

Assessing Brook Trout Habitat in a Peri-Urban Headwater Stream



Weighing an upper 12 Mile Creek Brook Trout, Source: I.D. Smith



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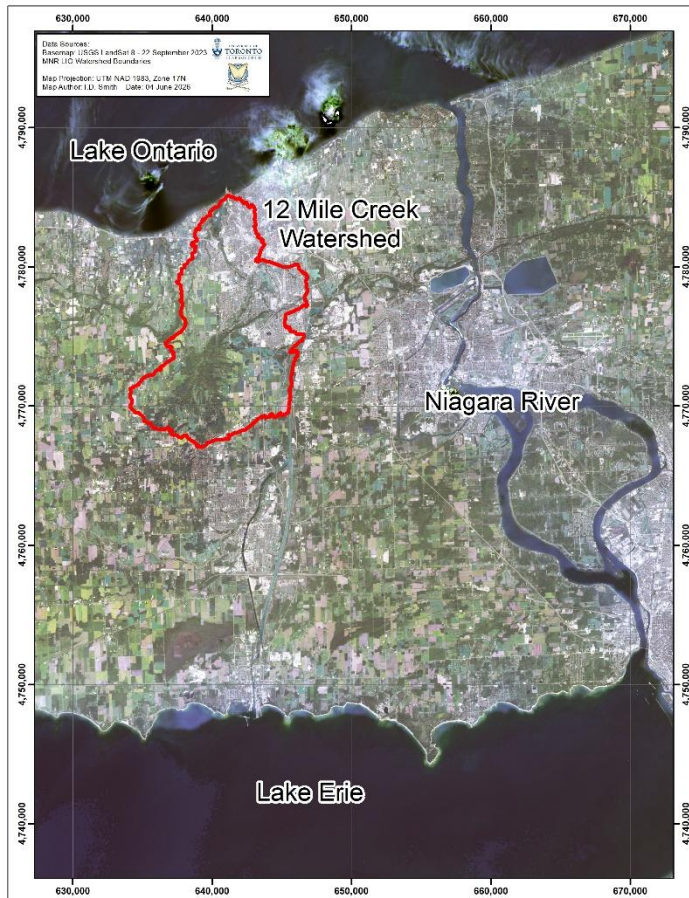
Presentation Outline

1. Introduction
2. Context (background)
3. Detailed Sampling
4. Findings
5. Summary
6. Recommendations
7. Questions



Dr. E. Ilyes & X. Ren backpack electrofishing, Source: I.D. Smith

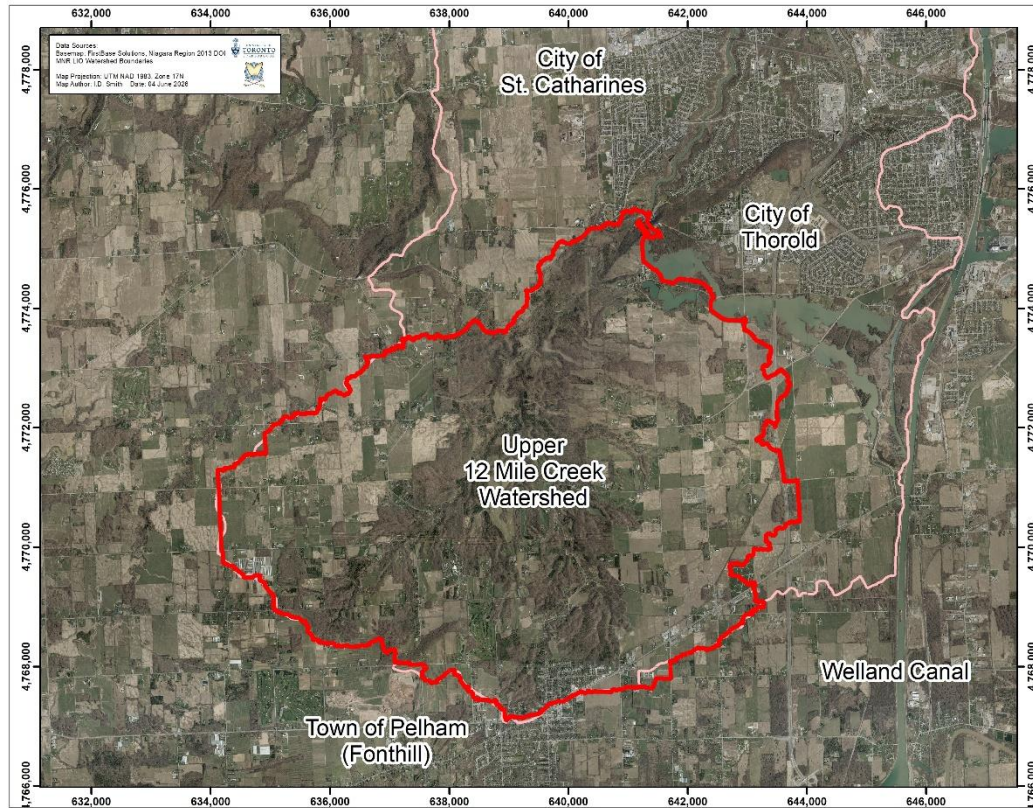
Introduction



The 12 Mile Creek Watershed, Niagara Peninsula, Ontario

- 12 Mile Creek, located in Pelham, Thorold, St. Catharines, Ontario
- 132 km² watershed area, drains to Lake Ontario
- Arguably, Niagara's last cold water stream system
- Active groundwater in headwaters due to Fonthill Kame delta
- Thought to still host a population of Brook Trout (*Salvelinus fontinalis*)

Introduction (Continued)



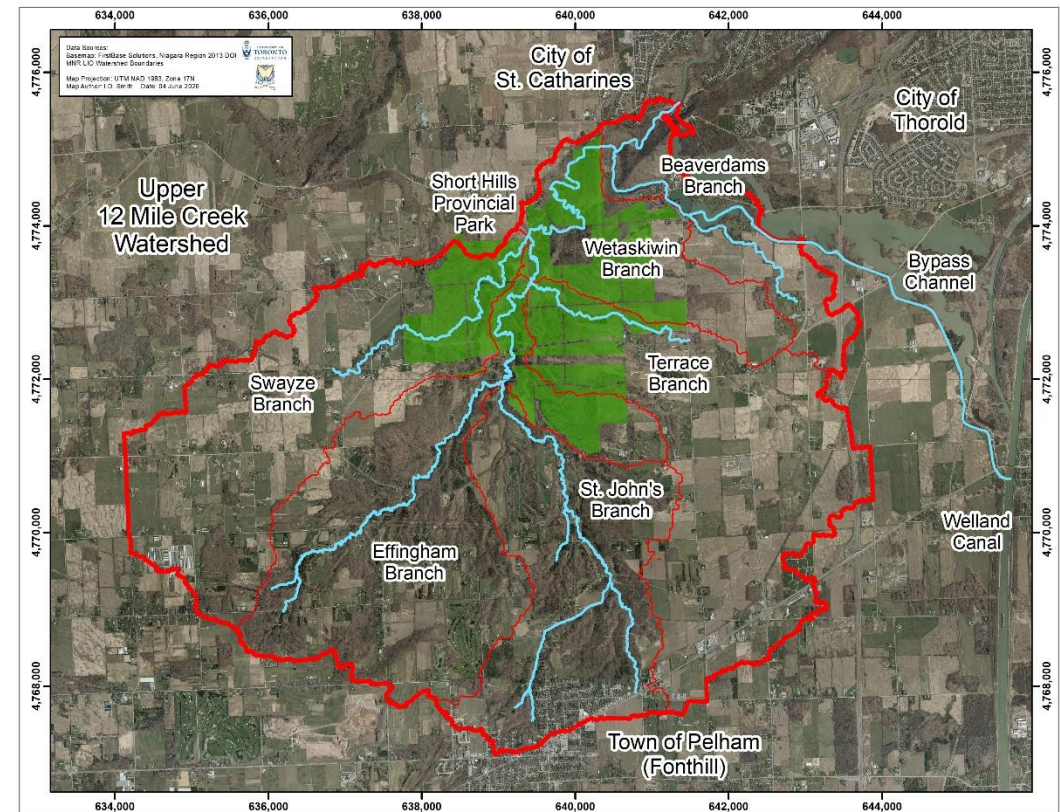
Upper 12 Mile Creek, Niagara Peninsula, Ontario

- ‘Upper’ 12 Mile Creek watershed is coldwater system
- 51 km² headwater sub-watershed area
- Warm water is diverted from the Welland Canal (Lake Erie water) into the watershed for power and drinking
- This entry point demarks upper vs. lower

Introduction (Continued)

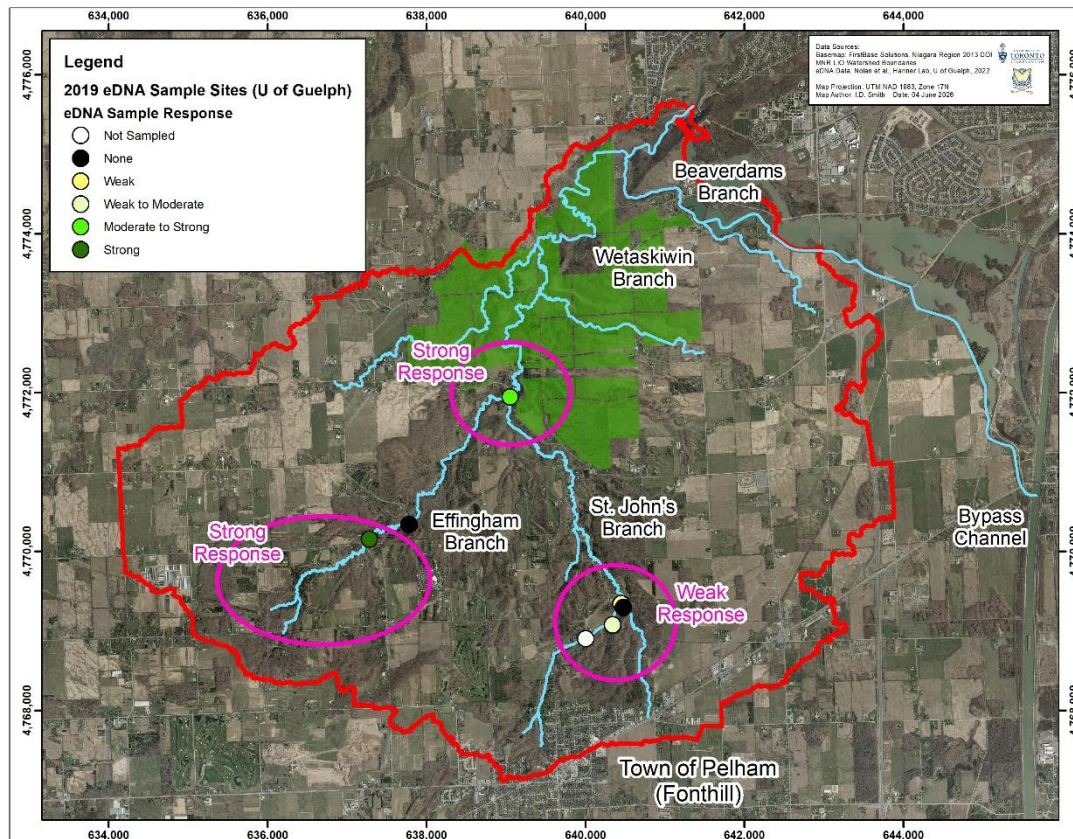


- 6 distinct ‘sub’ sub-watersheds
- All but 2 are intermittent or warmed, forest loss, agriculture, urbanization
- Effingham and St. John’s branches still permanent
- Good forest cover for both
- Very active groundwater discharge for both (Fonthill Kame delta)
- Short Hills Provincial Park at downstream (north) end of upper sub-watershed



‘Sub’ sub-watersheds of the upper 12 Mile Creek

Context



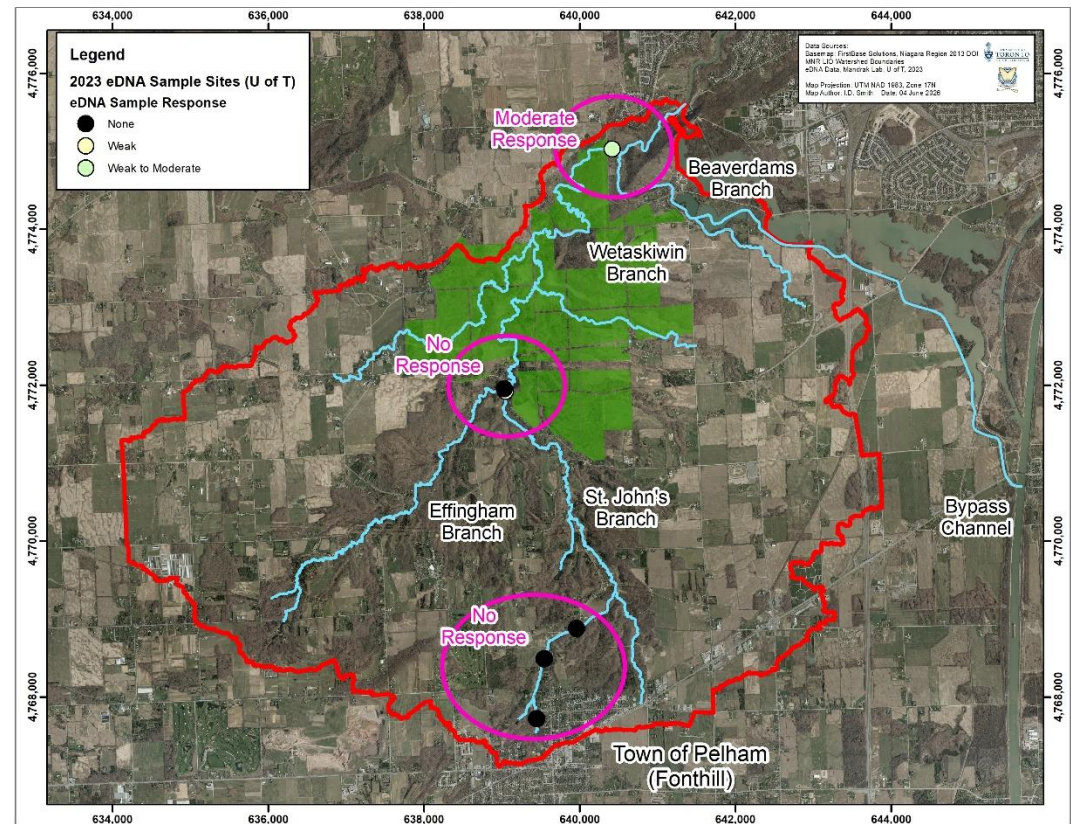
University of Guelph eDNA findings, September and November 2019 Source: Nolan, et al., 2022

- Persistent anecdotal evidence of Brook Trout still found in the upper 12
- MNR sampled Brook Trout in the Provincial Park in the mid 1980s
- Anglers report Brook Trout occasionally through the upper watershed
- University of Guelph (Hanner Lab) did eDNA sampling in 2019 to find Brook Trout

Context (Continued)

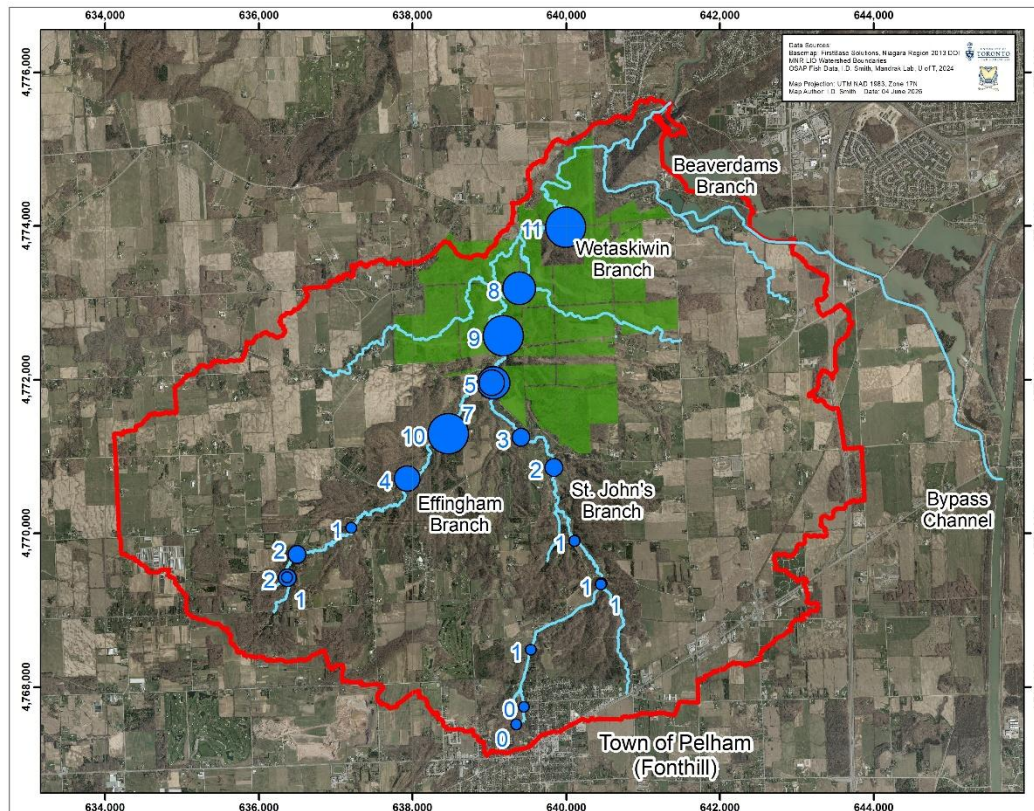


- University of Toronto (Mandrak Lab) resampled eDNA in 2023
- Effingham branch not resampled (investigators had seen numerous Brook Trout in these headwaters)
- No evidence of Brook Trout in more urbanized St. John's headwaters
- Surprising response at downstream end of upper 12



University of Toronto (Mandrak Lab) eDNA findings, October 2023 unpublished

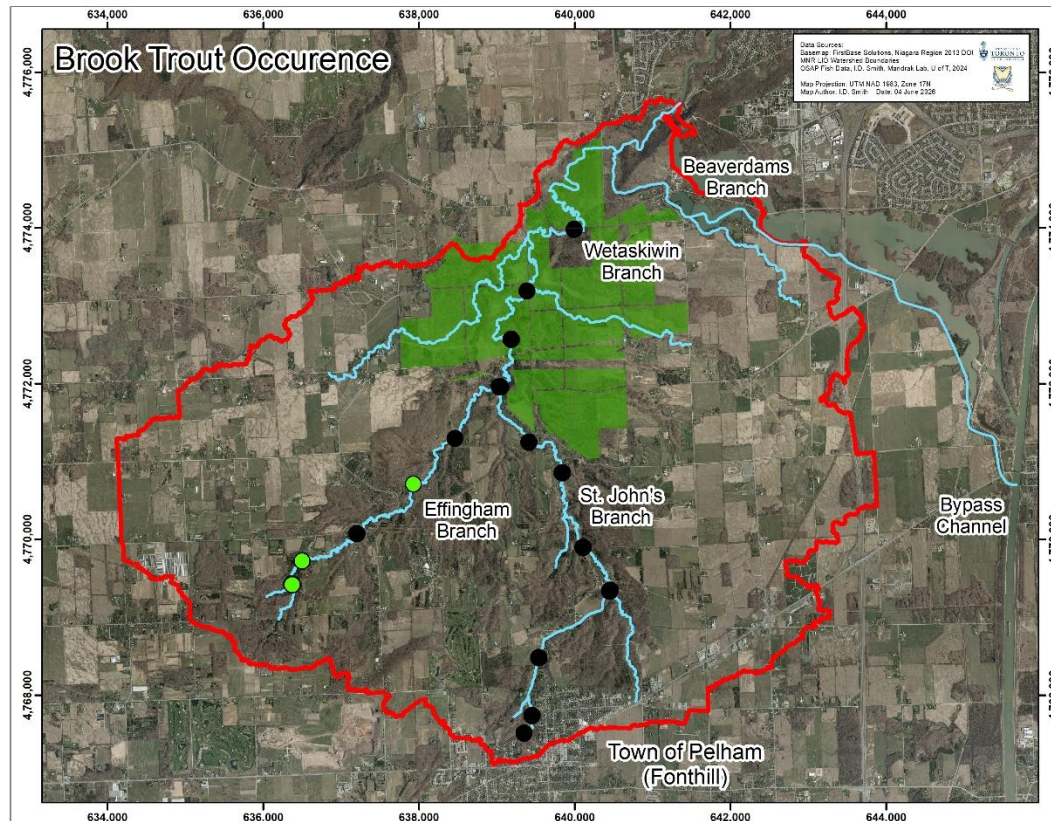
Context (Continued)



Species diversity through OSAP sampling, 2024

- Majority of sub-watershed OSAP sampled (randomly) for geomorphology, benthic macroinvertebrates, fishes
- Intermittent branches were not sampled
- Fish species diversity decreases into headwaters
- Benthic organism diversity and abundance generally good (Effingham branch best)

Context (Continued)



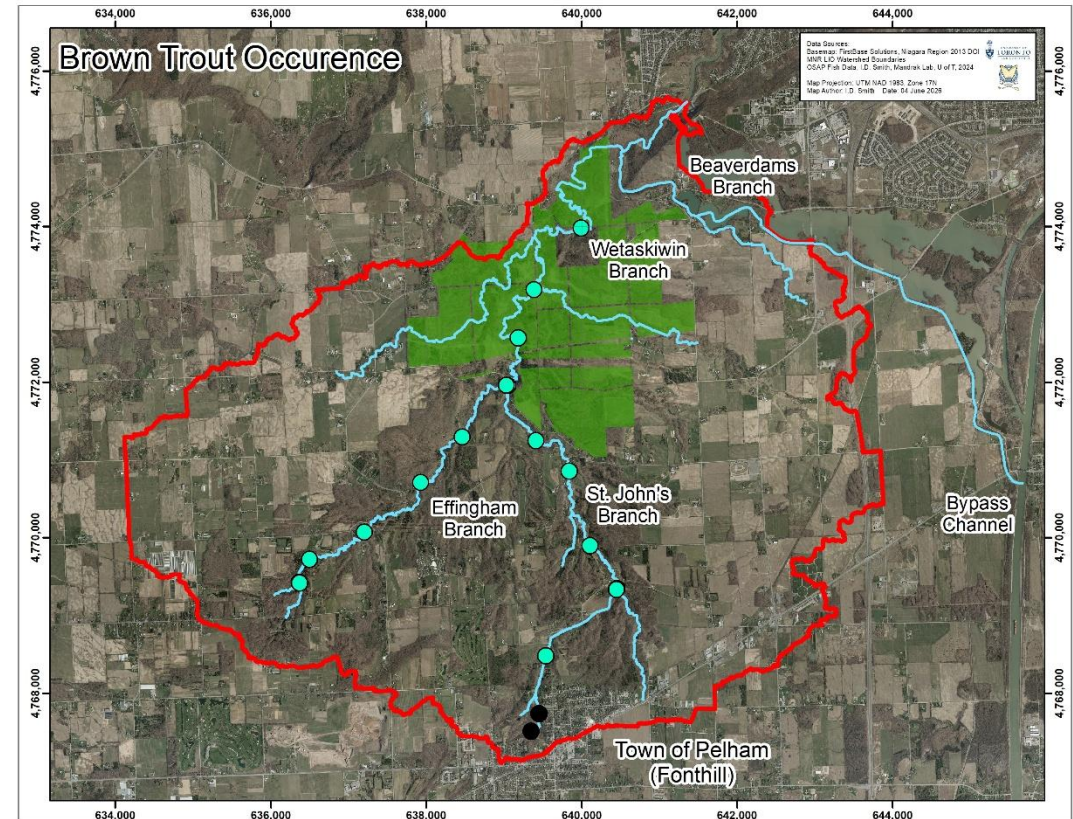
Brook Trout presence through OSAP sampling, 2024

- Brook Trout found only in Effingham branch
- Seemingly abundant in headwaters
- Infrequent occurrence downstream
- Thermal monitoring over past 10 years shows conditions favourable for Brook Trout only in the Effingham branch or extreme headwaters of the St. John's branch

Context (Continued)



- Brown Trout found through sub-watershed
- Upstream portion of St. John's branch devoid of any fishes
- Are Brown Trout out-competing or predated Brook Trout?



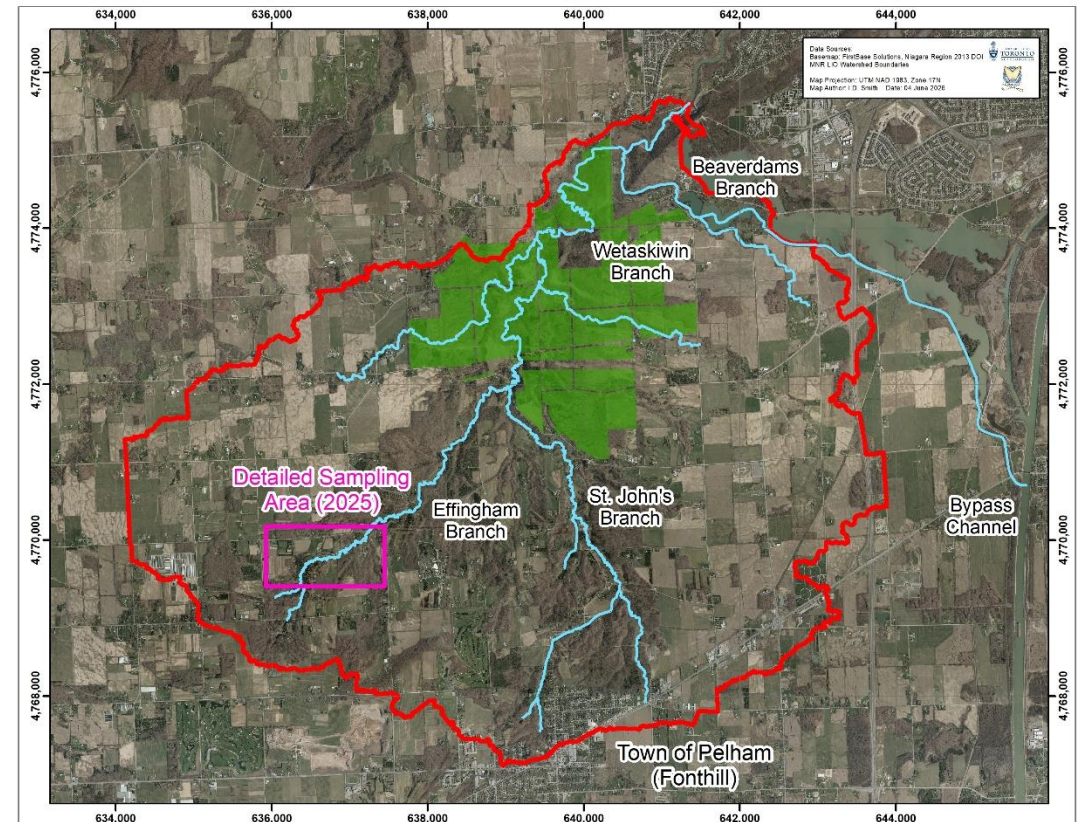
Brown Trout (*Salmo trutta*) presence through OSAP sampling, 2024

Detailed Sampling

- Intensive sampling of 2 km segment of the Effingham headwater channel in 2025
- Backpack electrofisher unit & blocker nets



Electrofishing a habitat segment at downstream blocker net Source: I.D. Smith



Detailed fish sampling area, 2025

Detailed Sampling (Continued)



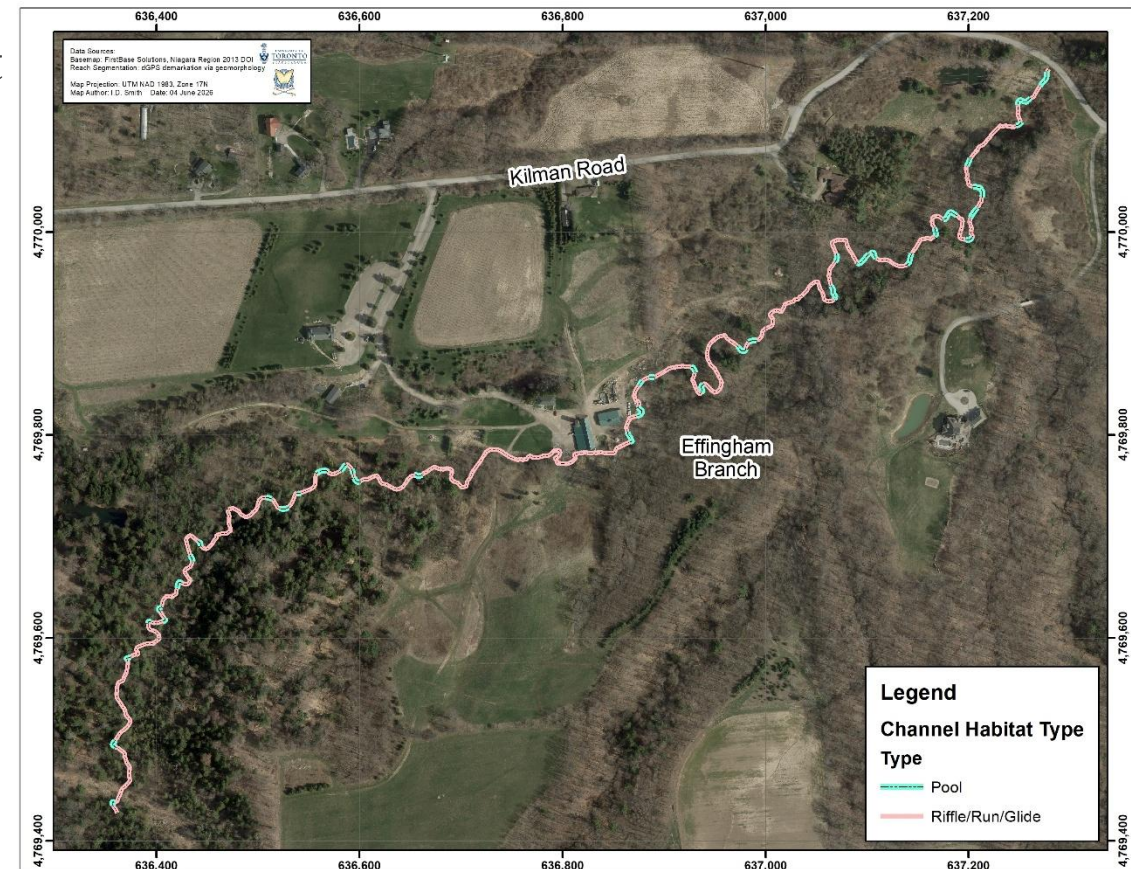
Detailed sampling area, geomorphic reach segmentation

- 2 km sample area (known to host Brook Trout) divided into 8 reaches
- Three private properties
- Reaches defined by changes in:
 - Stream morphology
 - Flow regime
 - Abutting land use

Detailed Sampling (Continued)



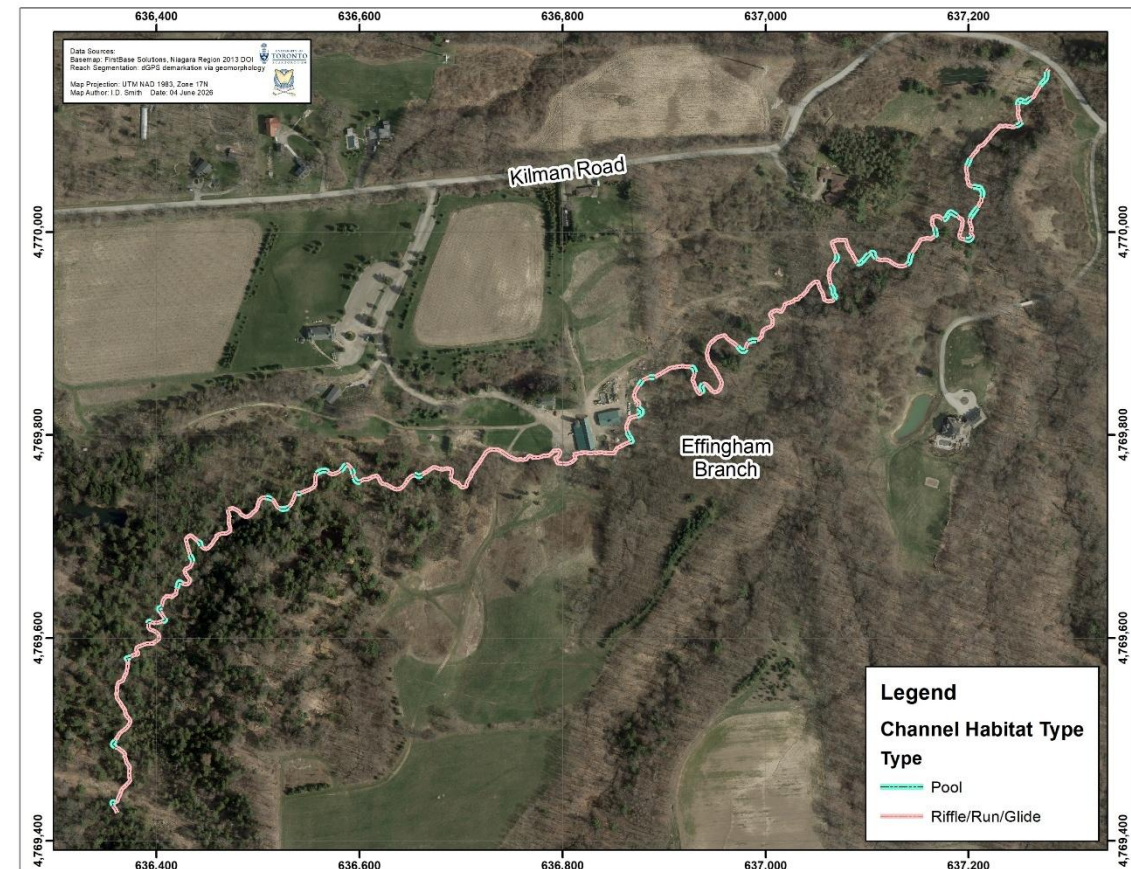
- Reaches further divided into 2 habitat types/segments:
 - Riffles/runs/glides, or
 - Pools
- 85 habitat segments, 46 riffles, 39 pools



Reach sub-segmentation, two habitat types generalized: riffles/runs/glides and pools identified and geolocated

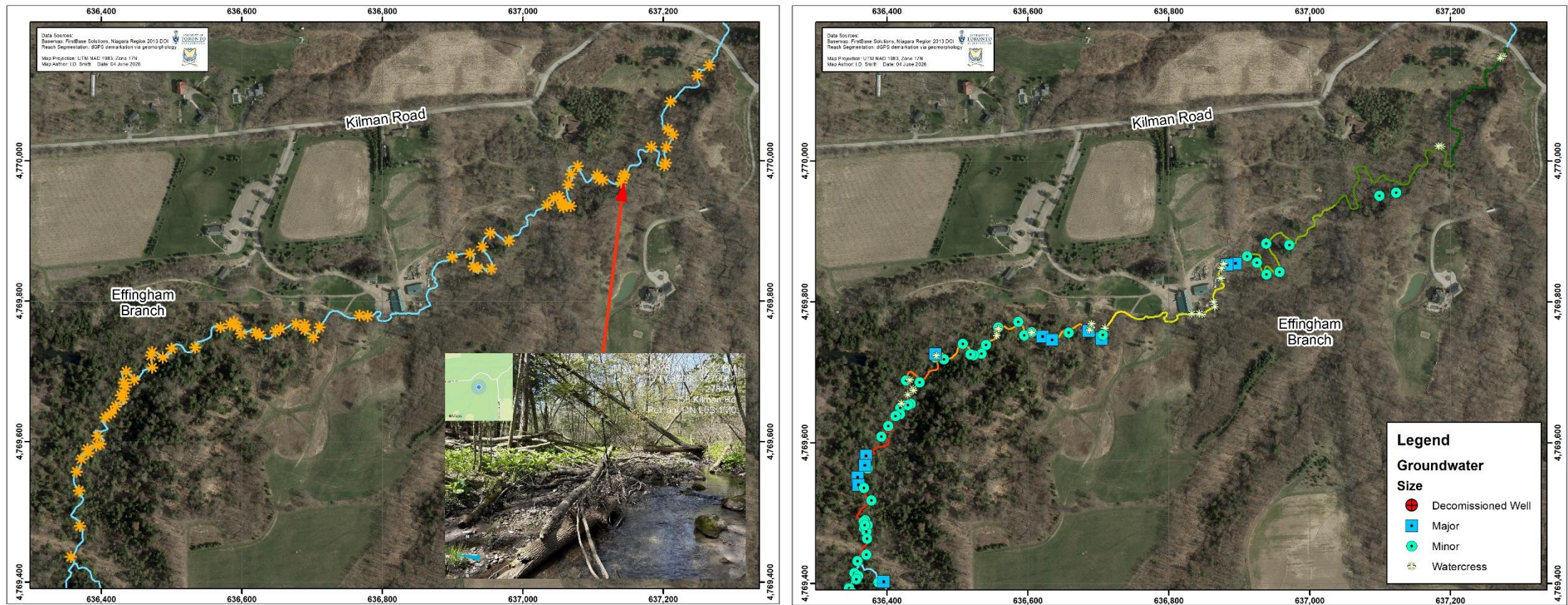
Detailed Sampling (Continued)

- Each habitat segment evaluated for:
 - Overbank groundwater influence
 - Woody structure/cover (Harman, et al., 2017)
 - Undercut banks (including root wads)
 - Stream morphology including DWF depth, DWF wetted width, DWF mean velocity, substrate (per OSAP, Stanfield 2017)
 - Water temperature, DO, turbidity, pH, % salt, conductivity (all at morning of fish collection effort)
 - Canopy cover (by densiometer at habitat centroid)



Reach sub-segmentation, two habitat types generalized: riffles/runs/glides and pools identified and geolocated

Detailed Sampling (Continued)



Detailed sampling area, large woody cover and groundwater inputs

Detailed Sampling (Continued)



- Fish sampled by habitat segment
- Two passes for each segment separated by at least two weeks
- Three electrofishing replicates per segment on sampling day
- All fishes sampled were measured for
 - Total length (mm)
 - Weight (g)
- All Brook Trout were photographed (left flank, both passes) and buccal swabbed (1st pass)

Weighing a Brook Trout at Reach 8, habitat segment Riffle 7, 26 September 2025

Findings



Brook Trout x Brown Trout hybrid, Reach 6, Pool 8 Source: I.D. Smith



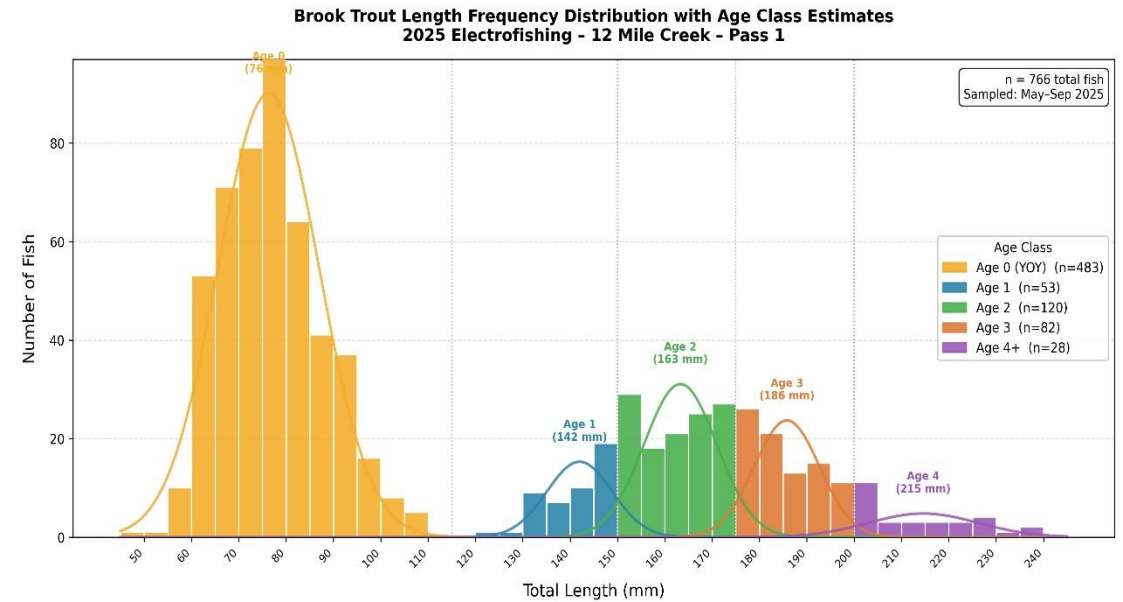
American Eel (*Anguilla rostrata*), Reach 8, Riffle 8
Source: I.D. Smith

- Brook Trout sampled:
 - 1st pass: 763, including 3 hybrids (“Tiger” Trout)
 - 281 adults (37%), 482 YOY (63%)
 - 2nd pass: 724, including 2 hybrids (“Tiger” Trout)
 - 242 adults (33%), 482 YOY (67%)
- Brown Trout sampled:
 - 1st pass: 539,
 - 167 adults (31%), 371 YOY (69%)
 - 2nd pass: 586,
 - 150 adults (26%), 482 YOY (74%)
- One other species found, (1) American Eel

Findings (Continued)



- Estimates of Brook Trout Abundance:
 - Using image comparisons for ‘marked’ recapture, Daniel Hu (next presentation) adults only: 466 adult Brook Trout, 95% CI = 438 to 501
 - Chapman (1951) estimate, all Brook Trout = 3,898, 95% CI = 3,377 to 4,420
 - Densities similar to Adirondak headwater systems (medium density)
- Ages estimated via von Bertalanffy (1938) growth modeling

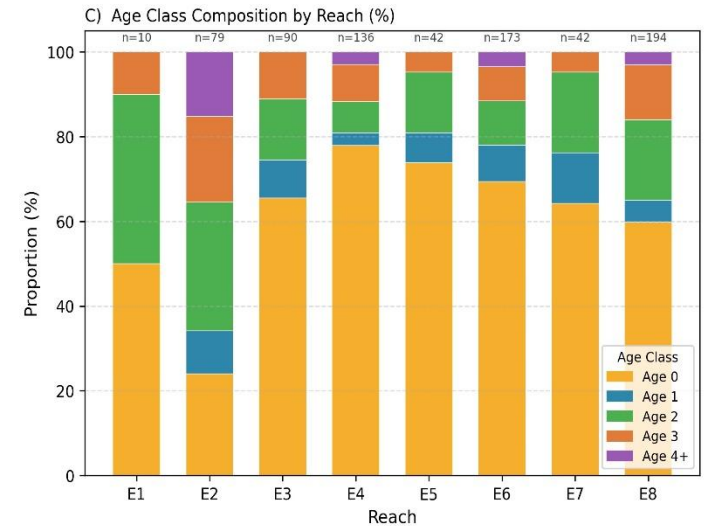
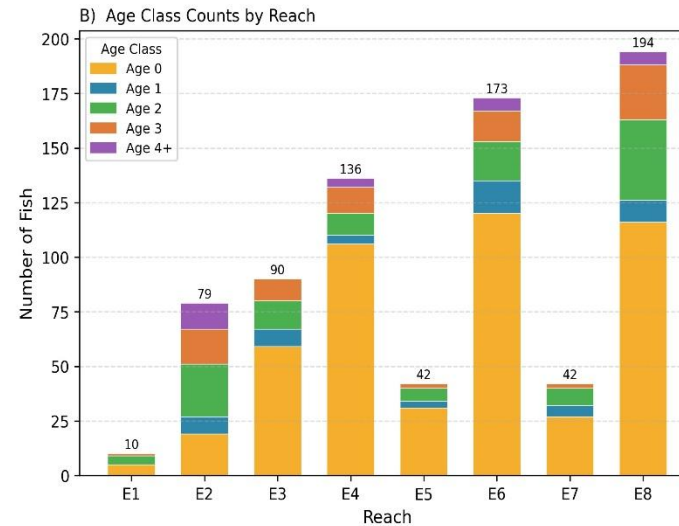
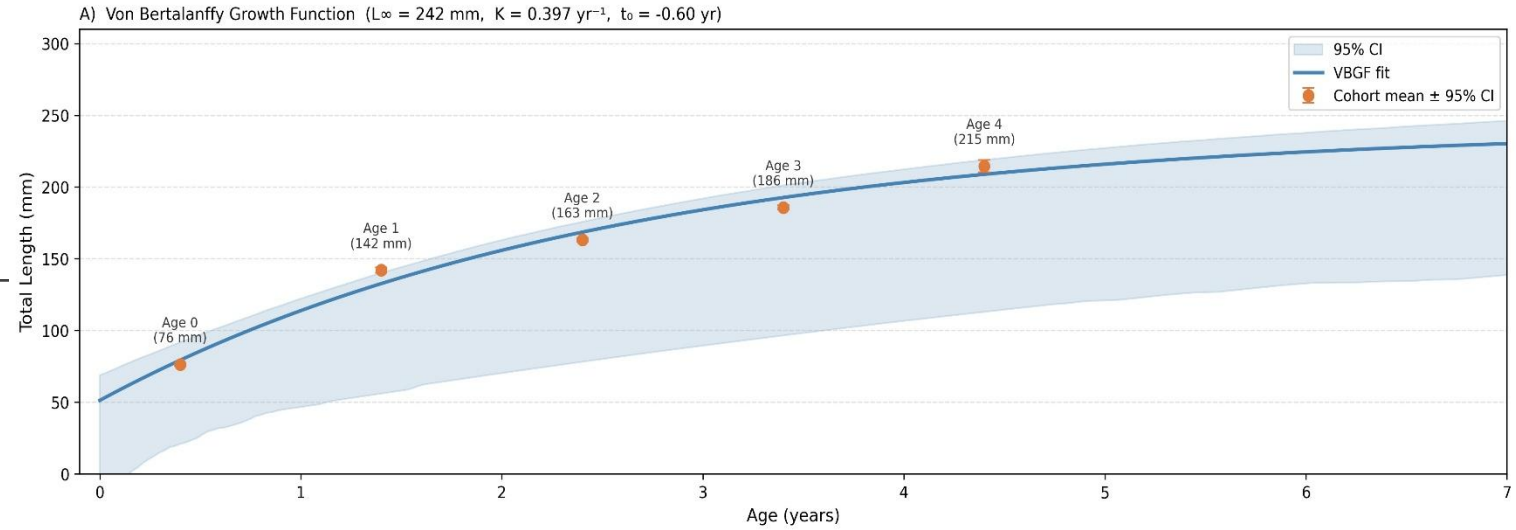


Brook Trout age modeling for Pass 1 fishes

Findings (Continued)



Brook Trout Growth & Age Structure - 12 Mile Creek, 2025 (Pass 1)



Brook Trout age classes and abundance by Reach

Findings (Continued)

Parent → Offspring ↓	E2	E3	E4	E5	E6	E7	E8
E2	5	-	-	-	-	-	-
E3	-	-	1	-	-	-	2
E4	-	3	-	-	1	-	4
E5	-	-	-	-	-	-	-
E6	-	1	3	1	-	1	2
E7	-	-	2	-	1	1	1
E8	-	1	-	1	3	-	3

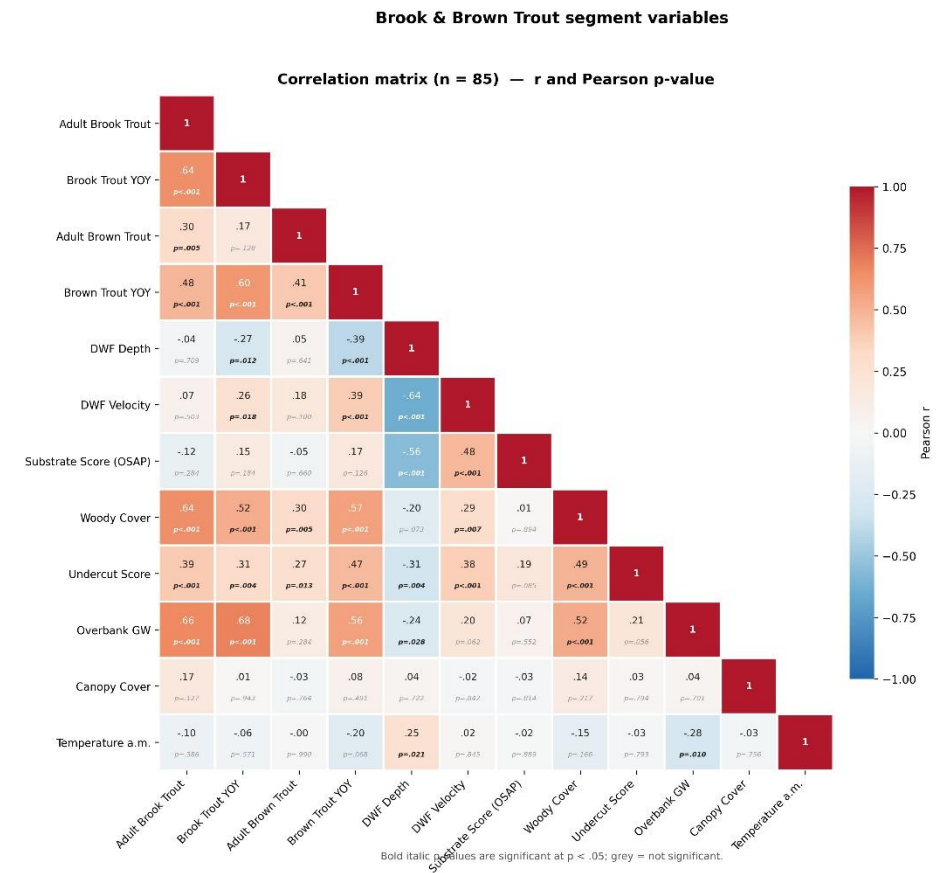
Brook Trout parents and offspring correlated across reaches

Genetic Analysis:

- 37 (age compatible) parent-offspring pairs identified (parents must be age 2 or older)
- 25 unique pairs of 37 total pairs
- 9 parent pairs inhabited the same reach (24%), 28 pairs crossed reaches (76%)
- 5 parents had two or more offspring detected
- Spatial patterns show substantial mobility of Brook Trout

Findings (Continued)

- Habitat Covariate Analysis:
 - Strongest correlations are:
 - Brook Trout abundance with groundwater
 - Brook Trout abundance with woody cover
 - Brook Trout and Brown Trout abundances are not negatively correlated
 - Stream temperature (morning of sampling) and canopy cover show no correlation with Brook or Brown Trout abundances



Findings (Continued)



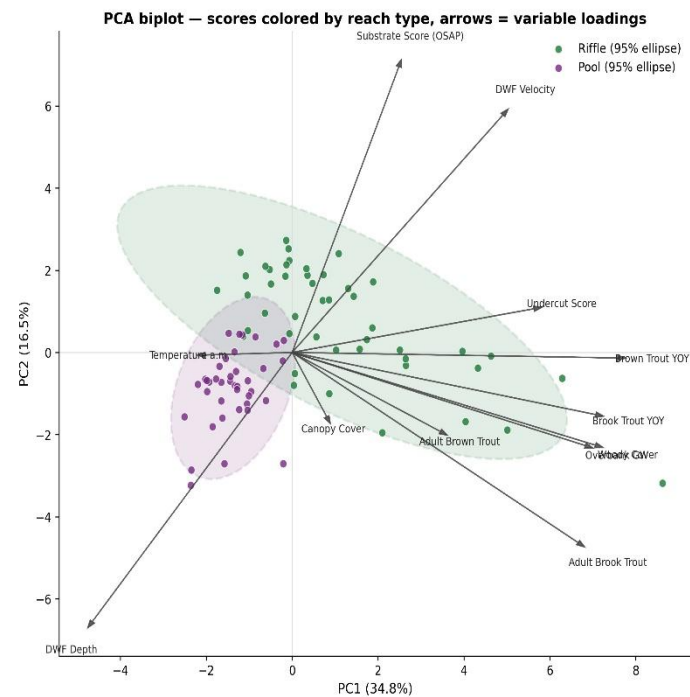
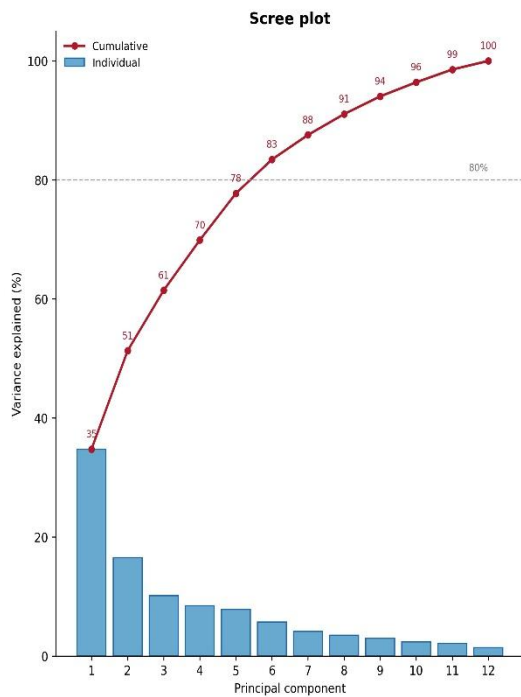
- Habitat Covariate Analysis segregated by habitat segment type:

Variable pair	Riffle r (n=46)	Pool r (n=39)
Adult Brook × Brook YOY	+0.71	-0.03
Adult Brook × Brown YOY	+0.55	-0.18
Brook YOY × Brown YOY	+0.56	-0.15
Adult Brook × Overbank GW	+0.72	+0.13
Adult Brook × Woody Cover	+0.71	+0.13
Brown YOY × Substrate (OSAP)	-0.32	+0.34

Correlation matrix by reach type — Brook & Brown Trout segment variables

Findings (Continued)

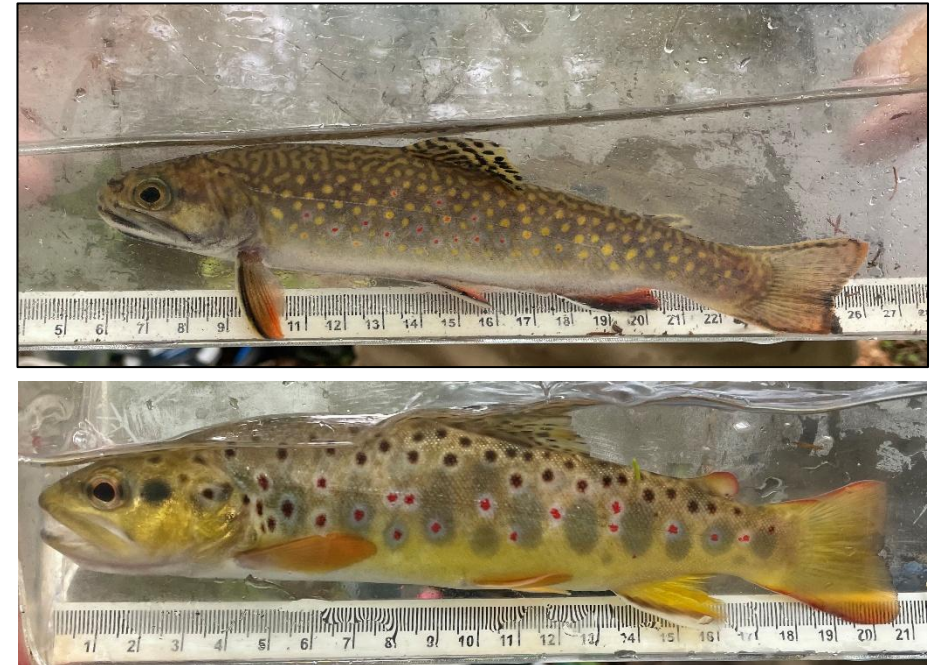
Principal Components Analysis – Brook & Brown Trout segment variables (standardized, n = 85)



- Principal Components Analysis:
 - PC1 (35% of variance), interpretable as ‘Productive Brook Trout Reach’ gradient relate Brook Trout abundance with groundwater and woody cover by reach and habitat segment
 - PC2 (17%), interpretable as ‘Physical channel form’ gradient relate substrate score and velocity with stream depth
 - PC3 (10%) relates warmer morning temperatures with Brown Trout abundance

Summary

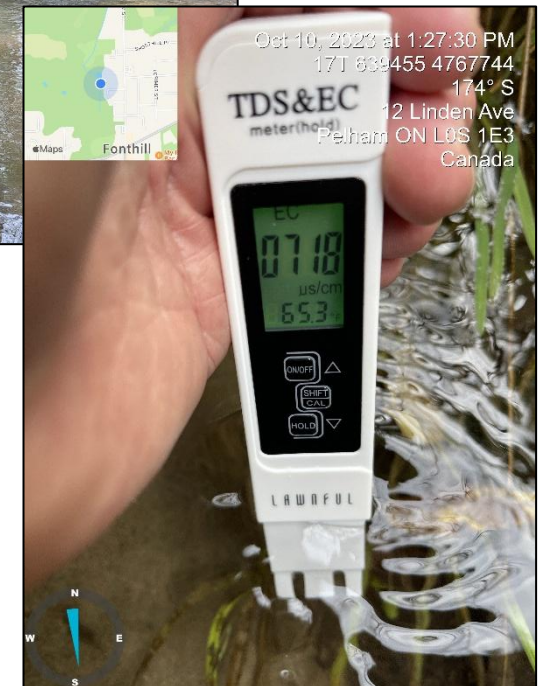
- A self-sustaining population of Brook Trout still exists within the upper 12 Mile Creek watershed
- This population is confined to the Effingham branch headwaters
- Population is relatively robust, densities similar to other stable eastern North American populations
- Evidence for limited Brook Trout occurrence exists at downstream locations; however, anecdotal historic observations are not supported by contemporary sampling
- Brook and Brown Trout co-occurrence are not negatively correlated; however, the species may compete for resources and habitat



Brook Trout (top) and Brown Trout collected in the upper 12 Mile Creek, 2025
Source: I.D. Smith

Summary (Continued)

- No Brook Trout in St. John's branch, more urbanized headwater
- Habitat values that are significant:
 - Overall system temperature strictly within the accepted cold-water limits (not tested by reach/habitat segment, but with systemic continuous thermal sensors)
 - Groundwater input to the channel important
 - Stable large woody cover important
 - Riffles/Runs/Glides with coarse bed sediments, moderate depth and velocity also important

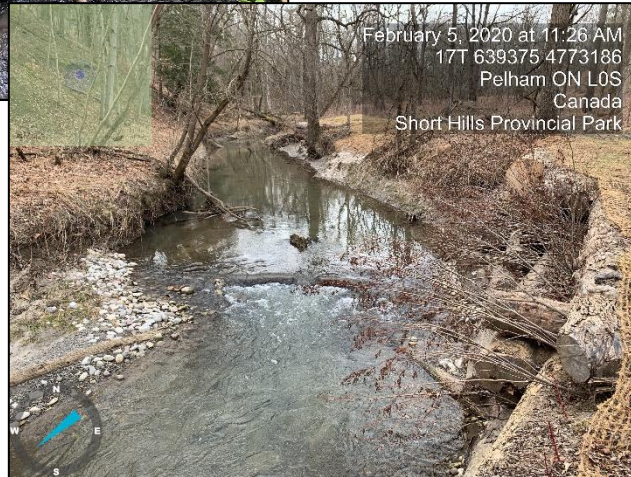


Large root wad habitat on the upper 12 Mile Creek, 2026
Measuring conductivity and temperature prior to eDNA sampling, 2023
Source: I.D. Smith

Recommendations



Finger drain and gravel pad, NPCA,
upper 12 Mile Creek, 2018
Source: I.D. Smith



Self scouring cross vane, upper 12 Mile Creek, 2020
Source: I.D. Smith

- Any restoration/rehabilitation activities to optimize native Brook Trout habitat should:
 - Maximize groundwater input to the channel, possibly using overbank groundwater capture structures (finger drains and substrate pads)
 - Include large woody cover (that is stable, i.e. cabled)
- Riffles/Runs/Glides should not be prone to aggradation (sediment fouling) and be self scouring (cross vanes or dual deflectors)
- St. John's branch has been improved greatly (municipality and conservation authority)

Acknowledgements



Tessa Anderson, M.Env.Sc., CERPiT,
Michael Silva, M.Env.Sc., Xiangyi Ren,
M.Env.Sc., Research Assistants, UTSC

Sarah Fuller, Laura Silverthorne, Michelle
Karam, Britt Quesnel of LandCare Niagara

Members of the former TUC Niagara
Chapter

Lydian Environmental Consulting Inc.

Colleagues in the Mandrak Lab at UTSC



Questions?



OSAP Site TW015, Effingham Branch, upper 12 Mile Creek; Rainbow Darter (*Etheostoma caeruleum*) from upper 12 Mile Creek Sources: I.D. Smith