A guide to the aquatic ecosystem classification for Ontario: How to interpret and use the classification

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Science and Research Branch

Ministry of Natural Resources

Ontario

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A guide to the aquatic ecosystem classification for Ontario: How to interpret and use the classification

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Data Availability: File geodatabase files associated with this report are available via GeoHub.

Abstract

The Ministry of Natural Resources (MNR) is responsible for sustainably managing and deriving economic benefit from the fisheries and water resources in Ontario’s estimated 500,000 km of rivers and streams. The aquatic ecosystem classification (AEC) reduces the complexity of these vast aquatic networks by using consistent, quantitative methods to create a standardized data foundation. The AEC is a science-based tool designed to group and classify Ontario’s rivers and streams into ecologically meaningful units based on their physical attributes. This guide provides high-level background on the development of the AEC, a brief overview of the components of the classification, and illustrative examples to aid interpretation. We have also included examples of common use cases to demonstrate how the AEC could be applied to research, monitoring, and resource management. These instructions are important. Please read them and refer to them when using the AEC.

Résumé

Un guide de la classification des écosystèmes aquatiques en Ontario : comment interpréter et utiliser la classification

Le ministère des Richesses naturelles (MRN) est responsable de la gestion durable des ressources halieutiques et hydriques de rivières et cours d’eau couvrant une superficie estimée de 500, 000 km en Ontario, ainsi que des retombées économiques qu’elles génèrent. La classification des écosystèmes aquatiques (CEA) réduit la complexité de ces vastes réseaux aquatiques en utilisant des méthodes quantitatives cohérentes pour établir une base de données normalisée. La CEA est un outil scientifique conçu pour regrouper et classer les rivières et les cours d’eau de l’Ontario en unités revêtant une importance écologique en fonction de leurs attributs physiques. Ce guide fournit des renseignements généraux sur l’élaboration de la CEA, un aperçu des composantes de la classification et des exemples illustratifs pour faciliter l’interprétation. Nous y avons inclus des exemples de cas courants pour démontrer comment la CEA pourrait être appliquée à la recherche, à la surveillance et à la gestion des ressources. Ces directives sont importantes. Veuillez les lire et vous y référer lors de l’utilisation de la CEA.

Acknowledgements

Many people contributed to the development of the classification system including the AEC Technical Committee (Peter Uhlig, Mike McMurtry, Helen Ball, Steve McGovern, Kent Todd, Sandra Orsatti, Steve Leney, and Jason Borwick), staff from the Provincial Geomatics Services Centre, conservation authorities across Ontario, and the federal Department of Fisheries and Oceans; and especially Stephanie Melles, Sarah Parna, Kimisha Ghunowa, Paul Seelbach, Lizhu Wang, Meagan Kindree, and Dan McKenney. We thank Nolan Pearce, Scott Gibson, and Kyla Standeven for helpful reviews of previous drafts. Funding for the AEC came from the then Ontario Ministry of Natural Resource's Far North Branch, the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health, and Fish and Wildlife.

Contents

Introduction

This document provides practical guidance on interpreting and using the aquatic ecosystem classification (AEC) for Ontario rivers and streams. It is a synopsis for users of the AEC. For a thorough explanation of the AEC technical details see Jones et al. (2025). This guide provides high-level background on the development of the AEC, a brief overview of the core components of the classification, and examples to illustrate interpretation. We have also included examples to showcase how the AEC can be applied to research, monitoring, and resource management. These instructions are important. Please read them and refer to them when using the AEC.

The AEC is hosted on Ontario GeoHub. The GeoHub repository contains core spatial data for the AEC and supplementary data (e.g., climate change projections, flow regime classification, and water growing degree days) that can be used to gain an in-depth understanding of rivers and streams in Ontario. The AEC data set is distributed in file geodatabase format. These geodatabases were generated using ArcGIS Pro v3.0.3 and are not backwards compatible with previous versions of ArcGIS. The AEC will receive periodic updates in response to user feedback. The current version of the AEC is Version 3, Revision 0.

Additional documentation (e.g., technical reports and peer-reviewed papers) is available on the Ontario GeoHub webpage. We encourage users interested in advanced applications of the AEC (e.g., statistical modelling) to review this documentation. The AEC Technical Report (Jones et al. 2025) provides complete and in-depth information on the theory and development of the AEC. Additional reports provide more in-depth information on flow regime classification (Jones et al. 2024), stream temperature modelling (Sutton et al. 2024), and understanding thermal regimes (Jones and Schmidt 2019).

The AEC is a science-based tool designed to group and classify Ontario’s rivers and streams into ecologically meaningful units. Stream reaches were assigned to hierarchical spatial units (e.g., classes, segments, and regions) by partitioning natural gradients in abiotic characteristics such as water temperature, turbidity, flow velocity, and stream size. Abiotic characteristics of the AEC were developed using several remotely sensed and modelled data that could correctly classify most streams in Ontario into their corresponding ecological units. The AEC also provides a standardized data foundation built using consistent, quantitative methods that can be updated as new information becomes available. This multi-scale hierarchical classification system can provide context to resource management staff to support landscape-scale planning and policy development.

Getting involved

During our many regional and local presentations about the AEC, we have gained much insight and learned from participant feedback. We encourage AEC users to continue providing information about where the classification works well and where it does not. We would like to hear from you if you think a change in class designation is warranted and why. For example, if a stream is classified as warmwater in the AEC but you are certain it is a coldwater stream from experience and have evidence, we would consider adjusting the AEC classification manually to reflect that knowledge. To submit comments, suggestions, or concerns about the AEC class assignments, please email the form included in the Ontario GeoHub zipped data packages (also provided in Appendix 1 of this report) to AEC@ontario.ca.

Navigating the AEC data suite

This brief overview provides general context for getting started navigating the data structure of the suite of AEC core and supplemental data, while more in-depth descriptions are provided throughout the remainder of this guide.

Disseminating this extensive collection of data as a single provincial package would be inconvenient and unpractical, therefore the province is partitioned into 13 smaller data packages (Figure 1). They contain the core of the AEC to which supplemental data can be joined (e.g., climate change projections). The core package partitions are based on major watersheds to the Great Lakes (e.g., Lake Ontario) and large northern rivers (e.g., Moose River). Each core package is split further into work units along drainage divides, with each work unit enclosing a self-contained directional stream network that flows continuously from headwaters to an outlet (Figure 1). The stream network is composed of stream sections called reaches, which are the AEC's fundamental spatial unit. They represent stream centre lines and include information describing physical and ecological attributes of the stream channel and its drainage area. Each reach has a unique provincial identifier that serves as the key between core AEC feature classes, and a link to the supplementary data sets. Reaches of similar size and character are grouped together to form stream segments and they are given their own provincially unique segment identifiers. The reaches comprising the segments share a similar habitat template. Segments are suitable units for broad-scale resource management (e.g., sampling site selection). In addition to the network lines representing real stream channels, virtual connectors ensure the continuity of network flow through lakes and along shorelines. The third line type represents streams that flow outside the province where provincial base data does not exist.

Spatial framework

The AEC partitions the province's stream network into fundamental spatial units called reaches. Reaches are sections of stream bounded by tributary confluences (i.e., interconfluence reaches; Figure 2A). Lakes were embedded into the stream network using virtual connector reaches that provide flow continuity through waterbodies. Throughout Ontario, lakes and streams are often connected in an alternating series of lentic (still water) and lotic (flowing water) reaches and, as a result, it is not possible to understand streams without also incorporating lakes (Jones 2010).

The spatial framework for the AEC was developed from two foundational data sets: the Ontario Integrated Hydrology (OIH) raster data set, which has a cell size of 30 m, and the Ontario Hydro Network (OHN) vector data from 2014. Information from these two data sets was combined to generate a pruned stream network with a uniform catchment area initiation threshold of 1 km^2 (i.e., all 1st order streams have catchment areas ≥ 1 km^2). This initiation threshold was used to standardize stream network density and remove intermittent (temporary) streams that are not a focus of this classification.

WUID	Name
1	Lake Erie - West
2	Lake Erie - East
3	Lake Ontario - West
4	Lake Ontario - Central
5	Lake Ontario - Kawarthas
6	Lake Ontario - East
7	St. Lawrence River
8	Ottawa River - Lower
9	Ottawa River - Central South
10	Ottawa River - Central North
11	Ottawa River - Upper
12	Lake Huron - South
13	Lake Huron - Bruce Peninsula
14	Georgian Bay - South - Lake Simcoe
15	Georgian Bay - Central
16	Georgian Bay - North - Lake Nipissing
17	Lake Huron - Manitoulin Island
18	Lake Huron - North
19	Lake Huron - North West
20	Lake Superior - East
21	Lake Superior - North East
22	Lake Superior - Lake Nipigon
23	Lake Superior - North West
24	Moose River
25	Harricanaw River
26	Albany River
27	Kinosheo River
28	Kapiskau River
29	Attawapiskat River
30	Ekwan River
31	Opinnagau River
32	Sutton River
33	Winisk River
34	Shagamu River
35	Severn River
36	Hayes River - A
37	Hayes River - B
38	English River
39	Bird River
40	Manigotagan River - A
41*	Manigotagan River - B
42	Bloodvein River - A
43	Bloodvein River - B
44*	Pigeon River
45	Upper Berens River
46*	Poplar River - A
47*	Poplar River - B

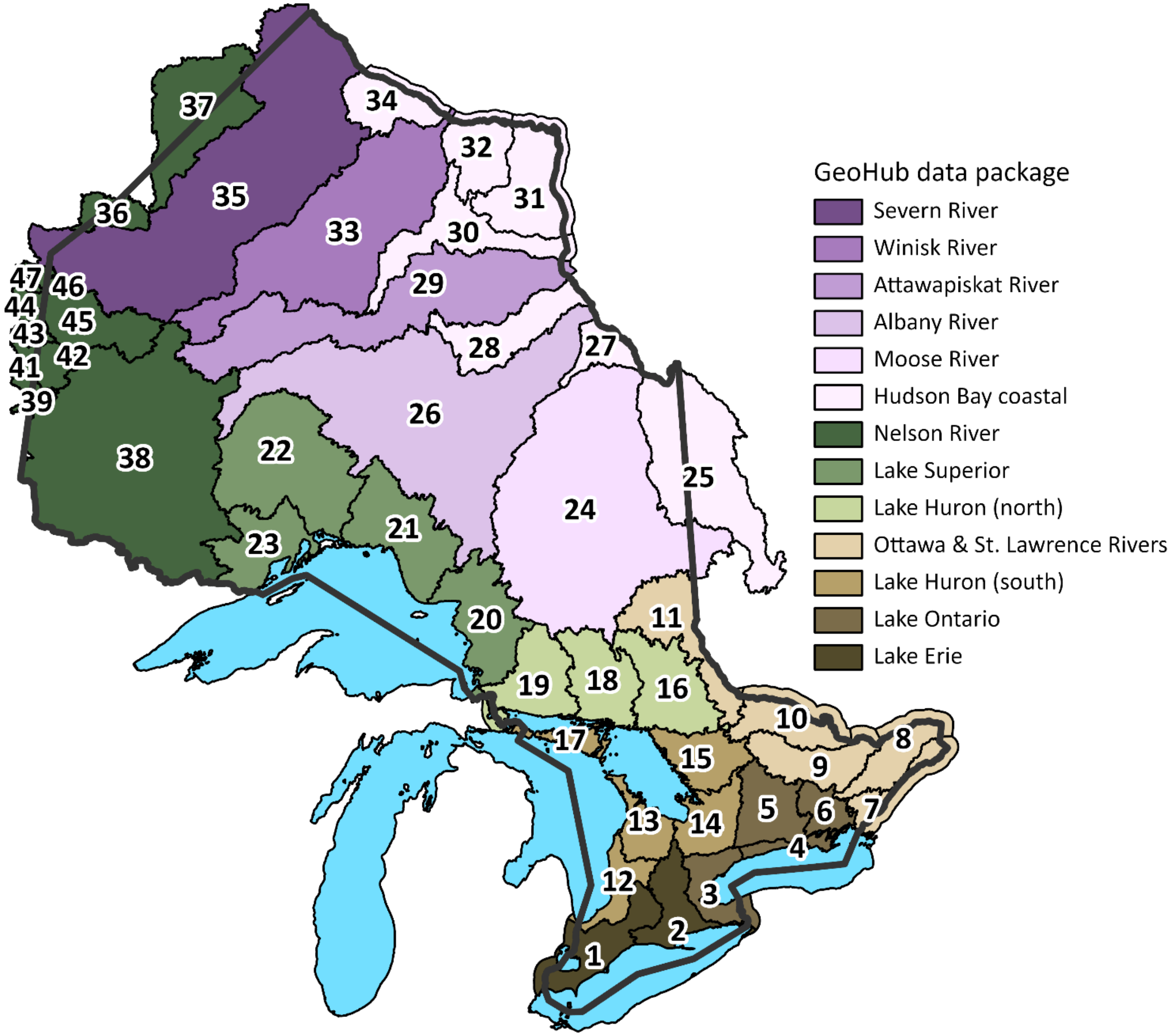


Figure 1. A map of the aquatic ecosystem classification (AEC) Ontario GeoHub data packages and work units, including their names and numeric identifiers. Several small work units along the Ontario-Manitoba border could not be fully processed or were excluded later because Ontario Integrated Hydrology data for that work unit was not available or they were missing other fundamental base data. The excluded work unit names are highlighted in grey and denoted by an asterisk (*). The final AEC data set includes 43 work units contained within 13 data packages.

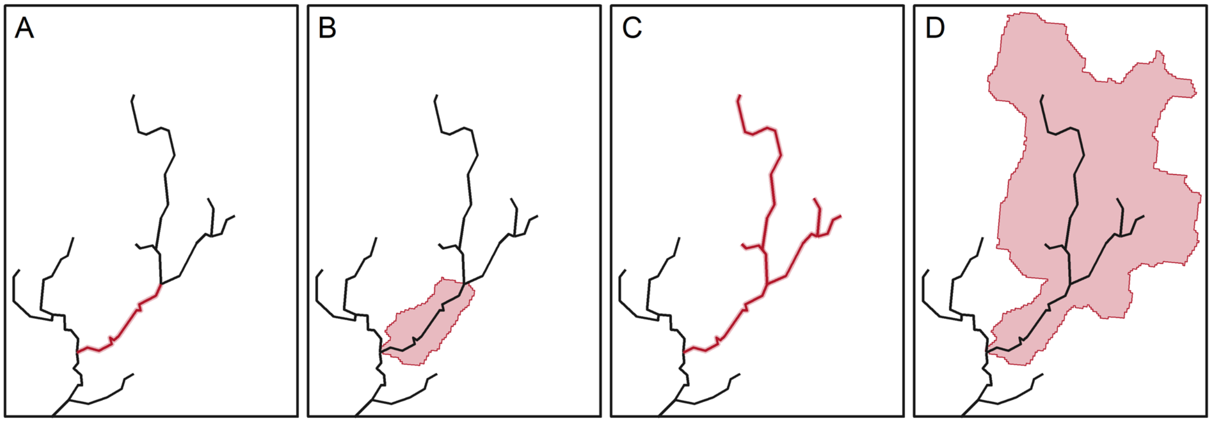


Figure 2. The four scales of landscape variable inventory collection illustrated using a small headwater watershed example. The red polygons and thick red lines represent a) the reach channel (RCh; 30 m raster), b) the reach contributing area (RCA), c) the upstream channel for the catchment (UCh; 30m raster), and d) the upstream catchment area (UCA).

Spatial hierarchy

The AEC is a hierarchical classification where fundamental reach units are aggregated into larger units called segments using the stream classes and reach size neighbourhoods. Segments are placed into a broader landscape context using productivity regions. The stream classes and productivity regions are discussed below, while details about size neighborhood assignment can be found in Jones et al. (2025).

Reach identifiers

Each AEC stream reach is assigned a unique alphanumeric identifier called a [ProvReachID]. The use of square brackets throughout this guide denotes an attribute field name. This unique identifier is the primary/foreign key that can be used to join AEC geodatabase tables in a 1:1 relationship and includes supplementary AEC data tables available on Ontario GeoHub (e.g., climate change projections). Reaches are also assigned a [ProvSegmentID] that identifies a group of reaches of similar size that share a stream class. For information on how segments are created refer to Jones et al. (2025).

Network line types

The AEC includes four network line types that differentiate the functions of a reach within the spatial stream network:

1) Real channels represent actual stream channels.

2) Virtual connectors are imaginary lines that provide flow continuity through inland waterbodies.

3) Shoreline reaches have a similar function to virtual connectors. These connections are found along the shorelines of the Great Lakes, Hudson Bay, and James Bay. The Ottawa River is also classified as a shoreline in the AEC.

4) The out-of-province line type identifies reaches that are fully or partially outside Ontario’s provincial border.

Virtual connector, shoreline, and out-of-province reaches are assigned fewer attributes than real channel reaches, and many of their attribute fields will be <null> (i.e., no data).

Reach lengths

The simplified reach length represents the length of the reach in metres. The reach geometry is a simplification of the rasterized Ontario Integrated Hydrology drainage lines. The simplification brings reach lengths closer to the lengths of the mapped Ontario Hydrographic Network (OHN) stream lines. However, the simplified lengths tend to underestimate true reach lengths because, in reality, streams meander more than their simplified AEC equivalents (Figure 3).

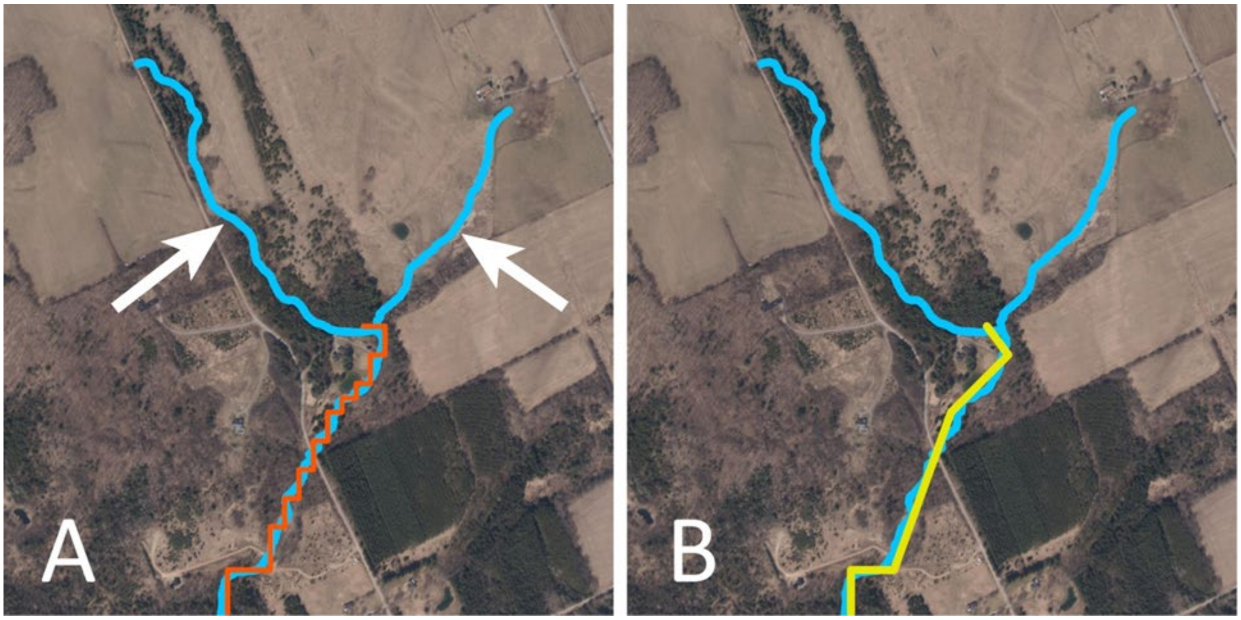
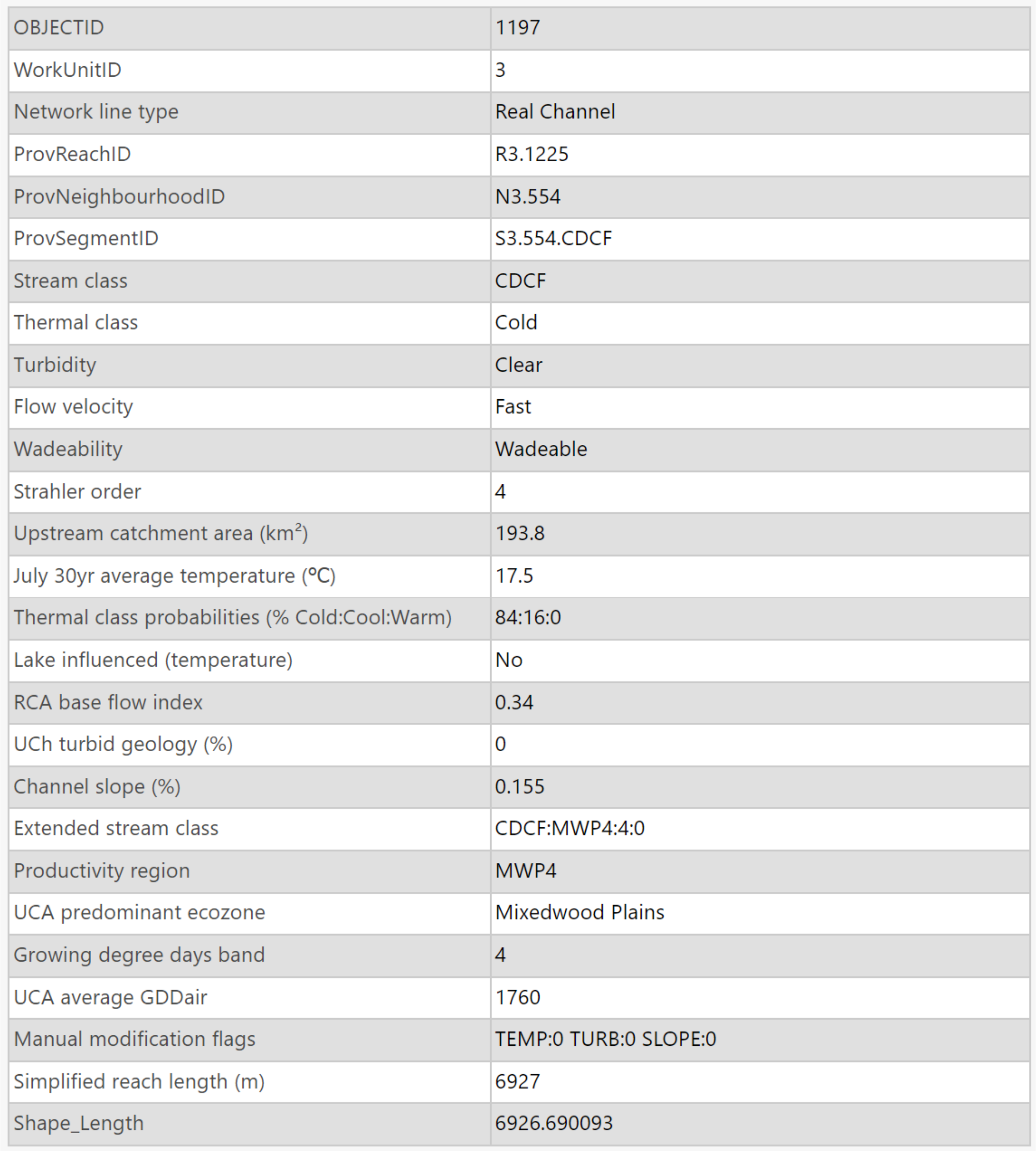


Figure 3. Comparisons of the Ontario Hydrographic Network (OHN) mapped blue lines and their processed aquatic ecological classification (AEC) equivalents. A) The orange “stepped” line shows the Ontario Integrated Hydrography (OIH) equivalent of the OHN blue lines used to create the AEC spatial data. The two generally overlap well because the OIH data was created using the OHN lines. The arrows show the OHN lines that were excluded from the AEC stream network because they have less than 1 km^2 upstream catchment area. B) The simplified AEC lines (yellow) shown in context of the original OHN lines. The length of the AEC reach (yellow) is less than its equivalent OHN reach (blue), which is the case for most reaches across the province. The 1 km^2 exclusion threshold and the shorter simplified AEC lines are the reason any analysis using the AEC data will consistently underestimate true stream length on the ground.

Core attributes

Each AEC stream reach contains information about several core attributes to support resource management applications. Attributes cover two broad categories of information: spatial and ecological (Figure 4; Table 1).



OBJECTID	1197
WorkUnitID	3
Network line type	Real Channel
ProvReachID	R3.1225
ProvNeighbourhoodID	N3.554
ProvSegmentID	S3.554.CDCF
Stream class	CDCF
Thermal class	Cold
Turbidity	Clear
Flow velocity	Fast
Wadeability	Wadeable
Strahler order	4
Upstream catchment area (km^2)	193.8
July 30yr average temperature (°C)	17.5
Thermal class probabilities (% Cold:Cool:Warm)	84:16:0
Lake influenced (temperature)	No
RCA base flow index	0.34
UCh turbid geology (%)	0
Channel slope (%)	0.155
Extended stream class	CDCF:MWP4:4:0
Productivity region	MWP4
UCA predominant ecozone	Mixedwood Plains
Growing degree days band	4
UCA average GDDair	1760
Manual modification flags	TEMP:0 TURB:0 SLOPE:0
Simplified reach length (m)	6927
Shape_Length	6926.690093

Figure 4. An example of the reach attribute table seen when using the ArcGIS Pro Explore tool. Refer to Table 1 to for attribute definitions.

Table 1. An overview and brief description of the core aquatic ecosystem classification (AEC) reach attribute table. The table fields have been organized into groups, which are separated by thicker lines. The fields within each group share a common theme (from top to bottom): network line function and identifiers, ecological classification codes, stream size metrics, ecological classification values, and metadata.

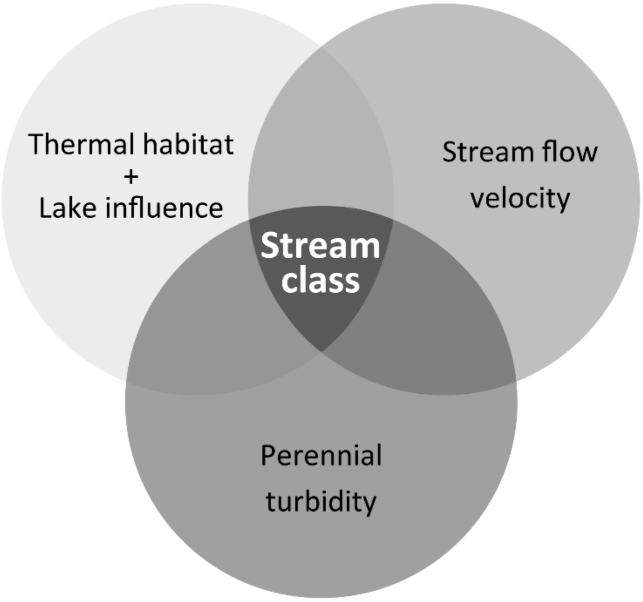
Field name	Description
WorkUnitID	The numeric AEC work unit identifier for use when working with data composed of multiple merged work units.
Network line type	The role a reach plays within the stream network spatial structure.
ProvReachID	A provincially unique reach identifier and the primary/foreign database key for joining core AEC feature classes, tables, and supplementary data tables.
ProvNeighbourhoodID	A provincially unique identifier for groupings of reaches that have similar upstream catchment areas.
ProvSegmentID	A provincially unique segment identifier for groupings of reaches that are part of the same stream class within the same size neighbourhood.
Stream class	A combination of abbreviated codes of a reach's thermal class, turbidity, and flow velocity that defines a reach's abiotic habitat template (e.g., cold = CD; Clear = C; Fast = F).
Thermal class	A probability-based membership to one of five thermal categories (cold, cold-cool, cool, cool-warm, warm) based on 30 years (1981-2010) of modelled water temperature.
Turbidity	Denotes whether a reach is perennially clear or turbid, based on proportion of clay geology underlying the upstream network channels (UCh).
Flow velocity	Denotes whether a reach is slow or fast flowing based on reach channel slope.
Wadeability	One of three categories describing the wadeability/navigation of the reach (wadeable, semi-wadeable, and non-wadeable).
Strahler order	An integer value that describes the position, and thus size, of a reach within the stream network (integers values range from 1 to 8, where headwaters at the outer branches of the network are assigned a value of 1, and the largest mainstem rivers in the AEC a value of 8; Strahler 1957).

Field name	Description
Upstream catchment area	The area of landscape draining to the lower end of a reach in square kilometres.
July 30yr average temperature	The average July water temperature of a reach calculated using 30 individually modelled years (1981-2010) of data in degrees Celsius.
Thermal class probabilities	The probabilities (%) of a reach belonging to one of the three primary thermal classes of cold, cool, or warm based on modelled stream temperatures for the period from 1981 to 2010. The three colon-separated values always add up to 100.
Lake influenced (temperature)	Denotes whether a reach's water temperature is influenced by one or more lakes upstream (yes or no). Modelled stream temperature conditions are potentially superseded by the influence those lakes exert on water temperature downstream.
RCA baseflow index	An indicator for cold groundwater seepage potential along the stream bed at the local intra-reach scale. It is based on the groundwater contribution potential of the geology types found in the reach contributing area (RCA), where seepage potential increases with increasing index values.
UCh turbid geology	The percentage of all upstream network channels (UCh) underlaid by turbidity producing clay geology.
Channel slope	The reach channel slope expressed as a percentage (i.e., metres of elevation drop for every 100 m of stream length). It is calculated by dividing the drop in elevation between the start and end point of a reach by the simplified length of the reach.
Extended class	A colon-separated combination of stream class, productivity region, Strahler order, and lake influence, providing further context for the stream class by including additional components with potential to influence the abiotic habitat template.
Productivity region	Denotes reach membership within one of nine provincial productivity regions, which are defined by the predominant upstream ecozone and growing degree band.
UCA predominant ecozone	The predominant (≥50%) terrestrial ecozone in the upstream catchment area (UCA).

Field name	Description
Growing degree day band	Denotes reach membership in one of five bands (i.e., value ranges) of average upstream catchment area growing degree days for air temperatures above 5°C.
UCA average GDD_{air}	Average upstream catchment area (UCA) growing degree days (GDD) for air temperatures above 5°C.
Manual modification flags	A set of integer codes that flag whether the thermal class, turbidity, or flow velocity (codes or values) have been assigned outside of the standard assignment rules.
Simplified reach length	The length of a reach based on the simplified line geometry (i.e., reduced vertices compared to the mapped blue lines) rounded to the nearest metre.
Shape_Length	A mandatory ArcGIS field added to each line feature class table and measured in metres (m).

Stream classes

Stream class is the primary attribute of the AEC. The classes are composed of three attributes: thermal habitat, perennial turbidity, and stream flow velocity. These continuous variables are discretized into categories (i.e., binned) and combined to form 20 unique stream classes (figures 5, 6). Thermal habitat assignment uses a probabilistic approach to assign stream reaches into one of five classes (cold, cold-cool, cool, cool-warm, warm), whereas perennial turbidity and flow velocity are discretized using defined thresholds to form two easily interpretable and ecologically meaningful groupings (clear and turbid; fast and slow). Visual differences among stream classes can be seen in figures 7 and 8. Group membership (i.e., affinity) diminishes near the thresholds. For example, two reaches with channel slopes of 0.01% and 0.14% would both be classified as slow because they fall below the slow/fast cutoff of 0.15%. However, the reach with a channel slope of 0.01% will flow more slowly than the reach with a channel slope of 0.14%. These caveats also apply for the turbidity class. Only real reaches are classified. Virtual connections (i.e., lakes and shorelines) and out-of-province reaches are not assigned a class.



Stream class	Thermal habitat	Perennial turbidity	Flow velocity
CDCF	Cold	Clear	Fast
CDCS			Slow
CDTF		Turbid	Fast
CDTS			Slow
CCCF	Cold-cool transitional	Clear	Fast
CCCS			Slow
CCTF		Turbid	Fast
CCTS			Slow
CLCF	Cool	Clear	Fast
CLCS			Slow
CLTF		Turbid	Fast
CLTS			Slow
CWCF	Cool-warm transitional	Clear	Fast
CWCS			Slow
CWTF		Turbid	Fast
CWTS			Slow
WMCF	Warm	Clear	Fast
WMCS			Slow
WMTF		Turbid	Fast
WMTS			Slow

Figure 5. The three fundamental aquatic ecosystem classification (AEC) stream attributes and the 20 stream classes that are created by combining the discretized categories of these continuous attributes.

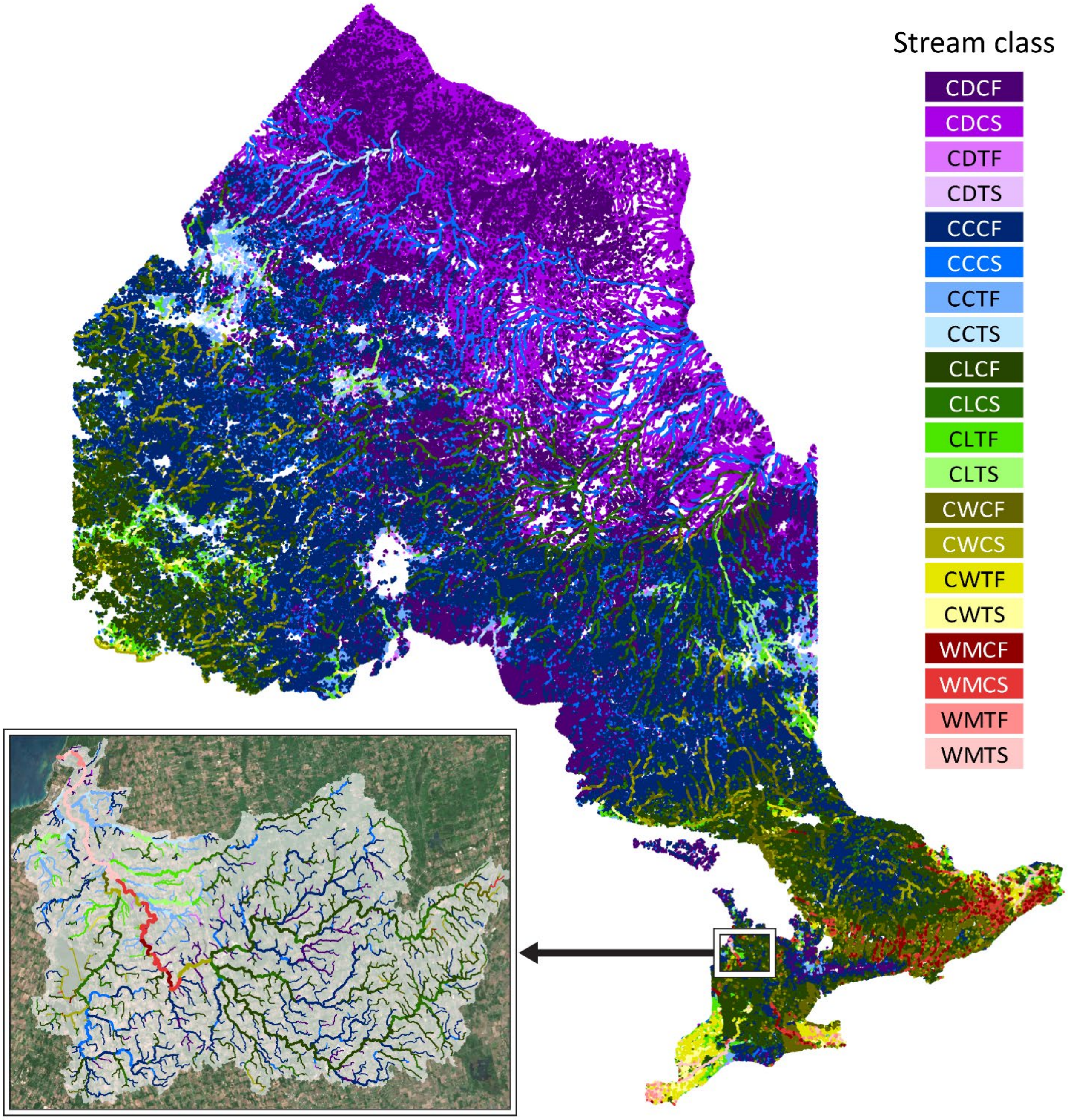


Figure 6. Distribution of the 20 aquatic ecosystem stream classes across Ontario. The inset shows the Saugeen River watershed in southwestern Ontario, where increasing line thickness corresponds with increasing Strahler stream order (Strahler 1957). A table of the hexadecimal and RGB (red, blue, and green) values of the class symbology colours is provided in Appendix 2. This colour symbology is also captured in the LYRX files included with each packaged work unit.

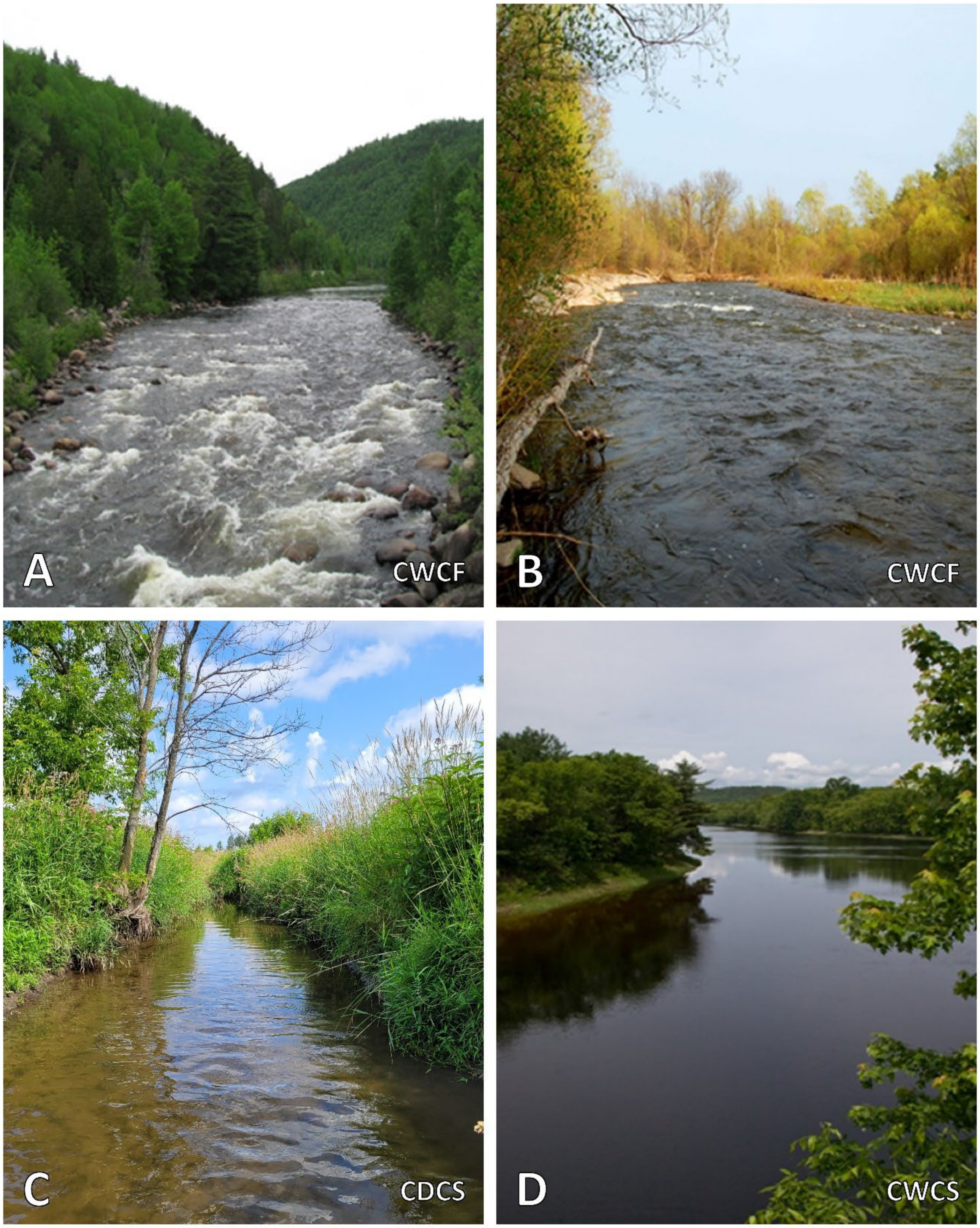


Figure 7. Examples of stream classes. The images only show the differences between turbidity and flow velocity because the thermal class can not be visually distinguished. (A) The Little White River near the HWY 546 crossing: semi-wadeable, low conductivity, cool-warm, clear, and fast. (B) The Credit River near Erindale: semi-wadeable, high conductivity, cool-warm, clear, and fast. (C) Innisfil Creek south of Barrie: wadeable, high conductivity, cold, clear, and slow. (D) The Mississagi River near Iron Bridge: non-wadeable, low conductivity, cool-warm, clear, and slow.

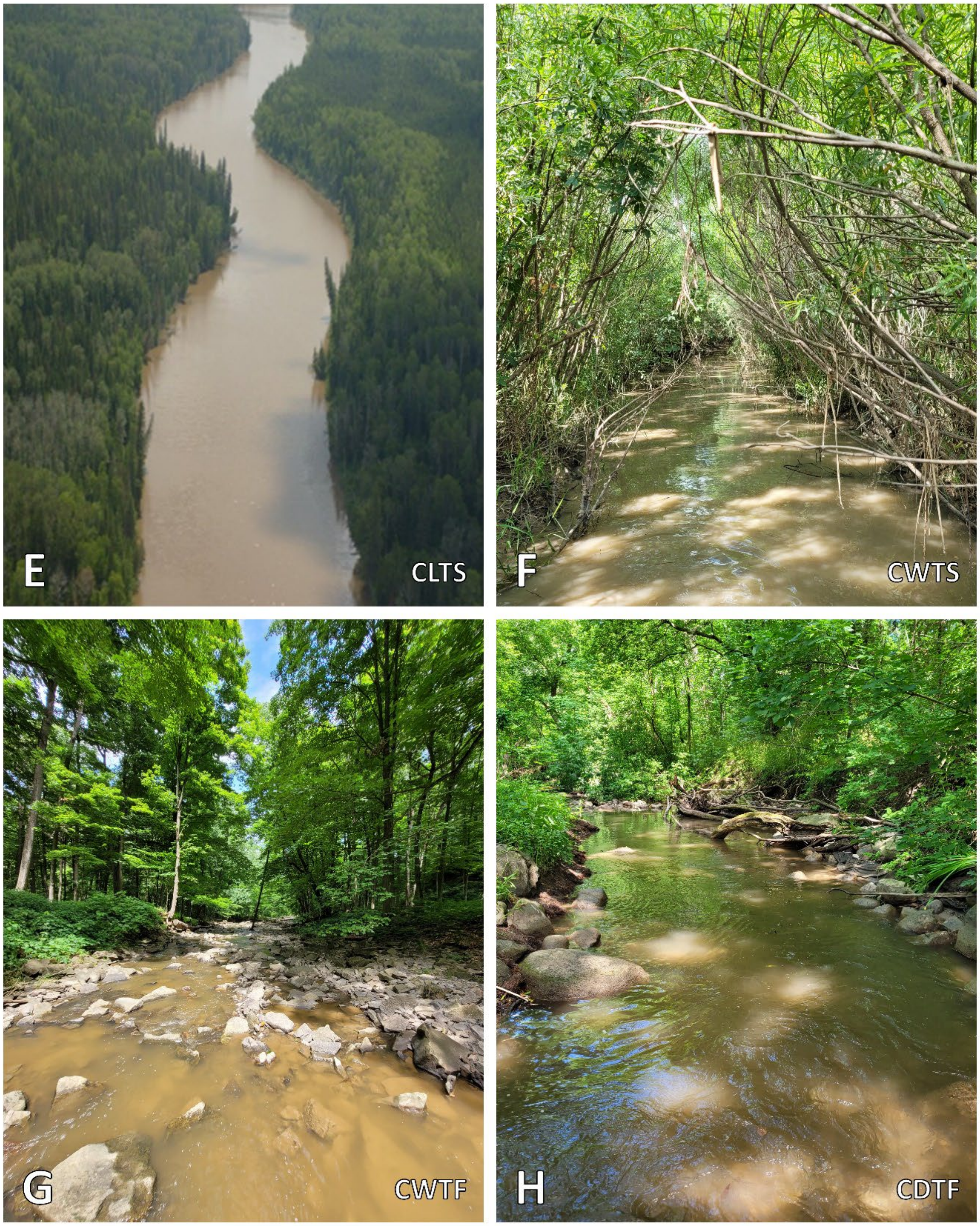


Figure 8. Examples of stream classes. The images only show the differences between turbidity and flow velocity because the thermal class can not be visually distinguished. (E) The Abitibi River north of Cochrane: non-wadeable, low conductivity, cool, turbid, and slow. (F) Jeannettes Creek south of Chatham: wadeable, high conductivity, cool-warm, turbid, and slow. (G) Fifteen Mile Creek west of St. Catherines: wadeable, high conductivity, cool-warm, turbid, and fast. (H) Unnamed creek west of Aurora: wadeable, high conductivity, cold, turbid, and fast.

Thermal habitat

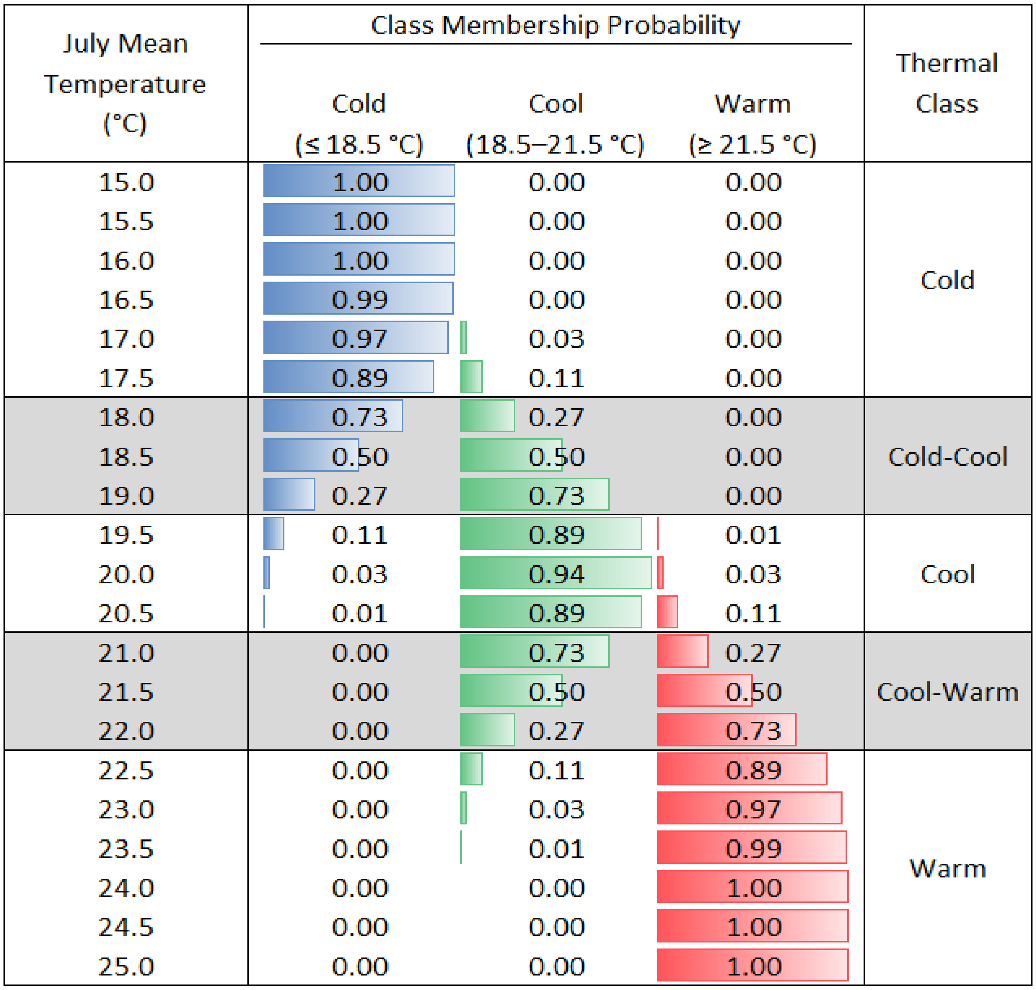
Water temperature is often described as a master variable and an ecological resource due to its influence on aquatic ecosystems (Brett 1971, Hannah and Garner 2015). For example, spatial and temporal variation in water temperature constrains the distribution and abundance of aquatic organisms in lotic systems longitudinally and over time (Vannote et al. 1980, Jones and Schmidt 2019). Understanding water temperature regimes is therefore essential for sustainable resource management within rivers and streams. Users are strongly encouraged to review Jones and Schmidt (2019), which provides a primer on understanding stream temperature, thermal classifications, and how fishes exploit the thermal environment in stream networks.

Temperature modelling and classification

In the AEC, thermal class is based on predicted July mean stream temperatures modelled using field data and remotely sensed covariates (Sutton et al. 2024). Predictions were generated for every year between 1981 and 2010. Given that the predictions are based on historical temperatures, the user may want to also consider the climate change stream temperature projections available for download in the AEC's supplementary data section on GeoHub (Sutton et al. 2024). Using the mean and standard deviation of the predictions, we used a probabilistic approach to establish the affinity of each reach to one of three primary thermal classes: cold (CD; <18.5°C), cool (CL; 18.5–21.5°C), and warm (WM; >21.5°C) (Figure 9). This approach accounts for interannual variability in stream temperatures and thermal habitat. Class membership probability is expressed as a proportion ranging between zero and one, with one representing 100% certainty of class membership.

A reach is assigned to one of the primary thermal classes (i.e., cold, cool, or warm) only when class membership probability exceeds 80%. If a reach's primary thermal class probability falls below 80%, it is assigned to the cold-cool (CC) or cool-warm (CW) transitional classes (e.g., a cold-cool stream may have a cold probability of 60% and a cool probability of 40%; grey bands on Figure 9). Higher membership probabilities suggest lower interannual variation (e.g., a reach with a 90% probability of being cold should have a July mean stream temperature >18.5°C only 10% of the time or one in ten years). The Thermal Class Probabilities (% Cold:Cool:Warm) field contains the class membership probabilities for the three primary thermal classes. For example, a value of 0:88:12 suggests a reach is cold 0%, cool 88%, and warm 12% of the time – placing it solidly in the cool thermal class.

The transitional cold-cool and cool-warm thermal classes help identify streams that fall between the primary thermal classes. These streams tend to flip from one class to another depending on if it is a hot or cold summer. The stream may be classified as warm during a hot summer, but cool during a colder summer (i.e., a cool-warm stream). The transitional classes are not intended as stand-alone classes. Rather, they should be grouped with their neighbouring class depending on the management purpose. For example, if the goal is protecting coldwater streams, then the cold-cool transitional class could be grouped with the cold thermal class, considering that many coldwater species are likely to be present in cold-cool streams during all but the warmest summers. The model predicted temperatures are based on contemporary data (1981-2010) and, as a result, they do not provide a reference (pre-European) context.



July Mean Temperature (°C)	Class Membership Probability			Thermal Class
	Cold (≤ 18.5 °C)	Cool (18.5–21.5 °C)	Warm (≥ 21.5 °C)	
15.0	1.00	0.00	0.00	Cold
15.5	1.00	0.00	0.00	
16.0	1.00	0.00	0.00	
16.5	0.99	0.00	0.00	
17.0	0.97	0.03	0.00	
17.5	0.89	0.11	0.00	
18.0	0.73	0.27	0.00	Cold-Cool
18.5	0.50	0.50	0.00	
19.0	0.27	0.73	0.00	
19.5	0.11	0.89	0.01	Cool
20.0	0.03	0.94	0.03	
20.5	0.01	0.89	0.11	
21.0	0.00	0.73	0.27	Cool-Warm
21.5	0.00	0.50	0.50	
22.0	0.00	0.27	0.73	
22.5	0.00	0.11	0.89	Warm
23.0	0.00	0.03	0.97	
23.5	0.00	0.01	0.99	
24.0	0.00	0.00	1.00	
24.5	0.00	0.00	1.00	
25.0	0.00	0.00	1.00	

Figure 9. An overview of the thermal classification framework from Jones et al. (2021). Thermal class is determined based on the probability of membership to three core thermal classes (cold, cool, and warm). This method uses 30 July mean stream temperature predictions to generate a probability distribution. Class membership is achieved when a probability threshold, in this case $p > 0.8$, is reached. When a reach does not meet this threshold, it is placed in a transitional class (illustrated by grey bands). Class membership probabilities are provided in the aquatic ecosystem classification (AEC) because this measure of uncertainty is useful in making decisions based on thermal class and the strength of the determination. See Jones and Schmidt (2019) and Jones et al. (2021) for a detailed overview of this classification framework.

The influence of lakes on stream temperature

Throughout Ontario, lakes and rivers are connected in an alternating series of lentic (still water) and lotic (running water) reaches. Streams flowing out of lakes (lake outlets) tend to be warmer than inflowing streams (Figure 10) because solar radiation warms the lake surface; think of lakes as large rivers with little riparian shade. This warm water is transported some distance downstream from the outlet before the stream returns to an equilibrium with the surrounding landscape (e.g., due to cold groundwater seeping into the stream through the stream bed). In the simplest terms, lake influence attenuates quickly in streams with small drainage areas (e.g., 5 km^2), whereas attenuation may take several kilometres in larger streams because of the large volume of warmed lake water.

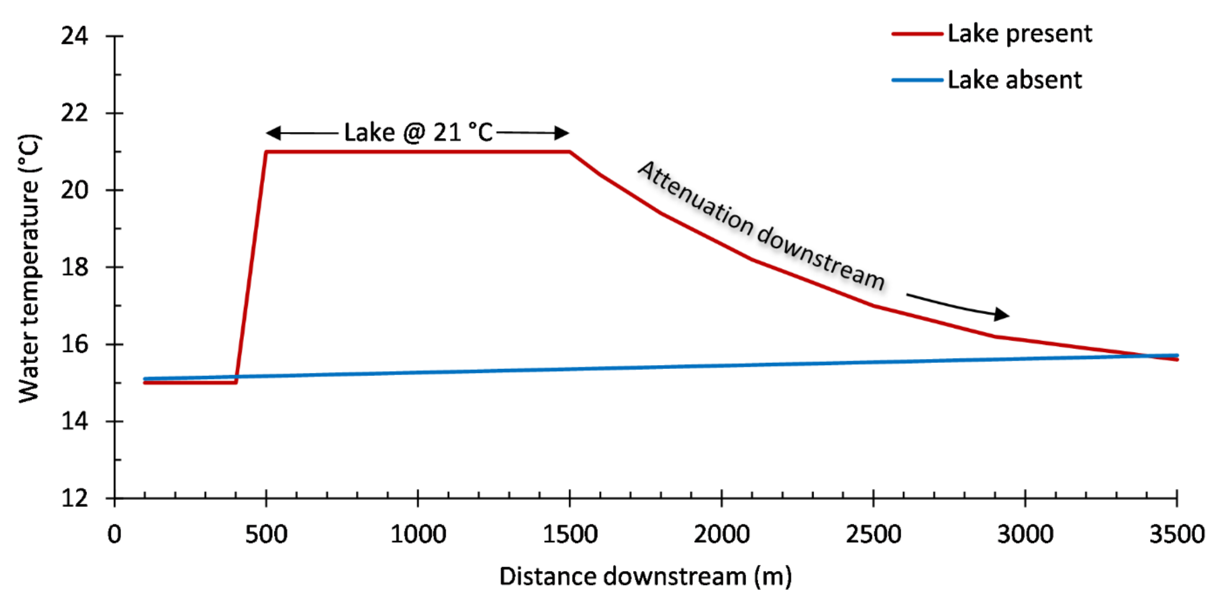


Figure 10. Two hypothetical examples showing the longitudinal change in water temperatures without a lake (blue) and with a lake (red). The lake increases water temperatures from the inflow stream. The outflow stream starts at the temperature of the lake but then decreases downstream until temperature returns to an equilibrium with the surrounding landscape. The stream without a lake shows a small increase in water temperatures typical of many streams as they increase in size.

The AEC provides predictions of mean July water temperatures. Water temperature is modelled both in the absence of lakes (stream model; Sutton et al. 2024) and for each individual lake's surface waters (lake model; Bachmann et al. 2019). To account for the influence of lakes, water temperature in the stream reach at the lake outlet will match the lake surface temperature prediction and then decrease with distance downstream to an equilibrium with the water temperatures predicted in the absence of a lake.

We have estimated the attenuation distance below all lake outlets using a metric called the lake effect index for temperature (LEI_T; Allerton et al. unpublished). The LEI_T can range between zero and one, with zero denoting no influence and one denoting the maximum amount of influence right at the outlet. To simplify interpretation, reaches are identified as lake influenced ($LEI_T \geq 0.1$) or not lake influenced ($LEI_T < 0.1$) using a binary flag (i.e., 0 or 1). This threshold ensures very small LEI_T values (e.g., 0.001) do not flag a reach as being lake influenced when the lake influence has declined to the point of being negligible.

The AEC includes a layer file that symbolizes lake influenced reaches as dashed lines coloured by the stream model thermal class (Figure 11). Once lake influence declines to negligible levels, (i.e., $LEI_T < 0.1$) the symbology returns to being a solid line. The AEC data also includes a point layer of modelled average July lake surface temperatures. The points are placed directly at the outlet of a lake. The predictions are assigned a thermal class using the same probability-based method described for stream reaches. The points are also colour-coded using the same colour scheme as the reach thermal classes. The temperature of reaches with drainage areas greater than 700 km^2 (i.e., large rivers) are primarily driven by air temperature and solar radiation, just like lakes, meaning that lakes have little to no warming effect on large rivers. In these cases, the reach lines are not dashed, nor do they have a lake outlet point prediction. Reaches are also not flagged as being lake influenced, nor do they have an outlet point prediction, when the lake (or pond) has a surface area to outlet upstream catchment area ratio less than 0.002 (i.e., <1/500). For example, a 0.1 km^2 pond with an outlet UCA of 100 km^2 has a ratio of 0.001, which means it is considered to not influence downstream temperature. This symbology scheme is intended to provide the user with insight into how lakes influence stream temperatures below their outlet.

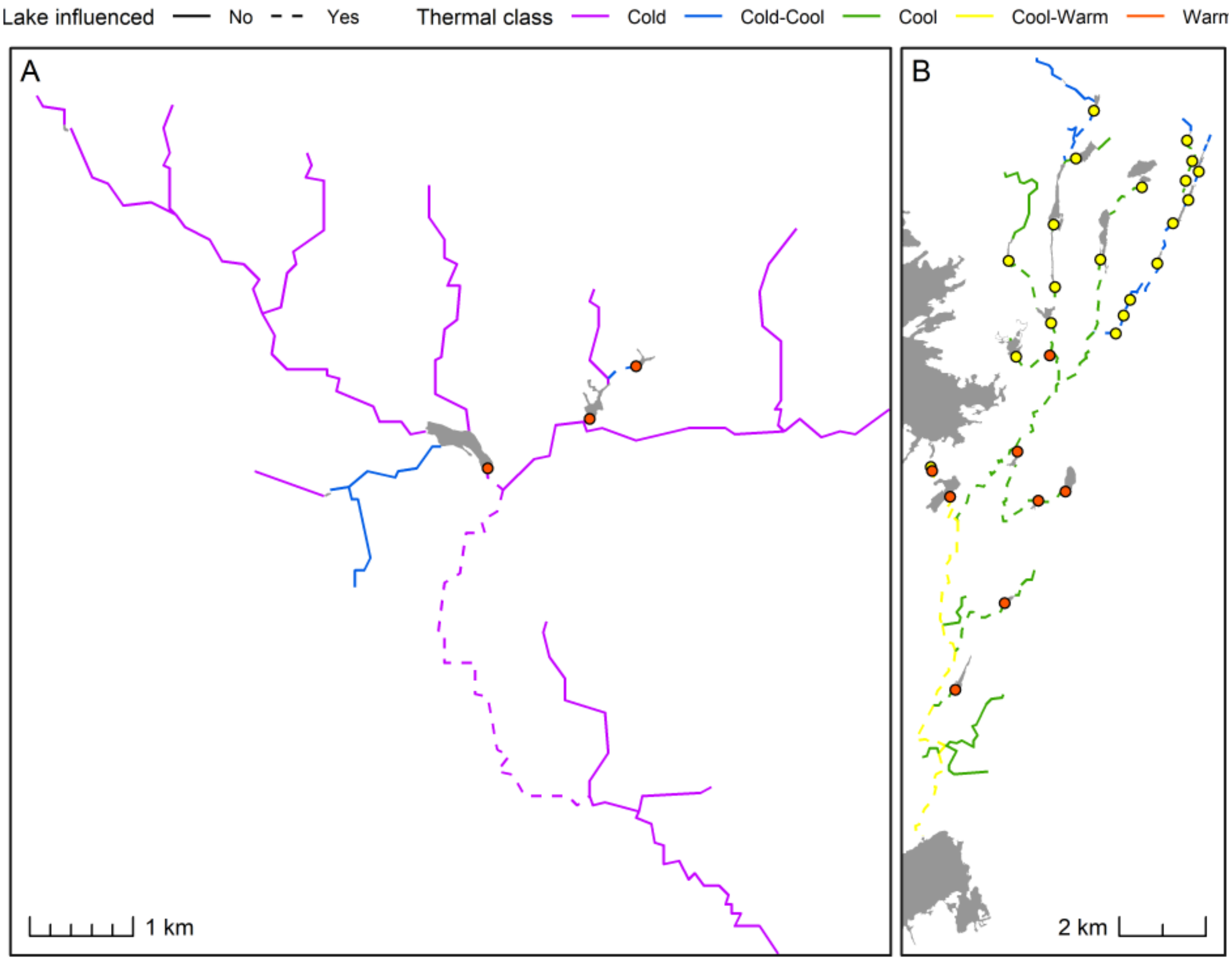


Figure 11. Examples of lake influence in (A) a small headwater stream and (B) a larger tributary. The lake surface temperature at the outlet (coloured points) is typically much warmer than the predicted stream temperature. Predicted stream temperatures below lake outlets (dashed line) should be interpreted with caution and likely fall somewhere between the predicted lake outlet and stream temperatures. In some cases, waterbodies will be too small to exert an influence on streams downstream of the outlet (e.g., the ponds in the upper left of panel A). In other cases, many sequential lakes lead to a continuous zone of lake influence (panel B).

The influence of dams on stream temperature

Dams can influence stream temperatures below their outlets depending on their design and reservoir size. Top-draw dams affect stream temperature like a lake as discussed above. Large bottom-draw dams, whose reservoirs stratify, usually discharge water from below the thermocline, which results in cooler stream temperatures below the dam during the summer months. In contrast, warm water (~4°C) at the bottom of the reservoir is discharged during the winter months, resulting in warmer downstream temperatures. The stratification reduces the annual range of stream temperatures. Like the influence of lakes, these effects attenuate with distance downstream from the dam until they become negligible. The influence of dams was not incorporated into the AEC and reaches downstream of large dams may be misclassified.

The influence of urbanization on stream temperature

Urbanized areas can artificially increase stream temperature because impervious surfaces (e.g., paved parking lots) and stormwater management ponds produce warm run-off during summer storms. In urbanized streams, temperatures can pulse very quickly giving stream biota no time to seek refuge in cooler parts of the stream network. Another urban source of artificially warm water is sewage treatment plant or industrial effluent. Conversely, leaking water mains can be a source of increased “groundwater” contributions that can have a cooling effect on streams. The location of the urbanized area in relation to the stream determines the strength of effects. Like lakes and dams, the thermal effects of urbanization attenuate with distance downstream. Highly urbanized reaches (UCA urbanization >25% and/or RCA urbanization >50%) were excluded from the data set during temperature model development and reaches from urbanized areas may be misclassified.

The influence of groundwater seeps on stream temperature

The GeoHub data includes a metric called baseflow index (BFI), which provides insight into the thermal regime of a reach beyond its thermal classification (Neff, et al. 2005). The BFI relates to localized hydrologic processes occurring below the reach contributing area (RCA) scale, where a higher value can be interpreted as greater potential for cold groundwater upwellings (i.e., seeps) within a reach. For example, a reach assigned to the warm thermal class that also has a higher RCA BFI value (>0.5) might have groundwater inflows along its bed that could provide thermal refugia for coldwater species in an otherwise warm stream.

Perennial turbidity

The turbidity (clarity or cloudiness) of a stream relates to its productivity (e.g., autotrophic vs. heterotrophic energy sources) and invertebrate and fish communities (e.g., sauger, mooneye, catfishes vs. trout, charr). In turbid streams, light penetration is limited, and energy sources are primarily allochthonous (i.e., imported from external sources) organic matter. Even relatively small turbid tributaries can decrease light penetration and influence the ecology of larger mainstem rivers. Many streams can be turbid during spring freshet and after rainstorms but are clear the remainder of the year. In the context of the AEC, streams are classified as turbid if they are cloudy for most of the year and across summer and winter low flow periods. Streams are classified as turbid when their nephelometric turbidity units (NTU) are greater than 10. The perennial turbidity of a stream is largely a function of the clay geology types (Barnett 1992) underlying the entire upstream channel (UCh), not necessarily the whole upstream catchment, because surface run-off is not a factor during low flows. Turbid streams are typically associated with very fine glaciolacustrine deposits (i.e., clay). Larger streams tend to require a smaller percentage of clay geology within the river channel to produce turbidity (see Jones et al. 2025 for drainage area specific threshold for upstream channel clay).

We recognize that a gradient of turbidity levels across Ontario reflects the types of geology and upstream channel percentage within each drainage. In some instances, high staining (i.e., dissolved organic matter, tannin) and turbidity can combine to reduce sunlight penetration. Many rivers are in agricultural areas that may have higher turbidity than predicted by their surficial geology due to erosion of soils and indirect nutrient additions that promote primary production of phytoplankton. These rivers are often a khaki green colour during low flow conditions in summer. Bioturbation caused by fish (e.g., carp) or mammals (e.g., muskrats, cattle) can persistently increase turbidity levels in many streams beyond what is expected due to clay geology.

Stream flow velocity

Stream channel slope is a determinant of flow velocity potential (i.e., current), which strongly influences organisms in running waters. Water velocity defines sediment size and food delivery and is a direct physical force acting on organisms. Channel slope was computed as rise over run along the length of each using the 30 m resolution Ontario Integrated Hydrology DEM. Channel slopes were categorized as slow (<0.15%) or fast (≥0.15%) moving. This threshold differentiates between streams with beds dominated by sands and finer sediments from those composed of larger sediments such as gravel and coarser substrates. This categorization is a generalization that averages over within reach differences of fast riffles and slow pools, which are assumed to occur along most reaches because of geomorphological processes operating at a scale below that of the AEC reach. Average reach slopes will misrepresent sudden elevation changes within a reach (e.g., waterfalls). For example, the channel slope of the Niagara River, not including the drop at Niagara Falls, is just 0.01, but including the falls is 0.20 (∼20x greater).

Stream size and wadeability

Stream size is used to further stratify streams over broad spatial scales, independent of stream class. Stream size determines many stream characteristics, with predictable changes as streams grow from headwaters to larger mainstem rivers. The River Continuum Concept (Vannote et al. 1980) describes downstream changes in depth, channel width, shading, velocity, discharge, and water temperature. Overlain on these abiotic gradients are corresponding changes in biological characteristics like riparian influence, organic matter size, and algae, benthic invertebrates, and fishes. The AEC provides upstream catchment areas (UCA) and Strahler order (Strahler 1957) as measures of stream size. In the Strahler order system, stream size is represented using integers: small streams (order 1–3), mid size streams (order 4–6), and lower reach large rivers (order >6). However, because Strahler order changes with the scale and accuracy of the DEM, the AEC also includes stream size based on drainage area divided into three categories (Figure 12) to address field-based sampling constraints: small, wadeable streams (UCA<200 km²), large, non-wadeable streams (≥2,000 km²), and intermediate size, semi-wadeable streams (UCA≥200 to <2,000 km²). For wadeable streams, more than 95% of the stream is wadeable and many sampling methods exist. For non-wadeable streams, 95% is boatable and methods designed for slow moving rivers and lakes might apply. Semi-wadeable streams are difficult to travel along, navigate within, and sample and will require a mixture of approaches. Exceptions to these rules include streams running through clay geology and organics because they tend to have U-shaped channels that can be non-wadeable, even in relatively small streams. Furthermore, backwater conditions in small to intermediate streams near the estuaries of the Great Lakes may only be accessible by boat depending on lake water levels.

Figure 12. Field examples of the wadeability categories based on upstream catchment area (UCA): wadeable streams (UCA<200 km²), semi-wadeable streams (UCA≥200 to <2,000 km²), and non-wadeable streams (≥2,000 km²).

Stream size neighbourhoods

Stream size neighbourhoods inform the creation of the stream segments. The neighbourhoods are defined using a set of size-based rules, which are described in detail in Jones et al. (2025). Using these neighbourhoods ensures reaches comprising the segments all share similar upstream catchment areas.

Productivity regions

Regions constitute the highest levels of the classification hierarchy in the AEC and are based on expectations of aquatic productivity. Unlike the bottom-up approach that aggregates the reaches into larger segment units, productivity regions are developed using a top-down approach, where ecozones are subdivided into smaller region units. Productivity is a key aspect of flowing waters with respect to fish harvest and ecosystem resilience. In lakes, productivity has three principal influences: morphometric (shape/dimension), edaphic (soil/geology), and climatic factors. It is difficult to generalize about the morphometry of streams and rivers across Ontario; however, the potential of the fluvial environment to produce biota can be approximated by combining growing degree days and conductivity, broadly akin to the morphoedaphic index (MEI).

Average upstream catchment air temperature growing degree days (GDD) >5 °C were used to approximate regional differences in the potential growth and development of ectotherms (e.g., fishes) during the growing season. Riparian shading related to stream size and turbidity, however, may alter expectations because high levels of turbidity and shade can reduce photosynthesis, potentially affecting productivity. Five growing degree day (>5 °C) bands occur in Ontario (Band 1: <700, Band 2: 700–1100, Band 3: 1100–1500, Band 4: 1500–1900, Band 5: ≥1900).

Ontario encompasses three ecozones of the terrestrial ecological land classification system (ELC; Crins et al. 2009): the Mixedwood Plains (MWP), the Ontario Shield (OSD), and the Hudson Bay Lowlands (HBL). The ecozones are largely defined by the differences in their surficial geology types, and the geology drives the amount and type of dissolved solids found in a stream. They are a key source of nutrients needed by aquatic organisms to grow and develop. We use water conductivity as a surrogate measure for the amount of dissolved solids (e.g., Ca^{2+}, Mg^{2+}, PO_4^{3-}). Average water conductivities for the ecozones are 571, 69, and 138 µS for Mixedwood Plains, Ontario Shield and Hudson Bay Lowlands, respectively. Generally, higher GDD and conductivity values mean higher the productivity potential of the stream.

Growing degree day bands and predominant (≥%50) upstream ecozones combine to create nine unique productivity regions across Ontario. Streams that originate within one ecozone (Ontario Shield) and drain into another (Hudson Bay Lowlands) carry their classification downstream and bleed into the neighbouring ecozone. They keep their classification because the water upstream does not instantly change character when it crosses an ecoregion boundary (Figure 13). These regions delineate large areas of potential differences in aquatic ecosystem productivity. As such, it does not consider inputs from urban areas and stormwater ponds that tend to increase the conductivity of water.

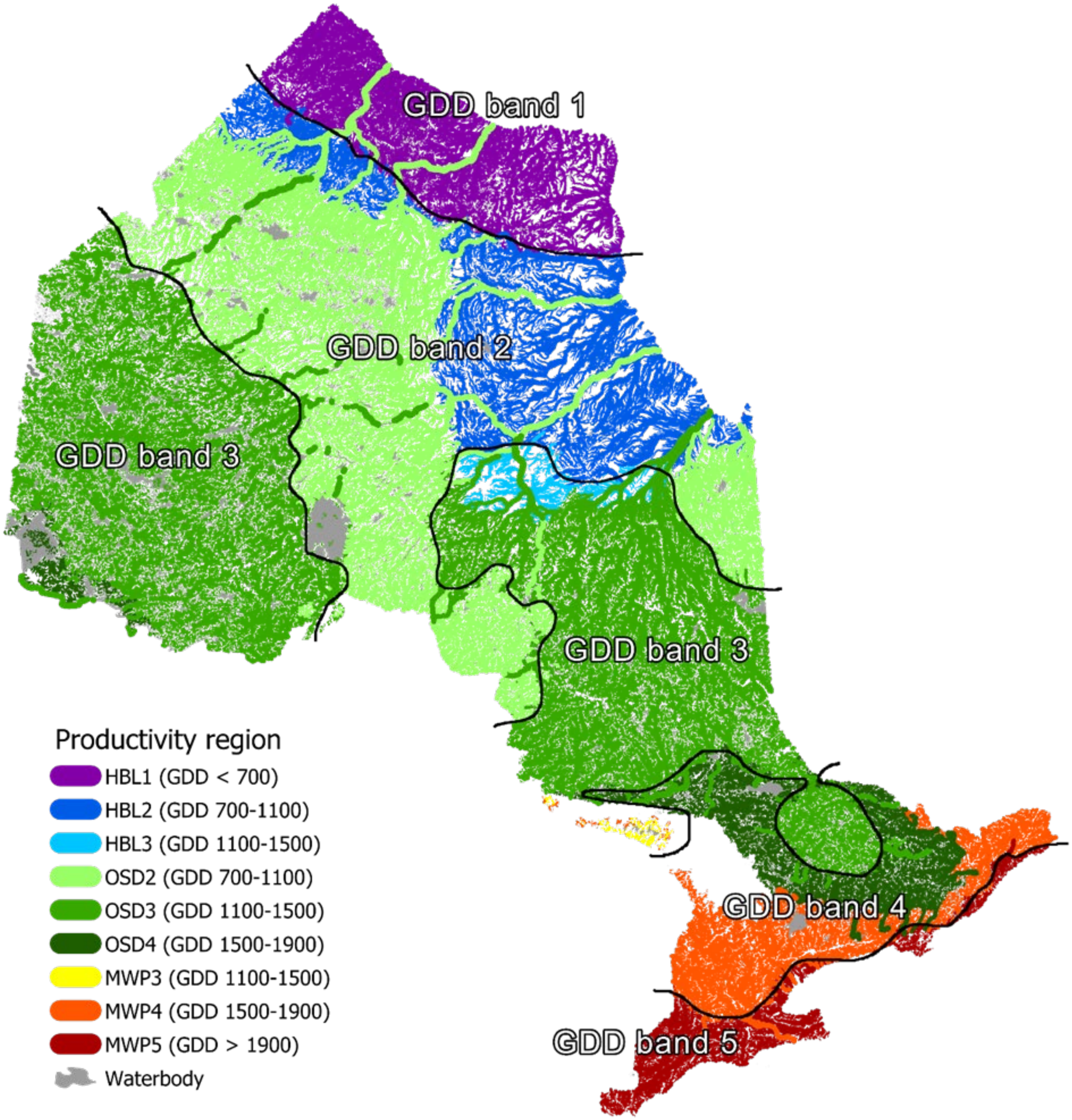


Figure 13. The combinations of bands of air growing degree days (GDD) >5 ˚C and ecozones create nine unique productivity regions that delineate large areas of potential differences in productivity across Ontario (HBL = Hudson Bay Lowlands; OSD = Ontario Shield; MWP = Mixedwood Plains). Some bleeding across regions can occur at their edges because the upstream influence of a region carries downstream for a distance, especially on large mainstem rivers.

Extended class attributes

The variables used in the classification (thermal habitat, perennial turbidity, and stream flow velocity) represent the main drivers of aquatic community composition. Although additional variables could be incorporated into the AEC classes, it would increase complexity and create many more class combinations – negating the goal of creating succinct ecologically meaningful classes. Additional variables are also likely to be highly correlated with those already included in the classification. Nevertheless, the AEC provides extended class codes that encode information about other attributes of ecological interest including: 1) potential biological productivity, 2) Strahler order, and 3) whether stream temperatures are influenced by one or more upstream lakes. The AEC extended class is composed of the primary stream class plus these additional attributes (Figure 14).

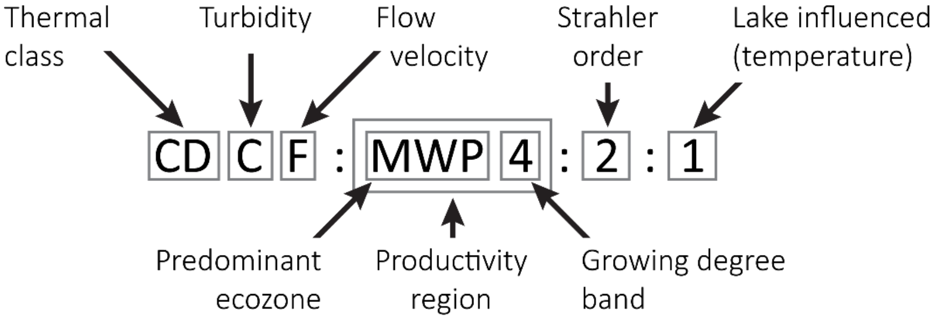


Figure 14. An example of the components of the AEC extended class for a single reach. The stream class is **CDCF** (thermal class = cold, turbidity = clear, flow velocity = fast), the productivity region is **MWP4** (MWP = Mixedwood Plains ecozone; growing degree band 4 or 1500 – 1900 GDD), the stream size is Strahler order **2**, and its temperature is influenced by an upstream lake(s) encoded as **1** (if the reach was not influenced by a lake this value would be 0). These components are described in more detail throughout this guide.

Manual attribute modifications

Manual corrections are occasionally applied to the AEC data in response to user feedback and based on expert opinion. Modifications are flagged in the [Manual Modification Flags] field of the reach attribute table (e.g., TEMP:1 TURB:0 SLOPE:0). Manual temperature class corrections were applied to improve consistency and continuity of the modelled temperature predictions. The turbidity class was manually adjusted according to field observations in several small areas where the presence of upstream clay geology did not appear to produce perennial turbidity. The velocity class of some tributaries near the Niagara River were manually adjusted from fast to slow because digital elevation model conditioning (i.e., “burn-in”) produced artificially steep slopes. Each class (thermal, turbidity, and velocity) has two associated field types: 1) the value fields that contain numerical values (e.g., [July 30yr average temperature (Celsius)] = 19.4 °C; [Thermal class probabilities (% Cold:Cool:Warm)] = 16:82:1) and 2) the code field (e.g., [Thermal class] = “Cool”). Table 2 shows the four possible flag values and hypothetical examples of how each type of modification might appear in the attribute table.

Table 2. Manual attribute modification flags with descriptions and examples.

Flag	Description	Example
0	No modifications	No values or codes were modified.
1	Both the values and the code has been modified	The [Thermal class] code field was modified from ‘CL’ to ‘CW’ and its associated value fields [July 30yr average temperature (Celsius)] and [Thermal class probabilities (% Cold:Cool:Warm)] were set to <null>.
2	Only the class code has been modified	The [Thermal class] code field was modified from “CL” to “CW” but its associated value fields [July 30yr average temperature (Celsius)] and [Thermal class probabilities (% Cold:Cool:Warm)] were not modified (all associated value fields are always modified together).
3	Only the value(s) has been modified	The value fields [July 30yr average temperature (Celsius)] and [Thermal class probabilities (% Cold:Cool:Warm)] were modified (all associated value fields are always modified together) but it’s associated code field [Thermal class] was not unmodified.

Reaches with out-of-province upstream catchments

Some streams have upstream connected reaches that flow into the province of Ontario from either Quebec or Manitoba. These out-of-province reaches do not have the required base data needed to perform the modelling/analyses with the same certainty as reaches whose entire upstream catchment area are fully attributed. We chose to still classify these rivers because the missing data only represents a minor fraction of the upstream, except near their headwaters. Three large rivers are affected: the Abitibi River, the last 8 km of the Moose River below the Abitibi confluence, and the Severn River and its tributary the Beaver Stone River (Figure 15).

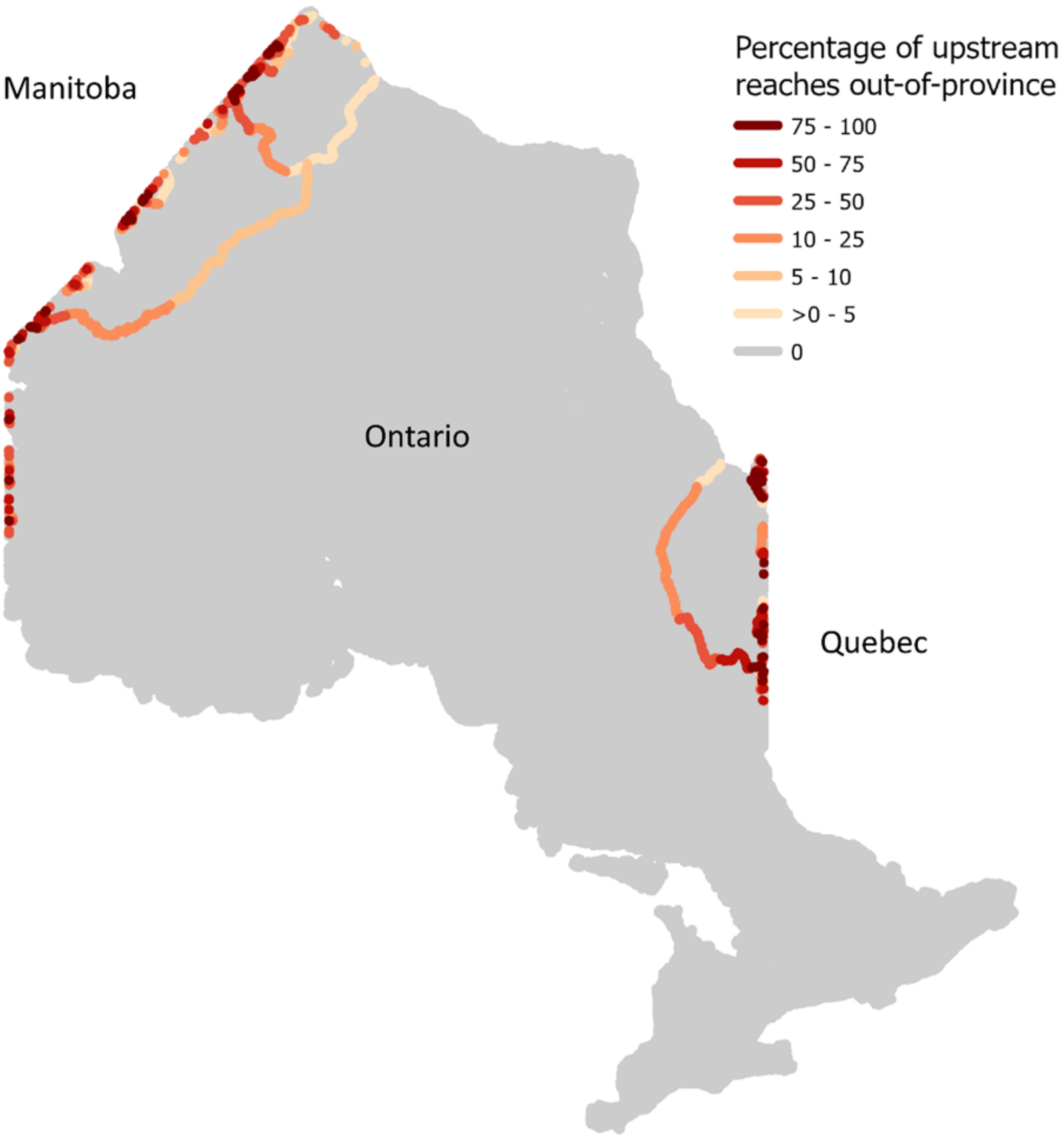


Figure 15. AEC stream reaches that have some percentage of upstream connected reaches outside Ontario's provincial border. Three large rivers are affected: the Abitibi River, the last kilometre of the Moose River below the Abitibi confluence near the Quebec border, and the Severn River and its tributary the Beaver Stone River near the Manitoba border.

Tips for displaying the data

The AEC makes use of a large, carefully selected, palette of colours to symbolize the various themes (e.g., stream class). Some factors can affect the legibility of these colours, or the ability to differentiate between them, when viewed on a computer screen. Here are some suggestions for improving colour visibility:

- **Adjust monitor settings:** adjust the brightness and/or contrast settings of your monitor until you can discern the individual symbology colours.

- **Change the GIS map background:** the legibility of the colour symbology also depends on the background on top of which the data is being displayed (i.e., topographic map, aerial imagery, dark grey canvas). If you cannot discern the colours, try switching to a different base map. Alternatively, you could place the work unit boundary polygon layer (.lyrx file) included with each work unit geodatabase between the base map and the feature class of interest. The default transparency of the work unit boundary polygon is 60% which can be adjusted to suite your specific needs.

Potential classification uses

AEC describes Ontario's riverine landscape with a level of detail that previously could only be obtained at the local scale. These spatial attributes can be used to support research, policy, and management of aquatic resources in Ontario. Understanding the general characteristics of streams is the first step toward effective management. Biologists can develop a better understanding of their management area from their desks without needing to conduct resource intensive site visits. The AEC can be used to used to stratify sampling designs, provide a provincially consistent spatial framework for monitoring and reporting, guide site selection to ensure efficient use of resources for coarse and fine-scale monitoring and field inventories, and develop context-dependent guidelines with criteria for specific stream types. The AEC may also help answer questions like where a species might be present in a stream network, what species could be stocked in a stream, and whether rehabilitation goals are achievable (i.e., can a stream support trout). Lastly, the AEC can help guide the selection and use of field sampling methods.

Species distributions

The AEC predicts general habitat conditions and thus can be used to understand where certain species may inhabit a drainage. This knowledge is useful when the user is unfamiliar with the area of interest and comprehensive fish sampling records do not exist. For example, a biologist wants to know where they should spend five days in the field to determine where brook trout are in a drainage. They can use the AEC to help guide where they, or a consultant, might use electrofishing or eDNA to sample. Given that brook trout are typically found in cold, cold-cool, and cool streams, the biologist may sample these AEC classes and allocate their five field days appropriately.

Biodiversity representation and unique habitats

Systematic approaches for representing terrestrial ecosystems are well developed and have been implemented around the world. Despite the imperiled state of freshwater biodiversity, systematic approaches for protecting freshwater systems are lacking. The protection of freshwater aquatic ecosystems is often the result of terrestrially protected lands. While terrestrial representation assessments are based on vegetation-landform classifications, an equivalent classification system with which to assess aquatic ecosystems had yet to be integrated. The AEC for rivers and streams provides a means to assess representation. The AEC also provides an understanding of the general distribution of habitat and where unique and relatively rare habitats can be found.

Identifying potential fish stocking locations

Biologists are often challenged to find locations to stock fish species, including highly valued sport fish (e.g., brook trout, Atlantic salmon) or species at risk. The AEC can be used to locate suitable habitat for a variety of fish species that will increase the likelihood that stocked fishes will be successful.

Stream restoration activities

Stream restoration is a common management activity that is often driven by local conservation groups (e.g., Trout Unlimited, fishing clubs). Typically, the goal of restoration is to make habitat conditions more suitable for a species of interest. The AEC can be used to assess the likelihood that the selected stream reaches will provide the desired result and prioritize restoration effort. For example, a fishing club is interested in a stretch of river that occasionally contains brook and brown trout. Unfortunately, this river has inherently low potential to become a great trout stream due to its landscape characteristics. The biologist suggests that the club focus efforts on another stream section that is degraded but has a high potential. This prioritization can help clubs achieve their restoration goals.

Sampling methods and safety

The AEC can help guide field sampling methods and inform health and safety considerations. Stream size, water conductivity and turbidity, and channel slope strongly influence the way we sample streams in the field. Conductivity influences our ability to effectively use electrofishing techniques. Turbidity limits our ability to see into the water to estimate substrate composition and see stunned fishes. Turbidity also presents challenges to safely wade and operate watercraft because we cannot see water depth or instream hazards (e.g., logs, rocks). Channel slope determines the speed at which water flows and influences sampling method selection and safety. These factors collectively influence our ability to measure physical, chemical, and biological variables, and each plays a role in the detection and catchability of different species (Jones et al. 2021, Millar et al. 2023).

Things to remember when using the AEC

1. The AEC is a general habitat template, not a species-specific model.

2. The AEC does not include very small, often temporary, streams. Although we recognize the value of these features, they are smaller than can be reasonably represented using provincial-scale base data (i.e., a 30 m digital elevation model). Streams in the AEC have a drainage initiation threshold of 1 km^2.

3. In Northern Ontario, many small perennial streams are missing or in the wrong location because visually obstructive canopy cover combined with an irregular stream network pattern on Precambrian geology makes stereographic interpretation difficult.

4. The AEC does not include identification of sub-reach habitat heterogeneity (e.g., pools, riffles). We recognize that heterogeneity exists at scales below the AEC reach level, but provincial-scale base data does not support work as such a fine spatial scale.

5. The AEC should be interpreted with caution in streams with considerable anthropogenic influence, such as highly urbanized streams and the tailwaters below dams – particularly with respect to bottom-draw dams that alter the thermal characteristics of streams. Unlike geology and stream size, human development changes quickly and would require frequent changes to the classification (see Jones et al. 2019).

6. Although the AEC groups stream reaches into discrete classes, the continuous nature of the underlying abiotic variables remains. Some streams may be close to class thresholds, leading to longitudinal "flip-flopping" between classes.

7. The AEC aims to achieve a high level of classification accuracy. However, some streams could be misclassified due to base data issues (e.g., inaccurate surficial geology) and/or modelling uncertainty. Small streams are more affected by underlying base data errors (e.g., geologic misclassification or spatial inaccuracies) than large rivers that encompass larger areas. Users can contribute to making corrections by sharing field observations via AEC@ontario.ca

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Appendix 1

Users of the AEC can provide valuable information about where the classification works well and where evidence suggests it can be improved. We would like to hear from you so we can adjust class designations if warranted. Please use the table below to submit possible errors for evaluation and consideration. Additional rows can be added if required.

Please email the completed form to aec@ontario.ca.

Name	
Position	
Organization	
Primary use of the AEC	

AEC reach ID [ProvReachID]	Current class	Suggested class	Reason for change
R7.1234	CLCF	CDCF	Measured average July water temperature was below 16 ˚C between 2015 and 2020
Mariposa Brook: R5.11983 to R5.11941	CWTS	CWCS	Main creek channel is not turbid during summer
Nowhere Creek: all reaches upstream of R33.1234	CDCF	CDTF	Entire upstream watershed is turbid all year

Appendix 2

AEC class colour symbology hexadecimal number (HEX #) and RGB (red, blue, and green) values.

Stream class	HEX #	Red	Green	Blue
CDCF	4C0073	76	0	115
CDCS	A900E6	169	0	230
CDTF	DF73FF	223	115	255
CDTS	E8BEFF	232	190	255
CCCF	002673	0	38	115
CCCS	0070FF	0	112	255
CCTF	73B2FF	115	178	255
CCTS	BEE8FF	190	232	255
CLCF	264500	38	69	0
CLCS	267300	38	115	0
CLTF	4CE600	76	230	0
CLTS	A3FF73	163	255	115
CWCF	636300	99	99	0
CWCS	A8A800	168	168	0
CWTF	E6E600	230	230	0
CWTS	FFFF9D	255	255	157
WMCF	900000	144	0	0
WMCS	E63535	230	53	53
WMTF	FF8D8D	255	141	141
WMTS	FFC8C8	255	200	200

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