LECTURE 2_14:
MAR. 4, 2014

WATER

WATER QUALITY AND WATER SECURITY & MAP LITERACY 4 (MQ.4)

Text Reference: Dearden and Mitchell (2012), Ch. 11, pp. 383-397.

T. Randall, Lakehead University, WA 2014

Outline

- *Activity:* Map Literacy List #4

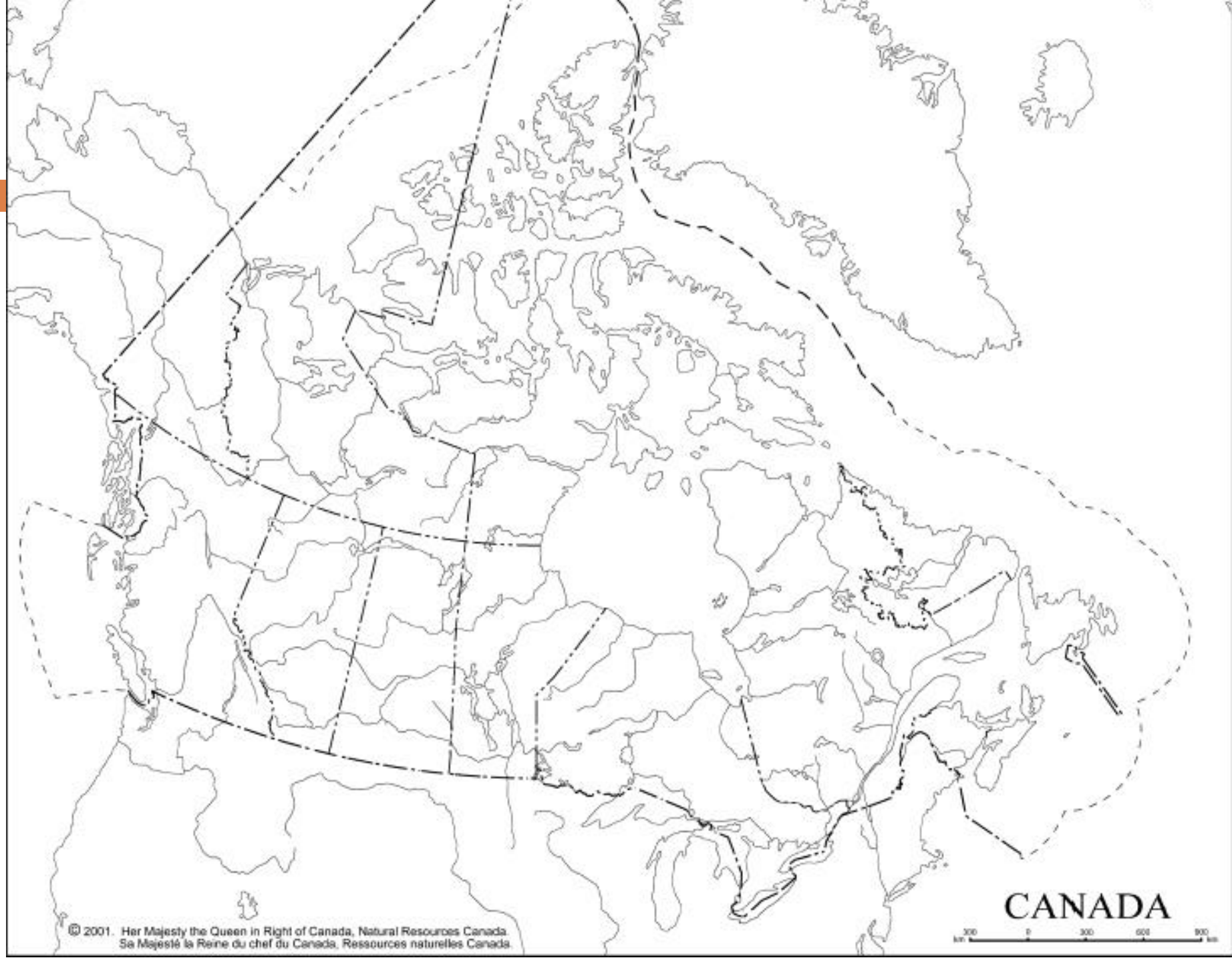
From: Dearden and Mitchell (2012)

- Water Quality
  - Monitoring by Environment Canada in partnership with other jurisdictions;
  - Point / Non-point pollution sources
  - Great Lakes
- Water Security
  - Walkerton and subsequent inquiry

Map Literacy 4

Water lectures

March 4, 2014


CANADA
© 2001. Her Majesty the Queen in Right of Canada, Natural Resources Canada.
Sa Majesté la Reine du chef du Canada, Ressources naturelles Canada.

Map Literacy (list 4, March 4, 2014)

Communities, Jurisdictions

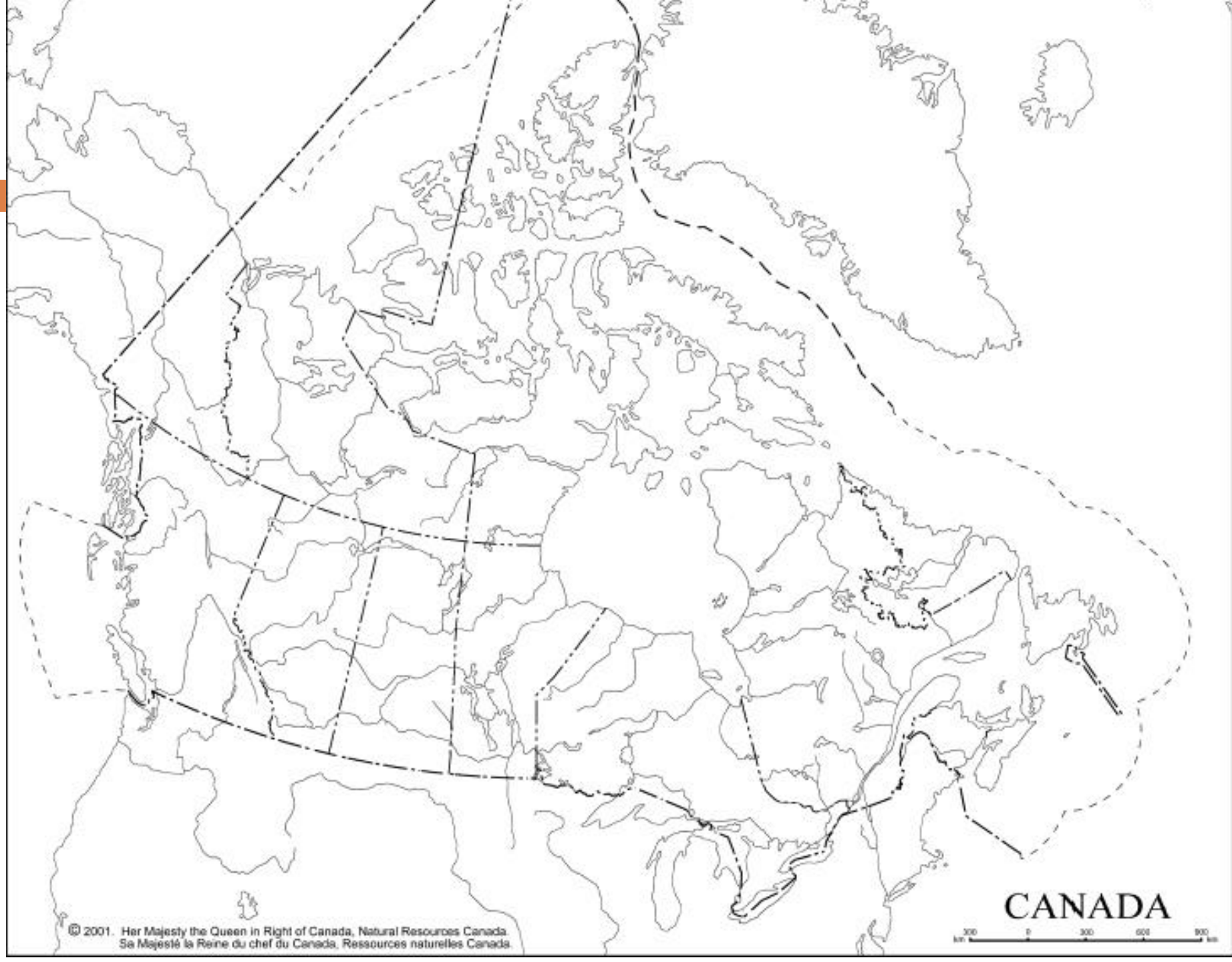
1. Calgary
2. Walkerton, ON

Natural Features

1. Fraser River
2. Columbia River
3. Lake Winnipeg
4. Red River
5. St. Lawrence River
6. James Bay
7. La Grande River
8. Great Bear Lake
9. Great Slave Lake

Basics (4):

- Yellowknife; Lake Huron; Lake Erie; Lake Ontario


CANADA
© 2001. Her Majesty the Queen in Right of Canada, Natural Resources Canada.
Sa Majesté la Reine du chef du Canada, Ressources naturelles Canada.

Recall from Last Lecture

- Water: human interventions in the hydrological cycle
  - Water diversions {dams; inter-basin diversions};
  - 4 reasons for water diversions:
    1. To increase community water supplies;
    2. To protect communities & infrastructure;
    3. To augment / increase river capacity;
    4. To concentrate / consolidate flows (for hydroelectric generation purposes)

Water Diversion

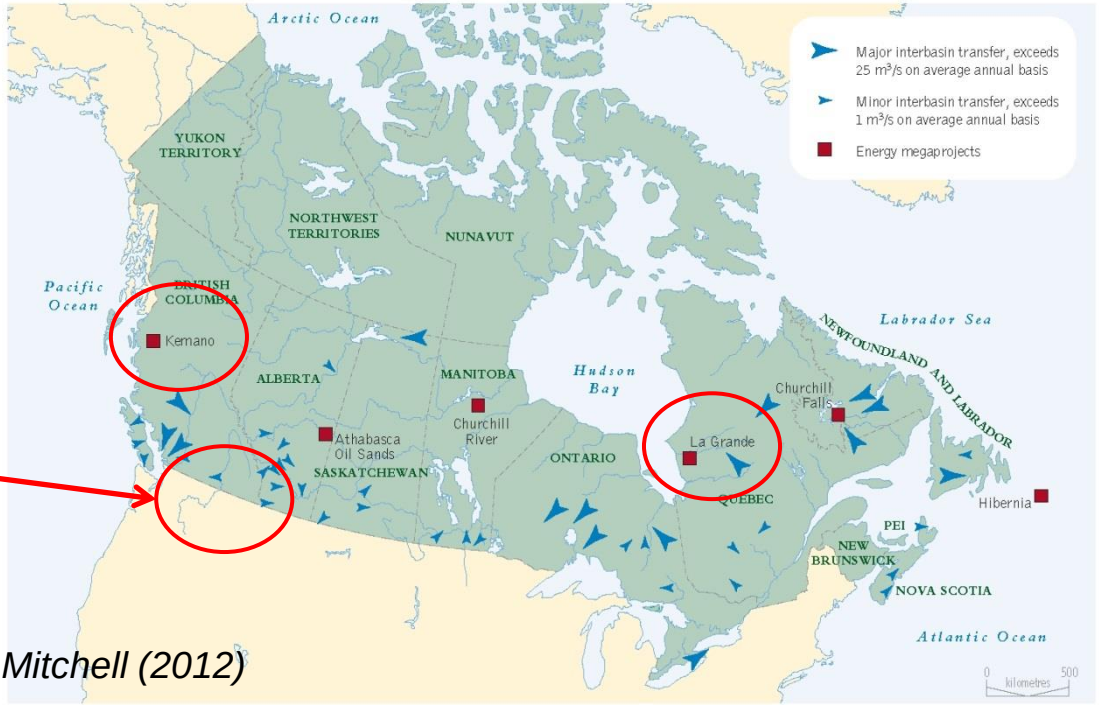
- **Dams**
  - (~900 large ones in Canada)
- **Inter-basin diversions**
  - (~60 large ones in Canada)

~333 (Quebec)

~149 (Ontario)

~131 (British Columbia)

Columbia



From: Dearden and Mitchell (2012)

Figure 11.1 | Hydroelectric megaprojects in Canada. *Source: Adapted from Day and Quinn (1992: 16).*

Red River Floodway

- Significantly abated the 1996 and 1997 flood events

Columbia River Treaty (Can-US)

Revelstoke Dam, completed 1984 but NOT part of Columbia River Treaty dams

http://www.nwd-wc.usace.army.mil/report/colmap.htm

La Grande River (James Bay Pr. Phase I)

- Part of hydro development originally proposed in 1971 to satisfy future electricity needs in Quebec;
- **Phase I: La Grande River**
  - Flow to this basin doubled via diversions from adjacent watersheds;
  - LG2, 3 and 4 constructed; LG1 deferred to Phase II;
  - Phase I completed in 1986
- **Phase II: announced 1985**
  - Energy for export to US;
  - Energy (low cost) to attract energy-intensive industries to PQ

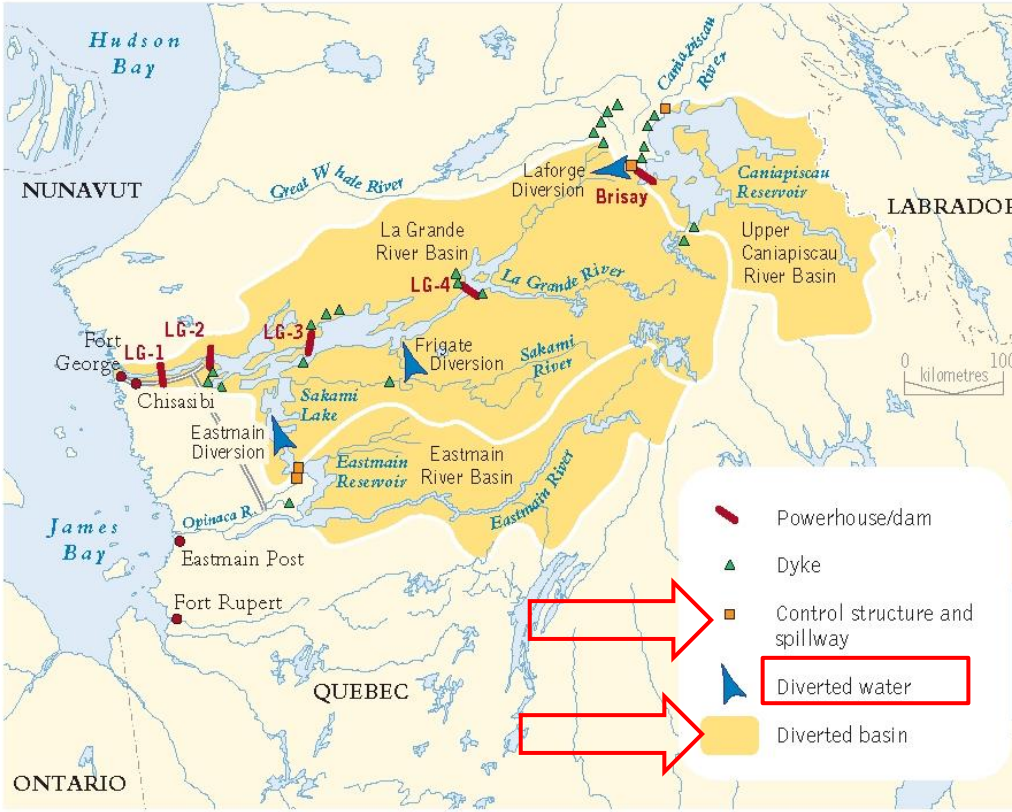


Figure 11.2 | La Grande River hydroelectric development project, Phase 1. *Source: D and Quinn (1992: 134).*

From: Dearden and Mitchell (2012)

James Bay Pr. Phase II (Great Whale Project)

- Like Phase I, continues to encroach on traditional territory of >10,000 Cree and Inuit;
- Encompasses an area ~size of France
- An agreement was reached "James Bay and Northern Quebec Agreement" in 1975 – between govts and these First Nations (the first '*modern*' land claims agreement)
- Agreement included provisions for: 1) land rights; 2) a process to deal with future hydro developments

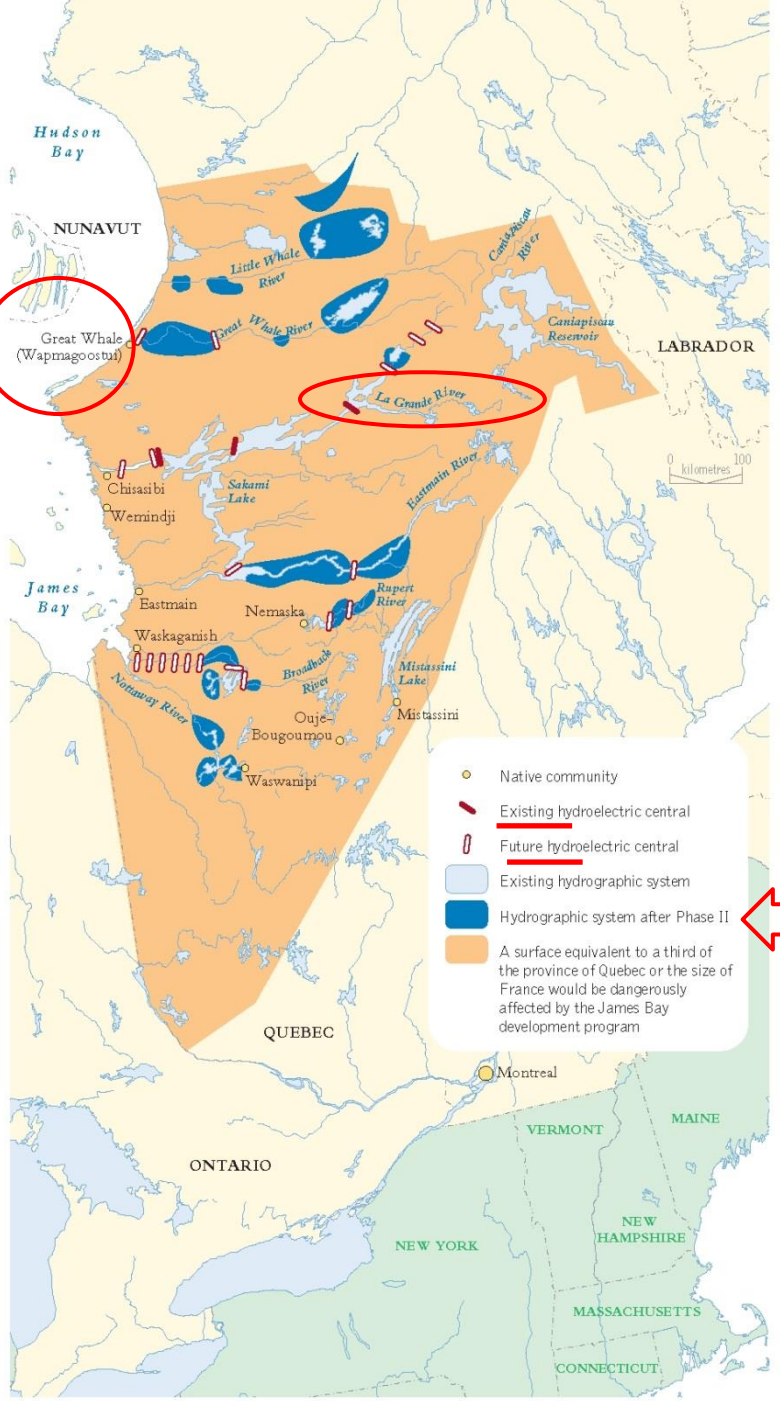


Figure 11.3 | The Great Whale project. *Source: Diamond (1990: 32).*

Outline

- *Activity:* Map Literacy List #4

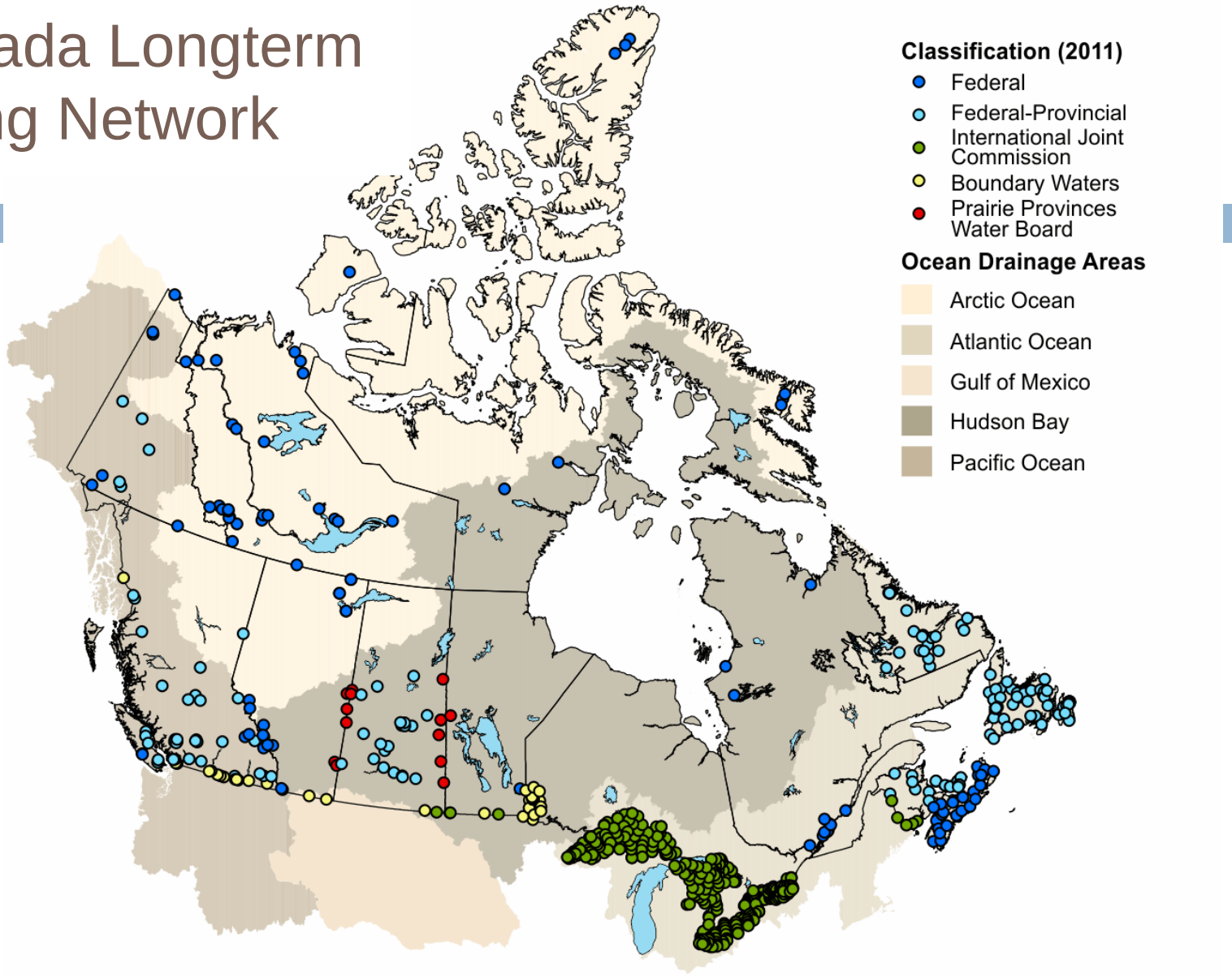
From: Dearden and Mitchell (2012)

- Water Quality
  - Monitoring by Environment Canada in partnership with other jurisdictions;
  - Point / Non-point pollution sources
  - Great Lakes
- Water Security
  - Walkerton and subsequent inquiry

Water Quality Assessments

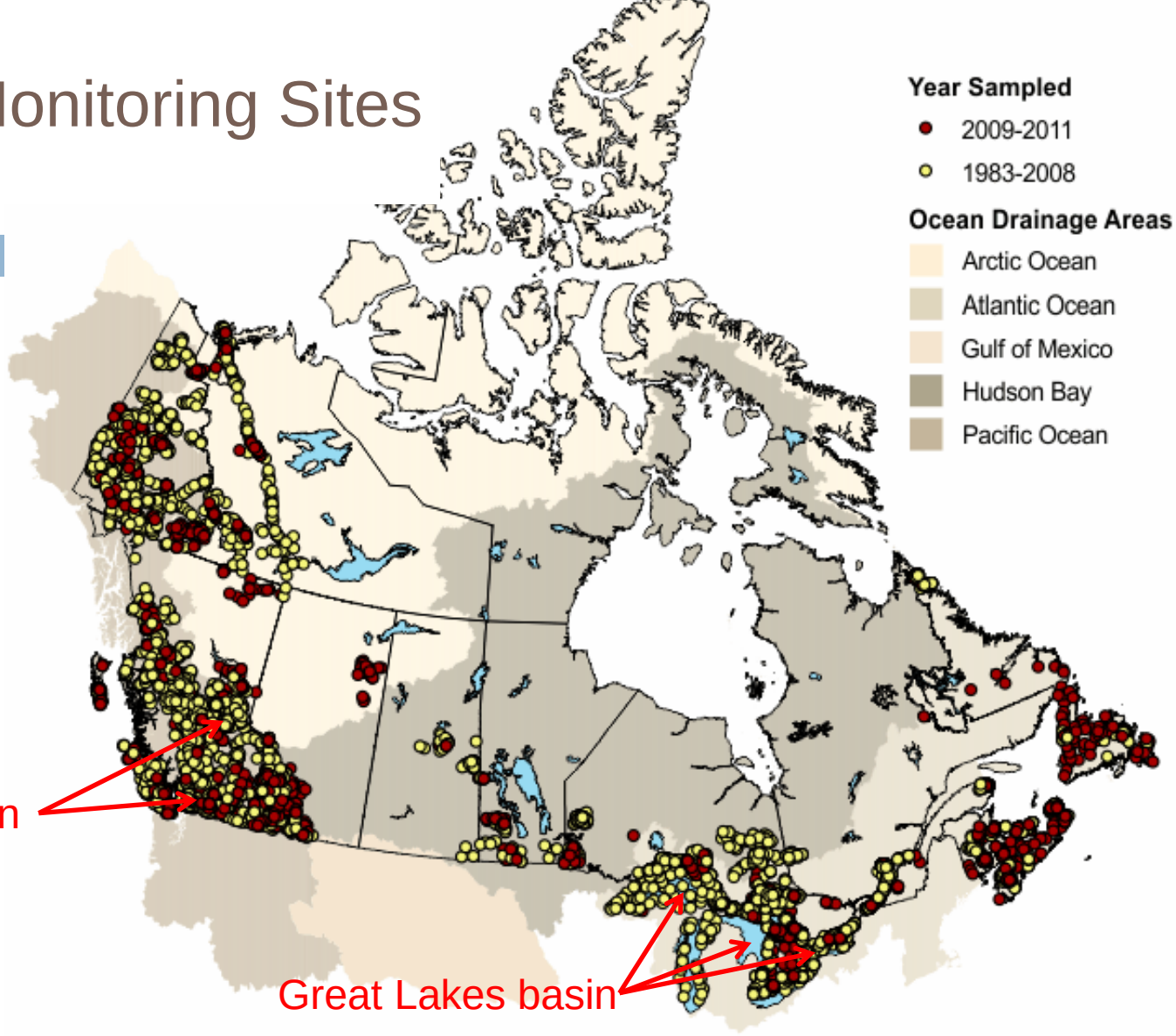
- Via Environment Canada's "*Freshwater Quality Monitoring program*"
- To assess and report on status/trends on the health of aquatic ecosystems, and "the ability of surface waters (rivers, lakes) to protect aquatic life"
- Water quality assessed at selected locations only…. a report in 2010 by Commission of Environment and Sustainable Development (issued by Office of the Auditor General) "*Environment Canada is **not adequately monitoring** the quality and quantity of Canada's surface water resources …*"

Env Canada Longterm Monitoring Network



Measurements regularly include physicochemical parameters such as temperature, pH, alkalinity, major ions, nutrients and metals. The network, intended specifically to supply water quality data in accordance with the Canada Water Act.

CABIN Monitoring Sites



Canadian Aquatic Biomonitoring Network (CABIN), integral part of national water quality monitoring network since 2006, incorporates biological information into traditional physicochemical water monitoring. – grew out of two early 90s pilot projects in the Great Lakes and in BC's Fraser River basin.

Water Quality (status in Canada, ~2006)

- Three key insights from EC (up to 2006)

1. Freshwater at 379 monitoring stations in *southern* Canada

2. Freshwater at 32 monitoring stations in *northern* Canada

Water Quality (status in Canada, ~2006)

- Three key insights from EC (up to 2006)

3. St Lawrence basin (including Great Lakes) – highest 'poor or marginal quality'

poor or marginal **28%**

while Maritime (Atlantic) and Arctic drainage basins have highest 'good' or 'excellent' quality

"good' or 'excellent' **71%**

Sources of Water Pollution

- main sources: Industrial, Urban Wastes (especially wastewater) and Agriculture
- **point sources:** e.g., manufacturing plants or sewage treatment plants
- **non-point sources:** e.g., agricultural and urban runoff; more difficult to identify since they cannot be associated with specific locations

End of pipe (point source) in Great Lakes basin from Dearden and Mitchell (2012)

Industrial point-source on Calumet R (Chicago) from Dearden and Mitchell (2012

Point Sources

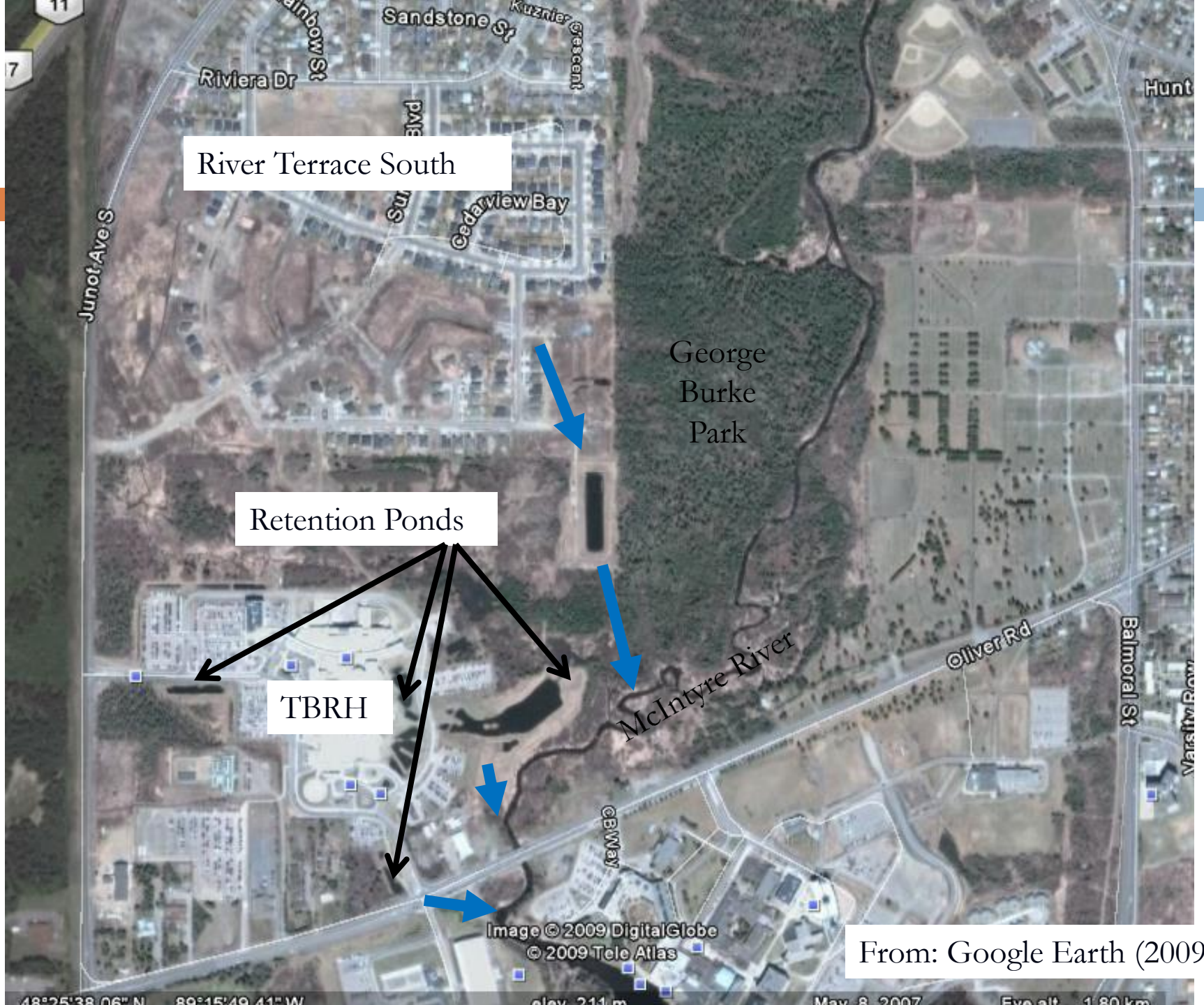
- Urban wastewater receives varying levels of treatment in Canada (Primary, Secondary, Tertiary); **many sewage treatment facilities are old and require expensive maintenance, upgrading, or replacement ("deferred maintenance") .. much of what has not been done;**
  - **Primary treatment** removes insoluble material,
  - **Secondary** removes bacteria, and
  - **Tertiary** removes *some* chemicals and nutrients
- ** There are designated quality levels specified for wastewater treatment, conditional on the nature of the receiving body of water. (cf. Speed River at Guelph WWTP, ON vs. Hamilton WWTP on Lake Ontario)
- Industry is also an important source of wastes
- Runoff from urban areas either flows directly into water bodies from roads and other non-point sources, or can be channelled by stormwater systems

Point Sources

- Industry is also an important source of wastes
- Runoff from urban areas (Stormwater) either flows directly into water bodies from roads and other non-point sources, or can be channelled by stormwater systems

Photo courtesy of NOAA

Series of retention ponds along east side of TBRH structure. Fountains to reduce/prevent mosquito larvae. TBRH site (Fall 2004).



From: Google Earth (2009)

Industry point sources of pollution …

- most prevalent chemicals

Table 11.1 | Top Releases of Chemicals to Water, 2001

Chemical	Releases (tonnes)
Ammonia (total)*	26,106
Nitrate ion in solution at pH equal to or greater than 6.0	22,450
Manganese (and its compounds)	1,157
Methanol	697
Zinc (and its compounds)	308

*Total includes both ammonia (NH_3) and ammonium ion (NH_4+) in solution.

Source: Statistics Canada (2003b: 18).

From: Dearden and Mitchell (2012)

Industry point sources of pollution …

Table 11.2 | Water Bodies Receiving More Than 500 Tonnes of Pollutants, 2001

Water Body	Total Release (tonnes)	Dominant Release	Share of Total Release (%)
Fraser River	9,168	Ammonia*	49.2
Lake Ontario	8,877	Ammonia*	41.6
Bow River	8,264	Nitrate ion	90.8
Ottawa River	3,066	Ammonia*	76.6
North Saskatchewan River	2,953	Nitrate ion	61.3
Red River	2,766	Ammonia*	72.7
Hamilton Harbour	1,516	Ammonia*	70.6
South Saskatchewan River	1,275	Nitrate ion	62.4
St Lawrence River	1,086	Nitrate ion	43.6

*Total includes both ammonia (NH_3) and ammonium ion (NH_4+) in solution.

Source: Statistics Canada (2003b: 18).

From: Dearden and Mitchell (2012)

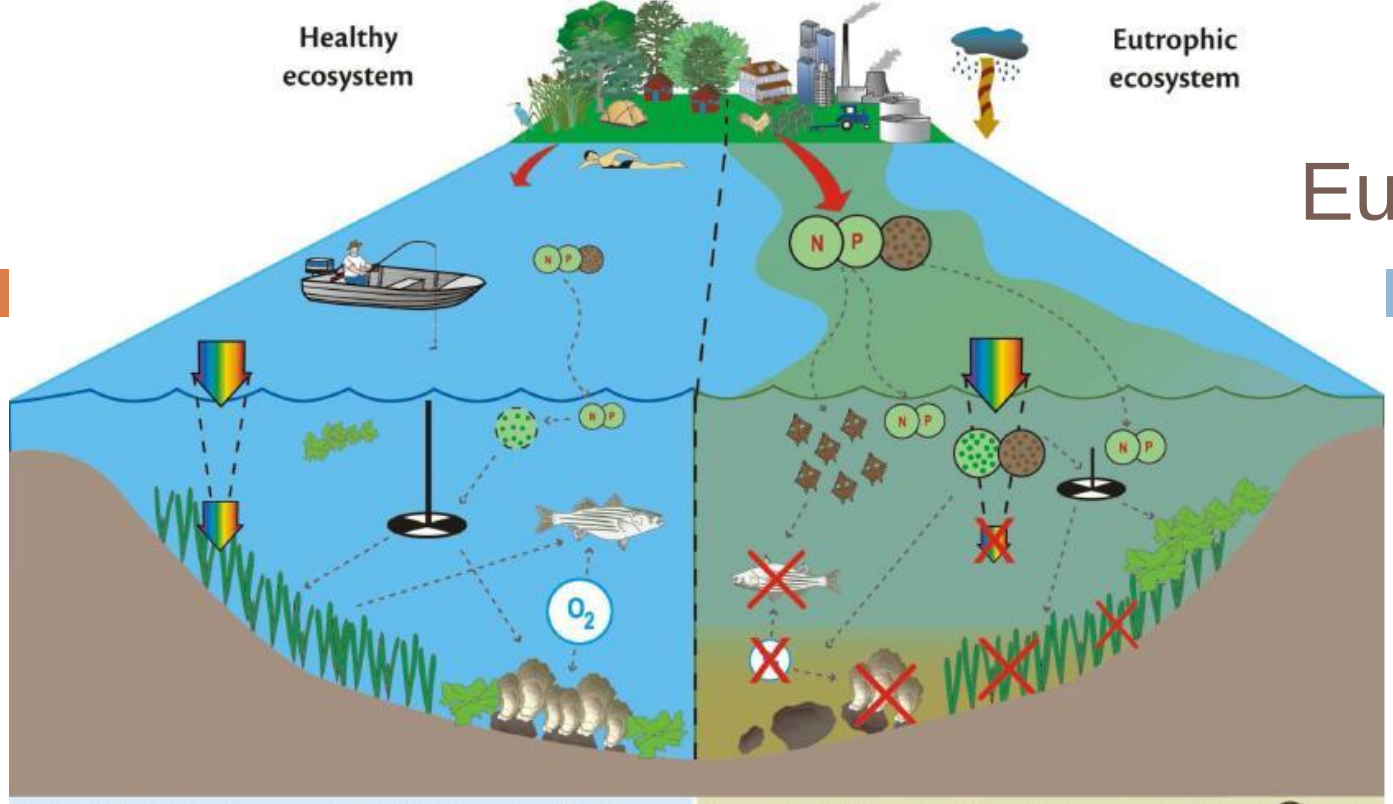
Non-point Sources

- Diffuse pollution has been a policy issue in the Great Lakes Basin since the 1960s – media declared that "Lake Erie was dying"….concerns arose about:
  - sedimentation from soil erosion;
  - eutrophication from nutrient loading; and
  - toxic chemicals

Courtesy of Jim Schafer … Orange-brown water from the Cuyahoga River spills out of Cleveland harbor and into Lake Erie, a regular occurrence during the late 1960s when this photo was taken by members of the city's Bureau of Industrial Wastes.

http://www.cleveland.com/science/index.ssf/2009/06/cuyahoga_river_fire_40_years_a.html

Eutrophication



In healthy ecosystems, nutrient inputs, specifically nitrogen and phosphorus, occur at a rate that stimulates a level of macroalgal and phytoplankton (chlorophyll *a*) growth in balance with grazer biota. A low level of chlorophyll *a* in the water column helps keep water clarity high, allowing light to penetrate deep enough to reach submerged aquatic vegetation. Low levels of phytoplankton and macroalgae result in dissolved oxygen levels most suitable for healthy fish and shellfish so that humans can enjoy the benefits that a coastal environment provides.

In a eutrophic ecosystem, increased sediment and nutrient loads from farming, urban development, water treatment plants, and industry, in combination with atmospheric nitrogen, help trigger both macroalgae and phytoplankton (chlorophyll *a*) blooms, exceeding the capacity of grazer control. These blooms can result in decreased water clarity, decreased light penetration, decreased dissolved oxygen, loss of submerged aquatic vegetation, nuisance/toxic algal blooms and the contamination or die off of fish and shellfish.

From Environment Canada (2011) but adapted by EC from Bricker et al. (2007)

Water Quality Issues

Government of Canada | Gouvernement du Canada

Environment Canada

- Nutrients (phosphorus and nitrogen)

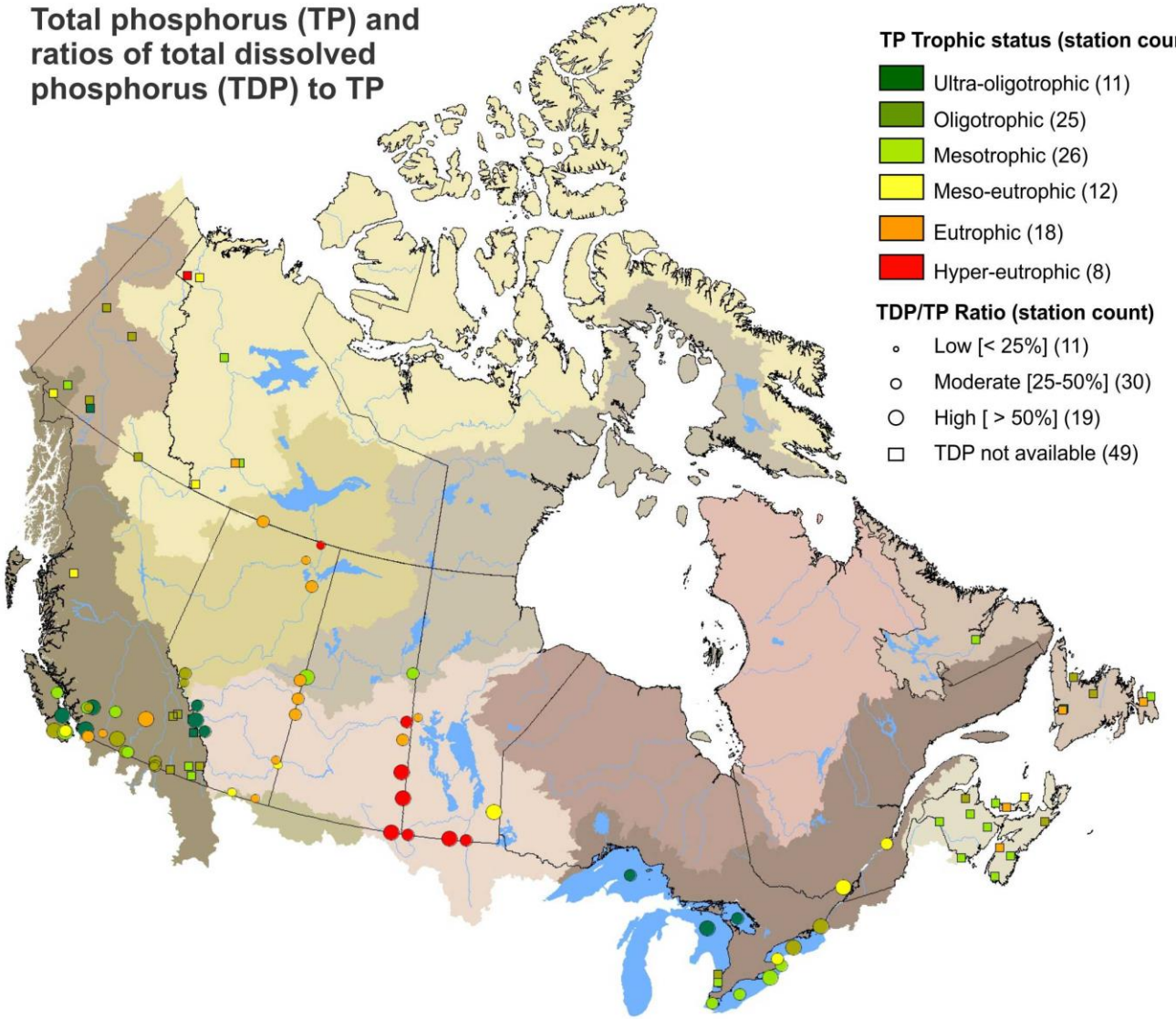
→ Eutrophication … 3 of 5 levels shown below…

"Ultra-oligotrophic"
total phosphorus <0.004 mg/L
low nutrients, low plant growth
high water clarity

"Mesotrophic"
total phosphorus 0.01 – 0.02 mg/L
moderate nutrients/plant growth
reduced water clarity

"Eutrophic"
total phosphorus 0.035-0.100 mg/L
high nutrients/plant growth
very limited water clarity

Environment Canada "*Phosphorus in Canada's Aquatic Ecosystems*" www.ec.gc.ca/



Concentration levels of total phosphorus (TP) and ratios of total dissolved phosphorus (TDP) to TP in rivers and the Great Lakes, Canada, 2004 to 2006. From Environment Canada. ** *Note that some areas have naturally low or high levels of phosphorus.*

The algae blooms

Algal blooms, Sept 2009 on Lake Erie

http://www.noaanews.noaa.gov/stories2013/images/

Above image from 2011 – the worst bloom in decades

- Swathes of blue-green algae (form due to high phosphorus inputs) … big news in 2013 on Lake Erie
- Potential tourism and shipping impacts?

Total Phosphorus Loadings (1976 → 1991) Lake Erie

- initial plans of International Joint Commission (IJC) for Great Lakes in 1970s to reduce municipal loading of nutrients

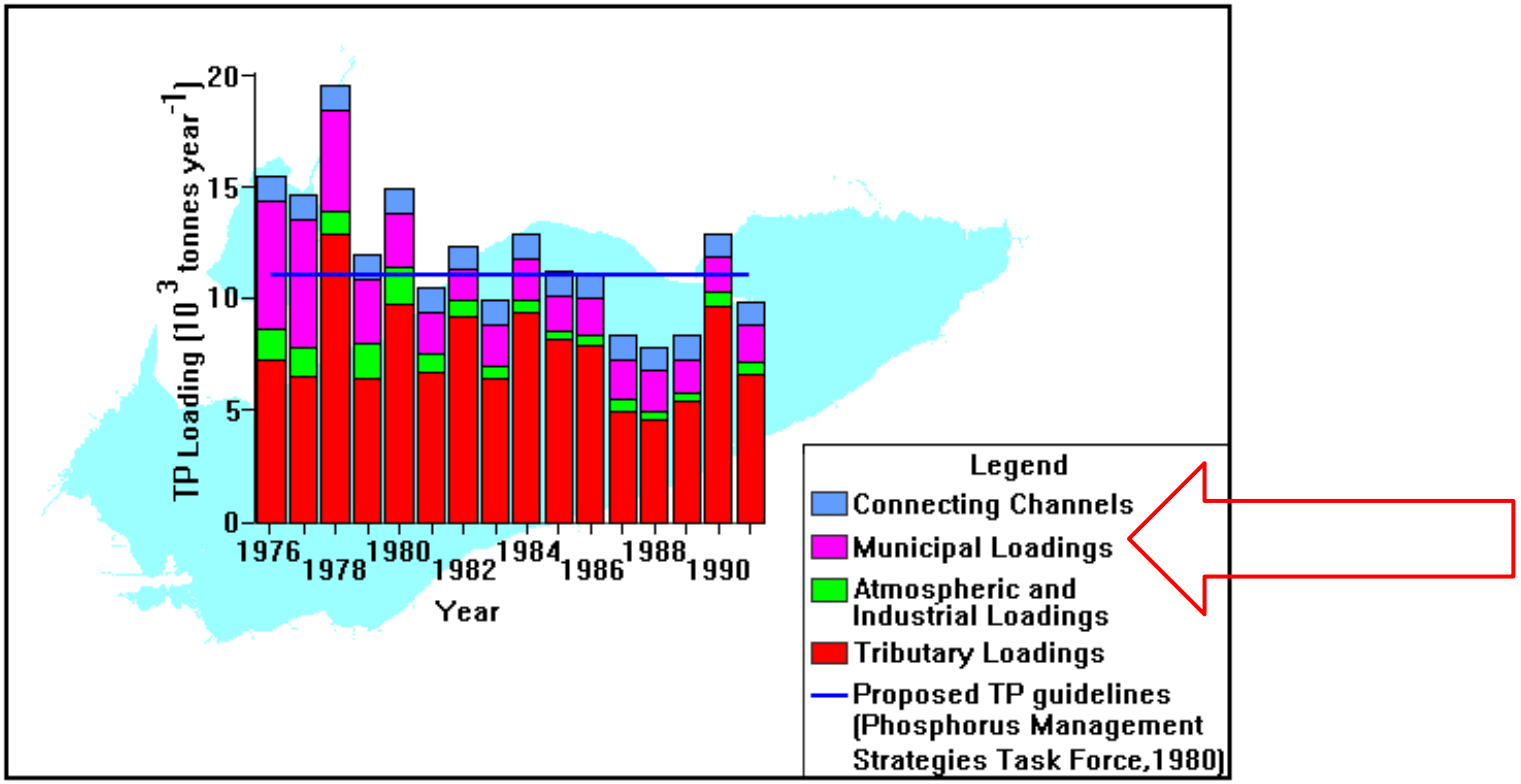


Figure 42 Lake Erie total phosphorus loads (Ref. 22). (Reproduced by permission)

PLUARG : International Reference Group on Great Lakes Pollution from Land Use Activities

- The IJC was asked to study pollution in the Great Lakes from agricultural, forestry and other land uses that are potential non-point sources;
- **the study was completed by PLUARG:**
  - Study focused on (1) eutrophication from elevated nutrients, and (2) toxic contaminants
  - They examined agriculture, urbanization, forestry, transportation, waste disposal, and natural processes;

PLUARG : International Reference Group on Great Lakes Pollution from Land Use Activities

- **PLUARG Study conclusions:**
  - the combined non-point inputs ranged from 32% to 90% of total phosphorus loads;
  - 1976 loads exceeded recommended targets in all the Great Lakes
  - this was the first credible science to document the important contribution of non-point sources to phosphorus loading, and was difficult (for governments) to ignore
  - other findings……

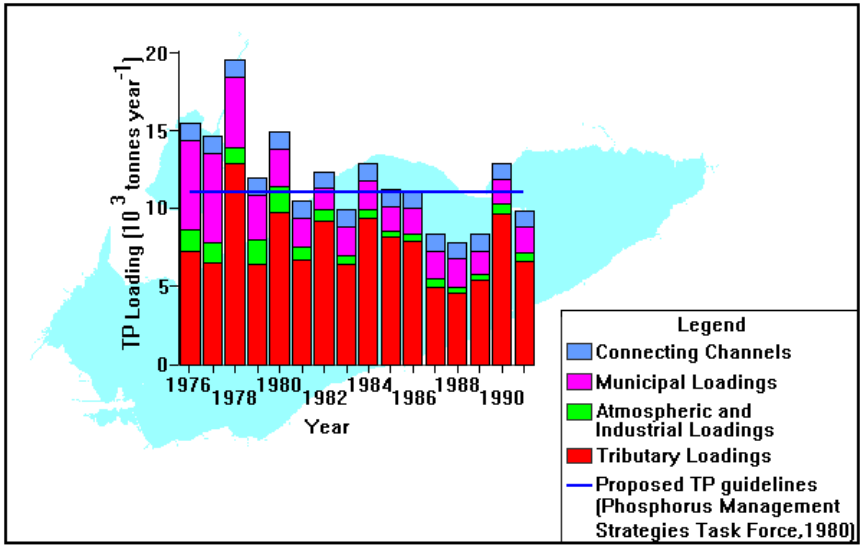


Figure 42 Lake Erie total phosphorus loads (Ref. 22). (Reproduced by permission)

PLUARG : International Reference Group on Great Lakes Pollution from Land Use Activities

- **PLUARG Study conclusions (Other major findings):**
  - Toxic substances such as PCBs were entering from diffuse sources, especially atmospheric deposition
  - Residues of organochlorine pesticides such as DDT were still entering via land drainage
  - Intensive agricultural operations were the main contributor of phosphorus
    - Erosion from crop production and urbanization were main sources of sediment
    - Urban runoff and atmospheric deposition were the major diffuse contributors of toxic substance

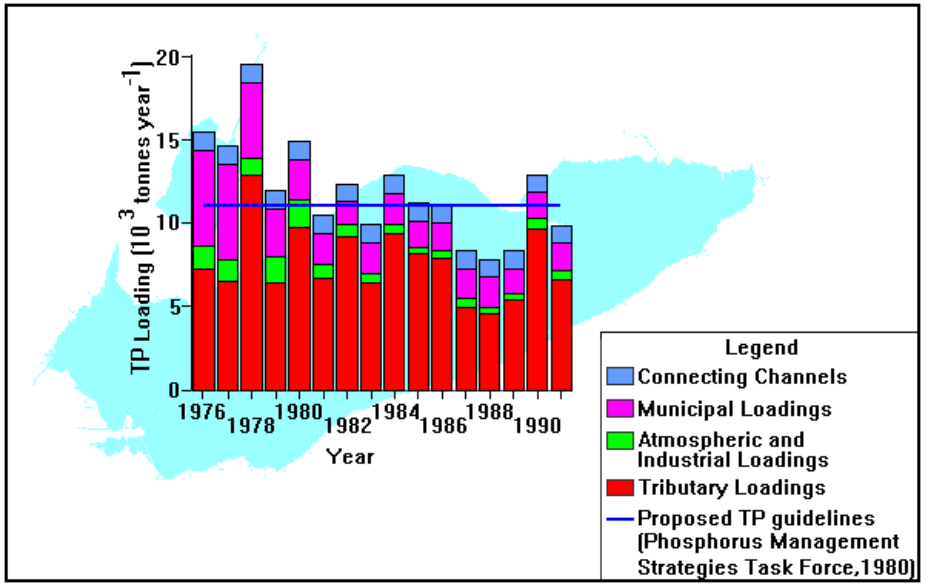
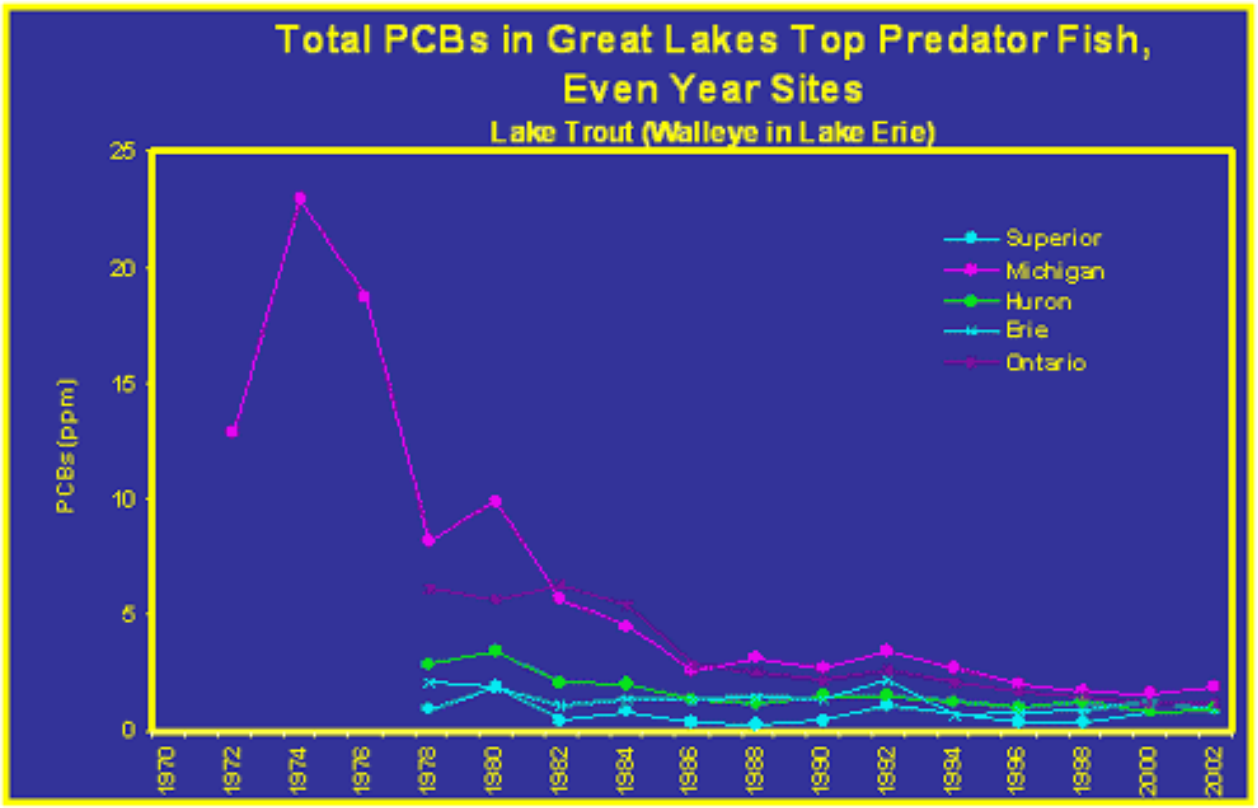


Figure 42 Lake Erie total phosphorus loads (Ref. 22). (Reproduced by permission)

Great Lakes Monitoring



The above graph illustrates that PCB concentrations in Great Lakes top predator fish are declining. However, it is important to note that the concentrations of this contaminant remain above the wildlife protection value of 0.16 ppm and the GLWQA criteria of 0.1 ppm. PCB fish advisories remain in place for all 5 of the Great Lakes.

Source: US Environmental Protection Agency
http://www.epa.gov/glindicators/fishtoxics/topfishb.html

Water Security

A daily necessity…

- A key concern in water management is to provide enough water of adequate quality for human use
- As of 2010, over 1 in 6 people on Earth lacked access to safe water supplies, and 2 of 5 had no access to adequate sanitation
- Per capita water use varies widely, from under 20 litres/day to over 500 l/day in countries like Canada
- minimums for human health is 3L/day in temperate climates; 5L/day in tropical areas;

Per Capita Water Use (Canada vs …)

Comparison of per capita residential water consumption (from Sharratt *et al.*, 1994) and costs (from Environment Canada, 1992).

jurisdiction	**water consumption (L/c/d)**	**water prices (1989 $CAD/m^3)**
USA	426	0.42
Ontario	***300***	***0.36***
Sweden	200	0.78
Germany	150	1.33
France	150	0.86
Australia	n/a	1.47

Notes: L/c/d = Litres per capita per day; 1000 L = 1 m^3.

Canadian water use …

- Most Canadians have access to treated, municipal water; others depend on private wells
- Canadians in rural areas use groundwater
- The relative abundance of water in Canada, the high levels of water use, and the myth of superabundance make most Canadians complacent about the adequacy and safety of their water supplies
- This changed in 2000, when the small town of Walkerton, Ontario experienced contamination of its water supply system by Escherichia coli .. in which 7 people died and >2,300 people became ill

The Walkerton Inquiry

- **A public inquiry established that:**
  - A well had been contaminated by manure, despite proper manure-spreading methods;
  - Chlorination equipment was being repaired and would have prevented contamination if it were operating;
  - Provincial government approval and monitoring programs were inadequate;
  - Well operators were not trained and there was a history of improper operating practices;
  - The water manager withheld adverse water quality information, delaying a boil-water advisory;
  - Government water-testing labs had been shut down due to budget cuts, and private labs weren't required to submit results;

Walkerton: Lessons and Recommendations

- **Inquiry recommended a multi-barrier approach to drinking water safety with**:
  - A comprehensive watershed management approach
  - A watershed-based source-protection plan framework
  - Planning at the local watershed level by those most affected, to ensure goodwill and acceptance
- Since this report, this approach has been adopted by other federal and provincial governments, Walkerton residents have been compensated financially, the Walkerton Clean Water Centre opened, and training has been provided across Ontario

Looking Ahead to the next lectures

Thursday, March 6th: “Water as a Hazard, its management and ethics around water”

Read ahead (Chpt. 11, Water, pp. 397 → 416)

References

- Dearden, P and Mitchell, B. 2012. *Environmental Change and Challenge*, Fourth Edition, Don Mills, Ontario: Oxford University Press {Chapter 11: 'Water'}

- Environment Canada. "About Fresh Water Quality Monitoring & Surveillance" http://ec.gc.ca/eaudouce-freshwater/default.asp?lang=En&n=50947E1B-1