



# Transboundary Groundwater Management in the Mackenzie River Basin, Canada

Ralph Pentland

*Transboundary  
Groundwater Management in  
the Mackenzie River Basin,  
Canada*

*The Groundwater Project*

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## *Transboundary Groundwater Management in the Mackenzie River Basin, Canada*

*The Groundwater Project  
Guelph, Ontario, Canada*

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Published by the Groundwater Project, Guelph, Ontario, Canada, 2026.

Pentland, Ralph.

Transboundary Groundwater Management in the Mackenzie River Basin, Canada /  
Ralph Pentland - Ottawa, Ontario, Canada, 2026.

16 pages

ISBN: 978-1-77470-013-6

DOI: <https://doi.org/10.21083/978-1-77470-013-6>

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#### APA (7th ed.) Citation

Pentland, Ralph. (2026). *Transboundary Groundwater Management in the Mackenzie River Basin, Canada*. The Groundwater Project. <https://doi.org/10.21083/978-1-77470-013-6>.



*Domain Editors:* Eileen Poeter and John Cherry.

*Board:* Eileen Poeter, Shafick Adams, John Cherry, Gabriel Eckstein, Kenneth Goldstein, Richard Jackson, Ineke Kalwij, Renée Martin-Nagle, Abhijit Mukherjee, Everton de Oliveira, Marco Petitta, and Chunmiao Zheng.

*Cover Image:* Groundwater Project (2025)

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## The Groundwater Project Foreword

The 2022 United Nations (UN) World Water Day theme “*Groundwater – Making the Invisible Visible*” was pivotal in raising global awareness about groundwater as an invaluable resource, and the year concluded with the UN Water Summit on Groundwater at the UNESCO headquarters. One of the key outcomes of the Summit was a call for governments and other stakeholders to scale up their efforts to better manage groundwater.

Groundwater makes up 99% of all liquid fresh water on Earth, underpinning its importance in providing drinking water to the world, sustaining food production, and maintaining healthy ecosystems. Many important global organizations have concluded that there is a freshwater crisis and given that nearly all freshwater is groundwater, the freshwater crisis is a groundwater crisis. During drought in many locales, groundwater is the only freshwater available, putting even more pressure on groundwater resources.

According to the World Health Organization and UNICEF ([WHO/UNICEF, 2025](#)), 2.1 billion people (1 in 4) live without safely managed drinking water and 3.4 billion people (4 in 10) live without safely managed sanitation. With groundwater directly supporting 8 of the 17 UN Sustainable Development Goals, groundwater is an invaluable resource. Safe and reliable access to groundwater directly supports the 2026 UN World Water Day (March 22) Theme “*Water and Gender Equality*” focusing on ensuring that women and girls have equal rights and leadership in water management.

The Groundwater Project (GW-Project), a registered Canadian charity founded in 2018, pioneers in advancing the understanding of groundwater by providing groundwater education to everyone. Recognizing that the world needs more highly skilled groundwater scientists to solve the water crisis, the GW-Project plays a pivotal role in creating the knowledge base for building the much-needed human capacity for the development and management of groundwater.

The GW-Project gained global recognition with publication of 64 original books, 94 translated books (in 59 languages), 7 interactive groundwater educational tools/modules, and over 50 high-quality educational videos, all made possible by a dedicated international group of over 1000 volunteer professionals from a broad range of disciplines throughout 70 countries on six continents. Academics, practitioners, and retirees contribute by writing and/or reviewing books aimed at diverse levels of readers including children, youth, undergraduate and graduate students, groundwater professionals, and the general public.

The GW-Project operates with the philosophy that high-quality groundwater education should be freely accessible for everyone, and to that end our publications are available free-of-charge on our [website](#). We thank our corporate sponsors and private donors for making this possible. Please consider sponsoring the GW-Project so we can continue to provide groundwater education free of charge.

**The Groundwater Project Board of Directors, January 2026**

## Foreword

The McKenzie River Basin is a huge watershed that covers one-fifth of the area of Canada and is the 12<sup>th</sup> largest drainage system in the world. The population of this basin is only 400,000 of which 10% are indigenous peoples living in 40 separate communities. The indigenous people lived off the land by hunting and trapping as some still do. The land is rich with resources including petroleum and minerals, which is why the total population has grown to ten times the indigenous population.

This book presents an important accomplishment of humanity. It describes an agreement to protect the surface water, groundwater, and ecology of the McKenzie River Basin with emphasis on groundwater, arrived at in 2015 between three Canadian provinces, two northern Territories and the federal government. What is most exceptional, is that the indigenous people played the decisive role in framing the language of the agreement such that protecting the land and its ecosystems is paramount with the goal of maintaining ecological integrity. This is unprecedented in Canada and likely anywhere else.

Canada is an affluent country with a modern economy strongly supported by exploitation of natural resources. In the early centuries, it was beaver fur for Europe and trees for English and French ships. Today's modern economy is strongly dependent on extraction of petroleum, minerals, and forest products—primarily by clear cutting. Ninety percent of the Canadian population lives in the south of Canada within 200 km of the border with the United States. The vast expanse of the country is the wilderness to the north, which is little seen by most Canadians.

Except for the McKenzie River Basin with its 2015 agreement, the unstated operating principle for land and water use in Canada, especially in the north, is that development is acceptable and desirable providing that the environmental damage is not excessive. The segment of Canadian society that defends the rights of nature is the indigenous community and it is this community that has shaped this governance agreement for the McKenzie River Basin even though indigenous people are a small minority of the population.

Sustainable development is a widely stated principle in theory and now it has good prospects for occurring in practice in the McKenzie River Basin. The author of this book, Ralph Pentland, a civil engineer by training, was the Director of Water Planning and Management for the government of Canada, for 13 years prior to 1991. Since then, he has been an advisor and consultant concerning national and international water and environmental issues, policies, and agreements, while serving on many boards and committees. Ralph Pentland is also co-author of the book: *Down The Drain: How We Are Failing to Protect Our Water Resources*.

John Cherry, The Groundwater Project Leader  
Guelph, Ontario, Canada, February 2026

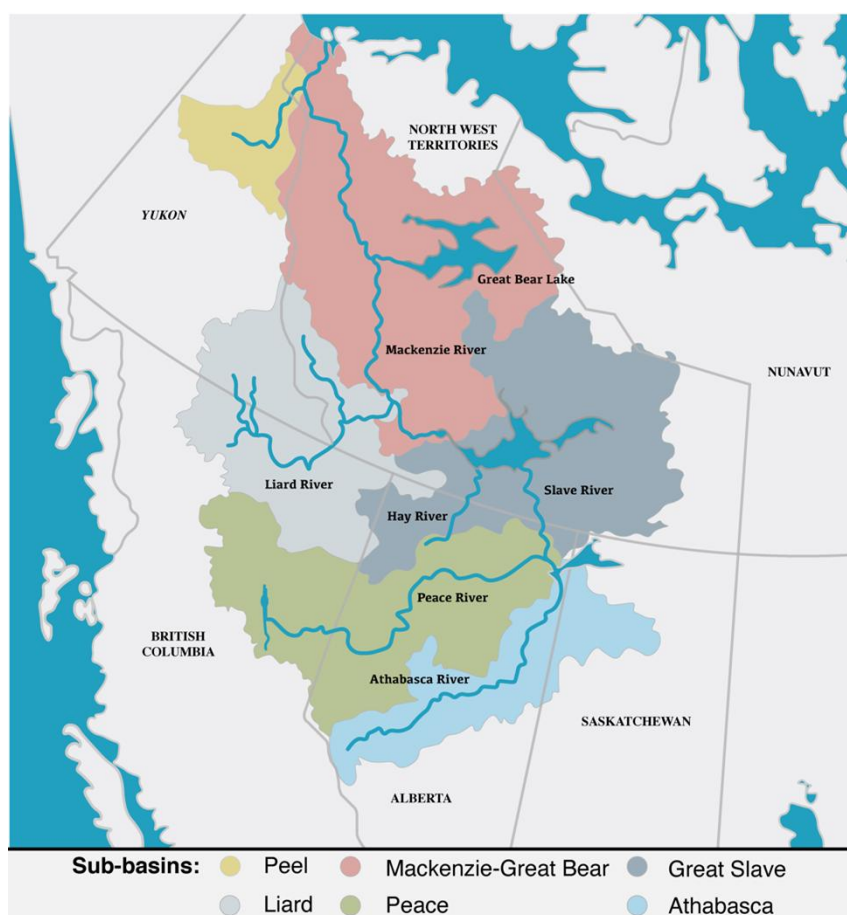
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## Preface

This book focuses on how groundwater is being dealt with in the Alberta—Northwest Territories Mackenzie River Basin Transboundary Agreement. The Mackenzie River is North America’s largest north-flowing river, is managed by five different provincial and territorial governments, and has some 50 significant transboundary tributaries (Figure 1). Due to these and other complexities, the Agreement has numerous unique features, including:

- a risk-informed approach designed to continually direct and redirect financial and human resources to ensure that emerging stresses can be pre-empted and avoided,
- a precautionary approach to groundwater and other aspects of ecosystem protection, and climate change adaptation, and
- an unprecedented level of direct Indigenous involvement.

This is perhaps one of the few remaining opportunities anywhere in the world where it is still possible to conceive of a truly integrated approach to protecting, rather than restoring surface water, groundwater, and related resources on a large river basin scale.



**Figure 1** - Mackenzie River Basin including 6 sub-basins(modified from Phare et al, 2016)).

## Acknowledgments

I deeply appreciate the thorough and useful reviews of and contributions to this book by the following individuals:

- ❖ Merrell-Ann Phare, International Joint Commission, Canada;
- ❖ Michael Miltenberger, North Raven, Canada;
- ❖ Gabriel E. Eckstein, Texas A&M University, United States of America;
- ❖ Ian Stewart, Kings College, Canada;
- ❖ Everton DeOliveira, President of Hidroplan, Director-President of the Instituto Água Sustentável (Sustainable Water Institute), Brazil;
- ❖ Amanda Sills, University of Guelph, Canada; and,
- ❖ John Williams, USGS, United States of America.

I am grateful for Amanda Sills and the Formatting Team of the Groundwater Project for their oversight and copyediting of this book. I thank Eileen Poeter (Colorado School of Mines, Golden, Colorado, USA) for reviewing, editing, and producing this book.

The sources of figures and/or tables are cited in their captions. Where a citation does not appear, the figures and/or tables are original to this book.

# 1 Introduction

The majority of Canada's major river and lake basins are transboundary, involving multiple provincial, local, and indigenous governments, and often the United States in basin management. Many of these transboundary situations are in remote locations where the understanding of groundwater aquifers is poor or non-existent, even though in many situations there are current or significant pending development pressures on sensitive groundwater aquifers. These were the conditions faced by the negotiators of the [Alberta Northwest Territories Mackenzie River Basin Bilateral Water Management Agreement](#) between 2011 and 2015, and by those attempting to implement the Agreement since that time.

The Mackenzie River is one of the great river systems of the world, the twelfth largest by drainage area and eleventh in mean annual discharge. It is a critical circumpolar river, and North America's largest north flowing river. The watershed covers 1.8 million square miles, draining one-fifth of Canada's land mass as shown in Figure 1 (Phare et al, 2016). Responsibility for management of the watershed is shared among five provincial and territorial jurisdictions: British Columbia; Alberta; Saskatchewan; Yukon; and the Northwest Territories. Transboundary water management agreements either have been, or are expected to be, negotiated between each of these jurisdictions.

The Alberta—Northwest Territories (NWT) agreement signed on March 18, 2015, includes protecting the quantity and quality of surface water; protecting the quantity and quality of groundwater; and protecting biology. In the cases of surface water quantity and quality, the science and methodologies supporting that protection are relatively straightforward, because the protection takes place at border crossings where hydrometric and water quality monitoring has been fairly robust for several decades (Figure 2). On the other hand, little is known about the location of major transboundary aquifers along the Alberta—Northwest Territories border, the quantity of groundwater contained in them, or its quality.



**Figure 2** - Mackenzie River Basin water quality monitoring points near the transboundary between Northwest Territories and Alberta. Circled numbers signify number of sampling points in proximity to that water body ([Mackenzie DataStream](#)).

The following sections explore the background of the negotiations, an overview of the agreement, a description of the critical role of indigenous peoples, a description of the groundwater provisions, and a brief look forward.

## 2 Background

The seeds of the current bilateral agreements go back to the 1970s and a report by the Mackenzie River Basin Committee (1981) which concluded:

*“Water is the essential natural resource of the Mackenzie River Basin. It provides habitat for fish and wildlife, and for the food chains which support them. Other resources, such as coal, oil, gas, and minerals require large amounts of water for their development. Navigation and hydroelectric power production add to the growing competition for water. Development of any resource, be it in one jurisdiction or several, could affect the use of water by altering flows, levels or water quality downstream. Hence, the need for cooperative management represents the greatest and most urgent challenge for the future.”*

By 1997, the nature of that cooperation began to take shape with the signing of the Mackenzie River Basin Master Agreement<sup>↗</sup> by the governments of British Columbia, Alberta, Saskatchewan, Canada, Yukon and the Northwest Territories. That Master Agreement established the Mackenzie River Basin Board, called for the subsequent negotiation of bilateral agreements between each government partner, and set out certain principles to guide the bilateral negotiations. Those principles dealt with matters such as ecological integrity, sustainability, recognition of other jurisdictions’ rights, information sharing, and dispute resolution. The Northwest Territories Lands and Resources Devolution Agreement<sup>↗</sup> of 2013 gave the territory provincial like powers, as prior to this devolution agreement, the NWT did not have administrative oversight of their natural resources. This agreement transferred responsibilities for public land, water, and resource management from the federal government to NWT self-governance.

The actual negotiation of bilateral agreements did not start until 2011, but in the meanwhile individual jurisdictions were advancing their own individual water policies. Perhaps one of the most influential of those individual policies was the Northwest Territories’ Northern Voices, Northern Waters Strategy<sup>↗</sup>. In that Strategy, the Indigenous-dominated government of the NWT recognized the fundamental importance of water to natural security and prosperity. “Clean and abundant freshwaters,” the Strategy preamble noted, “ensure healthy, productive ecosystems. These are essential to the social, cultural, and economic well-being of people”.

Rather than debate how much of that comprehensive health to sacrifice in pursuit of cash incomes – the typical terms of environmental discourse in much of the south – the territories’ goal is the preservation of the water “substantially unaltered in quality, quantity and rates of flow” and of all the “spiritual, cultural, public health, recreational, economic and ecological values” that water secures. Interestingly, that phrase, “substantially unaltered in quality, quantity, and rates of flow” was a guiding light for at least the NWT negotiators, and will undoubtedly continue to be so as site-specific objective-setting proceeds during implementation.

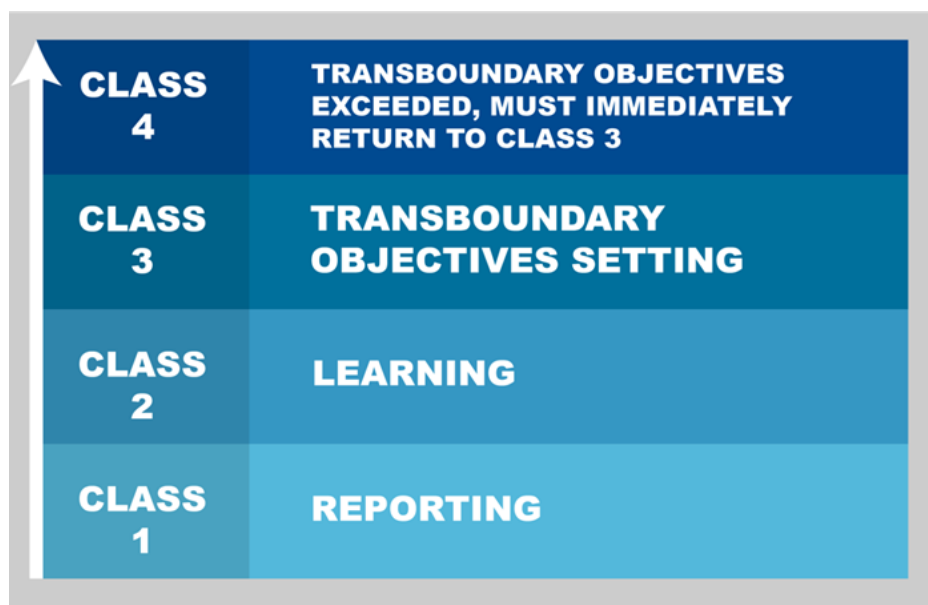
### 3 The Agreement

This bilateral agreement and others like it in the Mackenzie River Basin are unique in several ways (Pentland, 2015).

- It is one of the most comprehensive agreements of its type anywhere in the world, dealing simultaneously with water quantity, water quality, groundwater, biology, atmospheric sources of pollution, and overall ecological integrity.
- To the best of the author's knowledge, it is one of the very few transboundary agreements anywhere in the world that puts ecological integrity first. For example, environmental flows must be satisfied before even considering allocations for other purposes.
- It includes timeless, principled rules to protect ecological integrity, while simultaneously relying on a sound risk-informed approach to adapt to rapidly changing circumstances like climate change.
- Because bilateral and multilateral negotiations proceeded in parallel, the concepts in the agreements had unanimous buy-in throughout the Basin. At the beginning of the process, few people believed a Basin-wide approach was possible, but in essence it is being achieved.
- The negotiating process included an unprecedented level of direct Indigenous involvement. Throughout the process, the Government of the Northwest Territories (GNWT) negotiating team relied heavily on the input of an extremely active and involved Aboriginal Steering Committee.

A full description of the Agreement is well beyond the scope of this presentation, but some detail on the risk-informed management approach (Figure 3), which is a central feature of the Agreement, is included because it was critical to the way groundwater was included despite the dearth of knowledge about that resource in the Basin.

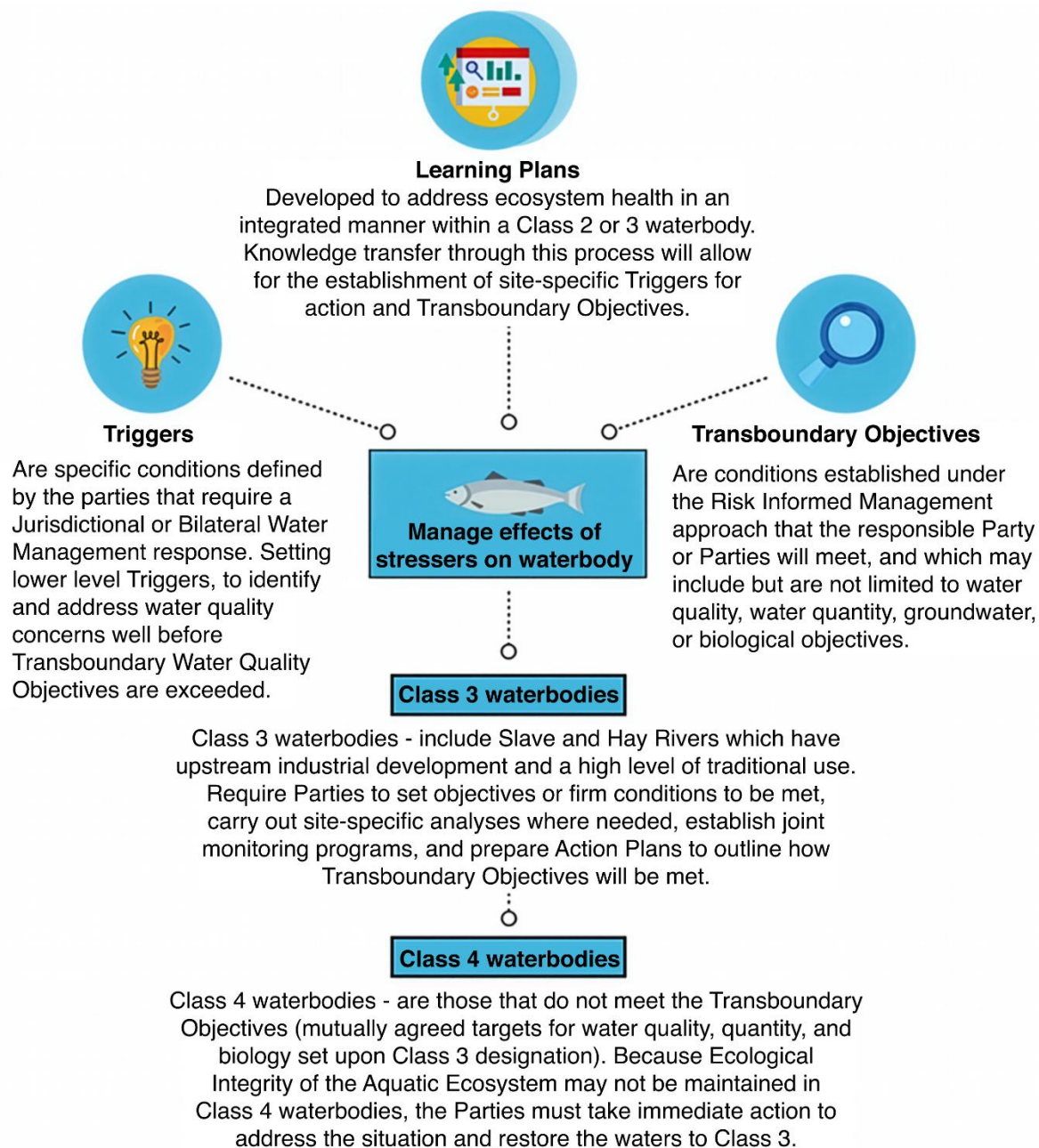
Under the risk-informed approach, the type and intensity of management actions increases as water bodies move from Class 1 to Class 4 (Figure 3 - Risk-informed management approach with management actions increasing moving from Class 1 to Class 4. Adapted from *Transcending Boundaries: Guidebook to the Alberta–Northwest Territories Mackenzie Basin Transboundary Water Agreement*, 2016 (Phare et al., 2016).). Class 1 is a water body with little current or anticipated demand. The class number increases as expected demand increases up to Class 4 which is a water body with more demand than it can supply. In that way, financial and human resources are continually redirected to the highest priority areas in such a way that emerging stresses can be pre-empted and avoided.



**Figure 3** - Risk-informed management approach with management actions increasing moving from Class 1 to Class 4. Adapted from *Transcending Boundaries: Guidebook to the Alberta—Northwest Territories Mackenzie Basin Transboundary Water Agreement*, 2016 (Phare et al., 2016).

For Class 1 water bodies where there is little or no current or anticipated development pressures, no immediate action is required. As a water body moves from Class 1 to Class 2, the Parties to the Agreement begin to develop “learning plans” to address important water quality, water quantity, groundwater, and biological factors in an integrated manner. This will usually involve the establishment of agreed-upon “triggers” calling for a jurisdictional or bilateral water management response. It may also involve beginning work on more specific “objectives” (Phare et al., 2016).

For Class 3 water bodies, learning plans, triggers, and transboundary objectives will be agreed upon on a case-by-case basis, and any trends resulting in diminishing aquatic ecosystem health will be addressed through appropriate management actions (Figure 4). Class 4 water bodies are those that do not meet the transboundary objectives, and where the ecological integrity of the aquatic ecosystem is not being maintained. In those cases, immediate action is required to bring the waters back into a Class 3 state.



**Figure 4** - Learning Plans are developed to address ecological health with Triggers and Transboundary Objectives put in place to manage the effects of stressors on waterbodies.

At the time the agreement was signed, no Class 4 water bodies were identified, and only the Slave and Hay Rivers were set at Class 3 (Figure 5). All other water bodies and all groundwater aquifers were set at Class 1 because, even though there are significant pressures in some specific areas, much of the basin still exists in a mostly natural state.



**Figure 5** - Mackenzie River Basin including six sub-basins. Class 3 water bodies include Hay River and Slave River.

## 4 The Critical Role of Indigenous Peoples

Indigenous governments in the Mackenzie River Basin quite appropriately see authority as a shared jurisdiction requiring their direct participation. This view reflects legitimate rights and authorities that have been formally recognized in land claims agreements, such as Treaty 8 and Treaty 11, in numerous court judgments, and in frameworks including the [Umbrella Final Agreement](#)<sup>7</sup> that helped to lay the foundation for indigenous self-governance. For example, under several such agreements, Indigenous signatories have a right to have waters that are on or flow through their traditional lands “remain substantially unaltered as to quality, quantity and rate of flow”. As mentioned earlier, this clause played an extremely important role in the negotiations.

A key element of the risk-informed management approach described above is the development of learning plans. Traditional Indigenous knowledge and information on the health of aquatic ecosystems and how they are being used will be utilized in concert with western science in every aspect of the learning plans. This traditional knowledge is being integrated with science because it is recognized that the users of the land and water are often best positioned to identify water-related problems and opportunities.

During implementation, the Parties are also required to exchange traditional knowledge and input. This provides an avenue for indigenous peoples to express their concerns about environmental health regarding proposed developments or actions. This serves both practical and legal needs. Governments have a legal duty to consult and, where necessary, accommodate the concerns of Indigenous peoples before they take actions or make decisions that may affect Aboriginal or treaty rights.

Fully engaging Indigenous peoples in information sharing and collaboration is not only an obligation it is also an opportunity for their values, ideas, and traditional knowledge to contribute to improved bilateral water management in the Mackenzie River Basin.

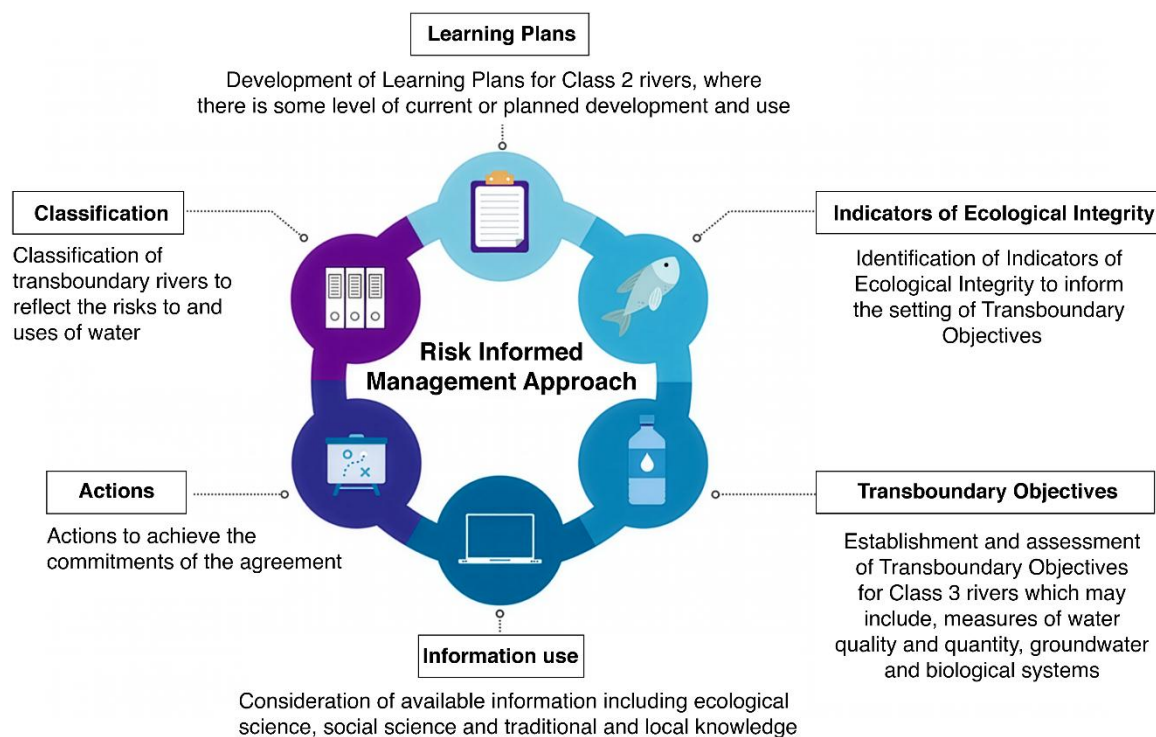
## 5 Groundwater Provisions

The groundwater provisions in the Agreement recognize the critical importance of protecting groundwater quantity and quality not only because of current and probable future human uses, but also because it sustains wetlands, streams, lakes, and other surface waters. Because groundwater moves so slowly, it may take a very long time for contaminated groundwater to appear. Contaminated groundwater is expensive, and sometimes even impossible to clean up groundwater after the fact.

For these reasons, the groundwater provisions in the agreement rely on the risk-informed management approach (Figure 6), which is exceptionally forward-looking, designed to preempt future problems and head them off before it is too late. Even though little groundwater is currently withdrawn or consumed in the Mackenzie River Basin due to the small population, future pressures on the resource are inevitable due to climate change and future population growth leading to more groundwater extraction, as well as gas and oil production including hydraulic fracturing, and other types of industrial development. Groundwater supply is the primary water source for towns in the Northwest Territory as well as the Liard Basin within Yukon and British Columbia.

The specific groundwater provisions are as follows.

- The Parties will establish and implement RIM (risk-informed management) classifications, Learning Plans, Transboundary Groundwater Objectives, and monitoring in accordance with the RIM approach.
- The Parties will manage Transboundary Groundwater, including the water quantity, water quality, physical structure, and transboundary surface water systems supported by Transboundary Groundwater in a manner that is protective and maintains the Ecological Integrity of the Aquatic Ecosystem.
- The Parties will use and share Transboundary Groundwater reasonably and equitably, as determined on a case-by-case basis.



**Figure 6** - Risk-informed management approach that to ensure proactive management of waterbodies occurs. This approach begins with Classification of all waterbodies and leads to Actions to intervene when Transboundary Objectives are exceeded.

Because of the inevitability of climate change impacts, the Parties will be applying these and other provisions very conservatively, for example in the application of the risk-informed management approach and the establishment of triggers and objectives. It is predicted that climate changes will reduce groundwater recharge in the region because of increased evaporation as well as increased frequency and intensity of rainfall events causing more overland runoff. Warmer temperatures will also increase evaporation, which will in turn result in less soil moisture and less groundwater recharge.

Aside from an exceedingly conservative scientific approach, as mentioned earlier, it is expected that implementation will also include unprecedented levels of involvement by Indigenous peoples. With strong links to the land and waters supporting their livelihoods and traditional ways of life, Indigenous governments will have extraordinarily meaningful roles in research, outreach and negotiations related to, for example, large-scale energy and other industrial projects. Both western and traditional knowledge, as well community-based monitoring is likely to play important roles in that regard.

[Exercise 1](#) and [Exercise 2](#) provide an opportunity to recall the critical aspects of transboundary groundwater management in the Mackenzie River Basin.

## 6 Looking Ahead

It is not too early to begin looking ahead to the time when some groundwater aquifers will begin to move from Class 1 to Class 2 requiring the formulation of learning plans. In the case of aquifers, the classifications will account for the level of existing or proposed development, the vulnerability of the aquifer(s), sensitive uses, existing or potential conflicts, and negative impact trends. For Class 2 aquifers, learning plans are likely to include, among other things, issue scoping, compilation of existing baseline data, collection of additional baseline data, monitoring, data analysis, and investigation into potential effect pathways.

In recognition of these needs, soon after the signing of the Alberta—Northwest Territories Agreement (March 18, 2015), the Government of the Northwest Territories (GNWT) contracted the preparation of a report consolidating: existing knowledge regarding groundwater resources; groundwater uses; potential impacts to groundwater; groundwater monitoring; and groundwater-surface water interactions to support the future development of learning plans. That kind of foresight will hopefully continue into the coming decades and beyond (VanGulck, 2016).

The river that Canada and the rest of the world know as the Mackenzie is also sometimes described by its Dene name, Dai Cho, the Great River (Pentland and Wood, 2013). The “Great River” and its vast basin have also been described by some as “the last water in the world”, in the sense that it is among the few places left in the world where it is still possible to conceive of a truly integrated approach to protecting, rather than restoring surface water, groundwater, and related resources on large river basin scale. It is indeed encouraging to see the many actors who share this vast and unique natural wealth coming together with common resolve to do just that.

## 7 Exercises

### Exercise 1

What agreement supported the rights of indigenous peoples to protect their water in the Mackenzie River basin?

[Click for solution to Exercise 1](#) ↓

[Return to where text linked to Exercise 1](#) ↑

### Exercise 2

What are the three groundwater provisions that will be used to assess development?

[Click for solution to Exercise 2](#) ↓

[Return to where text linked to Exercise 2](#) ↑

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## 9 Exercise Solutions

### Solution Exercise 1

The agreement that supported the rights of indigenous peoples to protect their water in the Mackenzie River basin is the Alberta—Northwest Territories Mackenzie River Basin Transboundary Agreement.

[Return to Exercise 1](#) ↑

[Return to where text linked to Exercise 1](#) ↑

### Solution Exercise 2

The three groundwater provisions that will be used to assess development are as follows.

1. The Parties will establish and implement RIM (risk-informed management) classifications, Learning Plans, Transboundary Groundwater Objectives, and monitoring in accordance with the RIM approach.
2. The Parties will manage Transboundary Groundwater, including the water quantity, water quality, physical structure, and transboundary surface water systems supported by Transboundary Groundwater in a manner that is protective and that maintains the Ecological Integrity of the Aquatic Ecosystem.
3. The Parties will use and share Transboundary Groundwater reasonably and equitably, as determined on a case-by-case basis.

[Return to Exercise 2](#) ↑

[Return to where text linked to Exercise 2](#) ↑

## 10 About the Author



For 13 years prior to 1991, **Ralph Pentland** was Director of Water Planning and Management in the Canadian Federal Government. In that capacity, he was responsible for negotiating and administering numerous federal—provincial and Canada—USA Agreements, was responsible for administering the Canada Water Act and the International River Improvements Act and was the primary author of the 1987 Federal Water Policy. Since 1991, Ralph served as a water and environmental policy consultant in many countries, served as Canadian Co-Chairman on several International Joint Commission Boards and Committees, collaborated with numerous non-governmental and academic organizations, including Chairing the Canadian Water Issues Council at the University of Toronto for a decade, helped negotiate major intergovernmental agreements in the Great Lakes–St. Lawrence and Mackenzie River Basins, assisted in the development of federal water export legislation, and was co-author of the book *Down the Drain: How We Are Failing to Protect Our Water Resources*. In 2019, Ralph became a Member of the Order of Canada. He is currently President of Ralbet Enterprises Incorporated, a Member of the Forum for Leadership on Water, a Board Member with LakePulse, and a Member of the Advisory Committee for Environmental Defense Canada.

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