



# Understanding Groundwater Impacts on Great Lakes Water Quality and Ecosystem Health

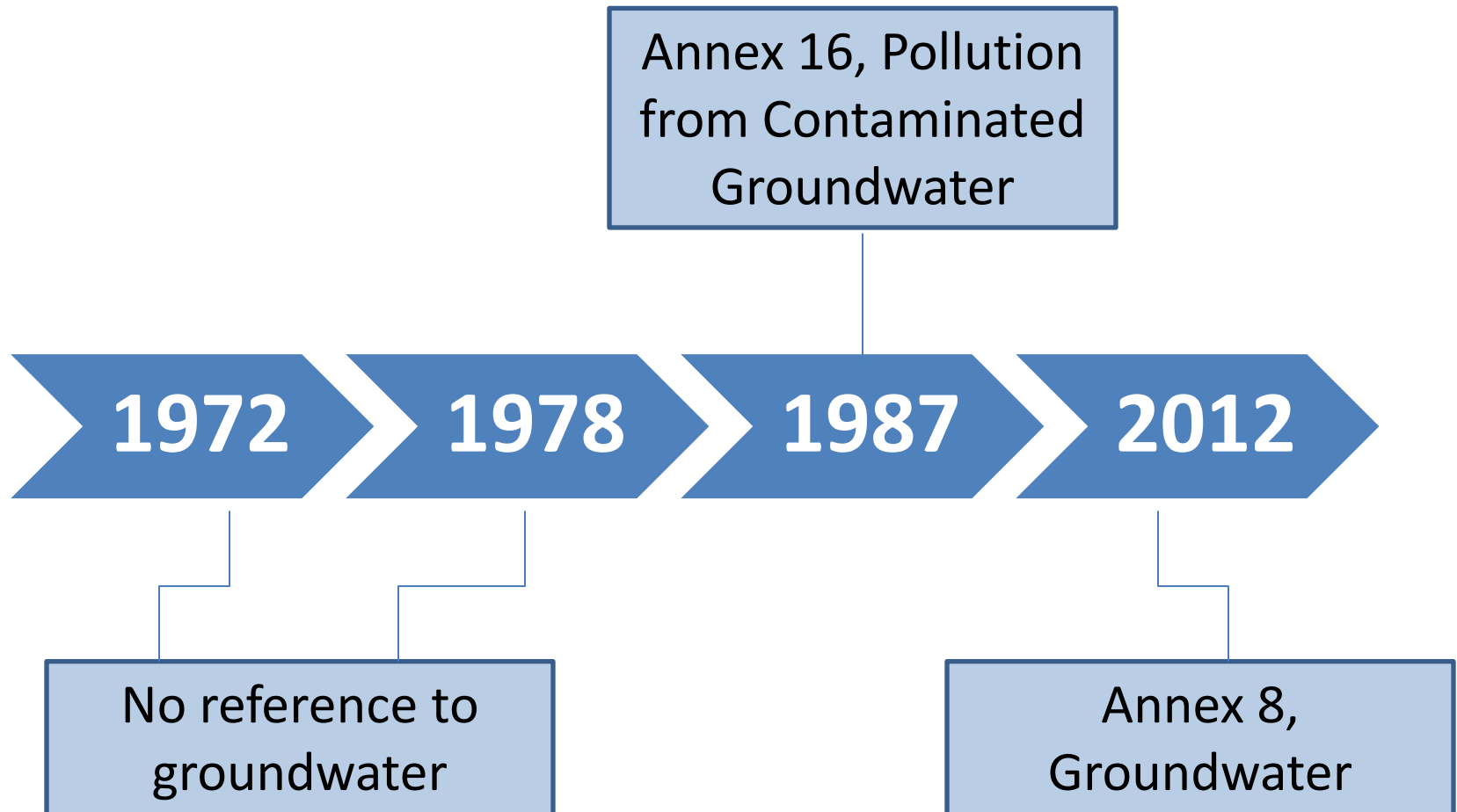
Dale Van Stempvoort – Environment and Climate Change Canada  
Norman Grannemann – United States Geological Survey

# Why is there a Groundwater Annex in the Great Lake Water Quality Agreement?



Source: Parks Canada

# Evolution of Groundwater focus in the Great Lakes Water Quality Agreement

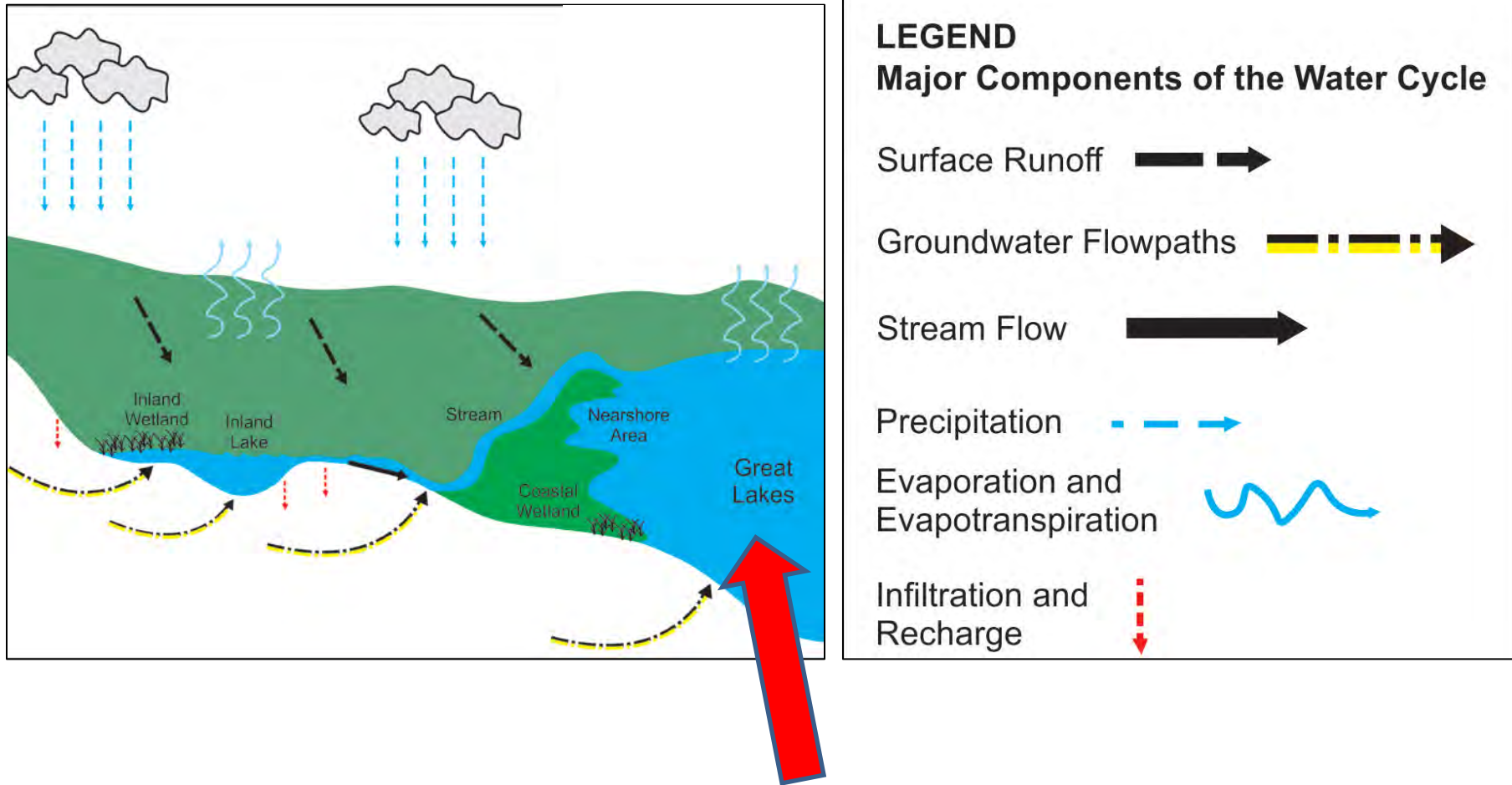


# The original Great Lakes Water Quality Agreement (GLWQA, 1972) did not mention groundwater



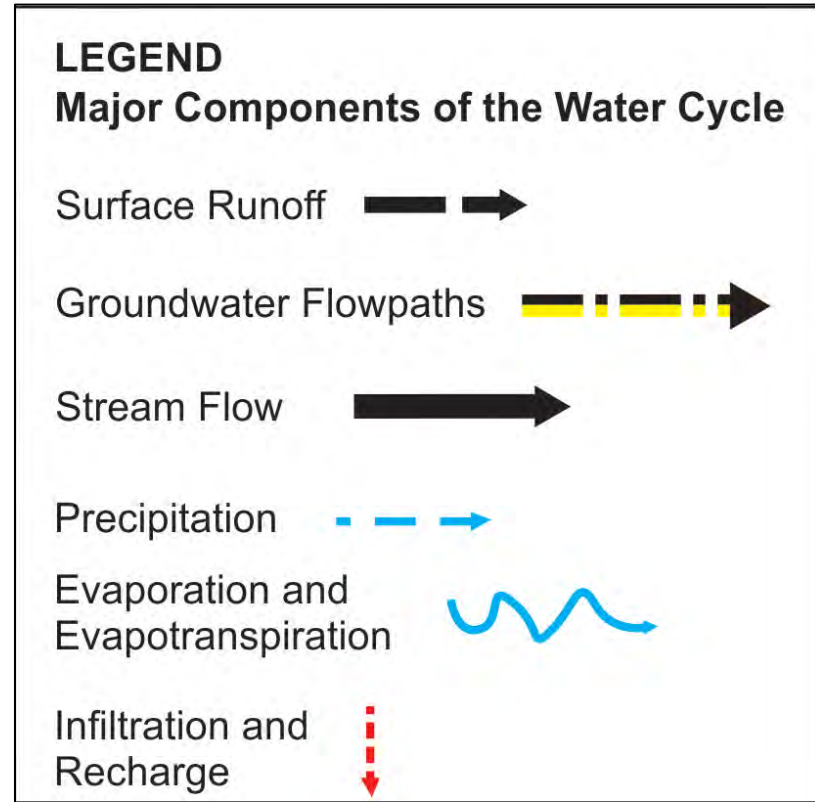
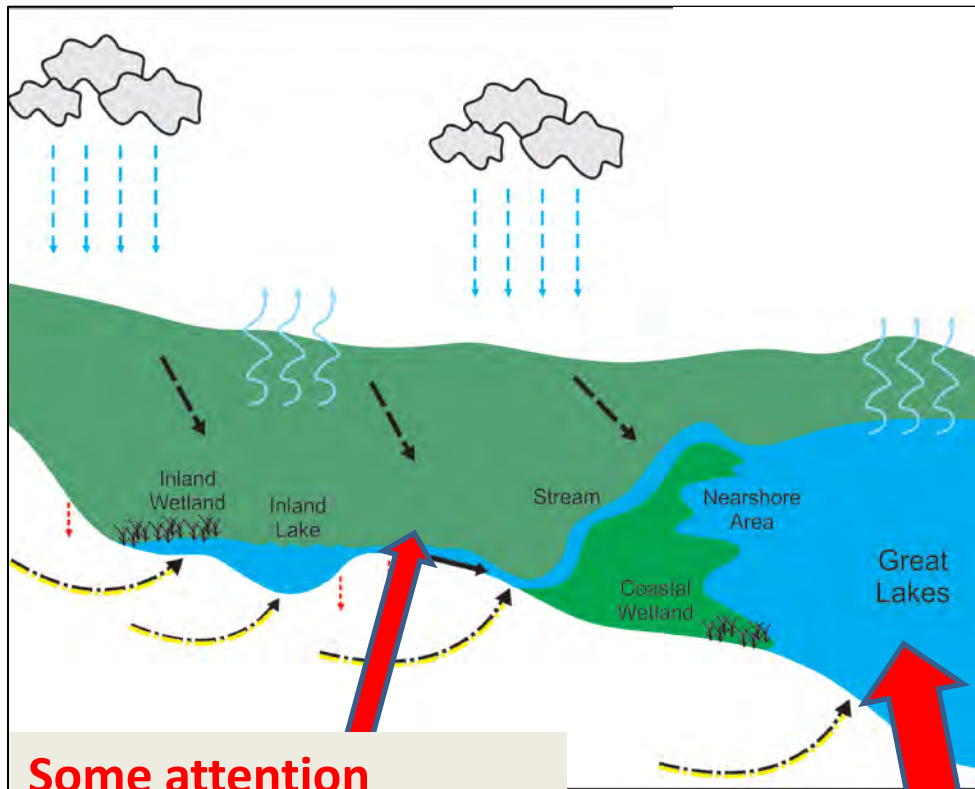
President Nixon and Prime Minister Trudeau sign the GLWQA in 1972

# 1972: Very little known about groundwater



**Focus of 1972 GLWQA: water quality of Great Lakes**

# Revised GLWQA 1978: Recognition of "Great Lakes Basin Ecosystem"



**Some attention shifting to surrounding basin**

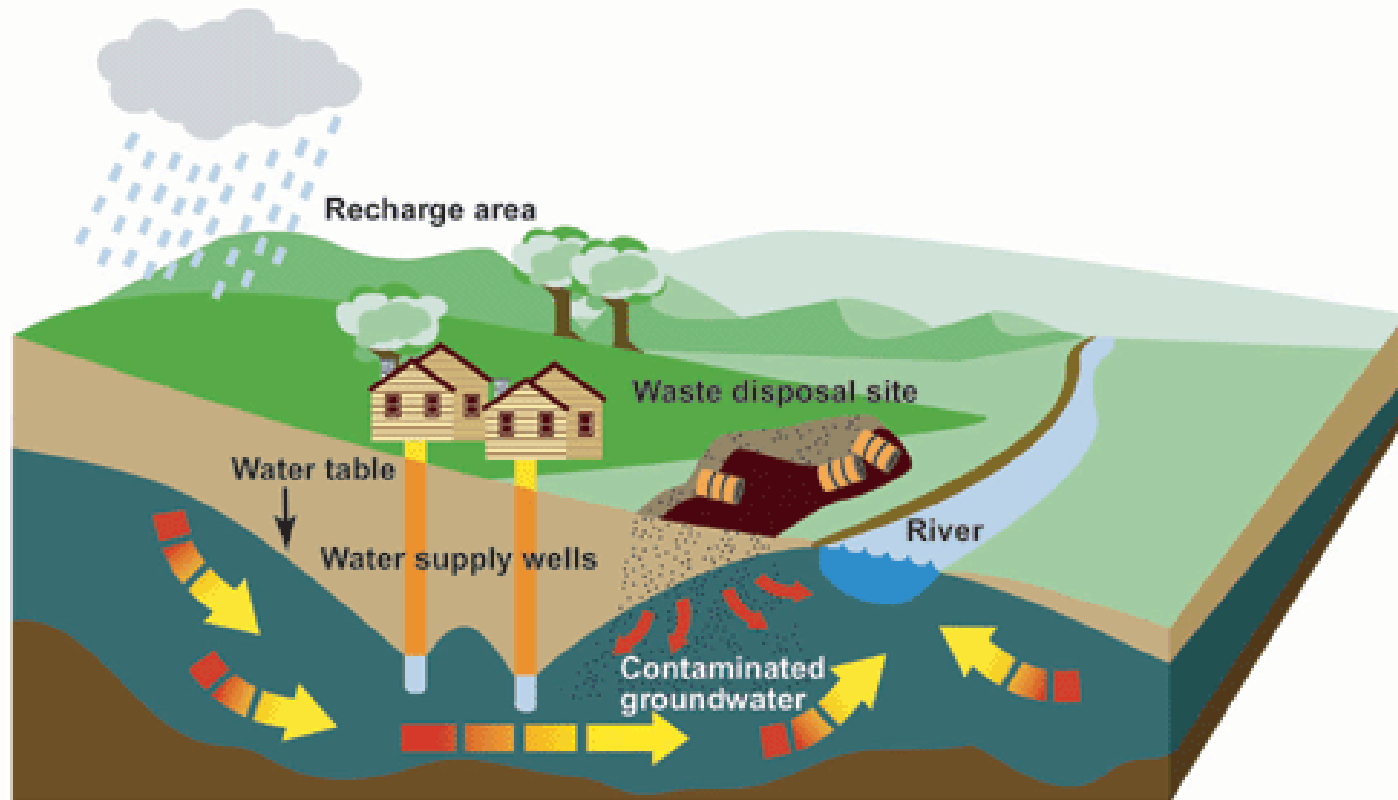
**Still focused on water quality of Great Lakes**

1978:  
The Love Canal  
disaster changed  
everything



# 1987: A new Annex (16) addressing “Pollution from contaminated groundwater”

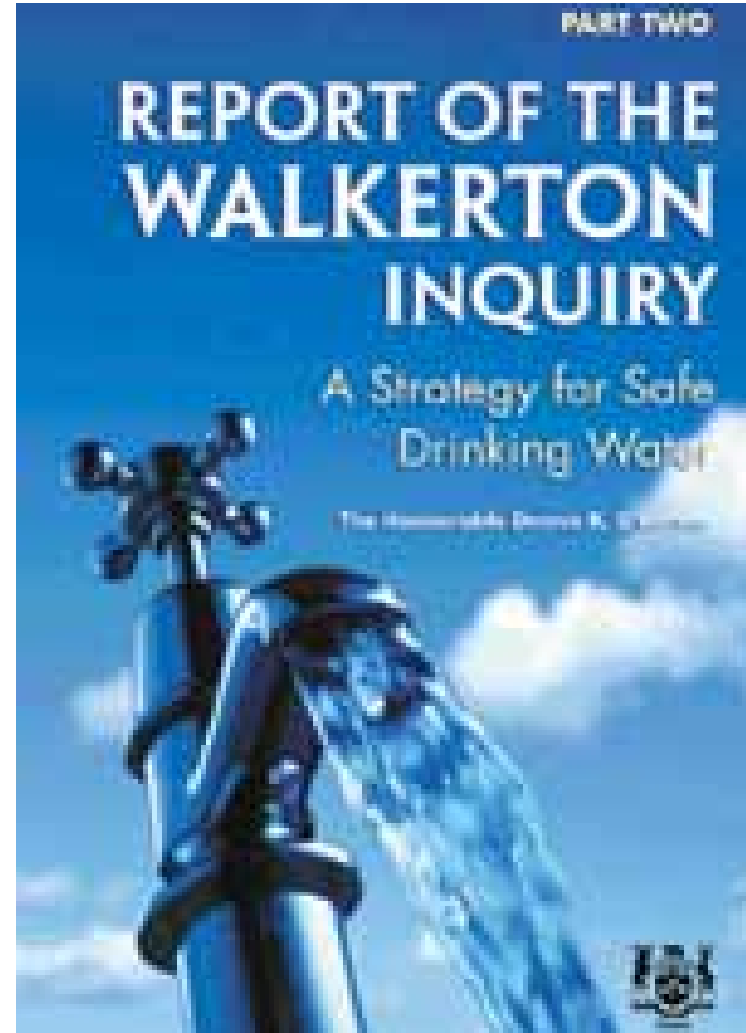
## Groundwater contamination from a waste disposal site



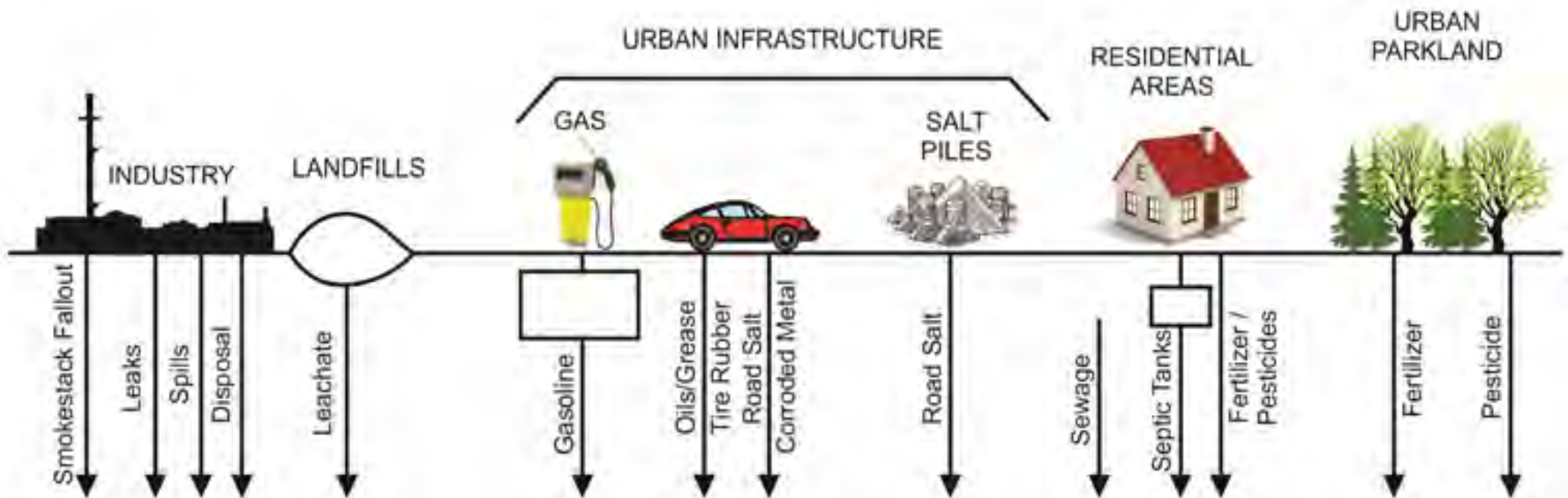
Source: Environment and Climate Change Canada: <https://www.ec.gc.ca/eau-water/>



2000:  
The “**Walkerton tragedy**” resulted in wide awareness of groundwater issues

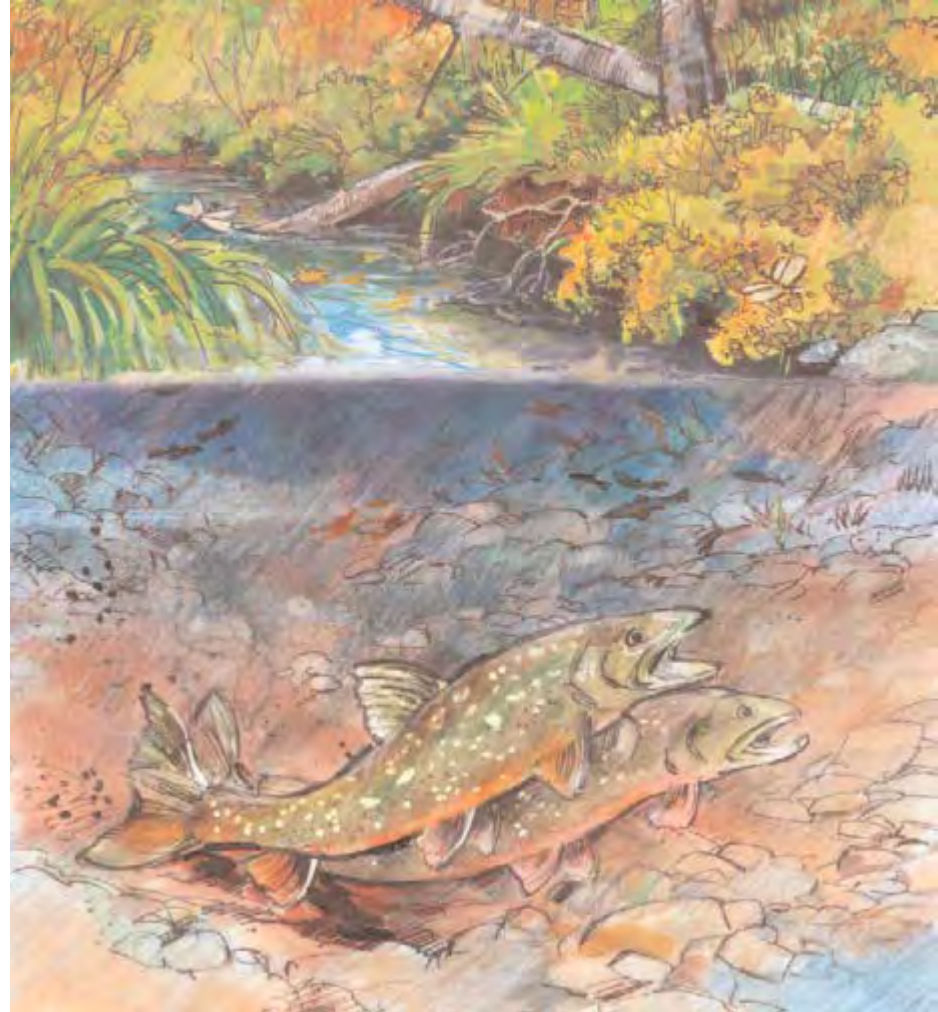


# Growing recognition that groundwater contamination is widespread



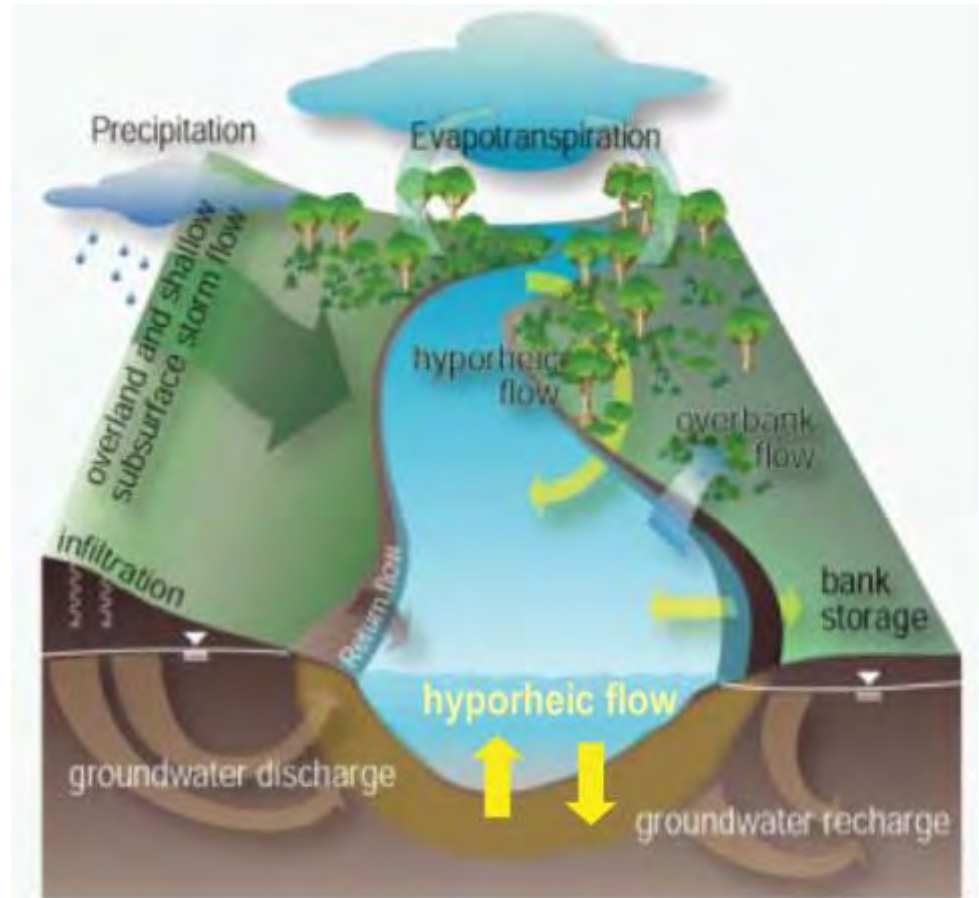
# Groundwater has many positive roles in the Great Lakes Basin

Source: Fisheries and Oceans Canada



# A more complete picture of groundwater is emerging.....

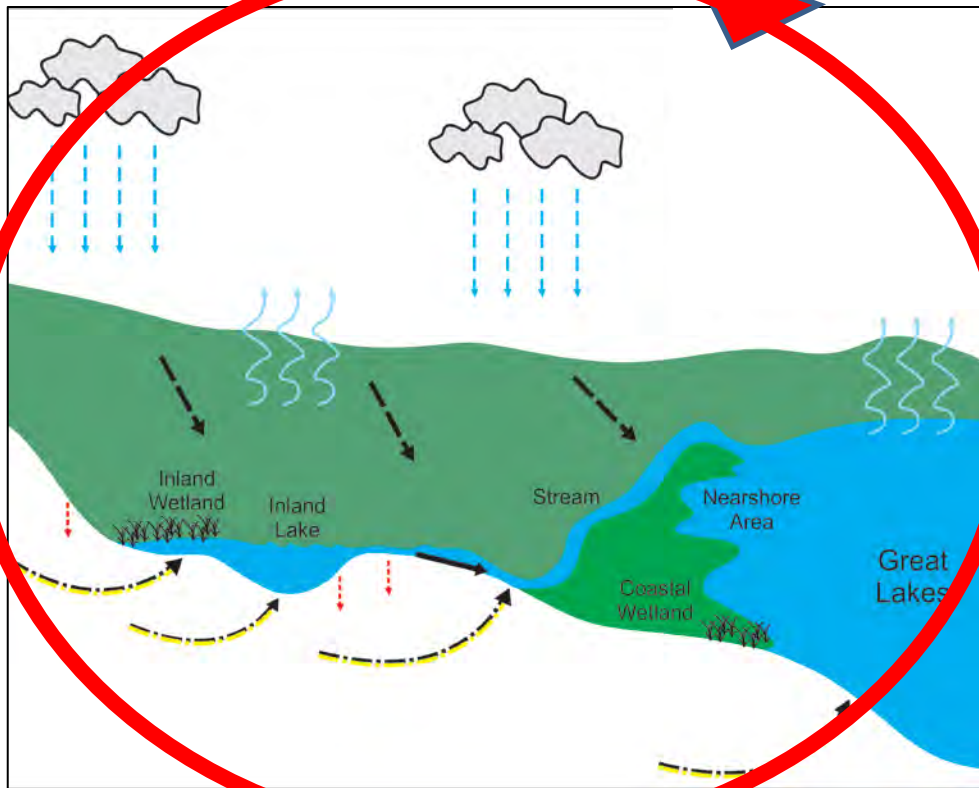
- Its interaction with surface water is complex and happens in both directions



Source: Harvey and Gooseff, 2015


# Latest revision of the GLWQA (2012)


- Provided an opportunity to take a more holistic approach to groundwater




## LEGEND

### Major Components of the Water Cycle


Surface Runoff 

Groundwater Flowpaths 

Stream Flow 

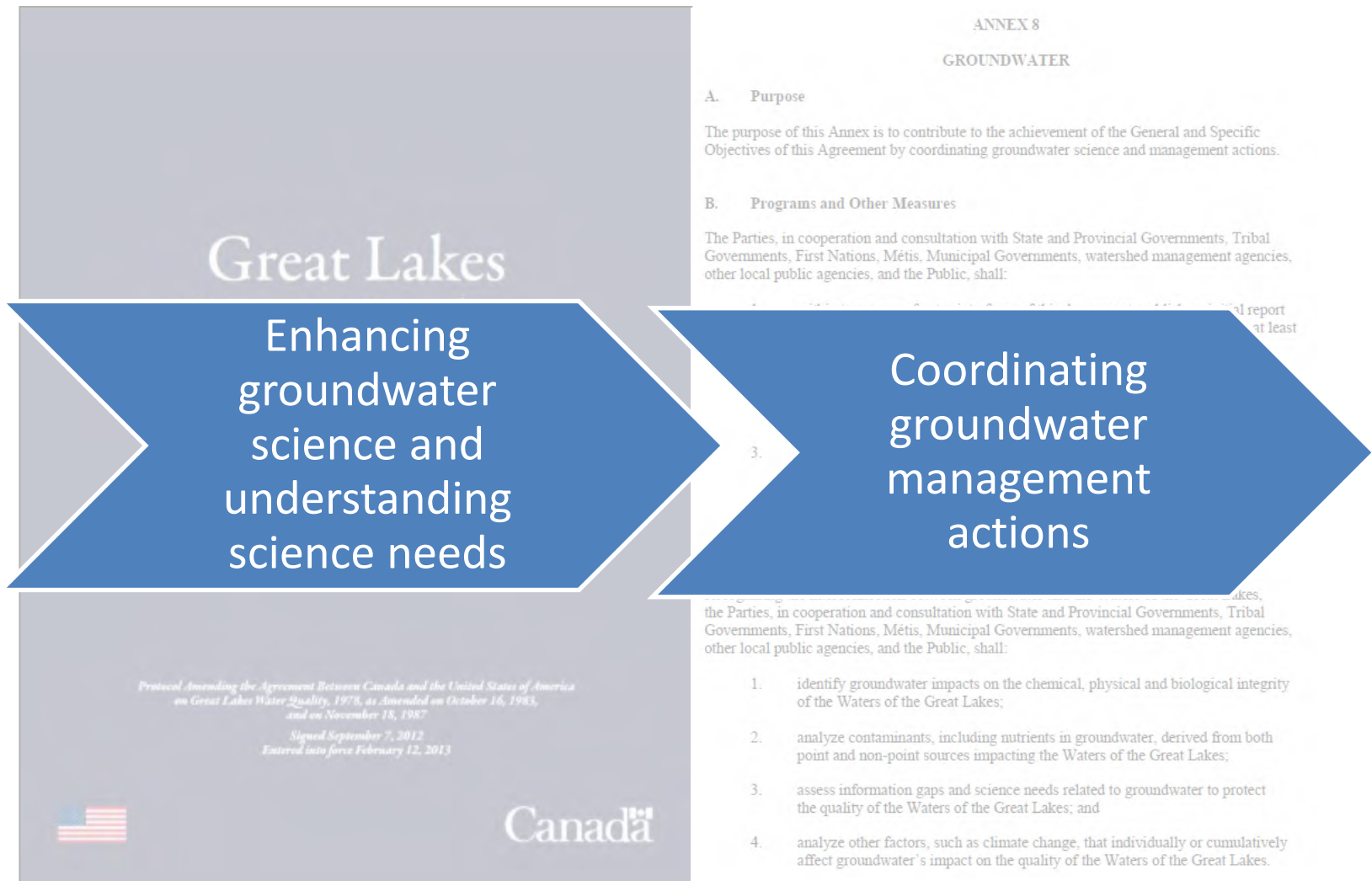
Precipitation 

Evaporation and Evapotranspiration 

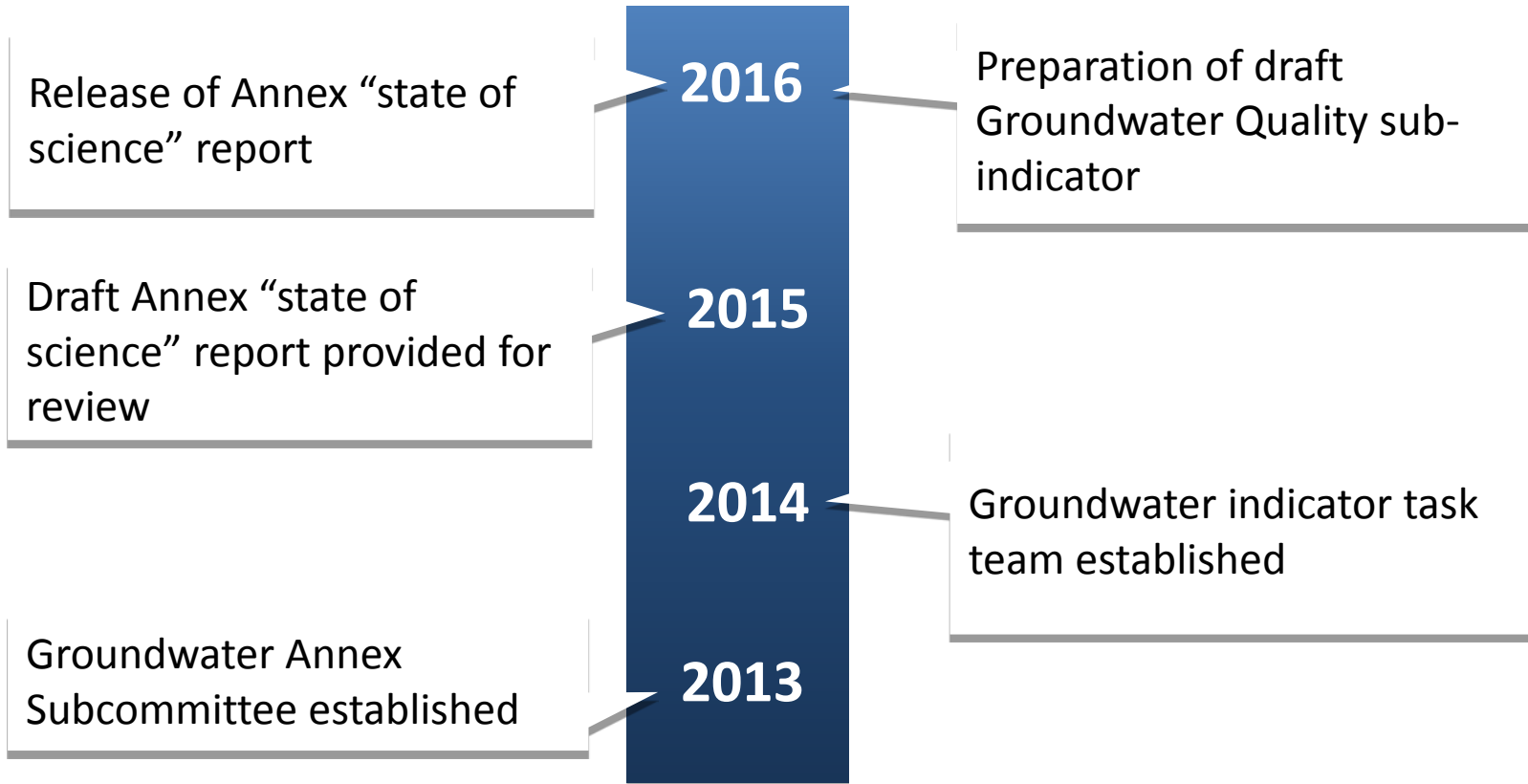
Infiltration and Recharge 



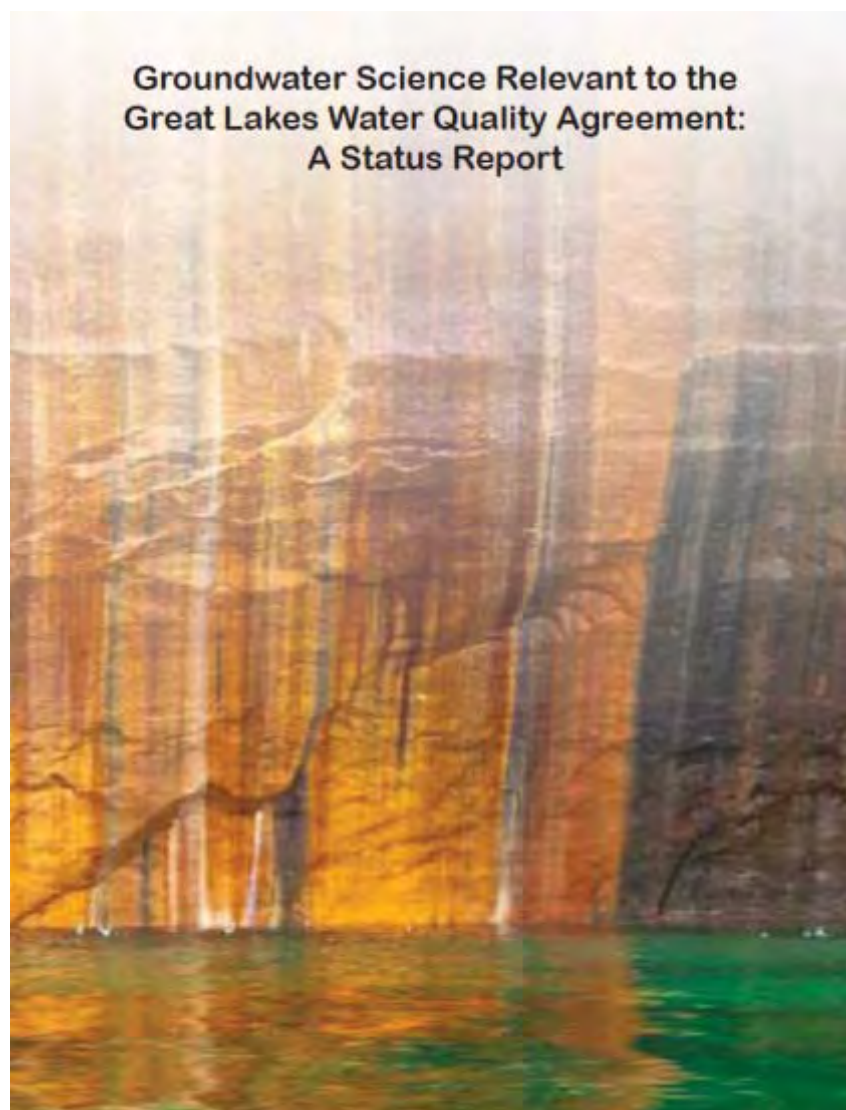
# Groundwater Annex of the 2012 Great Lakes Water Quality Agreement



# Progress has been made: (a) Groundwater Annex report, (b) draft groundwater indicator



The Annex report (2016) summarizes the state of the science, including science gaps





# The Annex report (2016) focuses on multidisciplinary issues

- Coastal wetland along Lake Huron strongly affected by seepage of groundwater

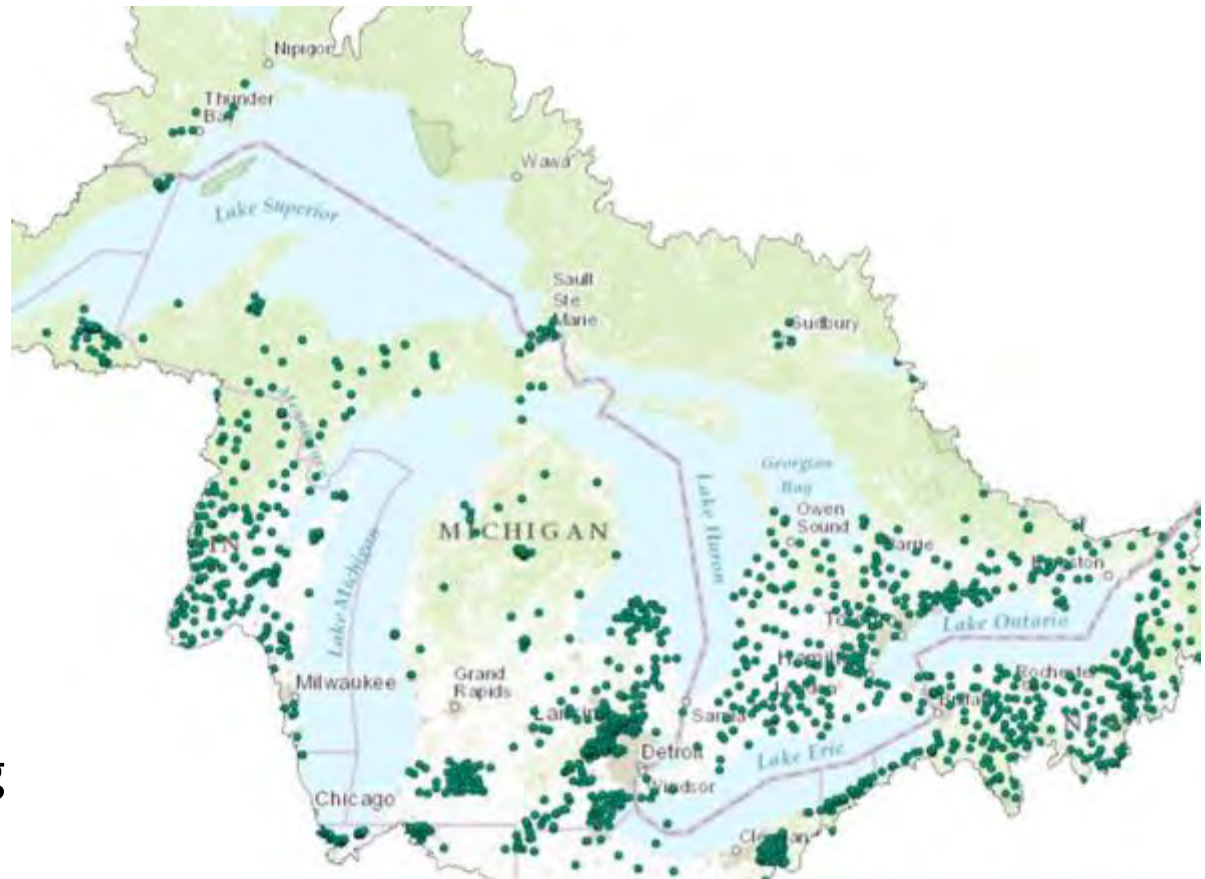


Near Tobermory, Ontario

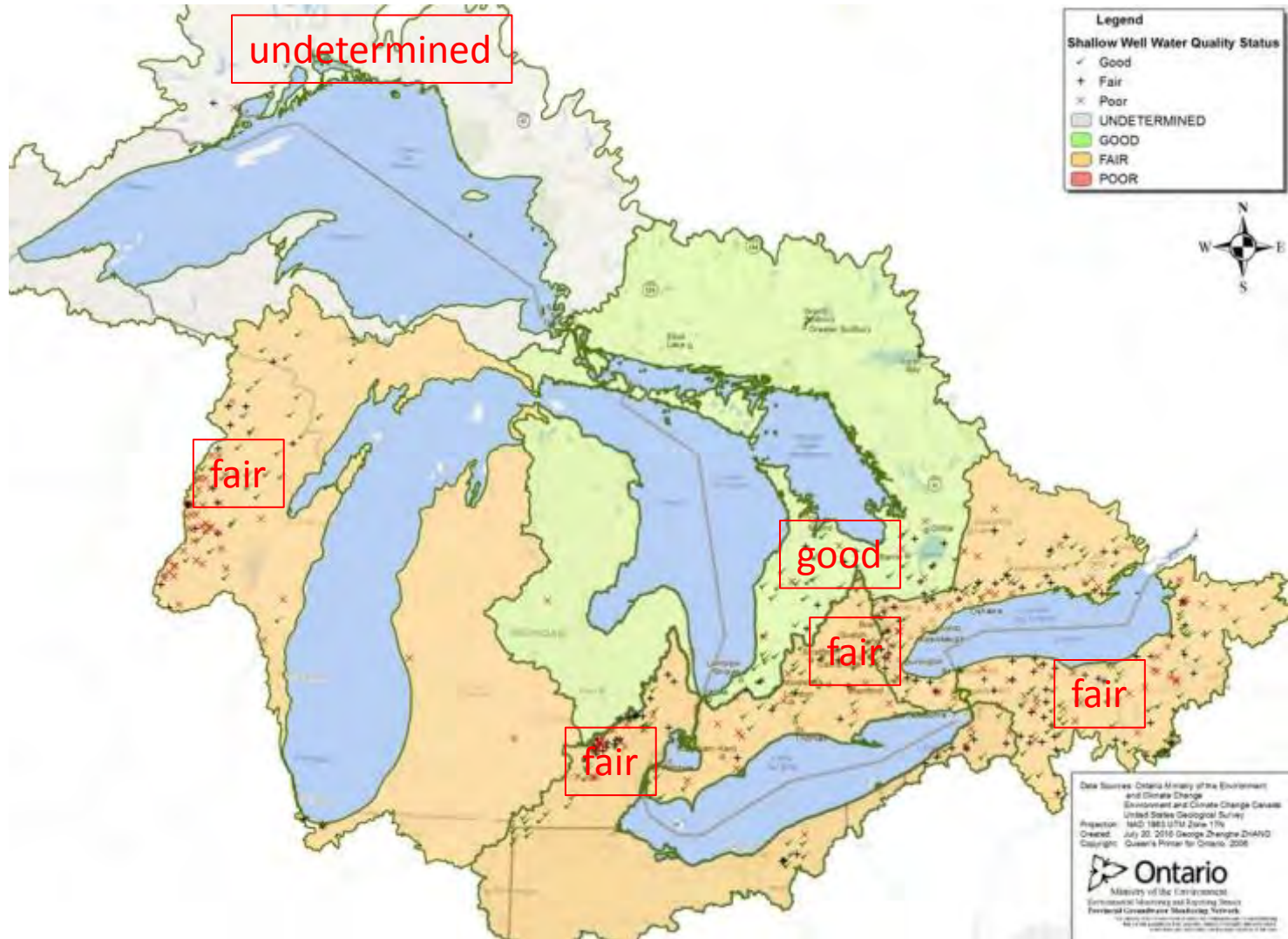
Photo: Martha Allen, Parks Canada Agency.

# The draft “Groundwater Quality sub-indicator” (2016) indicates data gaps

- Last GLWQA Indicator remaining to be developed
- Addresses GLWQA’s General Objective (viii): “be free from the harmful impact of contaminated groundwater”
- Based on data from available monitoring networks (USGS, Ontario MOECC)



# Preliminary assessment based on 2000-2015 nitrate and chloride data from shallow groundwater ( $\leq 40$ m below ground surface)







# Future role of Groundwater Annex: communication and coordination related to binational and domestic actions

**Enhancing groundwater science and understanding science needs**

**Coordinating groundwater management actions**

ANNEX 8  
GROUNDWATER

**A. Purpose**

The purpose of this Annex is to contribute to the achievement of the General and Specific Objectives of this Agreement by coordinating groundwater science and management actions.

**B. Programs and Other Measures**

The Parties, in cooperation and consultation with State and Provincial Governments, Tribal Governments, First Nations, Métis, Municipal Governments, watershed management agencies, other local public agencies, and the Public, shall:

1. within two years of entry into force of this Agreement, publish an initial report
2. within two years of entry into force of this Agreement, publish an initial report
3. identify groundwater impacts on the chemical, physical and biological integrity of the Waters of the Great Lakes;
4. analyze other factors, such as climate change, that individually or cumulatively affect groundwater's impact on the quality of the Waters of the Great Lakes.

*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*

*Signed September 7, 2012*  
*Entered into force February 12, 2013*

# Progress: Domestic Actions

Ontario Geological Survey:  
Ambient Groundwater  
Geochemistry program for  
Sudbury area initiated

2016

Ohio State University:  
Begins project on surface  
water-groundwater and  
dissolved phosphorus

Ontario Geological Survey:  
Release of results of Ambient  
Groundwater Geochemistry  
program for southern  
Ontario

2015

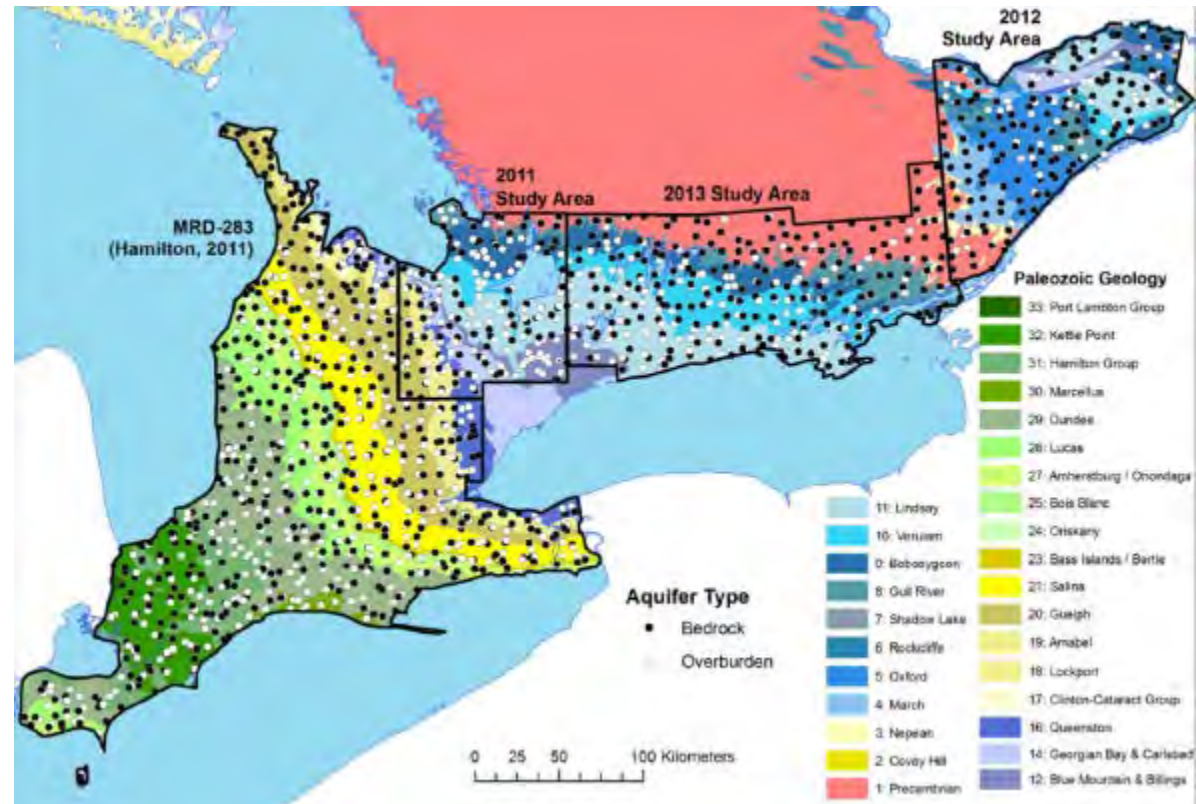
US Geological Survey:  
publishes “Circular on Water  
Quality in Glacial Aquifer  
System” which includes the  
Great Lakes

Environment and Climate  
Change Canada: Initiates a  
groundwater project  
(phosphorus loading to  
surface water) under Lake  
Simcoe/South-eastern  
Georgian Bay Clean-Up Fund

2014

2013

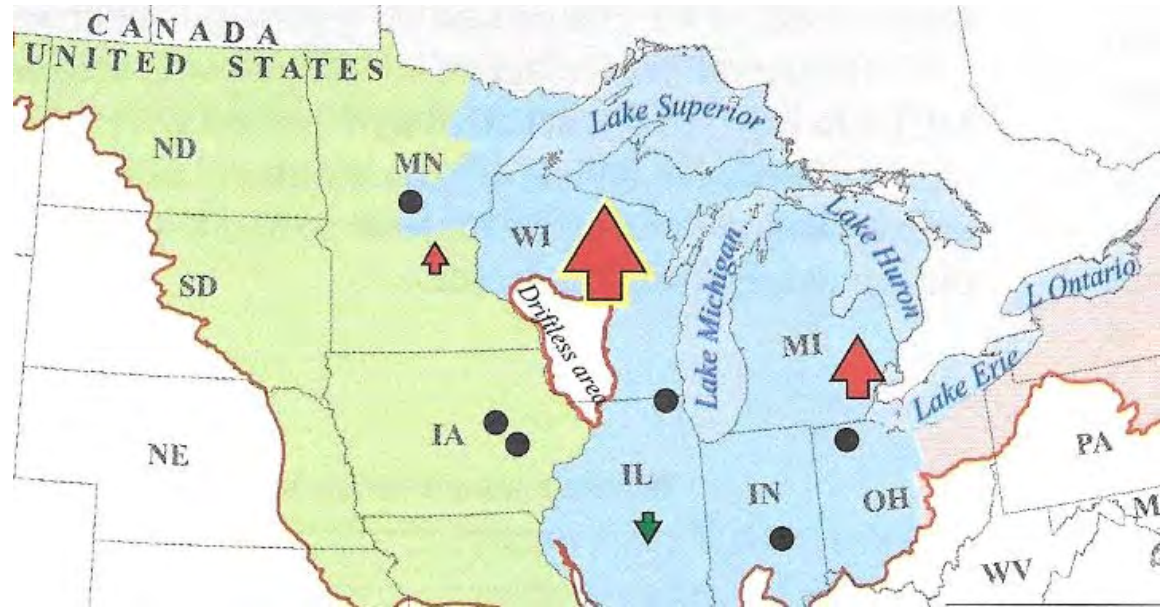
Release of data & maps for southern Ontario  
(*Ambient Groundwater Geochemistry, 2015*)  
provides very detailed “one-time” information



<http://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearch/ambient-groundwater-geochemistry>

# Statistically significant changes in nitrate in groups of wells (1988 to 2010)

USGS Circular 1352: "Water Quality in Glacial Aquifer System in Northern United States" (2014)



## Direction of change    Magnitude of change

Increase

Decrease

(mg-N)/L



Less than 0.1



0.1 to 0.5



Greater than 0.5



No significant change



# Groundwater Annex

## Priorities for Action (2017-19)

### Priority for Action

*1. Develop better tools to assess groundwater – surface water interaction and use them to assess regional-scale flow of groundwater to surface waters in the Great Lakes Basin.*

- Based directly on major science needs identified in the Annex report.
- Projects underway to support this priority: Michigan, Ontario, Natural Resources Canada, universities

# Groundwater Annex

## Priorities for Action (2017-19)

### Priority for Action

*2. Undertake a focused assessment of the geographic distribution of known and potential sources of groundwater contaminants relevant to Great Lakes water quality.*

- Based directly on major science needs identified in the Annex report.
- Projects underway to assess groundwater transport of phosphorus to surface water: Environment and Climate Change Canada, Ohio State University

# Groundwater Annex

## Priorities for Action (2017-19)

### Priority for Action

*3. Advance monitoring, surveillance and assessment of groundwater quality in the Great Lakes Basin.*

- Based directly on major science needs identified in the Annex report.
- Continuation of domestic programs (e.g., monitoring programs, Ontario's Ambient Groundwater Geochemistry)
- Further review, reporting on Groundwater quality sub-indicator