Cuyahoga River Watershed Study

Summit County Surface Water Management District

April 11, 2025

TETRA TECH

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EXECUTIVE SUMMARY

The Summit County Surface Water Management District (SWMD) was created to support communities in Summit County with stormwater management planning and to administer Summit County's municipal separate storm sewer (MS4) program. SWMD is composed of the city of Reminderville, village of Lakemore, and the following nine townships: Bath, Boston, Copley, Coventry, Northfield Center, Richfield, Sagamore Hills, Springfield, and Twinsburg. SWMD uses a watershed-approach and is conducting stormwater studies throughout Summit County. The Stormwater Drainage Manual sets "*the standards and guidelines for permitting land development throughout the County while reducing the damaging effects of accelerated stormwater runoff, soil erosion, and sedimentation*" (Summit County Engineer (SCE), 2020).

The objectives of this *Cuyahoga River Watershed Study* are to (1) identify areas impacted by flooding, erosion, and degraded water quality, (2) recommend projects to address flooding and erosion and to improve water quality, and (3) make recommendations to update the county's regulated MS4 mapping. SWMD hired Tetra Tech to support the study through a competitive bidding process and the scope of the study includes four general tasks, which correspond to the sections in this report:

1. **Summary of Available Data and Information** (Section 2.0). A desktop analysis and review of existing information and published studies (e.g., drainage complaints, illicit discharges, stormwater master plans [SWMPs] from the Northeast Ohio Regional Sewer District [NEORSD], Non-Point Source Implementation Strategies [NPS-IS], Watershed Action Plans [WAPs], and other studies).
2. **Geomorphic Assessment of Key Waterbodies** (Section 3.0). A field-based geomorphic assessment of key water courses to identify areas impacted by flooding, erosion, and degraded water quality.
3. **Baseline Recommendations** (Section 4.0). Identify issues within the study area that require regular monitoring or maintenance but do not warrant the designation of being a problem area.
4. **Identification of Problem Areas** (Section 5.0). Identify and characterize problem areas impacted by flooding, erosion, or degraded water quality. Identify opportunities to address drainage problems, reduce flooding, stabilize erosion, provide water quality treatment, and restore streams and wetlands through the use of BMPs or stormwater improvement projects.

This study covers 68-square miles in the northern portion of the SWMD and includes the city of Reminderville and the townships of Bath, Boston, Northfield Center, Richfield, Sagamore Hills, and Twinsburg. The other communities are either in the Tuscarawas River watershed or are part of other studies. The locations where Tetra Tech conducted geomorphic assessment of key water courses and spot checks of drainage complaints and service requests are shown in Figure ES - 1, Table ES - 1, and Table ES - 2.

During the desktop analyses and geomorphic assessment of key waterbodies, 41 locations were found as having minor drainage or erosion issues or unauthorized dumping. Tetra Tech developed baseline recommendations of no action, monitoring, or maintenance to address each of these 41 locations (Table ES - 3). Note that most drainage complaints (5 of 6, 83%) and half the service requests (1 of 2, 50%) were addressed by these baseline recommendations. The location, issue, and recommendations for these baseline recommendations are presented in Appendix F: no action (Table F- 1), monitoring (Table F - 2), and maintenance (Table F - 3).

This study identified 17 locations as problem areas. These locations are where Tetra Tech, in consultation with SCE, identified issues that required larger one-time improvement projects (i.e., not recurring baselines actions of monitoring and maintenance). Recommendations for implementation of these projects included channel restoration, drainage improvements, or notification of other entities. Problem areas have one-page descriptions in Sections 5.1 through 5.17 in this report and are summarized in Figure ES - 2 and Table ES – 4.

Tetra Tech did not identify any needed updates to the county's regulated MS4 mapping as a result of this study.

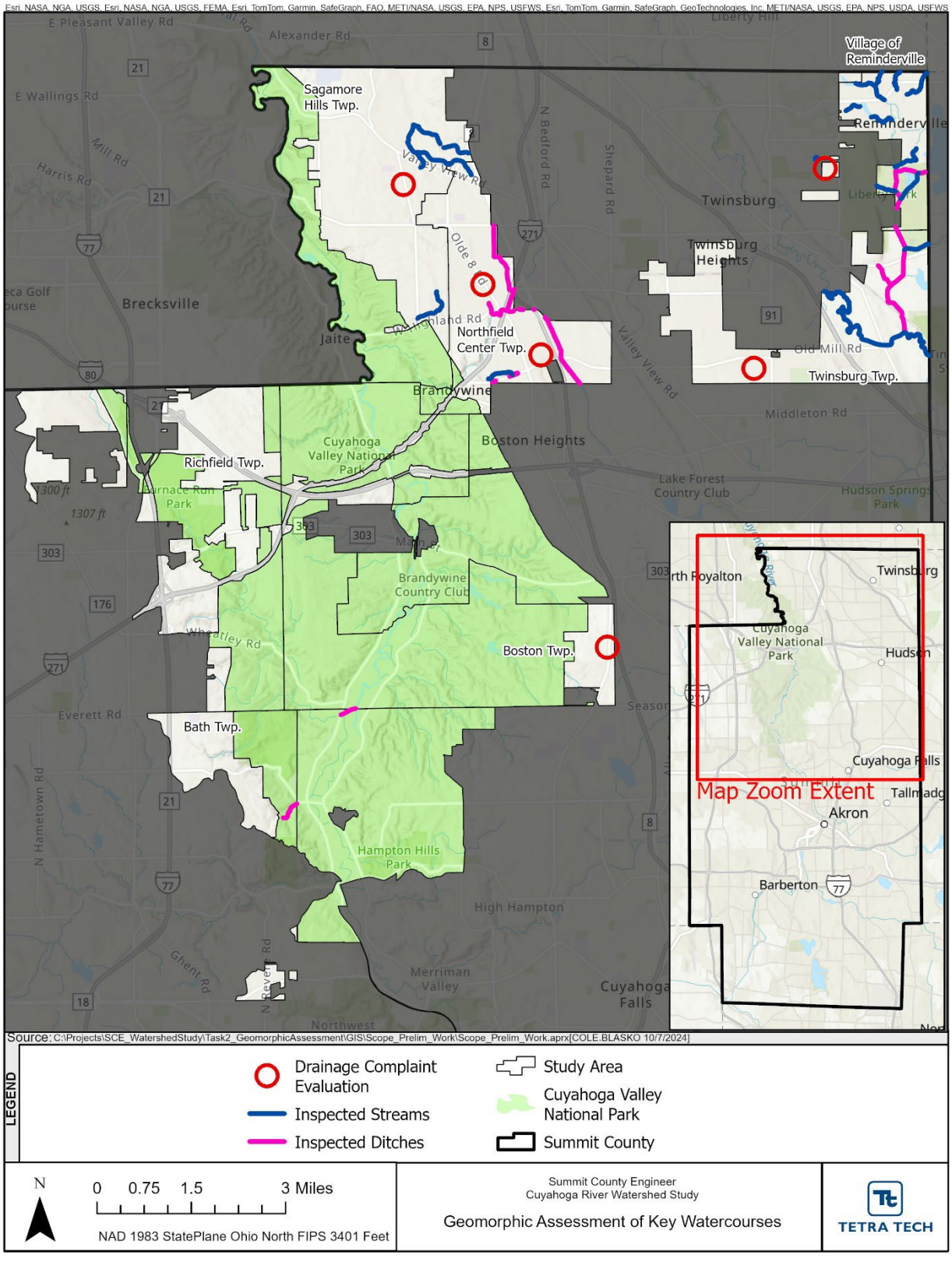

Figure ES - 1. Study area delineation and locations of geomorphic assessments

Table ES - 1. Summary of field-based geomorphic assessment of key watercourses

Date	Location	Priorities for inspection
March 17	Northfield Center Township	Brandywine Creek County Ditch
March 18	Northfield Center Township	Leach, Lemmon, Indian Creek Ditches
	Sagamore Hills Township	Select unnamed stream
	Cuyahoga Valley National Park (Bath Township and city of Cuyahoga Falls)	Furnace Run and Ira Creek County Ditches
March 19	Sagamore Hills Township	Sagamore Run and unnamed tributary
	Twinsburg Township	Tinkers Creek, Pond Brook County Ditch, and unnamed tributary to Pond Brook
March 20	City of Reminderville	Pond Brook, boating canal, restored wetlands, Aurora Lake, unnamed tributaries to Pond Brook, locations of flooding, structures pertinent to HEC-RAS model
March 21	City of Reminderville	Channel Brook, unnamed tributaries to Pond Brook
September 12	Northfield Center Township	Unnamed tributary to Brandywine Creek

Table ES - 2. Drainage complaints and service requests evaluated during the field-based geomorphic assessment

Street	Community	Subwatershed
Akron-Cleveland Road	Boston Township	Stefans Run
Anchor Lane	Northfield Center Township	Brandywine Creek
Marwell Boulevard	Twinsburg Township	Unnamed tributary to Tinker's Creek
North Boyden Road	Sagamore Hills Township	Unnamed tributary to Cuyahoga River
Olde 8 Road	Northfield Center Township	Brandywine Creek
Steffan Woods Drive	Twinsburg Township	Unnamed tributary to Pond Brook
West Twinsburg Road [a]	Northfield Center Township	Unnamed tributary to Brandywine Creek

Notes:
a. Two service requests submitted to the county were visited at two separate addresses along West Twinsburg Road.

Table ES - 3. Summary of issues and baseline recommendations

Recommendation	Drainage	Erosion	Drainage & Erosion	Unauthorized dumping
No action	9	5	2	--
Monitor	4	8	--	1
Maintenance	8	1	1	2

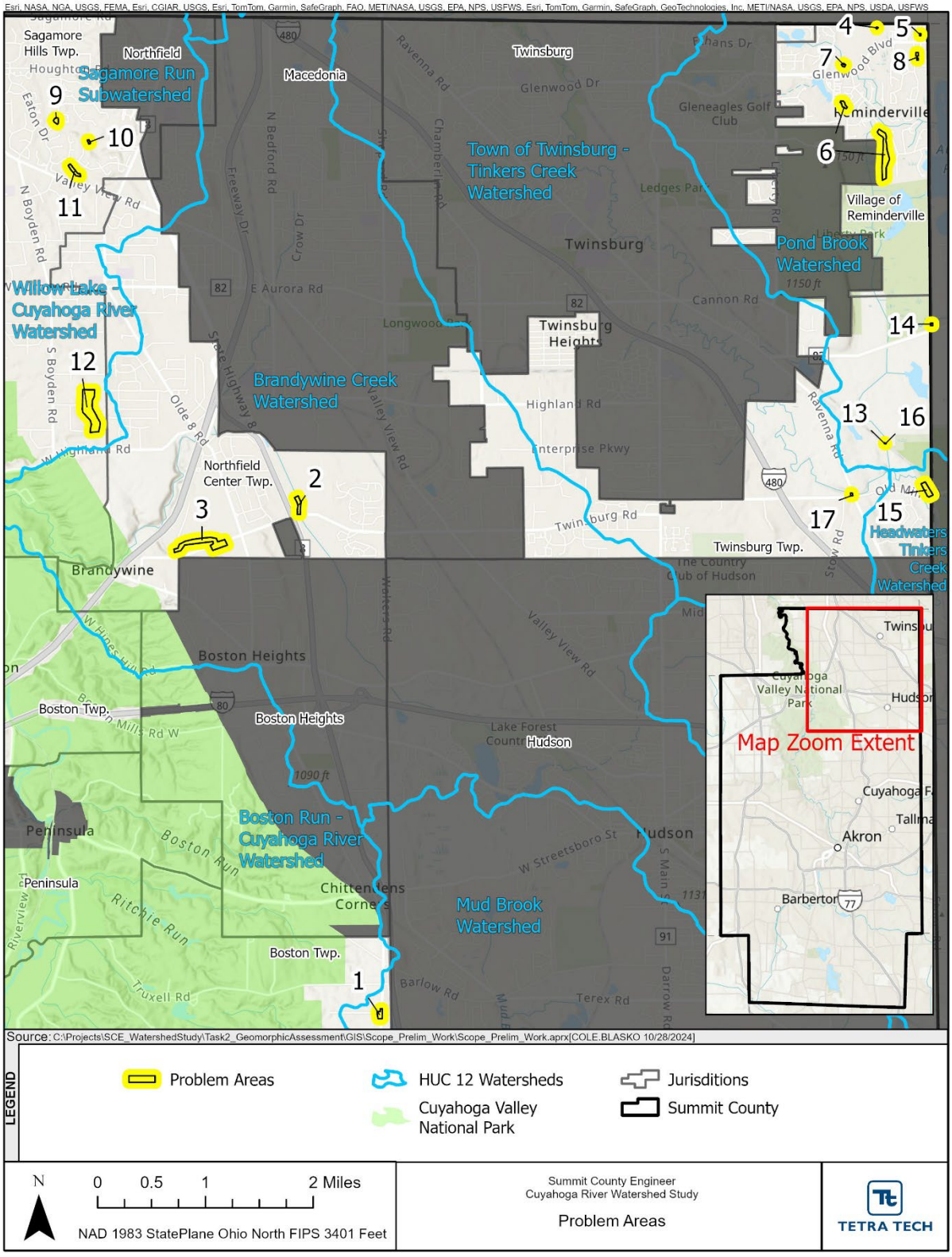

Figure ES - 2. Map of problem areas

Table ES - 4. Summary of problem areas

#	Name	Subwatershed	Community	Problem	Recommended Action
1	Akron Cleveland Road Drainage Complaint	Stefans Run [a]	Boston Township	Blocked and undersized road and driveway culverts	Reconfigure/upsize stormwater drainage system
2	Dumping along Brandywine Creek	Brandywine Creek	Northfield Center Township	Debris and trash in and along banks of Brandywine Creek	Notification of Summit SWCD
3	West Twinsburg Road Drainage Issues	Brandywine Creek [b]	Northfield Center Township	Widespread drainage issues causing flooding and erosion	Mechanical excavation and restoration of unnamed stream, roadside ditch stabilization
4	Erosion at Crossings Drive Culvert	Pond Brook	City of Reminderville	Erosion behind culvert headwall, soil slumping	Advise the City of Reminderville to monitor erosion
5	Florida Street Blocked Driveway Culvert	Pond Brook	City of Reminderville	Blocked and undersized driveway culvert	Advise the City of Reminderville to upsize the culvert
6	Aurora Shores Flooding and Erosion	Pond Brook	City of Reminderville	Backyard flooding, streambank erosion	Stabilize streambank erosion and address drainage issues
7	Channel Brook Failed Crossing	Pond Brook	City of Reminderville	Failed bridge crossing (water bypasses culvert), upstream ponding	Install new crossing; opportunity for wetland creation
8	Aurora Shores Tributary Erosion	Pond Brook	City of Reminderville	Homemade revetment impedes flow, streambank erosion	Landowner education and stream stabilization
9	Troubadour Drive Crossing	Sagamore Run [c]	Sagamore Hills Township	Misaligned and undersized road culvert (NEORSD problem area SCPA03)	Replace and upsize the culvert and realign the culvert inlet
10	Sagamore Run Erosion	Sagamore Run [c]	Sagamore Hills Township	Streambank erosion in backyard of residential property	Install bank toe protection
11	Walton Road Crossing	Sagamore Run [c]	Sagamore Hills Township	Two undersized culverts and downstream channel incision	Remove the second culvert, stabilize the stream and road embankment

#	Name	Subwatershed	Community	Problem	Recommended Action
12	Inverness Highlands Flooding and Erosion	Willow Lake [d]	Sagamore Hills Township	Widespread drainage issues causing flooding and erosion	Both stream restoration and drainage improvements in multiple locations
13	Undercut Railroad Bridge Abutments	Pond Brook	Twinsburg Township	Railroad bridge abutments on left and right streambanks are undercut	Notify railroad
14	Aurora Westerly WWTP Blocked Culvert	Pond Brook	Twinsburg Township	Blocked culvert inlet near a monitoring site for Auroa Westerly WWTP	Notification of the city of Aurora
15	Lowered Wetland Water Levels at the Tinker's Creek SNP	Tinkers Creek	Twinsburg Township	Water levels in wetlands at the Tinker's Creek SNP are lowering due to the installation of a new culvert	Notification of the Ohio Department of Natural Resources, Ohio EPA and USACE
16	Spill along Pond Brook	Pond Brook	Twinsburg Township	Spill containment	Ohio EPA notified in 2024
17	Ravenna Road Bridge Embankment Erosion	Tinkers Creek	Twinsburg Township	Erosion	Stabilize gully erosion

Notes
SNP = state nature preserve; WWTP = wastewater treatment plant.
a. Stefans Run is a tributary of Mud Brook that is a tributary to the Cuyahoga River.
b. This unnamed tributary to the Cuyahoga River runs parallel to West Twinsburg Road southeast of I-271 and has its mouth on Brandywine Creek just upstream of Brandywine Falls.
c. Sagamore Run is within the *Willow Lake-Cuyahoga River* HUC12 and is a direct tributary to the Cuyahoga River with its mouth just west of Sagamore Road.
d. This unnamed tributary to the Cuyahoga River has its mouth on the Cuyahoga River just upstream of the Vaughn Road (West Highland Road) bridge, which is downstream of the mouth of Brandywine Creek.

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ACRONYMS/ABBREVIATIONS USED IN THE MAIN REPORT

Acronyms/Abbreviations	Definition
2-D	two-dimensional
AOI	area of interest
BMP	best management practice
FEMA	Federal Emergency Management Agency
FIS	flood insurance study
GIS	Geographic Information System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HUC	hydrologic unit code
IDDE	illicit discharge detection and elimination
MS4	municipal separate storm sewer system
NEORSD	Northeast Ohio Regional Sewer District
NPDES	National Pollutant Discharge Elimination System
NPS-IS	nonpoint source implementation strategy
Ohio EPA	Ohio Environmental Protection Agency
SCE	Summit County Engineer
SCPH	Summit County Public Health
SNP	state nature preserve
SWCD	Soil and Water Conservation District
SWMD	Surface Water Management District
SWMM	Storm Water Management Model
SWMP	Storm Water Master Plan
U.S. EPA	U.S. Environmental Protection Agency
WAP	watershed action plan
WWTP	wastewater treatment plant

ACRONYMS/ABBREVIATIONS ONLY USED IN THE APPENDICES

Acronyms/Abbreviations	Definition
ASHA	Aurora Shores Homeowners Association
CVE	Chagrin Valley Engineering, LTD
CVNP	Cuyahoga Valley National Park
E. coli	*Escherichia coli*
NEFCO	Northeast Ohio Four County Regional Planning and Development Organization
ODOT	Ohio Department of Transportation
PCSWMM	Personal Computer Storm Water Management Model
SEC	Summit Ecological Consulting LLC
SMP	Summit Metro Parks
TCWP	Tinker's Creek Watershed Partners
TNC	The Nature Conservancy
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

Unit of measure	Definition
gpd	gallons per day
mL	milliliter
MPN	most probable number

1.0 INTRODUCTION

This *Cuyahoga River Watershed Study* focuses on flooding, erosion, and water quality in the northern portion of the Summit County Surface Water Management District (SWMD). This section briefly summarizes background information about stormwater management in Summit County (Section 1.1), the study objectives (Section 1.2), and the study area (Section 1.3).

1.1 BACKGROUND

Stormwater management in Summit County is evolving. In recent years, the Summit County SWMD was created to support communities in Summit County with stormwater management planning and to administer Summit County's municipal separate storm sewer (MS4) program. The Summit County Engineer (SCE) sought an expansion of the SWCD in 2022 to address new requirements for MS4s in Ohio and to administer projects funded by the American Rescue Plan Act (SCE 2024).

1.1.1 Surface Water Management District

Today, the SWMD is composed of the city of Reminderville, village of Lakemore, and the following nine townships: Bath, Boston, Copley, Coventry, Northfield Center, Richfield, Sagamore Hills, Springfield, and Twinsburg. All townships in Summit County are required to be part of the SWMD, while villages and cities can opt-in. Most villages and cities manage their own stormwater programs; such communities also operate their own MS4s.

The SWMD is a stormwater improvement program that functions as a utility (SCE 2024). The SWMD operates using a watershed-approach and is conducting stormwater studies throughout Summit County. Historically, stormwater management operated through municipal jurisdictions, which do not align with watersheds. Critical recommendations of *Reinventing Stormwater Management in Summit County* were to establish a team of watershed professions with technical expertise and to manage stormwater on a watershed-basis (Summit County 1998).

This study of the Cuyahoga River watershed includes only the city of Reminderville and the townships of Bath, Boston, Northfield Center, Richfield, Sagamore Hills, and Twinsburg. The other communities are either in the Tuscarawas River watershed or are part of other studies. The study area is further discussed in Section 1.3.

1.1.2 Stormwater Drainage Manual

The Stormwater Drainage Manual provided by the Summit County Engineer sets "*the standards and guidelines for permitting land development throughout the County while reducing the damaging effects of accelerated stormwater runoff, soil erosion, and sedimentation*" (SCE, 2020). Last revised on January 1st, 2020, the manual is organized in two main sections: performance requirements, and technical requirements. Requirements are given for all primary stormwater features including infrastructure (e.g., culverts, storm sewers, dams, etc.) and natural components (e.g., open water courses, wetlands, etc.).

The performance requirements give general descriptions of criteria that each stormwater feature must comply with to ensure protection of the welfare, health, and safety of the County's natural resources and environment. For example, the performance requirements "*establish the purpose, criteria, regulations, and means to administer and implement the Stormwater Management Program*" (SCE, 2020). The technical requirements "*provide an engineering reference source of standard design criteria, methodologies and design examples to establish stormwater control measures*" (SCE, 2020).

Perhaps most applicable to the baseline and problem area recommendations made herein, are the Stormwater Drainage Manual requirements related to culverts. Many aspects must be considered when evaluating the performance and design of culverts. The technical requirements for the design of a stormwater routing system only applies to culverts within the 100-year flood routing path. These technical requirements include, but are not limited to, hydraulic analyses to determine roadway inundation depths for the 100-year design storm, backwater analyses to determine upstream water surface elevations, and skew angles of the culvert relative to the natural channel direction. Applicable to all culverts, regardless of whether it is in the major 100-year flood routing path, the performance requirements specify, among other items, that "*the peak headwater depth during the 100-year frequency event shall be 1 foot below the finished grade adjacent to any existing or proposed building.*" (SCE, 2020).

Where applicable, the Stormwater Drainage Manual was referenced by Tetra Tech when developing the baseline and problem area recommendations herein.

1.1.3 Municipal Separate Storm Sewer System

In Ohio, the Ohio Environmental Protection Agency (Ohio EPA) delegated authority to issue National Pollutant Discharge Elimination System (NPDES) permits to authorize the discharge of effluent to waters of the state (i.e., streams, rivers, lakes, reservoirs). Ohio EPA issues individual NPDES permits for medium and large MS4s that serve communities of 100,000 or more people and issues general NPDES permits for small MS4s that serve communities with less than 100,000 people. On April 1, 2021, Ohio EPA issued its fourth general NPDES permit for small MS4s: *General Permit for Discharges of Storm Water from Small Municipal Separate Storm Sewer Systems* (OHQ000004). This general permit is effective from April 1, 2021, through March 31, 2026.

Summit County is a small MS4 with coverage under Ohio's general NPDES permit for small MS4s (OHQ000004): *Summit County and Others* (3GQ00065). Ohio EPA granted permit coverage for the fourth iteration of the general permit on May 25, 2021. Eleven cities, villages, and townships are co-permittees:

- Village of Lakemore
- City of Reminderville
- Bath Township
- Boston Township
- Copley Township
- Coventry Township
- Northfield Center Township
- Richfield Township
- Sagamore Hills Township
- Springfield Township
- Twinsburg Township

Summit County's MS4 program is cooperatively operated by the Summit County Engineer's Office, Summit County SWMD, Summit County Soil and Water Conservation District (Summit SWCD), Summit County Public Health District, and the Geographic Information System (GIS) Program in the Summit County Department of Community and Economic Development. The Summit County Public Health District assists with the Illicit Discharge Detection and Elimination (IDDE) program by completing dry weather outfall screenings, pollutant source tracking, and illicit discharge elimination. The Engineer's Office works with the GIS program to accurately map stormwater infrastructure. The Engineer's Office contracts with the Summit SWCD to provide public education and outreach opportunities, public involvement activities, and implementation of best management practices (BMPs).

1.2 STUDY OBJECTIVES

The objectives of the Cuyahoga River watershed study are to (1) identify areas impacted by flooding, erosion, and degraded water quality, (2) recommend projects to address flooding and erosion and to improve water quality, and (3) make recommendations to update the county's regulated MS4 mapping.

The study includes five general tasks, which correspond to the sections in this report:

1. **Summary of Available Data and Information** (Section 2.0). A desktop analysis and review of existing information and published studies (e.g., drainage complaints, illicit discharges, stormwater master plans [SWMPs] from the Northeast Ohio Regional Sewer District [NEORSD], Non-Point Source Implementation Strategies [NPS-IS], Watershed Action Plans [WAP], and other studies).
2. **Geomorphic Assessment of Key Waterbodies** (Section 3.0). A field-based geomorphic assessment of key water courses to identify areas impacted by flooding, erosion, and degraded water quality.
3. **Baseline Recommendations** (Section 4.0). Identify issues within the study area that do not warrant the designation of being a problem area, but still require regular monitoring or maintenance.
4. **Identification of Problem Areas** (Section 5.0). Identify and characterize problem areas impacted by flooding, erosion, or degraded water quality. Identify opportunities to address drainage problems, reduce flooding, stabilize erosion, provide water quality treatment, and restore streams and wetlands through the use of BMPs or stormwater improvement projects.

Tetra Tech did not identify any needed updates to the county's regulated MS4 mapping because it was not necessary to perform a comprehensive review of storm sewers within any subdivisions.

1.3 STUDY AREA

The study area is about 68-square miles in northern Summit County and includes municipalities that are part of the Summit County SWMD, the Cuyahoga Valley National Park, and is within the Cuyahoga River watershed (Figure 1) which is within the *Cuyahoga River* subbasin (hydrologic unit code [HUC] 04110002) in the *Great Lakes* region (HUC 04). The study area is primarily composed of one city and six townships (Table 1). The study area was developed using the following set of criteria:

- All townships within Summit County plus the villages and cities that have opted in to the SWMD were initially considered as part of the study area.
- The following were removed from the study area:
    - Any areas outside of the Cuyahoga River watershed. Note that the Little Cuyahoga River subwatershed is comprised entirely of incorporated cities and villages with their own stormwater programs and thus are not in the SWMD.
    - The village of Lakemore and Springfield Township were removed because those areas are part of another study that SCE has contracted.
    - The Yellow Creek subwatershed was removed because that is part of another study that SCE has contracted which was completed in 2019.
    - Main stem of the Cuyahoga River.
- Finally, the entirety of the Cuyahoga Valley National Park was included as part of the study area, including locations within the park that do not fall within the boundaries of municipalities not part of the SWMD.

The final delineation of communities and the lengths of streams and ditches included in this study are shown in Table 1 and Figure 1 below. In total, 9.7 miles of stream were inspected and 7.4 miles of ditches were inspected across six communities. No field work was conducted in Richfield Township.

Table 1. Communities in the study area

Community	Jurisdictional area (sq. mi.)	Area in this study (sq. mi.)	Stream length in this study (miles)	Ditch length in this study (miles) [a]
Bath Township	22.5	3.4	--	0.37
Boston Township	15.1	15.1	--	0.04
Northfield Center Township	5.3	5.3	0.81	3.47
City of Reminderville	2.2	2.2	3.94	1.20
Richfield Township	16.3	10.7	--	--
Sagamore Hills Township	11.3	11.3	3.36	--
Twinsburg Township	6.4	6.4	1.55	2.30
Cuyahoga Valley National Park [b]	36.7	36.7	--	0.63 [c]

Notes

a. A negligible length of ditch in Northfield Center Township was a road side ditch; otherwise, all ditch lengths are County Ditches who's lengths and Ditch Numbers are reported in Table 9.

b. The areas and lengths reported for the Cuyahoga Valley National Park overlap the communities listed in the table. Communities within the National Park that are not part of the SWMD include the cities of Akron and Cuyahoga Falls and the villages of Peninsula and Boston Heights.

c. Length includes ditch reaches in Bath Township, Boston Township, and the city of Cuyahoga Falls

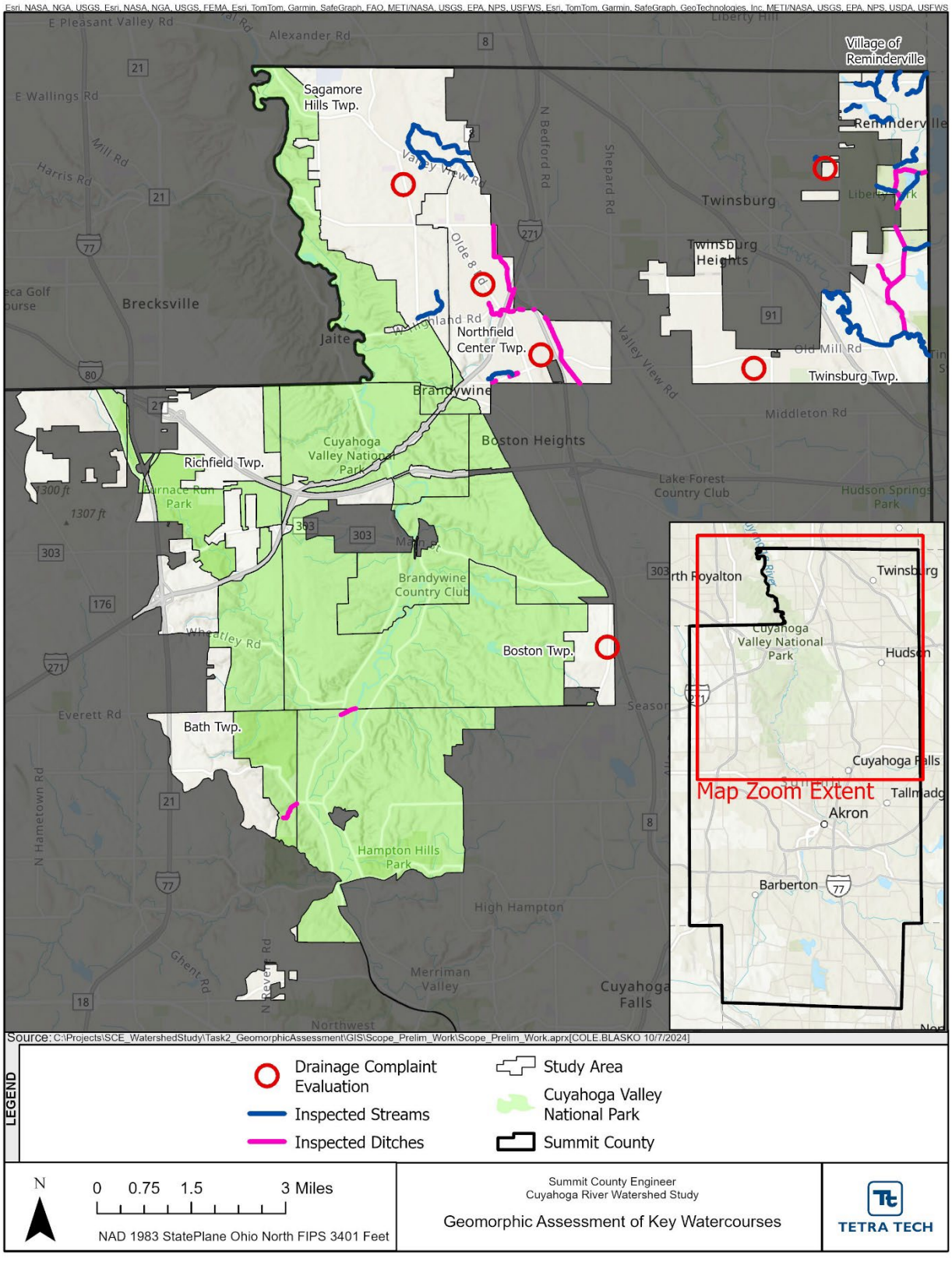


Figure 1. Study area delineation and locations of geomorphic assessments

2.0 SUMMARY OF AVAILABLE DATA AND INFORMATION

Tetra Tech conducted a comprehensive review of all available data and information to develop an understanding of watershed conditions, previous studies conducted, and existing issues that may or may not already be in process of being addressed. SCE provided Tetra Tech with much of this documentation including drainage complaints, service requests, illicit discharge detection and elimination reports, and several studies prepared by consultants. Tetra Tech also obtained and reviewed other data sources including NEORSD SWMPs, NPS-IS plans[1], and WAPs[2].

2.1 DRAINAGE COMPLAINTS AND SERVICE REQUESTS

Tetra Tech assessed stormwater issues identified by residents and submitted to SCE. First, drainage complaints submitted by residents on the SWMD online form[3] include information such as the location, name of landowner, contact information, nature of the issue and supporting documentation. SCE provided Tetra Tech with 62 drainage complaints. Of these, the location of only nine of them fell within the defined study area. All drainage complaint locations within the study area were visited during the geomorphic assessment of key watercourses (Section 3.0) as either part of a planned stream/ditch inspection or a separate visit specifically to address the drainage complaint (Figure 1).

SCE also provided Tetra Tech with a list of service requests after the initial geomorphic field inspection had been completed. For this reason, Tetra Tech was only able to visit two of the service requests. Both requests were located along West Twinsburg Road in Northfield Center Township and were assessed as part of the supplemental field work for that problem area.

The drainage complaints and service requests are addressed either under a baseline recommendation (Section 4.0) or defined problem area (Section 5.0).

2.2 ILLICIT DISCHARGE DETECTION AND ELIMINATION

Summit County and 11 co-permittees[4] own and operate regulated MS4s that are covered by Ohio's general NPDES permit for *Small MS4s* (Ohio EPA 2021). Summit County and the co-permittees must implement their illicit discharge detection and elimination (IDDE) programs. To meet this requirement, SCE contracts with Summit County Public Health (SCPH) to perform dry-weather monitoring. Refer to Appendix A for additional information about MS4s and IDDE reporting.

In 2023, SCPH identified 42 stormwater outfalls with dry-weather discharges, which is 13% of all screened outfalls. Many MS4 systems are intentionally designed to allow groundwater to flow through stormwater pipes which helps control the water table and prevents basements from flooding. However, screened outfalls with dry-weather discharges could potentially degrade water quality since the discharge would not be stormwater and could be untreated or partially treated sanitary wastewater. Sanitary wastewater can impair the designated recreation uses and aquatic life uses of Ohio waterways. Refer to Appendix A for additional discussion of dry-weather discharges.

[1] Ohio EPA publishes approved NPS-IS plans online: https://epa.ohio.gov/divisions-and-offices/surface-water/reports-data/approved-nine-element-nonpoint-source-implementation-strategies-in-ohio.
[2] Ohio EPA published endorsed WAPs online: https://epa.ohio.gov/divisions-and-offices/surface-water/reports-data/endorsed-watershed-action-plans.
[3] Surface Water Management District Drainage Concern Form: https://www.summitengineer.net/cgi-bin/queue/collect.pl?form_id=145.
[4] The 11 co-permittees are the village of Lakemore, city of Reminderville, and Bath, Boston, Copley, Coventry, Northfield Center, Richfield, Sagamore Hills, Springfield, and Twinsburg townships

2.3 NEORSD STORMWATER MASTER PLANS

SWMPs are watershed-scale planning documents to address water quality issues, stormwater-induced erosion, and the maintenance and improvement of stormwater conveyance along the regional stormwater system managed by the NEORSD. SWMPs identify problem areas within each watershed where spatial clusters of the aforementioned issues are addressed. More specifically, problem areas look at where building, transportation, or utility assets are impacted by stormwater or where stream health and function can be improved through baseline solutions and larger-scale alternative development. Baseline solutions restore and preserve the existing function of the stormwater system through stormwater controls, while alternatives enhance the system to increase functionality. Problem areas are addressed through baseline solutions, alternative development, or both. A series of models support these SWMPs and are summarized in Appendix B.

The Cuyahoga River South SWMP addresses ten subwatersheds that drain 290 square miles of the Cuyahoga River basin south of I-480. Of these ten subwatersheds, three of them have a combined total of 11 problem areas identified in the SWMP that coincide with the study area of this project. These 11 problem areas are discussed in detail in the sections below and are shown in Figure 2. One of these 11 problem areas identified by NEORSD is included as a problem area in this study. The status of completion/implementation of the baseline solutions and alternatives developed for the remaining ten NEORSD problem areas identified in the March 2019 Cuyahoga River South SWMP is currently unknown. Additionally, while these ten remaining NEORSD problem areas are within the Cuyahoga River Watershed study area, they did not fall on selected streams or ditches to be inspected.

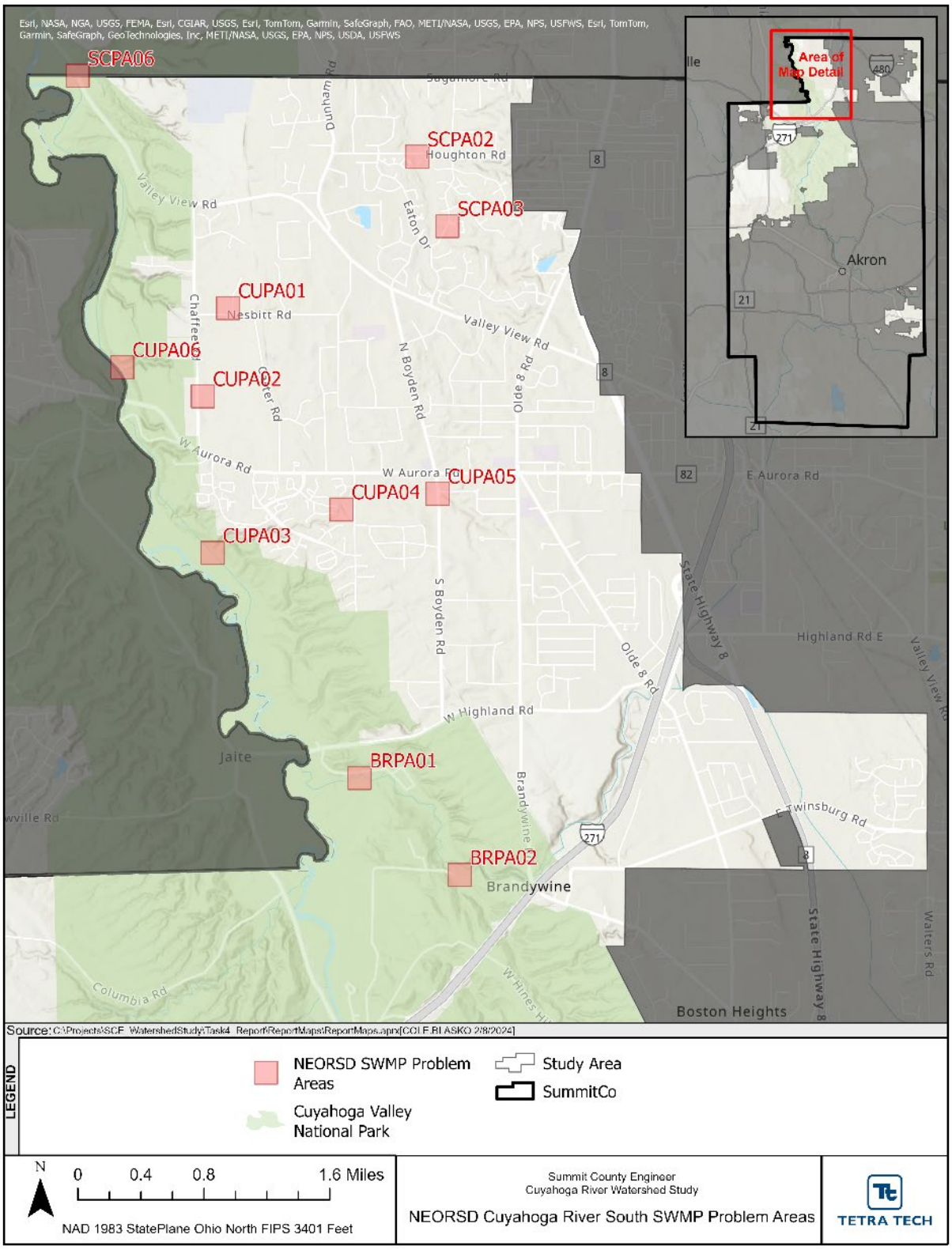


Figure 2. Locations of problem areas from the NEORSD Cuyahoga River South SWMP within this study area

2.3.1 Brandywine Creek SWMP Problem Areas

Two problem areas within the Brandywine Creek subwatershed coincide with the study area of this project (Table 2, Figure 2).

Table 2. Summary of Brandywine Creek problem areas of interest

Problem Area	Issues Identified	Baseline Solutions and Recommended Alternative Solutions
BRPA01	Erosion and flooding adjacent to Brandywine Ski Resort	No-net-loss of existing floodplain storage and riparian function. Notify ski resort owner of partially collapsed right abutment of pedestrian crossing, erosion around right & left abutment of vehicle crossing, and risk of flooding in high storm events. Remove steel pipe and replace with step pool/rock shoot. Enhance the floodplain and stream sinuosity while decreasing stream gradient through the Brandywine Ski Resort Property. Stabilize streambanks to withstand scour at existing crossings.
BRPA02	Erosion at Stanford Road crossing	Increase inspection frequency of Stanford Road crossing to assess worsening of current erosion and sedimentation conditions. Replace right abutment and pier cap of pier 2 of Stafford Road crossing. Add bank protection on left bank for 30 feet above crossing and for 160 feet on right bank below crossing.

2.3.2 Small Cuyahoga River East SWMP Problem Areas

Six problem areas within the Small Cuyahoga River East subwatershed coincide with the study area of this project (Table 3, Figure 2).

Table 3. Summary of Small Cuyahoga River East problem areas of interest

Problem Area	Issues Identified	Baseline Solutions and Recommended Alternative Solutions
CUPA01	Conveyance constrictions and high flow velocities	Repair the Chaffee Road crossing headwall. No-net-loss of existing floodplain storage and riparian function. Reattach upstream end section of pipe and place appropriately sized riprap at the inlet and outlet. Reroute channel from backyards on Nesbitt Road to rear property lines and around large pond by constructing two-stage channel along the rear property line with features to support proper geomorphic function/ecologic health. Upsize Summersweet Trail crossing (CH00328) to pass 100-year storm.

Problem Area	Issues Identified	Baseline Solutions and Recommended Alternative Solutions
CUPA02	Conveyance constrictions and shallow road and yard flooding	No-net-loss of existing floodplain storage and riparian function. Upsize Chafee Road crossing (CU00324_T001) and driveway crossing (CU00618_T001) to 5-foot high by 12-foot wide box culverts. Remove crossing (CU00497) and restore 500-feet of stream as a two-stage channel with features to achieve geomorphic function and ecologic health.
CUPA03	Erie Canal Towpath Crossing has worn abutments with cracks and spalls	Periodic inspections should be conducted to inspect the overall integrity of RSS crossing asset CU00366 since it is generally worn. Crossing CU00366 requires only structural repairs consisting of patching of spalls, epoxy injection to fill structural cracks, and sealing of abutments and wingwalls.
CUPA04	Hike and Bike Trail crossing is worn and exposed utility in stream	Recommend monitoring CU00369_U001 for changes in condition as field inspections indicate this exposed utility is stable. Crossing CU00370 requires only structural repairs consisting of patching worn concrete areas.
CUPA05	Flooding of access road and erosion encroaching house	No-net-loss of existing floodplain storage and riparian function. Purchase property (PPN 4501178) and demolish home Remove crossing (CU00381), daylight 210 feet of culverted stream (CU00383), and upgrade 600 feet of channel CU00382 to two-stage channel with grade control
CUPA06	Historic Dam causing gravel bar development downstream	The steep valley banks upstream of the Mud Catcher Dam are naturally highly erodible and are contributing sediment to the stream, which will likely continue indefinitely. Because the area behind the Mud Catcher Dam is full to the weir level, this sediment enters the Ohio & Erie Canal and has formed a large gravel bar at the mouth of ST East 6 into the canal. Upon investigation, these problems were not found to be a higher risk to BTUs at this time, nor did they present immediate threats to geomorphic function or ecologic health. As such, the SWMP recommends more frequent monitoring of these locations to determine if the risk increases and/or if geomorphic/ecologic issues emerge.

Note: BTU = building, transportation, or utility; RSS = regional stormwater system; SWMP = stormwater management plan.

2.3.3 Sagamore Creek SWMP Problem Areas

Three problem areas in the Sagamore Creek subwatershed coincide with this project's study area (Table 4, Figure 2).

Table 4. Summary of Sagamore Creek problem areas of interest

Problem Area	Issues Identified	Baseline Solutions and Recommended Alternative Solutions
SCPA02	Flooding of Houghton Road Impaired geomorphic function and ecological health	Debris partially blocks the inlet to the Houghton Road crossing and should be removed. No-net-loss of existing floodplain storage and riparian function. Repair Houghton Road crossing. Replace Houghton Road crossing with twin box culverts, each 6-feet (H) by 15-feet (W). Raise 650 ft of Houghton Road to an elevation of 877-feet. Remove outlet/embankment of Eaton Estates basin and restore wetland within existing basin footprint.
SCPA03	Flooding of Troubadour Drive (also listed as problem area in this study)	Increase monitoring and debris removal frequency at the Troubadour Drive crossing. No-net-loss of existing floodplain storage and riparian function. Sediment removal at Troubadour Drive crossing. Upsize Troubadour Drive crossing to twin 6-foot diameter RCP.
SCPA06	Flooding via backwater from Cuyahoga River and sedimentation under Canal Road crossing reducing the Sagamore Creek flows	Flooding is attributable to Cuyahoga River backwater flooding this is unable to be mitigated under this SWMP. As such, a flood warning system with signage should be used in this project area to prevent ingress/egress during extreme flood events. More frequent inspections are recommended to detect sediment buildups in the Canal Road crossing that could limit Sagamore Creek conveyance capacity and cause flooding during events where the Cuyahoga River has not reached flood stage.

Note: H = height; RCP = reinforced concrete pipe; W = width.

2.4 NONPOINT SOURCE IMPLEMENTATION STRATEGIES

NPS-IS plans are watershed-scale planning documents to address nonpoint sources of pollution. NPS-IS plans must identify causes and sources of impairment, delineate critical areas, define quantified goals and objectives to address the causes and sources of impairment, and identify and prioritize projects to meet those goals and objectives. Ohio EPA designed NPS-IS plans, including a document template, to meet U.S. Environmental Protection Agency (U.S. EPA) Nine Minimum Elements of Successful Watershed Plans. As such, in Ohio, to be eligible for nonpoint source grants through Clean Water Act Section 319(h) funding, a project must be identified in an NPS-IS plan. These plans are living documents that can be regularly updated to reflect changes in the watershed and to identify and prioritize additional projects.

Many NPS-IS plans have been developed throughout the Cuyahoga River watershed. Within the study area, seven NPS-IS plans have been developed since 2017 (Table 5). These plans are summarized in Appendix C

Table 5. NPS-IS plans covering the project area

Subwatershed	Hydrologic unit code (04110002)	Author	Publication year
Boston Run-Cuyahoga River	04 05	Summit Ecological Consulting, LLC	2020
Brandywine Creek	04 04	Tinker's Creek Watershed Partners	2020
Furnace Run	04 03	Summit SWCD	2025
Pond Brook	05 01	Chagrin Valley Engineering, LTD	2017
Town of Twinsburg-Tinkers Creek	05 04	Chagrin Valley Engineering, LTD	2017
Willow Lake-Cuyahoga River	05 05	Chagrin Valley Engineering, LTD	2020
Yellow Creek	04 02	Summit SWCD	2025

NPS-IS plans are developed using in-stream monitoring data, often collected by Ohio EPA, to identify impairments. None of the NPS-IS plans in the study area were developed using Ohio EPA's most recently collected data in 2017 and 2018. The historic data used to identify impairments and problem areas may not be representative of current (i.e., 2024-2025) conditions.

Many of the NPS-IS plans generally identify objectives that are consistent with the objectives of this study:

- to restore/stabilize streambanks, restore/reconnect floodplains, restore/enhance/protect riparian habitat, create/restore/enhance wetlands
- to remove barriers to fish and aquatic life passage,
- to install green infrastructure, retrofit/improve existing stormwater infrastructure, replace culverts

Refer to Appendix C for brief summaries of the projects or to the plans themselves for lists and detailed descriptions of the projects.

2.5 WATERSHED ACTION PLANS

Watershed Action Plans (WAPs) are also watershed-scale planning documents to address nonpoint sources of pollution. WAPs typically include inventories of natural features, demographics, cultural resources, and existing studies. These planning documents typically define watershed goals, delineate priority areas, and identify actions, implementers, and tracking metrics. While some actions include specific, shovel-ready projects, many actions are often general and conceptual.

U.S. EPA Region 5 does not recognize WAPs in Ohio as watershed planning documents that meet the Nine Minimum Elements of Successful Watershed Plans. As such, projects identified in a WAP (and not identified in an NPS-IS) are not eligible for nonpoint source grants through Clean Water Act Section 319(h) funding. In response to the determination that WAPs in Ohio to not meet the Nine Minimum Elements, Ohio EPA developed the NPS-IS framework specifically to meet the Nine Minimum Elements and to identify project eligible for 319(h) grant funding.

Two WAPs cover portions of the study area (Table 6). These two WAPs are summarized in Appendix C. One key project identified in the Tinker's Creek WAP was implemented: the three wetland cells southwest of the Aurora Shores development. No other key projects (with specific locations and actions) were identified in the study area.

Table 6. WAPs covering the project area

Subwatershed	HUC 04110002	Author	Publication year
Tinker's Creek	05 01, 05 04, 05 05	Tinker's Creek Watershed Partners	2016
Yellow Creek	04 02	NEFCO	2004

Note: HUC = hydrologic unit code; NEFCO = Northeast Ohio Four County Regional Planning and Development Organization.

2.6 AURORA SHORES STUDIES

The flooding in the Aurora Shores neighborhood of the city of Reminderville has been a longstanding issue. These flooding issues are influenced by upland drainage areas, streams and stormwater infrastructure within the neighborhood itself, and the Pond Brook restoration and constructed wetlands immediately downstream of the neighborhood. The Pond Brook restoration and constructed wetlands are in the Summit Metroparks Liberty Park – Pond Brook Conservation Area. As such, many studies have been conducted regarding the hydrology of the complex stream network in this area. In general, these studies have focused on addressing the existing flooding issues and assessing the impacts of the Pond Brook restoration and constructed wetlands in the Pond Brook Conservation Area.

The results of these studies are summarized in greater detail in Appendix D. In general, these studies focused on specific flood issues and did not holistically assess the entire watershed. For this reason, Tetra Tech built a two-dimensional (2-D) Hydrologic Engineering Center River Analysis System (HEC-RAS) model that incorporates all components of the complex watershed that may influence flooding. This includes the restoration of Pond Brook, the constructed wetlands, and associated Agri-Drains; Channel Brook; the boating canal; Aurora Lake and its spillway; the Clipper Cove aqueduct; and the multiple tributaries to Pond Brook. The development and results of the 2D HEC-RAS model are discussed in detail in the supporting memorandum named Aurora Shores 2-D HEC-RAS Model (Tetra Tech, 2025).

2.7 ALL OTHER PREVIOUS STUDIES

Multiple additional studies were conducted that do not fall under the categories discussed previously. These studies document the assessment of issues and any proposed improvements, restoration, rehabilitation, or alternatives for specific locations within the SWMD service area including:

- the Yellow Creek Watershed Technical Memorandum
- the Chaffee Road wetland area restoration
- the Dorwick Ditch rehabilitation project
- the Wye Road flood mitigation and alternatives study

Summaries of these studies are provided in Appendix E. Because these issues have already been addressed, they were not further evaluated as part of this study.

Additionally, Tetra Tech reviewed the revised 2016 Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for Summit County and incorporated areas (FEMA 2016). Tetra Tech downloaded the geospatial data associated with the 2016 revision and use the data in evaluating each problem area. Detailed descriptions of the results of the 2016 FEMA FIS study are provided in Appendix E.

3.0 GEOMORPHIC ASSESSMENT OF KEY WATERCOURSES

To support the identification of problem areas and opportunities to address such problem areas, Tetra Tech staff conducted field-based geomorphic assessments of key watercourses in March 2024. Tetra Tech conducted an additional field visit on September 12, 2024, to assess another stream reach of concern identified by SCE (Table 7). Based on the review of available data and information (Section 2.0) and consultation with SCE, the fieldwork targeted Pond Brook and the Aurora Shores neighborhood, drainage complaints and service requests in the study area, and select drainage ditches and streams (Figure 1). These prioritized locations are in Bath, Boston, Northfield Center, Sagamore Hills, and Twinsburg townships, and the cities of Reminderville and Cuyahoga Falls. The dates, locations, and priorities of the field-based geomorphic assessments are summarized in Table 7 and the locations of drainage complaints and service requests are summarized in Table 8.

During the fieldwork, Tetra Tech

- observed erosion at 27 locations and impacts from flooding or improper drainage at 36 locations
- observed unauthorized discharges or dumping at 5 locations
- assessed 141 structures
- characterized 97 channel banks (9.7-miles of stream and 7.4-miles of ditch) and 6 streambeds (0.8-mile)
- visited 6 drainage complaint locations
- visited 2 service request locations

The findings of the field work are summarized in an online storymap[5] and incorporated into the baseline recommendations in Section 4.0 and the descriptions of the problem areas in Section 5.0.

Table 7. Summary of field-based geomorphic assessment of key watercourses

Date	Location	Priorities for inspection
March 17	Northfield Center Township	Brandywine Creek (Co. Ditch #26)
March 18	Northfield Center Township	Leach, Lemmon, Indian Creeks (Co. Ditches #98, 24, 99)
	Sagamore Hills Township	Select unnamed stream
	Cuyahoga Valley National Park (Bath Township and city of Cuyahoga Falls)	Furnace Run and Ira Creek (Co. Ditches #123, 50)
March 19	Sagamore Hills Township	Sagamore Run and unnamed tributary
	Twinsburg Township	Tinkers Creek, Pond Brook (Co. Ditch #14), and unnamed tributary to Pond Brook
March 20	City of Reminderville	Pond Brook (Co. Ditch #14), boating canal, restored wetlands, Aurora Lake, unnamed tributaries to Pond Brook, flooding locations, structures pertinent to HEC-RAS model
March 21	City of Reminderville	Channel Brook, unnamed tributaries to Pond Brook
September 12	Northfield Center Township	Unnamed tributary to Brandywine Creek

[5] The weblink is https://storymaps.arcgis.com/stories/f3e5fbcde20e478e9a748c0df584c29a.

Table 8. Drainage complaints and service requests evaluated during the field-based geomorphic assessment

Street	Community	Subwatershed
Akron-Cleveland Road	Boston Township	Stefans Run [a]
Anchor Lane	Northfield Center Township	Brandywine Creek
Marwell Boulevard	Twinsburg Township	Unnamed tributary to Tinker's Creek
North Boyden Road	Sagamore Hills Township	Unnamed tributary to Cuyahoga River
Olde 8 Road	Northfield Center Township	Brandywine Creek
Steffan Woods Drive	Twinsburg Township	Unnamed tributary to Pond Brook
West Twinsburg Road [b]	Northfield Center Township	Unnamed tributary to Brandywine Creek

Notes
a. Stefans Run is a tributary of Mud Brook that is a tributary to the Cuyahoga River.
b. Two service requests submitted to the county were visited at two separate addresses along West Twinsburg Road.

The names and lengths of specific watercourses inspected are summarized in Table 9.

Table 9. Lengths of streams inspected during the field-based geomorphic assessment

Waterbody [a]	Length of watercourse inspection (miles)
Cuyahoga River	--
Tinkers Creek	1.55
Pond Brook (Co. Ditch #14)	3.40
Unnamed tributaries to Pond Brook or Channel Brook	3.94
Herrick Ditch (Co. Ditch #103)	0.10
Sagamore Run	2.98
Unnamed tributary	
Unnamed tributary to the Cuyahoga River [b]	0.73
Unnamed tributary to the Cuyahoga River [c]	0.46
Brandywine Creek (Co. Ditch #26)	1.91
Indian Creek, Leach Ditch, Lemmon Ditch (Co. Ditches #99, 98, 24)	1.54
Furnace Run (Co. Ditch #123)	0.26
Ira Creek (Co. Ditch #50)	0.37

Notes
a. Waterbodies are sorted from top to bottom as downstream to upstream. Indents indicate tributaries.
b. This unnamed tributary to the Cuyahoga River has its mouth on the Cuyahoga River just upstream of the Vaughn Road (West Highland Road) bridge, which is downstream of the mouth of Brandywine Creek.
c. This unnamed tributary to the Cuyahoga River runs parallel to West Twinsburg Road southeast of I-271 and has its mouth on Brandywine Creek just upstream of Brandywine Falls.

4.0 BASELINE RECOMMENDATIONS

During the desktop analyses and geomorphic assessment of key waterbodies, 41 locations were found as having minor drainage or erosion issues or unauthorized dumping. Tetra Tech developed baseline recommendations of no action, monitoring, or maintenance to address each of these 41 locations. As such, these locations did not receive the "Problem Area" designation.

Tetra Tech broadly categorized the issues identified at each of the 41 locations (Figure 3):

- **Drainage** (n=21, 51%): Drainage issues generally include restricted or blocked flow along a drainageway, which can include damaged or blocked culverts. This category includes drainage complaints filed with SCE. Tetra Tech, in consultation with SCE, determined that none of these drainage issues warranted identification as a problem area.

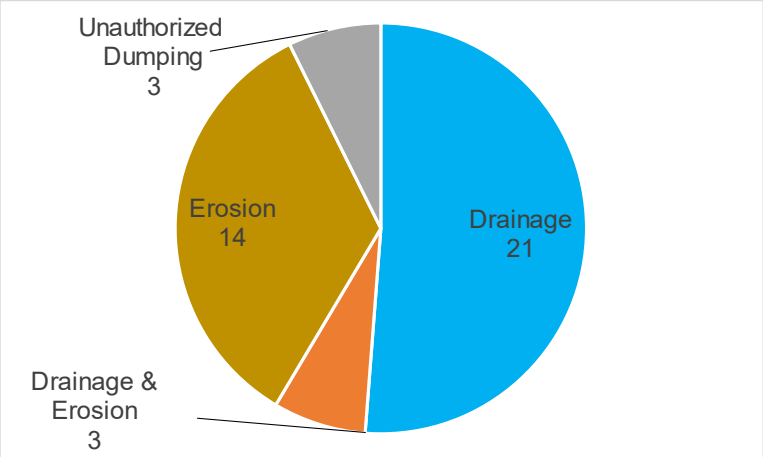


Figure 3. Categories of issues identified at the 41 locations that received baseline recommendations.

- **Erosion** (n=14, 34%): Tetra Tech observed active erosion at these locations during the geomorphic assessment in March 2024. In some cases, such erosion may threaten a structure (e.g., a condominium) or infrastructure (e.g., a roadway). In other cases, no structures or infrastructure is threatened. Erosion can be natural, anthropogenic, or a combination of natural and anthropogenic. Tetra Tech, in consultation with SCE, determined that none of these erosion issues warranted identification as a problem area.
- **Drainage and erosion** (n=3, 7%): This category includes locations with both drainage and erosion issues as described in the previous two bullets.
- **Unauthorized dumping** (n=3, 7%): Tetra Tech observed unauthorized dumping at three locations during the geomorphic assessment in March 2024. This category represents spills or unauthorized releases of liquid chemicals, solid material directly dumped into waterways, and solid material piled along the banks of waterways. These locations of unauthorized dumping are minor and in consultation with SCE, Tetra Tech has recommended baseline fixes rather than identifying them as problem areas.

For each of the 41 locations, Tetra Tech developed a baseline recommendation for SCE (Figure 4), which are broadly categorized as

- **No action** (n=16, 39%): No action is recommended for (1) natural processes that do not threaten structures or infrastructure or (2) for issues on private property that do not directly impact structures or infrastructure.

- **Monitor** (n=13, 32%): Monitoring is recommended to observe erosion and stormwater infrastructure over time to determine if and when intervention is necessary to protect infrastructure. Existing stormwater infrastructure can be monitored to determine when maintenance or replacement becomes necessary. New stormwater infrastructure installed to mitigate specific drainage or erosion issues can be monitored to determine if the drainage or erosion issues are mitigated.

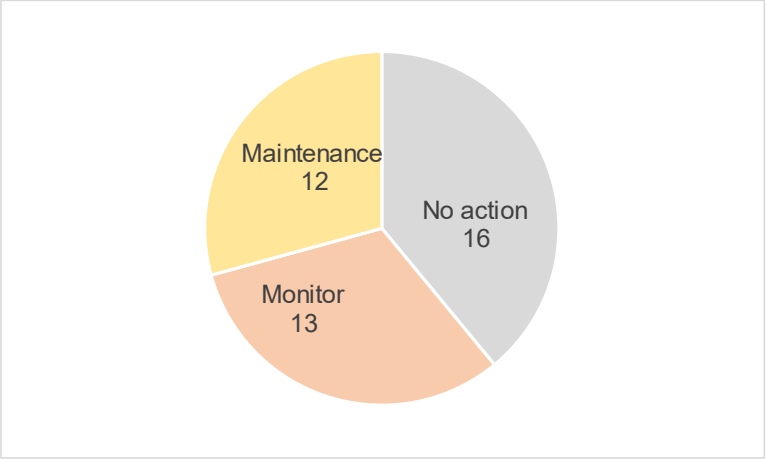


Figure 4. Baseline recommendations to address the 41 locations.

- **Maintenance** (n=12, 29%): Maintenance is recommended for stormwater infrastructure that is not operating correctly. Maintenance may include removing blockages from the channel or culverts, repairing minor erosion of streambanks, or clearing materials from unauthorized dumping sites. Maintenance recommendations for SCE address regional stormwater infrastructure. Maintenance of private infrastructure or private land is typically the responsibility of the private individual or organization and SCE may notify these entities of the recommended baseline solution.

The baseline recommendations and type of issue are summarized in Table 10 and Table 11. Further details are presented in Appendix F for each baseline recommendation: no action (Table F- 1), monitoring (Table F - 2), and maintenance (Table F - 3). Note that most drainage complaints (5 of 6, 83%) and half the service requests (1 of 2, 50%) were addressed by these baseline recommendations and these locations are specified in Appendix F.

Table 10. Summary of issues and baseline recommendations

Recommendation	Drainage	Erosion	Drainage & Erosion	Unauthorized dumping
No action	9	5	2	--
Monitor	4	8	--	1
Maintenance	8	1	1	2

The number of actionable baseline recommendations (i.e., not including recommendations of no action) made per mile of watercourse inspected varies greatly depending on the watershed (Table 11). This metric can be used as a proxy for the overall condition of the watershed and how monitoring and maintenance schedules should be prioritized. It also serves as the range of monitoring and maintenance locations that can be expected in watersheds that were not assessed in this study. Appendix F contains suggestions of monitoring (Table F - 2) and maintenance (Table F - 3) visit frequency per year.

Despite only inspecting a short segment of Ira Creek (0.37-miles), one location was recommended to be monitored and one location required maintenance. This resulted in the highest actionable baseline recommendations per mile of 5.4 (Table 11), which is largely driven by the proximity of Martin Road to the stream. The Pond Brook watershed had the most miles of watercourse inspected but had relatively few actionable baseline recommendations, with only 1.1 locations per mile. Much of the watercourse length in Pond Brook flows through forested or restored wetland areas, and as such, was a naturally functioning channel for most of its

length. On the other hand, in the Pond Brook subwatershed, all the actionable baseline recommendations are within the developed residential areas of Reminderville.

Unnamed tributaries to the Cuyahoga River had both high (4.1) and low (0) actionable baseline recommendations per mile. County ditches also have a wide range of actionable baseline recommendations per mile with Brandywine Creek having 2.6 and Indian Creek, Leach Ditch, and Lemmon Ditch having 0.6 locations per mile. Therefore, the designation of stream versus ditch, location within Summit County, and whether the watercourse is named do not appear to have an influence on the density of actionable baseline recommendations per mile of watercourse. Rather, this metric appears to depend more on anthropogenic influences, such as land use (residential neighborhoods), and proximity of watercourses to nearby infrastructure, such as roads.

Table 11. Summary of baseline recommendations and locations

Watershed	Length of watercourse inspected (miles)	Baseline recommendations					
		No action	Actionable baseline recommendations				
			Monitor	Maintenance	Total [a]	Rate (no. per mile)	
Ira Creek (Co. Ditch #50)	0.37	--	1	1	2	5.4	
Unnamed tributary to the Cuyahoga River [b]	0.73	1	1	2	3	4.1	
Brandywine Creek (Co. Ditch #26)	1.91	2	3	2	5	2.6	
Sagamore Run	2.98	5	2	2	4	1.3	
Tinkers Creek	1.55	--	1	1	2	1.3	
Pond Brook (Co. Ditch #14)	7.44	6	4	4	8	1.1	
Indian Creek, Leach Ditch, Lemmon Ditch (Co. Ditches #99, 98, 24)	1.54	1	1	--	1	0.6	
Unnamed tributary to the Cuyahoga River [c]	0.46	1	--	--	--	--	

Notes
a. The total number of actionable baseline recommendations is the summation of the monitor and maintenance baseline recommendations.
b. This unnamed tributary to the Cuyahoga River has its mouth on the Cuyahoga River just upstream of the Vaughn Road (West Highland Road) bridge, which is downstream of the mouth of Brandywine Creek.
c. This unnamed tributary to the Cuyahoga River runs parallel to West Twinsburg Road southeast of I-271 and has its mouth on Brandywine Creek just upstream of Brandywine Falls.

5.0 PROBLEM AREAS AND RECOMMENDATIONS

Problem areas were identified following the review of previous studies, desktop analyses of key datasets (e.g., drainage complaints) and geomorphic assessment of key watercourses. Tetra Tech, in consultation with SCE, identified areas with issues that required larger one-time improvement projects (i.e., not recurring baseline actions of monitoring and maintenance). Recommendations for implementation of these projects included drainage improvements, channel restoration, or notification of other entities. Tetra Tech identified 17 problem areas (Table 12 and Figure 5 through Figure 7). Concept plans are provided in Appendix G. Supporting model documentation (Tetra Tech, 2025a, b, and c) and cost estimates were provided to SCE as separate supporting documents associated with this report.

Table 12. Problem areas

#	Name	Subwatershed	Community	CP [a]
1	Akron Cleveland Road Drainage Complaint	Stefans Run [b]	Boston Township	Yes
2	Dumping along Brandywine Creek	Brandywine Creek	Northfield Center Township	No
3	West Twinsburg Road Drainage Issues	Brandywine Creek [c]	Northfield Center Township	Yes
4	Erosion at Crossings Drive Culvert	Pond Brook	City of Reminderville	No
5	Florida Street Blocked Driveway Culvert	Pond Brook	City of Reminderville	No
6	Aurora Shores Flooding and Erosion	Pond Brook	City of Reminderville	Yes
7	Channel Brook Failed Crossing	Pond Brook	City of Reminderville	Yes
8	Aurora Shores Tributary Erosion	Pond Brook	City of Reminderville	Yes
9	Troubadour Drive Crossing	Sagamore Run [d]	Sagamore Hills Township	Yes
10	Sagamore Run Erosion	Sagamore Run [d]	Sagamore Hills Township	Yes
11	Walton Road Crossing	Sagamore Run [d]	Sagamore Hills Township	Yes
12	Inverness Highlands Flooding and Erosion	Willow Lake [e]	Sagamore Hills Township	Yes
13	Undercut Railroad Bridge Abutments	Pond Brook	Twinsburg Township	No
14	Aurora Westerly WWTP Blocked Culvert	Pond Brook	Twinsburg Township	No
15	Lowered Wetland Water Levels at the Tinker's Creek SNP	Tinkers Creek	Twinsburg Township	No
16	Spill along Pond Brook	Pond Brook	Twinsburg Township	No
17	Ravenna Road Bridge Embankment Erosion	Tinkers Creek	Twinsburg Township	Yes

Notes
CP = concept plan; SNP = state nature preserve; WWTP = wastewater treatment plant.
a. Denotes whether a concept plan is included in this report.
b. Stefans Run is a tributary of Mud Brook that is a tributary to the Cuyahoga River.
c. This unnamed tributary to the Cuyahoga River runs parallel to West Twinsburg Road southeast of I-271 and has its mouth on Brandywine Creek just upstream of Brandywine Falls.
d. Sagamore Run is within the *Willow Lake-Cuyahoga River* HUC12 and is a direct tributary to the Cuyahoga River with its mouth just west of Sagamore Road.
e. This unnamed tributary to the Cuyahoga River has its mouth on the Cuyahoga River just upstream of the Vaughn Road (West Highland Road) bridge, which is downstream of the mouth of Brandywine Creek.

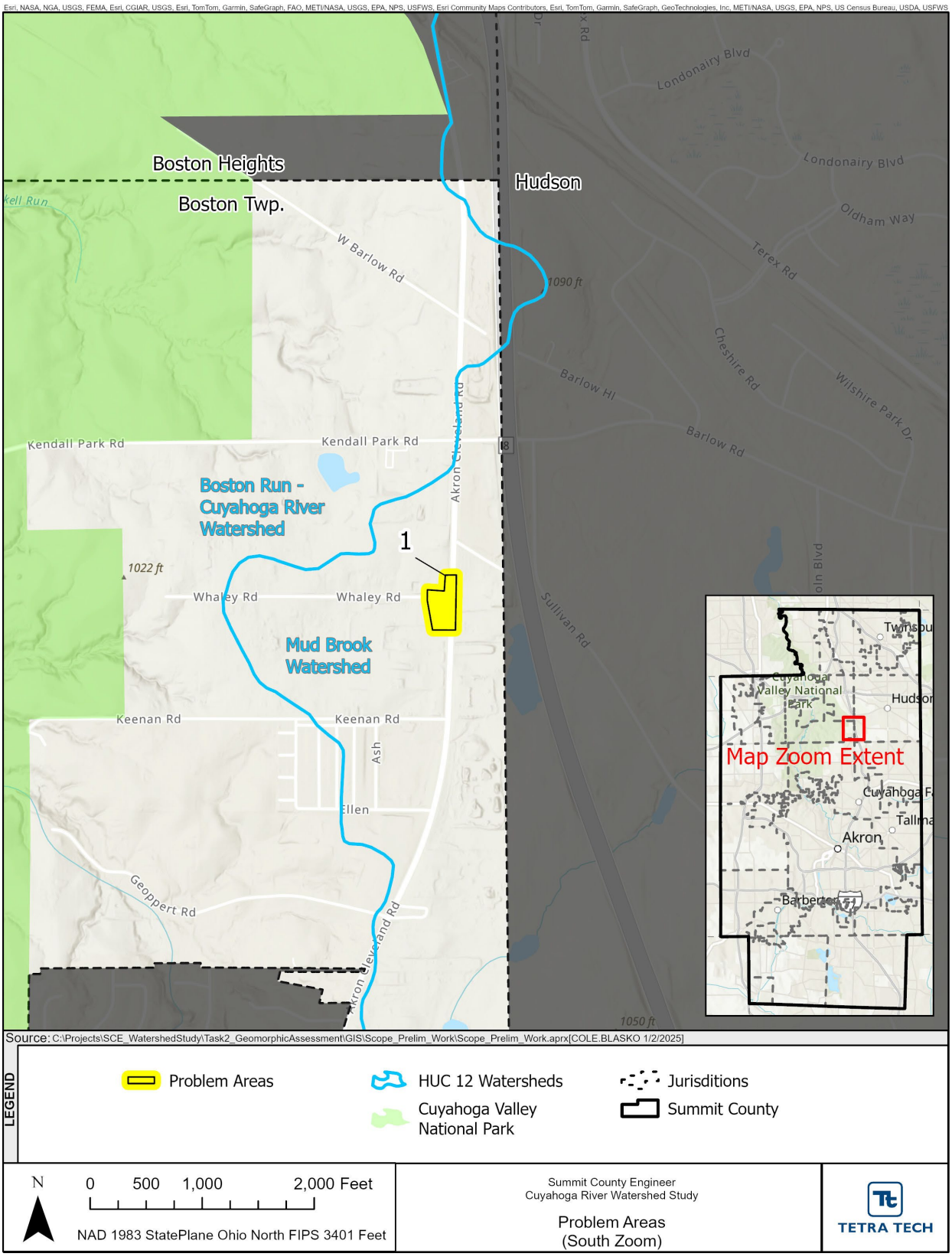


Figure 5. Map of problem areas zoomed to the southern extent of the study area

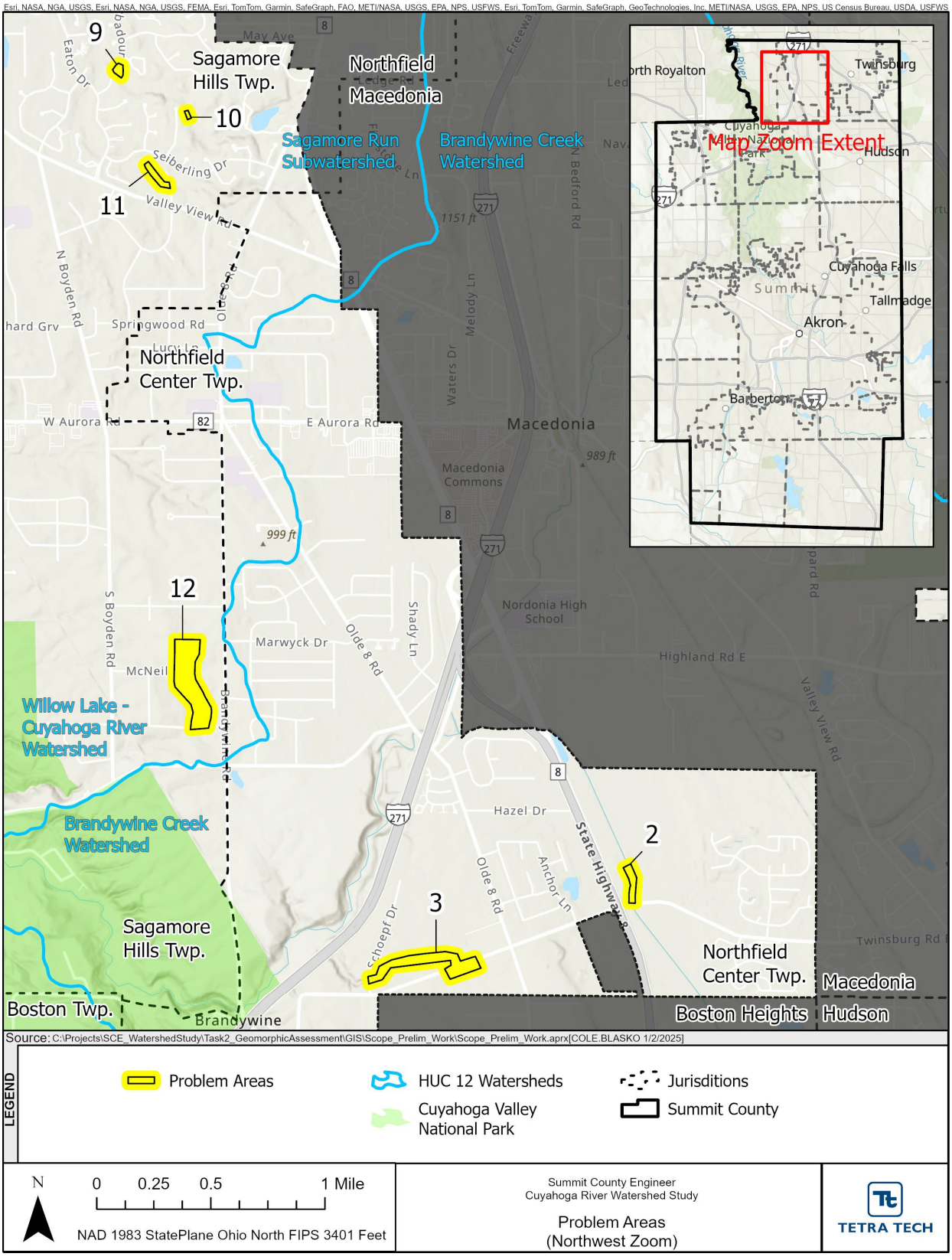


Figure 6. Map of problem areas zoomed to the northwestern extent of the study area

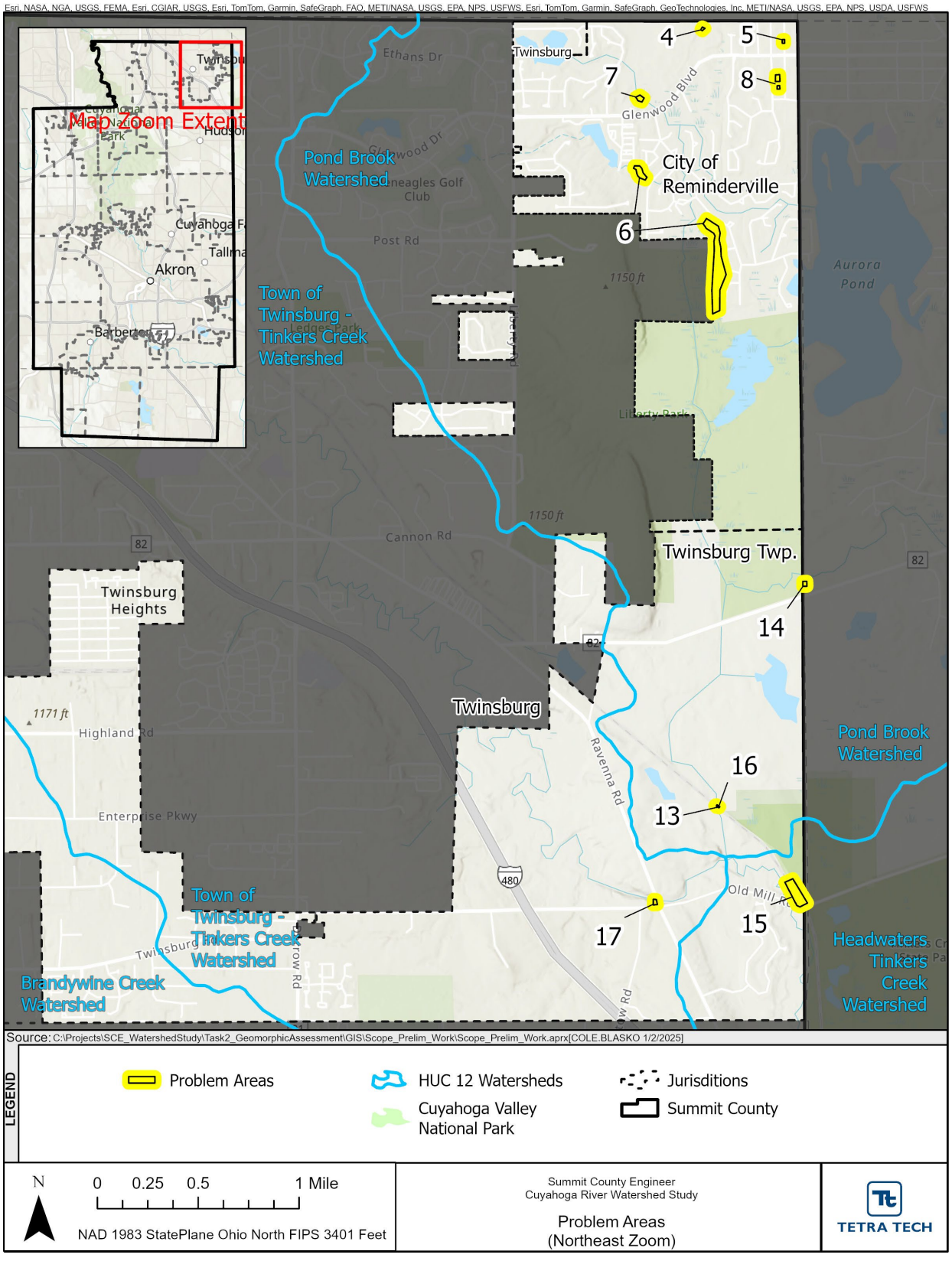


Figure 7. Map of problem areas zoomed to the northeastern extent of the study area

5.1 AKRON CLEVELAND ROAD DRAINAGE COMPLAINT

Summary of Problem Area #1 (ACDC_AOI_1)		
Location	5440 Akron Cleveland Road	Boston Township
HUC12 Watershed	Mud Brook (Stefans Run)	
Problems	Blocked and undersized road and driveway culverts	
Recommended Actions	Reconfigure/upsize stormwater drainage system	

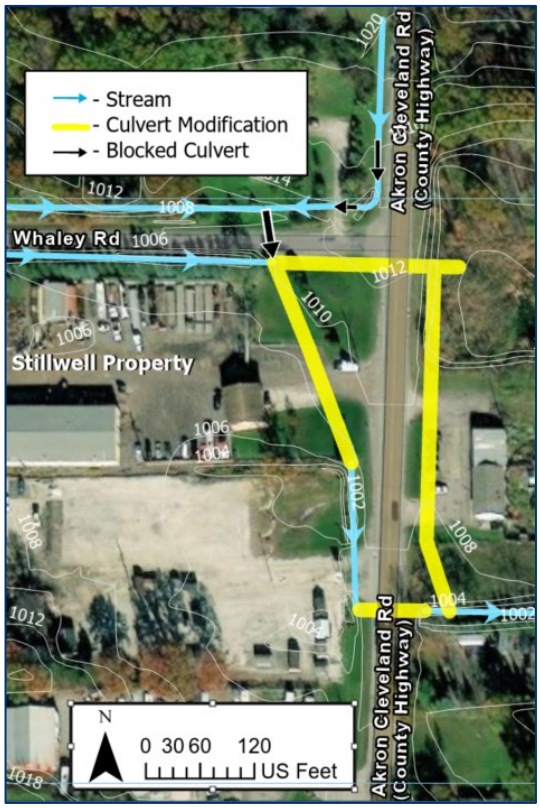


Figure 8. Stormwater drainage schematic.

A drainage complaint was filed with SCE regarding Akron Cleveland Road flooding near its intersection with Whaley Road. The culverts and flow pathways in the vicinity of this drainage complaint are shown in Figure 8.There are two components to this problem area. First, the downstream drainage on the Stillwell property is undersized and required a hydraulic analysis to determine the best feasible solution for increasing conveyance to relieve the flooding. SCE provided Tetra Tech with documentation (SCE, 2010) outlining the results of this hydraulic analysis that provided three alternatives of proposed stormwater improvements. Tetra Tech has provided SCE with concept plans (Appendix G) and the associated costs for these three alternatives as separate supporting documents to this report. The culvert modifications in Figure 8 show the location and extent of the proposed improvements. It is assumed the culvert under the driveway to the property south of the Stillwell property is adequately sized as its upsizing was not included in the alternatives SCE provided to Tetra Tech.

The second component of this problem area involves a drainage way that is in poor condition on private property. More specifically, Tetra Tech observed the following in March 2024 during a site visit:

- A culvert north of Whaley Road that runs parallel to Akron-Cleveland Road, is blocked.
    - Gravel blocks the inlet.
    - Vegetation blocks the outlet.
- A culvert under a driveway off Whaley Road is undersized and partially blocked (Figure 9).
- A culvert under Whaley Road is blocked with vegetation.

The condition and maintenance of these culverts is the responsibility of the resident at 5440 Akron Cleveland Road who submitted the drainage complaint. It is recommended that the blockages be cleared from the culverts and that regular maintenance occurs to ensure proper drainage.

Figure 9. Partially blocked driveway culvert.

5.2 DUMPING ALONG BRANDYWINE CREEK

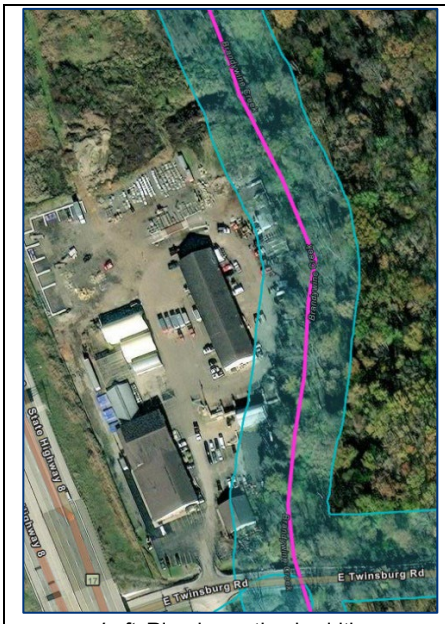
Summary of Problem Area #2 (BC_AOI_3)		
Location	East Twinsburg Road	Northfield Center Township
HUC12 Watershed	Brandywine Creek	
Problems	Debris and trash in and along banks of Brandywine Creek	
Recommended Actions	Notification of Summit SWCD	

Debris, trash, and sediment/soil were observed on the left streambank of Brandywine Creek (Figure 11) behind the Affordable Mulch & Landscape Supply Company. Just downstream, plant pots were observed in the stream and floodplain (Figure 10).

Figure 10. Plant pots along streambank.

A combination of gravity, erosion, and overland flow may transport the debris, trash, and sediment/soil on the steep downslope into Brandywine Creek. If the plant pots in Brandywine Creek and its floodplain are from the landscaping company, then Brandywine Creek is likely transporting materials discarded in the riparian corridor to downstream locations.

Tetra Tech recommends SCE notify the Summit SWCD to investigate the potential dumping of waste along Brandywine Creek and to enforce the 75-foot riparian setback on the left bank of Brandywine Creek as specified in section 937.05 of the Codified Ordinances of Summit County[6]. The discarded material should be removed from the riparian corridor.



Left: Riparian setback width.

Right Top/Bottom: Debris along the left streambank within the riparian setback.

Figure 11. Riparian setbacks along Brandywine Creek at *BC_AOI_3*.

[6] Riparian Setbacks codified ordinance: https://codelibrary.amlegal.com/codes/summitcounty/latest/summitco_oh/0-0-0-18532

5.3 WEST TWINSBURG ROAD DRAINAGE ISSUES

Summary of Problem Area #3 (TRUS_AOI_1)		
Location	West Twinsburg Road	Northfield Center Township
HUC12 Watershed	Brandywine Creek	
Problems	Widespread drainage issues causing flooding and erosion	
Recommended Actions	Mechanical excavation and restoration of unnamed stream	

As part of the geomorphic assessment, Tetra Tech visited the sites of two service requests along West Twinsburg Road, just west of Olde 8 Road. The service request at 295 West Twinsburg Road is addressed under a baseline recommendation (Section 4.0) and requires no action (Table F- 1). The service request at 148 West Twinsburg Road is addressed under this problem area, and it includes four roadside ditches along West Twinsburg Road that converge at an unnamed stream that flows north and perpendicular to West Twinsburg Road (Figure 12). The county owns the culvert that crosses Twinsburg Road. Residents state the roadway is frequently flooded.

Figure 12. Problem area overview.

The first component of this problem area involves the removal of the invasive vegetation that impedes stream flow along the segment perpendicular to West Twinsburg Road (Figure 13). Mechanical excavation of the stream will also be required where the channel has been filled in. These recommendations extend along the 0.5-mile reach from the property at 139 West Twinsburg Road (parcel 4001329) at the upstream end to Schoepf Drive at the downstream end.

Figure 13. Stream blocked with invasive vegetation.

The second component of this problem area involves stabilizing the erosion along the West Twinsburg Road ditches at multiple locations, some of which exhibit lateral erosion into the shoulder of the road and is less than 1-foot from the paved road surface (Figure 14). Moving the ditch away from the roadway to achieve shallower bank slopes and to create a safe distance between the road surface and the ditch may be preferred.

Tetra Tech has provided SCE with a concept plan (Appendix G) and the associated costs of the recommended actions in this problem area as separate supporting documents to this report. Due to the extent and severity of the drainage issue, this problem area may be a good candidate to enact the ditch petition process and/or a larger stream restoration project, at the discretion of SCE.

Figure 14. Erosion of roadside ditch

5.4 EROSION AT CROSSINGS DRIVE CULVERT

Summary of Problem Area #4 (AST_AOI_3)		
Location	Crossings Drive	Reminderville
HUC12 Watershed	Pond Brook	
Problems	Erosion behind culvert headwall, soil slumping	
Recommended Actions	Advise the city of Reminderville to monitor erosion	

Soil slumping and minor erosion were observed behind the downstream headwall of a culvert beneath Crossings Drive, which an unnamed tributary flows through (Figure 15). Tetra Tech, in consultation with SCE, recommends that the city of Reminderville be notified of the erosion and that the headwall be regularly monitored to ensure the condition does not become worse.

Figure 15. Erosion and slumping behind headwall.

5.5 FLORIDA STREET BLOCKED DRIVEWAY CULVERT

Summary of Problem Area #5 (AST_AOI_5)		
Location	10556 Florida Street	Reminderville
HUC12 Watershed	Pond Brook	
Problems	Blocked and undersized driveway culvert	
Recommended Actions	Advise the city of Reminderville to upsize the culvert	

A culvert beneath a residential driveway on the west side of Florida Street is blocked by leaves and soil on both the inlet and outlet sides (Figure 16). At a minimum, the culvert should be better maintained by the homeowner to prevent conveyance restrictions within the larger drainage system.

Furthermore, nearby houses immediately upstream and downstream of this house have larger diameter culverts beneath their driveways. If it is determined that this culvert is undersized, SCE recommends the city of Reminderville upsize the culvert to provide adequate conveyance of the upstream drainage area.

Summit County SWMD does not fund roadway or driveway projects but can aid in the funding of stream and/or ditch improvements outside of the roadway. The SWMD can also provide recommendations for stormwater projects that are under the purview of participating cities, townships, and villages; in this case the city of Reminderville. This problem area would be a good candidate for the SWMD to provide this recommendation.

Figure 16. Blocked driveway culvert.

5.6 AUROA SHORES FLOODING AND EROSION

Summary of Problem Area #6 (ASN_AOI_2,5,9)		
Location	Aurora Shores neighborhood	Reminderville
HUC12 Watershed	Pond Brook	
Problems	Backyard flooding, streambank erosion	
Recommended Actions	Stabilize streambank erosion and address drainage issues	

This problem area is made up of three areas of interest (AOIs) within the Aurora Shores neighborhood (ASN) as identified through the geomorphic assessment and review of past studies and available data. Other AOIs were identified in the Aurora Shores neighborhood but are addressed as baseline recommendations (Section 4.0).

ASN_AOI_2 and *ASN_AOI_5* are erosion issues along the unnamed tributary to Pond Brook and are upstream and downstream of Pirates Trail, respectively (Figure 17). Tetra Tech recommends the upstream erosion (*ASN_AOI_2*) be addressed through (1) construction of a floodplain bench on the right bank to repair the channel incision and provide additional flow capacity in the channel; and (2) stabilization of the left bank to protect the adjacent condominiums and parking lot. The downstream erosion (*ASN_AOI_5*) is caused by the modification of the natural meandering watercourse to a straight channel with a 90-degree turn northwest of the parking area on Driftwood Cove. Restoring the channel back to its natural course would require multiple property acquisitions and thus is not feasible. Tetra Tech therefore recommends stabilization of the right bank in place at the 90-degree left-turn to protect the parking lot at the top of the bank.

The restored downstream reaches of Pond Brook would also benefit from remediation of this erosion as these recommendations will provide protection from sedimentation. Tetra Tech has provided SCE with a concept plan (Appendix G) and the associated costs for the recommended actions in *ASN_AOI_2* and *ASN_AOI_5* as separate supporting documents to this report.

Top Left: Location of ASN_AOI_2 and ASN_AOI_5.
Bottom Left: Looking upstream - right bank erosion at ASN_AOI_2

Right: Looking downstream - right bank erosion at ASN_AOI_5.

Figure 17. Photographs of ASN_AOI_2 and ASN_AOI_5.

The flooding issues throughout the Aurora Shores neighborhood were assessed by Tetra Tech using a 2-D HEC-RAS model. The approach, scenarios, and results of that assessment are provided in the Aurora Shores 2-D HEC-RAS Model memorandum (Tetra Tech, 2025a). In summary, the results of the modeling found the following:

- Flooding does not originate from the Channel Brook watershed, the boating canal itself, or Aurora Lake. Some of the historic flooding was likely due water backing up at the Clipper Clove culvert, which conveys flows from Pond Brook underneath the boating canal. The culvert was upsized in Spring 2024 per specifications from the OHM (2021) study that showed a reduction in flood levels ranging from 0.1- to 1.1-feet for the 1-year event to the 2020 Labor Day event.
- Precipitation naturally pools in the backyards of homes along Windjammer Trail and Sea Ray Cove because the backyards are 6-inches lower than the ground elevation of the wetland and only 6-inches higher than the bottom of the ditch (Figure 18). Poor infiltration capacity and relatively flat existing topography worsen the issue and result in ponding on the properties for extended periods of time. These flooded areas are within the FEMA 100-year flood zone.
- A review of historic maps circa 1963 and 1906 shows that roads and buildings in the Aurora Shores neighborhood, specifically where the flooding of recent years has been observed, were built in low areas historically dominated by natural wetlands and swamps. Additionally, the increase in impervious area from the development of Aurora Shores increases runoff which is not fully offset by the limited number of detention basins in the neighborhood. The footprint of Aurora Lake has also approximately doubled in response to a four-foot increase in water surface elevation between 1906 and 1963.

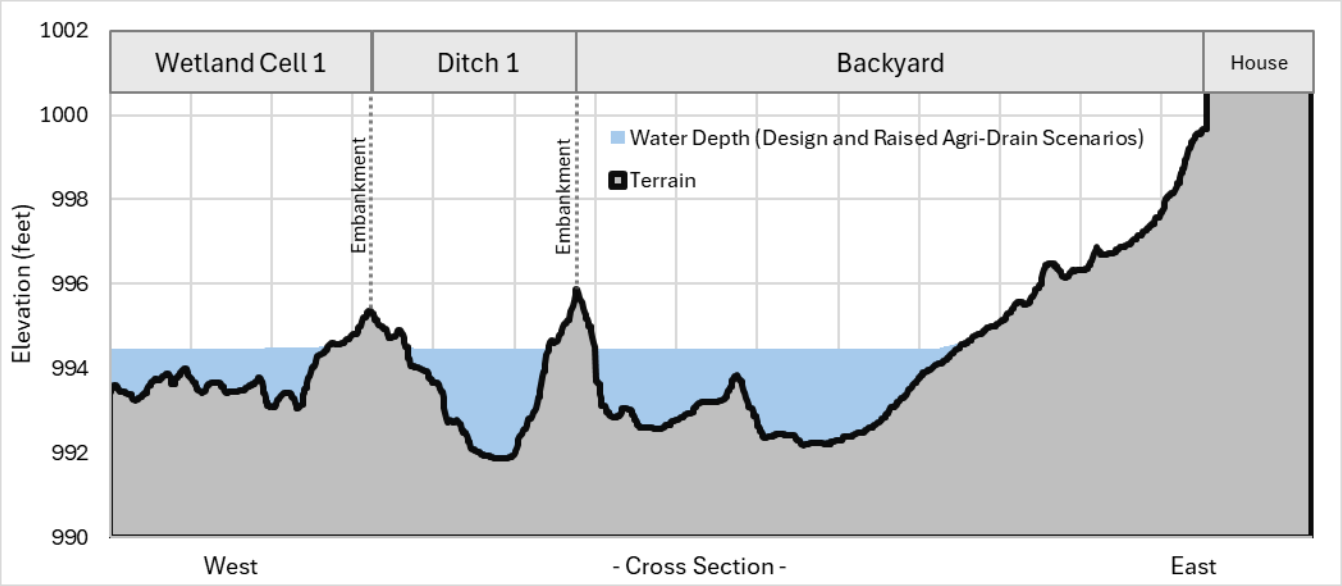


Figure 18. Cross section of terrain and water surface elevations downstream of the Agri-Drain and embankment structure.

To address this flooding issue, three alternatives have been developed which are discussed in depth in concept plans (Appendix G), cost estimates, and the Aurora Shores 2-D HEC-RAS Model memorandum (Tetra Tech, 2025a). In short, the three alternatives are as follows: (1) maintain the existing conditions and allow the backyards to flood within the FEMA 100-year floodplain; (2) install a system of field drains in an east-west direction to convey water to the adjacent ditch; and (3) install a system of field drains in a north-south direction to convey water to two constructed retention basins which are then emptied to the adjacent ditch via a pump station.

5.7 CHANNEL BROOK FAILED CROSSING

Summary of Problem Area #7 (AST_AOI_2)		
Location	Upstream of Glenwood Blvd.	Reminderville
HUC12 Watershed	Pond Brook	
Problems	Failed bridge crossing (water bypasses culvert), upstream ponding	
Recommended Actions	Install new crossing; opportunity for wetland creation	

Figure 19. Downstream side of failing bridge crossing.

Figure 20. Ponding upstream of the bridge crossing.

A bridge crossing over Channel Brook, upstream of Glenwood Boulevard and northwest of Crisfield Court is failing (Figure 19). The bridge crossing is on a gravel road that is not open to the public. Along the right bank, some of the streamflow is bypassing the double barrel culvert and undermining the crossing. Someone placed sandbags in an attempt to mitigate the bypassing streamflow. Channel Brook is ponding upstream of the bridge crossing (Figure 20). Several years ago, SCE staff had not observed any ponding at this site.

In consultation with SCE, Tetra Tech recommends that a new crossing be installed. This would be an opportunity to design the new crossing to act as a dam to continue to pond water upstream. This would provide additional wetland habitat and attenuate any high flows in Channel Brook that continue downstream to the Aurora Shores neighborhood.

Parcel data from Summit County[7] indicates that the bridge itself is on a parcel owned by the West Creek Conservancy (Parcel ID 6600093). However, if the new bridge were to create a wetland upstream of it, this wetland would largely exist on a parcel owned by "Willowbrook Master Association Inc.". This project would be a good candidate to be funded through the Clean Ohio Green Space Conservation Program[8].

Tetra Tech has provided SCE with a concept plan (Appendix G) and the associated costs for the recommended actions in this problem area as separate supporting documents to this report.

[7] Summit County Parcel Viewer 4.0 https://summitmaps.summitoh.net/ParcelViewer/
[8] Clean Ohio Green Space Conservation Program Application website: https://publicworks.ohio.gov/programs/clean-ohio/co-application

5.8 AURORA SHORES TRIBUTARY EROSION

Summary of Problem Area #8 (AST_AOI_7,8)		
Location	Florida Street	Reminderville
HUC12 Watershed	Pond Brook	
Problems	Homemade revetment impedes flow, streambank erosion	
Recommended Actions	Landowner education and stream stabilization	

Four recommendations were identified to address issues at multiple locations among residential properties between Florida and Maryland streets, downstream of Glenwood Boulevard.

First, a homemade revetment intended to prevent erosion from a Florida Street culvert outlet is blocking flow from a perpendicular swale (Figure 21), which results in ponding of water behind the revetment and obstructs flow along the main channel. Tetra Tech recommends SCE or Summit SWCD communicate the issues with the homeowner that built the revetment and have the revetment removed. SCE could also notify the city of Reminderville, in case the homemade revetment begins to impact neighboring properties or municipal infrastructure.

Figure 21. Homemade revetment with culvert outlet of tributary in background.

Second, a small tributary passes under Florida Street from the east and has its confluence with the main channel directly across from the revetment (Figure 21). The angle of the culvert outlet is poorly aligned and likely created the erosion that necessitated the construction of the revetment described previously. Tetra Tech recommends that the culvert be replaced with better alignment to prevent future erosion.

Third, the left cutbank of a rerouted ditch is eroding (3-feet tall by 25-feet long) at a 90-degree turn (Figure 22). The ditch was likely rerouted with the 90-degree turn as homes were built over the last decade. The floodplain along the left bank is a residential grassed yard. No woody vegetation is at the 90-degree turn that could stabilize the left cutbank. Tetra Tech recommends stabilizing this erosion.

Figure 22. Erosion along left cutbank.

Figure 23. Grade control.

Fourth, the downstream end of this reach, just east of Maryland Avenue contains haphazardly placed rip rap and debris (Figure 23). These materials function as grade control for the upstream reach and is preventing further downcutting. Tetra Tech recommends the rip rap and debris be monitored to ensure it remains in place and stable so that channel incision is prevented in the future.

Tetra Tech has provided SCE with a concept plan (Appendix G) and the associated costs for the recommended actions in this problem area as separate supporting documents to this report.

5.9 TROUBADOUR DRIVE CROSSING

Summary of Problem Area #9 (SR_AOI_3)		
Location	Troubadour Drive	Sagamore Hills Township
HUC12 Watershed	Willow Lake-Cuyahoga River (Sagamore Run)	
Problems	Misaligned and undersized road culvert	
Recommended Actions	Replace and upsize the culvert and realign the culvert inlet	

Figure 24. Looking upstream; culvert below Troubadour Drive.

The culvert below Troubadour Drive is made of concrete with a 36-inch diameter. The culvert is misaligned with the natural direction of the unnamed stream (Figure 24); the culvert inlet is perpendicular to streamflow. This skew angle is not in compliance with the Technical Requirements - Section 8.2 of the Stormwater Drainage Manual (SCE, 2020).

NEORSD identified this culvert as a problem area (SCPA03) and conducted hydraulic modeling which indicated road inundation depths of 0.3-feet at the 10-year event and 1.7-feet at the 100-year event. These inundation depths do not meet the specifications in the Technical Requirements – Section 4.4 of the Stormwater Drainage Manual (SCE, 2020). Adjacent homes are not impacted by these water surface elevations.

NEORSD recommended upsizing the culvert to a 150 lineal foot, double-barreled, circular reinforced concrete pipe with 6-foot diameter. Tetra Tech concurs with the NEORSD recommendation of replacing the culvert but disagrees on the size of the new culvert because the design of the new culvert will need to meet the specifications outlined in the Stormwater Drainage Manual (SCE, 2020) and other preferences. First, the skew angle must be at less than 45-degrees. Second, the culvert must be sized such that Troubadour Drive is not overtopped during the 10-year event, is not inundated by more than 4-inches at the 100-year event and provides the required attenuation/storage of flows for the ponding component of the HydroCAD model developed for Eaton Estates by Donald G Bohning & Associates, Inc. in 1995. Third, the final culvert design will be such that the crossing is not classified as a bridge (e.g., spans less than ten feet).

Tetra Tech developed an HY-8 model for this crossing to aid in the design specifications which resulted in the recommendation of replacing the culvert in a new location along Troubadour Drive with a ~10-ft span by 7-ft rise concrete box culvert. However, this design is contingent upon the flow estimates from the upstream drainage area which have a large degree of uncertainty due to the presence of multiple stormwater basins whose attenuation of peak flows is currently unknown. Therefore, a more detailed study of these basis is recommended prior to advancing the proposed culvert design. Tetra Tech has provided SCE with a concept plan (Appendix G), the associated costs for the recommended actions in this problem area, and full documentation of the HY-8 model (Tetra Tech, 2025b) as separate supporting documents to this report.

5.10 SAGAMORE RUN EROSION

Summary of Problem Area #10 (SR_AOI_6)		
Location	Deep Cove Drive	Sagamore Hills Township
HUC12 Watershed	Willow Lake-Cuyahoga River (Sagamore Run)	
Problems	Streambank erosion in backyard of residential property	
Recommended Actions	Install bank toe protection	

The left streambank of an unnamed stream is eroding (2-feet tall by 50-feet long; Figure 25). The unnamed stream drains a small reservoir (~0.7-acres) named Shore Lake 2 and flows northwesterly toward the cul-de-sac at the end of Deep Cove Drive.

Someone has installed wood planks in an effort to protect the streambank from further erosion. A couple hundred feet downstream, two homemade wood check dams were installed. The erosion does not currently threaten any structures, with single family residences over a hundred feet from the left streambank.

Tetra Tech recommends bank toe protection be implemented to prevent further erosion along the left streambank.

Tetra Tech has provided SCE with a concept plan (Appendix G) and the associated costs for the recommended actions in this problem area as separate supporting documents to this report.

Figure 25. Looking downstream; erosion along left streambank.

5.11 WALTON ROAD CROSSING

Summary of Problem Area #11 (SR_AOI_11)		
Location	Walton Drive	Sagamore Hills Township
HUC 12 Watershed	Willow Lake-Cuyahoga River (Sagamore Run)	
Problems	Two undersized culverts and downstream channel incision	
Recommended Actions	Leave the Walton Road culvert in place, remove the second culvert, stabilize the road embankment and stream	

This problem area is north of the Valley View Road – Walton Road intersection and is comprised of three components (Figure 26). First, the culvert (corrugated metal pipe; 5-foot diameter) under Walton Road is undersized with scouring at the inlet. Tetra Tech recommends this existing culvert remain in place. If the culvert were upsized, higher flows sent downstream would worsen the existing erosion and the downstream structures would flood more frequently. Rather, it is preferred that this culvert remain in place to attenuate the high flows. Leaving the undersized culvert in place will allow the area upstream of Walton Road to continue to flood and access its natural floodplain north of the existing stream. As such, stabilizing the east road embankment is necessary to prevent future erosion.

A second culvert (corrugated metal pipe; 2-foot diameter) is 20-feet downstream from the first culvert and further constricts flow (Figure 27). This culvert is beneath a small causeway that connects two grass yards. The causeway does not appear to serve any purpose. Tetra Tech recommends this culvert be removed to improve conveyance and restore the natural course of the stream.

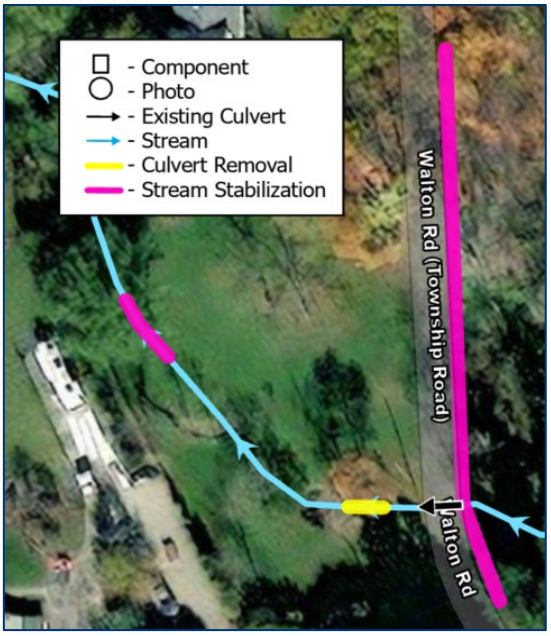


Figure 26. Locations of recommended actions.

Figure 27. Culvert recommended for removal.

The final component of this problem area on Sagamore Run is the incised reach along a flat, grassed yard with headcut erosion downstream of these two culverts (Figure 28). Tetra Tech recommends stabilizing the headcut to prevent further channel degradation from migrating upstream to the culvert under Walton Road.

Figure 28. Headcut erosion.

Tetra Tech has provided SCE with a concept plan (Appendix G) and the associated costs for the recommended actions in this problem area as separate supporting documents to this report.

5.12 INVERNESS HIGHLANDS FLOODING AND EROSION

Summary of Problem Area #12 (USSH_AOI_1,2,3)		
Location	Inverness Highlands	Sagamore Hills Township
HUC 12 Watershed	Willow Lake-Cuyahoga River	
Problems	Widespread drainage issues causing flooding and erosion	
Recommended Actions	Both stream restoration and drainage improvements in multiple locations	

The Inverness Highlands problem area covers a large spatial extent, spans multiple stream reaches and culverts, and addresses both flooding and erosion problems (Figure 29). Portions of this problem area are within the Inverness Highlands Phase V assessed subdivision and a portion of the work may be paid for with assessed subdivision funds. The erosion and drainage issues presented herein are interconnected and require a holistic solution to not disrupt the stream equilibrium and cause issues elsewhere. Due to the complexity of this problem area, Tetra Tech has provided SCE with a separate memorandum for this problem area (Tetra Tech, 2025c) which includes the following: (1) a summary of issues and components in the area, (2) detailed assessment on each issue/component including the HY-8 modeling of the Kiltie Lane culvert, and (3) recommended actions and alternatives. Tetra Tech has also provided SCE with concept plans (Appendix G) and the associated costs for the recommended actions in this problem area as separate supporting documents to this report.

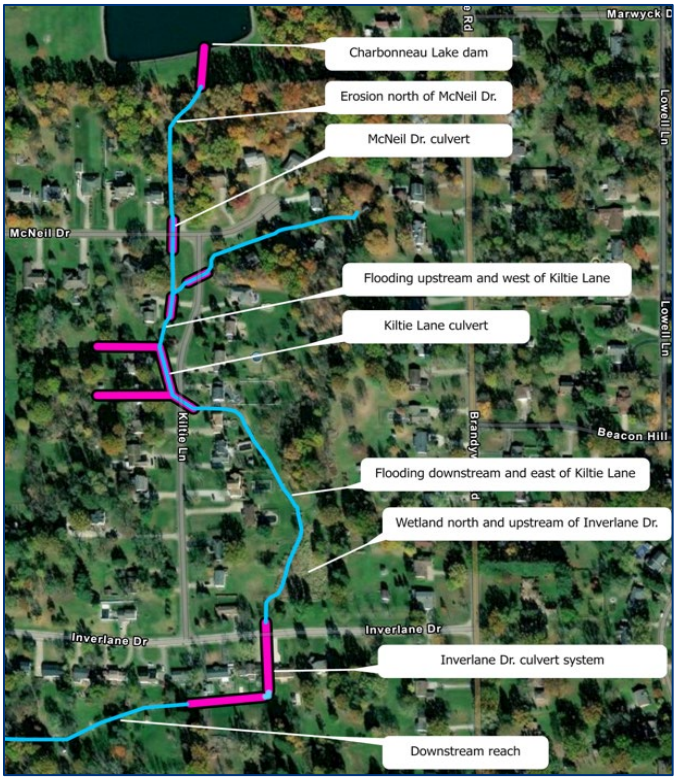


Figure 29. Inverness Highlands problem area overview.

As summarized in the supporting memorandum (Tetra Tech, 2025c), concept plans (Appendix G), and cost estimates, the actions to address the erosion and drainage issues in the Inverness Highlands problem area include the following activities:

- Stabilize the lateral erosion on the right bank of the reach upstream of McNeil Drive in its current location which may require the purchase of additional easement width.
- Remove the bridges that are obstructing flow in the reach downstream of the Kiltie Lane Culvert and the reach downstream of the Inverlane Drive culvert system.
- Repair the sinkhole above the Inverlane Drive culvert system by re-grading the yard and installing a new catch basin to prevent further washout and possible culvert damage.
- Reduce the 100-year peak flows entering the Kiltie Lane culvert via construction of a detention basin upstream of the Kiltie Lane culvert. The size and location of the detention basin will need to be finalized during the design phase after a topographic survey and more detailed modeling are conducted.

Finally, residents are encouraged to preserve the hydraulic capacity of the unnamed stream by keeping the channel free from obstructions, including yard waste and footbridges.

5.13 UNDERCUT RAILROAD BRIDGE ABUTMENTS

Summary of Problem Area #13 (PBTC_AOI_3)		
Location	near Old Mill Road	Twinsburg Township
HUC12 Watershed	Pond Brook	
Problems	Railroad bridge abutments on left and right streambanks are undercut	
Recommended Actions	Notify railroad	

Figure 30. Railroad bridge with undercut abutment.

The abutments of the Wheeling and Lake Erie Railway Company[9] bridge over Pond Brook are undercut at their bases on the left and right streambanks (Figure 30).

Tetra Tech recommends SCE notify the Wheeling and Lake Erie Railway Company of the undercut abutments because the bridge is owned by the railway. SCE could also contact the Public Utilities Commission of Ohio, which has jurisdiction over railroad companies and railways in Ohio.

[9] Online maps identify these rail lines as owned by the Norfolk & Western (N&W) Railway that is a predecessor to Norfolk Southern Railway.

5.14 AURORA WESTERLY WWTP BLOCKED CULVERT

Summary of Problem Area #14 (PBTC_AOI_2)		
Location	near East Aurora Road	Twinsburg Township
HUC 12 Watershed	Pond Brook	
Problems	Blocked culvert inlet near a monitoring site for Auroa Westerly WWTP	
Recommended Actions	Notification of the city of Aurora	

A culvert under the service driveway to the Aurora Westerly Wastewater Treatment Plant (WWTP; U.S. EPA ID OH0098043; Ohio EPA ID 3PD00046) is blocked by vegetation at the inlet. The culvert allows an unnamed tributary to Pond Brook to flow under the service driveway. The mouth of the unnamed tributary is at river mile 1.57 of Pond Brook. The unnamed tributary is sometimes identified as AU River 5.

A sign indicates that the downstream monitoring site (outfall 901 in permit 3PD00045*GD) is downstream of the blocked culvert (Figure 31). Tetra Tech recommends SCE notify the City of Aurora to inform them that the culvert blockage may affect water chemistry samples of the monitoring site.

Figure 31. Aurora WWTP monitoring site.

5.15 LOWERED WETLAND WATER LEVELS AT THE TINKER'S CREEK SNP

Summary of Problem Area #15 (PBTC_AOI_6)		
Location	Old Mill Road	Twinsburg Township
HUC 12 Watershed	Tinkers Creek	
Problems	Water levels in wetlands at the Tinker's Creek SNP are lowering due to the installation of a new culvert	
Recommended Actions	Notification of the Ohio Department of Natural Resources, Ohio EPA and USACE	

Water levels at the wetlands in Tinker's Creek State Nature Preserve (SNP)[10] have lowered since the installation of a new culvert beneath railroad tracks (Figure 32), which are owned by the Wheeling and Lake Erie Railway Company[11]. Tetra Tech staff observed that the invert elevation of the new culvert is lower than that of the old culvert, which is still in place to the south of the new culvert.

Local resident Geoff Baker developed a website[12] that describes the effects of the lowered water levels at Schweitzer Marsh, (also known as Tinker's Creek SNP), and his efforts to contact the Wheeling and Lake Erie Railway Company and government agencies to discuss solutions to mitigate the impacts of the new culvert.

Cursory review of historic aerial imagery and anecdotal information do indicate that wetland water levels have lowered and the wetlands appear to be draining.

Figure 32. New culvert that crosses railroad tracks.

The Tinker's Creek SNP, at 1230 Old Mill Road, is managed by the Division of Natural Areas and Preserves at the Ohio Department of Natural Resources. Tinker's Creek State Nature Preserve is adjacent to the Tinker's Creek State Park that is managed by Summit Metroparks as part of Liberty Park.

Tetra Tech recommends that SCE notify Ohio Department of Natural Resources, Ohio EPA, and the U.S. Army Corp of Engineers that the new culvert beneath the rail lines owned by the Wheeling and Lake Erie Railway Company is lowering the water levels of wetlands in the Tinker's Creek SNP.

[10] Tinker's Creek SNP: https://ohiodnr.gov/go-and-do/plan-a-visit/find-a-property/tinkers-creek-state-nature-preserve.
[11] Online maps identify these rail lines as owned by the Norfolk & Western (N&W) Railway that is a predecessor to Norfolk Southern Railway.
[12] Geoff Baker's website: https://mailchi.mp/a153de4fcba5/deathofawetland.

5.16 SPILL ALONG POND BROOK

Summary of Problem Area #16 (PBTC_AOI_4)		
Location	near Old Mill Road	Twinsburg Township
HUC 12 Watershed	Pond Brook	
Problems	Spill containment	
Recommended Actions	Notification of Summit SWCD and Ohio EPA	

A boom was observed on the left bank of Pond Brook near the railroad bridge (Figure 33) that did not fully contain an oily substance along the water surface. Given the proximity to the railroad lines, the source of the spill may be from railroad operations (e.g., a leak from a train car).

Tetra Tech recommends SCE notify Summit SWCD to investigate this spill. Summit County has notified Ohio EPA's Division of Environmental Response and Revitalization in 2024.

Figure 33. Containment boom on Pond Brook.

5.17 RAVENNA ROAD BRIDGE EMBANKMENT EROSION

Summary of Problem Area #17 (PBTC_AOI_7)		
Location	Ravenna Road	Twinsburg Township
HUC12 Watershed	Tinkers Creek	
Problems	Erosion	
Recommended Actions	Stabilize gully erosion	

A gully has formed below an outfall that drains a roadside ditch along Old Mill Road. The gully is along the downslope of the embankment and parallel to the Ravenna Road bridge over Tinker's Creek. The gully erosion is about 6-feet tall by 4-feet wide and 30-feet long (Figure 34). Tetra Tech recommends stabilizing the embankment to prevent sedimentation from reaching Tinkers Creek to preserve stream health. Summit County has informed Tetra Tech that that bridge crews will repair the gully erosion in 2025.

Tetra Tech has provided SCE with a concept plan (Appendix G) and the associated costs for the recommended actions in this problem area as separate supporting documents to this report.

Figure 34. Gully formation.

6.0 REFERENCES

6.1 REFERENCES CITED IN THE MAIN REPORT

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-----. 2025c. Inverness Highlands Problem Area. Supporting memorandum to the Cuyahoga River Watershed Study. Prepared for the Summit County Engineer, Surface Water Management District.

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APPENDIX A: SUMMARY OF IDDE

In the United States, municipal separate storm sewer systems (MS4s) for communities in urbanized areas must obtain coverage under a National Pollutant Discharge Elimination System (NPDES) permit to be authorized to discharge stormwater to waters of the United States. In Ohio, the *Small MS4* general NPDES permit (OHQ00004) covers regulated MS4s for communities with less than 100,000 residents (Ohio Environmental Protection Agency [Ohio EPA] 2021).

Summit County and 11 co-permittees[13] own and operate regulated MS4s (3GQ00065*DG)(Ohio EPA 2024a,b). As such, Summit County and the co-permittees must annually report on their illicit discharge detection and elimination (IDDE) programs that are required by the *Small MS4* general NPDES permit (Ohio EPA 2021, Part III.B.3). SCE contracts with the Summit County Public Health (SCPH) to perform dry-weather screening and to collect samples of any dry-weather discharge. A nuisance is declared if the dry-weather discharge contains *Escherichia coli* (*E. coli*) concentrations in excess of 1,030 most probable number (MPN) per 100 milliliters.

SCE provided copies of the annual IDDE reports for 2023. Table A - 1 summarizes pertinent information for co-permittees in the project area of this study. SCPH identified 42 stormwater outfalls with dry-weather discharges, which is 13% of all screened outfalls.

Table A - 1. Summary of 2023 annual IDDE reporting

Co-Permittee	Number of outfalls				
	Total	Screened	Screened & discharging	Nuisances	Could not locate [a]
Bath Township	133	27	7	3	1 (1)
Boston Township	4	1	0	0	0
Northfield Center Township	85	17	0	0	0
City of Reminderville	74	15	1	0	2
Richfield Township	70	14	2	1	2 (4)
Sagamore Hills Township	254	240	32	10	34 (9)
Twinsburg Township	70	14	0	0	3

Note a: The number of outfalls that could not be located or accessed. The number of locations that were determined to not be outfalls is in parentheses.

Many MS4 systems are intentionally designed to allow groundwater to flow through stormwater pipes which helps control the water table and prevents basements from flooding. However, screened outfalls with dry-weather discharges could potentially degrade water quality since the discharge would not be stormwater and could be untreated or partially treated sanitary wastewater. Sanitary wastewater can impair the designated recreation uses and aquatic life uses of Ohio waterways.

- **Bath Township**: SCPH observed dry-weather discharges from 7 stormwater outfalls (500 to 1,800 gallons per day [gpd]). Nuisances were declared at 3 outfalls (1,203 to 19,760 MPN/100 mL). One of the nuisance outfalls was addressed by repairing a nearby septic system; resampling found the *E. coli* at concentrations below nuisance levels. Two of the nuisance outfalls were resampled and found to discharge *E. coli* at concentrations below nuisance levels.

[13] The 11 co-permittees are the village Lakemore, city of Reminderville, and Bath, Boston, Copley, Coventry, Northfield Center, Richfield, Sagamore Hills, Springfield, and Twinsburg townships

- **Reminderville**: SCPH observed dry-weather discharges from 1 stormwater outfall (2,500 gpd).
- **Richfield Township**: SCPH observed dry-weather discharges from 2 stormwater outfalls (500 to 8,000 gpd). A nuisance was declared at 1 outfall (6,110 MPN/100 mL). The nuisance outfall was resampled and found to discharge *E. coli* at concentrations below nuisance levels.
- **Sagamore Hills Township**: SCPH observed dry-weather discharges from 32 stormwater outfalls (150 to 10,000 gpd). Nuisances were declared at 10 outfalls (2,481 to 17,330 MPN/100 mL). Six of the nuisance outfalls are in areas served by sanitary sewers and the nuisances were referred to the township, NEORSD, and SCE. Two of the nuisance outfalls were resampled and found to discharge *E. coli* at concentrations below nuisance levels. SCPH is investigating septic systems in the areas of two nuisance outfalls.

APPENDIX B. SUMMARY OF EXISTING MODELS

SCE obtained copies of eight Storm Water Management Models (SWMM), two Hydrologic Engineering Center – River Analysis System (HEC-RAS) models, and one HEC – Hydrologic Modeling System model (Table B-1). The models were originally provided to SCE by Wade Trim, a contractor for the Northeast Ohio Regional Sewer District (NEORSD), on April 18, 2022. The eight SWMM models were developed by NEORSD, its contractors, or the United States Army Corps of Engineers (USACE). Note that this appendix is exclusive to models developed by or in coordination with NEORSD and other models concerning Pond Brook are discussed in Appendix D.

The Rocky River – East Branch SWMM model covers a portion of Bath Township but is not further discussed here because the scope of this study is for the Cuyahoga River watershed.

Table B - 1. Existing models

Model name	Model	Year	Developer
Brandywine	SWMM	2022	NEORSD
Cuyahoga River – Brecksville & Sagamore Hills	HEC-RAS	2007	ARCADIS
Cuyahoga River - Independence	HEC-RAS HEC-HMS	2013	USACE
Cuyahoga River South - Small Tributaries East	SWMM	2021	NEORSD
Furnace Run	SWMM	2021	NEORSD
Mud Brook	SWMM	2021	NEORSD
North Fork Yellow Creek	SWMM	2021	NEORSD
Sagamore Creek	SWMM	2021	NEORSD
Tinker's Creek	SWMM	2021	NEORSD

B.1 CUYAHOGA RIVER – BRECKSVILLE & SAGAMORE HILLS

ARCADIS (2007) developed a HEC-RAS model for the Friends of the Crooked River to support the future removal of the Brecksville Dam across the Cuyahoga River. A model report was also submitted to the Ohio Environmental Protection Agency. The HEC-RAS model simulated four reaches: the Cuyahoga River upstream of the dam, the Cuyahoga River downstream of the dam, Chippewa Creek, and the Ohio and Erie Canal.

Three flow conditions were simulated: average flow, 10-year peak flow, and 100-year peak flow.

B.2 CUYAHOGA RIVER – INDEPENDENCE

USACE developed HEC-RAS and HEC-Hydrologic Modeling System models for the Cuyahoga River in the city of Independence to support a flood risk management study. Flooding of the Cuyahoga River in the city of Independence inundates commercial and industrial businesses at Old Rockside Road and Canal Road.

B.3 CUYAHOGA RIVER SOUTH

NEORSD developed the following seven SWMM models as part of the stormwater master planning for the Cuyahoga River South watershed:

- Brandywine (BREE)

- Cuyahoga River South Small Tributaries East (CUEE)
- Furnace Run (FREE)
- Mud Brook (MBEE)
- North Fork Yellow Creek (YCEE)
- Sagamore Creek (SCEE)
- Tinker's Creek (TCEB)

The SWMM models were developed in Personal Computer Stormwater Management Model Professional 2-Dimenstional (PCSWMM) platform, version 7.4.3240 (32-bit) using SWMM5 Engine 5.0.015. The models were developed using NEORSD standards from April 2018.

Seven flow conditions were simulated: 1-, 2-, 5-, 10-, 25-, 50-, and 100-year design storms.

APPENDIX C. SUMMARY OF PREVIOUS WATERSHED STUDIES

The study area is in eight HUC12 subwatersheds (Figure C - 1). Seven nonpoint source implementation strategy (NPS-IS) plans and two watershed action plans (WAPs) cover the study area.

All nine of these watershed-based studies were published before the Ohio Environmental Protection Agency (Ohio EPA 2023) published its new biological and water quality study of the Cuyahoga River watershed. As such, these watershed plans often do not include Ohio EPA's 2017 and 2018 biological, chemical, and habitat data. None of these plans account for Ohio EPA's new use support determinations or identifications of causes and source of impairment.

NPS-IS plans often recommend projects for Clean Water Act Section 319(h) grants to address water quality impairments. Section 319(h) grants cannot be used to address water quantity (e.g., flooding).

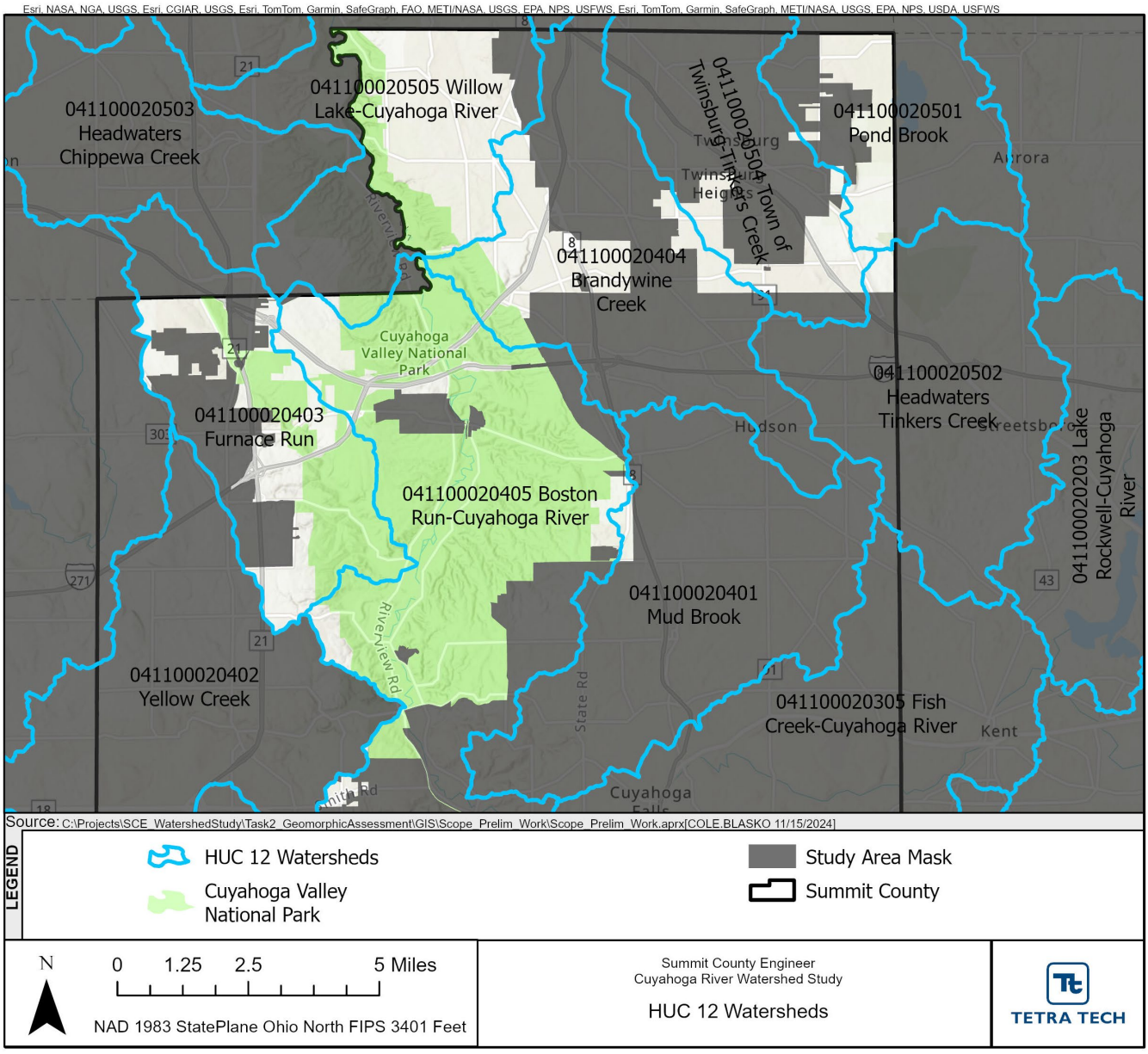


Figure C - 1. HUC12 watersheds that intersect the study area

C.1 BOSTON RUN-CUYAHOGA RIVER NPS-IS PLAN

Summit Ecological Consulting LLC (SEC 2020) developed the NPS-IS plan for *Boston Run-Cuyahoga River* (HUC 04110002 04 05) that Ohio EPA approved on February 21, 2020. The Cuyahoga River and many named tributaries flow through this 46-square-miles subwatershed. Westward flowing tributaries include Boston Run, Stanford Run, Haskell Run, Ritchie Run, Salt Run, Dickerson Run, Langes Run, Robinson Run, and Woodward Creek; while eastward flowing tributaries include Granny's Run, Slipper Run, and Sand Run. Much of the watershed is within the Cuyahoga Valley National Park (CVNP); portions of the watershed are also in the cities of Akron and Fairlawn.

SEC (2020) identified a single critical area: *Critical Area 1: Sand Run, City of Fairlawn, and the City of Akron*. This critical area is composed of high-gradient headwater streams in areas predominated by residential development and impervious surface. Urban runoff (e.g., flashy flows) degrade aquatic habitat and water quality and contribute to erosion and sedimentation.

To address the threat to aquatic life and degraded habitat, SEC (2020) identified nine objectives that will reduce flashy flows and erosion/sedimentation:

1. Remove three barriers to fish passage
2. Replace one inadequately functioning culvert
3. Stabilize 1,500-feet of rapidly eroding slopes along Sand Run in the Sand Run Metro Park
4. Restore floodplains and banks along 10,000-feet of the Cuyahoga River
5. Restore 50-acres of degraded wetlands
6. Remove 20,000-feet of drain tile
7. Remove 2,650-feet of pavement between North Portage Path and Merriman Road
8. Daylight 1,500-feet of culverted stream in the Sand Run Metro Park

SEC (2020) described three projects being led by Summit Metroparks (SMP) to begin addressing the objectives:

1. *Sand Run Restoration Project* (seeking funding)
2. *Valley View Golf Course, Phase II* (may seek additional funding)
3. *Sand Run Parkway Partial Decommissioning and Stream Daylighting* (seeking funding)

C.2 BRANDYWINE CREEK NPS-IS PLAN

The Tinkers Creek Watershed Partners (TCWP 2020) developed the NPS-IS plan for *Brandywine Creek* (HUC 04110002 04 04) that Ohio EPA approved on January 17, 2020. Brandywine Creek begins in the city of Hudson and flows for 11-miles to its confluence with the Cuyahoga River in the CVNP. Indian Creek is a major tributary to Brandywine Creek. The subwatershed is about 27-square-miles. Brandywine Falls are a 60-foot waterfall along Brandywine Creek in the CVNP, just southwest of the I-271 and OH-8 interchange.

TCWP (2020) identified a single critical area: *Critical Area 1: Upper Brandywine Creek HUC-12*. The critical area targets priority conservation areas that were previously identified in the *Brandywine Creek Balanced Growth Initiative Watershed Plan* (Brandywine Creek Watershed Planning Partnership 2013).

To improve poor fish community health and degraded habitat at certain monitoring sites and maintain good fish community health and functional habitat at other monitoring sites, TCWP (2020) identified six objectives:

1. Protect 100-acres of riparian habitat along Brandywine Creek and its tributaries

2. Restore and reconnect 10,000-linear-feet of stream
3. Adopt and enforce riparian setbacks in 4 of 9 communities
4. Restore 50-acres of vernal pools, wetlands, or floodplains along Brandywine Creek
5. Remove invasive species and plant native species in 50-acres of riparian or wetland areas
6. Install green infrastructure to treat stormwater runoff from 75-acres

TCWP (2020) described one of its projects to begin addressing the objectives: *Brandywine Creek Stream Restoration at Owen Brown*.

C.3 FURNACE RUN NPS-IS PLAN

The Summit County Soil and Water Conservation District (Summit SWCD, 2025a) has developed a draft NPS-IS plan for *Furnace Run* (HUC 04110002 04 03). Over half of the 20-square-mile subwatershed is forested, which includes portions of the CVNP and the Furnace Run Reservation of SMP. The designated aquatic life uses are attained at most monitoring sites; generally, water quality is good in the Furnace Run subwatershed.

Summit SWCD (2025a) identified two critical areas: *Streams and Riparian Areas* and *Prioritized Urban/Developed Land*. The *Streams and Riparian Areas* critical area is a 75-foot riparian buffer along 37-miles of Furnace Run and its tributaries. This critical area targets streambank restoration and several segments are identified as priority areas. The *Prioritized Urban/Developed* critical area is 4,472 -acres and priority areas were identified based on the Northeast Ohio Regional Sewer District's (NEORSD) stormwater master planning. This critical area targets reducing urban stormwater runoff.

To improve poor macroinvertebrate community health and degraded habitat at certain monitoring sites and maintain good fish and macroinvertebrate community health and functional habitat at other monitoring sites, Summit SWCD (2025a) identified six objectives:

1. Restore 10,000-linear-feet of streams
2. Stabilize 5,000-linear-feet of eroding streambanks
3. Plant 100-acres of native species in riparian or wetland areas
4. Restore and enhance 100-acres of degraded wetlands and other riparian areas
5. Remove one barrier to aquatic life passage
6. Acquire and preserve 200-acres of riparian areas and other important natural features

To improve poor macroinvertebrate community health at certain monitoring sites and maintain good fish and macroinvertebrate community health and functional habitat at other monitoring sites, Summit SWCD (2025a) identified three objectives:

1. Retain urban runoff on 200-acres of land by restoring or creating floodplain, riparian area, or wetland detention storage basins
2. Mitigate 100-acres of impervious surface through infiltrative green infrastructure
3. Replace two inadequately functioning culverts

Summit SWCD (2025a) described 13 projects to begin addressing the objectives for both critical areas, five of which have been listed as completed as of the 2025 report. Of the remaining eight projects, seven of them are long-term (7+ years) and the *Glencairn Forest Conservation* (A1; Western Reserve Land Conservancy) project is short-term (1- to 3-years).

C.4 POND BROOK NPS-IS PLAN

Chagrin Valley Engineering, LTD (CVE 2017a) developed the NPS-IS plan for *Pond Brook* (HUC 04110002 05 01) that Ohio EPA approved on July 5, 2017. Pond Brook is a tributary to Tinker's Creek, and the Pond Brook subwatershed (17-square-miles) is one of three subwatersheds that compose the Tinker's Creek watershed (96-square miles). Pond Brook begins at Pond Brook Lake and flows south to its confluence at Tinker's Creek at the in Twinsburg Township.

CVE (2017a) identified a single critical area, which is essentially the western half of the *Pond Brook* subwatershed. In this critical area, urban runoff has led to high turbidity and sedimentation that affects both Pond Brook and Tinker's Creek.

To improve poor fish community health and degraded habitat at certain monitoring sites and maintain good fish community health and functional habitat at other monitoring sites, CVE (2017a) identified five objectives:

1. Maintain 150-acres of previously restored area (i.e., invasive species management)
2. Maintain and monitor 15,000-feet of previously restored areas for adequate vegetation cover
3. Restore 7,300-linear-feet of stream and riparian corridor to create habitat and floodplain connectivity
4. Encourage 4 communities to implement stormwater control measures
5. Conduct annual planning meeting to develop objectives to accomplish the biological and habitat goals

CVE (2017a) described one project being led by SMP to begin addressing the objectives: *Pond Brook Phase 3 Stream Restoration.*

C.5 TINKER'S CREEK WAP

Representatives of TCWP, Ohio EPA, Cuyahoga County Board of Health, and Ohio University (McNutt et al. 2016) developed a WAP for the Tinkers Creek watershed (HUC 04110002 05 01, *05 02, *05 04). About 31% of the Tinker's Creek watershed is within Summit County. The plan establishes five general goals, targeted goals to meet water quality standards, and priority actions. McNutt et al. (2016) identified tasks, task activities, task partners, potential funding mechanisms, timeframes, and final indicators of completed tasks. The five goals for the Tinker's Creek watershed are:

1. Restore the beneficial uses
2. Reduce the impact of urbanization and impervious cover on and water quality
3. Educate local decision-makers about preserving wetlands and natural areas
4. Reduce nutrient loading
5. Reduce sedimentation

The objectives for Pond Brook include reestablishing natural channel morphology and reconnecting the floodplain (McNutt et al. 2016, p. 149). Specific tasks include restoring 16,000-feet of Pond Brook and its tributaries and acquiring and protecting 100-acres of wetlands. Some of the wetland restoration along Pond Brook proposed in the Tinker's Creek WAP was implemented and has been the focus of subsequent studies (e.g., the Aurora Shores Homeowners Association Annual Report summarized in Appendix D Section G.8).

C.6 TOWN OF TWINSBURG-TINKERS CREEK NPS-IS PLAN

CVE (2017b) developed the NPS-IS plan for *Town of Twinsburg-Tinkers Creek* (HUC 04110002 05 04) that Ohio EPA approved on August 8, 2017. The *Town of Twinsburg-Tinkers Creek* subwatershed (56-square-miles) is one

of three subwatersheds that compose the Tinker's Creek watershed (96-square miles). This subwatershed drains to Tinker's Creek from the confluence of Pond Brook downstream to the mouth on the Cuyahoga River. This subwatershed is 73% developed and 21% forest.

CVE (2017b) identified a single critical area that includes middle Tinker's Creek, Tinker's Creek Gorge, and Beaver Meadow Run. Heavy siltation, elevated turbidity and nutrients, and degraded habitat contribute to impairment of fish community health.

To improve poor fish community health at certain monitoring sites and maintain good fish community health at other monitoring sites, CVE (2017b) identified five objectives:

1. Restore 530-acres of riparian areas along Tinker's Creek at its tributaries
2. Plant trees in 70-acres of riparian areas along Tinker's Creek at its tributaries
3. Restore 9,500-linear-feet of Tinker's Creek and reconnect the floodplain
4. Remove 2 in-stream barriers along Tinker's Creek
5. Use green infrastructure to treat stormwater from 5-acres of impermeable area

CVE (2017b) described nine projects being led by TCWP to begin addressing the objectives:

1. *Wood Creek In-Stream Barrier Removal*
2. *Hutchinson Field Tributary Sediment Removal/Culvert Reconstruction*
3. *Shawnee Hills Parking Lot Green Infrastructure*
4. *Bear Creek Stream Restoration – Phase III*
5. *Bedford Heights Stream & Floodplain Wetland Restoration at the Bus Garage*
6. *Hawthorne Valley Country Club Riparian Buffer Enhancement and Potential Land Acquisition*
7. *Glenwillow Stream & Floodplain Wetland Restoration*
8. *Twinsburg High School Stream Restoration*
9. *Astorhurst Land Acquisition and Stream Restoration*

C.7 WILLOW LAKE-CUYAHOGA RIVER NPS-IS PLAN

CVE (2020) developed the NPS-IS plan for *Willow Lake-Cuyahoga River* (HUC 04110002 05 05) that Ohio EPA approved on May 7, 2020. This subwatershed drains 24-square-miles and contains 9-miles of the Cuyahoga River. Much of this subwatershed is within the CVNP or two reservations at Cleveland Metroparks (Beford Reservation and Brecksville Reservation).

CVE (2020) identified two critical areas. Critical Area 1 is riparian buffers along perennial streams tributary to the Cuyahoga River. This critical area targets protecting and restoring riparian areas and floodplains. Critical Area 2 is the upland subwatersheds draining to the streams in Critical Area 1. This critical area targets small urban drainages, with residential development, that need stormwater control and wetland restoration or enhancement.

To improve poor fish community health at certain monitoring sites and maintain good fish community health at other monitoring sites, CVE (2020) identified two objectives for Critical Area 1:

1. Restore and protect 1,000-acres of riparian vegetative buffer zone along
2. Restore 20,000-feet of altered stream channels and reconnect floodplains

CVE (2020) described eight projects to begin addressing the objectives for Critical Area 1:

1. *Restore Head cuts in Brecksville Reservation Headwater Streams*
2. *Summersweet Tr/Nesbitt Rd Stream Relocation and Floodplain Restoration (NEORSD CUPA01)*
3. *Chaffe Rd Roadway Crossing Replacement (Stream Restoration, Culvert Removal) (NEORSD CUPA02)*
4. *Riverview Rd / Wiese Rd/Greenhaven Pkwy*
5. *Cuyahoga River AOC Project #123 18,000-lineal-feet of Stream Restoration and 3-acres of Wetland Restoration*
6. *Sagamore Rd Stream Restoration West (17343 Sagamore Rd – 17115 Sagamore Rd)*
7. *Sagamore Rd Stream Restoration East (19359 Sagamore Rd – 18919 Sagamore Rd)*
8. *Glen Forest Trail Stream Restoration & Basin Retrofit*

To improve poor fish or macroinvertebrate community health and degraded habitat at certain monitoring sites and maintain good fish or macroinvertebrate community health and functional habitat at other monitoring sites, CVE (2020) identified two objectives for Critical Area 2:

1. Implement stormwater control measures to treat runoff from 50-acres
2. Use 100-acres of wetlands to reduce stormwater runoff, by protecting or enhancing existing wetlands or creating new wetlands.

CVE (2020) described one project to begin addressing the objectives for Critical Area 2: *Cuyahoga River AOC Candidate Project #62 Pleasant Valley 10-acre Wetland Restoration*.

C.8 YELLOW CREEK NPS-IS PLAN

Summit SWCD (2025b) developed the NPS-IS plan for *Yellow Creek* (HUC 04110002 04 02) that Ohio EPA approved on January 15, 2025. Yellow Creek is about 10-miles long and flows eastward to its mouth on the Cuyahoga River in the city of Cuyahoga Falls. Much of the 31-square-mile subwatershed is within Bath Township (Summit County). Portions of the subwatershed are in the CVNP, O'Neil Reservation of SMP, and the Bath Nature Preserve.

Summit SWCD (2025b) identified two critical areas: *Impervious Area Hotspots* and *Yellow Creek Main Stem and Associated Tributaries*. The *Impervious Area Hotspots* critical area is 3,600-acres of dense urbanization and high impervious cover. This critical area targets urban stormwater runoff. The *Yellow Creek Main Stem and Associated Tributaries* critical area is a riparian buffer. This critical area targets reducing urban sediment loading and restoring altered streams and habitat. Erosion and flooding are significant problems in the *Yellow Creek Main Stem and Associated Tributaries* critical area.

To protect functional habitat, Summit SWCD (2025b) identified three objectives for the *Impervious Area Hotspots*:

1. Implement stormwater management practices and retrofitting existing stormwater basins to reduce the rate and quantity of stormwater runoff from 730-acres
2. Establish a post-construction stormwater control measure inspection program
3. Stabilize 1,000-linear-feet of eroding streambank

To improve poor fish community health and degraded habitat at certain monitoring sites and maintain good fish or macroinvertebrate community health and functional habitat at other monitoring sites, Summit SWCD (2025b) identified five objectives for *Yellow Creek Main Stem and Associated Tributaries:*

1. Restore and protect 1,000-lenear-feet of riparian setback along residential parcels
2. Proved 200-acre-feet of flood storage and floodplain habitat
3. Remove 2 barriers to fish passage and restore natural flow from impoundments
4. Install 20 new stormwater control measures
5. Restore and protect 500-lenear-feet of riparian setback along commercial and public parcels

Summit SWCD (2025b) described 21 projects to begin addressing the objectives for both critical areas. Led by SCE SWMD and SWCD, the following 14 projects are short- (1- to 3-years) or medium-term (3- to 7-years):

1. Wye Road Flood Mitigation (SCE1)
2. Idle Brook Bankfull Wetland (D32)
3. I-77 Corridor/FirstEnergy ROW Bankfull Wetlands (D31)
4. Ghent Hills Detention (D30)
5. Camp Christopher Bankfull Wetland (D26)
6. Bonnebrook Dr Pond Outlet Modification (D22)
7. Stormwater regulation for sites > 1 acre (A1)
8. Post Construction Stormwater Control Measure Inspection Program (A2)
9. North Fork Stream/Floodplain Enhancement (SCE2)
10. North Fork Stream Re-alignment (D61)
11. Maple Dr., Stream Stabilization (D50)
12. N Cleve Mass. Road, Stream Stabilization (D45)
13. 901 Timberline (D-42)
14. Yellow Creek Headwaters Preserve Project (WWC1)

C.9 YELLOW CREEK WAP

The Northeast Ohio Four County Regional Planning and Development Organization (NEFCO 2004) developed a watershed action plan for *Yellow Creek* (HUC 04110002 04 02). The plan establishes nine goals, objectives to implement those goals, 70 priority areas, and actions. NEFCO (2004) identified stakeholders, possible funding mechanisms, expected improvements, and evaluation criteria for each action. The nine goals for the Yellow Creek watershed are:

1. Restore riparian corridors
2. Educate watershed stakeholders about best management practices to protect water quality
3. Maintain and protect potential groundwater recharge areas
4. Recognize and address areas that have highly erodible soils
5. Reduce imperviousness
6. Protect current forested areas and promote additional tree planting
7. Adopt conservation development practices
8. Increase the understanding, awareness, participation, and cooperation among all stakeholders regarding watershed and water quality issues
9. Establish a storm water utility for the communities within the watershed

While NEFCO (2004) identified specific locations for the actions, much of the information related to each action is general. For example, the activity “reconstruct stream segments to original meandering course” associated with Action #9 is to establish “riparian protection of the Cuyahoga River and tributaries” at 19 priority area locations within Objective 1.2 (Restore stream channel) of Goal #1 (Restore riparian corridors), and Action #9 has three stakeholders (riparian landowners, affected communities, and SWCD), eight potential funding mechanisms, two

expected improvements (restoration of natural course of channelized stream and restoration of natural wetlands adjacent to meandering stream), and one evaluation criterion (linear feet of restoration).

Developing brochures (15%), conducting meetings/workshops/demonstrations (17%), organizing field trips or outreach events (10%), developing websites (10%), and other outreach or planning (3%) constituted over half of the recommended actions. Providing trees to landowners (7%) and encouraging participation (7%) were also recurring activities. Direct implementation actions included “install vegetated circles in cul-de-sacs”, “incorporate permeable paving in less-trafficked areas”, and “retrofit curbed subdivisions with grassed roadside drainage ditch/swale”.

APPENDIX D. SUMMARY OF AURORA SHORES STUDIES

Previous studies related to the flooding in the Aurora Shores neighborhood are summarized in the subsections of this appendix and are in order of the oldest studies to the most recent studies conducted.

D.1 THE HYDROGEOLOGY AND GEOCHEMISTRY OF LIBERTY PARK, A BASELINE STUDY (2005)

A University of Akron Graduate Student, Kelly Shultz, conducted a baseline study of the hydrogeology and geochemistry of Liberty Park in August of 2005. The study area is in the Pond Brook watershed of Reminderville and Twinsburg. The study did not propose or recommend any improvements.

The main findings and information provided by this graduate thesis (Schultz 2005) that are relevant to Tetra Tech's study (i.e., two-dimensional [2-D] Hydrologic Engineering Center – River Analysis System [HEC-RAS] modeling and problem areas identification) include the following:

- Appendices of the report contain stream cross-sections and velocity measurements at the location of each cross-section. These data would be useful in creating a 2-D HEC-RAS model scenario that simulates Pond Brook before the restoration occurred. The cross-sections can be used to modify the terrain to match historic channel dimensions and the velocity measurements can be used to calibrate the model.
- Monitoring well 1, which is between wetland cells 2 and 3, is hydrologically connected to Pond Brook. Other monitoring wells throughout Liberty Park indicate very shallow groundwater depths, confirming the historic, and present wetland conditions.
- Analysis of precipitation and stage data indicate the channelized and straight reaches of Pond Brook drain quickly following a precipitation event.

D.2 POND BROOK/LIBERTY PARK FINAL MITIGATION PLAN (2006)

In April 2006 an unpublished compensatory mitigation report was prepared for the Ohio Department of Transportation (ODOT), District 4 by Wetlands Resource Center, EMH&T Inc., Oxbow River & Stream Restoration Inc., and Davey Resource Group (2006). The study covers the Pond Brook watershed in Reminderville and Twinsburg.

This study provides an overview of the Pond Brook restoration and changes in hydrography in relation to the multiple ditches and constructed wetlands associated with the Pond Brook restoration. In summary, 6,095-linear-feet of Pond Brook was restored downstream of the Tradewinds Cove crossing with a sinuosity of 1.5. Additionally, water sourced from a 50-acre upstream watershed is being diverted from Ditch 1 into Wetland Cell 1 via a newly constructed diversion embankments and Agri-Drain. Multiple other embankments, water control structures, and their associated elevations and dimensions are provided in the appendices of the report.

This study provided useful technical information when developing the 2-D HEC-RAS model including the following:

- Extents and locations of primary ditches and wetland cells and normal pool elevations.
- Locations and operational elevations of the Agri-Drains.
- Location and operational elevation of the water leveling pipe between Wetland Cell 1 and Wetland Cell 2
- Locations, elevations, and dimensions of constructed embankments, spillways, and earthen plugs

D.3 HYDROGEOLOGY OF A MODIFIED WETLAND, LIBERTY PARK, TWINSBURG, OHIO (2008)

A University of Akron Graduate Student, Bernard Dzirasah, conducted a study of the hydrogeology of the modified wetlands in Liberty Park in August of 2008. The study area is in the Pond Brook watershed of Reminderville and Twinsburg. The study did not propose or recommend any improvements.

The main findings and information provided by this graduate thesis (Dzirasah 2008) that are relevant to Tetra Tech's study (i.e., 2-D HEC-RAS modeling and problem areas identification) include the following:

- Pond Brook was channelized in 1970s.
- WWTP treated effluent outfalls to Ditch 1, which is parallel to the east side of Wetland Cell 1.
- Pond Brook is hydrologically connected to Wetland Cell 1 whose water table and potentiometric surface slope to the west and south. Thus, the wetland loses water to Pond Brook.
- Groundwater was at average depth of 92-centimeters in March 2006 in Wetland Cell 1, which is believed to be typical for spring conditions and normal precipitation.
- Pond Brook hydrology is flashy but returns to baseflow 2- to 4-days after precipitation.
- Restoration of natural meanders in Pond Brook slows the rapid removal of the water from wetland cell

D.4 MONITORING AND MANAGEMENT REPORT. POND BROOK WETLANDS MITIGATION CELLS 1-3 AND STREAM RESTORATION (2013)

A monitoring and management report was conducted by Davey Resource Group (2013) for the Pond Brook stream restoration and wetland cells. Overall, the report is focused on the biology and plant species within the wetlands.

The main findings and information provided by this study that are relevant to Tetra Tech's study (i.e., 2-D HEC-RAS modeling and problem areas identification) include the following:

- Physical measurements of the stream are provided in Appendix Q. These measurements helped inform the terrain of the 2-D HEC-RAS model built by Tetra Tech.
- Groundwater monitoring well data are provided in Appendix O of the report. Locations of these wells are shown to be on both sides of Ditch 1 in Appendix G. Well 2, on the west side of Ditch 1 within Wetland Cell 1, showed consistent water levels above the ground surface throughout the year. Wells 4, 5, and 6 are on the east side of Ditch 1 and in the backyards of homes on Windjammer Trail and Sea Ray Cove. Water levels of these wells ranged from zero to 5-feet below the ground surface in water year 2013.

D.5 SUMMIT METRO PARKS POND BROOK PHASE III STREAM RESTORATION PEER-REVIEW (2017)

Stantec (2017) conducted a peer-review study and HEC-RAS modeling of the Pond Brook stream restoration. The HEC-RAS model combines the completed Phases I and II of the Pond Brook restoration and simulated Phase III of the Pond Brook restoration both under pre- and post-construction scenarios. These phases extend from the Tradewinds Cove crossing at the upstream model extent to the State Route 82 (East Aurora Road) Bridge at the downstream model extent. The primary finding of this study is that implementation of Phase III of the restoration resulted in a decrease in water surface elevations at all stations.

D.6 HYDROLOGY STUDY, CHANNEL BROOK

Buckeye Engineering (2021) estimated the 100-year/24-hour peak flow in Channel Brook near Glenwood Boulevard using a HEC-RAS model originally developed by the U.S. Geological Survey (USGS) in 2021 that Buckeye Engineering updated with 2021 stream channel geometry. Buckeye Engineering (2021) evaluated three studies to select a maximum peak flood elevations:

- USGS flood study (2012): 215 cubic feet per second (cfs)
- StreamStats (2021): 460 cfs
- A detailed drainage area study (2021): 1,440 cfs

To estimate peak discharge, Buckeye Engineering (2021) found that USGS used TR-20 software in its 2012 flood study and the TR-20 modeling was based on conditions in the 1990s that predated the rapid development from low-density wooded rural residences to higher density residential subdivisions in the 2000s and 2010s. Additionally, rainfall from the 1990s was estimated to be 4.7-inches (versus the current estimate of 5.51-inches) for a 100-year/24-hour event.

In the detailed drainage area study, Buckeye Engineering (2021) relied on the Curve Number approach and HydroCAD software. This study accounted for the urban development of residential subdivisions by relying, in part, on interpretation 2017 aerial imagery.

Buckeye Engineering (2021) estimated water level elevations for the three estimated maximum peak flows and estimated locations that levees along Channel Brook could be overtopped. As expected, the larger the maximum peak flow, the more locations where the levees could be overtopped: 215 cfs, 2 locations; 460 cfs, 3 locations; 1,440 cfs, 10 locations).

To achieve their ultimate objective of selecting appropriately sized riprap to armor the banks of Channel Brook, Buckeye Engineering (2021) used hydrological results from the 1,440 cfs estimate of maximum peak flow (from their HEC-RAS modeling) in the RipRap Design System.

Recommended improvements that resulted from this study included the following:

- Stabilize levees where there are erosion scars.
- Increase berm top width to 10-feet.
- Remove vegetation from the levees.
- Armor the levee banks per the riprap sizes determined above.

CT Consultants surveyed the upper 700 feet of Channel Brook just downstream of Glenwood Boulevard in 2021. This survey data helped inform the terrain and Channel Brook bathymetry in the Tetra Tech's 2D HEC-RAS model in this location. Additionally, the Aurora Pond normal pool elevation was listed as 1002.1 feet, which was also considered during Tetra Tech’s 2-D HEC-RAS model development

D.7 CITY OF REMINDERVILLE, CLIPPER COVE FLOODING STUDY (2021)

A SWMM model was built to assess alternatives for solving the flooding issues upstream of the Clipper Cove culvert that acts as an aqueduct to convey flow from Pond Brook underneath the Channel Brook boating canal (OHM 2021). Twenty alternatives were explored that included culvert replacements, regrading of streams, diversions, pump stations, regional storage detention systems, installation of gates/weirs, property buyouts, and unique combinations of these.

The Clipper Cove aqueduct was replaced in March of 2024. Two of the six proposed upstream regional storage detention systems are present in *Google Maps* imagery as of April 2024. This upsizing of the Clipper Cove

aqueduct will increase flows downstream, thus requiring the additional upstream regional detention systems as assessed in other alternatives in this study. Additionally, the FEMA floodplain will be out of date due to the modifications of the Clipper Cove aqueduct and will trigger a 100-year floodplain revision resulting in an increase of the number of homes requiring insurance. Even with both alternatives implemented (i.e., the upsizing of the aqueduct and the additional regional detention), the 100-year level of service will likely not be reached. Thus, acquiring the lowest elevation properties will likely be the cheapest solution.

D.8 ASHA ANNUAL REPORT (2022)

The Aurora Shores Home Owners Association (ASHA) developed a PowerPoint presentation circa April 2022 that included the following:

- 15 photographs of flooding from July 17, 2021
- A brief history of Aurora Shores
- A summary of restoration activities
- Summaries of two graduate theses

The photographs presented street- and yard-flooding, sediment-laden runoff from construction sites, and stormwater backing up at road culverts.

Prior to development in the 1960s and 1970s, the area that is now Aurora Shores was wetlands. During development of the subdivision, the wetlands were drained and Pond Brook was channelized (straightened, widened to 30- to 40-feet, and deepened to 10-feet) to serve as a stormwater conveyance (ASHA 2022). Additionally, a segment of Pond Brook downstream of the Aurora Lake spillway was designated as a petition ditch. Three ditches were constructed in Aurora Shores that drained to Pond Brook. Water levels in Aurora Lake were controlled by an aqueduct from Pond Brook to Aurora Lake (upstream of Aurora Shores) and by a series of ditches between the lake and brook (ASHA 2022).

A restoration project was implemented that established three wetland cells to the southwest and south of Aurora Shores. The project included restoring 4.6-miles of streambank along Pond Brook. The project area is in Liberty Park that is managed by Summit Metroparks, with Summit Metroparks responsible for long-term maintenance of Pond Brook.

Both graduate theses sought to characterize the hydrology and water chemistry of Pond Brook and the restoration area (Schultz 2005, Dzirasah 2008). The theses found that water levels in Pond Brook change rapidly during and immediately following precipitation events and then take a few days to return to normal levels. Both theses also discussed the general challenges with restoration projects, including the difficulty in designing successful projects. The overall sentiment of the Annual Report is that the restoration of Pond Brook and the wetlands has increased flooding issues by not allowing water to quickly drain out of area.

APPENDIX E. SUMMARY OF ALL OTHER PREVIOUS STUDIES

Five additional studies covering areas within this project's study area are summarized in this appendix.

E.1 YELLOW CREEK WATERSHED TECHNICAL MEMORANDUM

Sustainable Streams (2019) developed a planning-level feasibility analysis for stream restoration and stormwater management in the Yellow Creek watershed. This study included rapid visual assessment of nearly 41 miles of streams throughout the watershed. Rapid visual assessment and conceptual project identification targeted streams with degraded habitat or where erosion threatened structures or infrastructure. Sustainable Streams (2019) identified 66 conceptual projects and 13 nonstructural efforts to improve conditions in the Yellow Creek watershed.

To delineate areas of risk, the study characterizes the Yellow Creek watershed and presents inventories of key natural resources and infrastructure. For example, Sustainable Streams (2019) identified 413 basins or lakes, 45 dams or in-line structures, 73 bridges, and 58 culverts. Evaluation of infrastructure focused on stream stability. The study also summarized 50 responses to a survey conducted by the Friends of Yellow Creek, where residents identified three key problems: erosion (72% of respondents), runoff (48%), and flooding or yard-ponding (42%). Using these datasets, Sustainable Streams (2019) delineated stream miles at three relative levels of risk along the 41 stream miles that were visually assessed: low (57%), medium (22%), and high (21%).

Sustainable Streams (2019) identified eight categories of conceptual opportunities:

- Improvement or protection of high infiltration areas in seven forested public land with type A or B soils
- Optimization of eight existing stormwater control measures, including armoring, maintenance (e.g., de-clogging), retrofitting, and replacement (e.g., upsizing)
- Installation of 29 new stormwater control measures, including bankfull wetlands, conventional basins, and amended swales
- Mitigating instability and downcutting in four seasonal channels, including armoring and installing a bypass channel
- Protection of streambanks along 12 reaches on private land via stabilization T
- Protection on streambanks along 12 reaches on private land via partial stabilization
- Programmatic and nonstructural improvements

The study includes a preliminary implementation plan for potentially high-impact projects.

In Sustainable Streams (2019), data are mapped in Appendix A, survey results are presented in Appendix B, hydrogeomorphic data are presented in Appendix C, conceptual opportunities are mapped and described in Appendix D, and high-impact opportunities are mapped in Appendix E.

E.2 CHAFFEE ROAD WETLAND AREA RESTORATION

The Nature Conservancy (TNC 2020) developed a conceptual plan to restore wetlands in a to the east of Chaffee Road in Sagamore Hills Township (Summit County). The former agricultural area floods frequently following storm events, which includes flooding of residential properties, overwhelming culverts, and overtopping a service road.

The conceptual plan is to expand and enhance existing wetlands. Wetlands footprint would be expanded via excavation that will also provide additional stormwater detention capacity. Spoils would be used in the enhancement of existing forest or meadow areas. The service road would be raised, the number of culverts would be reduced, and water control structures would be installed. The estimate cost is $475,110.

E.3 DORWICK DITCH REHABILITATION PROJECT

SCE commissioned a study of Dorwick Ditch to evaluate drainage conditions and determine potential costs of brining the ditch into county maintenance. Dorwick Ditch is in Northfield Center Township and the ditch runs along residential properties on Dorwick Drive and Olde Eight Road. The ditch is a small tributary to Brandywine Creek. Euthenics (2015) evaluated Dorwick Ditch and its tributaries, identified projects to remedy deficiencies in ditch function, and estimated costs for each alternative.

Euthenics (2015) identified three deficiencies preventing the Dorwick Ditch from functioning effectively:

- Ditch is clogged with debris and overgrown with vegetation
- Ditch width is inconsistent between segments (varies between 15- and 25-feet)
- Ditch has a variable flowline profile and sag areas that pond.

These same deficiencies impacted the ditches tributary to Dorwick Ditch. Euthenics (2015, p. 3-4) also evaluated four tributary ditches to Dorwick Ditch:

- Dorwick Ditch (northern extensions) is “in poor condition and does not function well.”
- Marwyck/Kenwick Ditch is “in fair conditions and functions adequately.”
- Kenwick/Pickwick Ditch is “in good condition and functions well.”
- Beacon Hills Ditch is “in fair conditions and functions adequately.”

Euthenics (2015) identified five rehabilitation projects:

- *Dorwick Ditch Rehabilitation– Alternative 1* ($825,597): The project is composed of a culvert replacement, enclosure of one ditch segment, and reconstruction and re-channelization of another ditch segment.
- *Dorwick Ditch Rehabilitation– Alternative 2* ($404,660): The project is composed of a culvert replacement and reconstruction and re-channelization of the ditch.
- *Dorwick Ditch (Extension) Rehabilitation* ($21,957): The project would re-channelize the ditch.
- *Marwyck/Kenwick Ditch Rehabilitation* ($17,568): The project would re-channelize the ditch.
- *Kenwick/Pickwick Ditch Rehabilitation* ($9,874): The project would re-channelize the ditch.
- *Beacon Hills Ditch Rehabilitation* ($20,354): The project would re-channelize the ditch.

Both alternatives to Dorwick Ditch include $204,125 to rehabilitate Dorwick Ditch’s outlet to Mitchell Ditch.

Euthenics (2015) also estimated costs for a ditch maintenance program. The equation used to calculate annual costs was based on an Ohio Department of Transportation runoff coefficient, parcel drainage area, and project cost. Euthenics (2015) estimated annual construction and maintenance costs for each parcel that would be affected by the rehabilitation projects.

E.4 WYE ROAD FLOOD MITIGATION & ALTERNATIVES STUDY

ms consultants (2019) conducted flood mitigation and alternatives study for SCE to address street flooding and erosion in the Wye Creek subwatershed, including the Sanctuary neighborhood, of the Yellow Creek watershed. ms consultants developed Storm Water Management Models (SWMM) and Hydrologic Engineering Center – River Analysis System (HEC-RAS) models and evaluated four alternatives.

The Wye Creek subwatershed is in Bath Township of Summit County and the 155-acre subwatershed is primarily residential. Flooding occurs in the Sanctuary neighborhood at multiple locations along Wye Road, including at The Bake Shop.

ms consultants (2019) developed Personal Computer Stormwater Management Model (PCSWMM) and HEC-RAS models to investigate flooding and erosion and to evaluate alternatives to mitigate the flooding and erosion. Stormflow from four precipitation events were simulated: 10-, 25-, 50, and 100-year precipitation events.

Modeling the existing conditions showed that stormflow from the 10-year precipitation even exceeds the capacity of the stormwater conveyance system. The model results indicated that localized flooding at The Bake Shop was caused by stormflows exceeding capacity of adjacent storm sewers, which causes surcharging. Model results also confirmed that erosion in Wye Creek occurs due to high stormflow velocities.

The model results, coupled with closed circuit television investigation, led ms consultants (2019, p. 3) to establish three goals for alternatives analysis:

- Reduce in-stream velocities in Wye Creek for up to the 25-year recurring stormflow
- Mitigate surface flooding in front of The Bake Shop
- Eliminate erosion along Wye Creek

ms consultants (2019) identified and evaluated four alternatives:

1. Install two new upstream detention basins
2. Install new 30-inch Wye Road relief storm sewer and install bioretention cells along Sanctuary Drive
3. Install one new upstream detention basin and modify an existing in-line detention basin
4. Combination of Alternatives #1 and #3

Through modeling, ms consultants (2019) found that all four alternatives reduce the chances of street flooding at The Bake Shop to varying extents and the four alternatives have different outcomes with reducing erosion in Wye Creek. ms consultants (2019, p. 10) recommended Alternative #4, with an opinion of probably cost of construction of $353,340. This Wye Road Flood Mitigation and Alternatives Study has advanced through design to a two-phase project. Phase 1 was constructed in 2024 and the Phase 2 contract has already been awarded with constructed scheduled to occur in 2025.

E.5 FEMA FIS STUDY, SUMMIT COUNTY

FEMA conducts Flood Insurance Studies (FIS) as necessary to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 (FEMA 2016). As applicable to this Cuyahoga River Watershed Study, the Summit County FIS was revised in 2016 and data used herein include floodplain delineations, flood depths, and channel bathymetry information.

In addition to the technical data listed above, the FIS also provides narrative summaries of each community in the study including a general description, principal flood problems, and existing flood protection measures in place.

APPENDIX F. BASELINE RECOMMENDATIONS

Table F- 1. Issues with no recommended action

ID	Latitude / Longitude	Type	Issue description	Tetra Tech's findings
ASN_3	41.33673096 -81.4068222	Erosion	The drainage easement has sinkholes and is caving-in.	The drainage easement and storm sewers are the responsibility of ASHA and property owners.
ASN_4	41.33692932 -81.40571594	Drainage	Pirates Trail culvert is at capacity during large precipitation events per the ASHA Annual Report.	The ASHA Annual Report does not indicate the road is inundated. No deficiencies or blockages that would decrease conveyance capacity were observed by Tetra Tech during the field inspection. Tetra Tech assumes the conveyance of the crossing, built circa 2011, meets the performance requirements outlined in the Stormwater Drainage Manual (SCE, 2020).
ASN_7	41.33562469 -81.4018631	Drainage	Tradewinds Cove culvert is at capacity during large precipitation events per the ASHA Annual Report.	The ASHA Annual Report does not indicate the road is inundated. No deficiencies or blockages that would decrease conveyance capacity were observed by Tetra Tech during the field inspection. Tetra Tech assumes the conveyance of the crossing, built circa 2009, meets the performance requirements outlined in the Stormwater Drainage Manual (SCE, 2020).
AST_1	41.33955765 -81.41033173	Drainage	A beaver dam is in the stream channel.	Natural processes are occurring.
BC_1	41.28565598 -81.50341034	Drainage & Erosion	Local erosion (4 locations) and log jams or large woody debris (6 locations) are along the stream channel.	Natural processes are occurring.

ID	Latitude / Longitude	Type	Issue description	Tetra Tech's findings
BC_5	41.29421234 -81.51833344	Erosion	Brandywine Creek Drive and backyard sheds are within 8-feet of the stream channel.	The bank is stable, with trees along the bank and a shale toe.
LLIR_1	41.30705261 -81.52336121	Drainage	A logjam or beaver dam is blocking flow that results in erosion on the left bank of a tributary to a county ditch.	Nearby utility lines are not threatened.
NBDC_1	41.32369995 -81.55323792	Drainage	**Drainage Complaint**: Pond runoff from 8144 North Boyden Road (Sagamore Hills Township) is conveyed to 8156 North Boyden Road via a small channel.	Does not involve county infrastructure.
PBTC_1	41.3143158 -81.40190125	Drainage	A beaver dam is in the stream channel, which results in downstream channel incision. The upstream channel is a flooded wetland.	The beaver dam is acting as grade control to prevent incision from migrating further upstream.
SR_2	41.33716583 -81.54827118	Drainage & Erosion	A log jam is in the stream channel and 30-feet of the left bank is eroding.	Natural processes are occurring.
SR_5	41.33433151 -81.54174805	Drainage	Two homemade wooden check-dams are in the stream channel.	The check dams are acting as grade control to prevent upstream channel incision.

ID	Latitude / Longitude	Type	Issue description	Tetra Tech's findings
SR_8	41.33198166 -81.53572845	Erosion	The left bank of is eroding along 18-feet of the stream channel	A nearby home is about 75-feet away and not threatened.
SR_10	41.32877731 -81.53721619	Erosion	Erosion is occurring on the cutbanks of a meandering stream reach. A concrete pipe is caved-in.	Natural processes are occurring.
SWDC_1	41.32616043 -81.42323303	Drainage	**Drainage Complaint**: Flooding at 2963 Steffan Woods Drive	No evidence of flooding. The property is well-sloped and no stream is along the property.
TRUS_2	41.27812958 -81.5254364	Drainage	**Service Request**: Ditch at 295 and 303 West Twinsburg Road needs cleaned out and driveway is eroding	No evidence of ditch being blocked at time of site visit and erosion of gravel driveway is minimal
USSH_7	41.29267883 -81.54878998	Erosion	The right bank is eroding along 25-feet of stream channel downstream of a culvert at South Boyden Road.	No structures or infrastructure is threatened.

Note: ASHA = Aurora Shores Homeowners Association.

Table F - 2. Issues with recommended monitoring

ID	Latitude / Longitude	Type	Issue description	Tetra Tech's monitoring recommendation	Monitoring Frequency
ALDC_1	41.28416443 -81.51099396	Drainage	**Drainage Complaint**: Cattails block flow at 7511 Anchor Lane.	Monitor culvert for blockages.	Annually
ASN_1	41.33655548 -81.39815521	Drainage	The Clipper Cove aqueduct was undersized and causing flooding at residences on Nautilus Trail and Anchorage Cove. The aqueduct was upsized in spring 2024.	Monitor for flooding and to determine if aqueduct upsizing was sufficient to prevent flooding in these areas.	Annually
ASN_8	41.33415604 -81.40164185	Erosion	The left streambank is eroding (5-feet tall by 40-feet long), which is about 50-feet away from the WWTP fence at the top of streambank. The erosion appears to be migrating slowly.	Monitor streambank for migration of erosion and determine if the WWTP becomes threatened.	Annually
AST_9	41.34345245 -81.39411926	Erosion	Grade control just upstream of the crossing at Maryland Ave is preventing downcutting and ensuring upstream bank stability.	Monitor to ensure grade control remains intact.	Annually
AST_11	41.3416748 -81.3988266	Drainage	The right bank is built up with spoil material from a ditch excavation. As such, the right bank is higher than left bank. At high flow conditions, any overbank flow would be in the direction of the houses on the left bank. Nearby homes with sandbags indicate possible past flooding. The Clipper Cove aqueduct upsizing in the spring of 2024 may mitigate this issue.	Monitor for flooding and to determine if aqueduct upsizing was sufficient to prevent flooding in this area.	Annually

ID	Latitude / Longitude	Type	Issue description	Tetra Tech's monitoring recommendation	Monitoring Frequency
BC_2	41.27758789 -81.49932861	Erosion	Power lines are about 10-feet from the streambank. Streambanks are stable.	Monitor streambanks for erosion encroachment on power lines.	Annually
BC_4	41.29453278 -81.51306152	Spill	Tanker truck spill.	Monitor clean-up and restoration.	Annually
IC_1	41.18041229 -81.58846283	Erosion	The left streambank is eroding at two locations, and a road and power lines are atop this streambank. Trees and roots stabilize the bank, along with rip rap emplaced at the toe. The downstream location (12-feet tall by 75-feet long) is 20-feet from a road and power lines. The upstream location (16-feet tall by 400-feet long) is 8-feet from a road and power lines.	Monitor streambanks for erosion encroachment on the road and power lines.	Annually
LLIR_2	41.29688263 -81.51986694	Drainage	A sewer line crosses the stream. No issues were observed at the time of the inspection.	Monitor to ensure the integrity of the sewer line.	Annually
PCTC_5	41.28476334 -81.39336395	Erosion	The right cutbank of Tinker's Creek is eroding (6- to 8-feet tall by 210-feet long) and encroaching on Old Mill Road. The top of the bank is 15-feet from Old Mill Road in some locations along the eroding bank. Review of historical imagery indicates about 1-foot of lateral erosion from 2005 to 2021.	Monitor streambank erosion for further encroachment along Old Mill Road.	Annually

ID	Latitude / Longitude	Type	Issue description	Tetra Tech's monitoring recommendation	Monitoring Frequency
SR_1	41.3364563 -81.54936218	Erosion	The left streambank is eroding (4-feet tall by 15-feet long). The top of the bank is 12-feet from a paved trail. Trees and roots are present along the streambank.	Monitor streambank erosion for further encroachment along the paved trail.	Annually
SR_9	41.3308754 -81.5337677	Erosion	At the inlet under Olde 8 Road, the 4- by 4-foot concrete box culvert is poorly aligned and minor scour is occurring behind the wingwall.	Monitor culvert and scour and determine if Olde 8 Road becomes threatened.	Annually
USSH_5	41.29323578 -81.54711151	Erosion	The left streambank is eroding (10-feet tall by 30-feet long). Trees and roots stabilize the streambank. The top of the bank is 40-feet from a building but the building is not currently threatened.	Monitor streambank erosion for toward the building.	Annually

Note: WWTP = wastewater treatment plant.

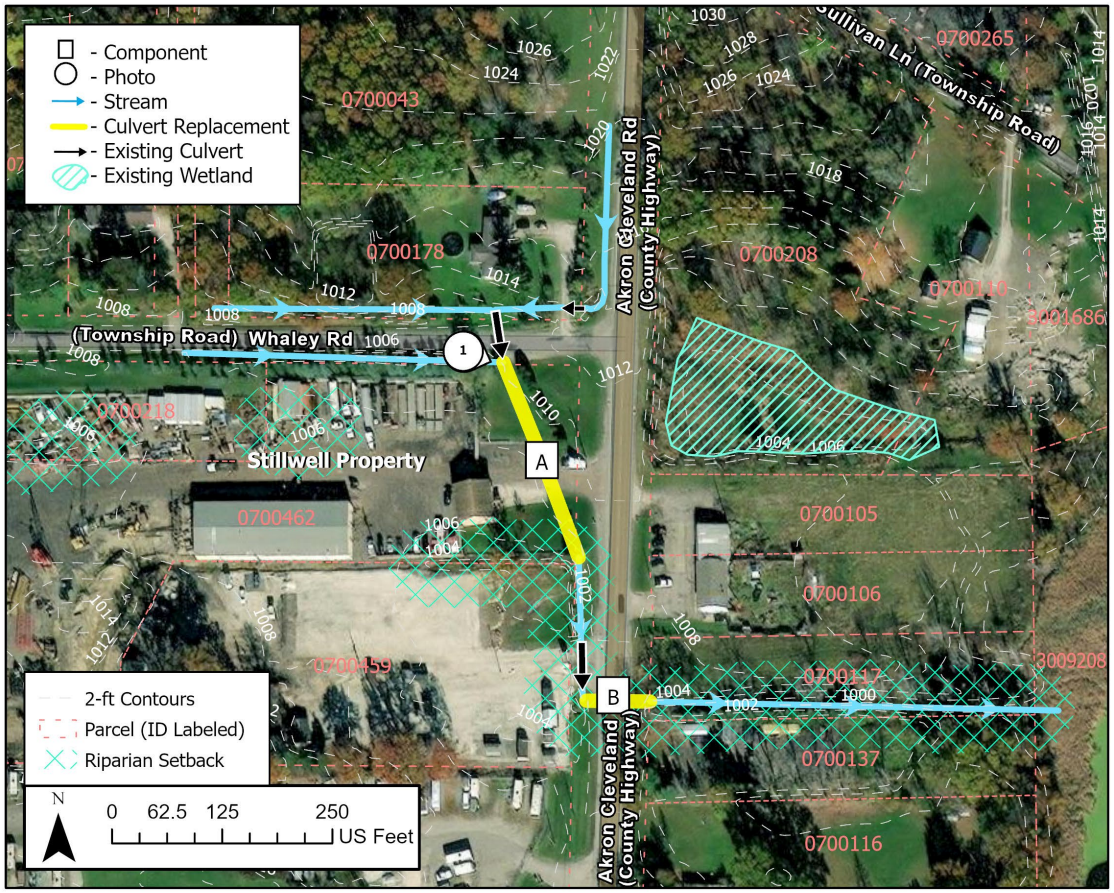
Table F - 3. Issues with recommended maintenance

ID	Latitude / Longitude	Type	Issue description	Tetra Tech's maintenance recommendation	Maintenance Frequency
ASN_6	41.33771133 -81.40195465	Erosion	A 1-foot tall headcut may migrate upstream to the Smugglers Cove culvert and cause bank erosion.	Stabilize headcut with rip rap as a grade control structure.	Annually
AST_4	41.34501648 -81.40153503	Drainage	The inlet (two plastic pipes with 1-foot diameters) at the Glenwood Boulevard crossing is completely buried and water is ponding upstream.	*Short-term*: Clear the inlet. *Long-term*: Replace and upsize the culverts.	Annually
AST_6	41.34598923 -81.39354706	Drainage	The channel is blocked with leaves, debris, and vegetation, which acts as grade control. The blockage backs-up water that submerges an upstream culvert, which limits the culvert's capacity.	Remove the blockage.	Annually
AST_10	41.34326553 -81.3948288	Unauthorized dumping	Silt fence is in channel - customer complaint.	Remove the silt fence and other construction material from the riparian area.	Annually
BC_6	41.29430389 -81.52033997	Unauthorized dumping	Trash is piled up on right bank within riparian zone and behind the fence of Infinity Paving.	Remove the debris. Contact Infinity Paving about debris removal.	Annually

ID	Latitude / Longitude	Type	Issue description	Tetra Tech's maintenance recommendation	Maintenance Frequency
IC_1	41.18111038 -81.58750916	Drainage	The inlet sides of two culverts under Martin Road (12-inch CMP and 18-inch concrete) are completely buried.	Clear the inlet.	Annually
MBDC_1	41.28027344 -81.44629669	Drainage	**Drainage Complaint**: Leaves block the storm drain inlet to a basin on Marwell Boulevard. The basin is still performing as intended. A resident has a catch basin in their yard but the yard likely still becomes saturated due to the lower grade (i.e., not due to the basin).	Clear the inlet.	Annually
MDDC_1	41.30018616 -81.52883911	Drainage	**Drainage Complaint**: Ditch maintenance is needed at 8758 Olde 8 Road, Northfield.	Perform routine maintenance to ensure debris is not blocking culvert.	Annually
SR_4	41.33504486 -81.54316711	Drainage	Large woody debris has built up at the inlet of a historic road bridge.	Clear the inlet.	Annually
SR_7	41.33267593 -81.53738403	Drainage	Debris partially blocks the primary outlet (6-inche PVC) of a retention basin that is downhill of a large impervious area (Lawrence School).	Clear the outlet.	Annually
USSH_4	41.29356384 -81.54605103	Drainage	Large woody debris and a cement block (fallen from the headwall) block the culvert inlet.	Clear the inlet.	Annually

ID	Latitude / Longitude	Type	Issue description	Tetra Tech's maintenance recommendation	Maintenance Frequency
USSH_6	41.29270935 -81.5483017	Drainage & Erosion	Large woody debris blocks the inlet to the culvert at South Boyden Road. The right streambank is eroding (3-feet tall by 25-feet long) but does not threaten any structures or the road.	Clear the inlet Monitor streambank erosion for encroachment.	Annually

APPENDIX G. CONCEPT PLANS



Project Details

Watershed: Mud Brook
HUC12: 041100020401
Municipality: Boston Township

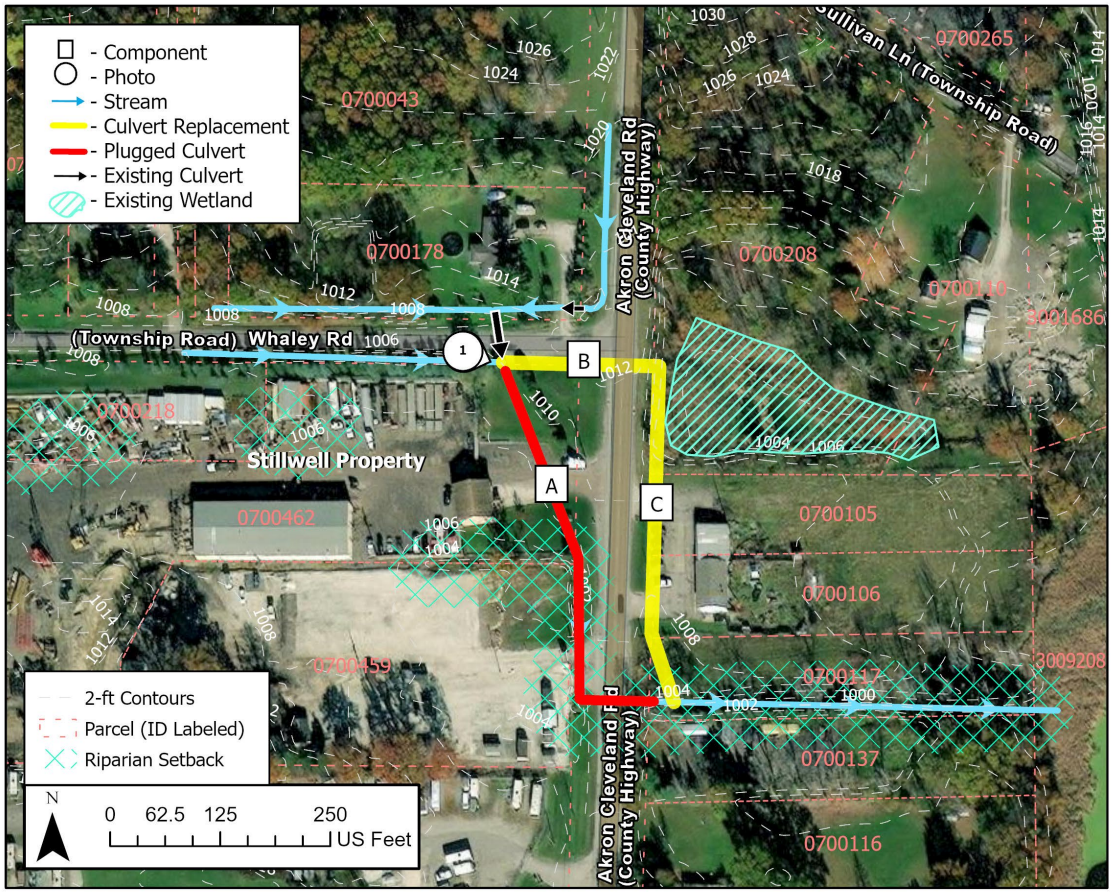
Field Visit Date:3/18/2024

Project Narrative

Inadequate drainage through the Stillwell property has caused repeated flooding along Whaley Rd. Summit County provided Tetra Tech with results of a hydraulic analysis of the flooding at this location ("Whaley Rd/Akron-Cleveland Rd Drainage Improvements Boston Township Inter Office Memorandum"). Alternative 1 proposes [A] - replacing the exising 12" Stillwell property storm sewer with 253 LF of 30" conduit and [B] - to replace the 2' x 5' box culvert under Akron-Cleveland Rd with 74 LF of 38" x 60" elliptical conduit. It is assumed the culvert under the dirveway at parcel 0700459 is adaquately sized to handle increased flows from the proposed 30" Stillwell culvert.

Summit County Engineer
Cuyahoga River Watershed Study
ACDC_AOI_1
Akron Cleveland Road Drainage
Complaint Alternative 1

TETRA TECH



Project Details

Watershed: Mud Brook
HUC12: 041100020401
Municipality: Boston Township

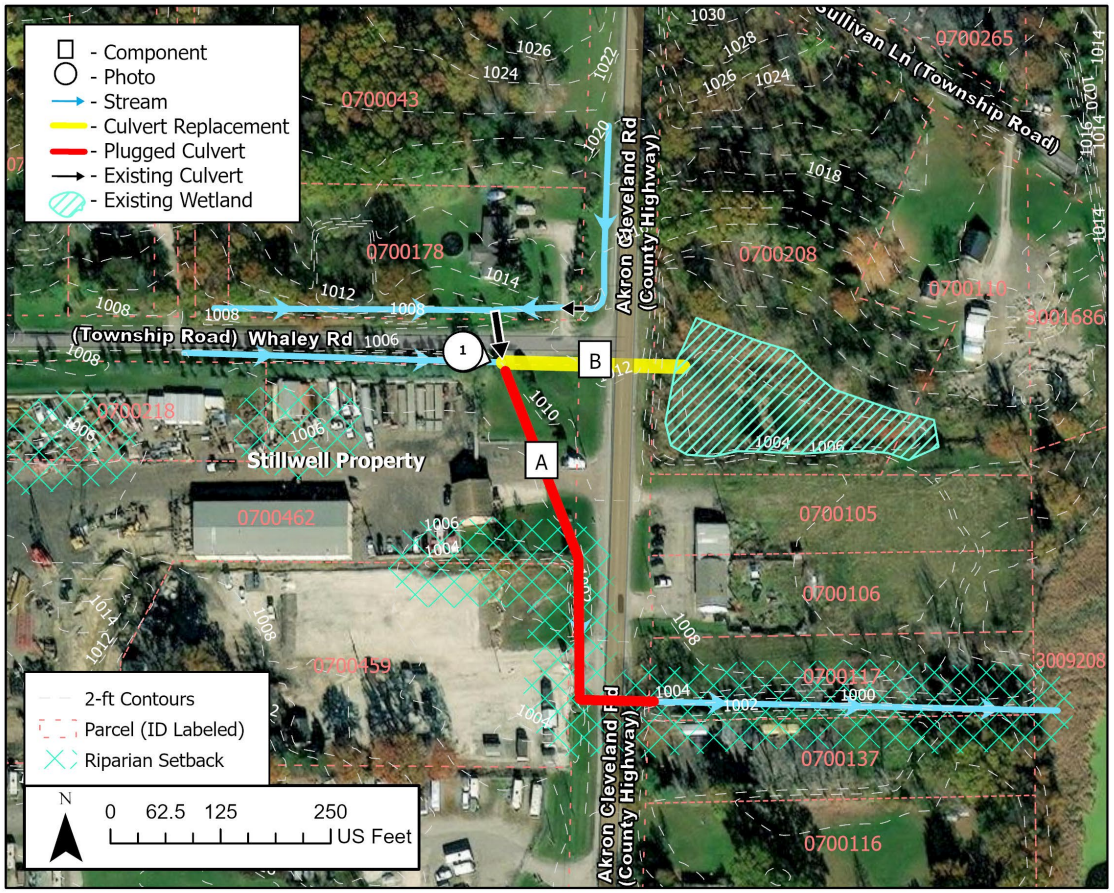
Field Visit Date:3/18/2024

Project Narrative

Inadequate drainage through the Stillwell property has caused repeated flooding along Whaley Rd. Summit County provided Tetra Tech with results of a hydraulic analysis of the flooding at this location ("Whaley Rd/Akron-Cleveland Rd Drainage Improvements Boston Township Inter Office Memorandum"). Alternative 2 proposes [A] - plugging the end of the exising 12" Stillwell property storm sewer and [B] - install 185 LF of 30" storm sewer down Whaley Rd. and under Akron-Cleveland Rd. [C] - replace the existing 15" storm sewer on Akron-Cleveland Rd with 401 LF of 30" conduit which will be built lower than the existing 15" storm sewer.

Summit County Engineer
Cuyahoga River Watershed Study
ACDC_AOI_1
Akron Cleveland Road Drainage
Complaint Alternative 2

TETRA TECH



Project Details

Watershed: Mud Brook
HUC12: 041100020401
Municipality: Boston Township

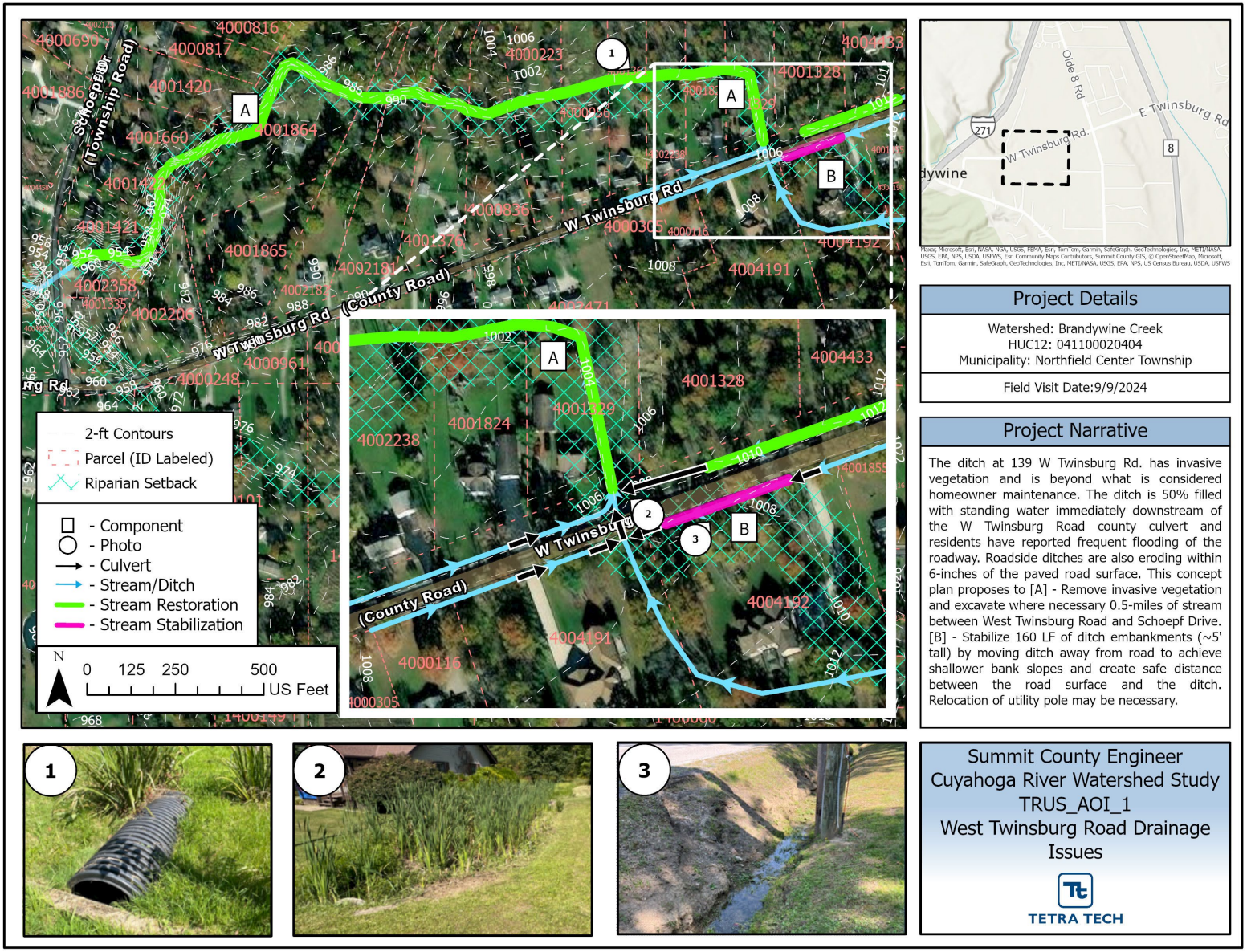
Field Visit Date:3/18/2024

Project Narrative

Inadequate drainage through the Stillwell property has caused repeated flooding along Whaley Rd. Summit County provided Tetra Tech with results of a hydraulic analysis of the flooding at this location ("Whaley Rd/Akron-Cleveland Rd Drainage Improvements Boston Township Inter-Office Memorandum"). Alternative 3 proposes [A] - plugging the end of the existing 12" storm sewer that drains Whaley Rd and [B] - install 230 LF of 30" storm sewer down Whaley Rd and under Akron-Cleveland Rd to the existing wetland on the east side of Akron-Cleveland Rd.

Summit County Engineer
Cuyahoga River Watershed Study
ACDC_AOI_1
Akron Cleveland Road Drainage
Complaint Alternative 3

TETRA TECH



Project Details

Watershed: Brandywine Creek
HUC12: 041100020404
Municipality: Northfield Center Township

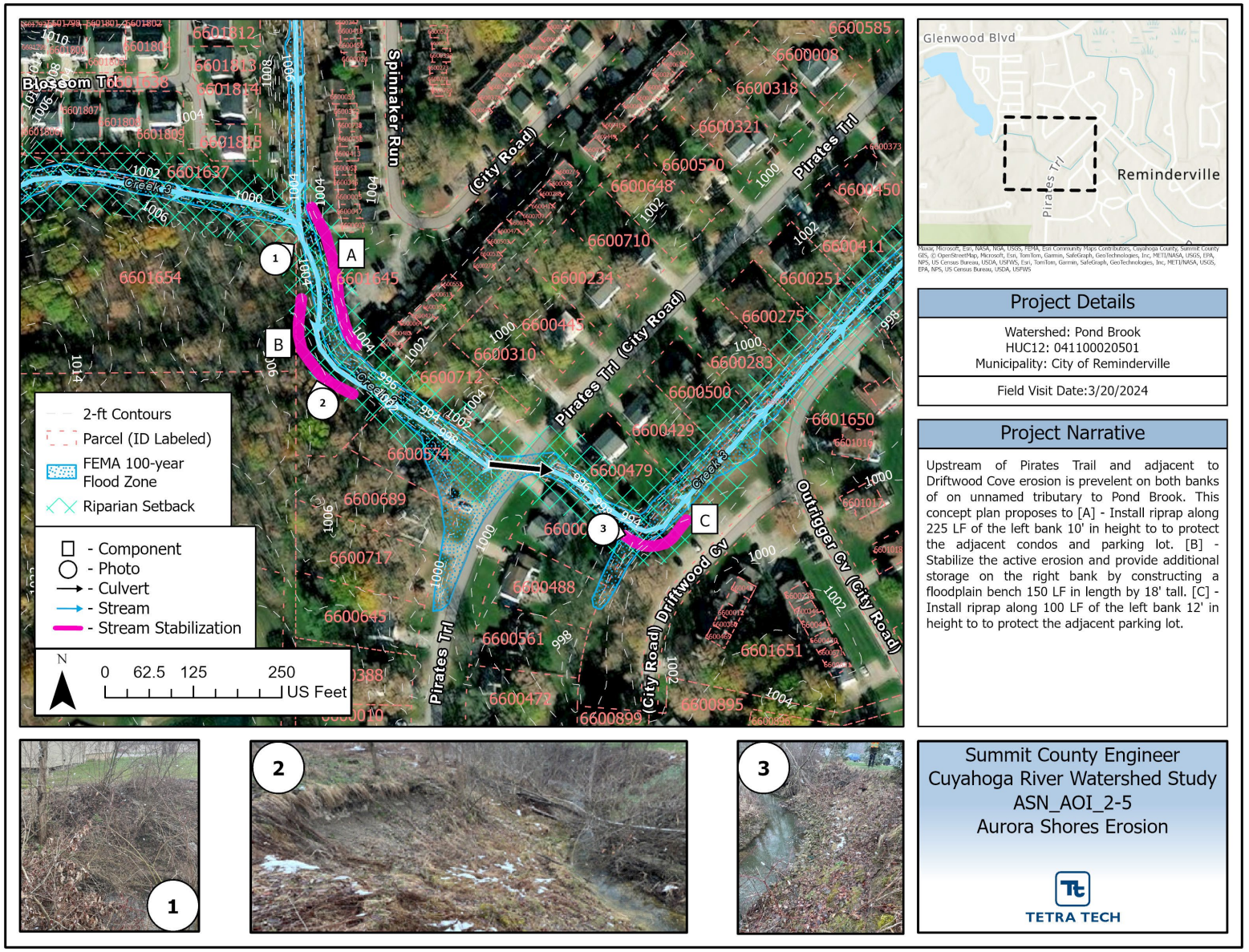
Field Visit Date:9/9/2024

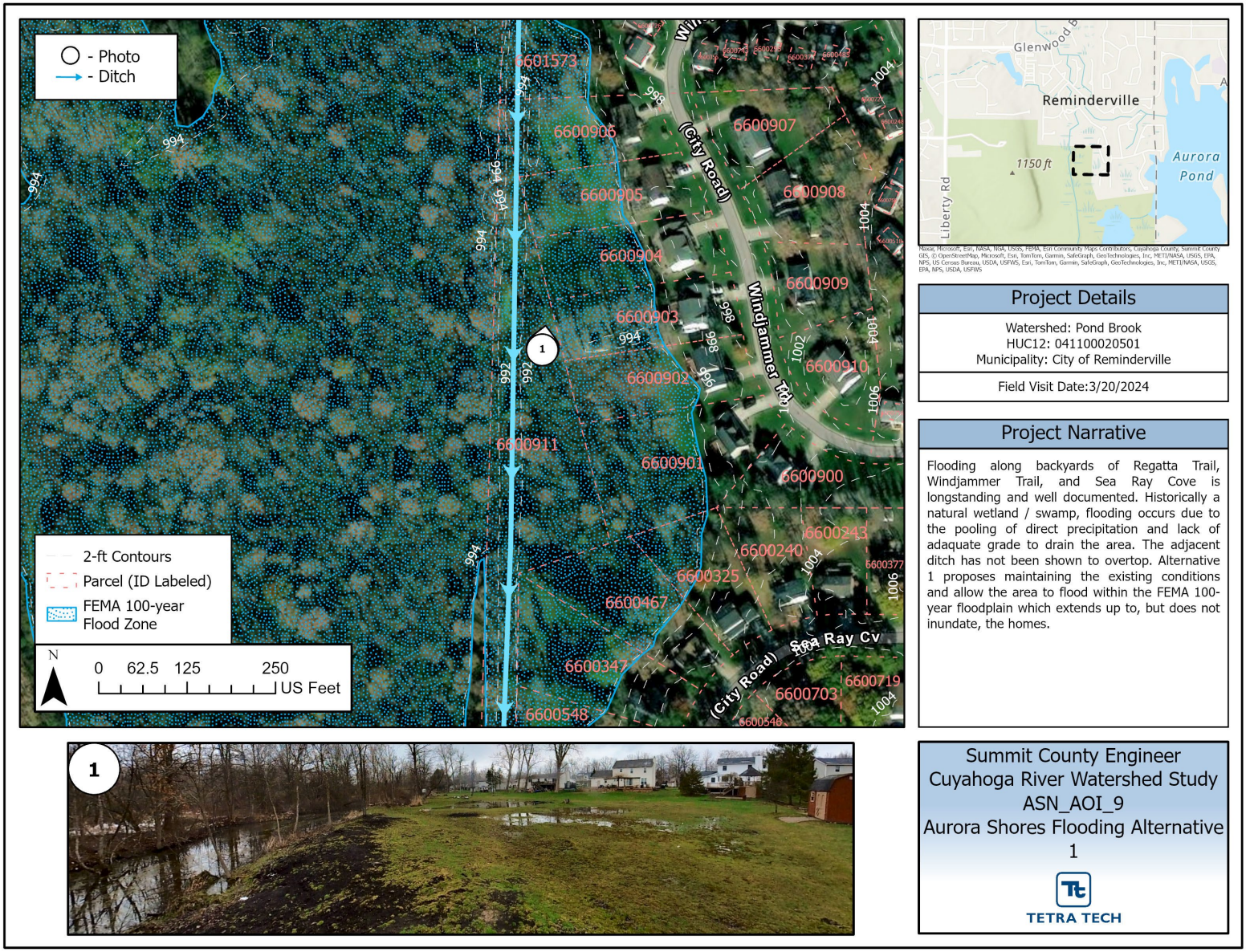
Project Narrative

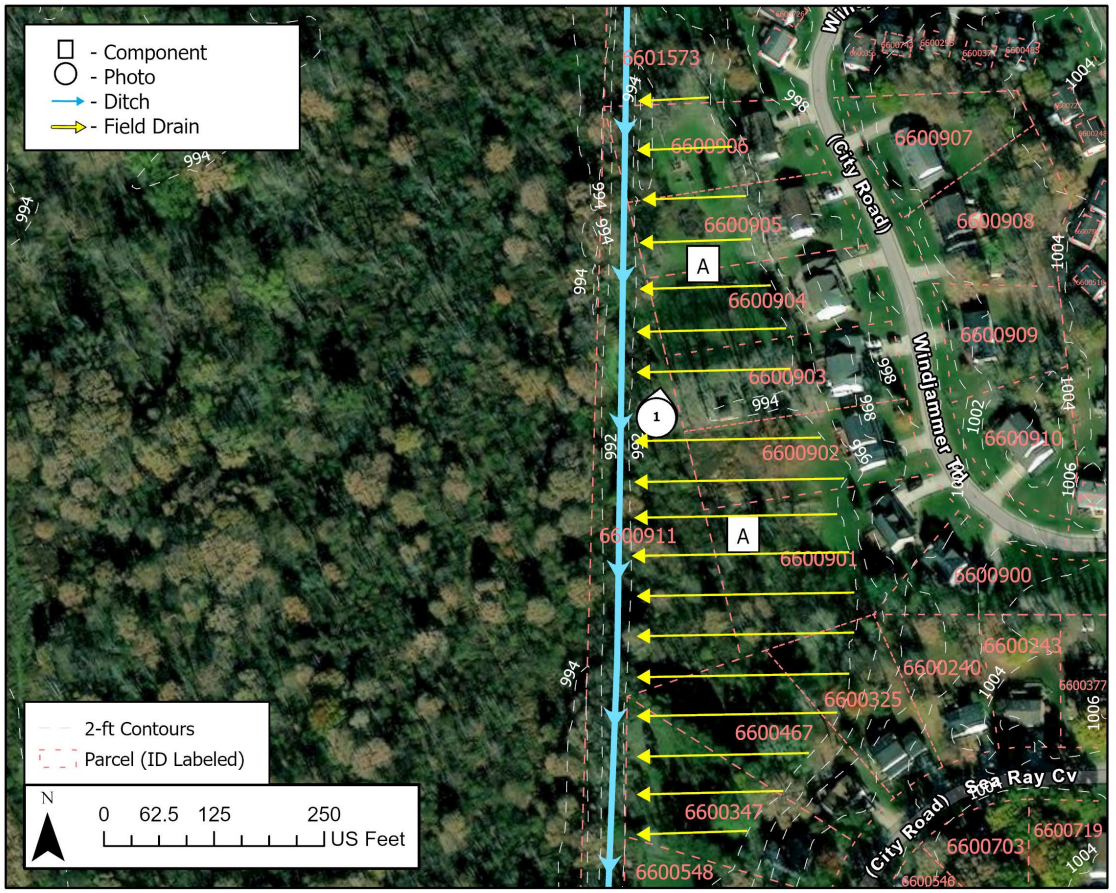
The ditch at 139 W Twinsburg Rd. has invasive vegetation and is beyond what is considered homeowner maintenance. The ditch is 50% filled with standing water immediately downstream of the W Twinsburg Road county culvert and residents have reported frequent flooding of the roadway. Roadside ditches are also eroding within 6-inches of the paved road surface. This concept plan proposes to [A] - Remove invasive vegetation and excavate where necessary 0.5-miles of stream between West Twinsburg Road and Schoepf Drive. [B] - Stabilize 160 LF of ditch embankments (~5' tall) by moving ditch away from road to achieve shallower bank slopes and create safe distance between the road surface and the ditch. Relocation of utility pole may be necessary.

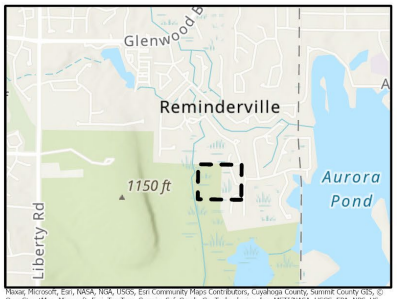
Summit County Engineer
Cuyahoga River Watershed Study
TRUS_AOI_1
West Twinsburg Road Drainage Issues

TETRA TECH


Blossom Trl
Spinnaker Run
(City Road)
Pirates Trl
Pirates Trl (City Road)
Creek 3
Driftwood Cv
Outrigger Cv (City Road)
A
B
C
1
2
3
2-ft Contours
Parcel (ID Labeled)
FEMA 100-year Flood Zone
Riparian Setback
- Component
- Photo
- Culvert
- Stream
- Stream Stabilization
N
0 62.5 125 250
US Feet
Glenwood Blvd
Reminderville
Project Details
Watershed: Pond Brook
HUC12: 041100020501
Municipality: City of Reminderville
Field Visit Date:3/20/2024
Project Narrative
Upstream of Pirates Trail and adjacent to Driftwood Cove erosion is prevelent on both banks of on unnamed tributary to Pond Brook. This concept plan proposes to [A] - Install riprap along 225 LF of the left bank 10' in height to to protect the adjacent condos and parking lot. [B] - Stabilize the active erosion and provide additional storage on the right bank by constructing a floodplain bench 150 LF in length by 18' tall. [C] - Install riprap along 100 LF of the left bank 12' in height to to protect the adjacent parking lot.
Summit County Engineer
Cuyahoga River Watershed Study
ASN_AOI_2-5
Aurora Shores Erosion
TETRA TECH


- Photo
- Ditch
2-ft Contours
Parcel (ID Labeled)
FEMA 100-year Flood Zone
N
0 62.5 125 250
US Feet
(City Road)
Windjammer Trl
Sea Ray Cv
Glenwood B
Reminderville
1150 ft
Aurora Pond
Liberty Rd
Project Details
Watershed: Pond Brook
HUC12: 041100020501
Municipality: City of Reminderville
Field Visit Date:3/20/2024
Project Narrative
Flooding along backyards of Regatta Trail, Windjammer Trail, and Sea Ray Cove is longstanding and well documented. Historically a natural wetland / swamp, flooding occurs due to the pooling of direct precipitation and lack of adaquate grade to drain the area. The adjacent ditch has not been shown to overtop. Alternative 1 proposes maintaining the existing conditions and allow the area to flood within the FEMA 100-year floodplain which extends up to, but does not inundate, the homes.
1
Summit County Engineer
Cuyahoga River Watershed Study
ASN_AOI_9
Aurora Shores Flooding Alternative 1
TETRA TECH





Project Details

Watershed: Pond Brook
HUC12: 041100020501
Municipality: City of Reminderville

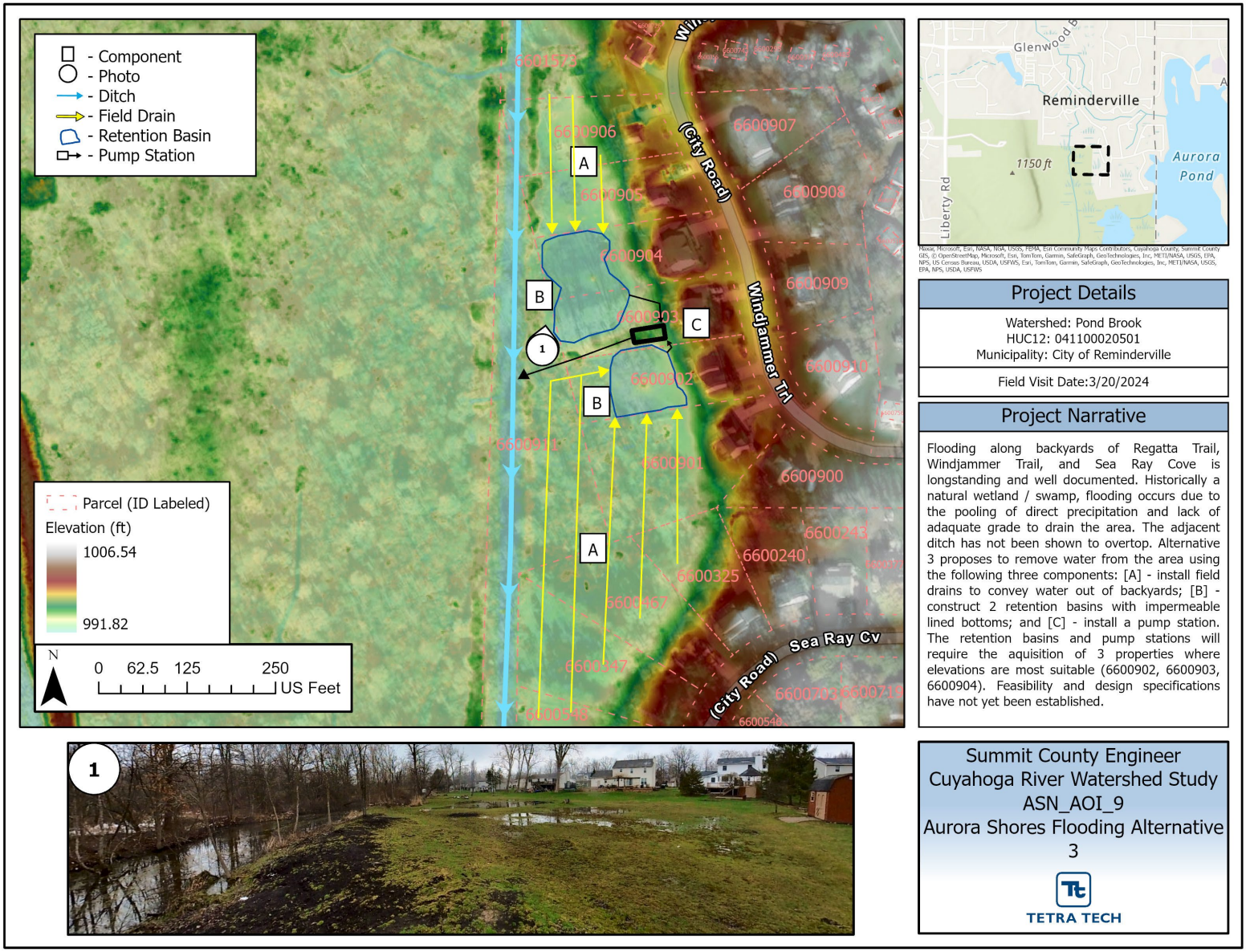
Field Visit Date:3/20/2024

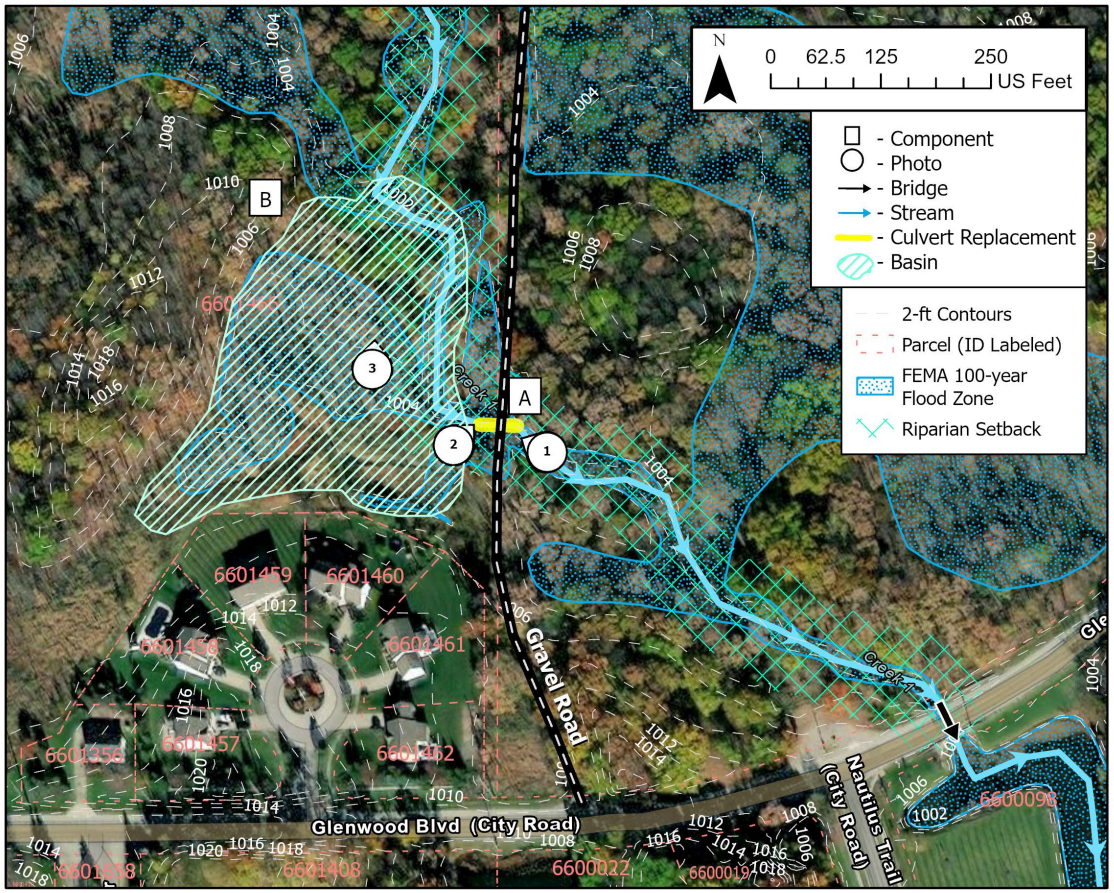
Project Narrative

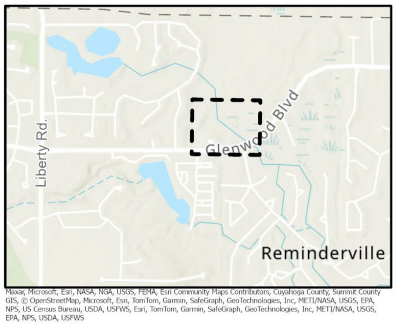
Flooding along backyards of Regatta Trail, Windjammer Trail, and Sea Ray Cove is longstanding and well documented. Historically a natural wetland / swamp, flooding occurs due to the pooling of direct precipitation and lack of adaquate grade to drain the area. The adjacent ditch has not been shown to overtop. Alternative 2 proposes to [A] - install a series of field drains in an east-west direction to convey water to the ditch. This alternative is not expected to solve the flooding issue but rather, will decrease the time in which the yards are flooded. Feasibility depends on detailed elevation survey to ensure adequate grade exists between the yards and ditch and design of the drains has not yet been established.

Summit County Engineer
Cuyahoga River Watershed Study
ASN_AOI_9
Aurora Shores Flooding Alternative 2

TETRA TECH


- Component
- Photo
- Ditch
- Field Drain
- Retention Basin
- Pump Station
Parcel (ID Labeled)
Elevation (ft)
1006.54
991.82
N
0 62.5 125 250
US Feet
(City Road)
Windjammer Trl
Sea Ray Cv
A
B
C
1
Glenwood
Reminderville
Aurora Pond
1150 ft
Liberty Rd
Project Details
Watershed: Pond Brook
HUC12: 041100020501
Municipality: City of Reminderville
Field Visit Date:3/20/2024
Project Narrative
Flooding along backyards of Regatta Trail, Windjammer Trail, and Sea Ray Cove is longstanding and well documented. Historically a natural wetland / swamp, flooding occurs due to the pooling of direct precipitation and lack of adaquate grade to drain the area. The adjacent ditch has not been shown to overtop. Alternative 3 proposes to remove water from the area using the following three components: [A] - install field drains to convey water out of backyards; [B] - construct 2 retention basins with impermeable lined bottoms; and [C] - install a pump station. The retention basins and pump stations will require the aquisition of 3 properties where elevations are most suitable (6600902, 6600903, 6600904). Feasibility and design specifications have not yet been established.
Summit County Engineer
Cuyahoga River Watershed Study
ASN_AOI_9
Aurora Shores Flooding Alternative 3
TETRA TECH





Project Details

Watershed: Pond Brook
HUC12: 041100020501
Municipality: City of Reminderville

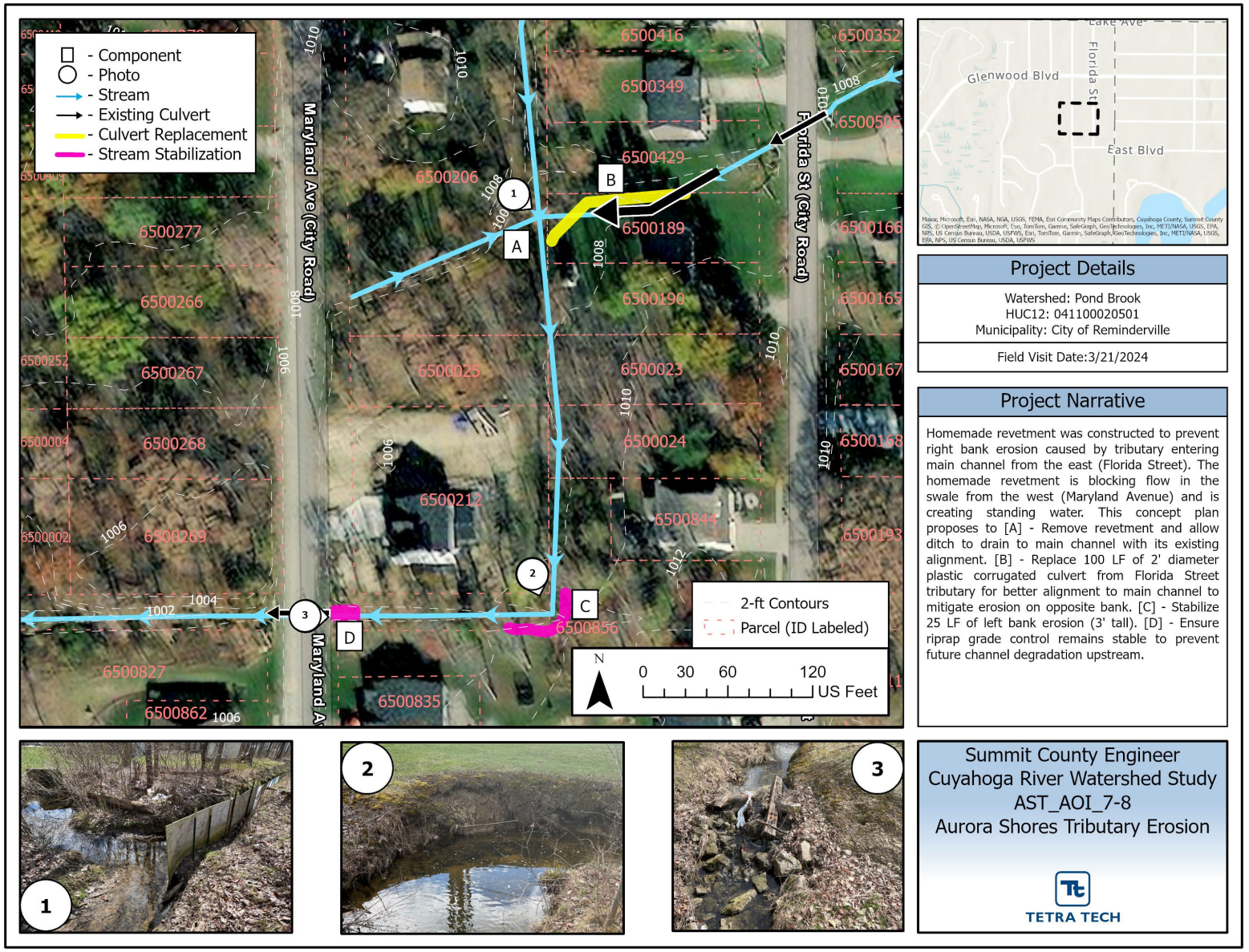
Field Visit Date:3/21/2024

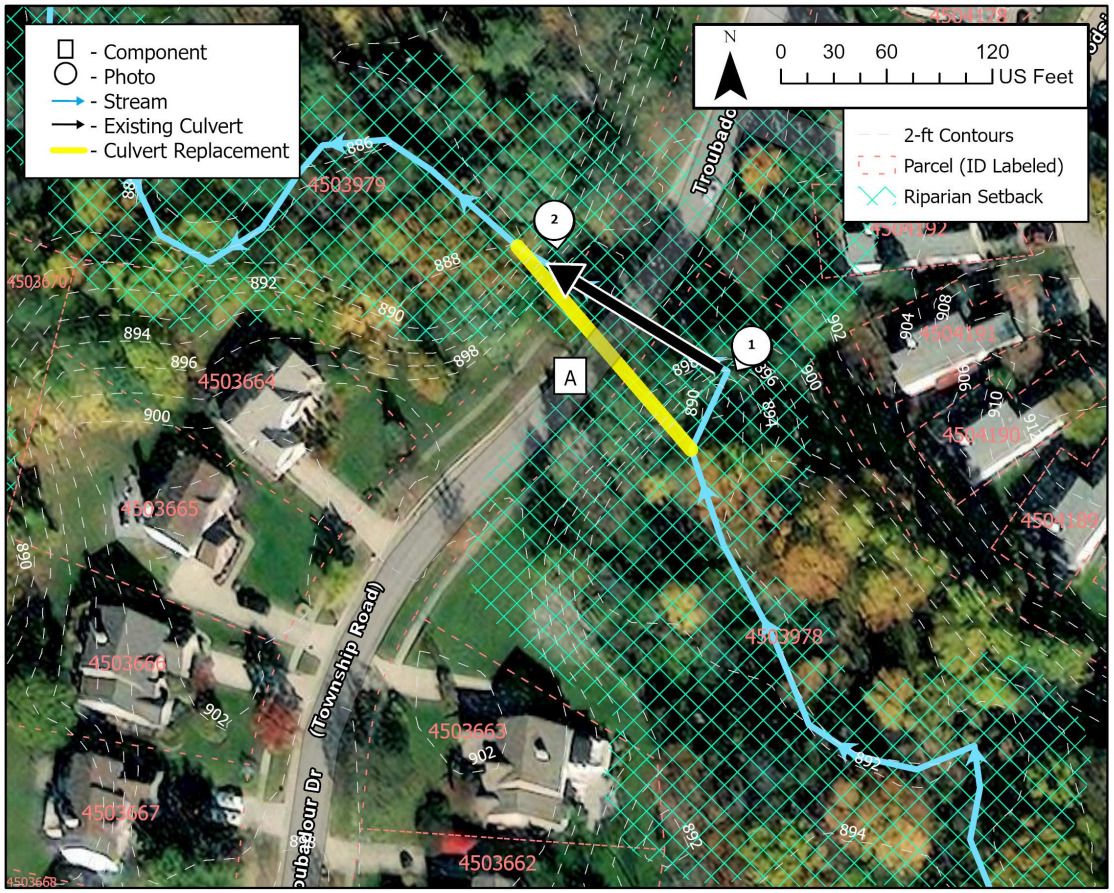
Project Narrative

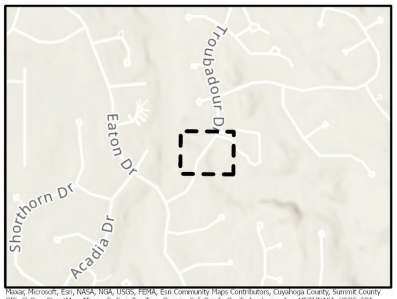
Flow has undermided gravel road crossing on right bank due to undersized culverts. Crossing is on parcel owned by West Creek Conservancy (Parcel ID 6600093). Sand bags placed as attempted fix of failed crossing. Extensive ponding upstream. This concept plan proposes to [A] - Installl new crossing. [B] - Design crossing such that similar storage capacity remains upstream. Benefits of this upstream storage include wetland habitat creation and attenuation of high flows going to Channel Brook in the Aurora Shores neighborhood.

Summit County Engineer
Cuyahoga River Watershed Study
AST_AOI_2
Channel Brook Failed Crossing

TETRA TECH


- Component
- Photo
- Stream
- Existing Culvert
- Culvert Replacement
- Stream Stabilization
Maryland Ave (City Road)
Florida St (City Road)
A
B
C
D
1
2
3
2-ft Contours
Parcel (ID Labeled)
N
0 30 60 120
US Feet
Lake Ave
Glenwood Blvd
Florida St
East Blvd
Project Details
Watershed: Pond Brook
HUC12: 041100020501
Municipality: City of Reminderville
Field Visit Date:3/21/2024
Project Narrative
Homemade revetment was constructed to prevent right bank erosion caused by tributary entering main channel from the east (Florida Street). The homemade revetment is blocking flow in the swale from the west (Maryland Avenue) and is creating standing water. This concept plan proposes to [A] - Remove revetment and allow ditch to drain to main channel with its existing alignment. [B] - Replace 100 LF of 2' diameter plastic corrugated culvert from Florida Street tributary for better alignment to main channel to mitigate erosion on opposite bank. [C] - Stabilize 25 LF of left bank erosion (3' tall). [D] - Ensure riprap grade control remains stable to prevent future channel degradation upstream.
Summit County Engineer
Cuyahoga River Watershed Study
AST_AOI_7-8
Aurora Shores Tributary Erosion
TETRA TECH





Project Details

Watershed: Willow Lake - Cuyahoga River
HUC12: 041100020505
Municipality: Sagamore Hills Township

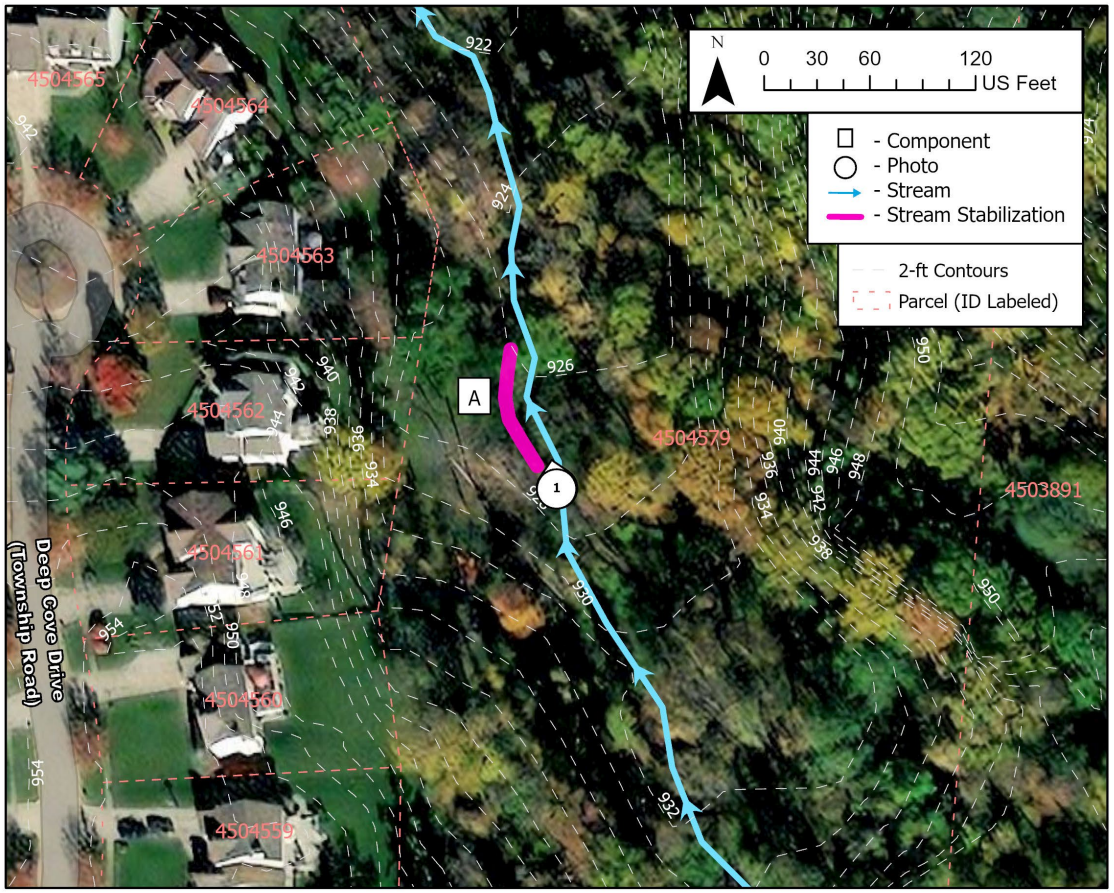
Field Visit Date:3/19/2024

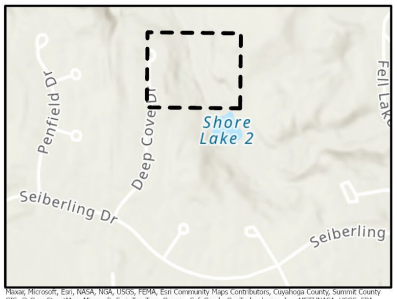
Project Narrative

The 36" Troubadour Dr. culvert is not aligned with the natural stream direction. This crossing is a problem area in the NEORSD SWMP where hydraulic modeling indicated the existing culvert is undersized and creates road inundation depths of 0.3 ft at the 10-year event and 1.7 ft at the 100-year event. Adjacent homes are not impacted by these WSEs. Tetra Tech modeled the crossing in HY8 and this concept plan proposes to [A] - replace the culvert with a re-aligned 150 LF box culvert at 10' wide and 7' tall. To achieve the height of 7' the existing elevation of the roadway may need to be raised or excavation of up to 2-ft may be required at the culvert inlet. Measures to mitigate downstream erosion may be required due to the increased flows.

Summit County Engineer
Cuyahoga River Watershed Study
SR_AOI_3
Troubadour Dr. Crossing

TETRA TECH





Project Details

Watershed: Willow Lake - Cuyahoga River
HUC12: 041100020505
Municipality: Sagamore Hills Township

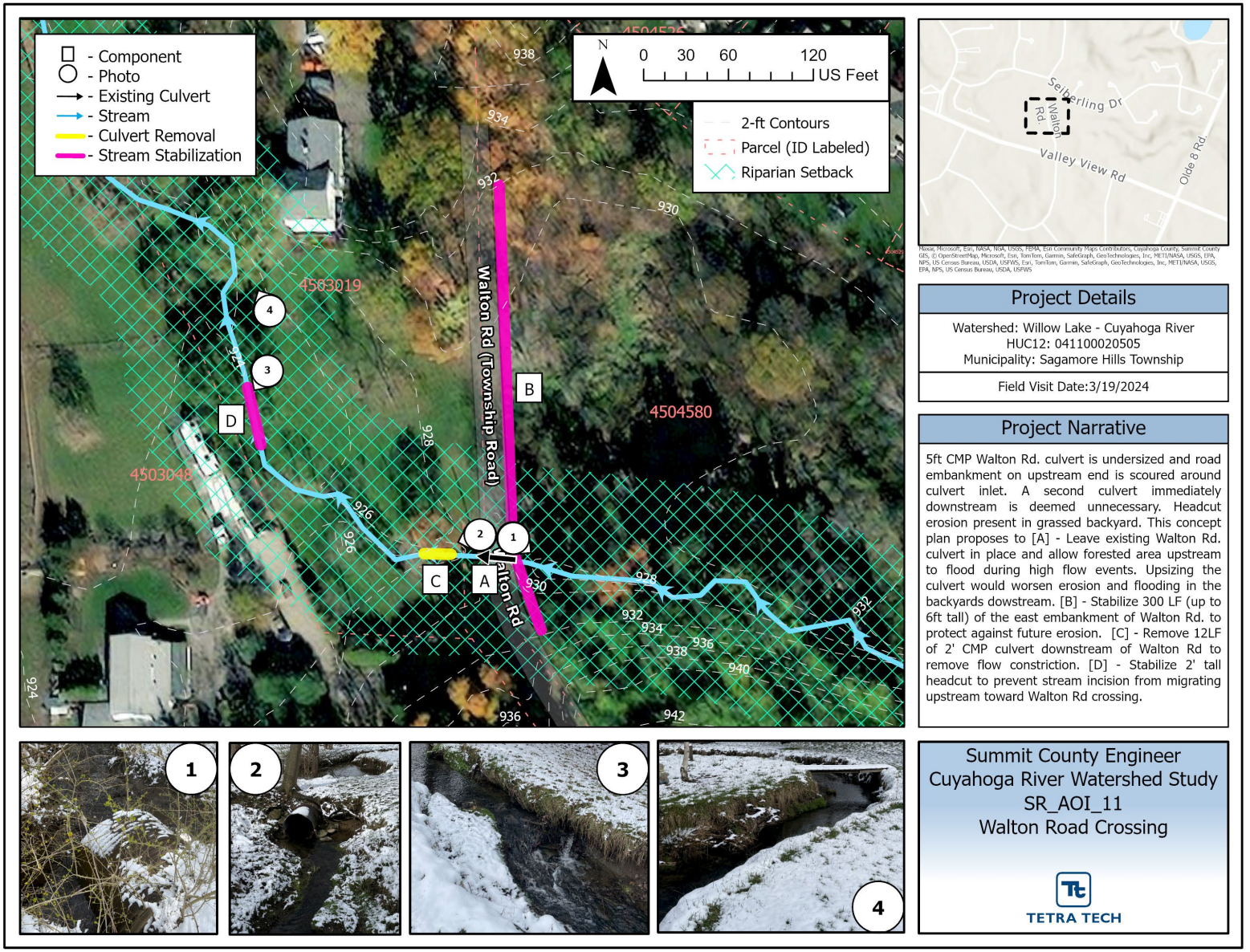
Field Visit Date:3/19/2024

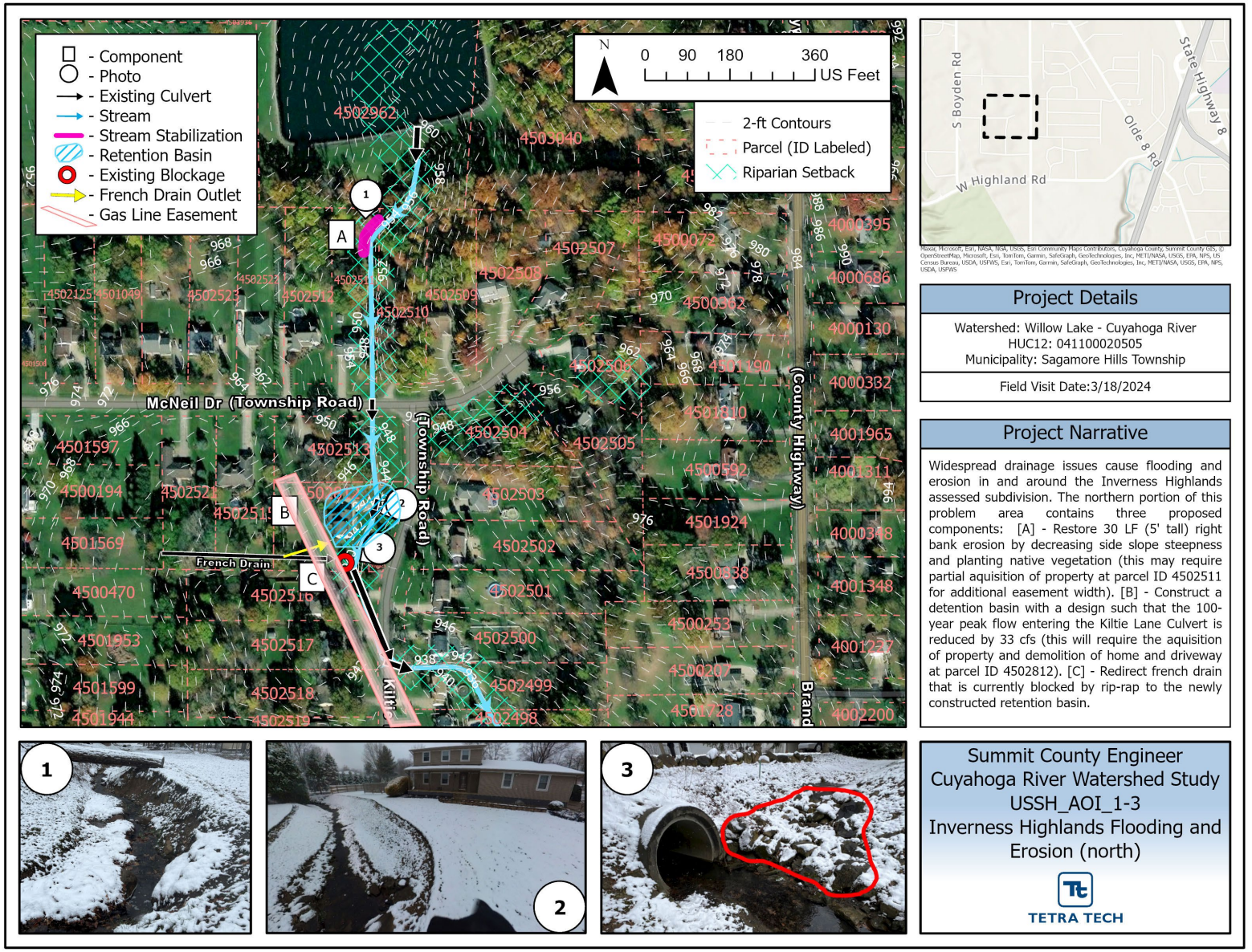
Project Narrative

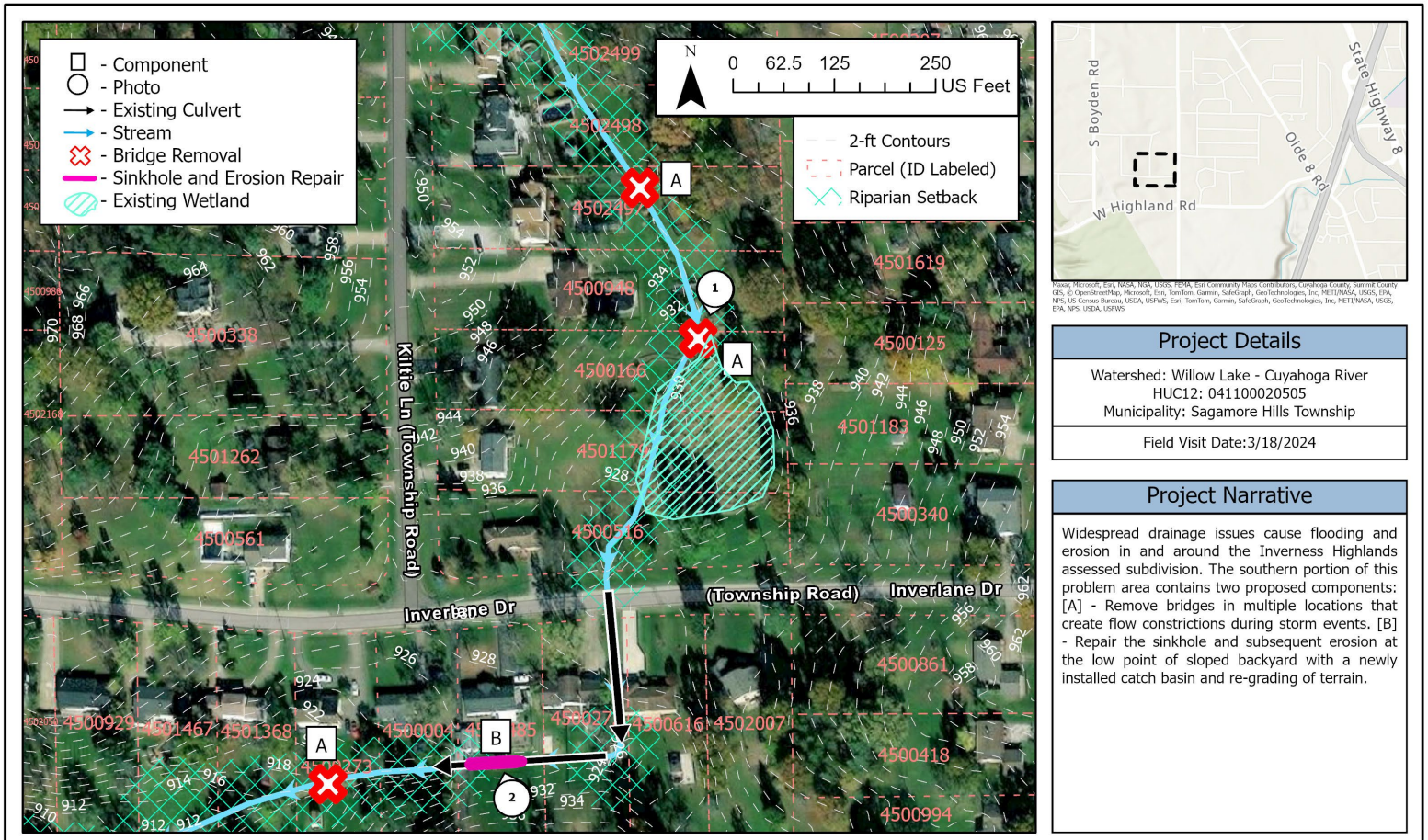
Erosion on left bank with homemade wood bank protection placed at downstream end. Erosion not threatening any structures. This concept plan proposes to [A] - Add rip rap toe protection to length of eroding bank (50 LF; 2' tall) to prevent additional erosion and advise homeowner to not mow grass directly up to bank.

Summit County Engineer
Cuyahoga River Watershed Study
SR_AOI_6
Sagamore Run Erosion

TETRA TECH


- Component
- Photo
- Existing Culvert
- Stream
- Culvert Removal
- Stream Stabilization
N
0 30 60 120
US Feet
2-ft Contours
Parcel (ID Labeled)
Riparian Setback
Walton Rd (Township Road)
Walton Rd
4503019
4503048
4504580
A
B
C
D
1
2
3
4
Selberling Dr
Valley View Rd
Olde 8 Rd
Project Details
Watershed: Willow Lake - Cuyahoga River
HUC12: 041100020505
Municipality: Sagamore Hills Township
Field Visit Date:3/19/2024
Project Narrative
5ft CMP Walton Rd. culvert is undersized and road embankment on upstream end is scoured around culvert inlet. A second culvert immediately downstream is deemed unnecessary. Headcut erosion present in grassed backyard. This concept plan proposes to [A] - Leave existing Walton Rd. culvert in place and allow forested area upstream to flood during high flow events. Upsizing the culvert would worsen erosion and flooding in the backyards dowstream. [B] - Stabilize 300 LF (up to 6ft tall) of the east embankment of Walton Rd. to protect against future erosion. [C] - Remove 12LF of 2' CMP culvert downstream of Walton Rd to remove flow constriction. [D] - Stabilize 2' tall headcut to prevent stream incision from migrating upstream toward Walton Rd crossing.
Summit County Engineer
Cuyahoga River Watershed Study
SR_AOI_11
Walton Road Crossing
TETRA TECH


- Component
- Photo
- Existing Culvert
- Stream
- Stream Stabilization
- Retention Basin
- Existing Blockage
- French Drain Outlet
- Gas Line Easement
N
0 90 180 360
US Feet
2-ft Contours
Parcel (ID Labeled)
Riparian Setback
McNeil Dr (Township Road)
(Township Road)
(County Highway)
French Drain
Kiltie
Brand
A
B
C
1
2
3
S Boyden Rd
State Highway 8
Olde 8 Rd
W Highland Rd
Project Details
Watershed: Willow Lake - Cuyahoga River
HUC12: 041100020505
Municipality: Sagamore Hills Township
Field Visit Date:3/18/2024
Project Narrative
Widespread drainage issues cause flooding and erosion in and around the Inverness Highlands assessed subdivision. The northern portion of this problem area contains three proposed components: [A] - Restore 30 LF (5' tall) right bank erosion by decreasing side slope steepness and planting native vegetation (this may require partial aquisition of property at parcel ID 4502511 for additional easement width). [B] - Construct a detention basin with a design such that the 100-year peak flow entering the Kiltie Lane Culvert is reduced by 33 cfs (this will require the aquisition of property and demolition of home and driveway at parcel ID 4502812). [C] - Redirect french drain that is currently blocked by rip-rap to the newly constructed retention basin.
Summit County Engineer
Cuyahoga River Watershed Study
USSH_AOI_1-3
Inverness Highlands Flooding and Erosion (north)
TETRA TECH



Project Details

Watershed: Willow Lake - Cuyahoga River
HUC12: 041100020505
Municipality: Sagamore Hills Township

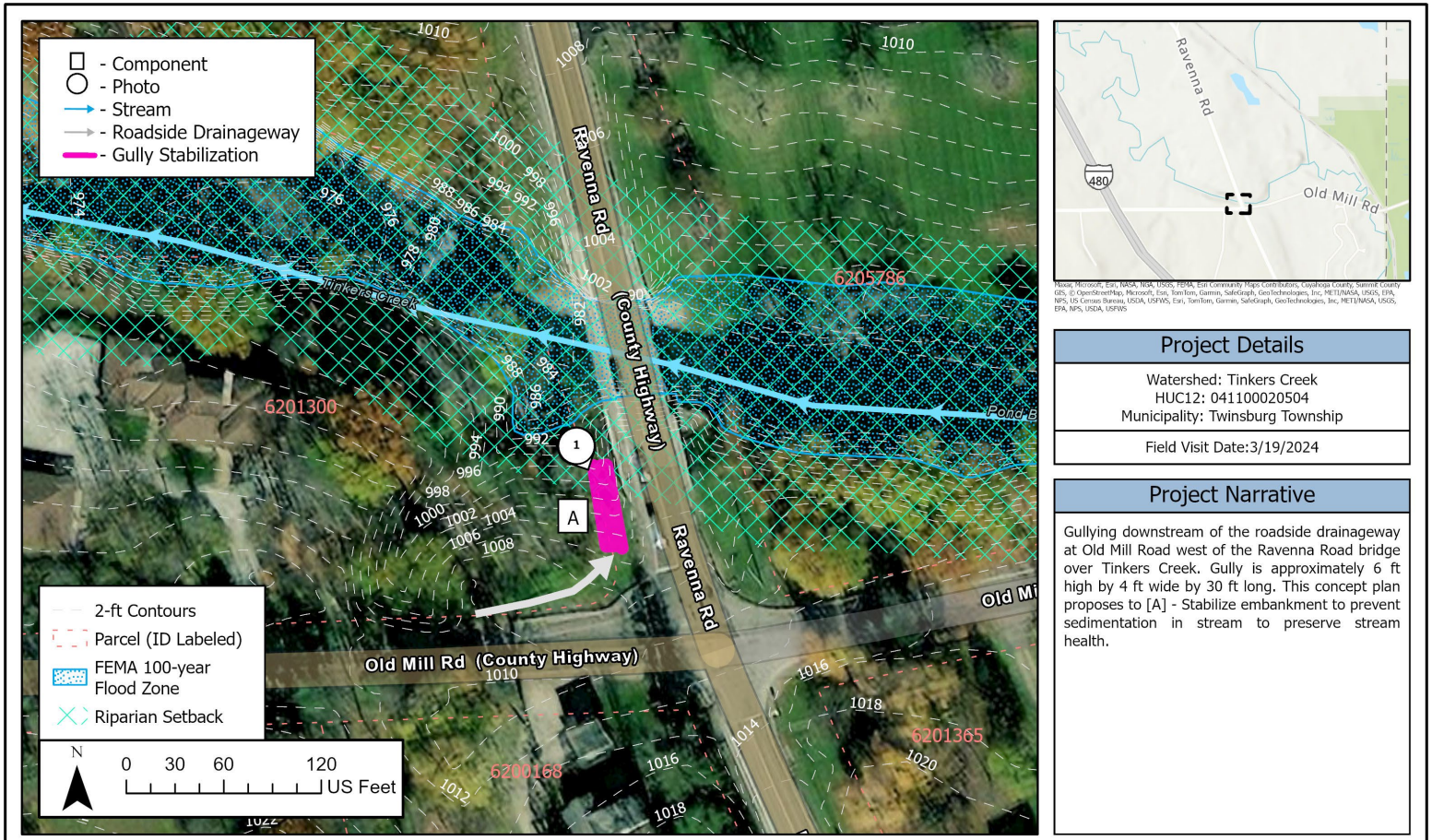
Field Visit Date:3/18/2024

Project Narrative

Widespread drainage issues cause flooding and erosion in and around the Inverness Highlands assessed subdivision. The southern portion of this problem area contains two proposed components: [A] - Remove bridges in multiple locations that create flow constrictions during storm events. [B] - Repair the sinkhole and subsequent erosion at the low point of sloped backyard with a newly installed catch basin and re-grading of terrain.

Summit County Engineer
Cuyahoga River Watershed Study
USSH_AOI_1-3
Inverness Highlands Flooding and Erosion (south)

TETRA TECH



Project Details

Watershed: Tinkers Creek
HUC12: 041100020504
Municipality: Twinsburg Township

Field Visit Date:3/19/2024

Project Narrative

Gullying downstream of the roadside drainageway at Old Mill Road west of the Ravenna Road bridge over Tinkers Creek. Gully is approximately 6 ft high by 4 ft wide by 30 ft long. This concept plan proposes to [A] - Stabilize embankment to prevent sedimentation in stream to preserve stream health.

Summit County Engineer
Cuyahoga River Watershed Study
PBTC_AOI_7
Ravenna Road Bridge Embankment Erosion

TETRA TECH