THE THAMES RIVER (*DESHKAN ZIIBI*) SHARED WATERS APPROACH TO WATER QUALITY AND QUANTITY

ThamesRiver CLEAR WATER REVIVAL

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Note: The Thames River Clear Water Revival Steering Committee partners have agreed that this document will be designated as a FINAL DRAFT until all the Steering Committee partners have the opportunity to endorse the Approach. The signed endorsement of partners that have recommended the Approach be adopted, and agree to continue to collaborate to voluntarily implement solutions to water issues in the Thames River watershed, may be found in Appendix I.

Note: Throughout this document, glossary terms are presented in ***bold italics***.

COMMEMORATION to GEORGE HENRY-BA, LARRY FRENCH-BA, and JAKE ALBERT-BA

Note: “-Ba” is the Ojibwe equivalent to “the late” in English.

Nminaaj'aa maaba Mangidaas, George Henry-ba, ma'iingan dodeman miinwaa Larry French-ba, jijaak dodeman, gaa-getnaamendamowaad ji-naadmowaawaad niw Anishnaaben Deshkan Ziibiing. Gii-dbaajdaanaawaa Anishinaabe'aadziwin maa nankiiwaad Steering and First Nations Engagement Committees. Gzhe-mnidoo miinwaa ki gii-mnaaj'aanaawaa gaa-gnoodmawaawaad iw nbiish. Neniizh da-mesnigaazawag.

We would like to honour the unwavering effort made by George Henry-ba, Wolf Clan, and Larry French-ba, Crane Clan, both of Deshkan Ziibing, to bring forth the concerns of their community regarding the health of Deshkan Ziibi. They generously shared their Indigenous worldview through their participation in the Steering and First Nations Engagement Committees. They honoured the Creator and Mother Earth by speaking up for the river. They will both be missed.

Ndamkwenmaanaa Jake Albert-ba, Kiinowaachegehjig miigiisiik-ba (Many Eagles Man that leave their mark), Ma'iingan doodeman, Deshkan Ziibiing bi-njibaa. Gii-baapi, gii-minwaangozi, gii-gzhewaadzi, miinwaa gii-kendaasa. Antler River Guardian from the 4 Directions (ARGFT4D) eshki-kinoomaagozid, gii-zaagtoon eyaad gojiing ji-kinoomaagzid kiing. Gii-bi-niigaaniid oodi eni-bboong. Gii-wiindmowaan eshkiniiginjin gaa-dbaajdang gaa-zhiwebak ARGFT4D miinwaa ge ezhi-gnawendang nbiish.

Eshki-maajtaad ARGFT4D, gii-nkweshkwaawaan raptors, Canadian Raptor Conservatory enjibaajig. Ow migizi, Rocco zhinkaaza. Miinwaa ge chi-mzise, Jake zhinkaaza. Naasaab noozwinan eyaamwaad, ow mzise, emaamo-mdaazhenmaad ow bneshiinh. Gii-zaagtoon ow chi-mzise ezhinaagzid. Miinwaa ge epiichi-gchi-piitendaagzid ezhi-bmaadzing. Wenjda go gii-zaagtoon wii-wiisinid. Gii-miijin shkonjiganan gii-bwaa-miijiwaad Antler River Guardians. Bmakzhiwed, gnawaabmaad, gii-noondaagzi "Hey niitaawis! Aaniish ezhinaagok oodi yaayin shpiming?!" Chi-mzisens gii-zhinkaanigoon, emaamo-shkiniigid aawi ARGFT4D biiweziimag. Eniigaaniid chi-mzise aawi eni-niibing. Mii dash Chi-zaawi-mzise gii-zhinkaanigoon oodi North American Indigenous Games (NAIG). Gegeti niigaaniiwi, chi-maamiikwendam. Gii-maajii-noondaagzi oodi NAIG wii-chi-maamiikwendamwaad oodi chi-nsaaknigewaad. Aapji go mdaazhendaan bmakzhiwed, miinwaa yaad nbiing. Wenpanad gii-yaad NAIG Team Ontario Canoe/Kayak team. Niibing enakiid oodi Aboriginal Sport and Wellness Council of Ontario ge Special Olympics Ontario, gii-zoongde'ed wii-wiindmowaad ezhi-znagendang nendmowining eshkiniiginjin. Miinwaa ge, gii-naadmowaan ebkaanzinjin wii-mno-nendmowaad gewiinwaa. Wenjda go zoongde'e miinwaa ge gii-nbwaakaa. Gii-zaag'aan biiweziimag miinwaa wiijkiwenyan. Kina wiya gaa-kenmaawaad Jake da-mna-dbaajmaawaad. Gaagnig pane da-mesnigoon. Chi-miigwech Jake-ba!

We would like to commemorate Jake Albert-ba, Kiinowaachegehjig miigiisiik-ba (Many Eagles Man that leave their mark), Wolf clan, of Chippewas of the Thames First Nation. He was funny, adventurous, kind and smart. He was an Antler River Guardian from the 4 Directions (ARGFT4D) student in the first year of the program. His love and passion for the outdoors and learning from the land was always apparent. He went on to be Team Leader for the program the following year. He presented to youth groups his own age and many other audiences on ARGFT4D experiences and water stewardship.

During the first year of ARGFT4D, the group met some raptors from the Canadian Raptor Conservatory. The bald eagle was named Rocco, and the turkey vulture was named Jake. As they shared the same name, Jake said the turkey vulture was his favourite bird. He loved how the vulture looked and how it was so important for the circle of life. As a growing man, he loved to eat and would eat the other Antler River Guardians' left overs if they weren't going to eat them. When canoeing on the river, he would see a turkey vulture in the sky and yell out "Hey Cousin! How's it look from up there?!" His nickname started out as Baby Vulture, as he was the youngest in the ARGFT4D family; he went on to be Leader Vulture the next year when he was the team leader, and then Golden Vulture when at the North American Indigenous Games (NAIG). Jake was a natural born leader, loud and proud; he started a cheering circle at the NAIG to get Team Ontario pumped up at the opening ceremonies! He was passionate about canoeing and loved being on the water. He made the NAIG Team Ontario Canoe/Kayak team with ease. As a summer student working for the Aboriginal Sport and Wellness Council of Ontario and Special Olympics Ontario, he bravely shared his struggles with mental health with other youth, as well as helped others with mental health issues. He was a very courageous and selfless young man. He loved his family and friends with all of his heart and was very loyal. Everyone who knew Jake has their own stories and memories to share. He will be forever missed. Chi-Miigwech Jake-ba!

ACKNOWLEDGEMENTS

THAMES RIVER CLEAR WATER REVIVAL STEERING COMMITTEE

First Nations

Four of the eight First Nations whose traditional territory overlaps the watershed have actively participated on the Steering Committee:

- Aamjiwnaang First Nation
- Bkejwanong Walpole Island First Nation
- Caldwell First Nation
- Chippewas of the Thames First Nation

The Chippewas of Kettle and Stony Point First Nation and Munsee Delaware Nation have been invited to participate, while Eelünaapéewi Lahkéewiit (Delaware Nation at Moraviantown) and Oneida Nation of the Thames participated in the early development of the TRCWR.

Federal Departments

- Environment and Climate Change Canada

Provincial Ministries

- Ontario Ministry of Agriculture, Food and Rural Affairs
- Ontario Ministry of the Environment, Conservation and Parks
- Ontario Ministry of Natural Resources and Forestry

Conservation Authorities

- Lower Thames Valley Conservation Authority
- Upper Thames River Conservation Authority

Municipalities

- City of London

FIRST NATIONS ENGAGEMENT COMMITTEE

- Aamjiwnaang First Nation
- Bkejwanong Walpole Island First Nation
- Caldwell First Nation
- Chippewas of the Thames First Nation
- Oneida Nation of the Thames

The Steering Committee would like to thank the participants in the First Nation Engagement Committee, the Water Quality Technical Committee, and the Water Quantity Technical Committee for their valuable input into this document.

PREAMBLE

While this undertaking was originally envisioned as a water management plan, our First Nations partners championed a more holistic approach, incorporating aspects of ***Indigenous Traditional Knowledge (ITK)*** and an awareness of the River's spirit, in addition to western science and management objectives. This intent is reflected in the title of this document: *The Thames River (Deshkan Ziibi) Shared Waters Approach to Water Quality and Quantity*. This document is one component of an over-arching ***watershed*** initiative called the "Thames River Clear Water Revival."

The following is what we understand to be a very general overview of the First Nations in the watershed, but is not necessarily comprehensive or definitive. The Anishinaabek People (Aamjiwnaang First Nation, Bkejwanong Walpole Island First Nation, Chippewas of the Thames First Nation, Chippewas of Kettle and Stony Point First Nation, and Caldwell First Nation), the Haudensaunee (Oneida Nation of the Thames), and the Wendat (Huron) have lived in the area since before Europeans arrived. Delaware Nation at Moraviantown, which is the settlement of the Lenape (Lunaapeew) People, was founded in 1792. A survey of the Caradoc Reserve in 1830 notes that approximately 160 Munsee-Delawares, another Lenape People, were living north of the Thames River.

The Anishinaabek People refer to the Thames River as *Deshkan Ziibi* (which means Antler River in Ojibwe / Anishnaabemowin language). The river has also been called *Askunessippi* (Antlered River) by the Neutrals and *La Tranchée* (later *La Tranche*, which means the Trench) by early French explorers, settlers and fur traders. In 1793, Lieutenant Governor John Graves Simcoe named the river the *Thames River* after the River Thames in England.

First Nations have a strong cultural and spiritual connection to water (Swain, Louttit and Hrudey 2006). With this relationship come responsibilities that are described in the Ontario Chiefs First Nations Water Declaration (Chiefs of Ontario 2008), which was written to support First Nation communities in dealing with the water challenges they face. The Water Declaration (Section 1.1.2.1) is a tool that can assist all peoples in protecting the waters from contamination. Participating in the Thames River Clear Water Revival is an example of how First Nations whose traditional territory overlaps the Thames River ***watershed*** are fulfilling their responsibility. The inclusion of the First Nation perspective and input is appropriate, timely and long overdue.

The Thames River Clear Water Revival Steering Committee partners have agreed that this document will be designated as a FINAL DRAFT until all the Steering Committee partners have the opportunity to endorse the Approach. The signed endorsement of partners that have recommended the Approach be adopted, and agree to continue to collaborate to voluntarily implement solutions to water issues in the Thames River watershed, may be found in Appendix I.

Note: Throughout this document, glossary terms are presented in ***bold italics***.

EXECUTIVE SUMMARY

The Thames River drains southwestern Ontario's second largest ***watershed***, an area of 5,825 km^2 (Map 1). The Thames River ***watershed*** is the largest riverine ***watershed*** in the Lake St. Clair drainage basin, and comprises approximately 25% of the Canadian Lake Erie basin. As a result, the Thames has the potential to significantly impact conditions downstream in Lake St. Clair and contributes to ***phosphorus loads*** in Lake Erie.

The Thames River is situated in a highly developed and highly agricultural area of southern Ontario. The water and forests in this region face on-going pressure from urban and rural land uses. The Thames River's rich cultural heritage and diverse recreational opportunities formed the basis for its designation to the Canadian Heritage Rivers System in 2000 (http://chrs.ca/the-rivers/thames/). Despite these pressures, the Thames remains one of the most biologically diverse rivers in Canada (Cudmore, MacKinnon and Madzia 2004). Continued vigilance in protecting the Thames ***watershed*** is vital. Most recently, the ***watershed*** has received attention for its role in impacting the health of the Great Lakes. Provincial and federal initiatives have identified the Thames River as a priority ***watershed*** to reduce ***phosphorus loads***, in order to reduce nearshore ***cyanobacteria blooms*** in Lake St. Clair. Local impacts to the Thames River ***ecosystem*** due to excess ***phosphorus*** and algae in the ***watershed*** also make enhanced actions to reduce ***phosphorus*** a current priority.

In Ontario, the responsibility for protecting surface water and ***groundwater*** from contamination is shared by numerous First Nations, Métis and Inuit, federal, provincial and municipal governments, and local agencies. There are also various naturalist groups, recreational associations, community groups, and concerned individuals focused on activities related to the Thames River. While many individual efforts may currently protect aspects of the Thames River ***watershed***, identifying and resolving water issues requires a collaborative approach that recognizes the complexity and inter-relatedness of ***hydrological*** and ecological processes at the ***watershed*** level.

It has been more than 40 years since a comprehensive water quality and quantity plan was prepared for the Thames River. *The Thames River (Deshkan Ziibi) Shared Waters Approach to Water Quality and Quantity* is a 20 year plan that balances protection and restoration of the Thames ***watershed***, while supporting economic and urban development through broad and strategic guidance for water quality and quantity. The challenge is to maintain the integrity of aquatic and terrestrial ***ecosystems*** while meeting human needs.

The inclusion of the First Nation perspective and input is appropriate, timely and long overdue. First Nations have a strong cultural and spiritual connection to water. With this relationship come responsibilities. Participating in the *Shared Waters Approach* is an example of how First Nations whose traditional territory overlaps the Thames River ***watershed*** are fulfilling their responsibility.

The *Shared Waters Approach* provides a context to unite and strengthen individual efforts for the benefit of the river. Ultimately, the *Shared Waters Approach* will translate into benefits including improved water quality, greater resilience from the effects of climate change, and enhanced recreational opportunities.

Technical studies in flood forecasting, water quality monitoring and analysis, urban ***Low Impact Development (LID)***, and rural ***Best Management Practices (BMPs)*** provided some updated background information. This information, combined with an understanding of the ***watershed's*** physical characteristics, current land uses, the state of local water and land resources, and existing water protection policies and programs, helped to identify critical issues in the ***watershed*** such as drought, flooding, poor water quality, climate change impacts, and rapid urbanization.

Three subcommittees were tasked with developing mission, goals and recommendations for the *Shared Waters Approach:*

1. The First Nations Engagement Committee developed a mission statement, three goals to achieve that mission, and recommendations to reach each goal.

   First Nations Mission Statement: That the importance of ***Indigenous Traditional Knowledge (ITK)*** in resolving environmental issues is recognized and included in decision-making around water protection.

   - Goal 1: Formalize a process where the spirit of the water is recognized
   - Goal 2: Improve involvement of First Nation communities
   - Goal 3: Improve awareness of First Nation communities

2. The Water Quality Technical Committee developed a mission statement and three goals to achieve that mission. Each Shared Waters Approach (SWA) partner then developed their own specific recommendations to meet each goal. Each partner's recommendations for each goal were then grouped into three areas: research and monitoring, stewardship and outreach, and acts, policies and regulations.

   Water Quality Technical Committee Mission Statement: To protect and improve water quality in the Thames River ***watershed*** in order to improve stream health and the potential impact of the Thames River on Lake St. Clair and Lake Erie.

   - Goal 1: Reduce total and ***soluble reactive phosphorus loads*** from the Thames River and reduce overall ***phosphorus concentrations*** in the river and its tributaries.
   - Goal 2: Reduce soil erosion from land and maintain geomorphic processes across the ***watershed***.
   - Goal 3: Improve water quality to support improved stream health, including aquatic life.

3. The Water Quantity Technical Committee developed a mission statement and four goals to achieve that mission. The committee then developed common recommendations and proposed actions to meet each goal.

   Water Quantity Mission Statement: To encourage a flow regime that provides sustainable ***environmental flow (eflow)*** while reducing flood risk.

   - Goal 1: Understand, develop and recommend ***environmental flow (eflow)*** needs in the Thames River ***watershed***
   - Goal 2: Improve understanding and mitigation of hazards associated with flooding and extreme flows in the Thames River ***watershed***
   - Goal 3: Research and recommend mechanisms to achieve acceptable ***eflow*** while reducing flood and drought risks
   - Goal 4: Expand water quantity monitoring to improve understanding of ***eflow*** needs, flood and drought risk, and climate change

Going forward, action and implementation plans will require resources (both funding and staff) as well as discussions with numerous groups in the ***watershed*** including, but not limited to, ***Indigenous*** peoples, municipalities and the agricultural community. Opportunities and barriers to implementation need to be identified in order to encourage action and change behaviour. After every five years of implementation, data will be gathered to reassess the conditions and characteristics of the ***watershed*** and identify changes. The Shared Waters Approach will be reviewed to determine what is working and what is not working, as well as current trends. Recommendations will be reviewed and appropriate changes will be implemented. It is anticipated that updates of the Shared Waters Approach will consider any major changes to the actions outlined in the Canada-Ontario Lake Erie Action Plan (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018).

The Thames River Clear Water Revival Steering Committee partners have agreed that this document will be designated as a FINAL DRAFT until all the Steering Committee partners have the opportunity to endorse the Approach. The signed endorsement of partners that have recommended the Approach be adopted, and agree to continue to collaborate to voluntarily implement solutions to water issues in the Thames River watershed, may be found in Appendix I.

Map 1. Thames River *watershed* showing First Nations, municipalities and conservation authorities

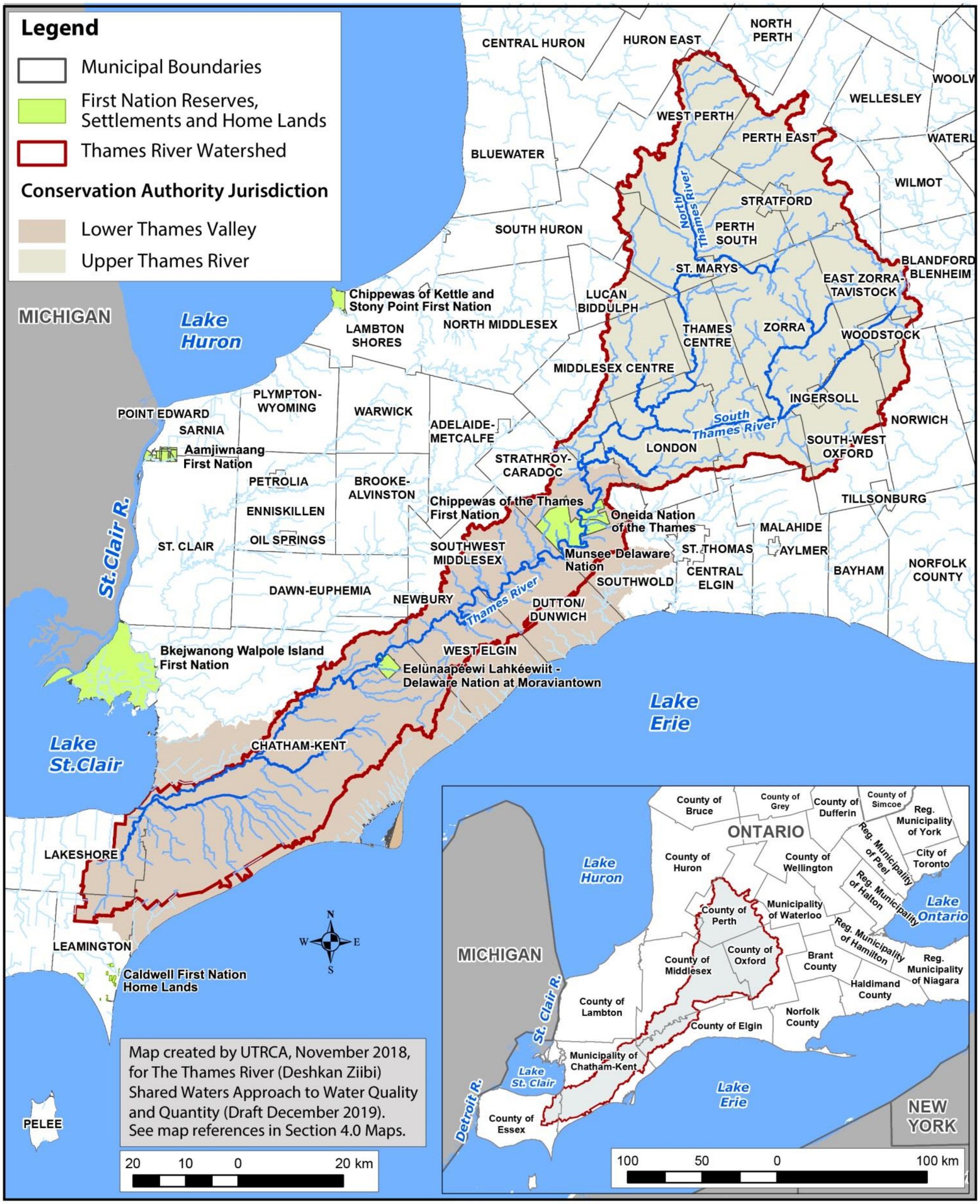


TABLE OF CONTENTS

COMMEMORATION to GEORGE HENRY-BA, LARRY FRENCH-BA, and JAKE ALBERT-BA ii

ACKNOWLEDGEMENTS iv

PREAMBLE v

EXECUTIVE SUMMARY vi

TABLE OF CONTENTS x

LIST OF FIGURES & TABLES xii

LIST OF MAPS xii

1.0 RATIONALE FOR AN UPDATED APPROACH TO WATER QUALITY AND QUANTITY 1

1.1 PERSPECTIVES TOWARD WATER 2

1.1.1 Global Perspective 2

1.1.2 First Nations Perspective 3

1.1.2.1 First Nations Water Declaration In Ontario 3

1.1.2.2 First Nations Traditional Teachings and Understandings 5

1.1.3 Canadian Perspective 7

1.1.3.1 Great Lakes Perspective 8

1.1.4 Local (Thames *Watershed*) Perspectives 10

1.1.4.1 Local First Nations Perspectives 10

1.1.4.2 Rural Perspective 12

1.1.4.3 Urban Perspective 12

2.0 *WATERSHED* STRATEGY FOR THE THAMES RIVER 14

2.1 THE COLLABORATIVE PROCESS 14

2.1.1 Membership of the TRCWR 16

2.1.1.1 First Nations 16

2.1.1.2 Federal Government 16

2.1.1.3 Ontario Government 16

2.1.1.4 Conservation Authorities 16

2.1.1.5 Municipalities 16

2.1.2 Committee Structure 16

2.2 COMMUNICATIONS AND ENGAGEMENT 17

2.2.1 First Nation Engagement 17

2.2.2 *Watershed* Stakeholder & *Indigenous* Engagement 18

2.3 *INDIGENOUS* TRADITIONAL KNOWLEDGE AND WESTERN SCIENTIFIC KNOWLEDGE 18
2.4 CLIMATE CONSIDERATIONS 19
2.5 GEOMORPHOLOGY OF THE THAMES RIVER 20
2.5.1 Channel Patterns 22
2.5.2 Discharge Volume 23
2.5.3 Erosional and Depositional Features 23
2.5.3.1 Thames River Mouth at Lake St. Clair 24
3.0 THE THAMES RIVER SHARED WATERS APPROACH TO WATER QUALITY AND QUANTITY 26
3.1 FIRST NATIONS MISSION, GOALS & RECOMMENDATIONS 28
3.1.1 Goal 1: Formalize a process where the spirit of water is recognized 29
3.1.2 Goal 2: Improve involvement of First Nation communities 30
3.1.3 Goal 3: Improve awareness of First Nation communities 30
3.2 WATER QUALITY MISSION, GOALS & RECOMMENDATIONS 31
3.2.1 Goal 1: Reduce total and *soluble reactive phosphorus loads* from the Thames River and reduce overall *phosphorus concentrations* in the river and its tributaries 32
3.2.1.1 Research & Monitoring Recommendations 32
3.2.1.2 Stewardship & Outreach Recommendations 36
3.2.1.3 Acts, Policies & Regulations Recommendations 41
3.2.2 Goal 2: Reduce soil erosion from land and maintain geomorphic processes across the *watershed* 44
3.2.2.1 Research & Monitoring Recommendations 44
3.2.2.2 Stewardship & Outreach Recommendations 47
3.2.2.3 Acts, Policies & Regulations Recommendations 50
3.2.3 Goal 3: Improve water quality to support stream health, including aquatic life 52
3.2.3.1 Research & Monitoring Recommendations 52
3.2.3.2 Stewardship & Outreach Recommendations 56
3.2.3.3 Acts, Policies & Regulations Recommendations 61
3.3 WATER QUANTITY MISSION, GOALS & RECOMMENDATIONS 64
3.3.1 Goal 1: Understand, develop and recommend *environmental flow* (*eflow*) needs in the Thames River *watershed* 65
3.3.2 Goal 2: Improve understanding and mitigation of hazards associated with flooding and extreme flows in the Thames River *watershed* 69

3.3.3 Goal 3: Research and recommend mechanisms to achieve acceptable *eflow* while reducing flood and drought risks ... 74

3.3.4 Goal 4: Expand water quantity monitoring to improve understanding of *eflow* needs, flood and drought risk, and climate change ... 78

4.0 MAPS ... 83

MAP REFERENCES ... 93

REFERENCES ... 95

GLOSSARY ... 105

APPENDICES ... 118

LIST OF FIGURES & TABLES

Figure 1. Diagram representing the relationship between the Thames River *watershed* initiatives and approaches to the natural environment ... 15

Figure 2. Profile of the Thames River ... 21

Table 1. Discharge, drainage areas and lowest average summer monthly flows of four largest river systems in southwestern Ontario, measured at most downstream hydrometric station. 23

LIST OF MAPS

Map 1. Thames River *watershed* showing First Nations, municipalities and conservation authorities ... ix

Map 1. Thames River *watershed* showing First Nations, municipalities and conservation authorities ... 84

Map 2. Thames River *watershed* showing First Nations reserves, settlements and home lands ... 85

Map 3. Thames River *watershed* within the Lake Erie drainage basin ... 86

Map 4. Canadian tributary annual loadings of *total phosphorus* by *watershed*, where the numbers at the mouths indicate 2003-2013 mean total *phosphorus loads* in metric tonnes per year ... 87

Map 5. Thames River *watershed* long-term monitoring locations ... 88

Map 6. Surface water and *groundwater* quality monitoring sites ... 89

Map 7. Aquatic (benthic and fish) monitoring sites ... 90

Map 8. Flow and *groundwater* monitoring stations ... 91

Map 9. Flood control structures, other dams or barriers, and pumps ... 92

LIST OF APPENDICES

Appendix A. Summary of 1975 Thames River Basin Management Study (Ministries of the Environment and Natural Resources 1975): Recommendations and Progress Summary

Appendix B. Supporting Rationale for First Nations Recommendations

Appendix C. Supporting Rationale for Water Quality Recommendations

Appendix D. Supporting Rationale for Water Quantity Recommendations

Appendix E. First Nation Engagement Strategy for the Thames River Clear Water Revival

Appendix E1. Profiles of First Nations

Appendix F. First Nations Connection to Water

Appendix G. Partner Responsibilities

Appendix H. Climate Change Projections

Appendix I. TRCWR Partner Endorsements

1.0 RATIONALE FOR AN UPDATED APPROACH TO WATER QUALITY AND QUANTITY

The Thames River ***watershed*** (Map 1) includes five First Nations and 25 municipalities (all or parts thereof). There are two conservation authorities in the ***watershed***: the Upper Thames River Conservation Authority (UTRCA) and the Lower Thames Valley Conservation Authority (LTVCA). The LTVCA jurisdiction also includes land that drains directly into Lake Erie or Lake St. Clair.

The most recent water quantity and quality plan for the Thames River was prepared more than 40 years ago, as part of the 1975 *Thames River Basin Management Study* by the Ministry of the Environment and the Ministry of Natural Resources. The 1975 study was initiated due to growing concern over problems in the ***watershed*** related to water quality, flooding, erosion, population growth and development. The study was based on an assessment of the availability and quality of surface water and ***groundwater***, an inventory of water uses and related land uses, and an evaluation of existing and potential water resource problems in the basin. Appendix A provides a summary of the recommendations from the 1975 *Thames River Basin Management Study*.

Although many groups have been involved in monitoring and reporting on the state of Thames River ***watershed*** resources since then, a comprehensive plan has not been developed for some time.

There are several reasons why an updated approach is needed for the Thames River:

- There is a shared responsibility for water.
- Appreciation for ***Indigenous Traditional Knowledge (ITK)*** of First Nation communities within the ***watershed*** was not incorporated in past water quality and quantity studies of the Thames River.
- There is a commitment from all levels of government to work with ***Indigenous*** partners to address the legacies of colonialism, such as residential schools, as well as close gaps and remove barriers, support ***Indigenous*** culture and reconcile relationships with ***Indigenous*** peoples, which would lead to meaningful partnerships.
- Competing demands on, and inputs to, the Thames River have changed over time (e.g., increased pressure from urbanization) and baseline information on the health of the river in the 1975 study is outdated.
- Social and environmental considerations have changed. In 1975, engineered structures such as dams were thought to improve the environment through flood control, hydropower generation and recreation. Now, the potential adverse impacts of dams are well documented and dam removal projects are gaining popularity.
- Information from recent climate change studies needs to be incorporated into water quantity resource decisions and, in particular, models of flood and low water events, to avoid or mitigate challenges caused by these extreme flow regimes.

- Improved ***wastewater treatment*** and technology have reduced ***phosphorus loadings*** since the mid-1970s, despite increases in population (O'Sullivan and Reynolds 2006).
- Urban and agricultural ***Best Management Practices (BMPs)*** have evolved with improved technology and increased experience.
- Site specific water quality studies have been completed throughout the ***watershed*** since 1975. Many of these studies point to the need for ***phosphorus*** reduction as this nutrient is having a major impact on the Thames River and downstream into Lake St. Clair and the western basin of Lake Erie.
- An increased focus on the health of the Great Lakes has identified the Thames River as a local, provincial, national, and binational priority tributary. This focus includes commitments respecting Lake Erie and/or the Thames River under:
    - *Thames River Clear Water Revival;*
    - 2012 Canada – U.S. *Great Lakes Water Quality Agreement (GLWQA)*, and the associated *Binational Nutrient Management Strategy*; Canada-Ontario Agreement on *Great Lakes Water Quality and Ecosystem Health 2014* (COA);
    - Ontario's *Great Lakes Protection Act* (GLPA);
    - *Canada-Ontario Lake Erie Action Plan* 2018;
    - Ontario's *Great Lakes Strategy;*
    - *Lake Erie Lakewide Action and Management Plan (LAMP);*
    - *Western Basin of Lake Erie Collaborative Agreement*; and
    - Great Lakes Commission's Joint *Action Plan for Lake Erie.*

The *Thames River Shared Waters Approach to Water Quality and Quantity* will be a key component of a broader ***Watershed*** Strategy, known as the Thames River Clear Water Revival (TRCWR), which considers all interactions of the land, water, plants, animals and people with the overall objective of improving the ecological condition of the Thames River. Improvements to the Thames River, by direct connection, will assist in improving water quality in the receiving water bodies of Lake St. Clair and Lake Erie.

The *Shared Waters Approach* (SWA) is a 20 year plan that provides broad and strategic guidance for water quality and quantity. The tables in Section 3 of the SWA outline the mission, goals and recommendations/proposed activities that have been developed for First Nations ***Indigenous Traditional Knowledge***, Water Quality and Water Quantity. Appendices B, C and D provide supporting rationale for this information.

The next step will be to conduct outreach and engagement to develop a prioritized work plan, with allocated budget and resources.

1.1 PERSPECTIVES TOWARD WATER

1.1.1 Global Perspective

Population growth, increased urbanization, and the impacts of climate change on water availability are all increasing the pressure on existing drinking water resources (World Health

Organization 2017). Between 2014 and 2050, the world population is expected to increase by 33% from 7.2 billion to 9.6 billion (United Nations Department of Economic and Social Affairs [UNDESA] 2014). During this period, urban populations are projected to grow by 61% from 3.9 billion to 6.3 billion (UNDESA 2014).

The relative scarcity of fresh water around the world leaves many nations susceptible to water stress. According to the World Water Council (http://www.worldwatercouncil.org/library/archives/water-supply-sanitation/), approximately 1.1 billion people worldwide do not have access to safe drinking water. Although 70% of the Earth is covered by water, less than 3% of the Earth's water is fresh, and most of what constitutes fresh water is locked in glacial ice or occurs as ***groundwater***. Furthermore, selected sources of fresh water are often too remote, meaning that less than 1% is available for human use (Cairns 2007). Compounding this issue is global climate change, which contributes to droughts, storms and flooding, and affects water quality and quantity in ways we are only starting to understand (World Water Assessment Programme 2009; Intergovernmental Panel on Climate Change [IPCC] 2014; United Nations Educational, Scientific, and Cultural Organization [UNESCO] 2017).

Access to clean water has been identified as the most serious environmental challenge facing the planet, having a greater influence on quality of life than air pollution, species extinction, depletion of natural resources, loss of habitat, and climate change (Corpuz 2006; Goldtooth 2006; UNESCO 2003). Therefore, the protection and stewardship of global water resources are of paramount concern.

1.1.2 First Nations Perspective

First Nations recognize that water is an integral part of life. It is seen as an entity that needs respect and safeguarding.

1.1.2.1 First Nations Water Declaration In Ontario

The Water Declaration of the Anishinaabek, Mushkegowuk and Onkwehonwe (Chiefs of Ontario 2008) speaks to the relationship of First Nation peoples to the waters, the condition of the waters, water rights and treaties, and self-determination. The Chiefs of Ontario water declaration poster, titled "*First Nations Water Declaration In Ontario"* summarizes the 2008 Ontario Chiefs First Nations Water Declaration.

First Nations Water Declaration In Ontario

The First Peoples (First Nations) of this land were / are placed here on Turtle Island otherwise known as North America by the Creator;
First Nations have responsibilities to their own territories that include lands and waters;
As First Nations, the Creator gave us a specific way of life, which included teachings on how to care for our mother the Earth;

Water is the life giving gift that our mother the Earth provides for all of us and it is through the relationship that women have with our Mother Earth that they are the keepers of the special ceremonies needed to ensure waters are respected and that future generations will continue to experience this gift.

The ***Indigenous*** peoples of Turtle Island have kept alive the ceremonies given to our ancestors by the Creator, which are passed down through time in order for us to continue the way of life the Creator had intended us to and;
We need to respect, honor and share the spirits of the waters in the ceremonies given to us by the Creator;
First Nations have a direct relationship with all waters including the rain waters, waterfalls, mountain springs, swamp springs, bedrock water veins, rivers, creeks, lakes, oceans, icebergs and the seas – to ensure that the waters provide for all living things on a daily basis;
First Nations in Ontario have the laws and the protocols to ensure clean waters for all living things;
First Nations have knowledge, laws and our own ways to teach our children about our relationship to waters;
First Nations in Ontario made treaties with the non-***indigenous*** people based on the continuation of all life and;
First Nations in Ontario's treaty making with the Crown created a relationship of rights for all parties and;
First Nations in Ontario's treaty relationships make certain that our internationally protected right to give our free and fully informed consent on all issues related to use and care of waters as our right and were not given over with the making of Treaties;
First Nations in Ontario's fundamental water rights is a relationship based on an expression of a power relationship between ourselves and the Creator and;
First Nations have rights to determine the key properties of waters including distribution, contents and legitimacy of water rights to restore the balance;
First Nations in Ontario have reviewed the state of the waters within each of our territories;
First Nations in Ontario have seen the need to retain, declare and assert our relationship with waters to ensure that there are clean waters for the future generations;
First Nation peoples in Ontario have met in Garden River First Nation territory to raise our voices in solidarity to speak for the waters.

We announce and proclaim our role as holders of rights and carriers of responsibilities to defend and ensure the protection, availability and purity of freshwaters and oceans;
This is our responsibility to the future generations – for those children yet unborn – as set out in this Water Declaration.

It is recognized that there are responsibilities that come with this special relationship. Participating in the Thames River Clear Water Revival is an example of how First Nations whose traditional territory overlaps the Thames River ***watershed*** are fulfilling their responsibility. First Nations maintain unique relationships with water and feel these perspectives should form an integral part of water governance (Mandamin 2012; McGregor 2009). Traditional teachings and understandings were shared by approximately 80 First Nations Elders, traditional knowledge holders and leaders from across Ontario during work undertaken by the Chiefs of Ontario in preparation for their submission to the Walkerton Inquiry in 2000 (McGregor 2012) and are similar to observations made by others throughout Canada (Anderson 2010; Anderson, Clow, and Haworth-Brockman 2011; Blackstock 2001; Phare 2011; Swain et al. 2006).

1.1.2.2 First Nations Traditional Teachings and Understandings

Water is alive.

It is a being with its own spirit. Water bodies are thought to have various personalities and responsibilities that require different demonstrations of respect. Water is understood to have feelings and can be sad and/or angry if not respected or treated properly. Water must be free to fulfill its responsibilities; it is not appropriate for people to interfere with water's life-giving duties.

Water is sacred.

Water is a sacred entity and must be treated as such. It is often used in ceremonies. It is a powerful medicine and must be respected as such. It has life-giving properties. We need water to live.

Water is a relative.

Not only is water alive and infused with spirit; it is a relative. One speaks to water as one would a relative, with caring and compassion. Water is not a commodity to be bought and sold. It is to be revered and treated with respect and dignity.

Water is part of a holistic system, a part of Creation.

Water is not a single, discrete aspect of the environment; it is part of a greater, interconnected whole. When one considers water, therefore, one must consider all that to which water is connected and related.

Water is key to survival.

Water is critical for the spiritual, emotional, physical, and intellectual life of First Nation people. The role of water in life must be recognized. Therefore, it is not appropriate to deprive others (including other beings of Creation, such as fish, plants, and land animals) of water, by hoarding water for oneself.

Appropriate water use is about proper relationships.

From a traditional perspective, one does not really use water or treat it as a commodity. One speaks to, and seeks permission from, water to utilize its life-giving properties. One should find an appropriate relationship with water based on respect and the recognition that water is a living spiritual force. Water is regarded as a gift. In traditional teachings and values, there are protocols to ensure that proper relationships with water are maintained so that water, in turn, is able to fulfill its responsibilities.

Water must be treated with an ethic of thanksgiving.

Water is critical to the survival of all life on Earth, and First Nation peoples are most thankful for water's existence. There are protocols and ceremonies for giving thanks to water and for establishing and maintaining a spiritual connection to water. In First Nation cultures, water is not taken for granted and its life-giving qualities are routinely recognized and honored.

People have specific responsibilities to protect water.

Everyone has a responsibility to care for the water. The recognition of women's role in creating life along with water means that women have a special bond with water. Consideration must be given to the gender of decision-makers, especially with respect to First Nation women, who have the responsibility of speaking for, and talking to, water in First Nation communities. This bond is often expressed in ceremonies, where the role of Anishinaabe women is to speak for the water. In the water ceremony the women make an offering to water, to acknowledge its life-giving forces and to pay respect. We have a responsibility to take care of the water, and this ceremony reminds us to do it.

Planning for water governance must take a long-term approach.

First Nations decision-makers consider seven generations. Decisions about water consider the wisdom of the elders and also recognize the impact such decisions will have on subsequent generations. It is both looking to the advice of the past and the potential for the future.

Knowledge regarding water must be shared.

First Nation peoples' unique views and values in relation to water must be shared with non-First Nation society. It is felt that current mainstream processes for protecting water are misguided, limited, and too dependent on the compartmentalized approach of science and technology. Traditional teachings around water would benefit the broader community, so non-First Nation people can also learn to develop proper relationships with water.

Language retention is critical.

Reclaiming language and re-naming the waters with their proper names, rather than the newcomers' names, is important in helping the waters heal and will also help the First Nation people heal as people.

The Shared Waters Approach strives to reflect these understandings.

1.1.3 Canadian Perspective

Canada contains 9% of the world's fresh water, surpassed only by Brazil and Russia. Ontario comprises 17.8% of the national fresh water reserves. Only Quebec, the Northwest Territories and Nunavut contain more fresh water than Ontario. Given that approximately 60% of Canada's fresh water drains to the north, away from the bulk of the Canadian population, the amount of freshwater in Ontario is significant.

According to Statistics Canada (2013), Canadians use approximately 250 litres of water per person, per day (http://www.statcan.gc.ca/pub/16-201-x/16-201-x2017000-eng.htm?contentType=application%2Fpdf), which is second in the world in total per capita withdrawal of water. The largest water users in 2013 were electric power generation, transmission and distribution (68%); manufacturing (10%); households (9%); agriculture (5%) and mining and oil and gas extraction (3%).

In 2008, Royal Bank of Canada (RBC) started polling Canadians about their attitudes toward water to determine if severe global water issues have any impact on how we think about and use our water and to monitor if these attitudes are changing. The results of the annual RBC Canadian Water Attitudes Study from 2008 – 2014 (RBC Blue Water Project 2014) have shown that Canadians are living under the illusion of an infinite water supply, having only a very vague idea of where their water comes from, where it goes and the importance of investing in the water infrastructure which makes that water available to them. This lack of awareness can be a real challenge to mobilizing citizen support to protect water or defend infrastructure budgets or programs.

The 2016 RBC Canadian Water Attitudes Study revealed a strong disconnect between water quality and quantity issues and the potential solutions to these issues. Attitude and knowledge about water issues do not necessarily reflect actions and behaviors. For example, the Canadian public continues to have high confidence in the quality of their drinking water, despite the heightened citizen awareness of the possible issues with drinking water that have emerged from recent news stories about unsafe drinking water in Flint, Michigan, and in First Nations communities. As well, three-quarters of Canadians agree that climate change will cause extreme weather events to happen more frequently, yet less than one-quarter are concerned about extreme weather causing droughts or flooding. More positively, this study also showed that Canadians view fresh water as Canada's most important natural resource by far, and see climate change as the top threat to this resource. Almost all respondents (95%) agree that Canada should take responsibility for managing its waters more efficiently and effectively.

Clearly, there is a need for additional education to increase public understanding of and support for actions to protect water and change behavior. With increasing education and awareness, as well as the increase in significant events impacting municipalities and the public, citizens are becoming aware of water's importance as a finite and vulnerable resource.

Recent school educational programs have reinforced the message that water bodies in Canada include ‘our own’ bodies. The human body is comprised of approximately 75% to 80% water. This message reinforces the notion that “water is life” and contains some parallels with the First Nations perspective. We jeopardize the health of our citizens and all peoples when we disregard the importance of water, regardless if it is in the Thames River or the Great Lakes.

1.1.3.1 Great Lakes Perspective

Phosphorus

In recent years, there has been a resurgence of algal blooms in Lake Erie, which last threatened the lake’s ***ecosystem*** in the 1960s and 1970s. Severe algal blooms at that time led to significant actions which resulted in dramatic ***phosphorus*** reductions. The key contributing factors to the current algae issues include changes in the timing and forms of ***phosphorus*** entering the lake from tributaries such as the Thames River, as well as altered precipitation patterns, nutrient cycling, and food web dynamics (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018). The ***phosphorus*** issue in Lake Erie is described in greater detail in Appendix C.

In response, the former Lake Erie Lakewide Management Plan (LaMP) Working Group developed a *Binational Nutrient Management Strategy* (Lake Erie LaMP 2011) which identified ***phosphorus*** reduction as a priority. Pursuant to the GLWQA Nutrients Annex (2012), binational ***phosphorus*** reduction targets were established for Lake Erie.

In Canada, provincial and federal initiatives identified the Thames River as a priority ***watershed*** to reduce nearshore ***cyanobacterial blooms*** in Lake St. Clair. Local impacts to the Thames River ***ecosystem*** due to excess ***phosphorus*** and algae in the ***watershed*** also make actions to reduce ***phosphorus*** a priority. Addressing existing and emerging water quality and quantity concerns will benefit all who live, work and play in the Thames River ***watershed*** and, by extension, Lake St. Clair and Lake Erie.

Canada and Ontario collaborated with key sectors and communities to develop a joint action plan for the Canadian side of Lake Erie, which was released in February 2018 (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018). The Canada-Ontario Lake Erie Action Plan (LEAP) identifies more than 120 federal, provincial, and partner actions to help achieve the goal of reducing the ***phosphorus load*** entering the western and central basins of Lake Erie by 40% from 2008 levels.

These new plans and targets aim to make significant improvements, similar to the successful past efforts of the Lake Erie community in achieving target ***phosphorus load*** reductions and changing attitudes.

Continuing implementation of other legislation, such as the Ontario Nutrient Management Act (NMA), also helps to address the impacts of agricultural nutrient sources on surface water and ***groundwater***. Many individual initiatives within the agricultural community, including on-farm soil health, nutrient control, and erosion reduction projects, are being supported by provincial and federal government agencies as well as the agricultural industry and organizations. Within urban communities, municipalities and partners continue to work to address nutrients through infrastructure improvements, education efforts, and new approaches, such as ***green infrastructure*** and ***Low Impact Development (LID)***.

Other Initiatives to Protect Water

The provincial and federal governments work together with US state and federal partners to set priorities for science and monitoring on Lake Erie and the St. Clair - Detroit River corridor, and to report out on the state of Lake Erie.

The goal of the updated Lake Erie *Lakewide Action and Management Plan (LAMP)* approach, redefined in the latest *GLWQA*, is to restore and protect the beneficial uses of Lake Erie and to focus on actions to reduce or prevent sources of impairments to these uses. The LAMP reports annually on the many initiatives underway by the binational partnership in monitoring, remedial actions, outreach and engagement, and reporting for the Lake Erie ***watershed***, including the St. Clair River - Lake St. Clair - Detroit River corridor.

Provincial and federal governments are working with partners to continue to address key issues in the Lake Erie Basin. In Ontario, work on Areas of Concern (AOCs) in the St. Clair and Detroit Rivers has progressed through the implementation of Remedial Action Plans (RAPs).

Another key priority for Ontario is safe drinking water, with the implementation of drinking water source protection programs throughout the province. In May 2000, the municipal drinking water system in Walkerton, Ontario, became contaminated with deadly bacteria. As a result, seven people died and more than 2,300 became ill (Ontario Ministry of the Attorney General. 2002. Report of the Walkerton Inquiry). The government of Ontario called an Inquiry to make recommendations to ensure the safety of the water supply system in Ontario. Following the Walkerton Inquiry, Justice O'Connor made 121 recommendations on a wide range of areas related to protecting drinking water. These recommendations are the building blocks of Ontario's drinking water protection framework. Today, Ontario has a comprehensive drinking water safety net from source to tap and has "the most ambitious source water protection program in Canada" with some of the country's "strongest treatment, testing, operator training and public reporting standards," according to Ecojustice's Canada's Drinking Water Report Card (Christensen 2006).

The Ontario government's Made-in-Ontario Environment Plan (2018) will focus on protecting air, lakes and rivers; addressing climate change; reducing litter and waste in communities and keeping land and soil clean; and conserving land and greenspace.

1.1.4 Local (Thames *Watershed*) Perspectives

1.1.4.1 Local First Nations Perspectives

Each First Nation is distinct in terms of culture, language, religion/ spirituality and history (Appendix E1). A brief description / overview of the local First Nations follows below.

Thirteen First Nations lived within the borders of Ontario prior to European contact:

- the Anishinaabek People (Mississauga, Ojibway/Chippewa, Pottawotami, Algonquin, and Odawa),
- the Mushkegowuk People (Cree),
- the Haudenosaunee People (Mohawk, Tuscarora, Seneca, Cayuga, Oneida, and Onondaga), and
- the Huron-Wendat People.

Following European contact, the Lenni Lenape Peoples (Delaware) moved into Ontario.

Eight First Nations have traditional territory that overlaps the Thames River ***watershed*** (Map 2):

- the Lunaapew (or Lenni Lenape) People:
  - Munsee Delaware Nation, and
  - Eelünaapéewi Lahkéewiit - Delaware Nation at Moraviantown;
- the Haudenosaunee People:
  - Oneida Nation of the Thames; and
- the Anishinaabek People:
  - Aamjiwnaang First Nation,
  - Bkejwanong Walpole Island First Nation,
  - Chippewas of the Thames First Nation,
  - Chippewas of Kettle and Stony Point First Nation, and
  - Caldwell First Nation.

The ***watershed*** is covered by the following Upper Canada Treaties:

- 1790 McKee Treaty (Treaty 2),
- 1792 Between the Lakes Purchase and Collins Purchase (Treaty 3),
- 1796 Chenail Écarté Treaty and London Township Treaty Purchase (Treaty 6),
- 1819 - 1822 Long Woods Treaties (Treaties 21 and/ or 25), and
- 1827 Huron Tract Treaty (Treaty 29).

It is important to note that Caldwell First Nation was not present when the treaties were being signed because they already had a verbal agreement in place.

Other important treaties include:

- 1794 Treaty of Amity, Commerce and Navigation or Jay Treaty, between Britain and the United States, which allows ***Indigenous*** people from Canada to live and work freely in the United States; and
- 1701 Nanfan Treaty or Fort Albany Treaty, which gave the Iroquois permanent hunting rights in southwest Ontario.

Four distinct First Nations, which include the Chippewas of the Thames First Nation, the Oneida Nation of the Thames, the Eelünaapéewi Lahkéewiit (Delaware Nation at Moraviantown), and the Munsee Delaware Nation, settled permanently along the banks of the Thames between the 1780s and 1840s. They have maintained a strong ***Indigenous*** presence along the river.

First Nations are organized into many different confederacies. The Three Fires Confederacy (in *Anishinaabemowin: Niswi-mishkodewin*) is also known as “the Council of Three Fires” or “the People of the Three Fires.” The council is a long-standing Anishinaabeg alliance of the Ojibway (or Chippewa), Odawa, and Potawatomi. In the Thames River ***watershed***, Aamjiwnaang First Nation, Bkejwanong Walpole Island First Nation, Chippewas of the Thames First Nation, Chippewas of Kettle and Stony Point First Nation, and Caldwell First Nation are members of the Three Fires Confederacy.

The Haudenosaunee Confederacy, meaning People of the Long House, have been called the Iroquois Confederacy by the French, and the League of Five Nations by the English. The Oneida Nation of the Thames (also known as Onyota’ a:ka, People of the Standing Stone) is a member of the Haudenosaunee Confederacy. Their settlement is the largest concentration of Oneida people in Canada.

Munsee Delaware Nation and Eelünaapéewi Lahkéewiit (Delaware Nation at Moraviantown) are the only Lenni Lenape People in Canada, except for a few hundred residing on Six Nations near Brantford, Ontario. The Moraviantown settlement was initiated by Moravian missionaries in 1792, making it one of the earliest communities in Southwestern Ontario and one of the few Moravian missions in Canada.

The Thames River is deeply ingrained in the stories and the history of First Nation communities living near the Thames River. Water stories gathered from several engagement and outreach sessions in the Aamjiwnaang First Nation community (Appendix F) reveal the negative impact that the disrespect towards and contamination of water has had on the spirit of these First Nation communities. They feel the river’s pain and need for protection and help; yet they feel a loss of control over the protection of this spiritual component of their culture. In some First Nations communities, severing ties with the water source has represented the single most harmful event in the history of the community (Ransom 1999). When the Thames River is termed a resource instead of a life source, the cultural and traditional connection to the Thames is disrespected. The perspective has to shift back to reverence of the river supporting life, just like the air we breathe supports life. It is sacred to all.

1.1.4.2 Rural Perspective

Statistics Canada defines "population centres" as having a population of at least 1,000 and no fewer than 400 persons per square kilometre, and "rural areas" as all other territory. Rural areas can include small municipalities, rural residential, quarries (aggregate extraction) and other non-urban land uses. Most residents in the rural landscape rely on individual ***groundwater*** wells for their drinking water supplies. According to the *Thames-Sydenham and Region* ***Watershed*** *Characterization Summary Report: Thames* ***Watershed*** *& Region* (Lower Thames Valley Conservation Authority et al. 2008), ***groundwater*** wells service all the communities upstream of London. This reliance on wells may provide a better understanding and an improved individual connection to sources of drinking water.

Aside from domestic residential needs, water is critically important in rural areas for many other uses. For example, the Thames River basin supports a wide diversity of farms that produce food, feed, fiber and fuel to supply both local and global markets. Crops require sufficient water to grow, and healthier soils retain more water that plants can access. Some high value crops are irrigated with surface water or ***groundwater***, which can sometimes be in limited supply. Excess water in fields during periods of high rainfall and snowmelt is managed through municipal drainage infrastructure to improve crop growth and reduce erosion. Livestock also need access to clean water for optimal growth and production.

It is recognized that there continues to be significant stressors on water quantity and quality that need to be addressed. Intensification of agricultural operations and increases in production often mean more water is required and more waste material needs to be managed responsibly. Farm products are subject to changing global markets that are outside of local control, which can create economic sustainability challenges and limit investment in longer term solutions to water issues. A changing climate may result in more extreme weather events, including droughts, storms and floods, which will impact individual farms, as well as municipal and rural infrastructure. Given the importance of water to rural land uses, a variety of ***BMPs***, focusing on water stewardship and conservation, has evolved to address some of these issues.

1.1.4.3 Urban Perspective

<u>Note:</u> *This section contains examples specifically related to the City of London and has not captured the individual perspectives and concerns of all the other groups, cities and towns within the Thames River* ***watershed****. This is a limitation of the current process which will next seek to broaden participation during further review and outreach.*

There has been considerable research on the attitudes of urban residents regarding the use and misuse of water. Although research specific to the Thames River ***watershed*** and the corresponding urban municipalities is limited, it can be said that the convenience of fresh, clean water supplied by municipalities makes it easy for residents to forget the source. For example, in London, many citizens are not aware of where their drinking water comes from (Abbruzzese et al. 2019, HETEK Solutions Inc. and Resource Management Strategies Inc.

2008). In urban areas, drinking water is provided, **wastewater** is treated, and ***stormwater*** is removed from properties without much consideration or worry from the homeowner. The successful operations of these water systems and the close proximity to the Great Lakes make the message of individual water stewardship a challenge. Events such as the Children's Water Festivals that are held in London, Woodstock, St. Thomas, and Chatham-Kent serve to increase public awareness and promote education.

Changes to the Building Code, making low flush toilets and low flow shower heads mandatory installations, as well as the introduction of more efficient appliances (e.g., laundry machines), have provided some reduction in water consumption (HETEK Solutions Inc. and Resource Management Strategies Inc. 2008). Furthermore, as water prices continue to rise due to municipal "true cost accounting," and as climate change adaptation measures are required to improve water conservation, it is expected that further reductions in water consumption will result.

The importance of the Thames River flowing through London has been recognized in many studies and reports, and is substantiated by neighbourhood groups and community perspectives. The river was recognized in the Thames Valley Corridor Plan (Dillon Consulting Ltd. and D.R. Poulton & Assoc. 2011) and, more recently, in The London Plan (City of London 2016), as "… the City's most important natural, cultural, recreational and aesthetic resource." The Corridor Plan and the related "Action Plan" provided the framework for subsequent property acquisitions, parkland management decisions and community event planning. A renewed community focus on the river has been empowered recently by the "Back to the River" initiative, led by the London Community Foundation and supported by the City of London and the UTRCA. This community mobilization initiative strives to revitalize a 5 km stretch of the Thames River centred on the Forks of the Thames in downtown London. The subsequent study to review the feasibility of the revitalization, titled the One River Municipal Class Environmental Assessment, was initiated in 2017.

2.0 *WATERSHED* STRATEGY FOR THE THAMES RIVER

In 2009, the City of London initiated dialogue with potential partners to discuss the need for a renewed effort to deal with water management problems in the Thames River ***watershed***. Two charrettes (meetings) were held to generate public interest and government commitment to the process. Following the charrettes, a voluntary, multi-partner ***watershed*** initiative called the Thames River Clear Water Revival (TRCWR) was launched as a venue to collaboratively address the most significant issues and challenges facing the Thames River. The TRCWR steering committee was formed in 2012 and a Terms of Reference for the Shared Waters Approach was developed in 2013 (www.thamesrevival.ca).

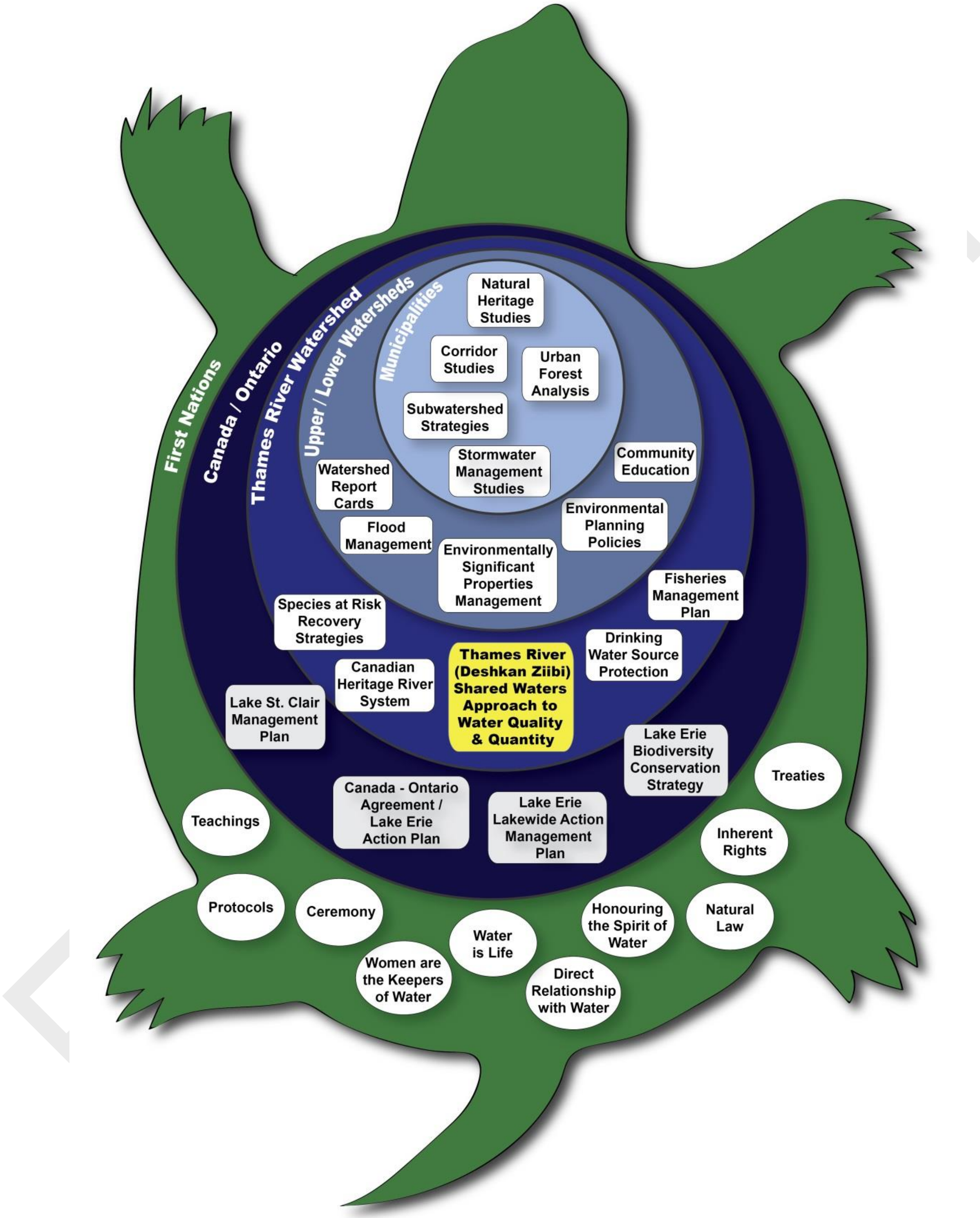
The TRCWR is a ***watershed*** initiative that considers all the interactions of land, water, plants, animals and people (Figure 1) with the overall objective of improving the ecological condition of the Thames River, which by direct connection will help to improve conditions in Lake St. Clair and Lake Erie. The intent of the TRCWR is to combine available information on forestry, fisheries, natural heritage, drinking water source protection, recreation and data from other planning processes so that linkages can be made for planning at the ***watershed*** scale.

2.1 THE COLLABORATIVE PROCESS

In Ontario, the responsibility for protecting surface water and ***groundwater*** from contamination is shared among numerous First Nations, Métis and Inuit, federal, provincial and municipal governments, and local agencies (Appendix G). Many policies have been developed by these various groups to address water quality and quantity issues. There are also various naturalist groups, recreational associations, community groups, and concerned individuals with either a mandate or strong interest in managing activities related to the Thames River.

While several individual efforts may currently be in place to protect aspects of the Thames River ***watershed***, identifying and resolving water issues requires a collaborative approach. This approach recognizes the complexity and inter-relatedness of ***hydrological*** and ecological processes at the ***watershed*** level, as well as social and spiritual aspects. As a result, the members of the TRCWR feel that the partnership is worthwhile and should continue. The Shared Waters Approach provides a context to unite and strengthen these individual efforts for the benefit of the river. Ultimately, the Shared Waters Approach will translate into benefits including improved water quality, greater protection from effects of climate change, and enhanced recreation opportunities.

Figure 1. Diagram representing the relationship between the Thames River *watershed* initiatives and approaches to the natural environment



2.1.1 Membership of the TRCWR

2.1.1.1 First Nations

Four of the eight First Nations whose traditional territory overlaps the ***watershed*** have actively participated on the Steering Committee:

- Aamjiwnaang First Nation,
- Bkejwanong Walpole Island First Nation,
- Caldwell First Nation, and
- Chippewas of the Thames First Nation.

The Chippewas of Kettle and Stony Point First Nation and Munsee Delaware Nation have been invited to participate, while Eelünaapéewi Lahkéewiit (Delaware Nation at Moraviantown) and Oneida Nation of the Thames participated early in the development of the TRCWR.

2.1.1.2 Federal Government

- Environment and Climate Change Canada (ECCC)

2.1.1.3 Ontario Government

- Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)
- Ontario Ministry of the Environment, Conservation and Parks (MECP)
- Ontario Ministry of Natural Resources and Forestry (OMNRF)

2.1.1.4 Conservation Authorities

- Lower Thames Valley Conservation Authority (LTVCA)
- Upper Thames River Conservation Authority (UTRCA)

2.1.1.5 Municipalities

- City of London

2.1.2 Committee Structure

The TRCWR is governed by a Steering Committee and supported by a Project Manager and Technical Working Subcommittees. The Steering Committee provides overall direction and guidance, oversees project accountability, and reports on progress to their respective partner organizations. The chair/co-chairs of the Steering Committee is/are elected based on their expertise and the stage of the project. The Project Manager is responsible for the overall coordination of the TRCWR and the integration of decisions. The Project Manager is the liaison between the Steering Committee and the Technical Working Subcommittees, and acts in an advisory capacity to the Steering Committee. Technical Working Subcommittees carry out specific tasks aligned on a topical basis and participate in technical forums to explore the state of the science and practice around various aspects related to the ***watershed***. These Technical Working Subcommittees report directly to the Project Manager and include a First Nations Engagement Subcommittee, Water Quality and Water Quantity Technical Subcommittees, and a Communications Subcommittee. Informal meetings of municipal staff have occurred over the past several years to provide updates and status reports (e.g., meetings with Chatham, Stratford, St. Marys, Middlesex and Oxford County); however, no formal group discussion has occurred.

2.2 COMMUNICATIONS AND ENGAGEMENT

The Steering Committee acknowledged that the assembly and, more particularly, implementation of the TRCWR will require strong partner participation to ensure its success. A dedicated website www.thamesrevival.ca was designed to allow access to background information, technical reports, newsletters, meeting minutes, and other materials pertinent to the TRCWR. Presentations at field tours, school groups, technical workshops and community groups, as well as exhibits at various community events provided additional opportunities to increase general awareness about the initiative. The Antler River Guardians From The 4 Directions (ARGFT4D), a First Nation youth group supported by the TRCWR, also helped develop awareness about the Thames River and the TRCWR initiatives.

2.2.1 First Nation Engagement

The TRCWR recognizes the knowledge, wisdom and compassion for the Thames River ***watershed*** and connection to the land that exists within First Nations. Several First Nations have been involved early in the TRCWR as equal partners at the governance level.

The intent of the First Nation Engagement Strategy (Appendix E), developed by the First Nation Engagement Committee, is to provide guidance on how to reach out to the eight distinct First Nations whose traditional territory overlap the Thames River ***watershed***, invite them to take part, and involve those who choose to engage in the TRCWR. Community engagement remains a challenge given the resource and capacity limitations of each First Nation. The First Nation Engagement Strategy seeks to improve those opportunities through collaborations. It is hoped that the common goal of protecting and improving the health of the Thames River ***watershed*** will be a bridge between cultures to seek a better understanding, more cultural awareness, and an improved relationship.

The engagement strategy provides some direction towards achieving this preferred engagement approach, but is not meant to replace the legal duty of federal and provincial governments to consult and accommodate First Nations based on the honour of the Crown, or to replace the principles reflected in the United Nations Declaration on the Rights of ***Indigenous*** Peoples. While engagement is anticipated to be the primary relationship tool, there may be aspects of program delivery that require formal consultation and accommodation of First Nation Title, Treaty and First Nation Rights.

Cross cultural programs, such as the Antler River Guardians From The Four Directions (ARGFT4D) youth program, are one mechanism for engaging the First Nation communities and provide partners with learning opportunities fostered through relationships. Through this program, project partners learn from communities about historical and current uses of the river and the way First Nations think and feel about the river, while the First Nations can further understand how the partner organizations are helping to protect the river through stewardship and ***ecosystem*** approaches. This type of cross cultural learning will help to inform water quality and quantity decisions.

2.2.2 *Watershed* Stakeholder & *Indigenous* Engagement

In 2009, the ***assimilative capacity*** of the river was being questioned by several municipalities and provincial agencies related to ***wastewater*** effluent. A focused discussion on ***wastewater*** soon broadened to a more holistic perspective of the health of the river. First Nations from several communities in the ***watershed*** were initially approached to seek their interest and support. Early discussions occurred with London District Chief's Council at the Southern First Nations Secretariat.

A charrette (meeting) was held in 2010 with approximately 40 attendees including First Nations, federal and provincial governments, municipalities and conservation authorities, followed by a second charrette in 2011 with another 40 attendees. These provided the enthusiasm and direction to pursue the idea of a ***watershed*** strategy for the entire Thames River from headwaters to outlet. A Steering Committee was struck and meetings and workshops continued for the next several years during which time issues were discussed and approaches were tested. Meetings with municipal staff occurred at various stages to seek their interest and input. As a result of stakeholder and ***Indigenous*** engagement, it was determined that an update was needed of the 1975 Thames River Basin Water Management Study, the last comprehensive look at the Thames River.

2.3 *INDIGENOUS* TRADITIONAL KNOWLEDGE AND WESTERN SCIENTIFIC KNOWLEDGE

Indigenous Traditional Knowledge (ITK) refers to the cumulative body of knowledge, belief and practice of ***Indigenous*** people regarding sustainability of local resources. ***ITK***, like any other type of knowledge, is dynamic, continuously adapting to contemporary situations and incorporating aspects of knowledge learned from others. However, methods of acquiring and accumulating ***ITK*** differ from those used to create and validate Western scientific ecological knowledge (McGregor 2004, Becker and Ghimire 2003). Instruction or knowledge of ***ITK*** comes from many sources, including Creation itself (Johnston 2003; McGregor 2004). Many stories and teachings are obtained from animals, plants, the moon, the stars, water, wind, and the spirit world. Knowledge is also gained through visions, ceremonies, prayers, intuitions, dreams, and personal experience.

From an ***Indigenous*** point of view, traditional knowledge developed over the millennia should not be compromised by an over-reliance on relatively recent and narrowly defined western reductionist scientific methods. ***ITK*** is most frequently preserved as oral tradition, accumulated and handed down each generation through traditional songs, stories, rituals, and beliefs. It concerns the relationship of living beings (including humans) with their environment (Berkes et al. 2000). Both ***ITK*** and Western scientific knowledge will be used to help inform water quality and quantity decisions and will be embedded throughout the Thames River Shared Waters Approach.

2.4 CLIMATE CONSIDERATIONS

Climate change considerations will be considered for all components of the ***watershed*** strategy, including each section of the Thames River Shared Waters Approach. The Intergovernmental Panel on Climate Change (IPCC) is the recognized authority for assessing the science related to climate change at the global scale. The IPCC was established in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular comprehensive assessments about the state of scientific, technical and socio-economic knowledge on climate change, its causes, potential impacts and future risks, and options for response strategies including adaptation and mitigation.

At the Canadian (federal) and provincial scale, there is no single definitive source of information on the impacts of climate change. Instead, there are many government agencies investigating the potential impacts of climate change. More frequent extreme weather events, such as floods and droughts, as well as higher air temperatures, are aspects of a changing climate that are expected to be the "new normal." Some of these impacts may result in considerable damage to infrastructure and increased insurance claims. ***Ecosystem*** changes, including loss of habitat, species changes, degraded water quality related to temperature and dissolved oxygen conditions, transport and release of contaminants, have all been identified as possible impacts related to climate change.

To understand and predict climate change impacts on the ***watersheds*** of the Great Lakes, the Ontario Climate Consortium (OCC) and OMNRF synthesized available science on the observed and projected impacts of climate change in the Great Lakes basin and investigated the current strengths and gaps in climate change science (McDermid et al. 2015). They determined that air temperature is the only measure that can currently be associated with changes in climate (Appendix H). According to Zhang et al. (2011a), air temperature in Canada has increased by approximately 1ºC over the past century, with increased annual precipitation over the past 50 years. These figures are consistent with global trends. Climate change projections suggest that over the next century, a further warming of 1ºC to 3.5ºC will occur across Canada (Meehl et al. 2007), while the results of the Global Circulation Model (GCM) simulations for southern Ontario indicate an average annual warming of 2ºC to 5ºC by the latter part of the 21st century (Zhang and Gough 2011b).

At a local scale, the Bkejwanong Walpole Island First Nation (WIFN) community members have observed several changes that could be attributed to climate change. Some of these include a change in fish species composition in Lake St. Clair, an increased number of fishermen going through the ice in the winter, a need to replant agricultural fields due to changes in soil moisture that prevents seed germination, a shift in food sources for waterfowl, an increased number of boating accidents from fluctuating water levels, an increased incidence of grass fires due to dry conditions, and an increased number of children with asthma.

Other impacts to water quality and quantity from climatic change projections could include:

- Impact on the amount of water moving downward from the surface water to ***groundwater*** and subsequent impact on amount of flow in a stream (***baseflow)*** from ***groundwater discharge*** (Pitz 2016).
- Increase in demand for irrigation water, especially on drought-prone soils or for shallow-rooted crops such as potatoes (Tan and Reynolds 2013).
- Creation of more favourable environmental conditions (warmer water temperatures, changes in salinity, higher carbon dioxide levels and changes in rainfall patterns) for certain microbes and algae (Mortsch, Alden and Scheraga 2003).
- Increase in the average temperature of ***aquifers*** due to warmer ground and air temperatures (Pitz 2016).
- Increase of nutrient, contaminants and sediment loads into watercourses due to the increase in frequency and magnitude of storms.
- Increased occurrence of winter snow squalls in southwestern Ontario due to increased ice-free conditions on Lake Huron as a direct result of warmer winter temperatures (https://www.lakehuron.ca/icecover).

Climate change adaptation requires collaboration in order to address sustainability and resilience. The Shared Waters Approach will move us forward in these discussions and decisions for the benefit of future generations.

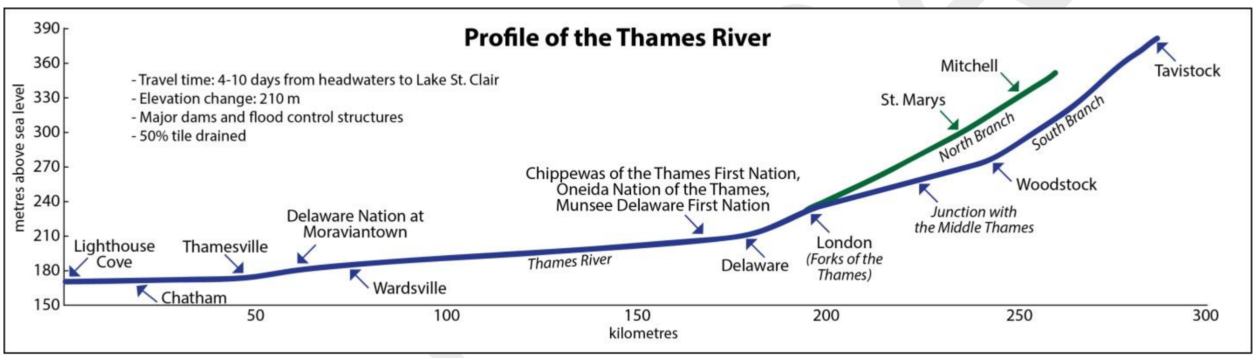
2.5 GEOMORPHOLOGY OF THE THAMES RIVER

The Thames River is 279 km long and drains an area of 5,825 km^2 (roughly the size of Prince Edward Island) in southwestern Ontario's agricultural heartland (Map 3). The river originates northeast of London and flows southwesterly into Lake St. Clair, which drains into Lake Erie via the Detroit River. As the largest ***watershed*** in the Lake St. Clair basin, the Thames River has the potential to impact conditions in Lake St. Clair and contribute to ***phosphorus loads*** to Lake Erie.

From a geographic perspective, the Thames River ***watershed*** can be divided into upper and lower ***watersheds***, with the village of Delaware, just west of London, as the approximate dividing point (Map 1). The broad upper ***watershed*** stretches north and east of Delaware and covers 3,420 km^2. It includes the river's three main branches: the North, South and Middle Thames Rivers. The convergence of the North and South Thames Rivers in London is known as the Forks of the Thames. The long, narrow lower ***watershed*** covers 2,405 km^2 and is bordered by the Sydenham River ***watershed*** to the north and small Lake Erie tributaries to the south.

The Thames River rises at three distinct points: near Mitchell (North Thames), at approximately 355 metres above sea level (masl); near Tavistock (South Thames, considered to be the main Thames River upstream of the Forks), at approximately 380 masl; and near Hickson (Middle Thames), at approximately 355 masl. Figure 2 shows that the river's elevation falls moderately (1.5 m/km) from the headwaters near Tavistock on the south branch to Delaware (approximately 205 masl), and Mitchell on the north branch to Delaware, and then flattens out considerably between Delaware and the river's mouth at Lighthouse Cove (< 0.2 m/km). As a result, it takes approximately a day and a half for water to travel from Tavistock to London in the upper ***watershed***, compared to four days for water to travel from London to Chatham in the lower ***watershed*** (Thames River Background Study Research Team 1997). As well, there is limited flow by gravity over the flat terrain in the lower Thames and the ditches that drain the farmland downstream of the City of Chatham are often pumped to their outlets.

Figure 2. Profile of the Thames River



The three main branches flow through rolling landscapes of glacial till plains and moraines. The river beds in the upper ***watershed*** are rocky, and the valley slopes are steep with bluffs or terraces on at least one side. The North Thames River, which occupies a former glacial spillway, is 77 km long. It originates from the convergence of several small tributaries in Logan Township, north of Mitchell. The river runs through a shallow but well defined river valley south of Mitchell that formed along the eastern edge of the Mitchell Moraine. Major tributaries to the North Thames include the Avon River, Flat Creek and Trout Creek.

The Middle Thames River is 26 km long. It originates near Hickson (southwest of Tavistock) and flows through Thamesford before joining the South Thames River between Ingersoll and Dorchester.

The South Thames River is 112 km long. It originates in a swampy area west of Tavistock and continues west through a drumlin field (a hilly glacial feature) located between Innerkip, Woodstock and Ingersoll. At Woodstock the South Thames River joins a glacial spillway. Cedar and Reynolds Creeks are the main tributaries of the South Thames River.

The North and South branches of the Thames River meet in London at the Forks. Downstream from the Forks, the Thames River is a more gently sloped, meandering river with a shallower gradient (Figure 2). It flows 187 km southwest through flat clay and sand plains, parallel to the Lake Erie shoreline, before emptying into Lake St Clair at Lighthouse Cove. Here in the lower reach of the River, the Thames emerged after thousands of years as a glacial lake. The river bed is soft and the water flow is gentle. The Thames passes through Delaware, Wardsville, Thamesville and Chatham, as well as the Chippewas of the Thames First Nation, Oneida Nation of the Thames, Munsee Delaware Nation, and Eelünaapéewi Lahkéewiit (Delaware Nation at Moraviantown) communities. The larger tributaries in the lower ***watershed*** include McGregor and Jeanettes Creeks.

The Thames is thought to be the first major river to have formed in Ontario following the retreat of the Wisconsin Glacier, about 14,000 years ago. The first land in Ontario to be free of glacial ice ("Ontario Island") is thought to have appeared to the northeast of the present Forks of the Thames in London (Chapman and Putnam 1984). In its earliest stage, the Thames spillway drained ***watersheds*** of the present Saugeen, Maitland and Grand Rivers and carried glacial meltwater southwest towards the headwaters of the Mississippi River (Wilcox et al. 1998).

Today, the Thames is the second largest ***watershed*** in southwestern Ontario and drains approximately 25% of the Ontario portion of the Lake Erie drainage basin (Thames-Sydenham and Region Source Protection Committee 2007). It should be noted that the jurisdiction of the Lower Thames Valley Conservation Authority includes lands that drain directly into Lake Erie and lands north of the mouth of the Thames that drain directly into Lake St. Clair, but these areas are not part of the Thames River ***watershed***.

2.5.1 Channel Patterns

Typical of large rivers in southern Ontario, the Thames developed on glaciofluvial deposits. The drainage network evolved piecemeal as various sections of land were freed from glacial ice. The glacier's retreat was spasmodic, interrupted by temporary re-advances and standstills (Chapman and Putnam 1984). An advance produced long narrow ridges of unsorted material, called moraines, through bulldozing and dumping, while a retreat deposited plains of till (sand and gravel) by gravity and from meltwater (Lorimer 1996). As a result, the Thames River and all of its associated tributaries and streams take on several channel patterns, but overall follow a dendritic drainage pattern with irregular meanders (Morisawa 1968). There are stretches where the meandering is more regular, such as near Wardsville and Dorchester, and reaches where the river is fairly straight, such as in the flat clay plains of the lower ***watershed*** downstream of Chatham.

There has been no significant shifting of the Thames River channel in the last century. This is likely due to the fact that the river does not have enough continuous power to erode its fluvial valley. There are, however, a few oxbows which suggest some limited or localized shifting in channel pattern. For example, a large oxbow known as the Coves, located downstream of the Forks in London, became disconnected from the river sometime in the late 1800s. Upstream of Delaware, there is a stretch of river where the valley contains significant amounts of alluvial material and meander scars where oxbows are relatively recent. There are also a few small oxbows between Thamesville and Chatham which are now wetlands.

2.5.2 Discharge Volume

The size of a river is measured by the amount of discharge, which is the volume of water flowing through a cross section of the stream channel per unit time, and is measured in cubic metres per second (cms). The Thames is the largest river tributary to Lake St. Clair and is one of the largest rivers in southwestern Ontario (Table 1).

Table 1. Discharge, drainage areas and lowest average summer monthly flows of four largest river systems in southwestern Ontario, measured at most downstream hydrometric station

Water Survey of Canada Hydrometric Station	Station Number	Drainage Area (km^2)	Data Coverage	Mean Annual Discharge (m^3/sec)	Lowest Average Summer Monthly Flows (m^3/sec)
Grand River at Brantford	02GB001	5200	1913-2016	58.2	26.05
Thames River at Thamesville	02GE003	5825	1938-2016	56	15.91
Saugeen River near Port Elgin	02FC001	3950	1914-2016	58.1	17.68
Maitland River at Benmiller	02FE001	2540	1989-2016	27.3	9.09

Note: Environment and Climate Change Canada and OMNRF, Low Water Response Program (August 2016).

Climate has the largest impact on the seasonal fluctuations in river flow. The Thames River displays extreme annual flow variations with pronounced discharge peaks in March and April and discharge lows in July and August. These flow characteristics are typical of rivers throughout southern Ontario and central Canada. Low flow or ***baseflow*** conditions occur roughly from May to October.

2.5.3 Erosional and Depositional Features

A variety of erosional and depositional features can be found along the Thames River. Bank erosion is visible at many of the outside meanders, but is most dramatic in areas where there are steep bluffs, such as at the Kilworth Bridge. Some banks, especially in the Komoka area, show rotational slips, where material from the top of the bank slides down, leaving a concave shaped bank. The reach of river from Delaware to the Kent County boundary line has many examples of mass wasting (slope movement), as well as undercut bluffs and abandoned channels.

Gullies are quite evident in the Delaware to Kent County reach, especially through the Munsee Delaware Nation. Here the tributary streams cut through the sandy soil down to the base level of the river, creating steep-sided narrow gullies along their lower courses.

Pool and riffle features are common in straight and meandering rivers and the Thames contains many excellent examples. The alternating deep (pool) and shallow (riffle) areas tend to be more or less evenly spaced along the river bed of the river. These features provide excellent conditions for fish.

Sand bars and islands are also quite common, especially in the mid- and upper Thames. Many of the bars and islands are comprised of pebbles, stones and boulders. The smaller materials are renewed frequently, whereas the larger materials were likely deposited during the glacial period when the river had greater power. The vegetation growing on some islands is quite mature, suggesting these features have not been significantly altered in recent times. Point bars are common at the inside turn of a meander and are made up of finer sediments such as coarse sand and pebbles; they are ephemeral in nature, shifting and changing with the discharge. Many of these bars provide excellent turtle nesting sites.

Levees are another depositional feature prevalent in the Thames River system. Each spring alluvium (sand and silt) is deposited by floodwaters on the land adjacent to the river. Over time this area becomes raised. In the “Chatham Flats” area, this alluvium has a reddish cast that contrasts with the grey clay of the surrounding landscape which originated under glacial Lake Whittlesey (Chapman and Putnam 1984).

2.5.3.1 Thames River Mouth at Lake St. Clair

As water from the Thames River enters Lake St. Clair’s shallow waters (average depth approximately 3.7 m), there is the potential for significant impacts to the lake and the lower reaches of the Thames due to the large volume of water and material carried by the river, including debris, ice, sediments, nutrients or chemical contaminants. The sediment discharged from the Thames River into Lake St. Clair is clearly and regularly visible in satellite imagery.

Lake St. Clair is shallower near the mouth of the Thames than the river itself, due to sedimentation. An offshore sandbar near the river’s mouth can create navigational problems for recreational boaters. The river, which is approximately 5 to 7 m deep when it enters the lake, carves a path approximately 1.8 m deep across the sandbar. This deepest point across the sandbar changes every year and is marked as the navigational channel by the Canadian Coast Guard each spring. It is not clear what proportion of the sediment that forms the sandbar comes from the Thames River. Debris also settles out in the shallow waters creating further navigational challenges in this area. From 1884 to 1948, the navigational channel was dredged but such activities have since ceased.

In the lower reaches of the ***watershed***, the land is so flat and the Thames River’s gradient is so shallow that water levels on Lake St. Clair can influence water levels in the river upstream almost to Thamesville. The low lying lands downstream of the City of Chatham are at or near the water level of the lake. As a result, dykes and ***pumping schemes*** have been developed along the lower reaches and up into some of the tributaries in order to manage drainage for agricultural purposes. There is approximately 120 km of dykes along the Thames River and its major tributaries of Jeannettes Creek and Big Creek. Associated with the dykes are approximately 40 pumps managed under the Drainage Act. The Thames River itself is dyked for approximately 15 km of its length through this stretch.

The areas downstream of the City of Chatham have long been subject to flooding due to river ice jams. Even minor ice jamming can cause flooding in the community of Lighthouse Cove at the mouth of the Thames River. Large ice jams have the potential to flood large portions of the former townships of Dover, Tilbury North and Tilbury East. This flood prone area covers approximately 170 km^2.

3.0 THE THAMES RIVER SHARED WATERS APPROACH TO WATER QUALITY AND QUANTITY

The TRCWR Steering Committee decided to focus on updating the 1975 Thames River Basin Water Management Study by addressing surface water and ***groundwater*** quality and quantity in the Thames River ***watershed***. Research by the Lake St. Clair Canadian ***Watershed*** Coordination Council (2009) and the Lake Erie Lakewide Management Plan (LaMP) (2011) showed that surface water quality and quantity in the Thames River ***watershed*** were impacting Lake St. Clair and Lake Erie. The reports also highlight the importance of ***groundwater*** quality in the ***watershed*** with respect to its importance as a source of drinking water. ***Groundwater*** also supports natural heritage features, such as watercourses, wetlands, forests, etc. Changes in g***roundwater*** quantity play a significant role in habitat loss where low water levels or decreased flows affect potential areas of habitat in the ***watershed***.

Technical studies in flood forecasting, water quality monitoring and analysis, urban ***Low Impact Development (LID)***, and rural ***BMPs***, funded by MECP under the Showcasing Water Innovation (SWI) program, provided some updated background information. The MECP also provided funding for a First Nations Youth Summer Stewardship program to promote understanding of ***Indigenous*** peoples' history and traditional ecological and spiritual knowledge.

Background research from the SWI projects, combined with an understanding of the ***watershed's*** physical characteristics, current land uses, the state of local water and land resources, and existing water protection policies and programs, helped to identify critical issues in the ***watershed*** such as drought, flooding, poor water quality, climate change impacts, and rapid urbanization. Through inter-agency collaboration, recommendations were developed to address these water quality and quantity issues, such as water conservation, stewardship, rural water quality programs and ***green infrastructure***/***LID*** projects. The Thames River Shared Waters Approach is the result of this effort.

The Shared Waters Approach is a 20-year comprehensive plan that balances protection and restoration of the Thames ***watershed***, including its streams, lakes and rivers as well as ***groundwater***, wetlands and natural areas, while supporting economic and urban development. The TRCWR Steering Committee decided that the Shared Waters Approach would be adaptive to ensure flexibility and relevance for at least 20 years. The benefit of using an adaptive approach is that it addresses a wide variety of connected issues with strategies that are developed in relation to each other.

After every five years of implementation, data will be gathered to reassess the conditions and characteristics of the ***watershed*** and identify any changes. Once these changes have been evaluated, the Shared Waters Approach will be reviewed to determine what is and is not working, as well as current trends. Recommendations will be reviewed and appropriate changes will be implemented. It is anticipated that the updates of the Shared Waters Approach will consider any major changes to the actions outlined in the Canada-Ontario Lake

Erie Action Plan (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018).

Going forward, action and implementation plans for incorporating ***Indigenous Traditional Knowledge (ITK)***, as well as the water quality and water quantity recommendations contained in the Shared Waters Approach, will require resources (both funding and staff). As well, discussions will be needed with numerous groups in the ***watershed*** including, but not limited to, ***Indigenous*** People, municipalities and the agricultural community. Community-based marketing will help to identify barriers to and opportunities for implementation, with the goal of encouraging action and changing behaviour.

The success of the Shared Waters Approach depends on a consensus-based decision process to determine how to implement the recommendations that have been developed to address key water quality and quantity issues. It is acknowledged that many stakeholders and partners will play a role in addressing the resources needed to undertake the report's initiatives and recommendations.

It should be noted that the three subcommittees (First Nations Engagement, Water Quality, and Water Quantity) each used different processes to develop their mission, goals, recommendations and, in the case of water quantity, proposed actions.

The First Nations Engagement subcommittee developed a mission statement, three goals to achieve that mission, and recommendations to reach each goal.

The Water Quality Technical subcommittee developed a mission statement and three goals to achieve that mission. Each subcommittee partner then developed their own specific recommendations to meet each goal, along with supporting rationale. Each partner's recommendations and rationale for each goal were then grouped into three areas: research and monitoring; stewardship and outreach; and acts, policies and regulations.

The Water Quantity Technical subcommittee developed a mission statement and four goals to achieve that mission. They then developed common recommendations, rationale and proposed actions to meet each goal.

3.1 FIRST NATIONS MISSION, GOALS & RECOMMENDATIONS

Mission Statement:
THE IMPORTANCE OF *INDIGENOUS TRADITIONAL KNOWLEDGE (ITK)* IN RESOLVING ENVIRONMENTAL ISSUES IS RECOGNIZED AND INCLUDED IN DECISION-MAKING AROUND WATER PROTECTION.

The pervasiveness of the traditional view of water and the related stewardship role for First Nations is stated in The Water Declaration of the Anishinaabek, Mushkegowuk and Onkwehonwe (Section 1.1.2.1). The Water Declaration provides a strong sense of how the goal of protecting water should be pursued. As well, ***ITK*** is not limited to the boundaries of the ***watershed***, but considers the greater context of the Great Lakes. The Thames ***watershed*** is part of a corridor from Lake Huron to Lake Erie, and the interconnectedness of this is considered in ***ITK***. For example, fishing, hunting and trade connects to a much larger area than the ***watershed*** boundary. Three goals have been developed to ensure that ***ITK*** has been incorporated.

- **Goal 1: Formalize a process where the spirit of the water is recognized**
- **Goal 2: Improve involvement of First Nation communities**
- **Goal 3: Improve awareness of First Nation communities**

The following tables provide a rationale and recommendations for each goal.

Please see Appendix B for additional rationale.

3.1.1 Goal 1: Formalize a process where the spirit of water is recognized

GOAL 1: FORMALIZE A PROCESS WHERE THE SPIRIT OF THE WATER IS RECOGNIZED
RATIONALE: • First Nations recognize the sacredness of water, the interconnectedness of all life, and the importance of protecting water from pollution, drought and waste. • Water is, and always has been, viewed by ***Indigenous*** people as a fundamental life-giving force. Water has medicinal properties, as well as cleansing and purifying powers, and should be collected and handled in certain ways. Respect must be shown to water, and is frequently expressed by offering tobacco. • Water is the interconnection among all living beings. Water sustains us, flows between us and within us, and replenishes us. • Water is significant to the lives of First Nation peoples on personal, community, clan, national and spiritual levels and must be protected and nurtured; it is not a commodity to be bought and sold. • The First Nation peoples of North America have a special relationship with water, built on our subsistence ways of life that extend back thousands of years. Traditional activities depend on water for transportation, drinking, cleaning and purification, and water provides habitat for the plants and animals gathered as medicines and foods. The ability to access good water shapes these traditional activities and relationships with the surroundings.
Recommendations
1. Acknowledge the spiritual value of the water with seasonal ceremonies. 2. Consider a spiritual value assessment as part of the consultation process. 3. Conduct a spiritual value assessment for the Thames River. 4. Incorporate teachings from Water Gatherings and other ceremonies: a. Consider seven generations; b. Prepare for change; c. Foster an understanding that water is more than a resource; d. Offer tobacco. 5. Develop a Spirit of the Water treaty to govern interactions with the water. 6. Give personhood rights to the river. 7. Engage First Nation communities to gather stories of spiritual connection to water. 8. Identify activities, projects and programs that bring people back to the river, help link people with the river and maintain that connection.

3.1.2 Goal 2: Improve involvement of First Nation communities

GOAL 2: IMPROVE INVOLVEMENT OF FIRST NATION COMMUNITIES

RATIONALE:

- Traditional knowledge developed over the millennia should not be compromised by an over-reliance on relatively recent and narrowly defined western reductionist scientific methods.
- Women play an important role in First Nation cultures as spokespersons for water and they carry the primary responsibility for protecting that water.

Recommendations

1. Make connections through interactive social events and meals.
2. Present to chief and council since council minutes are public.
3. Meet with the Environmental Committee of each First Nation where applicable.
4. Meet with Elder and Youth Advisory Councils.
5. Offer volunteer and paid opportunities to build interest and capacity.
6. Tailor engagement process to each First Nation community.
7. Identify cooperative opportunities to share professional experience.
8. Consider ***Indigenous Traditional Knowledge*** in all decision and policy making exercises around water protection.

3.1.3 Goal 3: Improve awareness of First Nation communities

GOAL 3: IMPROVE AWARENESS OF FIRST NATION COMMUNITIES

RATIONALE:

- The Truth and Reconciliation Commission of Canada (TRC) made 94 specific calls to action to redress the legacy of residential schools and advance the process of Canadian reconciliation. Eight of these recommendations ask for training that includes education on Aboriginal history, the legacy of residential schools, treaties and ***Indigenous*** rights, ***Indigenous*** law, Aboriginal - Crown relations, conflict resolution, human rights and anti-racism.

Recommendations

1. Provide both cultural awareness and sensitivity training.
2. Encourage teachings of natural law in the district school boards.
3. Acknowledge traditional territory and treaty lands.

3.2 WATER QUALITY MISSION, GOALS & RECOMMENDATIONS

Mission Statement:

TO PROTECT AND IMPROVE WATER QUALITY IN THE THAMES RIVER *WATERSHED* IN ORDER TO IMPROVE STREAM HEALTH AND THE POTENTIAL IMPACT OF THE THAMES RIVER ON LAKE ST. CLAIR AND LAKE ERIE.

- **Goal 1: Reduce total and *soluble reactive phosphorus loads* from the Thames River and reduce overall *phosphorus concentrations* in the river and its tributaries.**
- **Goal 2: Reduce soil erosion from land and maintain geomorphic processes across the *watershed*.**
- **Goal 3: Improve water quality to support improved stream health, including aquatic life.**

The following tables provide a rationale and recommendations for each goal, grouped into three areas:

- Research and monitoring;
- Stewardship and outreach; and
- Acts, policies and regulations.

The recommendations are listed separately for each TRCWR partner (i.e., First Nations, agencies, conservation authorities, municipalities).

Please see Appendix C for more extensive supporting rationale.

3.2.1 Goal 1: Reduce total and *soluble reactive phosphorus loads* from the Thames River and reduce overall *phosphorus concentrations* in the river and its tributaries

3.2.1.1 Research & Monitoring Recommendations

GOAL 1: REDUCE TOTAL AND *SOLUBLE REACTIVE PHOSPHORUS LOADS* FROM THE THAMES RIVER AND REDUCE OVERALL *PHOSPHORUS CONCENTRATIONS* IN THE RIVER AND ITS TRIBUTARIES
Research & Monitoring Recommendations

RESEARCH & MONITORING - RATIONALE:

- Decades of excess nutrient use in the Thames River ***watershed*** have resulted in nutrient enrichment in the river system, contributing to algal blooms in Lakes St. Clair and Erie, as well as the Thames and its tributaries. ***Phosphorus (P)*** sources across the Thames ***watershed*** include fertilizer, animal/human waste and other organic matter.
- The recent resurgence of harmful algal blooms in Lake St. Clair and the expansion of ***hypoxia*** in the Lake Erie central basin have led to the Thames River being identified as a binational priority Canadian tributary. In order to reduce nearshore ***cyanobacterial blooms***, a target has been established of a 40% reduction in spring ***P loads*** from 2008 levels. Reductions in the Thames River P also contribute to achieving the central basin P target.
- Since the 1960s, many water quality monitoring programs and studies have monitored P concentrations in the Thames River to understand local conditions and stream health over time, but most were not specifically designed to determine ***P loads*** from the Thames.
- Optimal monitoring for ***P loads*** requires frequent sample collection that is year-round, throughout the range of flow conditions, more frequent during high flow events, and supported by continuous flow data at the sampling locations.
- ECCC began monitoring Thames River ***P loads*** at Thamesville in 2012 and this information is used to measure progress towards achieving the Thames River ***P load*** reduction target of 40%. Early results indicate total annual ***P loads*** vary widely depending on annual flows, but average 325 tonnes with approximately 80% of ***P loadings*** occurring during storm events mainly in winter and spring. Various partners are also monitoring ***P loads*** as part of small ***subwatershed*** studies looking at the impact of land use and ***BMPs*** on ***P loads*** in Medway, Nissouri, Big, and Jeanettes Creeks.
- Since the 1970s, extensive research and monitoring studies have been conducted to understand sources and transport of nutrients in the Thames ***watershed***, with information used to develop implementation programs. Recent harmful algae blooms have renewed the focus on nutrient research in the Thames ***watershed***. A 2015 study (Nurnberg and LaZerte 2015a) completed for the UTRCA assessed 24 years of water quality data (83 stations), flow data (26 stations), and ***wastewater treatment plants*** (30) from across the Thames ***watershed***. The study determined that ***nonpoint*** rural and urban sources contribute approximately 87% of the Thames ***P load*** and that the majority of ***P loads*** occur in winter/spring runoff. All tributaries across the entire ***watershed*** contribute to ***P loads***, which are cumulative, increasing from the headwaters to the confluence of the North and South Thames and further increasing towards the river's mouth. ***Point sources***

GOAL 1: REDUCE TOTAL AND *SOLUBLE REACTIVE PHOSPHORUS LOADS* FROM THE THAMES RIVER AND REDUCE OVERALL *PHOSPHORUS CONCENTRATIONS* IN THE RIVER AND ITS TRIBUTARIES *Research & Monitoring Recommendations*
(urban ***wastewater treatment plants***) contribute approximately 13% of the Thames ***P load***. • Newer issues, such as more extreme weather events and changing land use practices, require continued work to adapt best practices for ***P load*** reduction and develop new approaches to implementation.
First Nations Recommendations
1. Ensure that First Nations are involved in monitoring any projects near First Nation community lands to build trust in the process and the results, and to build capacity in the community. 2. Measure ***wastewater*** output from First Nation communities, if possible, in order to determine ***phosphorus load***, develop acceptable criteria and determine reduction. 3. Measure ***phosphorus*** in sections of the river that border First Nation communities. 4. Develop a raw surface water and ***groundwater*** monitoring program for nutrients in interested First Nation communities.
Environment and Climate Change Canada (ECCC) Recommendations
1. Canada, with Ontario's support, will continue to work with conservation authorities and other partners to identify ***phosphorus*** sources and develop ***phosphorus*** reduction management strategies and plans for the Thames River ***watershed***. 2. Canada, Ontario and conservation authorities began in 2017 to implement a nested ***watershed*** monitoring approach in the Thames River and will continue to model and track nutrient dynamics and changes over time. 3. Canada will continue to investigate the exchange of nutrients between ***groundwater*** and surface water in the Thames River ***watershed*** to better understand the relationship between seasonal and year-to-year nutrient fluxes, land use and climate variations.
Ontario Ministry of the Environment, Conservation and Parks (MECP) Recommendations
1. Continue information gathering to help identify ***nonpoint sources*** and specific facilities within the ***watershed*** with potential to impact the Thames River and its tributaries. Actions: a. Support monitoring efforts to confirm the environmental benefits of ***Low Impact Development (LID)***. b. Support monitoring that identifies sources and source areas, and monitors changes from specific facilities, specific areas within the ***watershed*** and ***nonpoint sources***. c. Support the implementation and integration of monitoring data systems using the Water Information System by Kisters (WISKI) amongst Thames River partners to

GOAL 1: REDUCE TOTAL AND *SOLUBLE REACTIVE PHOSPHORUS LOADS* FROM THE THAMES RIVER AND REDUCE OVERALL *PHOSPHORUS CONCENTRATIONS* IN THE RIVER AND ITS TRIBUTARIES
Research & Monitoring Recommendations

increase access and support information sharing.

2. Continue to assess the water quality conditions of Lake St. Clair and the Thames River for the purposes of determining the severity and spatial scope of harmful algal blooms (HABs) and to identify the mechanistic drivers underlying the observed water quality and HABs patterns of these highly dynamic systems.

Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) Recommendations

1. Continue to gather, analyze and share edge of field monitoring data resulting from field studies of ***BMP*** implementation and other agricultural research to support ***phosphorus*** loss reduction efforts aligned with the Canada-Ontario Lake Erie Action Plan (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018).
2. Prioritize applied research and monitoring projects to assess ***BMP*** effectiveness when delivering cost share and other funding programs.

Ontario Ministry of Natural Resources and Forestry (OMNRF) Recommendations

1. Support updates of spatial data that identify the current baseline and change over time of vegetation cover including wetland, prairie, woodland and riparian corridors at a ***subwatershed*** level.
2. Collaboratively determine optimal target percentage cover for natural features that will filter ***phosphorus***, such as wetlands and riparian / in-stream vegetation, and work with partners to develop priorities for ***subwatersheds*** requiring enhancement.
3. Support effective monitoring and associated ***subwatershed*** enhancements.
4. Explore with partners the natural enhancement of the ***floodplain*** as a means to trap and transfer ***phosphorus*** to the terrestrial and/or local aquatic ***ecosystem***.

Conservation Authority (CA) Recommendations

1. Enhance monitoring along the river to measure progress towards Thames River ***phosphorus*** reduction loading targets.
   Actions:
   a. Assist partner agencies, as needed, to maintain the Thamesville automated monitoring station for the long term (2025+) to measure ***phosphorus loads***, using standardized load monitoring protocol.
   b. Work with partner agencies to determine monitoring needs and add/maintain long term stations at additional locations as needed along the Thames.
   c. Identify information gaps where more information is needed on impoundments and ***phosphorus*** processes.
   d. Work with partners to advance and develop best practices, where needed, for priority actions that will have the most impact in ***phosphorus load*** reduction,

GOAL 1: REDUCE TOTAL AND *SOLUBLE REACTIVE PHOSPHORUS LOADS* FROM THE THAMES RIVER AND REDUCE OVERALL *PHOSPHORUS CONCENTRATIONS* IN THE RIVER AND ITS TRIBUTARIES ***Research & Monitoring Recommendations***
through continued research, monitoring and demonstration.
Municipal Recommendations
1. Continue to investigate / research /enhance water quality ***BMPs*** in ***stormwater management (SWM)*** facilities. 2. Focus research to develop ***phosphorus*** reduction plans that are feasible in terms of volume and economics. 3. The City of London will coordinate its water quality monitoring with the Upper Thames River Conservation Authority to aid river improvement efforts and studies. 4. The City of London will undertake a pilot project using new technologies as an alternative to conventional tertiary treatment, with the objective of achieving effluent quality of 0.1 mg/l and will, upon successful completion of the pilot project, develop a plan to roll out ***phosphorus*** reduction technologies to the five major treatment plants (subject to upper level government funding partnerships). 5. The City of London will expand its current monitoring program to prioritize the retrofitting of ***stormwater ponds***, and will develop a ***stormwater pond*** retrofit program to improve operational performance and legacy ***phosphorus*** removal. To support this program, the City of London will evaluate the need to develop a ***stormwater*** sediment handling facility with the goal of repurposing ***stormwater pond*** sediment and appropriately managing the legacy ***phosphorus*** contained within it (subject to upper level government funding partnerships).

3.2.1.2 Stewardship & Outreach Recommendations

GOAL 1: REDUCE TOTAL AND *SOLUBLE REACTIVE PHOSPHORUS LOADS* FROM THE THAMES RIVER AND REDUCE OVERALL *PHOSPHORUS CONCENTRATIONS* IN THE RIVER AND ITS TRIBUTARIES
Stewardship & Outreach Recommendations

STEWARDSHIP AND OUTREACH - RATIONALE:

- Approximately 87% of the ***phosphorus load*** from the Thames River is from ***nonpoint*** agricultural and urban sources. Small load contributions across thousands of sites create the overall ***phosphorus load*** delivered from the ***watershed***.
- Controlling ***nonpoint sources*** requires changes on individual sites across the ***watershed*** and must be site-specific to particular land management and site characteristics.
- Approximately 80% of the ***P load*** occurs during storm events, mainly in winter-spring runoff (non-growing season).
- ***BMPs*** should focus on efforts to reduce peak flows and rate of runoff from land across the entire ***watershed***, to minimize nutrient loss from land during peak loading times. Changing climate trends with more extreme storm events are increasing the importance of rural and urban ***stormwater management***.
- Land use within the Thames River ***watershed*** is approximately 75% agricultural with highly productive farmland. The approach to reducing ***phosphorus*** runoff from agricultural lands can vary between operations due to the variability in soils, topography and agricultural systems across the ***watershed***. Agricultural ***BMPs*** that improve nutrient management, build soil health and slow the flow of water from the land will help to reduce nutrient loss from agricultural lands while maintaining productivity.
- Current ***BMPs*** for urban ***nonpoint source*** loadings focus on ***stormwater*** runoff. Urban ***stormwater management*** uses various ***BMPs*** that retain, slow down and infiltrate runoff to reduce runoff volumes and improve runoff quality. ***SWM*** strategies may include protecting/creating natural areas or features that slow down overland flow and provide storage capacity, designing communities that incorporate landscape approaches to slow storm runoff generation, using ***Low Impact Development (LID)*** techniques, and implementing pollution prevention stewardship programs.
- Across the ***watershed***, it is important to maintain natural heritage features, such as wetlands, ***floodplains*** and riparian buffers, which slow runoff, increase infiltration and utilize nutrients.

First Nations Recommendations

1. Ensure that First Nations are involved in any projects near First Nation lands to build trust in the process and to improve communication and engagement.
2. Partner with OMAFRA and the Indian Agricultural Program of Ontario to establish site specific farming practices for First Nation lands being leased to farmers.
3. Provide greater transparency about farming practices on the leased land as lease agreements are between each farmer, First Nation community members, band administration and Indian and Northern Affairs Canada.
4. Share ***Indigenous Traditional Knowledge (ITK)*** about options and approaches for

GOAL 1: REDUCE TOTAL AND *SOLUBLE REACTIVE PHOSPHORUS LOADS* FROM THE THAMES RIVER AND REDUCE OVERALL *PHOSPHORUS CONCENTRATIONS* IN THE RIVER AND ITS TRIBUTARIES

Stewardship & Outreach Recommendations

increased sustainability in crop and livestock production.

5. Decrease the rate of habitat loss, especially wetlands, within First Nation communities.

ECCC Recommendations

1. Canada and Ontario will explore the development of initiatives that support the implementation of local actions within high-risk areas for ***phosphorus loadings*** in the western and central basins of Lake Erie, including the Thames River ***watershed***.
2. Canada will create an application-based funding program in 2018 that provides $4.1 million over four years in financial support for projects demonstrating effectiveness of ***BMPs*** and/or innovative approaches to reducing ***phosphorus loads*** to Lake Erie, including the Thames River ***watershed***.
3. Canada, with support from its partners, will continue to develop, improve and apply Soil and Water Assessment Tool models in the Thames River to identify, and provide advice to partners on, strategies for optimizing ***BMPs***.

MECP Recommendations

1. Promote ***LID*** as part of the treatment train approach to ***stormwater management*** by supporting education and outreach efforts to municipalities (e.g., municipal engineers, planners, designers, construction, and operation and maintenance staff) and ***CAs*** (engineers, technologists, inspection staff, designers, planners) involved in ***stormwater management***, planning, designing, reviewing, approval, construction, and maintenance and inspection activities.
   <u>Actions:</u>
   a. Support incorporating new provincial guidance into manuals and other outreach and education materials for ***stormwater management*** based on reviews of current systems.
   b. Support outreach and education initiatives with various municipalities, schools and school boards and conservation authorities to expand awareness and implementation of ***LID*** and ***green infrastructure*** projects.
   c. Support developing a comprehensive monitoring program for the ***SWM LID*** in the ***watershed***.
   d. Support increasing technical staff capacity for the design, review, inspection and monitoring of the ***SWM LID*** projects across the ***watershed***.
2. Work with developers, municipalities, conservation authorities and others to promote and support the use of ***green infrastructure*** and ***LID*** systems for ***stormwater management***, including clarifying and enhancing policies as well as developing green standards. Ontario's draft ***stormwater LID*** guidance manual is aimed at helping proponents implement ***LID*** and ***green infrastructure***.
   3. Ontario and Canada, along with their partners will work together on the implementation of the Canada-Ontario Lake Erie Action Plan (Environment and

GOAL 1: REDUCE TOTAL AND *SOLUBLE REACTIVE PHOSPHORUS LOADS* FROM THE THAMES RIVER AND REDUCE OVERALL *PHOSPHORUS CONCENTRATIONS* IN THE RIVER AND ITS TRIBUTARIES
Stewardship & Outreach Recommendations

Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018), including efforts to reduce ***phosphorus loadings*** to the Thames River and Lakes St. Clair and Erie.

OMAFRA Recommendations

1. Continue to encourage the adoption of ***BMPs*** on farms in the Thames River ***watershed***.
   Actions:
   a. Improve soil health and resiliency by using more complex ***crop rotations***, including wheat and perennial forages.
   b. Increase infiltration, reduce erosion potential and improve soil health by using reduced tillage approaches including ***no-till*** and ***strip till***, to maintain more crop residue on the surface.
   c. Protect soils from erosion by planting and maintaining ***cover crops*** through the non-growing season to protect soils. Minimize nutrient loss and maximize crop uptake with nutrient management planning through 4 Rs approach (right source, right rate, right time, and right place). Avoid nutrient application in the non-growing season.
   d. Reduce streambank erosion, filter nutrients and sediment, reduce wind erosion, increase habitat, and help store water in the landscape by planting vegetated buffers / corridors along watercourses.
   e. Minimize nutrient losses from manure storages and livestock housing.
   f. Reduce erosion by engineering solutions to slow water down as it leaves the landscape (e.g., water and sediment control basins, terraces, controlled drainage, two-stage ditches, grassed waterways, end-of-pipe treatment ponds, filters, and constructed wetlands).
2. Promote ***phosphorus*** reductions from agricultural sources in accordance with the Canada-Ontario Lake Erie Action Plan (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018) to reduce ***phosphorus loadings*** to the Thames River and Lakes St. Clair and Erie.

OMNRF Recommendations

1. Collaboratively support outreach and stewardship work with partners and landowners to increase quantity and quality of natural vegetation cover on the landscape, including wetlands, riparian buffers, prairie and wooded areas.

CA Recommendations

1. Expand implementation of urban and rural ***BMPs*** that will have the most significant impact in reducing ***phosphorus*** and erosion runoff across the ***watershed***.
   Actions:

GOAL 1: REDUCE TOTAL AND *SOLUBLE REACTIVE PHOSPHORUS LOADS* FROM THE THAMES RIVER AND REDUCE OVERALL *PHOSPHORUS CONCENTRATIONS* IN THE RIVER AND ITS TRIBUTARIES
Stewardship & Outreach Recommendations

a. Expand the existing rural Clean Water Program to deliver an enhanced program targeted at best practices for ***phosphorus*** reduction across the entire UTRCA and LTVCA jurisdictions.
    i. Increase work with landowners to target the suite of priority actions for P and sediment loss reduction.
b. Expand the existing ***LID*** program to develop new design standards specifically for the Thames River ***watershed*** as per local ***watershed*** conditions and needs.
    i. Enhance CA technical capacity to implement the local design standards and policies with partners.
    ii. Increase capacity for education, outreach, and technical assistance to promote widespread adoption of ***LID***.
    iii. Expand work with developers, consultants, and municipal partners to collaborate on implementation of new policies and design standards for ***green infrastructure***.
c. Protect and enhance natural vegetation cover on the landscape.
    i. Advocate for natural vegetation restoration and protection.
d. Continue to use demonstration ***subwatersheds*** to engage landowners, increase adoption of ***BMPs***, measure environmental and economic benefits, and educate and motivate the broader ***watershed*** community.
e. Encourage practices that reduce peak flows and rate of runoff across the ***watershed***, to minimize nutrient loss.
    i. Work to establish optimal rates of drainage from land with consideration to reducing/managing peak flows of rural ***stormwater*** runoff across the system.
    ii. Work with drainage partners to review agricultural municipal drainage coefficients to determine optimal rates of water removed from land over time.
    iii. Implement projects to reduce rate of runoff (e.g., ***bioswales***, pervious pavement).
f. Develop and promote an urban nutrient reduction program with stakeholders.
g. Implement community based social marketing for ***watershed*** community action on nutrient reduction.
    i. Expand education and outreach on benefits of ***BMPs*** on nutrient reduction, including financial benefits.
    ii. Engage all sectors, including youth, on ***phosphorus*** issues.

Municipal Recommendations

1. Enhance public education and outreach including school programs, programs focused on the impacts of road drainage (such as Yellow Fish Road markings on catch basins, Stream Of Dreams, DePave Paradise), and information on the role of individual lot drainage and its impact on ***stormwater*** systems.

GOAL 1: REDUCE TOTAL AND *SOLUBLE REACTIVE PHOSPHORUS LOADS* FROM THE THAMES RIVER AND REDUCE OVERALL *PHOSPHORUS CONCENTRATIONS* IN THE RIVER AND ITS TRIBUTARIES
Stewardship & Outreach Recommendations

2. Continue to plan and fund sanitary system improvements including those that reduce overflows and bypasses at ***wastewater treatment plants*** and pumping stations.
3. The City of London will accelerate plans for separation of ***combined sewers***, including the design and construction of necessary ***stormwater*** outlets, with the target of separating 80% (17 km) of the City's ***combined sewer system*** by 2025 (subject to upper level government funding partnerships).
4. The City of London will circulate for agency and public review an implementation plan that provides the scope and timing for managing the highest priority sanitary sewer overflows as identified in the City's Pollution Prevention and Control Plan. To support the implementation, the City of London will facilitate a proof of concept in-field project of high-rate treatment technologies with the support of local industry and academic partners, and will continue its private property weeping tile disconnection program.
5. The City of London will incorporate ***LID*** and adaptive environmental management principles into the Dingman Creek ***subwatershed*** using the MECP's area-wide Environmental Compliance Approval pilot project, and will implement a program to maximize the treatment and infiltration of ***stormwater*** using ***LID*** technologies in built-out areas in coordination with the City's linear infrastructure renewal program (subject to upper level government funding partnerships).
6. Encourage, on a case by case basis, ***LID*** and other ***phosphorus*** reduction methods in redevelopment / retrofits.

   Actions:

   a. Remove excess inflow and infiltration by disconnecting private weeping tiles/foundation drains from the sanitary sewer in older urban areas (e.g., in London homes built between 1920 and 1985).
   b. Consider the use of ***stormwater*** master plans in smaller municipalities (e.g., Town of Ingersoll) that may have open ditches, to better control ***stormwater*** and address ***phosphorus loadings***.
   c. Consider using trees to help improve water quality and augment capacity of existing ***stormwater management*** systems.
   d. Prevent the loss of wetlands and/or encourage reinstatement of wetlands that have been lost.

3.2.1.3 Acts, Policies & Regulations Recommendations

GOAL 1: REDUCE TOTAL AND *SOLUBLE REACTIVE PHOSPHORUS LOADS* FROM THE THAMES RIVER AND REDUCE OVERALL *PHOSPHORUS CONCENTRATIONS* IN THE RIVER AND ITS TRIBUTARIES
Acts, Policies & Regulations Recommendations

ACTS, POLICIES AND REGULATIONS - RATIONALE:

- There are many policies, acts, regulations, agreements and plans that apply both directly and indirectly to reducing ***phosphorus***.
- Regulatory requirements for both ***point*** and ***nonpoint sources*** discharging to air, land or water bodies are set through key acts such as the Ontario Environmental Protection Act, the Ontario Water Resources Act, the Ontario Clean Water Act, and the Nutrient Management Act.
- In February 2016, Canada and the United States established 40% binational ***phosphorus*** reduction targets from 2008 levels for priority ***watersheds*** and the central basin of Lake Erie, under the Great Lakes Water Quality Agreement. Canada, Ontario, and partners are working together through the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health (see Appendix C).
- In October 2016, Ontario established the target of a 40% ***phosphorus load*** reduction by 2025 (from 2008 levels), using an adaptive management approach, for the Ontario portion of the western and central basins of Lake Erie, as well as an aspirational interim goal of a 20% reduction by 2020 to address algal blooms, as required under the Great Lakes Protection Act, 2015.
- The Canada-Ontario Lake Erie Action Plan (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018) identifies more than 120 federal, provincial and partner actions to help achieve the goal of reducing ***phosphorus*** entering the central basin of Lake Erie by 40% (from 2008 levels).
- On June 13, 2015, Ontario signed the Western Basin of Lake Erie Collaborative Agreement with Michigan and Ohio, collectively committing, through an adaptive management process, to a 40% total load reduction in the amount of total and ***dissolved reactive phosphorus*** entering Lake Erie's western basin by the year 2025 with an aspirational interim goal of a 20% reduction by 2020 (from a 2008 base year).
- Ontario worked with Lake Erie States through the Great Lakes Commission's Lake Erie Nutrient Targets Working Group on a Joint Action Plan for Lake Erie, which was adopted by the Commission on September 29, 2015, and contains 10 actions to help achieve a proposed 40% ***phosphorus load*** reduction to Lake Erie's western and central basins by 2025.

First Nations Recommendations

1. Develop agricultural management laws (through Land Code, band bylaw, etc.) in First Nation communities to address ***phosphorus*** use and discharge on leased land in First Nation communities.

GOAL 1: REDUCE TOTAL AND *SOLUBLE REACTIVE PHOSPHORUS LOADS* FROM THE THAMES RIVER AND REDUCE OVERALL *PHOSPHORUS CONCENTRATIONS* IN THE RIVER AND ITS TRIBUTARIES

Acts, Policies & Regulations Recommendations

ECCC Recommendations

1. Canada and Ontario will build on existing governance structures to ensure partner participation in the implementation of the Canada-Ontario Lake Erie Action Plan (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018). Parties identified in the plan will work together to develop an implementation plan that establishes timelines for actions and expected ***phosphorus*** reductions (as applicable), identifies lead agencies, and determines the investment required.

MECP Recommendations

1. Maintain focused environmental surveillance, inspection, compliance and enforcement of regulatory requirements (e.g., ***point source*** discharges and incident response).
2. Encourage responsible nutrient application and storage through the preparation of Nutrient Management Plans and Strategies. The Ministry inspectors encourage compliance with these activities and support the agricultural community in implementing elements of the Nutrient Management Act.

OMAFRA Recommendations

1. Encourage responsible nutrient application and storage through the preparation of regulated Nutrient Management Plans and Strategies that are required under the Nutrient Management Act, and also incorporate elements of the 4Rs approach.

OMNRF Recommendations

1. Work collaboratively with partners to implement actions outlined in A Wetland Conservation Strategy for Ontario 2017-2030, toward halting the ***net loss*** of wetlands and achieving a ***net gain*** in these features, which remove nutrients.

CA Recommendations

1. Work with municipalities to strengthen policies and bylaws to preserve natural cover.
2. Expand ***LID*** program to promote and enhance policies specifically for the Thames River ***watershed*** as per local ***watershed*** conditions and needs.
3. Continue to work with partners to support and implement programs and/or applicable policies that aim to reduce ***phosphorus***.

Municipal Recommendations

1. Encourage / implement natural vegetative cover along watercourses through policy (e.g., Official Plan, development agreements).

GOAL 1: REDUCE TOTAL AND *SOLUBLE REACTIVE PHOSPHORUS LOADS* FROM THE THAMES RIVER AND REDUCE OVERALL *PHOSPHORUS CONCENTRATIONS* IN THE RIVER AND ITS TRIBUTARIES
Acts, Policies & Regulations Recommendations

Actions:

a. Support programs that reinforce the need and desire to continue to acquire and designate ***floodplain*** lands for the purpose of both public access/safety and the maintenance of a vegetative corridor (e.g., London's Thames Valley Corridor Study (2011)).
b. Ensure valley lands with natural attributes that remove nutrients are maintained or restored through the land use subdivision process (e.g., park land dedication, wetland retention).
c. Encourage urban land use practices such as vegetated buffers adjacent to waterways, to improve water quality.

2. Consider ***phosphorus*** when developing ***stormwater management*** strategies and master plans.
3. Carry out periodic reviews and updates of all ***wastewater*** bylaws.

3.2.2 Goal 2: Reduce soil erosion from land and maintain geomorphic processes across the *watershed*

3.2.2.1 Research & Monitoring Recommendations

GOAL 2: REDUCE SOIL EROSION FROM LAND AND MAINTAIN GEOMORPHIC PROCESSES ACROSS THE *WATERSHED*   ***Research & Monitoring Recommendations***
RESEARCH AND MONITORING - RATIONALE: • Stream geomorphology refers to the geometry (shape) of a river or stream, which changes over time. It is affected by in-stream characteristics, such as slope, bed and bank material, flows, as well as erosion and deposition processes. When excess sediment is added to a waterway, through soil erosion, an imbalance occurs. • Water and wind erosion are key processes in degrading soils and affecting stream quality. Erosion from overland flow contributes to serious water quality degradation through sheet, rill and gully erosion. • Adverse impacts on aquatic habitat from suspended sediment in the Thames River include effects on fish, plants, insects and other invertebrates. • While there is a general understanding of annual soil loss, more information is needed to better assess seasonal variability in order to effectively improve stream health, including aquatic life. There is a need to better understand sediment and erosion transport in the river, including factors such as future river movement (meandering) and steep slopes. • There is a need for more local studies to monitor rural and urban ***BMPs*** to evaluate their effectiveness in controlling soil loss, determine optimum location, identify barriers to implementation, and understand the impacts of climate change.
First Nations Recommendations
1. Ensure that First Nations are involved in monitoring any projects near First Nation communities / lands to build trust in the process and in the results, as well as to build capacity in the community and improve communication and engagement. 2. Create research and monitoring opportunities for youth where possible. 3. Undertake better monitoring and mapping of erosion hot spots in First Nation communities.
ECCC Recommendations
1. Canada, Ontario and conservation authorities began in 2017 to implement a nested ***watershed*** monitoring approach in the Thames River and will continue to model and track nutrient dynamics and changes over time. 2. Canada will continue to investigate the exchange of nutrients between ***groundwater*** and surface water in the Thames River ***watershed*** to better understand the relationship between seasonal and year-to-year nutrient fluxes, land use and climate variations.

GOAL 2: REDUCE SOIL EROSION FROM LAND AND MAINTAIN GEOMORPHIC PROCESSES ACROSS THE *WATERSHED*   ***Research & Monitoring Recommendations***
MECP Recommendations
1. Promote implementation and monitoring of projects addressing erosion and sediment control from rural and urban sources, including active construction sites and development projects. 2. Provide information to educate and train the community on the implementation of ***LID*** and erosion and sediment control practices.
OMAFRA Recommendations
1. Continue to promote research and monitoring of erosion control ***BMP*** implementation on farms from a soil health perspective. 2. Share monitoring information, as appropriate, to support erosion control efforts in reducing soil losses from agricultural fields. 3. Prioritize applied research and monitoring projects to assess ***BMP*** effectiveness when delivering cost share and other funding programs.
OMNRF Recommendations
1. Support updates of spatial data that identifies the current baseline and change over time of vegetation cover, including wetland, prairie, woodland and riparian corridors, at a ***subwatershed*** level. 2. Collaboratively determine an optimal target percentage vegetation cover for each ***subwatershed*** and develop a prioritized work plan of ***subwatersheds*** requiring enhancement. 3. Support effective monitoring and associated ***subwatershed*** enhancements. 4. Explore natural enhancement of the ***floodplain*** as a means to trap sediment.
CA Recommendations
1. Identify and evaluate potential erosion hot spots, and recommend and implement a suite of ***BMPs***, where feasible. 2. Continue to promote routine maintenance of erosion control structures. 3. Work with member municipalities to implement a more effective program to monitor, inspect and enforce erosion and sediment control measures at construction sites. 4. Increase our understanding of the seasonal variability of field-scale soil loss. 5. Use best available data and local knowledge to develop targets for natural vegetation cover for each ***subwatershed***.
Municipal Recommendations
1. Use geomorphic analysis on a river reach basis, whenever possible, to understand meander patterns. 2. Capitalize on academic research opportunities to better understand the river in a

GOAL 2: REDUCE SOIL EROSION FROM LAND AND MAINTAIN GEOMORPHIC PROCESSES ACROSS THE *WATERSHED* *Research & Monitoring Recommendations*
changing climate and to seek improved methods of monitoring urban and rural impacts and adaptation strategies.

3.2.2.2 Stewardship & Outreach Recommendations

GOAL 2: REDUCE SOIL EROSION FROM LAND AND MAINTAIN GEOMORPHIC PROCESSES ACROSS THE *WATERSHED*
Stewardship & Outreach Recommendations

STEWARDSHIP & OUTREACH - RATIONALE:

- Tillage practices, vegetation clearing, site grading and construction activities can all expose soil to wind and water, increasing the potential for soil to be delivered to watercourses.
- The erosion potential of Ontario's agricultural soils is significant, due to factors such as soil type and slope. An estimated 54% of Ontario's farmland is in an unsustainable erosion risk category (OMAFRA 2016). The economic impacts of soil loss on yields are significant.
- All erosion control methods are based on preventing soil detachment or reducing the carrying power of wind and water, which may be exacerbated by extreme weather events due to climate change.
- Conservation measures should slow the rate and volume of overland runoff, reducing erosion and keeping sediment out of the Thames River. Delaying peak flows reduces the erosive impacts further downstream.
- Urban ***stormwater management*** strategies include designing communities that incorporate landscape approaches to slow storm runoff generation, and using site-specific ***BMPs*** such as ***Low Impact Development (LID)*** techniques.
- In rural areas, a suite of soil management ***BMPs*** can be employed to prevent and reduce soil erosion as well as improve soil health. ***BMPs*** can keep the soil covered, protect the soil surface from concentrated water flows, and manage the movement of water, reducing erosion and runoff.
- Across the ***watershed***, it is important to protect and create natural heritage features, such as wetlands, ***floodplains*** and riparian buffers, which slow and absorb runoff, helping to settle out sediment.

First Nations Recommendations

1. Create opportunities for youth to increase awareness and importance of environmental work.
2. Ensure that First Nations are involved in any projects near First Nations lands to build trust in the process and to improve communication and engagement.
3. Increase occurrences of softer natural shorelines (less shoreline hardening, i.e., sheet piling).
4. Develop a native species planting program for future plantings along the river shoreline.
5. Restore tributaries in the Lower Thames and encourage natural channel design to decrease erosion.
6. Improve spiritual connection of First Nation youth and non-native communities with water, and increase their awareness of the importance of clean water through teachings (water is the blood of Mother Earth).
7. Decrease rate of habitat loss, especially wetlands, within First Nation communities.

GOAL 2: REDUCE SOIL EROSION FROM LAND AND MAINTAIN GEOMORPHIC PROCESSES ACROSS THE *WATERSHED* ***Stewardship & Outreach Recommendations***
ECCC Recommendations
1. Canada, with support from its partners, will continue to develop, improve and apply Soil and Water Assessment Tool (SWAT) models in the Thames River to identify and provide advice to partners on strategies for optimizing ***BMPs***.
MECP Recommendations
1. Promote education and support training with First Nations, municipalities, ***CAs***, land developers, homebuilders associations, and the construction and landscape industries on ***LID*** opportunities and erosion and sediment control at active construction sites.
OMAFRA Recommendations
1. Continue to encourage adoption of ***BMPs*** on farms in the Thames River ***watershed***. Actions: a. Increase infiltration, reduce erosion, and improve soil health by using reduced tillage approaches, including ***no-till*** and ***strip till***, to maintain more crop residue on the surface. b. Protect soils from erosion by planting and maintaining ***cover crops*** through the non-growing season. c. Reduce streambank erosion, filter nutrients and sediment, reduce wind erosion, increase habitat, and help store water in the landscape by planting vegetated buffers along watercourses. d. Reduce erosion by engineering solutions to slow water down as it leaves the landscape (e.g., water and sediment control basins, terraces, controlled drainage, two-stage ditches, grassed waterways, end-of-pipe treatment such as ponds, filters, and constructed wetlands). e. Increase focus on the transfer of information to producers through industry, private consultants and producer groups.
OMNRF Recommendations
1. Work collaboratively with partners to promote ***BMPs*** within the Thames River ***watershed*** that reduce surface water flow and sedimentation and reduce wind erosion. 2. Collaboratively support partners to increase quantity and quality of natural vegetation cover, including wetlands, riparian corridors, windbreaks, prairie and wooded areas, to slow down flow and allow sediments to settle and reduce wind erosion.
CA Recommendations
1. Expand and target stewardship implementation to address erosion in ***subwatersheds*** across the Thames ***watershed***. Actions:

GOAL 2: REDUCE SOIL EROSION FROM LAND AND MAINTAIN GEOMORPHIC PROCESSES ACROSS THE *WATERSHED*

Stewardship & Outreach Recommendations

a. Expand implementation programs including the existing rural Clean Water Program and urban ***LID*** program across the Thames River ***watershed*** to reduce erosion and soil loss.
b. Develop effective inspection and monitoring program for sediment and erosion control for land development.
c. Continue to implement erosion reduction projects across the ***watershed***.
d. Enhance conservation authority erosion control programs that implement ***BMPs*** with rural landowners.
e. Develop education programs for land owners, developers and construction staff.
f. Develop catchment level erosion plans.
g. Identify, restore and protect priority stream corridor sections where possible.
h. Work towards a stream corridor enhancement plan that considers appropriate buffer widths for watercourses and smaller tributaries to reduce impacts of land runoff.
i. Protect, enhance and restore wetlands to reduce downstream erosion.
j. Continue to promote buffers along streambanks to aid in erosion control and streambank stabilization.
k. Promote ***conservation tillage*** and cropping, ***cover crops***, and ***crop rotation*** involving cereals and forages.

Municipal Recommendations

1. Expand and target stewardship implementation in order to reduce soil and sediments from entering waterways directly and through ***stormwater*** sewer systems.

Actions:

a. Strengthen land use policies that help to implement watercourse vegetative buffers.
b. Naturalize public parks and recreational facilities (e.g., golf courses) by planting more and cutting less, especially near watercourses.
c. Continue to strive to incorporate natural channel design and soil bioengineering into watercourse and slope rehabilitation projects.
d. Use land use change policies to increase the ability of developers to practice the use of ***LID***.
e. Incorporate ***LID*** into municipal design guidelines for development projects in accordance with Provincial Design Guidelines.

3.2.2.3 Acts, Policies & Regulations Recommendations

GOAL 2: REDUCE SOIL EROSION FROM LAND AND MAINTAIN GEOMORPHIC PROCESSES ACROSS THE *WATERSHED*
Acts, Policies & Regulations Recommendations

ACTS, POLICIES & REGULATIONS – RATIONALE:

- Excess sediment is considered a pollutant in the context of several pieces of legislation.
- Under the Ontario Great Lakes Strategy and the Canada-Ontario Agreement, Ontario has made commitments to support efforts with stakeholders to control sources of nutrients by promoting ***LID***, ***green infrastructure***, and sediment and erosion control practices at construction sites, as well as promote sediment and erosion control from other sources in the Great Lakes, with an emphasis on the Thames River ***watershed*** and the Lake Erie basin.
- Protecting valley lands and associated erosion hazards helps maintain natural functions such as nutrient removal and sediment control.

First Nations Recommendations

1. Develop agricultural management laws (through Land Code, band bylaw, etc.) in First Nation communities to ensure buffer zones for agricultural land leased in First Nation communities along the river are being maintained and amended, as required.

ECCC Recommendations

1. Canada and Ontario will build on existing governance structures to ensure partner participation in the implementation of the Canada-Ontario Lake Erie Action Plan (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018). Parties identified in the plan will work together to develop an implementation plan that establishes timelines for actions and expected ***phosphorus*** reductions (as applicable), identifies lead agencies, and determines the investment required.

MECP Recommendations

1. Encourage training opportunities for municipal and conservation authority staff to improve the understanding and implementation of erosion and sediment control (ESC) practices.
2. Work with ***CAs***, First Nations and municipal partners to respond to concerns of potential impact associated with erosion or sedimentation.
3. Promote compliance with approval documents with respect to ESC conditions, where applicable.
   Actions:
   a. Promote and support conferences and projects on ESC.
   b. Support training to ***CAs*** and municipal staff on Certified Inspector for Sediment and Erosion Control (CISEC).
   c. Promote information sharing with other ***CAs*** and municipalities developing and delivering best practices and programs that address ESC, and the coordination

GOAL 2: REDUCE SOIL EROSION FROM LAND AND MAINTAIN GEOMORPHIC PROCESSES ACROSS THE *WATERSHED*
Acts, Policies & Regulations Recommendations

between municipalities, ***CAs*** and those involved in projects and work where erosion and sediment control are an issue.

OMAFRA Recommendations

1. Continue to support the proper installation and maintenance of erosion control structures through the Soil Erosion Control Contractors Certificate program and design standards as described in OMAFRA Publication 832: Agricultural Erosion Control Structures: A Design and Construction Manual.

OMNRF Recommendations

1. Work collaboratively with partners to implement actions outlined in A Wetland Conservation Strategy for Ontario 2017-2030, toward halting the ***net loss*** of wetlands and achieving a ***net gain***.

CA Recommendations

1. Use all relevant policy and planning guidance as a means to reduce sedimentation and erosion.
   Actions:
   a. Continue to review and comment on sediment and erosion control plans through a collaborative effort with the MECP, municipalities, local OMNRF and Department of Fisheries and Oceans.
   b. Where feasible, conduct routine construction site inspections and enforce compliance where erosion and sediment control are deficient.
   c. Support municipalities in targeting municipal infrastructure affected by erosion.
   d. Consider provincial guidance on ***LID, SWM*** and ESC as part of CA policies and/or procedures.

Municipal Recommendations

1. Implement and enforce sediment and erosion control plans for site alteration / subdivision / construction sites.
2. Consider alternative methods to regulate soil loss such as the potential role that waste discharge bylaws or sewer use bylaws could have to augment the enforcement of sediment and erosion control plans.
3. Capitalize on park land dedication opportunities during land use planning changes and subdivision development proposals to increase public ownership and vegetative buffers surrounding waterways.

3.2.3 Goal 3: Improve water quality to support stream health, including aquatic life

3.2.3.1 Research & Monitoring Recommendations

GOAL 3: IMPROVE WATER QUALITY TO SUPPORT STREAM HEALTH, INCLUDING AQUATIC LIFE
Research & Monitoring Recommendations

RESEARCH & MONITORING - RATIONALE:

- Healthy streams provide suitable water quality and habitat for all life stages of aquatic species. There is a need for improved water quality in ***subwatersheds*** across the Thames to enhance stream health and to protect habitat for fish and aquatic communities.
- Threats to aquatic communities in the Thames River ***ecosystem*** include deforestation, siltation and turbidity, nutrient loading, harmful materials, altered water flow, watercourse barriers, non-native species, disturbance, and thermal pollution.
- Monitoring is essential to understanding current conditions and long-term changes affecting stream health. Enhanced ***subwatershed*** monitoring and research are needed to improve our understanding of priority issues and impairments, target remediation and evaluate the effectiveness of implementation efforts.
- Identifying and addressing gaps in water quality information and threats to aquatic life will be important to improving stream health and protecting aquatic species. Numerous past studies have identified a range of historic and site-specific contaminant issues in the Thames River. Additional studies are needed to fill information gaps as they relate to local ***ecosystem*** and human health (e.g., ***groundwater*** - surface water interactions, plastics, pesticides).
- A comprehensive data storage and management system is needed to better compile and share water quality, quantity and ecological data from multiple sources for the Thames ***watershed*** in a common system that can be used by Thames River partners.

First Nations Recommendations

1. Ensure that First Nations are involved in monitoring any projects near First Nation communities/ lands to build trust in the process and the results, and to build capacity in the community.
2. Develop a raw surface water and ***groundwater*** monitoring program in interested First Nation communities.

ECCC Recommendations

1. Canada, Ontario and conservation authorities began in 2017 to implement a nested ***watershed*** monitoring approach in the Thames River and will continue to model and track nutrient dynamics and changes over time.
2. Canada will continue to investigate the exchange of nutrients between ***groundwater*** and surface water in the Thames River ***watershed*** to better understand the relationship between seasonal and year-to-year nutrient fluxes, land use and climate variations.

GOAL 3: IMPROVE WATER QUALITY TO SUPPORT STREAM HEALTH, INCLUDING AQUATIC LIFE
Research & Monitoring Recommendations

MECP Recommendations

1. Continue to consider and assess polychlorinated biphenyls (PCBs) and perfluorinated compounds (PFCs) and their land-based sources in local tributaries (i.e., Pottersburg Creek).
2. Continue to monitor fish as needed at several locations along the length of the Thames River as part of the sport fish contaminant monitoring program, and provide fish consumption advice to anglers, subsistence fishers and their families, and First Nations and Métis communities, via the Guide to Eating Ontario Fish.
3. Continue to support environmental monitoring initiatives with Thames River Clear Water Revival (TRCWR) partners to identify areas having impaired water quality and the causal factors of any identified impairments.
4. Support efforts by the TRCWR partners to develop and implement information systems designed to assist in identifying causal factors of any water quality impairments.

OMAFRA Recommendations

1. Consider additional monitoring, research, and technology transfer efforts in the Thames River ***watershed*** to demonstrate the edge of field effectiveness of ***BMPs*** in current production systems and innovative agricultural techniques to increase adoption.

OMNRF Recommendations

1. Ensure Thames River ***watershed*** health stressors are addressed through the appropriate fisheries management process at the Fisheries Management Zone (FMZ) level and/or, if deemed necessary, as part of a ***watershed*** based planning approach co-led with partners. Lake Erie Fish Community Objectives and Management Plan objectives will also be considered during either of the above noted planning processes.
2. Encourage partners to follow standard protocols, where applicable, when monitoring fish and flowing waters.
3. Encourage partners to collect key water quality indicator parameters, following standardized sampling survey protocols during the course of sampling for other purposes and maintain an up-to-date inventory of these parameters whenever possible.

CA Recommendations

1. Enhance monitoring and information in ***subwatersheds*** to measure stream health conditions, better plan for and target implementation, and measure and report on progress.

   <u>Actions:</u>

   a. Ensure continued implementation of current long term monitoring and data collection programs in the Thames, including water chemistry, bacteria, benthic invertebrates, fish/other aquatics. Ensure methodology is compatible with standardized protocols for monitoring programs.

GOAL 3: IMPROVE WATER QUALITY TO SUPPORT STREAM HEALTH, INCLUDING AQUATIC LIFE
Research & Monitoring Recommendations

b. Build on the current monitoring program for the Thames ***watershed*** to further develop and implement an integrated monitoring strategy to support decision making.
c. Increase the level of routine water quality and stream health monitoring at existing long term ***subwatershed*** stations across the Thames to capture adequate data, where data gaps exist, to measure stream health (baseline conditions). Add new long term stations to key ***subwatersheds*** where there is minimal or no monitoring currently.
d. Establish new ***groundwater*** monitoring wells in areas identified as data gaps in Table 2-8 of the Lower Thames Valley Assessment Report (Thames Sydenham and Region Source Protection Committee 2015a) and Table 2-5 in the Upper Thames River Assessment Report (Thames Sydenham and Region Source Protection Committee 2015b) for the Thames ***watershed*** and in the Ontario Low Water Response: Draft Groundwater Indicator Site Selection Criteria undertaken by the UTRCA (2009).
e. Working with partners, implement enhanced monitoring in target ***subwatersheds*** to better assess conditions and develop plans for ***watershed*** protection and restoration needs.
f. Implement and expand the use of a comprehensive data storage and management system for all water quality, quantity, and ecological data collected for the Thames ***watershed*** (WISKI system).
g. Review and build on existing watercourse classification systems to develop a standardized system that provides information (e.g., thermal regime, species, flow, barriers) to support management and protection.
h. Investigate the knowledge gaps identified in the 2004 report on aquatic Species At Risk (SAR) in the Thames River ***watershed*** (Cudmore, MacKinnon and Madzia 2004).
i. Continue to assess the impact of dams and barriers on river health.
j. Complete the identification of natural heritage systems throughout the ***watershed***, including a comprehensively mapped watercourse layer.
k. Develop a comprehensively mapped watercourse layer to allow the next phase of system studies to include linkages between natural heritage, surface water and ***groundwater*** features.
l. Identify priority stream corridors as part of an implementation strategy/plan.
m. Encourage research in the Thames ***watershed*** to better understand emerging issues for surface water quality, ***groundwater*** quality and stream health.
n. Support partner agencies in addressing identified emerging issues (monitoring, implementation, control programs, etc.).

2. Monitor water quality within ***pump scheme*** areas to gain a better understanding of the impacts of the municipal pumping stations in the Lower Thames on rural and urban water quality.

GOAL 3: IMPROVE WATER QUALITY TO SUPPORT STREAM HEALTH, INCLUDING AQUATIC LIFE *Research & Monitoring Recommendations*
Municipal Recommendations
1. Implement monitoring procedures in order to prioritize funds and resources to those areas of the sewer systems that are most critical to water quality. 2. Continue to monitor seepage from both active and closed landfill sites to ensure the absence of offsite contamination and conduct periodic updates to ensure control measures are effective and successful. 3. Use standardized parameters for measurements/ locations of stream health, and seek secure full time funding in order to better synthesize information to recognize long term trends.

3.2.3.2 Stewardship & Outreach Recommendations

GOAL 3: IMPROVE WATER QUALITY TO SUPPORT STREAM HEALTH, INCLUDING AQUATIC LIFE
Stewardship & Outreach Recommendations

STEWARDSHIP & OUTREACH – RATIONALE:

- To improve water quality, urban and rural ***Best Management Practices (BMPs)*** should focus on reducing contaminants at the source. Contaminants include excessive nutrients or sediment, ***pathogens***, pesticides, fuels, and other chemicals and debris.
- Increasing infiltration and reducing peak flows and rates of runoff are also priorities to reduce delivery of contaminants, from both ***point*** and ***nonpoint sources***.
- The Thames River ***watershed*** has a mix of warm water, cool water and cold water watercourses, with the majority of them being warm water. These streams support diverse fish populations as well as Species at Risk and other aquatic life. There are a limited number of cold water streams left in the ***watershed***; therefore, it is important to maintain and restore these features, where possible.
- Maintaining, rehabilitating and expanding natural heritage features and systems is important to the protection and enhancement of water quality and stream health.
- Headwaters are the areas where watercourses begin and include swales, first and second order streams, areas of ***groundwater recharge and discharge***, and wetlands. Protecting these features directly benefits downstream water quality and aquatic ***ecosystem*** function, but they continue to be lost or degraded at a significant rate all across Southwestern Ontario including the Thames River ***watershed***.
- Riparian (streamside) areas that are well treed or vegetated are also critical to protecting water quality.
- Protecting and restoring natural stream channels, which typically have pools, riffles and meanders, is beneficial for stream health.
- Stream barriers such as dams can impact local water quality by altering flows, temperature, erosion and siltation, accumulating nutrients and sediment, and preventing movement of aquatic wildlife.
- Education and outreach efforts are important for providing landowners and ***watershed*** residents with information and technical assistance.

First Nations Recommendations

1. Ensure that First Nations are involved in any projects near First Nation communities/lands to build trust in the process and to improve communication and engagement.
2. Increase staff capacity to address all the important environmental concerns (e.g., establish an environmental committee).
3. Develop a minimum riparian buffer width that considers appropriate sizes and types of vegetation to address a variety of water quality issues (e.g., pollinator habitat, wildlife movement, erosion, chemicals, etc.).
4. Decrease rate of habitat loss, especially wetlands, within First Nation communities.
5. Improve spiritual connection of First Nation youth and non-native communities with water, and increase their awareness of the importance of the Thames ***watershed*** as a

GOAL 3: IMPROVE WATER QUALITY TO SUPPORT STREAM HEALTH, INCLUDING AQUATIC LIFE
Stewardship & Outreach Recommendations

component of the corridor connecting Lake Huron to Lake Erie.

ECCC Recommendations

1. Canada, with support from its partners, will continue to develop, improve and apply Soil and Water Assessment Tool (SWAT) models in the Thames River to identify and provide advice to partners on strategies for optimizing ***BMPs***.

MECP Recommendations

1. Support implementation and measurement of ***BMPs*** and ***LID*** practices per ministry programs and guidance for ***BMPs*** and ***LID***.
2. Consider ***Indigenous Traditional Knowledge (ITK)*** from First Nations, if offered, and encourage ***Indigenous*** participation in developing approaches for ***BMPs*** and ***LID*** and sharing ***ITK*** in the Thames River ***watershed***.

OMAFRA Recommendations

1. Encourage adoption of ***BMPs.***
2. Pursue opportunities to exchange information, feedback, approaches, and advice between ***Indigenous*** and non-***Indigenous*** agricultural groups.

OMNRF Recommendations

1. Work collaboratively with partners to review currently monitored key water quality indicators to measure progress toward improving stream health and identify any additional appropriate indicators.
2. Review and set realistic targets for each indicator.
   Actions:
   a. Collaborate with partners to classify stream segments as cold, cool or warm water thermal regimes based upon best available science.
3. Collaborate with partners to identify “natural heritage systems” across the ***watershed*** that incorporate principles included in “water resource systems” as described in the Provincial Policy Statement.
   Actions:
   a. Protect and enhance existing and potential cold water streams in the ***watershed*** by reducing thermal loading and protecting significant ***groundwater recharge*** and ***discharge*** areas.
   b. Protect and enhance cool water stream segments that have potential, with enhancement, to be restored to cold water stream segments.
   c. Identify, restore and protect priority stream corridor sections with increased riparian corridors and natural channel enhancement.
   d. Advocate for natural vegetation cover restoration and protection to protect

GOAL 3: IMPROVE WATER QUALITY TO SUPPORT STREAM HEALTH, INCLUDING AQUATIC LIFE

Stewardship & Outreach Recommendations

groundwater and stream health.

4. Advocate for the decommissioning of dams that are not used for one or more of the following purposes: to act as an upstream migration barrier to undesirable fish species, provide flood control, or generate hydroelectricity.
   Actions:
   a. Develop, in collaboration with partners, education and guidance about dams for landowners.
   b. Explore, with partners, funding incentives that help offset costs associated with decommissioning private dams as opportunities arise, with an emphasis on more sensitive stream segments such as those that contain brook trout and/or SAR.
5. Where decommissioning is not an option, explore techniques that reduce downstream thermal loading (e.g., pond bypass channels and bottom draw modifications).

CA Recommendations

1. Expand and target stewardship implementation to protect and enhance local water quality and stream health including fish and aquatic life in ***subwatersheds*** across the Thames River ***watershed***.
   Actions:
   a. Promote implementation of a suite of actions to improve stream health as recommended in the ***Watershed*** Report Cards.
   b. Expand implementation programs including the existing rural Clean Water Program and the urban ***LID*** program across the Thames River ***watershed*** to reduce water pollutants (***pathogens***, chemicals, nutrients).
   c. Develop separate strategies for cold water, cool water, and warm water stream management to help direct appropriate and effective actions to protect and enhance stream ecology within the Thames River ***watershed***.
   d. Protect and enhance existing and potential cold water streams in the ***watershed*** by reducing thermal loading and protecting significant ***groundwater recharge*** and ***discharge*** areas.
   e. Protect and enhance cool water stream segments that have potential, with enhancement, to be restored to cold water stream segments.
   f. Identify, restore and protect priority stream corridor sections with increased riparian buffers and natural channel enhancement.
   g. Identify and address ***groundwater*** and surface water connection and interaction in implementing protection and enhancement of streams, headwater and riparian wetlands to best protect both ***groundwater*** and surface water quality (temperature, contaminants, etc.).
   h. Advocate for natural heritage restoration and protection to protect ***groundwater*** and stream health.
   i. Advocate for "***net gain***" in wetland area, regardless of significance.
   j. Work with relevant ministries/agencies and municipalities to encourage advancements to urban and rural drain construction and drain maintenance

GOAL 3: IMPROVE WATER QUALITY TO SUPPORT STREAM HEALTH, INCLUDING AQUATIC LIFE
Stewardship & Outreach Recommendations

methods that protect aquatic habitat and improve fluvial geomorphic processes.

k. Work with municipalities to restore previously/historically enclosed stream reaches in potential target urban and rural stream sections.
l. Implement management practices on Thames River ***watershed*** flood control reservoirs to optimize water quality while maintaining critical reservoir functions, most notably protection of life and property from flood risks.
m. Review and refine criteria to support decommissioning of dams and barriers.
n. Work with barrier owners to undertake proper operation and maintenance or to remove/ decommission the structures.
o. Identify priorities for removal of dams and barriers.
p. Support efforts and provide technical assistance to naturalize or remove dams and barriers, where appropriate.
q. Naturalize dams and barriers (design and/or operation), where appropriate, to mimic natural ***hydrological*** processes and sustain healthy river ***ecosystems***, while reducing flood and drought risks.
r. Continue to mitigate any negative impacts of dams and barriers in the ***watershed***.
s. Educate the public and owners of dams and barriers on the impacts (positive and negative) of, and the potential risks and/or liabilities associated with, these structures, and provide guidance to help private owners make informed decisions regarding their structures.
t. Advocate for mitigation or decommissioning of dams and barriers, as opportunities arise, to improve stream health.
u. Invest in additional education programs designed to educate and involve students in stewardship activities.
v. Implement social marketing on the value of water quality and stream health protection to motivate ***watershed*** community action.
w. Communicate and share results on stream health conditions with ***watershed*** partners and ***watershed*** residents.
x. Expand communication tools, such as ***Watershed*** Report Cards for all ***subwatersheds*** across the Thames ***watershed***.

2. Implement measures and strategies to protect SAR since many of the measures directed at species recovery will also improve water quality.

   Actions:

   a. Implement water quality improvement recommendations from the draft Thames River Aquatic Ecosystem Recovery Strategy (Thames River Recovery Team 2007) and applicable species-specific recovery strategies to improve the aquatic ***ecosystem*** and encourage the long-term survival of SAR.
   b. Implement water quality improvement recommendations in the management plans for Species of Special Concern.
   c. Use the information on distribution, status, conservation priority rankings, biology and threats for each SAR found in reports such as the 2004 report on aquatic SAR in the Thames River ***watershed*** (Cudmore et al. 2004) to develop strategies for SAR protection.

GOAL 3: IMPROVE WATER QUALITY TO SUPPORT STREAM HEALTH, INCLUDING AQUATIC LIFE

Stewardship & Outreach Recommendations

Municipal Recommendations

1. Expand and target maintenance and outreach programs to protect and enhance local water quality and stream health.
   Actions:
   a. Expand street sweeping and catch basin cleanout in order to capture particulate matter before it reaches watercourses.
   b. Improve access to the river for recreational, spiritual, educational and entertainment purposes.
   c. Increase education regarding the proper disposal of medicines and pharmaceutical drugs.
   d. Enhance municipal awareness campaigns to better illustrate the cost of infrastructure challenges such as blocked pipes or clogged equipment that can occur due to cumulative impact from items such as dental floss, prescription drugs, FOG (fats, oils and grease) and hand wipes disposed of in municipal sewer systems.

3.2.3.3 Acts, Policies & Regulations Recommendations

GOAL 3: IMPROVE WATER QUALITY TO SUPPORT STREAM HEALTH, INCLUDING AQUATIC LIFE
Acts, Policies & Regulations Recommendations

ACTS, POLICIES & REGULATIONS - RATIONALE:

- There are many guidelines, policies, acts and regulations that could apply to improving and protecting stream health, and there are other tools that would assist indirectly.
- Federal and provincial governments have developed water quality standards, objectives and guidelines to protect both aquatic life and human water uses.
- Several provincial acts and regulations address discharges to, and protection of, the natural environment.
- The Ontario Water Resources Act, Clean Water Act and Environmental Protection Act provide the overarching authority for a variety of regulations controlling, preventing and mitigating discharges to air, land and water.
- The 2014 Provincial Policy Statement (PPS), Section 2.2, provides direction to planning authorities to protect, improve or restore both quality and quantity of water. Municipalities can utilize official plans, bylaws and other tools available through land use planning to protect and improve water quality, to be consistent with the PPS.

First Nations Recommendations

1. Promote / encourage that industrial cooling processes do not impact the quality (temperature, composition) of water being returned to the environment.

ECCC Recommendations

1. Canada and Ontario will build on existing governance structures to ensure partner participation in implementation of the Canada-Ontario Lake Erie Action Plan (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018). Parties identified in the plan will work together to develop an implementation plan that establishes timelines for actions and expected ***phosphorus*** reductions (as applicable), identifies lead agencies, and determines the investment required.

MECP Recommendations

1. Implement the strategies that support the Canada-Ontario Agreement and the Great Lakes Strategy to address contaminants of concern.
2. Continue to support regulations and encourage compliance for activities that manage waste or minimize, prevent or mitigate the release of emissions or contaminants to the environment.
3. Continue to provide protection and enhancement for SAR and their habitat through administration of the Endangered Species Act, 2007. This can be in the form of advice that mitigates harm or harassment to SAR individuals and/or damage and destruction of their habitat.

GOAL 3: IMPROVE WATER QUALITY TO SUPPORT STREAM HEALTH, INCLUDING AQUATIC LIFE
Acts, Policies & Regulations Recommendations

OMAFRA Recommendations

1. Support MECP's lead in implementing the strategies outlined in the Canada-Ontario Agreement, Great Lakes Strategy and the Lake Erie Action Plan (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018), which address contaminants of concern.

OMNRF Recommendations

1. Work collaboratively with partners to implement actions outlined in A Wetland Conservation Strategy for Ontario 2017-2030 (OMNRF 2017) toward halting the ***net loss*** of wetlands and achieving a ***net gain***.
2. If a ***watershed*** level fisheries management planning process is adopted, work collaboratively with partner agencies to develop objectives and strategies that can be incorporated into Official Plans.
3. Consider requiring the collection and reporting of data such as duration of fishing, time of day, and air and water temperature, as part of mandatory data fields to be reported by partners carrying out fisheries surveys authorized by the Fish & Wildlife Conservation Act, 1997. This additional information would be extremely useful toward identifying such aspects as thermal regime and catch per unit effort. Additionally, adherence to a standard protocol allows for the comparison of information across years and sites.
4. Continue to mitigate environmental impacts from dams through administration of the Lakes and Rivers Improvement Act (LRIA, 1990). This includes developing guidance that ensures the LRIA, 1990, is not a deterrent to decommissioning and/or mitigating low risk barriers.

CA Recommendations

1. Use current policy and planning tools, and update as needed, to protect and enhance local water quality and stream health including fish and aquatic life, in ***subwatersheds*** across the Thames ***watershed***.

Actions:

   a. Review and build on existing methodology to develop a standardized definition of natural hazards and natural heritage features that can be incorporated into municipal official plans and bylaws.
   b. Work with relevant ministries/agencies and municipalities to create new or enhance existing policy and guidance documents related to stream health, drain maintenance and design, SAR, ***environmental flow*** requirements, wetland and riparian protection, etc.
   c. Review land use policy and guidance documents to determine if they are effective in protecting sensitive areas, such as headwater streams and wetlands, or if better development guidelines are needed.
   d. Ensure that all ***subwatershed*** studies include a commitment to protect and enhance headwater drainage features.

GOAL 3: IMPROVE WATER QUALITY TO SUPPORT STREAM HEALTH, INCLUDING AQUATIC LIFE

Acts, Policies & Regulations Recommendations

   e. Work with other ministries/agencies to encourage streamlining of the approval process for removal of dams and barriers, where appropriate. Ontario's current dam removal regulations act as a deterrent for private and municipal dam owners wishing to decommission and remove obsolete dams.
   f. Encourage updates to municipal policies and, potentially, bylaws to incorporate upgrades to drain construction and maintenance requirements.
   g. Work with other ministries/agencies (Ontario Ministry of Transportation/OMAFRA) to encourage updates to their guideline and design standard documents to promote the use of natural channel design principles in drainage projects.
   h. Work with municipalities to strengthen policies and bylaws to preserve natural cover.
   i. Work with municipalities and counties to consider redefining the maximum extent of all wetland boundaries (evaluated and unevaluated) to take into account the overall ***hydrology***, such as high water marks, recharge and discharge areas, and ***aquifer*** mapping.
   j. Advocate for protective policy and implementation, including efforts to identify and preserve regionally significant headwater areas.
2. Communicate the results of updated policies to promote compliance with and effectiveness of land use regulations.

Municipal Recommendations

1. Develop and implement road salt management plans.
2. Utilize the tools available through land use planning to protect and improve water quality, where possible. For example, vegetative riparian buffers could be implemented through the parkland dedication requirement (Plan of Subdivision process). Enhancing parkland and/or increasing the amount of vegetated open space can ultimately improve water quality (by filtering overland flow and reducing the impacts of impervious surfaces, for example).
3. Review management of existing active and closed landfills to ensure strict adherence to Environmental Compliance Approvals and Ministry guidance.
4. Promote the existing Household Hazardous Waste information and depot programs that include MyWaste, the Orange Drop, Regeneration and other local municipal programs, to provide options for waste disposal in order to prevent entry into watercourses via the ***wastewater treatment*** process. All pharmaceuticals and prescription drugs should be returned to local pharmacies for proper disposal.
5. Improve enforcement of existing bylaws to increase compliance with proper sewer connections and reduce improper sewer use.

3.3 WATER QUANTITY MISSION, GOALS & RECOMMENDATIONS

Mission Statement:
TO ENCOURAGE A FLOW REGIME THAT PROVIDES SUSTAINABLE *ENVIRONMENTAL FLOW (EFLOW)* WHILE REDUCING FLOOD RISK.

- **Goal 1: Understand, develop and recommend *environmental flow (eflow)* needs in the Thames River *watershed***
- **Goal 2: Improve understanding and mitigation of hazards associated with flooding and extreme flows in the Thames River *watershed***
- **Goal 3: Research and recommend mechanisms to achieve acceptable *eflow* while reducing flood and drought risks**
- **Goal 4: Expand water quantity monitoring to improve understanding of *eflow* needs, flood and drought risk, and climate change**

The following tables provide recommendations, rationales and proposed activities for each goal, and were developed by and for First Nations, municipalities and conservation authorities.

Please see Appendix D for more extensive supporting rationale.

3.3.1 Goal 1: Understand, develop and recommend *environmental flow* (*eflow*) needs in the Thames River *watershed*

GOAL 1 : UNDERSTAND, DEVELOP AND RECOMMEND *ENVIRONMENTAL FLOW (*EFLOW*)* NEEDS IN THE THAMES RIVER *WATERSHED*
RECOMMENDATION 1: DEVELOP AN UNDERSTANDING OF THE AQUATIC, SEMI-AQUATIC AND RIPARIAN-DEPENDENT FAUNAL AND FLORAL ASSEMBLAGES AND HUMAN WATER USES
RATIONALE: • The Thames River flows through many diverse habitats and acts as a dispersion corridor to many flora and fauna species. As a result, the Thames River ***watershed*** supports one of the most diverse aquatic, semi-aquatic and riparian-dependent faunal communities within the Great Lakes basin. Most of these native species are sensitive to environmental changes, and are dependent on a particular quantity regime of stream flow. • The Thames River is also situated in a highly developed section of southern Ontario and, as such, faces many pressures from urban and rural land uses and other human activities. • The challenge is to maintain the integrity of aquatic ***ecosystems*** while meeting human needs.
Proposed Activities
1. Conduct an ***eflow*** study that incorporates the following activities: a. Identify the flora and fauna and human needs/interests that depend on the Thames River and its tributaries. b. Research and monitor to further understand the distribution, abundance, life history characteristics, habitat, and the extent and impacts of threats to aquatic, semi-aquatic and riparian-dependent faunal and floral assemblages. c. Support and expand research and broad-based monitoring to assess the physical, chemical and biological attributes of the Thames River important to aquatic and riparian-dependent assemblages and to human activities. d. Characterize streamflow variation including daily, seasonal and annual patterns as well as extreme events such as flooding and droughts. e. Identify critical / significant habitats for aquatic and riparian-dependent communities. f. Include all Thames River and tributary reaches including the distinct lower reaches influenced by Lake St. Clair. g. Undertake a First Nation traditional knowledge study and / or bring First Nation elders together to collect local traditional information in a cultural study to determine traditional uses of the river. h. Work with First Nations to gather ***Indigenous Traditional Knowledge (ITK)***, if offered, pertaining to the biology and ecology of the river. i. Include information from and investigate knowledge gaps identified in the 2004 report on aquatic SAR in the Thames River ***watershed*** (Cudmore et al. 2004).

GOAL 1 : UNDERSTAND, DEVELOP AND RECOMMEND *ENVIRONMENTAL FLOW (*EFLOW*)* NEEDS IN THE THAMES RIVER *WATERSHED*

RECOMMENDATION 2: DETERMINE SUSTAINABLE *EFLOW* NEEDS (E.G., HIGH AND LOW FLOWS) FOR AQUATIC, SEMI-AQUATIC AND RIPARIAN-DEPENDENT FAUNAL AND FLORAL ASSEMBLAGES AND HUMAN WATER USES

RATIONALE:

- There are many methods for determining ***eflow*** at the ***watershed*** scale.
- The most ecologically important aspects of a river's flow are low flows, high flow pulses and floods.
- Human land use and activities have influenced the degree and timing of flow events.
- Maintaining appropriate ***environmental flows*** in the Thames River and its tributaries is an evolving issue of concern as flow alterations are a primary contributor to degraded river ***ecosystems*** and lead to the loss of native, threatened and endangered aquatic and semi-aquatic species whose survival and reproduction are tightly linked to specific flow conditions.
- An understanding of the ***eflow*** needs for valued faunal and floral assemblages will allow water resource managers and First Nations to predict the impacts of various flow regimes and to establish low flow criteria to protect the integrity of these assemblages.
- It is expected that ***eflow*** needs are distinctly different in the lower river reaches influenced by Lake St. Clair than other upstream reaches**.**

Proposed Activities

1. Use technical expertise in areas such as ***hydrology***, ***hydrogeology***, ecology and biology, as well as the available body of research, to develop and use guidance documents on establishing ***eflow*** needs in the Thames River ***watershed***.
2. Undertake a ***watershed***-wide flood risk assessment of the natural environment.
3. Assess how the range of climate change possibilities may affect flood risks.
4. Identify information gaps for determining ***eflow*** needs in the Thames River ***watershed***.
5. Develop and execute a plan for filling priority information gaps.
6. Establish current and projected future human water quantity needs.
7. Record current conditions to serve as a baseline for evaluating ***ecosystem*** health in the future.
8. Consider ***eflow*** recommendations from the draft recovery strategy that has been developed for the Thames River ***watershed*** (Thames River Recovery Team 2007) and from management plans for Species At Risk, recognizing that the purpose of an ***eflow*** study is different than a recovery or management strategy.
9. Develop a broad-based communication and education plan to foster stewardship, appreciation and understanding around the importance of ***eflow*** to ***ecosystem*** health.
10. Develop education/information about flooding, flooding impacts, and the role of the natural environment in flood mitigation. Continue to improve public understanding that flooding is a natural process that has both positive and negative impacts on the natural environment.
11. Ensure ***eflow*** supports and encourages ***Indigenous*** traditional ways of life.

GOAL 1 : UNDERSTAND, DEVELOP AND RECOMMEND *ENVIRONMENTAL FLOW (*EFLOW*)* NEEDS IN THE THAMES RIVER *WATERSHED*

RECOMMENDATION 3: USE A WATER BUDGET TO ASSESS THE SUSTAINABILITY OF *EFLOW* NEEDS

RATIONALE:

- The water budget identifies where the water is, how the water moves between these areas, and trends in availability and use.
- Each component of the water budget is important to ***eflow***. In a water budget, each component is described and analyzed, including: precipitation, evapotranspiration (evaporation and plant uptake), ***groundwater recharge/discharge***, ***groundwater*** flow into and out of the ***watershed***, and surface runoff. Knowing where, when, and how much water is flowing into or out of these components can provide a means for calculating water availability.
- The frequency, timing and duration of surface water runoff affect the variability of flows. All of these components and the water budget itself are important in determining the sustainability of ***eflow***. Some of these components, such as ***groundwater recharge***, streamflow variability, and water use, may be directly influenced through human activity.
- Of particular relevance to managing ***eflow*** is the ability to separate the proportions of total river flow coming from the various sources. ***Baseflow*** refers to consistent inputs of water to the river that can generally be relied on even in times of low precipitation. ***Baseflow*** typically comes from ***groundwater*** inputs and is strongly linked to ***eflow***. Based on the ratio of ***groundwater discharge*** to total stream flow, the ***baseflow*** in the Thames River varies between 40-70% of total stream flow (Thames-Sydenham and Region Source Protection Committee 2007).
- In areas influenced by Lake St. Clair, it is extremely difficult to separate a ***baseflow*** component since the water level in the river is influenced by the lake, resulting in the presence of water in the watercourses even in times of extreme drought. During normal or low flow conditions, dyke and ***pump schemes*** heavily influence flows. This presents particular challenges for ***hydrologic modelling*** as the basic assumption that water during a rainfall event flows off the land, into the tributaries, and naturally makes it way to the river and eventually to the lake, is not necessarily true.

Proposed Activities

1. Build upon the conceptual understanding of the water budget developed in the Drinking Water Source Protection program (Thames-Sydenham and Region Source Protection Committee 2007) to go beyond sources of municipal drinking water, to assess the reliability and sustainability of flow in meeting ***eflow*** needs.
2. Monitor the components of the water budget in sufficient temporal and spatial detail to document uses, trends, losses, effects of weather and climate, ***ecosystem*** impacts and basic water resources inventories.
3. Evaluate the physical connectivity of streams, wetlands and other surface waters, ***groundwater*** and terrestrial environments (known as water resource systems and natural heritage systems in the Provincial Policy Statement) throughout the ***watershed***, and

GOAL 1 : UNDERSTAND, DEVELOP AND RECOMMEND *ENVIRONMENTAL FLOW (*EFLOW*)* NEEDS IN THE THAMES RIVER *WATERSHED*

integrate into the water budget.

4. Integrate the ***pump schemes*** located in the lower part of the ***watershed*** into the water budget.
5. Develop a plan to improve the ability of the ***watershed*** to sustainably meet ***eflow*** needs.
6. Determine and include First Nation water taking in the overall water budget.
7. Characterize streamflow variation including daily, seasonal and annual patterns, as well as extreme events such as flooding and droughts.
8. Educate the public about the water cycle, including finite water supply, where their water comes from (source), where it goes, and extreme weather events that cause droughts and floods, as well as the importance of water-related infrastructure and what they can do to help with ***eflow***. Include First Nation teachings about spiritual connection to water.

3.3.2 Goal 2: Improve understanding and mitigation of hazards associated with flooding and extreme flows in the Thames River *watershed*

GOAL 2 : IMPROVE UNDERSTANDING AND MITIGATION OF HAZARDS ASSOCIATED WITH FLOODING AND EXTREME FLOWS IN THE THAMES RIVER *WATERSHED*	
RECOMMENDATION 1: MODERNIZE *HYDROLOGIC* AN *HYDRAULIC* ANALYSES AND MODELS	
RATIONALE: • The Thames River ***watershed*** has been subject to varying degrees of flooding throughout history for a variety of reasons including land clearing, wetland destruction, tile drain installation, increased imperviousness, ice jams (lower Thames), high ***water tables***, climate change, etc. • ***Hydrologic*** analyses use ***watershed*** characteristics and meteorological inputs to estimate watercourse flows to aid in understanding risks and adaptation measures associated with flooding, ***eflows***, water budgets, erosion, sedimentation, and the potential impacts of climate change. • ***Hydraulic models*** are used to estimate water velocity and surface elevations along the Thames River, as well as other physical properties. These models are critical tools in understanding flood extent and risk and to evaluate geomorphologic processes such as erosion and sedimentation risk. • Many of the existing models/ analyses were created more than 25 years ago, do not reflect current ***watershed*** characteristics, and are not suitable for the wide range of applications. For example, existing ***hydrologic models*** in the ***watershed*** are event-based models, rather than continuous, and therefore are not useful in understanding potential long-term impacts of climate change, or in adequately assessing ***baseflow*** and ***eflow*** sustainability. Existing models typically assume that all flood waters remain on the surface, and do not include the detail required to understand and manage urban non-***fluvial flooding***, which can be highly complex. Existing ***hydraulic models*** in the ***watershed*** are considered one dimensional, whereas two dimensional ***hydraulic models*** generally provide much better estimates of flow velocities and a better overall understanding of flood hydraulics in hydraulically complex areas of interest, such as in highly developed urban areas. • Sediment transfer models are generally not available in the ***watershed***. The stream and river systems in Southern Ontario are generally known to have actively moving stream beds during high flow periods. Developing sediment transfer models should improve understanding of erosion and sedimentation processes in the ***watershed***.	
Proposed Activities	
1. Develop/update and maintain the ***hydrologic*** and ***hydraulic*** analyses and models. 2. Develop and maintain a ***watershed*** continuous ***hydrology model***. 3. Develop and maintain detailed dual drainage models for ***watershed*** urban areas. 4. Develop and maintain 2D ***hydraulic models*** for critical watercourse sections.	

GOAL 2 : IMPROVE UNDERSTANDING AND MITIGATION OF HAZARDS ASSOCIATED WITH FLOODING AND EXTREME FLOWS IN THE THAMES RIVER *WATERSHED*

5. Develop and maintain a sediment transport model.
6. Utilize ***hydrologic*** and ***hydraulic*** analyses and models to understand and assess climate change and mitigation measures.
7. Improve understanding of the impacts of Lake St. Clair water levels on flows in the lower reaches of the Thames River and tributaries.

RECOMMENDATION 2: REGULARLY UPDATE FLOOD AND EROSION HAZARD MAPPING

RATIONALE:

- Natural hazards are caused by naturally occurring physical and ecological processes which continuously shape and reshape the landscape. ***Floodplains***, unstable slopes and erosion are examples of natural hazards that pose risks and problems to society when they are not fully understood and/or planned for effectively.
- Erosion hazard mapping aids in understanding and managing erosion hazards. In keeping with the provincial hazard avoidance approach, development and site alteration is generally not permitted in riverine erosion hazard areas. More detailed field data collection and computer modelling could aid in better understanding and definition of erosion hazards.
- ***Floodplain*** mapping supports flood forecasting and warning, which informs emergency planning and response by identifying areas at risk of flooding. It also supports CA flood hazard planning and regulation activities, which direct development and site alteration away from flood hazard areas. In addition, modernized ***floodplain*** mapping can facilitate improved communication and understanding of flood risk.
- To maintain validity, ***floodplain*** mapping must be regularly updated in response to technological advances, changes to the landscape (e.g., land use, urbanization, storm drainage, watercourse crossings, etc.), climate change, and the availability of longer and more detailed data records.

Proposed Activities

1. Ensure current ***watershed*** erosion hazard mapping is available.
2. Ensure current ***watershed*** flood hazard mapping is available.
3. Incorporate potential climate change effects into erosion and flood hazard mapping.
4. Work with First Nation communities, if requested, to improve understanding of flooding on First Nation lands by incorporating climate and ***hydrological modelling*** with land use and watercourse information.
5. Continue to improve public understanding of flood and erosion risk through education and outreach programs.

GOAL 2 : IMPROVE UNDERSTANDING AND MITIGATION OF HAZARDS ASSOCIATED WITH FLOODING AND EXTREME FLOWS IN THE THAMES RIVER *WATERSHED*

RECOMMENDATION 3: IMPROVE AND MAINTAIN FLOOD FORECASTING AND WARNING PROGRAM

RATIONALE:

- The UTRCA and LTVCA provide flood messages to ***watershed*** municipalities and residents with flood forecasting and warning services related to ***fluvial flooding***.
- Messages focus on areas where lives and properties may be in danger due to flooding, and provide information on timing, severity and response. The type of message issued and the response requested/required, depend on the severity of the event.
- The UTRCA and LTVCA operate a number of recording stream gauges, snow measuring courses, precipitation gauges and weather stations, in partnership with Water Survey of Canada and MNRF, that are used to develop an in-depth understanding of how the ***watershed*** functions under extreme flows as well as weather, flow, ground, and snow conditions prior to and during the flood.

Proposed Activities

1. Continue to adapt flood forecasting and warning system to new technologies and incorporate climate change modelling, as appropriate.
2. Continue to improve municipal and public understanding of flood messages through education and awareness programs.
3. Continue to improve public understanding of different types of flood risk and role of natural environment in flood mitigation, through updated Emergency Flood Plans, education and information programs.

RECOMMENDATION 4: IMPROVE EMERGENCY RESPONSE TO FLOODING

RATIONALE:

- Emergency response to a flood is a municipal responsibility, with input and support from their emergency services, conservation authorities, Ministry of Natural Resources and Forestry, and Emergency Management Ontario. These plans deal with many types of emergencies but should include flood-related information in municipalities that are prone to flooding.
- Communication is an important part of emergency preparedness and response as well as flood warning. To mitigate flood risk, timely communication of accurate information is essential when coordinating multiple agencies. Information must also be provided to the general public as well as those directly affected by the flooding.

Proposed Activities

1. Maintain and improve municipal emergency management plans and conservation authority flood contingency plans to ensure they are compatible and consistent.

GOAL 2 : IMPROVE UNDERSTANDING AND MITIGATION OF HAZARDS ASSOCIATED WITH FLOODING AND EXTREME FLOWS IN THE THAMES RIVER *WATERSHED*

2. When requested, work with First Nations to develop flood contingency plans.
3. Continue with routine training and testing related to emergency management plans and flood contingency plans.
4. Continue to improve communications within and between agencies, as well as with the general public and vulnerable populations.
5. Continue to investigate improvements in technology and equipment in order to better respond to flood emergencies.
6. Consider the need to promote longer time frames for individual landowners' emergency response (e.g., promote shelter in place planning).

RECOMMENDATION 5: DEVELOP A *WATERSHED*-WIDE FLOOD RISK ASSESSMENT OF THE BUILT ENVIRONMENT

RATIONALE:

- It is important that the public understand and prepare for the risks associated with different types of flooding related hazards (i.e., watercourse, local drainage, ***groundwater***, erosion, sewer backup) on the built environment (i.e., houses, buildings, roads, sewers, bridges, and other structures).
- Flood risk is a combination of the likelihood of flooding and consequences resulting from the flooding. A flood risk assessment combines flood probability mapping with information on the potential consequences to specific flood areas.
- Consequences can include private and public infrastructure damage, loss of life, emergency service disruption, access disruptions, utility disruptions (e.g., drinking water, sanitary sewers, natural gas, electric power, communications, etc.). Identification of vulnerable populations (e.g., old, young) and critical infrastructure (e.g., hospitals, fire stations, schools) is an important consideration in evaluating consequences.
- Ultimately, a flood risk assessment will inform flood mitigation planning activities such as flood forecasting and warning, emergency response, structural flood mitigation measures, planning and regulations, education and outreach.
- Aligns with the climate change chapter of Ontario's Environment Plan (Ministry of the Environment, Conservation and Parks 2018), which commits the Province to:
    - Undertake a provincial impact assessment to identify where and how climate change is likely to impact Ontario's communities, critical infrastructure, economies and natural environment;
    - Develop an online tool that makes practical climate change impact information available for the public; and,
    - Work with industry to raise awareness among homeowners about the increasing risk of flooding.

GOAL 2 : IMPROVE UNDERSTANDING AND MITIGATION OF HAZARDS ASSOCIATED WITH FLOODING AND EXTREME FLOWS IN THE THAMES RIVER *WATERSHED*

Proposed Activities

1. Build on modelling, analysis and mapping to undertake a ***watershed***-wide flood risk assessment of the built environment.
2. Undertake a ***watershed***-wide ***groundwater*** flood risk assessment of the built environment.
3. Assess how the range of climate change possibilities may affect flood risks.
4. Work with First Nations, if requested, to undertake flood risk assessments.
5. Consider opportunities to align the ***watershed*** risk assessment with Ontario's Climate Change Impact Assessment and its findings, once made available.

RECOMMENDATION 6: IMPROVE *FLOOD RESILIENCY* OF THE BUILT ENVIRONMENT

RATIONALE:

- In the context of a ***watershed*** and water quantity, resilience can be defined as the capacity of individuals, neighbourhoods, businesses, institutions, the natural environment, and the ***watershed*** as a whole to quickly recover after a major flood event. With respect to the built environment in this context, resilient infrastructure will continue functioning throughout a major flood event, or will have the capability to be quickly restored to a functioning state after a major flood event.
- An overall flood mitigation plan would consider improvements to flood forecasting and warning, ***stormwater management***, and emergency response programs, but should also identify improvements to infrastructure ***flood resiliency*** which would help reduce flood risk.

Proposed Activities

1. Develop flood mitigation plans.
2. Consider ***flood resiliency*** in the design, operation and maintenance of infrastructure.
3. Evaluate infrastructure resilience to increased flood risks due to climate change and provide recommendations for improvement.
4. Continue educating public about the importance of ***flood resiliency***.
5. Ensure that potential flood damage is not increased by future development within the ***floodplain***.

3.3.3 Goal 3: Research and recommend mechanisms to achieve acceptable *eflow* while reducing flood and drought risks

GOAL 3 : RESEARCH AND RECOMMEND MECHANISMS TO ACHIEVE ACCEPTABLE *EFLOW* WHILE REDUCING FLOOD AND DROUGHT RISKS
RECOMMENDATION 1: DEVELOP AND / OR UPDATE OPERATION AND MAINTENANCE (O&M) PLANS, WHERE APPROPRIATE, TO REFLECT OPTIMIZATION OF *WATER CONTROL STRUCTURES* CONSIDERING *EFLOWS* AND FLOOD RISK
RATIONALE: • ***Water control structures*** have varying impact on flow regimes depending upon numerous factors including type and size, and subsequently, have varying impacts on flood risk and sustaining ***eflow*** needs. • The ***water control structures*** in the ***watershed*** include dams, dykes, channels and ***pumping schemes,*** as well as ***stormwater management*** facilities such as pipes, ponds and swales and rural drainage such as field tiles and municipal drains which, individually and collectively, have an impact on flood risk and sustaining ***eflow*** needs. • The UTRCA operates three dams to reduce flooding downstream and several smaller dams for recreational opportunities, flood control channels and dykes, and erosion control structures, on behalf of its member municipalities. • The LTVCA operates and maintains one dam on Sharon Creek, the integrated Indian-McGregor Creek Flood Control Project, and several dykes along the lower Thames and Lake St. Clair to protect agricultural lands from flooding. • Several municipalities operate and maintain smaller ***water control structures*** such as weirs, dykes, urban ***stormwater management*** systems, and rural drainage systems. • Numerous small ***water control structures*** and drainage infrastructure are owned, operated and maintained by private landowners, or collectively under the Drainage Act. • There are more than 40 dyke and ***pump schemes*** in the LTVCA ***watershed*** around the mouth of the Thames. These pumps are operated independently without an overall coordinated plan, and rely on the judgement and experience of pump commissioners, who are landowners within the scheme, not government or municipal employees. • It is important that operation and maintenance of all these structures give proper consideration to their impact on flood risk and the sustainability of ***eflow*** needs. • Many ***water control structures*** do not have updated O&M plans. • Some ***water control structures*** are no longer required for their original purpose or have not been properly maintained. Many of these structures also act as barriers and may affect the movement of aquatic life. Where these structures no longer meet a valid purpose or their negative impacts outweigh their benefits, consideration should be given to decommissioning.
Proposed Activities
1. Promote decommissioning of ***water control structures*** that no longer serve their intended purpose, when decommissioning will improve sustainability of ***eflow***. 2. Educate the public and structure owners on the impacts and benefits of ***water control***

GOAL 3 : RESEARCH AND RECOMMEND MECHANISMS TO ACHIEVE ACCEPTABLE *EFLOW* WHILE REDUCING FLOOD AND DROUGHT RISKS

structures, and the potential risks and/or liabilities associated with these structures. Provide guidance to help private structure owners make informed decisions regarding the operation, maintenance or decommissioning of their structures.

3. Promote and assist ***water control structure*** owners in undertaking proper operation and maintenance.
4. Identify priorities for removal or naturalization of ***water control structures*** to mimic natural ***hydrological processes***, while reducing flood and drought risks.
5. Support efforts and provide technical assistance to remove ***water control structures*** or naturalize design and/or operations to mimic natural ***hydrological processes***, while reducing flood and drought risks.
6. Develop, update or optimize structure operation and maintenance plans, as appropriate, to consider ***eflow*** and climate change while still maintaining flood control benefits, using modelling tools developed to assess flood risk and impacts of climate change as appropriate.
7. Develop generalized operation and maintenance plans for groups of similar structures, as appropriate.

RECOMMENDATION 2: INCREASE INFILTRATION AND REDUCE RUNOFF THROUGH *STORMWATER MANAGEMENT LOW IMPACT DEVELOPMENT (LID)* AND RURAL *BEST MANAGEMENT PRACTICES (BMPS)*, WHERE CONDITIONS PERMIT

RATIONALE:

- Land use activities, such as development and drainage, impact the quantity of surface water runoff and ***groundwater recharge*** by changing stream ***hydrology***. In rural areas, the ***watershed*** is experiencing intensification of tile drainage, and drainage works are using larger outlets, all of which remove water from the land faster. Some cropping and tillage practices can impact soil health, reducing permeability and water holding capacity, leading to increased runoff.
- The amount of impervious surfaces within the ***watershed*** has a direct effect on stream ***hydrology*** by decreasing water infiltration and increasing surface runoff, resulting in greater volume and rate of runoff, higher peak discharges, decreased flood peak width and shortened lag times between rain events and associated flood peaks.
- Changes in stream ***hydrology*** may impact water quality, stream habitat and aquatic biota through increased streambank erosion as channels become incised and banks steepen, undercutting and bank collapses increase, and channels become wider and deeper. Streambank erosion results in the loss of pool and riffle sequences, overhead vegetative cover and an increase in suspended sediment loadings. Higher water flows also lead to a less stabilized bed and a change in bed composition, leading to a decrease in species diversity. Additionally, the faster transport of water from the ***watershed*** results in less recharge of ***groundwater*** reserves and therefore lower ***baseflow*** discharge.
- Rural ***Best Management Practices (BMPs)*** can help to reduce runoff volume, velocity and peak flows, as well as increase infiltration and sustain ***eflow***. Different ***BMPs*** are often recommended based on the site specific conditions and individual management

GOAL 3 : RESEARCH AND RECOMMEND MECHANISMS TO ACHIEVE ACCEPTABLE *EFLOW* WHILE REDUCING FLOOD AND DROUGHT RISKS
considerations. • Urban ***stormwater management*** using ***LID*** is an innovative approach with a basic principle that mimics nature: manage rainfall and runoff at the source (where it lands), often at the lot level. This approach can be used to sustain ***eflow***. • If regularly maintained, ***stormwater management (SWM)*** infrastructure, including both conventional ***SWM*** and ***SWM LID***, reduces the effects of local urban flooding. The conventional ***SWM*** pond receives runoff and attenuates it, while ***SWM LIDs*** delay the peak of the ***hydrograph*** and mimic the natural ***hydrologic cycle*** of the site by using techniques such as infiltration and filtration. • ***Green infrastructure***, such as wetlands and woodlands, can substantially reduce flood damage costs to rural and urban infrastructure. Healthy forests also play a vital role in minimizing frequency, intensity and extent of flooding events by absorbing and rerouting water, diffusing its potentially damaging energy, before slowly releasing the water. The net ***hydrologic*** effect of the forest is to delay and reduce the size of the flood peak. Much of the water absorbed by healthy forest soils is drawn up by plant roots and transpired, moving back to the atmosphere as water vapor.
Proposed Activities
1. Support rural and urban ***stormwater management*** and development that are adaptive and resilient to potential climate change impacts and encourage infiltration techniques. 2. Promote ***Best Management Practices (BMPs)*** and ***Low Impact Development (LID)*** through innovative development, demonstration and education. 3. Expand educational programs on ***stormwater*** issues, ***BMPs*** and ***LIDs***. Involve local students and neighbourhoods in implementing ***BMP*** and ***LID*** projects to provide hands-on experience. 4. Improve funding/cost share programs that support ***BMP***/***LID*** implementation. 5. Target specific properties to promote ***BMP***/***LID*** implementation. 6. Increase technical support of ***BMP***/***LID*** implementation. 7. Expand monitoring of ***BMPs*** and establish monitoring program for ***LIDs*** in the ***watershed*** that is incorporated into the environmental data management system. 8. Work with First Nation communities, OMAFRA and the Indian Agricultural Program of Ontario to establish site specific farming practices for First Nation lands being leased to farmers. 9. Build on existing tools that include protection, enhancement and valuation of wetlands and riparian cover in maintaining ***baseflow***, protecting flood attenuation/storage areas and reducing downstream erosion. 10. Encourage sound conservation measures such as natural cover rehabilitation, reduced agricultural tillage, use of appropriate ground cover and preservation of water retaining areas for long-term flood control, flow augmentation and erosion control benefits. 11. Identify and protect areas of significant ***groundwater recharge***. Promote maintaining natural heritage in significant recharge areas of the ***watershed***. 12. In urban areas, support increased infiltration and recharge in natural areas, where ***groundwater mounding*** due to increased recharge will not impact urban structures.

GOAL 3 : RESEARCH AND RECOMMEND MECHANISMS TO ACHIEVE ACCEPTABLE *EFLOW* WHILE REDUCING FLOOD AND DROUGHT RISKS

13. Identify and protect areas of significant ***groundwater discharge***.
14. Discourage the diversion or transfer of water from one ***watershed*** to another as it will interfere with sustainability of ***eflow***.
15. Protect, enhance and restore ***green infrastructure*** such as wetlands and woodlands to maintain and enhance ***baseflow***, protect flood attenuation/storage areas and reduce downstream erosion.
16. Promote implementation of ***LID*** and ***green infrastructure*** and monitor their effectiveness.
17. Continue educating the public about the importance of conventional and ***LID SWM*** infrastructure operation and maintenance in reducing local flooding and improving water quality.

RECOMMENDATION 3: UPDATE LOCAL PLANNING, POLICY, AND REGULATORY TOOLS THAT ADDRESS FLOOD AND DROUGHT RISKS TO INCLUDE CLIMATE CHANGE AND *EFLOW* NEEDS.

RATIONALE:

- A range of legislation, regulations, policies and programs at all levels of government potentially impact flood and drought risk as well as sustaining ***eflow*** needs in the Thames River ***watershed***. At a local level, both the UTRCA and LTVCA, as well as ***watershed*** municipalities, have various local policies that address flood and drought risks as well as potentially sustaining ***eflow*** needs.
- The fundamental provincial role for all Conservation Authorities focuses on water related natural hazard prevention and management and includes flood and erosion control. ***CAs*** have a delegated responsibility from the Minister of Natural Resources to represent the provincial interests regarding natural hazards (flood and erosion) consistent with Section 3.1 of the Provincial Policy Statement.
- The UTRCA Environmental Planning Policy Manual is a comprehensive policy manual which facilitates implementation of the UTRCA's integrated systems approach for ***watershed*** planning.

Proposed Activities

1. Consider ***eflow*** when developing policy and other regulatory tools to address flood and drought risk.
2. Enhance technical guidance related to the consideration of climate change, including the potential options for integrating ***eflow*** requirements into the climate change considerations for ***floodplain*** management and mapping.
3. Update and maintain CA policies (e.g., Planning Policy Manual) to ensure currency with respect to reducing flood and drought risk as well as sustaining ***eflow*** needs.
4. Update and maintain municipal policies (e.g., ***Stormwater*** Guidelines, Official Plan Policies) to ensure currency with respect to reducing flood and drought risk as well as sustaining ***eflow*** needs.
5. Develop and maintain CA and municipal planning and policies to address climate change.

3.3.4 Goal 4: Expand water quantity monitoring to improve understanding of *eflow* needs, flood and drought risk, and climate change

GOAL 4: EXPAND WATER QUANTITY MONITORING TO IMPROVE UNDERSTANDING OF *EFLOW* NEEDS, FLOOD AND DROUGHT RISK, AND CLIMATE CHANGE.
RECOMMENDATION 1: MAINTAIN AND ENHANCE A SUSTAINABLE SURFACE WATER QUANTITY MONITORING PROGRAM
RATIONALE: • A sustainable surface water monitoring program provides consistent, long term data. • Consistent, long term water quantity monitoring is crucial to flood forecasting and warning programs as well as the operation of flood control structures. It is also important for understanding surface water/***groundwater*** interactions, assessing impacts of climate change, evaluating ***eflow***, interpreting water quality information and verifying ***hydraulic*** and ***hydrologic models***. • ***Hydrologic*** parameters of the Thames River have been measured for many years. Today, the UTRCA and LTVCA operate a sophisticated water quantity data collection network and data management system that measures, records and stores data on water levels in rivers and reservoirs, flow, precipitation, air temperature and water temperature from locations throughout the ***watershed***. • The data management system collects and stores time series data in a central database, as well as metadata about stations and sites. The data management system includes powerful analysis and reporting tools. • Provisional data is posted to the UTRCA and LTVCA web sites in near real-time, which allows anyone with an Internet connection to remotely monitor ***watershed*** conditions. • For flood forecasting, hazard mapping and modelling, and the management of flows, it is important to have reliable flow estimation through all reaches of the Thames River. • For a number of reasons, the Lower Thames has significantly fewer monitoring stations and gauges than the Upper Thames. • Deriving precipitation data from radar data sources may significantly improve monitoring and understanding of the spatial distribution of precipitation in the ***watershed***. Recent research has provided insight into the potential for processing and calibrating radar data (in conjunction with data from the local rain gauge network) in near real-time to support flood forecasting and warning, as well as providing a long-term record for improving ***watershed*** understanding. • Improved spatial coverage of precipitation data, through programs that utilize volunteers to report weather observations, should be encouraged to improve spatial data coverage of weather data.
Proposed Activities
1. Improve the water quantity monitoring program, particularly in the Lower Thames, to better support flood forecasting, the understanding of ***eflows***, climate change impacts, and water quality relationships. This monitoring program needs to be sustainable and

GOAL 4: EXPAND WATER QUANTITY MONITORING TO IMPROVE UNDERSTANDING OF *EFLOW* NEEDS, FLOOD AND DROUGHT RISK, AND CLIMATE CHANGE.

regularly reviewed and adjusted.

2. Establish a flow monitoring program for the lower reaches of the Thames River (and associated tributaries), that accounts for the influence of Lake St. Clair water levels on the water depth to flow relationship.
3. Establish a cost-effective automated system for obtaining, calibrating, storing, and utilizing radar rainfall data from both Canadian and American sources.
4. Encourage volunteer-based weather reporting programs (such as CoCoRaHS), which improve spatial coverage of weather data. Integrate data collected by such programs into centralized data management systems.
5. Develop and implement an automated notification system for flood forecasting based on near real-time data from the surface water monitoring stations.
6. Incorporate monitoring information in communication and education materials to improve public understanding of water quantity issues and the value of monitoring programs.
7. Review and assess ***watershed*** gauge distribution and effectiveness to ensure they adequately provide the information needed for monitoring and responding to a changing climate.
8. Develop and implement a sustainable monitoring program for the ***pumping schemes*** located in the lower reaches of the river.

RECOMMENDATION 2: IMPROVE EXISTING *GROUNDWATER* MONITORING PROGRAM

RATIONALE:

- Techniques for more accurately quantifying changes in recharge are needed. Estimation of recharge in the Thames River has relied on estimates derived from the water balance equation as a residual product of the water balance terms (precipitation, runoff, evapotranspiration and ***groundwater*** inflow/outflow). The method is generally considered to have relatively low accuracy.
- ***Groundwater*** monitoring data can be used to better understand several aspects of water management including ***groundwater flooding***, drought and ***environmental flow*** needs. ***Groundwater*** observations can also help support ***hydrological modelling***.
- The basic method to measure ***groundwater*** change is to install ***groundwater*** monitoring wells. A sustainable shallow ***groundwater*** monitoring network can measure recharge in shallow ***aquifers*** (less than 8 m), which are likely a major component of ***eflows***.
- Currently, there are 28 Provincial ***Groundwater*** Monitoring Network wells in 22 locations in the Upper Thames ***Watershed*** and 5 wells in 5 locations in the Lower Thames ***Watershed***. Unfortunately, this monitoring system is not sufficient to determine specifics about the location and quantity of ***groundwater*** in the Thames River ***watershed***, nor its interaction with the Great Lakes basin. Near real time ***groundwater*** observations are also limited and insufficient to support ***hydrological modelling*** applications for purposes such as data continuity, flood forecasting and warning, and low water response.
- Understanding of ***groundwater*** resources in the ***watershed*** would be improved by

GOAL 4: EXPAND WATER QUANTITY MONITORING TO IMPROVE UNDERSTANDING OF *EFLOW* NEEDS, FLOOD AND DROUGHT RISK, AND CLIMATE CHANGE.

undertaking an exercise to map ***aquifers*** across the ***watershed***. It is important to improve the ***groundwater*** monitoring program to understand the location and quantity of ***groundwater*** in the Thames River ***watershed*** and its interaction with the Great Lakes basin. An unknown portion of the water that infiltrates is transferred to deeper ***aquifers***, resulting in regional flow through bedrock and overburden units towards the Great Lakes. ***Groundwater*** monitoring is important to understanding and quantifying this transfer.

- UTRCA (2009) undertook a study to evaluate the suitability of the existing PGMN wells in the Upper Thames portion of the ***watershed*** for evaluating ***groundwater*** resources with respect to drought. The study recommended that many more ***groundwater*** monitoring wells be installed to support the Ontario Low Water Response program in the Thames ***watershed***.
- Incorporating monitoring information in communication and education materials would improve public understanding of ***groundwater*** quantity issues.
- Flood risk from ***groundwater flooding*** is generally not well understood. Rising ***groundwater*** can contribute to river flooding but may affect areas outside of the area inundated by surface water. ***Groundwater flooding*** is rarely a danger to life, but can cause significant damage. Causes for rising ***groundwater*** can be complex, especially in urban areas where recharge can follow underground infrastructure or where long or extreme rainfall events can cause high ***groundwater recharge*** which cannot discharge into the ***aquifer*** at an adequate rate.

Proposed Activities

1. Establish near real-time continuous monitoring of water level in ***groundwater*** monitoring wells to inform ***hydrologic modelling*** for purposes such as flood forecasting.
2. Establish new ***groundwater*** monitoring wells in areas identified as data gaps in Ontario Low Water Response: Draft Groundwater Indicator Site Selection Criteria (UTRCA 2009). A similar study should be undertaken for the Lower Thames portion of the ***watershed***, and recommendations similarly implemented.
3. Establish a monitoring program to support chemically based techniques or ***water table*** variation methods of estimating recharge.
4. Develop an improved understanding of ***groundwater*** infiltration and ***recharge*** areas, by building on information used to identify ***Significant Groundwater Recharge Areas (SGRAs)*** and highly vulnerable ***aquifers*** (HVAs), including in First Nations, where invited.
5. Identify and monitor areas of shallow ***groundwater*** or changing water levels that have potential for ***groundwater flooding***.
6. Establish a sustainable shallow ***groundwater*** monitoring network to measure recharge in shallow ***aquifers.***
7. Use ***groundwater*** monitoring data to map ***aquifers*** across the ***watershed***.
8. Incorporate monitoring information in communication and education materials to improve public understanding of ***groundwater*** quantity issues and the importance of a ***groundwater*** monitoring program.

GOAL 4: EXPAND WATER QUANTITY MONITORING TO IMPROVE UNDERSTANDING OF *EFLOW* NEEDS, FLOOD AND DROUGHT RISK, AND CLIMATE CHANGE.

RECOMMENDATION 3: ASSEMBLE AND ANALYZE HISTORICAL CLIMATE, SURFACE WATER AND *GROUNDWATER* MONITORING DATA, TOGETHER WITH INTERPRETATIONS OF FUTURE CLIMATE CHANGE PROJECTION DATA, TO BETTER UNDERSTAND THE LOCAL IMPACTS OF CLIMATE CHANGE.

RATIONALE:

- An understanding of the potential impacts of climate change at the ***watershed*** scale warrants its own study to determine the trends and / or presence of patterns in the data. There are two basic types of data that can be used to better understand climate change: historical data, and future projections.
- The Environment Canada meteorological stations and surface water gauges are best for observing long-term trends as they have long periods of record, they measure winter precipitation, and they have uniform quality control. The Conservation Authority surface water quantity network was established for the purposes of modelling flood events and flood forecasting, but many stations likely have not been collecting data long enough to trace climate change throughout the ***watershed***, and have generally not been maintained to the same quality standard as the EC stations.
- The production of future projected climate data sets is an area of intense research that is producing rapidly evolving results. The data is available in various scales both spatially and temporally, and with various assumptions about the anthropogenic impacts on the future climate. The various projected future climate data sets provide wide ranges of potential future climate variables. With the significant uncertainty implied by the range of predictions, it is important to consider the range of possibilities. There are several approaches available to potentially attempt to describe the confidence in the range of climate projections.
- The most common climate data variables of interest are temperature and precipitation. For the purposes of understanding the water cycle, precipitation is the variable of primary interest. Unfortunately, there is much more uncertainty in precipitation variables in projected future climate data sets than temperature variables. In order to transform the projected future climate data sets into projected future ***hydrological*** data sets (to assess the future water cycle), models need to be developed. Such models could then use historical and projected future climate data sets to assess predicted future changes to flood and drought risk, and ***eflow*** needs.

Proposed Activities

1. Compile data sets of potential future Thames River ***watershed*** climates with confidence levels, focusing on precipitation and temperature variables. Such data sets should be updated on an ongoing basis as new information becomes available.
2. Develop and calibrate continuous ***hydrologic watershed*** models to aid in assessing impacts to high flows (flood risk), low flows (droughts), and ***eflows*** in assessments of potential future climates. Include ***groundwater*** processes in the models.

GOAL 4: EXPAND WATER QUANTITY MONITORING TO IMPROVE UNDERSTANDING OF *EFLOW* NEEDS, FLOOD AND DROUGHT RISK, AND CLIMATE CHANGE.
3. Evaluate long-term trends in available historical surface water data (e.g., stream flow data) and climate data (e.g., precipitation data). 4. Evaluate long-term ***groundwater*** trends in available ***groundwater*** data such as the PGMN. 5. Educate residents and municipalities on the potential impacts of climate change and potential adaptation strategies.

4.0 MAPS

Map 1. Thames River ***watershed*** showing First Nations, municipalities and conservation authorities

Map 2. Thames River ***watershed*** showing First Nations reserves, settlements and home lands

Map 3. Thames River ***watershed*** within the Lake Erie drainage basin

Map 4. Canadian tributary annual loadings of ***total phosphorus*** by ***watershed***, where the numbers at the mouths indicate 2003-2013 mean total ***phosphorus loads*** in metric tonnes per year

Map 5. Thames River ***watershed*** long-term monitoring locations

Map 6. Surface water and ***groundwater*** quality monitoring sites

Map 7. Aquatic (benthic and fish) monitoring sites

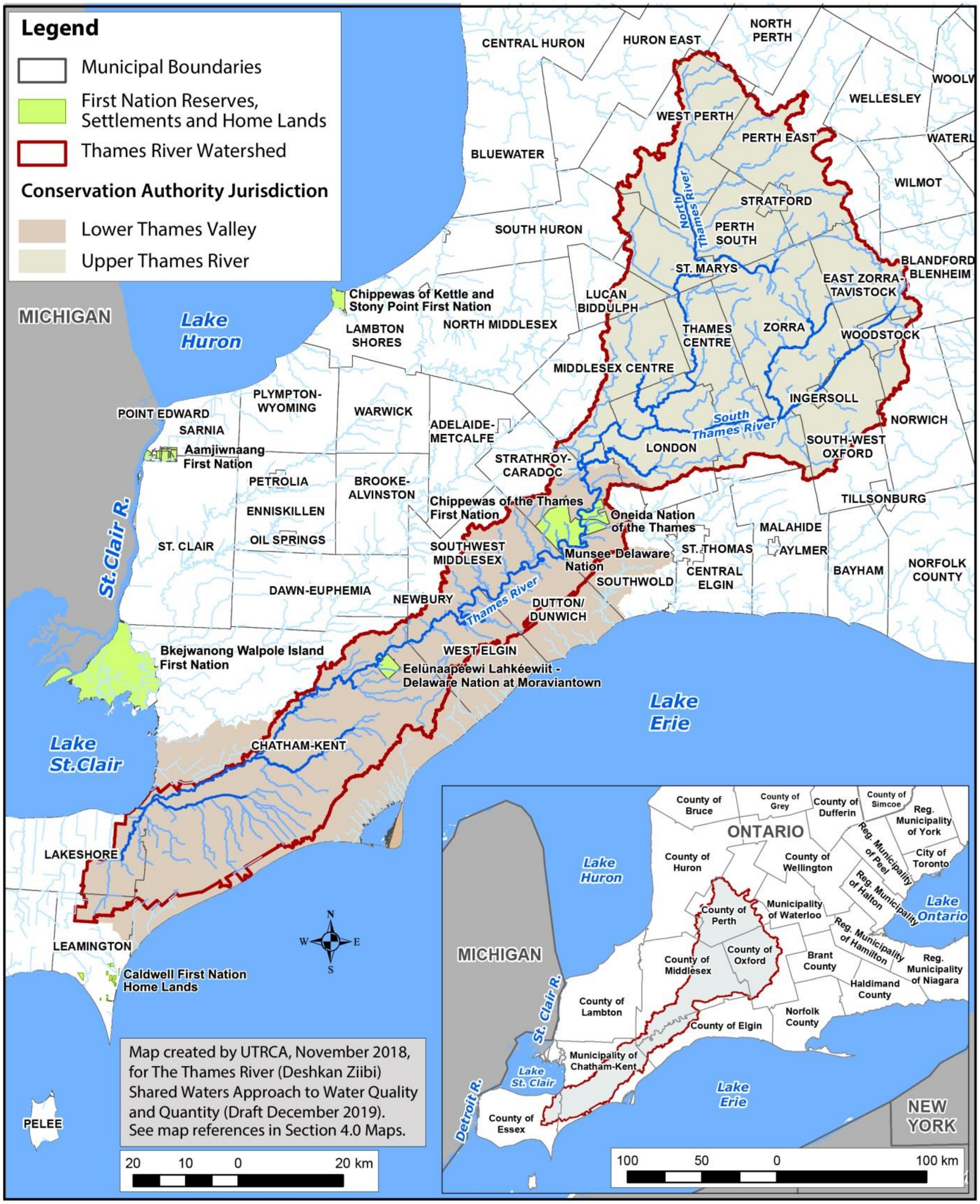
Map 8. Flow and ***groundwater*** monitoring stations

Map 9. Flood control structures and other dams or barriers

Map References

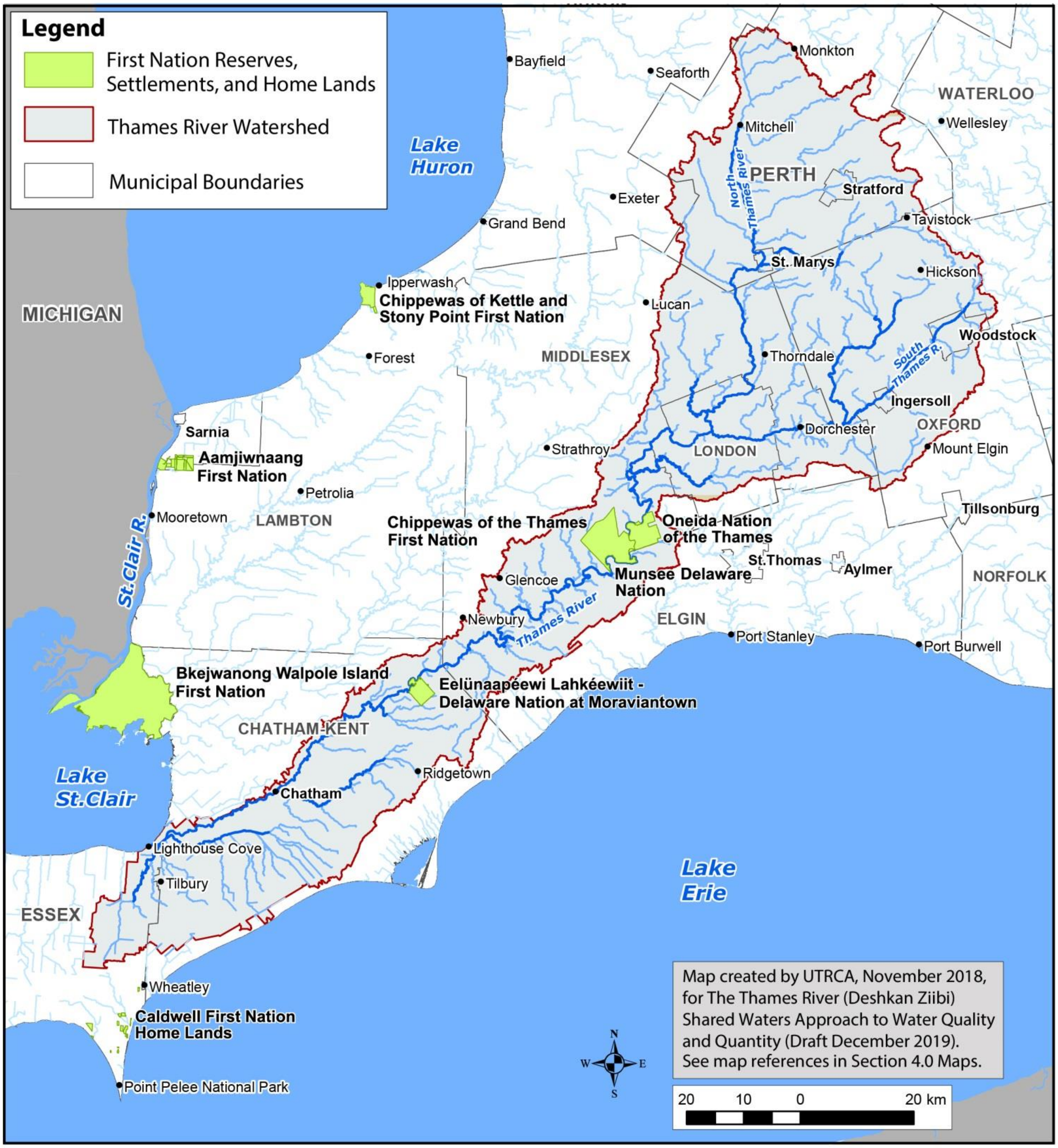
Map 1. Thames River *watershed* showing First Nations, municipalities and conservation authorities

See 1.0 Rationale for an Updated Approach to Water Quality and Quantity; and 2.5 Geomorphology of the Thames River.



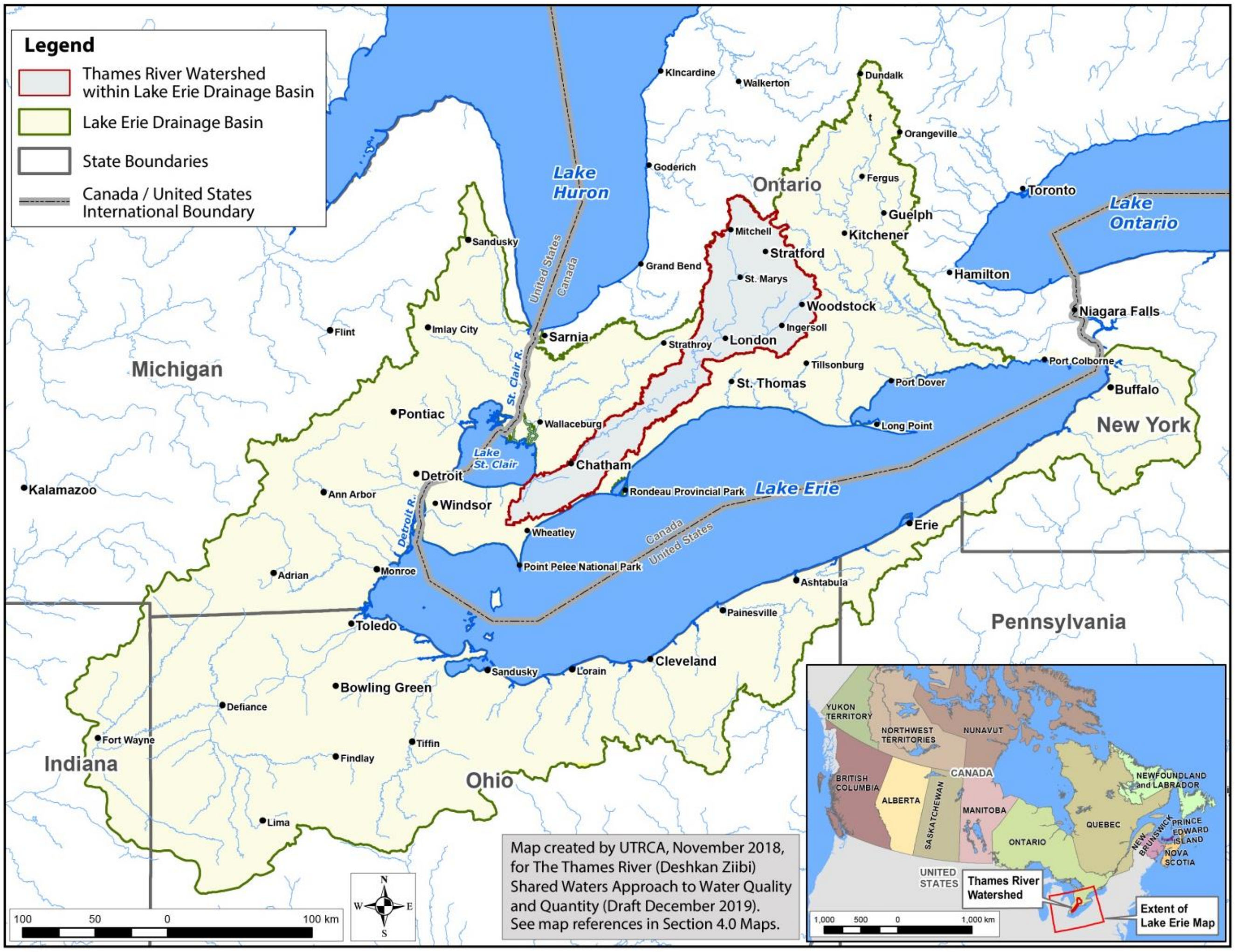
Map 2. Thames River *watershed* showing First Nations reserves, settlements and home lands

See 1.1.4.1 Local First Nations Perspectives.



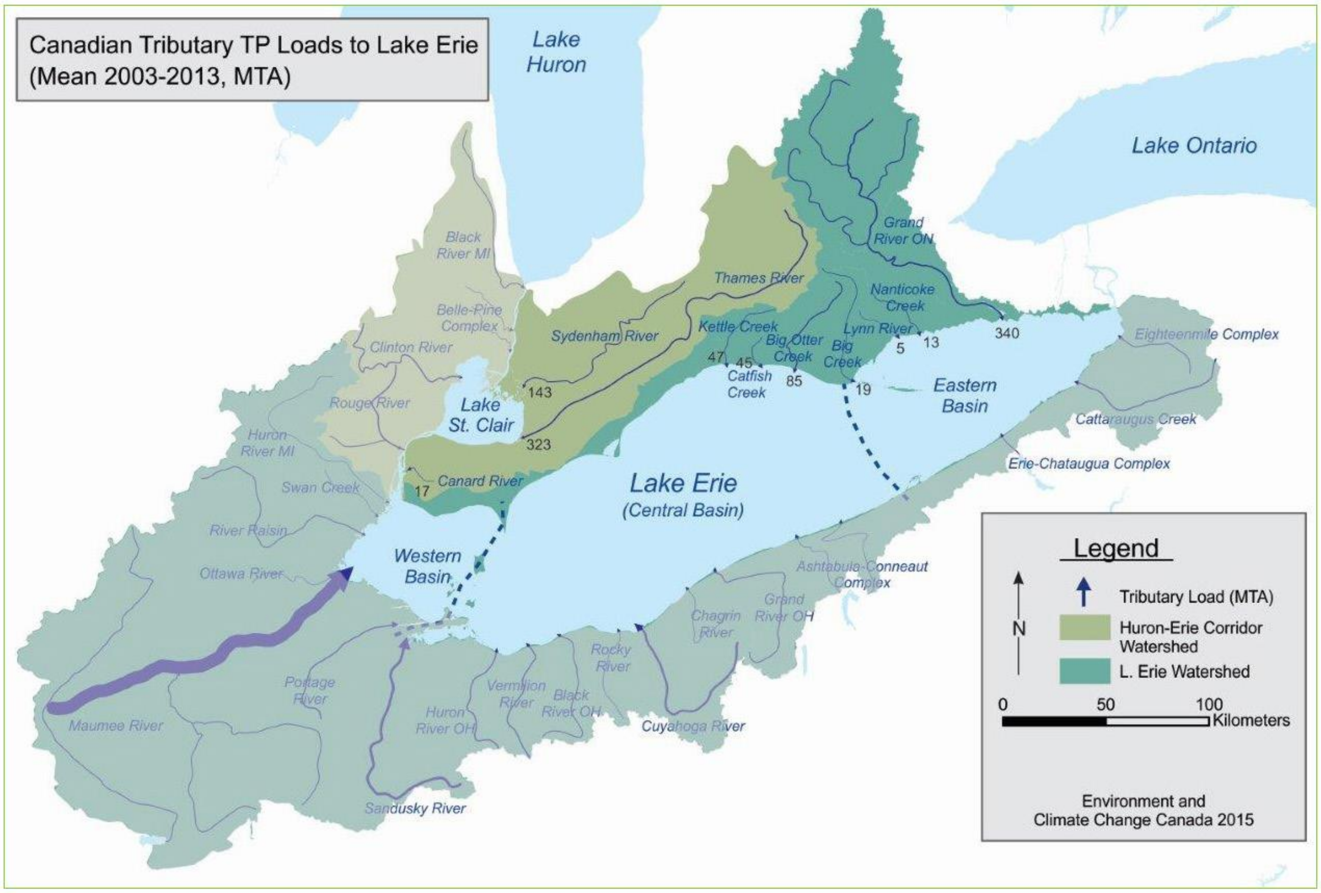
Map 3. Thames River *watershed* within the Lake Erie drainage basin

See 2.5 Geomorphology of the Thames River.



Map 4. Canadian tributary annual loadings of *total phosphorus* by *watershed*, where the numbers at the mouths indicate 2003-2013 mean total *phosphorus loads* in metric tonnes per year

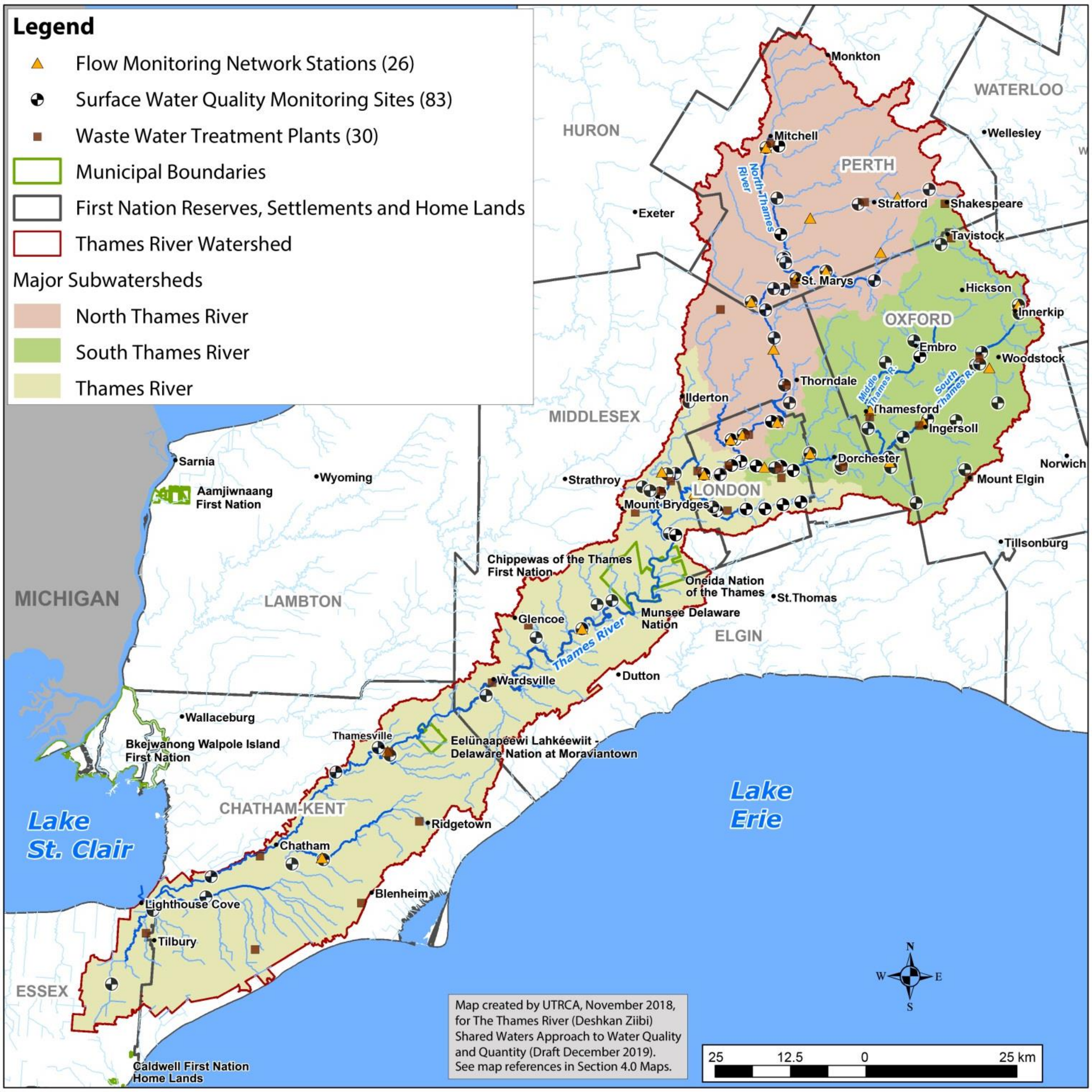
See Appendix C.1 Goal 1: Reduce total and ***soluble reactive phosphorus loads*** in the Thames River ***watershed***.



Source: Canada-Ontario Lake Erie Action Plan (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018).

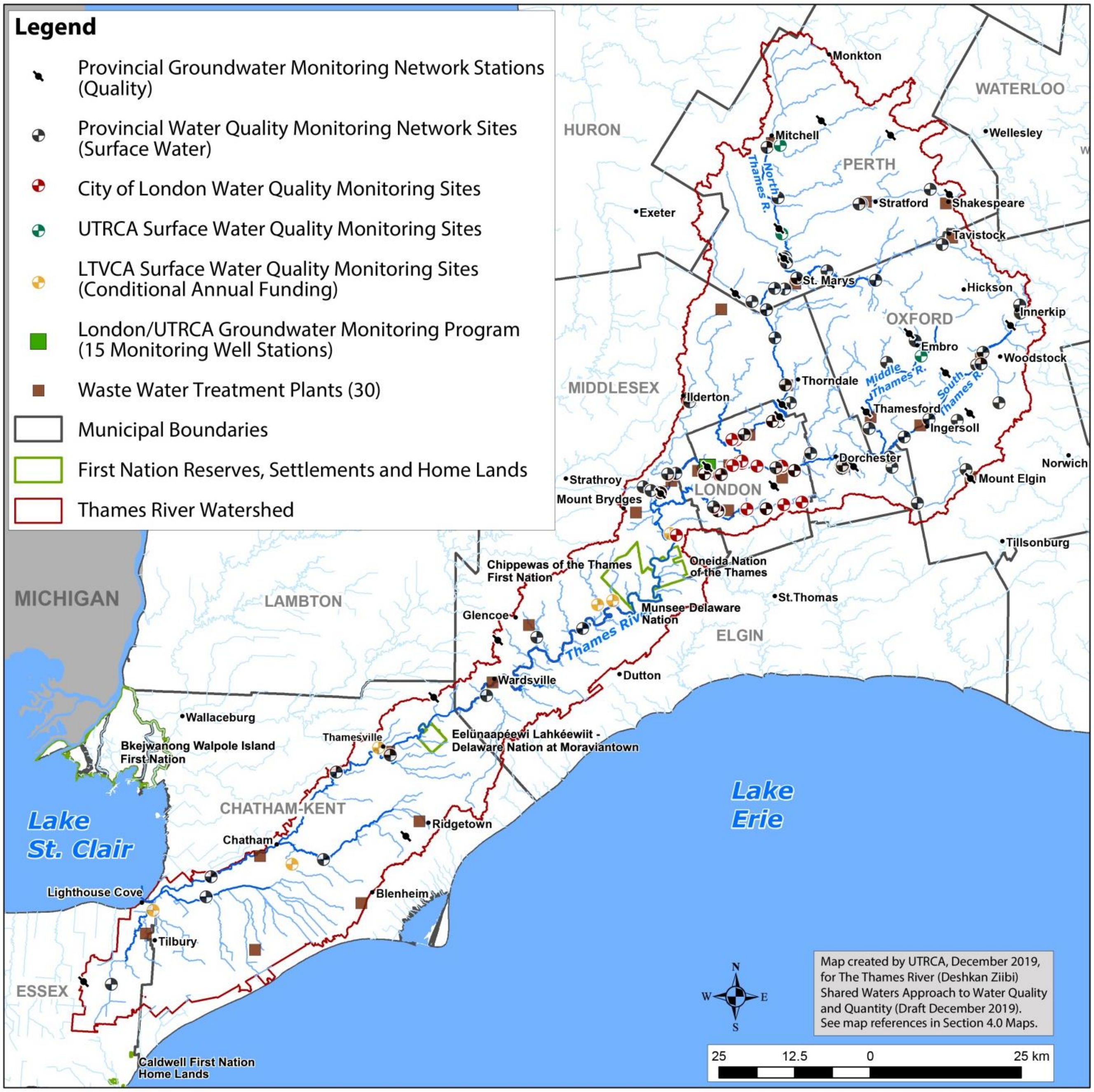
Map 5. Thames River *watershed* long-term monitoring locations

See Appendix C.1 Goal 1: Reduce total and ***soluble reactive phosphorus loads*** in the Thames River ***watershed***, for results of ***phosphorus*** and sediment loadings study (Nurnberg and LaZerte 2015a).



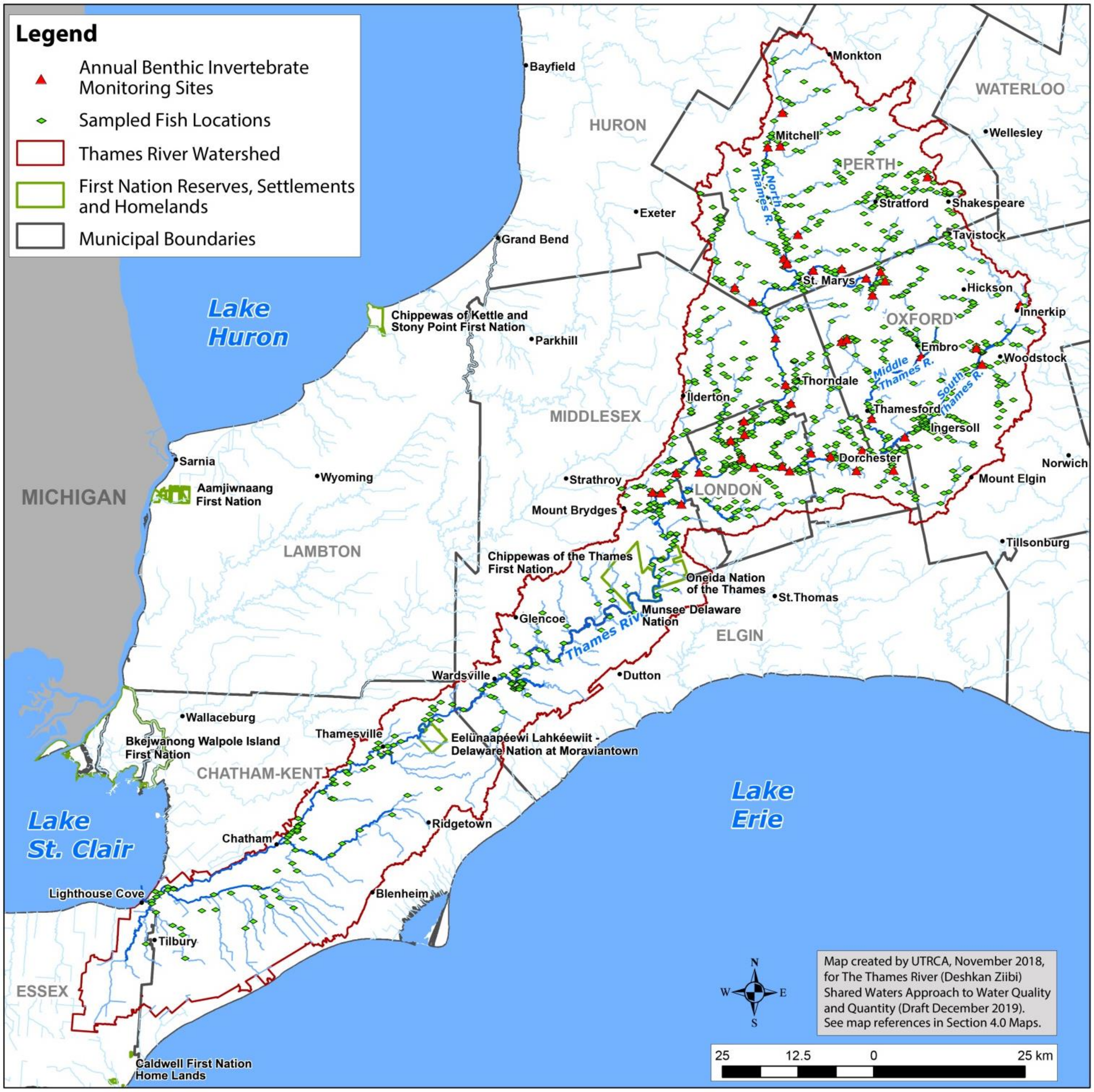
Map 6. Surface water and *groundwater* quality monitoring sites

See Appendix C.3.1 Research and Monitoring.



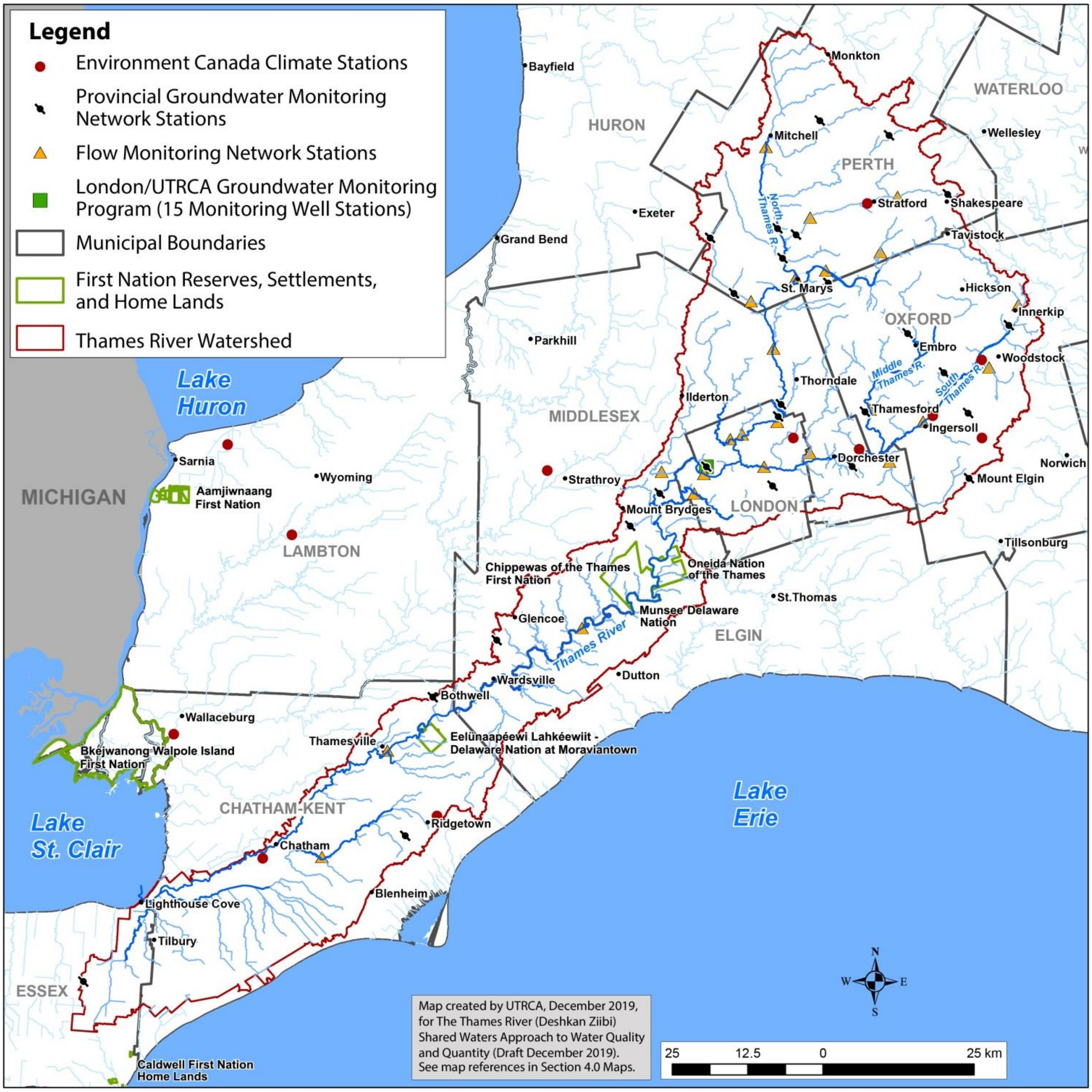
Map 7. Aquatic (benthic and fish) monitoring sites

See Appendix C.3.1 Research and Monitoring.



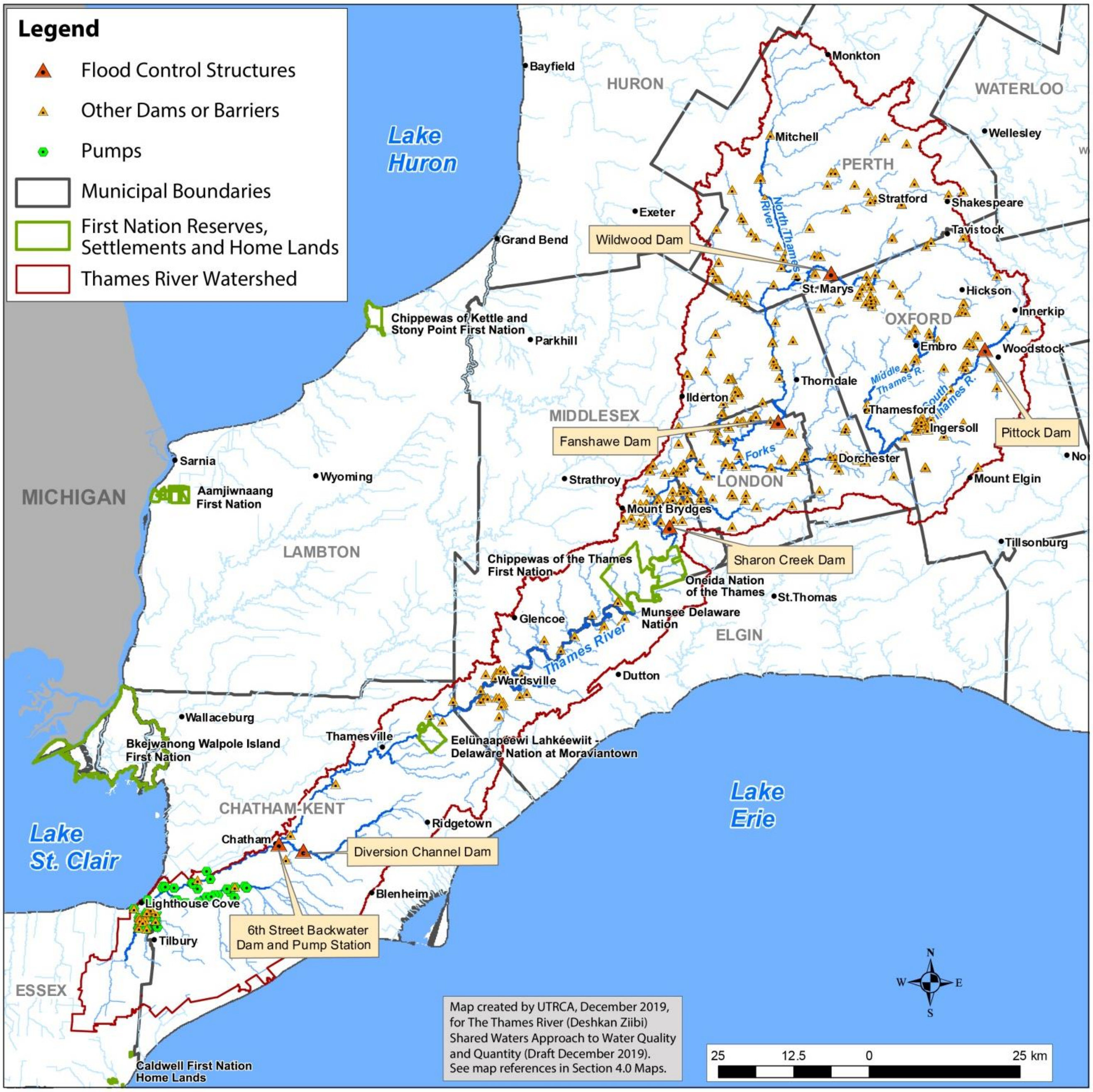
Map 8. Flow and *groundwater* monitoring stations

See Appendix D.2.3 Recommendation 3: Improve and maintain the flood forecasting and warning program; and K.4.1 Recommendation 1: Maintain and enhance a sustainable surface water quantity monitoring program.



Map 9. Flood control structures, other dams or barriers, and pumps

See Appendix D.3.1 Recommendation 1: Develop and/or update operation and maintenance plans, where appropriate, to reflect optimization of ***water control structures*** considering ***eflows*** and flood risk.



MAP REFERENCES

Maps Containing:

- **Conservation Authority Boundaries, Municipal Boundaries, Watercourses -** Information licensed under the Open Government Licence – Ontario https://www.ontario.ca/page/open-government-licence-ontario
- **Thames River Watershed -** Defined by Upper Thames River Conservation Authority (UTRCA) and Lower Thames Valley Conservation Authority (LTVCA)
- **Caldwell First Nation Home Lands -** Locations provided by Caldwell First Nation, April 28, 2018
- **First Nations -** Compiled Plan of the Indian Treaties and Purchases in the Province of Ontario (Morris Map 1943). Revision date October 19, 2017. Dataset accompanies book by J.L. Morris, C.E., D.E. Indians in Ontario, Department of Lands and Forests. Ontario 1943 (reprinted 1964). The GIS dataset supports, in part, the First Nations and Treaties Map produced by the Ministry of Indigenous Relations and Reconciliation, published May 20, 2014. For full reference and licensing see https://geohub.lio.gov.on.ca/datasets/compiled-plan-of-the-indian-treaties-and-purchases-in-the-province-of-ontario-morris-map-1943

Map 3. Thames River watershed within the Lake Erie drainage basin

- **US Place Names and Watercourses -** Information obtained from National Atlas of the United States https://catalog.data.gov/dataset/national-atlas-of-the-united-states
- **Lake Erie Watershed Boundary** - Obtained from Conservation Ontario

Map 4. Canadian tributary annual loadings of total phosphorus by watershed, where the numbers at the mouths indicate 2003-2013 mean total phosphorus loads in metric tonnes per year

- **Canada-Ontario Lake Erie Action Plan, 2018**

Map 5. Thames River watershed long-term monitoring locations

- **Provincial Water Quality Monitoring Network Sites (Surface) -** Ministry of the Environment Conservation and Parks (MECP)
- **City of London Water Quality Monitoring Sites (2105) -** Corporation of the City of London
- **UTRCA Water Quality Monitoring Sites (2017) -** UTRCA
- **LTVCA Surface Water Quality Monitoring Sites (Conditional Annual Funding) (2017) -** LTVCA
- **Waste Water Treatment Plants (2014) -** Locations provided by Municipalities

- **Flow Monitoring Network Stations (2017) -** Locations provided by Ministry of Natural Resources and Forestry (MNRF), UTRCA, and LTVCA
- **Major Watersheds -** Defined by UTRCA and LTVCA

Map 6. Surface water and groundwater quality monitoring sites

- **Provincial Water Quality Monitoring Network Sites (Surface) -** MECP
- **Provincial Groundwater Monitoring Network Stations (2016) -** Groundwater Level Data, Groundwater Chemistry Data, and Precipitation Data provided by MECP, UTRCA, and LTVCA
- **City of London Water Quality Monitoring Sites (2105) -** Corporation of the City of London
- **UTRCA Water Quality Monitoring Sites (2017) -** UTRCA
- **LTVCA Surface Water Quality Monitoring Sites (Conditional Annual Funding) (2017) -** LTVCA
- **London/UTRCA Groundwater Monitoring Program (15 Monitoring Well Stations) (2017) -** City of London and UTRCA
- **Waste Water Treatment Plants (2014**) **-** Locations provided by Municipalities

Map 7. Aquatic (benthic and fish) monitoring sites

- **Annual Benthic Invertebrate Monitoring Site -** UTRCA
- **Sampled Fish Location -** Location where electrofishing has been completed by UTRCA and/or LTVCA. UTRCA sites represent data before 2016. LTVCA sites represent sampling completed between 2001 and 2005.

Map 8. Flow and groundwater monitoring stations

- **Environment Canada Climate Stations –** Environment & Climate Change Canada
- **Provincial Groundwater Monitoring Network Stations (2016) -** Groundwater Level Data, Groundwater Chemistry Data, and Precipitation Data provided by MECP, UTRCA, and LTVCA
- **Flow Monitoring Network Stations (2017) -** Site locations provided by MNRF, UTRCA, and LTVCA
- **London/UTRCA Groundwater Monitoring Program (15 Monitoring Well Stations) (2017) -** City of London and UTRCA

Map 9. Flood control structures and other dams or barriers

- **Flood Control Structures and Other Dams and Barriers** - Defined by UTRCA, 2010, within the UTRCA watershed. Defined by LTVCA, 2019, within the LTVCA watershed.

REFERENCES

Abbruzzese, J., Y. Aldin, C. Eagles, K. Lemon and A. Watson. 2019. Commercial Water Claims: City of London. Assessment of Claims Made by London Residents. Community Engaged Learning Final Projects. 18. Western University. https://ir.lib.uwo.ca/se-ccel/18

Anderson, K. 2010. Aboriginal women, water and health: Reflections from eleven First Nation elders, Inuit and Metis grandmothers. Retrieved from http://www.pwhce.ca/womenAndWater.htm

Anderson, K., B. Clow and M. Haworth-Brockman. 2011. Carriers of water: Aboriginal women's experience, relationships and reflections. Journal of Cleaner Production, November. Retrieved from http://dx.doi.org/10.1016/j.jclepro.2011.10.023

Bailey, R. and A. Yates. 2003. Fanshawe lake ecosystem assessment and recovery strategy background report. Western Environmental Science and Engineering Research Institute. Department of Biology. University of Western Ontario. 19pp.

Becker, C.D. and K. Ghimire. 2003. Synergy between traditional ecological knowledge and conservation science supports forest preservation in Ecuador. Conservation Ecology. 8(1): 1.

Berkes, F., J. Colding and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications. 10(5):1251-1262.

Blackstock, M. 2001. Water: A First Nations' Spiritual and Ecological Perspective. BC Journal of Ecosystems and Management. Vol 1(1): 1-14. Retrieved from https://waterbucket.ca/cfa/files/2017/09/Water-FN-Spiritual-Ecological-Perspective_2001.pdf

Boelens, R., M. Chiba and D. Nakashima. 2006. Water and Indigenous peoples, knowledges of nature (pp. 108-115). Paris, FR: UNESCO.

Bradford, A. 2008. An Ecological Flow Assessment Framework: Building a Bridge to Implementation in Canada. *In* Canadian Water Resources Journal, 33(3): 215-232.

Bradshaw, C.J.A., B.W. Brook, K.S.-H. Peh and N.S. Sodhi, 2007. Global evidence that deforestation amplifies flood risk and severity in the developing world. Global Change Biology 13(11):2379-2395.

Brisbane Declaration. 2007. Environmental flows are essential for freshwater ecosystem health and human wellbeing. 10th International River Symposium and International Environmental Flows Conference. Brisbane, Queensland, Australia.

Brooker, M.P. 1985. The Ecological Effects of Channelization. The Geographical Journal Vol 151 (1): 63-69.

Brown, D.R. and K. Goff. 1981. Thames River Basin Water Management Study Technical Report: Groundwater Resources: Summary. Issue 14 of Water Resources Report. Ministry of the Environment, Water Resources Branch. 10pp.

Cairns, A. 2007. Studies by Undergraduate Researchers at Guelph (SURG).Vol 1 (1).

Canadian Council of Ministers of the Environment. 1999. Canadian water quality guidelines for the protection of aquatic life: Dissolved oxygen (freshwater). In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg).

Chapman, L.J. and D.F. Putnam. 1984. The Physiography of Southern Ontario, Third Edition. Ontario Geological Survey Special. Volume 2. Ministry of Natural Resources, Ontario.

Chiefs of Ontario. 2008. The Water Declaration of the Anishinaabek, Mushkegowuk and Onkwehonwe.

Christensen, R. 2006. Waterproof 2. Canada's Drinking Water Report Card. Sierra Legal Defence Fund.

City of London. 2016. The London Plan. Exciting. Exceptional. Connected. 465 pp.

Conservation Ontario. 2006. Establishing Ecological Flow Requirements: Synthesis Report.

Corpuz, V. 2006. Indigenous peoples and international debates on water: Reflections and challenges. In: R. Boelens, M. Chiba, and D. Nakashima (eds). Water and Indigenous peoples, knowledges of nature (pp. 24-35). Paris, FR: UNESCO.

Cudmore, B., C.A. MacKinnon and S.E. Madzia. 2004. Aquatic species at risk in the Thames River watershed, Ontario. Can. MS Rpt. Fish. Aquat. Sci. 2707: v + 123 p.

Delleur, J.W. 1999. The handbook of groundwater engineering. Boca Raton, FL: CRC Press.

Dillon Consulting Ltd. and D.R. Poulton & Associates. 2011. City of London Thames Valley Corridor Plan. Final Report. 47pp.

Dosskey, M.G., P. Vidon, N.P. Gurwick, C.J. Allan, T.P. Duval, and R. Lowrance. 2010. The Role of Riparian Vegetation in Protecting and Improving Chemical Water Quality in Streams. Journal of the American Water Resources Association (JAWRA):1-18.

Dove A., Richardson V., Baillargeon, J., Narayan, J. and Backus S. Canadian Tributary Loadings to Lake Erie 2012, 2013 and 2014 Water Years with an accounting of activities until March 2015. Environment Canada, Unpublished.

Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks. 2018. Canada-Ontario Lake Erie Action Plan (LEAP): Partnering on Achieving Phosphorus Loading Reductions in Lake Erie from Canadian Sources. 75 pp.

Estin, D. and J. Swaigen. 1993. Environment on Trial: A Guide to Ontario Environmental Law and Policy.Toronto: Emond-Montgomery Publishers. pp. 114-116.

Goldtooth, T. 2006. Indigenous Declaration at World Water Forum. [e-mail posting]. Retrieved from http://www.mail-archive.com/natnews-north@yahoogroups.com/ msg02284.html

Government of the United States and Government of Canada. 2012. Great Lakes Water Quality Agreement, Protocol Amending the Agreement Between Canada and the United States of America on Great Lakes Water Quality, 1978, as Amended on October 16, 1983, and on November 18, 1987. 54 pp with annexes.

Healy, R.W. and P.G. Cook. 2002. Using groundwater levels to estimate recharge. Hydrogeology Journal 10(1): 91-109.

HETEK Solutions Inc. and Resource Management Strategies Inc. 2008. City of London Water Efficiency Strategy. 145 pp.

Hutchinson Environmental Sciences Ltd. 2017. Natural Heritage Features and the Role in Mitigating Nutrient Impacts on Lake Erie: An Assessment of Best Management Practices and Approaches for Floodplains and Watercourses. Prepared for Environment and Climate Change Canada.

Intergovernmental Panel on Climate Change. 2014. 5th assessment report. Jiménez Cisneros et al. (eds). Cambridge University Press, Cambridge, UK, and New York, NY: Intergovernmental Panel on Climate Change. 229–269.

International Joint Commission. 2014. A Balanced Diet for Lake Erie.

Jacobs, D.M. 2012. Consulting and accommodating First Nations in Canada: a duty that reaps benefits. 21pp.

Jeffres, C.A., J.J. Opperman and P.B. Moyle. 2008. Ephemeral floodplain habitats provide vest growth conditions for juvenile Chinook salmon in a California river. Environmental Biology of Fishes. 83: 449-458.

Johnston, B. 2003. Honour Earth Mother. University of Nebraska Press. Lincoln. 173pp.

Johnston, B.H. 1976. Ojibway Heritage. McClelland & Stewart. 171 pp.

Lake Erie LaMP. 2009. Status of Nutrients in the Lake Erie Basin. Prepared by the Lake Erie Nutrient Science Task Group for the Lake Erie Lakewide Management Plan.

Lake Erie LaMP. 2011. Lake Erie Binational Nutrient Management Strategy: Protecting Lake Erie by Managing Phosphorus. Prepared by the Lake Erie LaMP Work Group Nutrient Management Task Group.

Lake St. Clair Canadian Watershed Coordination Council. 2009. Lake St. Clair Canadian Watershed Management Plan. 36pp.

Lake Simcoe Region Conservation Authority and Bradford, A. 2011. Towards a Framework for Determining Ecological Flows and Water Levels in the Lake Simcoe Watershed – A Guidance Document. Prepared for Ontario Ministry of the Environment. 29pp.

Linnansaari, T., Monk, W.A., Baird, D.J. and Curry, R.A. 2013. Review of approaches and methods to assess Environmental Flows across Canada and internationally. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/039. vii + 75 pp.

Lobb, D., N. Badreldin, M. Loro, S. Li, and B.G. McConkey. 2017. Soil degradation: The cost to agriculture and the economy.

Lorimer, S.E. (ed). 1996. Guide to the Natural Areas of London & Vicinity. London, Ontario. The McIlwraith Field Naturalists of London, Ontario, Inc.

Lower Thames Valley Conservation Authority (LTVCA). 1987. Lower Thames River Erosion Control Update Report.

LTVCA. 2013. Lower Thames Valley Watershed Report Card.

Lower Thames Valley Conservation Authority, Upper Thames River Conservation Authority, St. Clair Region Conservation Authority, Ontario Ministry of the Environment, and Conservation Ontario. 2008. Thames-Sydenham and Region Watershed Characterization Summary Report: Thames Watershed and Region (Upper Thames River and Lower Thames Valley Source Protection Areas). 48pp.

Maccoux, M. J., A. Dove, S.M. Backus, and D.M. Dolan. 2016. Total and soluble reactive phosphorus loadings to Lake Erie: A detailed accounting by year, basin, country, and tributary. Journal of Great Lakes Research, 42(6), 1151-1165.

Machusick, M.D. and R.G. Traver. 2009. The Observed Effects of Stormwater Infiltration on Groundwater. World Environmental and Water Resources Congress 2009: Great Rivers. pp 5343-5353.

MacLaren Engineers Inc. July 1987. Lower Thames River Erosion Control Update Report. Prepared for the Lower Thames Valley Conservation Authority.

MacLaren Engineers, Planners and Scientists, Inc. 1982. Pre-Feasibility Study of the Wardsville Dam and Reservoir Project. Prepared for the Thames River Implementation Committee.

MacLaren, J.F. Ltd. 1967. Report on the Lower Thames River Channel and Dike System from Chatham to Lake St. Clair for the Lower Thames Valley Conservation Authority.

MacLaren, J.F. Ltd. 1971. Preliminary Engineering Report to the Lower Thames Valley Conservation Authority on Flood and Erosion Control Works on the Lower Thames River from Chatham to Delaware.

Mandamin. J. 2012. N'guh izhi chigaye, nibi onji: I will do it for the water. In: A. Corbiere, D. McGregor, and C. Migwans (Eds.), Anishinaabewin niizh: Culture movements, critical moments (pp. 12-23). McChigeeng, ON: Ojibwe Cultural Foundation.

McDermid, J.L., S.K. Dickin, C.L Winsborough, H. Switzman, S. Barr, J.A. Gleeson, G. Krantzberg, P.A. Gray. 2015. State of Climate Change Science in the Great Lakes Basin: A Focus on Climatological, Hydrological and Ecological Effects. Prepared jointly by the Ontario Climate Consortium and Ontario Ministry of Natural Resources and Forestry to advise Annex 9 – Climate Change Impacts under the Great Lakes Water Quality Agreement, October 2015.

McGregor, D. 2004. Coming full circle: indigenous knowledge, environment, and our future. American Indian Quarterly, 28(3 & 4), 385-410.

McGregor, D. 2009. Honouring our relations: An Anishinabe perspective on environmental justice. In: J. Agyeman, R. Haluza-Delay, C. Peter and P. O'Riley (Eds.), Speaking for ourselves: Constructions of environmental justice in Canada (pp. 27-41). Vancouver, BC: University of British Columbia Press.

McGregor, D. 2012. Traditional Knowledge: Considerations for Protecting Water in Ontario. The International Indigenous Policy Journal. Article 11. Volume 3(3).

Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver and Z.C Zhao. 2007. Global climate projections. In: Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller. Cambridge University Press. Cambridge, UK and New York, NY. Chapter 10.

Metcalfe-Smith, J.L., S.K. Staton, G.L. Mackie, and N.M. Lane. 1997. Biodiversity of freshwater mussels in the lower Great Lakes drainage basin. Plenary presentation at the 3rd National Ecological Monitoring and Assessment Network Meeting, Saskatoon, Saskatchewan, 25 January 1997.

Metcalfe-Smith, J.L., S.K. Staton, G.L. Mackie, and I.M. Scott. 1999. Range, population stability and environmental requirements of rare species of freshwater mussels in southern Ontario. Environment Canada, National Water Research Institute, Burlington, Ontario. NWRI Contribution Number 99-058.

Metcalfe-Smith, J.L., S.K. Staton, G.L. Mackie, and E.L. West. 1998. Assessment of the current status of rare species of freshwater mussels in southern Ontario. Environment Canada, National Water Research Institute, Burlington, Ontario. NWRI Contribution Number 98-019.

Millward, A.A., K. Paudel and S.E. Briggs. 2011. Naturalization as a strategy for improving soil physical characteristics in a forested urban park. Urban Ecosystems 14(2): 261-278.

Ministry of Natural Resources (MNR). 2010. Policies and Procedures for Conservation Authority Plan Review and Permitting Activities.

MNR. 2012. Drainage Act and Conservation Authorities Act Protocol. https://www.ontario.ca/page/drainage-act-and-conservation-authorities-act-protocol.

Ministry of Natural Resources and Forestry (MNRF). 2002. Technical Guide: River and Stream Systems: Erosion Hazard Limit.

MNRF. 2017. A Wetland Conservation Strategy for Ontario 2017-2030. Queen's Printer for Ontario. Toronto, ON. 52 pp.

Ministry of the Environment and Climate Change. 2003. Stormwater Management Planning and Design Manual. Queen's Printer for Ontario. 379pp.

Ministry of the Environment and Energy. 1994a. Policies, guidelines, provincial Water Quality Objectives of the Ontario Ministry of Environment and Energy. July 1994.

Ministry of the Environment and Ministry of Natural Resources. 1975. Water Management Study Summary Report: Thames River Basin. 38pp

Morisawa, M. 1968. Streams: Their Dynamics and Morphology. Earth and Planetary Science Series. McGraw-Hill Book Company.

Morris, T.J. 2004. National recovery strategy for the round hickorynut (Obovaria subtrotunda, Rafinesque 1820) and the kidneyshell (Ptychobranchus fasciolaris, Rafinesque 1820): 2004-2009. Draft June 2004.

Mortsch, L., M. Alden and J.D. Scheraga. 2003. Climate Change and Water Quality in the Great Lakes Region – Risks, Opportunities and Responses. A Report Prepared for the Great Lakes Water Quality Board of the International Joint Commission. 135 pp.

Moudrak, N., A.M. Hutter and B. Feltmate. 2017. When the big storms hit: the role of wetlands to limit urban and rural flood damage. Prepared for MNRF. Intact Centre on Climate Adaptation, University of Waterloo.

Nurnberg, G. and B. LaZerte (Freshwater Research). 2015a. Water Quality Assessment in the Thames River Watershed – Nutrient and Sediment Sources.

Ontario Ministry of the Attorney General. 2002. Report of the Walkerton Inquiry. Part One: The Events of May 2000 and Related Issues, and Part Two: A Strategy for Safe Drinking Water. The Honorable Dennis R. O'Connor, Commissioner.

Ontario Ministry of Agriculture and Food. 1975. Design and Construction Guidelines for Work Under the Drainage Act. Prepared by Devos, A.J., A.J. Graham, H.H. Todgham, E.H. Uderstadt, and J.K. Young.

Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). 2011. Controlling Soil Erosion on the Farm: A practical guide to help Ontario farmers solve soil erosion problems.

OMAFRA. 2012. Best Management Practices for Phosphorus.

OMAFRA. 2016. Sustaining Ontario's Agricultural Soils: Towards a Shared Vision. 35pp.

O'Sullivan, P.E. and C.S. Reynolds. 2006. The Lakes Handbook Volume 2 Lake Restoration and Rehabilitation. 560pp.

Paul, M.J. and J.L. Meyer. 2001. Streams in the urban landscape. Annual Review of Ecology and Systematics. Vol 32: 333-365.

Phare, M.P. 2009. Denying the source: The crisis of First Nation water rights. Surrey, BC: Rocky Mountain Books.

Phare, M.P. 2011. Restoring the lifeblood: Water, First Nations and opportunities for change. Toronto, ON: Walter and Duncan Gordon Foundation.

Pitz, C. 2016. Predicted Impacts of Climate Change on Groundwater Resources of Washington State. Department of Ecology State of Washington. Publication No. 16-03-006.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B. Richter, R. Sparks and J. Stromberg. 1997. The natural flow regime: a paradigm for riverine conservation and restoration. Bioscience 47 (11): 769-784.

Poff, N.L. and J.K.H. Zimmerman. 2009. Ecological responses to altered flow regimes: a literature review to inform the science and management of environmental flows. Freshwater Biology 55(1):194-205.

Ransom, J. 1999. The waters. In Haudenosaunee Environmental Task Force (Ed.), Words that come before all else: Environmental philosophies of the Haudenosaunee. Cornwall Island, ON: Native North American Traveling College.

RBC 2014. Blue Water Project. Fluid Attitudes: A white paper featuring expert opinions on the findings of the 2014 RBC Canadian Water Attitudes Study.

RBC. 2016. Canadian Water Attitudes Study. 94pp.

Schraeder, H.A. 1996. The Fish Community. In Caveney (ed.) *Focus on the Thames: Natural and Cultural Heritage of the River, London, Ontario*. A joint publication of the McIlwraith Field Naturalists of London and the Upper Thames River Conservation Authority.

Schueler, T. and H. Holland (eds.). 2000. The Practice of Watershed Protection. Centre for Watershed Protection. Ellicott City, MD.

Susilo, K., N. Matasovic and R.S., Johnson. 2009. Considerations, opportunities, and strategies for infiltrating stormwater BMPs. World Environmental Congress 2009, 971-980.

Swain, H., S. Louttit and S. Hrudey. 2006. Report of the expert panel on safe drinking water for First Nations, Vol 1. Ottawa, ON: Minister of Indian Affairs and Northern Development.

Talbot, C.J., E.M. Bennett, K. Cassell, P.M. Hanes, E.L. Minor, H. Paerl, P.A. Raymond, R. Vargas, P.G. Vidon, W. Wallheim and M.A. Xenopoulos. 2018. The impact of flooding on aquatic ecosystem services. Biochemistry 141(3): 439-461.

Tan, C.S. and W.D. Reynolds. 2013. Impacts of Recent Climate Trends on Agriculture in Southwestern Ontario. Canadian Water Resources Journal 28(1): 87-97.

Taylor, I. 2004. Aquatic Ecosystem Recovery in the Thames River Watershed. Proceedings of the Species At Risk 2004: Pathways to Recovery Conference. March 2-6, 2004. Victoria, BC.

Thames River Background Study Research Team. 1997. Background Study: Thames River Watershed Ontario. Canadian Heritage Rivers System. 162pp + Appendices.

Thames River Implementation Committee (TRIC).1978. Erosion and Agricultural Practices Thames River Basin. 51pp.

TRIC. 1978. Progress report on implementation aspects of the Thames River Basin water management study.

TRIC. 1982. Practical Guide for Municipal Drains.

TRIC. 1982. Strategy for soil and water management in the Thames River Basin.

Thames River Recovery Team. 2007 (Draft) Recovery Strategy for the Thames River Aquatic Ecosystem in Canada [Proposed]. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa.

Thames-Sydenham and Region Source Protection Committee. 2007. Conceptual Water Budget. Final Draft. 253 pp.

Thames-Sydenham and Region Source Protection Committee. 2015a. Lower Thames Valley Source Protection Area Assessment Report. 185 pp.

Thames-Sydenham and Region Source Protection Committee. 2015b. Upper Thames River Source Protection Area Assessment Report. 237 pp.

Tharme, R.E. 2003. “A Global Perspective on Environmental Flow Assessment: Emerging Trends in the Development and Application of Environmental Flow Methodologies for Rivers.” River Research and Applications, 19: 397-441.

Toronto Region Conservation Authority. 2007. The Natural Functions of Headwater Drainage Features: A Literature Review.

United Nations Department of Economic and Social Affairs. 2014. World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352). New York: United Nations Department of Economic and Social Affairs, Population Division.

United Nations Educational, Scientific, and Cultural Organization (UNESCO). 2003. Water for people, water for life: The United Nations World Water Development Report. New York, NY: Berghahn Books.

UNESCO. 2017. The United Nations World Water Development Report 2017. Paris, France: United Nations Educational, Scientific and Cultural Organization.

Upper Thames River Conservation Authority (UTRCA). 2009. Ontario Low Water Response: Groundwater Indicator Site Selection Criteria – Draft. Prepared for Ontario Ministry of Natural Resources Water Resources Section.

UTRCA. 2012. Upper Thames River Watershed Report Cards.

UTRCA. 2017 (draft). Nutrient Reduction Project Preliminary Report: Identifying and Overcoming Barriers to Behaviour Change.

Van Meter, H.D., and M.B. Trautman.1970. An annotated list of the fishes of Lake Erie and its tributary waters exclusive of the Detroit River. The Ohio Journal of Science. Vol 70 (2): 65-78.

Waterloo Hydrogeologic, Inc. 2007. The Six Conservation Area FEFLOW modelling report, Upper Thames River Conservation Authority.

Wilcox, I., C. Quinlan, C. Rogers, M. Troughton, I. McCallum, A. Quenneville, E. Heagy and D. Dool. 1998. The Thames River watershed: A background study for nomination under the Canadian Heritage Rivers System. Upper Thames River Conservation Authority for the Thames River Coordinating Committee.

Wong, A.W. and D. Boyd. 2014. Environmental Flow Requirements in the Grand River Watershed. Grand River Water Management Plan. Grand River Conservation Authority.

World Water Assessment Program. 2009. The United Nations World Water Development Report 3: Water in a changing world. Paris, France: United Nations Educational, Scientific and Cultural Organization; London: Earthscan.

World Meteorological Organization. 2006. “Environmental Aspects of Integrated Flood Management.” Associated Programme on Flood Management. August 2006, Geneva, Switzerland. Pg. 34.

World Health Organization. 2017. Potable reuse: Guidance for producing safe drinking-water. Geneva: Licence: CC BY-NC-SA 3.0 IGO.

Zhang, X., R. Brown, L. Vincent, W. Skinner, Y. Feng and E. Mekis. 2011a. Canadian climate trends, 1950-2007. Canadian Biodiversity: Ecosystem Status and Trends 2010, Technical Thematic Report No. 5. Canadian Councils of Resource Ministers. Ottawa, ON. iv + 21 p.

Zhang, J.Y. and W.A. Gough. 2011b. Climate Change Scenarios for Ontario Utilizing a Statistical Downscaling Technique Based on Three Global Climate Models. Climate Lab Department of Physical and Environmental Sciences, University of Toronto, Scarborough. 15pp.

GLOSSARY

Aquifer:

An underground layer of layer of water-bearing permeable rock, fractured rock or unconsolidated material (gravel, sand, or silt) that has openings which contain water or allow water to pass through. Aquifers can range in size from a few square kilometres to several thousand square kilometres. Aquifers are large storehouses for *groundwater*.

Assimilative capacity:

The ability of a body of water to cleanse itself; its capacity to receive waste waters or toxic substances without deleterious effects and without damage to aquatic life or humans who consume the water.

Baseflow:

Consistent inputs of water to a river that can generally be relied on even in times of low precipitation. During periods in between storms and runoff events, stream flow is maintained by *groundwater* inputs (discharge) as long as the *water table* remains above the stream bottom (Delleur 1999). Baseflow is strongly linked to *environmental flow (eflow)*. Based on the ratio of *groundwater discharge* to total stream flow, the baseflow in the Thames River varies between 40-70% of total stream flow (Thames-Sydenham and Region Source Protection Committee 2007).

Best management practice (BMP):

A proven, practical and affordable approach to conserving and protecting soil, water and other natural resources in urban and rural areas.

Bioswale (infiltration swale, biofilter, grassed swale, or in-line bioretention swale):

A *low impact development (LID)* vegetated open channel specifically designed to attenuate and treat *stormwater* runoff for a defined water volume. A bioswale conveys large *stormwater* volumes from a source to a discharge point, similar to how an open ditch functions, but a bioswale also promotes slowing, cleansing, and infiltration of the stormwater along the way.

Buffer:

A vegetated area along a stream that helps to shade and partially protect the stream from the impact of adjacent land uses, by capturing potential pollutants before they move to surface waters.

Combined sewer overflow (CSO):

A discharge to the environment that occurs when the wastewater volume in a *combined sewer system* exceeds the capacity of the sewer system or *wastewater treatment plant*, usually as a result of a precipitation event. *Combined sewer systems* were designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water bodies. Combined sewer overflows (CSOs) contain not only stormwater but also untreated human and industrial waste, toxic materials, and debris.

Combined sewer system:

A sewage collection system of pipes and tunnels designed to collect both surface water runoff and sewage water in a shared system. Modern-day sewer designs exclude surface runoff from sanitary sewers, but many older cities and towns continue to operate previously constructed combined sewer systems. Combined sewers can cause serious water pollution problems during *combined sewer overflow (CSO)* events.

Confined aquifer:

An *aquifer* that has layers of impermeable material both above and below, causing it to be under pressure so that when the *aquifer* is penetrated by a well, the water will rise above the top of the *aquifer*.

Conservation authority (CA):

A local *watershed* management agency in Ontario that deliver services and programs to protect and manage water and other natural resources in partnership with government, landowners and other organizations. Conservation Authorities promote an integrated *watershed* management approach balancing human, environmental and economic needs. Conservation Authorities are organized on a *watershed* basis.

Conservation tillage:

Any form of agricultural tillage that minimizes the number and/or intensity of tillage passes, with the goal of maintaining plant residue or living cover on the soil surface to reduce runoff and soil erosion, conserve soil moisture, and keep nutrients and pesticides on the field.

Cover crop:

A crop grown primarily to protect and enrich the soil, rather than for the crop yield.

Crop rotation:

The practice of including a number of crop types in the annual cycling of selected crops to plant in a given field, most typically seen as at least three or more different crops in rotation. This practice helps to maintain nutrients in the soil, reduce soil erosion, and prevent plant diseases and pests.

Cyanobacteria (blue-green algae):

Single-celled bacteria that often form colonies in the form of filaments, sheets, or spheres in aquatic environments. Also called blue-green algae, this bacteria possess a type of chlorophyll not found in other bacteria that undergoes photosynthesis and, thus, can be influenced by excessive *phosphorus* concentrations. An example is Microcystis. Cyanobacteria can produce toxic substances — called *cyanotoxins* — with the potential to harm humans and other organisms.

***Cyanobacteria bloom*:**

A large, dense mass of *cyanobacteria*. Cyanobacteria blooms cover the water's and can look like thick pea soup, often blue-green in colour. Cyanobacteria blooms occur naturally, but high concentrations of *phosphorus* can cause the *cyanobacteria* to reproduce exponentially. Some *cyanobacteria* blooms can produce chemicals (*Cyanotoxins*) that are poisonous if swallowed by people, pets, or livestock.

Cyanotoxins:

Toxic biological compounds produced by *cyanobacteria* such as *Microcystis*, which produce the toxin *microcystin*. Cyanotoxins have potentially significant human health consequences if ingested or through skin exposure and may also be toxic to other organisms.

***Dissolved reactive phosphorus**:*

Phosphorus in dissolved form. The term 'reactive' refers to the reaction of phosphorus with a colour agent during analysis of phosphate concentrations in a laboratory. Phosphorus is transported through the *watershed* in various forms. The two components that comprise *total phosphorus (TP)* are particulate *phosphorus*, which is attached to particulate matter including sediment, and *dissolved reactive phosphorus* (including *soluble reactive phosphorus (SRP)*) which is more easily absorbed and available for plant growth.

Ecosystem:

Biological organisms and the non-living parts of the environment in which they live, linked together through nutrient cycles and energy flows.

Environmental flow (eflow):

Environmental flow, or *eflow*, describes the quantity and timing of flow required to sustain healthy river *ecosystems* as well as the human livelihoods that rely on these *ecosystems* (Brisbane Declaration 2007). The concept implies that aquatic *ecosystems* should be in a state of well-being where habitat quality and biotic integrity are supported by the flow regime.

Eutrophication:

Excess nutrient enrichment causing nuisance and harmful algal blooms that, in turn, can cause low dissolved oxygen levels and associated fish kills.

Flood plain:

A low lying area near water bodies, that may be flooded in higher flow conditions. Flood plains are natural features that convey and store water.

Flood resiliency:

The capacity of individuals, neighbourhoods, businesses, institutions, the natural environment, and the watershed as a whole to recover quickly after a major flood event.

Fluvial:

Of, relating to, or living in a stream or river.

Fluvial flooding (Riverine flooding):

When rainfall, snowmelt and/or ice jams cause overbank flooding, whereby water flows over the edges of a river or stream into the flood plain and beyond.

Green infrastructure:

Natural and human-made elements that provide ecological and hydrological functions and processes. Green infrastructure can include components such as natural heritage features and systems, parklands, stormwater management systems, street trees, urban forests, natural channels, engineered wetlands, bioswales, permeable surfaces, and green roofs.

Groundwater:

Water that has seeped down beneath the Earth's surface and has come to reside within the pore spaces in soil and fractures in rock. This process creates *water tables* and *aquifers*, which are large storehouses for groundwater. Groundwater includes soil moisture, permafrost, and immobile water in rock with very low permeability.

Groundwater discharge:

The movement of *groundwater* from the subsurface to the surface. When water moves out of the saturated ground to the surface through springs or seeps, it is referred to as groundwater discharge. Often groundwater discharges into wetlands, streams and rivers, providing *baseflow*. *Groundwater* is typically colder than surface water, about 9˚C. The *groundwater* cools the surface water and improves habitat for coldwater fish, such as brown trout, and other aquatic species. Natural groundwater discharge is controlled by topography and geology, with groundwater discharging in topographically low areas (e.g., valley floors) containing higher permeability sandstone layers or gravels.

***Groundwater flooding*:**

The emergence of *groundwater* at the ground surface away from river channels, or the rising of *groundwater* into man-made ground, under conditions where the 'normal' ranges of *groundwater* level and *groundwater* flow are exceeded.

Groundwater flooding generally takes longer to subside than *fluvial flooding* owing to the large volume of water that has to flow away to lower the *water table*. Impacts of groundwater flooding can occur before water levels reach the ground surface, when there is inundation of subsurface infrastructure (e.g., tunnels and basements.

Groundwater mounding:

A condition where the localized *groundwater* surface may temporarily rise below an infiltration *best management practice (BMP)* or *low impact development (LID)*. Mounding can occur in areas where infiltrating water intersects a *water table* and the rate of water entering the subsurface is greater than the rate at which water is conveyed away from the infiltration system (Susilo et al. 2009, Machusick and Traver 2009). It can be a problem if it changes the direction of water movement from vertical to horizontal, significantly slowing the movement of water through the soil and potentially mobilizing contaminants that are in the soil or in the *groundwater*.

Groundwater rebound:

The process by which *groundwater* levels recover from a period where they were kept artificially low (e.g., due to *groundwater* extraction). Groundwater rebound can cause negative effects such as flooding of subsurface infrastructure (e.g., tunnels and basements), as well as changes in geotechnical and geochemical properties that could result in settlement and corrosion of deeply founded structures.

Groundwater recharge:

The process by which water moves from the ground's surface down through the ground to an *aquifer*. Water moves faster and more easily through loose or permeable soils, such as sand and gravel, resulting in higher recharge rates. Areas with fractured bedrock close to the surface also have high recharges rates.

The land area where water seeps down into an *aquifer* is called a recharge area. Changes to the land in recharge areas can affect the quality and amount of water that moves from the surface into the ground. For example, paving over these areas or installing tile drainage can reduce the amount of water that soaks into the ground.

Hydraulic conductivity:

A measure of the ease with which a fluid (usually water) can move through pore spaces or fractures in soil or rock. High values indicate permeable material through which water can pass easily; low values indicate a less permeable material.

Hydraulic model (analysis):

A mathematical process to reproduce surface flow dynamics, using physical and/or mathematical models. Hydraulic models are used to estimate a river's water velocity, surface elevations, and other physical properties. These models are critical tools in understanding flood extent and risk, and evaluating processes such as erosion and sedimentation risk.

Hydrograph:

A graph showing either the amount of water in a specific location over time, or the rate of flow past a specific point versus time. Rate of flow is typically expressed in cubic metres or cubic feet per second (cms or cfs).

Hydrogeology:

A subset of *hydrology* that is concerned with the occurrence, distribution, and movement of *groundwater*. Hydrogeology is concerned with the manner in which *groundwater* is stored and its availability for use.

Hydrologic cycle (water cycle, hydrological cycle):

The continuous movement of water on, above and below the surface of the Earth. The mass of water on Earth remains fairly constant over time but the partitioning of the water into the major reservoirs (ice, fresh water, saline water, and atmospheric water) is variable, depending on a wide range of climatic variables. Water moves from one reservoir to another through the physical *(hydrological) processes* of evaporation, condensation, precipitation, infiltration, surface runoff, and subsurface flow.

Hydrologic model:

A simplified, conceptual representation of a part of the *hydrologic (water) cycle* that uses *watershed* characteristics and meteorological inputs to estimate watercourse flows. Hydrologic models are primarily used in understanding, predicting, and managing water resources. Surface water models are used to understand surface water systems and potential changes due to natural or anthropogenic influences. *Groundwater* models are computer models of *groundwater* flow systems, used by *hydrogeologists* to simulate and predict *aquifer* conditions

Hydrological processes:

The physical processes (evaporation, condensation, precipitation, transpiration, runoff) identified in the *hydrologic cycle* that affect the water found on the Earth and water found in the air.

Hydrology (hydrologic):

The study of the movement, distribution, and quality of water on the Earth, including the water cycle, water resources, and environmental *watershed* sustainability. Includes the effects of water on the Earth's surface, in the soil and underlying rocks, and in the atmosphere.

Hyporheic flow (underflow):

The flow dynamics and behavior in the *hyporheic zone*, which are important for surface water/*groundwater* interactions, as well as fish spawning, among other processes.

Hyporheic zone:

The dynamic region of sediment and porous space that lies below and alongside the main channel of the stream bed, where there is mixing of shallow *groundwater* and surface water. It is an area of rapid exchange, where water move into and out of the stream bed, carrying with it dissolved gas and solutes, contaminants, microorganisms, and particles. The hyporheic zone is a zone of biological and physical activity, and has functional significance for stream and river *ecosystems*. Depending on the underlying geology and topography, the hyporheic zone can be only several centimetres deep, or may extend up to tens of metres laterally or deep.

Hypoxia:

A lower-than-normal concentration of oxygen.

Indigenous:

An acceptable term to describe the first peoples of what is now North America. While Indigenous and First Nation are terms used interchangeably in both the urban and rural communities, Indigenous includes First Nations, Metis and Inuit. Unacceptable terms include Aboriginal or Indian, unless used in proper names or if someone self-identifies as such.

Indigenous Traditional Knowledge (ITK):

The cumulative body of knowledge, belief and practice of *Indigenous* people regarding sustainability of local resources. ITK, like any other type of knowledge, is dynamic, continuously adapting to contemporary situations and incorporating aspects of knowledge learned from others. Instruction or knowledge of ITK comes from many sources, including Creation itself (Johnston 2003; McGregor 2004). Many stories and teachings are obtained from animals, plants, the moon, the stars, water, wind, and the spirit world. Knowledge is also gained through visions, ceremonies, prayers, intuitions, dreams, and personal experience.

ITK is most frequently preserved as oral tradition, accumulated and handed down to each generation through traditional songs, stories, rituals, and beliefs. It concerns the relationship of living beings (including humans) with their environment (Berkes, Colding and Folke 2000). From an *Indigenous* point of view, traditional knowledge developed over millennia should not be compromised by an over-reliance on relatively recent and narrowly defined Western reductionist scientific methods.

Low impact development (LID):

A land planning and engineering design approach to manage *stormwater* runoff as part of *green infrastructure*. LID uses engineered, small-scale features to replicate the pre-development *hydrologic* regime of a *watershed* through infiltrating, filtering, storing, evaporating, and detaining stormwater runoff close to its source.

LID practices incorporate *green infrastructure* such as *bioswales*, engineered wetlands, and rain gardens to support the functions of traditional grey infrastructure (i.e., storm sewer pipes and outfalls). LID systems generally increase infiltration of rainwater runoff to minimize overland flow volumes, recharge *groundwater* systems, and improve water quality before the runoff reaches a *stormwater management* facility or open watercourse.

Macroinvertebrate:

An organism without a backbone that can be captured by a 500--µm net or sieve (i.e., visible to the eye without the aid of a microscope). Macroinvertebrates includes arthropods (insects, mites, scuds and crayfish), molluscs (snails, limpets, mussels and clams), annelids (segmented worms), nematodes (roundworms), and platyhelminthes (flatworms).

Microcystins:

Toxic biological compounds produced by freshwater *cyanobacteria* (genus *Microcystis*, especially *M. aeruginosa*). Microcystins can cause liver toxicity in animals, including humans. Microcystins may occur in large quantities and contaminate water supplies during *cyanobacteria blooms*.

Net gain vs. no net loss:

"Net gain" is a resource conservation and management principle under which, over the long term, unavoidable losses of natural feature areas or functional capacity are offset by gains at a ratio greater than 1:1, through restoration, enhancement, preservation, or creation of natural features or associated areas critical to the protection or conservation of natural feature functions.

"No net loss" is a resource conservation and management principle that focuses on stopping the loss of valuable natural features by replacing individual natural features removed from the landscape on a case-by-case basis, with the objective of having the natural features replaced and replicated on-site or as close to on-site as possible. The implementation of "no net loss" only maintains the current status with minimal opportunity for an actual gain in wetland resources, whereas "net gain" is a broader and more proactive long-range goal to increase the quantity and quality of the natural features on the landscape.

Nonpoint source pollution:

A combination of pollutants that come from many diffuse sources and occur when rainfall or snowmelt moves over land, through drainage, and through the ground, picking up natural and human-made pollutants and depositing them into lakes, rivers, wetlands, coastal waters and groundwater. Atmospheric deposition may also be considered a type of nonpoint source pollution.

No-till (zero tillage or direct drilling):

The practice of not tilling the soil before planting a new crop. Tilling involves turning over the first 15-25 cm of soil to incorporate surface crop residues, nutrients, and weeds into the soil. No-till practices leave the soil structure intact and protect the soil by leaving crop residue on the soil surface. Improved soil structure and cover increase the soil's ability to absorb and infiltrate water, which reduces soil erosion and runoff. No-till practices also slow evaporation, which promotes better absorption of rainwater and increases irrigation efficiency. No-till does not disrupt soil microorganisms, fungi and bacteria, which are critical to soil health.

Pathogens:

Disease-causing microorganisms, such as bacteria, fungi, and viruses, found commonly in sewage, hospital waste, agricultural runoff, and in water used for swimming.

Phosphorus (P):

A nutrient found in rocks, soils and organic material that is required by all organisms for the basic processes of life. Total phosphorus is a measure of all forms of phosphorus in a water sample, including particulate phosphorus, which is attached to particulate matter such as sediment, and *dissolved phosphorus* (including *soluble reactive phosphorus (SRP)*) which is more easily absorbed and available for plant growth.

Phosphorus in aquatic systems occurs as organic phosphate (phosphate that is bound to plant or animal tissue) and inorganic phosphate.

In freshwater lakes and rivers, phosphorus is often found to be the growth-limiting nutrient, because it occurs in the least amount relative to the needs of plants. If excessive amounts of phosphorus and nitrogen are added to the water, algae and aquatic plants can be produced in large quantities. When these algae die, bacteria decompose them, and use up oxygen. The loss of oxygen in the bottom waters can free phosphorus previously trapped in the sediments, further increasing the available phosphorus.

Domestic and industrial effluents (including soaps and cleaning products) and urban and agricultural inputs (such as fertilizer, pesticides, and sewage) are anthropogenic sources of phosphorus to water.

Phosphorus concentration:

The amount (mass) of *phosphorus* in a defined volume of water (e.g., milligrams per litre). Concentration is a useful parameter to assess water quality because it has biological significance to organisms of concern. Water quality regulation on the basis of concentration has long been used for sources of pollution such as wastewater treatment plants.

Phosphorus load (P load):

The total quantity of *phosphorus* by weight (e.g., tonnes per year) delivered by a watercourse over a given period of time.

Photosynthesis:

The process by which green plants and some other organisms use sunlight to synthesize foods from carbon dioxide and water. Photosynthesis in plants generally involves the green pigment chlorophyll and generates oxygen as a byproduct.

Point source pollution:

Any single identifiable source of pollution from which pollutants are discharged to a water body, such as a *wastewater treatment plant*. Pollutants produced can be traced back to a discrete source. Point sources have usually undergone some level of treatment before discharge; an exception is most combined sewer overflows.

Pumping scheme:

A connected system comprised of pumps and agricultural drains that removes water off the land in areas where there is limited flow by gravity (such as the flat terrain in the lower Thames River watershed). Pumping schemes are similar to urban storm sewers in design, in that gravity generally controls the flow of water, with pumping used to assist where needed.

Sedimentary rock:

Deposits of rocks that were formed from pre-existing rocks or pieces of once-living organisms that accumulated on the Earth's surface.

Sewage treatment plant (STP): See Wastewater treatment plant

Significant Groundwater Recharge Areas (SGRA):

One of four types of vulnerable areas identified in the Ontario Clean Water Act, 2006. A recharge area is considered significant when it helps maintain the water level in an *aquifer* that supplies a community with drinking water.

Soluble reactive phosphorus (SRP)

(See Dissolved reactive phosphorus)

Stormwater

Any precipitation including rain, snow, hail and sleet. When stormwater is absorbed into the soil, it is filtered and ultimately replenishes aquifers or flows into streams and rivers. In urban and developed areas, impervious surfaces, such as pavement and roofs, prevent stormwater from soaking into the ground. Instead, water flows as runoff into storm drains, sewer systems and drainage ditches and can cause flooding, erosion, turbidity, storm and sanitary sewer system overflow, and infrastructure damage. Stormwater runoff can also carry debris, chemicals, bacteria, eroded soil, and other pollutants into watercourses.

Stormwater management (SWM)

The process of detaining stormwater and removing pollutants. Stormwater management uses engineered designs and/or *green infrastructure* to capture and reuse stormwater runoff to maintain or restore natural *hydrology*. Pervious surfaces that are porous and allow rainfall and snowmelt to soak into the soil, gray infrastructure, such as culverts, gutters, storm sewers, and conventional piped drainage, as well as *green infrastructure* that protects, restores, or mimics the natural water cycle, all play a part in stormwater management.

Strip till:

An agricultural soil conservation system that uses minimum tillage. Strip till combines the soil drying and warming benefits of conventional tillage with the soil-protecting advantages of *no-till* by disturbing only the portion of the soil that is to contain the seed row. This type of tillage is performed with special equipment and may require the farmer to make multiple passes, depending on equipment and field conditions.

Subwatershed:

A portion of a larger watershed that drains into a particular tributary, stream, river or water body.

Total phosphorus (TP):

A measure of all the forms of *phosphorus*, dissolved or particulate, that are found in a sample.

Unconfined aquifer:

An *aquifer* whose upper water surface (*water table*) is at atmospheric pressure, and thus is able to rise and fall. Unconfined aquifers are usually closer to the Earth's surface than *confined aquifers* are, and as such are impacted by drought conditions sooner than *confined aquifers*.

Wastewater:

Any water that has been affected by human use, including used water from any combination of domestic, municipal, industrial, commercial or agricultural activities, and any sewer inflow or infiltration. Wastewater can contain physical, chemical and biological pollutants.

Wastewater may be conveyed in a sanitary sewer which conveys only sewage, or in a *combined sewer* which includes *stormwater* runoff and industrial wastewater. After treatment at a *wastewater treatment plant*, the effluent is discharged to a receiving water body.

Wastewater treatment plant (WWTP)

A facility where physical, chemical, and biological processes are used to remove contaminants from municipal wastewater and produce treated wastewater (or treated effluent) that is safe enough for release into the environment. A by-product of sewage treatment is a semi-solid waste or slurry, called sewage sludge, which undergoes further treatment before being suitable for disposal or application to land.

Some municipal wastewater will also carry industrial effluent which has usually received pre-treatment at the factories to reduce the pollutant load. If the sewer system is a combined sewer then it will also carry urban runoff (*stormwater*) to the wastewater treatment plant.

Water control structure:

Includes dams, dykes, channels and *pumping schemes*, as well as *stormwater* management (SWM) facilities such as pipes, ponds and swales, and rural drainage such as field tiles and municipal drains. Water control structures have varying impacts on flow regimes and, consequently, on flood risk and the ability to sustain *eflow* needs.

Watershed:

The land area or topographic region that drains into a particular stream, river or waterbody.

Water table:

The upper water surface of an *unconfined aquifer.*

APPENDICES

Appendix A. SUMMARY OF 1975 THAMES RIVER BASIN MANAGEMENT STUDY (Ministries of the Environment and Natural Resources 1975): RECOMMENDATIONS AND PROGRESS SUMMARY 3

References for Appendix A 17

Appendix B. SUPPORTING RATIONALE FOR FIRST NATIONS RECOMMENDATIONS 18

B.1 Goal 1: Formalize a process where the spirit of the water is recognized 18

B.2 Goal 2: Improve involvement of First Nation communities 18

B.3 Goal 3: Improve awareness of First Nation communities 19

Appendix C. SUPPORTING RATIONALE FOR WATER QUALITY RECOMMENDATIONS 20

C.1 Goal 1: Reduce total and *soluble reactive phosphorus loads* from the Thames River and reduce overall *phosphorus concentrations* in the river and its tributaries 21

C.2 Goal 2: Reduce soil erosion from land and maintain geomorphic processes across the *watershed* 32

C.3 Goal 3: Improve water quality to support improved stream health, including aquatic life 35

References for Appendix C 43

Appendix D. SUPPORTING RATIONALE FOR WATER QUANTITY RECOMMENDATIONS 46

D.1 Goal 1: Understand, develop and recommend *environmental flow (eflow)* needs in the Thames River *watershed* 46

D.2 Goal 2: Improve understanding and mitigation of hazards associated with flooding and extreme flows in the Thames River *watershed* 53

D.3 Goal 3: Research and recommend mechanisms to achieve acceptable *eflow* while reducing flood and drought risks 61

D.4 Goal 4: Expand water quantity monitoring to improve understanding of *eflow* needs, flood and drought risk, and climate change. 67

References for Appendix D 74

Appendix E. FIRST NATION ENGAGEMENT STRATEGY FOR THE THAMES RIVER CLEAR WATER REVIVAL 77

Background 77

Mission 80

Goals 80

Recommendations 80

Appendix E1. PROFILES OF FIRST NATIONS 83
Anishinaabeg (Ojibway word for "the original people") 83
Lenni Lenape/Lunaapeew (Lunaapeewi word for "the original people") Delaware Nation. 85
References for Appendix E 87
Appendix F. FIRST NATIONS CONNECTION TO WATER 88
F.1 ARGFT4D Interviews 88
F.2 Seven Fires Prophecy 89
F.3 Our Grandfathers were Chiefs: Water Stories Selection (Aamjiwnaang First Nation) 90
Appendix G. PARTNER RESPONSIBILITIES 110
G.1 Responsibilities of First Nations 110
G.2 Responsibilities of the Federal Government 110
G.3 Responsibilities of the Provincial Government 111
G.4 Responsibilities of Municipal Governments 112
G.5 Responsibilities of Conservation Authorities 112
References for Appendix G 113
Appendix H. CLIMATE CHANGE PROJECTIONS 114
Reference for Appendix H 116
Appendix I. TRCWR PARTNER ENDORSEMENTS 117

LIST OF TABLES & FIGURES

Table C1. *Phosphorus* and sediment loads on main sections of the Thames River 23
Figure D1. Components of the *hydrologic cycle* 49
Figure D2. Components of the *hydrologic cycle* with a focus on human water use 50
Figure D3. Types of *groundwater flooding* 53
Table E1. Two widely accepted approaches to involving First Nations. 79
Table E2. Traditional governance of Anishinaabeg Clans (Johnston 1976) 83
Table G1. Areas of responsibility for provincial ministries on the Steering Committee of the Shared Waters Approach 111

Appendix A. SUMMARY OF 1975 THAMES RIVER BASIN MANAGEMENT STUDY (Ministries of the Environment and Natural Resources 1975): RECOMMENDATIONS AND PROGRESS SUMMARY

RECOMMENDATION 1.

Glengowan Dam should be constructed for the primary purpose of flow augmentation. Furthermore, a study should be made of what type and level of recreational use, if any, could be provided at the reservoir.

***PROGRESS*:** A 1983 Environmental Assessment study that reviewed all the options potentially available to meet the combined objectives of flood control and water quality protection recommended that the construction of Glengowan Dam not proceed. Instead, a variety of alternate strategies to achieve the same ends was recommended:

- construction of the St. Marys Floodwall,
- enhanced maintenance of London's system of dykes,
- continued ***floodplain*** acquisition and regulation,
- diffuse source pollution control,
- sewage treatment plant upgrades,
- enhanced storm water management,
- wetland protection.

These alternate strategies were adopted by the UTRCA and have significantly influenced the development and delivery of conservation programs by the Authority for the past 30 years.

The environmental assessment also recommended that the UTRCA retain the option of constructing Glengowan Dam and Reservoir in the future, if needed. A study of the type and level of recreational use was never conducted, but would be considered if the Glengowan Dam is required in the future.

For a variety of reasons, the UTRCA began the process of officially closing the Glengowan Dam and Reservoir Project in 2012. An assessment of the land holdings for the Project was completed in 2016 to determine if they should be retained, divested or managed differently to meet the UTRCA mandates. In 2018, final approvals were granted to close all interests in the project.

RECOMMENDATION 2.

The Upper Thames River Conservation Authority (UTRCA) and the Ministry of Natural Resources (OMNR) investigate in detail the question of the limestone deposit at the Thamesford Dam site to determine the opportunity cost associated with its development, so that a decision can be made as to the feasibility of constructing the Thamesford Dam.

***PROGRESS*:** An investigation found a very rich limestone deposit situated almost entirely in the river valley immediately upstream of the proposed Thamesford Dam site. It was determined that it was not feasible to consider constructing a dam, due to the quality of the deposit and the strong possibility of the eventual quarrying of the deposits (Thames River Implementation Committee 1978, 1980).

RECOMMENDATION 3.

If construction of the Thamesford Dam is feasible, then the Thamesford Dam should be built primarily for flood control purposes. Furthermore, a study should be made of the desirable level of recreational use of the reservoir, ensuring that such use would not seriously constrain the primary use of the reservoir.

***PROGRESS*: ** Information was collected but not pursued due to the findings with respect to Recommendation 2.

RECOMMENDATION 4.

If construction of the Thamesford Dam is not feasible, then the Wardsville Dam should be constructed for flood control purposes only. A flow retarding structure rather than a conventional dam should be constructed to minimize the loss of agricultural land and to protect the yellow pickerel runs and spawning grounds. Detailed studies should be undertaken to ensure the design will permit the safe passage of fish, and to determine on a benefit-cost basis whether a 43,000 acre – foot or a larger retarding structure is the more economical. The environmental effects and the effects on road communications of the larger verses the smaller structure should be considered. There should also be close consultation with Indian Bands concerning the effects on reservation lands.

PROGRESS*:** Reports prior to 1975 included a 1965 report and a 1971 economic analysis. As well, the LTVCA undertook channel improvement work in Chatham to partially relieve the flooding problems. Alternatives such as channelization and control of development in ***floodplain areas were also explored to reduce the overall flood risk for the lower portion of the river.

In January 1982, the Thames River Implementation Committee (TRIC) authorized the Pre Feasibility Study of the Wardsville Dam and Reservoir Project (MacLaren Engineers, Planners and Scientists, Inc. 1982). This study determined that the costs of the dam exceeded the benefits. It further recommended that “a comprehensive, cost-effective and socially acceptable flood damage reduction strategy for the lower Thames be developed prior to proceeding with further studies on the Wardsville project.” As a result, the LTVCA Board of Directors decided to shelve the project.

RECOMMENDATION 5.

Prior to construction of any major dam, detailed studies should be undertaken to examine environmental effects, to determine methods of minimizing such effects and to determine what type of discharge structure and operating practices would best protect both reservoir and downstream water quality.

***PROGRESS*:** An Environmental Assessment study is required prior to the construction of any major dam, which would ensure that all of the environmental effects of any major dam on the Thames River are identified and all feasible alternatives adequately considered prior to any decisions on the final course of action. The assessment will also ensure that the adverse impacts of selected alternatives are reduced as much as possible. As Glengowan Dam was the only major dam construction proposed since the 1975 Thames River Basin Water Management Study, it is the only dam that underwent an Environmental Assessment.

RECOMMENDATION 6.

The City of London should immediately institute plans to upgrade its sewage treatment facilities to meet the waste loading guidelines outlined in this report. Specifically, this involves providing an effluent from all treatment plants equivalent in quality to the effluent from the Greenway sewage treatment plant as defined in this report.

PROGRESS: Sewage Treatment facilities in the City of London were upgraded to meet the waste loading guidelines. Dilution was not considered as a treatment option.

Programs, upgrades and improvements since 1975 have surpassed the effluent requirements for Greenway ***WWTP***. The newest plant, Oxford ***WWTP***, treats ***wastewater*** to tertiary standards.

RECOMMENDATION 7.

At several municipalities in the basin, the waste ***assimilative capacity*** of the receiving stream has been reached or exceeded. It is recommended that the municipalities of Mitchell, Stratford, Tavistock, Glencoe, Tilbury and Ridgetown should not increase their waste loadings from all sources to the receiving stream, and in some cases should reduce these loadings as described in Chapter 8 of this report.

PROGRESS: Growth limitations were imposed on the municipalities until the sewage treatment plants were able to meet requirements. The addition of the Thorndale ***WWTP*** and effluent criteria are the most recent examples of meeting current standards.

RECOMMENDATION 8.

Municipalities of Woodstock, Beachville, Ingersoll and Lambeth should adopt sewage treatment techniques selected from approved options as described in this report, either to provide immediately required upgrading or to accommodate additional growth if such growth is found to be desirable when other factors are considered.

PROGRESS: Upgrades did occur and continue to occur to meet current Environmental Certificate of Approvals. The community of Lambeth was amalgamated into London in 1993 and the small and outdated Southland ***WWTP*** has been decommissioned (2018) with ***wastewater*** pumped to Greenway ***WWTP*** for treatment.

RECOMMENDATION 9.

All municipalities should immediately undertake studies to determine the significance of existing urban runoff and runoff associated with future development as a source of pollutants, and take steps to control this waste input where it is found to constitute a water quality problem.

PROGRESS: ***SWM*** standards are developed with MECP requirements. However, the effectiveness of ***SWM*** practices in meeting these standards is still an issue and is being partly addressed through the evolution of ***stormwater management***, for example using ***Low Impact Development*** techniques.

RECOMMENDATION 10.

All affected municipalities enact and enforce sewer use bylaws to prevent industrial pollution problems. Industries discharging treated wastes and process waters directly to watercourses in the basin should implement waste treatment necessary to meet water quality objectives as outlined in this report.

PROGRESS: The Municipal Act permits, but does not require, municipalities to pass Sewer Use Bylaws restricting the type, temperature and composition of ***wastewater*** discharged into the municipal ***wastewater*** system. A bylaw is commonly created in urban municipalities where industrial and manufacturing uses (e.g. food processing plants) need to pretreat in order to safeguard the biologic process at the ***wastewater treatment plant***. With the exception of Elgin County, most of the municipalities have sewer bylaws.

The Municipal Industrial Strategy for Abatement (MISA) program was implemented in the mid 1980s/ early 1990s to monitor and control the effluent discharge to receiving water bodies from nine industrial sectors. It promoted the Sewer Use Model by- law developed by the province, developed draft regulations for the ***STPs*** in Ontario, and supported the work of the province, municipalities and industries to develop key aspects of both programs. The implementation of demonstration studies for sewer use in five municipalities, a 40 ***STP*** study, extensive participation in the MISA municipal ***STP***/sewer use regulation consultation, and the MISA ***Stormwater*** program were significant initiatives designed to address inputs and improve effluent standards and guidelines. The City of London and several municipalities along the Thames participated in these initiatives.

RECOMMENDATION 11.

Fertilizer application rates are to be limited to those recommended by the Ontario Ministry of Agriculture and Food, using services such as those at the University of Guelph for determining appropriate rates. Individual and group activity by the agricultural community and the active support of government agencies is important to implement this practice.

PROGRESS: Farmers use the OMAFRA recommendations for crop production, along with soil tests and expert opinions from certified crop advisers (CCAs), to set application rates.

Precision application rates are implemented through technology such as variable rate fertilizer applications using GPS systems, banding fertilizer application, slow release fertilizer technology and liquid manure spreading in ***no-till*** systems.

More recently, farmers, fertilizer dealers, CCAs and custom applicators are increasingly using the 4Rs approach (right rate, right source, right time, right place) for fertilizer and other nutrient applications.

RECOMMENDATION 12.

A program of restricting free access of livestock to streams should be commenced. It is recommended that the Ontario Department of Agriculture and Food take the lead role in undertaking a detailed study of the implications of such a program to farmers, of the best methods such as fencing or vegetative barriers, and of the feasibility of provincial subsidies to encourage such a program.

PROGRESS: Various incentive programs have been implemented for technical and financial assistance including:

- Ontario Soil Conservation and Environmental Protection Assistance Program (OSCEPAP) cost-sharing programs
- Private Lands Assistance Program (PLAP) cost-share program with MNRF
- Land Stewardship (LS) Program that cost-shared with Agriculture and Agri-Food Canada
- Environmental Farm Plan (EFP)
- Clean Water Program (CWP)
- Clean Up Rural Beaches (CURB) provided financial incentives to rural landowners to install measures to improve reservoir quality

Many of these programs provided funding and other assistance to farmers for streambank erosion control (e.g., installation of fencing or otherwise restrict free access of livestock to streams).

In addition, several education and stewardship initiatives have addressed livestock access to streams including:

- Pittock ***watershed*** – Manure Management and Water Quality Sub-Basin Study and the Pittock Sub-Basin Study funded by MOE
- Livestock Access Restriction Impacts
- Stratford Avon Environmental Enhancement Project was a multi-year demonstration of numerous ***BMP*** projects on farm and urban areas
- Thames River Implementation Committee (TRIC) investigated and carried out numerous pilot projects in the ***watershed***

Most programs currently operate on a voluntary basis unless there is documented evidence of impacts sufficient to warrant enforcement actions under the Ontario Water Resources Act and/or the federal Fisheries Act.

RECOMMENDATION 13.

Increase environmental surveillance and enforcement by appropriate government agencies to control farm waste discharges, particularly from intensive feedlot operations, and illegal septic tank connections to municipal drains.

PROGRESS: The Environmental Protection Act (EPA) is Ontario's key legislation for environmental protection. The act grants the Ministry of the Environment broad powers to deal with the discharge of contaminants which cause negative effects. Ontario's EPA has the authority to establish liability on the party which is at fault, including liability for corporate officers or directors who have failed to take all reasonable care to prevent unlawful discharges of contaminants into the environment. Note that this liability can be limited specifically for farmers under s.123 of the EPA.

The EPA specifically:

- prohibits the discharge of any contaminants into the environment which cause or are likely to cause negative effects - and in the case of some approved contaminants requires that they must not exceed approved and regulated limits.
- requires that any spills of pollutants be reported and cleaned up in a timely fashion.

In 1991, Clean Up Rural Beaches (CURB) Program was initiated to identify the relative impact of pollution sources, and develop a course of action to restore and maintain acceptable water quality at provincial rural beaches. CURB was to be a technical assistance and financial incentive program to encourage improved rural land management practices to reduce the impact from upstream pollution sources on rural swimming beaches. The CURB Program provided some funds to rural farmers to install measures that would improve reservoir quality.

MECP responsibilities under the Nutrient Management Act 2002 include risk-based inspections of large livestock operations and other livestock operations that are phased in due to construction / expansion.

Building permits trigger septic systems review, inspection and upgrades. However, there is no program that examines illegal septic connections to municipal drains. If the Drain Superintendents come across them in the course of their regular work, they will deal with them. However, often illegal septic connections are made into farm field tile before it enters the drain; therefore, there is no way for a Drain Superintendent to know that it is not a legitimate tile connection. This issue needs to be dealt with via Septic Inspections.

RECOMMENDATION 14.

Channel protection programs as described in the 1975 report be implemented, with initial emphasis on areas of greatest need which should be identified in detail by appropriate government agencies:

- Since its formation in 1961, the Lower Thames Valley Conservation Authority has pursued a vigorous program of streambank erosion control works. In 1967, the Authority commissioned a study of the Thames River from the river mouth to the easterly limits of the City of Chatham. This study (MacLaren Limited, 1967), set forth the areas along both sides of the rivers that required immediate erosion protection, and also classified the remaining areas according to need for protection.
- A second report (MacLaren Limited, 1971) documented bank erosion problems between Chatham and Delaware that need further action.

PROGRESS: Experience ’77 students documented erosion sites and the presence of existing vegetative buffer zones along stream margins, as well as areas where soil erosion control practices were in effect. The results of this effort were utilized in the selection of practical demonstration and pilot study areas including the Stratford Avon Environmental Enhancement Project and Private Lands Assistance Program.

Lands Directorate Canada completed a mapping exercise of the Upper Thames River ***watershed*** identifying soil erosion potential and sediment delivery potential to a watercourse (early GIS/modeling work) which provided the foundation for demonstration/ research projects such as Kintore Creek and Upper Avon River, as well as many others.

Around the time the 1975 report was being written, the LTVCA was involved in a joint federal/provincial/municipal/CA project to upgrade the flood and erosion protection works in the lower reaches of the Thames River downstream of Chatham. The project wrapped up a few years later with approximately 56 km of diking having been constructed or upgraded to protect the surrounding low lying farmland. Much of the diking was constructed with revetment style erosion protection composed of rip-rap or grout filled nylon mattress.

Aside from the large diking program in the 1970s, in the period between 1964 and 1988, the LTVCA was involved in 31 small scale erosion control projects along the Thames River. Typical projects included retaining walls, bank stabilization and rip-rap erosion protection. However, without continued funding from upper levels of government, no new projects have been undertaken since that time by the LTVCA.

In 1987, the Lower Thames River Erosion Control Update Report was drafted for the LTVCA. This report provided updates on the status of erosion prone areas and erosion control works described in earlier reports from 1967 and 1971. The report suggests that erosion in the lower reaches from Chatham downstream are “mainly due to undercutting of the bank by boat waves.” While there is not as much boat traffic on the Thames River as there was in previous decades, the debate continues over boat speeds on the river. Some community members feel that allowing higher boat speeds on the river would provide a boost to boating tourism in Chatham. Some property owners along the river are concerned that the speed limits are already too high and that boat wake is causing erosion and shoreline property damage, especially during years with high lake levels. Other causes of erosion in the lower reaches include flood flows and moving ice or ice jams. Areas of problematic erosion upstream of Chatham in the Lower Thames are also noted in the report but are generally not considered as significant an issue given that there is less development along the river in these upstream areas.

A considerable amount of erosion protection work had been completed in vulnerable areas prior to 1987, with the report noting that “Compared to the 1969 and 1971 reports, the number of designated high priority areas in this report represents a reduction of almost 75 percent. Moreover, the designated medium priority areas noted in this update report are almost half the total number designated in the previous two reports.”

Since the 1998 amalgamation of 23 municipal entities into the single tier municipality of Chatham-Kent, the capability of taking on erosion control projects at a municipal level has improved. Many projects that would previously have required the LTVCA to co-ordinate the various lower tier municipal stakeholders can now be conducted by the single tier municipality. Most recently, in 2019, Chatham-Kent received a federal grant from the federal Disaster Mitigation and Adaptation Fund to undertake repairs on the diking systems and associated erosion protection works that were constructed through the LTVCA in the 1970s.

RECOMMENDATION 15.

Rural oriented management practices and conservation practices should be applied with special rigor in headwater areas, and municipalities in these areas must pay special attention to sewage disposal practices to safeguard both local and downstream water uses.

PROGRESS: Generally, no efforts were made to target headwater areas with respect to programs and services. Two examples of ***watershed*** projects that occurred in headwater areas are the Stratford-Avon River Environmental Management Project and the Kintore ***watershed*** project. Headwater areas continue to be under pressure in agricultural areas due to landowners' desires to enclose headwater watercourses, either to increase farmable acreage or to make it easier for farm machinery.

Many headwater area municipalities (e.g., Stratford, Tavistock, Mitchell) undertook ***wastewater treatment plant*** improvements.

RECOMMENDATION 16.

Resolution of water quality problems in existing reservoirs be achieved by the two Conservation Authorities through appropriate combinations of bottom draw, destratification, algae control, disinfection of swimming areas, or modified operating policies as outlined in this report for each reservoir.

PROGRESS: In the UTRCA, there is a water quality feedback loop. An ultra-violet treatment system was used to treat a small swimming area at Fanshawe Conservation Area for many years but the reservoir is now closed for swimming.

The LTVCA only has one reservoir, at Sharon Creek. Its current operation includes the use of a bottom draw. More active measures were not implemented there.

Water quality is monitored in the reservoirs.

RECOMMENDATION 17.

The reservoirs be operated in such a manner as to ensure the maintenance of the specified minimum flows on a daily basis. Also, there should be close liaison between the Ministry of Natural Resources and the Ministry of the Environment to ascertain if alterations to these operating schedules would optimize the use of existing reservoirs for flow augmentation, without adversely affecting other uses.

PROGRESS: Conservation Authorities modified their operations in existing reservoirs since the completion of the basin study, including the addition of engineer(s) to establish the system which is currently in place.

At the UTRCA, high flows operate according to established operating curves. Low flow scenarios use adaptive management where climatic conditions and downstream water quality are considered.

Required minimum daily flows have not been calculated for Sharon Creek Dam in the LTVCA. However, the use of a bottom draw ensures that the downstream creek does not run dry. Sharon reservoir is not sufficiently large to augment flows in the Thames River.

RECOMMENDATION 18.

The Upper Thames River Conservation Authority and the Ministry of Natural Resources undertake detailed computer analysis to determine what modifications of reservoir operating practices would optimize their flood control and flow augmentation use and enhance their recreational use potential.

PROGRESS**:** Ongoing. Integration into water management operations of the UTRCA such as the regulated ***floodplain***.

RECOMMENDATION 19.

A program of corrective action concerning bank erosion from Chatham, upstream as far as Delaware, should be initiated by the Lower Thames Valley Conservation Authority in line with the Recommendations in the 1971 Report by James F. MacLaren Ltd. entitled “Flood and Erosion Control Works on the Lower Thames River from Chatham to Delaware.”

PROGRESS**:** Between 1964 and 1988, the LTVCA was involved in 31 small scale erosion control projects along the Thames River. Typical projects included retaining walls, bank stabilization and rip-rap erosion protection. More recently, federal funding has been received for a limited number of large municipal erosion projects within Chatham-Kent. However, without continued funding from upper levels of government, no new projects are being undertaken unless they are by private landowners or in emergency situations.

RECOMMENDATION 20.

Soil erosion control programs including strip cropping, ***crop rotation***, diversion terraces, grassed waterways and vegetative buffer zones or reforestation should be implemented throughout the ***watershed***, with initial emphasis on areas that should be identified by staff of the Ministries of Agriculture and Food, Natural Resources, and Environment.

PROGRESS: Various demonstration and incentive programs such as the Stratford Avon Environmental Enhancement Project, Ontario Soil Conservation and Environmental Protection Assistance Program, Land Stewardship Program, Environmental Farm Plan, Clean Water Program, and Joint Agricultural Soil and Water Conservation Program united Conservation Authorities and OMAFRA in cooperative delivery, technical and financial assistance to implement these and other ***BMPs*** on the landscape. Conservation Authority extension staff play a major role in this task.

RECOMMENDATION 21.

Environmental Impact Assessments of land drainage proposals be undertaken to screen out or modify proposals which would damage the environment and that selected wetlands of ecological importance, such as the Zorra Swamp, be protected from further drainage.

PROGRESS: Provisions exist in the Drainage Act for EIAs upon request. However, the costs for such are paid for by the requester. It was the position of TRIC that most agricultural drainage projects should not be subject to individual EAs, since this would create an unwieldy and time-consuming process that is unwarranted considering most of the agricultural lands are presently drained and the emphasis is on clean out and maintenance. Rather, major wetland areas deserve protection from drainage schemes and should be scrutinized under the EA Act.

Instead, TRIC used the OMAF publication titled Design and Construction Guidelines for Work Under the Drainage Act (OMAF 1975) to develop the Practical Guide for Municipal Drains (TRIC 1982), a concise and simplified handbook highlighting the need for environmental protection measures as an integral part of drain construction and clean-out projects. TRIC determined that there is a lack of consistently applied guidelines to ensure that drainage works are designed and constructed by drainage contractors in a manner that will protect the aquatic environment. The guidelines should identify the anticipated environmental impacts and measures to prevent or mitigate such effects. They encouraged that drainage works be supervised by properly qualified superintendents at the municipal level to ensure environmental concerns are considered, and that municipal drain site meetings and review of municipal drainage reports are important to changing attitudes toward erosion control.

As part of their Section 28 Regulatory review and permitting of Drainage Act proposals, CAs flag wetlands of significance and attempt to mitigate any damage to the environment and wetlands within the limits of their jurisdiction. The Drainage Act and Conservation Authorities Act Protocol (https://www.ontario.ca/page/drainage-act-and-conservation-authorities-act-protocol) provides provincially-approved guidance to conservation authority staff and municipal representatives (e.g., drainage superintendents) regarding the most appropriate practices and permit requirements for municipal drain maintenance and repair activities. Section 3.2.2 of the protocol outlines the procedures for works within a regulated wetland limit.

Through the wetland acquisition program developed in the 1980s, the UTRCA identified 10 wetlands for acquisition in Middlesex County, seven in Oxford County, and three in Perth County.

Land drainage proposals under the municipal planning process are subject to typical plan review processes.

RECOMMENDATION 22.

Prevention of water supply interference and ***groundwater*** quality impairment, rather than remedial action after the problem has occurred, should be practiced using the following procedures detailed in Chapter 7 of the 1975 report:

- Test drilling and test pumping to obtain information on potential interference should precede any firm commitment to develop a large ***groundwater*** taking.
- Proposed stream withdrawals should be considered in the light of possible effects on downstream users and of any available streamflow data. Particular attention should be paid to flow rates that can be expected during seasonal low flow periods.
- Prior to sewer, watermain or drainage ditch installation, studies should be undertaken to anticipate the likelihood of well interference. These studies should include water level monitoring in nearby wells to facilitate evaluation of any subsequent well interference problems.
- Preventive measures such as the intelligent siting of operations with high pollution potential and sound water well construction practices will aid in maintaining good ***groundwater*** quality.

- Continued upgrading of the water well inspection program and the existing water well regulations administered by the Ministry of the Environment will assist in preventing ***groundwater*** contamination.
- Where possible, activities such as landfills, feedlots, sludge spreading, and lagoons should located on soil and material which have significant clay mineral content (specifically, the clay mineral illite and montmorillonite having high absorption capacity to capture dissolved pollutants). An additional important advantage to the high clay content is reduced percolation rates which allow the bacterial reduction of organic substances.

PROGRESS: Legislation pertaining to water supply interference and ***groundwater*** quality impairment has been incorporated in the Ontario Water Resources Act and Environmental Protection Act, both administered by the MECP. Potential interference is identified early so that the problem can be assessed at an early stage, and arrangements to minimize disruption of affected water supplies can be undertaken.

Groundwater impairment is considered through the land use planning program including review of official plans, official plan amendments and proposals covering a variety of developments and land uses. Source Water Protection identified sensitive ***groundwater*** areas.

RECOMMENDATION 23.

To overcome communication and co-ordination problems relating to water management in the basin, and to implement planning on a ***watershed*** basis, a joint committee of government agencies and other appropriate bodies should be established. The committee should include representatives of the Ministries of Agriculture and Food, Environment, Housing, Natural Resources, and Treasury, Economics and Intergovernmental Affairs, the two Conservation Authorities, municipalities, citizen groups and the agricultural community.

PROGRESS: Thames River Implementation Committee (TRIC) was formed in the latter part of 1976 to meet this recommendation, which evolved into a joint program. It was agreed within TRIC that municipalities throughout the ***watershed*** have a key role to play in the further assessment and implementation of the recommendations and that effective communication with the municipalities would be essential to address the recommendations.

TRIC developed a three-year river basin management program and secured funds for the UTRCA and LTVCA to administer the program. Although it was never fully implemented, portions of the program were successfully implemented.

RECOMMENDATION 24.

Because of the interrelationships of water resource problems and solutions in the upper and lower ***watershed***, and in order to further the basin wide approach to water management advocated in this report, it is recommended that consideration be given to the amalgamation of the Upper Thames River Conservation Authority and the Lower Thames Valley Conservation Authority into a single authority.

PROGRESS: Explored in 1990’s in some detail, but not done. Although a basin-wide approach to the water management problems would have certain merits, it was determined that the disadvantages outweigh the advantages. It was also noted that each Authority covers an area that is very different from the other in terms of topography, land use and public attitude towards the river, with different problems that require different approaches and solutions to the conservation problems at hand. Other factors which negate the advantages of amalgamation include the large distance from the headwaters to the mouth, and the size of municipalities.

RECOMMENDATION 25.

Further controls of ***floodplain*** development under the Planning Act and through regulations administered by the Conservation Authorities be developed.

PROGRESS: Fill, Construction and Alteration to Waterways regulations for both CA's were both in place prior to 1975 and were updated in 2006 to Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses. Both Conservation Authorities have established appropriate ***floodplain*** regulations and land use controls.

Building Better Communities and Conserving ***Watersheds*** Act, 2017 provides further modernization of the regulatory regime by updating the Conservation Authorities Act. Further regulations related to these changes are pending.

CAs were delegated responsibilities to comment on planning proposals, in relation to the Provincial Policy Statement, by the Minister of Natural Resources in 1995, including ***floodplain*** management, hazardous slopes, Great Lakes shorelines, unstable soils and erosion which were included in an updated PPS in 1997, 2005 and 2014. In this delegated role, the CA is responsible for representing the "Provincial Interest" on these matters in planning exercises where the Province is not involved.

Hydrology and regulatory services unit was created at UTRCA. Special Policy Areas were identified where necessary to reflect existing historic ***floodplain*** development. New development has been restricted to use hazard avoidance in site planning and development.

RECOMMENDATION 26.

Develop an improved flood warning system.

PROGRESS: UTRCA hired first engineer in 1976 and many stream flow recording devices and rain gauges were purchased by both Conservation Authorities.

Core program of the LTVCA and UTRCA that is under continuous improvement. There have been numerous technological innovations since 1975 that have improved data collection, flood forecasting and warning municipalities and the public.

Municipal Flood Emergency Plans have been incorporated in most ***watershed*** municipalities where historic flooding has occurred, enabling both authorities to react quickly should flood emergencies arise.

RECOMMENDATION 27.

For long-term flood control, flow augmentation and erosion control benefits, it is recommended that sound conservation measures such as reforestation, sound agricultural tillage, use of appropriate ground cover and preservation of water retaining areas be encouraged and implemented. Reforestation and establishment of shrub cover along stream banks should be directed to areas where they would specifically aid in erosion control, stream bank stabilization and the improvement of fish habitats.

PROGRESS: The UTRCA and LTVCA have played a lead role in dealing with farmers and other landowners to implement specific soil conservation measures.

The Stratford Avon Environmental Enhancement Project and Thames River Implementation Committee (TRIC) focused on agricultural soil erosion. As programs evolved, aquatic habitat improvement was recognized as a need and was built into programs. TRIC developed and implemented a field program designed to demonstrate diffuse source control mechanisms such as minimum tillage, grassed waterways, streambank stabilization, cattle access, buffer strips, etc.

Some special efforts, such as a wetlands, wildlife and woodlands program and the Oxford County Terrestrial Ecosystem Study, allowed for increased demonstration and implementation.

RECOMMENDATION 28.

Municipalities and government agencies encourage and enforce careful construction practices during drainage ditch installations and other construction activities in and along water courses.

PROGRESS: Conservation Authorities and the Department of Fisheries and Oceans (DFO) have classified the drainage system in the ***watershed***. Conservation authorities provide Section 28 review function for all drainage activities in the ***watershed***.

Conservation Authorities have historically worked closely with Drainage Superintendents of Ontario, OMAFRA, municipalities, MNRF, contractors and, more recently, the DFO.

Spot and bottom cleanouts, which disturb the watercourse less than full dredging, are commonplace.

Some technical information has been created (a booklet on maintenance on municipal drains).

Several demonstrations have been carried out (e.g. Herder maintenance equipment).

In urban centres, ***stormwater management*** policies and procedures dictate ***Best Management Practices*** along watercourses. Additional environmental requirements are followed as per DFO, CA and MNRF regulations pertaining to working around watercourses.

RECOMMENDATION 29.

Development in areas of sand and gravel not be permitted to hinder infiltration or to degrade the quality of infiltrating water. This is particularly true of areas of municipal water supply, such as the Woodstock well field. In addition, areas providing significant ***baseflow*** such as the Harrington-Lakeside moraine should be protected.

PROGRESS: One recent action resulting from a concern for ***groundwater*** quality is the establishment of Wellhead Protection Areas around municipal wells.

Section 2.2.1 of the PPS states that planning authorities shall protect, improve or restore the quality and quantity of water by implementing necessary restrictions on development and site alteration to protect all municipal drinking water supplies and designated vulnerable areas (which include high infiltration / recharge areas); and protect, improve or restore vulnerable surface and ground water, sensitive surface water features and sensitive ***groundwater*** features, and their hydrologic functions.

The Ministry of the Environment conducted a ***groundwater*** mapping program for the Thames ***watershed*** in the early 1980s, which identified surficial water-bearing deposits that supply significant ***baseflow*** to adjacent streams. This information has been replaced with mapping of Significant ***Groundwater Recharge*** Areas and Highly Vulnerable ***Aquifers***, promulgated under the Clean Water Act by the Ministry.

This information can be used for constraint mapping to identify areas that require land use controls under the Planning Act to protect the streams identified, and should afford a satisfactory basis for future land use decisions to meet the requirements of this recommendation.

References for Appendix A

MacLaren Engineers Inc. July 1987. Lower Thames River Erosion Control Update Report. Prepared for the Lower Thames Valley Conservation Authority.

MacLaren Engineers, Planners and Scientists, Inc. 1982. Pre-Feasibility Study of the Wardsville Dam and Reservoir Project. Prepared for the Thames River Implementation Committee.

MacLaren, J.F. Ltd. 1967. Report on the Lower Thames River Channel and Dike System from Chatham to Lake St. Clair for the Lower Thames Valley Conservation Authority.

MacLaren, J.F. Ltd. 1971. Preliminary Engineering Report to the Lower Thames Valley Conservation Authority on Flood and Erosion Control Works on the Lower Thames River from Chatham to Delaware.

Ministry of Natural Resources. 2012. Drainage Act and Conservation Authorities Act Protocol. https://www.ontario.ca/page/drainage-act-and-conservation-authorities-act-protocol

Ministry of the Environment and Ministry of Natural Resources. 1975. Water Management Study Summary Report: Thames River Basin. 38pp.

Ontario Ministry of Agriculture and Food. 1975. Design and Construction Guidelines for Work Under the Drainage Act. Prepared by Devos, A.J., A.J. Graham, H.H. Todgham, E.H. Uderstadt, and J.K. Young.

Thames River Implementation Committee (TRIC). 1978. Progress report on implementation aspects of the Thames River Basin water management study.

TRIC. 1982. Practical Guide for Municipal Drains.

TRIC. 1982. Strategy for soil and water management in the Thames River Basin.

Appendix B. SUPPORTING RATIONALE FOR FIRST NATIONS RECOMMENDATIONS

FIRST NATIONS *INDIGENOUS TRADITIONAL KNOWLEDGE* MISSION STATEMENT:

THE IMPORTANCE OF *INDIGENOUS TRADITIONAL KNOWLEDGE (ITK)* IN RESOLVING ENVIRONMENTAL ISSUES IS RECOGNIZED AND INCLUDED IN DECISION-MAKING AROUND WATER PROTECTION.

The pervasiveness of the traditional view of water and the related stewardship role for First Nations is stated in The Water Declaration of the Anishinaabek, Mushkegowuk and Onkwehonwe (Section 1.1.2.1). The Water Declaration provides a strong sense of how the goal of protecting water should be pursued. As well, ITK is not limited to the boundaries of the ***watershed***, but considers the greater context of the Great Lakes. The Thames ***watershed*** is part of a corridor from Lake Huron to Lake Erie, and the interconnectedness of this is considered in ITK. For example, fishing, hunting and trade connects to a much larger area than the ***watershed*** boundary. Three goals have been developed to ensure that ITK has been incorporated.

B.1 Goal 1: Formalize a process where the spirit of the water is recognized

Some components of this process may include:

- Acknowledging the spiritual value of the water with seasonal ceremonies;
- Consideration of a spiritual value assessment as part of the consultation process (such as an Environmental Assessment or Permit To Take Water);
- Conducting a spiritual value assessment for the Thames River (e.g., Appendix C);
- Incorporating teachings from Water Gatherings and other ceremonies, such as considering seven generations (past, present and future), preparing for change, fostering an understanding that water is more than just a resource, and offering tobacco;
- Developing a Spirit of the Water Treaty to govern interactions with the water;
- Giving personhood rights to the river;
- Engaging First Nation Communities, including the Bkejwanong Walpole Island First Nation Water Working Group, to gather stories of spiritual connection to water and places; and
- Identifying activities, projects and programs that bring people back to the river, help link people with the river, and maintain that connection.

B.2 Goal 2: Improve involvement of First Nation communities

Some components of this process may include:

- Interactive social events with activities and a meal to make connections;

- Presenting to Chief and Council. First Nation Council minutes are public. In addition to community meetings, these minutes provide another opportunity to inform the community;
- Meeting with the Environment Committee of each First Nation, where applicable. This committee consists of both staff and community members, so it also provides a good opportunity for engagement;
- Meeting with Elder and Youth Advisory Councils that meet to discuss topics chosen by the resource staff. The input of elders and youth will give more importance to the initiative in the community;
- Offering volunteer / paid opportunities so that interest and capacity is built in First Nation communities and in the youth;
- Recognizing that the engagement process will need to be tailored to each First Nation community (e.g., large charrettes, small open houses, partner with established events, open houses);
- Identifying cooperative opportunities to share professional experience (e.g., sharing GIS expertise, developing a recreational fishing program); and
- Consider ITK in all decision and policy making exercises around water protection.

B.3 Goal 3: Improve awareness of First Nation communities

Some components of this process may include:

- Cultural awareness and sensitivity training for non-native partners;
- Encouraging teachings of natural law in the district school boards; and
- Acknowledging traditional territory and treaty lands.

Appendix C. SUPPORTING RATIONALE FOR WATER QUALITY RECOMMENDATIONS

WATER QUALITY MISSION STATEMENT:

TO PROTECT AND IMPROVE WATER QUALITY IN THE THAMES RIVER *WATERSHED* IN ORDER TO IMPROVE STREAM HEALTH AND THE POTENTIAL IMPACT OF THE THAMES RIVER ON LAKE ST. CLAIR AND LAKE ERIE.

The Thames River is situated in a highly agricultural part of southern Ontario with many urban centres and rural communities. As a result, water quality in the river has undergone many changes over the past century. Surface water quality has fluctuated, partly in response to changes in urban land use, ***stormwater management***, ***wastewater treatment***, industrial waste management, agricultural practices, and other land management practices. Weather and climate-related issues, as well as local geology and soil type, also affect surface water quality.

The issue of impaired water quality, including excess nutrients in the Thames River, is not new. Since the late 1950s, many site-specific and issue-related studies have been conducted to understand sources of water quality impairment in the ***watershed*** and develop implementation programs to address those sources. Extensive work has been undertaken in the agricultural, municipal and industrial sectors to protect water quality, contributing to a general improvement in surface water quality over the past 30 plus years. However, ongoing stressors, changes in land use, and climate issues continue to put pressure on the Thames. As a result, generally little additional improvement has been made in river water quality in recent years. Partnerships between government, academia, industry, property owners, and local communities are needed to continue finding solutions to water quality problems.

The First Nations, federal and provincial agencies, municipalities, and conservation authorities have developed three common goals to achieve the water quality mission for the Thames. The goals of reducing ***phosphorus loads*** and erosion speak to minimizing the impact of the Thames River on Lake Erie and Lake St. Clair, as well as addressing water quality issues in the Thames. The third goal speaks mainly to improving river and stream health. Under each goal, recommendations were developed that reflect various agency mandates and program responsibilities. A lack of recommendation by any particular agency does not indicate a lack of support or interest. Note also that the municipal recommendations were developed by the participating municipalities and may not apply to all municipalities in the ***watershed***. Through further and continued outreach to other municipalities, the municipal perspective may be broadened and reflect additional viewpoints and input.

Each goal is discussed in the following pages. The recommendations and actions to meet each goal are grouped into three areas:

- Research and monitoring;
- Stewardship and outreach; and
- Policy and regulations.

C.1 Goal 1: Reduce total and *soluble reactive phosphorus loads* from the Thames River and reduce overall *phosphorus concentrations* in the river and its tributaries

The Thames River has experienced excess levels of nutrients for decades, resulting in nutrient enrichment in the river system and contributing to algal blooms in Lakes Erie and St. Clair, and in the Thames River and tributaries. ***Phosphorus*** is the primary nutrient that promotes excess growth of aquatic plants and algae. Dissolved oxygen in the water is consumed when these plants decay, which can result in low oxygen conditions that are harmful to sensitive aquatic organisms, including fish. In recent years, ***phosphorus*** has also triggered the growth of harmful algal blooms including ***cyanobacteria*** species such as *Microcystis*, which can impair drinking water, aquatic life and recreational uses.

There are many different sources of ***phosphorus*** in the Thames River ***watershed***, including fertilizer, animal/human waste and other organic matter (Upper Thames River Conservation Authority 2017). Sources of ***phosphorus*** are generally considered to be either ***point sources*** (e.g., municipal and industrial ***wastewater treatment plants***) or **nonpoint *sources*** (e.g., runoff from across rural and agricultural areas and urban ***stormwater***). ***Point sources*** tend to be measured on a regular basis and their variability is relatively low because treatment processes are controlled, resulting in discharges with fairly consistent quality. On the other hand, ***nonpoint sources*** are highly variable in quality and quantity over the course of the year (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018).

Phosphorus is transported through the ***watershed*** in various forms. The two components that comprise ***total phosphorus (TP)*** are particulate ***phosphorus***, which is attached to sediment, and dissolved ***phosphorus*** (including ***soluble reactive phosphorus (SRP)***) which is more easily absorbed and available for plant growth.

The total quantity of ***phosphorus*** by weight delivered by a watercourse over a given period of time is known as the ***phosphorus load***. Various studies have provided estimates of the load from the Thames River and other tributaries. Differences in the estimates are a reflection of the variability in the years measured, as well as the methods, scope and timeframe of the studies. Despite this variation, most estimates fall within a similar range. The average annual load for the Thames River is approximately 323 tonnes of ***total phosphorus*** (Map 4), including 125 tonnes of ***soluble reactive phosphorus*** (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018). Environment and Climate Change Canada (ECCC) studies indicate that the Thames is the largest Canadian contributing ***watershed*** of ***phosphorus*** to the western basin of Lake Erie (Maccoux et al. 2016).

In February 2016, Canada and the United States adopted binational ***phosphorus*** reduction targets for Lake Erie's western and central basins and nearshore priority areas under the Great Lakes Water Quality Agreement. The Thames River was identified as a priority tributary for a 40% reduction (from 2008 levels) in spring loads of ***total phosphorus*** and ***soluble reactive phosphorus***.

Thames River Watershed Phosphorus Loadings

Numerous monitoring studies and modeling efforts have provided a range of ***phosphorus loadings*** for the Thames. More data is being collected that provides improved annual loading estimates that, over time, will better reflect the variability that occurs with different levels of precipitation, seasonality, activities and efforts on the landscape, and other factors.

ECCC is monitoring ***phosphorus loads*** in the Thames River to track progress in meeting reduction targets. Early results indicate that approximately 80% of loadings occur during wet weather and snowmelt events, and one-third to one-half of ***TP loading*** for the Thames is ***SRP***. Loadings in the Thames River are highly variable year to year based on precipitation events, their timing and magnitude of the event (Dove et al. Unpublished).

Thames River Phosphorus Loadings Study

In 2015, the Upper Thames River Conservation Authority (UTRCA) oversaw a study funded by the MECP through the Showcasing Water Innovation program to complete an assessment of water quality and flow data for the Thames River to determine timing of delivery and source areas of ***phosphorus*** and sediment loadings across the Thames ***watershed*** (Nurnberg and LaZerte 2015a). Loadings were determined using data from 83 water quality stations, 26 flow gauges, and 30 ***wastewater treatment plants*** across the Thames River ***watershed*** for the period 1986-2012 (Map 5).

The study shows that the total amount of ***phosphorus*** and sediment in the river that eventually reaches Lake St. Clair (the load) is highly dependent on water flows. Annual loads vary, influenced by annual flows. Loads follow the seasonal pattern of flows so that the highest loads occur during wet periods in the winter and spring.

Results suggest that all tributaries across the ***watershed*** contribute to the ***phosphorus load*** in the Thames. Loads are cumulative, increasing from the headwaters towards the Forks in London, where the North Thames and South Thames Rivers combine, and further increase towards the mouth. Sixty percent of the annual ***TP load*** is contributed by the North Thames and South Thames Rivers (i.e., upstream of the Forks); 40% of the load is added to the river from the Forks to the outlet at Lake St. Clair (Table C1).

The study estimated the annual export of nutrient and sediment loads from the Thames River into Lake St. Clair at 342 tonnes/year ***TP***, 187 t/yr ***SRP***, and 113,000 t/yr total suspended sediment. ***Nonpoint sources*** (runoff from rural and urban areas) dominate total ***phosphorus loads***, contributing approximately 87% of the load in the Thames. The 30 ***wastewater treatment plants (WWTPs)*** in the Thames River ***watershed*** contribute approximately 13% of the total ***phosphorus load*** (Nurnberg and LaZerte 2015a).

Table C1. *Phosphorus* and sediment loads on main sections of the Thames River

Section of the Thames River	Area km^2	*Total Phosphorus* Average Annual Load %	Total Suspended Sediment Load %	Total *Phosphorus Load* tonne/km^2	Total Suspended Sediment Load tonne/km^2
South Thames River	1346	28%	16%	0.06	13.46
North Thames River	1427	32%	18%	0.07	14.25
Thames River Forks in London to Lake St. Clair	3089	40%	65%	0.04	23.97

The numerous small and larger dams and reservoirs along the Thames River and its tributaries can affect the timing of ***phosphorus*** and sediment load delivery through the ***watershed***. During times of highest load delivery (i.e., major fast-moving flow events) much of the load moves through the small and large reservoirs; however, some of the ***phosphorus load*** will be retained in bottom sediment and eventually released into the water. This delayed release can result in localized nuisance and harmful algae blooms, generally in the summer and fall when water temperatures are elevated. As well, small impoundments created in the Lower Thames Valley Conservation Authority (LTVCA) ***watershed*** by the dyke and ***pump schemes*** designed to facilitate agricultural drainage, can similarly have some effects on the fate of ***phosphorus***.

Canadian Lake Erie Phosphorus Issues

With a total surface area of 25,700 km^2 and an average depth of only 19 m, Lake Erie is the shallowest, smallest (by volume), warmest and most reactive of the Great Lakes to weather changes and ***phosphorus*** inputs. It is also the most biologically diverse and productive lake, with more than 130 fish species that support large commercial and recreational fisheries (Van Meter and Trautman 1970). Lake Erie provides a number of important ecological and economic services, including drinking water supply for over 680,000 municipal residents in the Canadian portion of the basin, diverse recreational and aesthetic opportunities, important food and forage, spawning, nursery and refuge habitat for aquatic and terrestrial species.

The lake's characteristics also make it the most susceptible of the Great Lakes to excess ***phosphorus***. The result has been harmful blooms of ***cyanobacteria*** in the western basin, low oxygen ian the central basin, and nuisance, fouling algae in the eastern basin (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018).

Binationally, the western basin receives on average 61% of the total Lake Erie ***phosphorus loads*** (5,492 tonnes ***total phosphorus*** annually) with Canada contributing 647 tonnes (12%) and the U.S. contributing 4,407 tonnes (80%). ***Phosphorus loadings*** from Lake Huron and the atmosphere make up the remainder. Of the western basin loads from Canadian sources, more than 99% are discharged to the Huron-Erie corridor (which includes the Thames River) (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018).

The average annual load for the Thames River is approximately 323 tonnes of ***total phosphorus*** (Map 4), including 125 tonnes of ***soluble reactive phosphorus*** (Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks 2018). The Thames is the fifth greatest contributor of ***total phosphorus*** out of all the tributaries that empty into Lake Erie, and the largest Canadian source of ***phosphorus*** (Maccoux et al. 2016).

Historical Perspective

Prior to European settlement, the estimated annual ***TP load*** to Lake Erie was 3,000 metric tonnes (O'Sullivan and Reynolds 2006). By 1900, it is estimated that the load increased to about 9,000 tonnes per year with the majority of ***phosphorus*** entering the lake from untreated municipal and industrial ***wastewater*** and a significant proportion coming from spring runoff, conveyed via tributaries, largely as a result of deforestation and draining of wetlands. The ***phosphorus*** content of this runoff was largely attributable to soil chemistry rather than to added manure or fertilizer.

From about 1900 onward, steady population growth resulted in increasing loads, largely from sewage and ***phosphorus***-based detergents. Loadings from agricultural land also increased due to deforestation and land use changes, especially after the Second World War when innovations in agricultural technology and fertilizer production allowed the expansion of hybrid corn production and increased application of commercial fertilizers.

The annual load for Lake Erie peaked at about 28,000 tonnes in 1968 and had a clear impact on algal blooms and ***hypoxia*** in the 1960s and 1970s. This was a major driver for the signing of the Great Lakes Water Quality Agreement (GLWQA) in 1972, in which the Governments of Canada and the U.S. agreed to reduce ***phosphorus loads*** to Lake Erie by more than 50% (to 14,600 tonnes/ year). In the 1978 revision of the GLWQA, the two countries agreed to further reduce ***phosphorus loads*** to Lake Erie to 11,000 tonnes/year.

Canada, the U.S. and partners invested billions of dollars in ***point source*** pollution (sewage treatment plants) and in limiting ***phosphorus*** in household detergents. Extensive research into ***nonpoint sources*** (agricultural runoff) also began. As a result, by 1981 annual ***TP loading*** had reached the GLWQA target load of 11,000 tonnes. Algae blooms in Lake Erie decreased significantly throughout the 1980s.

By the mid-1990s, without noticeable increases in loadings, excess algae growth in Lake Erie re-emerged as an issue. In 2011, concentrations of the algal toxin ***microcystin*** in the open waters of Lake Erie's western basin were 50 times higher than the World Health Organization limit for safe body contact and 1,200 times higher than the limit for safe drinking water. In

August 2014, algal toxins forced closure of the Toledo, Ohio, drinking water treatment plant and private water users on Pelee Island, Ontario, were warned not to bathe in or drink Lake Erie water. The incident affected more than 500,000 people.

There are many reasons why it now takes less ***phosphorus*** to trigger an algae bloom, requiring further load reductions in ***watersheds*** such as the Thames:

- *Different form of **phosphorus**:* There has been an increased loading of the soluble form of ***phosphorus***, which is more readily used by plants and algae.
- *Different source of **phosphorus**:* The majority of the load (71% of the Canadian ***SRP load*** and 93% of the ***TP load***) is from ***nonpoint sources*** such as agricultural, rural and urban runoff.
- ***Phosphorus*** *legacy effects:* ***Phosphorus*** that has settled in lake and river sediments can be released and remobilized, years later.
- *Climate change:* Climate models predict warmer temperatures, decrease in snowfall events and increase in rainfall events, with greater precipitation in winter, spring and fall. As much as 90% of the ***TP load*** to a river can be delivered during storm events, especially during winter and early spring when soils are saturated, thawed, uncovered, and without growing vegetation. Algae blooms in Lake Erie are larger and more persistent in wet years, when tributary flows of ***phosphorus*** are greater.
- *Shifting ecological systems:* Lake Erie's nutrient cycling and food web structures are changing. For example, invasive quagga mussels accumulate ***phosphorus*** and are increasing the proportion of ***SRP*** near the lake bed.

Binational Phosphorus Plans & Strategies

In response to the resurgence of algal blooms in Lake Erie in recent decades, the Lake Erie Lakewide Action and Management Plan (LAMP) formed a Nutrient Science Task Group in 2007 to assess the status of nutrients in Lake Erie (Lake Erie LaMP 2009) and to develop the Lake Erie Binational Nutrient Management Strategy (Lake Erie LaMP 2011). In 2012, Canada and the U.S. signed a new GLWQA which includes an increased focus on nutrients and algal blooms (Government of the United States and Government of Canada 2012).

In February 2016, Canada and the United States adopted binational ***phosphorus*** reduction targets for Lake Erie's western and central basins and nearshore priority areas under the Great Lakes Water Quality Agreement, including:

- 40% reduction (from 2008 levels) in spring loads of ***total phosphorus*** and ***soluble reactive phosphorus*** for the Maumee River to minimize harmful algal blooms in the western basin;
- 40% reduction (from 2008 levels) in ***phosphorus loadings*** to the central basin, with a new binational loading target of 6,000 tonnes per year of ***total phosphorus***; and
- 40% reduction (from 2008 levels) in spring loads of ***total phosphorus*** and ***soluble reactive phosphorus*** for priority tributaries.

In Canada, the Thames River and Leamington area tributaries were identified as priority tributaries to reduce localized nearshore ***cyanobacteria blooms*** in Lake St Clair (near mouth of the Thames) and Lake Erie (near Point Pelee). These tributaries also contribute to the Canadian central basin ***phosphorus*** target.

Canada, Ontario, and partners are working together through the Canada–Ontario Agreement on Great Lakes Water Quality and Ecosystem Health, 2014 (COA) to meet Canada's share of the targets and commitments under the GLWQA. In October 2016, under the Great Lakes Protection Act, the Minister of the Environment, Conservation and Parks adopted a target of 40% ***phosphorus load*** reduction by 2025 (from 2008 levels), using an adaptive management approach, for the Ontario portion of the western and central basins of Lake Erie, as well as an aspirational interim goal of a 20% reduction by 2020.

In keeping with the need for early action, Ontario also signed the Western Basin of Lake Erie Collaborative Agreement with the U.S. states of Michigan and Ohio on June 13, 2015 collectively committing to work to achieve, through an adaptive management process, a recommended 40% total load reduction in the amount of total and ***dissolved reactive phosphorus*** entering Lake Erie's western basin by 2025, with an aspirational interim goal of a 20% reduction by 2020 (from 2008 base year). Working with the U.S. states bordering Lake Erie, through the Great Lakes Commission, Ontario collaborated on the development of a joint action plan for Lake Erie (September 2015), which aligns with other binational and domestic nutrient efforts currently underway.

To meet these federal and provincial commitments, an action plan was developed in 2018 by Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks called the Canada-Ontario Lake Erie Action Plan (LEAP). LEAP identifies more than 120 federal, provincial and partner actions to help achieve the goal of reducing ***phosphorus*** entering Lake Erie by 40% in order to reduce algal blooms, including actions in the Thames River ***watershed***. ***Phosphorus*** enters Lake Erie from many sources, including runoff from agricultural lands, urban centres, sewage treatment plants and septic systems. Actions in LEAP include encouraging effective techniques to keep ***phosphorus*** on farmland and out of the ***watershed***, improving wetland conservation, and upgrading municipal ***wastewater*** treatment and collection systems.

C.1.1 Research and Monitoring

Research

There is a long history of programs that address ***nonpoint sources*** of nutrients in the Thames ***watershed*** and many studies were driven by the need to reduce nutrients in the Thames ***watershed*** and Lake Erie. Since the 1970s, extensive studies have been conducted to understand sources and develop implementation programs, including many ***subwatershed*** studies and specific research ***on Best Management Practices (BMPs)***. These studies were instrumental in developing ***BMPs***, many of which are still used today. Some major studies include the Pollution from Land Use Activities Reference Group studies (1972-1979), Thames River Water Management Study (1972-1975), Stratford-Avon River

Environmental Management Project (1980-1984), Kintore Creek ***Watershed*** Studies (1984-1998), Soil and Water Environmental Enhancement Program (1986-1988), Rural Beaches Strategy Program (1985-1991), Clean Up Rural Beaches Program (1991-1996), Livestock Pollution Prevention Project (1996-2005), and City of London ***Subwatershed*** Studies (1990s). After 2000, a number of research and demonstration projects were carried out including Adopt-A-***Watershed*** (2005-2008), Collaborative Action Approach (2008), Greencover (2006-2008), and ***Watershed Best Management Practices*** Evaluation Project (2011-2013). As well, the Clean Water Program was initiated in 2001 as a delivery program for ongoing stewardship work and other demonstration projects. The historic studies for the Thames are well documented and available on the Agri-Environmental Archive (https://atrium.lib.uoguelph.ca/xmlui/handle/10214/13065).

There is a renewed focus on nutrient research in the Thames ***watershed*** as a result of the resurgence of major algal and cyanobacterial blooms in Lake Erie and Lake St. Clair, in addition to the identification of the Thames River as a federal and provincial priority for ***phosphorus load*** reduction. New issues, such as climate extremes and changing land use practices, call for additional work to adapt previous practices.

There are many research projects planned or underway in the Thames ***watershed*** and in Lake St. Clair to better understand issues around the sources of nutrient loading and to assess the occurrence and extent of harmful algal blooms. These projects involve modelling, water monitoring, and demonstration/evaluation of ***BMPs***. Many of the projects were presented at the Focus on the Thames Forum (April 2018) and are documented in the Nutrient Reduction Project Catalogue 2018 (http://thamesriver.on.ca/nutrient-project-catalogue/). Extensive research that is relevant to understanding nutrient sources and solutions in the Thames has also recently been done elsewhere, including in the U.S.

Monitoring

Since the 1960s, water quality has been monitored in the Thames River ***watershed*** through various long term programs and studies that measure current conditions and long term changes in water quality and aquatic health (Lower Thames Valley Conservation Authority et al. 2008). Programs that include long term nutrient concentration monitoring include the MECP Provincial Water Quality Monitoring Network (PWQMN), City of London Thames River Monitoring Program, and conservation authority (CA) ***subwatershed*** monitoring (see Monitoring in Section 3.2.3.1).

The existing, long term monitoring programs were designed to measure ambient water quality concentrations (including nutrient concentrations) at stream locations in the ***watershed***, and have provided good information for this purpose. However, these programs were not specifically designed to determine ***phosphorus loads*** from the Thames. A gap analysis study (Nurnberg and LaZerte 2015b) identified, as expected, that the existing PWQMN sampling in the Lower Thames presented significant challenges for determining ***phosphorus loadings*** from tributaries in this part of the Thames ***watershed***. Historically, there were some short term studies designed to measure ***phosphorus loading*** from the Thames and select tributaries (e.g., Pollution from Land Use Activities Reference Group studies; Kintore Creek Paired ***Watershed*** Study).

Optimal monitoring for ***phosphorus loads*** requires a monitoring design that allows for frequent sample collection year round and throughout the range of flow conditions, with greater frequency during high flow events. As well, optimal monitoring for ***phosphorus loads*** requires continuous flow data at the location where water samples are collected.

ECCC began monitoring the Thames River for ***phosphorus load*** in 2012 (Dove et al., unpublished). The goal is to measure ***phosphorus loads*** from main Lake Erie tributaries (including the Thames), and track progress towards achieving ***phosphorus*** reduction targets. ECCC added an automated, year round sampler in early 2014 on the Thames River at Thamesville, where there is already a Water Survey of Canada flow gauging station. The Thamesville gauge location was chosen because attempting to measure flows any further downstream is complicated by the influence Lake St. Clair water levels on the water depth to flow relationship.

Through the MECP Great Lakes Surveillance Program, in 2016, a four-year water quality and harmful algal blooms (HABs) assessment project was initiated in Lake St. Clair and the mouth of the Thames River to Chatham in order to better understand the natural range in water quality conditions that occur throughout the ice-free season and to better ascertain the spatial scope of HABs and their associated risk (i.e., ***cyanotoxins***).

Some other current studies in the Thames ***watershed*** include nutrient load monitoring in their study design and implementation. Examples include the Multi-***Watershed*** Nutrient Study initiated by MECP in 2014, which examines the connection between land-use and water quality in headwater agricultural streams with sites in the Thames ***watershed*** including Nissouri Creek (UTRCA) and Big Creek (LTVCA); the Thames River ***Phosphorus*** Dynamics Study led by the University of Waterloo in conjunction with MECP, began in 2016 to examine ***phosphorus*** movement and the change in ***phosphorus*** species from the headwaters to the lake; and the Priority ***Subwatershed*** Projects initiated by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) in 2015 including Medway Creek (UTRCA) and Jeanettes Creek (LTVCA).

C.1.2 Stewardship and Outreach

Nonpoint sources contribute the majority of the ***phosphorus load*** to Lake Erie (ECCC and MECP 2018). While individual sites may only have a relatively small loss of ***phosphorus***, the cumulative impact of these small losses across thousands of sites creates the overall ***phosphorus load*** delivered from the Thames ***watershed***.

Controlling ***nonpoint sources*** is challenging because solutions require changes on thousands of individual sites and must be tailored to particular land management and biophysical site characteristics (ECCC and MECP 2018). ***Best Management Practices*** should focus on efforts to reduce peak flows and rate of runoff in areas across the entire ***watershed***, to minimize nutrient loss from land during peak loading times.

Rural and Agricultural BMPs

Land use within the Thames River ***watershed*** is approximately 75% agricultural with highly productive farmland (Lower Thames Valley Conservation Authority and Upper Thames River Conservation Authority 2008). Changes in agricultural practices in Ontario, in combination with a changing climate, have led to an increased risk of nutrient loss, particularly in the non-growing season when there is an increased risk of runoff from bare, snow-covered, frozen or saturated soil.

Over the past decades, farm size has increased and production has intensified to create more efficient food production. Fencerows and windbreaks have also been removed from many farms to accommodate the larger equipment, which has helped increase productivity but adds to the risk of wind and water erosion (ECCC and MECP 2018). It is estimated that 82% of farmland in Ontario is losing organic matter — an important component of healthy soil — and 68% of Ontario's cropland has a risk of erosion above the annual rate of soil regeneration.

Improving nutrient management, building soil health and slowing the flow of water off the land's surface are essential to reducing environmental impacts. Healthy soils retain water and nutrients while reducing runoff that can carry nutrients to waterways. Better soil health also helps deal with climate change and weather extremes.

Practices such as diverse ***crop rotation***, ***conservation tillage*** and ***cover crops*** are all important in building and maintaining soil health (ECCC and MECP 2018). Agricultural ***BMPs*** are also used to prevent or reduce nutrient loss while maintaining productivity. Examples include ***cover crops***, ***conservation tillage***, structural erosion control, and "4R" nutrient stewardship (right source, right rate, right time, and right place). A number of agricultural ***BMPs*** are outlined in ***Best Management Practices*** for ***Phosphorus*** (OMAFRA 2012). The approach to reducing ***phosphorus*** runoff from agricultural lands can vary between operations, due to the variability in soils, topography and agricultural systems within the Lake Erie basin and the Thames ***watershed***.

There is on-going research to measure the impact of ***BMPs*** on water quality. While there are challenges with monitoring the complexity of nutrient loading sources, field and ***subwatershed*** scale research has provided evidence supporting the effectiveness of many ***BMPs*** in mitigating the loss of ***phosphorus*** and other nutrients from farms.

Water quality stewardship programs to address issues, including ***nonpoint sources*** of ***phosphorus***, have been implemented for more than 30 years across the Thames ***watershed***. A number of these programs continue today. Education and outreach are critical to reaching landowners across the ***watershed*** with information and technical assistance.

Urban BMPs

The International Joint Commission (IJC) identified lawn and garden fertilizers, pet waste, erosion from construction sites, and organic matter (e.g., leaves, grass clippings and other plant debris) as the main sources of nutrients in ***stormwater*** runoff in the Lake Erie basin (IJC 2014).

Municipal waste water treatment plants, which are the main contributors of municipal ***point source*** loadings, have been greatly improved over time. Current ***BMPs*** for urban ***nonpoint source*** loadings focus on sewer overflows and ***stormwater*** runoff.

While new urban growth occurs with full municipal services, the legacy issues persist from past urban developments. For instance, ***combined sewer systems*** in older developments convey sewage and storm runoff in one pipe. Urban storm runoff occurs when precipitation from rain and snowmelt flows over land and impervious surfaces, such as city streets, sidewalks and parking lots, without infiltrating into the ground. Storm runoff collects pollutants such as ***phosphorus*** and is conveyed into storm sewer systems and then into watercourses. During periods of high rainfall and / or snow melt, the volume of water entering these pipes may exceed the capacity of the ***stormwater*** infrastructure, resulting in ***combined sewer overflows*** where untreated or partially treated water goes directly to the surface waters. Some ***watershed*** municipalities are systematically addressing this issue by separating the sanitary sewer and storm runoff and reducing inflow and infiltration into separated sewers.

In some areas, ***stormwater management (SWM)*** ponds are used to temporarily detain runoff before it reaches the watercourse. Urban ***stormwater management*** aims to reduce the runoff under the post-development conditions to pre-development conditions using various techniques including using detention, retention, and infiltration/filtration techniques to reduce runoff and improve runoff quality. A ***SWM*** strategy may include protecting natural areas that improve water quality by slowing down overland flow and providing storage capacity, incorporating landscape approaches in designing communities to slow storm runoff generation, and implementing pollution prevention stewardship programs.

Low Impact Development (LID) is the next step in the evolution of ***SWM***. ***LID*** focuses on managing rain where it falls and can be applied to many land uses including residential and commercial properties. The goal of ***LID*** is to mimic a site's pre-development ***hydrology*** by using designs and landscape features to infiltrate, filter, store, evaporate and detain runoff as close as possible to its source. There are commitments under the Great Lakes Water Quality Agreement and the Canada-Ontario Agreement to support training, education and promotion of ***LIDs***. The Canada-Ontario Lake Erie Action Plan (ECCC and MECP 2018) includes a commitment for Ontario to work with partners to promote and support the use of ***green infrastructure*** and ***LID*** systems for ***stormwater management***. The Province of Ontario is developing a ***LID*** guidance manual to complement the MECP's 2003 ***Stormwater Management*** Planning and Design Manual. A ***LID*** program is being implemented in the Upper Thames River ***watershed***. Demonstration and education is a key part of this program to move ***LIDs*** forward as a standard practice in the ***watershed***.

Natural Heritage Features and Systems

While reducing nutrient loss at the source is a key implementation priority, improving and restoring natural heritage features can provide additional opportunities for improving water quality. Wetlands, ***floodplains***, and riparian buffers are examples of ***green infrastructure*** that use natural processes to slow runoff, increase infiltration, and utilize nutrients (Hutchinson Environmental Sciences Ltd. 2017).

Implementation actions can involve creating new ***green infrastructure*** on the landscape or enhancing and protecting existing features. Programs are available in the Thames River ***watershed*** to establish or enhance natural heritage features. Conservation Authorities provide services for projects to establish watercourse buffers, retire fragile land, create wetlands, and implement in-stream natural channel design. These practices can be incorporated in both urban and rural settings.

C.1.3 Acts, Policies and Regulations

There are many policies, Acts, and regulations that apply directly to reducing ***phosphorus*** (e.g., Canada - Ontario Lake Erie Action Plan, Ontario Great Lakes Protection Act) and there are other tools that would come at this indirectly (e.g., Drainage Act, Planning Act). Other tools that are within these categories could include, but are not limited to, the following:

- Conservation Authorities Act
- Nutrient Management Act
- Clean Water Act
- Municipal Bylaws
- Municipal Official Plans
- Ontario Water Resources Act

In general, MECP sets out regulatory requirements for both ***point*** and ***nonpoint sources*** discharging to the environment or water bodies, through key acts such as the Environmental Protection Act, Ontario Water Resources Act, and Clean Water Act. These acts set out the requirements associated with the regulation of specific discharges to air, land and water. Sections in these acts also provide for and outline authorizing documents such as environmental compliance approvals, permits and other regulatory instruments governing discharges to the environment. The ministry has roles in developing, implementing, monitoring and overseeing compliance and enforcement of environmental legislation, and has roles in management of spills, emergencies, and creation and delivery of policies, programs and legislation through the relevant acts.

OMAFRA is responsible for those aspects of the Nutrient Management Act related to approvals, licensing and certification, and the maintenance of a registry to store information on nutrient management strategies and plans. MECP is responsible for all other aspects, including compliance and enforcement. Policy is jointly developed by the two ministries.

C.2 Goal 2: Reduce soil erosion from land and maintain geomorphic processes across the *watershed*

Stream geomorphology refers to the geometry (shape) of a river or stream, which changes over time. It is affected by in-stream features, such as slope, bed and bank material, and flows, as well as erosion and deposition processes. Rivers and streams establish a balance of water and sediment that flows through channels in a natural system, which shapes the waterway into a series of meanders, riffles and pools. When more sediment is added to the waterway, through soil erosion, an imbalance occurs.

Water and wind erosion are key processes in degrading soils and affecting stream quality. Erosion from overland flow contributes to serious water quality degradation through sheet, rill and gully erosion. Tillage practices can expose soil to wind and water, often leading to increased soil loss as compared to areas that are protected by vegetation. In urban and rural areas, vegetation clearing, site grading and construction activities expose soil to the elements of wind and water, increasing the potential for soil to be delivered to watercourses.

Excessive levels of sediment and minerals in water may increase turbidity and inhibit the penetration of sunlight, which reduces the production of photosynthetic organisms. Adverse impacts on aquatic habitat from suspended sediment in the Thames River include effects on fish, fish eggs, plants, invertebrates, and insects.

The erosion potential of Ontario’s agricultural soils is significant, due to factors such as soil type and slope. An estimated 54% of Ontario’s farmland is in an unsustainable erosion risk category (OMAFRA 2016). Preventing soil erosion and maintaining healthy soils is a priority for sustainable agricultural production and minimizing nutrient and soil loss from land to watercourses. Healthy soils with high levels of organic matter and good soil structure will retain water and nutrients, thereby reducing runoff that can pollute waterways (OMAFRA 2016).

The economic impacts of soil loss on agricultural yields are significant. One study estimates that degraded soils are costing the agricultural economy more than $3 billion annually in Canada (Lobb et al. 2017).

As well, climate change is bringing more extreme weather events to Ontario. As a result, exposed soil is at an increased risk of erosion during the non-growing season. It is essential to adapt land management practices that will counter these new climate extremes. Average erosion rates between March and August have increased 10-20% per decade over recent decades. A single intense storm can now account for 60% of annual soil loss (OMAFRA 2016). The impact of runoff over unfrozen ground during the winter months has recently been identified as an important issue.

A study completed by the Thames River Implementation Committee (TRIC) in 1978 evaluated the relative magnitude of agricultural land practices on water quality in the Thames River ***watershed*** (Thames River Implementation Committee 1978). It examined the nature, extent and intensity of erosion and sedimentation problems in relation to the physiographic characteristics of the Thames River ***watershed***. The TRIC report identified drainage intensification (increase in tile and open drains) and lack of sufficient watercourse buffers as contributing to accelerated streambank erosion and increased sediment loads entering watercourses. TRIC also identified certain tillage and cropping practices that contributed to erosion and sediment delivery to watercourses.

The TRIC report was instrumental in establishing the foundation for agricultural erosion control programs in southwestern Ontario. Although progress has been made, new issues such as the impact of extreme weather and unforeseen impacts of tillage practices have added to the issues identified in the TRIC report.

The Ontario government has released a made-in-Ontario environment plan to help protect air, land and water, address litter and reduce waste, support Ontarians to continue to do their share to reduce greenhouse gas emissions, and help communities and families prepare for climate change. When it comes to fighting climate change specifically, Ontario intends to implement a balanced approach to reducing emissions and preparing families for the impact of climate change in order to maintain both a healthy economy and health environment.

C.2.1 Research and Monitoring

There is a need for more local studies to monitor rural and urban ***BMPs*** to evaluate their effectiveness in controlling soil loss, determine optimum locations, and identify barriers to implementation. The impact of climate change on rural and urban ***BMPs*** also needs study. While there is a general understanding of annual soil loss, more information is needed to better assess seasonal variability in order to effectively improve stream health, including aquatic life.

In addition, there is a need to better understand sediment and erosion transport in the river. Factors such as future river movement (meandering) and steep slopes come into play. Municipal infrastructure and recreation projects, in particular, are affected by riverbank erosion especially when located close to meandering waterways (MNRF 2002). Emergency erosion control projects can interrupt natural river processes, deflecting erosive energy downstream and creating further issues.

Ontario’s climate is changing. Being prepared to minimize the negative impacts of climate change and having access to consistent and comprehensive information and services will help decision makers identify risks and vulnerabilities across the province, and take action to prepare for future climate change impacts.

C.2.2 Stewardship and Outreach

Erosion is a natural process that is impacted by human activities. Erosion has two distinct actions: soil detachment and soil movement. All erosion control methods are based on preventing detachment or reducing the carrying power of wind and water, which may be exacerbated by climate change.

Soil erosion is often worse in areas of high runoff where the rate of precipitation exceeds the rate of infiltration. Conservation measures that slow the rate and volume of runoff are important in removing surface water without excessive soil loss. Slowing overland flow runoff will reduce erosion and help keep sediment out of the Thames River allowing nutrients to be taken up by vegetation or filtered through soil as ***groundwater*** is recharged.

In urban areas, ***stormwater*** is a source of sediment and nutrient runoff during rain events. ***LID*** approaches can be implemented to slow the speed of runoff and increase infiltration/filtration. By delaying peak flows, ***LID*** helps to reduce erosive impacts of runoff further downstream.

Vegetation plays an important role in preventing and mitigating the effects of erosion. Vegetated riparian buffer zones slow the velocity of the water, and wetlands absorb runoff, helping to settle out sediment. Naturalized public parklands have been shown to slow water runoff and absorb sediment (Millward, Paudel and Briggs 2011).

In rural areas, a suite of measures is encouraged to prevent, reduce and control erosion. Several soil management ***BMPs*** can be employed simultaneously to improve soil health and limit erosion, depending on the type of erosion, topography, soil type, and land use. ***Conservation tillage***, ***crop rotation*** and ***cover crops*** can all help to keep soil covered. Drainage and erosion control structures such as grassed waterways, watercourse buffers, and water and sediment control basins (WASCoBs) protect the soil surface from concentrated water flows and manage the movement of water, reducing erosion and runoff (OMAFRA 2011).

C.2.3 Acts, Policies and Regulations

Excess sediment is considered a pollutant in the context of several pieces of legislation including the Fisheries Act and MECP legislation. The negative effects of sediment and the associated contaminants are the rationale for addressing erosion and sedimentation issues.

Under the Ontario Great Lakes Strategy and the Canada-Ontario Agreement, Ontario has made commitments to support efforts with stakeholders to control sources of nutrients by promoting ***LID*** and ***green infrastructure*** and sediment and erosion control practices at construction sites, as well as promote sediment and erosion control from other sources in the Great Lakes, with an emphasis on the Thames River ***watershed*** and the Lake Erie basin.

Agencies are working with partners to improve the understanding and implementation of erosion and sediment control (ESC) practices including promoting and supporting conferences, projects and delivery of training by ***CAs*** and others on ESC.

Protecting valley lands and associated erosion hazards helps maintain natural functions such as nutrient removal and sediment control. Park land dedication through the plan of subdivision process can ensure valley lands are designated for public park space. All municipalities have the ability to require a certain percentage of land to be dedicated for public park space instead of cash in lieu.

C.3 Goal 3: Improve water quality to support improved stream health, including aquatic life

The Thames River is one of the most biologically diverse rivers in Canada, and is home many Species At Risk (SAR). There is, however, a need for improved water quality to enhance stream health in ***subwatersheds*** across the Thames, and to protect habitat for fish and aquatic communities, including SAR and top predators (LTVCA 2013, UTRCA 2012). Healthy streams provide suitable water quality and habitat for all life stages of aquatic species.

Other threats faced by the aquatic communities in the Thames River ***ecosystem*** (Taylor 2004) include deforestation, siltation and turbidity (erosion), nutrient loading (and associated harmful algae effects), harmful materials (including organic wastes, minerals, toxic chemicals, and other hazardous substances), altered water flow, watercourse barriers that prevent movement of aquatic species, non-native species, disturbance (from development or recreational activities) and thermal pollution (i.e., any process that changes the ambient water temperature).

Reducing contaminants in streams, for example through ***BMPs*** that minimize urban and agricultural runoff and ***point source*** pollution, is important to ensure water quality supports healthy stream communities. A healthy stream system can also, through natural processes, reduce pollutants such as bacteria, nutrients and sediment.

There is a direct connection between ***groundwater*** and surface water in the Thames ***watershed***. ***Groundwater*** contributes 40-70% of stream flow in the Thames ***watershed*** and, therefore, is a significant determinant of water quality and stream health. ***Groundwater*** can both dilute and be a source of contaminants in surface water. In the Thames ***watershed***, there are up to four overburden ***aquifers*** and several bedrock ***aquifers*** that contribute to ***groundwater discharge*** and stream flow.

The Thames River ***watershed*** has a mix of warm water, cool water and cold water watercourses, with the majority of them being warm water. These streams all support diverse fish populations as well as SAR and other aquatic life.

Cold water streams are distinguished from warm water streams by cooler water temperatures and the composition of the fish populations. Cold water streams support high quality aquatic ***ecosystems*** and are important to the diversity of fish and aquatic life in the Thames. They are located in ***groundwater discharge*** areas and generally in areas associated with intact natural heritage features, such as forest cover and wetlands. There are a limited number of cold water streams left in the ***watershed***; therefore, it is important to maintain and restore these features, where possible.

Headwaters are the areas where watercourses begin. They include swales, first and second order streams, areas of ***groundwater recharge*** and ***discharge***, and wetlands (TRCA 2007). Protecting headwater features directly benefits downstream water quality. Headwaters are critical to aquatic ***ecosystem*** function but continue to be lost or degraded at a significant rate in Southwestern Ontario through land use changes such as infilling, enclosures, channelization, vegetation removal, etc.

Riparian, or streamside, areas that are well treed or vegetated are critical to protecting water quality. These areas filter runoff and pollutants, reduce erosion, and lower stream temperatures by shading the water.

Identifying and addressing gaps in water quality information and threats to aquatic life will be important to improving stream health and protecting aquatic species. There is public concern regarding emerging contaminants in water; for example, the RBC Canadian Water Attitudes Study found increased public concern for the health of fish and drinking water related to emerging contaminants (RBC 2016). Research specific to the Thames ***watershed*** is needed to identify issues and understand causes of impairment at the ***watershed*** and ***subwatershed*** level.

C.3.1 Research and Monitoring

Research

Research specific to the Thames ***watershed*** is needed to fill information gaps related to surface water and ***groundwater*** quality and stream health.

Numerous past studies identify a range of historic and site specific contaminant issues in the Thames River (e.g., PCBs, pesticides, nutrients, plastics, etc.). Additional studies are needed to further understand and monitor emerging contaminants of concern in the Thames as they relate to ***ecosystem*** and human health. The RBC Canadian Water Attitudes Study (RBC 2016) found increased public concern for the health of fish and drinking water related to pharmaceuticals, ingredients from personal care products and microbeads in the water system.

Understanding the interactions of ***groundwater*** and surface water is essential to understanding and managing the physical, chemical and biological characteristics of streams throughout their length. Research is needed to better understand the chemical transformations between ***groundwater*** and surface water, and impacts on stream health. ***Groundwater*** may carry legacy contaminants, such as road salt and nitrates, that originated from anthropogenic (i.e., manmade) sources. These contaminants may accumulate in ***groundwater*** over decades, without degrading, before being discharged. Research is needed to understand the magnitude of this issue and how to mitigate the impact of these contaminants on surface water. More groundwater monitoring locations, including multi-level monitoring to assess ***aquifers*** at different depths, would improve our understanding of the interaction between ***groundwater*** and surface water.

Enhanced ***subwatershed*** information is needed to improve our understanding of priority issues, target remediation and evaluate the effectiveness of implementation efforts. Resource inventories and assessments (e.g., natural heritage, stream corridors, aquatic species, dams and barriers) are needed as part of the development of plans to improve stream health.

Monitoring

Monitoring is essential to understanding current conditions and long term changes affecting stream health. A wide variety of variables can be used to assess water quality and understand stressors in the river system that impact aquatic life. These include physical parameters (such as temperature and turbidity); chemical parameters (such as nutrients and metals); microbial parameters (such as fecal coliform and other ***pathogens***) and aquatic biological community parameters (such as fish and invertebrates, including invasive species). The choice of monitoring protocol depends on the intended purpose but data with similar performance characteristics can be pooled and compared.

Since the 1960s, water quality has been monitored in the Thames River ***watershed*** through various long term programs and studies that measure current conditions and long term changes in water quality and aquatic health (Lower Thames Valley Conservation Authority et al. 2008). Map 6 and Map 7 show monitoring sites for the following on-going monitoring programs:

- MECP Provincial Water Quality Monitoring Network (PWQMN): The PWQMN is the most extensive monitoring program in the Thames ***watershed***. It was initiated in the 1960s, partnering with UTRCA and LTVCA to assess long term ambient water quality across the ***watershed***. Water samples are taken generally from March to November at 24 stations in the UTRCA (monthly) and a further 6 or 7 (alternate monthly) stations in the LTVCA. The samples collected along the Thames River and its tributaries are analyzed for 37 parameters.
- UTRCA and LTVCA Water Quality Monitoring Sites: The ***CAs*** monitor 9 additional ***subwatershed*** water quality monitoring stations in the Thames River basin for a similar range of parameters as identified in the PWQMN. Six of these are sites located in the Lower Thames ***watershed***, sampled monthly and year round, and funded by a grant from MECP COA.
- City of London Thames River Water Quality Monitoring Program: Initiated in 1963 to monitor the Thames and its tributaries at 19 sites within the City of London.
- MECP Provincial ***Groundwater*** Monitoring Network (Quality and Quantity): started in 2001, partnering with UTRCA and LTVCA to assess long term ***groundwater*** levels at 37 monitoring wells across the ***watershed***. Twenty-eight wells are monitored by the UTRCA for water level; 24 of these are also monitored for ***groundwater*** quality. Nine wells are monitored by the LTVCA for water levels; 7 of these are also monitored for ***groundwater*** quality.
- City of London/UTRCA ***Groundwater*** Monitoring Program: An additional 15 wells are monitored for ***groundwater*** quality and levels (quantity) at the Sifton Bog Environmentally Significant Area in the City of London.
- Flow Monitoring Network: UTRCA and LTVCA operate 27 recording stream gauges, precipitation gauges and weather stations, in partnership with Water Survey of Canada and MNRF. An additional 15 gauge stations for other water quantity parameters are monitored by the UTRCA and LTVCA.

- Benthic Invertebrate Monitoring Program: Initiated in 1997 by UTRCA to assess benthic organisms (aquatic invertebrates that live in stream sediments), which are indicators of stream health. Sampling occurs at more than 100 stations annually in the Upper Thames ***watershed***. Monitoring in the LTVCA was done in 2003-2005 and started again in 2014 with about 12 samples each year. The University of Windsor is a partner in the current LTVCA program. The benthic invertebrate community of the Thames River was first monitored in 1972 by MECP for the 1975 Thames River Basin Water Management Study.
- Fish Monitoring Program: Initiated in 1999 by UTRCA to assess fish species present in the ***watershed***. In addition to this on-going program, there are other sites that are monitored or inventoried for a short time for a variety of reasons.
- Municipal Waste Water Treatment Plant Monitoring: Regulated monitoring of waste water treatment plants and their receiving waters at 30 sites.

Other monitoring programs (not represented in either map):

- Health Unit Bacteria Monitoring: Started in 1970s to monitor some local recreational beaches for swimming. Also partnership with UTRCA for ambient bacteria (*E. coli*) monitoring at PWQMN sites.
- Sport Fish Contaminant Monitoring Program: MECP and MNRF monitor contaminant concentration in fish, including in sections of the Thames, to provide consumption advice to the public.
- Industrial ***Point Source*** Monitoring: Regulated monitoring of industrial direct discharges and their receiving waters. The MECP requires industrial dischargers to obtain an Environmental Compliance Approval which imposes strict effluent criteria and a number of conditions associated with operation, maintenance and reporting.
- MECP Regional Monitoring Program: Routine monitoring and monitoring for compliance and enforcement activities includes chemical, microbiological, algal, ***cyanobacterial*** and benthic invertebrate sampling.
- MECP Great Lakes Surveillance Program: In 2016, a four-year water quality and harmful algal blooms (HABs) assessment project was initiated in Lake St. Clair and the Thames River in order to better understand the natural range in water quality conditions and to better ascertain the spatial scope of HABs. Monitoring of nutrients, chemistry, chlorophyll a, ***cyanotoxins*** including ***microcystins*** and phytoplankton community was undertaken along the extent of the Canadian shoreline of Lake St. Clair and at the mouth of the Thames River to Chatham.

Other Contaminants: A number of other agencies and research institutions are monitoring contaminants in the Thames as part of contaminant studies.

Work is underway in the Thames ***watershed*** to develop a comprehensive data storage and management system in order to better compile and share data. The goal is to include water quality, quantity and ecological data for the Thames ***watershed*** from multiple sources in a common system for use by Thames River partners.

C.3.2. Stewardship and Outreach

To improve water quality, ***BMPs*** should focus on both ***point source*** and ***nonpoint source*** pollution. For ***point sources***, removing ***combined sewers*** as well as weeping tile connected to sanitary sewers is important to reduce peak flows. For ***nonpoint sources***, practices to reduce peak flows and rate of runoff are important to minimize pollutants reaching watercourses. Maintaining, rehabilitating and expanding natural heritage features, including natural stream structure, also play a key role in improving water quality and stream health.

Rural and Urban BMPs

Addressing pollutants at the source is a key implementation priority. Pollutants in rural areas are typically carried into streams during rain or snowmelt events, through overland runoff or via tile drainage. Agricultural ***BMPs*** are used to reduce runoff from agriculture while maintaining productivity. Examples include ***cover crops***, ***conservation tillage***, and ***structural erosion control***. Examples of potential contaminants that can be controlled through ***BMPs*** include pesticides, fuels, excessive nutrients, and pathogens (Environmental Farm Plan, 4th Ed., Ontario Soil and Crop Improvement Association).

Water quality stewardship programs to address rural and agricultural issues have been implemented across the Thames ***watershed*** for more than 30 years. A number of programs are currently in place to support agricultural ***BMPs***. Education and outreach efforts are important for providing landowners across the ***watershed*** with information and technical assistance.

Urban ***stormwater*** runoff is caused when rain and snowmelt flows over land and impervious surfaces (e.g., roofs, streets, sidewalks, and parking lots) without infiltrating into the ground. The ***stormwater*** runoff can collect pollutants such as nutrients, ***pathogens***, pesticides, fuels and other chemicals and debris, which can impair water quality. The polluted runoff flows into storm drains, through storm sewer systems and ultimately into natural watercourses (UTRCA 2017 draft).

Sanitary sewers collect ***wastewater*** generated inside buildings and transport it through the sewer system to ***wastewater treatment plants***, where it is treated before being discharged. Although ***wastewater*** treatment has improved greatly over time, current treatment methods (e.g., biological process) are not designed to remove all contaminants (e.g., pharmaceuticals, micro plastics). In addition, existing ***stormwater*** and sewer systems can be inadequate to handle peak flows, particularly in areas where the infrastructure services more development than it was originally designed for. Some areas have aging infrastructure where the sanitary sewer network is cross-connected with the ***stormwater*** network together in one pipe (***combined sewer***), or where sewers are separated but ***stormwater*** is purposefully directed to sanitary sewers to prevent basement flooding, or where weeping tile is directed to the sanitary sewer.

Urban ***stormwater management (SWM)*** is designed to increase infiltration and reduce runoff. A ***SWM*** strategy may include protecting natural areas that improve water quality by slowing down overland flow and providing storage capacity, designing communities to reduce

stormwater generation through techniques such as ***LID***, and implementing pollution prevention stewardship programs. Routine municipal operations such as street sweeping, catch basin cleaning, road salt management and sewer use bylaw enforcement and outreach can help to protect stream health. The marketing tag line, "Slow it down; Soak it up; Keep it clean" is used by several urban communities and environmental groups to illustrate the ideal ***BMP*** practices.

Natural Heritage Features and Systems

Improving and restoring natural heritage features and systems in the Thames ***watershed*** is important to the protection and enhancement of water quality.

Water temperature is an important component of stream health. Cold water, cool water and warm water stream systems are under stress due to human disturbance and climate change. Cold water and cool water streams can become warm water streams, while warm water streams can become too degraded to support the species that rely on them for critical life stages. Maintaining and restoring natural heritage features in significant ***groundwater recharge*** areas maintains a flow path along the ***aquifer***, which cools the water and then feeds cold water to streams in discharge areas. ***Groundwater*** dependent ***ecosystems***, such as wetlands, should also be protected as they are generally associated with ***groundwater discharge*** areas. Maintaining other natural heritage features such as upland woodlands and riparian corridors will also protect stream health.

Research indicates that natural channels, which typically have pools, riffles and meanders, that flow through well vegetated riparian zones produce improved water quality (Dosskey et al. 2010). Natural channels should be protected, enhanced or recovered and riparian corridors maintained and enhanced. As compared to natural channels, straightened channels often have increased peak flows, erosion, sediment buildup, and increased temperature (Brooker 1985).

Stream barriers such as dams alter flows, temperatures, erosion and siltation. They also prevent fish and wildlife movement. Many of these structures have modified the ***hydrology*** and the ability to sustain healthy river ***ecosystems***, often separating habitat types that may be essential for the survival of many species. These structures can also impact localized water quality. For example, nutrient and sediment buildup in impoundments can result in nuisance and harmful algal issues. The current approach for removing ***water control structures*** that are no longer required for their original purpose, such as the Dingman Creek Weir, Hodges Pond Dam and many privately owned barriers, has often been to respond to opportunities for removal rather than to strategically target structures for removal. Also, there are new alternatives for dams that may address some biological needs without complete removal, such as structures for fish passage.

C.3.3 Acts, Policies and Regulations

There are many guidelines, policies, acts and regulations that could apply to improving and protecting stream health. Several provincial acts and regulations address discharges to, and the protection of, the natural environment. For example, the Ontario Water Resources Act, the Clean Water Act, and the Environmental Protection Act provide the overarching authority for a variety of regulations controlling, preventing and mitigating discharges to air, land and water. There are also tools that would come at this indirectly. For example, the 2014 Provincial Policy Statement, Section 2.2, provides direction to planning authorities to protect, improve or restore both quality and quantity of water. Progress toward accomplishing many of the recommendations contained in a Shared Waters Approach can be realized through implementing recommendations of natural heritage systems studies, and further identifying water resource systems. These systems consist of ***groundwater*** features, ***hydrologic*** functions, natural heritage features and areas, and surface water features, which are all necessary for the ***watershed's*** ecological and ***hydrological*** integrity.

Federal and provincial governments have developed water quality standards, objectives and guidelines to protect both aquatic life and human water uses. Human uses include drinking water, crop irrigation, animal watering, recreation uses, and aesthetic value. The MECP has published provincial objectives and guidelines for aquatic life and human water uses (Ministry of the Environment and Energy 1994a), while the Canadian Council of Ministers of the Environment has published the Canadian Environmental Quality Guidelines for the protection of aquatic life (Canadian Council of Ministers of the Environment. 1999).

Other tools that would come at this indirectly could include, but are not limited to, the following:

- Lakes and Rivers Improvement Act,
- Environmental Protection Act,
- Conservation Authorities Act,
- Nutrient Management Act,
- Clean Water Act,
- Municipal Bylaws,
- Municipal Official Plans,
- Pesticides Act, Cosmetic Pesticides Ban Act, 2008, and Ontario Regulation 63/09, and
- Fisheries Act and Fish & Wildlife Conservation Act, 1997.

As well, there are numerous requirements under the Environmental Protection Act that address waste collection, disposal and environmental approvals for waste, such as:

- Landfill design standards (O. Reg. 232),
- Standards for disposal sites, the management, tracking and disposal of hazardous and liquid industrial waste (O. Reg. 347),
- Requirements for landfill gas collection (O. Reg. 217),
- Requirements for municipal Blue Box programs (O. Reg. 101/94),
- Requirements for the industrial, commercial and institutional sector to reduce waste and recover resource ('3Rs' regulations: O. Reg. 102/94, 103/94 and 104/94),

- Requirements for producers of pharmaceuticals and sharps to establish free collection locations across Ontario for pharmaceuticals and sharps no longer needed by consumers (O. Reg. 298/12), and
- Ontario Compost Quality Standards (O. Reg. 347) and Guidelines for the Production of Compost.

References for Appendix C

Brooker, M.P. 1985. The Ecological Effects of Channelization. The Geographical Journal Vol 151 (1): 63-69.

Canadian Council of Ministers of the Environment. 1999. Canadian water quality guidelines for the protection of aquatic life: Dissolved oxygen (freshwater). In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg).

Dosskey, M.G., P. Vidon, N.P. Gurwick, C.J. Allan, T.P. Duval, and R. Lowrance. 2010. The Role of Riparian Vegetation in Protecting and Improving Chemical Water Quality in Streams. Journal of the American Water Resources Association (JAWRA):1-18.

Dove A., V. Richardson, J. Baillargeon, J. Narayan, and S. Backus. Canadian Tributary Loadings to Lake Erie 2012, 2013 and 2014 Water Years with an accounting of activities until March 2015. Environment Canada, Unpublished.

Environment and Climate Change Canada and Ontario Ministry of the Environment, Conservation and Parks. 2018. Canada-Ontario Lake Erie Action Plan (LEAP): Partnering on Achieving Phosphorus Loading Reductions to Lake Erie from Canadian Sources. 75 pp.

Government of the United States and Government of Canada. 2012. Great Lakes Water Quality Agreement, Protocol Amending the Agreement Between Canada and the United States of America on Great Lakes Water Quality, 1978, as Amended on October 16, 1983, and on November 18, 1987. 54 pp with annexes.

Hutchinson Environmental Sciences Ltd. 2017. Natural Heritage Features and the Role in Mitigating Nutrient Impacts on Lake Erie: An Assessment of Best Management Practices and Approaches for Floodplains and Watercourses. Prepared for ECCC.

International Joint Commission. 2014. A Balanced Diet for Lake Erie.

Lake Erie LaMP. 2009. Status of Nutrients in the Lake Erie Basin. Prepared by the Lake Erie Nutrient Science Task Group for the Lake Erie Lakewide Management Plan.

Lake Erie LaMP. 2011. Lake Erie Binational Nutrient Management Strategy: Protecting Lake Erie by Managing Phosphorus. Prepared by the Lake Erie LaMP Work Group Nutrient Management Task Group.

Lobb, D., N. Badreldin, M. Loro, S. Li, and B.G. McConkey. 2017. Soil degradation: The cost to agriculture and the economy.

Lower Thames Valley Conservation Authority. 2013. Lower Thames Valley Watershed Report Card.

Lower Thames Valley Conservation Authority, Upper Thames River Conservation Authority, St. Clair Region Conservation Authority, Ontario Ministry of the Environment, and

Conservation Ontario. 2008. Thames-Sydenham and Region Watershed Characterization Summary Report: Thames Watershed and Region (Upper Thames River and Lower Thames Valley Source Protection Areas). 48pp.

Maccoux, M.J., A. Dove, S.M. Backus, and D.M. Dolan. 2016. Total and soluble reactive phosphorus loadings to Lake Erie: A detailed accounting by year, basin, country, and tributary. Journal of Great Lakes Research, 42(6), 1151-1165.

Millward, A.A., K. Paudel and S.E. Briggs. 2011. Naturalization as a strategy for improving soil physical characteristics in a forested urban park. Urban Ecosystems 14(2): 261-278.

Ministry of Natural Resources and Forestry. 2002. Technical Guide: River and Stream Systems: Erosion Hazard Limit.

Ministry of the Environment and Energy. 1994a. Policies, guidelines, provincial Water Quality Objectives of the Ontario Ministry of Environment and Energy. July 1994.

Nurnberg, G. and B. LaZerte (Freshwater Research). 2015a. Water Quality Assessment in the Thames River Watershed – Nutrient and Sediment Sources.

Nurnberg, G. and B. LaZerte (Freshwater Research). 2015b. Gap Analysis for nutrients in the LTVCA.

Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). 2011. Controlling Soil Erosion on the Farm: A practical guide to help Ontario farmers solve soil erosion problems.

OMAFRA. 2012. Best Management Practices for Phosphorus.

OMAFRA. 2016. Sustaining Ontario's Agricultural Soils: Towards a Shared Vision. 35pp.

O'Sullivan, P.E. and C.S. Reynolds. 2006. The Lakes Handbook Volume 2 Lake Restoration and Rehabilitation. 560pp.

RBC. 2016. Canadian Water Attitudes Study. 94pp.

Taylor, I. 2004. Aquatic Ecosystem Recovery in the Thames River Watershed. Proceedings of the Species At Risk 2004: Pathways to Recovery Conference. March 2-6, 2004. Victoria, BC.

Thames River Implementation Committee. 1978. Erosion and Agricultural Practices Thames River Basin. 51pp.

Toronto Region Conservation Authority. 2007. The Natural Functions of Headwater Drainage Features: A Literature Review.

Upper Thames River Conservation Authority (UTRCA). 2012. Upper Thames River Watershed Report Cards.

UTRCA. 2017 (draft). Nutrient Reduction Project Preliminary Report: Identifying and Overcoming Barriers to Behaviour Change.

Van Meter, H.D., and M.B. Trautman.1970. An annotated list of the fishes of Lake Erie and its tributary waters exclusive of the Detroit River. The Ohio Journal of Science. Vol 70 (2): 65-78.

Appendix D. SUPPORTING RATIONALE FOR WATER QUANTITY RECOMMENDATIONS

WATER QUANTITY MISSION STATEMENT:

TO ENCOURAGE A FLOW REGIME THAT PROVIDES SUSTAINABLE *ENVIRONMENTAL FLOW (EFLOW)* WHILE REDUCING FLOOD RISK

Four goals have been developed for the ***watershed*** to achieve the water quantity mission, along with recommendations and proposed activities to achieve each goal.

D.1 Goal 1: Understand, develop and recommend *environmental flow (eflow)* needs in the Thames River *watershed*

Environmental flows, or ***eflows***, describe the quantity and timing of flows required to sustain healthy river ***ecosystems*** as well as the human livelihoods that rely on these ***ecosystems*** (Brisbane Declaration 2007). The concept implies that aquatic ***ecosystems*** should be in a state of well-being where habitat quality and biotic integrity are supported by the flow regime. This aspect of ***environmental flow*** is also discussed as stream health in the water quality section.

An ***environmental flow*** (***eflow***) assessment of quantity and timing involves determining the natural flow regime (or the acceptable departure from the natural flow regime) needed to maintain the valued features of the ***ecosystem***, and identifying critical aspects of the ***hydrologic cycle*** that support the flow regime (Tharme 2003). To protect aquatic, semi-aquatic and riparian-dependent floral and faunal assemblages in the Thames River ***watershed***, an adequate portion of the water budget must be reserved for the ***ecosystem*** while still meeting human needs. Common concerns identified by ***eflow*** assessments include: the potential for insufficient water to maintain biological processes during drought conditions (i.e., when there are many competing needs for scarce water), and the impacts on aquatic habitat from flow variability caused by human activity such as land-use change and dams. Understanding the ***eflow*** needs for valued faunal and floral assemblages will allow water resource managers and First Nations to predict the impacts of various flow regimes and establish low flow criteria to protect the integrity of these assemblages.

D.1.1 Recommendation 1: Develop an understanding of the aquatic, semi-aquatic and riparian-dependent faunal and floral assemblages and human water uses

The Thames River flows through many diverse habitats and acts as a dispersion corridor for many flora and fauna species. With its many habitats, nutrient rich waters, long growing season and connection with the Great Lakes, the Thames River ***watershed*** supports one of the most diverse aquatic, semi-aquatic and riparian-dependent faunal assemblages within the Great Lakes basin (Thames River Background Study Research Team 1997). This assemblage includes more than 90 species of fish (Schraeder 1996), 30 species of freshwater mussels (Metcalfe-Smith et al. 1997, Metcalfe-Smith et al. 1999, Metcalfe-Smith et al. 1998, Morris 2004), and 30 species of reptiles and amphibians (Thames River Recovery Team 2007). In a 2004 study, it was found that 16% of Canada's threatened and endangered species, and an additional 11% of Canada's species of special concern, occurred in the Thames River ***watershed***. Many of the native species that live within the Carolinian Zone, which the Thames River flows through, are not found anywhere else in Canada (Cudmore, MacKinnon and Madzia 2004).

The Thames River is situated in a highly developed section of southern Ontario and, as such, faces many pressures from urban and rural land uses and other human activities. The ***watershed ecosystems*** provide many benefits to society including the supply of water, sediment transport, moderation of floods and droughts, biodiversity, commercially important native species, recreational opportunities, and aesthetic values (Bradford 2008). Given that more than half a million people live in the ***watershed***, native species face many stressors from urban and rural land uses. Most of these native species are sensitive to environmental changes, and are dependent on a particular quantity regime of stream flow. The challenge is to maintain the integrity of aquatic ***ecosystems*** while meeting human needs.

A substantial portion of the lower river reaches are significantly influenced by Lake St. Clair, creating conditions very different from the rest of the ***watershed***, particularly during low flow periods. In these reaches, the water level in the river can never fall lower than that of the lake. This ever-present water masks the presence of river ***baseflow*** that would otherwise be easily recognizable in free-flowing river sections. As such, it may be difficult to perceive drought conditions since there is plenty of water in these lower river sections due to the lake level. In addition, the water in the river near its mouth may end up being heavily influenced by mixing with lake water. Hence, it is expected that ***eflow*** needs are distinctly different in the lower river reaches influenced by Lake St. Clair than other upstream reaches.

D.1.2 Recommendation 2: Determine sustainable eflow needs (e.g., high and low flows) for aquatic, semi-aquatic and riparian-dependent faunal and floral assemblages and human water uses

There are many methods for determining ***eflow*** at the ***watershed*** scale. In March 2010, the Ontario Ministry of the Environment contracted Lake Simcoe Region Conservation Authority (LSRCA) to work with various ***watershed*** partners to develop a guidance document for in-stream flow requirements for water quantity-stressed ***subwatersheds*** (LSRCA and Bradford 2011). As reported in Conservation Ontario (2006) and Wong and Boyd (2014), the Grand River Conservation Authority completed a study in 2005 on eight reaches in the Grand River ***watershed*** with Trout Unlimited Canada, Parish Geomorphic Ltd, and academics that assessed currently available techniques on ***environmental flow*** requirements.

Linnansaari et al. (2013) provides a summary of four general categories of approaches (***hydrological***, ***hydraulic*** rating, habitat simulation and holistic methodologies and frameworks), and reviews their benefits and weaknesses.

Maintaining appropriate ***environmental flows*** in the Thames River and its tributaries is an evolving issue of concern. Flow alterations are a primary contributor to degraded river

ecosystems and lead to the loss of native, threatened and endangered aquatic and semi-aquatic species whose survival and reproduction are tightly linked to specific flow conditions (Poff and Zimmerman 2009). These species have evolved with, and intimately depend upon, natural patterns of ***hydrological*** variability. Naturally high and low water levels create habitat conditions essential to reproduction and growth, and drive ecological processes required for ***ecosystem*** health. The most ecologically important aspects of a river's flow are low flows, high flow pulses and floods.

Low flows determine the amount and characteristics (e.g., temperature, flow velocity, connectivity, etc.) of aquatic habitat that is available for most of the year. From this seasonally varying baseline of low flows, several kinds of flow "events" (i.e., extreme low flows, high flow pulses, small floods and large floods) may occur that typically trigger responses in aquatic organisms. Extreme low flows occur during times of drought and may alter water chemistry, concentrate prey species, and dry out low-lying areas in the ***floodplain***. Extreme low flows are often associated with higher water temperature and lower dissolved oxygen conditions. These very low flows can reduce connectivity, thereby restricting movement of some aquatic organisms. Because native species may be adapted to the extreme low flow events that naturally occur, these periodic events may allow native species to outcompete generalist invasive species that are not adapted to extreme low flows.

High flow pulses occur during rainstorms or brief periods of snowmelt. Water levels rise above low flow levels but do not overtop the channel banks. For many organisms, these short-term changes in flow may provide necessary respite from stressful low flow conditions. These pulses of fresh water may relieve higher water temperatures and low dissolved oxygen availability typical of low flow conditions, flush wastes, and deliver organic matter that nourishes the aquatic food web. High flow pulses typically facilitate improved access to up- or downstream areas for mobile organisms.

Flooding is a natural ecological process that plays an integral role in ensuring biological productivity and habitat diversity in the ***floodplain*** (World Meteorological Organization 2006). For example, important nutrients, organic material, sediment and mineral deposits distributed by flood water and deposited on the landscape can provide improved plant growth and overall ***ecosystem*** health. The redistribution of sediment and subsequent creation of sand bars, not just from scouring, but from adding new sediment, is used by turtles for nesting habitat. Reduction of overbank flow can have a substantial effect on turtle nesting success. When flooding is prevented, so is the natural scouring action of sandy banks. These banks become vegetated in the absence of scouring and are unsuitable nesting habitat for turtles.

Other positive benefits of flooding include the replenishment of ***groundwater*** and the creation of ephemeral pools for amphibian breeding in upper ***floodplain*** areas. Floods allow fish and other mobile organisms to access ***floodplains*** and habitats such as secondary channels, backwaters, sloughs, and wetlands (Jeffres et al. 2008, Talbot et al. 2018). These areas can provide significant food resources allowing for fast growth, offer refuge from high-velocity, lower-temperature water in the main channel, or be used for spawning and rearing.

Small floods may recharge shallow ***aquifers*** and the ***hyporheic zone*** important to ***macroinvertebrates*** and riparian plants.

Other impacts of flooding on the natural environment may be less positive and, in some cases, can result in environmental degradation. Flooding can increase riverbank erosion and sedimentation, and spread pollutants. Extended periods of flooding can change local landscapes and habitats, altering everything from how future floods will play out to how animals will use habitats in these newly created regions, potentially causing a shift in species composition (Poff et al. 1997). For example, turtle nests are able to withstand flash flooding; however, eggs do not survive if the nests are inundated with water for a longer period of time (ca. 48 hours). By prolonging periods of high water, it is suspected that flood management practices have been contributing significantly to the extremely low recruitment of spiny softshell turtles (S. Gillingwater, Upper Thames River Conservation Authority, pers. comm.). Furthermore, many species may not adapt to the flashy, intense summertime flooding events predicted by most climate change studies. Changes in climate that increase the severity of summer storm events would make these issues worse into the future.

Human land use and activities have influenced the degree and timing of flow events. Each of these flow conditions plays an important role in the long-term health of a river ***ecosystem***. Native organisms' life histories are tied to the timing, magnitude, duration, and frequency of these events.

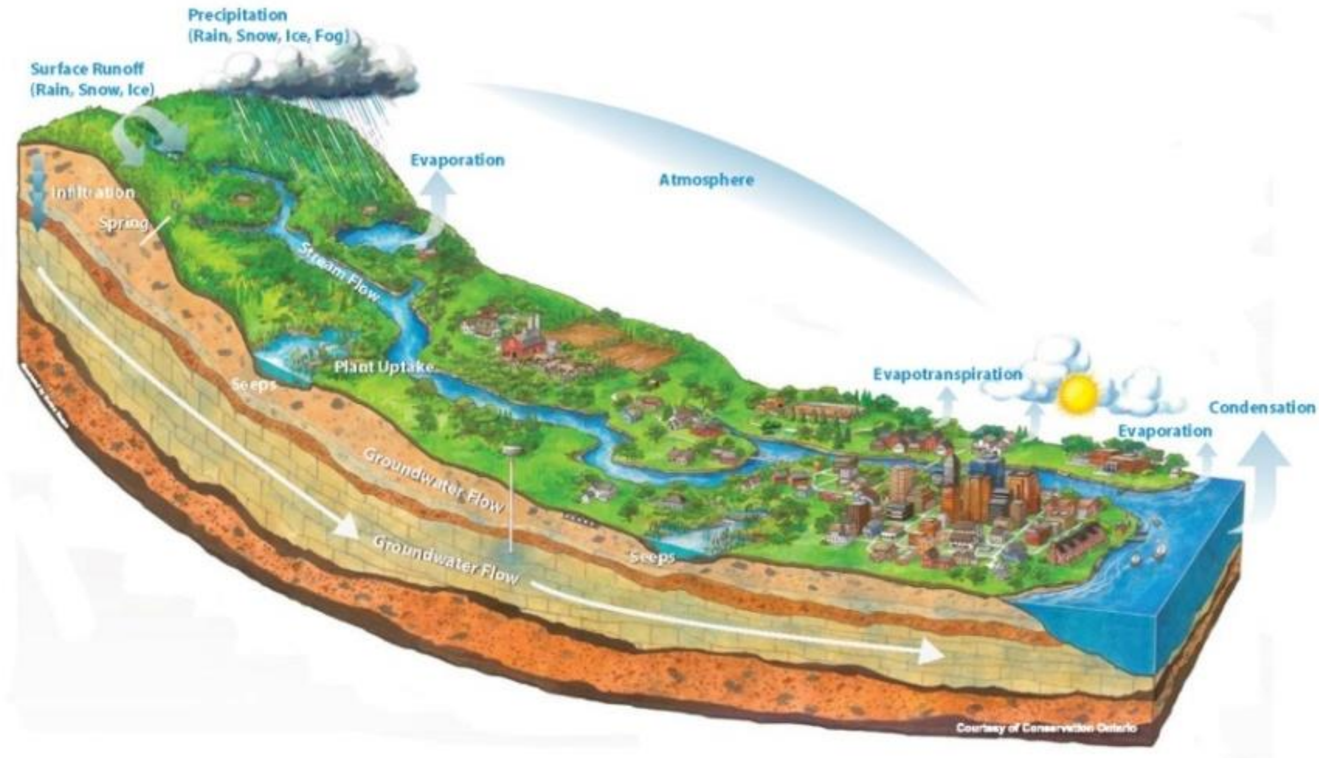
D.1.3 Recommendation 3: Use a water budget to assess the sustainability of eflow needs

A water budget quantifies or estimates the various components of the ***hydrologic*** system and the interaction between those components (Thames-Sydenham and Region Source Protection Committee 2007). The water budget identifies where the water is (water bodies and **aquifers**), how the water moves between these areas, and trends in availability and use.

In a water budget, each component of the ***hydrologic cycle*** (illustrated in Figure D1) is described and analyzed, including: precipitation, evapotranspiration (evaporation and plant uptake), ***groundwater recharge/discharge***, ***groundwater*** flow into and out of the ***watershed***, and surface runoff. Knowing where, when, and how much water is flowing into or out of these components can provide a means for calculating water availability.

Human water use is also considered in the water budget (illustrated in Figure D2). In Ontario, the withdrawal of large volumes (50,000+ L/day) of surface water or ***groundwater*** is governed by the provincial Permit to Take Water (PTTW) program and regulated by Section 34 of the Ontario Water Resources Act (with a few exceptions for emergency firefighting and livestock watering) and the Water Taking and Transfer Regulation (Ont. Regulation 387/04). The permit requires users to record information such as daily water use. This information is submitted to the Ministry's reporting system, which is a useful tool in quantifying certain types of water use. This information can be helpful when developing a water budget.

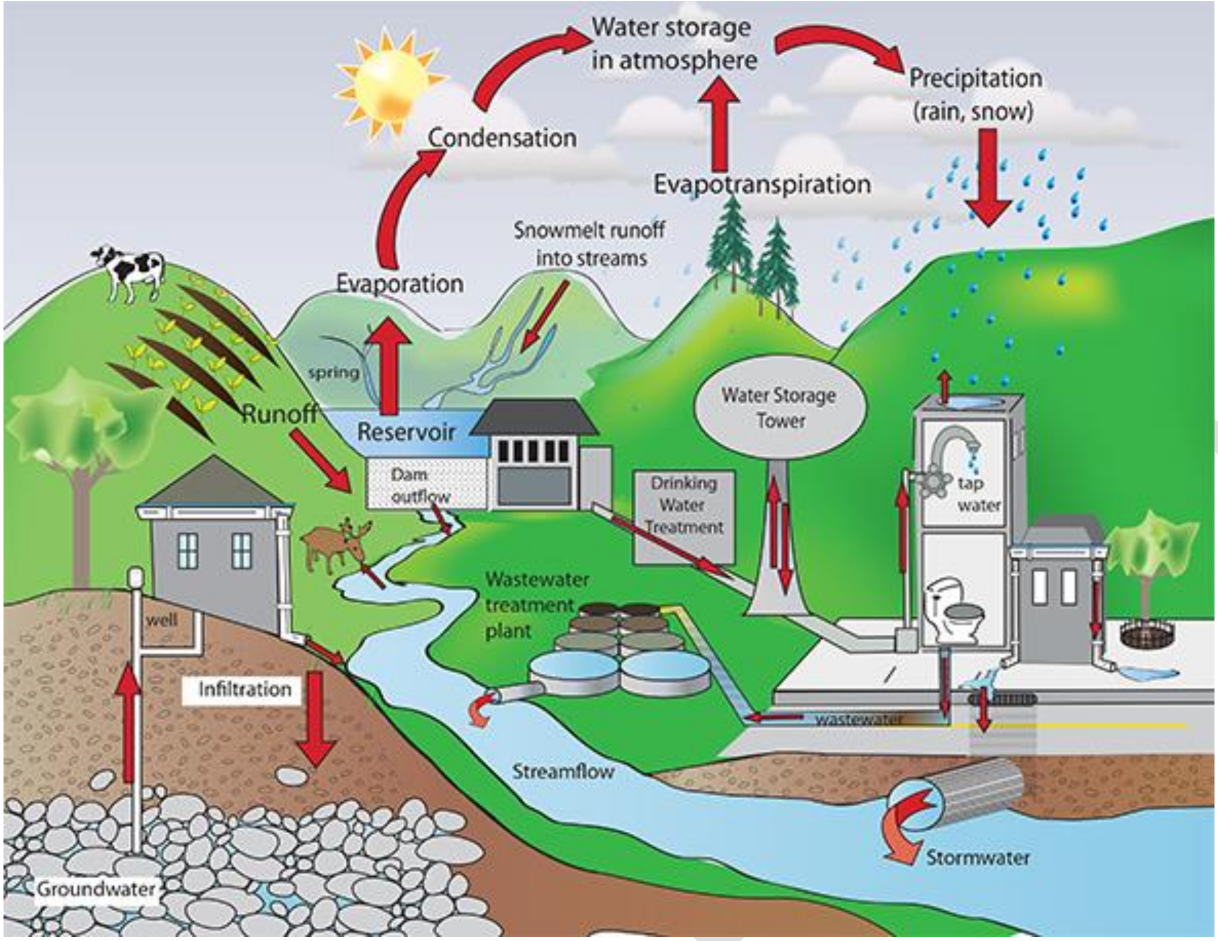
Figure D1. Components of the *hydrologic cycle*



Graphic: Conservation Ontario

The Drinking Water Source Protection (DWSP) program recently compiled data needed to summarize the municipal water supply in the Thames River ***watershed***. Local drinking water supplies come from both surface water and ***groundwater*** sources. Rural areas generally rely upon individual private wells or, less often, on small communal systems where a number of homes, businesses or institutions are connected to a well. It can be generally noted that urban municipalities to the north and east of London (e.g., Stratford, Mitchell, St. Marys, Woodstock, and Ingersoll) rely on ***groundwater*** wells. London and towns and cities to the south and west (e.g., Komoka, Delaware, Chatham) primarily rely on surface water from the Great Lakes. In London, Lake Huron (85%) and Lake Erie (15%) supply municipal water via two pipelines and associated treatment facilities. These facilities also service 14 surrounding municipalities in a regional water supply system. In London, after the municipal water has been used and consumed, it is treated in one of five pollution control plants and discharged to the Thames River, contributing to the overall flow of the river.

Figure D2. Components of the *hydrologic cycle* with a focus on human water use



Graphic: Cary Institute of Ecosystem Studies

DWSP studies did much to further the knowledge of the water budget in the Thames ***watershed***, but its scope did not go beyond the conceptual stage and focused on sources of municipal drinking water. As a result, aspects of the water budget important for maintenance of watercourse flow, such as ***groundwater***, were not considered beyond a basic determination of ***baseflow***.

Each component of the water budget is important to ***eflow***. Precipitation is the main driver of the water budget. Precipitation moves across the surface and through the subsurface before entering stream channels and flowing out of the ***watershed***. The major water budget loss is through evapotranspiration. On average, the Thames carries 40% of the precipitation which falls on the ***watershed*** each year to Lake St. Clair. The other 60% evaporates, is transpired by plants, or is stored in ponds, wetlands or ***groundwater***. These percentages vary seasonally; there is less runoff in the summer owing to the large amount of evapotranspiration.

Of particular relevance to managing ***eflows*** is the ability to separate the proportions of total river flow coming from the various sources. ***Baseflow*** refers to consistent inputs of water to the river that can generally be relied on even in times of low precipitation. ***Baseflow*** typically comes from ***groundwater*** inputs and is strongly linked to ***eflows***. Based on the ratio of

groundwater discharge to total stream flow, the ***baseflow*** in the Thames River varies between 40-70% of total stream flow (Thames-Sydenham and Region Source Protection Committee 2007).

In areas influenced by Lake St. Clair, it is extremely difficult to separate a ***baseflow*** component since the water level in the river is influenced by the lake, resulting in the presence of water in the watercourses even in times of extreme drought. During normal or low flow conditions, dyke and ***pump schemes*** heavily influence flows and present particular challenges for modelling. Much of the land under agricultural production near the mouth of the Thames River is near or below Lake St. Clair water levels. In order to continue making use of the land, dykes protect the land from being flooded by the lake. However, the land still needs drainage and is heavily modified by constructed drains. In order to get the water off the land and out of the drains, numerous pumps are used to pump the water over the dykes into Lake St. Clair, the Thames River, or some of its larger tributaries. These pumps can be expensive to run and, therefore, are usually not operated unless the water held back in the drains is going to affect agricultural production. During high flow conditions, such as a spring melt event, ***baseflow*** will contribute a very small fraction of the overall flow and the ***pump schemes*** may not be operated.

In some cases, the pumps can be opened up to allow water to flow back into the drains from the lake to facilitate irrigation. These pumps can have significant impacts on water quantity as they trap water behind the dykes. They can create stagnant conditions for extended periods, may maintain water in the drain when a natural watercourse would otherwise be dry, or cause a drain to go dry when a natural watercourse would otherwise be flowing. This presents particular challenges for ***hydrologic modelling*** as the basic assumption that water during a rainfall event flows off the land, into the tributaries, and naturally makes it way to the river and eventually to the lake, is not necessarily true. Unfortunately, due to the history of the development of these dyke and ***pump schemes***, there is rarely any record kept of when the pumps are used and how much flow they pass.

The frequency, timing and duration of surface water runoff affect the variability of flows. All of these components and the water budget itself are important in determining the sustainability of ***eflow***. Some of these components, such as ***groundwater recharge***, streamflow variability, and water use, may be directly influenced through human activity.

D.2 Goal 2: Improve understanding and mitigation of hazards associated with flooding and extreme flows in the Thames River *watershed*

The Thames River ***watershed*** has been subject to varying degrees of flooding throughout history. Major flooding has been recorded as far back as 1791, with severe floods in 1883 and 1937. The 1937 flood was the impetus for the formation of the Upper Thames River Conservation Authority (UTRCA) and is the basis of ***floodplain*** regulation in the Thames River ***watershed***. Less damaging, but still significant, floods occurred in 1947, 1948, 1968, 1977, 1997, 2000, 2008, 2009 and 2018.

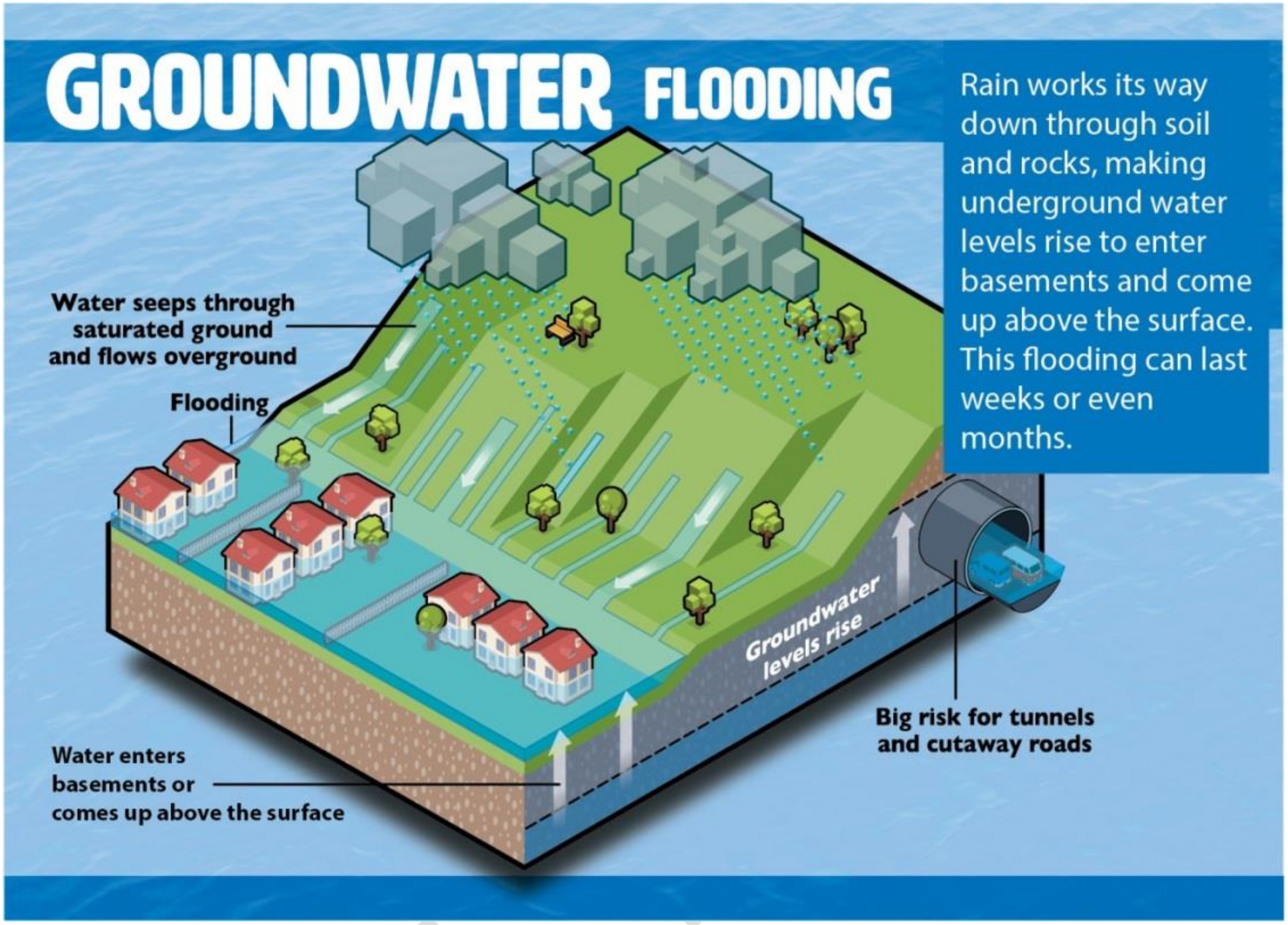
In the Thames River ***watershed***, flooding and localized flash flooding can occur for a number of reasons. The clearing of forested land for agriculture and urban growth, destruction of wetlands, installation of tile drains on farmland, and increase of impervious land in urban centres (e.g., paving) has reduced the land’s natural absorption and retention abilities. Since the soil is primarily composed of a silt and clay material, which inhibits infiltration, precipitation runs directly to the watercourses instead of percolating down into the soil or pooling at the surface. Watercourses can be overloaded by a heavy rainfall over a short period, which is more likely to occur in the summer. A similar process can happen with rapid melting of snow in late winter or early spring when the soil is still frozen or saturated, causing most of the meltwater to run off directly into the river.

In the Lower Thames Valley Conservation Authority (LTVCA) ***watershed***, the river downstream of Thamesville is also subject to ice jams that can aggravate typical spring flooding. Ice jams can cause water levels to rise swiftly and cause flooding within minutes of the ice jam forming. The area around the river’s mouth is particularly susceptible as the ice usually breaks up on the river before the ice in Lake St. Clair melts, making it difficult for the river ice to push out into the lake. In an attempt to mitigate this, there are extensive dyke works downstream of the City of Chatham. Major flooding events related to ice jams occurred in 1968, 1979, 1981, 1984 and 1985.

Groundwater flooding (Figure D3) is the emergence of ***groundwater*** either above the ground’s surface or into subsurface infrastructure, such as basements, underground parking garages, etc. ***Groundwater*** levels vary seasonally (highest in the late winter or early spring) and the impact of ***groundwater flooding*** can be severe under conditions where normal ranges of ***groundwater*** levels and flow are exceeded.

Flooding due to a high ***water table*** can look similar to river flooding; however, the contributing factors and management of this type of flooding are different. For example, ***groundwater flooding*** can occur when the ***water table*** is in a seasonal high (e.g., thaw or freshet conditions), and/or there is intense rainfall during a period of high infiltration (when vegetation is dormant). Changes in land use can also result in flooding due to a high ***water table***, particularly in urban environments.

Figure D3. Types of *groundwater flooding*



Graphic: NERC Science

Resulting ***groundwater*** levels can rise a metre or more above already elevated conditions. ***Groundwater flooding*** can last longer than surface water flooding because ***groundwater*** moves slowly through saturated pores in the ***aquifer*** below ground level. High ***groundwater*** levels are maintained by extended periods of precipitation that has not reached the ***water table***, as well as slow ***groundwater*** velocity. Having the ability to monitor shallow ***groundwater*** levels is important to managing water and responding to flood events.

Extreme flows can cause erosion hazards that can lead to damage to public and private infrastructure. Erosion hazards are part of the conservation authority (CA) planning and regulatory program. In many cases, particularly in the lower reaches of the Thames, the flood control infrastructure, such as dykes, may also provide erosion protection.

Hazards associated with extreme flows continue to evolve in the Thames River ***watershed***. Changes in land use, such as expanding urbanization, affect how water moves across the ***watershed***, and can increase the number of people and amount of infrastructure at risk. Climate change complicates predicting future risks and future impacts of decisions made today. Advances in technology can allow for an improved understanding of hazards associated with extreme flows.

While it may be possible to reduce risks, some risks cannot be prevented and, therefore, may need to be mitigated. A risk mitigation plan will provide direction on the various ways to mitigate these risks, including:

- flood forecasting and warning,
- ***stormwater management***,
- emergency response programs,
- flood proofing of existing at-risk public and private infrastructure,
- removal or relocation of existing at-risk infrastructure, where appropriate,
- constructing new flood reduction infrastructure such as dykes or channels, and
- upgrading existing flow impediments such as undersized culverts/bridges at road/rail crossings.

D.2.1 Recommendation 1: Modernize hydrologic and hydraulic analyses and models

Hydrologic analyses use ***watershed*** characteristics and meteorological inputs to estimate watercourse flows. These analyses are important in understanding risks and adaptation measures associated with flooding. They are also useful for understanding other processes such as ***eflows***, water budgets, erosion, sedimentation, and the potential impacts of climate change. ***Hydrologic*** analyses determine appropriate flood flow values for analysis with ***hydraulic models***.

Hydraulic models are used to estimate water velocity and surface elevations along the Thames River, as well as other physical properties. These models are critical tools in understanding flood extent and risk. They are also used to evaluate geomorphologic processes such as erosion and sedimentation risk. ***Hydraulic models*** may be used to assess the ***hydraulic*** impacts of the range of flow regimes predicted by climate change research.

Many of the existing models/analyses were created more than 25 years ago, do not reflect current ***watershed*** characteristics, and are not suitable for the wide range of applications discussed above. Recognizing the many critical applications of these analyses and models, it is important to update existing models/analyses to reflect current characteristics and to benefit from modern modelling techniques, computer systems and data sources. Also of note, the existing models/analyses do not cover the entire ***watershed***; in particular, little is currently available for the Lower Thames portion of the ***watershed***. As such, new models/analyses need to be developed for these areas.

The downstream reaches of the Thames River, from Thamesville to the mouth, present a variety of challenges in terms of modelling. The significant influence of water levels in Lake St. Clair on the river's lower reaches needs to be incorporated into the models. The more complex ***hydrologic***/***hydraulic*** issues in the downstream reaches, such as the impacts of dyke and ***pump schemes*** and ice jamming, should also be incorporated. A model that incorporates ice jamming would be particularly useful for flood forecasting in the downstream reaches of the Thames River for communities such as Lighthouse Cove and the City of Chatham.

There are several other more advanced ***hydraulic***/***hydrologic models***/ analyses improvements that would benefit the understanding and management of water quantity in the ***watershed***. Many of these improvements are now feasible due to recent technological advances in computer software and hardware. Such improvements include developing a continuous ***hydrologic model***, developing dual drainage ***hydraulic models*** of urban areas, developing 2D ***hydraulic models*** for select areas, and developing sediment transfer modeling.

Existing ***hydrologic models*** in the ***watershed*** are event-based models (i.e., a single rainfall or snowmelt event is represented). A continuous ***hydrologic model*** represents a longer period (e.g., one year) containing multiple periods of wet (rainfall or snowmelt) and dry (between rainfall and snowmelt events). A continuous ***hydrologic model*** of the Thames River ***watershed*** would be particularly useful in contributing to an understanding of potential long-term impacts of climate change, and should be developed. Coupling a continuous ***hydrologic model*** with a ***groundwater*** model may be important in adequately assessing ***baseflow*** and ***eflow*** sustainability.

Detailed flooding processes in developed urban areas can be highly complex. In addition to ***fluvial flooding*** caused by natural river systems overtopping their banks, urban flooding can often occur due to mechanisms such as sanitary system back-up into basements and poor (or absent) ***stormwater*** drainage systems. Existing models typically assume that all flood waters remain on the surface, and do not include the detail required to understand and manage urban non-***fluvial flooding***. Developing a dual drainage model that accounts for both surface runoff and runoff contained in underground pipe systems would contribute to understanding and managing urban non-***fluvial flooding***.

Existing ***hydraulic models*** in the ***watershed*** are considered one-dimensional (1D). 1D ***hydraulic models*** have traditionally been utilized to estimate flood levels of river systems, and are considered well-established and well-suited for this purpose in many situations. Two dimensional (2D) ***hydraulic models*** can generally provide much better estimates of flow velocities than 1D models and can provide a better overall understanding of flood hydraulics in hydraulically complex areas of interest, such as in highly developed urban areas, and should be developed for select areas.

Sediment transfer models are generally not available in the ***watershed***. Southern Ontario's stream and river systems typically have actively moving stream beds during high flow periods. Developing sediment transfer models should improve understanding of erosion and sedimentation processes in the ***watershed***.

D.2.2 Recommendation 2: Regularly update flood and erosion hazard mapping

Natural hazards are caused by naturally occurring physical and ecological processes which continuously shape and reshape the landscape. ***Floodplains***, unstable slopes and erosion are examples of natural hazards that pose risks and problems to society when they are not fully understood and/or planned for effectively.

Erosion is a natural process that can pose a risk to life and property and cause social disruption. The natural movement of watercourses and valley slopes due to erosion can be aggravated by human activities and the impact of these activities can occur locally or some distance away.

In keeping with the provincial hazard avoidance approach, development and site alteration is generally not permitted in riverine erosion hazard areas. Erosion hazard mapping aids in understanding and managing erosion hazards. Currently, guidance for mapping riverine erosion hazard extents is described in the River and Stream Systems: Erosion Hazard Limit Technical Guide (MNR 2002). Aerial photography and digital elevation information can be useful sources of information to monitor erosion processes and identify the extent of potential erosion hazards. Updating erosion hazard mapping as new information sources become available aids in understanding and managing erosion hazards. More detailed field data collection and computer modelling could improve understanding and definition of erosion hazards.

Floodplain mapping supports flood forecasting and warning, which informs emergency planning and response by identifying areas at risk of flooding. It also supports CA flood hazard planning and regulation activities, which direct development and site alteration away from flood hazard areas. In addition, modernized ***floodplain*** mapping can facilitate improved communication and understanding of flood risk.

Currently, guidance for mapping ***floodplains*** is described in the River and Stream Systems: Erosion Hazard Limit Technical Guide (MNR 2002). Producing ***floodplain*** mapping generally involves plotting the results of ***hydrologic*** and ***hydraulic analysis*** on base mapping. ***Watershed*** topography, in the form of a digital elevation model (DEM), is a critical data input for modern ***hydrologic*** and ***hydraulic models***. DEMs are rapidly becoming more accurate and reliable.

To maintain validity, ***floodplain*** mapping must be regularly updated in response to technological advances, changes to the landscape (e.g., land use, urbanization, storm drainage, watercourse crossings, etc.), climate change, and the availability of longer and more detailed data records.

D.2.3 Recommendation 3: Improve and maintain the flood forecasting and warning program

The UTRCA and LTVCA provide ***watershed*** municipalities and residents with flood forecasting and warning services related to ***fluvial*** flooding. The aim of this system is to provide flood messages to specific agencies and officials in the ***watershed***. Messages focus on areas where lives and properties may be in danger due to flooding, and provide information on timing, severity and response. Operating the flood forecasting and warning program requires an in-depth understanding of how the ***watershed*** functions under extreme flows, as well as weather, flows, ground, and snow conditions prior to and during the flood.

The UTRCA and LTVCA operate a number of recording stream gauges, snow measuring courses, precipitation gauges and weather stations, in partnership with the Water Survey of Canada and the Ministry of Natural Resources and Forestry (Map 8). The snow measuring courses and weather stations provide detailed information on the flood potential in the ***watershed***. The additional information provided by the stream gauge recorders enables CA staff to monitor the progress of runoff events throughout the ***watershed***. This data is most useful in predicting the magnitude and time of arrival of peak flows and water levels at downstream locations. The long-term historical record at these stations is also critical in assessing the risks from flooding.

Weather information and stream flow prediction models further enhance CA efforts to improve flood responses by assisting with predictions of flood peaks. Municipalities are also encouraged to have their own Emergency Flood Plans which guide the municipal response to the warnings and forecasts provided by the conservation authorities.

A variety of flood messages may be issued by the conservation authority through a flood event. The terminology used is consistent with conservation authorities across Ontario, and in line with that used by the MNRF and Environment and Climate Change Canada (ECCC). The severity of the event determines the type of message issued and the response required.

Historically, most flooding in the Thames River ***watershed*** occurs during the spring snowmelt and there is generally sufficient time to provide advance warning. In contrast, predicting flooding events from localized, intense rainstorms can be difficult and often does not allow for advance warning. High level climate change studies suggest that such events could become more common. Ice jam related flooding is another example of flooding that provides almost no lead time for flood warnings. While warnings can be issued noting that conditions are right for an ice jam, there may be only minutes between initial ice jam formation and the resulting flooding.

D.2.4 Recommendation 4: Improve emergency response to flooding

Emergency response to a flood is a municipal responsibility, with input and support from their emergency services (i.e., police, fire, EMS), conservation authorities, MNRF, and Emergency Management Ontario (within the Ontario Ministry of Community and Social Services). Part of this response includes developing and testing municipal emergency management plans, and training response personnel. These plans deal with many types of emergencies but should include flood-related information in municipalities that are prone to flooding. Conservation authorities maintain flood contingency plans which are limited to their responsibilities for flood forecasting and warning, as described in Appendix K.2.3. The involvement of the Ontario Ministries of Municipal Affairs and Housing (MMAH) is limited to providing financial assistance following sudden, unexpected natural disasters.

Communication is an important part of emergency preparedness and response as well as flood warning. To mitigate flood risk, timely communication of accurate information is essential when coordinating multiple agencies. Information must also be provided to the general public as well as those directly affected by the flooding.

D.2.5 Recommendation 5: Develop a watershed-wide flood risk assessment of the built environment

Flood risk is a combination of probability or likelihood of flooding, and consequences or damages resulting from the flooding. Previous sections describe updating ***hydrologic*** and ***hydraulic analysis***, ***groundwater flooding*** understanding, and ***floodplain*** hazard mapping, which can be used to inform flood probability and describe flood risk spatially.

It is important that the public understand and prepare for the risks associated with different types of flooding related hazards (i.e., watercourse, local drainage, ***groundwater***, erosion, sewer backup). This information is relevant not just to homes and businesses in the ***floodplain***, but also to the general public. The built environment includes houses, buildings, roads, sewers, bridges, and other structures.

A flood risk assessment combines flood probability mapping with information on the potential consequences to specific flood areas. Consequences can include private and public infrastructure damage, loss of life, emergency service disruption, access disruptions, utility disruptions (e.g., drinking water, sanitary sewers, natural gas, electric power, communications, etc.). Identification of vulnerable populations (e.g., old, young) and critical infrastructure (e.g., hospitals, fire stations, schools) is an important consideration in evaluating consequences. Typically a flood risk assessment strives to assign monetary values to the various consequences to facilitate evaluation and comparison; however, the information can potentially be presented in other manners to aid in communicating flood risk. Ultimately, a flood risk assessment will inform flood mitigation planning activities such as flood forecasting and warning, emergency response, structural flood mitigation measures, planning and regulations, education and outreach.

It is important to assess these risks before considering how they will be impacted by climate change. Risk assessment should initially be undertaken with the current climate conditions, and then various climate change impacts can be added to expand the risk assessment.

To improve access to climate science, the province is supporting the establishment of a new climate change organization that will provide leading edge, relevant and practical information to support the public and private sectors in making informed and evidence-based decisions regarding climate change adaptation and resilience. As well, the province will be conducting a Provincial Climate Change Risk Assessment to determine Ontario's most urgent climate change vulnerabilities and how to best address them. The assessment will be applied to a wide range of sectors, including (but not limited to) public assets and infrastructure, and natural and water resources. This will help build a better regional understanding of how and where current and anticipated climate change impacts will affect Ontario's communities, infrastructure, ***ecosystems***, and economies. The information collected from these provincial initiatives may enable communities in the Thames ***watershed*** to better protect themselves from climate impacts such as flooding.

D.2.6 Recommendation 6: Improve flood resiliency of the built environment

In the context of a ***watershed*** and water quantity, ***flood resiliency*** can be defined as the capacity of individuals, neighbourhoods, businesses, institutions, the natural environment, and the ***watershed*** as a whole to quickly recover after a major flood event. With respect to the built environment in this context, resilient infrastructure will continue functioning throughout a major flood event, or will have the capability to be quickly restored to a functioning state after a major flood event.

Building upon the results of the flood risk assessment, a flood mitigation plan could identify improvements to infrastructure ***flood resiliency*** that would help reduce flood risk. An overall long-term flood mitigation plan would consider improvements to flood forecasting and warning, ***stormwater management***, and emergency response programs (as discussed elsewhere), but should also consider various items to reduce risk to the built environment, including:

- Flood proofing existing at-risk public and private infrastructure,
- Removing or relocating existing at-risk infrastructure, where appropriate,
- Constructing new flood reduction infrastructure such as dykes or channels,
- Upgrading existing flow impediments such as undersized culverts/bridges at road/rail crossings, and
- Implementing climate change mitigation and adaptation strategies and actions.

It will be particularly important for infrastructure ***flood resiliency*** improvements to consider potential impacts of climate change due the long life-span of most infrastructure.

D.3 Goal 3: Research and recommend mechanisms to achieve acceptable *eflow* while reducing flood and drought risks

Traditionally, flow risks were considered independently from ***environmental flow*** needs, largely due to lack of understanding of these needs. Moving forward, addressing ***eflow*** needs should be considered together with reducing flooding and drought risks. ***Water control structure*** operations, ***Best Management Practices (BMPs)***, and policies and regulations are tools that can be used to consider ***eflow*** while reducing flooding and low flow risks.

D.3.1 Recommendation 1: Develop and/or update operation and maintenance plans, where appropriate, to reflect optimization of water control structures considering eflows and flood risk

The ***water control structures*** in the ***watershed*** include dams, dykes, channels and ***pumping schemes***, as well as ***stormwater management (SWM)*** facilities such as pipes, ponds and swales, and rural drainage such as field tiles and municipal drains. Individually and collectively, these structures have an impact on flood risk and sustaining ***eflow*** needs. Improvements to urban ***SWM*** facilities and rural drainage (beyond improved operation and maintenance discussed in this section) are discussed separately under D.3.2. Some of these structures also represent barriers to passage for fish and other wildlife, which is discussed separately under C.3.

The UTRCA operates one flood control dam (Fanshawe) and two flood control/flow augmentation dams (Wildwood and Pittock) (Map 9). Collectively, the three dams greatly reduce flooding downstream. The UTRCA also operates and maintains several smaller dams for recreational opportunities, flood control channels and dykes, and erosion control structures, on behalf of its member municipalities.

The LTVCA operates and maintains one dam on Sharon Creek, the integrated Indian-McGregor Creek Flood Control Project (includes the 6th Street Dam and the Diversion Channel Dam), and several dykes along the lower Thames and the Lake St. Clair shoreline in Essex County and the Municipality of Chatham-Kent to protect agricultural lands from flooding.

Several municipalities operate and maintain smaller ***water control structures*** such as weirs, urban ***SWM*** systems, and rural drainage systems. Numerous small ***water control structures*** and drainage infrastructure are owned, operated and maintained by private landowners or collectively under the Drainage Act.

There are more than 100 dyke and ***pump schemes*** in the LTVCA ***watershed*** around the mouth of the Thames. These ***pumping schemes*** ensure that the water levels in the open drains and ditches remain low enough to allow the agricultural field tiles to drain excess water off the land by gravity flow. These pumps are operated independently without an overall coordinated plan, and rely on the judgement and experience of pump commissioners, who are landowners within the scheme, not government or municipal employees. Consideration should be given as to whether formal plans should be required for operation of these schemes.

Water control structures have varying impacts on flow regimes and, consequently, on flood risk and the ability to sustain ***eflow*** needs. Factors include the type and size of structure. Impacts may also change with a changing climate. Operation and maintenance (O&M) plans can consider these impacts, but many ***water control structures*** do not have O&M plans. Plans that do exist may require updating and modernization as they have remained largely unchanged even though better information is available, such as real time rainfall, flow monitoring, and ***hydrologic/ hydraulic*** models.

The degree of detail needed in an O&M plan will vary significantly. For example, a large structure such as Fanshawe Dam is expected to need a much more detailed O&M plan than a small historic mill dam or drainage works. Also, it is expected that O&M plans could be generalized for certain classes of ***water control structures***, such as ***SWM*** structures within a particular ***subwatershed*** or municipality.

Where possible and appropriate, changes to operation and maintenance or decommissioning of a structure should be considered to optimize flood risk reduction and sustain ***eflow***. Some ***water control structures***, such as many mill ponds, are no longer required for their original purpose. Many of these structures have not been properly maintained despite provincial safety requirements. Many of these structures also act as barriers and affect the movement of aquatic life (as discussed in C.3). Where these structures no longer meet a valid purpose or their negative impacts outweigh their benefits, consideration should be given to decommissioning.

D.3.2 Recommendation 2: Increase infiltration and reduce runoff through stormwater management practices such as Low Impact Development and rural Best Management Practices, where conditions permit

Land use activities, such as development and drainage, impact the quantity of surface water runoff and ***groundwater recharge***. In rural areas, the ***watershed*** is experiencing intensification of tile drainage and drainage works are using larger outlets, all of which remove water from the land faster. Some cropping and tillage practices can impact soil health, reducing permeability and water holding capacity, leading to increased runoff.

In urban areas, the increase in impervious surfaces has a direct effect on stream ***hydrology*** by decreasing water infiltration and increasing the volume and rate of surface runoff. The result is higher peak discharges, decreased flood peak width, and shortened lag times between rain events and associated flood peaks (Paul and Meyer 2001).

These changes in stream ***hydrology*** may impact water quality, stream habitat and aquatic biota through increased streambank erosion. Channels become incised and banks steepen, resulting in undercutting, more bank collapses, and the channels becoming wider and deeper (Poff et al. 1997, Bailey and Yates 2003). Streambank erosion results in the loss of pool and riffle sequences as well as overhead cover, and an increase in suspended sediment loadings

(Schueler and Holland 2000). In urban areas, bank stabilization techniques such as concrete or rip rap structures may be used to minimize property damage; however, these techniques lead to even further incision (Poff et al. 1997).

Higher water flows create a less stable streambed and change the streambed composition, leading to a decrease in species diversity. The faster transport of water from the ***watershed*** also results in less recharge of ***groundwater*** reserves and, therefore, lower ***baseflow*** discharge (Bailey and Yates 2003).

As climate change increases the frequency and magnitude of storms, approaches that reduce runoff in large rain events will become increasingly important. Conventional ***stormwater management*** practices, such as ***SWM*** ponds, reduce and delay peak flows but do not reduce runoff volume and rarely enable infiltration.

Rural ***BMPs*** are approaches used to conserve soil and water, improve soil health and maintain or increase productivity. Different ***BMPs*** are often recommended based on the site specific conditions and individual management considerations. Adopting a suite of ***BMPs*** can help to reduce runoff volume, velocity and peak flows, as well as increase infiltration and sustain ***eflow***. Several programs have been successful in encouraging the implementation of rural ***BMPs***, particularly in southwestern Ontario and within the Thames River ***watershed***. A practical guide to help Ontario farmers solve erosion problems entitled “Controlling Soil Erosion on the Farm,” (Ontario Ministry of Agriculture, Food and Rural Affairs 2011) provides a summary of several ***BMPs*** that rural landowners can implement.

Urban ***stormwater management*** using ***Low Impact Development (LID)*** is an innovative approach with a basic principle that mimics nature: to manage precipitation and runoff at the source (where it lands), often at the lot level. This approach can be used to sustain ***eflow***. ***LID*** practices encourage infiltration, filtration, storage, evaporation and runoff detention close to its source. The adoption of ***LID*** may reduce the need for (or size of) ***SWM*** ponds for each development to address climate change impacts. Refer to the Credit Valley Conservation ***LID*** website for a list of ***LID*** practices.

Conventional and ***LID SWM*** infrastructure are both very important in reducing the effects of local urban flooding. A conventional ***SWM*** pond receives and attenuates runoff, while ***SWM LID*** delays the peak of the ***hydrograph*** by using techniques such as infiltration and filtration. Conventional and ***LID SWM*** infrastructure help achieve the following outcomes:

- Reduce occurrences of excessive stream erosion,
- Reduce flooding risk (public safety, damage to property and infrastructure),
- Maintain appropriate diversity of aquatic life and opportunities for human uses,
- Preserve ***groundwater*** and ***baseflow*** characteristics, and
- Protect water quality.

Regular maintenance of conventional ***SWM*** ponds ensures that the volume of the pond is not reduced by accumulated sediment. Maintaining pond volume is necessary to ensure the pond will have room to attenuate peak flows and reduce the risk of downstream flooding.

The Province of Ontario is developing an ***LID*** guidance manual to complement ***Stormwater Management*** Planning and Design Manual (Ontario Ministry of the Environment and Climate Change 2003). With the implementation of ***LID*** systems and features, monitoring is recommended to demonstrate the effectiveness of ***LID*** and encourage its promotion as an important component of ***stormwater management***. Maintenance of ***SWM LID*** features will ensure they continue to operate the way they were designed by maintaining their infiltration, filtration and conveyance capacities. When properly maintained, the ***LID*** feature will delay the time to peak flows and may reduce the impact of local flooding.

Green infrastructure, such as wetlands and woodlands, can substantially reduce flood damage costs to rural and urban infrastructure. A recent study showed that wetlands are a cost-effective measure that can reduce the financial and social impacts of flooding in Canada (Moudrak, Hutter and Feltmate 2017). Healthy forests also play a vital role in moderating water movement over the landscape by minimizing the frequency, intensity and extent of flooding events (Bradshaw et al. 2007). Forests absorb and reroute water, diffusing its potentially damaging energy, before slowly releasing the water. The net ***hydrologic*** effect of a forest is to delay and reduce the size of the flood peak. Much of the water absorbed by healthy forest soils is drawn up by plant roots and transpired (released as vapour from leaves), moving back to the atmosphere as water vapour.

D.3.3 Recommendation 3: Update local planning, policy, and regulatory tools that address flood and drought risks to include climate change and eflow needs

A range of legislation, regulations, policies and programs at all levels of government potentially impact flood and drought risk as well as help to sustain ***eflow*** needs in the Thames River ***watershed***. Examples include: the Ontario Water Resources Act (OWRA), Clean Water Act (CWA, 2006), Conservation Authorities (CA) Act, Drainage Act, Ontario Low Water Program, and Provincial Policy Statement (PPS, 2014).

The fundamental provincial role for all ***CAs*** focuses on water-related natural hazard prevention and management and includes flood and erosion control (MNR, 2010). ***CAs*** have a delegated responsibility from the Minister of Natural Resources to represent the provincial interests regarding natural hazards (flood and erosion) consistent with Section 3.1 of the PPS. These delegated responsibilities require ***CAs*** to review and provide comments on comprehensive municipal policy documents (Official Plans and zoning bylaws) and applications submitted pursuant to the Planning Act as part of the Provincial One-Window Plan Review Service. It should be noted that land use planning is only one of the tools for implementing these interests.

In addition to ***CAs***' legislative requirements and mandated responsibilities under the CA Act as regulatory authorities, their role as ***watershed***-based, resource management agencies also allows them to review municipal policies, planning documents and applications pursuant to the Planning Act as a "public commenting body." To inform the review of municipal planning documents and planning applications, under the Planning Act, ***CAs*** have developed policies related to their Board-approved mandates and agreements for technical services with municipalities and other levels of government. Such CA policies are advisory and may be incorporated into an Official Plan, in which case they become adopted as municipal policy.

At a local level, both the UTRCA and LTVCA, as well as ***watershed*** municipalities, have various local policies (many of which are related to provincial policies and regulations) that address flood and drought risks as well as potentially sustaining ***eflow*** needs. Building upon updated technical information described previously, such as updated ***hydrologic***/***hydraulic models***, ***stormwater LID*** approaches, and flood risk assessment, it is important that local policies and programs be updated to reflect improved data and information, given this provides the basis for the review of development applications.

The building code is being reviewed to consider additions to address the issue of basement flooding in urban areas. Basement flooding caused by excess surface water in addition to surcharging sewer systems has recently caused extensive damage and insurance costs throughout southern Ontario. Several Ontario municipalities are recommending changes to building code standards (e.g., back flow prevention, sump pump back-up power supply) as part of their climate change adaptation strategies.

Local neighbourhood improvements are also being considered in urban areas where ***LID*** techniques can lessen the stress on already 'at capacity' storm sewer systems. These relatively minor actions on private property can collectively have substantial positive impacts in reducing localized flooding.

The UTRCA Environmental Planning Policy Manual is a comprehensive policy manual that facilitates the implementation of the CA's integrated systems approach for ***watershed*** planning. The manual includes local policies on environmental planning areas of interest including natural hazards, natural heritage, and natural resources. The manual also includes local policies on Municipal Plan Review and CA Act Section 28 Review and Approvals process.

The LTVCA has drafted an Environmental Planning Policy Manual that is similar to the UTRCA's policy manual.

Excerpt from Conserving our Future (MNRF 2017):

(http://apps.mnr.gov.on.ca/public/files/er/mnrf-17-044-conserving-our-future-en.pdf)

*The science-based, **watershed** management programs and services that conservation authorities provide will be increasingly required in the face of climate change and the resulting vulnerabilities to biodiversity and natural resources in the province. These programs and services include those mandated by the Province, assigned by municipalities and developed by conservation authorities in response to local needs and priorities*.

A changing climate with shifting patterns of warmer, wetter, and drier conditions will affect the natural environment and biodiversity differently across the province. As a result, there is *considerable variability in the scale and range of programs and services delivered by any individual conservation authority.*

Amendments to the Planning Act require that official plans contain policies related to climate change. Municipalities require guidance material and technical criteria to assist decision-makers with implementing the policies of the PPS. Updated ***stormwater management*** guidelines, climate change adaptation criteria, etc., will be required to support long-term planning.

Activities on the land can have a significant impact on many processes within the ***hydrologic cycle***. The municipal planning process provides municipalities with the opportunity to control and positively influence land use. For example, site plan control can be used to manage the quantity of water leaving a development site by requiring implementation of ***stormwater management*** measures, in order to address flooding and drought risks as well as achieve ***eflow***.

Water takings in Ontario are governed by the OWRA and the Water Taking Regulation (O. Reg. 387/04). Section 34 of the OWRA requires anyone taking 50,000 litres of water or more on any day, with some exceptions, to obtain a permit. Section 34 of the OWRA and the amended Water Taking Regulation indicate the requirements of the permit system, including the factors a Director must consider in issuing a permit, notification and consultation, data collection and reporting. The regulation also addresses water takings in high use ***watersheds*** and the Great Lakes basin. Some TRCWR partners have recommended that both the Permit to Take Water and Ontario Low Water Response (OLWR) programs would benefit from an ***eflow*** approach.

Under the CWA, 2006, technical work was completed to evaluate stress on municipal drinking water sources in Ontario through a water budget modelling tool. The water budget for the Thames-Sydenham and Region looked at the balance of water within the ***watersheds*** of the Upper and Lower Thames River ***watersheds***, as well as the St. Clair Region ***watershed***. The results of the water budget assessments for the Thames-Sydenham and Region concluded that there were no significant water quantity risks for assessed municipal drinking water systems in the Region. As a result, no water quantity policies were included in the Thames-Sydenham and Region Source Protection Plan. This assessment, however, did not consider the stress or risks to systems other than municipal drinking water systems. The risks to the natural systems and the sustainability of ***eflows*** have not yet been fully assessed in the ***watershed***, but should be given some consideration.

Section 3.0 of the PPS, 2014, emphasizes that development shall be directed away from areas that may be prone to flooding and/or other natural hazards. Although the PPS, 2014, does not use the word “***eflow***,” it speaks about integrating water resources while maintaining ecological integrity on a ***watershed*** basis.

D.4 Goal 4: Expand water quantity monitoring to improve understanding of *eflow* needs, flood and drought risk, and climate change.

Monitoring networks need to consider surface water and ***groundwater*** quantity, as well as historical climate data.

D.4.1 Recommendation 1: Maintain and enhance a sustainable surface water quantity monitoring program

Consistent, long-term water quantity monitoring is crucial to flood forecasting and warning programs as well as the operation of flood control structures. It is also important for understanding surface water/***groundwater*** interactions, assessing impacts of climate change, evaluating ***eflow*** requirements and whether they are being met, and properly interpreting water quality information within the ***watershed*** and the Great Lakes. Water quantity data is required to calibrate and verify ***hydraulic*** and ***hydrologic*** models. These models are needed to create ***floodplain*** mapping, which informs regulatory programs. The models also aid in decision making around all the activities discussed above.

A sustainable surface water monitoring program provides consistent, long-term data. The monitoring network requires ongoing maintenance and capital planning. To respond to changing needs, the program needs to be reviewed regularly and adjusted as required. While consistency is important, the flexibility to adapt is also required. Long-term sustainable funding and staffing resources will be important to the program's success and maintaining the value of the program.

Hydrologic parameters of the Thames River have been measured for many years. Early European settlers recorded flood events as far back as 1792. The first Water Survey of Canada gauge station on the Thames was installed downstream of the Forks in London, in 1916.

Today, the UTRCA and LTVCA operate a sophisticated water quantity data collection network and data management system that measures, records and stores data from locations throughout the ***watershed*** (Map 8). The monitoring program collects data on water levels in rivers and reservoirs, flow, precipitation, air temperature and water temperature. Many of these stations are operated in co-operation with the Water Survey of Canada and OMNRF. The UTRCA also collects snow survey information, which is used for flood forecasting and warning, as well as reservoir operations.

The data management system collects and stores time series data in a central database, as well as metadata about stations and sites. Provisional data is posted to the UTRCA and LTVCA web sites in near real-time, which allows anyone with an Internet connection to remotely monitor ***watershed*** conditions. The data management system includes powerful analysis and reporting tools. There is the potential for the system to be utilized to develop an automated notification system based upon the near real-time surface water monitoring data to improve flood forecasting and warning program response.

At present, the Lower Thames has significantly fewer monitoring stations than the Upper Thames. This disparity has arisen over time due to a variety of factors. The tributaries in the Lower Thames all tend to be short systems flowing directly into the main Thames River. The small drainage areas and lack of development that could be impacted by flooding has meant that these tributaries have not been prioritized for gauging. The impact of Lake St. Clair water levels on monitoring flows in the lower reaches of the Thames River and tributaries presents challenges for extracting meaningful information from water levels. This has discouraged the installation of stream gauges downstream of Thamesville.

Gauging, for purposes other than flood control, has not occurred in the Lower Thames. There are three gauges on the lower main Thames River and only two gauges on lower tributaries. These two tributary gauges facilitate operation of the Indian-McGregor Creek Flood Control System, and only one provides information about water discharging from that ***subwatershed***. The lack of gauges on the lower tributaries results in a significant data gap.

For flood forecasting, hazard mapping and modelling, and the management of flows, it is important to have reliable flow estimation through all reaches of the Thames River. The most common method for determining the flow in rivers is to measure water levels and construct a rating curve of the relationship between flow and water depth measurements. However, the ability to establish such a relationship is significantly more complicated if the river is not free flowing. The lower reaches of the Thames River are generally not free flowing as the water in the river encounters resistance as it attempts to flow out into Lake St. Clair. This slows down the water in the river and the river requires a greater depth to pass the same amount of water. The higher the water level in the lake, the more resistance it provides and the deeper the river needs to be to pass the water. In this way, the rating curve becomes dependent on the lake level at the outlet as well as the river level at the gauge. Therefore, standard gauging techniques cannot be used. The slope of the Thames flattens out just downstream of Thamesville. From this point downstream, Lake St. Clair begins to affect the rating curve. To monitor flows in the lower reaches of the Thames River, more expensive techniques are required but have not been implemented, to date.

For all but the most extreme floods, the water levels on Lake St. Clair will affect flood levels in the City of Chatham. Water levels on Lake St. Clair can also have an impact on the formation of ice jams, how much water passes though the jam, the jam’s duration, and the areas affected by the flooding.

There are more than 100 dyke and ***pump schemes*** in the LTVCA ***watershed*** around the mouth of the Thames. These ***pumping schemes*** ensure that the water levels in the open drains and ditches remain low enough to allow the agricultural field tiles to drain excess water off the land by gravity flow. Historically, there has been virtually no monitoring of pump operation and flows related to the ***pumping schemes***. Recently, some effort has been undertaken to begin monitoring with flow meters attached to the discharge pipes of several ***pump schemes***. However, much more work needs to be done to establish a sustainable monitoring program of the ***pumping schemes*** to improve understanding of the system.

Deriving precipitation data from radar data sources may significantly improve monitoring and understanding of the spatial distribution of precipitation in the ***watershed***. Combined with ***hydrologic models*** and analysis, the spatially distributed rainfall can provide an understanding of flows in ungauged ***watersheds***. Climate change research is predicting that there will be more frequent and more intense localized rainfall events, making the sparse precipitation network inadequate. Recent research has provided insight into the potential for processing and calibrating radar data (in conjunction with data from the local rain gauge network) in near real-time to support flood forecasting and warning, as well as providing a long-term record for improving ***watershed*** understanding. The ECCC radar station in Exeter provides good coverage over the Upper Thames portion of the ***watershed***, but does not have the range to properly cover the Lower Thames portion of the ***watershed***. Currently, the U.S. NEXRAD system performs better over the Lower Thames. Recent upgrades to the Exeter station may improve its usefulness in the Lower Thames. While the NEXRAD data is freely available in near real-time, the cost of the ECCC data prevents it from being used for this purpose.

Improved spatial coverage of precipitation data, through programs that utilize volunteers to report weather observations, should be encouraged. This could significantly improve spatial data coverage of weather data. The CoCoRaHS Canada program (Community Collaborative Rain, Hail and Snow Network) is a non-profit, community-based network of volunteers of all ages and backgrounds working together to measure and map precipitation across Canada. By using low-cost measurement tools, stressing training and education, and utilizing an interactive website, the aim of CoCoRaHS is to provide the highest quality data for natural resource, education and research applications. Programs such as CoCoRaHS should be encouraged and methods established to integrate data collected by such programs into centralized data management systems.

D.4.2 Recommendation 2: Improve existing groundwater monitoring program

Groundwater monitoring data can be used to better understand several aspects of water management including ***groundwater flooding***, drought and ***environmental flow*** needs. ***Groundwater*** observations can also help support ***hydrological modelling***. It is important to improve the ***groundwater*** monitoring program to understand the location and quantity of ***groundwater*** in the Thames River ***watershed*** and its interaction with the Great Lakes basin. The basic method to measure ***groundwater*** change is to install ***groundwater*** monitoring wells.

Recharge is the component of the water budget that replenishes ***groundwater***. Some ***groundwater*** is recharged outside of the ***watershed*** yet contributes to ***groundwater*** inside the Thames ***watershed***. Most recharge is derived within the ***watershed***. ***Groundwater*** provides the ***baseflow*** which will sustain the ***watershed's eflow*** needs. Anthropogenic changes such as land use or climate change can modify recharge. For example, climate change can alter precipitation and evaporation, leading to changes in the thickness of the unsaturated zone and alteration of the runoff - recharge relationship. Loss of recharge can deplete ***aquifers*** and cause other changes such as ***groundwater*** temperature or chemical changes. Expansion of urban land use and associated surface and sub-surface infrastructure results in changes in recharge distribution and mechanisms, and has variable impacts on recharge rates (net decrease, net increase or minimal change). Other land use changes or changes in agricultural practices can similarly affect ***groundwater recharge***. Improving understanding of the relationships between vegetation and ***groundwater recharge*** would also aid in a better understanding of the overall water cycle and is essential to sustainable water management.

Due to land development (urban and agricultural), locations and timing of ***groundwater recharge*** and ***discharge*** are being modified. A sustainable ***groundwater*** monitoring program would measure the effects of these changes on drought, high ***groundwater (groundwater flooding***), and ***environmental flows***.

A sustainable shallow ***groundwater*** monitoring network can measure recharge in shallow ***aquifers*** (less than 8 m), which are likely a major component of ***eflows***. Source protection mapping identifies areas where the ***water table*** is shallow, such as Significant ***Groundwater Recharge*** Areas (***SGRA***) and Highly Vulnerable ***Aquifers*** (HVA). Shallow ***aquifers*** are often in areas of shallow sand and areas where wetlands, seeps or shallow ***groundwater*** have direct connection with surface water.

Estimation of recharge in the Thames River has relied on estimates derived from the water balance equation as a residual product of the water balance terms (precipitation, runoff, evapotranspiration and ***groundwater*** inflow/outflow). Thus, the success of this approach relies on the ability to estimate each component. The method is generally considered to have relatively low accuracy. Techniques are needed to more accurately quantify changes in recharge. The ***water table*** fluctuation method is a small spatial scale, physically based technique, for estimating recharge on an annual basis utilizing water level data from ***groundwater*** monitoring wells. The ***water table*** fluctuation method uses seasonal precipitation induced fluctuation of the ***water table*** and the ***aquifer***'s specific yield to estimate recharge (Healy and Cook 2002). Improved ***groundwater*** monitoring is needed to employ these techniques. There are also chemically based techniques such as tracers, isotopes or conservative constituent ratios to estimate recharge.

Groundwater monitoring in the Thames ***watershed*** has demonstrated that the highest recharge occurs primarily between mid-November and early May. There is limited recharge between June and October. As well, an unknown portion of the water that infiltrates is transferred to deeper ***aquifers***, resulting in regional flow through bedrock and overburden units towards the Great Lakes. ***Groundwater*** monitoring is important to understanding and quantifying this transfer.

Improved ***groundwater*** monitoring should also focus on improving the understanding and quantifying of factors that control recharge:

- precipitation;
- evaporation and evapotranspiration;

- surface runoff;
- the ground surface topography (steep slopes experience greater overland flow and less recharge than subdued or hummocky topography);
- the vertical ***hydraulic conductivity*** of the surficial deposits (i.e., different rates at which water can infiltrate into the ground such as sand plains vs. clay or till plains);
- land use (impermeable materials such as buildings and streets reduce recharge, as do areas with artificial drainage); and
- the gradient of the ***water table*** (how water moves away from the area of recharge).

Historically in the Thames River ***watershed***, some ***aquifer*** mapping was completed in 1981 as part of the Thames River Basin Water Management Study Technical Report: Groundwater Resources (Brown and Goff 1981) and, more recently, the Six Conservation Authority FEFLOW modelling report (Waterloo Hydrogeologic 2007). The Brown and Goff 1981 relied on the water well information system up to 1973 and on 19 test holes that were drilled during 1972-73 in order to study overburden ***aquifers***. More recent ***aquifer*** mapping was completed in the eastern portion of the ***watershed*** as part of the water budget analysis completed for drinking water source protection studies. However, the source protection mapping was primarily targeted at municipal well supply protection. The remainder of the mapping depended on the best available data, which was a catalogue of the drillers' descriptions from the Water Well Information System. Unfortunately, driller logs can only be used to conceptualize the ***groundwater*** flow regime based on whether the material prohibits or transmits water. Understanding of ***groundwater*** resources in the ***watershed*** would be improved by undertaking an exercise to map ***aquifers*** across the ***watershed***. ***Groundwater*** monitoring is important to be able to understand and map these resources.

Measurements of water levels in wells provide a fundamental measurement of the ***groundwater*** resource. Currently, there are 28 Provincial ***Groundwater*** Monitoring Network (PGMN) wells in 22 locations in the Upper Thames ***watershed*** and five wells in five locations in the Lower Thames ***watershed***. These wells are monitored in partnership with CA staff and the Ministry of the Environment, Conservation and Parks. These wells were installed or acquired to monitor low water response and focused on acquiring data on drinking water supply ***aquifers***. Unfortunately, this monitoring system is not sufficient to determine specifics about the location and quantity of ***groundwater*** in the Thames River ***watershed***, nor its interaction with the Great Lakes basin. Near real time ***groundwater*** observations are also limited and insufficient to support ***hydrological modelling*** applications for purposes such as data continuity, flood forecasting and warning, and low water response.

The Ontario Low Water Response (OLWR) program was initiated in 2000 as a response to the extremely dry conditions in 1998 and 1999. It was formed by the OMNRF in partnership with the Ministries of the Environment, Agriculture, Food and Rural Affairs, and Municipal Affairs and Housing, as well as Conservation Ontario and Ontario's conservation authorities. The intent of this program is to provide advanced warning of reduced water availability through the use of water supply indicators. The existing PGMN was established to monitor the impact of drought on drinking water supplies. The wells are developed at depths deeper than 8 m to determine when drinking water supplies may be at risk. Water level variations appear to be a useful tool for analyzing water quantity. UTRCA (2009) undertook a study to evaluate the suitability of the existing PGMN wells in the Upper Thames portion of the ***watershed*** for evaluating ***groundwater*** resources with respect to drought. The study recommended that many more ***groundwater*** monitoring wells be installed to support the OLWR program in the Upper Thames portion of the ***watershed***. The additional ***groundwater*** monitoring wells recommended by the study should be installed. A similar study should be undertaken for the Lower Thames portion of the ***watershed***, and recommendations similarly implemented.

Incorporating monitoring information in communication and education materials would improve public understanding of ***groundwater*** quantity issues. Rising ***groundwater*** can contribute to river flooding but may affect areas outside of the area inundated by surface water. ***Groundwater flooding*** is rarely a danger to life, but can cause significant damage. Causes for rising ***groundwater*** can be complex especially in urban areas where recharge can follow underground infrastructure or where long or extreme rainfall events can cause high ***groundwater recharge*** which cannot discharge into the ***aquifer*** at an adequate rate. Flood risk from ***groundwater flooding*** is generally not well understood. Examples of ***groundwater flooding*** are when sump pumps cannot meet the demands of infiltration and water rises above the basement floor drain or where water seeps in around the foundation and damages finished interior basements.

D.4.3 Recommendation 3: Assemble and analyze historical climate, surface water and groundwater monitoring data, together with interpretations of future climate change projection data, to better understand local impacts of climate change

An understanding of the potential impacts of climate change at the ***watershed*** scale warrants its own study to determine the trends and / or presence of patterns in the data. There are two basic types of data that can be used to better understand climate change: historical data, and future projections.

With respect to historical data, the two main networks that monitor meteorological and surface water in the ***watershed*** are the ECCC network and the conservation authority networks. The ECCC meteorological stations and surface water gauges are best for observing long-term trends as they have long periods of record, they measure winter precipitation, and they have uniform quality control. The conservation authority surface water quantity network was established for the purposes of modelling flood events and flood forecasting, but many stations likely have not been collecting data long enough to trace climate change throughout the ***watershed***, and have generally not been maintained to the same quality standard as the ECCC stations. The PGMN, which was established in 2001, monitors ***groundwater*** levels and, in some cases, quality. It does not currently have a long period of record, and detecting climate change trends may be challenging.

With respect to future projected data, there are numerous academic, government, and non-government sources of future projected climate data. The production of future projected climate data sets is an area of intense research that is producing rapidly evolving results. The data is available in various scales both spatially and temporally, and with various assumptions about the anthropogenic impacts on the future climate. The various projected future climate data sets provide wide ranges of potential future climate variables. With the significant uncertainty implied by the range of predictions, it is important to consider the range of possibilities. There are several approaches available to potentially attempt to describe the confidence in the range of climate projections.

The most common climate data variables of interest are temperature and precipitation. For the purposes of understanding the water cycle, precipitation is the variable of primary interest. Unfortunately, there is much more uncertainty in precipitation variables in projected future climate data sets than temperature variables. In order to transform the projected future climate data sets into projected future ***hydrological*** data sets (to assess the future water cycle), models need to be developed (as described previously in section 3.3.2.1) and utilized. Such models could then use historical and projected future climate data sets to assess predicted future changes to flood and drought risk, and ***eflow*** needs.

References for Appendix D

Bailey, R. and A. Yates. 2003. Fanshawe lake ecosystem assessment and recovery strategy background report. Western Environmental Science and Engineering Research Institute. Department of Biology. University of Western Ontario. 19pp.

Bradford, A. 2008. An Ecological Flow Assessment Framework: Building a Bridge to Implementation in Canada. *In* Canadian Water Resources Journal, 33(3): 215-232.

Bradshaw, C.J.A., B.W. Brook, K.S.-H. Peh and N.S. Sodhi, 2007. Global evidence that deforestation amplifies flood risk and severity in the developing world. Global Change Biology 13(11):2379-2395.

Brisbane Declaration. 2007. Environmental flows are essential for freshwater ecosystem health and human wellbeing. 10th International River Symposium and International Environmental Flows Conference. Brisbane, Queensland, Australia.

Brown, D.R. and K. Goff. 1981. Thames River Basin Water Management Study Technical Report: Groundwater Resources: Summary. Issue 14 of Water Resources Report. Ministry of the Environment, Water Resources Branch. 10pp.

Conservation Ontario. 2006. Establishing Ecological Flow Requirements: Synthesis Report.

Cudmore, B., C.A. MacKinnon and S.E. Madzia. 2004. Aquatic species at risk in the Thames River watershed, Ontario. Can. MS Rpt. Fish. Aquat. Sci. 2707: v + 123 p.

Healy, R.W. and P.G. Cook. 2002. Using groundwater levels to estimate recharge. Hydrogeology Journal 10(1): 91-109.

Jeffres, C.A., J.J. Opperman and P.B. Moyle. 2008. Ephemeral floodplain habitats provide vest growth conditions for juvenile Chinook salmon in a California river. Environmental Biology of Fishes. 83: 449-458.

Lake Simcoe Region Conservation Authority and Bradford, A. 2011. Towards a Framework for Determining Ecological Flows and Water Levels in the Lake Simcoe Watershed – A Guidance Document. Prepared for Ontario Ministry of the Environment. 29pp.

Linnansaari, T., Monk, W.A., Baird, D.J. and Curry, R.A. 2013. Review of approaches and methods to assess Environmental Flows across Canada and internationally. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/039. vii + 75 pp.

Metcalfe-Smith, J.L., S.K. Staton, G.L. Mackie, and N.M. Lane. 1997. Biodiversity of freshwater mussels in the lower Great Lakes drainage basin. Plenary presentation at the 3rd National Ecological Monitoring and Assessment Network Meeting, Saskatoon, Saskatchewan, 25 January 1997.

Metcalfe-Smith, J.L., S.K. Staton, G.L. Mackie, and I.M. Scott. 1999. Range, population stability and environmental requirements of rare species of freshwater mussels in southern Ontario. Environment Canada, National Water Research Institute, Burlington, Ontario. NWRI Contribution Number 99-058.

Metcalfe-Smith, J.L., S.K. Staton, G.L. Mackie, and E.L. West. 1998. Assessment of the current status of rare species of freshwater mussels in southern Ontario. Environment Canada, National Water Research Institute, Burlington, Ontario. NWRI Contribution Number 98-019.

Ministry of Natural Resources. 2010. Policies and Procedures for Conservation Authority Plan Review and Permitting Activities.

Ministry of Natural Resources and Forestry (MNRF). 2002. Technical Guide: River and Stream Systems: Erosion Hazard Limit.

MNRF. 2017. Conserving Our Future. A Modernized Conservation Authorities Act. 34pp.

Ministry of the Environment and Climate Change. 2003. Stormwater Management Planning and Design Manual. Queen's Printer for Ontario. 379pp.

Morris, T.J. 2004. National recovery strategy for the round hickorynut (*Obovaria subtrotunda*, Rafinesque 1820) and the kidneyshell (*Ptychobranchus fasciolaris*, Rafinesque 1820): 2004-2009. Draft June 2004.

Moudrak, N., A.M. Hutter and B. Feltmate. 2017. When the big storms hit: the role of wetlands to limit urban and rural flood damage. Prepared for MNRF. Intact Centre on Climate Adaptation, University of Waterloo.

Ontario Ministry of Agriculture, Food and Rural Affairs. 2011. Controlling Soil Erosion on the Farm: A practical guide to help Ontario farmers solve soil erosion problems.

Paul, M.J. and J.L. Meyer. 2001. Streams in the urban landscape. Annual Review of Ecology and Systematics. Vol 32: 333-365.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B. Richter, R. Sparks and J. Stromberg. 1997. The natural flow regime: a paradigm for riverine conservation and restoration. Bioscience 47 (11): 769-784.

Poff, N.L. and J.K.H. Zimmerman. 2009. Ecological responses to altered flow regimes: a literature review to inform the science and management of environmental flows. Freshwater Biology 55(1):194-205.

Schraeder, H.A. 1996. The Fish Community. In Caveney (ed.) *Focus on the Thames: Natural and Cultural Heritage of the River, London, Ontario.* A joint publication of the McIlwraith Field Naturalists of London and the Upper Thames River Conservation Authority.

Schueler, T. and H. Holland (eds.). 2000. The Practice of Watershed Protection. Centre for Watershed Protection. Ellicott City, MD.

Talbot, C.J., E.M. Bennett, K. Cassell, P.M. Hanes, E.L. Minor, H. Paerl, P.A. Raymond, R. Vargas, P.G. Vidon, W. Wallheim and M.A. Xenopoulos. 2018. The impact of flooding on aquatic ecosystem services. Biochemistry 141(3): 439-461.

Thames River Background Study Research Team. 1997. Background Study: Thames River Watershed Ontario. Canadian Heritage Rivers System. 162pp + Appendices.

Thames River Recovery Team. 2007. (Draft) Recovery Strategy for the Thames River Aquatic Ecosystem in Canada [Proposed]. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa.

Thames-Sydenham and Region Source Protection Committee. 2007. Conceptual Water Budget. Final Draft. 253 pp.

Tharme, R.E. 2003. “A Global Perspective on Environmental Flow Assessment: Emerging Trends in the Development and Application of Environmental Flow Methodologies for Rivers.” River Research and Applications, 19: 397-441.

Upper Thames River Conservation Authority. 2009. Ontario Low Water Response: Groundwater Indicator Site Selection Criteria – Draft. Prepared for Ontario Ministry of Natural Resources Water Resources Section.

Waterloo Hydrogeologic, Inc. 2007. The Six Conservation Area FEFLOW modelling report, Upper Thames River Conservation Authority.

Wong, A.W. and D. Boyd. 2014. Environmental Flow Requirements in the Grand River Watershed. Grand River Water Management Plan. Grand River Conservation Authority.

World Meteorological Organization. 2006. “Environmental Aspects of Integrated Flood Management.” Associated Programme on Flood Management. August 2006, Geneva, Switzerland. Pg. 34.

Appendix E. FIRST NATION ENGAGEMENT STRATEGY FOR THE THAMES RIVER CLEAR WATER REVIVAL

NOTE: This Appendix is currently under review.

"The river moves from land to water to land, in and out of organisms, reminding us what native peoples have never forgotten: that you cannot separate the land from the water, or the people from the land."

Lynn Noel

Background

"We live in a different spiritual world, and we have a different outlook towards water. We have a spiritual connection to the land and water that is the lifeblood of the Nations…We benefit from the land and the water, and the medicines of the water are powerful. If we pollute the water we pollute ourselves. Without water how are we going to live? Water connects everyone all over the world therefore it is our responsibility to share our knowledge and wisdom to support each other to protect our lands and waters."
(Tu Cho Conference, 2006).

The First Peoples (First Nations) of this land were placed on Turtle Island, otherwise known as North America, by the Creator. The Creator gave the First Peoples a specific way of life which included teachings on how to care for our mother, the Earth. Water is the life giving gift that Mother Earth provides for all living things. First Nations have a direct relationship with all waters including the rain waters, waterfalls, mountain springs, swamp springs, bedrock water veins, rivers, creeks, lakes, oceans, icebergs and the seas.

The First Peoples of Turtle Island have kept alive the ceremonies given to their ancestors by the Creator, which are passed down through time to continue the way of life the Creator had intended. Women, through their relationship with Mother Earth, are the keepers of the special ceremonies needed to ensure waters are respected and that future generations will continue to experience this gift. We need to respect, honor and share the spirits of the waters in the ceremonies given by the Creator to ensure that the waters provide for all living things on a daily basis.

The Thames River, located within the agricultural heartland of southwestern Ontario in close proximity to Lake St. Clair and Lake Erie, was one of the first rivers in Ontario formed following the retreat of the last continental ice sheet 15,000 years ago. First Nation peoples, who had been living south of the Great Lakes, settled in southwestern Ontario after the retreat of the ice from the Wisconsin glaciations (Wilson and Horne 1995, London and Middlesex Historical Society 1998). As a result, First Nations in Ontario have the knowledge, laws and the protocols to ensure clean waters for all living things. This unique perspective and relationship with the lands and waters within the Thames River ***watershed*** may include matters of Aboriginal Title, Treaty and Aboriginal Rights, as well as ***Indigenous Traditional Knowledge (ITK)*** and economic interests (Jacobs 2012). It is essential, therefore, that First Nations provide their opinion and stories with respect to their history, knowledge and identity as it relates to the Thames River.

First Nations in Ontario (Appendix G1) made treaties with the non-***indigenous*** people based on the continuation of all life and made treaties with the Crown to create a relationship of rights for all parties. Ontario's First Nations fundamental water rights are based on a power relationship between First Nations and the Creator. First Nations ensured that the internationally protected right to give free and fully informed consent on all issues related to use and care of waters, including the distribution, contents, and legitimacy of water rights, were not given over with the making of Treaties. First Nations in Ontario have reviewed the state of the waters within each of their territories and have seen the need to retain, declare and assert their relationship with waters to restore the balance and to ensure that there are clean waters for the future generations.

The Thames River was formally designated a Canadian Heritage River in the year 2000. The designation recognizes that the land, the river, and the people who live within the catchments of the Thames River ***watershed*** are interrelated, interconnected and inseparable. Given that the river is a shared resource, the responsibility for water management is shared among the First Nations, federal and provincial agencies, conservation authorities, and ***watershed*** municipalities. A visionary, long-term regional strategy is needed to align the efforts of these key partners to improve the health of the Thames River so that future generations can benefit from, and contribute to, the sustainability of this vital, natural relationship.

The Thames River Clear Water Revival (TRCWR) has recognized the knowledge, wisdom and compassion for the Thames River ***watershed*** and connection to the land that exists within First Nations. One of the key goals of the TRCWR is the desire to confirm interest and gain participation from First Nations who have stewardship and spiritual responsibilities; archival and oral knowledge; and territorial interests, such as hunting and gathering grounds, tied to the ***watershed***. This engagement strategy recognizes that First Nations are involved as equal partners at the governance level of the TRCWR, have been involved early in the TRCWR, and will be given control over the engagement process. The intent of the engagement strategy is to provide guidance to partners in the TRCWR about engagement with the eight distinct First Nations in the Thames River ***watershed***. It is hoped that the common goal of protecting and improving the health of the Thames River ***watershed*** will be a bridge between cultures to seek a better understanding, more cultural awareness, and an improved relationship. Since much of the engagement process will be internal, this will facilitate the transfer of knowledge and ensure that all parties are acting in good faith.

The engagement strategy contained in this document provides background, goals and some direction towards achieving engagement with the First Nations. However, this engagement strategy is not meant to replace the legal duty of federal and provincial governments to consult and accommodate First Nations based on the honour of the Crown (Table E1). While engagement is anticipated to be the primary relationship tool, there may be aspects of program delivery that require formal consultation and accommodation of Aboriginal Title, Treaty and Aboriginal Rights.

Table E1. Two widely accepted approaches to involving First Nations.

Two widely accepted approaches to involving First Nations that stem from:

a) A desire to seek the best, most widely supported product (Engagement),
b) The need to meet legal requirements (Consultation/Accommodation).

Engagement (Interest-based)	Consultation/Accommodation (Rights-based)
Develop a proactive engagement process so that knowledge transfer and information exchanges occur early to inform program development and implementation, primarily where activities do not adversely impact constitutionally protected rights or title matters. **Building relationships.**	Develop a consultation and potential accommodation process where an action has the potential to adversely impact proven or asserted Aboriginal or treaty rights. **Meeting legal duties.**

Engagement: Respect + Understanding = Trust

Engagement is appropriate when common or shared interests in the lands and resources occur. It is important to recognize that:

- Successful engagement takes place in the context of effective working relationships,
- Relationships develop over time,
- Relationships occur between people, not institutions or organizations.

Engagement of First Nations can:

- Lead to understanding and sharing of knowledge,
- Provide input that informs policy and program direction,
- Identify requirements for, and foster, effective consultation and potential accommodation,
- Contribute to program design and implementation.

Consultation and Accommodation:

According to the Supreme Court, a legal duty arises "when the Crown has knowledge, real or constructive, of the potential existence of the Aboriginal right or title and contemplates conduct that adversely affects it."

A legal duty to consult arises when three elements are present:

1. There is contemplated Crown conduct,

2. There are rights (potential or established),
3. There is an anticipated adverse impact.

Mission

To identify and implement efforts to engage First Nations throughout the development and implementation of the Thames River Clear Water Revival.

Goals

1. Ensure that First Nations have the resources to engage members, sustain involvement and build capacity.
2. Develop an engagement process that shares knowledge and incorporates First Nation interests with respect to the Thames River and its ***watershed***.
3. Increase cross-cultural awareness of activities and learnings that link people with the River.
4. Determine when rights based consultation (through understanding of treaties) and accommodation (traditional way of life) is needed.
5. Develop long-term cooperative and collaborative relationships where First Nations become active partners in planning and implementing ***watershed*** management initiatives and future resource activities.
6. Raise awareness and support for the Thames River Clear Water Revival strategy by encouraging representation on various committees, identifying additional First Nation members with an interest, seeking opportunities for dialogue, and involving First Nations in project delivery wherever and whenever possible.

Recommendations

1. Assemble a First Nations engagement and diversity committee comprised of at least one representative from each of the First Nation communities:
   a. Create opportunities for First Nations to participate through a variety of means:
      i. As a committee member
      ii. As a participant in activities related to the TRCWR
      iii. As part of a mail-out list
   b. Ensure compensation for First Nation participants
      i. Travel costs
      ii. Meeting time
      iii. Honoraria for guest speakers
2. Contact each First Nation to determine engagement and consultation protocols
3. Identify opportunities to engage with each First Nation community, recognizing First Nations prefer outreach at their community events and facilities. This may include:
   a. Training sessions
      i. Ensure knowledge transfer occurs in both directions (e.g. traditional knowledge, emerging issues, cultural and spiritual components, awareness and sensitivity, etc.)

   ii. Share information (e.g. technical studies being planned, developed or implemented within or adjacent to First Nation communities or areas of interest)

b. Presentations to councils and chiefs
   i. The band council is the governing body of the First Nation, so proper consultation can only proceed with the cooperation of the band council.
   ii. Presentations to Chief and Council create an official record that engagement has occurred. Engaging with Council on this level ensures that decisions made will be long standing.
   iii. A robust engagement strategy would provide band councils the resources to conduct their own engagement or to cooperate with agencies in the engagement process.
   iv. Chief and Council decide whether or not to engage the community and also authorize resource staff persons to represent the First Nation in governing bodies, committees, etc.
   v. First Nation governance structures often include aspects of consensus that are not obvious. Make an effort to understand the processes, the appropriate contacts, the timing of council meetings and elections, and the means of outreach at each First Nation.

c. Pow-wows
   i. Provides an opportunity to post interactive displays, speak with First Nation residents in an informal setting, and enjoy the culture. This type of interaction can help to build trust and improve communication. All Powwows are family oriented.
   ii. The Anishnabek Nation's Pow-wow guide provides some explanations of Pow-wows and provides etiquette: http://www.anishinabek.ca/wp-content/uploads/2019/04/2019PowWowGuide.pdf?fbclid=IwAR1V5PmexIQBhxkMN95qcVJB32-EuzsenCDXEFZT51FtOm-RrJj88fzHtLc

d. Learning (Talking) circles
   i. Elders are very influential in First Nation communities. The input of the elders is based on traditional knowledge and gives more weight or importance to issues with respect to the community. Elders maintain the oral knowledge of the community and they play a significant and important role in the passing of this oral knowledge to the younger generation.
   ii. Resource staff meet with community members to listen to issues of concern

e. Tribal council meetings

f. Conferences

g. Community events such as open houses and community forums since Traditional Knowledge is collective and held by the community:
   i. Provides a forum for the community to speak directly

ii. Important to widely advertise and to include incentives (food, prizes, field trips, live entertainment, etc.)
iii. Decisions are greatly influenced by consensus and majoritarian decision-making is avoided if possible.

h. Staff meetings

4. Identify aspects of program delivery that require formal consultation and possible accommodation of Aboriginal Title, Treaty and Aboriginal rights.
5. Identify First Nation interests, concerns, values and priorities. These may include:
   a. Economic development
   b. Education, Language and Culture
   c. Capacity Building
   d. Youth (e.g. First Nation Youth Peoples Council)
   e. Health (mental, physical, facilities, traditional healing, specialists)
   f. Environment (access to resources and cumulative impacts)
   g. Infrastructure (clean water, housing, utilities, internet, sewers)
   h. Cultural heritage (history, archaeology, land use)
6. Investigate best practices for engagement with each First Nation community to determine how information will be shared. This includes the guiding principles for sharing communication as well as the medium for distributing information. It is dependent upon:
   a. the type of information being shared, and
   b. the concerns and issues of the First Nation,

   It is also important the engagement is led by First Nations to:
   a. minimize the risk that agencies will alienate First Nation governments by engaging communities without government to government consultation, and
   b. Knowledge holders may be potentially sensitive to sharing information and may be more likely to share knowledge if the First Nation is administering the study because the collective will retain ownership.

Appendix E1. PROFILES OF FIRST NATIONS

Anishinaabeg (Ojibway word for “the original people”)

The Anishinaabek are one of the largest nations in Ontario and include Ojibway/Chippewa, Mississauga, Algonquin, Nipissing, Odawa, Saulteux and Pottawatomi Nations. The Pottawatomi, Ojibway and Odawa Nations are part of the 3 Fires Council.

Anishinaabeg communities were diverse and autonomous, made up of several family groups. Governance based on clan system, where different families within each community belonged to a different clan (Table E2). Clans represented the five basic individual and social needs of the people and divided up the work such that one clan would be responsible for leadership, and the others defense, sustenance, learning and healing.

Elders and women have special roles in the clans with respect to teaching values, knowledge and spiritual lessons and in choosing leaders. Decisions were made by consensus where every individual had a say in the issue and much time was taken to discuss the issue. Most communities would have all five clans represented so that all the needs of the community would be met. Clans were passed through the father (patrilineal society).

Table E2. Traditional governance of Anishinaabeg Clans (Johnston 1976)

Dodem/ Totem/ Clan	Public Duty	Significance	Type of Profession
Crane, Loon, Goose, Hawk, etc. (10 clans)	Leadership	Outgoing, Communicator, Vocal	Headman, Chief
Bear, Wolf, Lynx (3 clans)	Defense	Courage, Strength, Strategic Thinker	Warrior
Martin, Beaver, Moose, etc. (6 clans)	Sustenance	Endurance, Patience, Strength, Skills	Hunter
Catfish, Pike, Sucker, etc. (5 clans)	Learning	Generous, Understanding, Knowledgeable, Patient, Wise	Teacher
Turtle, Otter, Snake, etc. (6 clans)	Healing	Unique, Special gifts, spirit of healing and preserving life	Healer

Note: The clan system may vary, region to region.

In the long standing ways of the Anishinaabeg, it is inherently understood that all of creation is interconnected. Anishinaabeg culture values water as precious and sacred to their being. Anishinaabeg women believe water is critical for maintaining life and giving life. They speak about the human body being comprised mostly of water and they consider it their duty to care for and protect the water in their role as Anishinaabe-kwewag (original women, literally). Since water is an integral part of their being, they respect it and seek to safeguard it.

The Thames has provided for the Anishinaabeg through many years of their existence. The connection to the Thames River is ingrained in the stories and history of the Anishinaabeg.

The river is in their being of who they are. They owe their gratitude and protection to it. The impact of the disrespect and constant pressure of contamination of the water has had a negative impact on the spirit of the First Nation communities living near and connected with the Thames River. They feel the pain of the river and its need for protection and help. When the Thames River is termed a resource instead of a life source, the cultural and traditional connection to the Thames is disrespected. The view has to shift back to reverence of the river supporting life, just like the air we breathe supports life. It is sacred to all.

Bkejwanong Walpole Island First Nation

- Located near Wallaceburg, Ontario at the mouth of the St. Clair River. The territory encompasses six islands that have been occupied by Ojibwe, Potawatomi and Odawa peoples for thousands of years.
- Citizenship of approximately 4400 people, with approximately half living in the community.
- Contains some of the most diverse wetlands, oak savannas and tall grass prairies in the Great Lakes region.
- Local economy depends on recreation and tourism as well as agriculture. The largest employer is the First Nation, which delivers programs and services to the community. There are also a number of private and First Nation run business enterprises.

Chippewas of the Thames First Nation

- Located on north bank of the Thames River approximately 20 km southwest of London.
- Community established in 1819 as one of the many reserves created following the Huron Tract Cessions.
- Between 1834 and 1885, several parcels were ceded, sold and leased such that the community reserve is currently 3,334 hectares in size.
- Nation has registered membership of approximately 2,500 with approximately 900 members living in the community.
- Largest employer is the Nation, which requires staff to administer its government offices and services. Other key industries include health care, construction, manufacturing and agriculture.
- Business centre has seven fully serviced commercial lots developed for office space and light manufacturing with the aim of creating additional jobs and opportunities.

Aamjiwnaang First Nation (means "meeting place by the rapid water")

- Located along the south shores of St. Clair River near the City of Sarnia.
- Community was established in 1827 as a result of the Amherstburg Treaty.
- Reserve lands were originally 40 square km, but land sales to industry have reduced lands to less than 5 square km in size.

- Nation has registered membership of approximately 2140 people, with approximately 900 people living in the community.
- Employment in Aamjiwnaang includes core administrative and program delivery, as well as positions in the industrial park.

Chippewas of Kettle and Stony Point First Nation

- Located along the shores of Lake Huron, 35 km northeast of Sarnia.
- Reserve lands are 9,496 square km.
- Nation has approximately 2,500 members, of which 900 live in the community.
- Historically, Canada used the War Measures Act to appropriate the Stony Point Reserve during WWII, and did not return it back after the war to First Nation ownership as promised. After continued failed negotiations, some First Nation members began occupying the former Camp Ipperwash and nearby Ipperwash Provincial Park. During a confrontation with Ontario Provincial Police, Dudley George, a member of the Kettle and Stony Point First Nation, was shot and killed. It was eight years before the incident led to a provincial inquiry, which concluded that the provincial government was at fault. In 2007, the Ontario Provincial Government announced its intention to return the 56 ha Provincial Park back to Chippewas of Kettle and Stony Point First Nation. The settlement was finalized on April 2016, and along with a $95 million payment, the land was signed over.

Caldwell First Nation

- Comprised of Potawatomi, Odawa, and Ojibwa (Chippewa).
- Historically, the Caldwell Nation lost land on Pelee Island more than 220 years ago as a result of a questionable lease by an Indian Department official. The Nation was not present at a treaty meeting in 1790 where the Chiefs from several other Nations in the region sold large tracts of land in exchange for the creation of reserves.
- The Nation is currently in the process of establishing a reserve for the community in the Leamington and Point Pelee area. It is the only federally recognized Indian Band in southern Ontario without reserve land of its own.
- Citizenship of approximately 300 people.
- Conducts its business in a community centre in Leamington.

Lenni Lenape/Lunaapeew (Lunaapeewi word for "the original people") Delaware Nation

The Delaware Nation includes three recognized Lunaapeew communities in Canada: Munsee-Delaware Nation, Moravian of the Thames First Nation, and the Delaware of the Six Nations. There is widespread belief that the Lunaapeew were the original tribe of all Algonquin speaking peoples, and this gave the Lunaapeew great respect and the authority to settle disputes between rival tribes. The Lunaapeew were not migratory and occupied homeland for thousands of years before the Europeans. White settlement forced the Lunaapeew to relocate.

The Lunaapeew are organized into three clans (Turtle, Turkey and Wolf), which are determined by matrilineal descent. As a result, the mother's eldest brother was more significant as a mentor to the male children than the father, who was of a different clan. Each clan had a chief that represented the clan at tribal councils. Decision making power was split between the clan chiefs. Female elders could remove leaders of whom they disapproved.

Munsee Delaware Nation

- Found along the northern shore of the Thames River about 25 km southwest of London. First settled along the Thames River in the late 1700s at the close of the America Revolution, after being dispossessed of their homeland in New York and New Jersey because of decades of war, strife and starvation.
- The reserve is approximately 3 square km. The Munsee people relied on the pickerel as a major food source. Maple sugar supplemented the Munsee diet. Today, Munsees continue to make maple syrup.
- The Nation has a registered population of approximately 550 people, with approximately 170 people living in the community.
- Creating jobs for youth by tapping into the emerging green economy.

Eelünaapéewi Lahkéewiit (Delaware Nation at Moraviantown)

- First came to this region more than 200 years ago with the Moravian missionaries and built the community of Fairfield, after being dispossessed of their homeland in New York and New Jersey. The War of 1812 erupted near Fairfield and the Battle of the Thames stopped the Americans, who then burned Fairfield in retaliation.
- The reserve is called Moraviantown and is located on the southern shores of the Thames River, about 40 km east of Chatham. Originally, Moraviantown was 202 square km, but today measures 12 square km.
- There are approximately 1100 registered members, with 550 living in the community.
- The pickerel and other fish species have provided the Delaware with a food source for the past 200 years.

Oneida Nation of the Thames

- Historically, the Oneida allied itself with the American colonists in the American Revolution, until Oneida communities became targets of the American militia. In 1840, a large group of Oneida left their homelands in upper New York State and settled along the southern shores of the Thames River, 20 km southwest of London. They were primarily attracted to the Thames because it offered water transportation, fishing and excellent farmland.
- Largest Oneida membership in the region with approximately 5600 members and approximately 2100 living in the community.

- Continue to practice traditions and ceremonies, and Oneida language is taught to children in school.
- The long-term care facility has 90 full and part time positions.

References for Appendix E

Jacobs, D.M. 2012. Consulting and accommodating First Nations in Canada: a duty that reaps benefits. 21pp.

Johnston, B.H. 1976. Ojibway Heritage. McClelland & Stewart. 171 pp.

Appendix F. FIRST NATIONS CONNECTION TO WATER

F.1 ARGFT4D Interviews

Following are interviews of First Nations community members, conducted by the Antler River Guardians of the 4 Directions (ARGFT4D). This First Nations Youth Summer Stewardship program, funded by the Ministry of the Environment, Conservation and Parks, promoted understanding of ***Indigenous*** peoples' history and traditional ecological and spiritual knowledge.

Connection to Nibi (WATER): Sarnia Resident of First Nation Ancestry

The City of Sarnia is home to Aamjiwnaang. The name Aamjiwnaang has several meanings related to water. One meaning is "place by the fast moving water", another is "where the spirit of the water lives". Before the river was dredged for transportation, there were rapids at the mouth of where Lake Huron flows into the St. Clair River. The St. Clair is so blue and clear and iridescent that when the water would flow over the rapids the sunlight would fluoresce off it making it look like it was alive and dancing as it flowed. The Aamjiwnaang people believe that water has a spirit, just as all things have spirits, and that it was the spirit of the water dancing as it sparkled and flowed. This spirit needs to be nurtured, not ignored. Many ceremonies are held to pay respect to the water, to remember where the spirit lives and how important it is. Aamjiwnaang honor the water by having ceremonies during the full moon. As the moons' gravitational force pulls the water toward it we pray to Nookmis (grandmother moon). We thank her as women; for the blessings of the ability to carry a child and to bring new life into the world. We thank her for everything she provides for all of creation. The ceremonies are performed to show respect for the spirit of the water, to raise awareness so that it is protected instead of taking it for granted.

Water is about life, and without water there can be no life. Water, in the form of ice and snow is the blanket that protects Mother Earth while she sleeps. We are all too familiar with the need of that blanket to prevent soil erosion from our farmlands and to prevent the decreases seen in lake levels, and to prevent algae blooms due to rapid warming of the waters when the Great Lakes fail to freeze during the winter. Water in the form of rain both cleanses the land and stabilizes the ***water table***. Water supports the wildlife that is harvested: both animal and plant life on land and from the water itself. And finally water is what we are made from.

As women, we are charged with protecting the water. Our bodies are themselves moved by water with the pull of the moon. Like the tides of the sea, the water within us moves our spirits and bodies. We see the effects of water on our bodies as the moon phases, with retention of water and flow of our blood. During pregnancy we carry our unborn within our wombs in a body of life giving water, carrying all that we ingest to nurture our growing child, until such time as our water breaks. It is then that we labour for hours to hear those first cries which we celebrate again with water; our tears of joy and gratitude at new life. This is carried on through generations, passed down from woman to child. The water we carry has been passed from generations before, and as a woman I passed to my children. Through my daughter, she too will pass the water to her children.

Connection to Nibi (WATER): Marina Plain

Our Ojibway culture has always nurtured the relationship between water and all things in creation. We are made of water, and so are the plants and animals in this world; we need it to survive. Our name Aamjiwnaang, from what I'm told by elders, means "Place by the Fast Moving Water". Our responsibility as Anishnaabeg is to care for Ahki –Mother Earth. Therefore, we must continually bring awareness to plight of caring for the water.

In Aamjiwnaang, as with most people; we use water for drink, to cook, bath, swim and fish. What is different about our culture is that we honor the water by having ceremony during full moon, as the moons' gravitational force pulls the water toward it. During that time we pray to Nookmis (grandmother moon) and we thank her as women; for the blessings of the ability to carry a child and to bring new life into the world. We thank her for everything she provides for all of creation.

We are deeply concerned for our water, including the oceans, the Great lakes, rivers, streams and creeks that are impacted by the ongoing spills and water extraction activities. Locally, we know that the Great Lakes are in danger and therefore endangering the livelihood, health and well-being of the people locally and round the world.

Please continue to help save our Nibi, water is life. Chi Miigwetch,

F.2 Seven Fires Prophecy

The seven fires prophecy is an Anishinaabeg prophecy that marks phases, or epochs, in the life of the people on Turtle Island, a Native American name for the North American continent. The seven fires of the prophecy represent key spiritual teachings for North America, and suggest that the different colors and traditions of the human beings can come together on a basis of respect. It predates the arrival of the Europeans, and contains information for the future lives of the Anishinaabeg which are still in the process of being fulfilled. The teachings of the seven fires prophecy state that when the world has been befouled and the waters turned bitter by disrespect, human beings will have two options to choose from, materialism or spirituality. If they choose spirituality, they will survive, but if they choose materialism, it will be the end of it.

Chief Duckworth

The environment is important, and it has to be a collaborative process. We are living in the Seventh Fire Prophecy, which is a crucial time for our children and our grandchildren. Reaching youth is most important, encouraging them to be the stewards and protectors of the land. This is the time when the First Nations will ask us to stop destroying the planet. We need to get serious and make positive change. If we chose to stop the destruction, then we have a chance to hold back the tide. If not, we will destroy the planet. Teachings of the seventh fire also say that there will be people that we have never seen before.

F.3 Our Grandfathers were Chiefs: Water Stories Selection (Aamjiwnaang First Nation)

Note: There are several ways to spell Anishinaabeg words using the English language. For example, *k* and *g* are used interchangeably emitting the same sound (Anishinaabeg or Anishinaabek). Double vowels are also used interchangeably to indicate the long sound of 'ee' (miigwech or meegwech). Lastly, *ch* and *tch* are used interchangeably (in miigwech and miigwetch).

Simon

Living on the St. Clair River as a child, I used to play in that water, swim in it, all activities to do with water, fishing, boating, and skiing. I feel that now, that I'm older, if I go into the water at all anymore, I get these migraines, really bad migraines. If I just go swimming in the water like I did, something reacts. Really bad migraines. That's just something that's happened to me. I know that there are other people that things have happened to them of greater, more pain and suffering than I have.

I don't understand why people don't see the water as life, because that's what it is. We're all 90% made of water and we're not treating the water, the earth, ourselves properly. We're not respecting ourselves when we don't respect the water and the land.

We're lost right now. We're wants over needs. If we could get our needs in order, and put the wants behind us… we'd come to a realization that down the road, we're going to be suffering bad, and it's not even that far down the road. With things that we're doing to the planet, it's not recovering. It's not. And it hasn't been healing itself in quite some time. When the planet can't heal itself, what happens? Disasters happen. Ice ages happen. We're putting ourselves in harm's way by not respecting the water, by not respecting ourselves, and the land.

Water has nothing to do with colour or race, where you live. It has to do with life, just living, just having the basic essential. That's the most basic one. We can't survive without water. And yet, we're dumping things in our supplies and not even caring about it. Some of these things we're dumping, the water treatment plants cannot take out. We're actually hurting the water treatment plants by dumping things in our sinks daily, in our toilets. Common household cleaning products hurt us as well. People don't realize that.

We've lost our way; we've been lost for quite some time. No money. All the money in the world, all the gold and jewels, what are they worth if you're thirsty? If you don't have water you don't survive. Whatever money means to you, whatever it represents to you, if you don't have water, that representation of your life, how it revolves around what you think is important right now, it's not; because you can't survive. Nobody can survive. Money isn't going to stop thirsty people.

There's a rebellion in the midst. People are talking about governments treating the people wrongly. How long does government think that citizens are going to take that? Protests are getting out of hand. Clearly we're not listening to the people anymore. People are getting hurt. Basic essentials. We just got to understand who we are, why we're here and how much longer we really want to be here. Thank you.

Mark

I'm from Aamjiwnaang First Nation. And I'd say water means a lot because I'm aware of the fluoride and chlorine and who knows what else is in our water systems and I believe it's a battle for our health. Not only water, but food. Could be possibly population control thing going on. But other than that there are other ways to get clean water in your system. There are water machines you can get - I can't give any names - but I know at the water bug they have some of these things for sale. Also if you go there you can get… mineral drops to put in your water. And get all that nice healthy water into your body. Also coconut. Coconut water. Good source for it.

I drink it every day. That's my number one drink… I need it in my body every day. I feel dehydrated without it. I also know apparently there's filters you can get for your showers too, so you're not absorbing stuff through when we're taking showers. Check into it.

Adam

Water, it's a great thing. It's life itself. You can't live without it. Good to drink, swim, fish. All good. Water helps grow the crops. It's nice to keep it clean even though we're going to shambles. Water is just everything. What can you do without water? You gotta have it. Everybody needs it. Can't do without it. So you need water, clean water. Boys have fun in it. Girls have fun in it. All good things with it. Balloon fights, swimming, whatever. All good. Hopefully it stays clean. Even though it's not a very good possibility. It hurts. There you go. There's my video about water.

Just swimming in it, playing tag in the water up on the river front. Many years swam in that water. Used to go in the river in January for iceberg, polar bear dip. That would snap you nice and fresh wake up call.

Christine's Mom and Brother

Brother: First time I went fishing was down at the river, I can't remember who, either my mom or my dad, pulled a fish out of the river and threw it at me. It was flopping around on the river bank.

Mother: It was flopping back down towards the river and he thought it was coming towards him. He was screaming and crying. We had to catch it and tell him that it wasn't going to get him… so, it was our first fishing memory, just down by the river here. Not something I'll ever forget. Until this day, he doesn't eat fish.

Brother: Nope. Fish and chips, as long as it's dead.

Unknown speaker

The story that I have to share about the river is been part of my life since I was really, really little. I remember my father taking me there when it was still a natural shoreline that doesn't look anything like it does today. I learned how to swim in that river when I was probably 3-4 years old. In my teenage years, I spent lots and lots of time, every day we were in the river. We had our inner tubes… we just went there. That was our hangout. We hung out on the river bank and we were in the river every day, swimming. I can even remember, we didn't let the oil slicks deter us. There was a really bad oil spill once. We had to stay away. But as soon as they cleaned it up we were right back in the river. I remember we used to jump, in and out, or in between the oil slicks that would come down the river. The mercury balls that used to float on top of the water, we didn't know better; we used to play with them. We didn't know better. Knowing today, that was a bad thing. That's a really bad thing that happened.

To see the transformation from the natural flow of the water… because it's all controlled now, the bricks and stuff that line the river bank to keep the erosion from happening. I'm very fortunate that I've been able to go there. We've done water ceremonies, we sang song, we've offered tobacco there. In my later years, as a grandmother now, I do that work, and pray for the water and do water ceremonies.

It's been quite the experience, it's taking me through my whole life, whenever, I've been home. It's the river that keeps me connected here to this place, Aamjiwnaang, which refers to that swift flowing water, the vast flowing water that swirls, where the people gather. So it's that '"ziibii", that water. That's that river. And the lakes, the connecting lakes, the "ajwagaaming", that's the original name of the territory that the people call this place. They called it "ajwagaaming", because it is the place where the water swirls and it was one of the major crossing areas for the people on the trade routes in our history. I'm very, very connected to the water, because I know that we are made of water and it's sacred. And like the slogan that's out there today, I've said it many, many times: water is life. Without that water we would not exist. Miigwetch.

Shaun

I'm a member from Aamjiwnaang First Nation. I wanted to share a quick story from when I was younger. I grew up here; in the area of the reserve here. Most people know the waboosh trail and that area. I grew up in the area. The people from the community know, there's a creek, Talfourd Creek that runs through the reserve and passes through the middle here. When I was younger we used to run around, get all the neighborhood kids together, play tag, or a game known as manhunt. We called it survival back then. We'd get together and play in the bush and what not. I used to use that creek as a source to lead me into the bush deeper and it helped me to find my way back out so I didn't get lost. I also used it as like, if I'm being chased, and didn't want the kids on my tail, I would take a chance and dive in and cross to the other side and continue to play. I'm pretty sure, back then our parents used to tell us to stay away from the creek but we never listened. They used to tell us back then that it was being dirty from the places around here. I feel bad for the kids today because now, I've heard it's probably even worst now. The life in it has dwindled, I'm pretty sure. There's very little life in it now. I'm glad I got to share that. I had time. It's been a part of my life knowing the creek that run through our land here.

Angela

I love the water because we went swimming in it during the summer all the time. I love the water, because sitting by, when my uncle used to fish, he would sit there and fish all the time. So now, when I sit by the water, I always think of my Elders that have passed on and that always used to go fishing.

Caitlin

I went swimming in the water, at the beach in Canatara with Right to Play. We go every summer and I never want to get out of the water. We'll play football in the water and that's always fun because my brother would catch the football and pretend he's fumbling it and fall in the water but jump up with the ball in his hand. That's always fun.

Jennifer

I'm from Aamjiwnaang reserve. I have 3 children and we always went swimming at Canatara Park for the fresh waters and everything to do there and that was happy times of growing up with my kids. Thank you.

TJ

I've noticed that the water coming from the plants, it's got more chemicals… but then they disperse it from the chemicals into the ditches. Most of the time is at nighttime that I feel they contaminate our ditches and waters and even the ships coming in the channels here, they're little sneaky too. I don't know what the government is doing about this. I notice when I have bottle water as well with my tea, that there's slick in the cup that's kind of greenish.

When I was growing up, well, we weren't very involved with it. We just took it for granted… we never paid attention to what they were doing really because we thought they were doing the proper things by the bylaws, the chemicals, the plants. But they weren't. They were getting away with stuff. But they seem to have stepped up a little bit now. But they still could do a lot better. I wouldn't even swim in that water anymore. We used to.

We'd swim from Dow, sometimes if you're brave enough we'd try to go across to Port Huron creek, but we'd always end up downriver because of the current. We swam quite a bit and thought everything was good and found out it wasn't. I don't think I got any sick from it. But all the fish and the other stuff was contaminated with the waste.

We fished. We used to eat the fish out of there. Then we slowed down. Go back to Eekinjig to fish there too, but that got bad.

It's not cleaned up around here yet. The way I see it. I don't know how they're going to improve it. The way I look at it, they push stuff in there to clean it up. Then that stuff there might be the one contaminating it too. Maybe we're stuck with it. I don't know if they can cleanse that out. The atmosphere, the air.

Oh man, I feel sorry. I pray for them that they don't get a short life or disease in their bodies or whatever. That's sad. I don't want to think about that too. Pretty soon we won't be here at all.

Unknown speaker

My favorite memory with the water is that I've learned to swim in the river, and I've taught all my children to swim in the river and they've all had a lot of fun.

Darren

Boozhoo. My name means Man who searches for spiritual things and I'm from the seagull clan and I'm from Aamjiwnaang, my spirit rises from Aamjiwnaang. I'm going to talk about our seven grandfathers teachings. I'll be back and forth to my phone here, because I want to get the pronunciations proper because the teaching I'm sharing is about that and how it relates to the water.

First one, when we talk about is love, zaagi'idiwin. Through the course of these grandfather teachings, they all have the root ode and win in them. Ode is our heart and win is life, so these are ways of life that we have to be cognizant of when we talk and we look at the water we have here. We have so much water that runs through Aamjiwnaang. We look at it and we have to be truthful about what we see and what we do.

Debwewin, again as that ode - De.bwe.win, debwewin - so the truth has to be part of who we are, of that water out there. They call it XXXX - which means clean water. We're lucky to have that here in our area, and some of our neighbors used that name: clean water, as well. I believe it's taken from us.

When we talk about water, we have to have respect; we have to have respect for it. We know what industry's doing to it, but we have to have that respect to be able to think and talk about the water and know that it's ours. There are so many things out there where people think that they can buy water, but it's not to be bought and sold. And I think it's up to the Anishinabek to have that respect, Mnaadendimowin, for that water. And have that respect again in your heart - ode, Mnaadendimowin, is in this word. We have to look at that respect for our little babies and elders so that they always have that water, that nice XXXX that runs by us.

The other thing is that we must be honest, we must be honest and say that whatever we do to the water, impacts it. Whether it's negatively or positively. My mom she left me with this teaching to tell people because the 7 grandfather teachings are so important to us. And to understand them, this way through our language, is even more important. What she says is that: we don't have to travel miles around, and chase people around about all these water protest, we should be taking what's here.

When we talk about our name, when we give our introduction, when we say, Aamjiwnaang XXXXX, what we're talking about is: our spirit rises from Aamjiwnaang. Aamjiwnaang is a meeting place, a spiritual place beside the water, beside that clear water. To be honest about it, this is the water we need to be concerned about. People in their territory need to be concerned about their own water. We look at water in different ways. We use it in different ways. And that water comes to us for us here. That's water is for us in Aamjiwnaang. Honestly, Gwekwaadziwin - I hope I'm pronouncing these properly. Again. To be honest about it. We're from Aamjiwnaang. And Aamjiwnaang is in our heart. And it has to be, it has to be first. Going through these words, something that we have to stop and think about.

Aamjiwnaang we talk about many different things. We have many different faces. We have many different people looking at issues and what not in many different ways. But we have to do it together. We can't have people expressing different views. It would help us more to sit down in the circle and I've worked on many projects in Aamjiwnaang and we always questioned how we do it. Do we do it this way, or this way. People would be adamant about the way they want it done. But once we sit down and talk about the way it has to be done, we have to be humble about it and say 'we're all part of Aamjiwnaang, we have to do it in this way'. The word for that is Dbaadendiziwin, humility. To know in that circle that we're part of that. A lot of teachings come from an elder along the way was: how in that circle we look at ourselves. There's going to be a time and a place where you're going to be called upon, we're you're going to be ogimaa, the leader of that circle. You're going to be called upon at some time for your gift to lead us in Aamjiwnaang in what we're doing. So it's important to have that humility, so you can listen and participate with everybody else who's there. That's that about humility. It's something that people need to come to, because when you help and you're humble, you put more forward in there.

Ok I'm trying to pronounce… Aakwa'ode'ewin, that's bravery. Bravery has a lot to do with integrity about who you are and what you have in your heart and how you share it and how you use your personal belief to be part in humility of that circle. Bravery is pretty easy to transform itself though. Because, if you're not humble, if you don't have love, if you're not honest about things, and you don't respect, it can be quickly turned into stupidity. And that's something that we really need to step away from, and be part of each other in Aamjiwnaang.

Wisdom, Nbwaakaawin. As you walk through all these teachings, wisdom is the only one that doesn't have ode in it. It doesn't have it from the heart because to get wisdom you have to have all of this in your heart before you can take it as wisdom. Now the thing I was talking about with my mom and these are her teachings that she's asked me to pass along when she left us: is that we always have to watch out for that water. It's right there. We need to go there, we need to make those offerings to our water here because the other water can be strong and safe without us doing our part. And, it is as important for the men to do this as it is for the women. It's important to support the women in the work that needs to be done with the water. The youth are pretty intense in their defense of the water, but you need to start here, you need to start in Aamjiwnaang, you need to come back here. Certain times of year we can do this, during solstice, but the important time to do it, there's a moon in march where we cast off, when we can cast those things off to the water and ask that water to heal us too. But we have to do our part to heal the water. Just want to say Miigwetch, that's my little story. Miigweech.

Ron

I'm here to tell you a couple of water stories because I think water is the most important resource we have and we need to do a better job of protecting it and maintaining our waterways so that the wildlife in it can thrive. The wildlife that we catch in the water can be eaten. I live on the other side of the river here and I was fishing in the St.Clair and I caught a couple of fish. One of them had a little gulf ball on it. I had some people check it. It was like a cancer spurt, they said, from drinking the water from chemical plants, they're polluting the water. I think we can do a better job and be more conscientious of the environment around us because the more we abuse our resources, the more they deplete.

The other thing that I would say is, if I could pack to go to South Dakota I would. I stand behind the people at the Dakota access pipeline. They have the right to protest to not have the pipeline go through their land if they don't want it. And the government's trying to force it, which they might do, but I still don't believe it's right. Anyways, we need to do a better job of taking care of our waterways. Thank you.

Unknown female and male speakers

Her: Since I've been young, I've been able to bathe in French river around Nipissing First Nation and I'm concerned how long we'd be able to do that for, how long that water would be clean.

Him: I've never been able to do this here.

Her: I wouldn't.

Him: I wouldn't trust the water here. It's so contaminated with Chemical Valley around us. We have the largest portion of freshwater in the world. It's just slowly getting destroyed. I wonder how long, before it's just not good at all.

Roger

I'm speaking about the water issues I had in Aamjiwnaang. I grew up in this area for the last 70 years. As a kid we use to swim in the creeks, we used to eat the fish out of there, we used to go fishing in springtime when the fish run, we'd spearfish, and that was how we provided food for our family. We had a big family here; I think it was 8 kids and 2 adults. There were 10 of us. And sometimes my grandmother lived with us.

In the springtime we did a lot of fishing for pike… not pickerel…that's that other fish…there used to be some trout. We used to clean them all up and eat fish for about 2-3 weeks. What we caught. Also, we did a lot of trapping in that creek. We knew all different kinds of turtle, there used to be all different kinds of species there. All I see is 2 left there, just the painted turtle and the snapping turtle. But we used to see them all over and all kinds of wildlife. We used to trap the muskrats, not the beaver so much, but the mink. The beavers are coming back, there's quite a few because nobody traps them no more. I don't know what lives there anymore. I don't go back to the creek as much as I used to. We used to spear frogs in the springtime. Big bull frog. We used to fry them up. They were also good. Also helped our meals.

I learn how to swim in that creek. Every time it would flood, like in the springtime, my older brothers taught all of us to swim there. We swam with the turtles, got bit by the turtles. We used to see a lot of small minnows. We'd go fishing by the river for pickerel, in the river.

In April or May we used to make great bonfires right along the beach. Everybody had a dock. There used to be a dock every 2-3 feet. All kinds of docks. Everybody had motorboats, canoes, etc. At that time of the year, there was good fishing from the docks and up to 100 feet offshore. A lot of kids learned to swim there. Everybody looked out for everybody. All the kids watch the smaller ones. Good fishing, good swimming, nice beach to walk on, lots of campfires and cookouts down there.

Years ago, my dad used to tell me that when it used to flood they couldn't drink the well water. That's one thing we had before we had tap water, was well water… until we had that problem with the pollution in the ground over there. We used to have a good well spring. We had good drinking water. I think it was in 1953 we got city water. That was different. They ran a water line down our street when they constructed that Shell plant in 1953. So we were able to tie into the water line. We were first, others didn't have water. There was not even water along river road. People came to our house to get their drinking water from the city. We had an outside tap and they'd come fill up pails of water and take it home for drinking and cooking. Sometimes, they'd leave a pie, a loaf of bread, some venison or fish. We never expected a payment. It was just a trade-off, something to eat, or something they grew or something they made. That's how it used to be years ago. People helped one another. It's hard to find that today. All because of the mighty dollar. It rules us and seizes our lives.

I can go back to all the meat we had that were all provided. We had 3 gardens, one for corn and squash, daily vegetables, cucumber, beans, tomatoes, all that good stuff, for salad. Another place, just potatoes, strictly potatoes. We had a cold room under our house in the basement. We heated upstairs with a woodstove so downstairs stayed cool all the time, so we were able to keep our produce and fruit a lot longer. We watered that garden with the well water. I think it was better for the plants than the city water ever was. Today my brother still collects water for his garden, the rainwater.

Those are some things I remember about growing up as a kid. And after a while the banks started to erode because of the big ships, and all the big waves that washed the hillside. It took away our beach, our docks. They constructed 2 steel docks now. I think we need more of our regular docks. There used to be boat houses, everybody that lived on the river front had a boat back in the 50s and 60s. We surely enjoyed our beach and river front. Now all we do is walk along, no trees, no berries. There used to be fruit trees, lots of wild flowers. Now nothing there, it's just grass and lots of rocks, cement pieces. Nothing natural. It's all gone. It's not the same. I'd like to see that come back. I don't know if it's going to come back. I guess that's all I have to say today and I hope things change soon… Thank you.

Robert

I'm from Aamjiwnaang First Nation. I've been a member here for 47 years now. One of the good things I remember about growing up was when I was about 2-3 years old going down to the river with my parents Al and Harriet Adams, and there was actually a beach back then - it would have been 71-72 - we used to go swimming down there, which was a lot of fun. We had a beach just like Canatara. It didn't go out as far, but still we had a beach. We could just go out our front door. Anybody could go play at the beach whenever they wanted. Another thing I remember too is back then, is the amount of species. We would swim and see a beaver in the river. The amount of fish, they would bump into you when you're in the water. Nowadays, there's not as many fish.

I don't know the reason about the fish, but one thing that's different is there are a lot of species that have come back. From what I understand, it has a lot to do with the zebra mussels cleaning the water. I don't know if that's a good environmental impact or not. But I believe that's what's going on. The water is a lot cleaner, therefore a lot of land animals are either being pushed out of their region or coming back to the reserve. Which I think is pretty cool, now. It's probably an environmental issue, why they're returning to the reserve. I believe they're getting pushed out of their own territories and so coming back here to reside. I believe a lot of the animals, their flight patterns have changed. There's quite a lot of migratory birds that are showing up now that never ever came to the reserve or this area before.

As far as the river goes, it's part of the blood for a lot of the members here that use it traditionally for their own enjoyment, but not only that but to live off the land. It's a well-known fact people are getting cancer from eating the fish, the animals around here, that not only drink from the water, but depend on the land surrounding the water… people are getting cancer from eating the game around here. This, kind of sucks, because there used to this place called the rock, where everybody gathered down on the river. We'd go swimming. Well, it's not there any more; it's been moved.

I believe they've dredged a lot of the river front. It's eroded quite a bit because of the shipping, big waves, shipping down the river. It'd be really great if we could restore it. To have that back again. It would be wonderful to have a gathering spot where we all get together again. I think that's one of the most important things that I'd like to see happen. I'd like to see another gathering spot. Maybe another beach or maybe some kind of enclosed area.

Rene

Hello, I'm from Aamjiwnaang First Nation. Water is important for everybody because we're 70%, our bodies. It helps us heal, it helps us stay nurtured, it gives us mineral and vitamin. Any kind of pollution that destroys that balance in your body, that's why all these diseases have come around. Now all of these pipelines and spill and poison into the ground that seeps into the water, that's why everybody has gotten even more sick over the centuries.

Water is important to me because it means life for my children, my grandchildren, my great grandchildren and for everybody on the earth, and for everything on the earth. Not just us humans, but the four-legged, the trees, the grass, the animals, the water breathers, all of them.

We need to do something about it. Our seventh generation standing up about it in Standing Rock, and they're fighting the devil workers for the pipelines out there. I support them fully. Lot of my brothers from the army, navy and armed forces are heading out there this weekend. They're leaving Monday. To help protect them and the water for our people, for our earth, for our mother. We need to do something about this. Please help. Make your voice heard. Call your governor, councilor, whoever. It's something that needs to be done otherwise there won't be anything left for anybody. That's why water is important to me. Thank you for listening.

Teresa

Hi, my Ojibwe name is XXXXX, that means old woman. My grandfather Stewart Rodgers named me that when I was just learning how to walk. Back then we lived on River road and when we were on River road, we always looked out to the water and I wanted to go to the water all the time. My dad and everybody said: 'no you're too little, you can't go over there'. Well, one day, when I grew up a little bit more and we came back here to visit, I decided that I was going to leave my grandpa Stewart's house, go across River road, go down to the bank and onto the shore. I was standing there, talking to the water, and for some reason I remember it was a woman I was talking to. I was telling her how I loved the water, how beautiful it is, I wished I could swim, so that I could be in the water, rather than on top. My dad was so afraid because he couldn't find me. Then he came down the embankment to look for me. He found me walking way far away. And I was picking up all the pretty rocks that water had made smooth. It was so clean back then. I'm 64 years old, and I might have been 4 years old when I did that.

Today, I walk and I looked over across the river, and I don't see a sparkling blue like I used to. I know that there's a big pollution in the Pacific Ocean with radiation and orca whales are dying from it, from the radiation from when Japan had their Tsunami. Here, there's no tsunami, but we still have a lot of chemicals in our water and it's done purposely. For that reason, it makes me want to cry. Not just for our future, our children's future, our children's children's future --- what are they going to have left when we've destroyed everything? All for what? Money? I'm poor so I can say that. I've been rich and I can say that. I may not have a lot of money, but I'm still very very rich. And I hope that this project helps the water people and all the good things that should be done to make water available to our children's children and the future. Thank you.

Ronald

I'm from Aamjiwnaang First Nation. My clan is seagull. I'm Anishinabek, part of the Ojibwe nation and Anishinabek nation. My water story is back when I was 8, 9 or 10, here at Lake St.Clair. That's probably the last time I remember the ice freezing over enough to actually go fishing on the river. There's ice fishing that goes on today, but that's in the bays. Due to warm temperature it hasn't frozen over since then. That was almost 20 years ago. That's one of the thing I do miss about the water.

I'm a very water person. I like to be around the water. I don't see myself settling down anywhere away from the water. I was born in the States, I'm from the actual desert, so I understand both sides of the water perspectives: where it's plentiful and where there's no water. That's one of the things I really do miss, winter when it freezes over. That year, me, my father, my uncle and my 2 cousins were out and we pulled, I think it was, I caught 4 that day and the total was 12. I walked away with the most because I caught 4. We didn't even have shacks or anything. I remember we just walked out there and used to be able to start fires on the water. That stuff you don't do anymore except more up North. In fact, I'm planning a trip up North to go ice fishing again, or at least somewhere else, because I do miss it a lot, now that I really think about it.

Norman

I always like to talk about, to open up with, the time when we had the opportunity to participate during the phased development of the Bluewater Bridge Authority and the second span. Growing up in Aamjiwnaang with that was an eye-opener, knowing that there were ancestors up and around the lake, along the river, even on the Port Huron side.

Going across one time with Allan Plain and seeing an archeological dig site. We went down near Fort Gratiot in Port Huron, and we saw St. Clair College there and they were excavating it and showing us and telling us that the fish bones used to be a quarter size of the spine, that they were finding a lot of tools, and netting, and how vast this area used to be, before the dredging of the river. It's always a reminder of how important this area was for nutrients, but also probably even gill setting development. Knowing that this area was, and still is kind of pristine. The lifestyle that you choose, or your family chooses or the way that you want to wake up in the morning and greet the world. Because, when you imagine how much water is actually flowing through the great lakes or through St. Clair River, and through Aamjiwnaang and Pekamjiwnaang, through the St. Lawrence Seaway, you try to understand how impactful that is, how important it is to stand up and protect this water.

Again there is so many other nations and children out there that don't quite have the accessibility to clean water, or the opportunity to swim in water or play in water. And most of the time, a lot of people think about the concept of traditional knowledge or traditional practices and they always forget about the children. When you look at the babies or the lifestyle that surrounds having your livelihood around water.

I know there are a lot of mother or grandmothers actively women empowerment focusing around protecting the water. As we're seeing right now, currently in the prairies, Dakota, Lakotas, Oglala's lands, we're seeing it. It's the same thing when I went to BC. It's the same situation that we see. How vast the ***watersheds*** are for the Fraser valley for the Sekina and how important those ***watershed*** there, either stemming from the alpine down the valleys to the ***floodplains***.

It is important knowing where that water is coming from whether as an ***aquifer*** or as water coming out of your tap, you need to know exactly what lifestyles are dependent on that, what kind of minerals or what kind of environments, even bacteria - some good some bad. Again it's understanding how important that flow of water is. It relates back to the water source, whether if it's a wetland established on top of a mountain or a nearby swamp, or a mashkiig, and how it slowly percolates through the soil, or it comes from precipitation, or is actually trucked into that territory, depending on if that community is under water boiling advisory.

It's very important to understand the story of our ancestors of Point Edward, Sarnia and port Huron. How important our lifestyle, how back then they weren't so dependent on industry or scientific evidence, looking at baseline. There was no need for looking at chaos that was established in the Great Lakes, whether through the American-Canadian revolution, or even with the French or British there are millions of millions of people here now and it's important that everyone knows how much water needs to be sustainable and clean, and to realize how impactful this water, and the spirit of water is needed.

From participating with the ancestors, and when the ancestors came back to our land, when we repatriated them back into the land, it was very important because we had a lot of visitors, a lot of knowledge people, and elders come into our community and shared their teachings. Knowing that and witnessing how much traditional value there was in this community and how much bring in the lodges into our community and share these teachings. Even growing up in my family, just being around, becoming a fire keeper or developing a lodge or putting up a teepee, or my aunt doing a caravan to go across a few states to go to ceremonies, it's always joyful when the next generation has an opportunity to see how beautiful either the Midewiwin lodges, the rain dance lodges or the sweat lodges or whatever they choose to participate in.

Because it was also an awakening and also an important step that our chiefs, Craig Rogers and Philip Maness were creating an atmosphere around our community bringing back the pow-wow, bringing in our own language conference that one time, and listening to the Anishinaabemowin and actually be able to come to the community center and youth center and listen to those words, the elders, to hear the prayers. During those prayers, we got to witness and see our sisters, and aunts and grandmothers, lift up that water and pray for that water. To understand that your cousin is going through a berry fast when she's coming through her woman and becoming a woman. And knowing that her grandmother and her aunt were also participating and showing her what they were taught when they were kids.

That was the same thing I heard when I was also participating in the First Nation water declaration with the Chiefs of Ontario; when we went up to Grand Treaty 3 territory and listened to those elder speak and witnessing 2 days consultation on the water declaration and hearing the vast difference between the rural communities in Northern Ontario and southern communities. That was my first time understanding that not everyone lives off of tap water that people had to survive off the mainstream of the natural process. Those elders had a lot of stories to share from when they were kids and how their grandparents had to travel through the waterways and even how the warriors also traveled through from Lake Winnipeg to here, the Sault Ste-Marie area. Or even just traditional knowledge ways, the water serpent, listening to how important the frogs are. How when the frogs stop singing that's a pause in the natural world.

We're seeing quite a few different pauses in the country here and there, depending on the climate or the natural setting, the habitat or the biomes, because even today our community is under a species at risk scenario too. That's not just based on migration animals, based on animals hibernating that actually call Aamjiwnaang their home, or the great lakes their homes. So it's really important to realize those life cycles or those life stories or that traditional knowledge those elders have.

I wrote about, in my little blog, a story that I shared with the environment department too, how beautiful it was too to be part of a ceremony on snake island, across from Turtle Island, in Toronto. We had that ceremony that morning. We just flew back from an all chiefs conference and a resolution was just passed to uplift the water declaration. That next morning we were able to have a ceremony with Elder Gary Siu from Mississauga of New Credit and at the time Regional Chief Angus Toulouse and his wife. We started a fire. It wasn't just based on that declaration, there was more spirit behind it. Knowing that Elder Josephine started the walk and when she first enabled that walk and had the vision and thought about the prophecies, she had to become the action. And everyone followed after, all the ladies and women and grandchildren. And she walked. I remember when she did come through here.

We went up on the riverside all the way up to XXXXXX and taking the time to look at the impact of industrialization and urbanization. Because of the channels that cut through townships. There was one time, we were walking past Sagana, and there was one channel with only small puddles of water, but there was this huge foot fish swimming, stagnant in one little area of water. It's because of the tides coming in and out, but this one fish was still living in this one little section of water. And imagining how long it took for the next channel flow through. It's important because it's adaptation too, but also referring back to how the natural process is. That little fish is still trying to survive in that one section. Pretty cool to see how important that water is to one species.

And we continued up to Oskota. Me and my aunt stopped walking with her for the first time. Over the years Josephine continued to advocate and help with the chiefs and become a role model. That's how we continued to follow through with the water declaration, was to follow through with the concepts of the great lakes water annex that the tribal and first nations governments were finally available to participate in that. Took a few negotiations to go to Niagara Falls and so now we have different technicians to go to these meetings which is pretty cool. Just to see the impacts and the opportunities that have been centered around the Great Lakes and how the protection and cleaning has been over the years. And looking at areas of concerns and cleaning those areas. Again Aamjiwnaang is a huge industrial area, both sides of the river need that clean up.

It's a few things we try to do as well. I know the environment department in Aamjiwnaang is seeking to continue to educate the community and advocate outside of Aamjiwnaang to fully re-establish traditional knowledge but also get the scientific base and create more opportunities for the students, youth to participate. Again when I was a youth, I had an opportunity from our youth worker and working with our youth worker and through the community to be able to continue to reach that next level and to advocate further and to become political or activist. It's really nice to witness the transition of your spirituality into your daily life and profession. Sometimes it's difficult to keep that profession up, it's an opportunity to always live and understand that you have that responsibility either at work, at home, or in your community to have value and ethics and to understand that life is important, on that water.

And still to remember our ancestors. When you pray, in the morning, or at night, or wherever you are during your day or travels, always remember, always give thanks. That was the main message that was shared during the Dakota access pipeline too. Just pray and not be violent, and to remind everyone in the world that there's a different opportunity in this world to be at peace and to be with each other. And we hopefully continue to share that. That's one thing that was shared as well by the Unist'ot'en camp in Northern BC was the value of protecting the land, sustaining the land and to keep it pristine because the next generation won't have that lifestyle again. To continue to share that knowledge of what you heard, learn in these camps, within these traditional forms and ceremony. When you're embedded in it, it's pretty cool.

Corey

I grew up in Winnipeg, Manitoba, where the Red River meets the Assiniboine River. The thing I remember is, what water was cleanest was in Winnipeg and then, now educated, that I know you were swimming in poison when you're put into the pool with chlorine and everything they put in there. The earliest memory of me being able to swim in anything clean was 30 years ago. Evolution has happened since then. Lots of pollution from everybody, a collective; it's not just one race that's done this, it's been a collective. But when you're not taught anything different, that's how we express ourselves to the environment.

Now, more so because of the pipeline, it's going to be hard to find any clean water. I can't remember her name, but she was an activist at Standing Rock, she said that it's not about the rivers being polluted, they already are. It's a collective choice at this moment in time, to change our ways. And if we don't start doing that soon, we're not going to have that time to fix anything, it will be too late. With that said hopefully fossil fuels end in 2017.

According to what I know, in our youth, we have to teach our youths these things. We can't sit around anymore and play video games all day long, we have to quit the alcoholism and the drugs and focus on this younger generation. This younger generation is pasted to phones on a constant basis, so there has to be this information coming down, like an ad, a pop-up. That information has to come that same way on Facebook. It just has to be there, whether or not you want it to be there, it's gotta pop-up to bring that awareness. It's got to be posted down on almost every social media site there is on a daily basis.

I don't like to think about Standing Rock because it makes me very angry at what's going down there right now. I don't need to explain that, most native know what's going on, see what's going on. I think David Suzuki would be a good spokesman for this kind of movement. I think I would be a good spokesman for this kind of movement.

That's it, it's not about my generation, it's about who we're leaving it to. So as adults, we have to start changing things, start leading by example, not just talking about. To lead by example is the way to go. Chi Miigwech.

Randi

I'm just going to share my story from when I was probably about 15 years old, me and my friends were down at the river swimming and we found an old beer bottle that was in the river. So we dove in and grabbed it. We ripped our cigarette pack in half and we wrote a message. We wrote: 'whoever found this bottle, write us back'. So we wrote down the band office's address because we didn't want no creeper trying to find us. And we put it in the bottle, we found a baggie, got a hair tie out of our hair and wrapped it around the bottle, and threw it in the river. We forgot about it. At the time Phil Manness was the chief and, he gave us a call one day. He says: 'we received a letter at the band office addressed to you'. We says: 'what?' So we went and got it. And sure enough someone had received our bottle. It was months down the way. They wrote us back. They were from the Niagara area. They thought it was a really neat idea to find our bottle, however, they complained that it was in a dirty beer bottle and that it was written on cigarette pack. That we should next time put it in a fancy wine bottle, maybe some fancy paper and seal it with a cork. But it was a fun experience and that was something we did with the water. Thank you.

Lakota

I am Aamjiwnaang from Sarnia and also half Oneida. I was raised in the city.

Hold on, stop. I don't know why it's making me emotional. *Crying*

As a kid I was always out playing in Mother Nature all the time, I loved every aspect of her. The sun, the trees, water. I was always in the water, playing in the rivers. And it is a part of my life, and not only my life, our lives. And us as human beings are whole bodies are 90%

water. I never thought that we would have to really, actually come to where we're truly are thinking about our water sources, are we going to have it for our lifetime or for my children or my grandchildren. I always heard stories that might be but I truly never thought I would see it.

Now to see what my people are going through so everybody can have it, not only our people, everybody on the earth, all kinds of people, all god's people, creation's people. So we can all have it. It stumbles upon my mind, why us Aboriginals are almost the only people that are fighting for all generations to come. It just breaks my heart to think that maybe my children won't be able to freely and safely, free-mindedly play in the water, have balloon fights, or simply go get a drink from the tap or from bottle. I just ask that we just all, together, try to think of not only the world but us as all god's beings and creations.

Christopher

My water story is when I was young. I used to always go swimming in the St. Clair River. I really enjoyed swimming and jumping of the big weight freighters into the river. That is what I really remember about growing up in the Sarnia area with our lake and our beaches. Swimming, boating, all that kind of water exercises that we can do.

I just don't like how the environment is going with the contamination that's going on with the water. How it's being even bottled up and shipped overseas. I don't agree with that as well. I just wish that everything, everybody, as humans as a whole can find different ways to help clean up the environment, clean up the water, so everybody can enjoy it. Not just for recreation but also for, we need it to survive and live.

Audrey

Action. *Laugh*. All the water bottles that are left with water in them, I just use it to go and water my plants and get them all healthier and keep growing. Miigwech.

Blair

I'm from Aamjiwnaang First Nation and have been living here basically my whole life. When I think about the water, I think about the St. Clair River and all the stories I've heard from back when it was more of a fast flowing - it still is - but more of a fast-flowing rapid pace. And how the water, once upon a time, the rapids would create spirits, lying beneath the surface and that's how Aamjiwnaang got its name, the place where the water meets, flows.

Aaron

Being a member of Aamjiwnaang First Nation, I'm proud to say that I'm part of the Great Lake society. Even though there are five major Great Lakes, I think we should consider a petition out to say that Lake St. Clair should be a Great Lake since you cannot see across or swim across it. With that in mind, maybe we should consider making it the sixth. Thank you.

Samantha and Kaitlyn

We've lived on the reserve since we were born. She's 21 and I'm 20. We lived in the same house that my mom, built, no moved in. And this is Aamjiwnaang reserve I'm talking about. I've lived here, I'm 20, so 20 years. And I've been using the water since my entire life. Swimming, drinking, cooking, showering, all the basic things.

One time I went sea-doing. This was in grand bend. Me and my boyfriend were walking down the boardwalk in Grand Bend and we see a sign that says: rent a sea-doo, and we decided to rent one. So we rented a sea-doo. We were just 20 mins in, going over the speed limit they told us to. We were flooring it, going down the water. All of a sudden, I felt very scared, so I gripped him. All of a sudden we fell. I blacked out. Woke up in pain on my stomach. I found out a couple days later that I ended up having a concussion. Had to take off work. But it was fun, I would do it again even though I had that complication.

I always go swimming; I went fishing with my dad and right to play in Sarnia. Tony our mentor, helped us, would take our boat to the river, supply the fishing pole - you can bring your own, the worms and the bait. We caught tiny little fish, but nothing we can eat. He takes us on beach days as well. Take two vans, sometimes takes a couple of trips because of how many kids show up. We'd go swimming, spend the day, have a picnic, eat, stroll around. We'll play football, catch.

<u>Briana</u>

This summer I traveled to Mingo Falls which is in Cherokee North Carolina. It was so nice to experience the water on another reserve. It felt so fresh. Basically, it was the feel of nice fresh mountain water, something I never experienced. And it just felt nice to have that experience on a different reserve.

<u>Vanessa</u>

Water to me is a responsibility. It's a symbolic form of how we relate and connect to our environment. Growing up here in Aamjiwnaang, there has been a disconnect between myself and the water, due to how the health is in our environment, the health of the water. It is a reflection of the health of our own bodies. Learning more about how we better connect with our environments, how we have always connected as Anishinabek people to the Great Lakes, is what I continue to learn and grow from. It helps us as ***Indigenous*** people connect to other nations and other places in the world where ***Indigenous*** people are fighting for the water. It connects us, as human beings, to one another. Most importantly, it just shows our responsibility to the environment; how we treat the water and how we defend the water.

<u>Unknown speaker</u>

We're building a cottage on Manitoulin Island. 6 of our cousins live out there. We always get to go swimming and diving for things. It's always fun to be in the water and to have fun with everybody together at the same time.

We go to lots of beaches in the summer because we do have a big family, so when we're all there, it's nice. And XXXX and my cousin, they're very close so they always go diving. We always go diving because my mom, my uncle, he takes us in his truck. We find good rocks to dive from. It makes me feel happy because I'm with my family.

We go fishing with our other uncle at his trailer sometimes. One time I caught a big fish. He tried to make me hold it, but I was too scared because it felt hard on the inside.

When we go diving, who gets the thing first. We'll play Frisbee sometimes with my cousins and uncles. We also play Marco Polo a lot. Sometimes my dad and my cousin see how far we can go swimming down the beach and I get to scared because I don't want to drown.

Unknown speaker

Being at the water has become such an important part of our family activities. It's a chance for us to reconnect with each other and with nature. It's a chance for us to take our children from the busy city and away from all the technology and to just rejuvenate. I find that we spend as much time as possible in the water, in the warmer months, but also in the colder months. It's just, as I said, a real chance for us to reconnect with one another. With the hustle and bustle of everyday life, and the stress that happens, I find myself more at peace and my children more at peace when we're at the water. Just the sound of the waves.

Lindsey

In our community I think water is super super important and sacred to us because we have the Great Lakes in our area, we have the St.Clair River. Those are two very very important bodies of water to not only us, but to the world in fact because they hold the most freshwater. That gives us kind of an important role in Aamjiwnaang to be protectors and to take care of it, and to just appreciate it. We have an awesome gift here, living with so much freshwater.

Personally, I love whenever I get angry feelings or stress feelings, that I have that water to either sit in or sit beside, listen to it. It's sad that we're not able to drink it. But that's ok. It's still very beautiful. That's what makes this area so important and why we're even name Aamjiwnaang is because of that water, that it's so sacred and important.

Verline

I live in Aamjiwnaang First Nation, I grew up in Aamjiwnaang First Nation. Our family house is right up on riverfront so, swimming was our whole summer. We swam from the moment we got up until mom called us in at night. This past year, the year before, my two kids who are 9 and 11, at the time, I never let them swim in the river because I'm afraid of all the chemicals we have there. My husband is an enviro guy, so he knows everything about the environment, he was reassuring me that it was ok for them to swim there now because they've done a lot of cleaning up. This past year I've actually let my kids swim in the river, which is to me, that's life, swimming in the river, spending your whole summer there. To see them swimming was just awesome. I just thought I should share that. I feel much better now letting them swim where I swam as a child.

Ravena

I'm the Aamjiwnaang ambassador 2016-2017. I'm 26 years old. I work at the Aamjiwnaang First Nation childcare center. My mom always told me, when she was little she used to go into the bush and get plants to help her use for when she was sick. Now, we can't do that here. If we wanted to have plants we'd have to go outside the reserve because the water's contaminated. Once that gets to the plants, it doesn't have its full benefit.

Nicole

One of my favorite memories as a child was going up North fishing with my dad, some of my cousins and his friends. It was always so peaceful on the lake and whether or not you caught fish it didn't matter. It was just about spending time with family. Sitting and relaxing on the boat. It was just something we did when we were younger and I don't know why we haven't continued that tradition here, but maybe we should.

Unknown speaker

There's a lot of water in Aamjiwnaang and it's been really helpful for becoming comfortable with water, because not a lot of people are comfortable with water. They're afraid to swim and are scared of dying, drowning. But, I used to go to the beach all the time, and swim in pools. This summer actually I got to experience to go white water rafting in Ottawa. It was really awesome because I didn't have the fear of chemicals or knowing there's a big blob underneath the surface, at the ground level. There wasn't any massive pollution in it. So it was very comfortable going down that river.

Because, just like when you swim you see all the refineries and stuff, you hear stories about chemical spills. They say that it's gotten to Wallaceburg. So when you go swimming, you just imagine swimming in all those chemicals. Thinking about chemicals, I know that they stay for a long time. And the way the industry manage things, they'll say that's it's below a certain level so it's not dangerous. But it still dangerous because it's still there. Doesn't mean that it's gone. It's just at an acceptable level were you won't immediately develop a cancer or illness from it. You'll just get it later in life after swimming for 20 years.

When I was little, I would just be very comfortable swimming and I didn't know about water quality and the concern for it. I remember just like having a really good time. A couple years ago I started working for the YMCA where we try and build strong kids in communities. One of the things that they do is teach kids how to swim. That's really important because places like Sarnia a lot of people go to the beach. They have the risk of drowning. So it's really important to teach people how to swim. I think it would be easier to do that if they weren't afraid of the quality of the water. They'd be able to practice swimming and be able to just swim more. And the awesomeness instead of in a pool, where it's all gross sometimes.

They'd be able to go out into nature, swim in the river. I know it's dangerous because of the current but it's right out there.

I've never swam outside of Aamjiwnaang over here, but I think a lot of people have. Actually I've gone canoeing over there, but that's different. It was… nice. I think the best part of it was looking at all the nature around. It was fun, but I like swimming more. That's my favorite activity to do in the water.

Unknown speaker

I guess, water, first off, would mean, water is life. I hold women in a high regard. Women are the backbone of our community. They hold water, they create life. I feel that water is so important to us nowadays, more than ever because government and companies and corporations are damaging the water supply, our freshwater supply.

My main interest as playing a part in the community is to help fix that for our next 7 generations. If we don't stand up now, and support these people in Standing Rock, or people in our own communities, the water supply is going to run short, it's going to get contaminated even more. It's so important to acknowledge this right now, in today's society, that we are Anishinaabek, we are the ones that are supposed to be taking care of mother earth.

I feel that, the need for information to spread out is so important so that we will have a chance at life. I think that what we're going through in our communities is spreading the word and the support from our leadership is key. I have a family, I have a daughter, she's 3. She's going to be the next people in charge of the community to help out with that. Water is life. It's essential so we need to keep moving forward.

We are fortunate enough to have filtration system to our city, but many communities are not as fortunate as us. Our northern communities, our northern sisters and brothers are not, they're suffering with boiled water alerts. We are so fortunate and blessed to be tied in with the city. As much as I wish we had our own filtration system, it's something in the works. Having that clean water, I think we're very, very lucky compared to others. And I feel bad because I think everybody should have clean water.

Appendix G. PARTNER RESPONSIBILITIES

NOTE: This Appendix is currently under review (2019).

G.1 Responsibilities of First Nations

As part of ancient systems of ***Traditional Ecological Knowledge (TEK), Indigenous*** people bear the knowledge and the responsibility to care for the waters upon which they depend for survival (Boelens, Chiba, and Nakashima 2006). This knowledge is based on ancient philosophies, the principles of which are used to determine which new information might appropriately be incorporated to address contemporary challenges. Although no one is exempt from caring for and paying respect to the water, many Indigenous Nations such as the Anishinaabeg, Mushkegowuk, and Onkwehonwe and others are the holders of the rights to the water. With this right comes a special responsibility for water, and it is the duty of the women from many Indigenous Nations to share this knowledge and to care and protect the water and the Great Lakes for generations to come. Water ceremonies and harvesting protocols reinforce the responsibility and sacred obligations that First Nations have to the water (Phare 2009). This responsibility is important to First Nation rights, as there is no value in holding rights to something that has been destroyed.

Indigenous people are not only concerned about water in their communities, but on their traditional territories as well (McGregor 2012). Although hundreds of ***Indigenous*** communities maintain crucial connections to the waterways of the Great Lakes, there is an ongoing struggle to have ***Indigenous*** voices heard in the decision-making processes that affect their lives, lands, and waters. Taking care of water has been part of their knowledge for most of their history. It is only recently that they have not been able to exercise these responsibilities and fulfil their obligation to protect the spiritual value of the water.

G.2 Responsibilities of the Federal Government

The Canadian federal government's role in protecting and managing sources local water supplies, as well as operating and supervising local water systems, is very limited. The federal government has no direct role in regulating water takings off federal or aboriginal lands, or in monitoring or gathering information on the quality of drinking water actually provided by provincially or territorially regulated municipal water systems. The most significant activities related to water resource management are focussed on research. The Geological Survey of Canada for example, has undertaken a number of modest research projects on ***groundwater*** sources, and Environment Canada monitors water levels, flows and the presence of certain contaminants in major surface water bodies, such as the Great Lakes and St. Lawrence River.

The federal government could, under certain circumstances, employ its jurisdiction over navigable waters, fish habitat, or international waters to regulate water takings that might interfere with navigation, damage fish habitat, or remove waters from an international water body. However, in practice the federal government has been reluctant to exercise these authorities, principally due to concerns over interfering with provincial jurisdiction over natural resources management. The Fisheries Act also prohibits the deposit of "deleterious substances" into waters frequented by fish. These provisions may also have the effect of providing some protection for the quality of surface water. However, in practice the administration and enforcement of these provisions has been largely left to provincial and territorial governments.

G.3 Responsibilities of the Provincial Government

Table G1. Areas of responsibility for provincial ministries on the Steering Committee of the Shared Waters Approach

MINISTRY	AREAS OF RESPONSIBILITY
Agriculture, Food and Rural Affairs	Supports Ontario's agri-food sector, enforces and improves food safety, and strengthens Ontario's rural communities.
Environment, Conservation and Parks	Works to protect, restore and enhance the environment to ensure public health and environmental quality.
Natural Resources and Forestry	Oversees the province's natural resources and works to safeguard Ontario's forests, fisheries, wildlife, mineral aggregates, Crown lands, and waters.

The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) helps to build a stronger agri-food sector by investing in the development and transfer of innovative technologies, retaining and attracting investment, developing markets, providing regulatory oversight, and providing effective risk management tools. The ministry also helps enable rural Ontario to build strong, vital communities with diversified economies and healthy social and environmental climates, as well as promoting the wise use of rural Ontario's land and water resources.

The origins of OMAFRA go back more than 150 years. With the reorganization of the Ontario government in 1972, the former Department of Agriculture and Food was renamed the Ministry of Agriculture and Food. In 1994, the Ministry of Agriculture and Food was renamed the Ministry of Agriculture, Food and Rural Affairs.

The Ministry of the Environment, Conservation and Parks (MECP) has a clear mandate to protect water resources in the Province of Ontario. Before 1950, surface water and ***groundwater*** takings were unregulated in Ontario. Instead, common law rules of riparian rights, requiring that upstream landowners not interfere with quality or level of water flowing past their land to the detriment of people living downstream, applied (Estin and Swaigen 1993). In response to increasing pressures on water supplies and water quality in the immediate post-war period, the province began to exercise regulatory control over the use of water resources through the adoption of the Ontario Water Resources Act (OWRA) in 1956. At the same time that it began to control water use through the adoption of the OWRA in 1956, the provincial government moved to establish a provincial regulatory framework for water quality and the operation of local water and sewage systems.

In 1972, the Ministry of the Environment was established as a portfolio in the Executive Council of Ontario. The Ministry was merged with, and split from, the Ministry of Energy several times from 1993 to 2002. Following the 2014 Ontario election, climate change was added to the ministry's portfolio and its name changed to the Ministry of the Environment and Climate Change. Following the 2018 Ontario election, the Ministry's name was changed again, to the Ministry of the Environment, Conservation and Parks.

The MECP is the legislative authority to manage water and establishes standards for drinking water quality, including requirements regarding the frequency of testing and the public reporting of adverse test results. Approval is required by the Ministry to construct and operate private communal or municipal water and sewage systems. The Ministry also regulates and permits water taking activity using the permit to take water program, as required by Section 34 of the Ontario Water Resources Act.

The Ministry of Natural Resources and Forestry is responsible for protecting Ontario's biodiversity while promoting economic opportunities in the resource sector and supporting outdoor recreation opportunities. The Ministry also sustainably manages Ontario's fish and wildlife resources; leads the management of Ontario's Crown lands, water, oil, gas, salt and aggregates resources; ensures the sustainable management of Ontario's Crown forests; protects people, property and communities from forest fires, floods and droughts; and develops and applies geographic information to help manage the province's natural resources.

G.4 Responsibilities of Municipal Governments

Local land-use planning decisions can have significant impacts on watersheds. Municipal governments have a role in the wise stewardship of water and policy direction on the protection of surface and ***groundwater*** sources, through tools such as the Drainage Act in rural municipalities, and water infrastructure in urban municipalities (such as drinking water, stormwater, wastewater).

G.5 Responsibilities of Conservation Authorities

Conservation authorities have played a significant role in Ontario's natural resource management landscape for nearly 70 years. Conservation authorities are unique organizations, established on ***watershed*** rather than political boundaries and operated on a cooperative basis by local municipalities within the ***watershed*** in order to better serve local needs and allow for resource management from a science-based perspective. Using the tools provided within the Conservation Authorities Act, and with support from participating municipalities and the province, conservation authorities protect people from water-related natural hazards, provide recreational and educational opportunities, support science and research, and conserve and protect the natural environment.

The Thames is the only river in Ontario with two conservation authorities (Upper Thames River CA and Lower Thames Valley CA) sharing responsibility for one river. While management principles are similar between the conservation authorities, decisions and plans for the river occur independently for the two river reaches.

References for Appendix G

Boelens, R., M. Chiba and D. Nakashima. 2006. Water and Indigenous peoples, knowledges of nature (pp. 108-115). Paris, FR: UNESCO.

Estin, D. and J. Swaigen. 1993. Environment on Trial: A Guide to Ontario Environmental Law and Policy.Toronto: Emond-Montgomery Publishers. pp. 114-116.

McGregor, D. 2012. Traditional Knowledge: Considerations for Protecting Water in Ontario. The International Indigenous Policy Journal. Article 11. Volume 3(3).

Phare, M.P. 2009. Denying the source: The crisis of First Nation water rights. Surrey, BC: Rocky Mountain Books.

Appendix H. CLIMATE CHANGE PROJECTIONS

THEME	GENERAL PROJECTIONS	TREND	CONFIDENCE	
	PHYSICAL EFFECTS			
CLIMATE **Air Temperature**	• 1.5ºc - 7ºc increase by 2080s • Greater increases in winter • Increased frost-free period and growing season	↑	high evidence, high agreement	●
Precipitation (ppt.)	• 20% increase in annual ppt. by 2080s • Increase in rain, decrease in snow • Increase spring ppt., decrease summer ppt. • More frequent extreme rain events	↑	high evidence, medium agreement	◒
Drought	• Increased frequency and extent of drought	↑	low evidence, high agreement	◒
Wind	• Increased wind gust events	↑	low evidence, low agreement	🚫
Ice Storms	• Increased frequency of freezing rain events	↑	low evidence, low agreement	🚫
ICE DYNAMICS	• Projected decreases in ice cover duration, thickness and extent • Increased mid-winter thaws, changing river ice dynamics	↓	<u>Lakes</u> medium evidence, high agreement <u>Rivers</u> low evidence, low agreement	◒ 🚫
WATER TEMPERATURE	• 0.9ºC – 6.7ºC increase in surface H_2O temperature by 2080s • 42 – 90 day increase in ice free season • Increased period of stratification	↑	<u>Lakes</u> high evidence, low agreement <u>Rivers</u> low evidence, high agreement <u>Wetlands</u> low evidence, low agreement	◒ ◒ 🚫
WATER LEVELS	• H_2O levels in Great Lakes fluctuate up to 1.5 m • H_2O levels peaked in Great Lakes in 1980s and have decreased since • Projections suggest fluctuations around lower mean H_2O levels in Great Lakes • Lower H_2O levels due to warmer temperatures, evaporation, evapotranspiration, drought and ppt.	↓	<u>Lakes</u> high evidence low agreement <u>Rivers</u> low evidence, high agreement <u>Wetlands</u> low evidence, low agreement	◒ ◒ 🚫

THEME	GENERAL PROJECTIONS	TREND	CONFIDENCE
GROUNDWATER	• Recharge greatest in winter	↑	low evidence, low agreement
NATURAL HAZARDS **Flood** **Fire**	• Increases in flood severity and frequency • Increases in number and extent of fires	↑ ↑	medium evidence, medium agreement medium evidence, medium agreement
ENVIRONMENTAL POLLUTANTS			
CHEMICAL EFFECTS **(Oxygen, Acidity, *Phosphorus*, Nitrogen, Carbon, Mercury & other organohalogens)**	• Increase in dissolved organic carbon, ***phosphorus*** and nitrogen • Increase to toxicity and mobilization of mercury • Increased concentrations of CO_2 in water resulting in lower pH (more acidic)	↑	low evidence, low agreement
ECOLOGICAL EFFECTS			
AQUATIC SPECIES	• Coldwater range contraction: cold water fish and Painted Turtle • Warm water range expansion: cool and warm water fish, American Bullfrog, Northern Leopard Frog • Competition change due to range expansions and contractions • Fragmented rivers may impede expansion of species • Advances in spring phenology of amphibians	**N/A**	Range Shifts medium evidence, medium agreement Genetic changes low evidence, low agreement Altered phenology low evidence, low agreement Habitat alteration medium evidence, medium agreement
PATHOGENS & PARASITES	• Increase in range and prevalence • Change in parasite – host relationships	**N/A**	Aquatic low evidence, low agreement Trees & Plants low evidence, high agreement Wildlife low evidence, low agreement

THEME	GENERAL PROJECTIONS	TREND	CONFIDENCE

TREES & PLANTS	• Range contraction: boreal species, Spruce-Fir zone, Jack Pine, White Pine • Range expansion: Oak-Birch zone, Carolinian species, Sugar Maple, Hickory • Climate niche for tree species will shift northwards • Trees in south will experience reduced growth rates, reproductive failure, increased disease and mortality • Forest fragmentation will reduce tree migration • Plant productivity will increase • Distribution and abundance of wetland vegetation will change where species requiring little water (sedges, grasses, wet meadows, trees) will replace emergent and submergent species	**N/A**	Range Shifts medium evidence, medium agreement Genetic changes medium evidence, medium agreement Altered phenology medium evidence, medium agreement Habitat alteration medium evidence, medium agreement	
WILDLIFE	• Specialist species range contraction: Canada Lynx, Alder Flycatcher, Northern Flying Squirrel • Generalist species range expansion: Southern Flying Squirrel, White-tailed Deer, American Woodcock, Fisher, Red Fox • Geographic barriers, biotic stress and landscape fragmentation will impede species migration • >45% decrease in optimal habitat for 100 climate threatened bird species in Ontario • Increased risk of hybridization (e.g. Carolina and Black-capped Chickadee) • Earlier breeding and hatching of bird species • Asynchrony between environment and life history needs • Disruption of predator-prey relationships	**N/A**	Range Shifts medium evidence, medium agreement Genetic changes low evidence, low agreement Altered phenology medium evidence, medium agreement Habitat alteration medium evidence, medium agreement	
INVASIVE SPECIES	• Non-native species increasingly become established • Current invasive species expand ranges further north	**N/A**	Aquatic low evidence, high agreement Trees & Plants low evidence, high agreement Wildlife low evidence, low agreement	

Reference for Appendix H

McDermid, J.L., S.K. Dickin, C.L Winsborough, H. Switzman, S. Barr, J.A. Gleeson, G. Krantzberg, P.A. Gray. 2015. State of Climate Change Science in the Great Lakes Basin: A Focus on Climatological, Hydrological and Ecological Effects. Prepared jointly by the Ontario Climate Consortium and Ontario Ministry of Natural Resources and Forestry to advise Annex 9 – Climate Change Impacts under the Great Lakes Water Quality Agreement, October 2015.

Appendix I. TRCWR PARTNER ENDORSEMENTS

The Thames River (Deshkan Ziibi) Shared Waters Approach to Water Quality and Quantity (also known as the Approach) is a product of the Thames River Clear Water Revival, a voluntary partnership of First Nations, federal and provincial agencies, conservation authorities, and the City of London. The Approach is envisioned as a 20 year plan, with five year review and annual work planning meetings. There are no legal or financial obligations for any current or future partners.

The Thames River Clear Water Revival Steering Committee partners have agreed that this document will be designated as a FINAL DRAFT until all the Steering Committee partners have the opportunity to endorse the Approach.

The following partners have recommended the Approach be adopted and agree to continue to collaborate to voluntarily implement solutions to water issues in the Thames River watershed. As partners officially endorse the Approach, their endorsement will be added to this appendix.