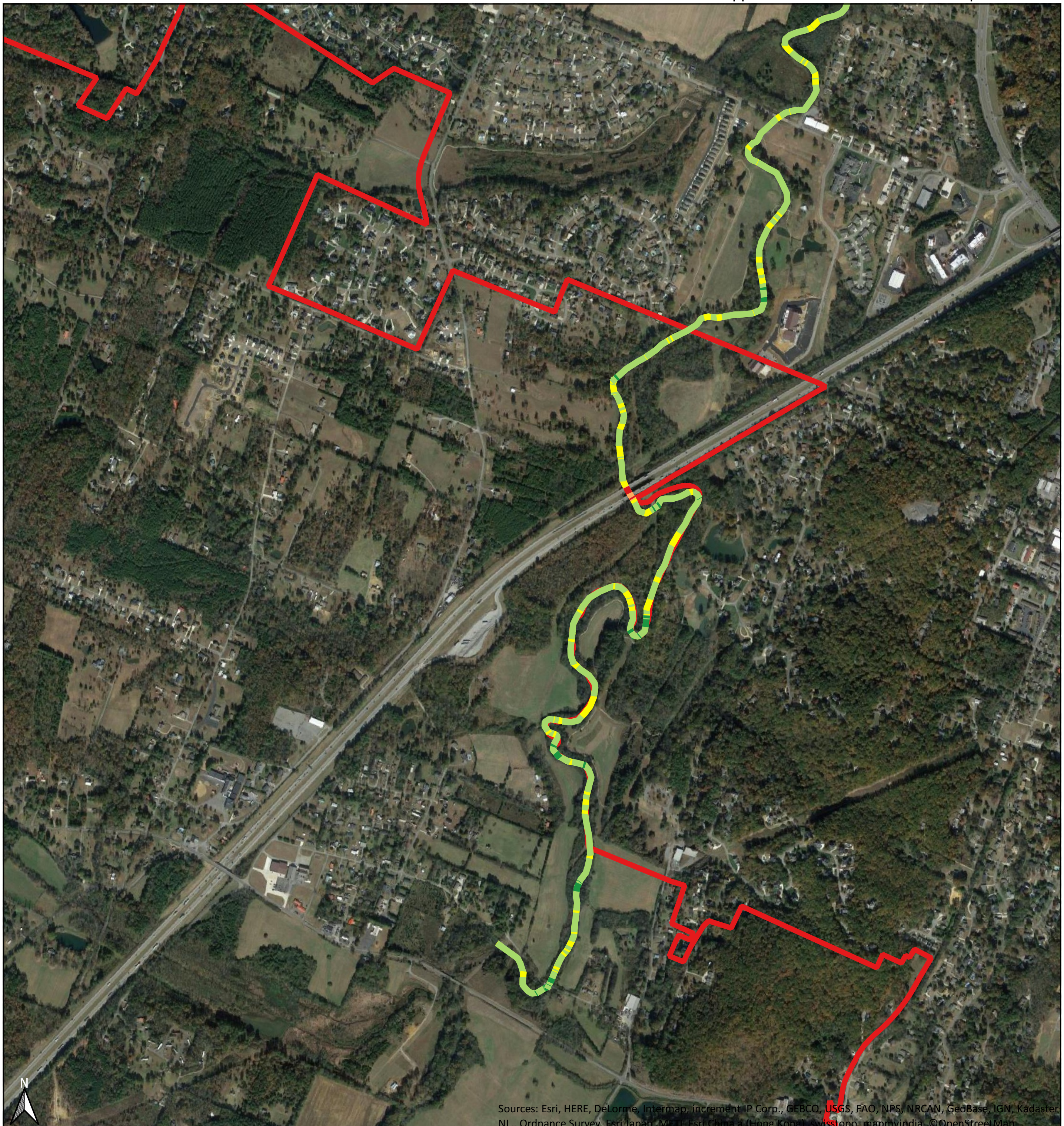
HDSS Stream Corridor Functional Rating for the Candies and Bigsby Creeks: Map 1



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

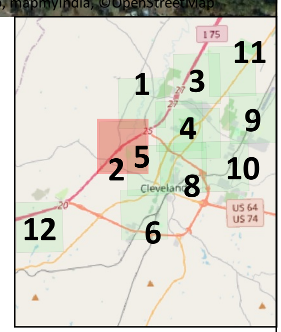
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

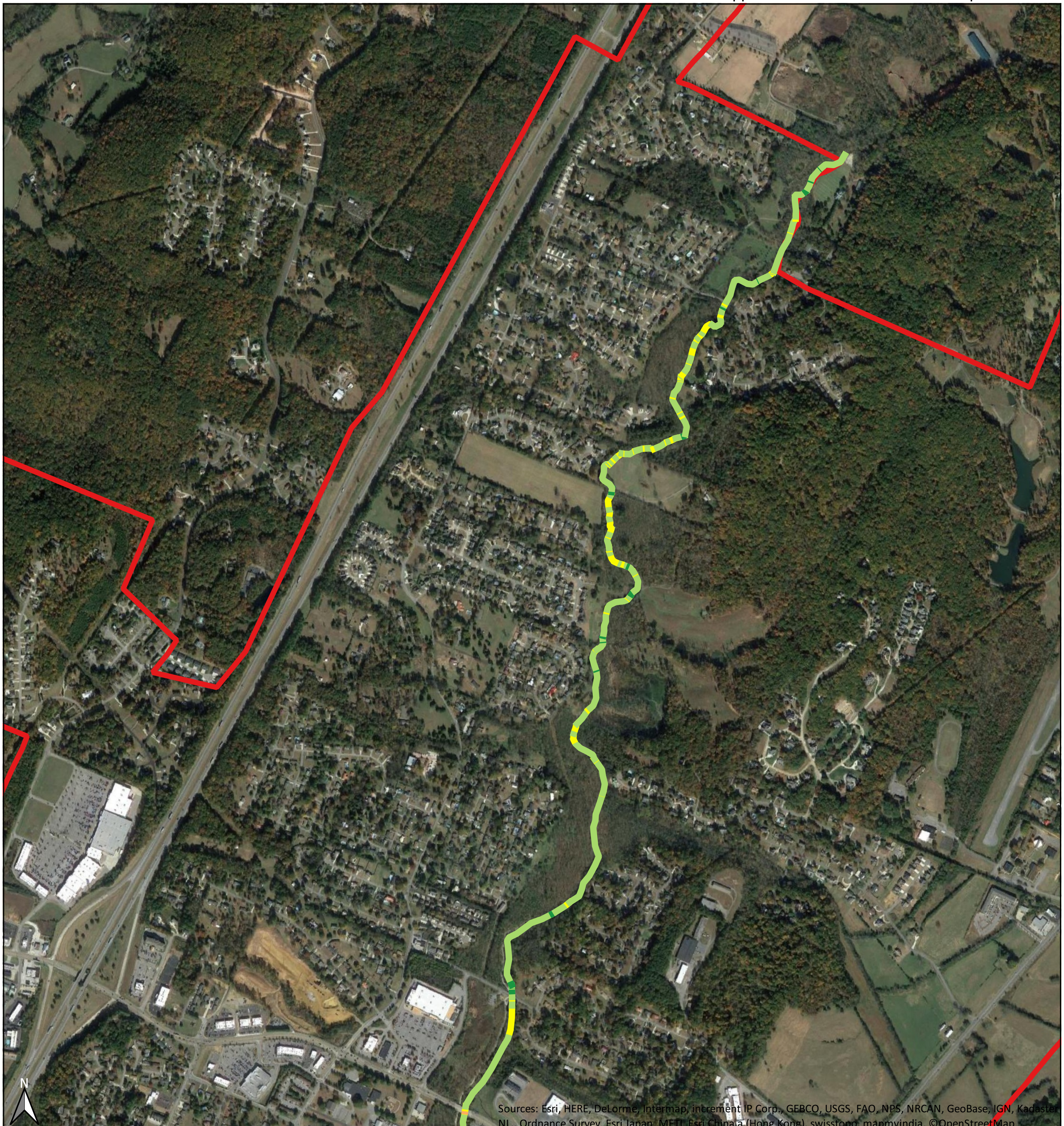
HDSS Stream Corridor Functional Rating for the Candies Creek: Map 2



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

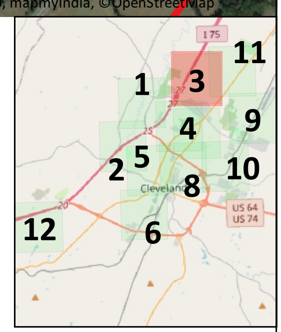
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

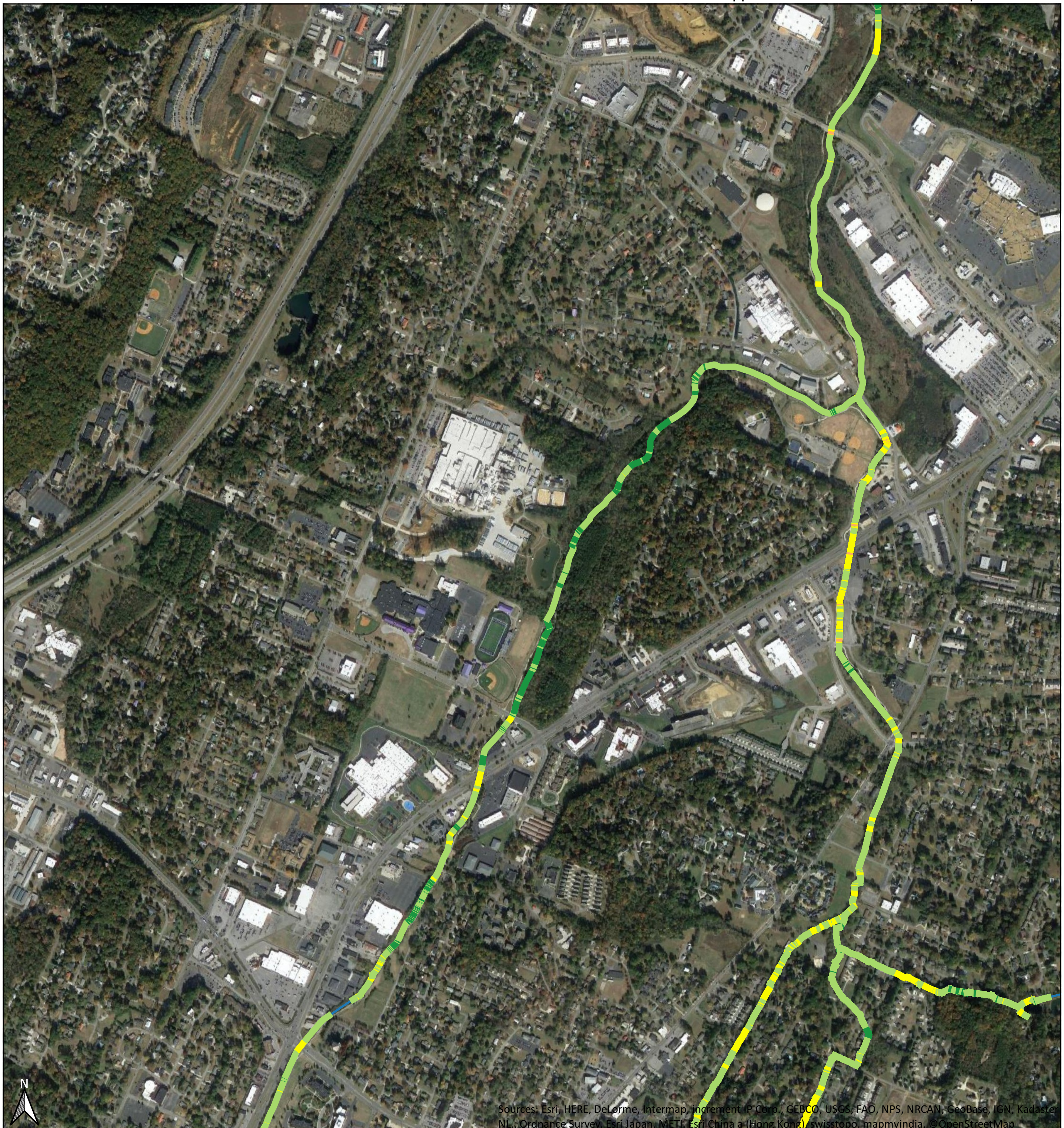
- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

HDSS Stream Corridor Functional Rating for the South Mouse Creek: Map 3



0 0.3 0.6 km
0 0.2 0.4 mi

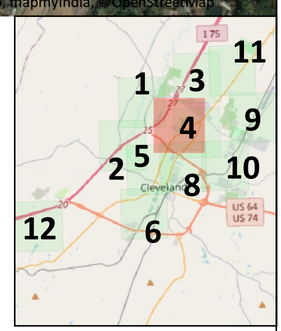
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

HDSS Stream Corridor Functional Rating for the South Mouse Creek: Map 4



0 0.3 0.6 km

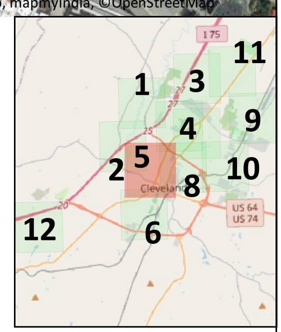
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

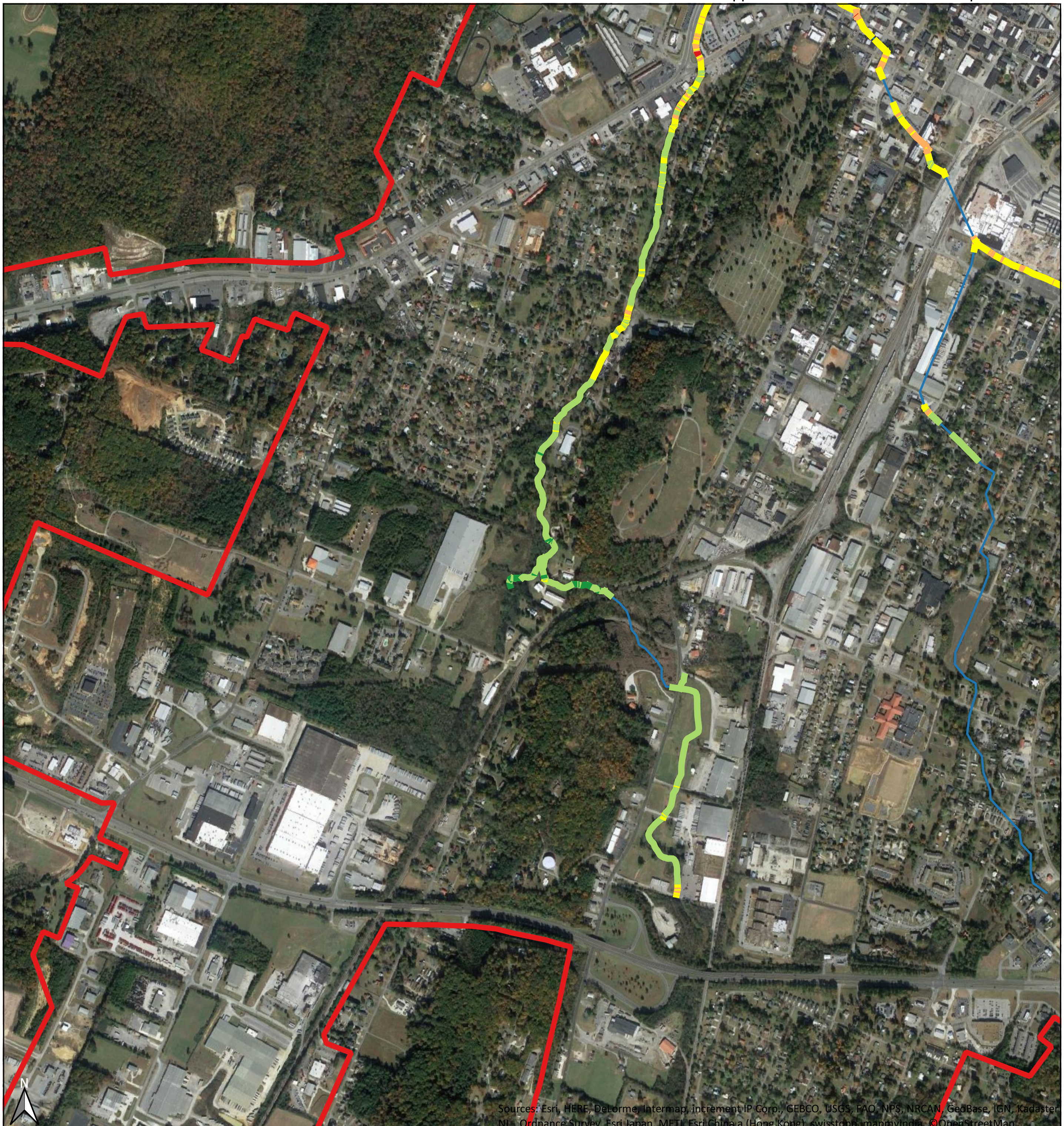
HDSS Stream Corridor Functional Rating for the South Mouse Creek & Woolen Mill Branch: Map 5



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

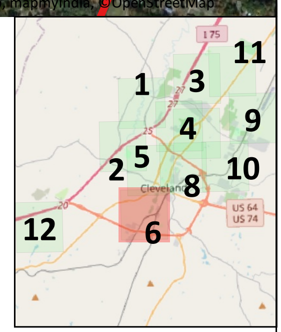
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

HDSS Stream Corridor Functional Rating for the South Mouse Creek: Map 6



0 0.3 0.6 km

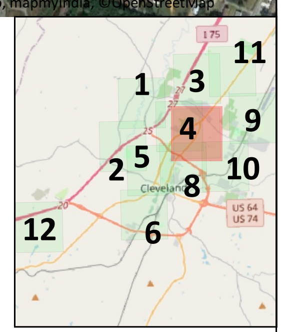
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

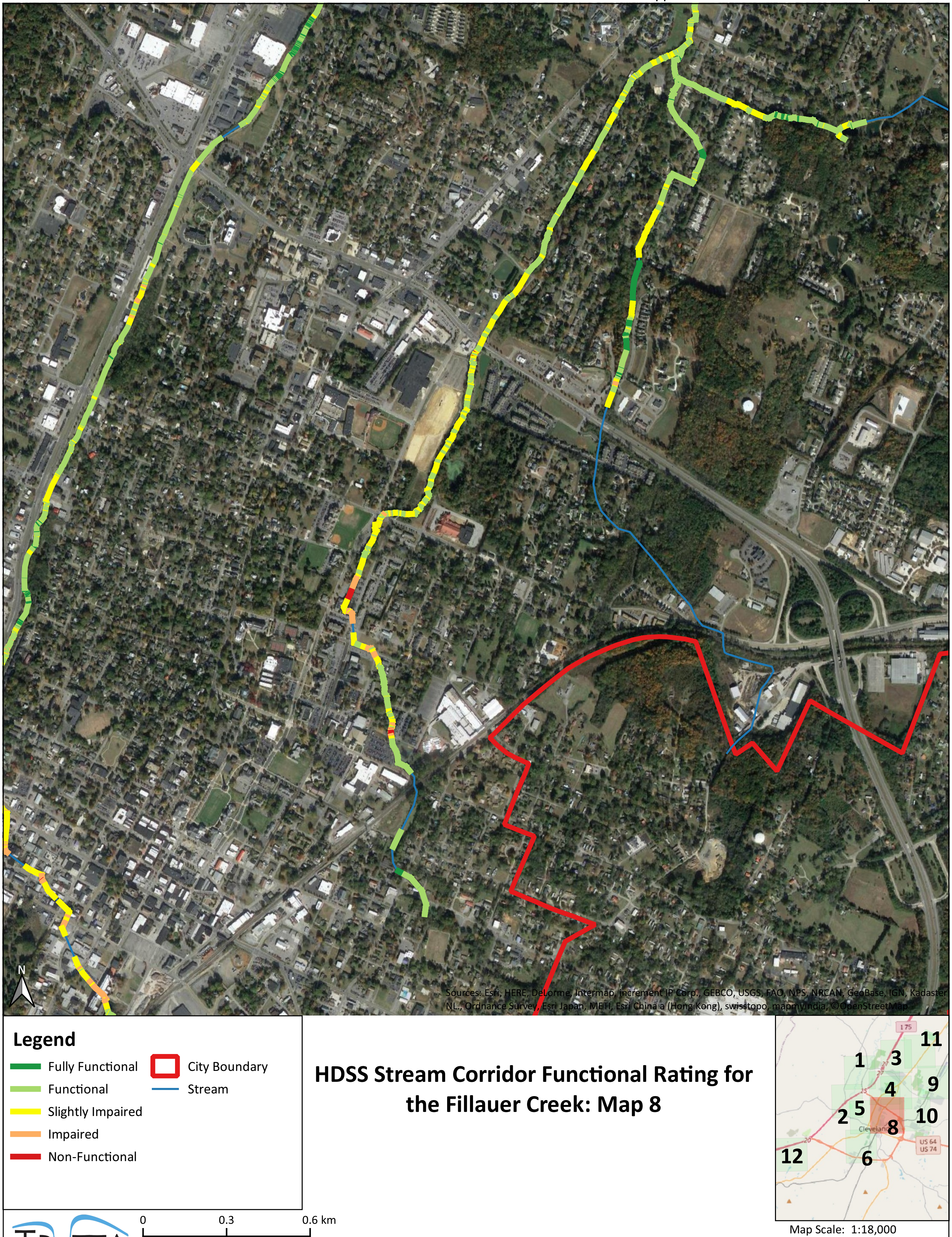
HDSS Stream Corridor Functional Rating for the Fillauer Creek: Map 7



TRUTTA Environmental Solutions, LLC

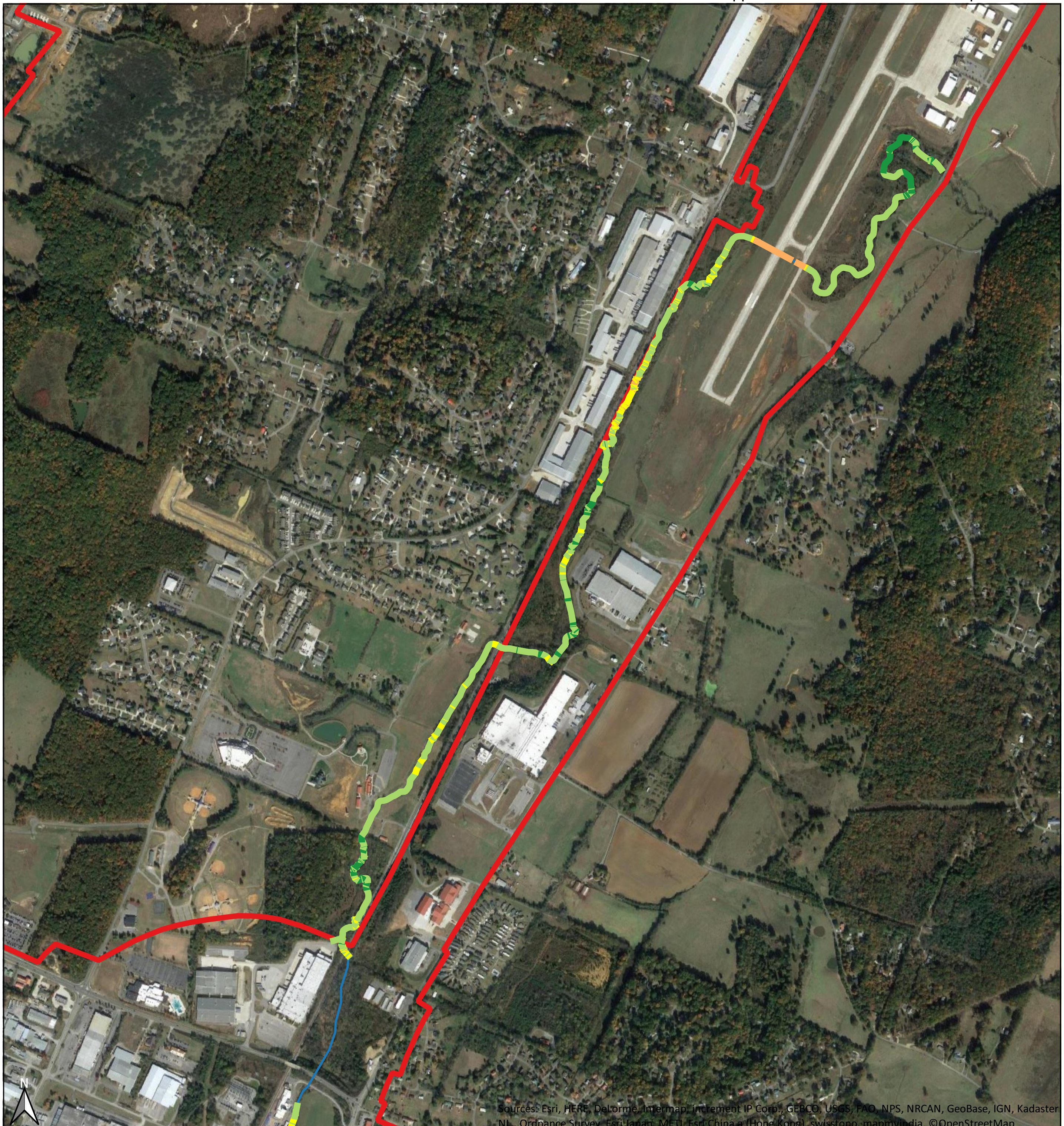
0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



HDSS Stream Corridor Functional Rating for the Fillauer Creek: Map 8

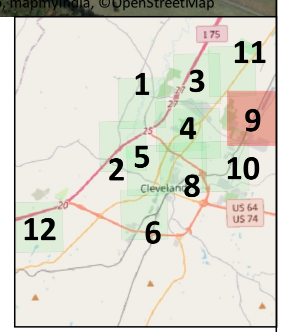
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

HDSS Stream Corridor Functional Rating for the Little Chatata Creek: Map 9



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km

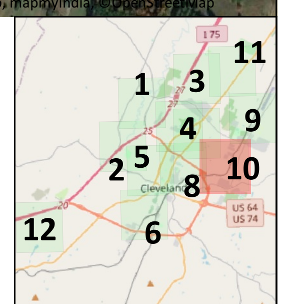
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

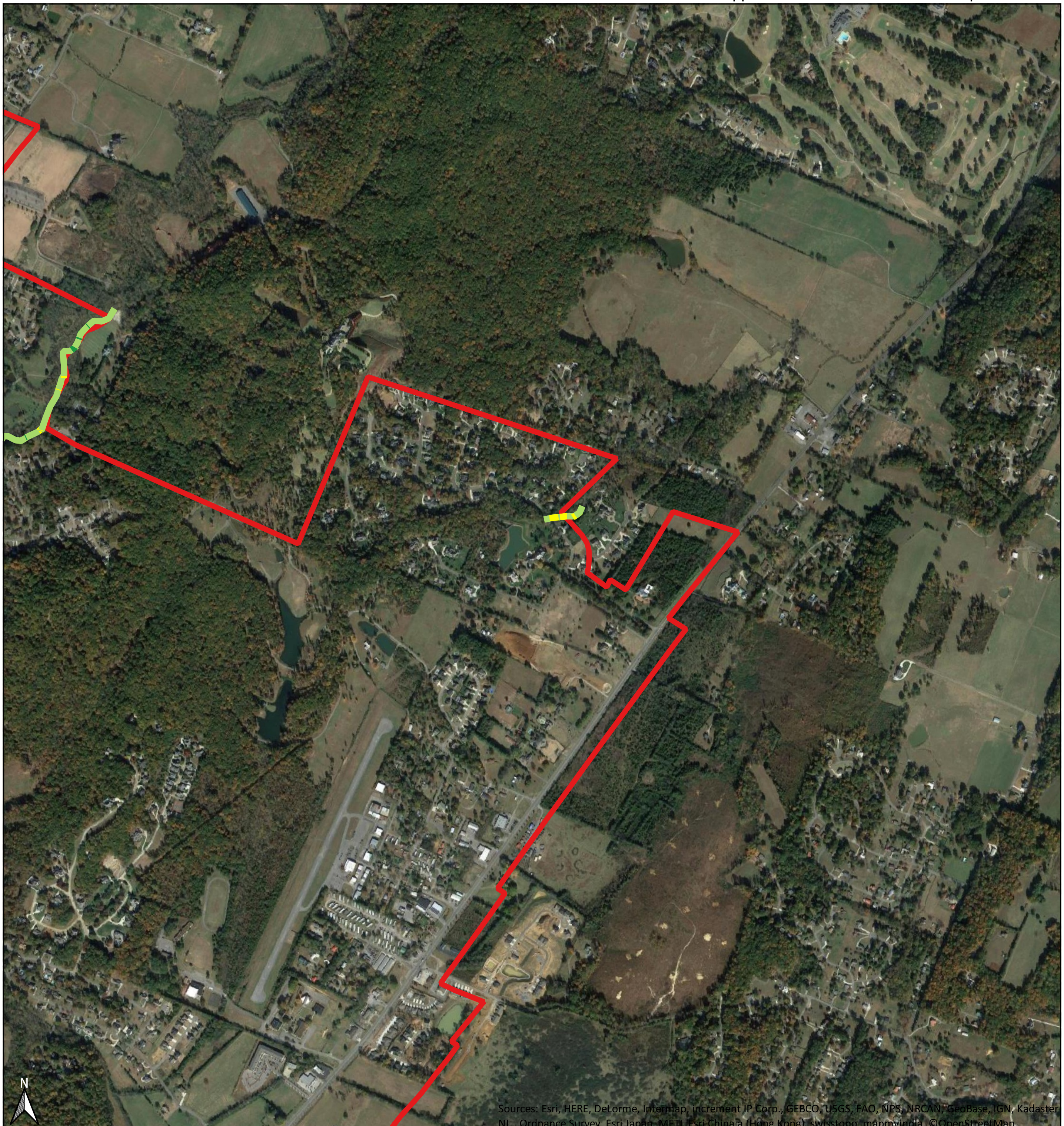
HDSS Stream Corridor Functional Rating for the Little Chatata Creek: Map 10



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

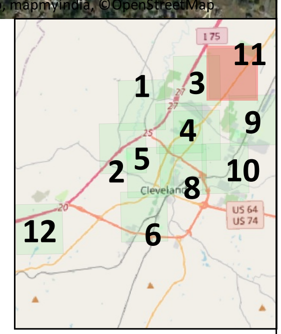
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

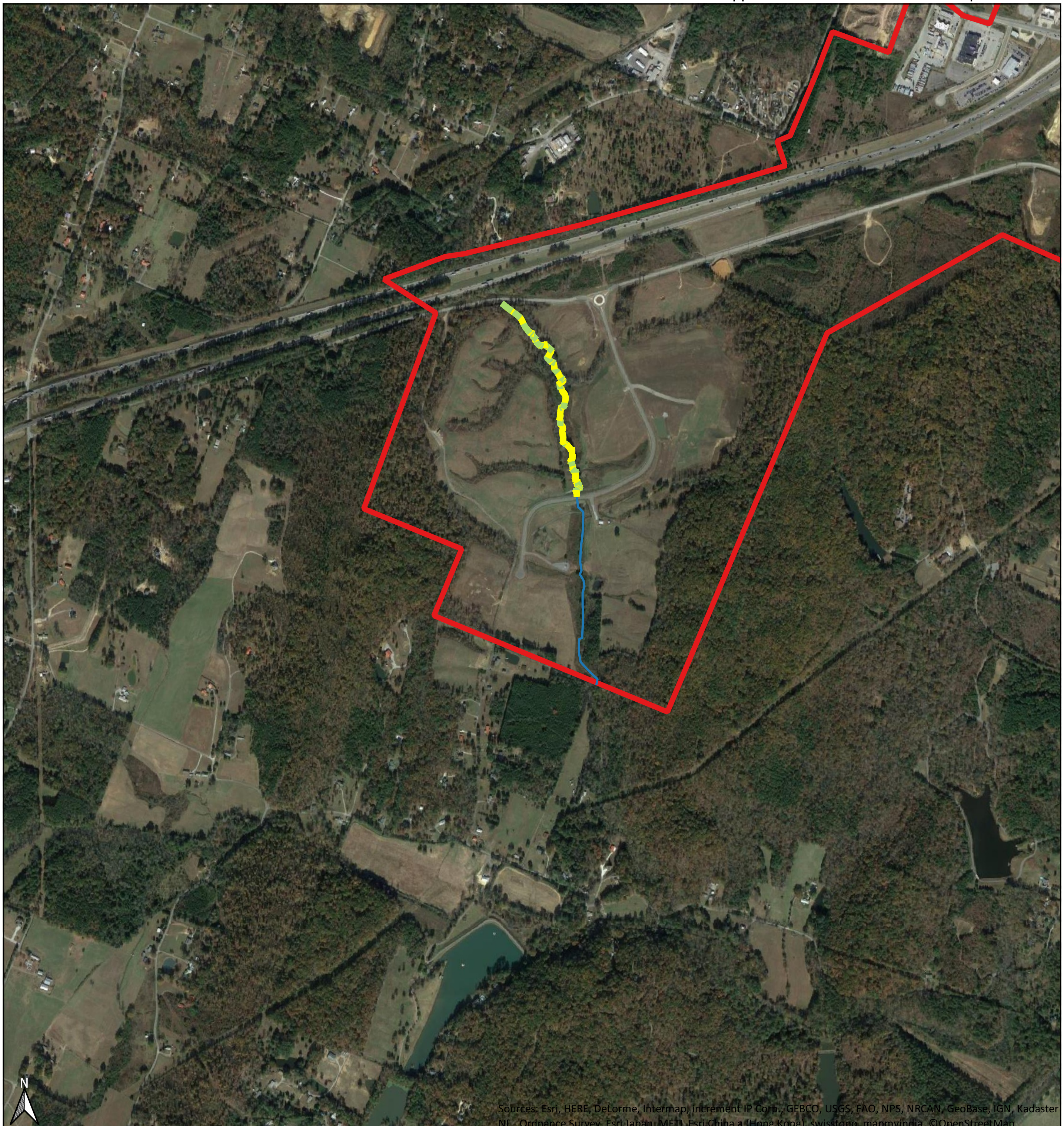
HDSS Stream Corridor Functional Rating for the Little South Mouse Creek: Map 11



0 0.3 0.6 km

0 0.2 0.4 mi

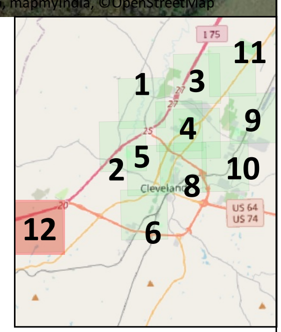
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Fully Functional
- Functional
- Slightly Impaired
- Impaired
- Non-Functional
- City Boundary
- Stream

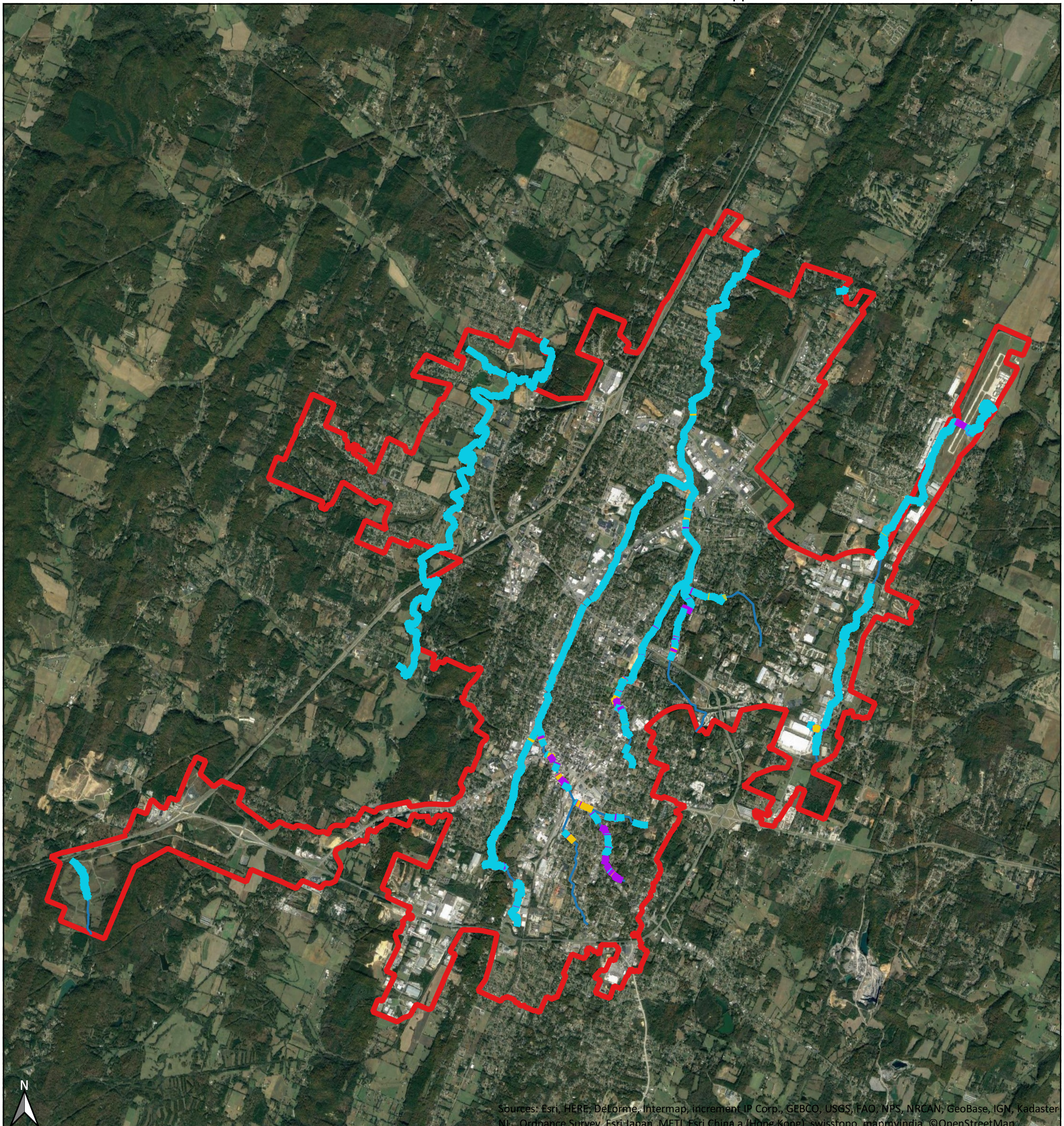
HDSS Stream Corridor Functional Rating for the Spring Branch: Map 12



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

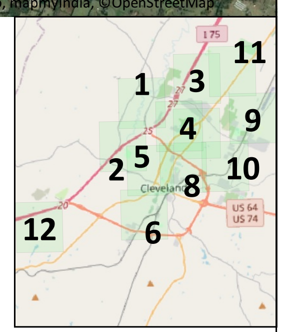
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Unmodified
- Modified
- Highly Modfied
- CIty Boundary
- Stream

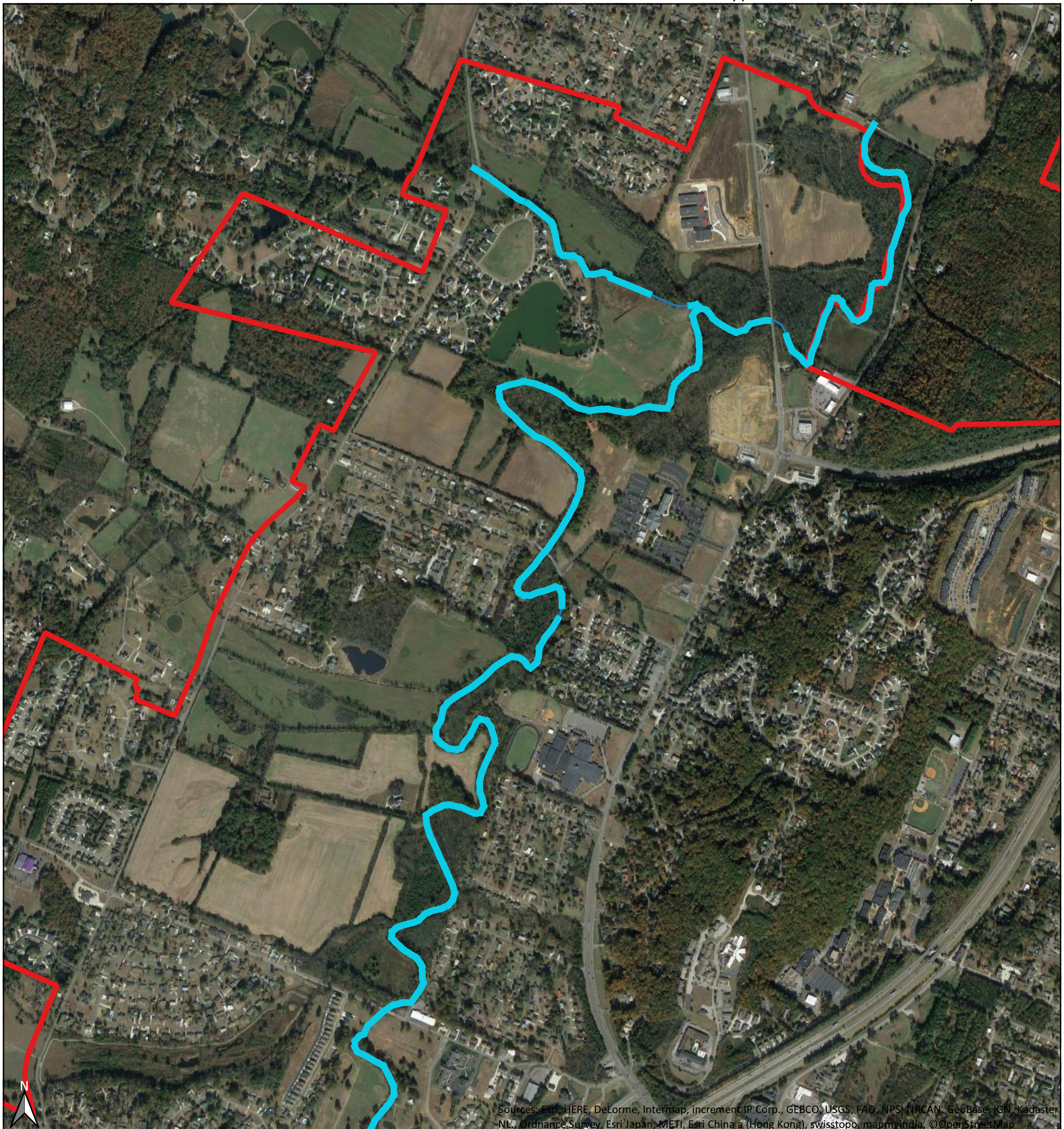
HDSS Stream Corridor Modification Rating for Cleveland, TN



TRUTTA Environmental Solutions, LLC

0 1 2 km
0 1 2 mi

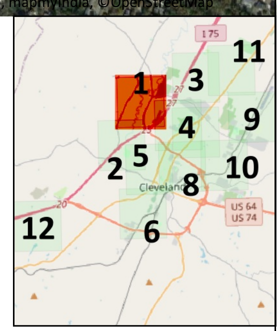
Map Scale: 1:95,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Unmodified
- Modified
- Highly Modfied
- City Boundary
- Stream

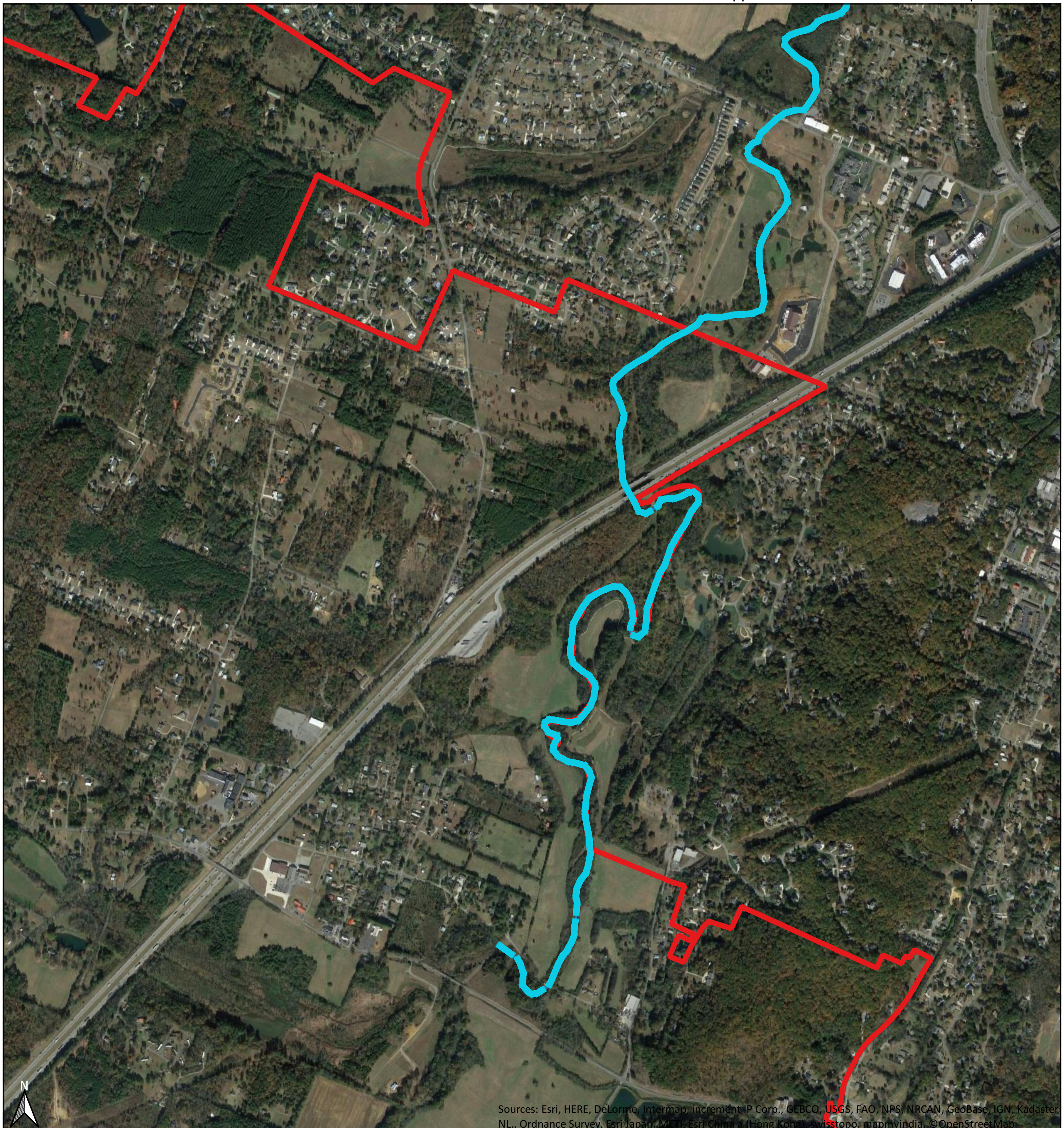
HDSS Stream Corridor Modification Rating for the Candies and Bigsby Creeks: Map 1



0 0.3 0.6 km
0 0.2 0.4 mi

TRUTTA Environmental Solutions, LLC

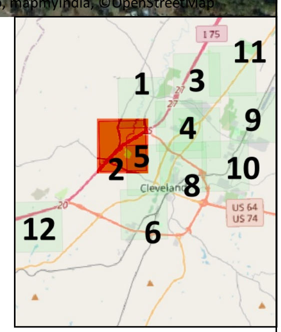
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Unmodified
- Modified
- Highly Modfied
- City Boundary
- Stream

HDSS Stream Corridor Modification Rating for the Candies Creek: Map 2

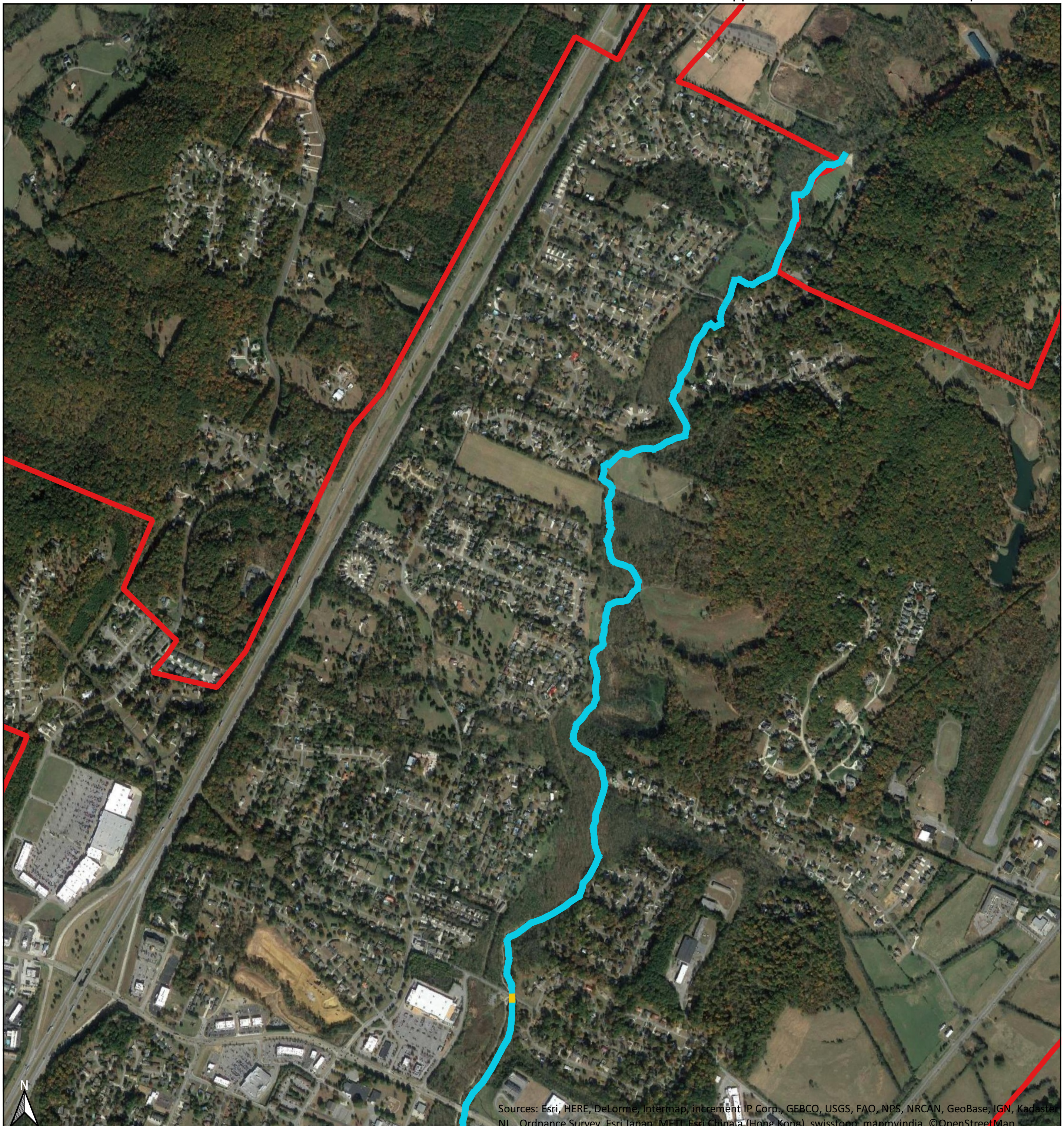


TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km

0 0.2 0.4 mi

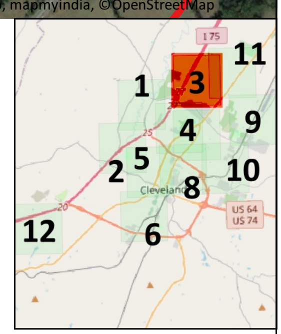
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Unmodified
- Modified
- Highly Modfied
- City Boundary
- Stream

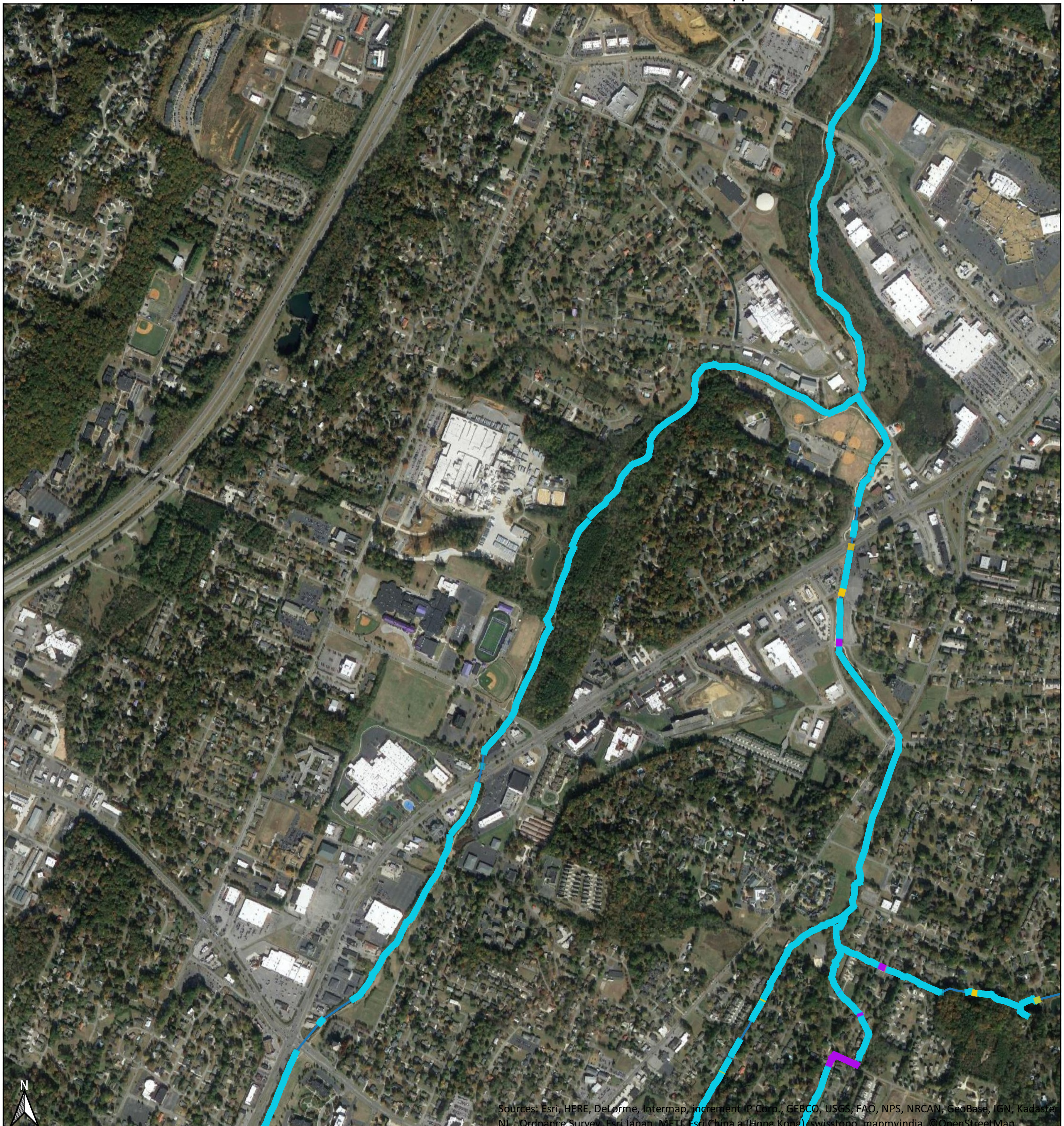
HDSS Stream Corridor Modification Rating for the South Mouse Creek: Map 3



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

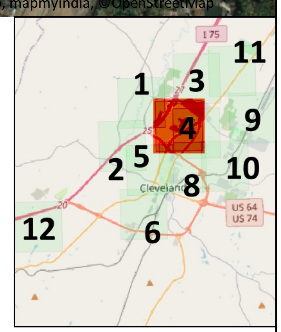
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

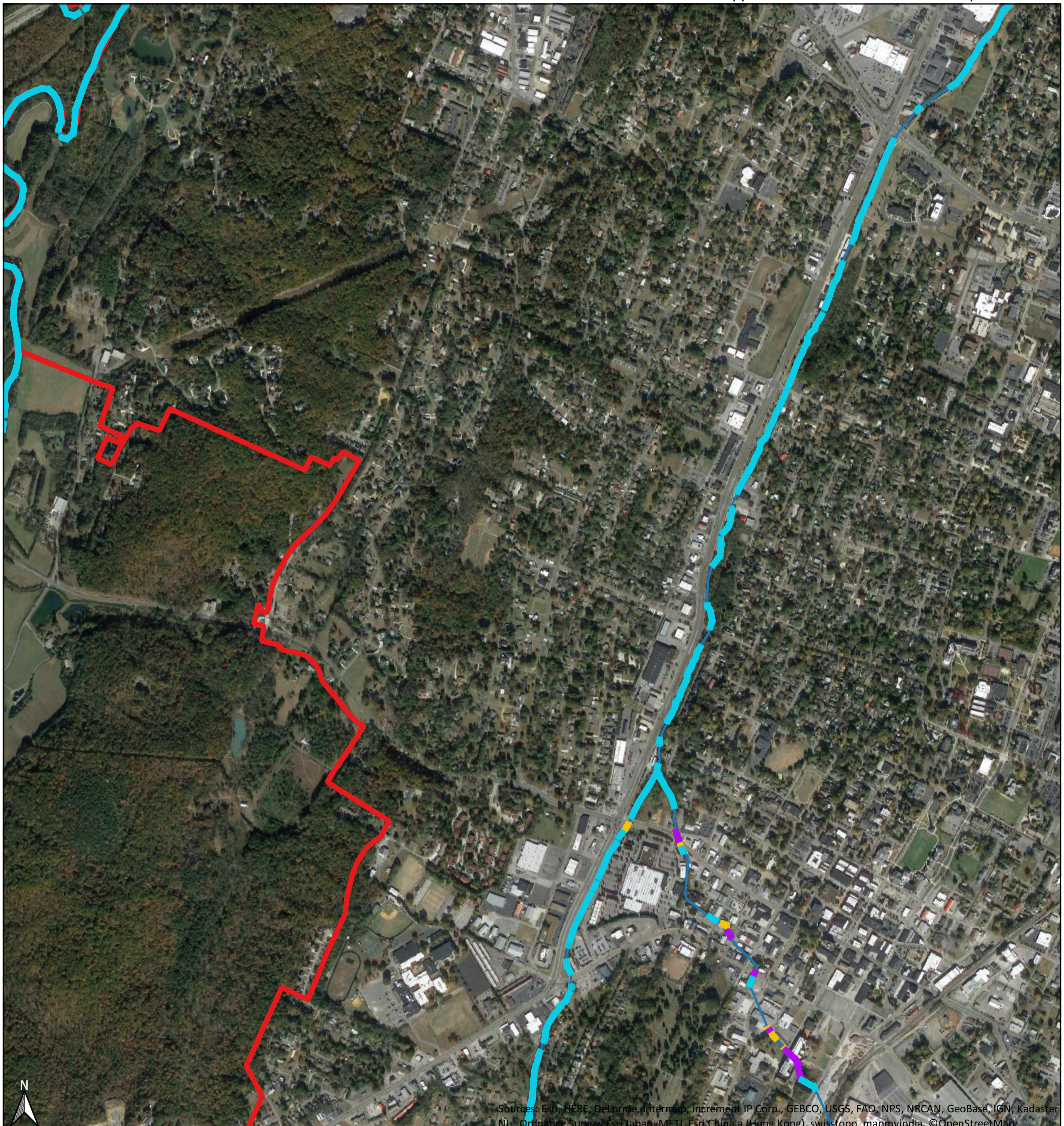
- Unmodified
- Modified
- Highly Modfied
- City Boundary
- Stream

HDSS Stream Corridor Modification Rating for the South Mouse Creek: Map 4



0 0.3 0.6 km
0 0.2 0.4 mi

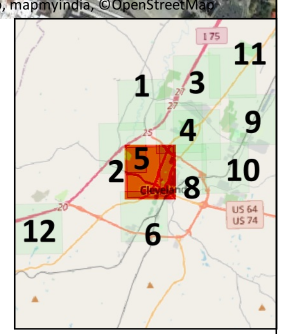
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Unmodified
- Modified
- Highly Modfied
- City Boundary
- Stream

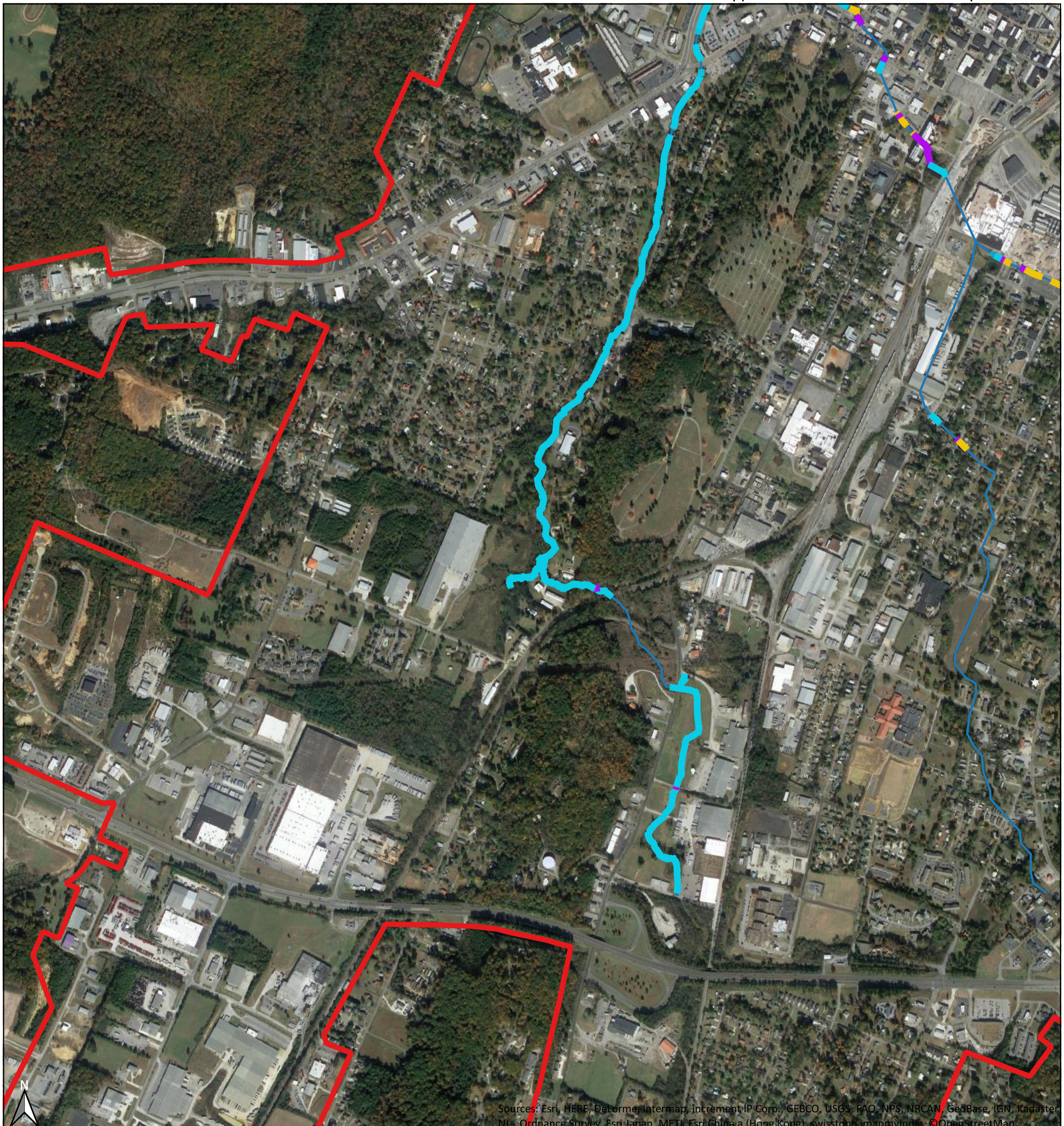
HDSS Stream Corridor Modification Rating for the South Mouse Creek & Woolen Mill Branch: Map 5



0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

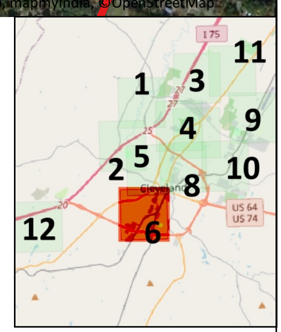
TRUTTA Environmental Solutions, LLC



Legend

- Unmodified
- Modified
- Highly Modfied
- City Boundary
- Stream

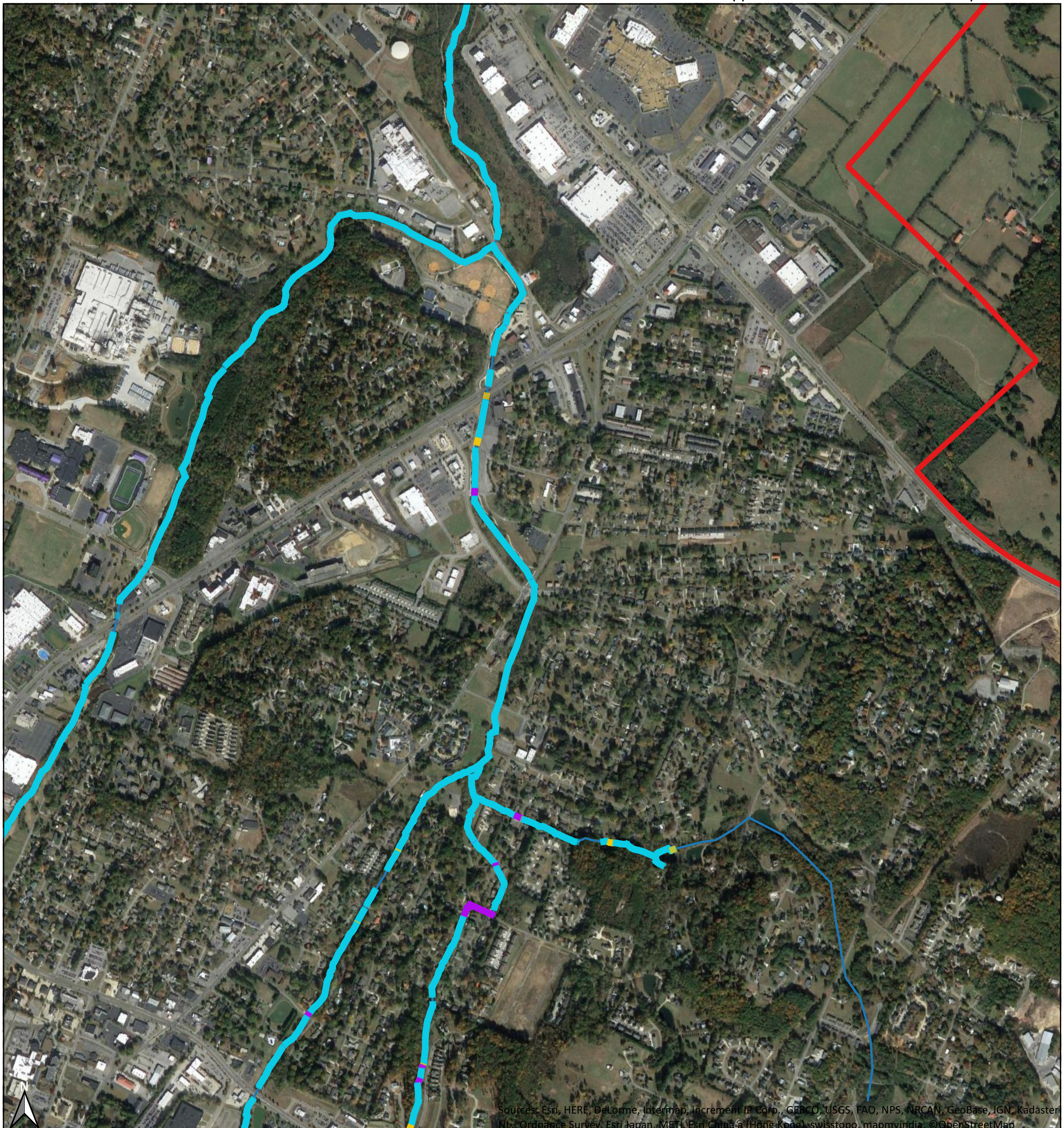
HDSS Stream Corridor Modification Rating for the South Mouse Creek: Map 6



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

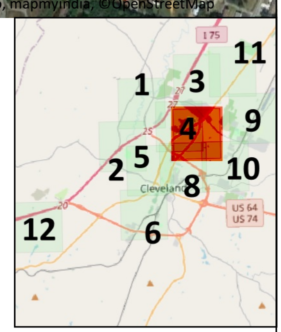
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Unmodified
- Modified
- Highly Modfied
- City Boundary
- Stream

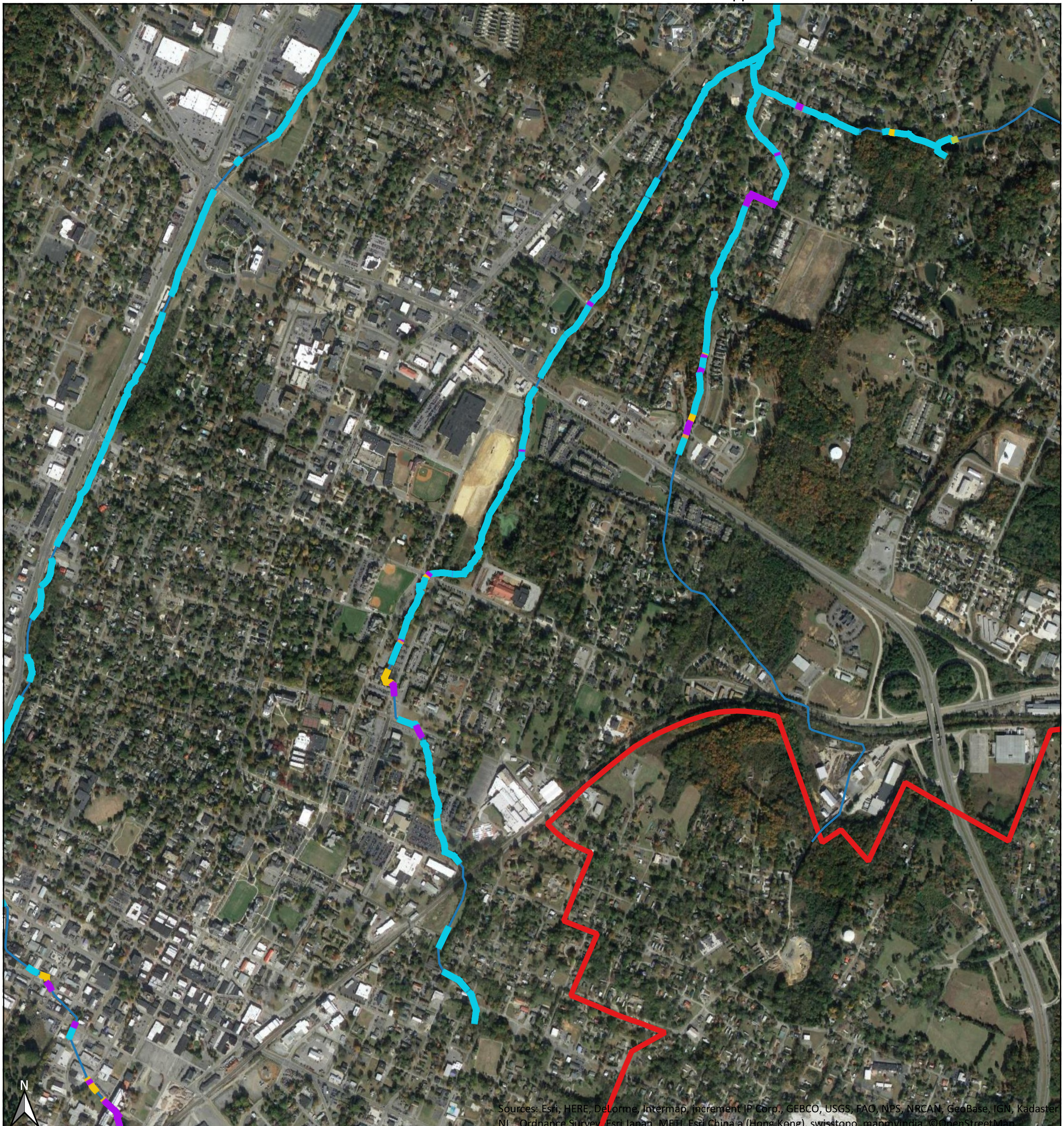
HDSS Stream Corridor Modification Rating for the Fillauer Creek: Map 7



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

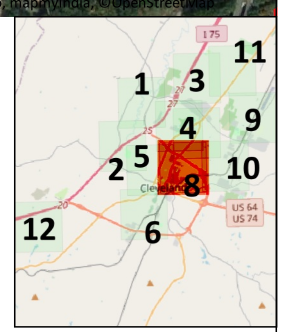
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Unmodified
- Modified
- Highly Modfied
- City Boundary
- Stream

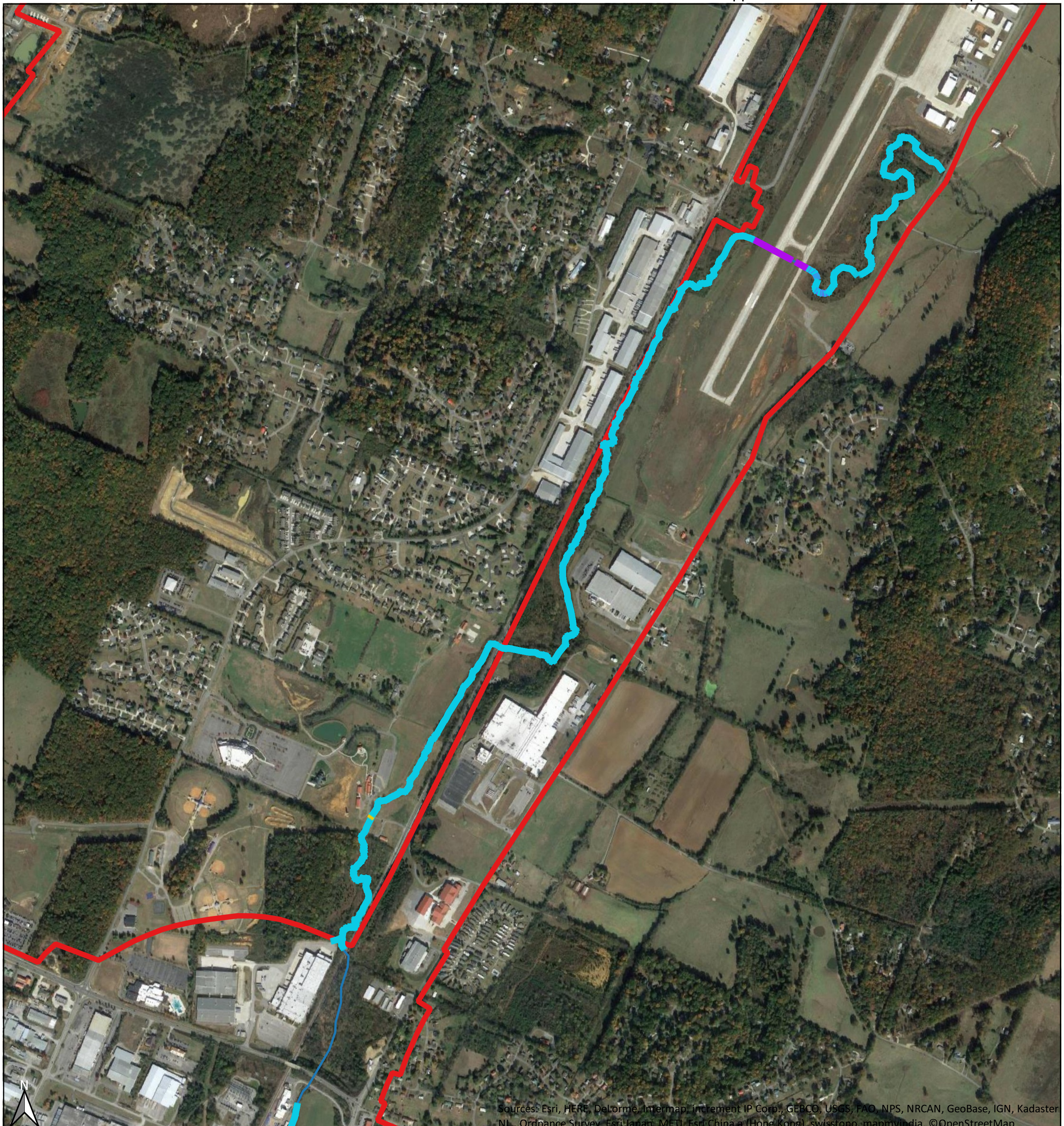
HDSS Stream Corridor Modification Rating for the Fillauer Creek: Map 8



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

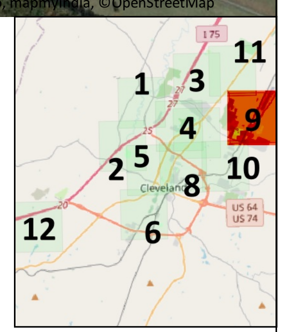
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Unmodified
- Modified
- Highly Modfied
- City Boundary
- Stream

HDSS Stream Corridor Modification Rating for the Little Chatata Creek: Map 9

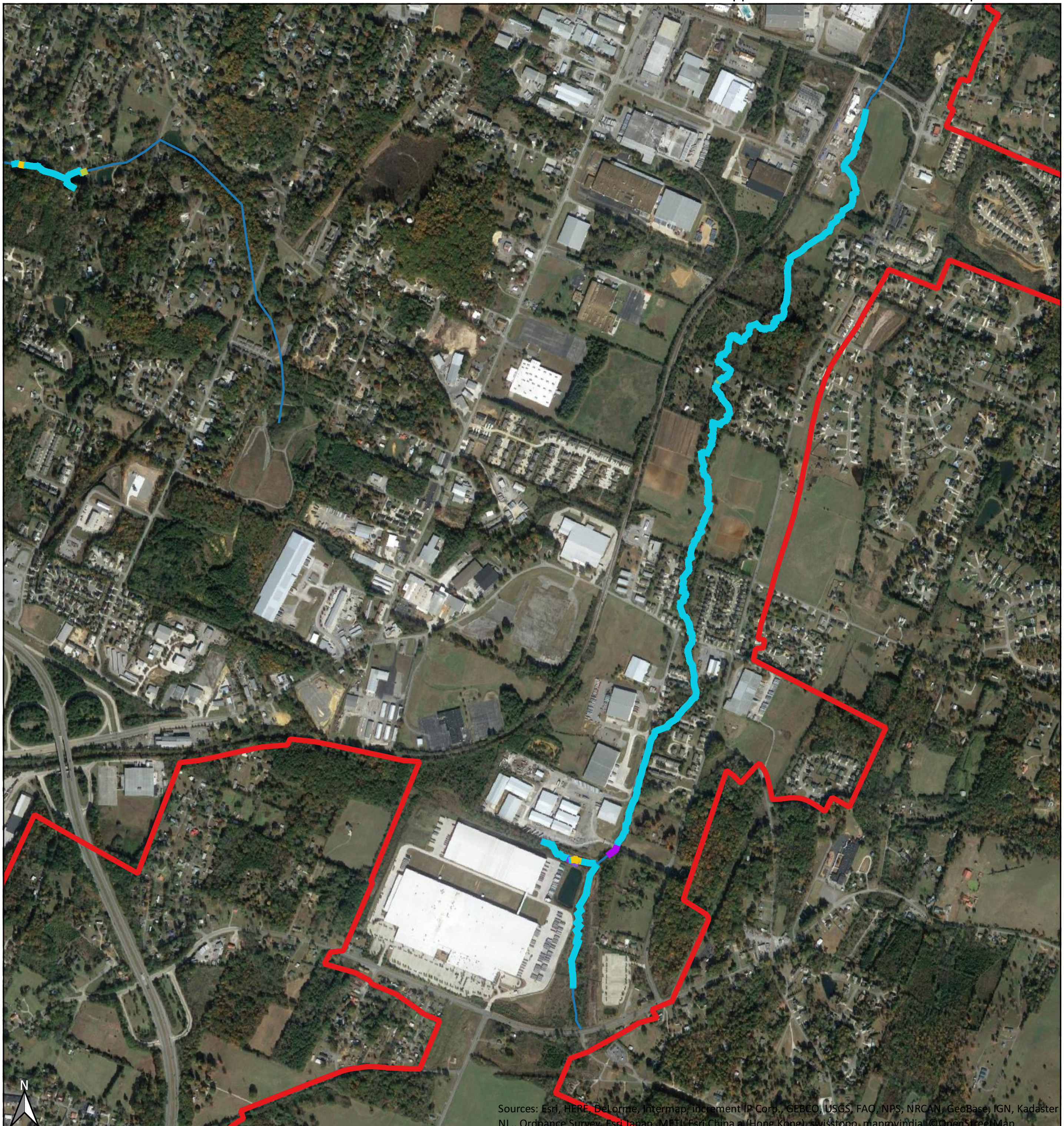


TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km

0 0.2 0.4 mi

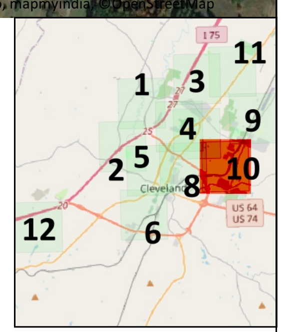
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

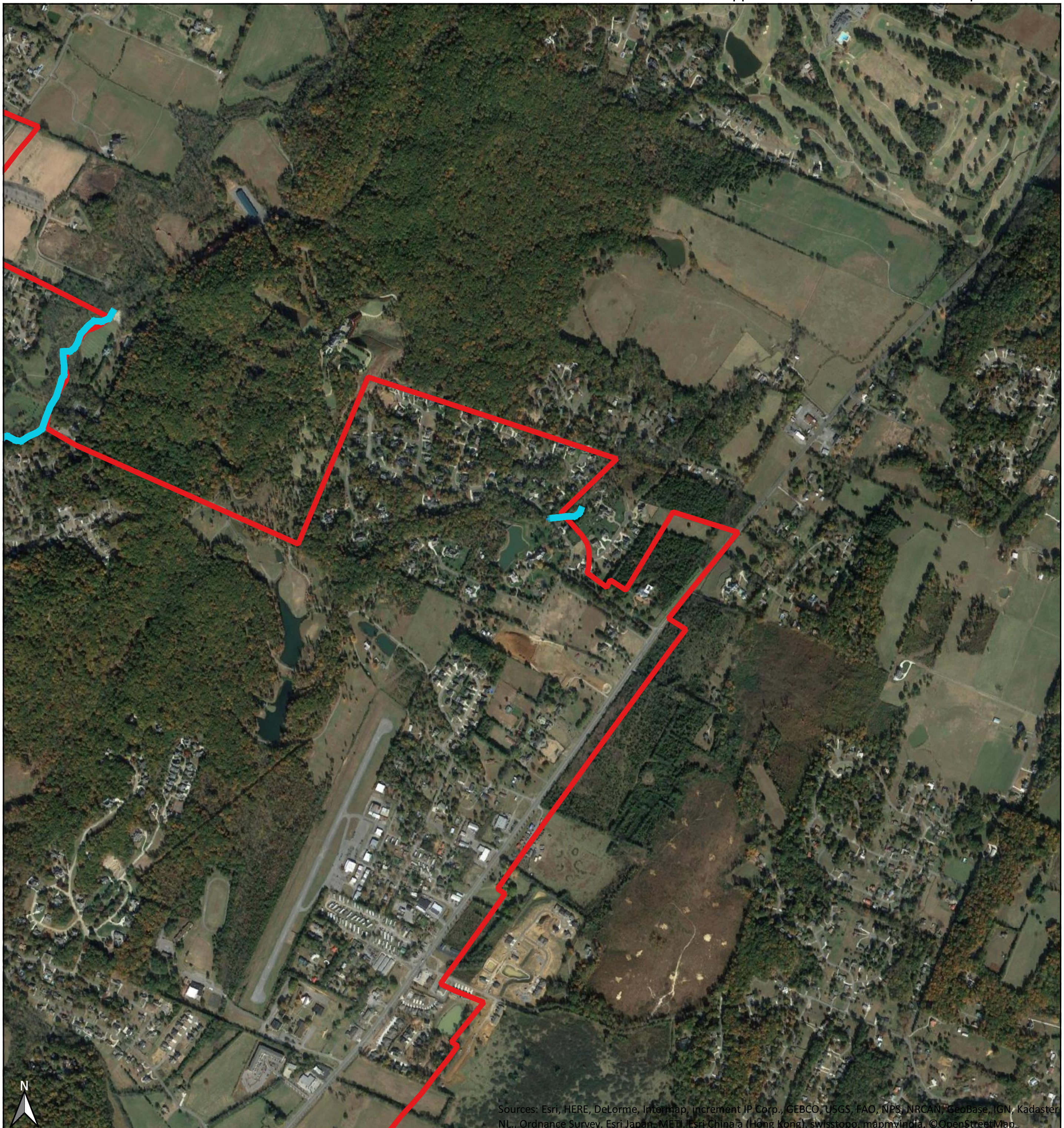
- Unmodified
- Modified
- Highly Modfied
- City Boundary
- Stream

HDSS Stream Corridor Modification Rating for the Little Chatata Creek: Map 10



0 0.3 0.6 km
0 0.2 0.4 mi

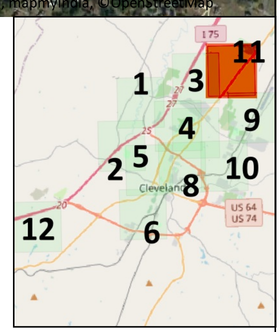
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Unmodified
- Modified
- Highly Modfied
- City Boundary
- Stream

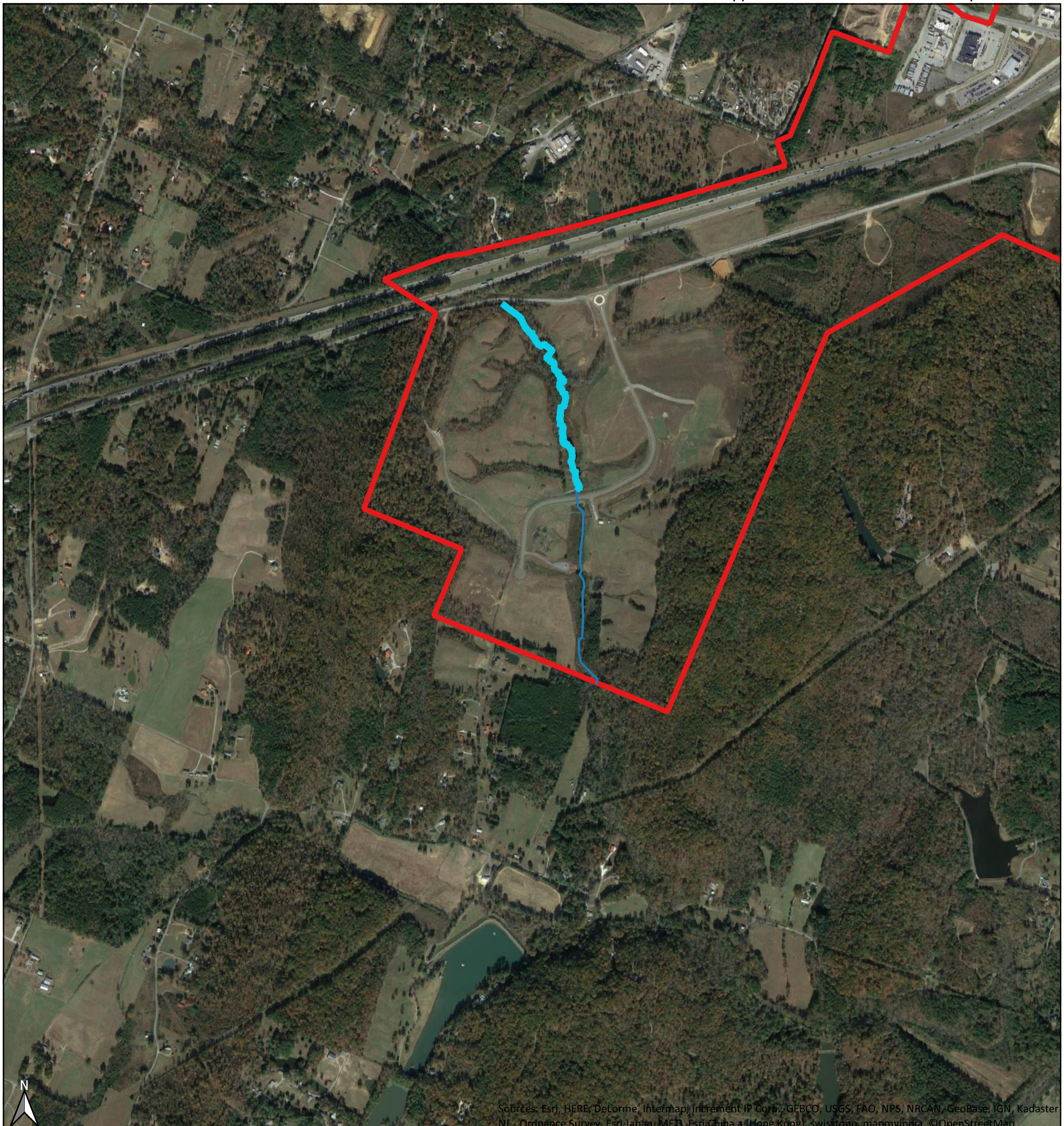
HDSS Stream Corridor Modification Rating for the Little South Mouse Creek: Map 11



TRUTTA ENVIRONMENTAL SOLUTIONS, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

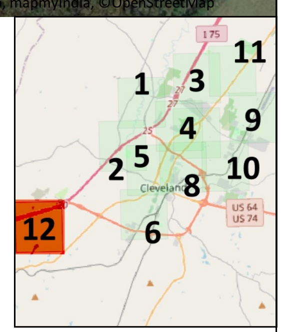
Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters



Legend

- Unmodified
- Modified
- Highly Modfied
- City Boundary
- Stream

HDSS Stream Corridor Modification Rating for the Spring Branch: Map 12



TRUTTA Environmental Solutions, LLC

0 0.3 0.6 km
0 0.2 0.4 mi

Map Scale: 1:18,000
Map CRS: EPSG:26916
Coordinate Units: Meters

Appendix 6 - Description of Data Naming Conventions

Notes on general syntax. No capitalization until first letter after an underscore.

Continuous Data. This information is classified for each meter of the surveyed streams. The ID for each meter (mid) only occurs once in this dataset as the cross-sectional scores for the condition only occur once for each meter. The continuous data table has general header information followed by the function condition score and type and the modification score and type.

General Header Information

np	abc	Name pf project	
ns_T	abc	Name of stream	
ns_C	1.2	Code number of Name of stream	
ss_T	abc	Name of stream segment	
ss_C	abc	Code number of stream segment	
pf	abc	boat, dual boat, backpack, tablet	bt, dbt, pk, tb
dq_C	1.2	Data quality score	
dq_T	abc	data quality type	
dq_M	abc	data quality modifier type	
vt	1.2	StreamView video track number	
cn	abc	Classifier Name	
da	abc	day month and year in text format	
tm	abc	time of day local in text format	
mid	1.2	ID of each meter within surveyed streams	
sid	1.2	ID for second of survey video	

Video Track Number, time and Date allow data referencing between data files and StreamView Videos.

Function (condition)

fc_Bd	1.2	Functional score of streambed	*score 1-5
fc_Bk_L	1.2	Functional score of left streambank	*score 1-5
fc_Bk_R	1.2	Functional score of right streambank	*score 1-5
fc_Rp_L	1.2	Functional score of left riparian	*score 1-5
fc_Rp_R	1.2	Functional score of left riparian	*score 1-5
ft_Bd	abc	Functional classification of streambed	*FF,F,SI,I,NF
ft_Bk_L	abc	Functional classification of left streambank	*FF,F,SI,I,NF
ft_Bk_R	abc	Functional classification of right streambank	*FF,F,SI,I,NF
ft_Rp_L	abc	Functional classification of left riparian	*FF,F,SI,I,NF
ft_Rp_R	abc	Functional classification of left riparian	*FF,F,SI,I,NF
Rating	1.2	Stream Corridor functional rating score	*score 1-5
RateName	abc	Stream Corridor functional rating classification	*FF,F,SI,I,NF

FF=Fully Functional=1; F=Functional=2; SI= Slightly Impaired=3; I=Impaired=4;
NF=Non-Functional=5

Modification

mc_Bd	1.2	Modification condition score of streambed	**score 7-9
mc_Bk_L	1.2	Modification score of left streambank	**score 7-9
mc_Bk_R	1.2	Modification score of right streambank	**score 7-9
mt_Bd	abc	Modification classification of streambed	**U,M,HM
mt_Bk_L	abc	Modification classification of left streambank	**U,M,HM
mt_Bk_R	abc	Modification classification of right streambank	**U,M,HM
Mod1	1.2	Stream Corridor modification rating classification	**score 7-9
ModGroup	abc	Stream Corridor modification rating classification	**U,M,HM

**U=Unmodified=7; M=Modified=8; HM=Highly modified=9

Discrete Point Data. This data represents the specific type and location of things observed during the stream survey. In this dataset, not all meter IDs (mid) need to occur as discrete objects may not be observed within every meter of the stream. Additionally, the meter ID (mid) may occur more than once if multiple objects occur at the same location. The file start with a general header information (the same information as the continuous data) and follows with the point type, groups, cross-sectional location, and the condition of the object (called severity).

General Header Information

np	abc	Name pf project	
ns	abc	Name of stream	
pf	abc	Boat, dual boat, backpack, tablet	bt,dbt,pk,tb
dq_C	1.2	Data quality score	
dq_T	abc	Data quality classification type	good, bad
vt	1.2	StreamView video track number	
cn	abc	Classifier Name	
da	abc	day month and year in text format	
tm	abc	time of day local in text format	
mid	1.2	ID of each meter within surveyed streams	

Video Track Number, time and Date allow data referencing between data files and StreamView Videos.

Points

pc	abc	Point Code	(classification software single letter code)
pn	abc	Point Name	(see table A below)
pt	abc	Point Type	(see table A below)
pg	abc	Point Group	(see table A below)
pl_C	1.2	Point Location code	(see table B below)
pl_T	abc	Point Location type	(see table B below)
ps_C	1.2	Pont Severity code	score 7-9***
ps_T	abc	Point Severity type	Minor, Moderate, Severe
pt_CM	abc	Point comment	

***Severity Scores - Minor=7; Moderate=8; Severe=9

Table A. Discrete point feature codes

pc	pn	pt	pg
a	Exposed Pipe	PI-EX	Pipe Impact
s	Intake	PI-IN	Pipe Impact
f	Manhole Stack	PI-MS	Pipe Impact
g	Pipe	PI-OH	Pipe Impact
d	Outfall	PI-OF	Pipe Impact
v	Culvert	RD-CV	Road Impact
x	Concrete Low Water Crossing	RD-LW	Road Impact
c	Dirt Low Water Crossing	RD-4D	Road Impact
z	Overhead Bridge	RD-OH	Road Impact
p	Sedimentation	SD-OH	Sediment
o	Excess Fines	SD-EF	Sediment
i	In Channel Bars	SD-CB	Sediment
u	Vegetated Islands	SD-VI	Sediment
e	In Channel Vegetation	VEG	Sediment
m	Large Woody Debris	OH-LW	Other
n	Trash	TR	Other
b	Fish Barrier	FB	Other
l	Live Stock	LS	Other
q	Construction	CN	Other
j	Debris Jam	JM	Other
h	Fence	OH-O2	Other
k	Incoming Channel	IC	Other
w	Side Channel	SC	Other
y	Recreational Site	RS	Other

Table B. Discrete point feature locations code and type

pl_C	pl_T
0	All
1	Left Bank
2	Both Banks
3	Right Bank
5	In-channel