Water-based research, opportunities and goals at Toronto and Region Conservation Authority

Water Frontiers Seminar

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Toronto and Region Conservation Authority

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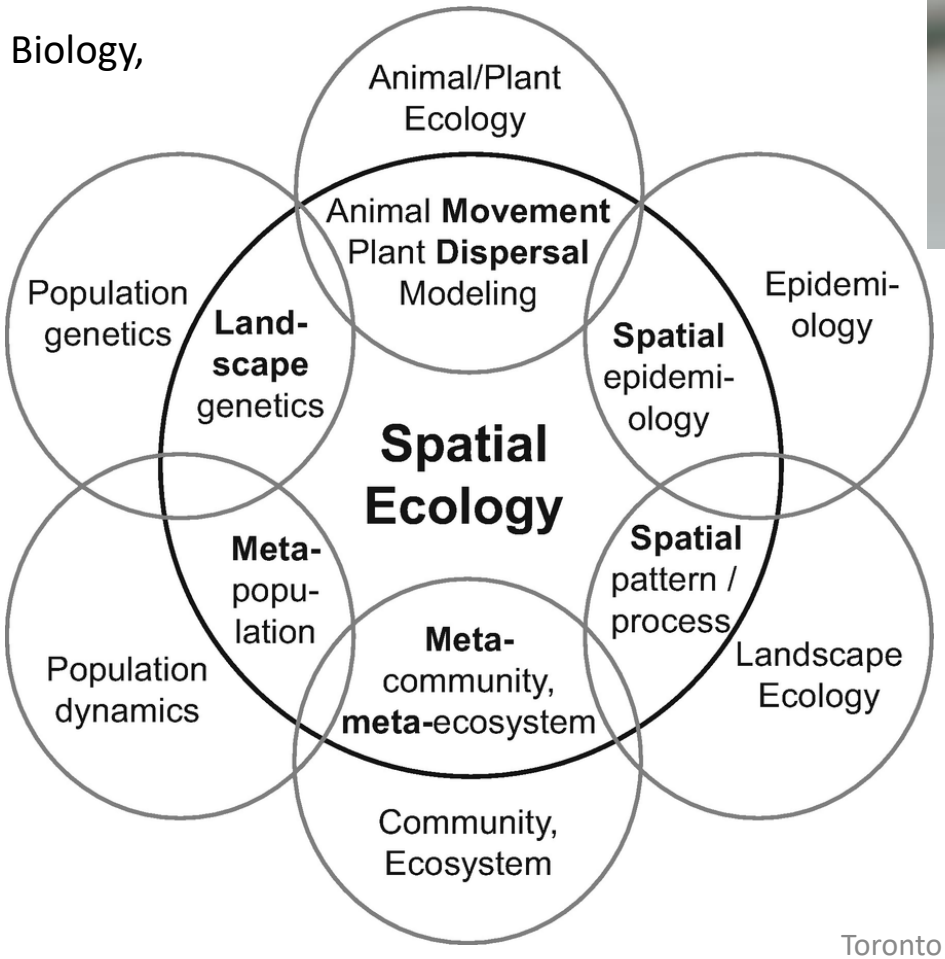
Research Areas

1. Conservation & Strategic Planning
2. Connectivity
3. Compensation & Mitigation



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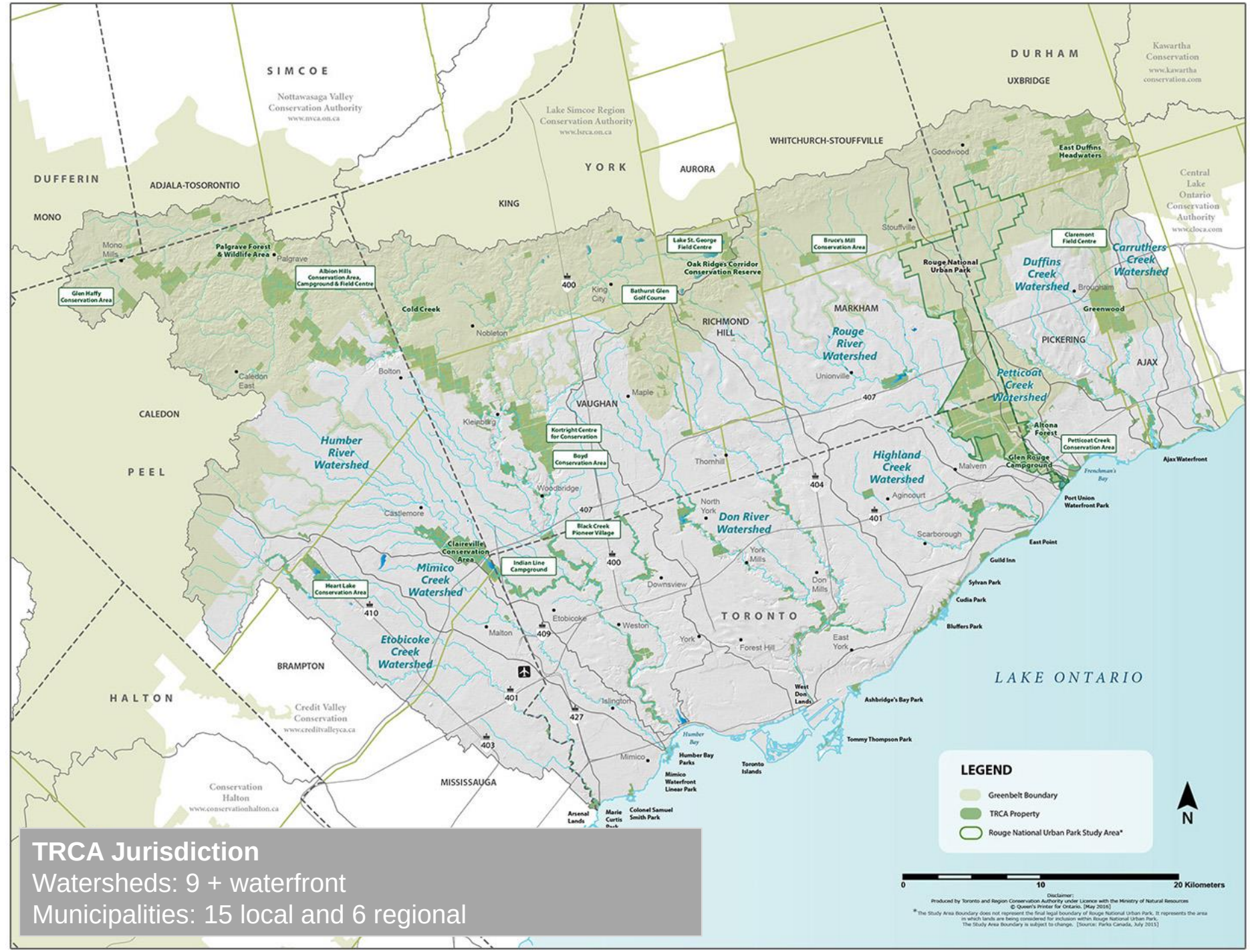
Agenda

- Organizational Background
  - Jurisdiction, Mission, Strategic Priorities, and Research Agenda

- Water Related Goals
  - Relevant Business Units, ongoing projects, future opportunities



TRCA Jurisdiction
Watersheds: 9 + waterfront
Municipalities: 15 local and 6 regional

OUR VISION

The quality of life on Earth is being created in rapidly expanding city regions. Our vision is for a new kind of community—The Living City—where human settlement can flourish forever as part of nature's beauty and diversity.

OUR MISSION

To protect, conserve and restore natural resources and develop resilient communities through education, the application of science, community engagement, service excellence and collaboration with our partners.

TRCA Service Areas, Strategic Plan, & Research Agenda

Watershed Studies and Strategies

Water Risk Management

Regional Biodiversity

Greenspace Securement and Management

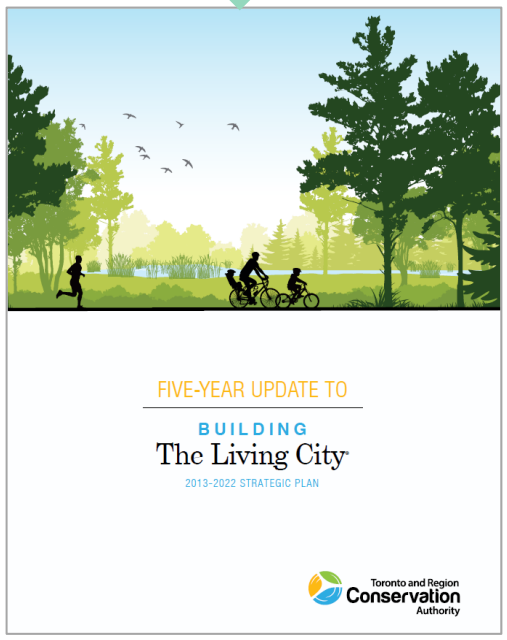
Tourism and Recreation

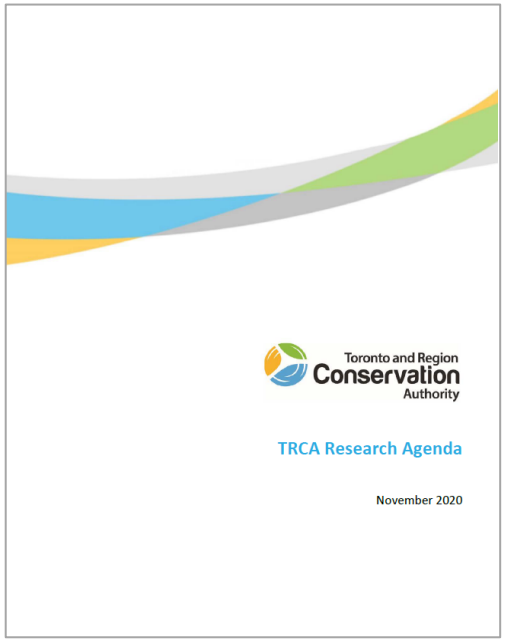
Planning and Development Review

Education and Outreach

Sustainable Communities

Corporate Services





TRCA Strategic Priorities

1. Green the Toronto region's economy
2. Manage our regional water resources for current and future generations
3. Rethink greenspace to maximize its value
4. Create complete communities that integrate nature and the build environment
5. Foster sustainable citizenship
6. Tell the story of the Toronto region
7. Build partnerships and new business models
8. Gather and share the best urban sustainability knowledge
9. Measure performance
10. Accelerate innovation
11. Invest in our staff
12. Facilitate a region-wide approach to sustainability

Path forward for the next 10 years?

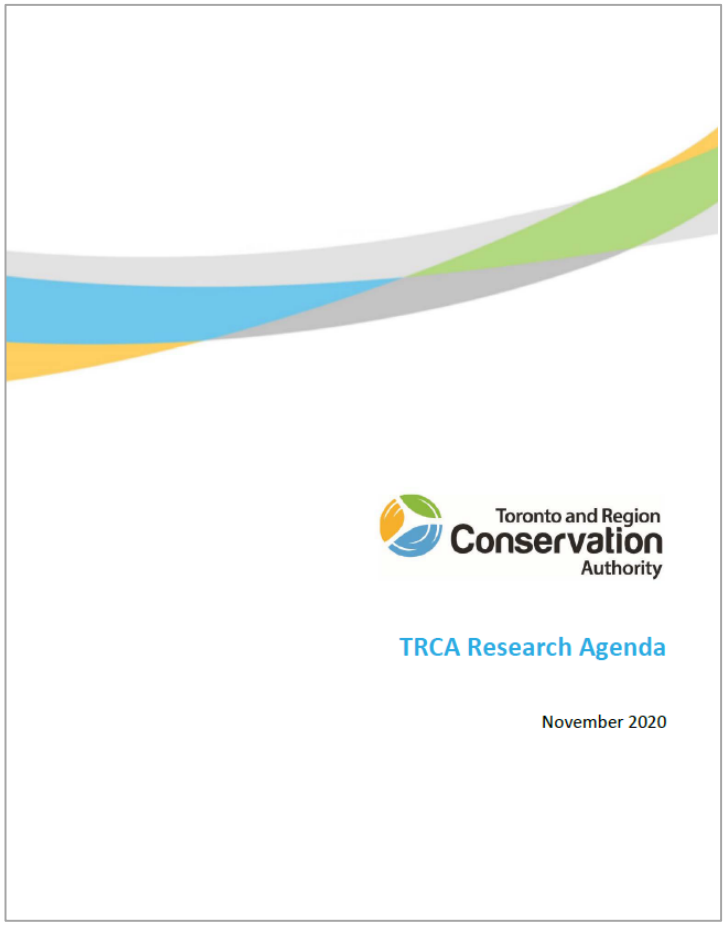
Toronto and Region Conservation Authority

TRCA Research Agenda
What is it?

- A living document that provides a series of curated overarching questions and specific example questions to help guide, coordinate, and target TRCA's applied research initiatives to fill in the identified knowledge gaps in a proactive way.

- Focuses on the strategic priorities and desired outcomes related to integrated management of natural hazards and natural heritage. (Strategy 1-5, 8-9)

- Not intended to represent a comprehensive list of all TRCA research needs, but to highlight the best available information of the critical gaps



STRATEGIC PRIORITY 2: MANAGE OUR REGIONAL WATER RESOURCES FOR CURRENT AND FUTURE GENERATIONS

Desired Outcomes	Guiding Research Questions	Example Research Questions
1. 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.	a. What are the most important direct and indirect stressors and impacts of urbanization and climate change on aquatic ecosystem health and resilience in the region? b. Which stressors and impacts can be most effectively managed by TRCA and municipal partners? How?	• How can various planning processes (e.g. watershed, land use, infrastructure) avoid, minimize, mitigate, and compensate for the cumulative impacts of urban development on aquatic health? • Can we build high-density development without the need for permanent dewatering? • What are the available opportunities to enhance the overall positive impact on aquatic ecosystem? How can these be promoted through planning processes? • How can landscape planning and urban design address water quality and quantity impairment issues? • At what point do water quality changes and associated additive stressors impact the dominant wetland community type(s) in shallow open water wetland ecosystems? • What are the demonstrated site-based solutions that can maintain water balance post-development? How can they be applied in the Toronto region? • How does the restoration and/or enhancement of natural systems improve biodiversity? • Can incorporating new natural systems into redevelopment improve biodiversity? (e.g. Downsview Bombardier redevelopment). • Is there a subsurface permeability threshold below which recharge mitigation is not practical? • Can "Best Efforts" be quantified?
2. Adaptive measures to address climate change are integrated into infrastructure projects to ensure their durability and resilience.	a. What risk does climate change present to existing infrastructure assets (including green infrastructure) and how can they be managed in TRCA and municipal practices (e.g. flood and erosion mitigation, integrated stormwater management)?	• What risks does climate change pose to TRCA and TRCA assets in flood control and flood risk management? • How can we map risks and vulnerabilities more effectively and translate them to effective conservation and resilience practices? • How can we develop design criteria and management approaches to mitigate and adapt more effectively in the region? • What practices will help to increase the resilience of sensitive aquatic structures and functions? • What are the best methods to quantify the cumulative economic impact of erosion hazards to help demonstrate the value of remedial works and to show the return on investment for various projects?
3. Toronto Region waterways are suitable for swimming, fishing, and recreational activities.	a. How can eco-hydrology, water quality, and biodiversity and habitat conservation principles and practices be more fully incorporated into the management of aquatic ecosystems?	• What impact do TRCA's flood and flow management activities have on aquatic and terrestrial ecosystem and human well-being? • What are the best practices for establishing and applying ecohydrology and water quality practices planning and restoration projects? • How can in-stream flow regime and water quality be managed to sustain biodiversity over the next 100 years? • How can we protect vulnerable aquatic ecosystems that support overall biodiversity in the region?
4. Source water quality and quantity is maintained or improved.	a. What are the major direct and indirect threats to source water, in the face urbanization and climate change, that can be effectively managed by TRCA and its partners? How can efficacy be improved within policy and practice framework.	• Can we quantify the impacts do development activities have on the groundwater system? • How can groundwater recharge and discharge functions be maintained with ongoing development and climate change? • What tools and restoration practices and principles work best to maintain or improve source water within natural systems? • Is the existing policy framework sufficient for effective protection of source water?
5. 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.	a. How can erosion hazards and associated risks be most effectively identified and mapped throughout the region? b. How does flood risk perception in flood prone communities influence management approaches and community behavior to increase effectiveness in managing risks?	• Are current hydrology models accurately estimating erosion hazards? How can such models be improved? What are the monitoring requirements for such models? • What are the remote sensing services that can utilized to perform the estimation of flood and erosion hazards? • What percentage of people living in flood prone areas are aware of their risk

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Water Related Goals – TRCA Teams

- Solicited business units for ongoing research/work and opportunities, including:

1. ECS - Regional Ecosystem Science Program
2. ECS - Integrated Water Management
3. Watershed Planning & Reporting
4. Hydrogeology & Source Water Protection
5. Restoration and Resource Management
6. Hydrometrics
7. Flood Infrastructure
8. Erosion Risk Management
9. Aquatic Monitoring & Management

Ecosystem & Climate Science: Regional Ecosystem Science Program

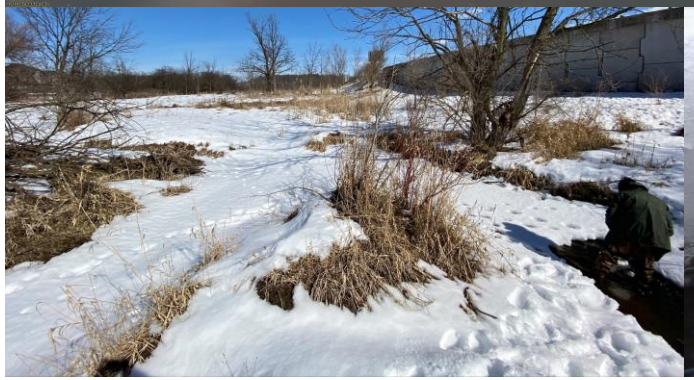
- Aquatic Ecosystems Applied Research
  - Water Resource System
  - Aquatic Habitat & Biodiversity
  - Aquatic Barriers & Fish Movement
  - Ecohydrology

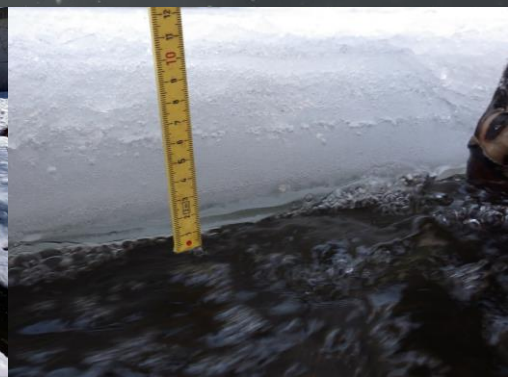
- Terrestrial Ecosystems Applied Research
  - Natural Heritage System
  - Habitat & Biodiversity
  - Wildlife Movement & Habitat Connectivity
  - Invasive Species

- Key challenge - integration of terrestrial and aquatic ecosystems

Ecosystem & Climate Science: Redside Dace Overwinter Habitat

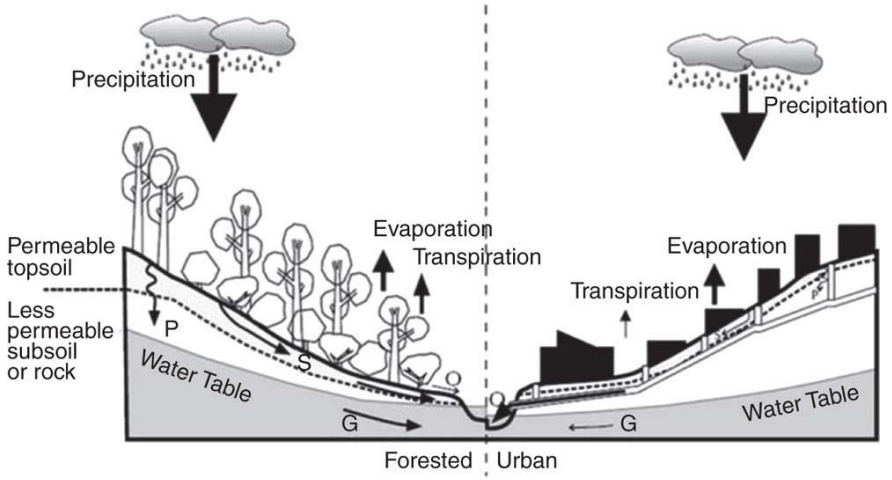
- Redside Dace is an endangered minnow species
- Very little is known about the overwintering habitat requirements
- Both environmental and species presence-absence are being recorded
- Underwater video surveys are being completed monthly
- Passive Integrated Transponder (PIT) tags will be used to determine where they reside and move throughout the winter season
- Best Management Practices (BMPs) guidelines for habitat enhancement and conservation will be completed

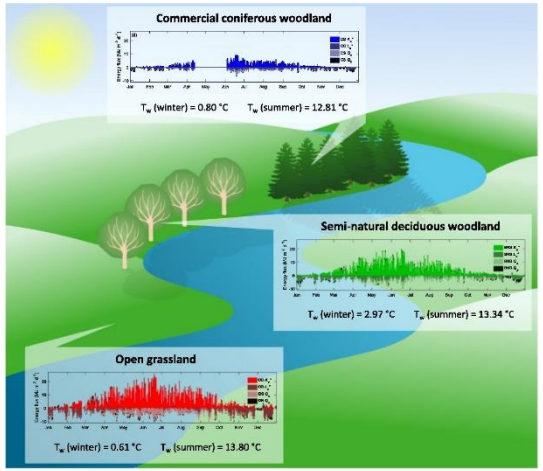




Ecosystem & Climate Science: Research Opportunities

- **Ecohydrology** – flow is important to many aquatic species, determining relevant thresholds for habitat suitability to conserve biodiversity
- **Ponds to streams** – determine how do SWMP performance is related to instream conditions and biodiversity
- **Terrestrial-Aquatic Ecosystem Connections** – identify how land use and natural cover modifies processes between ecosystems





Dugdale *et al.* 2018 *Science of the Total Environment*

Ecosystem & Climate Science: Integrated Water Management

- Site scale stormwater quantity and quality control research;
- Modeling of LID impacts at the site scale;
- Integration of climate sensitivity analysis for stormwater management;
- Cost benefit analysis of green infrastructure;
- Watershed scale stormwater management (grey and green infrastructure)
- **Key Challenge -** Advocacy for green infrastructure and its role in stormwater management by enforcing stricter development criteria.

Ecosystem & Climate Science: LID Training Treatment Tool (TTT)

- Provides municipalities the framework to consider Green Infrastructure for stormwater management systems, climate change adaptation/mitigation strategies and ecological sustainability
- Incorporates best practices and current new research in LID planning and design;
- robust methods to evaluate whether a site meets required stormwater management criteria;
- provides municipalities estimated costs to achieve criteria;
- evaluates the impact of the site stormwater management at broader scales.
- A user-friendly tool that has a robust stormwater model engine that aids site retrofit and new developments in meeting SWM criteria using GI while providing a cost/benefit analysis

Ecosystem & Climate Science: Research Opportunities

- Co-benefit calculations for Green Infrastructure (e.g., biodiversity, economic, social)

- Watershed scale LID impact analysis – site level application but how do these processes scale up to the watershed level?

- Climate projections at finer temporal scale (hourly) – better understand short-term responses of LID infrastructure and change design as needed

Watershed Planning & Reporting

- WPR Functions:
  - Development of watershed plans
  - Development of watershed reporting products
  - Input into municipal Official Plans
  - Tracking watershed plan implementation and changes in watershed health over time
- Key Challenge - Integrating technical disciplines for holistic understanding of watersheds

Watershed Planning & Reporting: Etobicoke Creek Watershed Plan

- Project required to help inform decisions on future land use and infrastructure
- Project:
  - Characterizes existing watershed conditions
  - Assesses impacts to watershed through analysis of impacts from future land use and climate change scenarios
  - Develops a management framework to protect, enhance, and restore the watershed
- Outcome/product: completed watershed plan

Watershed Planning & Reporting: Research Opportunities

- Ways of better integrating the various technical disciplines through the impact assessment modelling typically done as part of watershed planning (i.e. assessing future land use and climate change scenarios).
  - Hydrology, hydrogeology, water quality, erosion, aquatic ecosystem.
- Consistency in how to apply climate projections through modelling across disciplines.
- Ways of better visualizing the effects of future scenarios by the public and by decision-makers. Making these results interactive and easy to understand.

Hydrogeology and Source Water Protection

- Review of Land Development Files
- Review of Municipal Environmental Assessments
- Provide advice on Potable Water Management for TRCA facilities
- Provision of advice to municipal partners with respect to Drinking Water Source Protection
- Key challenge - balancing our need to gather data and respond to the wide variety of requests we receive

Hydrogeology and Source Water Protection: White Paper on Remedial Options

- Waterfront Toronto is mitigating flood risk at the mouth of the Don River in Toronto
- Excavation of 1.5 million cubic metres of soil; most of it contaminated
- Desire to minimize off-site disposal of soil and water
- Bench Scale and Pilot Scale testing of technologies with soil and groundwater from the site
- White Paper on Remedial Technologies issued to Waterfront Toronto and the Green Municipal Fund
- Ongoing remediation of soil and water generated through

Hydrogeology and Source Water Protection: Research Opportunities

- GIS-based methodologies for the screening of sites for geothermal energy storage
- Deep boreholes in the City of Toronto
- Geophysical methods for urban areas

Restoration and Resource Management (RRM)

- list of activities/functions
  - Restoration Prioritization and Strategic Planning
  - Wetland Restoration
  - Stream and Shoreline Restoration
  - Reforestation and Forest Management
  - Invasive Species Management
- Key challenges
  - Key Performance Indicator Measurement
    - Ecosystem Services
    - Wildlife Use in Restored Areas
    - Understanding limiting factors to project success

RRM: Wetland Projects Key Performance Indicators

- Significance of Project
  - Modelling water retention and quality treatment of restored wetlands calibrated to real data to determine the extent of ecosystem services they provide
- Project Description
  - Using level logger data to track storage volumes over time in selected restored wetlands in urban, rural and near urban areas
  - Calibrating a storage and water quality model to predict performance of all restored wetland
  - Linking retention factors and hydroperiod to vegetation communities and wildlife use through monitoring
- Project Outcome
  - To determine the storage and water quality performance of wetland projects and how the overall wetland restoration program is contributing to Ecosystem Services
- Next Steps
  - We have deployed level loggers and will be collecting the data for at least one season
  - Use the data to determine average storage volume retention and water quality treatment over time
  - Calibrate a retention model to determine the overall performance of the wetland restoration program

RRM: Research Opportunities

- Potential Research Opportunities
  - Impact/influence of phragmites/phragmites removal on fish and wildlife populations (particularly fish and turtles)
  - Data collection/analysis on response of wildlife (non fish) to wetland restoration
  - Native bi-valves – where are they, is their habitat limited, can we restore wetlands to improve their populations
  - Limiting factors for muskie populations in the Toronto waterfront
  - Impact of Climate Change on restored natural features

Engineering Services - Hydrometrics

- Primarily tasked with operating the flood forecasting and warning system
- Also involved with high level water quality and monitoring programs
- These include real-time automated sampling and multiparameter sondes

Hydrometrics: University of Waterloo Ajax Phosphorus Monitoring

- Monitoring the loads and speciation of phosphorus at a L. Ont outfall in Ajax, Ontario.
- Monitoring 2 twin sewershed for flow and event based samples.
- Supporting developing a model for urbanized sewersheds and the impacts of nutrient delivery to L.Ont.
- Also analyzing microplastics, rain isotopes and other parameters.

Hydrometrics: Research Opportunities

- More focus on chloride and nutrient monitoring
- Improving land to lake connections
- Emerging water quality issues – microplastics, metals, tire dust, etc.

Flood Infrastructure and Hydrometrics (FIH)

- TRCA FIH operates and manages 27 flood control structures including 12 dams, 9 flood control channels and 6 dykes.
- The Hydrometric Program manages over 100 hydrometric stations including stream gauges, precipitation gauges, climate stations, and snow courses. Approximately 50 stations provide real-time data for TRCA's Flood Forecasting and Warning Program
- FIH operates numerous flow-weighted water quality stations for specialized WQ projects in both closed pipe and open channel environments

FIH: Dam Liquefaction Potential

- Dam Safety Review determined that Stouffville Dam was at risk of a liquefaction failure during a seismic event.
- Sand layer under the dam could liquefy during earthquake causing dam embankment to fail
- Specialized geotechnical investigation was initiated using cone penetration soil testing and Shear wave velocity measurement by means of MASW (Multi Channel Analysis of Surface Waves)
- Study determined that dam deformation during seismic event was not enough to cause dam failure

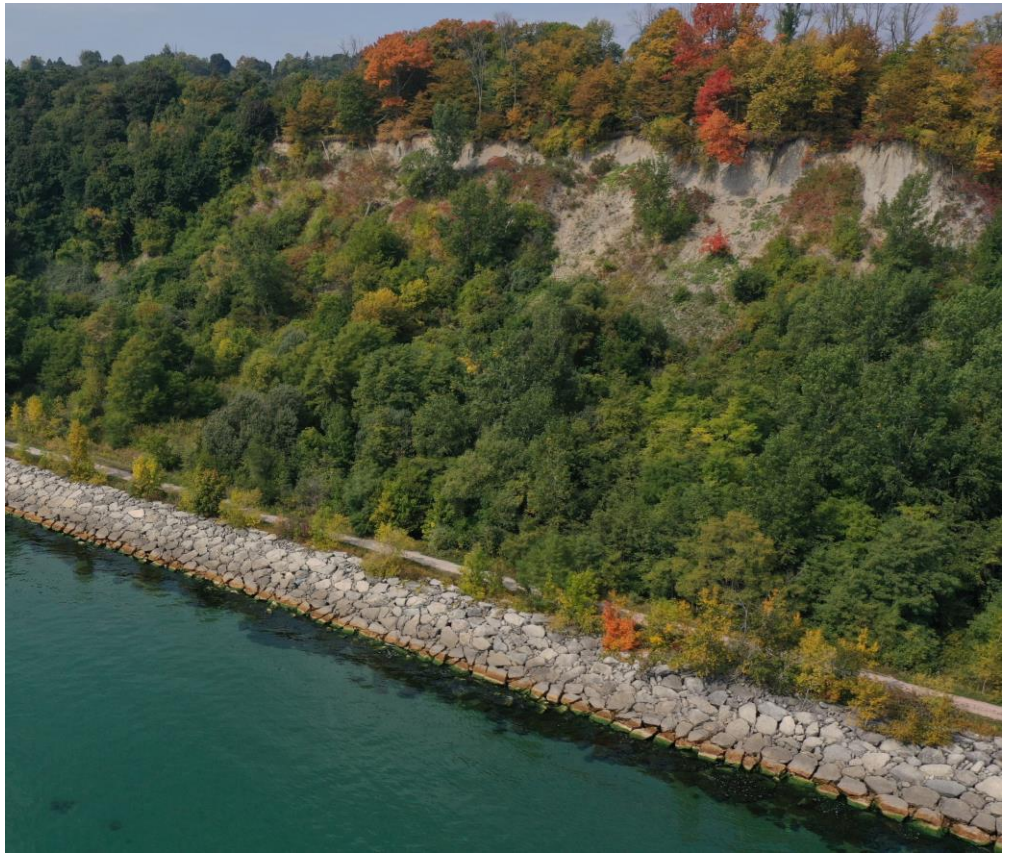
FIH: Research Opportunities

- Optimization of dam gate operations at G. Ross Lord Dam. Currently gate operations are optimized for large, hurricane type events. This is too conservative for short-duration, thunderstorm events and does not allow TRCA to make use of reservoir storage. Extensive meteorological and hydraulic analysis is required to change operating rules.

- Risk Analysis for Dam Safety = Probalistic vs. Deterministic criteria for dam safety. Risk analysis will be the next big push in dam safety as it allows dam owners to target deficiencies. Research and expertise is required to be able to quantify probability for failure modes to occur in dams.

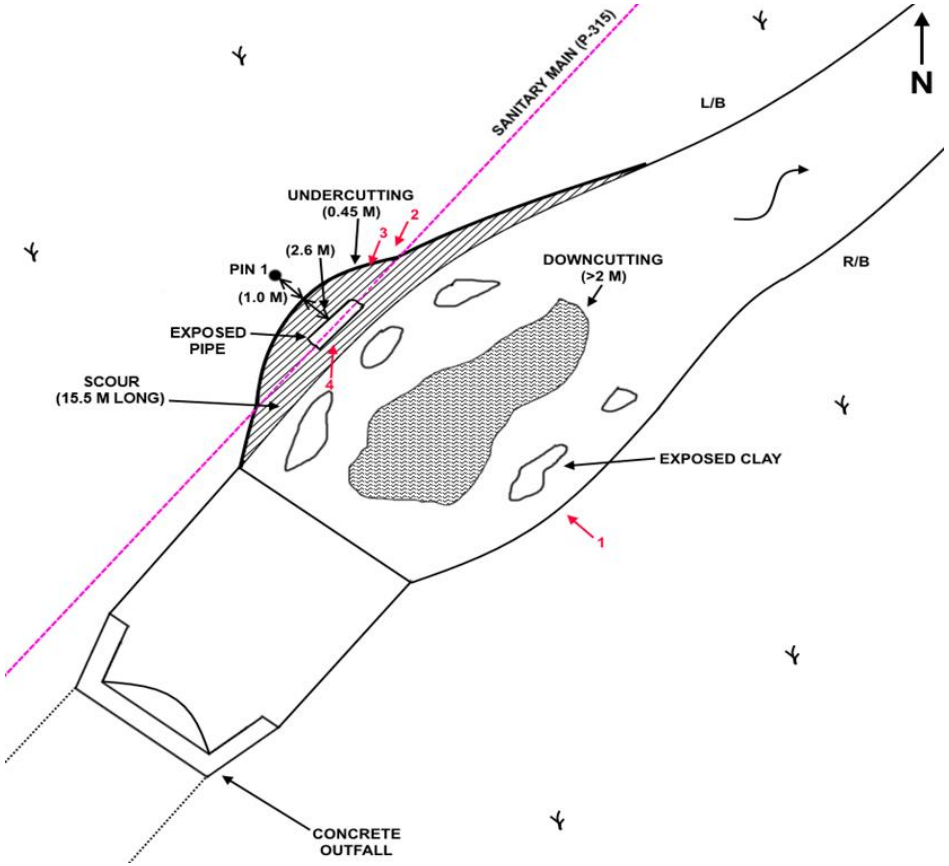
Erosion Risk Management (ERM)

- Support the CA mandate of natural hazard management through assessing erosion hazards and inspecting TRCA's extensive network of existing erosion control structures (700+ structure)
- Programming varies depending on funding received from TRCA's municipal partners and can be tailored to align with other asset management goals.
- Region of York, Region of Peel, and Toronto Water all work with TRCA to assess risk to their linear assets from erosion through comprehensive annual inspection programs.
- Key challenge – increased erosion with more frequent high-intensity storm events stressing infrastructure.



ERM: Stream, Erosion and Infrastructure Database (SEID) rebuild and digital twinning

- ERM staff are in discussion with Dr. Tamer El-Diraby to rebuild our existing database that houses information related to erosion hazards and erosion control structures
- Goal of rebuild will be to modernize database to include elements such as machine learning to identify key features from photos
- Longer term research tied to this project will focus on asset management and digital twinning of the dataset to improve accessibility to data
- TRCA ERM staff are meeting with the U of T team to refine the scope of work and develop a plan to progress this project



ERM: Research Opportunities

- Quantifying the return of investment that considers infrastructure, social, environmental, and other criteria for erosion control works to help justify infrastructure investments

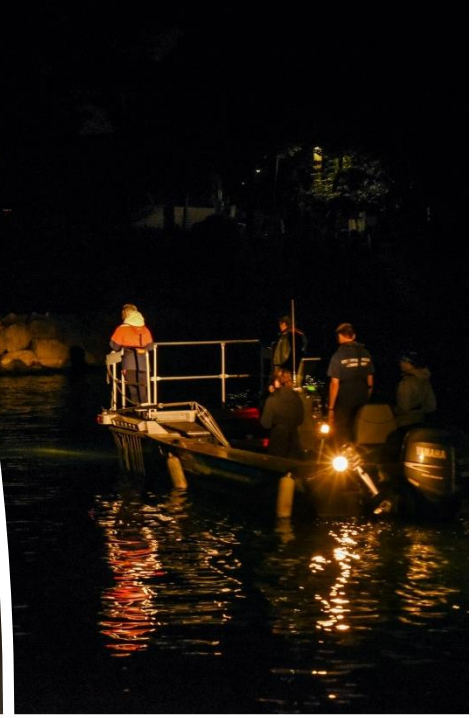
- Improving resiliency of erosion control structures to prepare for intense events that are anticipated. This could also tie in to commentary on effectiveness of current or historic techniques to help inform asset owners.

Aquatic Monitoring & Management

- Our project managers, scientists, biologists, technicians, and other field staff lead and deliver multiple monitoring programs including:
  - Regional Watershed Monitoring Program
  - Waterfront Monitoring Program
  - Surface Water Quality Monitoring/Steams and Lake Ontario
  - Groundwater Well Monitoring
  - Natural Channel Design Monitoring Program
  - Various pre / post construction and compliance monitoring programs for specific projects and land use planning initiatives
  - Countless monitoring projects related to restoration, engineering projects, and R and I initiatives
  - Support the Watershed Planning Corporate initiative

AMM Field Services

- Fish Community sampling
  - Electrofishing
    - Boat & backpack
    - Day & night / lake & stream
  - Various nets & traps
- Benthic Invertebrate sampling
  - Benthic sampling & identification
  - Mosquito larvae rearing
- Water quality
  - Stream & lake & Ground water
  - Grab samples / Automated sampling
- Sediment sampling
- Head water Drainage Feature evaluation
- Water temperature & level monitoring
- Stream Geomorphology monitoring



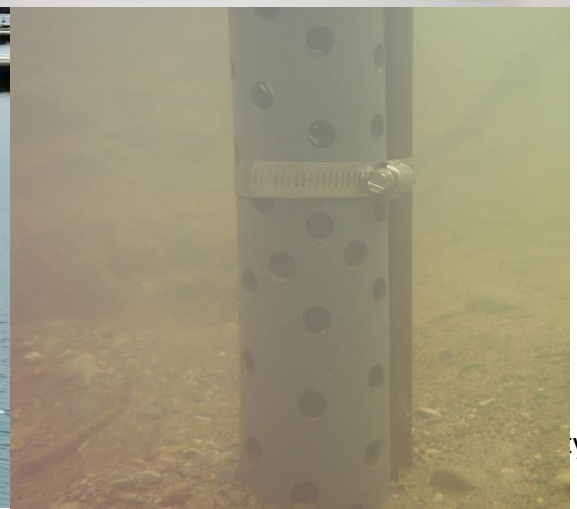
Services

Monitoring plan development	Short & long-term monitoring Temporal & spatial monitoring Study design advice and implementation
Pre and post construction/restoration monitoring	Baseline data Fish “rescues” Temporal trends
Fisheries Act Authorizations	Application & negotiation Compliance monitoring Permitting
Aquatic ecology advice	Restoration planning Statistical analysis
Data Management	Report writing Trend analysis Data QA/QC and hub center

AMM Research and Partner Initiatives

- Acoustic Telemetry Study –DFO, Carleton University, U of T
- Asian Carp Surveillance – DFO
- Sea Lamprey Control Program – DFO
- NSCIN trap net program- MNRF
- Toronto Waterfront Aquatic Habitat Restoration Strategy Update –DFO, Environment Canada, RAP
- Toronto Remedial Action Plan –RAP
- Canada Goose Management – R&I,

Specialized Equipment



TRCA Teams & Contacts

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4. Hydrogeology & Source Water Protection (don.ford@trca.ca)
5. Restoration and Resource Management (john.stille@trca.ca)
6. Hydrometrics (calvin.hitch@trca.ca)
7. Flood Infrastructure (craig.mitchell@trca.ca)
8. Erosion Risk Management (matthew.johnston@trca.ca)
9. Aquatic Monitoring & Management (rick.portiss@trca.ca)

Thanks for your time!

Toronto and Region Conservation Authority