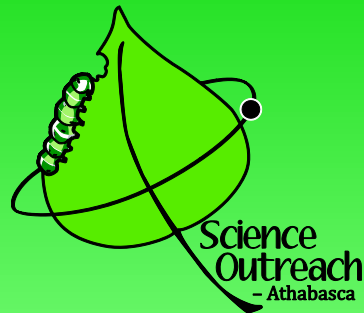


Athabasca River Basin: from glacier to delta

Robert G. Holmberg
Emeritus Professor, Athabasca University



Objectives of Presentation

- Why work with a river basin?
- What is the Athabasca River Basin?
 - Physical features of the ARB
 - Why the ARB is important
 - Concerns about the ARB
- Athabasca University and the ARB

Definition

Area of land where precipitation drains into a stream or lake =

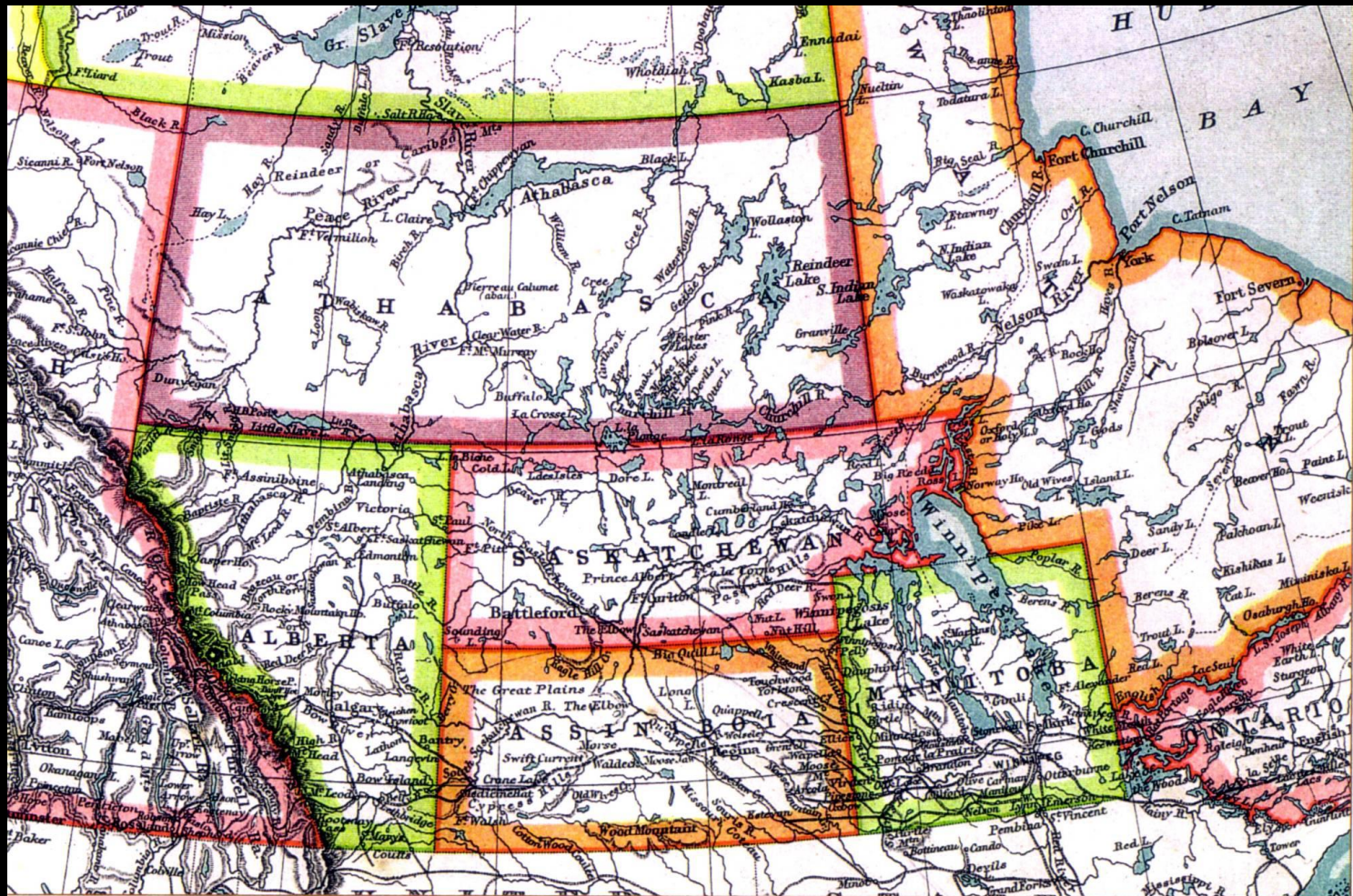
- catchment area
- drainage basin
- watershed



Why work with a river basin?

1. Stability of water & land areas versus changing political boundaries

Example:
Western
Canada,
1905



Example:

Fort McMurray Boundaries

- Fort McMurray (Hudson Bay Company) 1870
- Village of McMurray (with Waterways) 1947
- Town of McMurray 1948
- Town of Fort McMurray 1962
- City of Fort McMurray 1980
- Regional Municipality of Wood Buffalo (merged with Improvement District 143) 1995

Data: Wikipedia, 30 Dec. 2009

Photo: R.G. Holmberg, 2005

Why work with a river basin?

2. Integration & accumulation of impacts on water, land & organisms

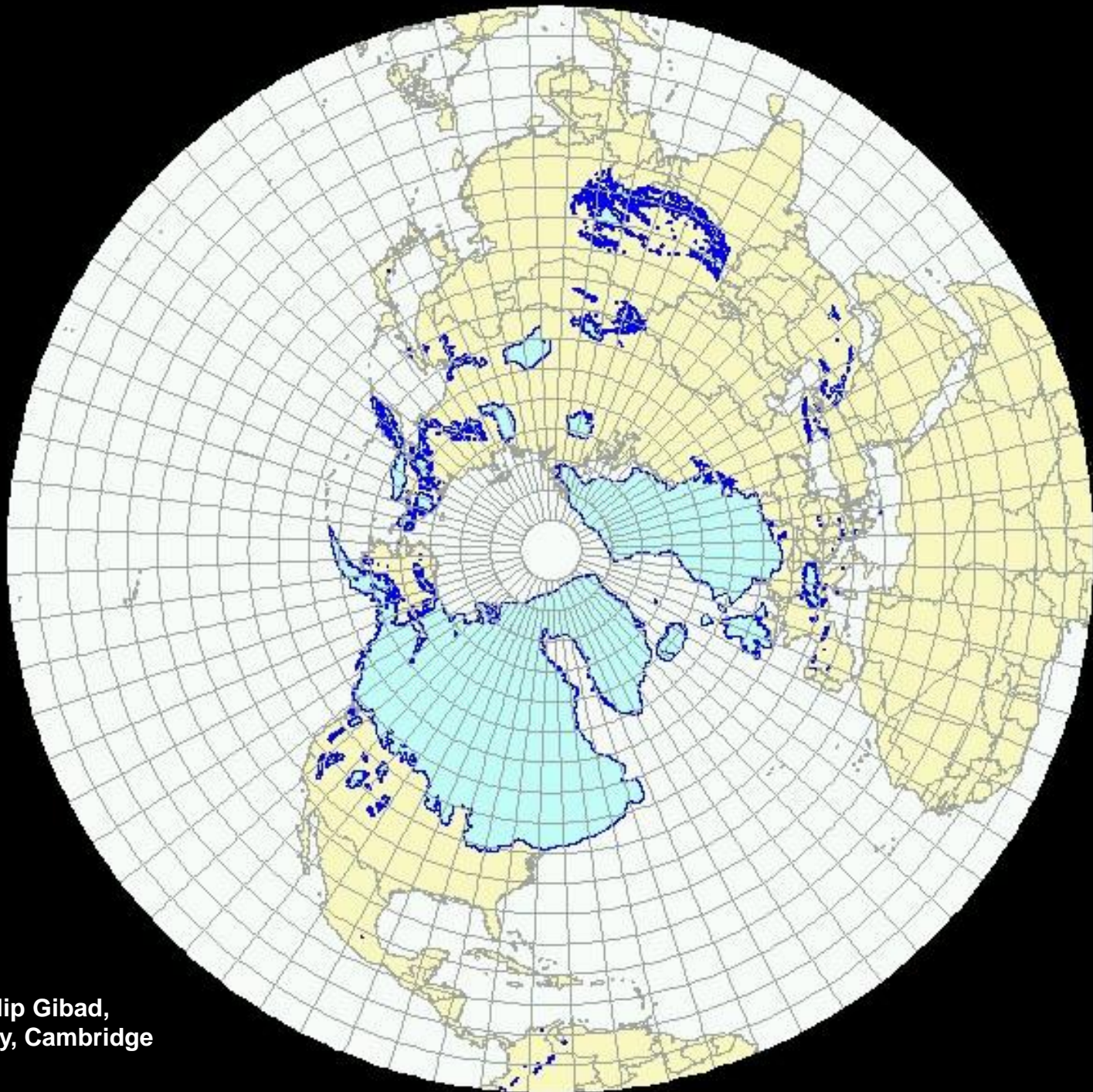
Photo: Athabasca River near Athabasca, 2007, R.G. Holmberg

Why work with a river basin?

3. Implications for humans:

- ecological sustainability**
- health**
- water, food, fibre, minerals & energy**
- economic sustainability**

**Maximum
extent of
last
glaciation
(21,000-14,000
years before
present)**



Source: Jürger Ehlers and Philip Gibad,
2004 via Cambridge Quaternary, Cambridge
University, 2005

Alberta River Basins

- 7 basins
- 5 sub-basins of the Saskatchewan

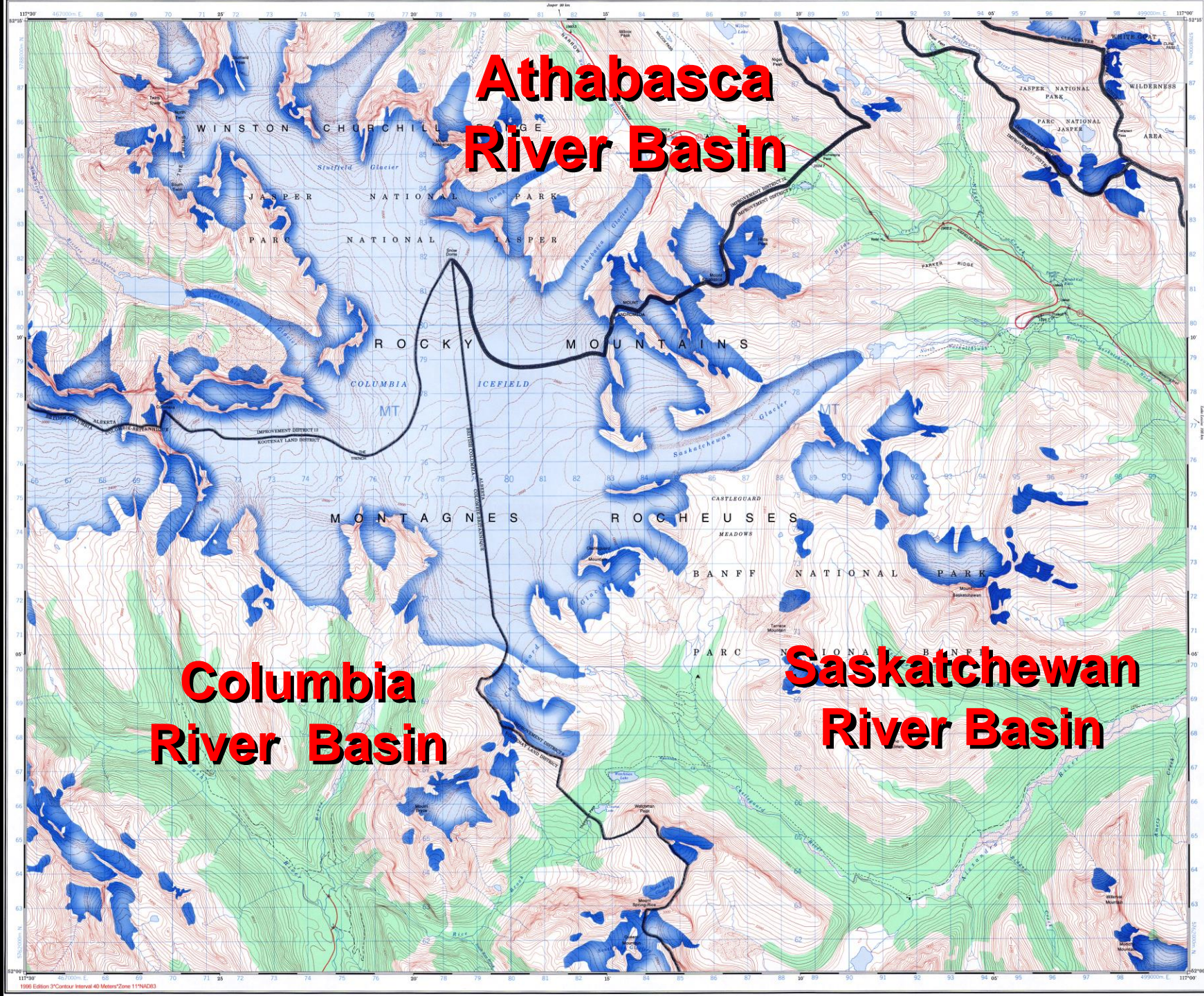


What is the Athabasca River Basin (ARB)?

- ~1,230 km long
- ~133,000 km²
- >101 tributary rivers
- >307 named creeks
- >328 named lakes
- no dams or reservoirs

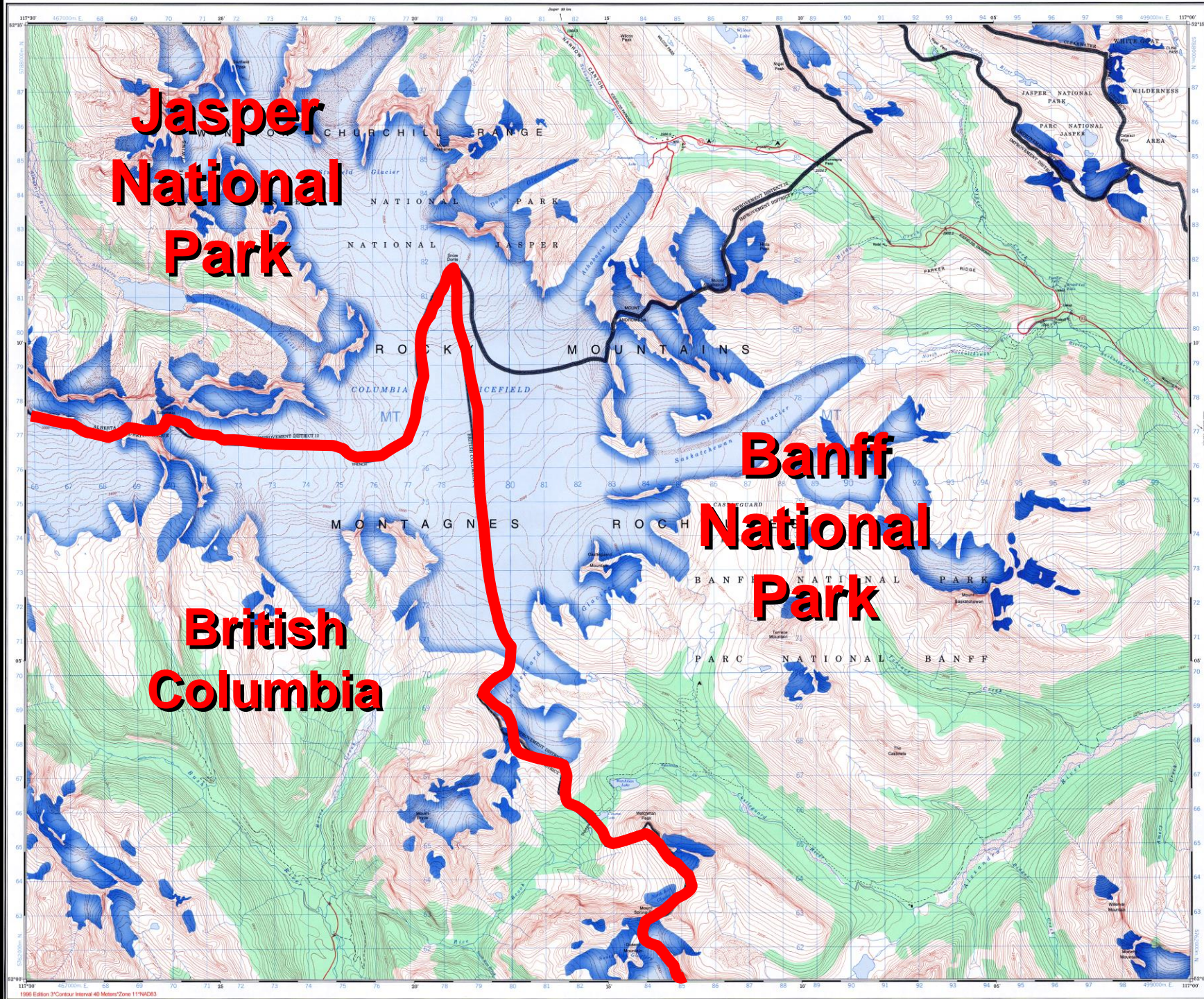


Columbia Ice Field



Some river basins are used as political boundaries ...

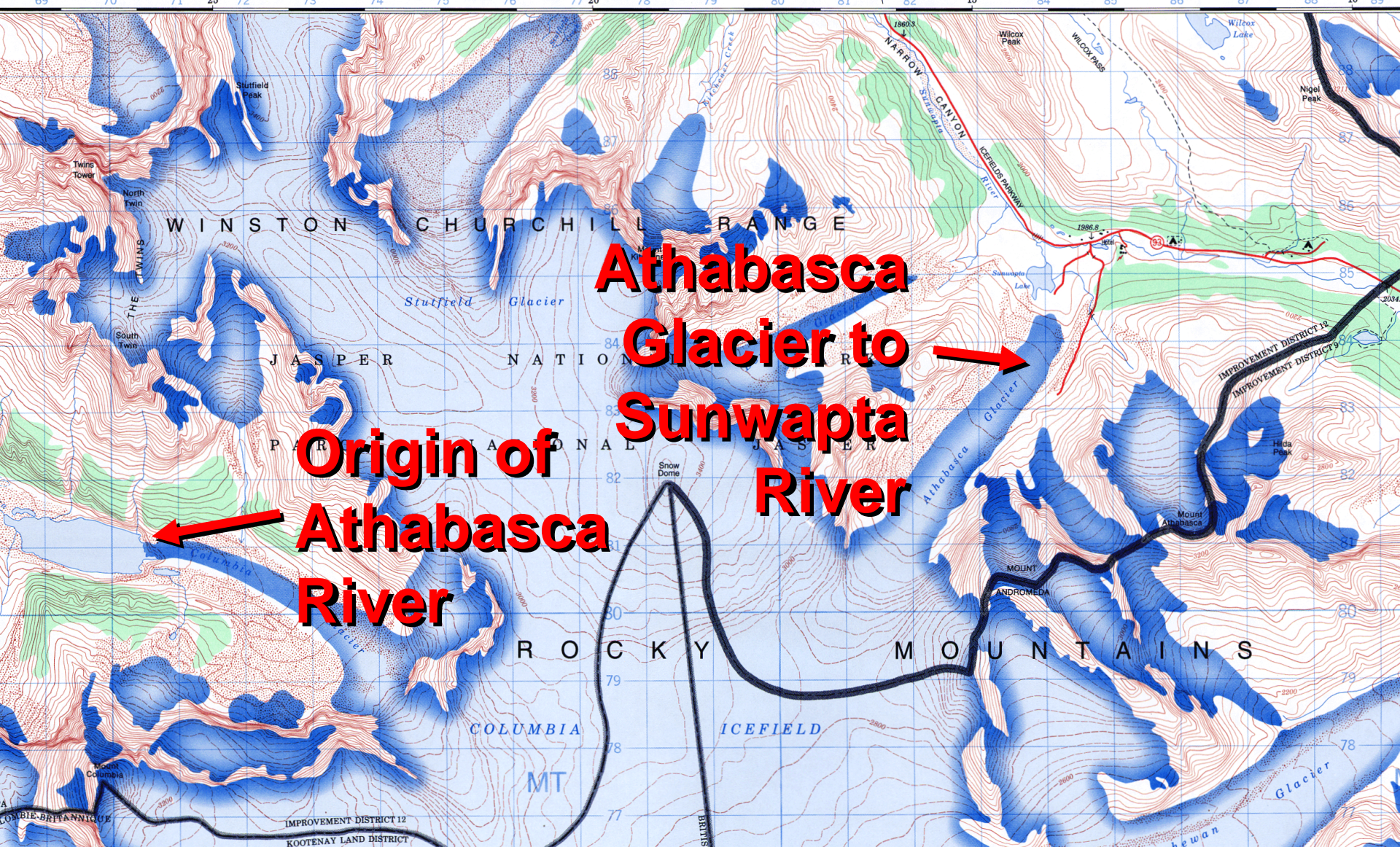
Columbia Ice Field



Athabasca Glacier, 2002

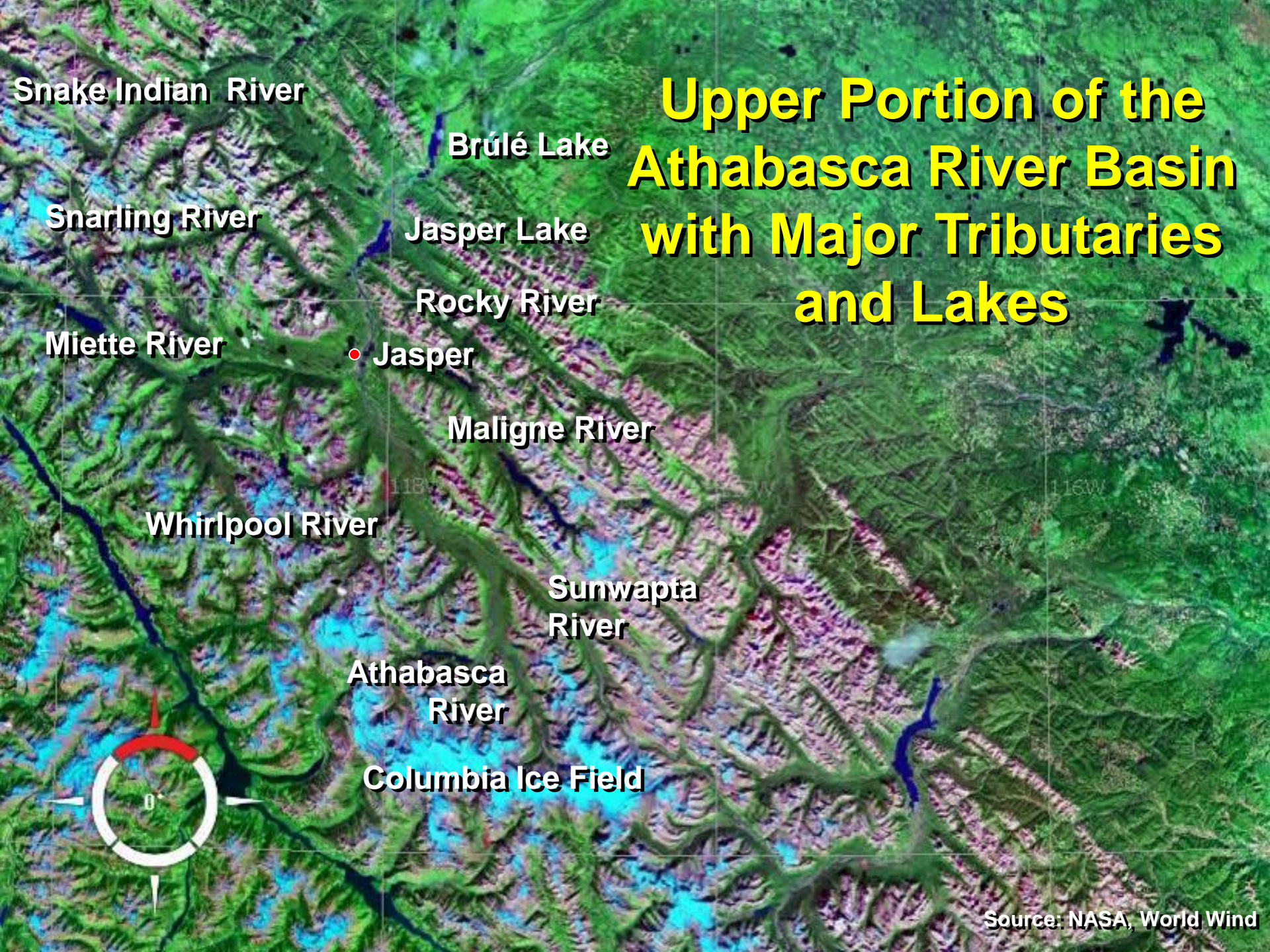


Photo: R.G. Holmberg



Columbia Ice Field

Upper Portion of the Athabasca River Basin with Major Tributaries and Lakes



Athabasca Falls, 2007

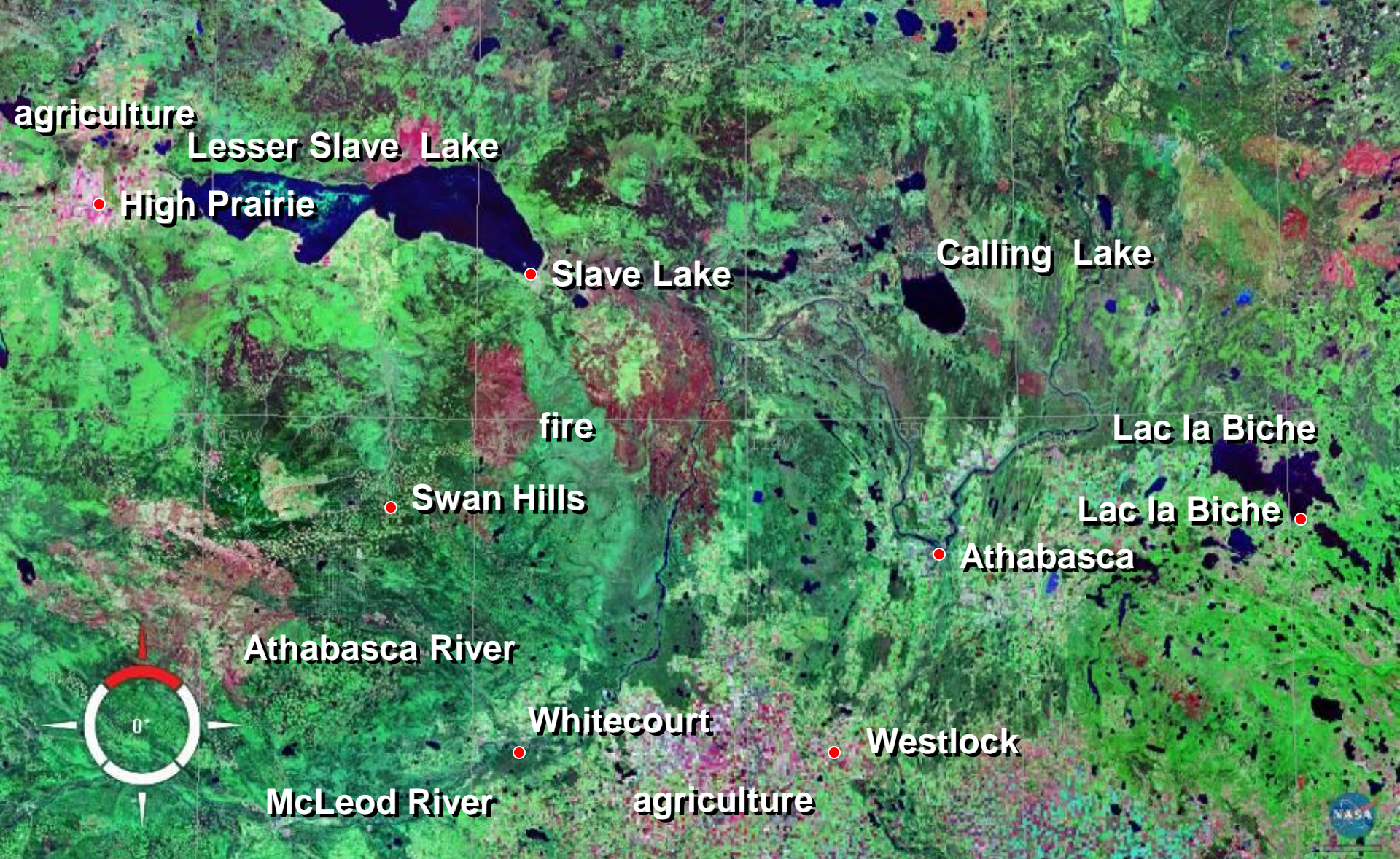


Photo: R.G. Holmberg,

Athabasca River near Jasper, 2005

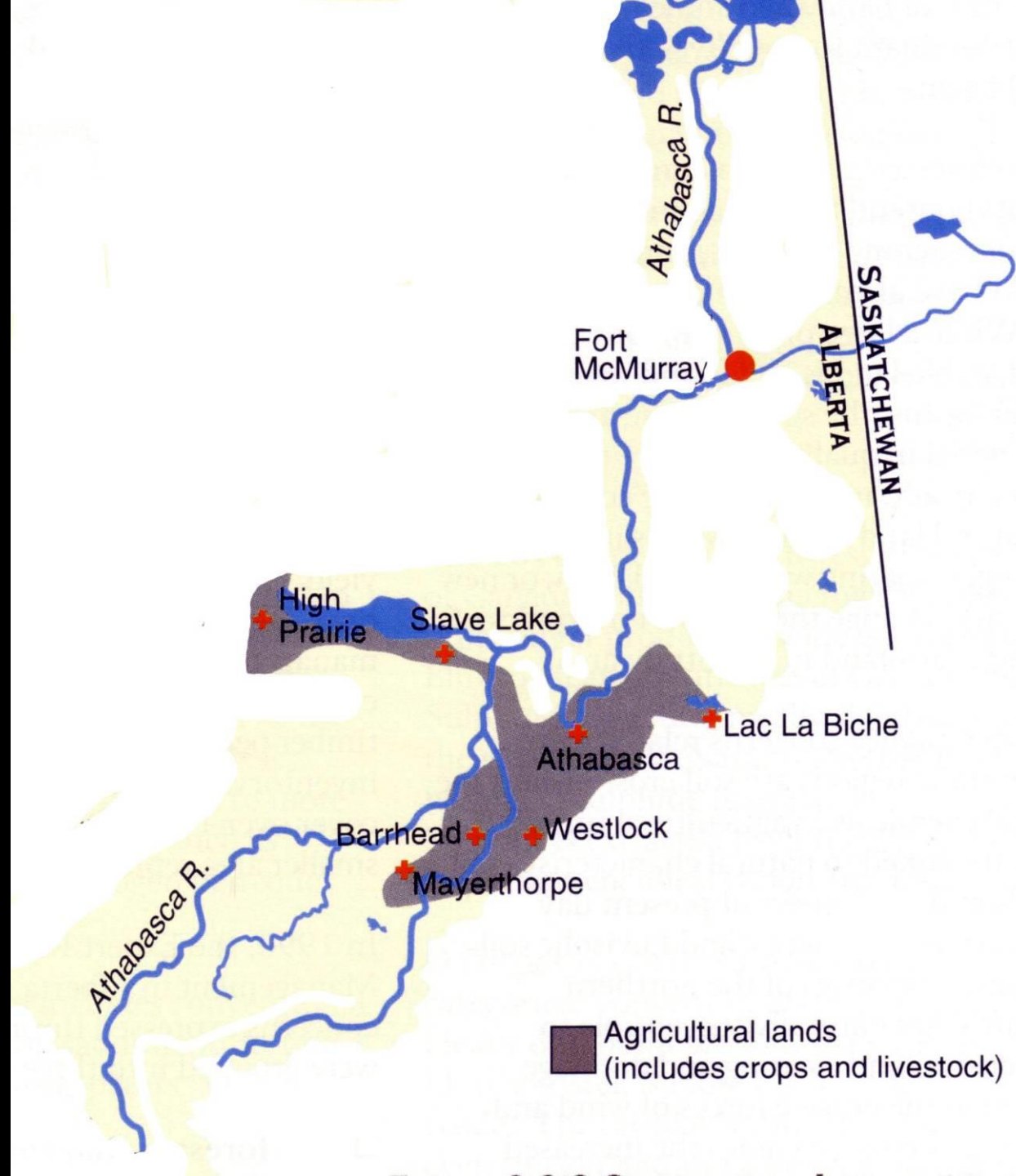


Photo: R.G. Holmberg,



Central Part of Athabasca River Basin

Agriculture in the Athabasca River Basin



Town of Athabasca from Athabasca River, 1991



Photo: R.G. Holmberg

Athabasca River downstream from Athabasca, 1987



Photo: R.G. Holmberg

Portaging Grand Rapids (1.6 km), Athabasca River, circa 1903-06



Big Cascade Rapids , Athabasca River, circa 1910

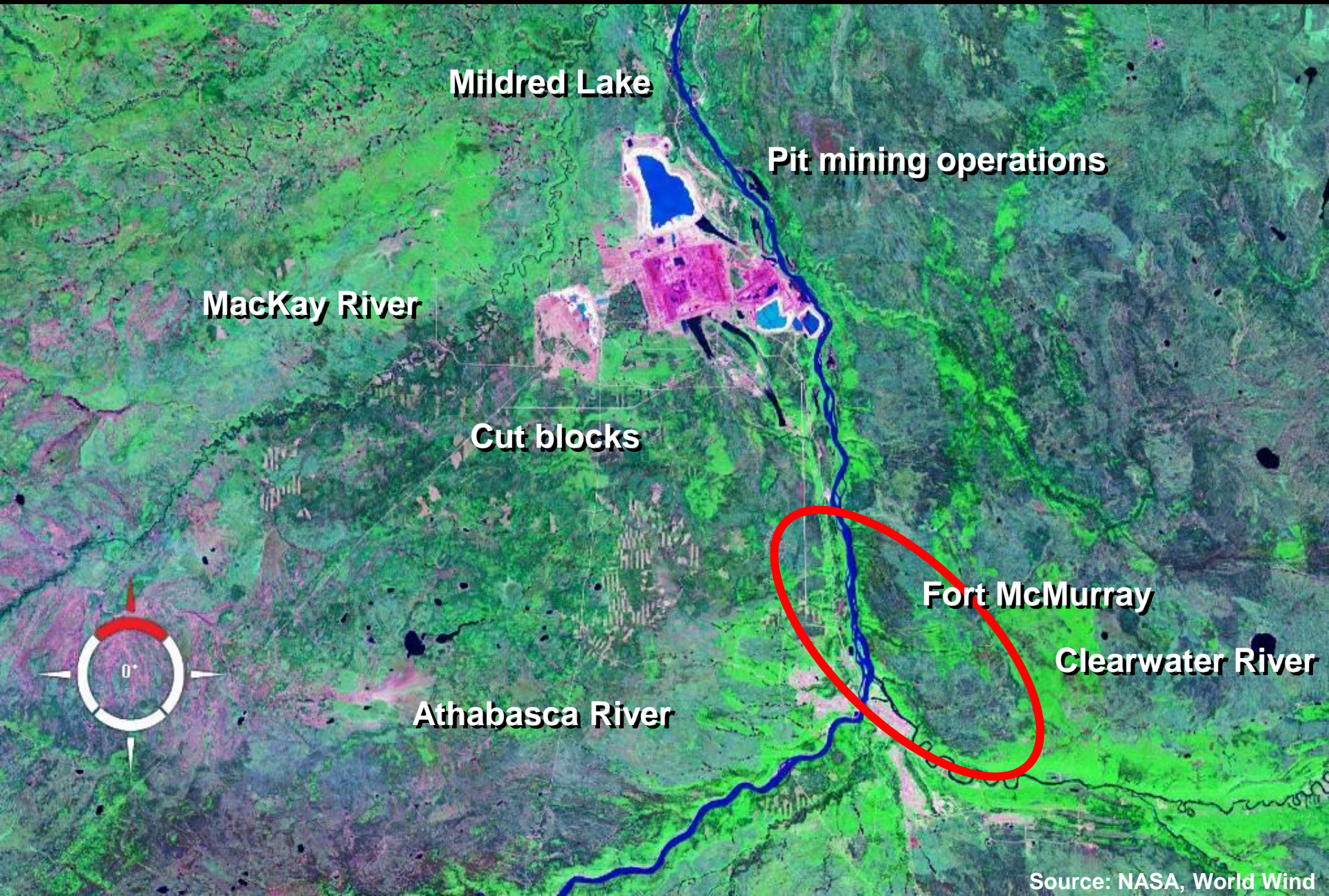


Photo: Canadian Department of the Interior, Library and Archives Canada PA-169585,
http://www.collectionscanada.ca/archivianet/020115_e.html

Fort McMurray – Athabasca and Clearwater Rivers, 2005



Fort McMurray Area



Athabasca River at Fort MacKay, 1996



Photo: R.G. Holmberg



Fishing lodge at Namur Lake, 2004



Peace-Athabasca Delta Area

Source: NASA, World Wind

Sand Dunes near Athabasca River, 1998



Photo: R.G. Holmberg

Peace- Athabasca Delta



Source: Northern
River Basins
Study Final
Report

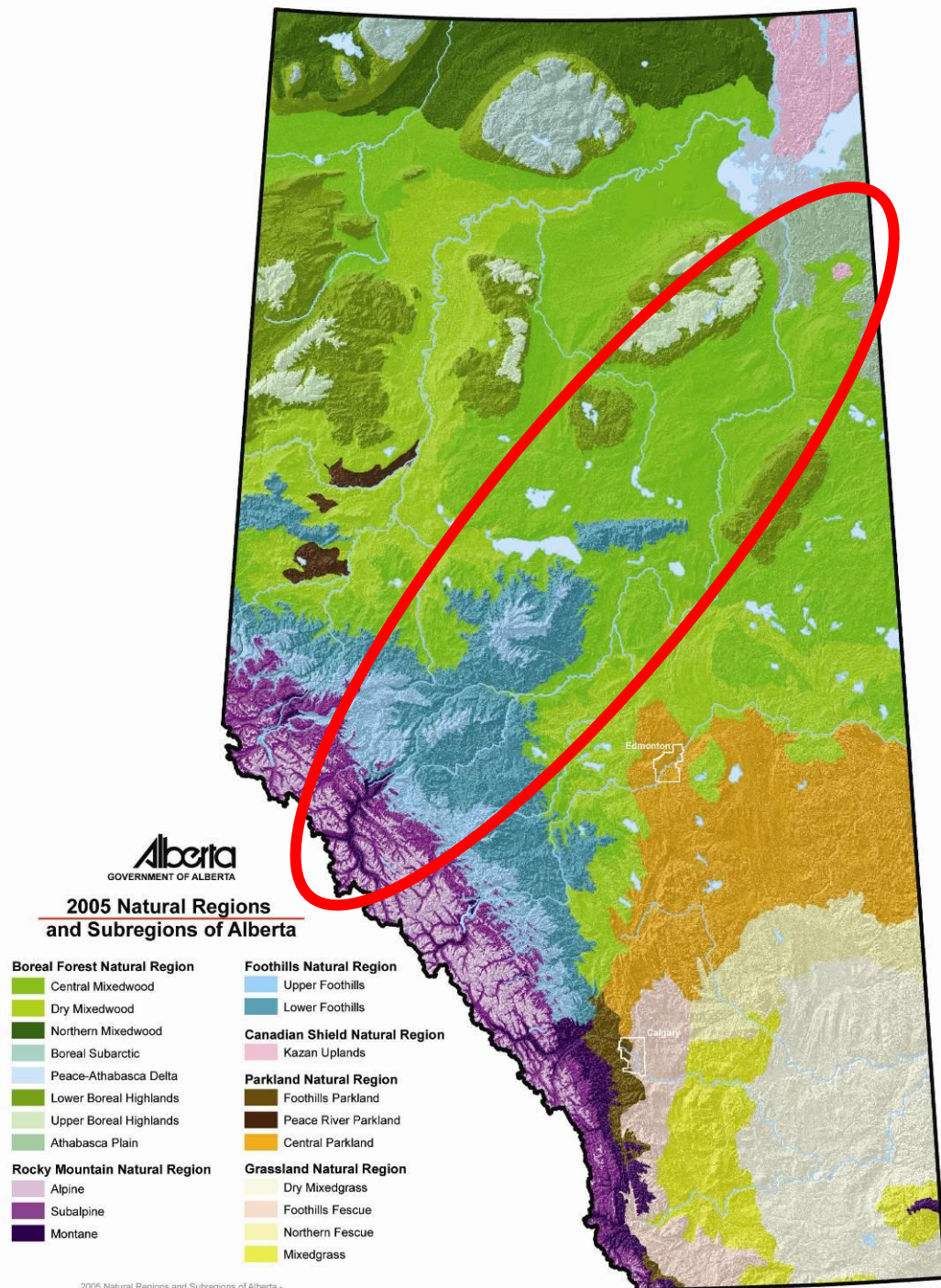


Peace- Athabasca Delta

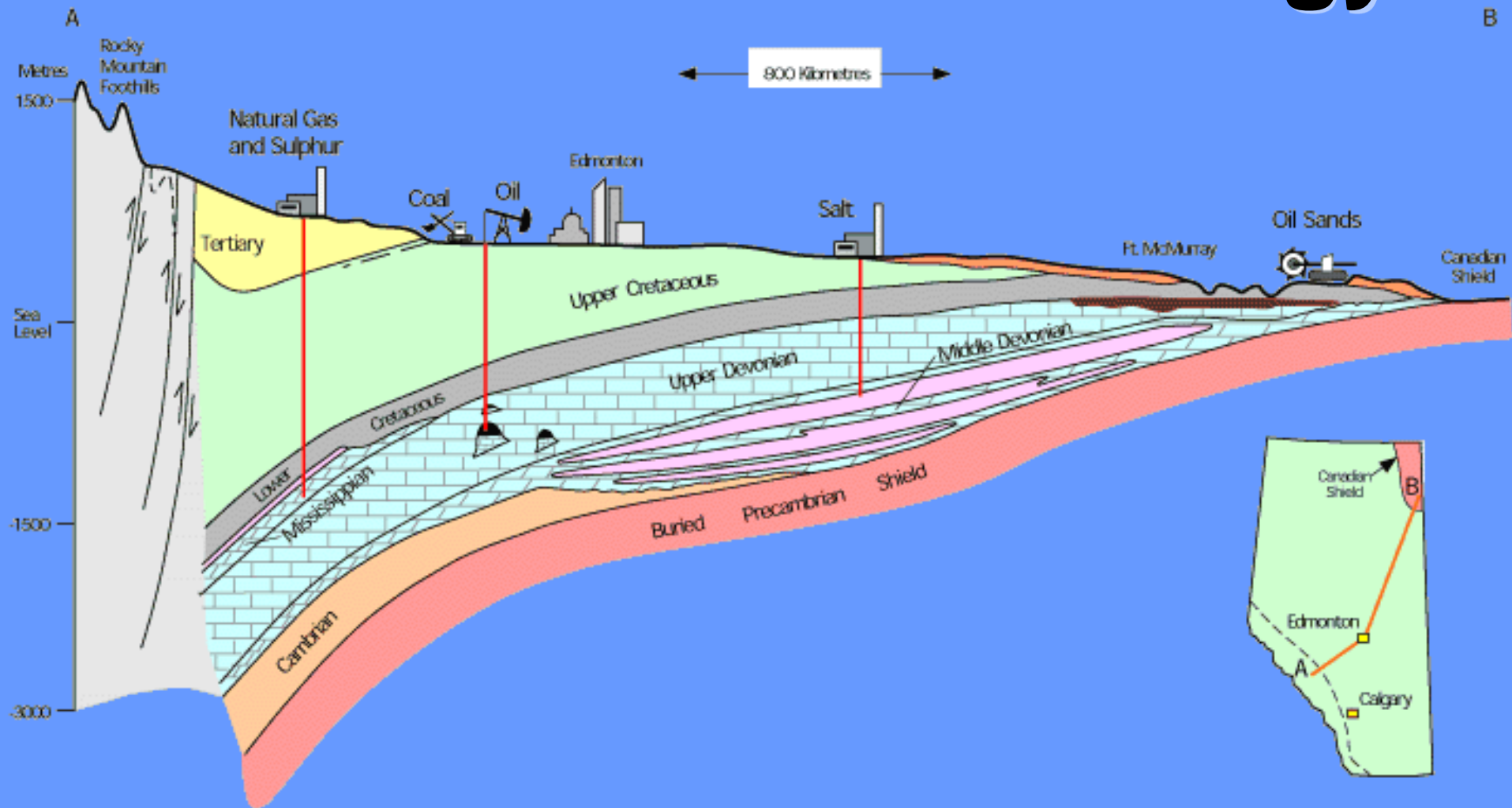
- 4,100 km²
- >1,000 lakes
- sensitive to water levels
- all 4 major N.A. bird flyways converge here

What is the ARB?

- 3 natural regions and 11 sub-regions



What is the ARB? Geology



Athabasca River elevation at origin 1,231 m (foot of glacier), at mouth 205 m

Source: www.abheritage.ca/abnature/geological/photos/... via Royal Alberta Museum; Mussieux, R. and M. Nelson. A Traveller's Guide to Geological Wonders in Alberta; artist Dan Magee

What is the ARB?

- ~160,000 people
(1 city, 12 towns,
>75 villages, etc.)

Photo: Athabasca, R.G. Holmberg



An aerial photograph of the city of Wood Buffalo, Alberta, Canada. The image shows a dense urban area with numerous parking lots filled with cars, several large commercial and industrial buildings, and a prominent red brick building complex in the center. The text is overlaid on the top left of the image.

Regional Municipality of Wood Buffalo

69,989 people
(Fort McMurray 66,573)

Data Source Statistics Canada, 2015
Photo: Fort McMurray, 2004,
R.G. Holmberg

Towns of the ARB

Town	Population
Whitecourt	10,204
Hinton	9,882
Edson	8,414
Slave Lake	6,651
Westlock	5,101
Barrhead	4,579
Jasper	3,948
Athabasca	2,965
High Prairie	2,564
Lac la Biche	2,314
Mayerthorpe	1,320
Swan Hills	1,301
Total	59,243

Data Source Statistics Canada, 2015

Photo: Jasper, 2007, R.G. Holmberg

What is known about the ARB?



Major Research Studies - **completed**

- Agriculture Canada: black flies, methoxychlor
- AOSERP¹ for Syncrude
- EIAs² for AlPac and other pulp mills
- Northern Rivers Basins Study³
- Northern Rivers Ecosystems Initiative⁴
- CEMA⁵ recommendations about oil sands

¹ Alberta Oil Sands Environmental Research Program, 1970s

² Environmental Impact Assessments, 1990s

³ Athabasca, Peace and Slave River basins, ended 1996

⁴ Environment Canada: offshoot of Northern River Basins Study, 1996-2003

⁵ Cumulative Environmental Management Association ?-2016



Major Research Studies – on going

- Foothills Research Institute (formerly Foothills Model Forest, 1992)
- EMAN⁵ ecological monitoring
- EMEND⁶ project studies logging and fire
- Alberta Biodiversity Monitoring Institute (AMBI)

⁵ Environment Canada: Ecological Monitoring and Assessment Network, 1994-

⁶ Ecosystem Management Emulating Natural Disturbance, 1997-



Major Research Studies – on going

- **RAMP⁷ monitors water in oil sands area**
- **CONRAD⁸ oils sands (industries, government & universities)**
- **WBEA⁹ monitors air in oil sands area**
- **ARB Initiative¹⁰ models water flow**

⁷ Regional Aquatics Monitoring Program, 1997-

⁸ Canadian Oil Sands Network for Research and Development

⁹ Wood Buffalo Environmental Association

¹⁰ Sustainable Water Management in the Athabasca River Basin Initiative



Why is the ARB important?

1. Human survival
2. Resources
3. Ecological problems
4. Political interests
5. Intellectual interest



Why is the ARB important?

1. Human Survival

- Oxygen, $\text{CO}_2 \rightarrow \text{O}_2$
- Water for drinking, washing
- Food – wild and agriculture
- Fiber – wild, silviculture & agriculture

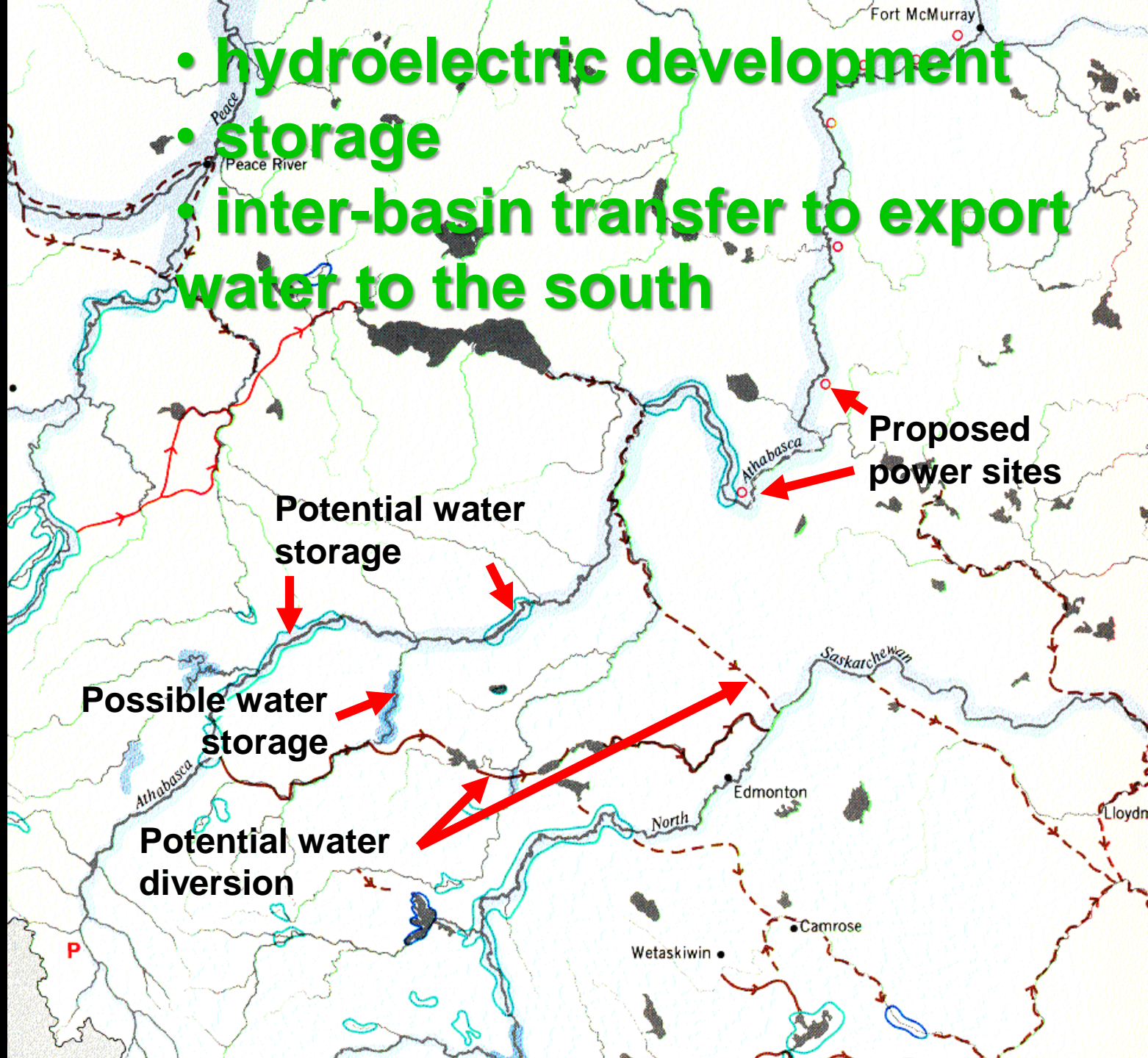
Why is the ARB important?

2. Resources – renewable

- Air, water & soil as “free” raw materials for agriculture, forestry & industry**
- Air and water for waste “treatment” (= dilution)**
- Hydroelectricity (potential)**

Potential Water Use

- hydroelectric development
- storage
- inter-basin transfer to export water to the south



Why is the ARB important?

2. Resources – renewable – wood

- Wood for lumber and plywood
- >12 mills in ARB

Photo: Sundance Forest Products, near Edson, 2007, R.G. Holmberg

Why is the ARB important?

2. Resources – renewable - pulp

1. Hinton, Weldwood of Canada, 1957, bleached kraft

2. Whitecourt, Millar Western Pulp, 1988, bleached chemi-thermo-mechanical

3. Whitecourt, Alberta Newsprint Co., 1990, thermo-mechanical + paper mill

4. Slave Lake, Slave Lake Pulp, 1991, bleached chemi-thermo-mechanical

5. Athabasca, Alberta-Pacific Forest Industries, 1992, bleached kraft

Why is the ARB important?

2. Resources – renewable

- Large mammals and fish for food
- Hunting and fishing guides
- Tourism

Why is the ARB important?

2. Resources – non-renewable

- Conventional oil & natural gas



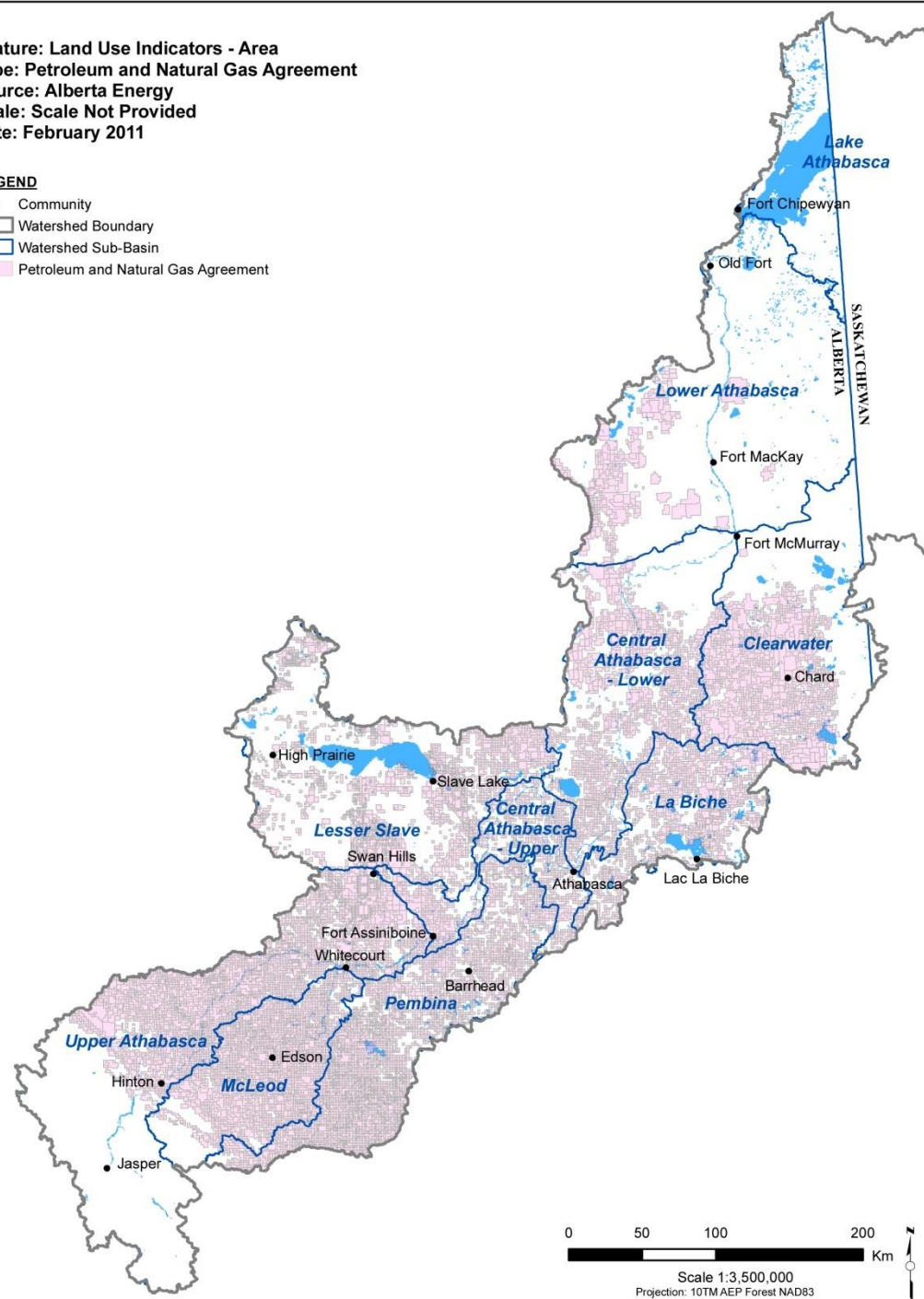
Conventional Oil & Natural Gas Agreements / Leases in the ARB, 2011

Source: Athabasca Watershed
Council, State of the Watershed
Report, Phase 1, Appendix A2: Maps
from the Preliminary Atlas, 2011

Feature: Land Use Indicators - Area
Type: Petroleum and Natural Gas Agreement
Source: Alberta Energy
Scale: Scale Not Provided
Date: February 2011

LEGEND

- Community
- ▭ Watershed Boundary
- ▭ Watershed Sub-Basin
- ▭ Petroleum and Natural Gas Agreement



Landscape fragmentation by seismic lines, roads, wells, pipelines and processing plants



Photo: Alberta, 2003, R.G. Holmberg

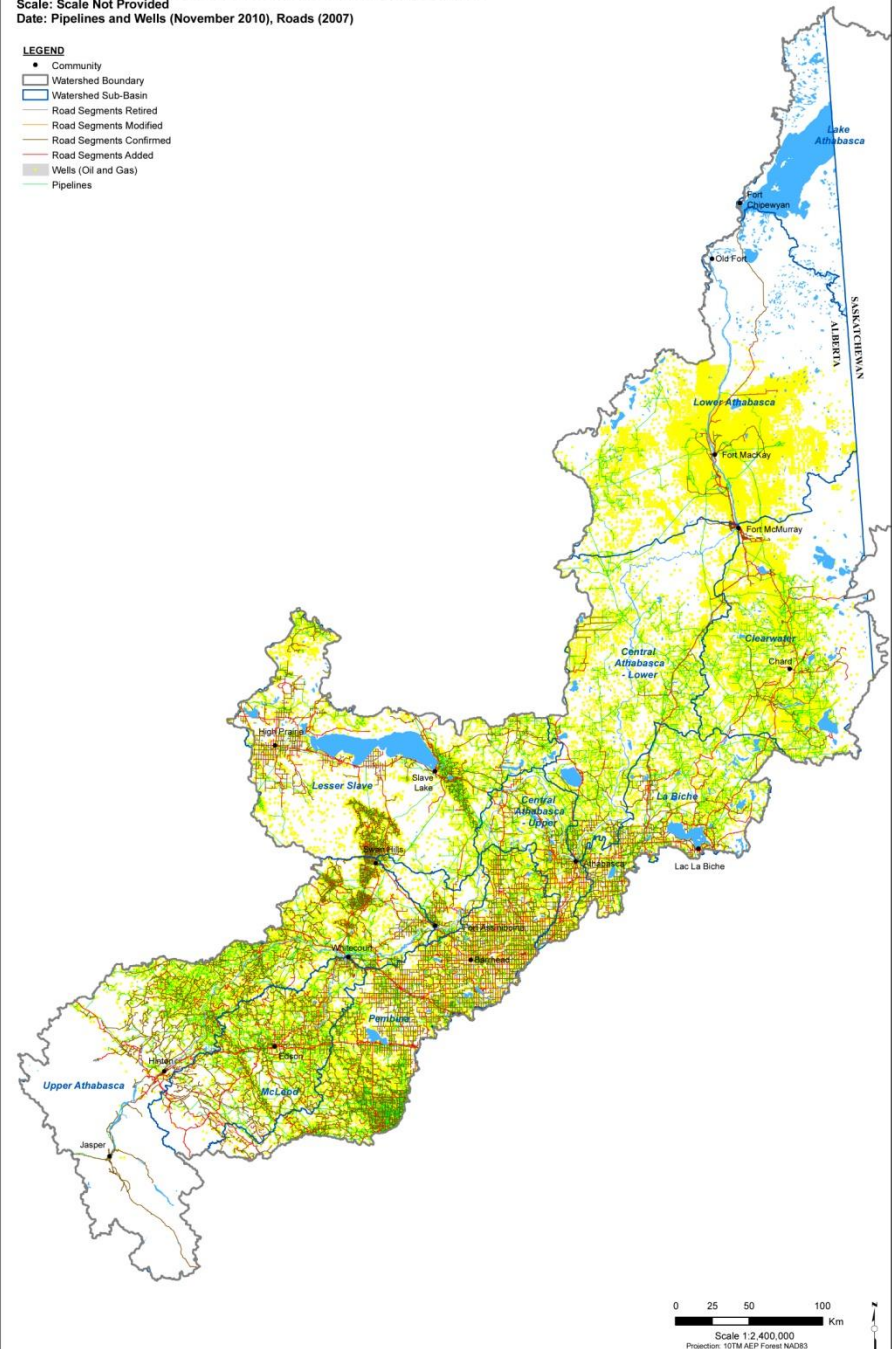
Pipelines, Oil Wells & Roads in the Athabasca River Basin, 2007/2010

Source: Athabasca Watershed
Council, State of the Watershed
Report, Phase 1, Appendix A2: Maps
from the Preliminary Atlas, 2011

Feature: Land Use Indices - Linear
Type: Pipelines, Wells, and Roads
Source: Energy Resources Conservation Board and Natural Resources Canada
Scale: Scale Not Provided
Date: Pipelines and Wells (November 2010), Roads (2007)

LEGEND

- Community
- Watershed Boundary
- Watershed Sub-Basin
- Road Segments Retired
- Road Segments Modified
- Road Segments Confirmed
- Road Segments Added
- Wells (Oil and Gas)
- Pipelines



Why is the ARB important?

2. Resources – non-renewable

- Oil/tar sands or bitumen



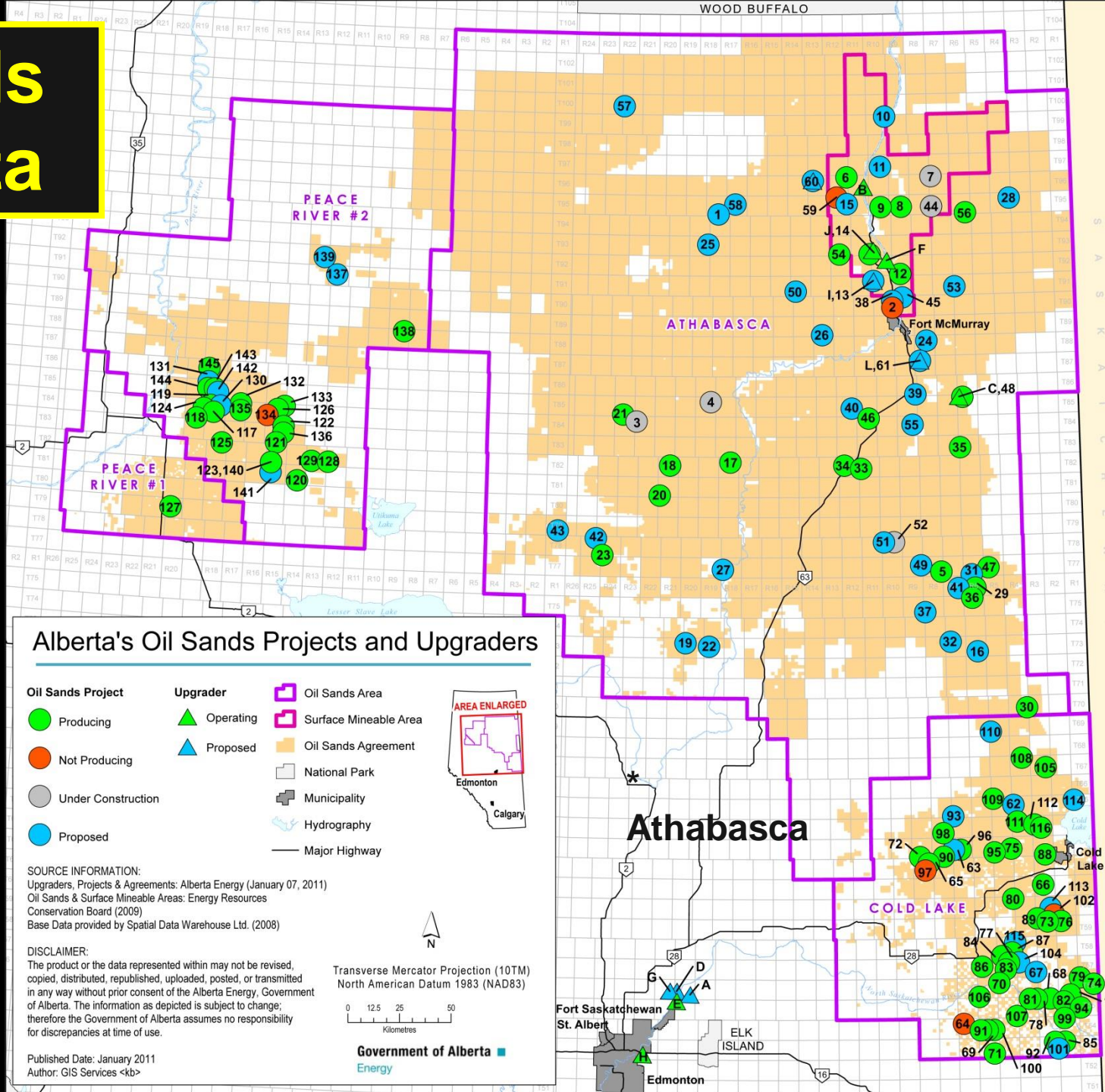
Source: Geological Survey of Canada, 1892

Oil Sands in Alberta



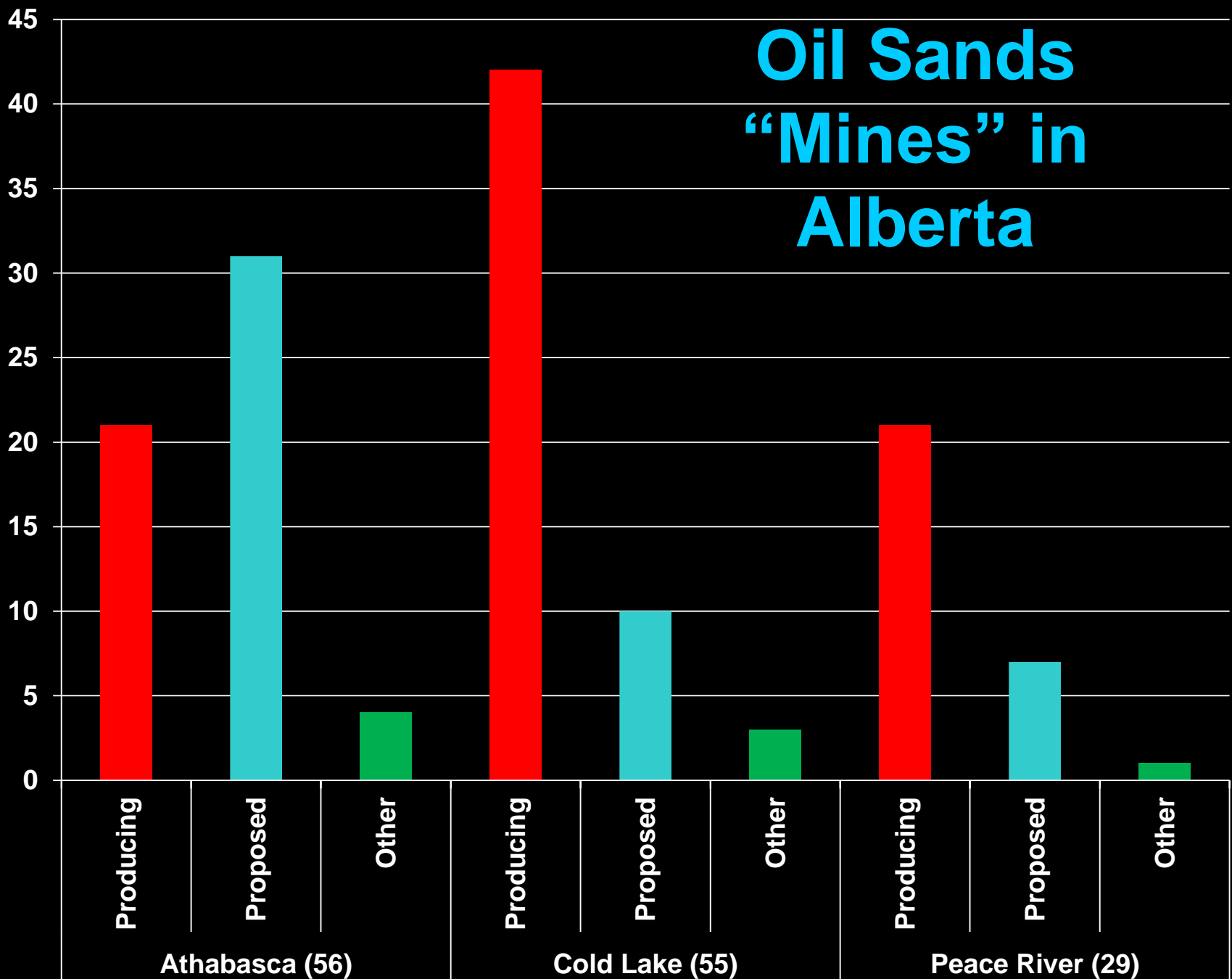
Source: Government of Alberta

Oil Sands in Alberta



Source: Government of Alberta, 2011

Oil Sands “Mines” in Alberta



Surface / Pit Mining



Photo: Fort McMurray area, 2004, R.G. Holmberg



**Pit mining
restricted to
bitumen less
than 70 m deep**

Photo: Fort McMurray area, 2004, R.G. Holmberg

Tailings Ponds: 720 million m³ in 130 km²



Data Source: ercb.ca/portal/server.pt/gateway/PTARGS_0_0_303_263_43/, October 2010

Photo: Suncor plant, 1998, R.G. Holmberg

In situ Oil “Mines”

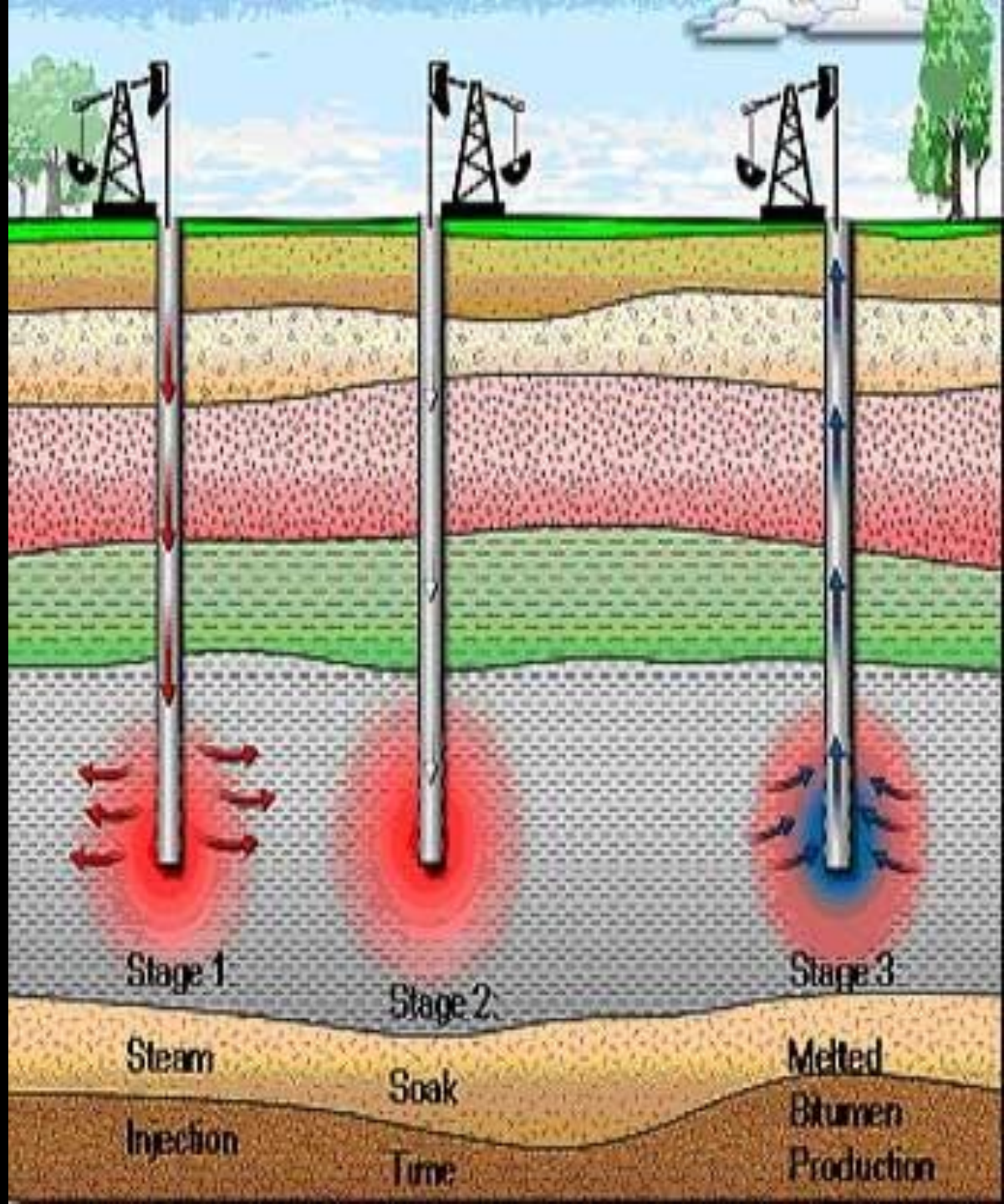
- 15% land disturbance but much fragmentation
- Uses lots of natural gas (13% of Canadian total in 2007, 60% by 2030?)
- Uses considerable amounts of water

Photo: Near Fort McMurray,
2005, R.G. Holmberg

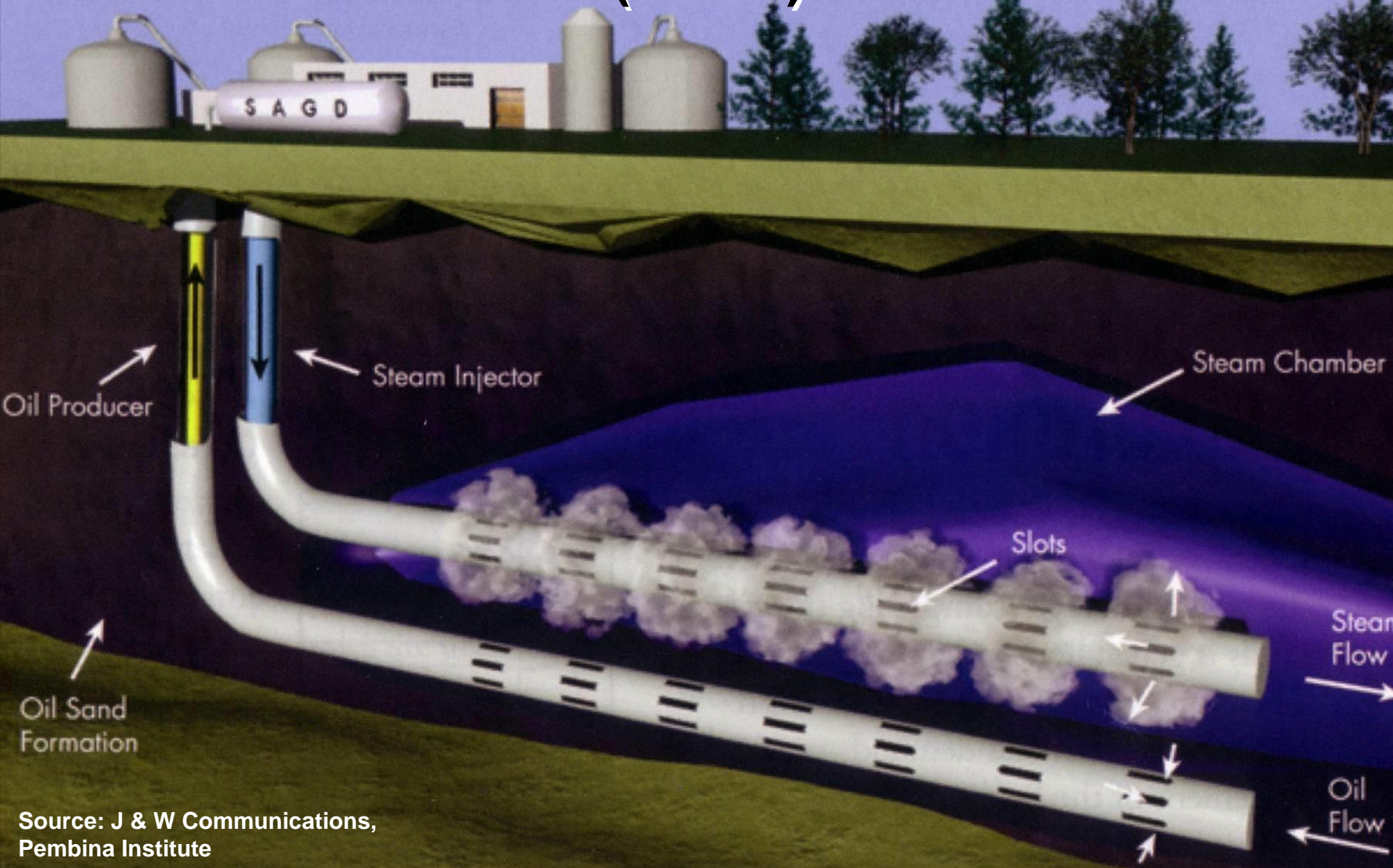
***In Situ* Mining: Cyclic Steam Stimulation (CSS) = Primary**

**6-8 month
cycles**

Source:
www.alistairsweeny.com/blackbonanza/index.php/Roger_Butler

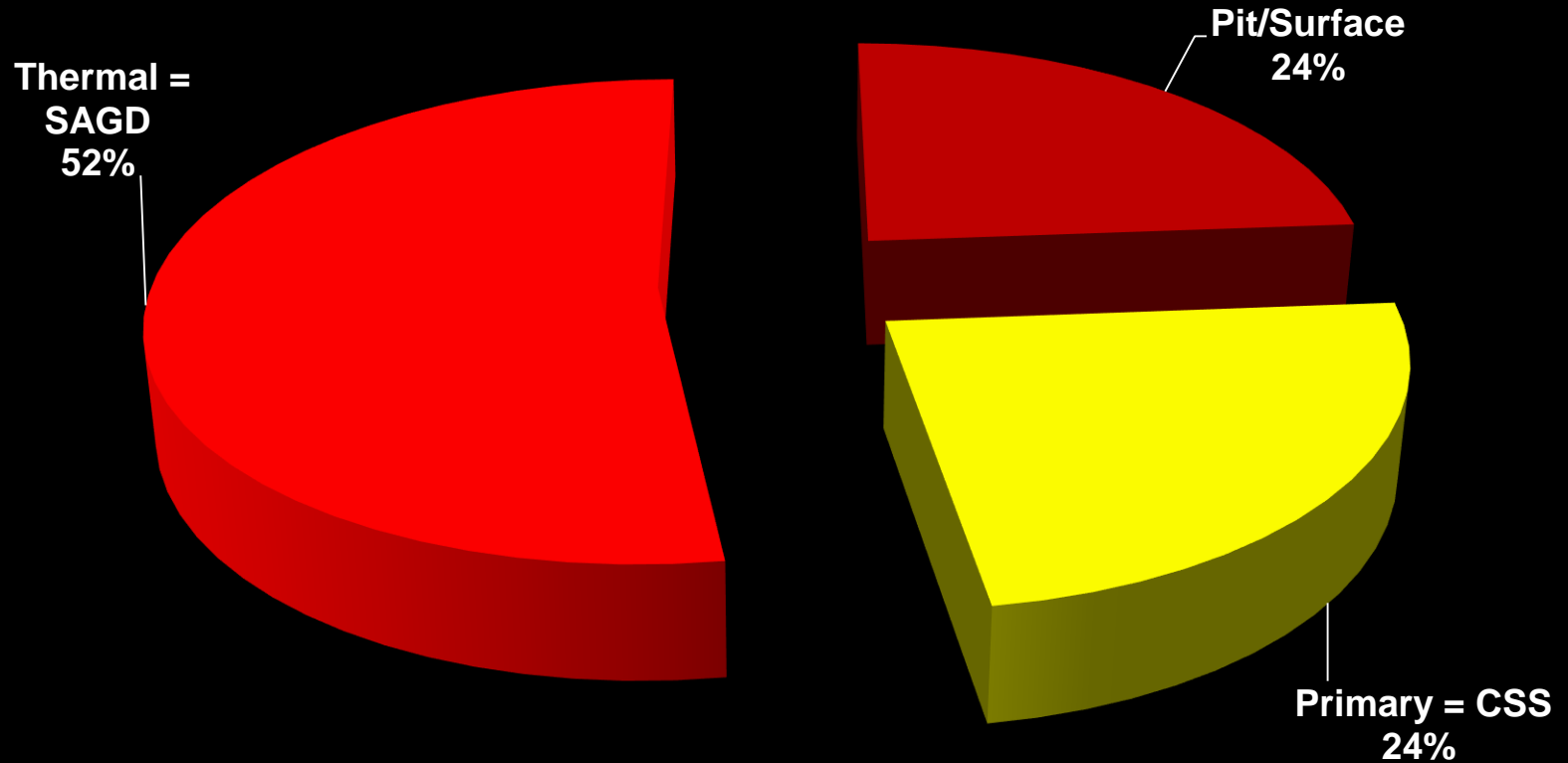


***In Situ* Mining: Steam Assisted Gravity Drainage (SAGD)**



Source: J & W Communications,
Pembina Institute

Types of Oil Sands “Mines” in ARB



n = 21

+ 31 proposed

+ 4 other

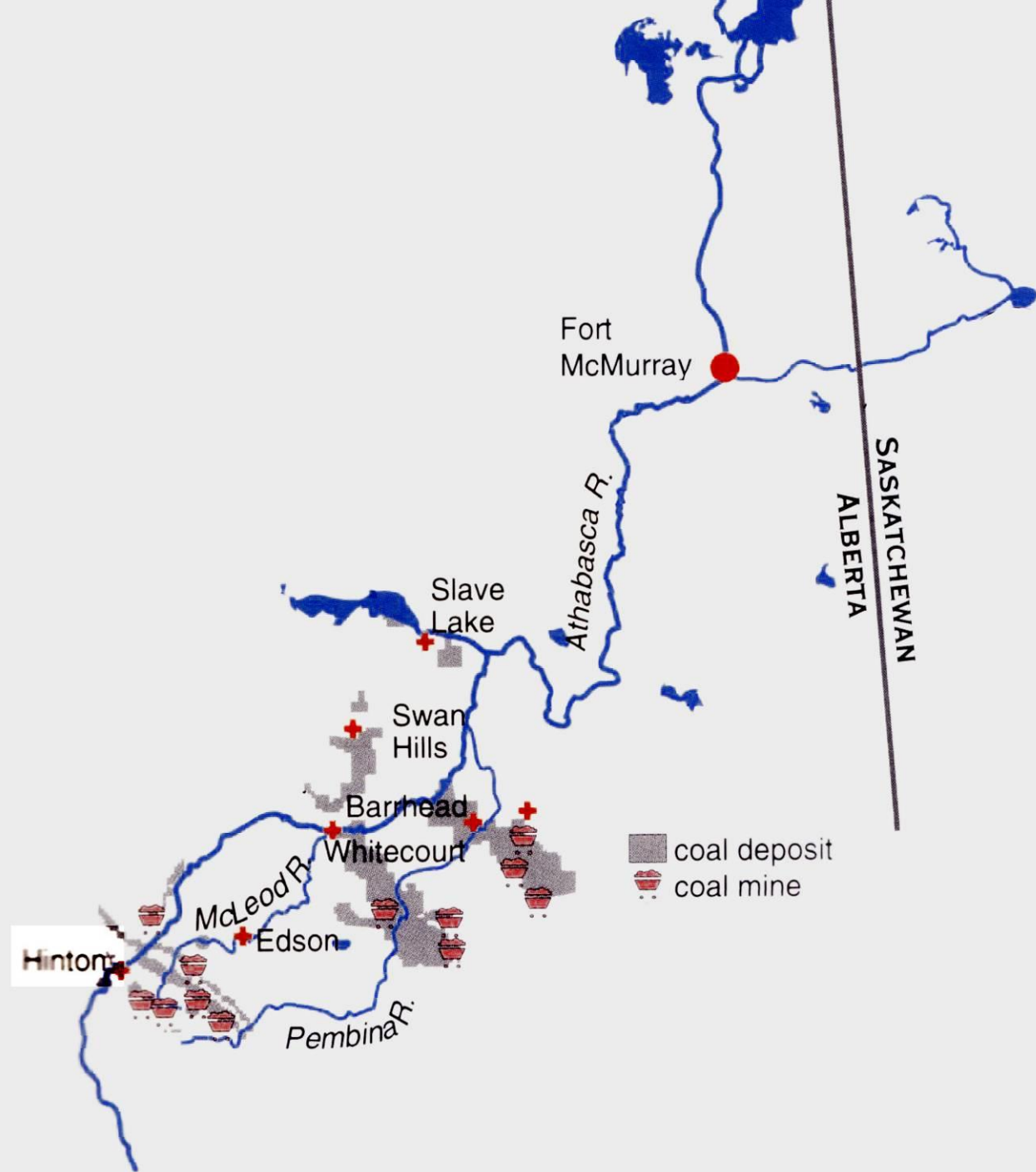
+ 5 experimental

Source: Alberta Energy,
January 2011

Why is the ARB important?

2. Resources – non-renewable

- **Coal**



Source: Northern River Basins Study,
Report to the Ministers, 1996

Why is the ARB important ?

2. Resources – non-renewable

- Peat





Why is the ARB important ?

2. Resources – non-renewable

- Gravel, limestone and other minerals

Fort Assiniboine area, 2007

Village site



Gravel mining



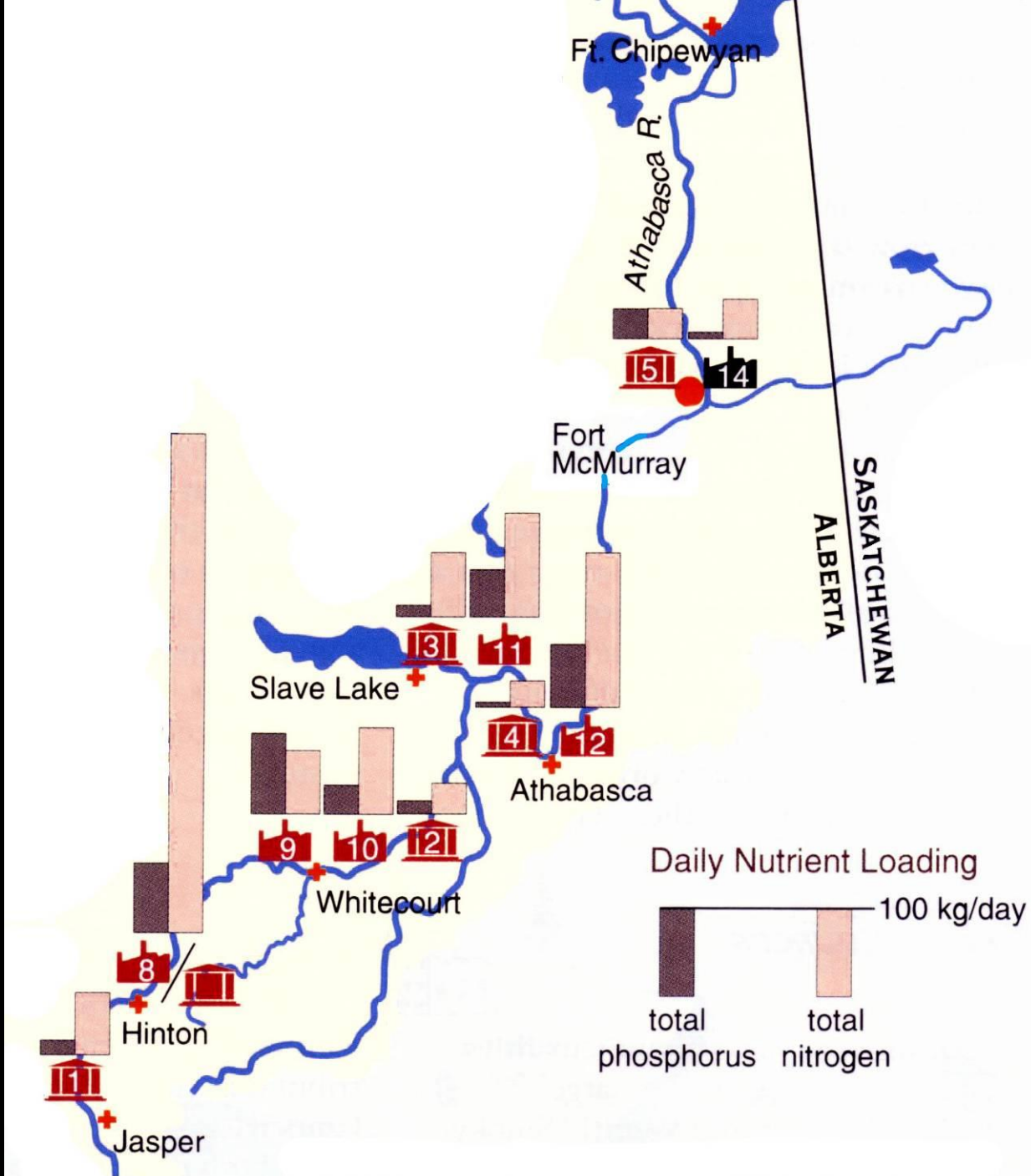
Whys is the ARB important?

3. Environmental Problems

- **Water quality, especially toxic chemicals and disease-causing organisms**
 - natural e.g. mercury, polycyclic aromatic hydrocarbons (PAHs), cyanobacterial toxins
 - industrial wastes e.g. chlorinated organics
 - erosion from logging
 - agricultural run-off and wastes
 - municipal wastes



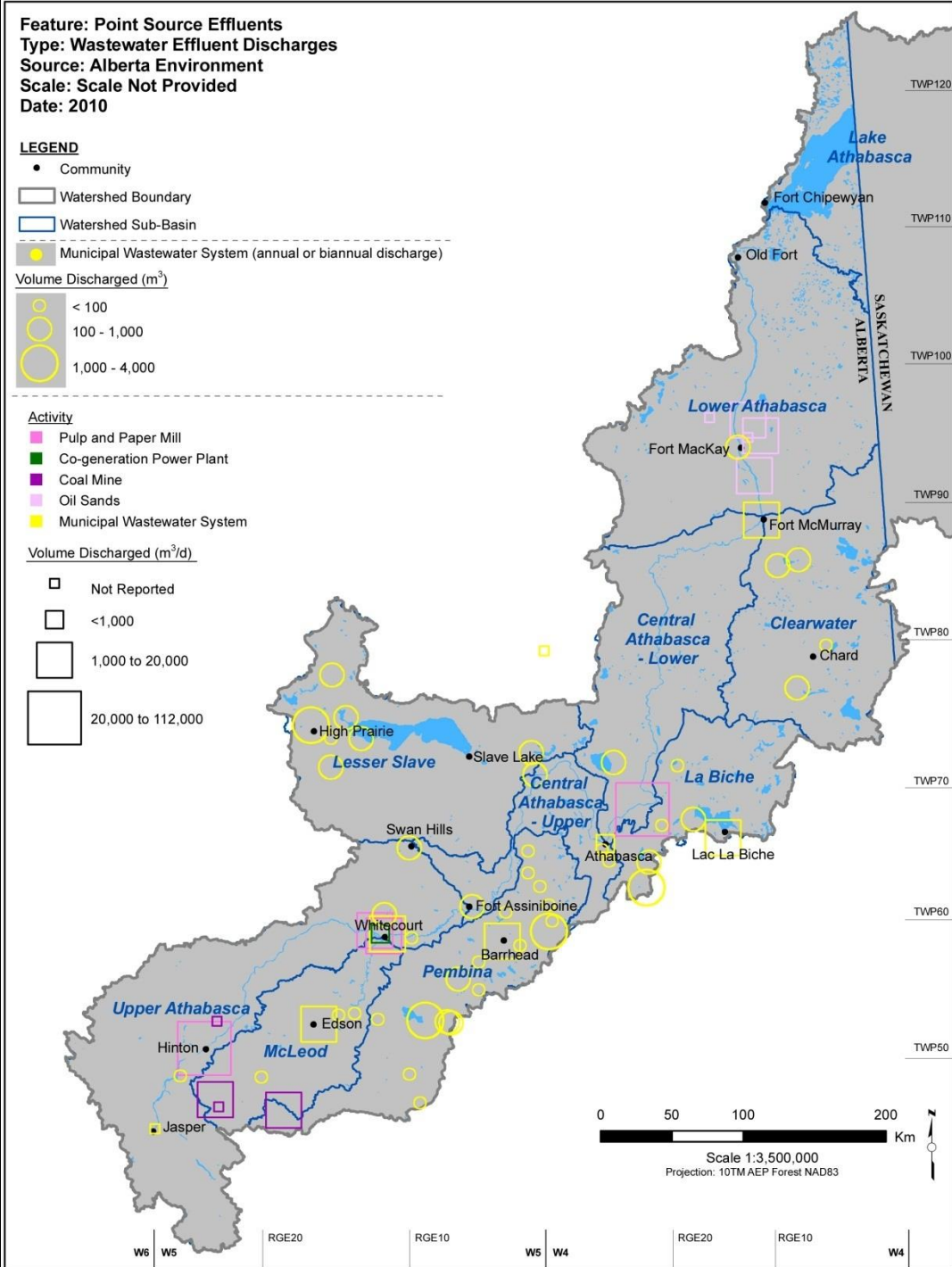
Point Sources of Nutrient Inputs in the Athabasca River Basin, <1996



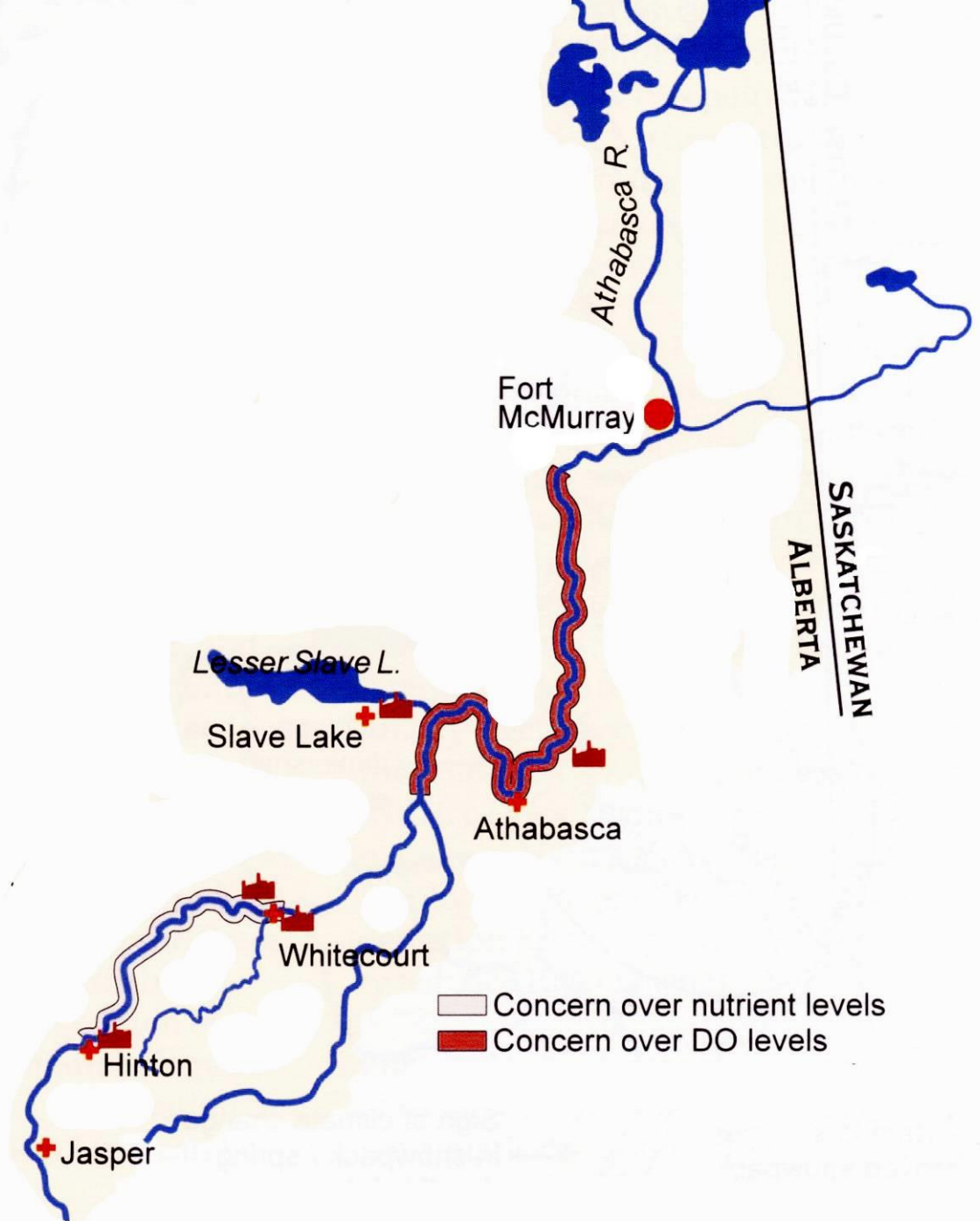
Source: Northern River Basins Study,
Report to the Ministers, 1996

Point Sources of Wastewater Effluents in the Athabasca River Basin, 2010

Source: Athabasca Watershed Council, State of the Watershed Report, Phase 1, Appendix A2: Maps from the Preliminary Atlas, 2011



Nutrient and Oxygen Concerns in the Athabasca River Basin



Source: Northern River Basins Study,
Report to the Ministers, 1996

Why is the ARB important?

4. Political

- Export of rural resources to urban areas
- Distribution of government taxes and benefits



Why is the ARB important?

4. Political

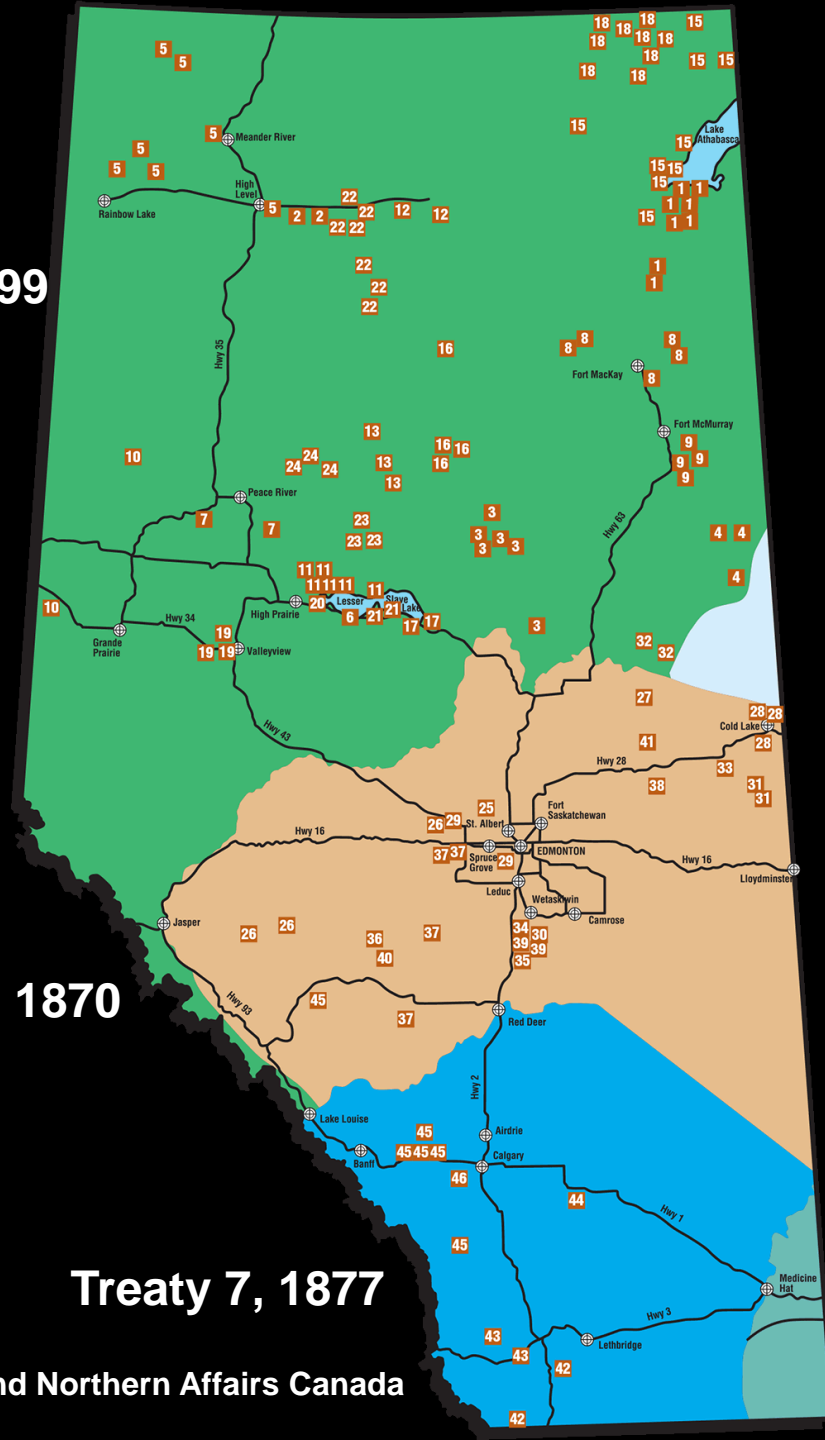
- Treaties 6 and 8 used the Athabasca River as a boundary

Treaty 8, 1899

Treaty 6, 1870

Treaty 7, 1877

Map: Indigenous and Northern Affairs Canada



Why is the ARB important?

5. Intellectual Interest

- Archeology and pre-history
- History: early explorers, fur trade transportation
- Biology: many unknown or poorly understood organisms
- Geography: Athabasca flowed south via the Tawatinaw Valley



Legislative Protection: Federal

- **Fisheries Act**
- **Navigable Waters Act**
- **Environment Assessment Act**
- **Environmental Protection Act**

Many parts “streamlined” in 2012



Legislative Protection: Provincial

- **Water Act**
- **Public Lands Act**
- **Wildlife Act**
- **Forests Act**
- **Wilderness Areas, Ecological Reserves and Natural Areas Act**
- **Oil Sands Conservation Act**



Legislative Protection

- Regulations & reporting (= monitoring)
- Enforcement



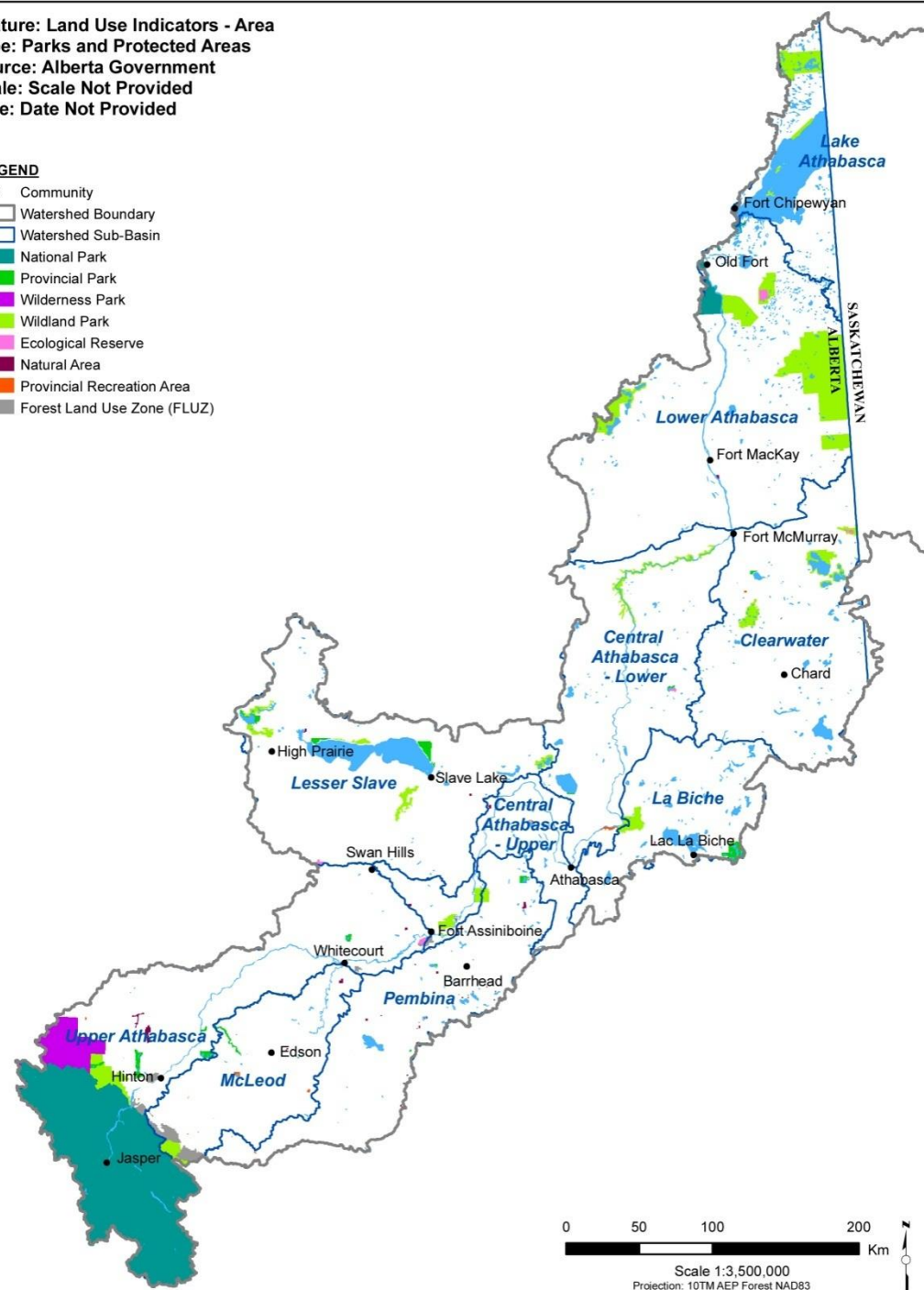
Parks & Protected Areas in the Athabasca River Basin

Source: Athabasca Watershed Council, State of the Watershed Report, Phase 1, Appendix A2: Maps from the Preliminary Atlas, 2011

Feature: Land Use Indicators - Area
Type: Parks and Protected Areas
Source: Alberta Government
Scale: Scale Not Provided
Date: Date Not Provided

LEGEND

- Community
- Watershed Boundary
- Watershed Sub-Basin
- National Park
- Provincial Park
- Wilderness Park
- Wildland Park
- Ecological Reserve
- Natural Area
- Provincial Recreation Area
- Forest Land Use Zone (FLUZ)



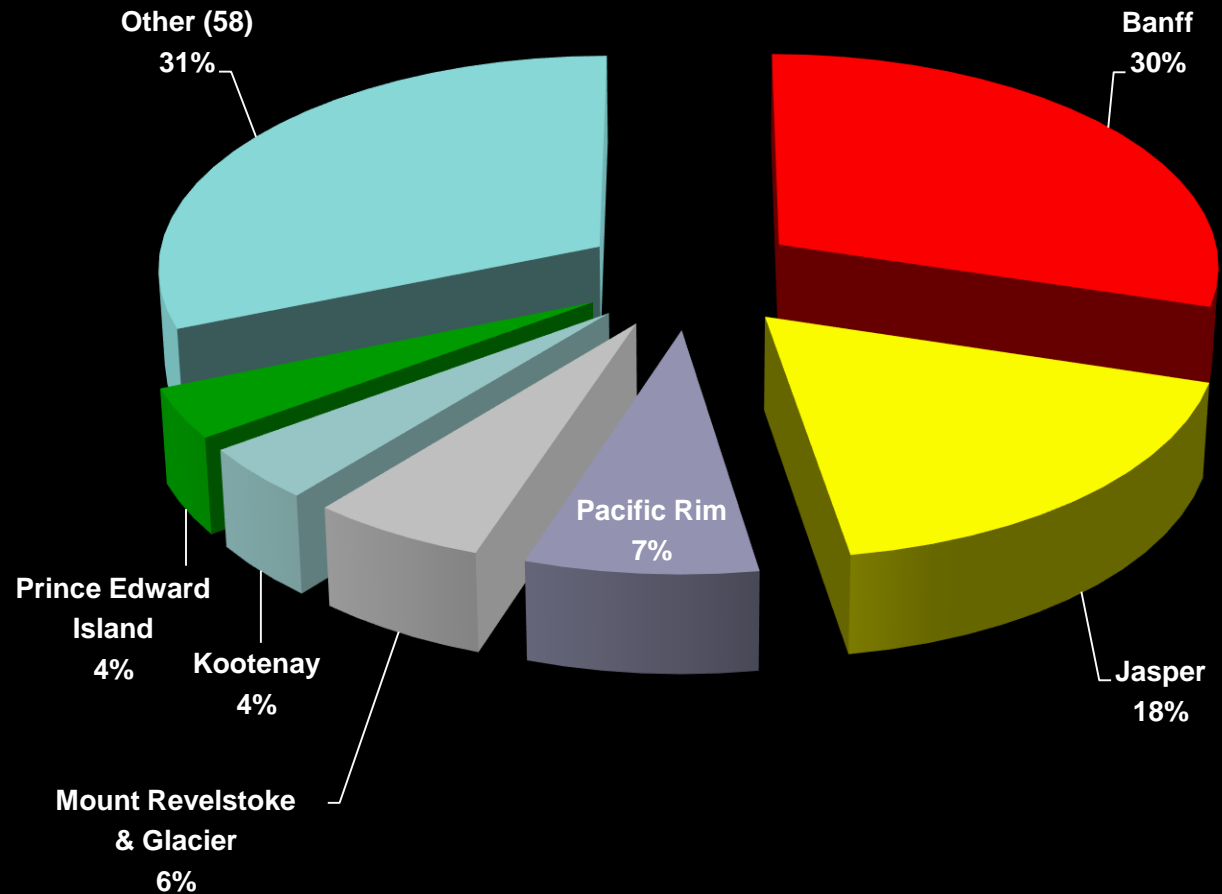
Conservation within ARB

CDN parks (Jasper & Wood Buffalo)	2
AB wildland parks	17
AB + SK (2,240 km²) parks	11 + 1
AB wilderness park (part of Willmore)	1
AB ecological reserves	6
AB natural areas	29
AB bird sanctuaries & wildlife area	4

Visitors to 64 Canadian National Parks

Jasper:

- 2nd most visited federal park
- 1,868,797 visitors in 2009-2010

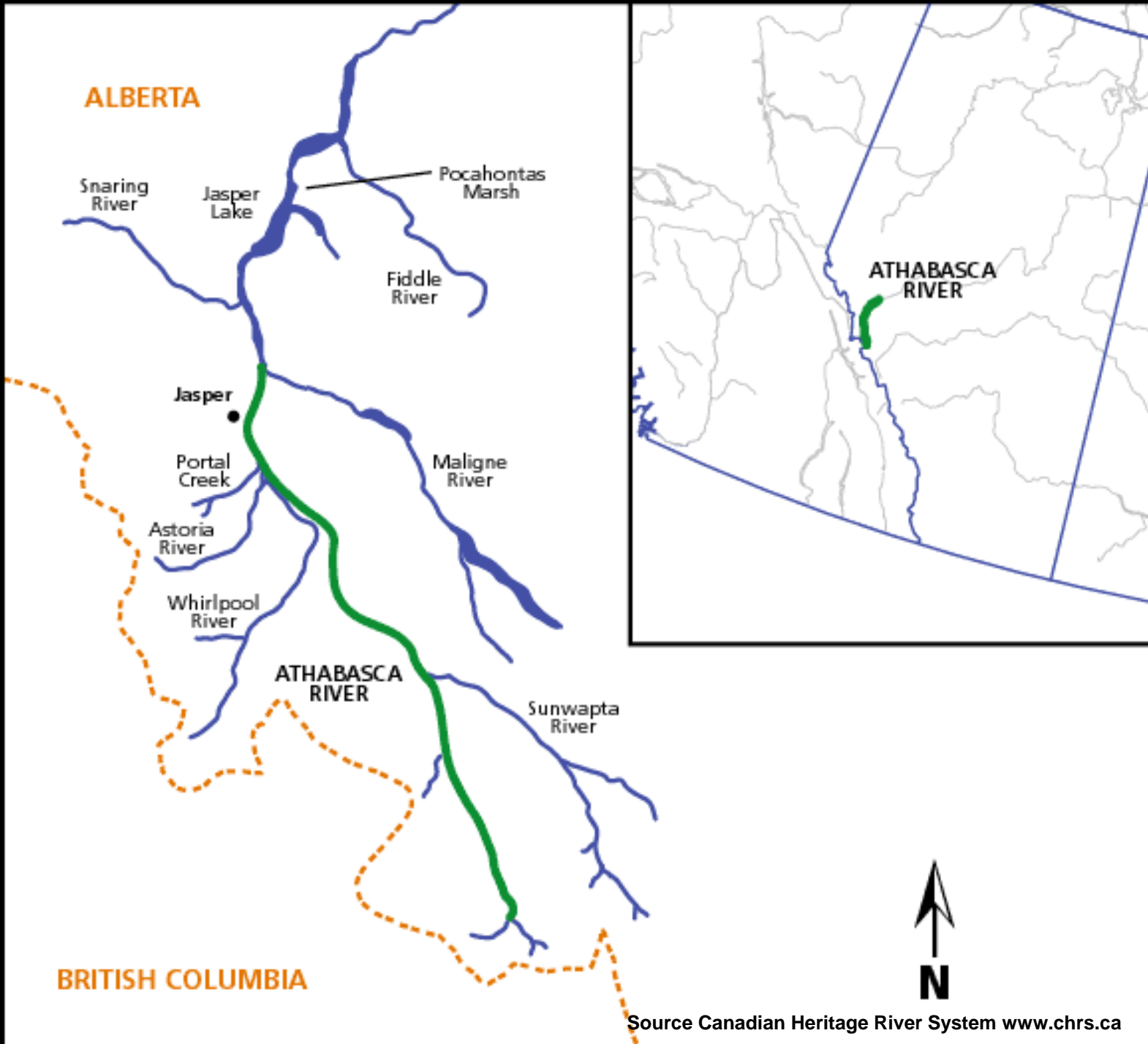


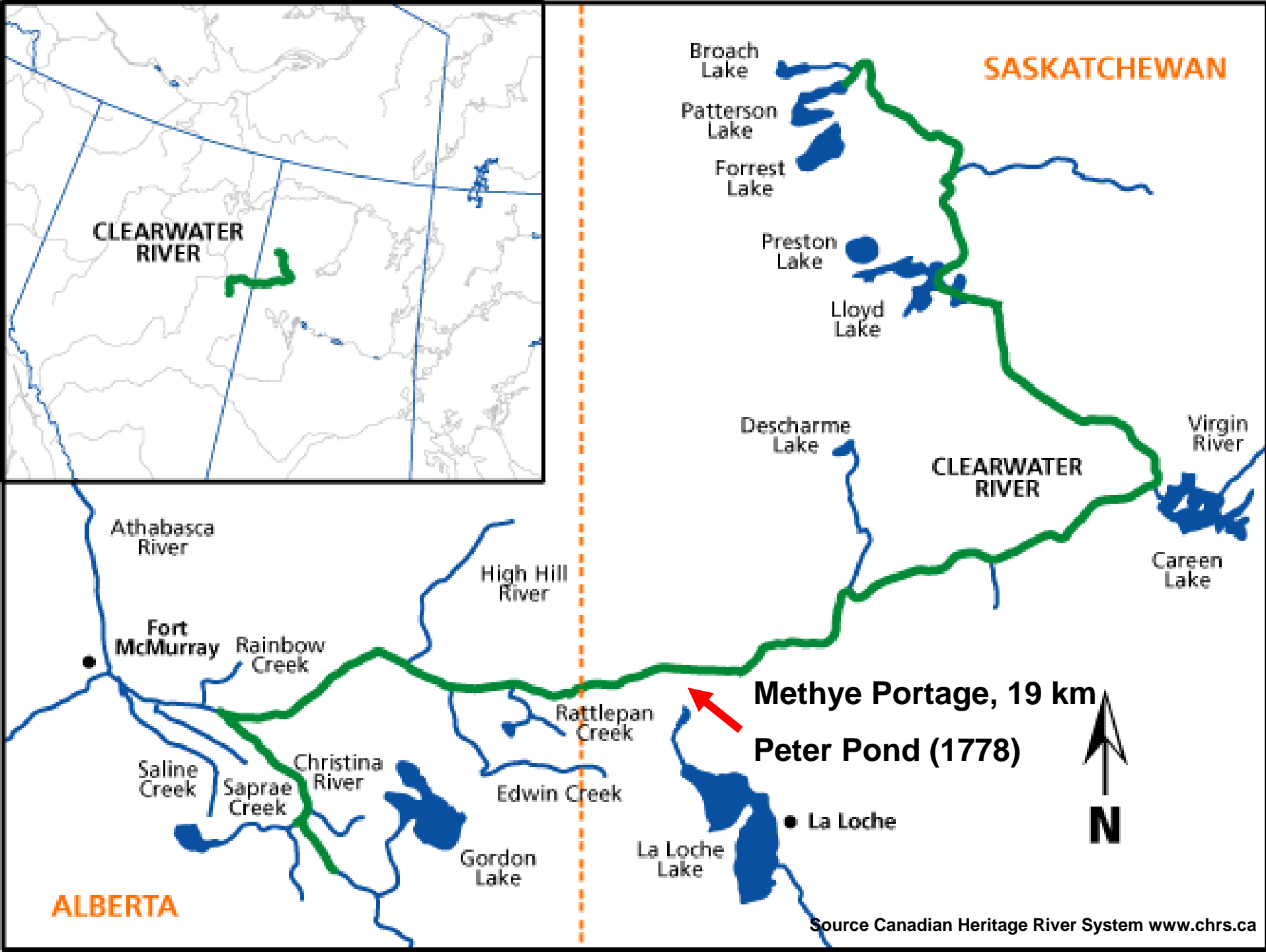
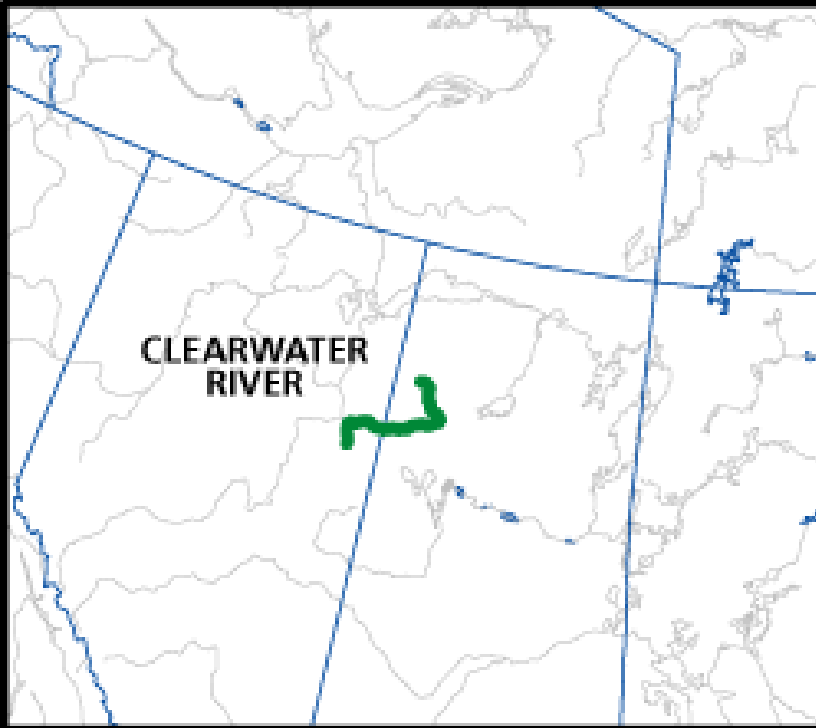
Athabasca River: a Canadian Heritage River

- nominated for natural features, historical significance & river recreation
- Jasper National Park (1989)
- Clearwater in Saskatchewan (1987) and Alberta (2004)



Heritage Rivers of Canada





Basic Concerns of Everyone

Can I drink the water?



Can I eat the fish?



Can I swim in the water?



Is there enough water for all uses?

Concerns - General

- **Water supply: too much / too little & timing**
- **Seasonal vs. year-to-year**
- **Flooding (rainfall, snowpack and snowmelt, ice jams) , e.g. Pembina River sub-basin, Fort McMurray**
- **Drought**
- **Transport of suspended and dissolved materials**
- **Habitat maintenance**

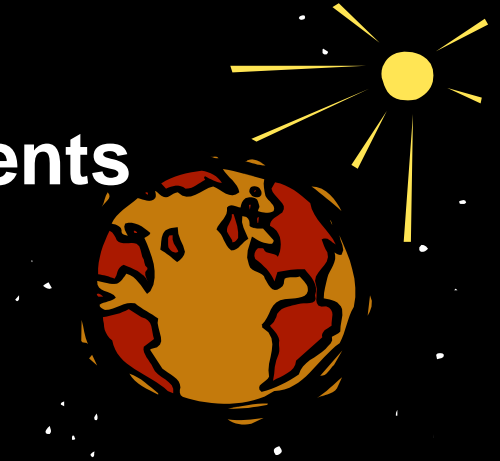
Concerns - General (continued)

- Over-exploitation of resources
 - renewable → non-renewable
 - non-renewable → exhausted too quickly



Concerns - General (continued)

- Global warming → may be less water (in certain locations) for:
 - native and agricultural plant growth
 - water for municipalities and industries
 - dilution → increased concentrations of toxins
 - flooding of habitats with nutrients



Concerns – Specific Groups

- **Oil and Pulp Industries**

- sufficient water for processes via licenses, tradable rights and performance standards
- storage of water
- water quality and water treatment (pre- / post-)
- enough water for effluent dilution
- spills
- aquatic organisms

Photo: Millar Western
Pulp, Whitecourt, 2007,
R.G. Holmberg

Concerns – Specific Groups

- Forestry
 - tree growth
 - drought
 - fire
 - tree-feeding insects
 - tree diseases
 - tree biodiversity
 - use of hybrids

Concerns – Specific Groups

- **Agriculture**
 - precipitation for plant growth
 - water for livestock
 - nutrient run-off
 - crop and livestock diseases
 - insect pests / pollinators

Photo: Near Baptiste Lake, 2007,
R.G. Holmberg

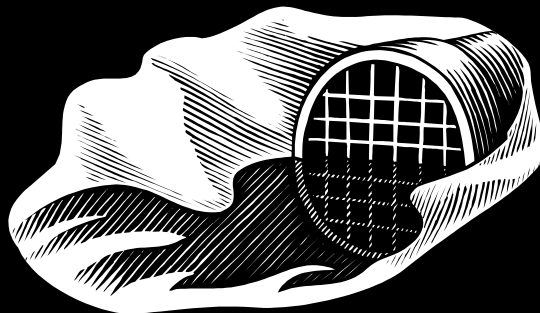
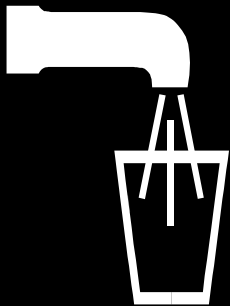
Concerns – Specific Groups

- **Fisheries**
 - water quantity and timing
 - water quality / toxicity
 - habitats
 - catch limits
 - exotics



Concerns – Specific Groups

- **Municipalities**
 - potable water
 - sewage treatment
 - flooding
 - wise use of water



Concerns – Specific Groups

- **Conservationists**

- water (in-stream flow needs) and land for organisms and their habitats
- toxins
- biological diversity
- habitat fragmentation
- river morphology via wide variation of water flow

Concerns – Specific Groups

- **Tourism**
 - water and land recreation
 - range of accessibilities (easy to difficult)
 - diversity of experiences



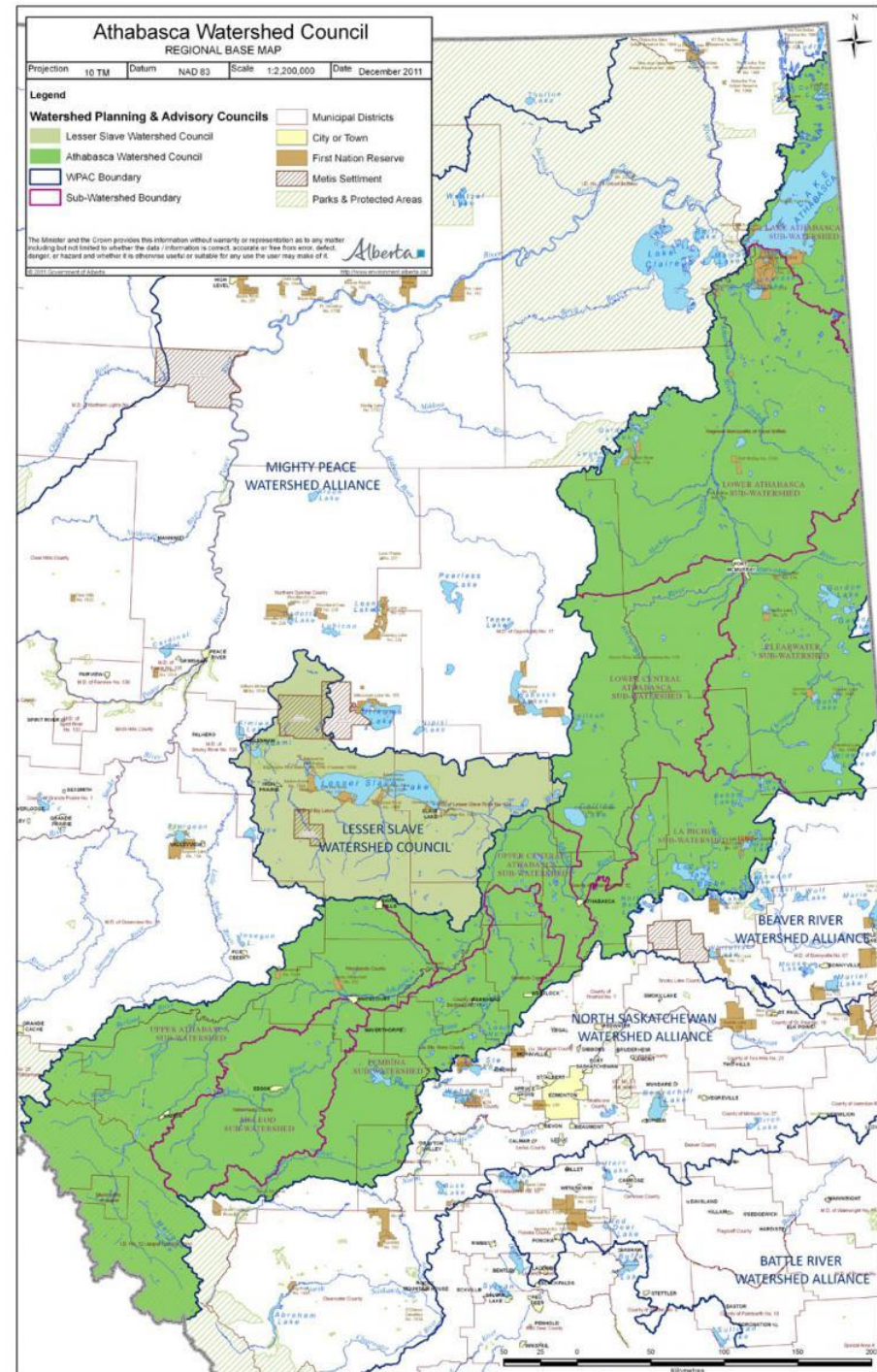
What is happening at the provincial level?

- WPACs = Water Planning Advisory Councils for each Alberta river
 - state of the watershed reports
 - integrated watershed management plans
 - recommendations to government



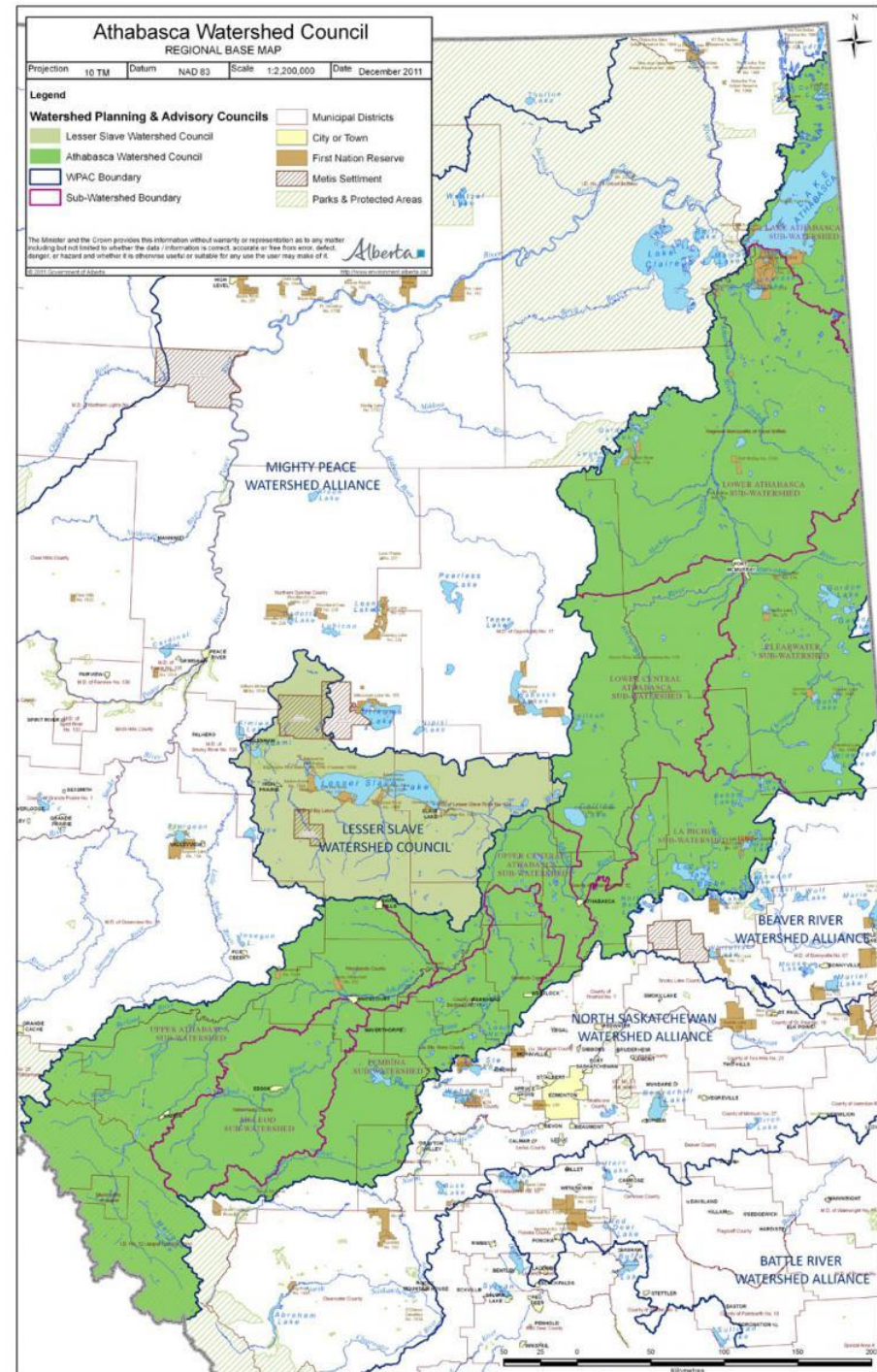
What is happening at a more local level?

- Lesser Slave Watershed Council
www.lswc.ca
- Athabasca Watershed Council
awc-wpac.ca



Requests

- Become a member of the Athabasca Watershed Council (free)
- Consider becoming a board member of the AWC



What is happening at Athabasca University?

1. Creation of Athabasca River Basin Research Institute (ARBRI) 2007-2008

- Scope and structure by Interim Director, Dr. David Lockey
- Web site: arbri.athabascau.ca
- Current Acting Director, Dr. Lisa Carter

What is happening at Athabasca University?

- 2 “water” professors via Campus Alberta Innovates Program (CAIP)

**Dr. Janye Wang,
CAIP Chair,
Computational
Sustainability and
Environmental
Analytics**



**Dr. Chris Glover,
CAIP Chair for
Hydrology and
Environmental
Health**



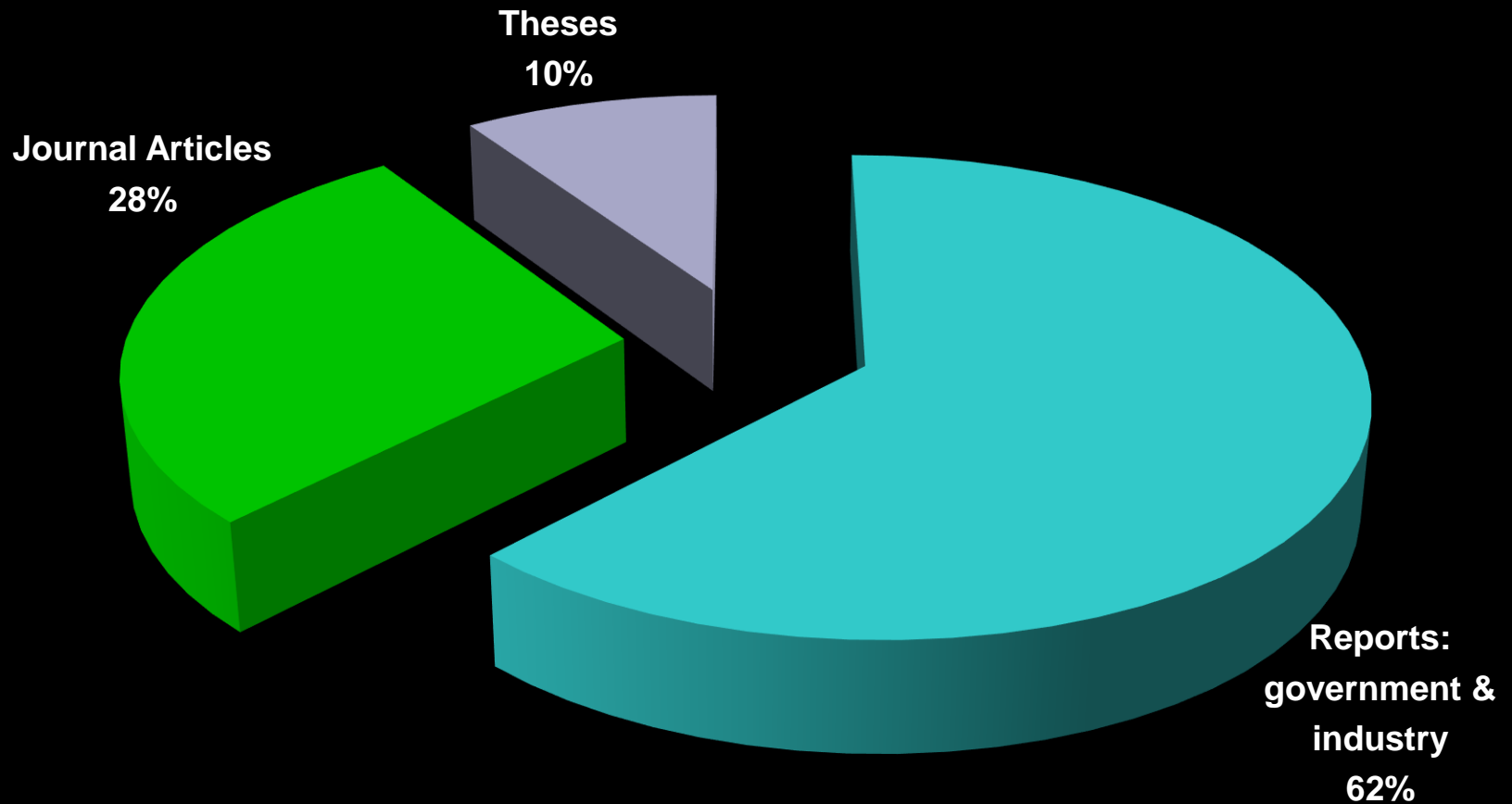
What is happening at Athabasca University?

2. Repository of the Athabasca River Basin*

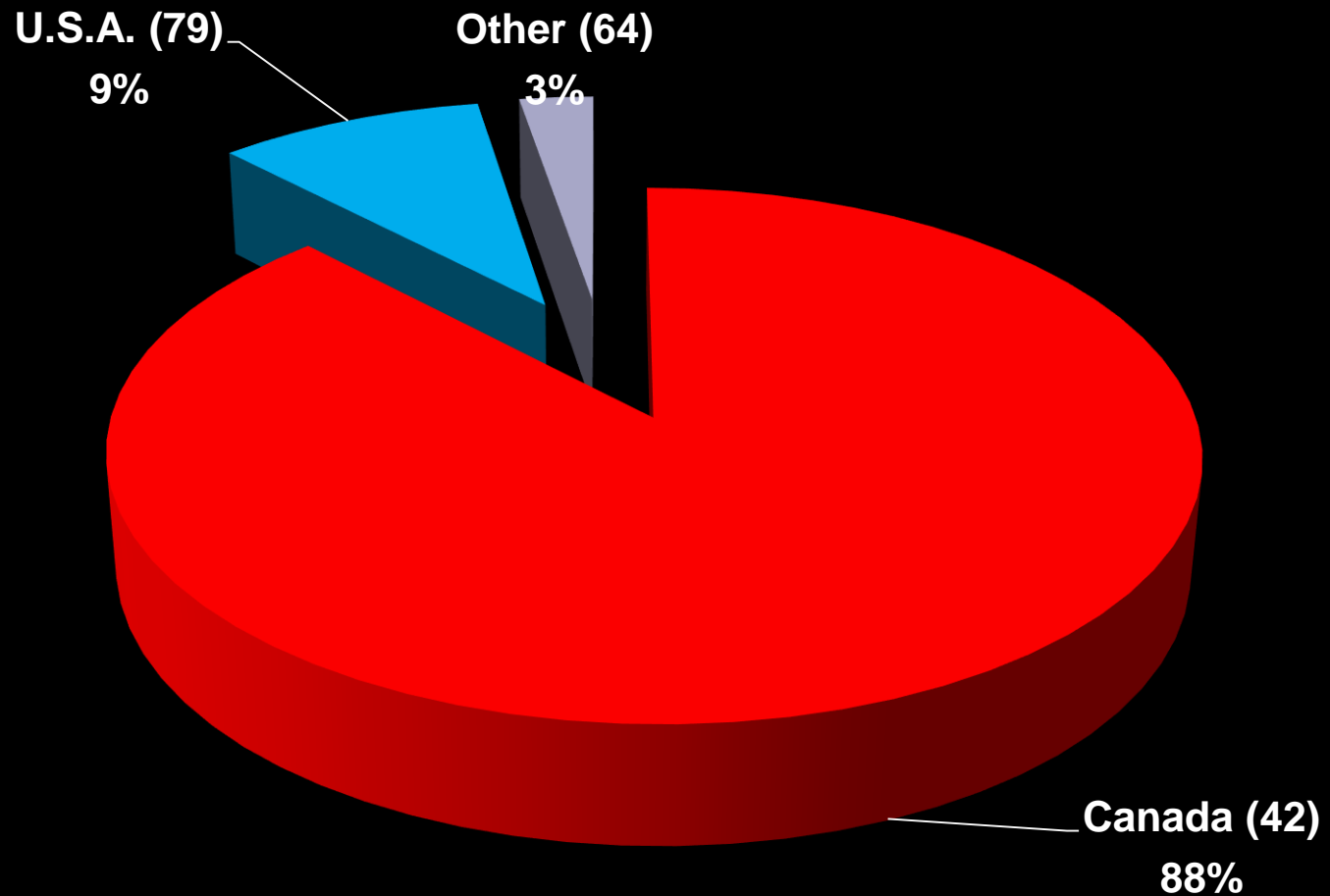
- Free, on-going, on-line, searchable database**
- Comprehensive:**
 - >35,000 science, social science, historic and economic references**
- www.barbau.ca**

* Project of Athabasca River Basin Research Institute (ARBRI), Athabasca University Library, Science Outreach – Athabasca, AU faculty & staff

Science Publications Related to the ARB



Home Universities (n = 185) of ARB Theses



Of 2,123 Canadian theses, 57% = U of A, 12% = U of C

N = 2,417

What is happening at Athabasca University:

3. Creation of Athabasca River Basin Image Bank

Why?



- Document what is happening
- Document resources
- Electronic archive
- Contents: photographs, maps, drawings, audio clips, video clips, slide shows
- Temporary location:
<http://digicon.athabascau.ca/cdm/search/collection/aurive>

My Hopes for the ARB

1. Integrated planning for accumulated impacts (e.g. interactions of pulp mill effluents with oil sand PAHs)
2. Monitoring – arms-length, long term and public access
3. Remediation money held in trust (i.e. outside of resource companies and loop holes closed)



My Hopes for the ARB

4. Research – primarily funded by resource consumers and effluent producers
5. Informed public – interested and active in their river basin
6. AU Library = central depository for all published materials related to the ARB



Questions?



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