Board of Directors Meeting
Agenda

October 28, 2022

9:30 A.M.

The meeting will be conducted via a video conference

Members of the public may view the livestream at the following link:

https://video.isilive.ca/trca/live.html

8.4. PARTNERS IN PROJECT GREEN EXECUTIVE MANAGEMENT COMMITTEE MINUTES

8.4.1 Meeting #1/22 held on March 22, 2022

8.4.2 Meeting #2/22 held on June 7, 2022

8.5. EXECUTIVE COMMITTEE HEARING MINUTES

8.5.1 Meeting held on September 9, 2022

9. MATERIAL FROM EXECUTIVE COMMITTEE MEETING

Executive Committee Minutes

9.1. SECTION I - ITEMS FOR THE BOARD OF DIRECTORS ACTION

9.1.1. AGRICULTURAL LEASE RENEWAL - FORMER WILSON AND SPEIRS PROPERTY

Renew 1-year agricultural lease agreement on Toronto and Region Conservation Authority (TRCA) owned lands located east of Humber Station Road and south of Castlederg Sideroad, being Part of Lots 12 and 13, Concession 5, in the Town of Caledon, Regional Municipality of Peel, Humber River watershed

(Link to report, excluding appendices: Executive Committee RES.#B83/22)
PDF Page 10/129

9.1.2. AGRICULTURAL LEASE RENEWAL - FORMER GILLAN PROPERTY

Renew 1-year agricultural lease agreement on Toronto and Region Conservation Authority (TRCA) owned lands located south of Coolihans Sideroad and east of Glen Haffy Road, being Part of Lot 35, Concession 2, in the Town of Caledon, Regional Municipality of Peel, Humber River watershed

(Link to report, excluding appendices: Executive Committee RES.#B84/22)
PDF Page 14/129

9.1.3. ACQUISITION FROM 31, 33, 35, 37, 39 LAKELAND DRIVE, TORONTO

Acquisition of property located south of Lakeland Drive and east of Kipling Avenue, municipally known as 31, 33, 35, 37, and 39 Lakeland Drive, in the City of Toronto under the "Greenspace Acquisition Project for 2021-2030," Flood Plain and Conservation Component, Humber River watershed

(Link to report, excluding appendices: Executive Committee RES.#B85/22)
PDF Page 18/129

9.1.4. TRCA REAL PROPERTY PORTFOLIO SURPLUS LAND STRATEGY

Assessment of Toronto and Region Conservation Authority's (TRCA) Real Property Portfolio and Recommendation of a Strategy that Reflects Organizational Objectives and Aligns Real Estate Solutions to Meet those Objectives in the Most Effective and Efficient Manner

(Link to report, excluding appendices: Executive Committee RES.#B86/22)
PDF Page 24/129

9.1.5. SERVICE LEVEL AGREEMENTS FOR INFRASTRUCTURE PLANNING AND PERMITTING PLAN REVIEW SERVICES

Update on service level agreements for infrastructure planning and permitting plan review services, environmental assessment and development application review services with provincial and other agencies undertaking infrastructure and utility projects

(Link to report: Executive Committee RES.#B87/22)
PDF Page 39/129

9.2. SECTION II - ITEMS FOR THE EXECUTIVE COMMITTEE ACTION (FOR INFORMATION OF THE BOARD)

9.2.1. APPLICATION FOR PERMIT PURSUANT TO S.28.0.1 OF THE CONSERVATION AUTHORITIES ACT (MINISTER'S ZONING ORDER, ONTARIO REGULATION 345/22)

Issuance of permission pursuant to Section 28.0.1 of the Conservation Authorities Act (CA Act) to make site alterations within a Regulated Area to enclose a portion of the Pomona Mills Creek watercourse and site grade within lands located south of Langstaff Boulevard, east of Yonge Street, City of Markham, Regional Municipality of York

(Link to report, excluding appendices: Executive Committee RES.#B88/22)
PDF Page 42/129

9.3. SECTION III - ITEMS FOR THE INFORMATION OF THE BOARD

9.3.1. 2022 SIX MONTH FINANCIAL REPORT

Receipt of Toronto and Region Conservation Authority's (TRCA) unaudited expenditures as of the end of the second quarter, June 30th, 2022, for informational purposes

(Link to report, excluding appendices: Executive Committee RES.#B89/22)
PDF Page 55/129

9.3.2. GREENSPACE SECUREMENT MANAGEMENT PLAN

Summary report on the Toronto and Region Conservation Authority (TRCA) Greenspace Securement Management Plan

(Link to report, excluding appendices: Executive Committee RES.#B90/22)
PDF Page 62/129

9.4. SECTION IV - ONTARIO REGULATION 166/06, AS AMENDED

9.4.1. TOWN OF CALEDON - 13540 CALEDON KING TOWNLINE ROAD SOUTH (ALBION)

13540 CALEDON KING TOWNLINE ROAD SOUTH (ALBION)

The purpose is to facilitate the construction of stormwater management infrastructure associated with a new residential plan of subdivision located at 13540 Caledon King Townline Road South, in the Town of Caledon

(Link to report: Executive Committee RES.#B91/22)
PDF Page 81/129

9.4.2. TOWN OF CALEDON - 9861 COLUMBIA WAY (ALBION)

9861 COLUMBIA WAY (ALBION)

The purpose is to facilitate the construction of a new single family home on the subject property, with associated servicing. The property is located on the south side of Columbia Way, between the King-Caledon Townline and Mount Hope Road, in the Town of Caledon

(Link to report: Executive Committee RES.#B92/22)
PDF Page 85/129

9.4.3. TOWN OF CALEDON - 13540 CALEDON KING TOWNLINE ROAD SOUTH (ALBION)

13540 CALEDON KING TOWNLINE ROAD SOUTH (ALBION)

The purpose is to facilitate the site grading and servicing for a draft approved residential plan of subdivision located at 13540 Caledon King Townline Road South, in the Town of Caledon

(Link to report: Executive Committee RES.#B93/22)
PDF Page 89/129

9.4.4. CITY OF BRAMPTON - COLERAINE DRIVE AND COUNTRYSIDE DRIVE

COLERAINE DRIVE AND COUNTRYSIDE DRIVE

The purpose is to undertake works within a TRCA Regulated Area of the Humber River Watershed in order to facilitate the realignment of Segment 2 of Rainbow Creek utilizing a natural channel design located south of Countryside Drive and West of Coleraine Drive, in the City of Brampton

(Link to report: Executive Committee RES.#B94/22)
PDF Page 94/129

9.4.5. STANDARD DELEGATED PERMITS FOR RECEIPT - STAFF APPROVED AND ISSUED

Receipt of permits pursuant to Ontario Regulation 166/06, as amended, for applications under item 10.5 which were received at the October 7, 2022 Executive Committee Meeting

(Link to report: Executive Committee RES.#B95/22)
PDF Page 100/129

9.5. OCTOBER 7, 2022 EXECUTIVE COMMITTEE MEETING CLOSED SESSION ITEMS

9.5.1. RIZMI HOLDINGS LIMITED – UPDATE ON OLT APPEALS

Pursuant to Section C.4.(e) of the TRCA Board of Directors Administrative By-Law, as the subject matter consists of litigation or potential litigation, including matters before administrative tribunals

Executive Committee RES.B#96/22

(The confidential report will be circulated to Board Members separately)

10. CLOSED SESSION

11. NEW BUSINESS

NEXT MEETING OF THE BOARD OF DIRECTORS #8/22, TO BE HELD ON NOVEMBER 10, 2022 AT 9:30 A.M. VIA VIDEO CONFERENCE

John MacKenzie, Chief Executive Officer

/jh

Item 7.1

Section I – Items for Board of Directors Action

TO:	Chair and Members of the Board of Directors Friday, October 28, 2022 Meeting
FROM:	Anil Wijesooriya, Director, Restoration and Infrastructure
RE:	**VALUE INCREASE-VENDOR OF RECORD ARRANGEMENT FOR SUPPLY AND DELIVERY OF VARIOUS PLANT MATERIALS** Contract No. 10022885

KEY ISSUE

Value increase required to complete the term of Contract No. 10022885 – Vendors of Record (VOR) arrangement for supply and delivery of various plant materials.

RECOMMENDATION:

WHEREAS Toronto and Region Conservation Authority (TRCA) is engaged in a variety of programs/projects that require a significant volume of native trees and shrubs;

AND WHEREAS TRCA solicited proposals through a publicly advertised process and awarded Contract No. 10022885 to Neil Vanderkruck (NVK) Holdings Inc., Dutchmaster Nurseries Ltd., Sheridan Nurseries Ltd., Verbinnens Nursery Ltd., Hillen Nurseries Ltd., and Baker Forestry Services at the May 22, 2020 Board of Directors Meeting (RES.#A62/20);

AND WHEREAS TRCA has been involved in projects which have a greater demand for various plant material than originally estimated for this contract;

THEREFORE LET IT BE RESOLVED THAT staff be directed to increase the value of the contract by a total not to exceed $750,000, plus applicable taxes, in order to allow work to continue until the contract expiry date of July 31, 2023, thereby increasing the upper limit of the contract from $2,250,000 to $3,000,000.

BACKGROUND

TRCA requires large volumes of native trees and shrubs for habitat restoration and erosion control, as well as education and outreach initiatives with municipal, regional and community partners.

Through a VOR arrangement for various plant materials, Vendors are authorized to provide these goods and services for a defined period and with fixed pricing. In accordance with the contract documents for the VOR arrangement, staff may allocate goods and services to a specific vendor on the VOR list based on:

- TRCA's determination that a vendor has (and the other vendors on the VOR list do not have) the ability to deliver specific species;
- Availability of plant material that conforms to the Canadian Standards for Nursery Stock, 9th Ed.; and/or
- Optimal pricing for a particular project that is necessary or highly advisable in the circumstances (for reasons of safety, quality or value for money).

Furthermore, where the vendors on the VOR list are not able to supply goods for a particular project TRCA to meet its deliverables, staff are authorized to procure the required services following TRCA's Procurement Policy.

At Board of Directors Meeting held on May 22, 2020, Resolution #A62/20 was approved as follows:

> *THAT TRCA staff be directed to establish a Vendor of Record arrangement with Neil Vanderkruk (NVK) Holdings Inc., Dutchmaster Nurseries Ltd, Sheridan Nurseries Ltd., Verbinnen's Nursery Ltd., Hillen Nurseries Ltd., and Baker Forestry Services for the supply of various plant materials for a three-year period from August 1, 2020 to July 31, 2023.*

RATIONALE
TRCA staff have been utilizing this VOR contract since August 1, 2020 to accommodate the need for various plant material for habitat restoration and engineering projects, as well as education and outreach initiatives throughout TRCA's jurisdiction. Plant Nurseries provide TRCA staff with unit pricing and availability of upwards of 83 different plant species.

Categories of plant species under this VOR contract include the following:

- Deciduous Shrubs 1 Gallon & 2 Gallon;
- Deciduous Trees 2 Gallon, 3 Gallon, 15 Gallon;
- Coniferous Trees 2 Gallon & Balled and Burlapped

It is estimated that in order to reach the full three (3) year term of this contract (August 1, 2020 to July 31, 2023) a value increase in the amount of $750,000, plus applicable taxes will be required. This value is estimated based on the daily expenditures under this contract at the time of writing this report. The original value of this contract was underestimated, as TRCA has taken on projects that have a greater need for plant material than originally anticipated.

The Restoration & Infrastructure division within TRCA has taken on a large portfolio of projects that utilize various plant material, including:

- Rouge National Urban Park – Riparian and wetland plantings;
- Tommy Thompson Park – Wetland, riparian and forest plantings;
- Clareville Conservation Area – Restoration planting;
- Albion Hills Conservation Park – Restoration planting;
- Robinson Creek – Restoration planting and
- Paul Coffey Park – Riparian and stream planting

While TRCA staff make every reasonable effort to accurately forecast expenditures under these VOR contracts at the time of award, increases or decreases in plant requirements have and will continue to have an impact on the total value of these contracts.

Relationship to Building the Living City, the TRCA 2013-2022 Strategic Plan
This report supports the following strategies set forth in the TRCA 2013-2022 Strategic Plan:
Strategy 1 – Green the Toronto region's economy
Strategy 3 – Rethink greenspace to maximize its value
Strategy 6 – Tell the story of the Toronto region

Strategy 10 – Accelerate innovation

FINANCIAL DETAILS

The original Vendors of Record (VOR) arrangement for supply and delivery of plant materials, Contract No. 10022885, approved at the May 22, 2020 Board of Directors Meeting was valued at $2,250,000 for the three year term. The value of the extension required to complete the term of this contract is estimated at $750,000, raising the total value to $3,000,000 plus applicable taxes.

All vendors on the VOR list understand both the potential cost and resource implications associated with changes in workload. The goods and services under this VOR contract will be provided on an “as required” basis with no minimum orders guaranteed.

This VOR ensures consistent pricing and streamlined delivery of various plant material to improve operational efficiency at TRCA projects.

Plant material purchased through this VOR is used to support a variety of capital and cost recoverable project accounts. The funds required for supply and delivery of various plant materials are budgeted directly within these accounts.

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Date: September 7, 2022

Item 7.2

Section I – Items for Board of Directors Action

TO:	Chair and Members of the Board of Directors Friday, October 28, 2022 Meeting
FROM:	Sameer Dhalla, Director, Development and Engineering Services
RE:	**TRCA’S UPDATED NATURAL HERITAGE SYSTEM (NHS) AND WATER RESOURCE SYSTEM (WRS) MAPPING**

KEY ISSUE
Board approval of Toronto and Region Conservation Authority's (TRCA) updated regional target Natural Heritage System (NHS) and Water Resource System (WRS) mapping. These products inform TRCA and its municipal partners in land use planning, ecosystem restoration and management, land securement, and other conservation efforts in the watersheds of the Toronto region.

RECOMMENDATION:

WHEREAS urbanization and climate change continue to impact ecosystem health and community well-being, unless mitigated;

AND WHEREAS provincial policies direct municipalities to protect and enhance key natural heritage and hydrological features and areas as part of the land use planning process;

AND WHEREAS TRCA, as a science-based organization, generates and shares up-to-date information on natural heritage and water resources to support TRCA’s initiatives and those of its partner municipalities;

AND WHEREAS TRCA has developed two science-based proactive screening tools: first, the updated regional target Natural Heritage System (NHS) mapping, and second, Water Resources System (WRS) mapping. These products provide an update to the mapping component of the Terrestrial Natural Heritage System Strategy (TNHSS) approved by the TRCA Board in 2007;

AND WHEREAS TRCA’s approach for developing the updated regional target NHS and WRS mapping aligns with the ecological principles of the TNHSS, and the Natural Systems planning principles of The Living City Policies for Planning and Development in the Watersheds of the TRCA as approved by the Board of Directors in 2014;

AND WHEREAS TRCA engaged regional and local municipalities, neighbouring conservation authorities, provincial ministries, agricultural communities, the Building Industry and Land Development Association (BILD), and Indigenous communities in the development of the mapping and incorporated feedback into the screening tools;

AND WHEREAS the draft updated mapping has already been informing the initiatives of TRCA and its partner municipalities, including Municipal Comprehensive Reviews and local municipal Official Plan Reviews, watershed planning, ecosystem restoration and management, land securement and management, climate adaptation initiatives, and land use and infrastructure planning processes;

THEREFORE, LET IT BE RESOLVED THAT the Board of Directors approve TRCA's updated regional target NHS and WRS mapping and that these products be used as screening tools to support and inform municipal natural heritage and water resource systems planning, implementation of The Living City Policies for Planning and Development in the Watersheds of the TRCA, and TRCA programs and services related to the management of conservation authority lands;

AND THAT TRCA staff communicate the final approval of the TRCA's updated regional target NHS and WRS mapping to all its partners and stakeholders engaged in the consultation process related to its updating and development.

BACKGROUND

Urbanization is the process of converting natural cover (e.g., woodland, wetland, meadow) or agricultural land to urban land uses usually dominated by impermeable surfaces (e.g., buildings, roads, parking lots). Within TRCA's jurisdiction, just over half of the land base has been converted to urban land uses. Left unmitigated, urbanization has a negative impact on ecosystem functions and services that are vital for watershed health and community well-being. These impacts are further exacerbated by climate change and associated extreme events unless measures are put in place to build resilience.

Provincial policies recognize these challenges and require that municipal growth management strategies and policies protect, restore, and enhance natural systems. The Provincial Policy Statement (PPS, 2020) and provincial plans support natural systems planning by requiring municipalities to identify and protect NHS and WRS in their Official Plans (OP).

TRCA's partner municipalities often rely on TRCA to provide up-to-date data and science-based information that they can use to achieve policy conformity and shared objectives for environmental resilience and sustainable communities. In this regard, TRCA has developed updated NHS and WRS mapping to assist our partner municipalities in growth management exercises including infrastructure planning and other conservation efforts as they see fit.

The analysis used to produce this mapping is based on well accepted scientific foundations with a view to informing natural heritage and water resource systems planning and management over the long term. Given the long-term planning horizon in OPs, the growth and development pressures in TRCA's watersheds, and the ongoing effects of urbanization and climate change, a science based, long term view is critical to sustainability and resilience.

The objective of the NHS and WRS mapping is to provide updated science-based information that aligns with the ecological principles of TRCA's Terrestrial Natural Heritage System Strategy, approved by the Board of Directors in 2007 (Resolution #A306/06) and the natural systems planning principles of TRCA's Living City Policies (2014). The mapping is intended to inform ecosystem planning and management activities for TRCA and its partner municipalities, including watershed planning, land use and infrastructure plan reviews, ecosystem restoration and management, and Municipal Comprehensive Reviews (MCRs) and lower tier municipal OP conformity.

The mapping can be used as a screening tool and is meant to identify opportunities and facilitate partnerships for healthy and resilient natural systems within the Toronto region. Given that these tools were developed at a regional scale based on the best available data and information of the time, they will require refinements based on finer level data, as appropriate, for application at a site scale.

As screening tools, this mapping is not intended to replace the need for additional investigation and field data collection part of current planning processes. Accordingly, these tools are not intended to disrupt or prohibit existing permitted uses (e.g., agriculture) or change current decision-making regarding site-specific planning and infrastructure approvals.

The following two sub-sections provide more detail on the approach used to develop TRCA's updated regional target NHS and WRS mapping screening tools.

TRCA's updated Natural Heritage System (NHS)
In the early 2000s, TRCA developed a regional Terrestrial Natural Heritage System Strategy (TNHSS) applying an ecosystems approach to establish a network of natural cover (forest, wetland, meadow, successional, bluffs and beach) within the Toronto region targeted for protection and restoration. The primary intent was to address the declines in native biodiversity by focusing on terrestrial natural cover. After an extensive consultation process, the TRCA Board approved the TNHSS in 2007.

The TNHSS was used by several municipalities for informing their own natural heritage systems planning and helped inform various ecosystem protection, restoration, and management efforts by TRCA and partner municipalities. Integrated into TRCA's The Living City Policies, the TNHSS reflects the fundamental principles of ecology and conservation science that a diverse, robust, and well-connected natural heritage system is the foundation of a sustainable and resilient community.

Since 2007, landscape changes due to our jurisdiction's continued growth and intensification and the impacts of climate change demonstrate the need for updates the mapping of the TNHSS. The current update for NHS mapping, embodies the principles of the TNHSS and builds on them, with analysis that spans both terrestrial and aquatic ecology including natural heritage features and areas.

Using a science-based integrated systems approach, the mapping identifies existing natural heritage features and areas and priority areas with potential for restoration and enhancement of ecological functions. These restoration areas provide cohesiveness and connectivity necessary for maintaining robust, resilient natural systems. This approach includes both terrestrial and aquatic ecosystem priorities as well as the linkages between them (i.e., hydrological linkages) and accounts for the contribution of entire watersheds - from urban to rural areas - to achieve natural heritage functions.

TRCA's updated regional target NHS promotes TRCA's ecosystem health that supports natural systems and the ecosystem services they provide in a region heavily impacted by land use and climate change. It aligns with the PPS (2020) that require municipalities to identify natural features and areas and protect them for the long term (PPS 2020; 2.1.1) and emphasizes that "*the diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of natural heritage system, should be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features and ground water features*" (PPS 2020; 2.1.2).

Technical approach:
To produce the mapping, multiple data sets were used as input criteria in an optimization model called MARXAN. The data sets were both existing and new and characterized ecosystem features and functions. MARXAN helped staff to identify the most strategic areas that maximizes inclusion of highest priority areas for all input criteria. The input criteria included existing natural features and areas such as woodlands, wetlands, and Areas of Natural and Scientific Interest.

New analyses were completed to identify priority areas for aquatic and terrestrial species habitat. These include priority upland areas important for sensitive in-stream habitat, important hydrological linkage areas, areas with high suitability for various species and vegetation communities, wildlife connectivity/movement priority areas, and areas with high biodiversity. A consolidated municipal NHS map that included all NHS mapping in the municipal official plans in TRCA's jurisdiction (as of 2018) was also used as one of the input criteria.

Detailed methods and the full list of criteria are summarized in the NHS Update Summary Report included here (Attachment 1) and highlighted in the online dashboard (Link here).

Applying this approach, TRCA's updated regional target NHS (Figure 1) identifies about 35% of the TRCA's jurisdiction as NHS comprising *Existing Natural Cover* (ENC) (23.3%) and *Potential Natural Cover* (PNC) (11.9%) that can be prioritized for protection and restoration, respectively; *Contributing Areas (16.5%)* were also identified as part of the target system as areas meant to support NHS features and functions.

Contributing Area include areas that are ecologically important but mostly within urban land uses where traditional restoration opportunities may be limited due to existing conditions (e.g., built areas) and/or planned objectives (e.g., approved for future development). Contributing Areas are intended for sustainable and resilient urban design solutions, where Low Impact Development and Green Infrastructure (GI) can be implemented.

Strategically targeting ENC, PNC, and Contributing Areas prioritizing both natural and built portions of TRCA's watersheds for protection, restoration, and GI enhancements, will result in a healthy and resilient NHS that sustains ecosystem functions and services over the long term.

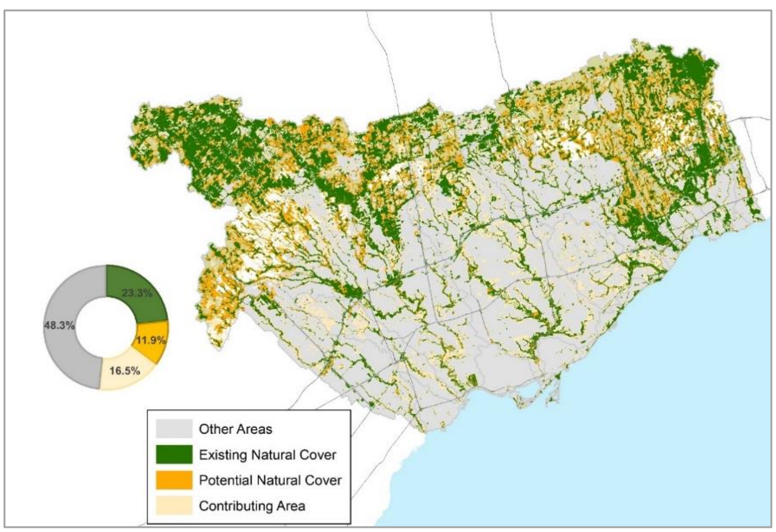


Figure 1: TRCA's updated regional Target Natural Heritage System (NHS).

TRCA Water Resource System (WRS)

The Water Resource System (WRS) is defined and described in provincial policies and plans. Specifically, the Growth Plan for the Greater Golden Horseshoe (2020) highlights that the Water Resource System (WRS) includes Key Hydrological Features and Key Hydrological Areas that are important for hydrological functions over long term which are needed to sustain ecosystems and our communities.

Additionally, the Greenbelt Plan highlights that both the NHS and WRS are vital components of natural systems and should be managed as an integrated system. Protecting the WRS is imperative for protecting water quality and quantity, aquatic and terrestrial ecosystem health, and for mitigating erosion and flooding.

There are eight key components of the WRS that were delineated using definitions provided in the Growth Plan (2020). The WRS is the output of compiled and consolidated information from various data sources across TRCA's watersheds, including both field and modelled data. The components include:

Key Hydrologic Features

- Permanent and Intermittent streams
- Inland lakes and their littoral zones
- Seepage areas and springs
- Wetlands

Key Hydrologic Areas

- Significant Groundwater Recharge Areas (SGRAs)
- Highly Vulnerable Aquifers (HVAs)
- Significant Surface Water Contribution Areas (SSWCAs),
- Ecologically Significant Groundwater Recharge Areas (ESGRAs).

Of these eight components, two KHAs - Highly Vulnerable Aquifers (HVAs) and Significant Groundwater Recharge Areas (SGRAs) - were developed to satisfy requirements of the Source Protection Plan for Credit Valley, Toronto and Region and Central Lake Ontario region (CTC-SPC 2015) under the Clean Water Act (2006). Thus, there is already a process in place for HVAs and SGRAs, which is detailed in other referenced materials. These layers were used as-is for the WRS mapping. The other two KHA data layers - ESGRAs and Seepage areas and Springs - were generated by TRCA with guidance from the Province and partner CAs to ensure complete mapping of WRS across TRCA watersheds. The remaining data layers were updated and refined based on available data.

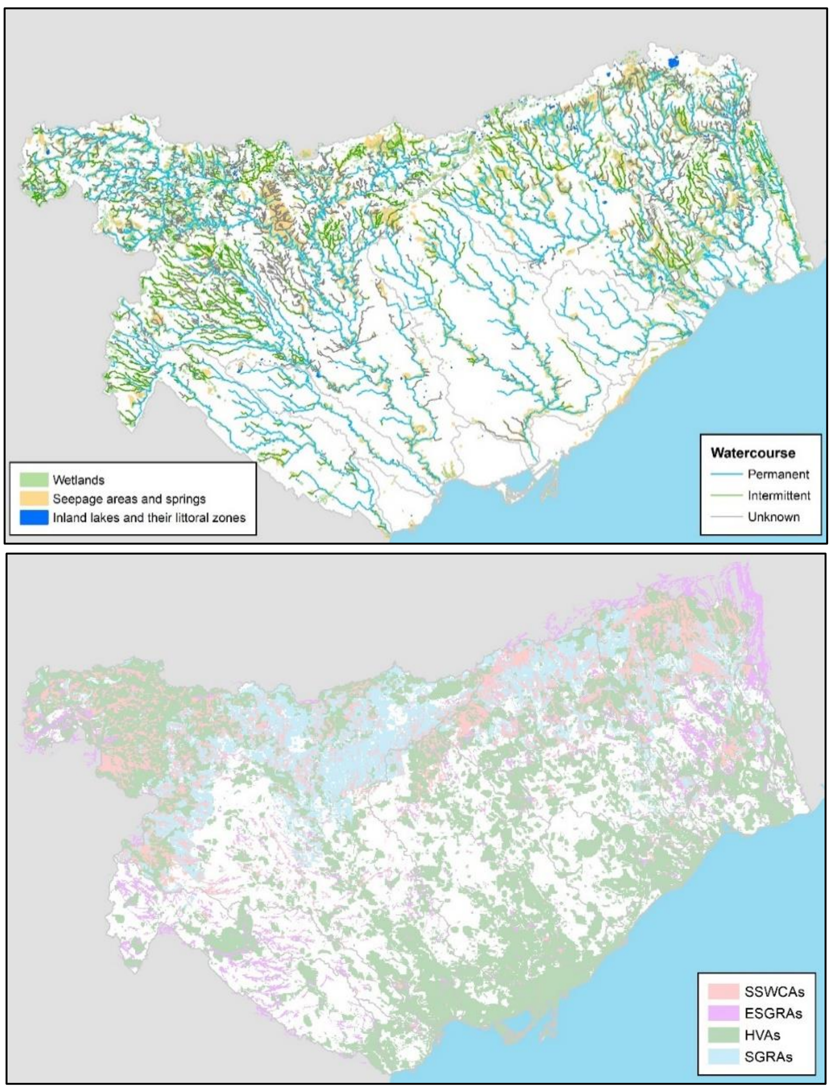
Detailed methods are summarized in the WRS Summary Report included here (Attachment 2) and highlighted in TRCA's Watershed and Ecosystem Reporting Hub (Link here).

TRCA's WRS mapping (Figure 2) includes 64.8% of TRCA jurisdiction. This includes HVAs (43.3%), SGRAs (29.1%), ESGRAs (13.9%), seepage areas and springs (10.4%), SSWCAs (9.3%), wetlands (4.4%), and inland lakes and their littoral zones (0.4%). Classification of watercourses found that permanent (46.6%) and intermittent (21.1%) streams make up most of the watercourses, however, there remains a large portion of unknown watercourses (i.e., data deficient; 32.2%).

The highest area coverage in the WRS is due to two KHAs - HVAs and SGRAs. As discussed above, these are also protected through Source Water Protection policies and have separate processes for implementation.

Other KHAs (ESGRA and SSWCA) and KHFs (seepage areas and springs) also cover substantial portions of TRCA's jurisdiction and may extend outside the natural areas into the built environment. While this doesn't preclude policy requirements for avoidance, where possible, key hydrological features and functions should be maintained through mitigation measures (i.e., water balance). The WRS mapping provides a broader system picture of ecohydrological processes occurring on the landscape that can better inform the finer levels of the planning at the site scale where further field level data can inform management actions to protect and enhance the WRS.

As outlined in the earlier section, the WRS mapping is based on a systematic and science-based method and provides a robust screening tool for TRCA and its municipal partners to identify important hydrological features and areas for their various initiatives.



(a)

(b)

Figure 2: TRCA's Water Resource System Mapping (a) Key Hydrologic Features, and (b) Key Hydrologic Areas.

Engagement Approach and Feedback
TRCA staff engaged with municipal staff on a regular basis throughout the development of TRCA's updated regional target NHS and WRS mapping. Specifically, this has mostly occurred with initiatives related to watershed planning and MCR processes. In addition, upon completion of the draft mapping, TRCA staff hosted a technical webinar (virtual) on October 2021 where draft mapping and information was shared with the representatives from local and regional municipalities, the Province (MECP, NDMNRF, MMAH), and other conservation authorities (CVC, LSRCA, CLOCA, CH, NVCA). A total of 65 participants attended the webinar and provided feedback at and after the webinar during the commenting period.

TRCA staff also hosted a virtual meeting with First Nations in October 2021 to share information on TRCA's updated regional target NHS and WRS mapping and receive feedback. This meeting was attended by 10 representatives from Beausoleil First Nation, Curve Lake First Nation, Mississaugas of the Credit First Nation, and Six Nations of the Grand River.

Lastly, TRCA staff presented TRCA's updated regional target NHS and WRS mapping information to representatives of the Building Industry and Land Development (BILD), Peel Agricultural Advisory Working Group, Durham Agricultural Advisory Committee, and York Region Agricultural and Agri-Food Advisory Committee meetings in February and March 2022.

TRCA's updated regional target NHS and WRS mapping information and draft data layers were shared at these engagement sessions, which yielded more than a hundred comments. Overall, the external comments were generally supportive of the intent, structure, and content of the draft mapping. It should be noted that some participants had seen the draft mapping previously through discussions with TRCA Watershed Planning and Ecosystem Science staff for MCR, Settlement Area Boundary expansion, and watershed planning discussions.

Overall, the feedback indicates that the draft mapping is helpful as a high-level screening tool to inform natural heritage and water resource system protection, restoration, and enhancement initiatives. More specifically, many comments focused on site-level data accuracy and suggestions for revisions, which have been completed by TRCA staff. There were some comments seeking clarification on the intent of these tools and how they are meant to be implemented. In response, this was clarified in the updated report and the mapping disclaimers. The comments sheet (Attachment 3) documents all comments received and how TRCA staff addressed them through revisions and/or provided response to, as appropriate.

Furthermore, the draft versions of the TRCA's updated regional target NHS and WRS mapping have already been used by TRCA staff and municipal staff to inform the NHS and WRS mapping and policy directions in the updated Regional Official Plans, many of which have been adopted by Regional Councils (and are pending final approval from the Province).

Additionally, some municipalities such as The City of Toronto have incorporated components of the NHS (e.g. subset of the Contributing Areas) and WRS (e.g. wetlands, ESGRAs) mapping directly into their OP schedules. These draft screening tools have also been used to inform various TRCA initiatives including watershed planning (Etobicoke Creek Watershed Plan), land use and infrastructure plan reviews, and ecosystem restoration, with appropriate refinements.

RATIONALE
With the conclusion of the technical analysis, review, and engagement with partner municipalities, the Province, agricultural communities, BILD, and Indigenous communities, TRCA's regional target NHS and WRS mapping has now been finalized. All the comments

received from the engagement have been incorporated and appropriate revisions have been made. The final draft of the screening tool and the data layers have informed the MCR processes, as intended.

This multi-year initiative to develop a strategic, defensible, and operational science-based screening tool provides a robust basis for informing the protection and enhancement of the natural heritage and water resource systems of the region within TRCA's jurisdiction. These tools can inform various initiatives of TRCA, and its municipal partners as outlined earlier and will be accessible for viewing through TRCA's Watershed and Ecosystems Reporting Hub. These regional tools will be kept up to date at a regional scale through regular updates on a three-to-five-year cycle to align with other strategic initiatives. At finer scales they will be refined through watershed planning processes (e.g., Etobicoke Creek Watershed Plan and Humber River Watershed Plan) as well as through land use and infrastructure planning processes that can provide additional site level data.

We recommend that the TRCA Board of Directors approve the TRCA's regional target NHS and WRS mapping to support biodiversity and ensure that ecosystem features and functions within the Toronto region remain resilient to the pressures of urbanization and a changing climate. The mapping is intended to be used as a regional scale screening tool that should be refined, as appropriate, if it is to be applied at the site scale. A more comprehensive discussion of biodiversity initiatives that TRCA is currently involved in will be provided in a future Board report.

Relationship to Building the Living City, the TRCA 2013-2022 Strategic Plan
This report supports the following strategies set forth in the TRCA 2013-2022 Strategic Plan:
Strategy 2 – Manage our regional water resources for current and future generations
Strategy 3 – Rethink greenspace to maximize its value
Strategy 4 – Create complete communities that integrate nature and the built environment
Strategy 12 – Facilitate a region-wide approach to sustainability

FINANCIAL DETAILS
The development of the TRCA's updated regional NHS and WRS mapping and engagement was supported by capital funding from the regional municipalities of York, Peel, and Durham and the City of Toronto (capital levy accounts 104-23, 120-62, and 120-02). Additionally, TRCA staff secured external funding in the form of grants from Mitacs Inc. and Great Lakes Sustainability Fund to complete parts of the project.

DETAILS OF WORK TO BE DONE
As updates to existing TRCA documents, policies, plans and processes occur or as new documents are produced, TRCA's updated regional NHS and WRS mapping will be referenced. The updated NHS and WRS mapping also helps staff achieve Living City Policies and associated guidelines, watershed planning, land use and infrastructure plan review processes, ecosystem restoration and management, and land acquisition and management activities.

TRCA's updated regional NHS and WRS mapping will be posted on TRCA's website and will be reviewed every three to five years to reflect new science and any major updates on the ground confirmed through site and area specific processes, fieldwork, and scientific studies. TRCA will communicate the approval of TRCA's updated regional NHS and WRS mapping to our provincial, municipal and conservation authority partners as well as other partners and stakeholders including those consulted in the development and updating of the NHS and WRS mapping.

Item 7.2

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Date: August 29, 2022
Attachments: 2

Attachment 1: NHS Update Summary Report 2022
Attachment 2: WRS Summary Report 2022

Attachment 1:
NHS Update Summary Report 2022

TRCA Updated Target Natural Heritage System: A Summary Report

Prepared By:
Watershed Planning and Ecosystem Science
Development and Engineering Services
August, 2022

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EXECUTIVE SUMMARY

What is a Natural Heritage System (NHS)?

The impacts of urbanization and land conversion to urban uses have resulted in biodiversity habitat loss, fragmentation, and degradation that have affected ecosystem functions. Recognizing these impacts and the need to protect existing natural features/areas, as well as to restore potential ecologically functioning areas, the concept of an NHS was incorporated into the Provincial Policy Statement (PPS) in 1994. According to the PPS (2020), an NHS is:

> *"a system made up of natural heritage features and areas and linkages intended to provide connectivity (at the regional or site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species, and ecosystems. These systems can include natural heritage features and areas, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored or have the potential to be restored to a natural state, areas that support hydrologic functions, and working landscapes that enable ecological functions to continue".*

TRCA's updated regional target NHS (2022): An Overview

TRCA developed a regional strategy using a systems approach in 2007, referred to as the Terrestrial Natural Heritage System Strategy (TNHSS), to establish, protect, and restore a network of natural cover (forest, wetland, meadow, successional, bluffs and beach) across TRCA's jurisdiction. The primary focus was on improving terrestrial biodiversity (habitat and species) and ecosystem health. The natural heritage system identified in 2007 covered 30% of TRCA's jurisdiction including 25% existing natural cover and 5% potential areas to be restored to natural cover.

Building on the TNHSS, in 2022 TRCA completed an update to the technical component of the strategy using updated data and an integrated approach. TRCA's updated regional target NHS (2022) delineates key natural heritage features and areas that are important for TRCA's terrestrial and aquatic ecosystem health across the landscape. The updated regional target NHS:

- Builds on the systems approach of the TNHSS and ensures the regional target NHS remains current and relevant to achieve TRCA and its municipal partners' natural heritage objectives as land use and climate continue to change.
- Identifies the most strategic areas for the NHS that should be targeted for protection, restoration, and enhancements to improve terrestrial and aquatic ecosystem health and resilience within and across watershed boundaries based on the most up-to-date science and data.
- Provides an integrated and comprehensive decision support tool, as well as a series of stand-alone datasets, that helps to characterize terrestrial, aquatic, and hydrological priorities within and across the watersheds. This can inform various TRCA and municipal initiatives for ecosystem management and climate adaptation.

How was TRCA's updated regional target NHS identified?

Various datasets, both existing and new, that characterized ecosystem features and functions were used in the model to delineate the target NHS (2022).

These data are mainly classified into four major groups (described in Section 3.3. and Table 1):

- **Locked-in natural features and areas** – This group mainly includes 9 available datasets on natural features and areas that should be included by default within the NHS, such as all woodlands, wetlands, areas of scientific interest etc. In an urban landscape such as ours, these are the last remaining areas that contribute to overall ecosystem health.
- **Aquatic functions** – This group includes 6 datasets that identify the priority areas for aquatic species and habitat, including the upland areas that are important contributing areas for sensitive in-stream habitat and areas important for hydrological linkages.
- **Terrestrial functions** – This group includes 21 data layers that identify priority areas for terrestrial species and habitat, including areas predicted to have high suitability for multiple groups of species, connectivity priority areas, and areas with high diversity and/or combination of species and vegetation communities.
- **Municipal NHS** – This includes 1 consolidated data layer reflecting the areas that were identified as NHS priorities in municipal official plans (as of when the analysis was completed in 2020).

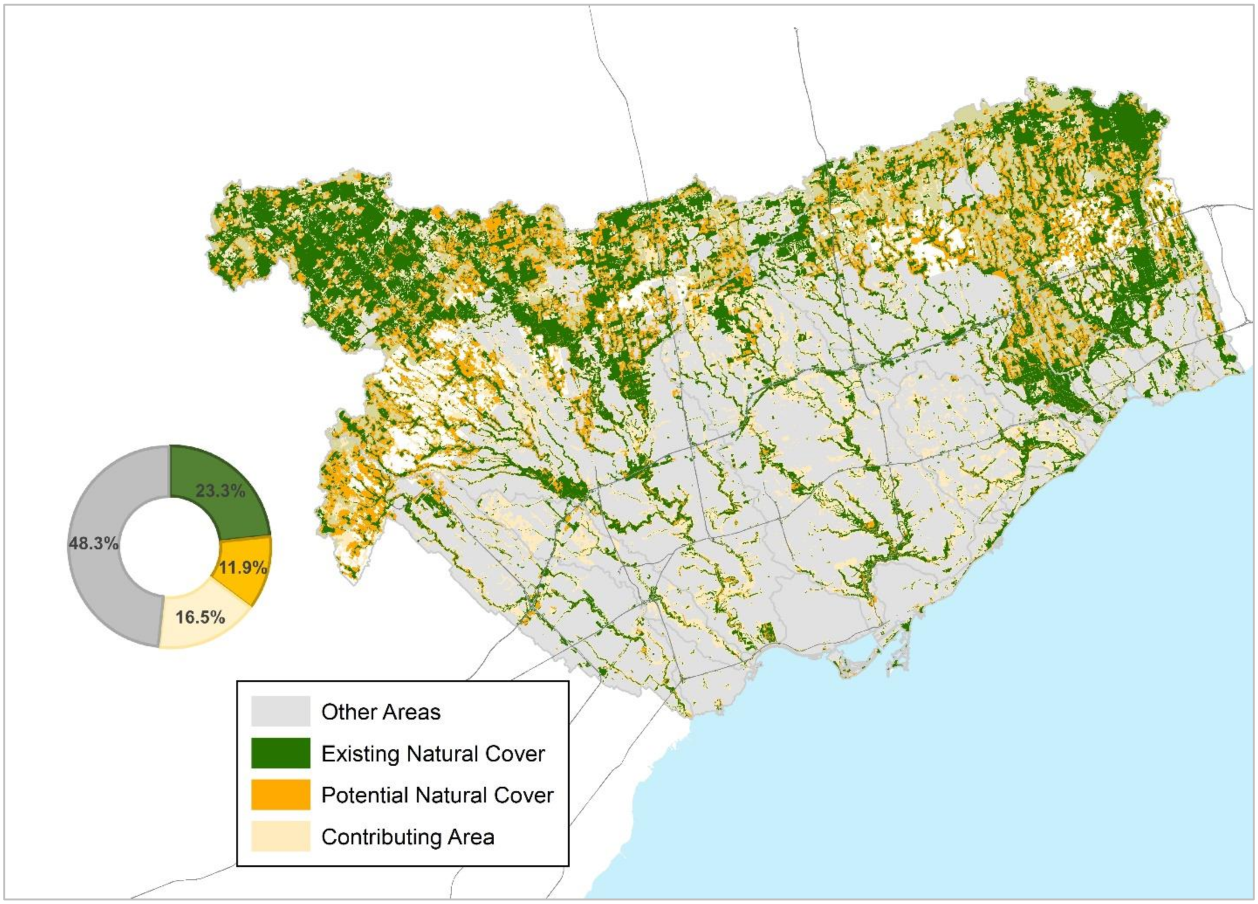
The locked-in natural features and areas were included by default in TRCA's regional target NHS as they represent mostly existing features. The other three groups of data layers were used to select additional areas, mostly for restoration and enhancements, using an optimization tool called Marxan (Ball et al. 2009). Marxan has been used globally to identify strategic areas for conservation based on various criteria and their set targets. It integrates and evaluates multiple criteria and their various combinations to identify the most optimal areas that can maximize the highest priority areas for all natural heritage functions selected for the target NHS.

In this analysis the proportion of representation for all criteria were set to select the highest functioning areas that equates to about 40% of the watershed area at watershed scale and 50% of the regional area at the regional scale. This allowed for identification of the most optimal and strategic areas for the target NHS that aligned with the ecological needs across TRCA's each individual watersheds and the region. These additional areas were merged with the locked-in areas to identify TRCA's regional target NHS.

The identified areas for TRCA's target NHS were then classified into three tiers with different yet related management focus based on their land use and land cover conditions as listed below:

- **Existing natural cover (ENC)** - Includes natural cover such as locked in features and areas that are important for natural heritage functions that could be targeted for protection
- **Potential natural cover (PNC)** – Includes expanded areas important for natural heritage functions that could be targeted for restoration, if feasible
- **Contributing areas** – Includes additional areas important for natural heritage functions *but* where traditional protection and restoration are likely not feasible and could be targeted for Low Impact Development and Green Infrastructure implementation. This is a new category

introduced in the TRCA's updated regional target NHS that aims to account for the contribution of the entire landscape including the built portions to achieve the NHS objectives.



What does TRCA's updated regional target NHS mean?

TRCA's updated regional target NHS is a science-based screening tool that highlights the existing and potential features and areas that are important for long term health and resilience of ecosystems in TRCA's jurisdiction. Provincial directions require municipalities to provide adequate protection and enhancements to the natural heritage system. TRCA's updated regional target NHS is intended to be a tool for TRCA and its municipal partners to inform various strategic and site level initiatives (with appropriate refinements). This includes informing watershed and subwatershed planning, land use and infrastructure planning, land securement and management, ecological restoration and green infrastructure implementation, municipal comprehensive reviews, and official plan review processes. TRCA's updated regional target NHS is not intended to disrupt existing decision-making processes, but rather to inform them based on up-to-date science and to identify partnership opportunities to facilitate collaborative conservation initiatives.

TRCA's updated regional target NHS identifies 35% of the TRCA's jurisdiction as target NHS comprising of existing natural cover (23.3%) and potential natural areas (11.9%). An additional 16.5% of the jurisdiction is identified as the Contributing Areas that support the NHS features and functions, but where traditional restoration opportunities may be limited due to its existing conditions (e.g., built areas) and/or future plans (e.g., approved for future development). The Contributing Areas are mostly within the urban land uses that have been identified as important for various ecological functions.

In terms of management implications, existing natural cover should ideally be targeted for protection and the potential cover should be targeted for restoration to increase natural cover quantity and quality, where possible. Given that the TRCA’s jurisdiction is highly urbanized, the existing natural cover is under various direct and indirect stress from urbanization as well as other stressors like climate change. The existing and potential natural areas identified in the target NHS will be a critical backbone of our ecological system across the jurisdiction for a healthier NHS. However, protecting and restoring these areas may not be enough to ensure long term resilience of the NHS given the exacerbated impacts and uncertainties associated with the combined effects of urbanization and climate change together.

TRCA’s updated regional target NHS identifies additional areas in the form of Contributing Areas where various enhancement opportunities, especially through green infrastructure and LID implementation could be targeted to improve ecosystem functions and services. This ensures that both natural and built portions of TRCA’s jurisdiction is strategically targeted for protection, restoration, and enhancements for a healthy and resilient NHS that can sustain ecosystem functions and services in the long run.

1. INTRODUCTION

1.1. Background

Urbanization pressure has continued to drive land conversion from natural cover to various land uses, dominated by impermeable built infrastructure. This has direct and indirect effects on ecological systems including its form and functions that provide various ecosystem services that humans benefit from and value. For example, the biophysical structures in the landscape (e.g., woodlands, wetlands) and the processes happening within them (e.g., net primary productivity and infiltration) enable proper functioning of the ecosystem (e.g., providing habitat for viable species populations and maintaining water flows). This produces important ecosystem services (e.g., wildlife viewing opportunities and flood protection) that benefit human well-being in various ways (e.g., improving mental health and safe communities). These ecosystem service benefits have numerous monetary and non-monetary values associated with them (e.g., savings in health care costs and insurance costs) that are important considerations to be accounted for in all aspects of decision-making at TRCA and its municipal partners for a resilient ecological and social system in Toronto and region. The interconnectedness between ecosystem function, services, and human well-being has been highlighted by United Nation’s Millennium Ecosystem Assessment (2005).

Land conversion to urban uses have resulted in biodiversity habitat loss, fragmentation, and degradation that have affected ecosystem functions including wildlife populations’ ability to persist in the landscape over long term (Saunders et al. 1991). Recognizing these impacts and the need to protect existing natural features and areas as well as to restore potential ecologically functioning areas the concept of Natural Heritage System (NHS) was incorporated into the Provincial Policy Statement (PPS) in 1994 (OMNR 2010). Based on the PPS (2020) NHS is defined as

> *“a system made up of natural heritage features and areas and linkages intended to provide connectivity (at the regional or site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species, and ecosystems. These systems can include natural heritage features and areas, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored or have the potential to be restored to a natural state, areas that support hydrologic functions, and working landscapes that enable ecological functions to continue.”*

TRCA and partner municipalities continue to recognize the need for strengthening ecosystem health across the jurisdiction. There are several policies, plans, programs, strategies, and initiatives put it place that aims to achieve this. TRCA Terrestrial Natural Heritage System Strategy (hereafter referred to as the TNHSS or the Strategy) (TRCA 2007) is one such initiative that was developed, through support of TRCA municipal partners to establish, protect, and restore a network of natural cover (forest, wetland, meadow, successional, bluffs and beach) across TRCA’s jurisdiction. The primary focus was on improving terrestrial biodiversity (habitat and species) and ecosystem health. The natural heritage system identified in 2007 covered 30% of TRCA’s jurisdiction including 25% existing natural cover and 5% potential areas to be restored to natural cover. The core principle of the Strategy was to increase quantity, quality, and distribution of terrestrial biodiversity across the entire jurisdiction, which would also enable a steady provision of other ecosystem services as co-benefits (e.g., flood protection, pest reduction, increased recreation, and aesthetic opportunities) that are vital for human well-being.

1.2. Rationale for TRCA’s updated regional target NHS

TRCA’s TNHSS has facilitated numerous initiatives to strengthen regional biodiversity, habitat, and ecosystems in the TRCA jurisdiction through protection, land acquisition and management, restoration, watershed planning, and development and infrastructure planning. In addition, TRCA staff has used the Strategy and the terrestrial NHS identified in 2007 to inform partner municipalities and Conservation Authorities to help achieve their natural heritage objectives and delineate the NHS by providing them with the technical advice, methodical approaches, and data. Given the utility of the regional target NHS to TRCA and its municipal partners in providing the systems-based information at watershed and regional scales, there is an ongoing need and interest in keeping it current and relevant with updated information from local and global science.

As such, TRCA completed a technical update to the 2007 terrestrial NHS to delineate TRCA’s updated regional target NHS (2022). It provides an update to the technical component of the Strategy using new data and an integrated approach. It delineates key natural heritage features and areas that are important for TRCA’s terrestrial and aquatic ecosystem health across the landscape. The updated regional target NHS:

- Aligns with the provincial guidance and builds on the systems approach of the TNHSS and ensure regional target NHS remains up-to-date to achieve TRCA and its municipal partners natural heritage objectives within the broader context of land use and climate change.
- Identifies most strategic areas for NHS that should be targeted for protection, restoration, and enhancements to improve terrestrial and aquatic ecosystem health and resilience within and across watershed boundaries based on the most up-to-date science and data.
- Provides an integrated and comprehensive decision support tool as well as a series of stand-alone datasets that helps to characterize terrestrial, aquatic, and hydrological priorities within and across the watersheds, which can inform various TRCA and municipal initiatives for ecosystem management and climate adaptation.

The need for the update was primarily driven by the land use and land cover changes on the ground over past decade and half, policy updates, and availability of the new data and updated science on natural systems management, especially within urban and near-urban context. More specifically, the following four key points helped scope TRCA’s updated regional target NHS:

- *Consolidated information on municipal Official Plan natural heritage systems as well as other updated land cover and land use information since 2007*
  Since 2007 there have been several land use and land cover changes in the TRCA’s watersheds. In addition, TRCA’s partner municipalities had advanced substantially in terms of developing their own NHS in their Official Plans. These regional and local municipal target NHS are the primary vehicles to protect and restore natural areas through their specific policy coverage. It is

important for TRCA's regional target NHS to account for the municipal priorities for NHS along with the science-based information on ecosystem forms and functions to ensure ecosystem and watershed health over long term.

- *Updated science and practice of natural systems planning (in an urban context):*
  Over the past decade and half the science and practice of natural systems planning has evolved substantially, especially in the urban context. Building on the principle of systems thinking, natural systems planning has progressed from focusing on only one component of the landscape (e.g., natural verses built, terrestrial verses aquatic) to an integrated mosaic of land, water, and built infrastructure, where all parts of the mosaic interact and contribute to ecosystem function at various levels. This evolved approach emphasizes expanded and creative ways of managing the landscape through protection, restoration, and urban design that can improve overall terrestrial and aquatic ecosystems in urban and near urban areas.
- *Identified existing climate change vulnerabilities of natural systems:*
  There has been an increased emphasis on the impact of climate change on ecosystem health over long term. TRCA has developed improved understanding and data that outlines climate change vulnerabilities of the natural system within its watersheds. This update to the target NHS provides an opportunity to incorporate this information to NHS planning and inform improve overall resilience of natural systems.
- *Available expanded field data and analytical capacity of TRCA:*
  TRCA's regional inventory and monitoring as well as special projects have amassed a large amount of field data and modelled ecological data that allows for advanced analysis to understand and inform NHS planning and implementation across TRCA jurisdiction. This includes field data on habitat and biodiversity as well as modelled data on habitat connectivity, habitat suitability, climate vulnerabilities etc.

1.3. Benefits of TRCA's updated regional target NHS?

TRCA's updated regional target NHS is intended to enable TRCA and its municipal partners to continue to be leaders in urban ecosystem planning and management. The target NHS and its associated data is intended to inform various initiatives of TRCA and its municipal partners. This includes watershed planning, policy planning, development and infrastructure planning, ecological restoration planning, and land management and acquisition. As more details become available at finer scales (e.g., watershed, sub-watershed, MESP, individual site) the regional information from the TRCA updated target NHS may be refined to add detailed information to reflect watershed and site level needs.

TRCA's updated regional target NHS will support many of the strategic objectives in the TRCA Strategic Plan 2013-2022, including Strategy 3: Rethink greenspace to maximize its value, Strategy 4: Create complete communities that integrate nature and built environment, and Strategy 8: Gather and share the best urban sustainability knowledge. More specifically, the project will benefit TRCA and its municipal partners by:

- Identifying strategic opportunities to protect, enhance, restore, and manage for terrestrial, aquatic, and hydrological functions across TRCA's jurisdiction.

- Maximizing impact and cost-efficiency by directing ecosystem protection, management, and restoration efforts to where they are most needed, will provide the greatest benefit to ecosystem service delivery, and are likely to be most successful.
- Demonstrating TRCA's value to its partner municipalities that provides the most up-to-date science and practice in ecosystem management.
- Positioning TRCA and its municipal partners as the leaders in urban ecology science, policy, and practice.

2. GOAL AND OBJECTIVES

The overarching goal of this project is to use the most-up-to-date data and systems and science-based information to identify TRCA's updated regional target NHS that provides information on the key natural heritage features and areas including areas important for various ecosystem functions and processes and should be targeted for protection, restoration, and enhancement to ensure healthy and resilient ecosystems and watersheds over long term.

In doing so, this project will deliver a series of technical data layers and science-based information that can be used as stand-alone decision support tools to inform various initiatives of TRCA and its municipal partners.

The science-based regional target NHS is intended to be refined through finer level information available at watershed and site level studies through additional scientific data collection or modelling, community and stakeholder input, and indigenous community engagement.

The key objectives for the project are to:

1. Identify the current state of science for natural systems management and TRCA and municipal partner needs for updated regional target NHS
2. Incorporate available data on municipal Official Plan NHS to inform TRCA's regional target NHS
3. Incorporate up-to-date information on habitat connectivity and climate vulnerabilities of the natural system to inform TRCA's regional target NHS
4. Generate and use new data on ecosystem functions and needs including terrestrial and aquatic habitat and biodiversity priorities as well as significant hydrological linkages to inform TRCA's regional target NHS
5. Integrate all science-based data to identify the most strategic areas for to be included within TRCA's updated regional target NHS for protection, restoration, and enhancements
6. Engage municipal partners, stakeholders, indigenous communities, and general public on TRCA's updated regional target NHS for gain feedback and facilitate implementation.

3. DATA AND METHODS

The TRCA updated regional target NHS was developed in three distinct phases, each achieving a set of project objectives as illustrated in Figure 1. This section will provide an overview of the general approach and details on individual data that was used as input criteria in NHS delineation, which is discussed further in the following subsections.

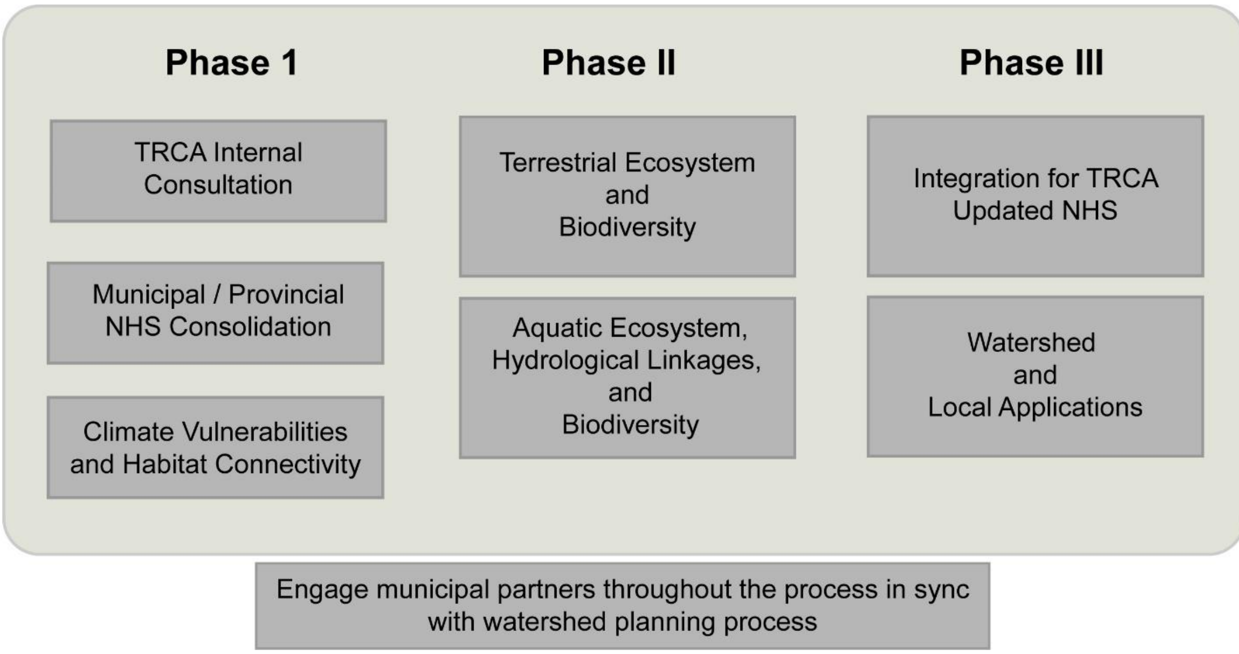


Figure 1: Project phases and objectives

3.1. Phase 1: Municipal NHS and Climate Vulnerability Data

Phase 1 of the project focused on achieving objectives 1 and 2. First, the internal consultation identified the update needs, helped define the project scope, and an overall approach. The Terms of Reference (ToR) and the internal technical advisory team was developed to guide the project. Second, all partner municipalities NHS was analyzed to inform TRCA updated target NHS as appropriate for biodiversity and habitat enhancement (discussed in Section 3.1.1). This was completed by strategically leveraging the financial support provided by the Great Lakes Sustainability Fund (GLSF) from 2015-2018 to evaluate the TRCA TNHS (2007) implementation success in municipal official plans and policies. Third, the existing climate change vulnerabilities of the terrestrial biodiversity and habitat were identified to inform TRCA updated target NHS (mostly based on the Peel NS VA framework (TRCA, 2017)) (discussed in Section 3.1.2.

3.1.1. Municipal NHS consolidation

Municipalities are the planning authority for local land use planning decisions and therefore play a critical role in the identification and protection of NHS. A mapped NHS is an important tool for land use planning and can help ensure land use planning decisions are not compromising the ecological, social or economic benefits that natural areas provide. TRCA developed a study with the Great Lakes Sustainability Fund (TRCA 2018) to evaluate how the implementation of TRCA's Terrestrial Natural Heritage System Strategy (TNHSS) aligns with municipal NHS. The results of the study provided insights on where the synergies and gaps were in terms of delineating NHS that could inform future NHS initiatives.

A spatial overlap analysis was completed to compare NHSs delineated in municipal OP Schedules (as of 2015) with the target Terrestrial Natural Heritage System (TNHS) (TRCA 2007) to: (i) Understand the extent of TRCA TNHS adoption in municipal Ops (schedules & maps); (ii) Understand the extent of habitat protection in municipal natural heritage systems; (iii) Identify the reasons for differences and similarities between TRCA TNHS and municipal NHS.

Municipal NHS boundary layers were combined with the most up-to-date natural heritage system information from the Oak Ridges Moraine Conservation Plan, the Greenbelt Plan, and the Niagara Escarpment Plan to consolidate an up-to-date municipally adopted (final or in draft form) NHS layer. Federally protected natural heritage in the Rouge National Park, as it existed in 2015, was also included in this layer. The consolidated municipal adopted NHS layer was overlaid with the TRCA target TNHS to assess the extent of overlap between the two (Fig. 2). The consolidated NHS spatial overlap data was used in conjunction with the natural cover data and broad land use data to understand the synergies and discrepancies between municipal and TRCA NHS and implications on current and future habitat protection.

This analysis suggests there is almost 85% overlap between the TRCA TNHS and the consolidated municipal NHS (approximately 60 000 ha). This level of overlap indicates a high rate of adoption of TRCA recommendations by municipalities. Most of the overlap coincides with existing natural cover and areas with some level of policy protection, either as TRCA regulated areas (e.g., within flood plains) or from provincial legislation (e.g., Greenbelt and Oak Ridges Moraine). Nevertheless, 15% of the TRCA TNHS (12000 ha) was not captured within the consolidated municipal NHS. Despite these exclusions, municipal NHS added a further 26 000 ha in their NHS that might offset some of the gaps in habitat, provided that these areas have similar form and function when it comes to habitat and wildlife conservation.

Most of the 12 000 ha of TNHS areas that municipal NHS excluded are either classified as potential natural cover or existing meadows in the TRCA TNHS. This includes agricultural areas that are outside of the Greenbelt or Oak Ridges Moraine plans in rural zone and meadows and/or other open space areas in urban and urbanizing zones. As discussed earlier, this reflects the increased susceptibility of meadows to land use change given that they have limited protection status in the current policy framework. In addition, a few existing forests and wetlands in the TRCA TNHS were also excluded in municipal NHSs, mostly in rural and urbanizing zones. Though it is important to include them in a municipal NHS to prevent habitat loss, further investigation may be needed to confirm that these are in fact still present in the landscape given the time lag between the TRCA TNHS and municipal NHSs. Lastly, data processing errors such as slivers during data clipping or shift in digitizing boundaries also resulted in some mismatch between the TRCA TNHS and municipal NHS.

The 26,000 ha of the jurisdiction that were included in municipal NHSs and not in the TRCA TNHS have the potential to provide additional wildlife habitat. Some of these areas are forests and wetlands that were missed by the TRCA TNHS, likely due to data processing errors. The majority of these are in the uncategorized natural cover type, which means they are not existing habitat and may reflect areas that municipal Ops have targeted for habitat restoration and enhancement. A significant portion of these are agricultural lands in rural areas, especially where there are provincial designations.

The watershed analysis also highlighted that the NHS coverage is generally higher in watersheds such as the Humber, Rouge, Duffins, Petticoat, and Carruthers, which have higher natural cover as well as coverage of provincial plan policies because of the Oak Ridges Moraine Conservation Plan, the Niagara Escarpment Planning & Development Plan and the Greenbelt Plan. This highlights that the provincial policies are generally facilitating NHS protection as intended. In urban and urbanizing zones, the added areas in municipal NHS constitute areas zoned for different land uses such as active recreation (e.g., golf courses, parks) or institutional and commercial zoning.

The watershed analysis also indicated that in the highly urbanized watersheds and along the waterfront additional areas in municipal NHS seem to include active recreation areas, golf courses, and other "open" land uses. These areas are traditionally not included in NHS as defined by TRCA and other conservation authorities. This raises questions regarding whether the added NHS areas are inflating the perception of habitat protection or whether these areas provide opportunities to be innovative regarding habitat and wildlife conservation, especially in urban areas where natural cover is low and traditional restoration and protection opportunities may be limited. Cautious and innovative implementation of NHS may be needed in such areas to ensure that these function as NHS for habitat and wildlife.

Three key recommendations from this analysis highlighted that there is a need to

(i) Develop additional policy guidance to protect natural habitats not sufficiently addressed more fully in current policy frameworks, particularly in future urban growth areas as these are the most vulnerable to removal, and

(ii) Develop protection policies for local natural features not protected under provincial policy, particularly in rural areas that have defaulted to the provincial systems.

(iii) Recognize the contribution of the areas that may not traditionally fit the definition of NHS (e.g., open land uses in urban portions of the jurisdiction) but may provide ecological functions and services, especially in built portions of the landscape, that otherwise would not be available if these areas did not exist.

This information was used in the TRCA's updated regional NHS to ensure that the updated NHS would incorporate these elements more strongly based on science and data. Various ecological assessments were conducted to ensure that the strategic areas including those that are not sufficiently covered by policy frameworks are identified (further discussed in Section 3.2). Additionally, the final NHS delineation used the municipal NHS as one of the inputs to capture the municipal priorities, as appropriate (further discussed in section 3.3).

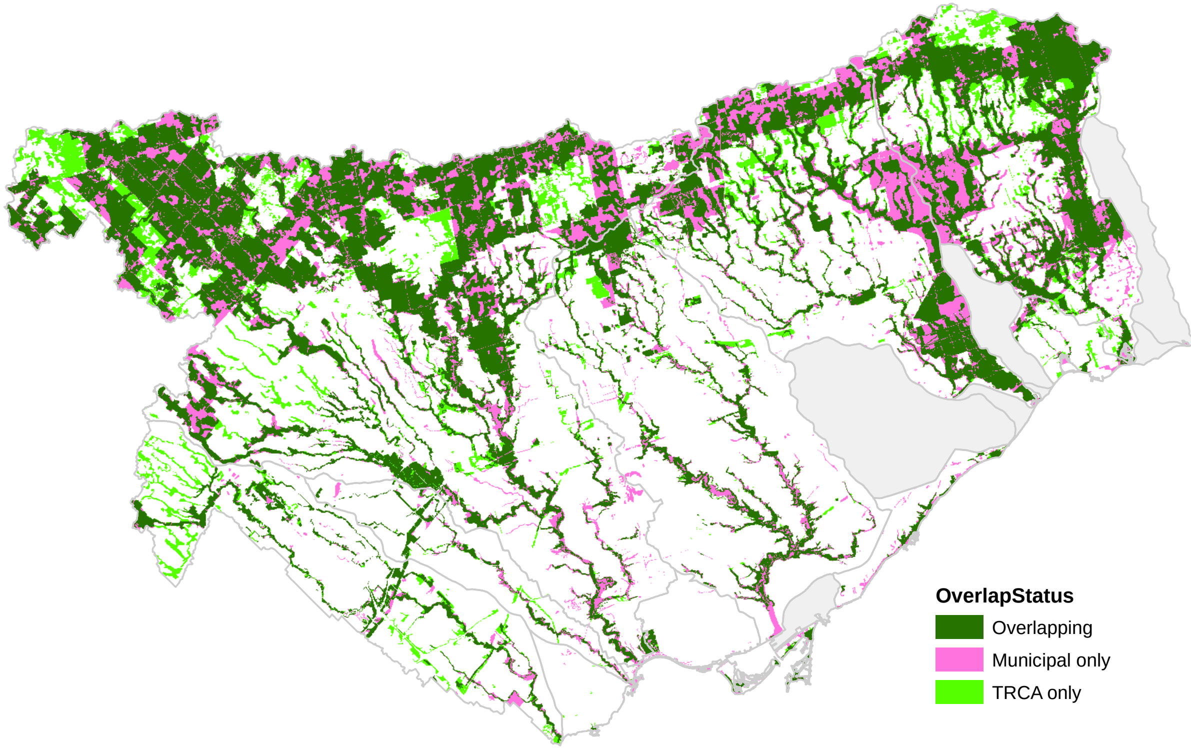


Figure 2 : Overlap of municipal and Terrestrial Natural Heritage System Strategy 2007.

3.1.2. Climate change vulnerabilities

Climate change is currently impacting natural systems in the Toronto Region and future projected climate change is expected to intensify these impacts. These climate change projections predict increased frequency and magnitude of precipitation events as well as temperature extremes in the Great Lakes region (Magnuson et al. 1997). Improving natural systems planning require the consideration of factors that influence the function and resilience of natural systems. A better understanding of climate change resiliency is linked to the hydrological links between terrestrial and aquatic systems, the vulnerability of natural system components to climate change, and the contribution of the urban forest and other components of the urban matrix to the natural system.

To account for the effects of future climate change on natural systems, TRCA and the Ontario Climate Consortium (OCC) developed a framework (Tu et al. 2017) for the Region of Peel. The indicators used in the Peel framework were then expanded to be applied to TRCA's jurisdiction (TRCA 2020). Under this framework, vulnerability indicators were used to assess the degree of vulnerability of natural systems, and the key ecosystems they provide, to climate change and extreme weather impacts (TRCA 2020).

For a climate change vulnerability assessment (CCVA), a vulnerability indicator is considered a representation of a natural systems component or attribute able to provide information regarding its adaptive capacity in response to a climate-induced impact. The five vulnerability indicators were: habitat patch score, climate sensitivity of native vegetation, wetland hydrological stability, soil drainage rating, and ground surface temperature (Figure 3).

- Habitat patch score is a strong indicator of ecosystem vulnerability because of its interrelations with multiple vulnerability factors. Habitat patch score represents the quality of habitat patch based on its size, shape, and influence of the surrounding matrix using the TRCA Landscape Analysis Model (TRCA 2007). TRCA’s LAM analysis ranks patches from L1 to L5, where L1 is the highest quality (TRCA 2007). The lower quality habitat patches (L4, L5) have smaller sizes, linear shape with high edge effects, and are situated in areas with higher levels of urbanization. These lower quality patches are expected to be stressed and thus more vulnerable to climate change impacts.
- Sensitive vegetation that are more impacted by increasing seasonal temperatures and increasing variability in precipitation will be negatively affected by climate change due to disrupting functional processes. Namely, these functions include hydrological processes, fertility processes, and potential dynamic interaction between hydrology and fertility. Climate sensitivity of native vegetation is based on the number of vulnerable processes. The climate sensitive vegetation community’s information was extracted from the TRCA Ecological Land Classification (ELC) field data with input from TRCA’s biologists and broader literature. The list of ELC codes used to identify this indictor is provided in the Appendix in Tu et al. (2017).
- Wetland vulnerability increases where soils remain dry for extended periods are more vulnerable to colonization by upland vegetation and invasive species leading to potential adverse impacts. Wetland sensitivity to climate change would be based on receiving inputs of water only from precipitation and local catchment runoff were more vulnerable than wetlands receiving additional water inputs from groundwater or from larger riparian systems. The vulnerable wetlands may be areas that could be targeted for restoration to reduce the vulnerability to climate change.
- Soil drainage relating to poor drainage will produce shallower root networks and increased potential for localized inundation, contributing to higher relative vulnerability. Scoring for climate vulnerability was based on the soil surveys from well drained to poorly drained or no drainage (e.g., urban) classification. Although soil drainage is a climate change vulnerability indicator that cannot lead to actual actions to reduce the negative effects of climate change as it is a landscape condition. However, it can identify areas in the landscape where there is a greater risk to climate change.
- Ground surface temperature represents the potential heat and drought stress throughout the natural system leading to the drying of soil and forest understories, plant heat stress, reduction in natural system thermal regulation, and loss of thermal refuges for heat-intolerant species. Scoring was based on ground surface temperatures under three data percentiles of equal thirds. The areas in the landscape with high ground surface temperature are considered as having high vulnerability and any natural system component within such areas are considered more vulnerable.

Spatial mapping of vulnerability indicators, where data were available, provides large aid in understanding and characterizing current vulnerability. Ultimately, the vulnerable areas can be used as an overlay to inform NHS planning process to guide where climate adaptation measures are most needed.

Results of terrestrial system climate change vulnerability assessment for individual indicators show that for

1. 16% of all habitat patches (9% of TRCA's jurisdiction) are low quality and are thus have high vulnerability. Most of them are situated in urban zones. These habitat patches are already in degraded conditions and climate change impacts will further exacerbate their ecological form and functions.
2. 0.2% of all ELC vegetation communities surveyed (0.1% of TRCA's jurisdiction) are climate sensitive and are mostly located in the northern parts – mostly within Greenbelt zone including urban river valleys where there is habitat for sensitive species of vegetation. These vegetation communities are likely protected from land use changes but climate change impact may still affect these communities. Targeted adaptation measures are needed to protect and enhance these communities and/or assist them to transition to functionally similar vegetation that allows for ecosystem health.
3. 1% of wetlands used in this analysis (0.4% of TRCA's jurisdiction) are highly vulnerable because they are only precipitation-fed. 2% are moderately vulnerable because they are further from a groundwater or riparian source. The highly vulnerable wetlands should be explicitly targeted for further protection and/or climate adaptation measures focused on building its resilience through hydrological enhancements. These measures are especially important if these wetlands are in the urban or urbanizing landscapes where additional consideration may be needed to maintain and enhance its functionality. Further consideration includes wetland water balance measures, hydroperiod maintenance, etc. and will have direct and indirect affect on regional biodiversity as well.
4. 51% of TRCA's jurisdiction is highly vulnerable due to poor soil drainage. Any natural features and functions may be further compromised in these areas due to climate impacts.
5. 37% of TRCA's jurisdiction is highly vulnerable due to high ground surface temperature. These areas are vulnerable due to high imperviousness and the lack of natural cover. Further climate impacts will exacerbate the effects of the urban landscape.

The additive mapping of all vulnerability indicators (Fig. 3F) shows that in summary 52% of the TRCA jurisdiction is highly vulnerable (scores ≥ 0.66). Additive scores also show that 19% of natural cover is highly vulnerable (scores ≥ 0.66) and 36% of natural cover is moderately vulnerable (scores between 0.33 and 0.66).

These climate vulnerable areas were compared with the TRCA's updated regional NHS to ensure that the updated NHS would incorporate the vulnerable areas into the protection, restoration, and enhancement opportunities, as appropriate (further discussed in section 3.3.2.2).

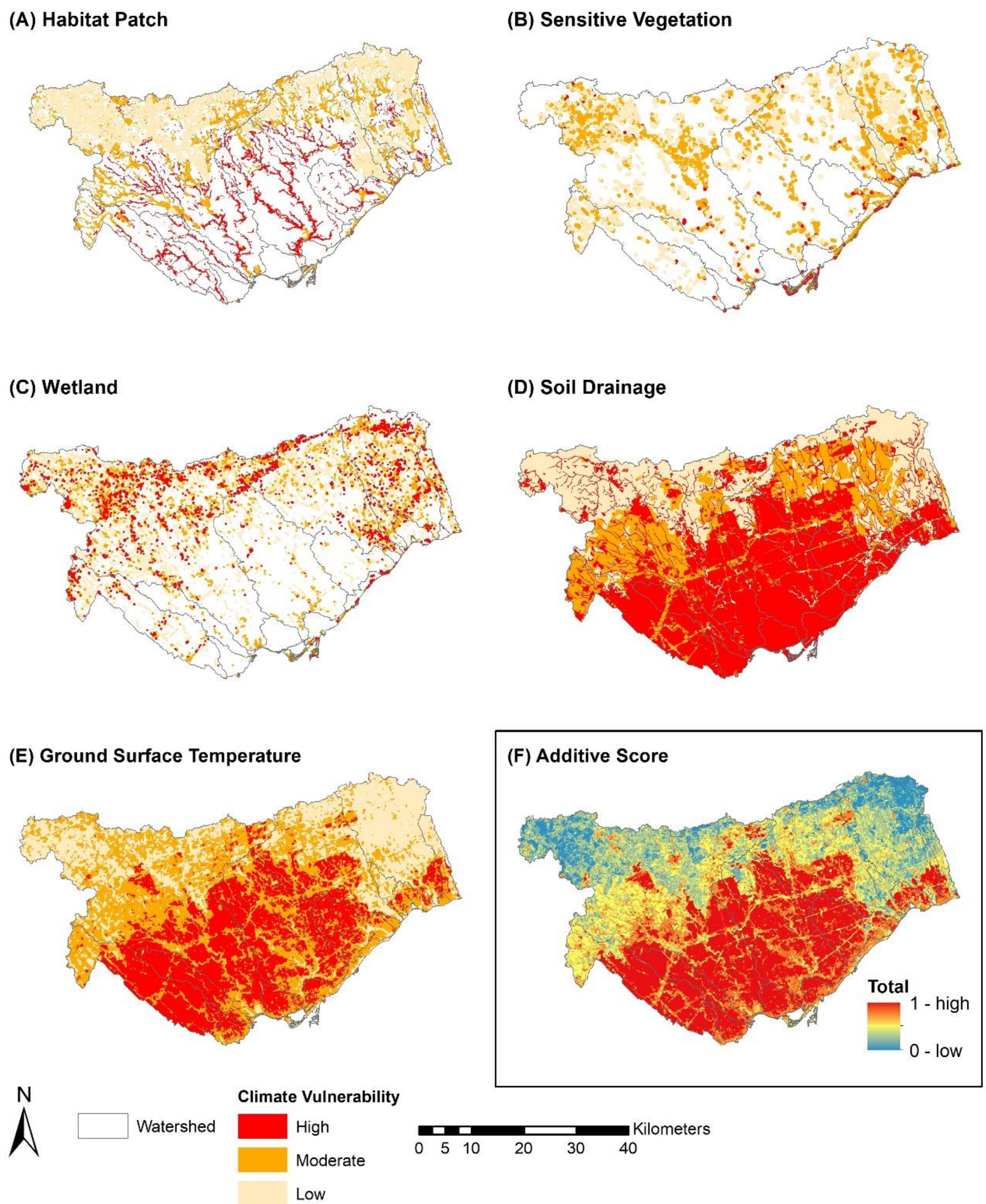


Figure 3: Summary of climate vulnerability indicators of (A) habitat patch score, (B) climate sensitivity of native vegetation, (C) wetland hydrological stability, (D) soil drainage rating, I ground surface temperature, and (F) additive vulnerability in the TRCA jurisdiction (total score 1 is the highest vulnerability) as 100-m grid unit.

3.2. Phase 2: Ecosystem Features and Functions

Phase 2 of the project includes analysis required to achieve objective 3, which focused on identifying strategic areas for conservation based on terrestrial and aquatic ecosystem needs across entire jurisdiction as well as their hydrological connections to ensure that the integrated system is resilient over long term.

As such, this phase focussed on generating a more comprehensive spatial data and models that could provide information on the priority areas for ecosystem functions and processes across urban-rural and natural-built gradient. This includes data on biodiversity distribution, habitat connectivity priorities for specific groups of species, and priorities based on habitat suitability for various groups of terrestrial and aquatic biodiversity that could be used as input to identify TRCA's regional target NHS. More specifically there were five key sub-objectives for this phase as listed below:

1. Quantify biodiversity metrics in terms of alpha, beta, and gamma diversity for avian species, flora species, and vegetation communities
2. Update the habitat connectivity models based on various movement groups of species to identify priority areas for connectivity
3. Complete a Functional Trait Analysis (FTA) for avian and amphibian species to identify key functional trait groups of species and complete a Habitat Suitability Analysis (I) to identify priority areas for terrestrial habitat function
4. Complete a Functional Trait Analysis (FTA) for fish species to identify key functional trait groups and complete a Habitat Suitability Analysis (I) to identify priority reach contributing areas for aquatic habitat function
5. Complete analysis to identify Ecologically Significant Groundwater Recharge Area (ESGRA) that reflects key hydrological linkages between terrestrial and aquatic systems that are responsible for replenishing groundwater systems that directly support sensitive areas like coldwater streams and wetlands

3.2.1. Biodiversity metrics (alpha and beta diversity)

TRCA's vision is to strive for human settlement that can flourish alongside nature's beauty and diversity. An assessment of key biodiversity metrics in the TRCA jurisdiction can help to improve understanding of species richness (alpha), site-to-site differences in community composition (beta), and overall diversity (gamma) within the jurisdiction (TRCA 2022b). Alpha diversity is commonly used biodiversity metric and is important to highlight where highest species richness occur in the jurisdiction. Beta diversity, however, is generally less discussed due to its inherent complexity. Generally, it helps determine areas of high biodiversity where species diversity overlaps between two different habitats (representing 'ecotones') which are unique areas relative to other sites in the jurisdiction (e.g., areas containing unique composition of species or vegetation communities indicating unique habitat conditions or presence of less common species). As such, beta diversity often complements alpha diversity sites for conservation.

In addition, TRCA has species L-rank (local rank) system, which is a species scoring and ranking system to provide guidance for natural heritage protection and management within the jurisdiction. The L-rank system uses scoring and ranking to convey individual species' ecological needs or constraints and to portray such complexities on a simple ordinal scale (TRCA 2010). For example, for fauna species their local occurrence, population trends, habitat dependence, area sensitivity, mobility restriction and sensitivity to development determines whether they are more or less of a concern from the regional perspective overall. Generally, L1 to L3 species and/ or vegetation communities are considered regional species / vegetation communities of conservation concern. In this analysis 27 L1 to L3 avian species, 278 flora species, and 19 ELC vegetation communities were used to calculate alpha, beta, and gamma diversity across the jurisdiction (see TRCA 2022b for details and methods using avian species).

Using the data on 27 avian L1-L3 species found in TRCA's jurisdiction, 144 locations were identified as areas with high alpha diversity (Figure 4). These areas contained more than eight L1-L3 species and indicated areas with high species richness. In addition, 62 locations were identified as areas with high beta diversity indicating areas with specific habitat conditions that supports less common species and species composition (Fig. 4). In these locations relatively rare species of birds across TRCA jurisdiction were found such as least bittern (*Ixobrychus exilis*) and yellow-billed cuckoo (*Coccyzus americanus*). Conservation of areas with high alpha diversity (species richness) and beta diversity (species turnover) will contribute towards conservation of overall gamma diversity that includes the overall species richness of TRCA's jurisdiction.

In Phase 3, both alpha and beta diversity data would be used as input criteria to identify strategic biodiversity areas to be included in TRCA's regional target NHS.

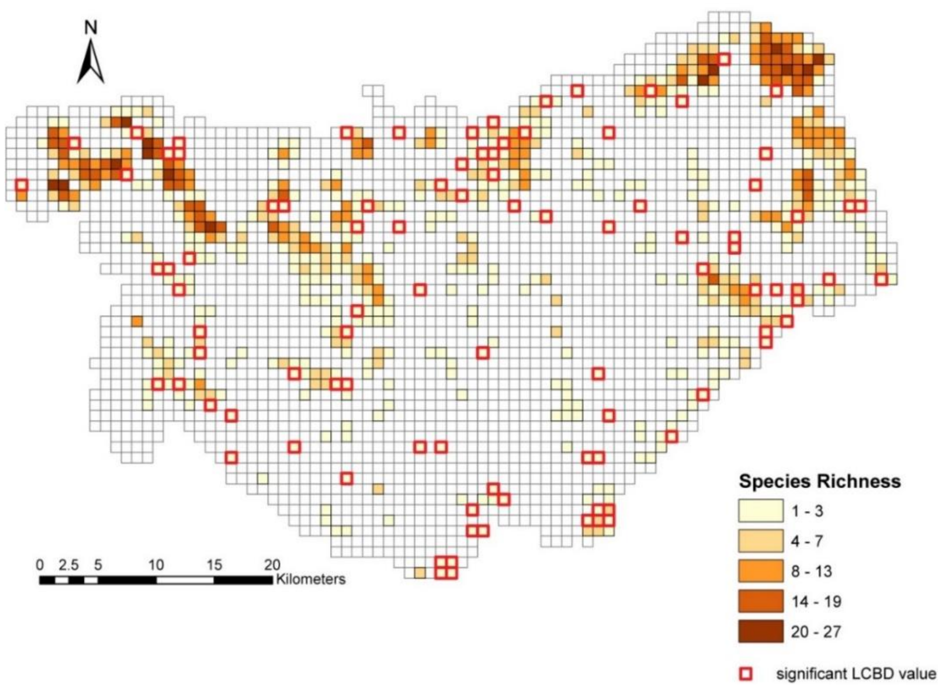


Figure 4: Avian alpha diversity across the entire TRCA's jurisdiction in 1-km cells with urban-adapted species (L4 species) excluded. Significant sites for beta diversity in the entire extent with high local contribution to beta diversity (LCBD) values are indicated.

3.2.2. Habitat connectivity

Habitat connectivity and movement corridors are important for wildlife to access resources for various life cycle processes including feeding, breeding, limiting competition, avoiding predation, and to adapting to the habitat changes caused by various disturbances such as land use and climate change. Changes in landscapes that alter the amount and configuration of habitat can either facilitate or impede critical wildlife movements.

The habitat connectivity analysis completed for this study identified the priority areas for habitat connectivity and wildlife movement for general high quality habitat patches (regional connectivity) and for four specific groups of species of birds and amphibians (species group specific regional connectivity).

For birds, habitat connectivity between forest patches and between wetland patches were deemed important and for amphibian species habitat connectivity between wetland patches and between forests and wetlands were deemed important to model to identify priority areas for connectivity. These species movement groups were selected based on the species composition in TRCA's jurisdiction and their habitat movement needs. This information provides a refinement to TRCA's habitat connectivity analysis completed for general habitat patches (TRCA 2015).

Habitat connectivity analyses were completed using a modeling tool called Circuitscape (McRae et al 2008). Circuitscape uses a circuit theoretic approach, which has widely used for habitat connectivity analyses (Caroll et al. 2011, Urban et al. 2009, McRae et al. 2008). Here, landscapes are represented through land use and land cover maps as resistance surfaces. Low resistance values are assigned to land use and land cover classes such as habitat patches and other natural areas that are most permeable to movement. High resistance values are assigned to land covers such as fully built-up areas that are hostile and may impede wildlife movement. Based on the resistance map and the distance between the habitat patches regional connectivity metric, cumulative current density, is calculated. This reflects the relative probability of wildlife movement from every habitat patch to every other habitat patch in the landscape. This metric helps identify the least cost path among habitat patches to identify potential corridors for movement and places higher emphasis on pathways that represent the last remaining pathway left for movement. Thus, relatively higher values indicate that any changes to it will have larger impact on the overall regional connectivity among all habitat patches. In this study these relatively higher current density areas (top 50%) were delineated to identify the priority areas for regional connectivity for all habitats as well as between forests, wetlands, and forests-wetlands.

Figure 5 shows that the priority areas for regional connectivity is higher in the northern and eastern portions of the TRCA's jurisdiction including north Humber, Rouge, and Duffins watersheds. In addition, the connectivity priority is higher in the ravine system across TRCA's jurisdiction (Figure 5). These areas contain most of the natural cover and habitat, thus also provide important linkage corridors. However, the priority areas for different species group vary substantially based on which habitat types are targeted for connections (Figure 6). This indicates that different species groups have different habitat needs and thus needs a functional approach to assess habitat connectivity.

For example, the priority areas for habitat connectivity between forest patches for bird species, were identified along the ravine corridors and areas in and around large patches of forest areas (Figure 6A). This is intuitive given that most of forest patches are concentrated in these areas and provides stepping-stone habitat during life stages (hatch-year birds) and certain times of the year such as migratory periods. However, for connectivity between wetland patches for birds the corridor priorities are a bit dispersed (Figure 6B). This is attributed to the fact that the wetlands do not follow the linear pattern that forest patches may follow through ravines. Thus, for bird species to get to the nearest wetland with least cost path, they might have to fly through the broader landscape rather than the ravine system. As such, having a more hospitable and less hostile landscape matrix is important for bird species in this group.

For amphibian species groups (e.g., wood frogs (*Lithobates sylvaticus*), gray treefrogs (*Dryophytes versicolor*), and spring peepers (*Pseudacris crucifer*)) the connectivity priority between forests and wetlands follows the natural areas in the ravine system and the broader areas in the greenbelt areas. These areas have less hostile landscape through which amphibians can move and contain most of the forests and wetland patches. As for the wetland patch connectivity for amphibians, the connectivity priorities are a bit dispersed yet more concentrated than for birds given that their movement is more limited as it needs to be across the landscape, which may have higher resistance for these species.

The regional connectivity priorities among high-quality habitats as well as for species group specific habitat patches provide important criteria for delineating TRCA’s regional target NHS. Some of these priorities are within existing natural features and areas but many are outside, which allows for delineation of potential areas for linkages and connectivity restoration for long term resilience of NHS.

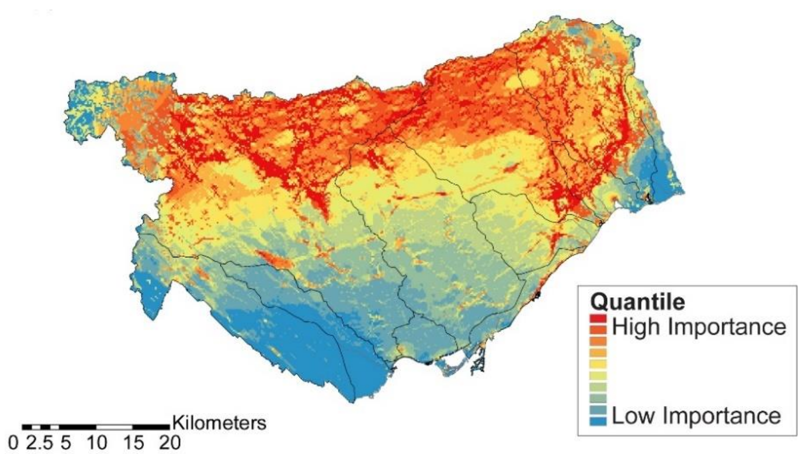


Figure 5: Target regional connectivity across TRCA jurisdiction.

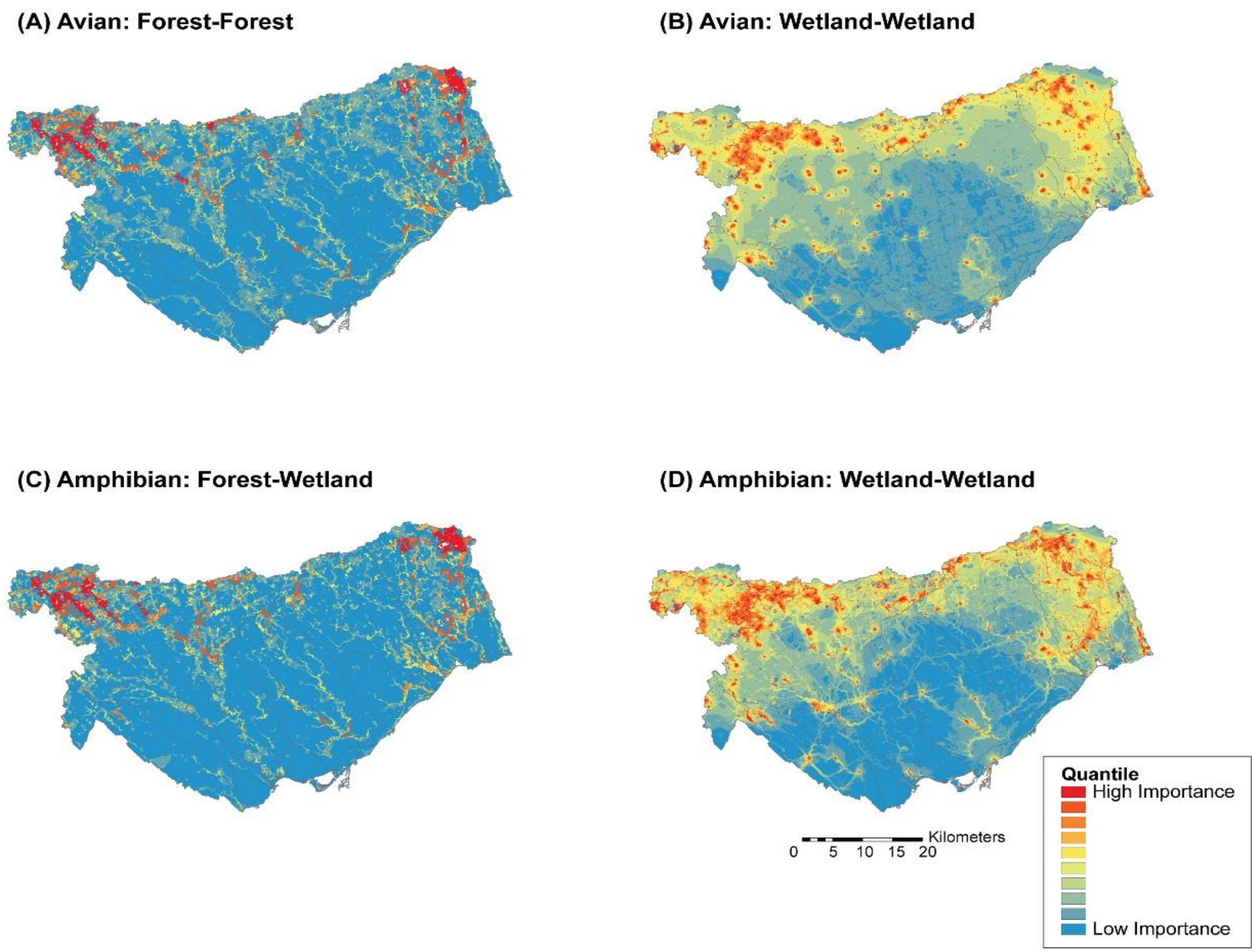


Figure 6: Habitat connectivity of movement guilds for: (A) avian forest-forest, (B) avian wetland-wetland, (C) amphibian forest-wetland, and (D) amphibian wetland-wetland habitat.

3.2.3. Terrestrial habitat suitability

Urbanization and climate change have various direct and indirect impacts on ecosystem structure, function, and services. This includes changes in habitat quantity, quality, and connectivity as well as changes in the characteristics of the surrounding landscape and their climatic conditions. These changes interact with various species needs and requirements, which ultimately determines their persistence in the landscape and the overall health and resilience of our ecosystems, habitats, and biodiversity. Assessments such as the Habitat Suitability Analysis (HSA) aims to understand the capacity of any landscape to provide habitat provisioning service across its boundary given its current characteristics and species composition and can help identify priority areas for conservation to ensure long term health and resilience of the ecosystem.

HSA for TRCA's jurisdiction was completed for various Functional Trait Groups (FTGs) of avian and amphibian species in the TRCA jurisdiction. FTGs are distinct groups of species classified based on their similar requirements, characteristics, and ability to adapt to their environment (TRCA 2022b). The environment could span from natural to urban areas. Using the avian and amphibian data collected between 2007-2017 and information on their key characteristics (e.g., breeding, foraging, diet), a functional trait analysis was completed to identify 21 FTGs of birds and four FTGs of amphibian within TRCA's jurisdiction. For avian species, the RQL fourth-corner analysis (Dray et al. 2014) was used and for amphibian FTGs TRCA's internal expert knowledge was used due to fewer number of species in the jurisdiction to statistically determine these groupings.

Out of all FTGs, only five FTGs of birds (aerial insectivores, forest insectivores, forest canopy, grassland, and ground-nesting) and all four FTGs of amphibians (arboreal, swamp, wetland, woodland) were used for HSA. This was based on data availability and model accuracy of each of these FTGs. The presence data of these FTGs were used to create pseudo-absences (Dray and Legendre 2008), which were then used together as the response variable in the HSA model. The HSA model used the Boosted Regression Tree technique (Elith et al. 2006), where the species data were related to the independent variables such as quantity and quality of habitat patches, Ecological Land Classification (ELC) vegetation communities, landscape connectivity metrics, various land use and land cover information (e.g., total amount of land use and natural cover), and other landscape characteristics (e.g., patch quality of natural cover based on maximum patch size and amount of edge). (For additional details refer to the technical report TRCA 2022b)

Figure 7 shows habitat suitability for the selected FTGs across TRCA's jurisdiction. All FTGs were strongly influenced by natural cover distribution, which is as expected given that most core habitat for these species are present within natural cover boundaries like forests and wetlands. For avian FTGs the results indicate that some groups such as Forest Canopy dependent group showed higher habitat suitability close to existing forests and wetlands indicating their need for natural cover in the landscape. Others such as Aerial Insectivores showed high suitability close to natural cover, but they also depicted more medium suitability in older residential neighborhoods with high urban canopy indicating that urban street and backyard trees play an important role in biodiversity habitat provision.

The has results provide important input to delineate TRCA's updated regional target NHS as they help identify existing and potential habitat areas that are priority for our regional biodiversity.

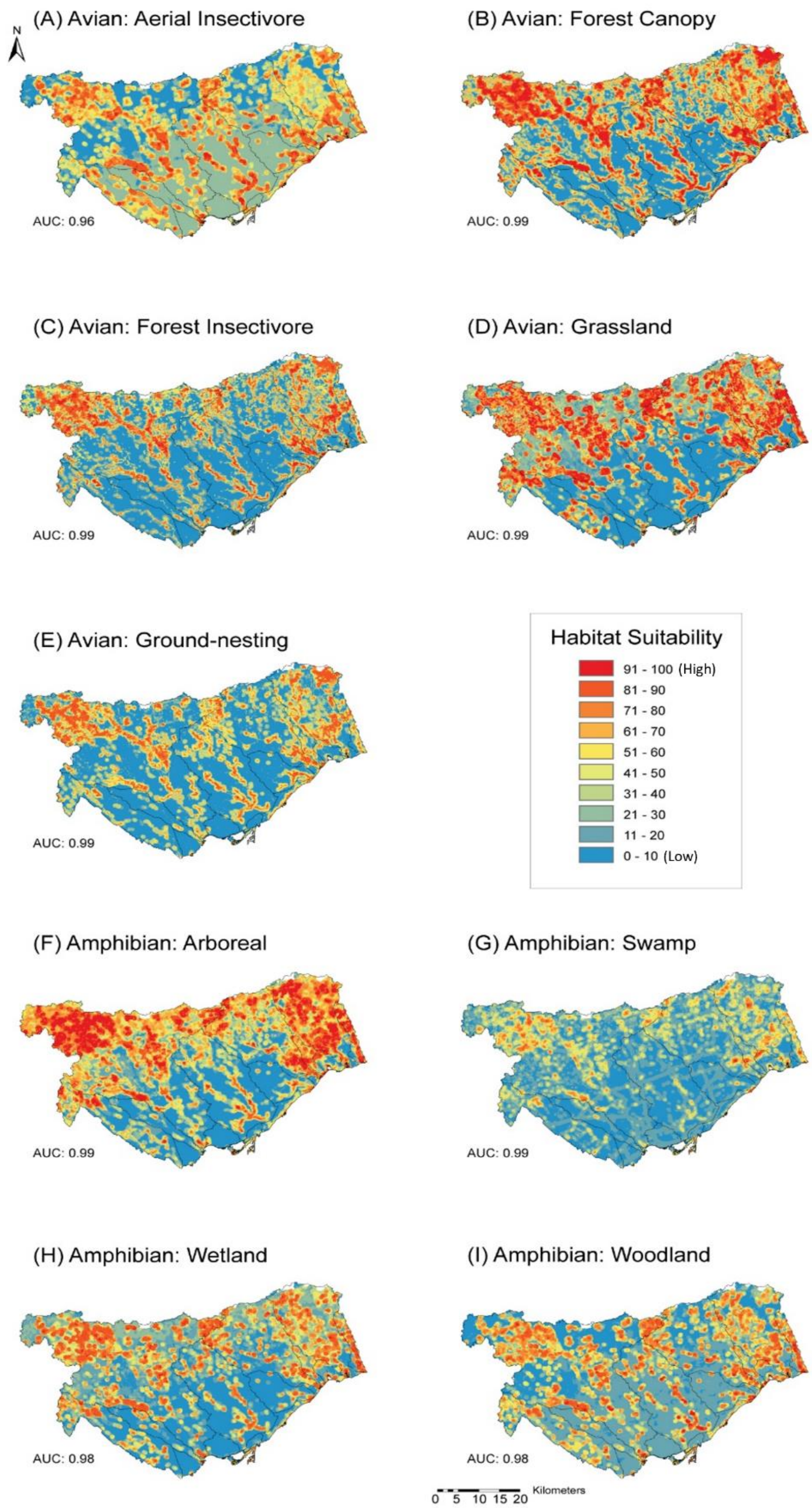


Figure 7: Habitat suitability maps of five avian (A-E) and four amphibian (F-I) functional trait groups.

3.2.4. Aquatic habitat suitability

TRCA's jurisdiction has the most densely populated watersheds within Canada where more than 50% of land use and land cover is urbanized and is dominated by impervious built cover such as roads, parking lots, buildings etc. This high amount of imperviousness, mostly resulting from natural cover changes to impervious surfaces, represents a key driver of change to fish habitat in urban streams. To better understand the effect of urbanization on fish habitat, a modelling approach to assess habitat suitability for fish species was used across TRCA's jurisdiction. This aligns with the terrestrial Habitat Suitability Analysis (HSA) discussed in section 3.2.3.

HSA for fish species was completed for six identified Functional Trait Groups (FTGs) of fish species (coldwater, coolwater, continuous-slow flow, strong flow, warmwater, and slow-warmwater) found in TRCA's jurisdiction. FTGs are distinct groups of species classified based on their similar requirements, characteristics, and ability to adapt to the urban environment (TRCA 2022a). The environment could span from natural to urban areas. The Functional Trait Analysis was used to identify these FTGs using the presence-absence data on 30 fish species collected between 2001-2019 and their key traits/characteristics including migration, adult substrate preference, thermal tolerance, spawning temperature, stream flow preference, nest guarding, and maximum total length. The identified six FTGs' instream habitat segments were then related to the broader landscape by delineating a Reach Contributing Area (RCA) and calculating three key landscape characteristics including riparian cover, imperviousness, and stream order for each RCA. These variables were used as independent variable in HSA (using the Boosted Regression Tree method (Elith et al. 2006)) that identified the priority ranking of each RCA for fish FTGs. (For additional details refer to the technical report TRCA 2022a)

Figure 8 from the HSA results for four FTGs of fish with the best predictive models (continuous-slow flow, coldwater, warmwater, strong flow). Notably, these FTGs were influenced by the type of riparian cover and/or were sensitive to stream order at the RCA-level. It is evident that most of the priority RCAs for coldwater fish species groups are concentrated in the RCAs with less built/impervious and more natural areas. For other FTGs of fish the results are more scattered and individual RCAs characteristics become more important determinant of priorities. Unfortunately, not all FTGs (slow-warmwater, coolwater) produced well-fitting models for habitat suitability based on RCA-level landscape characteristics potentially due to rarity or unmeasured in-stream habitat characteristics. While the rarer slow-warmwater species group is more adapted to lower amounts of natural cover, coolwater species are sensitive to landcover that would result in the increase of in-stream temperatures. This demonstrates the importance modelling with in-stream temperatures such as identifying coolwater streams that could not be identified from landscape characteristics.

The HSA results for fish FTGs provide important information on priority conservation areas in the upland areas that contribute to the quality of in-stream fish habitat. These data layers will be used as input layers in TRCA's updated regional target NHS to ensure aquatic habitat and biodiversity needs are incorporated.

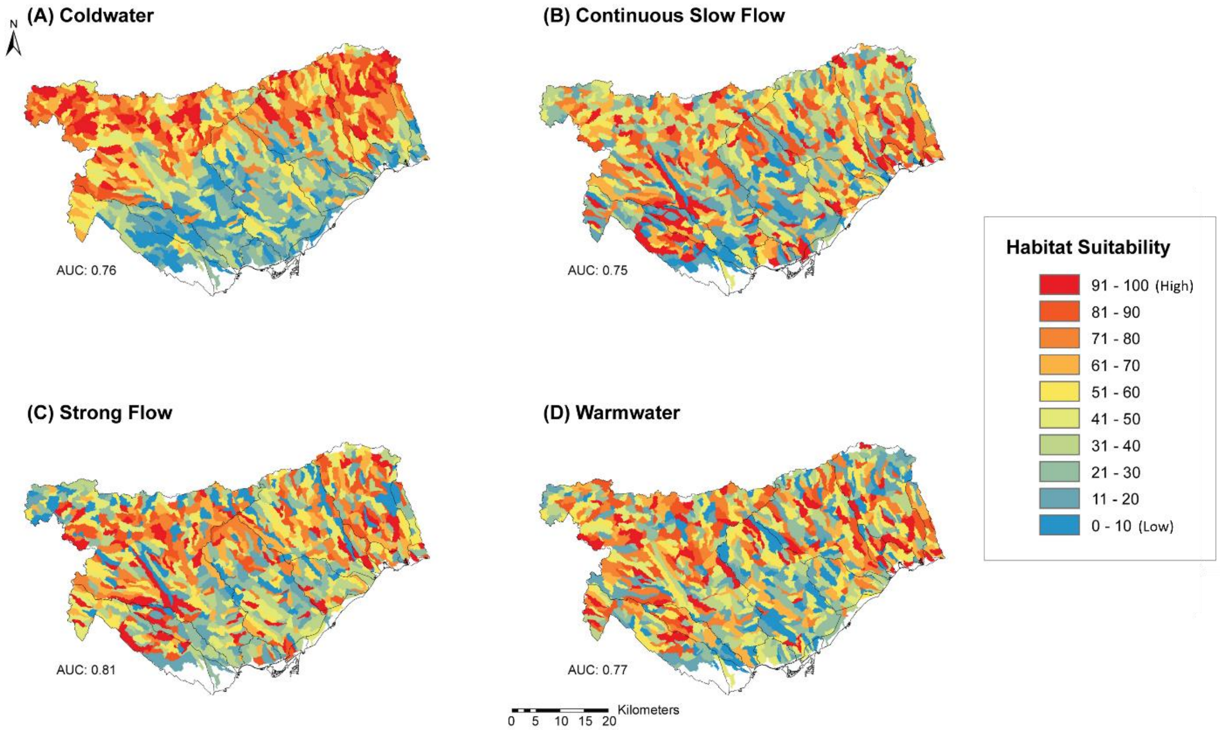


Figure 8: Habitat suitability maps of fish functional trait groups: (A) coldwater, (B) continuous slow flow, (C) strong flow, and (D) warmwater within 125-ha reach contributing areas.

3.2.5. Ecologically Significant Groundwater Recharge Area (ESGRA)

An Ecologically Significant Groundwater Recharge Area (ESGRA) can be defined as an area of land that is responsible for replenishing groundwater systems that directly support sensitive areas like coldwater streams and wetlands (Greenbelt Plan 2017). The protection of groundwater-dependent ecologically sensitive areas depends, in part, on understanding where on the landscape the groundwater comes from and taking steps to ensure the recharge function of these areas is protected. ESGRAs are identified using regional-scale modelling to predict where groundwater recharge at a given location will emerge or "discharge" within ecologically sensitive areas (for more details on methods refer to TRCA 2019).

Figure 9 shows the distribution of ESGRAs in TRCA's jurisdiction. Many of the ESGRAs are concentrated in the natural areas across the jurisdiction indicating the importance of linkages for groundwater-dependent ecosystems including groundwater-obligate wetland flora, coldwater aquatic habitat, and fen wetland communities. Particularly, the Greenbelt and northern parts of the jurisdiction as well as ravines act as major recharge areas. Additionally, some ESGRAs extend beyond natural areas into built portions of the landscape because of the hydrological linkages of these ground water dependent ecosystems as recharge areas through their subsurface linkages.

Mapping ESGRAs helps to identify areas important for groundwater recharge functions that can inform various protection, restoration, and green infrastructure and LID implementation initiatives. The protection of natural heritage features and areas, such as streams and wetlands, are connected to ESGRAs and their recharge function. This will continue to support important ecological functions, including provision of habitat for groundwater-dependent plants and wildlife. ESGRAs are also identified as important component of watershed planning and are included in the definitions of significant groundwater recharge areas in the Growth Plan for the Greater Golden Horseshoe (Growth Plan) (2019) and Greenbelt Plan (2017). Mapping of ESGRAs is used as one of the inputs in the updated NHS.

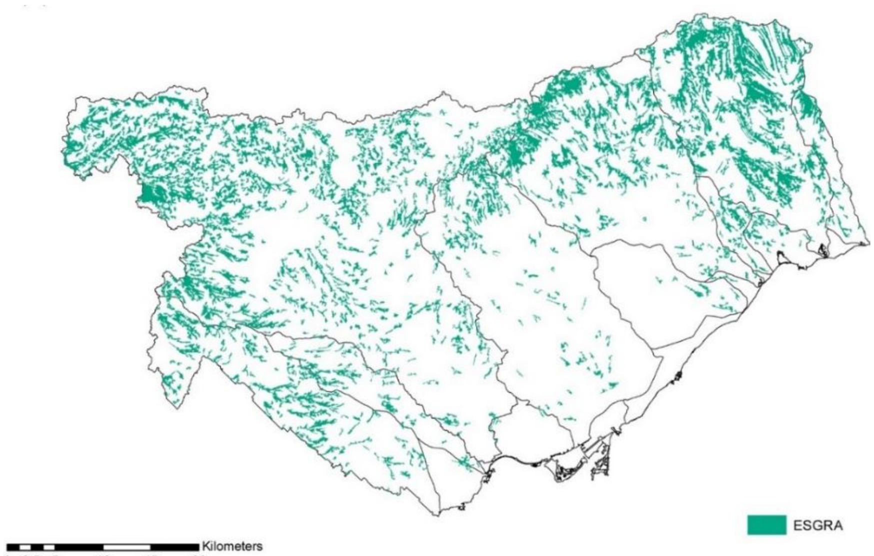


Figure 9: Map of the Ecologically Significant Groundwater Recharge Area (ESGRA) across TRCA jurisdiction.

3.3. Phase 3: Integration for target NHS

Phase III of the project focuses on objective 6 and 7 to integrate all the data layers to delineate the TRCA’s updated regional target NHS and to engage TRCA’s partner municipalities and conservation authorities, indigenous communities, and key stakeholders for their feedback and information on the mapping products. This phase also includes a rapid assessment of implications of potential land use and climate change on the TRCA’s updated regional target NHS mapping.

3.3.1. Delineating TRCA’s updated regional target NHS

TRCA’s updated regional target NHS was delineated based on 36 criteria that represents different natural heritage features and areas, ecological functions, and municipal NHS priorities. Many of existing key natural heritage features and areas were included within TRCA’s updated regional target NHS in line with the Natural Heritage Reference Manual (OMNR 2005).

To identify additional areas an optimization model called Marxan was used that helped integrate all criteria and identify the most strategic locations to maximize the highest functioning areas for each criteria. The model output was then processed further based on refined information and expert knowledge. The following sections will describe each step in more detail (additional details are provided in the technical document available upon request).

3.3.1.1. Criteria

In total, 36 ecological criteria and an additional landscape cost variable reflecting the difficulty to be included in the NHS were used in the Marxan analysis (Appendix I). These criteria were selected based on the Provincial Policy Statement (2020) definition of NHS that highlights the importance of existing natural cover as well as other areas that support various ecological and hydrological features and functions including linkages that could be existing currently and/or restored in future across the landscape.

The 36 criteria used are broadly classified into four groups for ease of communications – namely locked-in features and areas, aquatic ecological function-based criteria, terrestrial ecological function-based criteria, and municipal NHS.

Locked-in Criteria

Locked-in areas include eight criteria that represent key natural heritage features and areas such as wetlands, woodlands etc. that are based on available data and are deemed critical for the NHS and are included by default into the TRCA’s updated regional target NHS. This aligns with the definition of the NHS in PPS (2020) with the difference that PPS focuses on significant features, however for TRCA’s updated regional target NHS all existing natural heritage features are included. This is important given that TRCA's jurisdiction is highly urbanized and has limited and fragmented natural cover, which should be protected and enhanced, where possible, to make the overall NHS more resilient. These key natural heritage features and areas include the following

1. ***Wetlands:*** This layer encompasses TRCA's natural cover data (TRCA 2017) identified from orthophotos, Ecological Land Classification (ELC) at vegetation communities' level (TRCA 2021), and provincial wetland data including provincially significant wetlands (NDMNRF 2021), and restored wetlands in TRCA's jurisdiction (2021).
2. ***Fish Habitat:*** These features are associated with the regulated watercourse layer (TRCA) and a 10-m buffer and directly account for aquatic habitat. All fish habitat are considered equal under the *Fisheries Act* of Canada.
3. ***Woodlands:*** All forest and successional forest natural cover derived from orthophotography and restored forests through TRCA were considered as woodland due to the importance of protecting remnant existing natural cover in this landscape.
4. ***Valleylands:*** Valleylands are represented by the crest of slope, which therefore include all areas that are riparian within valleys and ravines. The crest of slope is within regulation mapping as part of TRCA Regulated Area throughout the jurisdiction.
5. ***Wildlife Habitat:*** Ecologically Significant Areas (ESAs 2015) identified by the City of Toronto, Areas of Natural and Scientific Interest (ANSIs) identified by province (NDMNRF 2020), and migratory habitat for birds including all natural cover within 5-km buffers from the Lake Ontario shoreline (OMNR 2005; Archibald et al. 2017) were included as additional wildlife habitat.
6. ***TRCA Conservation Lands:*** Natural cover including wetlands, forests, successional areas, meadows, and beach and bluffs within TRCA property were included in the TRCA's updated regional target NHS.
7. ***Areas of Natural and Scientific Interest (ANSI):*** Areas of Natural and Scientific Interest (ANSI) are relevant to natural heritage protection in addition to scientific study or education. ANSI areas are protected under the Planning Act (1990) and Natural Heritage policies of the Provincial Policy Statement (2020). These areas have natural landscapes or features that have been identified as important for life science or earth science values. Life science is relevant for biodiversity and natural landscapes that are relatively undisturbed vegetation and landforms. Earth science is geological in nature and represent significant landforms in Ontario and may be exemplar for ongoing geological processes.
8. ***Habitat of Endangered and Threatened Species:*** As part of the consideration of the previous 7 criteria, habitat of endangered and threatened species relies on the protection of these features. Any habitat loss and disturbances to natural cover will result in greater vulnerability for these species. Similarly, these criteria are in line the focus of L-rank fauna, flora, and vegetation communities at TRCA to maintain both the quality and quantity of natural cover (TRCA 2017).

Terrestrial and Aquatic Ecology Functions-based Criteria

Other planning units were then based on 27 ecological function-based criteria in addition to the municipal natural heritage systems (Table 1). Ecological criteria were based on terrestrial and aquatic ecosystem features that would indicate planning units that were valuable to conserve. Terrestrial features were based on habitat suitability, connectivity, biodiversity, and natural cover (Table 1). Ecological criteria for aquatic ecosystem features were based on habitat suitability, Ecologically Significant Groundwater Recharge Areas (ESGRAs), and percentage of riparian natural cover and forest cover at the reach contributing area (RCA) level (Table 1). Percentage of riparian natural cover and forest cover was summarized by 30-m buffers of the watercourse accounting for estimated stream width.

Municipal NHS

Finally, we deemed that the municipal natural heritage systems (see section 3.1.1) may add protection to prevent development in these areas and account for the municipal priorities that may be associated in these areas. Consequently, municipal natural heritage planning units are not guaranteed to be protected and are not locked-in for the Marxan analysis.

Table 1: List of 36 criteria and cost relating to ecological and natural heritage system (NHS) features that are included in the Marxan analysis. Beige sections are locked-in criteria. Bracketed numbers are the number of criteria involved in each of the categories.

Category	Type	Date	Source	Summary
Locked-in ecological & NHS feature and area (8)	Wetlands	2020	TRCA	• TRCA updated wetland for Water Resource System (2020) including Provincially Significant Wetlands (PSWs), wetlands identified using ELC, natural cover (orthophotos), planner notes • Restored wetlands • All wetlands are represented
	Fish Habitat	2020	TRCA	• Existing mapped watercourses with a 10-m buffer • All watercourses are represented
	Woodlands	2017	TRCA	• All forests and successional forest are represented
	Valleylands	2019	TRCA	• Represented by crest of slope
	Wildlife Habitat	2017	City of Toronto TRCA	• Includes Toronto Environmentally Significant Areas (ESA), migratory bird habitat (all natural cover 5 km from shoreline; OMNR 2005; Archibald et al. 2017)
	TRCA Conservation Lands	2015	City of Toronto	• All natural cover within TRCA property are represented
	Areas of Natural and Scientific Interest (ANSI)	2020	Ontario Ministry of Natural Resources and Forestry	• Consists of Earth and Life Science
	Habitat of endangered and threatened species	2017	TRCA	• Mainly included by criteria above
Ecological Function-based Criteria: Terrestrial (20)	Remaining natural cover	2017	TRCA	• Includes any remaining natural cover not locked-in above
	9 Habitat suitability analysis (HSA)	2020	TRCA	• Habitat suitability of avian and amphibian functional trait groups (see section 3.2.1.3)
	4 Connectivity	2020	TRCA	• Pinchpoint connectivity of avian and amphibian movement guilds (see section 3.2.1.2)
	3 Alpha diversity (richness)	2020	TRCA	• L1-L3 types of flora, avian, ELC (see section 3.2.1.1)
	3 Beta diversity	2020	TRCA	• L1-L3 types of flora, avian, ELC (see section 3.2.1.1)
Ecological Function-based Criteria: Aquatic (7)	2 Riparian natural cover	2020	TRCA	• All natural cover and forest cover as riparian cover summarized for reach contributing areas (RCAs)
	4 HSA	2020	TRCA	• Habitat suitability of fish functional trait groups (see section 3.2.2.1)
	ESGRA	2020	TRCA	• Presence of ESGRA (see section 3.2.2.2)
Municipal NHS (1)	Municipality NHS in their existing Official Plans (as of 2017 but refined for major changes by 2020)	2020	TRCA	• Municipal Terrestrial Natural Heritage System (see section 3.1.1)

3.3.1.2. Criteria Integration

The 36 criteria for delineating TRCA’s updated regional target NHS was integrated using a tool called Marxan and then conducting additional post-processing to incorporate expert knowledge and refined information on the ground that was available through engagement process.

Marxan Modeling

Marxan is an optimization modelling tool that has been widely used for conservation planning purposes to identify reserve systems (Ball et al. 2009). It achieves the targeted conservation goals, such as ecological representation within individual planning units (e.g., one hectare hexagons) based on a set of criteria. Marxan functions as a separate software and data was compiled in ArcGIS to support the input in Marxan. Targets were then set for the individual criterion and Marxan aims to identify the most strategic areas that maximizes the set target for all criteria with minimal cost. Locked-in criteria are first included in the selection and the remaining solution accounts for the rest of the criteria for the optimization. The final output from Marxan identifies the specific planning units as the solution from the optimization process. The resulting data layer was further refined using expert knowledge, land cover and land use data, and feedback from the engagement process to recommend management options (see below).

For TRCA’s updated regional target NHS, Marxan model was run at one hectare resolution at two different spatial extents – a regional and a watershed extent. Out of the 36 criteria layers, 8 were locked-in and was automatically included in all models runs. The remaining 28 criteria were used to identify additional strategic priority areas that helped to meet the set targets for each of the 36 criteria layers at both scales.

The targets were set such that at the top 50% and top 40% of the highest functioning areas were selected at the regional scale and the watershed scale, respectively. In other words, TRCA’s updated regional target NHS would identify close to 50% of the areas regionally and 40% of the areas for each watershed that are priority for natural heritage features and functions. These targets are in line with the updated recommendations that suggest that in highly fragmented landscapes such as areas dominated by urban and/or agricultural land uses, close to half of the area is needed to ensure natural system resilience (Chan et al. 2006, Crossman et al. 2007, Vallecilli et al. 2018, Crist et al. 2021).

Final Results and Refinements

Figure 10a and 10b shows the outputs for the regional and watershed scale analysis, which were then combined to get the final priorities that captured the needs of both regional and watershed scales (Figure 10c). This approach ensured that the updated NHS recognized the overall regional needs without undermining the individual watershed priorities, needs, and opportunities. For example, the priorities, needs, and opportunities for protection, restoration, and enhancements in a highly urbanized watershed (e.g., Etobicoke) may not be captured if only a regional scale is evaluated, which will be biased towards a more natural area dominated watershed. This will compromise the health of the urban watersheds that would then compromise the overall health and resilience of the region over the long term.

The regional scale output (Figure 10a) includes about 48.3% of TRCA’s jurisdiction to meet the set criteria of top 50% ecologically functioning areas. Out of this about half comprising of 25% of the region are locked-in area and remaining are selected based on the ecological functions as identified by the ecological criteria used. As expected, most of the selected areas at the regional scale are in the relatively natural parts of the region (e.g., northern and eastern portions of the region and in the ravine systems) as these are ecologically most functioning areas. Thus, at regional scale the priorities are biased towards the naturalized portions of the region and does not capture a more local priorities such as of urbanized watersheds.

The watershed scale output (Figure 10b) includes about 48.6% of TRCA’s jurisdiction, which totals to the similar amount as the regional scale. However, the distribution of the selected areas is different at this scale. The locked-in area in each watershed is different and varies from about 20% in a more urbanized watersheds such as Mimico to about 64% in a more naturalized watershed such as Duffins. To meet the set target of 40% of each watershed Marxan algorithm selected all the locked in areas first and then tried to represent top 40% of the ecological functions for each watershed. In doing so, the algorithm identified same amount of priority areas in urbanized watersheds as in the more naturalized watersheds (which is close to 40%). This when combined resulted in the total of about 48.6% of the jurisdiction.

It is worth noting that in urbanized watersheds, not all identified areas may have opportunities for traditional management actions for NHS like protection or restoration activities such as in areas with built forms like parking lots and residential houses. However, these areas could be targeted for enhancements through various green infrastructure and low impact development implementation including urban canopy enhancements through tree planting, native gardens, naturalized ponds, permeable pavements etc. These management actions along with protection and restoration together can strengthen the health and resilience of NHS functions across urban-rural gradient in TRCA’s jurisdiction.

Given that the regional and watershed level analysis identifies different but important areas for conservation of ecosystem functions and services across urban-rural gradient, TRCA’s updated regional target NHS combined the identified priorities as a hybrid solution (Figure 10c). The hybrid map includes about 52% of the jurisdiction and ensures that the top 50% of the region and top 40% of all watersheds are represented in the TRCA’s regional target NHS.

Furthermore, the hybrid map was further refined based on available land use and land cover data, expert knowledge, and engagement feedback from stakeholders and identified priority areas were classified into three tiers to inform appropriate management recommendations using the decision tree presented in Figure 11.

The final output mapping showcases the:

- **Existing natural cover (ENC)** - Includes about 23.3% of the jurisdiction that comprise of natural cover such as locked in features and areas that are important for natural heritage functions that could be targeted for protection.
- **Potential natural cover (PNC)** – Includes about 11.9% of the jurisdiction and comprise of expanded areas important for natural heritage functions that could be targeted for restoration, if feasible, with willing landowners.
- **Contributing areas** – Includes additional 16.5% of the jurisdiction that comprise of areas important for natural heritage functions BUT where traditional protection and restoration are likely not feasible and could be targeted for Low Impact Development and Green Infrastructure implementation with willing landowners. This could be further classified by built or un-built/open area land use types which can provide further insights into what type of activities are possible with willing landowners.

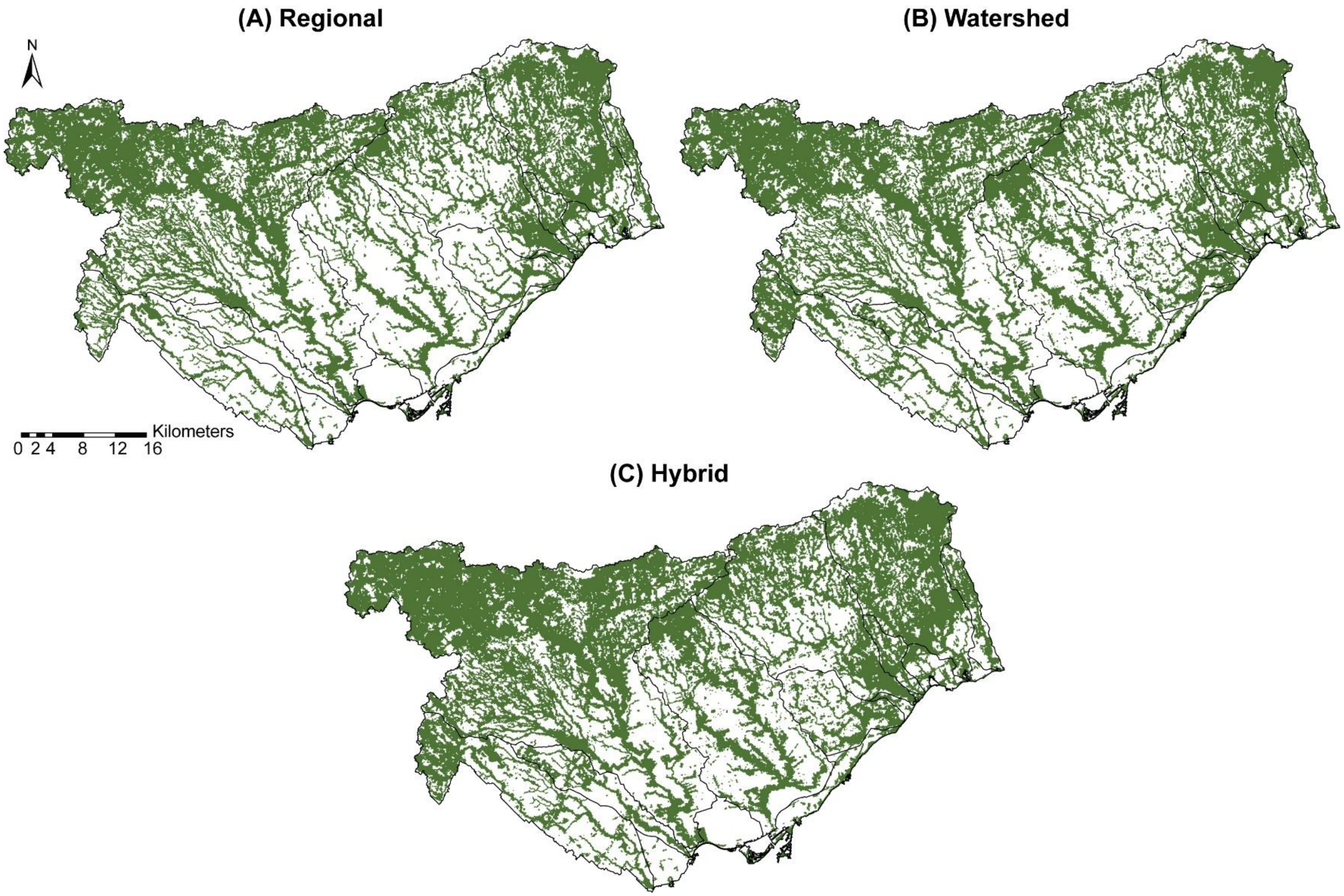


Figure 10: Comparison of Marxan solutions for (A) regional level, (B) watershed level, and (C) hybrid approach.

TRCA's updated regional target Natural Heritage System (NHS)

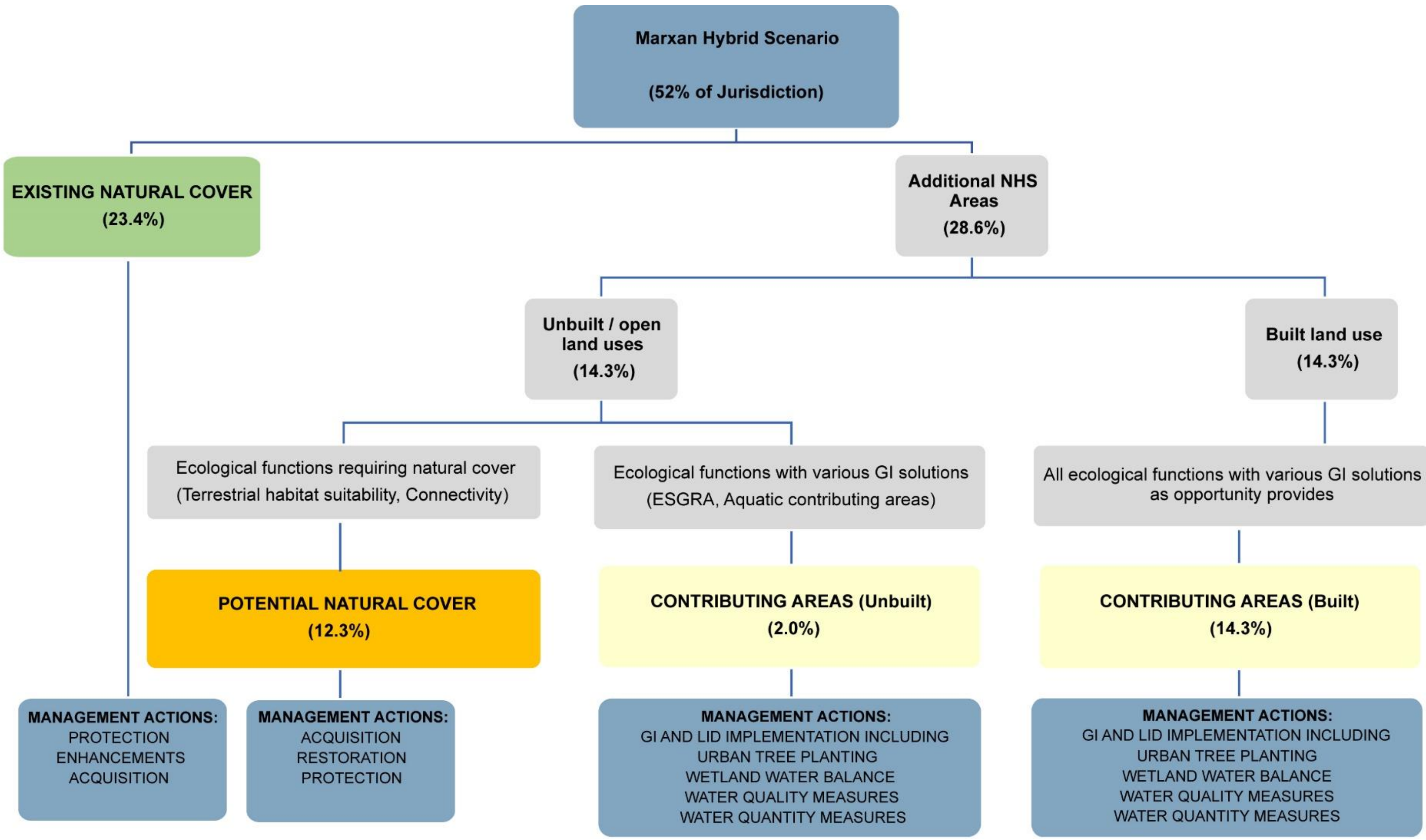


Figure 11: Tiered classification of the TRCA's updated regional target NHS into the Existing Natural Cover, Potential Natural Cover, and Contributing Areas.

TRCA’s updated regional target Natural Heritage System (NHS)

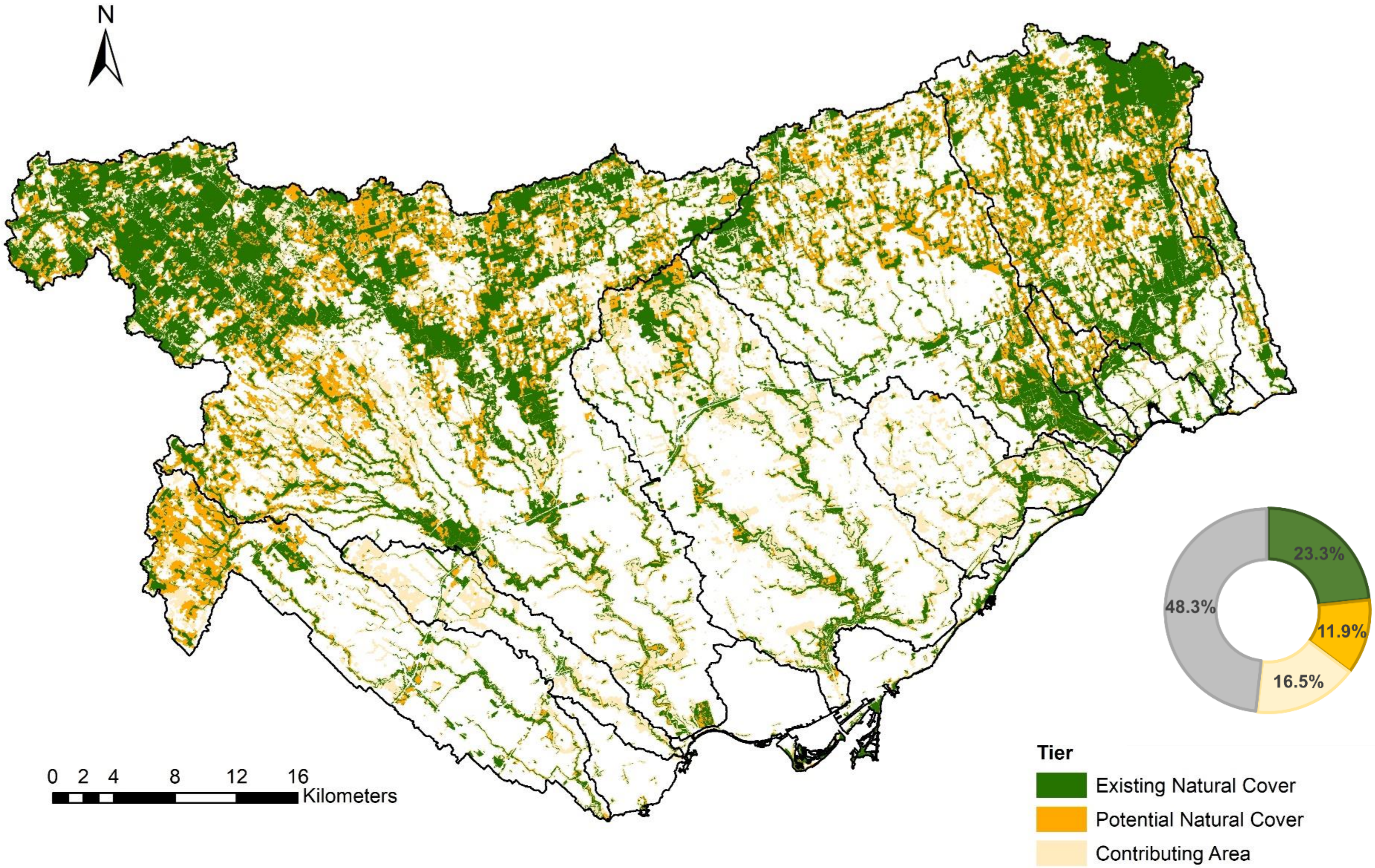


Figure 12: TRCA's updated regional target NHS with the Existing Natural Cover, Potential Natural Cover, and Contributing Areas.

Table 2: TRCA's updated regional target NHS distribution across watersheds based on the percentage of the jurisdiction.

Tier	Percentage of jurisdiction										
	Total tier	**Etobicoke**	**Mimico**	**Humber**	**Don**	**Highland**	**Rouge**	**Petticoat**	**Duffins**	**Carruthers**	**Waterfront**
Existing natural cover	**58001 ha**	2293 ha	560 ha	28053 ha	4361 ha	991 ha	7499 ha	661 ha	11154 ha	949 ha	1480 ha
	(23.3%)	(0.9%)	(0.2%)	(11.3%)	(1.8%)	(0.4%)	(3.0%)	(0.3%)	(4.5%)	(0.4%)	(0.6%)
Potential natural cover	**29614 ha**	2614 ha	129 ha	13677 ha	1203 ha	208 ha	4623 ha	622 ha	5543 ha	670 ha	260 ha
	(11.9%)	(1.1%)	(0.1%)	(5.5%)	(0.5%)	(0.1%)	(1.9%)	(0.3%)	(2.2%)	(0.3%)	(0.1%)
Contributing areas	**40989 ha**	3033 ha	2224 ha	14418 ha	8113 ha	2955 ha	4340 ha	295 ha	3290 ha	518 ha	1642 ha
	(16.5%)	(1.2%)	(0.9%)	(5.8%)	(3.3%)	(1.2%)	(1.7%)	(0.1%)	(1.3%)	(0.2%)	(0.7%)
Grand total	**128604 ha**	**7940 ha**	**2912 ha**	**56148 ha**	**13678 ha**	**4154 ha**	**16531 ha**	**1578 ha**	**19987 ha**	**2137 ha**	**3382 ha**
	(51.7%)	**(3.2%)**	**(1.2%)**	**(22.6%)**	**(5.5%)**	**(1.7%)**	**(6.6%)**	**(0.6%)**	**(8.0%)**	**(0.9%)**	**(1.4%)**

Table 3: TRCA's updated regional target NHS distribution across watersheds based on the percentage of each watershed.

Tier	Percentage of each watershed									
	Etobicoke	**Mimico**	**Humber**	**Don**	**Highland**	**Rouge**	**Petticoat**	**Duffins**	**Carruthers**	**Waterfront**
Existing natural cover	10.8%	7.4%	30.8%	12.2%	9.4%	22.4%	27.4%	39.5%	23.9%	10.2%
Potential natural cover	12.3%	1.7%	15.0%	3.4%	2.0%	14.0%	25.8%	19.6%	16.9%	1.8%
Contributing areas	14.3%	29.4%	15.8%	22.7%	27.9%	13.4%	12.2%	11.7%	13.0%	11.3%
Watershed total	**37.4%**	**38.6%**	**61.7%**	**38.3%**	**39.3%**	**49.8%**	**65.3%**	**70.8%**	**53.8%**	**23.3%**

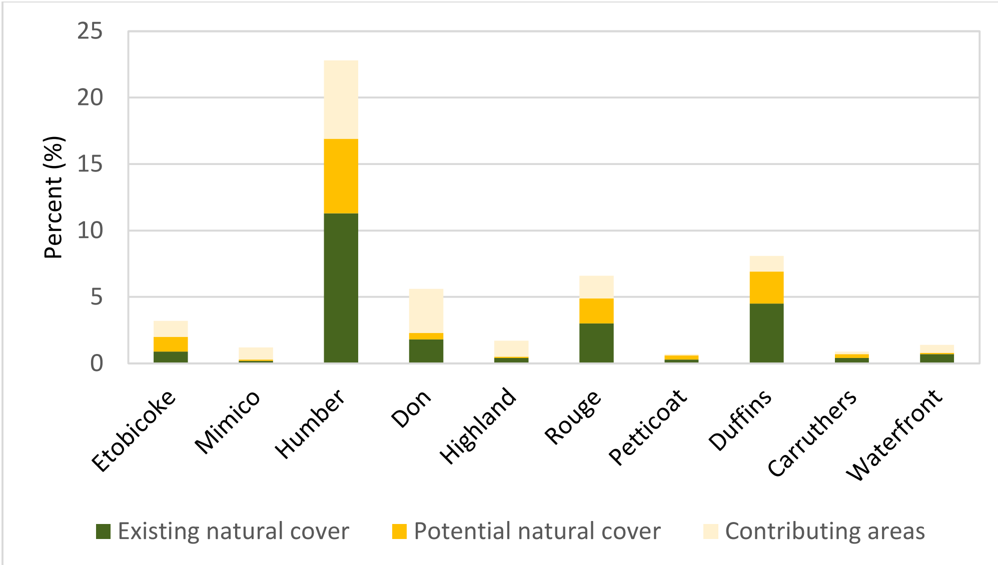


Figure 13: TRCA’s updated regional target NHS across watersheds based on the percentage of the jurisdiction.

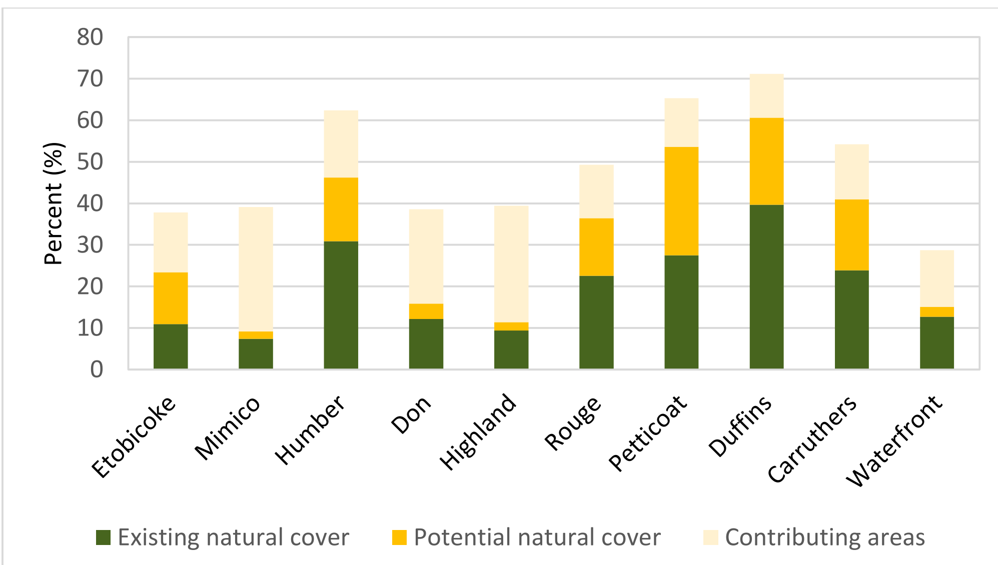


Figure 14: TRCA’s updated regional target NHS across watersheds based on the percentage of each watershed.

3.3.2. Target NHS and future land use and climate implications

3.3.2.1. Future land use implications

Urbanization in Toronto and region is ever increasing with urban land uses making up more than half of land cover within the jurisdiction. This is expected to continue with population growth expected to increase towards the mid-century (Ontario Ministry of Finance 2020). Many municipalities in Toronto and Region have included potential urban expansion areas in their recent draft Official Plan updates to accommodate these increases (Peel Official Plan, Durham Official Plan, York Official Plan). Urbanization alters biodiversity across the landscape by converting natural landcover to urban land uses dominated by built surfaces, which adversely affects habitat and biodiversity (Johnson and Munshi-South 2017, Nelson et al. 2009, Turrini and Knop 2015). These negative impacts can be mitigated to some extent by reducing urban sprawl and intensifying development within city boundaries using sustainable urban design and ecosystem sensitive design solutions. These solutions help support human population growth as well as provide opportunities for healthy and resilient ecosystem functions and services that benefit ecology and community well-being (Milder 2012, Norton et al. 2016).

In Ontario the Provincial Policy Statement (PPS 2020) recognizes the challenges associated with urbanization and thus provides guidance to municipalities to identify and adequately protect the important areas for natural heritage and water resource systems. It provides guidance through multiple provincial plans such as the Greenbelt Plan (2020), Oak Ridges Moraine Plan (2020), Niagara Escarpment Plan (2020), and the Growth plan (2020). Furthermore, PPS directs municipalities to identify NHS and WRS in their Official Plans and provide details on protecting and enhancing them. TRCA's updated regional target NHS provides a science-based information and screening tool for partner municipalities to achieve their NHS goals and objectives in their Official Plans as well as in subsequent land use and infrastructure planning processes.

Table 4 and Figure 15 highlights the distribution of TRCA's regional target NHS across the three broad land use zones in TRCA's jurisdiction; Greenbelt, Whitebelt, and Urban Zones. This analysis provides a breakdown of TRCA's updated regional target NHS distribution in each of these land use zone to provide insights on implementation opportunities and challenges.

Table 4: TRCA's updated regional target NHS distribution across Greenbelt, Whitebelt, and Urban portions of TRCA jurisdiction.

Tier	Total	Percent of TRCA Jurisdiction that is Target NHS and Contributing Areas		
		Greenbelt Zone	Whitebelt Zone	Urban Zone
Existing Natural Cover	23.3%	38063 ha (15.3%)	2624 ha (1.1%)	17287 ha (7.0%)
Potential Natural Cover	11.9%	18774 ha (7.5%)	5242 ha (2.1%)	5592 ha (2.2%)
Contributing Area	16.5%	9042 ha (3.6%)	2851 ha (1.1%)	29085 ha (11.7%)

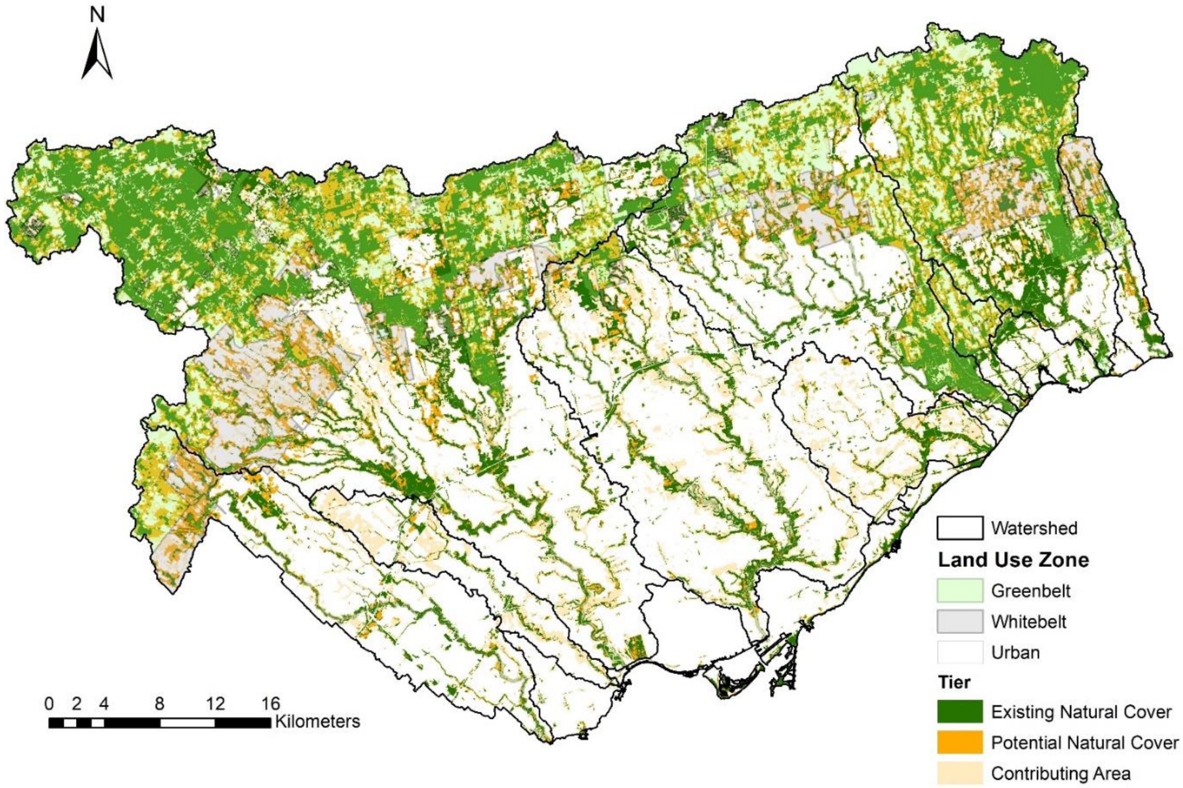


Figure 15: Land use zones and their overlap with the target Natural Heritage System 2022.

Greenbelt Zone includes areas within the Greenbelt including the provincial NHS and protected countryside designations. These areas are deemed safer from land use changes unless modifications are made to the Greenbelt Act. These areas are often restricted from development and provides greater level of protection from urbanization and land use changes. Most of the existing natural cover (15.3% out of 23% jurisdiction wide) is found to be within the Greenbelt, which indicates that they have better protection from future land use changes. It also contains some potential natural cover areas (7.5% out of 12%) that provides opportunities for restoration with willing landowners. The contributing areas in the Greenbelt Zone are limited (about 3.6% out of 16%) and could provide a good opportunity for implementation of various green infrastructure and LID in rural context, where restoration may not be possible.

Whitebelt Zone includes areas that are not currently urban but may be open to future urbanization as deemed necessary through Official Planning processes. These areas mostly include farmlands and some natural areas, mostly within the valley and stream corridors and conservation lands. These areas do not warrant same level of protection from urbanization, unless there are other regulatory provisions in place (e.g. wetlands, flood and erosion hazard etc.). This zone includes limited amount of existing and potential natural cover of TRCA’s updated regional target NHS at about 1% and 2% respectively. There is also limited contributing areas (about 1%). This is largely because most of this zone is dominated by agricultural lands and has limited natural cover to start with. In addition, these areas mostly have undefined valley and stream corridors that limits riparian natural areas as well. Despite the limited natural areas, the identified target NHS areas in this zone still make up about 10,000 hectares that could be either protected, restored, and enhanced through land use and infrastructure planning processes and/or conservation planning initiatives or alternately, degraded and lost to future urbanization, which will affect the overall regional NHS objectives.

Urban Zone includes areas within current urban boundaries. Most of the areas have already been converted to urban land uses with some remnant natural cover, mostly within valley and stream corridors and conservation lands. Despite being heavily urbanized, this zone includes about substantial portion of existing natural cover identified in the TRCA’s updated regional target NHS (7% out of 23%). These areas warrant protection that are often provided through regulations related to valley and stream corridors and wetland protection and other municipal regulations such as City of Toronto’s Ecologically Significant Areas. This zone also includes some potential natural cover areas for restoration (2.2% out of 12% identified in the target NHS), which are often around existing natural cover that can bolster the ecological functions of the existing natural heritage. Additionally, the urban zone includes large portion of the contributing areas (11.7% of the 16% identified in the target NHS) that can support the ecological functions of the existing and potential natural cover areas. These are largely in the built land uses and implementation of various green infrastructure and low impact development such as urban forest canopy enhancement, native gardens, meadow restoration, naturalized ponds, green roofs, permeable pavements etc. to make urban areas more ecological and hydrologically functional and reduce the negative impacts of urban matrix.

The urban areas, which remnant habitat are the existing natural cover representing 17,287 ha (7%) of the NHS in the jurisdiction. There is the smallest opportunity for potential natural cover with 5,592 ha (2.2%) available compared to all the land use zones due to the majority of areas being built in the jurisdiction. In urban areas, enhancement opportunities will rely heavily on contributing areas (29,085 ha, 11.7%). By considering these contributing areas, whether through green infrastructure implementation such as urban forest canopy or low impact development, the influence of the urban matrix could be reduced and enhance the habitat quality of the remnant existing natural cover to ensure ecosystem function.

Across Toronto and region, there are areas where future urban development and infrastructure is being planned through various land use and infrastructure planning processes (e.g., Seaton lands, Highway 413) as this analysis was being completed. Where information was available, they were used in a post-processing step to refine the TRCA’s updated regional target NHS. Mostly, the potential natural cover areas identified in the models were converted to contributing areas recognizing that these areas are important ecologically but may not have the opportunities to undertake traditional restoration. In such cases, TRCA’s recommendation is to treat them as contributing areas and prioritize for green infrastructure and LID implementation as appropriate through sustainable urban planning and design principles that incorporates ecological and/or hydrological functions identified for the area.

Furthermore, since the land use and infrastructure planning processes are on-going as per municipal needs, it is important to note that the TRCA’s regional target NHS is used as a screening tool and a science-based information for NHS planning at finer scales to achieve the regional NHS goals and objectives, as appropriate. Achieving the protection, restoration, and enhancement opportunities at site level can scale up to ensure a functioning NHS that supports healthy and resilient ecosystems and communities across the region.

3.3.2.2. Future climate change implications

Climate change is one of the major drivers of change for natural systems globally. In Toronto and region, the future projected climate change is expected to intensify climate impacts on the regional natural systems. To mitigate and adapt to the climate impacts for resilient natural systems, it is important to better understand the vulnerability of natural systems to climate change. Improved understanding of what and how climate drivers affect different natural system components can guide impact mitigation and adaptation actions on the ground.

Using the climate change vulnerability assessment (CCVA) results (described in Section 3.1.2.), the TRCA's updated regional target NHS was evaluated to identify how much of medium and high vulnerability areas are included in the target NHS. The improved understanding of the NHS' ability to address climate vulnerabilities of the ecosystem components will help inform management actions as appropriate. Five key vulnerability indicators were used to assess the climate vulnerabilities of natural systems in TRCA's jurisdiction: habitat patch score, climate sensitivity of native vegetation, wetland hydrological stability, soil drainage rating, and ground surface temperature (described in Section 3.1.2). For each of the indicator high and medium vulnerability classes were spatially overlapped with the TRCA's updated regional target NHS to assess how much of these areas are included in the NHS. Table 5, Figure 16, and Figure 17 highlight the results of this analysis.

Table 5: Distribution of climate vulnerable areas (medium and high) in TRCA's updated regional target NHS.

	Climate Vulnerability Indicators									
	Habitat Patch		Climate Sensitive Vegetation		Wetland Vulnerability		Soil Drainage		Ground Surface Temperature	
	Med	High	Med	High	Med	High	Med	High	Med	High
Existing Natural Cover	25209	16069	4333	157	2040	964	10299	16273	23864	2040
	89.6%	75.8%	94.5%	74.0%	100%	100%	19.6%	12.9%	23.7%	2.2%
Potential Natural Cover	1181	1008	80	20	0	0	10937	5298	18794	1520
	4.2%	4.8%	1.7%	9.6%	0%	0%	20.9%	4.2%	18.6%	1.6%
Contributing Areas	948	1496	98	13	0	0	7873	24010	23381	13096
	3.4%	7.1%	2.1%	6.0%	0%	0%	15.0%	19.0%	23.2%	14.2%
Non-NHS areas	805	2629	75	22	0	0	23326	80745	34784	75776
	2.9%	12.4%	1.6%	10.4%	0%	0%	44.5%	63.9%	34.5%	82.0%

Note: Percentages represent the total tier in each climate vulnerability indicator

Overall, most of the identified medium and high vulnerability habitat patches, climate sensitive vegetation, and wetlands are included within the target NHS. However, there are still some areas outside of the target NHS, mostly related to meadow cover that have relatively lower ecological value and was not included in the target NHS. In contrary, for soil drainage and ground surface temperature indicators, the target NHS included much lower percent of the identified medium and high vulnerability areas. This is largely because the first three indicators are associated with natural cover that NHS could provide better support and the last two indicators are reflective of the landscape conditions and helps to identify where the natural systems have added vulnerability and thus is at a greater risk from climate change impacts. For these two indicators target NHS alone cannot be enough to address the vulnerabilities, rather a broader urban matrix management is needed. Further discussion and distribution of these indicators are illustrated in Figure 14 and 15 and discussed below.

Most of the **habitat patches** with medium and high vulnerabilities to climate are included within the target NHS (17,076 ha or 88% of the high and 26,391 ha or 97% of the medium vulnerability areas) (Figure 15a). Existing natural cover includes about 76% high and 90% medium, potential natural cover includes 5% high and 4% medium, and contributing areas includes about 7% high and 3% medium vulnerability areas. This indicates that in TRCA’s jurisdiction most of the climate vulnerable habitat patches are included within the target NHS, thus achieving the target NHS will ensure that the climate vulnerabilities of the habitat patches are mostly addressed, thus ensuring resilient habitats. In addition, this also indicates that the target NHS has substantial areas that are vulnerable to climate impacts, which can act as a threat multiplier when combined with the land use change impacts. Thus, adequate climate adaptation and land use impact mitigation measures need to be put in place in habitat conservation initiatives. There are some climate vulnerable areas (12% of the high and 3% of medium vulnerability areas) are outside the target NHS, which mainly consists of low ecological function meadow habitat patches such as along highway corridors.

Most of the **climate sensitive vegetation** vulnerable to increasing seasonal temperatures and increasing variability in precipitation are included in target NHS (190 ha or 90% of the high and 4,512 ha or 99% of the medium vulnerability areas) (Figure 15b). Existing natural cover includes about 74% high and 95% medium, potential natural cover includes 10% high and 2% medium, and contributing areas includes about 6% high and 2% medium vulnerability areas. Like the first indicator, this one also shows that the target NHS provides adequate support to the climate sensitive vegetation in TRCA’s jurisdiction if the management recommendations are achieved in these areas. However, some areas (about 23 ha or 11% of high and medium vulnerability areas) are outside the target NHS. These include mostly coastal vegetation outside of the boundaries of NHS. These areas can be addressed by maintaining the existing natural cover or considering potential natural cover in nearshore areas.

Vulnerable wetlands with limited sources of water inputs (e.g., precipitation fed wetlands), the climate change impacts, specifically replated to precipitation pattern changes, may result in dry conditions for extended periods of time. This makes them more vulnerable to colonization by upland vegetation and invasive species leading to potential adverse impacts. All vulnerable wetlands were included the target NHS (1,021 ha or 100% of the high and 2,141 ha or 100% of the medium vulnerability areas) (Figure 15c). Existing natural cover includes all high and medium vulnerability areas. For these areas, protecting the feature is important but also focus should be on enhancing hydrological connections to the wetland to ensure their long-term resilience. All wetlands were locked-in features and none would be outside of the target NHS.

Unlike the first three indicators, most areas with poor **soil drainage** across the region that may produce shallower root networks and increased potential for localized inundation, contributing to higher relative vulnerability are not included in the target NHS. This indicator helps to identify where the natural systems have added vulnerability and thus is at a greater risk from climate change impacts. About less than half of the areas with medium and high vulnerability due to soil drainage conditions are included in the target NHS (45,581 ha or 36% of the high and 29,109 ha or 56% of the medium vulnerability areas) (Figure 15d). Existing natural cover includes about 13% high and 20% medium, potential natural cover includes 4% high and 21% medium, and contributing areas includes about 19% high and 15% medium vulnerability areas. All these areas that amounting to thousands of hectares highlight a major challenge to the target NHS. In these areas protecting and restoring features and functions of natural cover alone may not be enough to ensure resilience, given the uncertainties and extreme events that climate change brings about. Additional adaptation measures to address the hydrological and soil conditions will need to be incorporated in the management framework to ensure NHS functions over long term. This analysis also highlights that more than half of the high (67%) and medium (45%) vulnerability areas for soil drainage are outside of target NHS that may have implications on other climate adaptation initiatives that should be addressed to avoid unintended consequences of climate change.

Ground surface temperature represents the potential heat and drought stress throughout the natural system leading to the drying of soil and forest understories, plant heat stress, reduction in natural system thermal regulation, and loss of thermal refuges for heat-intolerant species. Like soil drainage this indicator also helps to identify where the natural systems have added vulnerability and thus is at a greater risk from climate change impacts. About 16,656 ha or 18% of the high and 66,039 ha or 66% of the medium vulnerability areas were included in the target NHS (Figure 15e). Existing natural cover includes about 2% high and 24% medium, potential natural cover includes 2% high and 19% medium, and contributing areas includes about 14% high and 23% medium vulnerability areas. These thousands of hectares of high and medium vulnerability areas in the target NHS are largely due to the high ground surface temperature of the surrounding matrix that is affecting the natural systems, including in the existing features. This vulnerability is reflective of the greater imperviousness and the urban heat island effect. The existing cover might be protected physically but the high vulnerability due to this indicator needs to be managed / mitigated if the ecosystem component is to sustain itself over long term. Likewise, the potential and contributing areas should be restored and enhanced through increasing urban forest canopy by increasing vegetation cover and reducing impervious surfaces, which could reduce the heat impacts on the natural systems overall.

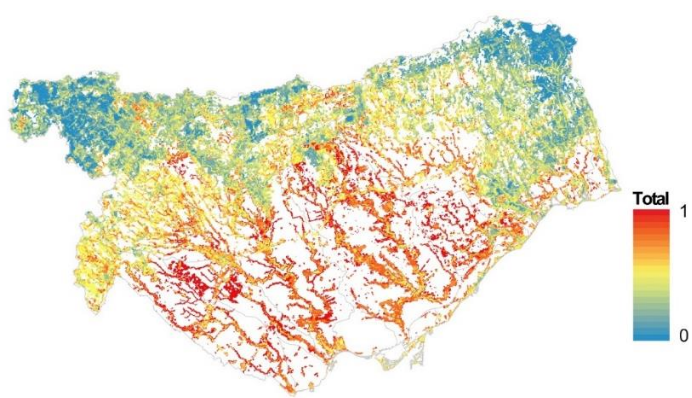


Figure 16: Distribution of additive scores of climate change vulnerability assessment indicators in the TRCA's updated regional target Natural Heritage System (0 indicates low vulnerability and 1 indicates higher vulnerability).

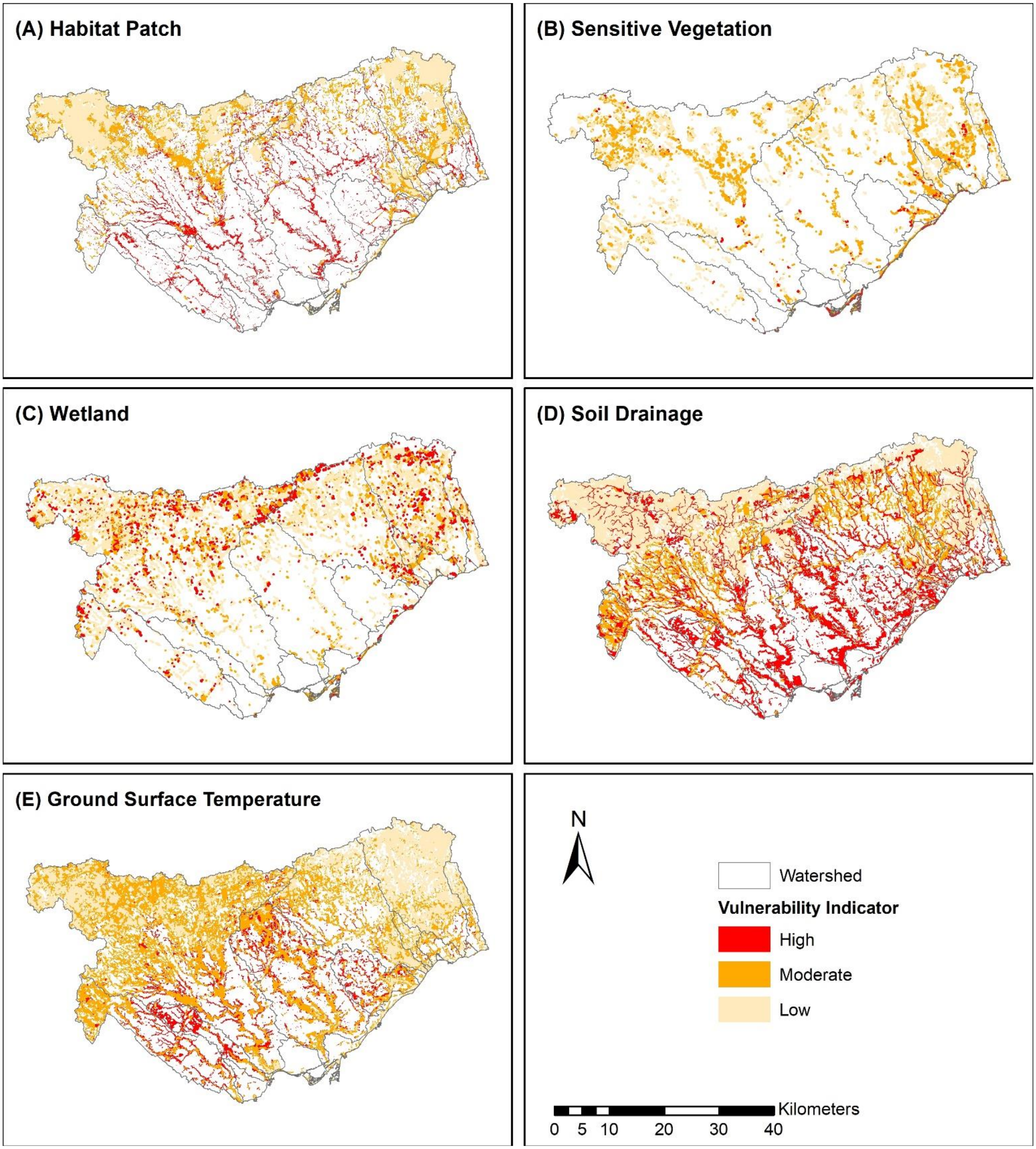


Figure 17: Distribution of climate change vulnerability assessment indicators in the TRCA’s updated regional target Natural Heritage System.

3.3.3. Watershed and local-level refinement

TRCA's updated regional target NHS was used to inform the Watershed Planning process for Etobicoke Creek Watershed Plan (ECWP) for watershed-level refinements in addition to local-level refinements from engagement sessions with conservation authorities, municipalities, BILD, and agricultural advisory communities. For Watershed Planning, the updated regional target NHS was refined using further detail from additional finer-level data that informed additional potential natural cover based on Restoration Opportunities Planning (ROP) as well as future development (ROPA Mayfield West and Whitebelt) in the watershed. From the engagement sessions, comments were addressed using additional detail provided through internal discussion or requested data internally/externally that led to local-level refinements.

The watershed-level refinements for ECWP identified additional potential natural cover, but also the conversion of the regional target NHS due to future land use changes from ROPA Mayfield West and the Whitebelt. First, for additional potential natural cover, ECWP had finer-level data for aquatic and terrestrial ecological function (Appendix 1) that was used to identify high scoring areas with high ecological function that may require restoration not included in the updated regional target NHS. Second, detailed data defining the future development in this watershed were used to refine the updated regional target NHS using ROPA Mayfield West and identified natural areas maintained their existing natural cover, potential natural cover and contributing area designations. All built-up areas identified in the ROPA were converted as built-up contributing areas. Third, the Whitebelt development assumed that a separately derived Conservation Authority NHS (TRCA and Credit Valley Conservation) served as the backbone for refining existing and potential natural cover within the Whitebelt. This maintains the goal that adding potential natural cover would widen corridors and enhance connectivity of the Conservation Authority NHS in addition to the high scoring areas.

The local-level refinements from the NHS engagement sessions were first addressed with site-level comments. Site-level comments include the refinements of existing natural cover, where there were further land use changes that were not present in the TRCA natural cover (2017) layer. These areas were flagged by comments indicating that the existing natural cover had already been removed or will be undergoing development. Potential natural cover was added where possible when comments were received, including alignments with the municipal NHS where warranted. In areas where potential natural cover would not be possible due to future development, these areas were converted into contributing areas. The assumption is that the ecological function that once drove the selection of these areas in the updated regional target NHS remain necessary in an urbanized landscape.

4. CONCLUSION

TRCA's updated regional target Natural Heritage System (NHS) provides science-based information and a screening tool that highlights the existing and potential features and areas that are important for long-term health and resilience of ecosystems in TRCA's jurisdiction. It is based on the systems approach and the principles of NHS as outlined by the province as well as TRCA's Terrestrial Natural Heritage System Strategy (2007). The core principle includes increasing quantity, quality, connectivity, and distribution of ecosystems, both structurally and functionally, across the entire jurisdiction. This would enable a steady provision of various ecosystem services (e.g., clean air and water, flood protection, pest reduction, increased recreation, and aesthetic opportunities) that are vital for human well-being. The target NHS accounts for current and future changes in land use and climate and identifies areas where impact mitigation and adaptation actions could strategically benefit the long-term health and resilience of the natural systems across the region.

Provincial directions require municipalities to provide adequate protection and enhancements to natural heritage system. TRCA’s updated regional target NHS is intended to be a tool for TRCA and its municipal partners to inform various strategic and site level initiatives (with appropriate refinements). This includes informing watershed and subwatershed planning, land use and infrastructure planning, land securement and management, ecological restoration and green infrastructure implementation, and municipal comprehensive review and official plan review processes. TRCA’s updated regional target NHS is not intended to disrupt existing decision-making processes, but rather to inform them based on up-to-date science and to identify partnership opportunities to facilitate collaborative initiatives.

TRCA’s updated regional target NHS identifies 36% of the TRCA’s jurisdiction as target NHS comprising of existing natural cover (24%) that should ideally be targeted for protection and potential natural areas (12%) that should be targeted for restoration, where opportunities exist with willing landowners. This will help increase natural cover quantity and quality across TRCA’s jurisdiction. Given that the TRCA’s jurisdiction is highly urbanized, the existing natural cover is under various direct and indirect stress from urbanization as well as other stressors like climate change. The existing and potential natural areas identified in the target NHS will be a critical backbone of our ecological system across the jurisdiction for a healthier NHS.

However, protecting and restoring existing and potential natural cover areas may not be enough to ensure long term resilience of NHS given the exacerbated impacts and uncertainties associated with the combined effects of urbanization and climate change together. Thus, TRCA’s updated regional target NHS identifies additional 16% of the jurisdictional area in the form of Contributing Areas that are intended to support the NHS features and functions, but where traditional restoration opportunities may be limited due to its existing conditions (e.g., built areas) and/or planned objective (e.g., approved for future development). The Contributing Areas are mostly within the urban land uses, that have been identified as important for various ecological functions. Here, various enhancement opportunities, especially through green infrastructure and LID implementation could be targeted to improve ecosystem functions and services. This ensures that both natural and built portions of TRCA’s jurisdiction is strategically targeted for protection, restoration, and enhancements for a healthy and resilient NHS that can sustain ecosystem functions and services on the long run.

5. REFERENCES

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Attachment 2:
WRS Summary Report 2022

TRCA Water Resource System: A Summary Report

Prepared By:
Watershed Planning and Ecosystem Science
Development and Engineering Services
August, 2022

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Summary

The development of Water Resource System (WRS) data layers for Toronto and Region Conservation Authority (TRCA) provides robust decision support tools and information to guide various TRCA and municipal initiatives, including watershed planning, restoration planning, land use, and infrastructure planning. Notably, the development and update of the WRS within TRCA's jurisdiction is intended to assist municipal partners with achieving provincial policy conformity that requires them to identify the WRS through watershed planning. Components of the WRS are critical to the overall function and health of watersheds. Broadly, the total amount and protection afforded to Key Hydrologic Features (KHFs) and Key Hydrologic Areas (KHAs) within a watershed is related to water quality, water quantity, aquatic ecosystem health, terrestrial ecosystem health, erosion, hydrogeology, and flooding. WRS components defined in the *Growth Plan* (2020) include:

Key Hydrologic Areas (KHAs)

- Significant Groundwater Recharge Areas (SGRAs);
- Highly Vulnerable Aquifers (HVAs);
- Significant Surface Water Contribution Areas (SSWCAs);
- Ecologically Significant Groundwater Recharge Areas (ESGRAs);

Key Hydrologic Features (KHFs)

- Permanent streams;
- Intermittent streams;
- Inland lakes and their littoral zones;
- Seepage areas and springs;
- Wetlands.

In 2019 a review was conducted by the Ecosystem and Climate Science team to assess the various data layers that are used for mapping the WRS within the TRCA jurisdiction. This identified that many KHF and KHA data layers had several issues that contributed to a higher level of mapping uncertainty, including a high level of error associated with the spatial location of the current features/areas as well as with errors associated with their configuration, size, and shape of features/areas. Further, the review revealed other issues, including that existing data layers were somewhat outdated (>5 years), were produced for cartographic purposes only, had many versions that varied in scope and mapping, or did not include features/areas that had been identified in more recent policy updates.

This report summarizes TRCA's systematic approach, methods, and resulting data that helps to delineate TRCA's WRS. This addresses a large share of the previously highlighted issues associated with

existing data layers and provides an increased level of accuracy from previous versions. This document provides details around several WRS features and areas, including: (1) Ecologically Significant Groundwater Recharge Areas (ESGRAs), (2) Seepage areas and springs, (3) inland lakes and littoral zones, (4) wetlands, (5) intermittent/permanent streams, and (6) Significant Surface Water Contribution Areas (SSWCAs). Notably, outside of refinements and overlapping between WRS layers, there are only two layers that map new areas for the WRS, including ESGRAs and Seepage areas and Springs. Other components, including both Highly Vulnerable Aquifers (HVAs) and Significant Groundwater Recharge Areas (SGRAs) are also part of the WRS, but are developed to satisfy requirements of the *Source Protection Plan* for the Credit Valley, Toronto and Region and Central Lake Ontario region (CTC-SPC 2015) under the *Clean Water Act* (2006). Thus, there is already a process in place for HVAs and SGRAs, which is detailed in other referenced materials.

Altogether, the WRS has an aerial footprint of 66.3% for the TRCA jurisdiction, where most KHAs and KHFs are found in the urbanized (32.0%), followed by greenbelt (29.4%), and whitebelt (4.9%) lands. However, most of this footprint was related to Source Water Protection layers, where HVAs (43.3%) and SGRAs (29.1%) represent the largest aerial footprints for the jurisdiction. When considering newly developed layers (ESGRA and Seepage areas and Spring) the aerial footprint of new mapped areas for the WRS only equates to 2.5% (~6,100 Ha) of the TRCA jurisdiction. After HVAs (43.3%) and SGRAs (29.1%), the footprint of KHAs and KHFs (from largest to smallest) includes ESGRAs (13.6%), seepage areas and springs (10.5%), SSWCAs (9.3%), wetlands (4.6%), and inland lakes and their littoral zones (0.4%). Lastly, classification of watercourses found that permanent (46.2%) and intermittent (21.2%) streams make up most of the watercourses in the TRCA, however, there remains a large portion of unknown watercourses (i.e., data deficient; 32.6%).

Overall, this project has produced scientifically robust mapping products, where the methods outlined in this document detail how the amount of uncertainty is reduced as much as possible. Notably, KHFs and KHAs may be subject to development, such as within the whitebelt, and require watershed planning exercises. To that end, these data products will be useful for TRCA and its partners in the many land use and infrastructure planning processes they undertake, such as watershed planning, restoration planning, settlement area boundary expansions, and achieving provincial policy conformity through municipal comprehensive reviews. Specifically, these data products can be used by municipalities to identify the WRS to provide for the long-term protection of key hydrologic features, key hydrologic areas, and their functions, as required by provincial policies. Similar to Natural Heritage System (NHS) planning, municipalities should adopt consistent policies for the protection of the WRS. This should include, at a minimum, protection policies for key hydrologic features and appropriate mitigation policies for key hydrologic areas through Official Plans.

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INTRODUCTION

Broadly, the Water Resource System (WRS) as defined and/or referred to in various Ontario provincial policies (*Provincial Policy Statement* (PPS; 2020), *Growth Plan* (2020), *Greenbelt Plan* (2017), and *Oak Ridges Moraine Conservation Plan* (ORMCP; 2017) comprises of both Key Hydrological Features (KHFs) and Key Hydrological Areas (KHAs). Specifically, the WRS as defined in the *Growth Plan* (2020) is considered to include, "*ground water features* and areas and *surface water features* (including shoreline areas), and *hydrologic functions*, which provide the water resources necessary to sustain healthy aquatic and terrestrial ecosystems and human water consumption." The components of the WRS, are:

Key Hydrologic Areas (KHAs)

- Significant Groundwater Recharge Areas (SGRAs);
- Highly Vulnerable Aquifers (HVAs);
- Significant Surface Water Contribution Areas (SSWCAs);
- Ecologically Significant Groundwater Recharge Areas (ESGRAs);

Key Hydrologic Features (KHFs)

- Permanent streams;
- Intermittent streams;
- Inland lakes and their littoral zones;
- Seepage areas and springs;
- Wetlands.

As water is essential for our survival and the health of the natural environment that it supports. This concept is recognized in many of TRCA's strategic priorities, but is central to the strategic priority of, "Manage our regional water resources for current and future generations" (TRCA 2018). Here, desirable outcomes within this priority include:

- Natural aquatic ecosystem functions within the nine watersheds are protected and enhanced using the best available tools and data to target investments for the best results;
- Adaptive measures to address climate change are integrated into infrastructure projects to ensure their durability and resilience;
- Toronto Region waterways are suitable for swimming, fishing, and recreational activities;
- Source water quality and quantity is maintained or improved;

- Known flood and erosion risks, as part of the TRCA Erosion and Hazard Mitigation Strategy which, if funded, can mitigate known risks in the jurisdiction, are being addressed by TRCA and stakeholders on a priority basis.

To meet these desirable outcomes, it requires a robust understanding of the WRS, where KHFs and KHAs are components of a watershed that are required to maintain or improve key processes and functions, such as the resulting biodiversity that the WRS supports. From a holistic perspective, the water resource system can encompass hydrological, infrastructure, ecological, and human processes that involve water (Brown et al. 2015). Notably this includes biogeophysical processes (the hydrologic cycle and ecosystem function) and human activities/uses (construction, operation, removal of infrastructure, water consumption) (Brown et al. 2015). At a basic level, this means identifying KHFs and KHAs that support these processes so they can be considered for mitigation, compensation, protection, or restoration in management or planning decisions.

Given the importance of the WRS, there have been many policy documents that outline KHFs and KHAs, which as a result feature in many planning development processes. The development of WRS data layers for TRCA provides robust decision support tools and information to guide various TRCA and municipal initiatives, including watershed planning, restoration planning, land use and infrastructure planning. Notably, the development and update of the WRS within TRCA's jurisdiction is intended to assist municipal partners with achieving provincial policy conformity that requires them to identify the WRS for its long-term protection. This can be achieved through incorporating the WRS in municipal comprehensive reviews, settlement area boundary expansions, Official Plans, natural heritage system planning, among other strategic planning development exercises.

Identified Needs & Process

Ecosystem and Climate Science alongside *Watershed Planning and Reporting* with the support of the *Business Intelligence and Data Analytics* team have consistently met the WRS data needs for external and internal uses with the best available data. However, like any data product, best management practice, guideline, or tool, it requires a regular evaluation to ensure that needs are met, and that the product remains the best science-based evidence available.

This project undertook an evaluation process to identify needs externally and internally alongside an assessment of the feasibility and needs for the creation and update of various WRS components (Figure 1 and Table 1). Initial scoping identified that separate processes exist for the creation and update of Highly Vulnerable Aquifers (HVAs) and Significant Groundwater Recharge Areas (SGRAs). Both HVAs and SGRAs were developed for the TRCA jurisdiction to satisfy requirements of the *Source Protection Plan* for the Credit Valley, Toronto and Region and Central Lake Ontario region (CTC-SPC 2015) under the *Clean Water Act* (2006).

For the remaining components, we found that half of the WRS components, no data layers existed as of the start of 2020 and out of those that existed, 2 of 3 existing layers had many identified issues requiring an update to improve accuracy and provide the best data available (see wetlands and inland lakes sections below for further details; Table 1). Firstly, both the 'wetland' and 'inland lakes and their littoral zones' layers were subject to jurisdiction wide Quality Assurance and Quality Control (QA/QC) analysis using the best and newest data available to provide the most up to date products. For wetlands, this meant refining several available layers into one single data product. Secondly, the remaining three layers that did not exist as of the beginning of 2020 required an individual project-based approach for each layer to first conceive of a methodology to implement the creation of data layers with strong consideration given to feasibility (Figure 1). This consisted of using the best available knowledge and/or data to delineate seepage areas and springs, intermittent and permanent stream classifications, and Significant Surface Water Contribution Areas (SSWCAs; Table 1). Altogether the work completed in this program addresses the largest gaps in knowledge by providing data products that can be used by internal and external partners for various land use and infrastructure planning processes.

Table 1. A list of key hydrologic features and areas that were subject to this evaluation and development project. Listed are the six layers, a status of their availability at the end of 2019, whether they map new areas in the jurisdiction, lead and partner groups involved. **NB:** WPES – Watershed Planning & Ecosystem Science; ORMGP – Oak Ridges Modelling Groundwater Program; BIDA - Business Intelligence & Data Analytics.

WRS Component	2019 Availability	New Areas Mapped	Lead	Partner
Seepages areas and Springs	N	Y	WPES	ORMGP
Wetlands	Y	N	WPES	BIDA
Inland lakes and their littoral zones	Y	N	WPES	BIDA
Permanent and Intermittent Streams	N	N	WPES	-
ESGRAs	Y	Y	WPES	BIDA/ORMGP
SSWCAs	N	N	WPES	-
HVAs*	Y	N	-	-
SGRAs*	Y	N	-	-

*Separate processes exist for the development of this layer (see CTC-SPC 2015).

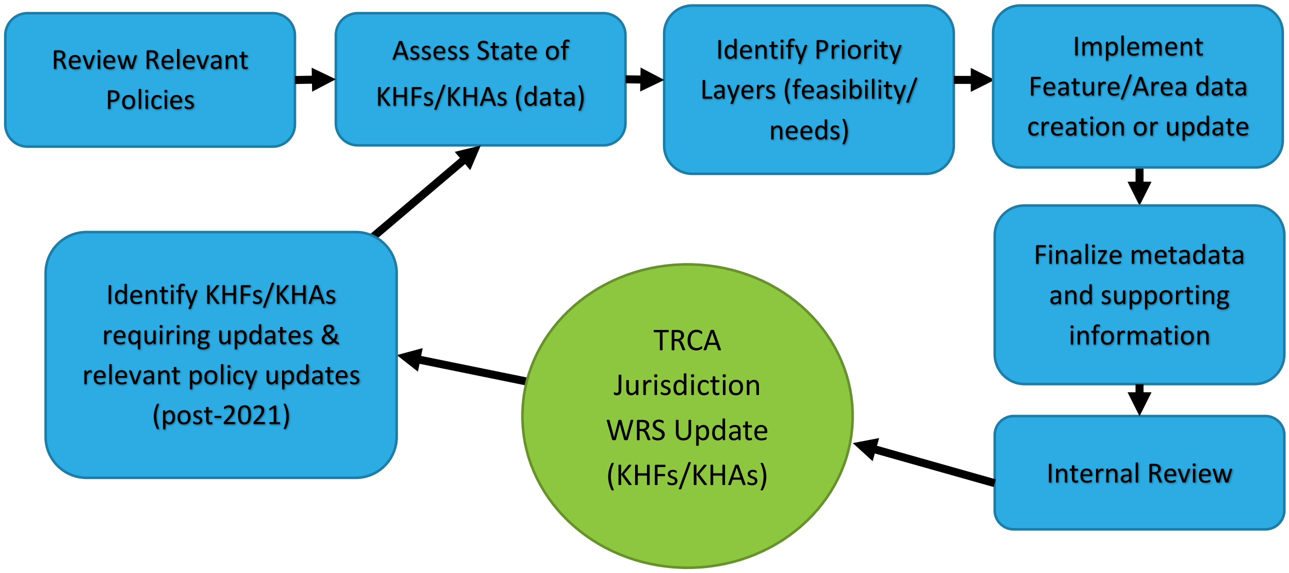

Figure 1. The process undertaken for the development and update of Key Hydrologic Features (KHFs) and Key Hydrologic Areas (KHAs).

Potential Uses of Data Layers

As is the case with any mapping product, there is a level of uncertainty with KHF and KHA data layers due to sampling, model, and data errors that may exist in the process of delineating features or areas. The data presented here should be viewed as the best available scientific knowledge applied to produce these mapping products. However, the project team has focused on minimizing error to the best possible ability in the development of the product. Notably, when possible, field data was used in the creation, update, and implementation of creating these data products (as there is greater certainty with field collected data) to ensure that uncertainty is reduced as much as possible. Regardless, as is the case with any data layer, on the ground validation is strongly recommended at the site level and should be considered to validate the presence, scale, size, and shape of KHFs and KHAs presented in this document. Ultimately, TRCA is confident that these data layers can be used by municipal partners to identify the WRS as required by provincial policies and allow for appropriate policies to ensure the protection of KHFs and KHAs.

METHODS & ANALYSIS

Below we provide the definition, data, methods, and analysis involved in the creation of KHFs and KHAs for the TRCA jurisdiction. Proceeding this we provide a brief overview of the features and areas for the jurisdiction to provide some context for the data products (see Jurisdiction Overview & Mapping). This includes data layers included in Table 1, which includes: seepage areas and springs, wetlands, inland lakes and their littoral zones, intermittent/permanent streams, ESGRAs, and SSWCAs. Although HVAs and SGRAs are not a key focus of the work presented in this document we include references to methods and analysis as well as provide a jurisdiction overview for them as they are also components of the WRS. Lastly, the implications and future considerations are provided to give some context as to what the mapping products might mean for the previously mentioned planning development processes.

Seepage Areas & Springs

A seepage area and/or spring is considered a location of the emergence of groundwater, generally occurring when the water table is at the surface. Prior to 2020 TRCA did not have a comprehensive seepage areas and springs layer for the jurisdiction that met this definition. Here the seepage areas and springs layer was developed by the Ecosystem and Climate Science (ECS) team at TRCA in collaboration with the Oak Ridges Moraine Groundwater Program (ORMGP) team. The ECS team devised a methodology that best approximates this key hydrologic feature (seepage areas and springs), which is developed using two sub-parts:

1. A linear layer describing the watercourses where groundwater discharge in the stream is predicted to be stronger than the regional average stream discharge (i.e., describing strongly discharging streams);

2. A polygon layer describing areas with strong potential for groundwater discharge at surface (i.e., water seeping out of the ground, at least during part of the year). This layer is also refined to eliminate areas of extensive urban land cover, where subsurface and surface infrastructure interferes with discharge processes.

Specifically, the discharging watercourse layer was a product of the output from a steady-state solution of the TRCA Expanded Groundwater Flow Model (TEGWFM; ORMGP 2018). For the second component, the potential discharge area is a product produced by Oak Ridges Moraine Groundwater Group (ORMGP) in 2020. This layer identifies areas where the water table potentially exceeds ground surface elevation produced by interpolating shallow water level measurements. Both these layers were combined and refined to remove areas with land cover classes defined as urban areas (this includes airport, commercial, high density residential, industrial, institutional, landfill, medium density residential, mixed commercial entertainment, railway, and road land uses).

Post-processing of the resulting layer was required as there were many small features within the watercourse and elsewhere that likely do not represent a significantly sized feature that would contribute a large amount of discharge within a given watershed (i.e., features that were < 1 hectare in size). Further, many small seepage areas were identified within urban recreational areas (e.g., urban parks, greenspaces) and along the shoreline of Lake Ontario. The reality with these small urban features is that these are not “seepage areas and springs”, as groundwater does not tend to reach the land surface as it is likely to be intercepted, diverted, and drained by urban infrastructure. Below are the criteria used to filter the final layer (Table 2). In total, approximately 7.8% of the layer was removed using these criteria.

Table 2. Criteria, action, representative area, and percentage applied during post-processing to produce the final layer of seepage area and springs.

Criteria		Action	Area (ha)	Aera of Percentage
1	Does not touch 30-m watercourse buffer; less than 1 ha	Remove	363.6	1.3%
2	Overlaps 500-m buffer along shoreline; less than 5ha	Remove	80.1	0.3%
3	Does not touch 30-m watercourse buffer; greater than 1 ha, falls within recreational	Remove	385.1	1.4%
4	Does not touch 30-m watercourse buffer; greater than 1 ha, does not fall within recreational	Keep	1,159.2	4.1%
5	Overlaps 30-m watercourse buffer; falls within natural cover	Keep	17,774.9	62.4%
6	Overlaps 30-m watercourse buffer; does not fall within recreational	Keep	7,363.9	25.8%
7	Overlaps 30-m watercourse buffer; falls within recreational	Remove	1,367.0	4.8%

Wetlands

As per the *Provincial Policy Statement* (2020), a wetland is defined as “lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs and fens.” Wetlands support many sensitive species and can contribute to mitigating erosion and flooding but can also present a natural hazard to surrounding development.

Prior to 2020 there were several different variations of wetland layers available across the jurisdiction including wetlands as classified in and TRCA’s ortho-photo interpreted natural cover data, field collected Ecological Land Classification (ELC) data, Ontario Ministry of Natural Resources and Forestry (OMNRF) wetland data, supplemented by other available data from various sources such as from field verifications for planning purposes and recently restored wetlands. Each of these data layers were targeted for specific purpose and had different level of accuracies and spatial coverage. The layer developed here consolidates these layers and refines it to reflect the latest information from the field and orthophoto interpretation (described below). The TRCA’s consolidated wetland layer was developed by the TRCA Business Intelligence and Data Analytics (BIDA) group and was updated in collaboration with ECS in 2020. A subsequent QA/QC process was completed using the latest orthophotography imagery from 2019.

The undertaking to develop this layer included three key data layers as follows:

1. **Natural cover layer** - from 2017 orthophoto interpretation. This layer is made according to TRCA internal technical standard ‘2017 Land use Natural Cover Class Definitions’.
2. **TRCA ELC wetland layer** - extracted from Ecological Land Classification data. The data is collected on an annual basis from 1996 to 2019 in various locations by biologists according to Ecological Land Classification System.
3. **OMNRF wetlands** - evaluated using the Ontario Wetland Evaluation System (OWES). The data collection date varies from 2000 to 2020.

The QA/QC process consisted of a visual verification of whether the TRCA’s natural cover and the field collected wetland polygons match the 2019 Southern Central Ontario Orthophotography (SCOOP) image (OMNRF 2019). Both the field collected ELC wetland and OMNRF wetland layers were updated for regulation limit criteria in 2019 and 2020, which included detailed field verified comments from TRCA staff and other stakeholders, where field visits and further discussion were conducted. This information was documented in the TRCA’s data update commenting tool developed by BIDA, which was thoroughly used in this wetland update for QA/QC. Any additional wetland polygons that were included from TRCA's natural cover data were also verified using orthophoto, existing data in the commenting tool, and additional discussion with TRCA staff, if there was any uncertainty in terms of its classification, boundary, or existence. All the updated data layers were consolidated into one wetland layer in GIS, which was followed by the rigorous QA/QC process using the workflow outlined in Figure 2, which essentially focused on final visual checking to assess whether the updated wetland polygons matched the 2019 SCOOP image. This essentially resulted in the following key steps:

- Remove clearly developed/graded/paved areas from wetlands; keep the remaining portions unless there is a compelling reason or clear visual evidence to the contrary.
- In some cases, if the GIS inspector is unsure whether the wetland polygon or portion of it still exist or not, further confirmation is need. The commenting tool can be used to collect advise from other professional staff to verify.
- Since ELC wetland and MNRF wetland was checked for updating regulation limit criteria layer (wetland AOI) in 2019 and 2020, the corresponding historical action layer can be used as a reference to perform QA/QC.
- Also, an accuracy assessment to ensure data quality check will be implemented to ensure there is no duplicate polygon and to establish an accuracy standard for the final data layer. 5% of the wetland data will be selected to perform quality check.

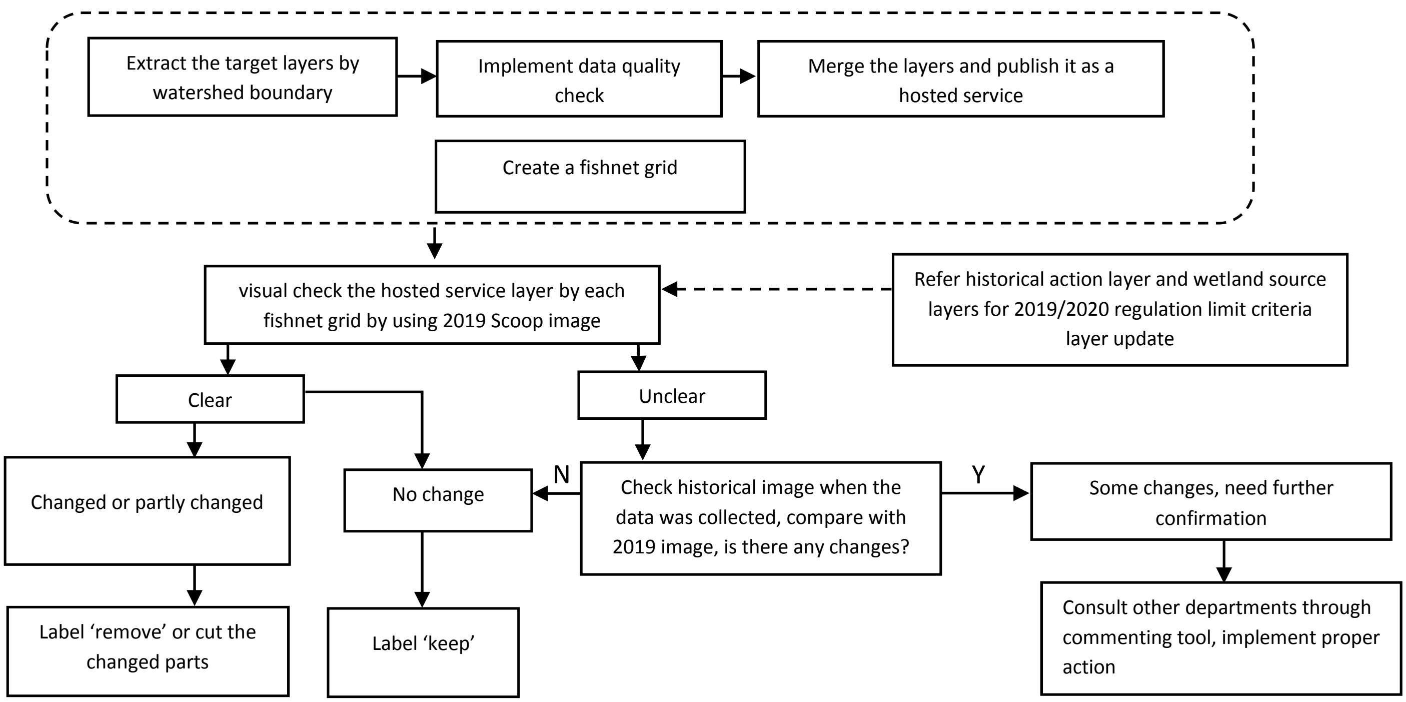

Figure 2. Overall workflow for wetland refinement process that was completed for 32,352 features across the TRCA jurisdiction.

Altogether the 32,352 wetland records were assessed across the whole jurisdiction. Wetlands included in the 2019 and 2020 regulation limit update (only includes wetlands larger than 0.5 ha) were also applied on the final layer such that 113 wetlands are added, 951 wetlands are removed. The only outstanding feature is one wetland record in ELC data that was uncertain due to watercourse realignment. This record has been submitted to Policy Planning group to identify and will be verified with the 2021 regulation limit update. Lastly, the accuracy assessment was completed using a subset of 1,598 wetland records using the 2019 orthophotography data, which indicated that 105 records had some inaccuracies, which has since been corrected. This suggests that the overall accuracy of the updated wetland layer is 93.4%, which is relatively high for this type of data at the regional scale. For site level applications it is recommended that further verification is conducted using a more targeted field surveys, as appropriate.

Inland lakes and their littoral zones

Inland lakes and their littoral zones are defined as permanent standing bodies of water, usually freshwater, larger than a pool or pond or a body of water filling a depression in the earth's surface (Greenbelt Plan 2017). The inland lakes and littoral zones layer available was developed by the TRCA Business Intelligence and Data Analytics (BIDA) group about 10 years ago and was largely intended for cartographic purposes. As satellite imagery was the only data used to delineate features, all waterbody types are included in this layer, which includes:

- **Lakes** - naturally occurring, but may have portions of the shoreline which are artificial;
- **Natural ponds** - generally smaller than a 'lake', often no name, includes beaver ponds;
- **Estuary** - found exclusively along Lake Ontario shoreline upstream from river mouth to first riffle or approximately 77m ASL, yet confined to 'backwater' areas of coastal marshes;
- **Stormwater Management Ponds** (SWMPs)[1] - only those with water should be delineated (no 'dry' ponds to be included);
- **Artificial** - golf course pond, farm pond, reservoir, gravel, or quarry pit, man-made on-line pond;
- **Aggregate** – associated with provincial pits and quarries mapping and feature may be subject to an active aggregate licence. Site level assessments should be completed to validate.
- **Unknown** - includes temporary SWMP or any water body in an actively developing area, any other water body that does not fit in to the other classes.

For the refinement of the inland lakes and littoral zones layer, further screening to address a few issues with accuracy of mapping and overlap with wetland features were completed. The following steps were taken to refine the inland lakes and littoral zones layer:

1. A waterbody was removed if layer overlapped with refined wetland layer when it was 2/3 or more covered by wetland;
2. Field verified data took precedence for delineating the outline of a particular feature;
3. Orthophotography verification was completed to determine if the feature is still on the landscape via most recent data from 2019 (remove/edit if it is not still on the landscape or changed in shape);
4. Identify stormwater infrastructure where possible, using existing data and orthophotography, so it can be separated from non-stormwater features (where possible).

In total 3,887 waterbody features were checked, where 1,433 were removed and 125 added given the criteria above. The resulting refined layer has 2,329 inland lakes and their littoral zones where 649 have been identified as stormwater infrastructure. For the purposes of this report, we report numbers that exclude SWMPs where they have been identified.[1]

[1] Stormwater Management Ponds (SWMPs) are not considered to be an inland lake, but due to a combination of data limitations and methodology we cannot identify all SWMPs. Where possible they have been identified and can be removed from this layer.

Permanent & Intermittent Streams

Permanent streams and watercourses are classified based on having a continual flow within an average climate year. In contrast, intermittent streams flow during wetter seasons, but are dry at certain predictable times during an average climate year. Altogether, both types of features contribute to the overall function and flow of water in the watershed (Stanfield 2017). Here the permanent and intermittent streams layer was developed by the ECS team at TRCA in 2020.

To develop this layer many different sources of data were used, which differed by watershed (please see details in Appendix A). The base layer for this work was the TRCA watercourse layer (except for Carruthers Creek – which uses a finer resolution layer consistent with the recent watershed plan). Here the watercourse layer is matched with data that provides information about the permanency of flow within a particular reach of the system. The data used to infer permanency of flow within reaches includes:

- Headwater Drainage Features Survey Data
- Baseflow Data
- TRCA Instream Temperature Data
- TRCA Instream Barrier Survey Data
- RWMP Fisheries and Temperature Data
- TRCA Historical Fisheries Data
- Orthophotography Interpreted 2017 and 2018 Imagery
- Valley and Stream Crossings Survey Data

For each of these data sources, the coverage of each data source through space and time differs throughout the jurisdiction, meaning that some watersheds and areas may be missing some data sets or have data from different points in time (see Appendix A for watershed-based details). Where possible, the TRCA regulated watercourse was classified as permanent or intermittent. Where there is clear data deficiency for a particular reach they have been classified as unknown. Where on the ground surveys have been completed, formal survey data was used to assess watercourse permanency and there is likely higher certainty with these classifications (this applies to Carruthers and Etobicoke Creeks). It must be noted that most watersheds (7 in total) have not had a formal survey dedicated to defining watercourse permanency and all the remaining watercourses have been defined using the best available data listed above. There are plans moving forward to conduct formal surveys alongside watershed plans and as data becomes available this can be used to update classifications here.

Ecologically Significant Groundwater Recharge Areas (ESGRAs)

An Ecologically Significant Groundwater Recharge Area (ESGRA) can be defined as an area of land that is responsible for replenishing groundwater systems that directly support sensitive areas like coldwater streams and wetlands (Greenbelt Plan, 2017). The protection of groundwater-dependent ecologically sensitive areas depends, in part, on understanding where on the landscape the groundwater comes from and taking steps to ensure the recharge function of these areas is protected (Figure 3). ESGRAs are identified using regional-scale modelling to predict where groundwater recharge at a given location will emerge or “discharge” within ecologically sensitive areas.

The ESGRA layer was developed in 2019 for entire jurisdiction by the Ecosystem and Climate Science team at TRCA in collaboration with the Oak Ridges Moraine Groundwater Program (ORMGP). An ecologically sensitive system that ESGRAs support includes fens (type of rare wetland that depends on groundwater inputs), groundwater dependent cold water fish species, and groundwater dependent plant species. Relevant to this data layer, ESGRAs are defined under the *Growth Plan for the Greater Golden Horseshoe* (2020) and the *Greenbelt Plan* (2017). The term also has policy associations in TRCA’s *Stormwater Management Criteria* (2012). Mapping of ESGRAs can be used to inform decisions around municipal growth through the land use and infrastructure planning processes. Extensive documentation has been developed for the ESGRA layer and is found in TRCA (2019) and is available upon request.

The ability to establish hydrogeological connections between areas of land and groundwater-supported ecosystems has been enhanced by significant improvements in understanding of regional-scale hydrogeology. As part of Source Water Protection (SWP), water budget models were developed for many watersheds in southern Ontario in the mid-2000s. These water budget models provided the knowledge and the modelling framework necessary for a more detailed assessment of groundwater-dependent ecosystems. In 2012, Lake Simcoe Region Conservation Authority (LSRCA) completed ESGRA modelling and mapping for the western Lake Simcoe drainage basin; LSRCA subsequently completed mapping for most of the remainder of the drainage basin over 2013-2015. Central Lake Ontario Conservation Authority (CLOCA) completed ESGRA modelling and mapping for their entire jurisdiction in 2014.

Building on these precedents, TRCA contracted the Oak Ridges Moraine Groundwater Program (ORMGP) to complete reverse particle tracking for the watersheds of TRCA jurisdiction using existing SWP numerical models following the methodology used by LSRCA and CLOCA. Using the model outputs, TRCA staff developed a methodology for mapping ESGRAs that maximizes the protection of groundwater-dependent ecosystems while minimizing the area of the watershed that is covered by ESGRAs. The details of this methodology are outlined TRCA (2019). This updated mapping supersedes the version of the map appearing in the 2012 *Stormwater Management Criteria* and uses a methodology that is consistent with neighbouring conservation authorities.

Briefly, the (reverse) particle tracking analysis reveals the connectivity between groundwater recharge and discharge areas throughout the TRCA jurisdiction(Marchildon et al. 2016). Pairing particle tracks from the expanded groundwater model (Marchildon et al., 2016) with data from Highly Dependent Groundwater Ecosystems (HDGEs; fish, flora, and fens) allowed us to determine where ESGRAs are likely to found on the landscape. Details of this approach can be found in TRCA (2019) and plain language memos that accompanied the work (Taylor et al. In Review). The methodology presented here was the result of a multidisciplinary collaboration between TRCA staff and representatives from Credit Valley Conservation and the Oak Ridges Moraine Groundwater Program, altogether providing varied skillsets and experience including: hydrogeologists, ecologists, and geomatics and policy specialists.

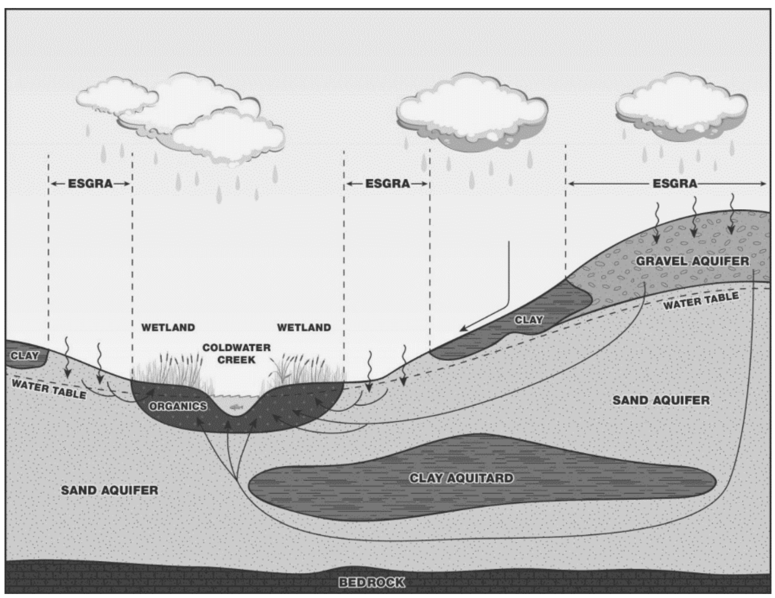

Figure 3. Conceptual drawing of Ecologically Significant Groundwater Recharge Areas in a landscape context.

Significant Surface Water Contribution Areas (SSWCAs)

An SSWCA is defined in the *Growth Plan for the Greater Golden Horseshoe* (2020) as, “Areas, generally associated with headwater catchments, that contribute to baseflow volumes which are significant to the overall surface water flow volumes within a watershed.” Municipalities have sought further clarity from the province (Ministry of Environment, Conservation and Parks), herein the definition of SSWCAs is focused on contribution to baseflow volumes that are significant to surface water flow volumes, which is more specific than simply delineating headwaters. This does not include headwaters into SSWCAs, because SSWCAs only protect groundwater contribution in some headwater areas. See also previous TRCA memos on ESGRAs, other KHFs, and technical methodologies for SGRAs, HVGRAs and HVAs under the Credit Valley – Toronto Region – Central Lake Ontario (CTC) Source Protection Area (CTC-SPC 2015).

Based on discussion with municipal staff the following methodology was offered for delineating SSWCAs, “SSWCAs are those areas which are both SGRAs and ESGRAs; the methodologies used to delineate SGRAs and ESGRAs should be used to identify SSWCAs.” Under this definition, SSWCAs would therefore comprise the areas of overlap between ESGRAs and SGRAs (or in the case of SGRAs, unclipped layers based on Technical Rule 45, e.g. High Volume Groundwater Recharge Areas; HVGRAs). HVGRAs were identified for the Source Protection Program based on the volume of recharge that occurs, not where water resources contributing to recharge expresses itself in streams. Conversely, ESGRAs are identified as the most likely site of groundwater recharge for the receiving feature that they support (streams and wetlands), but not based on the volume of water that they contribute. Those overlap areas then, are areas that provide a large volume of groundwater recharge, and where that recharge has been found through groundwater modelling to support sensitive areas like coldwater streams and wetlands. In other words, the “significant” component of the SSWCA term would be covered through volume contributions identified by HVGRAs, and the “surface water contribution areas” component of the SSWCA term would be covered by recharge-discharge connections to sensitive receiving features, as identified by ESGRAs. An important virtue of this methodology is that it would not expand the total size of the WRS very much, as there would be a high overlap with other WRS components; however, there may be a distinct policy implication.

Highly Vulnerable Aquifers (HVAs)

The HVA layer was developed to satisfy requirements of the *Source Protection Plan* for the Credit Valley, Toronto and Region and Central Lake Ontario region (CTC-SPC 2015) under the *Clean Water Act* (2006). Here aquifers are defined as water-bearing permeable rock, fractures within rocks, or loose materials (such as gravel, sand, or silt). Vulnerability of aquifers is considered to be related to the depth to aquifer, soil type and thickness to provide an indication of the potential protection provided by materials above the aquifer (CTC-SPC 2015). Details of the methodology used to develop this layer can be found in CTC-SPC (2015).

Significant Groundwater Recharge Areas (SGRAs)

The SGRA layer was developed to satisfy requirements of the Source Protection Plan for the Credit Valley, Toronto and Region and Central Lake Ontario region (CTC-SPC 2015) under the *Clean Water Act* (2006). Groundwater recharge occurs when rain/snow seeps down into an aquifer and generally this is associated with particular soil types (e.g., loose sand/gravel). SGRAs are delineated using a water budget modelling process, where the high potential recharge areas are delineated by the method outlined in full in CTC-SPC (2015). Details of the methodology used to develop this layer can be found in CTC-SPC (2015).

MAPPING & JURISDICTION OVERVIEW

Considering KHFs and KHAs that have an aerial footprint, the amount of area they represent within the jurisdiction varies overall, within planning zones (greenbelt, whitebelt and urban), and across the watersheds found within the TRCA jurisdiction. Altogether the WRS is found to have an aerial footprint of 66.3% (164,655 ha) in the TRCA jurisdiction (note this excludes permanent and intermittent watercourses which are linear features; Figure 4). Without source protection layers (HVAs and SGRAs; which are not part of this update) this area reduces to 25.7% (63,852 ha; Figure 4). If we consider the layers with new spatial footprints (ESGRAs and Seepage Areas and Springs) the area reduces further to 23.3% (57,761 ha). Lastly, considering overlap with pre-existing and refined layers the new spatial area added to the WRS has an aerial footprint of 2.5% (6,091 ha; Figure 4). Altogether, while the spatial footprint of all WRS layers is sizeable (66.3%), most of this aerial coverage is related to Source Water Protection areas and when considering new layers, only 2.5% is a new addition to the WRS.

Within the three broad planning zones/areas in the TRCA jurisdiction (greenbelt, whitebelt and urban), the overall WRS (considering all layers with 66.3% coverage) has a coverage of 29.4% in the greenbelt, 4.9% in the whitebelt, and 32.0% within urbanized areas (Table 3 and Figure 4). Notably, when only considering the new additions to the WRS (representing only 6,091 hectares or 2.5% of the jurisdiction), the breakdown follows a similar pattern (1.6% greenbelt, 0.2% whitebelt, and 0.7% urban; Table 3). Specifically, most features and areas have higher numbers and aerial footprints within the greenbelt, where seepage areas and springs, wetlands, inland lakes and littoral zones, ESGRAs, SSWCAs, SGRAs are all found to have >50% of their areas in designated greenbelt areas (Figure 4; Figures 5-12; Table 4). In contrast, HVAs have the largest portion (~50%) within urbanized areas (Table 4). Lastly, while whitebelt areas generally have lower aerial footprints of WRS features and areas, there is still 12,091 hectares of WRS in the whitebelt (out of a possible 19,092 ha hectares or 63.3%) that are present (Table 4).

Altogether KHFs with an aerial footprint include seepage areas and springs (10.5%), wetlands (4.5%), and inland lakes and their littoral zones (0.4%; Table 5; Figures 5-7). The only new layer is seepage areas and springs, while the wetland and inland lake layers have simply been refined and updated. For KHAs, the HVAs (43.3%) and SGRAs (29.1%) represent the largest aerial footprints for the jurisdiction (Table 5; Figure 10,11). As mentioned these layers were developed to satisfy requirements of the Source Protection Plan for the Credit Valley, Toronto and Region and Central Lake Ontario region (CTC-SPC 2015) under the *Clean Water Act* (2006). For the remaining KHAs, ESGRAs (13.9%) and SSWCAs (9.3%), as SSWCAs largely overlap with SGRAs and ESGRAs, the SSWCA aerial footprint is mostly not unique (Table 5; Figure 8,9).

Across the watersheds there is a notable pattern where eastern watersheds (e.g., Carruthers, Duffins, Rouge) tend to have higher amounts of KHFs and KHAs compared to central and western watersheds in the jurisdictions (Table 5). One exception to this is the Humber River watershed which has the highest numbers of KHFs and KHAs compared to other watersheds within the central and western portions of the jurisdiction (Table 5). While this is likely related to the amount of impervious surface and historical development practices throughout the jurisdiction, it should be noted that impervious cover does not necessarily preclude all KHFs and KHAs, though it can play a direct role in disrupting natural discharge and recharge processes which these layers represent.

The final KHF, permanent and intermittent streams, are a classification of regulated watercourse, where we find that there is about 1,777 kilometers of permanent streams within the TRCA jurisdiction, representing the largest share of watercourses (46.2%; Table 6; Figure 12). In general, the watersheds that are more developed tend to have higher amounts of permanent watercourse, including Etobicoke (54.6%), Mimico (85.3%), Don (68.4%), Highland (88.7%) and Carruthers (50.5%). Intermittent streams represent approximately 817 kilometers of watercourse within he TRCA jurisdiction (21.2%; Table 6). In general, the smaller watersheds in the jurisdiction that still have subwatershed with lower impervious cover, tend to have the highest amount of intermittent streams, including Carruthers (49.4%), Petticoat (49.9%) and Etobicoke (31.7%; Table 6). Lastly, there are roughly one third of watercourses (1,252 kms; 32.6%) that remain unknown (Table 6). The highest amounts of unknown watercourses are associated with the largest watersheds, Humber River (38.0%) and Duffins Creek (50.2%; Table 6).

Table 3. Summary of water resource system features and areas as percentages of aerial footprints within the jurisdiction for each land use zone (greenbelt, whitebelt, and urban).

WRS Layers	Greenbelt	Whitebelt	Urban
All WRS	73,168 (29.4%)	12,091 (4.9%)	79,396 (32.0%)
WRS without HVA + SGRA	37,772 (15.2%)	5,574 (2.2%)	20,506 (8.3%)
ESGRA + Seeps	33,862 (13.6%)	5,137 (2.1%)	18,762 (7.6%)
New WRS Additions	3,910 (1.6%)	437 (0.2%)	1,743 (0.7%)

Table 4. Summary of water resource system features and areas as total hectares and percentage within each land use zone (greenbelt, whitebelt, and urban).

Feature/Area	Greenbelt	Whitebelt	Urban
Seepage Areas and Springs	17150 (65.5%)	1486 (5.7%)	7563 (28.9%)
Wetlands	7751 (70.0%)	700 (6.3%)	2617 (23.6%)
Inland Lakes and Littoral Zones	626.5 (67.1%)	28.4 (3.0%)	279.2 (29.9%)
ESGRA	18721 (54.1%)	3846 (11.1%)	12044 (34.8%)
SSWCA	15732 (68.2%)	2155 (9.3%)	5183 (22.5%)
HVA	39945 (37.1%)	4891 (4.5%)	62711 (58.3%)
SGRA	54844 (75.9%)	6866 (9.5%)	10536 (14.6%)

Table 5. Summary of water resource system features and areas as total hectares and percentage within each spatial area (watershed and the jurisdiction total).

Feature/Area	Etobicoke	Mimico	Humber	Don	Highland	Rouge	Petticoat	Frenchman's Bay	Duffins	Carruthers	Waterfront	Jurisdiction
Seepage areas and Springs	903.2 (4.3%)	235.1 (3.1%)	11095.8 (12.2%)	2250.4 (6.3%)	540.0 (5.1%)	4978.3 (14.8%)	294.6 (12.2%)	125.5 (4.6%)	4793.6 (17.0%)	720.0 (18.1%)	266.5 (2.3%)	26202.9 (10.5%)
Wetlands	508.6 (2.4%)	55.5 (0.7%)	5004.9 (5.5%)	322.9 (0.9%)	78.7 (0.7%)	1935.9 (5.8%)	266.1 (11.0%)	271.3 (10.0%)	2359.0 (8.4%)	367.0 (9.2%)	237.5 (2.0%)	11407.5 (4.6%)
Inland Lakes and Littoral Zones	49.2 (0.2%)	33.8 (0.4%)	480.0 (0.5%)	33.6 (0.1%)	0.8 (0.0%)	172.1 (0.5%)	0.6 (0.1%)	0.4 (0.4%)	149.0 (0.5%)	11.5 (0.3%)	3.3 (4.3%)	934.3 (0.4%)
ESGRA	2765.7 (13.0%)	758.3 (10.0%)	14468.0 (15.9%)	1714.5 (4.8%)	193.3 (1.8%)	5595.3 (16.7%)	403.8 (16.7%)	256.8 (9.5%)	7743.9 (27.4%)	687.2 (17.3%)	39.8 (0.3%)	34626.6 (13.9%)
SSWCA	95.2 (0.4%)	132.0 (1.7%)	11446.7 (12.6%)	1060.2 (3.0%)	68.4 (0.6%)	4373.3 (13.0%)	144.1 (6.0%)	46.0 (1.7%)	5517.1 (19.6%)	173.4 (4.4%)	13.3 (0.1%)	23069.6 (9.3%)
HVA	5441.4 (25.6%)	2005.8 (26.6%	38094.0 (41.9%)	16813.7 (47.1%)	5115.8 (48.3%)	13876.9 (41.4%)	924.8 (38.3%)	1179.0 (43.7%)	13683.3 (48.5%)	1767.6 (44.5%)	8698.9 (73.8%)	107601.0 (43.3%)
SGRA	121.9 (0.6%)	0.0 (0.0%)	42461.8 46.7%)	1036.6 (2.9%)	0.0 (0.0%)	13054.5 (38.9%)	509.4 (21.1%)	75.3 (2.8%)	14483.8 (51.3%)	502.2 (12.6%)	0.0 (0.0%)	72245.5 (29.1%)

Table 6. Summary of total and percentage of permanent, intermittent, and unknown stream classes in each watershed, and jurisdiction total and percentage of the jurisdiction. Frenchman's Bay and Waterfront are excluded due to the absence of data.

Watercourse Type	Etobicoke	Mimico	Humber	Don	Highland	Rouge	Petticoat	Duffins	Carruthers	Jurisdiction
Permanent	143.5 (54.6%)	55.0 (85.3%)	727.0 (38.2%)	200.3 (68.4%)	69.4 (88.7%)	289.2 (56.7%)	9.5 (18.0%)	240.1 (40.3%)	43.1 (50.5%)	1777.2 (46.2%)
Intermittent	83.3 (31.7%)	3.5 (5.5%)	453.4 (23.8%)	43.0 (14.7%)	3.5 (4.4%)	105.0 (20.6%)	26.4 (49.9%)	56.6 (9.5%)	42.1 (49.4%)	816.8 (21.2%)
Unknown	36.2 (13.8%)	5.9 (9.1%)	723.0 (38.0%)	49.7 (17.0%)	5.4 (6.9%)	115.5 (22.7%)	17.0 (32.1%)	299.4 (50.2%)	0.1 (0.1%)	1252.3 (32.6%)

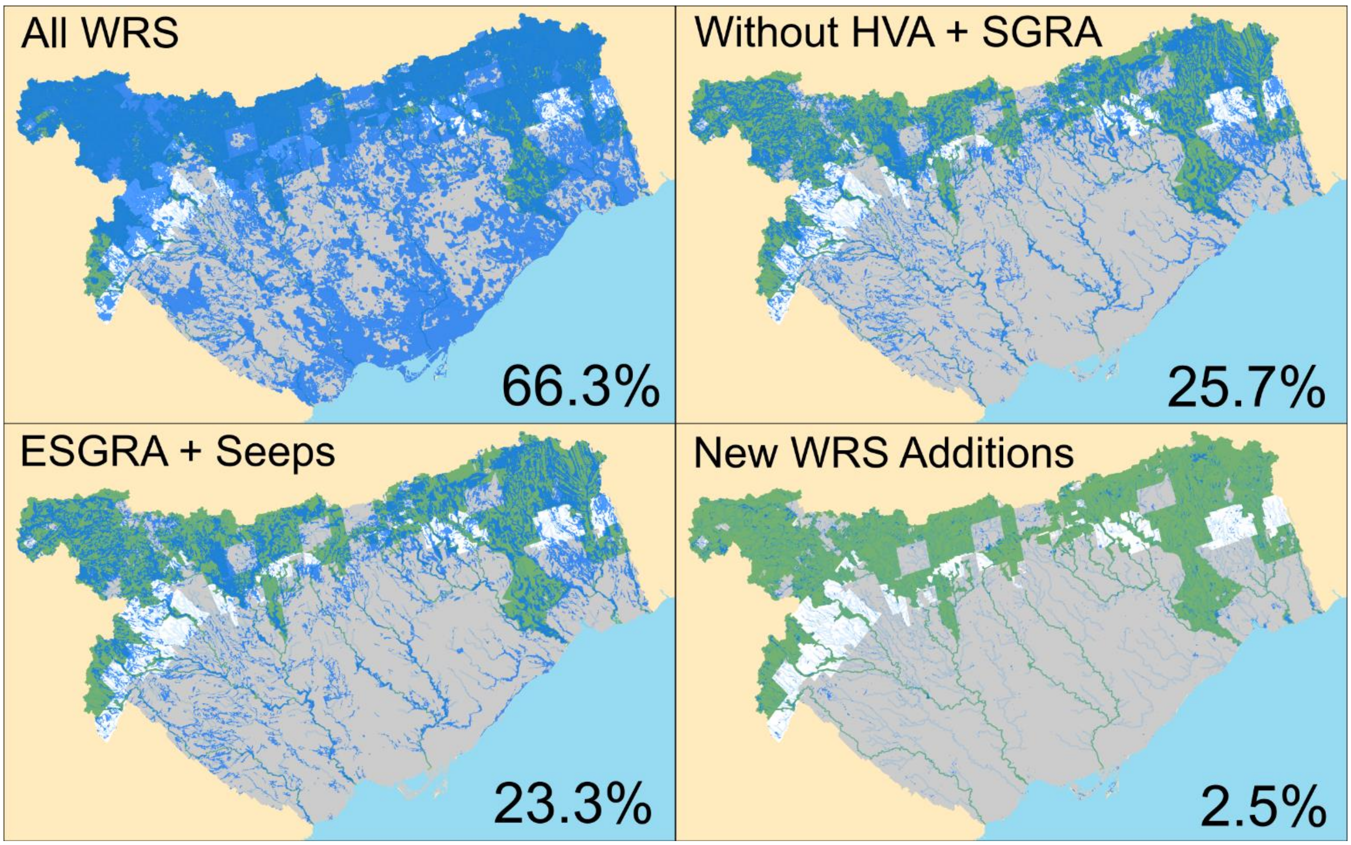

Figure 4. Maps show the WRS aerial footprint (A) with Source Protection layers (SGRAs and HVAs), (B) without Source Protection layers (SGRAs and HVAs), (C) layers that are new and have unique footprints (Seepage areas and Springs and ESGRAs), and (D) uniquely new areas included in the WRS. These overlayed on the Greenbelt, whitebelt, and urbanized portions of the TRCA jurisdiction. Percentages represent the total aerial footprint of combinations.

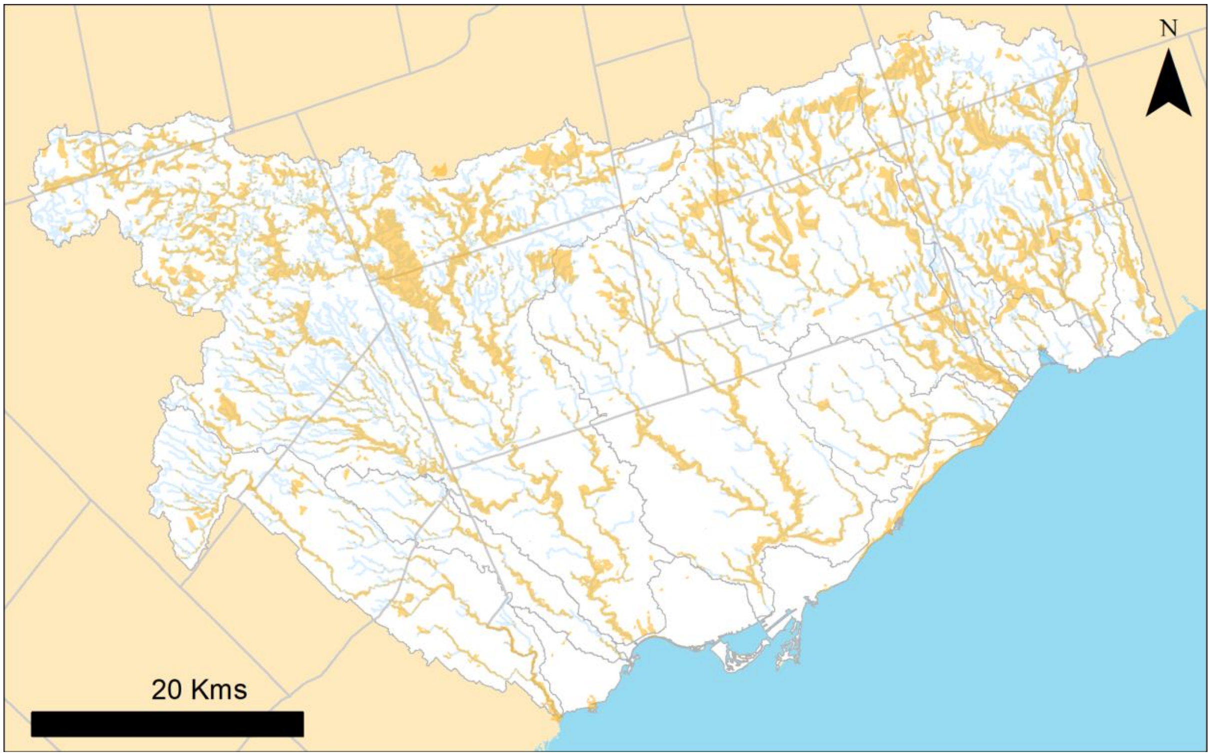

Figure 5. Shown are the seepage areas and springs in the TRCA jurisdiction (orange polygons and polylines). Features have been enlarged slightly to better identify features at this scale.

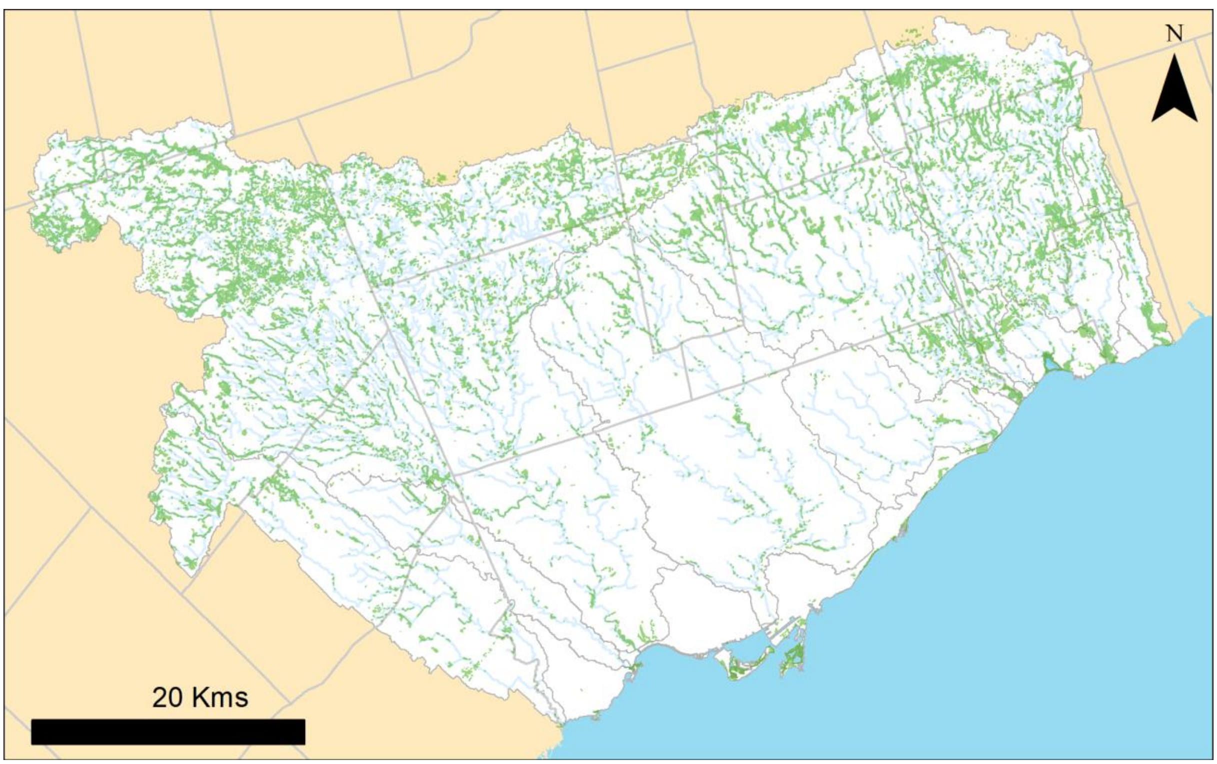

Figure 6. Shown is the refined wetland layer in the TRCA jurisdiction (green polygons). Features have been enlarged slightly to better identify features at this scale.

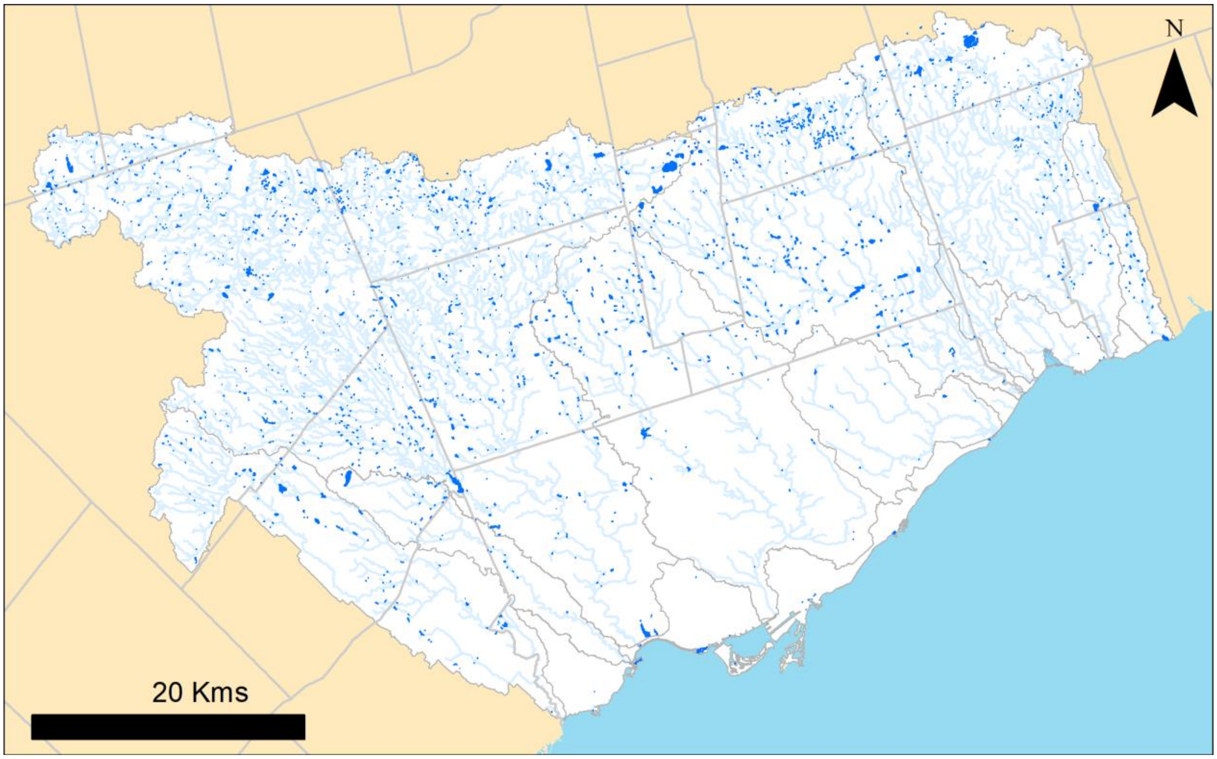

Figure 7. Shown is the refined inland lake and littoral zones layer in the TRCA jurisdiction (dark blue polygons). Features have been enlarged slightly to better identify features at this scale.

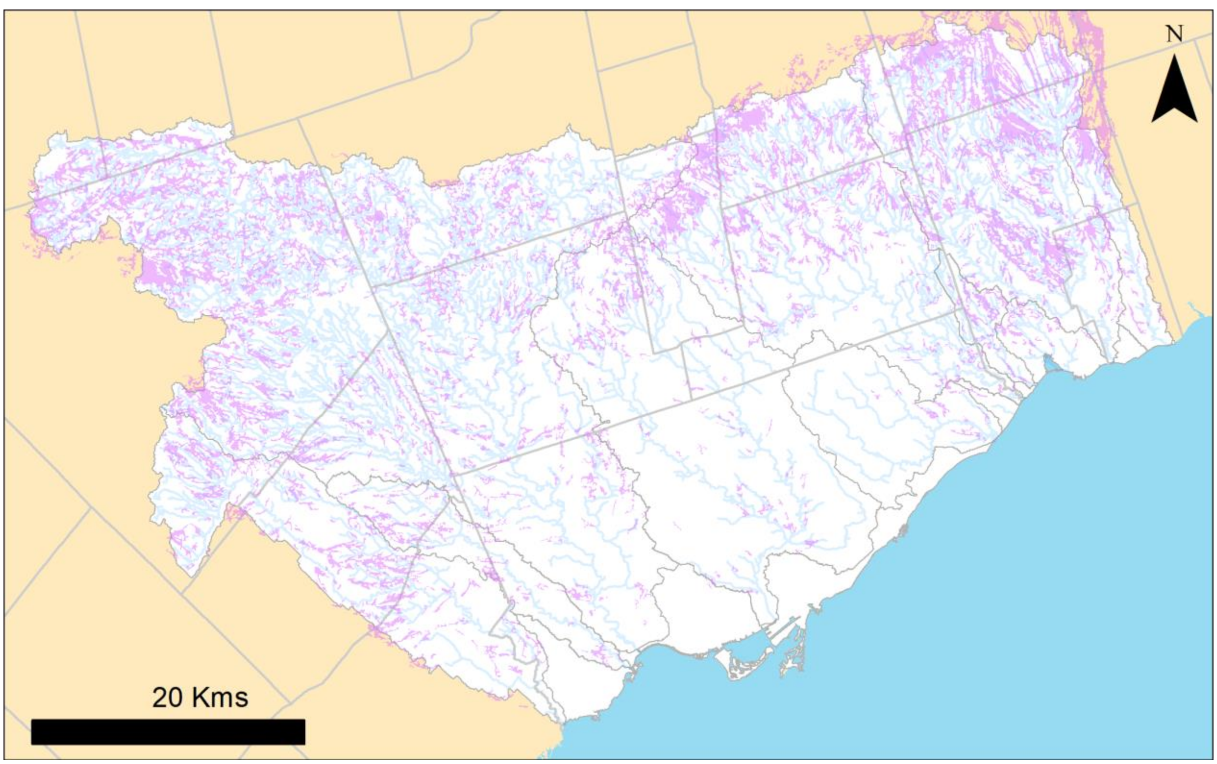

Figure 8. Shown is the Ecologically Significant Groundwater Recharge Areas (ESGRAs) layer in the TRCA jurisdiction (purple polygons).

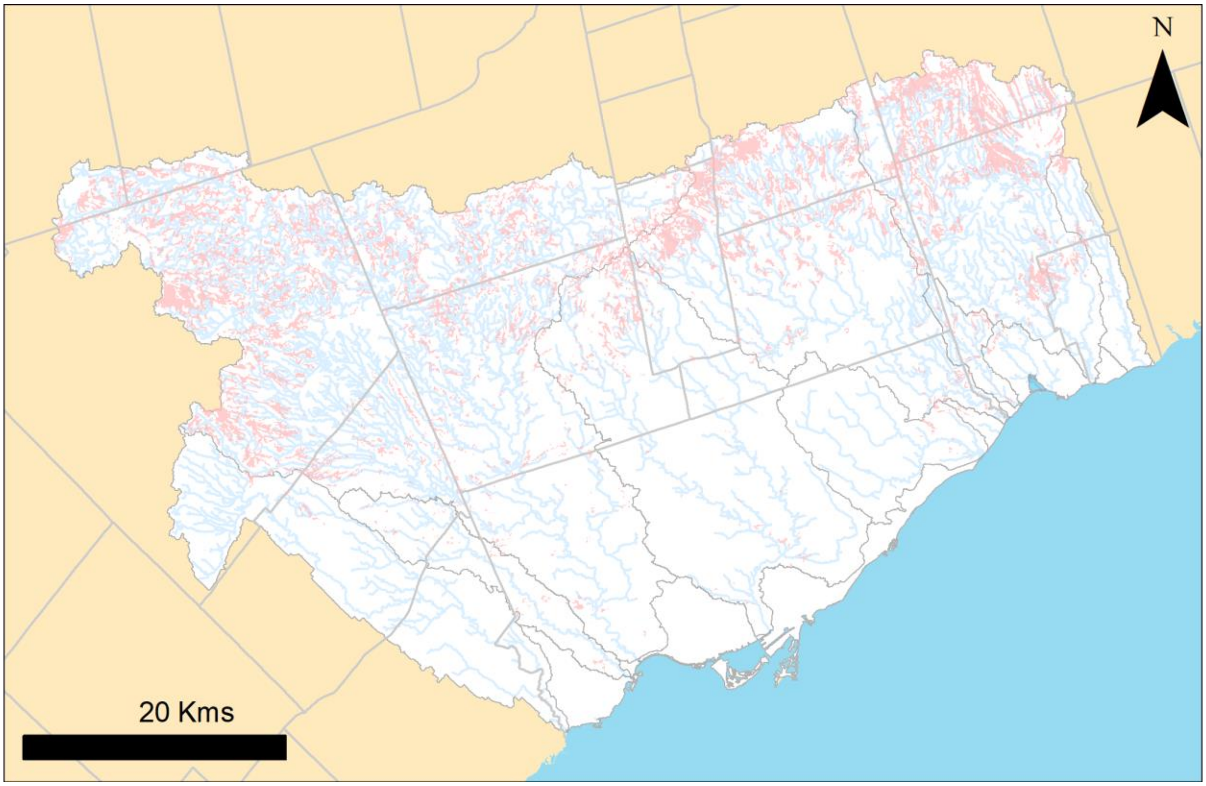

Figure 9. Shown is the Significant Surface Water Contribution Areas (SSWCAs) layer in the TRCA jurisdiction (pink polygons).

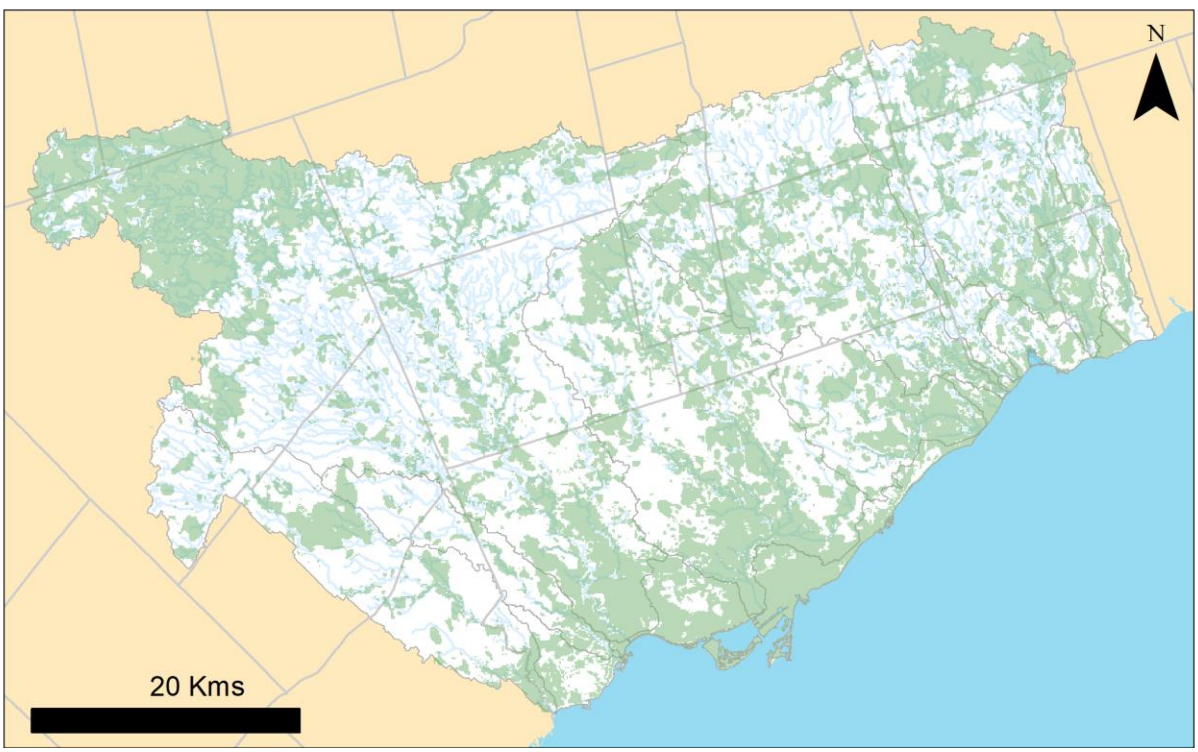

Figure 10. Shown is the Source Water Protection layer, Highly Vulnerable Aquifers (HVAs), in the TRCA jurisdiction (green polygons).

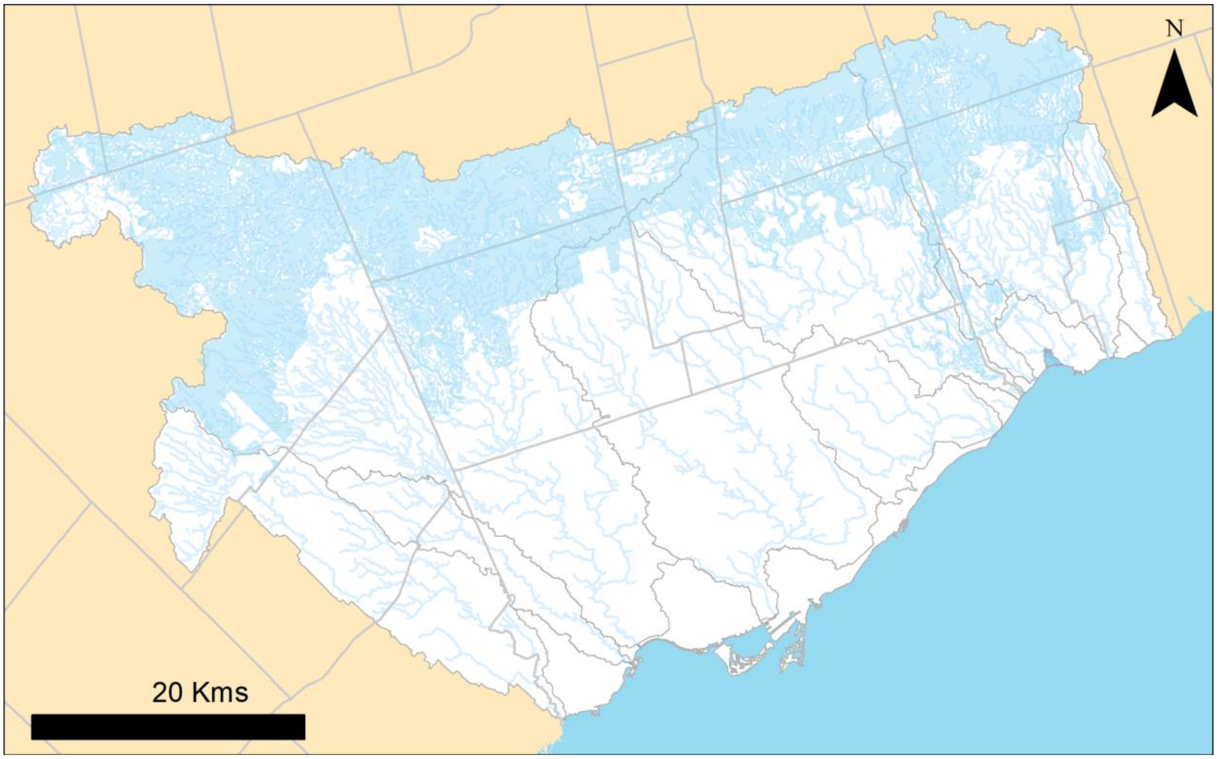

Figure 11. Shown is the Source Water Protection layer, Significant Groundwater Recharge Areas (SGRAs) in the TRCA jurisdiction (light blue polygons).

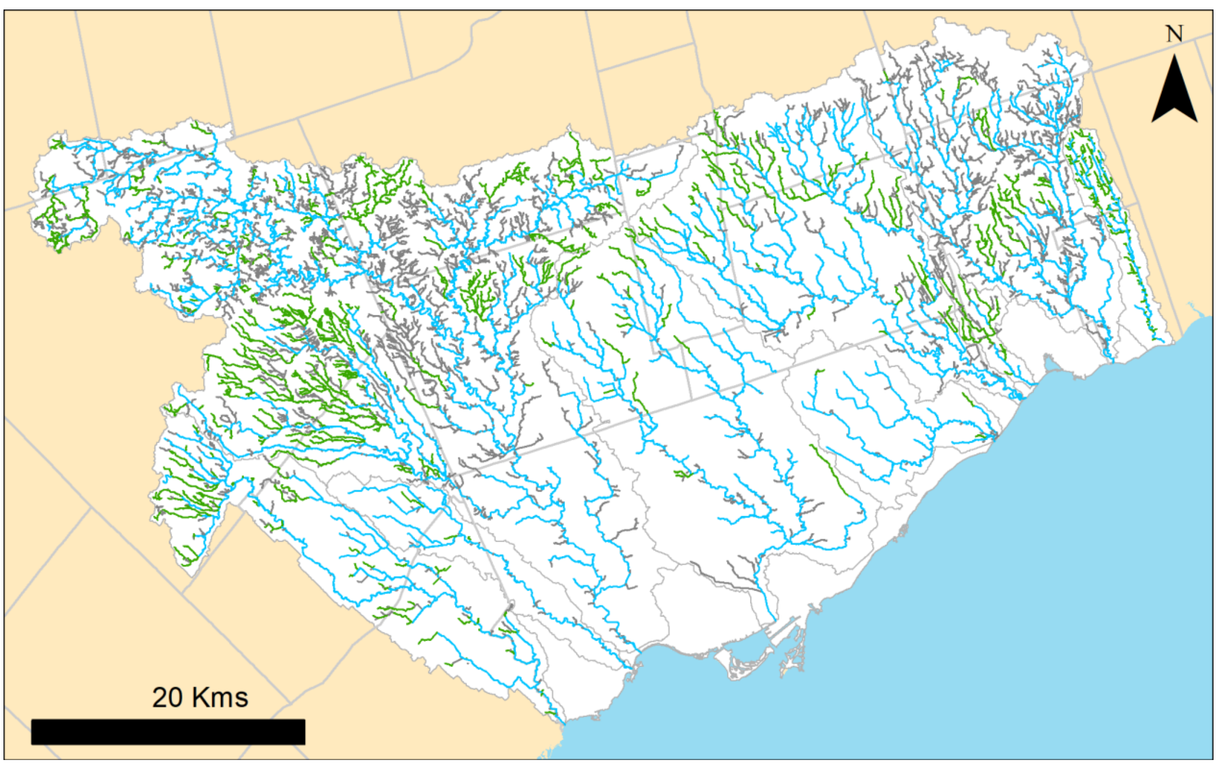

Figure 12. Shown is the permanent (blue) and intermittent (green) watercourse layer in the TRCA jurisdiction. Also shown are the unknown watercourses (data deficient; dark grey).

IMPLICATIONS

Reviewing the mapping of KHFs and KHAs reveals that most WRS components are either found within protected greenbelt (29.4%) or the urbanized (32.0%) areas of the TRCA jurisdiction. This implies that these components are afforded protection through the *Greenbelt Plan* (2017) or have been subject to development activities that have already occurred or were initiated at the time of this report. The remaining portion of the jurisdiction that may be subject to development, the whitebelt, represents a total of 19,092 hectares within the TRCA jurisdiction (4.9% of the jurisdiction), yet only contains 7.3% of WRS components (or 12,091 hectares). As outlined in Figure 4 and Table 3 only 437 hectares are new additions with the mapping completed as part of this work.

Under the *Growth Plan* (2020), municipalities are required to undertake watershed planning to inform the protection of water resources and decisions around planning for growth. Both the *Growth Plan* (2020) and the *Greenbelt Plan* (2017) require municipalities to identify and protect the features, areas, and functions of the Water Resource System, of which ESGRAs are one type of area. Relevant to this is the presence and aerial footprint of WRS within the whitebelt of the TRCA jurisdiction. It should be noted that the presence of a KHF and KHA is not prohibitive to potential development but presents opportunities for the mitigation and protection of the WRS components. These data layers are intended to be a tool to help aid decision makers, specifically partners through best management practices, decision support tools, and information to guide various TRCA and municipal initiatives, including watershed planning, restoration planning, land use and infrastructure planning.

One example is through the implementation and guidance provided in TRCA's *Stormwater Management Criteria* (2012). Within the *Stormwater Management Criteria*, section 6.2.1 outlines criteria for development and infrastructure applications within three types of significant groundwater recharge area, one of which is ESGRAs. Further detail on geographic applicability and study requirements are outlined in appendices D and E of the *Stormwater Management Criteria*. However, the development and update of the WRS within TRCA's jurisdiction is mainly intended to assist municipal partners with achieving provincial policy conformity that requires them to identify the WRS for its long-term protection. This can be achieved through incorporating the WRS in municipal comprehensive reviews, settlement area boundary expansions, Official Plans, natural heritage system planning, among other strategic planning development exercises.

Lastly, within urban areas, identified KHFs and KHAs represent an opportunity for enhancement of biogeophysical processes that support the WRS. For instance, restoring or enhancing groundwater recharge through the implementation of Low Impact Design (LID) within urban settings can benefit ESGRAs and SGRAs alongside development and may help to either mitigate the impact or enhance the function of KHFs and KHAs alongside developed lands.

FUTURE CONSIDERATIONS

There is a continual need to evaluate and update KHFs and KHAs on both a short-term and long-term schedule to ensure the latest products are available for TRCA and its partners given on the ground monitoring and surveys that are completed every year. As regulated wetlands and watercourse layers are updated annually these will need to be adjusted to complement the revisions. On the longer term, there is a need to ensure the best science available has been used to produce the most accurate data product for use by TRCA and its partners. Notably, as new data becomes available or new models are produced this will help to inform the mapping of KHFs and KHAs.

Mapping of the KHFs and KHAs has identified the need to invest more time and effort to not only understand stream permanency (close to one third of watercourses are unknown), but by extension there is an identified need to map as many Headwater Drainage Features (HDFs) as possible, especially in areas that may be subject to near future development. Here we mapped permanency using best available data, which provides some evidence and certainty of stream permanency (which is why we used it). One solution is to address this through the cycle of watershed plans using modified field approaches, however, this will likely take well over 10 years to fully complete, meaning there may be some feature losses before this can be completed. Other planning processes can play a role in this regard, where subwatershed plans, master environmental servicing plans, among others can help to fill these gaps. Regardless, addressing this ongoing gap will be beneficial to TRCA and its partners moving forward.

Altogether the mapping products produced here represent the best available knowledge and employ scientifically sound methodology. As with any method there is a degree of error that should be considered and at the site level on the ground validation is strongly recommended. The research and science team at TRCA is best positioned to ensure that both short- and long-term needs for mapping the WRS are met in partnership with other internal TRCA groups. The project here and the future work cycle of evaluation, maintenance, and QA/QC will be led through ECS with support of partner groups such as WPR, BIDA, and others.

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APPENDIX A – PERMANENT AND INTERMITTENT STREAM CLASSIFICATION

To develop this layer many different sources of data were used, which differed by watershed. The base layer for this work was the TRCA watercourse layer (except for Carruthers Creek – which uses a finer resolution layer consistent with the recent watershed plan). Here the watercourse layer is matched with data that provides information about the permanency of flow within a particular reach of the system. Data used to infer permanency of flow within reaches used many different data sources, including:

- Baseflow Data
- Headwater Drainage Features Survey Data
- TRCA Instream Temperature Data
- TRCA Instream Barrier Survey Data
- RWMP Fisheries and Temperature Data
- TRCA Historical Fisheries Data
- Air photo Interpreted 2017 and 2018 Imagery
- Valley and Stream Crossings Survey Data

Details related to each watershed and the relevant data sources used can be found below for all TRCA watersheds. Where formal surveys have been completed to assess watercourse permanency there is likely higher certainty with classifications (Carruthers and Etobicoke Creeks). It must be noted that the remaining watersheds have not a had a formal survey dedicated to defining watercourse permanency, and all watercourses that have been defined using the best available data.

Carruthers Creek

Data Sources

1. Carruthers Creek Headwaters Survey Protocol Data 2015
2. Carruthers Instream Barrier Survey Data and Imagery 2016
3. Instream Temperature Data and Related Field Notes 2012
4. Arc Hydro Lines (5 ha drainage) and LiDAR imagery 2015

Mapping Methodology

Permanent Watercourses were those that were identified in the field during the 2017 HDF surveys following the TRCA HDF protocol. For the watercourses not surveyed during the 2017 HDF field surveys, other data was used to augment the understanding of instream water conditions during mid to late summer. In this case the presence of flowing or connected water in the channel during the mid to late summer timeframe was used to define a permanent watercourse. All other information that indicated that there was a dry watercourse was then used to identify intermittent watercourses. Finally, the ArcHydro lines developed for the 2017 HDF surveys were used as an overlay on the LiDAR

Hillshade layer to identify intermittent watercourses where no other field surveys had been undertaken. Where the Archydro lines aligned with a visible drainage feature on the LiDAR Hillshade layer, those features where then classified as intermittent watercourses.

Etobicoke Creek

Data Sources

1. Baseflow Data 2001-2019
2. Headwater Drainage Features Survey 2020
3. TRCA Instream Temperature Data 2005 and 2020
4. TRCA Instream Barrier Survey Data 2006-2008
5. RWMP Fisheries and Temperature 2001-2019
6. TRCA Historical Fisheries Data
7. Air photo Interpreted 2017 and 2018 Imagery

Mapping Methodology

Permanent and Intermittent watercourses were specifically surveyed in the Etobicoke Headwaters subwatershed in 2020. However, those headwater drainage features that were surveyed were only those that occurred at road and watercourse crossings. There are many unsurveyed watercourses that occur between road crossings for which there is no data. For watercourses in the southern portion of the watershed multiple data sources were used in the classification process. Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse, the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

It must be noted that only the headwaters subwatershed had a formal survey dedicated to defining watercourse permanency and all other watercourses were that their condition defined by the best available data, such as baseflow or instream barrier surveys.

*Photo reference in the data field refers to actual photo data from barrier inventories as well as field measurement data.

Duffins Creek

Data Sources

1. Baseflow Data 2001-2019
2. 2006 Instream Temperature Data and Related Notes
3. Existing Fisheries Data Historical and TRCA 2003-2020
4. MNRF Instream Barrier Data 2008 2009
5. Air photo Interpreted 2018 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse, the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

*Photo reference in the data field refers to actual photo data from barrier inventories.

Petticoat Creek

Data Sources

1. TRCA Baseflow Data 2001-2019
2. RWMP Fisheries and Temperature Data 2001-2019
3. TRCA Historical Fisheries Data
4. Air photo Interpreted 2017 and 2018 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse then the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

*Photo reference in the data field refers to actual photo data from barrier inventories.

Rouge River

Data Sources

1. Baseflow Data 2001-2019
2. TRCA Instream Barrier Survey Data 2006
3. TRCA Instream Temperature Data 2005
4. RWMP Fisheries and Temperature 2001-2019
5. TRCA Historical Fisheries Data
6. Air photo Interpreted 2017 and 2018 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse then the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

*Photo reference in the data field refers to actual photo data from barrier inventories.

Highland Creek

Data Sources

1. Baseflow Data 2001-2019
2. TRCA Instream Barrier Survey Data 2004
3. RWMP Fisheries and Temperature 2001-2019
4. TRCA Historical Fisheries Data
5. Air photo Interpreted 2017 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse, the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

*Photo reference in the data field refers to actual photo data from barrier inventories.

Don River

Data Sources

1. Baseflow Data 2001-2019
2. TRCA Instream East Don Barrier Survey Data 2006
3. TRCA Instream Temperature Data 2005
4. RWMP Fisheries and Temperature 2001-2019
5. TRCA Historical Fisheries Data
6. Air photo Interpreted 2017 and 2018 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse, the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

*Photo reference in the data field refers to actual photo data from barrier inventories.

Humber River

Data Sources

1. Baseflow Data 2001-2019
2. Valley and Stream Crossings Survey 2017
3. TRCA Instream Temperature Data 2007-2008
4. RWMP Fisheries and Temperature 2001-2019
5. TRCA Historical Fisheries Data
6. Air photo Interpreted 2017 and 2018 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse, the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities. *Photo reference in the data field refers to actual photo data.

Mimico Creek

Data Sources

1. Baseflow Data 2001-2019
2. TRCA Instream Barrier Survey Data 2009
3. RWMP Fisheries and Temperature 2001-2019
4. TRCA Historical Fisheries Data
5. Air photo Interpreted 2017 and 2018 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse then the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

*Photo reference in the data field refers to actual photo data from barrier inventories.

Peel SABE Area (Etobicoke, Humber)

Data Sources

1. 2007 and 2008 Instream Temperature Data and Related Notes
2. 2017 VSC Culvert Survey Data and Imagery
3. TRCA Baseflow Data 2000-2017
4. Existing Fisheries Data
5. Interpreted

Mapping Methodology

Because there was no actual HDF survey conducted for the SABE area of Peel Region there has been no specific data collected that targets the question around the permanent or intermittent nature of the watercourses within the study area boundary. As such, data needed to be drawn from other sources, and in some cases due to the nature of the data, it required interpretation or expert judgement to be applied to help define the WRS. Many of the data points that help to define the understanding of watercourse permanency are based in many cases by a single point in time measurement and is sometimes at a coarser scale of resolution than would be ideal for this exercise. In many cases there is evidence to define that a watercourse is a permanently flowing watercourse, however there are instances, particularly in the West Humber where the starting point of this permanently flowing condition may need further field refinement.

For this study area the presence of flowing or connected water in the channel during the mid to late summer timeframe was used to define a permanent watercourse. All other information that indicated that there was a dry watercourse was then used to identify intermittent watercourses. In some cases, there is a permanent watercourse upstream and an intermittent watercourse downstream. This condition could be due to groundwater recharge and discharge conditions, or from human induced landscape functional changes, such as groundwater or surface water pumping. In some locations further field investigation is warranted to help to better refine the understanding of watercourse permanency.

In a few watercourses it was noted in the data file that the data source was interpreted. In these cases, there is a transition zone between two data points where there was evidence to identify an intermittent watercourse upstream, and a permanent watercourse downstream. In these cases, classification was determined based on air photo interpretation, informed largely by the vegetation condition surrounding the watercourse.

APPENDIX B – SUGGESTED COLOUR PALETTE FOR MAPPING THE WRS

Table 1C. The colour palette used in this report and recent watershed plans for key hydrologic features and areas.

Feature/Area	Polyline/ Outline Thickness	Colour	Hex Code	RGB
Seepage Areas and Springs	0.5		#FFD580	255 213 128
Wetlands	0.5		#9CD480	156 212 128
Inland Lakes and their Littoral Zones	0.5		#0070FF	000 112 255
Streams - Permanent	0.7		#00C5FF	000 197 255
Streams - Intermittent	0.7		#38A800	056 168 000
Streams - Unknown	0.7		#828282	130 130 130
ESGRAs	0.5		#EFB9FF	239 185 255
SSWCAs	0.5		#FFCDCE	255 206 206
HVAs	0		#B9D9B9	185 217 185
SGRAs	0		#CBEDF9	203 237 249

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Toronto and Region Conservation Authority

Item 7.3

Section I – Items for Board of Directors Action

TO:	Chair and Members of the Board of Directors Friday, October 28, 2022 Meeting
FROM:	Anil Wijesooriya, Director, Restoration and Infrastructure
RE:	**REQUEST FOR TENDER FOR SUPPLY AND DELIVERY OF VARIOUS AGGREGATES FOR THE ASHBRIDGES BAY TREATMENT PLANT LANDFORM PROJECT – HEADLAND 4** RFT No. 10038221, 10038222

KEY ISSUE

1. Award of Request for Tender (RFT) No. 10038221 - Supply and Delivery of 13,000 tonnes of 100 - 700 mm Core Stone; and
2. Award of Request for Tender (RFT) No. 10038222 – Supply and Delivery of 18,400 tonnes of 4 – 6 tonne non-stackable Armour Stone.

RECOMMENDATION:

WHEREAS Toronto and Region Conservation Authority (TRCA) is engaged in a project that requires supply and delivery of various aggregates;

AND WHEREAS TRCA solicited tenders through a publicly advertised process;

THEREFORE, LET IT BE RESOLVED THAT RFT No. 10038221 be awarded to Glenn Windrem Trucking at a total cost not to exceed $526,500, plus applicable taxes, to be expended as authorized by TRCA staff;

THAT TRCA staff be authorized to approve additional expenditures to a maximum of $52,650 (approximately 10% of the tender cost), plus applicable taxes, in excess of the contract cost as a contingency allowance if deemed necessary.

THAT RFT No. 10038222 be awarded to the second lowest bid from Gott Natural Stone '99 Inc. for the reasons stated below at a total cost not to exceed $1,606,872, plus applicable taxes, to be expended as authorized by TRCA staff;

THAT TRCA staff be authorized to approve additional expenditures to a maximum of $160,687 (approximately 10% of the tender cost), plus applicable taxes, in excess of the contract cost as a contingency allowance if deemed necessary.

THAT should TRCA staff be unable to negotiate a contract with the above-mentioned bidders, staff be authorized to enter into and conclude contract negotiations with other bidders that submitted tenders, beginning with the next lowest bid meeting TRCA specifications;

AND FURTHER THAT authorized TRCA officials be directed to take whatever action may be required to implement the contract, including the obtaining of necessary approvals and the signing and execution of any documents.

BACKGROUND
TRCA, in partnership with the City of Toronto, has commenced construction of three shore-connected breakwaters and a headland-beach system as part of the Ashbridges Bay Treatment Plant (ABTP) Landform Project located on the north shore of Lake Ontario, in the City of Toronto.

The Ashbridges Bay area has been the subject of several environmental assessments intended to identify a solution to local shoreline erosion and sediment deposition issues while considering approved planning initiatives and current uses in the project area.

Erosion control for long-term shoreline stability and protection of existing facilities, as well as management of sediment from the Coatsworth Cut navigation channel were identified as critically important to the City of Toronto. An integrated approach was decided upon which included the development of detailed designs and construction of the ABTP Landform as a solution to the erosion and sediment control issues at Ashbridges Bay.

Construction of the ABTP Landform, in accordance with the detailed designs, was authorized during the City Council meetings on April 16 and 17, 2019.

At TRCA’s Board of Directors meeting #4/19, held on April 26, 2019, RES.#A58/19 provided staff with direction to negotiate and enter into and execute one or more service agreements with the City of Toronto to construct the Ashbridges Bay Treatment Plant Landform. On June 26, 2019, TRCA and the City of Toronto executed an Interim Letter Agreement allowing TRCA to undertake preconstruction activities. The Final Agreement for construction of the ABTP Landform Project was effective September 30, 2019, with construction activities officially beginning on January 13, 2020.

A comprehensive implementation phasing plan for the landform was prepared as part of detailed design. Construction of the Landform was split into three components and three corresponding cells, constructed from west to east. Each phase involved the construction of a confinement berm to isolate the fill area from the lake, the filling of the cell, the construction of a protective headland-beach system, and submerged shoal habitat features.

There are also central and east breakwater components, which together, provide a long-term solution to address the sedimentation issue within the Coatsworth Cut navigation channel which TRCA currently maintains through a $250,000 per year dredging program.

Given the scope of the Landform Project, an estimated five-year phased approach is required to construct the works that commences in 2020. The phases are as follows:

- Phase 1 – Construction of the Cell 1 confinement berm, filling of Cell 1, and construction of the headland-beach system and submerged shoals associated with Cell 1
- Phase 2 – Construction of Cell 2 confinement berm, filling of Cell 2, construction of headland-beach system and submerged shoals associated with Cell 2
- Phase 3 – Construction of the Cell 3 confinement berm, filling of Cell 3, and armourstone and rip-rap placement
- Phase 4 and 5 – Construction of Eastern and Central Breakwater, and shoal construction

At the time of writing this report, construction of all three confinement berms, filling of Cell 1 and Cell 2 and construction of Headland 2 and 3 are complete.

Approval to award Contract #10020798 for supply and delivery of material required for the construction of the Cell 1 confinement berm was recommended for approval at Executive Committee meeting #4/19 held on Friday May 3, 2019 and was approved at the Board of Directors meeting #5/19 held on Friday May 24, 2019.

RATIONALE

A request for Tender for supply and delivery of various aggregate materials to Ashbridges Bay Treatment Plant Landform Project – Headland 4 was posted on the public procurement website, Biddingo.com on August 22, 2022 and closed on September 6, 2022. One (1) addendum was issued to respond to questions received.

A total of seven (7) companies downloaded the documents and four (4) submissions were received from the following Bidder(s):

- Glenn Windrem Trucking
- Gott Natural Stone '99 Inc.
- H.R. Doornekamp Construction Ltd
- J.C. Rock Ltd.

The Procurement Opening Committee opened the Tenders on September 6, 2022 with the following results:

RFT # 10038221 – Supply and Delivery of 13,000 Tonnes of 100-700 mm Core Stone to Ashbridges Bay Landform Project – Headland 4

Bidder	Fee (Plus HST)
Glenn Windrem Trucking	$ 526,500
J.C. Rock Ltd.	$ 564,590
H.R. Doornekamp Construction Ltd	$ 715,000
Gott Natural Stone '99 Inc.	$ 897,520

A Committee consisted of the consulting engineer and a TRCA site supervisor conducted quarry visits. The engineer report concluded that the 100-700 mm Core Stone material at Glenn Windrem Trucking's quarry "is suitable"

Staff reviewed the bid received from Glenn Windrem Trucking against its own cost estimate and has determined that the bid is of reasonable value and meets the requirements as outlined in the RFT documents. Therefore, it is recommended that contract No.10038221 be awarded to Glenn Windrem Trucking at a total cost not to exceed $526,500, plus 10% contingency, plus applicable taxes, it being the lowest bid meeting TRCA's specifications.

RFT # 10038222 – Supply and Delivery of 18,400 Tonnes of 4 – 6 Tonne Piece Non-Stackable Armourstone to Ashbridges Bay Landform Project– Headland 4:

Bidder	Fee (Plus HST)
J.C. Rock Ltd.	$ 1,393,248
Gott Natural Stone '99 Inc.	$ 1,606,872
Glenn Windrem Trucking	$ 1,628,400
H.R. Doornekamp Construction Ltd	$ 1,932,000

The committee inspected three (3) quarries listed by J.C. Rock Ltd. The engineer report concluded that stone material of one of J.C. Rock Ltd. quarries was “not suitable”, while the material from the other two (2) quarries “met low end of specification. However, a source of larger material was not identified”. J.C. Rock also requested that the stone sizing requirement of the tender specifications be removed and stated that they would be unable to meet the requirements without this change. Based on the above staff recommend that J.C. Rock Ltd. bid be rejected as it does Not meet the requirements as outlined in the RFT documents.

The committee also inspected two (2) quarries listed by Gott Natural Stone '99 Inc. The engineer’s report stated about the first quarry “Our overall comment on the 4-6 tonne armour stone is that the stone is suitable and the supply available seems to be sufficient.”

Staff reviewed the bid received from Gott Natural Stone '99 Inc. against its own cost estimate and has determined that the bid is of reasonable value and meets the requirements as outlined in the RFT documents. Therefore, it is recommended that contract No.10038222 be awarded to Gott Natural Stone '99 Inc. at a total cost not to exceed $1,606,872, plus 10% contingency, plus applicable taxes, it being the lowest bid meeting TRCA’s specifications.

Relationship to Building the Living City, TRCA’s 2013-2022 Strategic Plan
This report supports the following strategies set forth in the TRCA 2013-2022 Strategic Plan:
Strategy 2 – Manage our regional water resources for current and future generations
Strategy 7 – Build partnerships and new business models
Strategy 12 – Facilitate a region-wide approach to sustainability

FINANCIAL DETAILS
The estimated project cost for construction of the Ashbridges Bay Treatment Plant Landform Project is $96 million net of all applicable taxes ($97.7 million net of HST recoveries).

Funds to support these contracts will be recovered through the service agreement with the City of Toronto and tracked under account code 183-02.

Report prepared by: Ahmed Al-Allo; Jet Taylor
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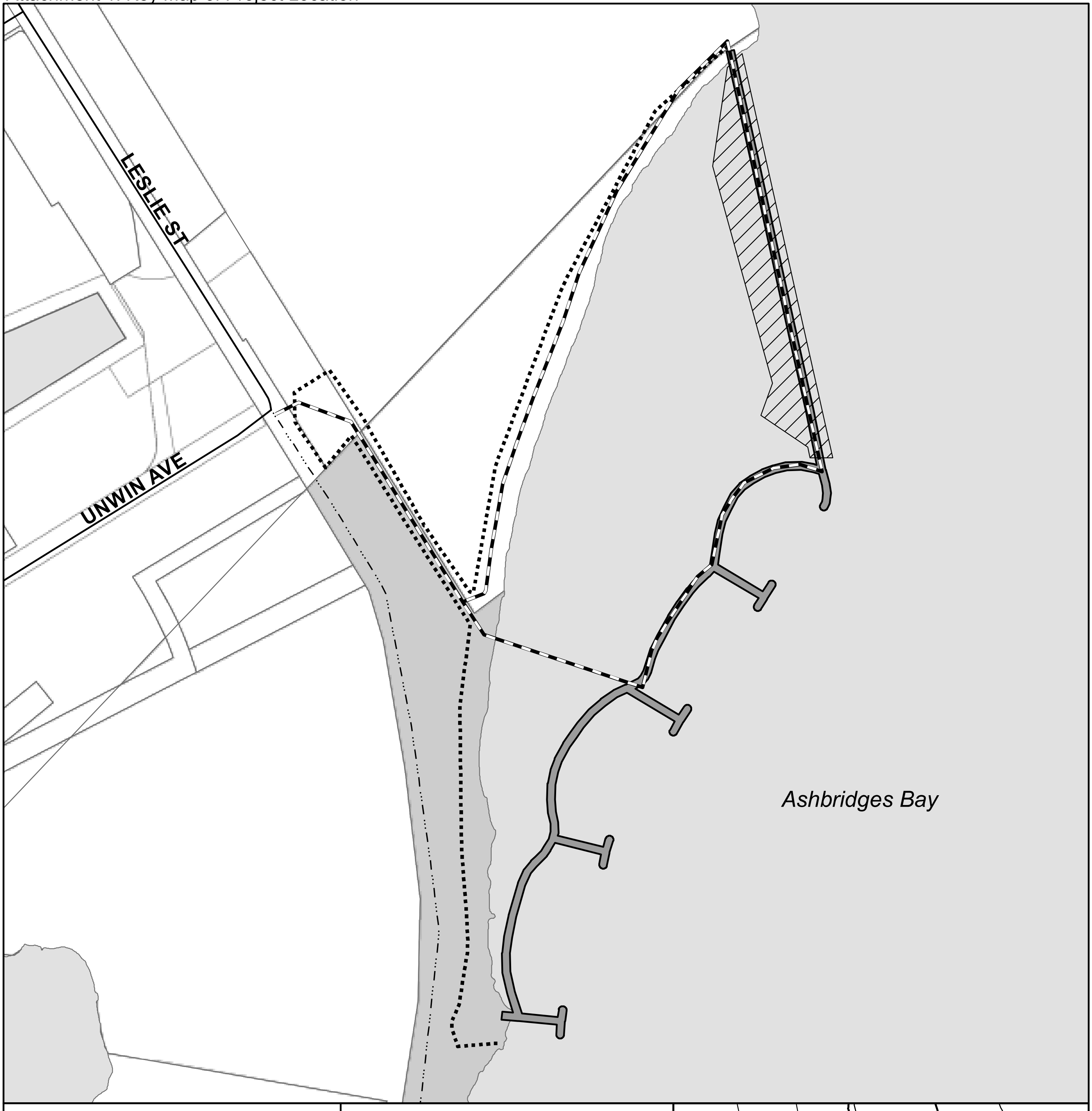
For Information contact: Jet Taylor, (365) 566-2378
Email: jet.taylor@trca.ca
Date: October 20, 2022
Attachments: 2

Attachment 1 - Key Map of Project Location
Attachment 2 - Project Progress Photos

Attachment 1: Key Map of Project Location



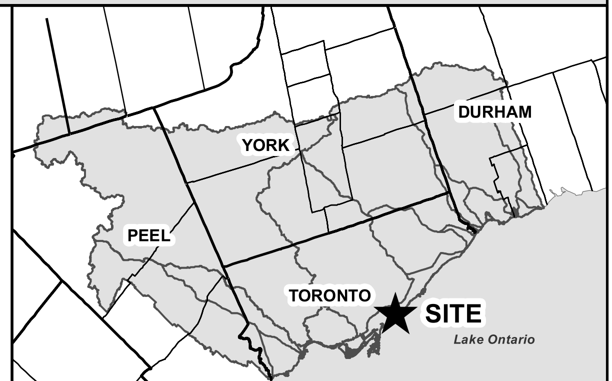
Legend

- Tommy Thompson Park Trail
- Truck Access
- Project Fencing
- Material Dumping Area
- Proposed Landform
- TRCA Property
- Parcel Assessment

Toronto and Region Conservation Authority

N

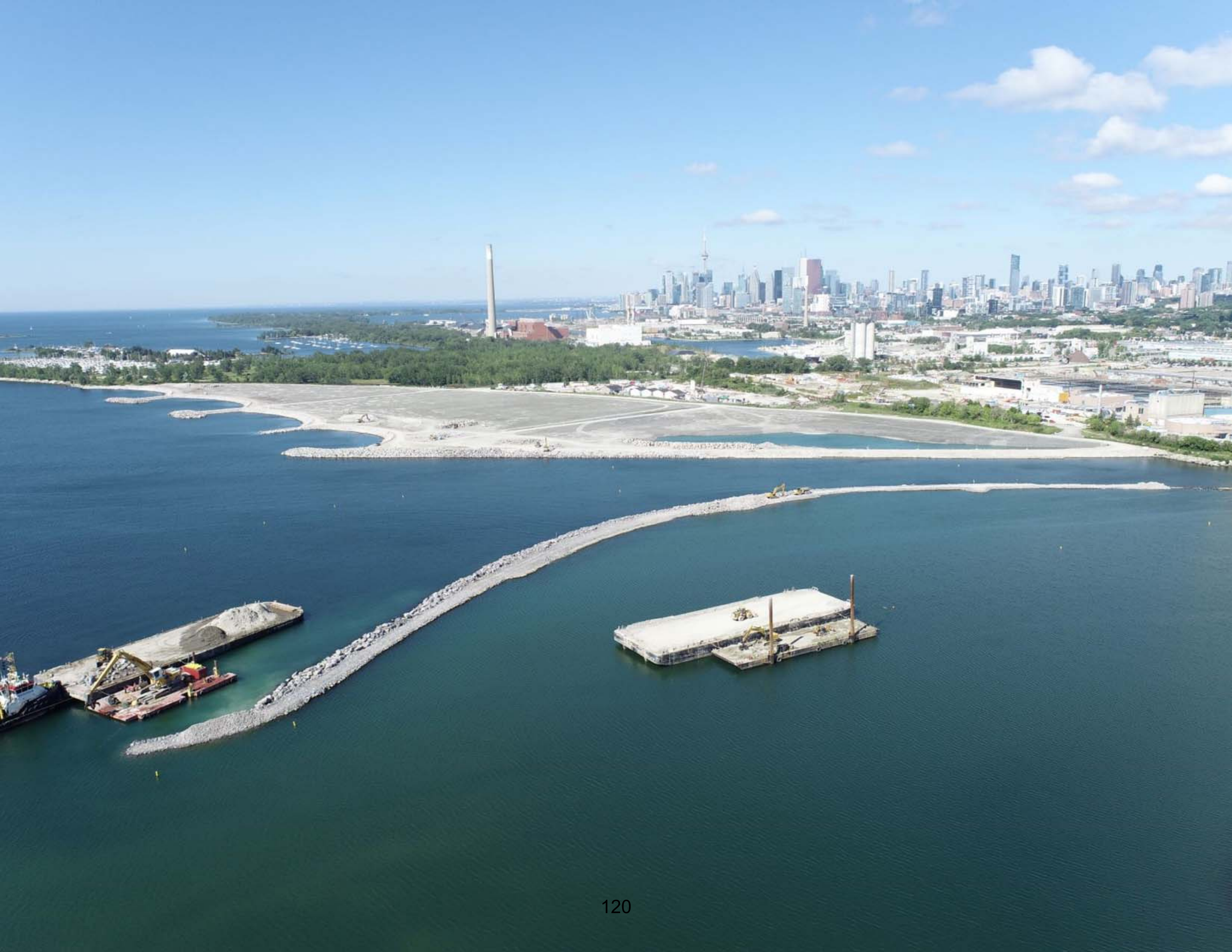
0 125 250 Meters



Key Map

Attachment 2: Project Progress Photos

August 11, 2022
Source: Toronto and Region Conservation Authority



Item 8.1

Section III – Items for the Information of the Board

TO: Chair and Members of the Board of Directors
Friday, October 28, 2022 Meeting

FROM: Sameer Dhalla, Director, Development and Engineering Services

RE: UPDATE ON TRCA'S SHORELINE HAZARD MAPPING PROJECT

KEY ISSUE

Toronto and Region Conservation Authority's (TRCA) Lake Ontario Shoreline Hazard maps are a key technical output necessary to fulfill TRCA's mandate and specific TRCA Strategic Plan objectives to identify and reduce flood and erosion risks and protect communities. Shoreline hazard maps are one of the foundational pieces of several programs within TRCA, including flood forecasting and warning, and land use planning and regulation. Leveraging National Disaster Mitigation Program (NDMP) funding, TRCA Engineering Services has completed a comprehensive Lake Ontario Shoreline Hazard mapping study.

RECOMMENDATION:

THAT the update on the Lake Ontario Shoreline Hazard Mapping Project be received;

THAT TRCA staff communicate to member municipalities and stakeholders with shorelines in TRCA's jurisdiction the results of TRCA's Lake Ontario Shoreline Hazard Mapping project;

AND FURTHER THAT staff report to the Board of Directors when future comprehensive Lake Ontario Shoreline Hazard Mapping projects are completed.

BACKGROUND

The 60-kilometre stretch of Lake Ontario shoreline in TRCA's jurisdiction extends from the Etobicoke Creek watershed in the west to the Carruthers Creek watershed in the east. The lands along the shoreline are subject to naturally occurring processes that give rise to shoreline hazards in the form of lake-based flooding, erosion, and dynamic beach movement. These shoreline hazards are quantified and delineated to help improve the accuracy of TRCA's regulation mapping, assist with land use planning, infrastructure design, erosion management, and emergency management planning along the Lake Ontario shoreline.

The previous shoreline flood hazard standards were developed using information from the Ministry of Natural Resources and Forestry (MNRF) in 1989, making them over 30 years old. Since 1989, multiple significant events have occurred, which necessitates an update to the flood hazard limit. In 2017 and 2019, record water levels in Lake Ontario were greater than the 100-year limit established in 1989. Also, the International Joint Commission (IJC) implemented a new regulation plan for the St. Lawrence Seaway and Lake Ontario in 2017. The plan, known as Plan 2014, is expected to result in a broader range of water levels, depending on the return period considered. Taken together, these factors produce higher return period lake levels and larger flood hazard limits than those previously calculated.

The Shoreline Hazard mapping study was an opportunity to recharacterize shoreline erosion and dynamic beach hazards using new lake level information, new base mapping information based on LiDAR, and information from site-specific studies. All calculations and procedures used were consistent with provincial policy, provincial technical guides, and TRCA's Living City Policies and its section 28 regulation under the Conservation Authorities Act (Ontario 166/06).

At Board of Directors Meeting #8/21, held on Friday, October 22, 2021, RES.#A208/21 - was approved as follows:

IT IS RECOMMENDED THAT the Update on the Delegated Authority to Award Contract No. 10035896 For TRCA Shoreline Hazard Mapping Update be received.

RATIONALE

Completion of this project has resulted in the creation of new shoreline hazard information incorporating the latest data, and technologies to better support land use, infrastructure and emergency management planning, and engineering standards development. The new shoreline hazard information will be used to update TRCA regulation mapping along the entire Lake Ontario shoreline across TRCA's jurisdiction. Currently, TRCA's regulation mapping contains an estimated shoreline hazard limit as one of the criteria that make up the regulated area as prescribed in Ontario Regulation 166/06. Ultimately, the updated mapping serves to better protect people and property from shoreline flooding, erosion, and dynamic beach hazards.

The shoreline hazard mapping project was a multi-phased process that required several studies to be completed prior to map generation:

1. The first phase consisted of the development of the 100-year Lake Ontario flood level required to delineate the Lake Ontario Shoreline Flood Hazard.

2. The second phase consisted of the development of the Lake Ontario Shoreline Erosion Hazard and the Lake Ontario Dynamic Beach Hazard.

3. The final phase was the development of the final mapping product, which identifies the three aforementioned hazard limits, topographical information (contour lines) overlaid on recent aerial imagery depicting geospatial data such as roads, houses, bridges, and other similar infrastructure. The project also defined the overall Lake Ontario Shoreline Hazard Limit, which is the hazard limit that is the furthest landward extent of the flooding, erosion, and dynamic beach hazard limits.

All mapping was completed on a reach-by-reach basis. The TRCA shoreline was divided into a total of 49 reaches based on shoreline characteristics such as the changes to shoreline exposure, shoreline orientation, shoreline type, and locations of artificial lakefill areas.

The technical studies and the mapping were completed by qualified professional coastal engineers (W. F. Baird & Associates) and geotechnical engineers (Grounded Engineering) retained by TRCA. Throughout the project, TRCA Policy Planning, Development Planning and Permits, and Engineering Services staff provided direction to the consultants. This project was also supported by TRCA's Restoration & Infrastructure staff who provided valuable background data. All methods used are consistent with TRCA's Living City Policies, Ontario Regulation 166/06, as well as MNRF's Technical Guides.

Lake Ontario Shoreline Flood Hazard

The Lake Ontario Flood Hazard Limit is defined as the 100-year flood level plus an allowance for wave uprush. The 100-year flood level was obtained by performing statistical analyses on historical water level data between 1962 to 2020 and incorporates the changes made to the regulation of Lake Ontario levels under Plan 2014. The methods used in this study are consistent with those presented in the Toronto Islands Flood Risk Characterization Study presented to the TRCA Board at Meeting #6/19 on Friday, June 21, 2019. The 100-year Lake Ontario flood level for TRCA's jurisdiction was determined to be 76.2m (vertical datum of IGLD85) for the entire jurisdiction. This level is higher when compared to the previous 100-year flood levels of 75.8m west of Yonge Street and 75.7m east of Yonge Street.

A technical study was also undertaken to determine the hazards associated with wave uprush that occur when shorelines are exposed to wave action, driving the water to levels above the 100-year flood level. The technical study involved the use of a two-dimensional spectral wave model called MIKE21 SW and other shoreline profile modelling using coastal engineering models such as CSHORE and EurOtop. The modelling results produced the wave uprush allowance for each of the 49 reaches. This assessment is an improvement over the previous flood hazard estimation exercise, which used the standard 15m wave uprush allowance across the jurisdiction.

Lake Ontario Shoreline Dynamic Beach Hazard

The Lake Ontario Shoreline Dynamic Beach Hazard is the landward limit of the flooding hazard plus a 30m dynamic beach allowance, or a distance determined by an accepted coastal study. Dynamic beach hazards only apply to beaches of sufficient size and depth, and which contain deposits overlying suitable material. For this update to the Shoreline Dynamic Beach Hazard limits, site visits and desktop assessment were undertaken to confirm the locations of dynamic beaches in TRCA's shorelines. A total of 13 dynamic beaches were identified. At these locations, a 30-m hazard line was plotted offset from the Lake Ontario Shoreline Flood Hazard. However, at locations where the beach is obstructed by a significant physical barrier, such as a road or cohesive bluff, the dynamic beach hazard limit was not extended beyond the barrier.

Previous TRCA mapping only identified 9 dynamic beach hazard locations. The updated technical study has resulted in the identification of a total of 13 dynamic beach locations and refinements to the dynamic beach hazard limits of the previously identified locations.

Lake Ontario Shoreline Erosion Hazard

The Lake Ontario Shoreline Erosion Hazard is defined as the sum of the 100-year toe erosion allowance and the stable slope allowance. The 100-year toe erosion allowance estimates how much a shoreline would recede over a 100-year time period and is calculated using historical aerial images and topographic data. Additional procedures were applied to consider major public revetments and large lakefill projects where appropriate.

The stable slope allowance predicts the long-term stable slope from the toe erosion allowance. A geotechnical study was undertaken to determine appropriate stable slope allowances across the entire shoreline by examining soil characteristics, groundwater conditions, and by undertaking modelling using slope stability software. Based on TRCA's guidelines that require a minimum factor of safety of 1.5, stable slope was determined for each of the 49 reaches. In locations with insufficient data, a stable slope allowance of 3H:1V was used as per MNRF Technical Guide.

The updated erosion hazard limits are an improvement over the previous hazard mapping exercise, which used the standard 30 m erosion allowance and a 3H:1V stable slope allowance.

Lake Ontario Shoreline Hazard Mapping
To create shoreline hazard maps, the technical studies' results were transposed onto base maps. Prior to finalization, various TRCA experts within TRCA's Engineering Services, Planning and GIS business units completed a detailed review of the resulting hazard lines to ensure that the mapping products were consistent with mapping standards from provincial Technical Guides, TRCA's Living City Policies and Ontario Regulation 166/06. A total of 97 map sheets were generated and stamped by a Professional Engineer.

A public-facing Shoreline Hazard Map viewer, together with a set of Frequently Asked Questions, will be made available on a TRCA website.

Project deliverables include digital hazard lines overlaid on digital base mapping of the entire TRCA shoreline. This new process allows for the development of custom mapping products, where needed, with less staff time involved in developing and orienting set-size map sheets. Mapping is frequently requested by municipal partners, the development industry and associated professional consulting firms, as well as the public. Custom maps can be prepared easily based on the needs of the user; consulting engineers well-versed in hazard mapping can request the full suite of mapping information, whereas the public can be provided simplified maps with the hazard limit overlaid on an aerial photo base. In all instances, the full mapping product can be made available via the existing TRCA data request channels for any interested party.

An example of the updated shoreline hazard mapping product is shown in **Attachment 1**.

Outcomes and Next Steps
The updated shoreline hazards maps do not change the inherent risks of a given location; it is a technical process that provides an updated *understanding* of the risks based on the best available information. Even though the shoreline hazard maps were comprehensively updated across TRCA's jurisdiction, emerging issues and other program updates will need to be addressed and completed. These consist of the following:

- TRCA's approaches to managing natural hazards with respect to planning and development are in accordance with provincial standards as outlined in The Living City Policies. The development and infrastructure planning process advances through a complex hierarchy. Therefore, it is possible for the update to shoreline hazard mapping to occur at various stages of the planning hierarchy.
    - As a result, there may be instances where TRCA staff have already reviewed and are in support of a proposed development on the basis of information that changes mid-process.
    - The *Conservation Authorities Act* is the jurisdictional authority in the permitting process and does not provide for the grandfathering of historical planning decisions. For transitional files (as recognized by TRCA staff), where it is technically feasible and appropriate, innovative design approaches may be considered to address site constraints and accommodate the development while meeting current regulatory requirements. TRCA is committed to utilizing the best available information to achieve the policy objectives noted in Section 8.3 of The Living City Policies, including minimizing the risk to people and property due to natural hazards.
    - The best available information may include site specific studies and quality control checks. It is important to recognize that a solution may not always be technically feasible, and that the above only applies to transitional files that have recent previous support from TRCA staff for the same application.

- TRCA's Regulation Limit will need to be updated using the new shoreline hazard limits. This will be undertaken by Engineering Services, Planning Policy and Regulation, and Business Intelligence and Data Analytics (GIS) staff. The updated mapping will be communicated to the Board of Directors via the Annual Regulation Mapping Update by the Planning Policy and Regulation team, as per the current practice.

- Development and Engineering Services will work with Restoration and Infrastructure, and Policy Planning to actively maintain TRCA's shoreline hazard map set on an ongoing basis, which could include actions such as incorporating new shoreline protection infrastructure and technical studies as they become available.

- Development and Engineering Services, together with Policy Planning, will communicate to municipal partners on the results of TRCA's revised shoreline hazard mapping updates through the TRCA website. Staff will provide a summary of the project and an opportunity for stakeholders and interested members of the public to view, in greater detail, the updated mapping.

    - As a first step in communicating the information, TRCA planning staff recently met with City of Toronto planning staff to explain the mapping update and discussed options for informing landowners. TRCA Policy Planning staff will report back to the Board of Directors on next steps in this process through a report on the Annual Regulation Mapping Update in early 2023.

Relationship to Building the Living City, the TRCA 2013-2022 Strategic Plan
This report supports the following strategies set forth in the TRCA 2013-2022 Strategic Plan:
Strategy 2 – Manage our regional water resources for current and future generations
Strategy 4 – Create complete communities that integrate nature and the built environment
Strategy 7 – Build partnerships and new business models

FINANCIAL DETAILS
NDMP will fund 50% of the project costs and remaining costs were funded through TRCA's Flood Protection and Remedial Studies program account 107-02, supported by funding from the City of Toronto, as well as funding from the Region of Durham. Funds were tracked in account 107-18

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Date: October 28, 2022
Attachments: 1

Attachment 1: Example of a Lake Ontario Shoreline Hazard Map Sheet

Attachment 1 - Example of a Lake Ontario Shoreline Hazard Map Sheet

Toronto and Region Conservation Authority Lake Ontario Shoreline Flooding and Erosion Hazards

Toronto and Region Conservation Authority
Head Office
5 Shoreham Drive
Toronto M3N 1S4
https://trca.ca

Toronto and Region Conservation Authority

This map presents the Lake Ontario shoreline hazard mapping completed on a reach-based assessment. The Lake Ontario shoreline within the TRCA jurisdiction was segmented into 49 reaches based on common features such as wave exposure, bank/bluff height, shoreline composition, etc.

The 1:2,000 scale digital terrain model from 2015 and orthoimagery from 2020 have been used to produce and map the shoreline flooding, erosion and dynamic beach hazard limits. Local irregularities and physical shoreline conditions affecting the hazard limits may not have been apparent in the terrain model or orthoimagery. The hazard mapping is a living document and reflects the potential hazard conditions using the most recent available shoreline data. Hazard limits will change over time, for example as the shoreline retreats or as large municipal shore protection projects are added or damaged. **Where development is proposed on a property or properties within the study area, the location and extent of hazard limits should be reviewed with regard to the most current and detailed site information available, with due consideration to the effect of shoreline conditions on adjacent properties and their associated shoreline and non-shoreline hazards. This map does not include non-shoreline hazards, i.e., those hazards not pertaining to coastal processes, such as valley and stream corridor flood and erosion hazards.**

Legend

Hazard Mapping

- Toe of Bank/Bluff
- Shoreline Erosion Hazard Limit
- 100-year Toe Erosion Allowance
- Shoreline Flooding Hazard Limit
- 100 Year Flood Level
- Dynamic Beach Hazard Limit

Basemap Features

- Elevation Contour, 1 m interval

Toe of Bank/Bluff
The toe of bank/bluff is the transition from the gently sloping beach to the steep portion of the bank or bluff slope. The Toe of Bank/Bluff was defined by interpretation of the 2020 aerial photographs and the 2015 elevation contour data.

Shoreline Erosion Hazard Limit
The landward limit of the Shoreline Erosion Hazard Limit is the sum of the *Stable Slope Allowance* plus a *100-year Toe Erosion Allowance* measured landward from the toe of the shoreline bank or bluff.
The *Stable Slope Allowance* is defined as a horizontal allowance, measured landward from the toe of the shoreline bank/bluff, determined on a reach basis using borehole data and a geotechnical analysis.

100-year Toe Erosion Allowance
The 100-tear Toe Erosion Allowance reflects the average annual erosion/recession rate that would be expected to occur over 100 years, and was assessed for each reach.

Shoreline Flooding Hazard Limit
The Shoreline Flooding Hazard Limit is defined as the 100 Year Flood Level plus an allowance for Wave Uprush and other water related hazards. The allowance for Wave Uprush was determined on a reach basis using a representative profile for each of the 49 reaches of the shoreline.

100 Year Flood Level
The 100 Year Flood Level is defined as the peak instantaneous stillwater level (i.e., mean lake level plus storm surge) having a combined probability of being equalled or exceeded during any year of 1% (i.e., probability, P=0.01).
The 100 Year Flood Level elevation for TRCA's Lake Ontario jurisdiction is 76.17 metres IGLD1985, or 76.09 metres CGVD28.

Dynamic Beach Hazard Limit
Typically the Dynamic Beach Hazard Limit is defined as the sum of the Flooding Hazard Limit plus 30 metres measured horizontally. There may be deviations of this approach where justified by a site specific technical study or the application of engineering judgement.

Elevation
Topographic elevation contours are derived from 2015 LiDAR dataset acquired by Airborne Imaging. The data was acquired on various dates betweem April/May, 2014 and April, 2015. The LiDAR Digital Terrain Model (DTM) is a 1 metre resolution gridded raster representing the bare-earth terrain derived from a classified LiDAR point cloud. Topographic contours are shown at 1 metre intervals.

Lake Ontario Water Level
The Lake Ontario Chart Datum (Low Water Datum, IGLD1985) elevation is: 74.2 metres.
At the time of the elevation data collection, the Lake Ontario monthly mean water level for April 2014 was 74.83 m and for April 2015 was 74.62 m (IGLD1985).
Corresponding with the aerial photography shown in this map, the Lake Ontario monthly mean water level for April 2020 was 75.32 metres and for May 2020 was 75.36 metres (IGLD1985).
Water Level information is provided by Canadian Hydrographic Service, Fisheries and Oceans Canada.

http://www.waterlevels.gc.ca/

Vertical Datums
The measurement of water levels uses a different vertical datum than that of land. Lake Ontario water levels are referenced to International Great Lakes Datum 1985 (IGLD1985). Elevations on this map are referenced to a land datum, Canadian Geodetic Vertical Datum of 1928 (CGVD28).
The relationship between the lake and geodetic datums varies around the lake. For the TRCA Lake Ontario shoreline the vertical datum conversion between IGLD1985 and CGVD28 is documented by Natural Resources Canada at benchmark station TORO 1-1959 (also known as 59U9526 and 59U541) established by the Canadian Hydrographic Service in Toronto Harbour at the south side of Queen's Quay.
Elevations in IGLD1985 = CGVD28 + 0.083 metres.

Aerial Photography
The 2020 acquired aerial imagery at 8 cm resolution by First Base Solutions. Data was collected April and May 2020.

Scale 1:2,000

1 centimetre = 20 metres

0 50 100 150 200 250 Metres

N W E S

Map Projection:	Universal Transverse Mercator, Zone 17
Horizontal Datum:	North American Datum 1983
Grid Spacing:	100 metres

Mapping Prepared by:

Map Publication Date:
11 May 2022

LICENSED PROFESSIONAL ENGINEER
11May.2022
D.C. WILLIAMSON
PROVINCE OF ONTARIO

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